Handbook of Mineralogy

The *Handbook of Mineralogy* series is a Five Volume set authored by John W. Anthony, Richard A. Bideaux, Kenneth W. Bladh, and Monte C. Nichols, and published by Mineral Data Publishing. Each mineral known at the time of publication occupies one page of the handbook.

In 2001 the copyright for the *Handbook of Mineralogy* was given to the Mineralogical Society of America by Kenneth W. Bladh, Richard A. Bideaux, Elizabeth Anthony-Morton and Barbara G. Nichols and the remaining volumes were shipped to the MSA warehouse in Chantilly, VA.

Along with the copyright, MSA was given pdf files of each page of the handbook. These are freely distributed to the public on this website.

In 2002, the MSA council established an editorial office, headed by Dick Bideaux, for the purpose of updating and maintaining the mineral database of the *Handbook of Mineralogy* and to continue converting the text files to PDF files for on-line access through the MSA website.

After Dick Bideaux's untimely death in 2004 the MSA council organized an editorial committee in 2006 headed by Frank Dudas (MIT) to complete the task. This website is being organized to that end.

Ken Bladh (Wittenberg University), one of the original authors of the Handbook, was appointed Editor of the *Handbook of Mineralogy* database by MSA Council action in June 2010, after Frank Dudas was unable to continue in that role. Professor Bladh’s initial goal is to bring the online Handbook up to date by adding pdf pages for all new minerals approved by the IMA after the publication of each original Handbook volume. Revision of the Handbook to reflect all IMA approved changes in nomenclature and new mineral data will be undertaken after the new minerals project is completed.

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Abelsonite $C_{31}H_{32}N_4Ni$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Small aggregates, to 1 cm, of thin laths or plates.

Physical Properties: *Cleavage:* Probable on $\{11\overline{1}\}$. Hardness = < 3 D(meas.) = 1.33–1.48 D(calc.) = 1.45

Optical Properties: Semitransparent. *Color:* Dark grayish purple, pale purplish red, reddish brown. *Luster:* Submetallic to adamantine.
Optical Class: [Biaxial.] *Absorption:* Strong reddish brown to reddish black. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 8.508(24)$ $b = 11.185(27)$ $c = 7.299(15)$ $\alpha = 90°51(15)'$ $\beta = 114°08(12)'$ $\gamma = 79°59(13)'$ Z = 1

X-ray Powder Pattern: Green River Formation, Utah, USA.
10.9 (100), 3.77 (80), 7.63 (50), 5.79 (40), 3.14 (40), 5.51 (35), 6.63 (30)

Chemistry: (1) Green River Formation, Utah, USA; electron microprobe analysis gave Ni 11%–14%; based on mass spectroscopic and IR results, the composition conforms to nickel porphyrin.

Occurrence: Of secondary origin on fracture surfaces in oil shale.

Association: Albite, orthoclase, pyrite, quartz, mica, dolomite, analcime.

Distribution: In the USA, in a drill core from Wosco, Big Pack Mountain Quadrangle, and several other localities in or near the Mahogany Zone, Green River Formation, Uintah Co., Utah, and in the Piceance Creek Basin, Rio Blanco Co., Colorado.

Name: Honors Philip Hauge Abelson (1913–), American organic geochemist, President of the Carnegie Institution of Washington, D.C., USA, and Editor of *Science*.

Type Material: The Natural History Museum, London, England, 1979,135; National Museum of Natural History, Washington, D.C., USA, 143566, 145712.

References: (1) Milton, C., E.J. Dwornik, P.A. Estep-Barnes, R.B. Finkelman, A. Pabst, and S. Palmer (1978) Abelsonite, nickel porphyrin, a new mineral from the Green River Formation, Utah. Amer. Mineral., 63, 930–937. (2) Storm, C.B., J. Krane, T. Skjetne, N. Telnaes, J.F. Branthaver, and E.W. Baker (1984) The structure of abelsonite. Science, 223, 1075–1076. (3) Mason, G.M., L.G. Trudell, and J.F. Branthaver (1989) Review of the stratigraphic distribution and diagenetic history of abelsonite. Organic Geochemistry, 14, 585–594.

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Abernathyite $K_2(UO_2)_2(AsO_4)_2 \cdot 6H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As thick tabular crystals, composed of {001} and {110}, to 3 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = > 3.32 D(calc.) = 3.572 Fluoresces yellow-green under LW and SW UV. Radioactive.

Optical Properties: Transparent. *Color:* Yellow. *Streak:* Pale yellow. *Luster:* Weakly vitreous.
Optical Class: Uniaxial (–), anomalously biaxial (–). *Pleochroism:* O = yellow; E = pale yellow to colorless. $\omega = 1.597$–1.608 $\epsilon = 1.570(3)$ 2V(meas.) = ∼5°

Cell Data: *Space Group:* $P4/ncc$. a = 7.176(8) $c = 18.126(10)$ Z = 4

X-ray Powder Pattern: Fuemrole No. 2 mine, Utah, USA.
9.14 (10b), 3.84 (8b), 3.34 (8), 5.63 (7), 3.59 (7), 2.79 (6b), 2.28 (6)

Chemistry:

	(1)	(2)
UO_3	57.7	56.97
P_2O_5	1.5	
As_2O_5	21.6	22.89
K_2O	9.5	9.38
H_2O^+	9.9	
H_2O^-	4.6	
H_2O		10.76
Total	104.8	100.00

(1) Fuemrole No. 2 mine, Utah, USA; microchemical analysis, H_2O^+ by loss on ignition; corresponds to $K_{1.94}(UO_2)_{1.92}[(As_{1.79}P_{0.21})_{\Sigma=2.00}O_4] \cdot 7.68H_2O$. (2) $K_2(UO_2)_2(AsO_4)_2 \cdot 6H_2O$; $6H_2O$ assigned from crystal-structure analysis.

Mineral Group: Meta-autunite group.

Occurrence: A rare secondary mineral coating fractures in bleached asphaltic sandstone hosting a Colorado Plateau-type uranium deposit (Fuemrol No. 2 mine, Utah, USA).

Association: Scorodite, zeunerite, heinrichite.

Distribution: In the USA, found at the Fuemrole No. 2 mine, Temple Mountain, Emery Co., Utah; from Cave Hills and Slim Buttes, Harding Co., South Dakota; at the West mine, Saguache Co. and the Clyde Long property, San Juan Co., Colorado; from near Tuba City, Coconino Co., Arizona. In the Riviéral mine, Lodève, Hérault, France. At Sailauf, northeast of Aschaffenburg, Bavaria, Germany.

Name: To honor Jess Abernathy, Moab, Utah, USA, mine owner who found the first specimens.

Type Material: National Museum of Natural History, Washington, D.C., USA, 112650.

References: (1) Thompson, M.E., B. Ingram and E.B. Gross (1956) Abernathyite, a new uranium mineral of the metatorbernite group. Amer. Mineral., 41, 82–90. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Surv. Bull. 1064, 220–222. (3) Ross, M. and H.T. Evans, Jr. (1964) Studies of the torbernite minerals (I): The crystal structure of abernathyite and the structurally related compounds $NH_4(UO_2AsO_4) \cdot 3H_2O$ and $K(H_3O)(UO_2AsO_4)_2 \cdot 6H_2O$. Amer. Mineral., 49, 1578–1602.

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Abhurite $Sn_{21}^{2+}O_6Cl_{16}(OH)_{14}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. As thin, six-sided crystals, platy to tabular on (0001), showing $\{01\overline{1}5\}$ and {0001}, to 2 mm; as cryptocrystalline crusts. *Twinning:* On {0001}.

Physical Properties: *Fracture:* Hackly. *Tenacity:* Fragile [*sic*]. Hardness = 2
D(meas.) = 4.42 (synthetic). D(calc.) = 4.417

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Opalescent. *Optical Class:* Uniaxial (+). $\omega = 2.06$ $\epsilon = \sim 2.11$ 2V(meas.) = Small, observed on strained plates.

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. $a = 10.0175(3)$ $c = 44.014(2)$ Z = 3

X-ray Powder Pattern: Sharm Abhur Cove, Saudi Arabia.
2.5313 (100), 2.8915 (70), 4.139 (50), 3.404 (50), 2.8175 (50), 3.271 (35), 3.244 (35)

Chemistry:

	(1)	(2)
Sn	73.4	73.44
Cl	15.7	16.71
O	11.0	9.43
H	0.4	0.42
Total	100.5	100.00

(1) Sharm Abhur Cove, Saudi Arabia; Sn by wet chemical analysis, Cl by ion-specific electrode, O by neutron activation, H by CHN analyzer. (2) $Sn_{21}O_6Cl_{16}(OH)_{14}$.

Occurrence: In blisterlike protuberances on the surface of a tin ingot recovered from a ship wrecked possibly 100 years ago (Sharm Abhur cove, Saudi Arabia).

Association: Romarchite, kutnohorite, aragonite.

Distribution: From the cargo of a ship wrecked in a Red Sea cove known as Sharm Abhur, about 30 km north of Jiddah, Saudi Arabia. From the cargo of a ship wrecked off Hidra, Norway. From a ship wrecked about 30 km north-northwest of St. Ives, Cornwall, England.

Name: For the Saudi Arabian locality at Sharm Abhur Cove.

Type Material: Royal Ontario Museum, Toronto, Canada; National Museum of Natural History, Washington, D.C., USA, 162403.

References: (1) Matzko, J.J., H.T. Evans, Jr., M.E. Mrose, and P. Aruscavage (1985) Abhurite, a new tin hydroxychloride mineral, and a comparative study with a synthetic basic tin chloride. Can. Mineral., 23, 233–240. (2) (1989) Amer. Mineral., 74, 500 (abs. ref. 1). (3) Von Schnering, H.G., R. Nesper, and H. Pelshenke (1981) $Sn_{21}Cl_{16}(OH)_{14}O_6$, das sogenannte basische Zinn(II)-chlorid. Zeits. Naturforsch., 36b, 1551–1560 (in German with English abs.). (4) Edwards, R., R.D. Gillard, and P.A. Williams (1992) The stabilities of secondary tin minerals: abhurite and its relationships to Sn(II) and Sn(IV) oxides and oxyhydroxides. Mineral. Mag., 56, 221–226.

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Abramovite $Pb_2SnInBiS_7$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Crystals, lamellar, to 1 mm, striated slightly parallel to elongation. *Twinning:* Lamellar on {100}.

Physical Properties: *Cleavage*: Perfect on {100}. *Fracture*: n.d. *Tenacity*: n.d.. Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color*: Silver gray; white with yellowish gray tones in reflected light. *Streak*: Black. *Luster*: Metallic.
Optical Class: n.d. *Bireflectance*: Weak. *Anisotropism:* Distinct.
R_1-R_2: (400) 14.0–32.9, (470) 13.9–29.0, (550) 15.7–29.9, (590) 16.4–30.2, (650) 17.9–30.8, (700) 18.9–31.2

Cell Data: *Space Group*: $P\bar{1}$. a = 23.4(3) b = 5.77(2) c = 5.83(1) α = 89.1(5)° β = 89.9(7)° γ = 91.5(7)°

X-ray Powder Pattern: Kupol fumarole field, Kudryavy volcano, Kurile Islands, Russia.
3.90 (100), 3.84 (71), 5.90 (36), 2.921 (33), 3.166 (26), 2.040 (20), 2.186 (18)

Chemistry:

	(1)
S	20.66
Se	0.98
Cu	0.01
Cd	0.03
In	11.40
Sn	12.11
Pb	37.11
Bi	17.30
Total	99.60

(1) Kupol fumarole field, Kudryavy volcano, Iturup Island, Kurile Islands, Russia; average of 4 electron microprobe analyses, corresponding to $Pb_{1.92}Sn_{1.09}In_{1.06}Bi_{0.89}(S_{6.90}Se_{0.13})_{\Sigma=7.03}$.

Occurrence: A product of precipitation from fumarolic gases (600° C) in an active stratovolcano.

Association: Pyrrhotite, pyrite, wurzite, galena, halite, sylvite, anhydrite.

Distribution: Kupol fumarole field, Kudryavy volcano, Iturup Island, southern Kurile Islands, Russia.

Name: Honors Russian mineralogist Dmitry Vadimovich Abramov (1963–) of the A.E. Fersman Museum, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (catalog no. 3436/1).

References: (1) Yudovskaya, M.A., N.V. Trubkin, E.V. Koporulina, D.I. Belakovsky, A.V. Mokhov, M.V. Kuznetsova, and T.I. Golovanova (2007) Abramovite, $Pb_2SnInBiS_7$, a new mineral species from fumaroles of the Kudryavy Volcano, Kurile Islands, Russia. Zap. Ross. Mineral. Obshch., 136(5), 37–43 (in Russian, English abstract); (2008) Geol. Ore Dep., 50, 551–555 (in English). (2) (2009) Amer. Mineral., 94, 1075 (abs. ref. 1).

Abswurmbachite $(Cu, Mn^{2+})Mn_6^{3+}SiO_{12}$

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Crystal Data: [Tetragonal] (by analogy to braunite). *Point Group:* [$4/m$ $2/m$ $2/m$.] Anhedral grains, to 50 μm.

Physical Properties: Hardness = n.d. VHN = 870–950, average 920 (25 g load). D(meas.) = n.d. D(calc.) = 4.96 (synthetic).

Optical Properties: Opaque. *Color:* Black; gray in reflected light. *Streak:* Brownish black. *Luster:* Metallic. *Anisotropism:* Weak.

Cell Data: *Space Group:* [$I4_1/acd$.] $a = 9.406(1)$ $c = 18.546(3)$ Z = [8]

X-ray Powder Pattern: Synthetic $(Cu_{0.98}Mn^{2+}_{0.02})_{\Sigma=1.00}Mn^{3+}_6SiO_{12}$.
2.702 (100), 1.6507 (30), 2.350 (15), 2.133 (15), 1.459 (14), 1.4016 (11), 1.6627 (10)

Chemistry:

	(1)
SiO_2	10.1
TiO_2	0.23
Al_2O_3	0.58
Fe_2O_3	4.7
Mn_2O_3	72.1
CuO	11.6
MgO	< 0.04
CaO	0.16
Total	99.47

(1) Evvia Island, Greece; by electron microprobe, corresponds to $(Cu_{0.88}Mn^{2+}_{0.10}Ca_{0.02})_{\Sigma=1.00}$ $(Mn^{3+}_{5.51}Fe^{3+}_{0.36}Al_{0.07}Ti_{0.02}Cu_{0.02})_{\Sigma=5.98}Si_{1.03}O_{12}$.

Polymorphism & Series: Forms a series with braunite.

Occurrence: In very low-grade, high-pressure metamorphic Mn, Al-rich quartzites.

Association: Quartz, shattuckite, tenorite, sursassite, piemontite, ardennite, rutile, hollandite, clinochlore.

Distribution: At Mili, Evvia Island, and Apikia, Andros Island, Cyclades Islands, Greece.

Name: To honor Dr. Irmgard Abs-Wurmbach (1938–), German mineralogist.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany; National Museum of Natural History, Washington, D.C., USA.

References: (1) Reinecke, T., E. Tillmanns, and H.-J. Bernhardt (1991) Abswurmbachite, $Cu^{2+}Mn^{3+}_6[O_8/SiO_4]$, a new mineral of the braunite group: natural occurrence, synthesis, and crystal structure. Neues Jahrb. Mineral., Abh., 163, 117–143. (2) (1992) Amer. Mineral., 77, 670 (abs. ref. 1).

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Acanthite Ag_2S

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Primary crystals are rare, prismatic to long prismatic, elongated along [001], to 2.5 cm, may be tubular; massive. Commonly paramorphic after the cubic high-temperature phase ("argentite"), of original cubic or octahedral habit, to 8 cm. *Twinning:* Polysynthetic on $\{\bar{1}11\}$, may be very complex due to inversion; contact on $\{\bar{1}01\}$.

Physical Properties: *Cleavage:* Indistinct. *Fracture:* Uneven. *Tenacity:* Sectile. Hardness = 2.0–2.5 VHN = 21–25 (50 g load). D(meas.) = 7.20–7.22 D(calc.) = 7.24 Photosensitive.

Optical Properties: Opaque. *Color:* Iron-black. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Weak.
R: (400) 32.8, (420) 32.9, (440) 33.0, (460) 33.1, (480) 33.0, (500) 32.7, (520) 32.0, (540) 31.2, (560) 30.5, (580) 29.9, (600) 29.2, (620) 28.7, (640) 28.2, (660) 27.6, (680) 27.0, (700) 26.4

Cell Data: *Space Group:* $P2_1/n$. $a = 4.229$ $b = 6.931$ $c = 7.862$ $\beta = 99.61°$ Z = 4

X-ray Powder Pattern: Synthetic.
2.606 (100), 2.440 (80), 2.383 (75), 2.836 (70), 2.583 (70), 2.456 (70), 3.080 (60)

Chemistry:

	(1)	(2)	(3)
Ag	86.4	87.2	87.06
Cu		0.1	
Se	1.6		
S	12.0	12.6	12.94
Total	100.0	99.9	100.00

(1) Guanajuato, Mexico; by electron microprobe. (2) Santa Lucia mine, La Luz, Guanajuato, Mexico; by electron microprobe. (3) Ag_2S.

Polymorphism & Series: The high-temperature cubic form ("argentite") inverts to acanthite at about 173 °C; below this temperature acanthite is the stable phase and forms directly.

Occurrence: A common silver species in moderately low-temperature hydrothermal sulfide veins, and in zones of secondary enrichment.

Association: Silver, pyrargyrite, proustite, polybasite, stephanite, aguilarite, galena, chalcopyrite, sphalerite, calcite, quartz.

Distribution: Widespread in silver deposits. Localities for fine primary and paramorphic crystals include: from Jáchymov (Joachimsthal), Czech Republic [TL]. In Germany, at Freiberg, Schneeberg, Annaberg, and Marienberg, Saxony; and from St. Andreasberg, Harz Mountains. In Mexico, large paramorphs from Arizpe, Sonora; in the Rayas and other mines at Guanajuato; and from many mines in Zacatecas, Chihuahua, etc. In the USA, at Butte, Silver Bow Co., Montana; Tonopah, Nye Co., and the Comstock Lode, Virginia City, Storey Co., Nevada. From various mines at Cobalt, Ontario, Canada. At Chañarcillo, south of Copiapó, Atacama, Chile.

Name: From the Greek for *thorn*, in allusion to the shape of the crystals.

Type Material: Emperor's collection, Vienna, Austria, 2592.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 191–192 (acanthite), 176–178 ("argentite"). (2) Frueh, A.J., Jr. (1958) The crystallography of silver sulfide, Ag_2S. Zeits. Krist., 110, 136–144. (3) Sadanaga, R. and S. Sueno (1967) X-ray study on the α–β transition of Ag_2S. Mineral. J. (Japan), 5, 124–143. (4) Petruk, W., D.R. Owens, J.M. Stewart, and E.J. Murray (1974) Observations on acanthite, aguilarite and naumannite. Can. Mineral., 12, 365–369. (5) (1960) NBS Circ. 539, 10, 51. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 1.

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Acetamide CH_3CONH_2

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals are prismatic, to 5 mm, with prominent $\{11\overline{2}0\}$; as small stalactites and in granular aggregates.

Physical Properties: *Fracture:* Fine conchoidal. Hardness = 1–1.5 D(meas.) = 1.17 D(calc.) = 1.15 Soluble in H_2O, taste very bitter; volatilizes on exposure to air and sunlight.

Optical Properties: Transparent. *Color:* Colorless, gray if included with carbonaceous material. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (–). $\omega = 1.495(2)$ $\epsilon = 1.460(2)$

Cell Data: *Space Group:* $R3c$ (synthetic). $a = 11.44(3)$ $c = 13.50(3)$ $Z = 18$

X-ray Powder Pattern: Chervonograd, Ukraine.
5.7 (100), 3.54 (91), 2.86 (78), 3.32 (30), 2.17 (14), 3.98 (9), 3.83 (9)

Chemistry: (1) Chervonograd, Ukraine; yields a positive qualitative test for NH_3; identification depends on close agreement of its X-ray powder pattern with that of synthetic acetamide.

Occurrence: In burning waste coal heaps, formed between 50 °C and 150 °C.

Association: Sal ammoniac (Chervonograd, Ukraine).

Distribution: From near Chervonograd, L'vov-Volyn' coal basin, Ukraine. At Shamokin, near Burnside, Northumberland Co., Pennsylvania, USA.

Name: For ACETic acid and AMIDE, for ammonia in its composition.

Type Material: Mining Museum, St. Petersburg Mining Institute, St. Petersburg, 1086/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 77109.

References: (1) Srebrodol'skii, B.I. (1975) Acetamide CH_3CONH_2 – a new mineral. Zap. Vses. Mineral. Obshch., 104, 326–328 (in Russian). (2) (1976) Amer. Mineral., 61, 338 (abs. ref. 1). (3) (1976) Mineral. Abs., 27, 80 (abs. ref. 1). (4) Srebrodol'skii, B.I. (1986) Phases of mineral formation on spoil heaps of coal mines. Doklady Acad. Nauk SSSR, 290, 173–174 (in Russian). (5) Jeffrey, G.A., J.R. Ruble, R.K. McMullan, D.J. DeFrees, J.S. Binkley, and J.A. Pople (1980) Neutron diffraction at 23 K and *ab initio* molecular-orbital studies of the molecular structure of acetamide. Acta Cryst., 36, 2292–2299. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 19.

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Actinolite $Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed crystals, to 15 cm; columnar, may be kinked or bent; radiating fibrous to asbestiform; granular to massive. *Twinning:* Simple or lamellar, common ∥ {100}; lamellar, less common ∥ {001}.

Physical Properties: *Cleavage:* Good on {110}, with intersections of 56° and 124°; parting on {100}. *Tenacity:* Brittle, tough in fibrous aggregates ("nephrite jade"). Hardness = 5–6 D(meas.) = 3.03–3.24 D(calc.) = [3.07]

Optical Properties: Transparent to translucent. *Color:* Bright green to grayish green; in thin section, colorless, pale green to deep green. *Streak:* White. *Luster:* Vitreous, silky. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = pale yellow, yellowish green; Y = pale yellow-green, green; Z = pale green, deep greenish blue. *Orientation:* $Y = b$; $Z \wedge c$ = 14°–18.5°. *Dispersion:* $r < v$, weak. α = 1.613–1.646 β = 1.624–1.656 γ = 1.636–1.666 2V(meas.) = 79°–86°

Cell Data: *Space Group:* $C2/m$. a = 9.891(1) b = 18.200(1) c = 5.305(1) β = 104.64(1)° Z = 2

X-ray Powder Pattern: Sobotin, Czech Republic. (ICDD 25-157).
2.719 (100), 2.543 (100), 3.401 (80), 8.47 (70), 4.91 (70), 3.143 (70), 2.959 (70)

Chemistry:

	(1)		(1)
SiO_2	55.17	MnO	0.18
TiO_2	0.17	MgO	16.21
Al_2O_3	2.69	CaO	12.08
FeO	11.07	Na_2O	0.82
		Total	98.39

(1) Southeast Anglesey, Wales; by electron microprobe, corresponding to $(Ca_{1.83}Na_{0.22})_{\Sigma=2.05}(Mg_{3.41}Fe^{2+}_{1.26}Al_{0.23}Fe^{3+}_{0.05}Mn_{0.02}Ti_{0.02})_{\Sigma=4.99}(Si_{7.79}Al_{0.21})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with tremolite and ferro-actinolite.

Mineral Group: Amphibole (calcic) group: $0.5 \quad Mg/(Mg + Fe^{2+}) \quad 0.89$; $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; Si ≥ 7.5.

Occurrence: Produced by low-grade regional or contact metamorphism of magnesium carbonate, mafic, or ultramafic rocks; also in glaucophane-bearing blueschists.

Association: Talc, epidote, chlorite, glaucophane, pumpellyite, lawsonite, albite.

Distribution: Many localities. In Austria, on Mt. Greiner, Zillertal, and at Untersulzbachtal. From Zermatt, Valais, Switzerland. At Snarum and Arendal, Norway. From the Ural Mountains, Russia. In the USA, from Gouverneur, St. Lawrence Co., New York; Franklin and Newton, Sussex Co., New Jersey; Chester, Windsor Co., Vermont; in the Fairfax quarry, Centreville, Fairfax Co., Virginia; Crestmore, Riverside Co., California; at Salida, Chaffee Co., Colorado. "Nephrite jade" occurs, in the USA, south and east of Lander, Fremont Co., Wyoming; north from Cape San Martin, Monterey Co., California; and around Jade Mountain, near the Kobuk River, Alaska. Along the Fraser River, British Columbia, Canada. Around Mt. Cook, South Island, New Zealand. Fine material from the Kunlun Mountains, Sinkiang Uighur Autonomous Region, China.

Name: From the Greek for *ray*, in allusion to the mineral's common radiating fibrous habit.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 389–391. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 249–262. (3) Mitchell, J.T., F.D. Bloss, and G.V. Gibbs (1971) Examination of the actinolite structure and four other C2/m amphiboles in terms of double bonding. Zeits. Krist., 133, 273–300. (4) Gibbons, W. and M. Gyopari (1986) A greenschist protolith for blueschist in Anglesey, U.K. In: B.W. Evans and E.H. Brown, Eds., Blueschists and eclogites, Geol. Soc. Amer. Memoir 164, 217–228. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 229–231.

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Acuminite $SrAlF_4(OH)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As acute dipyramidal crystals, showing {110}, {$\bar{1}$11}, and rare {$\bar{1}$12}, resembling spearheads, to 1 mm; in groups of crystals. *Twinning:* On {100}, as contact twins.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 3.5 D(meas.) = 3.295(10) D(calc.) = 3.305(5) Becomes yellow on exposure to X-rays.

Optical Properties: Transparent, yellowish if coated by "limonite". *Color:* Colorless, white. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = 15(1)°$. *Dispersion:* $r > v$, strong. $\alpha = 1.4507(3)$ $\beta = 1.4528(3)$ $\gamma = 1.4624(3)$–$1.4627(3)$ 2V(meas.) = 46°–57°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 13.223(1)$ $b = 5.175(1)$ $c = 14.251(1)$ $\beta = 111.61(2)°$ Z = 8

X-ray Powder Pattern: Ivigtut, Greenland.
4.767 (10), 4.706 (10), 3.505 (10), 3.353 (10), 2.075 (9), 3.310 (8), 3.286 (8)

Chemistry:

	(1)	(2)
Ca	0.02	
Sr	37.04	38.84
Al	11.86	11.96
F	33.52	33.68
OH	[6.82]	7.54
H_2O	[7.80]	7.98
Total	[97.06]	100.00

(1) Ivigtut, Greenland; by AA, Al by CDTA, F by electrolysis; OH calculated from charge balance, H_2O from theory; corresponds to $Sr_{0.98}Al_{1.02}F_{4.07}(OH)_{0.93}\cdot 1.00H_2O$.
(2) $SrAlF_4(OH)\cdot H_2O$.

Polymorphism & Series: Dimorphous with tikhonenkovite.

Occurrence: In a small cavity in a specimen from a strontium-rich portion of a cryolite deposit.

Association: Fluorite, jarlite, thomsenolite, pachnolite, ralstonite, gearksutite, celestine.

Distribution: In the Ivigtut cryolite deposit, southwestern Greenland.

Name: From the Latin *acuminis*, *sharp point*, for *spear head*, the characteristic shape of the crystals.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Pauly, H. and O.V. Petersen (1987) Acuminite, a new Sr-fluoride from Ivigtut, South Greenland. Neues Jahrb. Mineral., Monatsh., 502–514. (2) (1988) Amer. Mineral., 73, 1492 (abs. ref. 1). (3) Krogh Andersen, E., G. Ploug-Sørensen, and E. Leonardsen (1991) The structure of acuminite, a strontium aluminium fluoride mineral. Zeits. Krist., 194, 221–227.

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Adachiite $CaFe_3Al_6(Si_5AlO_{18})(BO_3)_3(OH)_3(OH)$

Crystal Data: Hexagonal. *Point Group*: 3*m*. Crystals are hexagonal prismatic, to 2 cm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 7
D(meas.) = n.d. D(calc.) = 3.228

Optical Properties: Transparent. *Color*: Brownish purple to bluish purple, black (massive aggregates). *Streak*: n.d. *Luster*: n.d. *Pleochroism*: Strong, *O* = dark green to dark blue, *E* = brownish yellow.
Optical Class: Uniaxial (–). ω = 1.674(2) ε = 1.644(2)

Cell Data: *Space Group*: *R*3*m*. *a* = 15.9290(2) *c* = 7.1830(1) Z = 3

X-ray Powder Pattern: Kiura mine, Saiki City, Oita Prefecture, Japan.
2.584 (100), 4.002 (65), 2.043 (52), 4.225 (40), 4.9602 (34), 3.4553 (34), 2.9027 (33)

Chemistry:

	(1)	(2)
Na_2O	0.84	
CaO	3.34	5.24
MgO	2.32	
FeO	11.90	20.15
B_2O_3	10.09	9.77
Al_2O_3	36.70	33.37
TiO_2	0.46	
SiO_2	29.79	28.09
H_2O	3.10	3.37
Total	98.54	100.00

(1) Kiura mine, Japan; average of 13 electron microprobe analyses, H_2O calculated from stoichiometry, OH^- confirmed by IR spectroscopy, Fe^{2+} estimated from structural analysis; corresponding to ${}^{X}(Ca_{0.62}Na_{0.28}\square_{0.10})_{\Sigma=1.00}{}^{Y}(Fe_{1.58}Al_{0.81}Mg_{0.55}Ti_{0.06})_{\Sigma=3.00}{}^{Z}(Al_{5.81}Fe_{0.14}Mg_{0.05})_{\Sigma=6.00}$ ${}^{T}(Si_{5.15}Al_{0.85})_{\Sigma=6.00}O_{18}B_{3.01}O_9{}^{V}(OH)_3{}^{W}[(OH)_{0.56}O_{0.44}]_{\Sigma=1.00}$. (2) $CaFe_3Al_6(Si_5AlO_{18})(BO_3)_3(OH)_3(OH)$.

Mineral Group: Tourmaline group.

Occurrence: In a hydrothermal vein that cuts a lateritic metamorphic emery (corundum and hercynite) deposit.

Association: Margarite, chlorite, diaspore, schorl.

Distribution: From the Nabagasako adit, Kiura mine, Saiki City, Oita Prefecture, Japan.

Name: Honors Tomio Adachi (b. 1923), an amateur mineralogist.

Type Material: National Museum of Nature and Science, Tsukuba, Japan (NSM-M43748).

References: (1) Nishio-Hamane, D., T. Minakawa, J-i. Yamaura, T. Oyama, M. Ohnishi, and N. Shimobayashi (2014) Adachiite, a Si-poor member of the tourmaline supergroup from the Kiura mine, Oita Prefecture, Japan. Journal of Mineralogical and Petrological Sciences, 109, 74-78.
(2) (2015) Amer. Mineral., 100, 334 (abs. ref. 1).

Adamite $Zn_2(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Typically as crystals elongated along [001], [010], rarely [100], to 8 cm, may be equant; showing dominant {101} and {110}, with {011}, {210}, {010}, {120}, many other forms, usually in radial aggregates, fanlike rosettes, or crystalline crusts.

Physical Properties: *Cleavage:* {101}, good; {010}, poor. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 4.32–4.48 D(calc.) = 4.435–4.444 May fluoresce and phosphoresce lemon-yellow under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Pale yellow, honey-yellow, brownish yellow, reddish; rarely white, colorless, blue, pale green to green, may be zoned; bright green (cuprian); bright pink, rose, or purple (cobaltian); in transmitted light, colorless or faintly tinted. *Luster:* Vitreous.
Optical Class: Biaxial (+), may be biaxial (–). *Pleochroism:* In pale colors if cuprian or cobaltian. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$ or $r > v$, strong. $\alpha = 1.708–1.722$ $\beta = 1.734–1.744$ $\gamma = 1.758–1.773$ 2V(meas.) = 78°–90°

Cell Data: *Space Group: Pnnm.* $a = 8.304–8.386$ $b = 8.524–8.552$ $c = 6.036–6.058$ Z = 4

X-ray Powder Pattern: Mapimí, Mexico.
2.448 (10), 4.897 (9), 2.967 (9), 2.698 (8), 1.608 (8), 5.944 (6), 4.242 (6)

Chemistry:

	(1)	(2)
As_2O_5	38.96	40.08
SiO_2	0.26	
ZnO	56.78	56.78
H_2O	3.53	3.14
Total	99.53	100.00

(1) Mapimí, Mexico. (2) $Zn_2(AsO_4)(OH)$.

Polymorphism & Series: Dimorphous with paradamite; forms a series with olivenite.

Occurrence: A secondary mineral in the oxidized zone of zinc- and arsenic-bearing hydrothermal mineral deposits.

Association: Smithsonite, hemimorphite, scorodite, olivenite, calcite, quartz, Fe–Mn oxides.

Distribution: A number of localities; some for studied material or fine specimens include: from Chañarcillo, south of Copiapó, Atacama, Chile. In Mexico, large crystals at the Ojuela mine, Mapimí, Durango; in the Hidalgo mine, Zimapán, Hidalgo; and from Santa Eulalia, Chihuahua. In the USA, at Gold Hill, Tooele Co., Utah, and in the Mohawk mine, Clark Mountains, San Bernardino Co., California. At the Cap Garonne mine, near le Pradet, Var, France. From Reichenbach, near Bensheim, Hesse, and in the Clara mine, near Oberwolfach, Black Forest, Germany. In England, from several places in Cornwall, and at Caldbeck Fells, Cumbria. In the Kamariza mine, Laurium, Greece. Large crystals from Tsumeb, Namibia. At the Puttapa zinc mine, near Beltana, and on Mt. Painter, Flinders Ranges, South Australia.

Name: Honoring Gilbert-Joseph Adam (1795–1881), French mineralogist, who supplied the first specimens.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 864–866. (2) Mrose, M.E., D.E. Mayers, and F.A. Wise (1948) Adamite from the Ojuela mine, Mapimi, Mexico. Amer. Mineral., 33, 449–457. (3) Hill, R.J. (1976) The crystal structure and infrared properties of adamite. Amer. Mineral., 61, 979–986. (4) Hawthorne, F.C. (1976) A refinement of the crystal structure of adamite. Can. Mineral., 14, 143–148. (5) Kato, T. and Y. Miura (1977) The crystal structures of adamite and paradamite. Mineral. J. (Japan), 8, 320–328. (6) Toman, K. (1978) Ordering in olivenite-adamite solid solutions. Acta Cryst., 34, 715–721. (7) Chisholm, J.E. (1985) Cation segregation and the O–H stretching vibration of the olivenite-adamite series. Phys. Chem. Minerals, 12, 185–190.

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Adamsite-(Y) $NaY(CO_3)_2 \cdot 6H_2O$

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Crystal Data: Triclinic, pseudo-orthorhombic if twinned. *Point Group:* $\overline{1}$. Crystals are acicular to fibrous, to 2.5 cm, elongated along [001], flattened on {001}, showing {010} and {001}; in spherical radiating groups, which rarely are reticulated. *Twinning:* By reflection on {001}, common.

Physical Properties: *Cleavage:* Perfect on {001}; good on {100}, {010}. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.27(2) D(calc.) = 2.27

Optical Properties: Transparent to translucent. *Color:* Colorless, white, may be pale pink or pale purple. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge a = 14°$. $\alpha = 1.480(4)$ $\beta = 1.498(2)$ $\gamma = 1.571(4)$ 2V(meas.) = 53(3)° 2V(calc.) = 55°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.2592(4)$ $b = 13.0838(7)$ $c = 13.2271(5)$ $\alpha = 91.130(1)°$ $\beta = 103.554(1)°$ $\gamma = 90.188(1)°$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
12.81 (100), 6.45 (70), 4.456 (60), 4.291 (60), 2.571 (60), 2.050 (50), 2.869 (30)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	25.10	25.89	Ho_2O_3	0.90	
Y_2O_3	22.88	33.21	Er_2O_3	2.83	
Ce_2O_3	0.37		Tm_2O_3	0.27	
Nd_2O_3	1.41		Yb_2O_3	1.04	
Sm_2O_3	1.02		CaO	0.05	
Gd_2O_3	1.92		Na_2O	8.64	9.11
Tb_2O_3	0.56		H_2O	29.90	31.79
Dy_2O_3	3.28		Total	100.17	100.00

(1) Mont Saint-Hilaire, Canada; by electron microprobe, seven analyses on three crystals, CO_2 and H_2O by TGA, confirmed by IR and crystal-structure analysis; corresponds to $Na_{1.00}(Y_{0.72}Dy_{0.06}Er_{0.05}Gd_{0.04}Nd_{0.03}Yb_{0.02}Sm_{0.02}Ho_{0.02}Ce_{0.01}Tb_{0.01}Tm_{0.01})_{\Sigma=0.99}(CO_3)_{2.04} \cdot 5.94H_2O$.
(2) $NaY(CO_3)_2 \cdot 6H_2O$.

Occurrence: A rare late-stage, low-temperature hydrothermal mineral in an alkalic pegmatite dike associated with an intrusive alkalic gabbro-syenite complex.

Association: Thomasclarkite-(Y), horváthite-(Y), donnayite-(Y), petersenite-(Ce), rhodochrosite.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Professor Frank Dawson Adams (1859–1942), McGill University, Montreal, Canada, geologist and petrologist, who studied the Monteregian Hills, of which Mont Saint-Hilaire is one.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 82939, 82940.

References: (1) Grice, J.D., R.A. Gault, A.C. Roberts, and M.A. Cooper (2000) Adamsite-(Y), a new sodium-yttrium carbonate mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 38, 1457–1466. (2) (2001) Amer. Mineral., 86, 1112 (abs. ref. 1).

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Adelite $CaMg(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals tabular on {001}, or elongated along [100], showing {100}, {001}, {110}, {011}, {$\overline{2}$21}, to 5 mm; may be hemispherulitic, commonly granular, massive.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.71–3.76 D(calc.) = [3.78]

Optical Properties: Translucent to transparent. *Color:* Colorless, white, gray, bluish gray, yellowish gray, yellow, pale green, pinkish brown, brown; colorless in transmitted light. *Luster:* Resinous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, weak. $\alpha = 1.712$ $\beta = 1.721$ $\gamma = 1.731$ 2V(meas.) = 68° to ∼90°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.43$ $b = 8.85$ $c = 5.88$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.16 (10), 4.13 (7), 2.59 (7), 2.33 (7), 1.609 (7), 4.96 (6), 2.98 (6)

Chemistry:

	(1)	(2)
As_2O_5	50.28	52.17
FeO	0.08	
MnO	0.48	
CuO	0.32	
PbO	2.79	
MgO	17.90	18.30
CaO	24.04	25.45
BaO	0.23	
Cl	trace	
H_2O	3.90	4.08
Total	100.02	100.00

(1) Långban, Sweden. (2) $CaMg(AsO_4)(OH)$.

Mineral Group: Adelite group.

Occurrence: A rare mineral in a metamorphosed Fe–Mn orebody (Långban, Sweden); on willemite-franklinite ore from a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Sarkinite, arsenoclasite, braunite, hedyphane, fredrikssonite (Långban, Sweden); hausmannite, magnetite, copper (Kittel mine, Sweden); hodgkinsonite, barite, allactite, rhodochrosite, franklinite, willemite; chlorophoenicite (Franklin, New Jersey, USA); alleghanyite, kraisslite, sphalerite, rhodochrosite, willemite, franklinite; johnbaumite–svabite, zincite, barite, calcite (Sterling Hill, New Jersey, USA).

Distribution: In Sweden, from Långban and at Jakobsberg, Värmland, and in the Kittel mine, Nordmark. At St. Andreasberg, Harz Mountains, Germany. From Sterling Hill, Ogdensburg, and Franklin, Sussex Co., New Jersey, USA.

Name: From the Greek for *indistinct*, as it typically lacks transparency.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 1. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 804–806. (3) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 655. (4) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541, esp. 501.

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Admontite $MgB_6O_{10} \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are poorly developed or corroded, to about 1 mm, elongated along [001], flattened parallel to {100}.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–3 D(meas.) = 1.82 D(calc.) = 1.831 Slowly decomposed in H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge c \simeq 45°$. *Dispersion:* $r < v$. $\alpha = 1.442(2)$ $\beta = [1.500]$ $\gamma = 1.504(2)$ 2V(meas.) = ∼30°

Cell Data: *Space Group:* $P2_1/c$. $a = 12.68(2)$ $b = 10.07(2)$ $c = 11.32(2)$ $\beta = 109.68(10)°$ Z = 4

X-ray Powder Pattern: Schildmauer, Austria.
7.60 (10vb), 12.08 (9), 2.68 (9), 3.93 (8), 5.29 (7), 3.09 (6), 5.72 (4)

Chemistry:

	(1)	(2)
B_2O_3	[54.50]	55.66
MgO	10.20	10.74
H_2O	35.30	33.60
Total	[100.00]	100.00

(1) Schildmauer, Austria; B_2O_3 by difference, H_2O by thermogravimetry. (2) $MgB_6O_{10} \cdot 7H_2O$.

Occurrence: In a gypsum deposit.

Association: Gypsum, anhydrite, hexahydrite, löweite, eugsterite, pyrite, quartz.

Distribution: From Schildmauer, near Admont, Styria, Austria.

Name: For Admont, Austria, near the original locality.

Type Material: n.d.

References: (1) Walenta, K. (1979) Admontit, ein neues Boratmineral aus der Gipslagerstätte Schildmauer bei Admont in der Steiermark (Österreich). Tschermaks Mineral. Petrog. Mitt., 26, 69–77 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 205 (abs. ref. 1). (3) Dal Negro, A., L. Ungaretti, and R. Basso (1976) The crystal structure of synthetic hydrated borates: (II) $MgO \cdot 3B_2O_3 \cdot 7H_2O$. Crystal Structure Communications, 5(3), 433–436. (4) Walenta, K. (1982) Zum Chemismus von Admontit und Machatschkiit. Schweiz. Mineral. Petrog. Mitt., 62, 177–183 (in German).

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Adolfpateraite $K(UO_2)(SO_4)(OH)(H_2O)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As hemispherical crystalline aggregates, to 3 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~ 2
D(meas.) = n.d. D(calc.) = 4.24 Green fluorescence under LW UV.

Optical Properties: Transparent to translucent. *Color*: Sulfur-yellow to greenish yellow.
Streak: Pale yellow. *Luster*: Vitreous.
Optical Class: Biaxial (n.d.). α = 1.597(2) β = n.d. γ = 1.659(2)
Pleochroism: *X* = colorless, *Y* = n.d., *Z* = yellow.

Cell Data: *Space Group*: $P2_1/c$. a = 8.0462(1) b = 7.9256(1) c = 11.3206(2)
β = 107.726(2)° Z = 4

X-ray Powder Pattern: Svornost shaft, Jáchymov district, western Bohemia, Czech Republic.
5.386 (100), 5.218 (85), 7.658 (76), 3.718 (46), 3.700 (37), 3.489 (27), 2.747 (17)

Chemistry:

	(1)	(2)
K_2O	9.86	10.70
SO_3	18.17	18.19
UO_3	63.66	64.97
H_2O	[5.80]	6.14
Total	97.49	100.00

(1) Svornost shaft, Jáchymov district, western Bohemia, Czech Republic; average of 4 electron microprobe analyses, H_2O calculated, presence of OH, H_2O, SO_4 and $UO^{2+}{}_2$ confirmed by IR and Raman spectroscopy; corresponding to $K_{0.94}(UO_2)_{1.00}(SO_4)_{1.02}(OH)_{0.90}(H_2O)_{1.00}$.
(2) $K(UO_2)(SO_4)(OH)(H_2O)$.

Occurrence: A secondary mineral in the oxidized zone of a uranium deposit.

Association: Gypsum, schoepite, čejkaite.

Distribution: From the Geschieber vein, fifth level of the Svornost (Einigkeit) shaft, Jáchymov (Sankt Joachimsthal) ore district, western Bohemia, Czech Republic.

Name: Honors Adolf Patera (1819-1894), Czech chemist, mineralogist, and metallurgist, who invented the technology for processing uranium ores from Jáchymov for the production of uranium-based colors.

Type Material: Department of Mineralogy and Petrology, National Museum in Prague, Czech Republic (P1P 3/2011).

References: (1) Plášil, J., J. Hloušek, F. Veselovský, K. Fejfarová, M. Dušek, R. Škoda, M. Novák, J. Čejka, J. Sejkora, and P. Ondruš (2012) Adolfpateraite, $K(UO_2)(SO_4)(OH)(H_2O)$, a new uranyl sulphate mineral from Jáchymov, Czech Republic. Amer. Mineral., 97, 447-454.

Adranosite-(Fe) $(NH_4)_4NaFe_2(SO_4)_4Cl(OH)_2$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. Crystals tetrahedral, to 1 mm, with dominant {100}, {110}, and {111}; also as divergent sprays of acicular crystals.

Physical Properties: *Cleavage*: Present on {001}. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d. D(meas.) = 2.18(1) D(calc.) = 2.195

Optical Properties: Transparent. *Color*: Pale yellow. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (-). ω = 1.58(1) ε = 1.57(1)

Cell Data: *Space Group*: $I4_1/acd$. a = 18.261(2) c = 11.562(1) Z = 8

X-ray Powder Pattern: La Fossa Crater, Vulcano, Aeolian Islands, Italy.
9.134 (100), 4.569 (83), 3.047 (79), 6.462 (36), 3.232 (29), 2.891 (11), 4.135 (10)

Chemistry:

	(1)	(2)
Na_2O	5.01	4.69
K_2O	0.82	
Fe_2O_3	15.77	24.18
Al_2O_3	5.11	
SO_3	50.96	48.18
Cl	3.71	5.37
$(NH_4)_2O$	[15.76]	15.77
H_2O	[2.75]	2.73
–O=Cl	0.84	1.21
Total	99.05	100.00

(1) La Fossa Crater, Italy; average of 12 electron microprobe analyses, H_2O calculated from structure refinement, $(NH_4)_2O$ calculated from the difference between the theoretical value of the site and the K content; corresponding to $(NH_4)_{3.89}K_{0.11}]_{\Sigma=4.00}Na_{1.04}(Fe_{1.27}Al_{0.64})_{\Sigma=1.91}(SO_4)_{4.10}Cl_{0.67}(OH)_{1.96}$.
(2) $(NH_4)_4NaFe_2(SO_4)_4Cl(OH)_2$.

Occurrence: A sublimate found on pyroclastic breccia in volcanic fumaroles (Italy); an anthropogenic product of a burning coal dump (Anna mine, near Aachen, North Rhine-Westphalia, Germany).

Association: Thermessaite, pseudocotunnite, bismuthinite or barberiite, salammoniac, anhydrite, sassolite, sulfur (Italy); clairite, tschermigite, rostite/khademite, boussingaultite/mohrite (Germany).

Distribution: From La Fossa Crater, Vulcano, Aeolian Islands, Italy.

Name: As the Fe^{3+} analog of *adranosite* – the base name for the ancient god of fire Adranos.

Type Material: Reference Collection, Department of Chemistry, University of Milan (# 2010-02) and the Museum "C.L. Garavelli," Department of Earth and Geoenvironmental Sciences, University of Bari (N 9389), Italy. Anthropogenic material from the Natural History Museum, Vienna, Austria (N 9389).

References: (1) Mitolo, D., F. Demartin, A. Garavelli, I. Campostrini, D. Pinto, C.M. Gramaccioli, P. Acquafredda, and U. Kolitsch (2013) Adranosite-(Fe), $(NH_4)_4NaFe_2(SO_4)_4Cl(OH)_2$, a new ammonium sulfate chloride from La Fossa Crater, Vulcano, Aeolian Islands, Italy. Can. Mineral., 51, 57-66. (2) (2014) Amer. Mineral., 99, 2437 (abs. ref. 1).

Aegirine $NaFe^{3+}Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, showing {110}, with blunt to steep terminations, to 35 cm, striated lengthwise, can be bent or twisted. In sprays of acicular crystals, fibrous, in radial concretions. *Twinning:* Simple and lamellar twinning common on {100}.

Physical Properties: *Cleavage:* Good on {110}, (110) ∧ $(1\bar{1}0)$ ∼87°; parting on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.50–3.60 D(calc.) = 3.576

Optical Properties: Translucent to opaque. *Color:* Dark green to greenish black, reddish brown, black; bright green to yellow-green in thin section. *Streak:* Pale yellowish gray. *Luster:* Vitreous to slightly resinous.
Optical Class: Biaxial (–); varieties rich in Ca, Mg, Fe^{2+} are (+). *Pleochroism:* X = emerald-green, deep green; Y = grass-green, deep green, yellow; Z = brownish green, green, yellowish brown, yellow. *Orientation:* $Y = b$; $X \wedge c = -10°$ to 12°; $Z \wedge a = 6°$–28°. *Dispersion:* $r > v$, moderate to strong. *Absorption:* $X > Y > Z$. α = 1.722–1.776 β = 1.780–1.820 γ = 1.795–1.836 2V(meas.) = 60°–70°

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 9.658$ $b = 8.795$ $c = 5.294$ $\beta = 107.42°$ Z = 4

X-ray Powder Pattern: Narssârssuk, Greenland.
2.900 (100), 6.369 (90), 4.416 (80), 2.983 (70), 2.4701 (60), 1.7293 (60), 1.3975 (60)

Chemistry:

	(1)		(1)
SiO_2	51.35	CaO	1.25
TiO_2	1.10	Na_2O	12.66
Al_2O_3	2.15	K_2O	0.15
Fe_2O_3	28.66	H_2O^+	0.12
FeO	2.24	H_2O^-	0.17
MgO	0.10	Total	99.95

(1) Itapirapurã, São Paulo, Brazil; corresponds to $(Na_{0.94}Ca_{0.02}K_{0.01})_{\Sigma=0.97}(Fe^{3+}_{0.83}Fe^{2+}_{0.07}Al_{0.07}Ti_{0.03}Mg_{0.01})_{\Sigma=1.01}(Si_{1.98}Al_{0.02})_{\Sigma=2.00}O_6$.

Mineral Group: Pyroxene group.

Occurrence: Common in alkalic igneous rocks, carbonatites, and pegmatites. From regionally metamorphosed schists, gneisses, and iron formations; in blueschist facies rocks, and from sodium metasomatism in granulites. An authigenic mineral in some shales and marls.

Association: Potassic feldspar, nepheline, riebeckite, arfvedsonite, aenigmatite, astrophyllite, catapleiite, eudialyte, sérandite, apophyllite.

Distribution: Some localities for good crystals are: in Norway, at Rundemyr, near Kongsberg; from Skaadoe, near Brevik; on Låven and other islands, Langesundsfjord; and at Drammen and Arendal. In the Alnö complex, Sweden. At Huesca, Huesca Province, Spain. From the Lovozero and Khibiny massifs, Kola Peninsula, Russia. At Narssârssuk, Greenland. From Oldonyo Dili, Tanzania. Large crystals from Mt. Malosa, Zomba district, Malawi. In the USA, from Pitcairn, Russell, and LaSalle, St. Lawrence Co., and at Natural Bridge, Jefferson Co., New York; at Magnet Cove, Hot Spring Co., and from Granite Mountain, near Little Rock, Pulaski Co., Arkansas; in the Bear Paw Mountains, Hill Co., Montana. Large crystals from Mont Saint-Hilaire, Quebec, Canada.

Name: From *Ægir*, the Scandinavian sea-god, as first described from Norway.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 364–366. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 482–519. (3) Frondel, C. and C. Klein (1965) Ureyite [kosmochlor], $NaCrSi_2O_6$: a new meteoritic pyroxene. Science, 149, 742–744.

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Aenigmatite $Na_2Fe_5^{2+}TiSi_6O_{20}$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\bar{1}$. Crystals poorly developed, prismatic, to 8 cm; as irregular segregations. *Twinning:* By rotation ⊥ $(01\bar{1})$ or about [010] of the pseudomonoclinic cell; polysynthetic.

Physical Properties: *Cleavage:* Good on {010}, {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 3.81 D(calc.) = [3.84]

Optical Properties: Translucent to opaque. *Color:* Velvet-black; in thin section, reddish brown to black. *Streak:* Reddish brown. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow brown; Y = red-brown; Z = dark brown to black. *Orientation:* $Y = b$; $Z \wedge c = 45°$. *Dispersion:* $r < v$, very strong. α = 1.793–1.81 β = 1.804–1.82 γ = 1.87–1.90 2V(meas.) = 30°–50°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.406(13)$ $b = 10.813(14)$ $c = 8.926(6)$ $\alpha = 104°56(9)'$ $\beta = 96°52(11)'$ $\gamma = 125°19(6)'$ Z = 2

X-ray Powder Pattern: Kola Peninsula, Russia.
8.09 (vs), 3.145 (vs), 2.706 (s), 2.547 (s), 2.937 (ms), 2.119 (ms), 2.414 (m)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	39.62	38.3	41.84	MgO	1.65	0.82	
TiO_2	9.66	8.37	9.27	CaO	0.44	1.42	
Al_2O_3	0.64	2.56		Na_2O	7.20	6.35	7.19
Fe_2O_3	4.64			K_2O	0.04	0.02	
FeO	33.92	40.2	41.70	Cl	0.02		
MnO	2.46	1.93		H_2O^+	0.05		
				Total	100.34	99.97	100.00

(1) Khibinite quarry, Kirovsk, Kola Peninsula, Russia. (2) Motzfeldt centre, Greenland; by electron microprobe. (3) $Na_2Fe_5TiSi_6O_{20}$.

Polymorphism & Series: Forms a series with wilkinsonite.

Mineral Group: Aenigmatite group.

Occurrence: A primary constituent in sodium-rich alkalic volcanics, pegmatites, and other silica-poor igneous rocks.

Association: Aegirine, augite, riebeckite, arfvedsonite, hedenbergite, fayalite, ilmenite.

Distribution: Notable studied occurrences include: at Naujakasik, near the Tunugdliarfik Fjord, and on the Kangerdluarssuk Plateau, in the Ilímaussaq intrusion; from Narssârssuk; and elsewhere in Greenland. In the Khibiny and Lovozero massifs, Kola Peninsula, Russia. At Sandefjord, Norway. From Cuddua Mida, Sicily, Italy. In the USA, from Granite Mountain, near Little Rock, Pulaski Co., Arkansas, and Santa Rosa, Sonoma Co., California. In Australia, from Warrumbungle volcano, Nandewar volcano, and the Mt. Warning complex, New South Wales; and the Peak Range Province, Queensland. From Logan Point quarry, Dunedin volcano, New Zealand.

Name: From the Greek for *riddle*, apparently an allusion to its (formerly) uncertain chemical composition.

Type Material: Mining Academy, Freiberg, Germany, 29166.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 403–404. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 640–654. (3) Thompson, R.N. and J.E. Chisholm (1969) Synthesis of aenigmatite. Mineral. Mag., 37, 253–255. (4) Jones, A.P. (1984) Mafic silicates from the nepheline syenites of the Motzfeldt centre, South Greenland. Mineral. Mag., 48, 1–12.

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Aërinite $\mathbf{Ca_4(Al,Fe^{3+},Mg,Fe^{2+})_{10}Si_{12}O_{35}(CO_3)(OH)_{12}\cdot 12H_2O}$

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Crystal Data: Monoclinic. *Point Group:* n.d. As masses of cryptocrystalline fibers; earthy, compact.

Physical Properties: Hardness = ∼3 D(meas.) = 2.48(2) D(calc.) = [2.46]

Optical Properties: Semitransparent. *Color:* Blue to blue-green.
Optical Class: Biaxial (–). *Pleochroism:* Intense; X = bright blue; $Y = Z$ = pale beige.
$\alpha = 1.510(5)$ $\beta = 1.560(5)$ $\gamma = 1.580(5)$ 2V(meas.) = n.d. 2V(calc.) = 63°

Cell Data: *Space Group:* n.d. $a = 14.690(15)$ $b = 16.872(15)$ $c = 5.170(15)$ $\beta = 94°45'$
Z = [2]

X-ray Powder Pattern: Saint-Pandelon, France.
14.65 (100), 4.050 (80), 2.721 (75), 2.812 (50), 3.798 (35), 3.651 (35), 2.135 (35)

Chemistry:

	(1)	(2)
SiO_2	36.91	37.87
TiO_2	trace	
Al_2O_3	17.20	18.64
Fe_2O_3	7.31	
FeO	3.47	7.00
MnO	0.10	
MgO	3.15	6.
CaO	12.03	11.93
Na_2O	0.27	2.70
K_2O	0.04	0.12
H_2O	17.79	15.45
CO_2	2.30	
P_2O_5	0.71	
Total	101.28	99.71

(1) Saint-Pandelon, France; H_2O by TGA, CO_2 by chromatography; corresponds to $(Ca_{4.04}Na_{0.16}K_{0.02})_{\Sigma=4.22}(Al_{6.36}Fe^{3+}_{1.72}Mg_{1.47}Fe^{2+}_{0.91}Mn_{0.03})_{\Sigma=10.49}(Si_{11.59}P_{0.19})_{\Sigma=11.78}O_{35.21}(OH)_{12.11}(CO_3)_{0.99}\cdot 12.54H_2O$. (2) Morocco.

Occurrence: A hydrothermal mineral of the zeolite facies, formed at relatively low temperature, in fractures cutting mafic igneous rocks (Saint-Pandelon, France).

Association: Prehnite, scolecite, mesolite (Saint-Pandelon, France).

Distribution: At Caserras, Juseu, and Estopiñan, Huesca Province; Tartaren, Lerida Province; and other less-well-defined localities in Spain. From Saint-Pandelon, Landes, France. In Morocco, at Ourika. From the Gunsight Mountains, Pima Co., Arizona, USA.

Name: From the Greek for *sky blue* for its distinctive color.

Type Material: Wroclaw University, Wroclaw, Poland, II–8890; National School of Mines, Paris, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1025.
(2) Termier, H. and G. Termier (1946) Sur la presence d'aérinite au Maroc. Compt. Rend. Soc. Géol. France, 78–80 (in French). (3) (1948) Chem. Abs., 42, 7204 (abs. ref. 2). (4) Azambre, B. and P. Monchoux (1988) Précisions minéralogiques sur l'aérinite: nouvelle occurrence à Saint-Pandelon (Landes, France). Bull. Minéral., 111, 39–47 (in French with English abs.).

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Aerugite $Ni_{17}As_6O_{32}$

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Crystal Data: Hexagonal (synthetic). *Point Group:* $\overline{3}\ 2/m$. Fine-grained crystalline, massive, as crusts, to 2 mm thick.

Physical Properties: Hardness = 4 D(meas.) = 5.85(7) D(calc.) = 5.772

Optical Properties: Semitransparent. *Color:* Dark grass-green, blue-green, pale brown. *Streak:* Pale green, pale blue-green.
Optical Class: [Uniaxial.] ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic). $a = 5.9511(5)$ $c = 27.5676(20)$ Z = 1

X-ray Powder Pattern: Johanngeorgenstadt, Germany.
2.060 (vvs), 3.76 (vs), 2.329 (s), 5.05 (s), 2.862 (s), 2.492 (s), 1.485 (s)

Chemistry:

	(1)	(2)	(3)	(4)
P_2O_5	0.14			
As_2O_5	36.57	36.3	37.6	35.19
Bi_2O_3	0.24			
Fe_2O_3	trace			
FeO		1.3	0.6	
CoO	0.54	1.2	0.7	
NiO	62.07	60.9	61.3	64.81
CuO	0.34	0.3	0.7	
Total	99.90	[100.0]	100.9	100.00

(1) Johanngeorgenstadt, Germany. (2) Do.; total Fe as FeO, recalculated after deduction of quartz 13.9%; corresponds to $(Ni_{15.91}Fe_{0.34}Co_{0.31}Cu_{0.08})_{\Sigma=16.64}As_{6.15}O_{32}$. (3) South Terras mine, Cornwall, England; total Fe as FeO; corresponds to $(Ni_{15.77}Co_{0.18}Fe_{0.17}Cu_{0.17})_{\Sigma=16.29}As_{6.29}O_{32}$. (4) $Ni_{17}As_6O_{32}$.

Occurrence: A rare secondary mineral in hydrothermal Ni–As–U ore deposits.

Association: Bismuth, bunsenite, xanthiosite (Johanngeorgenstadt, Germany); xanthiosite (South Terras mine, Cornwall, England).

Distribution: From Johanngeorgenstadt, Saxony, Germany. In the South Terras mine, St. Stephen-in-Brannel, Cornwall, England.

Name: From the Greek for *copper rust*, an allusion to its appearance.

Type Material: The Natural History Museum, London, England, 32590 and 1907,103.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 870. (2) Davis, R.J., M.H. Hey, and A.W.G. Kingsbury (1965) Xanthiosite and aerugite. Mineral. Mag., 35, 72–83. (3) Fleet, M.E. and J. Barbier (1989) Structure of aerugite ($Ni_{8.5}As_3O_{16}$) and interrelated arsenate and germanate structural series. Acta Cryst., 45, 201–205.

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Aeschynite-(Ce) $(Ce, Ca, Fe, Th)(Ti, Nb)_2(O, OH)_6$

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Crystal Data: Orthorhombic; commonly metamict. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic ‖ [001], also tabular {010} and striated on {010} parallel to [100], to 10 cm; also massive.

Physical Properties: *Cleavage:* {100}, interrupted; parting ‖ {010} when nonmetamict. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–6 VHN = 593–734
D(meas.) = 5.19(5) D(calc.) = 5.617 (synthetic $CeTiNbO_6$). Radioactive; magnetic.

Optical Properties: Translucent, transparent in very thin fragments. *Color:* Black, brown, light brown to yellow; reddish brown to light brown in transmitted light. *Streak:* Nearly black to brown. *Luster:* Submetallic, resinous to waxy; dull when altered.
Optical Class: Isotropic when metamict. $n = 2.26(1)$

Cell Data: *Space Group: Pmnb* (synthetic $CeTiNbO_6$). $a = 7.538$ $b = 10.958$ $c = 5.396$
$Z = 4$

X-ray Powder Pattern: Synthetic $CeTiNbO_6$.
2.975 (100), 3.024 (80), 3.106 (35), 2.698 (30), 5.48 (25), 4.431 (25), 2.037 (25)

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	29.64	23.85	$(La, Dy)_2O_3$	5.60	
Ta_2O_5		6.97	Ce_2O_3	18.49	19.50
TiO_2	21.81	22.60	FeO	3.17	4.28
SnO_2	0.18	trace	CaO	2.75	2.52
ThO_2	15.75	15.42	LOI	1.07	
$(Y, Er)_2O_3$	1.12	4.53	Total	99.58	99.67

(1) Miass, Russia. (2) Hidra Island, Norway.

Polymorphism & Series: Dimorphous with lucasite-(Ce); forms series with nioboaeschynite-(Ce) and with aeschynite-(Y).

Occurrence: In nepheline syenites and alkali syenite massifs; in granite pegmatites; in carbonatites in alkalic rocks; a detrital mineral in placers.

Association: Feldspar, zircon, samarskite, columbite, allanite, titanite.

Distribution: From around Miass and Zlatoust, Vishnevy-Ilmen Mountains, Southern Ural Mountains, Russia. In Norway, on Hidra (Hitterö) Island, from near Arendal, at Frikstad, and elsewhere. In Germany, at Döbschütz and Königshaln, Lausiter Bergland. From near the Leckbachscharte, Habachtal, and in the Lohninger quarry, near Rauris, Austria. At Val Bedretto and Val Nalps, Tavetsch, Graubünden, Switzerland. In the USA, from south of Darby, Ravalli Co., Montana, and in the Henderson molybdenum mine, Clear Creek Co., Colorado.

Name: From the Greek for *shame*, in allusion to the fact that early chemists had difficulty with separations of titanium from zirconium in some samples; *cerium* for the dominant rare-earth element.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 793–797 [eschynite]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 489–496. (3) Alexandrov, V.B. (1962) The crystal structure of aeschynite. Doklady Acad. Nauk SSSR, 142, 181–184. (4) Fleischer, M. (1966) Rare earths in the aeschynite-priorite series. The status of lyndochite [aeschynite-(Ce)]. Mineral. Mag., 35, 801–809. (5) Ewing, R.C. (1976) A numerical approach toward the classification of complex, orthorhombic, rare-earth, AB_2O_6−type Nb-Ta-Ti oxides. Can. Mineral., 14, 111–119. (6) (1964) NBS Mono. 25, 3, 24.

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Aeschynite-(Nd) $(Nd, Ce, Ca)(Ti, Nb)_2(O, OH)_6$

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Crystal Data: Orthorhombic; metamict. *Point Group:* [$2/m$ $2/m$ $2/m$ probable] [by analogy to aeschynite-(Ce)]. As tabular and prismatic crystals, to several mm, and as equigranular and radiating clusters, massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 4.60–5.04 D(calc.) = n.d. Radioactive.

Optical Properties: Semitransparent. *Color:* Dark to pale brown, brownish black; yellowish orange to reddish orange in thin section; dark gray in reflected light. *Streak:* Pale yellowish brown. *Luster:* Adamantine.
Optical Class: Isotropic to biaxial. *Pleochroism:* Weak to distinct. *Dispersion:* Weak to strong. n = 2.1–2.4 (metamict). 2V(meas.) = 78°–82°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Bayan Obo, China; nearly metamict, with only one line, at 2.03 Å, before heating; after heating at 800 °C gives an aeschynite pattern.
2.93 (10), 3.00 (9), 1.575 (7b), 1.95 (6), 1.53 (6b), 5.45 (5), 2.64 (5)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8		0.06	FeO		trace
Nb_2O_5	30.16	21.40	MnO	0.06	trace
Ta_2O_5	0.04	1.24	MgO	0.44	0.35
SiO_2	0.65	0.04	CaO	2.96	0.73
TiO_2	22.46	28.65	Na_2O	0.42	0.07
ThO_2	1.33	7.72	K_2O	trace	trace
Al_2O_3	0.54	0.64	H_2O^+	0.96	1.27
RE_2O_3	37.99	36.54	H_2O^-		0.10
Fe_2O_3	1.99	1.36	Total	100.00	100.17

(1) Bayan Obo, China; $RE_2O_3 = La_2O_3$ 2.30%, CeO_2 13.16%, Pr_6O_{11} 2.67%, Nd_2O_3 13.71%, Sm_2O_3 2.32%, $(Eu, Gd)_2O_3$ 1.87%, Y_2O_3 1.26%, Dy_2O_3 0.70%; corresponds to $[Nd_{0.30}Ce_{0.29}Ca_{0.19}Pr_{0.06}La_{0.05}Sm_{0.05}Na_{0.05}(Eu, Gd)_{0.04}Mg_{0.04}Y_{0.03}Dy_{0.02}Th_{0.02}]_{\Sigma=1.14}(Ti_{1.00}Nb_{0.82}Fe^{3+}_{0.09}Al_{0.04}Si_{0.04})_{\Sigma=1.99}[O_{5.62}(OH)_{0.38}]_{\Sigma=6.00}$. (2) Do.; $RE_2O_3 = CeO_2$ 7.23%, Pr_6O_{11} 2.63%, Nd_2O_3 18.45%, Sm_2O_3 4.46%, Eu_2O_3 0.62%, Gd_2O_3 1.39%, Tb_2O_3 2.11%, Y_2O_3 0.73%, Dy_2O_3 0.48%, Er_2O_3 0.29%, Yb_2O_3 0.22%; corresponds to $(Nd_{0.40}Ce_{0.16}Th_{0.11}Sm_{0.10}Pr_{0.06}Ca_{0.05}Y_{0.04}Gd_{0.03}Mg_{0.03}Na_{0.01}Eu_{0.01})_{\Sigma=1.00}(Ti_{1.29}Nb_{0.58}Fe^{3+}_{0.06}Al_{0.05}Ta_{0.02})_{\Sigma=2.00}[O_{5.45}(OH)_{0.55}]_{\Sigma=6.00}$.

Occurrence: In veins in slate and metamorphosed dolostone.

Association: Aegirine, riebeckite, barite, fluorite, albite, phlogopite, magnetite.

Distribution: From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China.

Name: For similarity to *aeschynite-(Ce)*, with *neodymium* as the dominant rare-earth element.

Type Material: n.d.

References: (1) Zhang Peishan and Tao Kejie (1982) Aeschynite-(Nd). Scientia Geologica Sinica, 4, 424–428 (in Chinese with English abs.). (2) (1984) Amer. Mineral., 69, 565 (abs. ref. 1).

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Aeschynite-(Y) $(Y, Ca, Fe, Th)(Ti, Nb)_2(O, OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 10 cm, commonly tabular, less commonly prismatic, forms {001}, {010}, {021}, {110}, {210}, {111}; granular.

Physical Properties: *Cleavage:* Perfect on {100}, {010}, and {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 4.82–4.93 D(calc.) = 5.5 Magnetic.

Optical Properties: Semitransparent. *Color:* Pale yellow, yellow-orange, pale greenish yellow. *Streak:* White, pale yellow, reddish yellow. *Luster:* Submetallic to pearly on crystal faces, resinous to waxy on fracture surfaces.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, strong.
$\alpha = 2.19$–2.28 $\beta = 2.21$–2.30 $\gamma = 2.34$–2.50 2V(meas.) = 70°–80°

Cell Data: *Space Group: Pmnb.* $a = 7.44$–7.50 $b = 10.92$–11.04 $c = 5.18$ Z = 4

X-ray Powder Pattern: "Southern China".
2.902 (10), 1.059 (7), 1.051 (7), 4.34 (5), 2.715 (5), 5.27 (4), 2.503 (4)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_5	17.99	23.35	UO_2	4.01	5.35	PbO	0.06	0.84
Ta_2O_5	0.89	1.15	Al_2O_3	trace		MgO	0.04	0.15
SiO_2	0.38	0.40	$(Y, Er)_2O_3$	28.76	25.62	CaO	1.02	1.80
TiO_2	32.91	27.39	Ce_2O_3	1.97	2.48	Na_2O	0.22	0.90
SnO_2	0.12	0.18	FeO	1.48	1.43	K_2O	0.19	0.18
ThO_2	7.69	4.28	MnO	0.27	0.30	H_2O^+	1.88	2.56
ZrO_2	trace	1.33	ZnO		0.09	Total	99.88	99.78

(1) Urstad, Norway; Ce_2O_3 includes $(La, Dy)_2O_3$. (2) Arendal, Norway; Ce_2O_3 includes $(La, Dy)_2O_3$.

Polymorphism & Series: Forms two series, with aeschynite-(Ce) and with tantalaeschynite-(Y).

Occurrence: In granite and granite pegmatites; in ankerite-dolomitic carbonatites; as a detrital mineral in placers.

Association: Euxenite, monazite, xenotime, allanite, zircon, fergusonite, thorite, synchysite, gadolinite, chernovite, columbite, biotite, muscovite, titanite, corundum.

Distribution: From many localities in Norway, including: at Urstad, on Hidra (Hitterö) Island; Sätersdalen; at Kåbuland, Mölland, and Birkeland; near Arendal, Mörefjär, and Salterö; at Frikstad. In Russia, at Miass, in the Ilmen Mountains, Southern Ural Mountains. In Switzerland, from Piz Lucendro, near the St. Gotthard Pass, on Pizzo Rotondo, Val Bedretto, and Val Nalps, Tavetsch, Graubünden; and elsewhere. In Italy, on Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont. At Böckstein, near Bad Gestein, Austria. From Tongafeno, Ambedabao, Ambohitromby, near Ambatofotsy, Tomboarivo, and other localities in Madagascar. From the Embabaan district, Swaziland. A number of other less-well-defined localities are known.

Name: For similarity to *aeschynite-(Ce)*, with *yttrium* as the dominant rare-earth element.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 793–797 [priorite]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 489–496 [priorite]. (3) Levinson, A.A. (1966) A system of nomenclature for rare-earth minerals. Amer. Mineral., 51, 152–158 [priorite = aeschynite-(Y)]. (4) Chi Ling-Yi (1974) Taiyite [= aeschynite-(Y)], a new variety of aeschynite-priorite group. Acta Geol. Sin. 91–94 (in Chinese with English abs.) (5) (1976) Amer. Mineral., 61, 178 (abs. ref. 4). (6) Sommerauer, J. and L. Weber (1972) Aeschnit-(Y,Gd,Dy,Er), ein neues Zerrkluftmineral der zentralen Schweizer Alpen. Schweiz. Mineral. Petrog. Mitt., 52, 75–91 (in German with English abs.).

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Afghanite $(Na, Ca, K)_8(Si, Al)_{12}O_{24}(SO_4, Cl, CO_3)_3 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $6mm$, or $\overline{6}\ m2$. As stout to slender, thin tabular laths and as rounded grains.

Physical Properties: *Cleavage:* Perfect on $\{10\overline{1}0\}$. *Fracture:* Conchoidal. Hardness = 5.5–6 D(meas.) = 2.55 D(calc.) = 2.65

Optical Properties: Transparent. *Color:* Blue; in thin section, colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.523(2)$ $\epsilon = 1.529(2)$

Cell Data: *Space Group:* $P6_3/mmc$, $P6_3mc$, or $P\overline{6}2c$. $a = 12.77(3)$ $c = 21.35(4)$ $Z = 3$

X-ray Powder Pattern: Sar-e-Sang, Afghanistan.
3.688 (100), 3.298 (100), 4.82 (80), 3.997 (60), 2.865 (60), 2.130 (60), 1.792 (60)

Chemistry:

	(1)	(2)
SiO_2	30.8	32.96
Al_2O_3	25.	25.45
CaO	16.5	11.98
Na_2O	12.6	12.52
K_2O	2.7	3.07
Cl	4.6	3.98
H_2O	0.7	
CO_2	0.4	
SO_3	8.5	10.82
$-O = Cl_2$	1.0	0.9
Total	100.8	99.88

(1) Sar-e-Sang, Afghanistan; corresponds to $(Na_{4.86}Ca_{3.52}K_{0.69})_{\Sigma=9.07}(Si_{6.13}Al_{5.87})_{\Sigma=12.00}O_{25.21}[Cl_{1.55}(SO_4)_{1.27}(CO_3)_{0.11}]_{\Sigma=2.93} \cdot 0.46H_2O$. (2) Edwards, New York, USA; by electron microprobe, corresponds to $(Na_{4.63}Ca_{2.45}K_{0.75})_{\Sigma=7.83}(Si_{6.28}Al_{5.72})_{\Sigma=12.00}O_{24.08}[(SO_4)_{1.55}Cl_{1.29}]_{\Sigma=2.84}$.

Mineral Group: Cancrinite group.

Occurrence: In thin veinlets cutting lazurite crystals (Sar-e-Sang, Afghanistan); in silicified limestone xenoliths in pumice (Pitigliano quarry, Italy).

Association: Lazurite, sodalite, nepheline, phlogopite, olivine, diopside, vesuvianite, calcite, pyrite.

Distribution: At Sar-e-Sang, Badakhshan Province, Afghanistan. In Russia, in the Malaya Bystraya and Tultuy lazurite deposits, near Lake Baikal, and in other unspecified deposits in eastern Siberia. From Lyadzhuar-Darinsk, Pamir Mountains, Tajikistan. In Italy, at the Pitigliano quarry, near Grosseto, Tuscany; on Monte Somma, Campania; from Vetralla and Bassano, Latium. In the Edwards mine, Edwards, St. Lawrence Co., New York, USA. At Lake Harbour, Baffin Island, Newfoundland, Canada.

Name: For the country of first occurrence, AFGHANistan.

Type Material: Mineralogy-Crystallography Laboratory, University Pierre and Marie Curie, Paris; National School of Mines, Paris, France; The Natural History Museum, London, England, 1969,72.

References: (1) Bariand, P., F. Cesbron, and R. Giraud (1968) Une nouvelle espèce minérale: l'afghanite de Sar-e-Sang, Badakhshan, Afghanistan. Comparaison avec les minéraux du groupe de la cancrinite. Bull. Soc. fr. Minéral., 91, 34–42 (in French with English abs.). (2) (1968) Amer. Mineral., 53, 2105 (abs. ref. 1). (3) Hogarth, D. (1979) Afghanite: new occurrences and chemical composition. Can. Mineral., 17, 47–52. (4) Parodi, G.C., P. Ballirano, and A. Maras (1996) Afghanite from Mount Vesuvius: a rediscovery. Mineral. Record, 26, 109–114.

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Afwillite **$Ca_3(SiO_3OH)_2 \cdot 2H_2O$**

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Crystal Data: Monoclinic. *Point Group:* m. Crystals prismatic, elongated and striated ‖ [010], to 11 cm, many tabular on {100} and {201}; in radial fibrous spherulites; massive.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}\}$; good on {100}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.630 D(calc.) = 2.643(5) Piezoelectric.

Optical Properties: Transparent. *Color:* Colorless or white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 31.2°$ *Dispersion:* $r < v$.
$\alpha = 1.616$–1.618 $\beta = 1.619$–1.621 $\gamma = 1.631$–1.634 2V(meas.) = 50°–56°

Cell Data: *Space Group:* Cc. $a = 16.278(1)$ $b = 5.6321(4)$ $c = 13.236(1)$ $\beta = 134.898°$ Z = 4

X-ray Powder Pattern: Kimberley, South Africa.
2.83 (100), 6.61 (90), 3.18 (90), 2.73 (90), 3.28 (70), 2.15 (70), 2.34 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	33.96	34.65	35.09
Al_2O_3, Fe_2O_3	0.60		
MgO		trace	
CaO	49.28	48.94	49.13
F		0.18	
H_2O^+	15.89	16.08	15.78
H_2O^-	0.12	0.01	
$-O = F_2$		0.10	
Total	99.85	99.76	100.00

(1) Kimberley, South Africa. (2) Crestmore, California, USA. (3) $Ca_3(SiO_3OH)_2 \cdot 2H_2O$.

Occurrence: A product of contact metamorphism of limestones.

Association: Apophyllite, natrolite, thaumasite, merwinite, spurrite, gehlenite, ettringite, portlandite, hillebrandite, foshagite, brucite, calcite.

Distribution: From the Dutoitspan diamond mine, Kimberley, and the Wessels mine, near Kuruman, Cape Province, South Africa. In Ireland, at Scawt Hill, near Larne, Co. Antrim. From the Schellkopf, near Brenk, Eifel district, and on the Zeilberg, near Maroldsweisach, Bavaria, Germany. At Campomorto, Montalto di Castro, Lazio, Italy. From Nahal Ayalon, Israel. In the USA, at Crestmore, Riverside Co., California. In the Mihara mine and at Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: Honoring Alpheus Fuller Williams (1874–1953), General Manager, DeBeers Consolidated Mines, Kimberley, South Africa.

Type Material: The Natural History Museum, London, England, 1925,80; National Museum of Natural History, Washington, D.C., USA, 95237.

References: (1) Parry, J. and F.E. Wright (1925) Afwillite, a new hydrous calcium silicate, from Dutoitspan Mine, Kimberley, South Africa. Mineral. Mag., 20, 277–285. (2) (1925) Amer. Mineral., 10, 447 (abs. ref. 1). (3) Switzer, G. and E.H. Bailey (1953) Afwillite from Crestmore, California. Amer. Mineral., 38, 629–633. (4) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 50–53. (5) Malik, K.M.A. and J.W. Jeffrey (1976) A re-investigation of the structure of afwillite. Acta Cryst., 32, 475–480. (6) Kusachi, I., C. Henmi, and K. Henmi (1989) Afwillite and jennite from Fuka, Okayama Prefecture, Japan. Mineral. J. (Japan), 14, 279–292.

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Agardite-(La) $(La,Ca)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6. Crystals acicular, prismatic, to 3 mm, in tufted groups, spherical rosettes.

Physical Properties: Hardness = n.d. D(meas.) = 3.65(5) D(calc.) = 3.62(1)

Optical Properties: Semitransparent. *Color:* Grass-green to dull green, yellowish green to intense bluish green, rarely nearly colorless.
Optical Class: Uniaxial (+). $\omega = 1.715(2)$ $\epsilon = 1.795(2)$

Cell Data: *Space Group:* $P6_3/m$ or $P6_3$. $a = 13.586(4)$ $c = 5.931(5)$ $Z = 2$

X-ray Powder Pattern: n.d. ; presumably very similar to agardite-(Y).

Chemistry: (1) Red Cloud fluorite mine, New Mexico, USA; analysis not given, by electron microprobe, average of analyses on four crystals, $(OH)^{1-}$ calculated for charge balance; stated to correspond to $(Al_{0.36}La_{0.29}Ce_{0.21}Nd_{0.08}Pr_{0.03}Y_{0.02}Gd_{0.02}Sm_{0.01})_{\Sigma=1.02}(Cu_{5.50}Ca_{0.42}Pb_{0.06}Fe_{0.02}Zn_{0.01})_{\Sigma=6.01}[(AsO_4)_{2.74}(SiO_4)_{0.25}(VO_4)_{0.02}(SO_4)_{0.02}]_{\Sigma=3.03}(OH)_{5.76} \cdot 3H_2O$.

Mineral Group: Mixite group; Nd and Ce have also been noted as dominant rare-earth elements, but the corresponding species have not been fully described.

Occurrence: In small amounts in the oxidized zone of hydrothermal mineralized breccia and polymetallic mineral deposits (Red Cloud mines, New Mexico, USA).

Association: Fluorite, bastnaesite, barite, quartz (Red Cloud fluorite mine, New Mexico, USA); chrysocolla, malachite, azurite, mimetite, vanadinite, conichalcite, wulfenite, mottramite, cerussite, quartz (Red Cloud copper mine, New Mexico, USA); smithsonite, aurichalcite, hydrozincite, azurite, cuprian adamite, calcite, chrysocolla, zincaluminite, gibbsite (Kamariza mine, Greece).

Distribution: From the Red Cloud fluorite and copper mines, Gallinas district, Lincoln Co., New Mexico, USA. In the Kamariza mine, Laurium, Greece (Ce > La in part). In England, from Wheal Alfred, Phillack, Cornwall (Nd-rich); at the Brandy Gill and Deer Hills mines, Caldbeck Fells, Cumbria. In the Clara Mine, near Oberwolfach, and other localities in the Black Forest, Germany (Ce > La in part). From the Sa Duchessa mine, near Iglesias, Sardinia, Italy (Nd-rich in part, some with Ce > La).

Name: By analogy to *agardite*-(Y), with its rare-earth content dominated by *lanthanum*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 148987, 148988.

References: (1) Modreski, P.J. (1983) Agardite-(La), a chemically complex rare-earth arsenate from the Gallinas district, Lincoln Co., New Mexico. In: Anthony, J.W., Ed., Oxidation mineralogy of base metal deposits: Fifth Joint Mineralogical Society of America – Friends of Mineralogy Symposium, Tucson, Arizona. (2) Fehr, T. and R. Hochleitner (1984) Agardite-La, ein neues Mineral von Lavrion, Griechenland. LAPIS, 9(1), 22, 37 (in German). (3) (1985) Amer. Mineral., 70, 871 (abs. ref. 2).

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Agardite-(Y) $(Y,Ca)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals are acicular hexagonal prisms, elongated along [0001], a few mm long, may be stepped or hollow tubes; in radiating fibrous aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 3.61–3.72 D(calc.) = 3.66(4)

Optical Properties: Semitransparent. *Color:* Blue-green to yellow-green. *Optical Class:* Uniaxial (+). $\omega = 1.701$–1.723 $\epsilon = 1.777$–1.815

Cell Data: *Space Group:* $P6_3/m$. $a = 13.583(2)$ $c = 5.895(2)$ Z = 2

X-ray Powder Pattern: Bou Skour mine, Morocco.
11.73 (10), 2.938 (8), 2.451 (8), 4.43 (7), 3.54 (7), 2.692 (6), 2.558 (6)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
As_2O_5	31.50	32.28	RE_2O_3	1.2		Gd_2O_3		0.62
P_2O_5		0.03	La_2O_3		2.68	CuO	45.35	44.50
SiO_2		0.15	Ce_2O_3		0.44	PbO		4.60
Bi_2O_3		0.04	Pr_2O_3		0.21	CaO	2.60	0.65
Al_2O_3		0.20	Nd_2O_3		1.15	H_2O	11.35	[10.47]
Y_2O_3	7.5	4.08	Sm_2O_3		0.08	Total	99.50	[102.18]

(1) Bou Skour mine, Morocco; contains very little malachite and quartz; spectrographic analysis of RE = La 0.01%, Pr, Nd 0.3%, Sm 0.15%, Gd, Tb 0.04%, Dy, Ho, Er 0.01%, Tm, Yb, Lu 0.025%; corresponds to $[(Y,RE)_{0.38}Ca_{0.12}]_{\Sigma=0.50}(Cu_{5.86}Ca_{0.23})_{\Sigma=6.09}[(AsO_4)_{2.83}(OH)_{0.68}]_{\Sigma=3.51}(OH)_6 \cdot 3H_2O$. (2) Santa Lucia mine, Sardinia, Italy; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $(Y_{0.38}Pb_{0.22}La_{0.17}Nd_{0.07}Gd_{0.04}Al_{0.04}Ce_{0.03}Pr_{0.01}Ca_{0.03})_{\Sigma=0.99}(Cu_{5.91}Ca_{0.09})_{\Sigma=6.00}[(AsO_4)_{2.97}(SiO_4)_{0.03}]_{\Sigma=3.00}(OH)_6 \cdot 3H_2O$.

Mineral Group: Mixite group.

Occurrence: In the oxidation zone of some copper deposits.

Association: Azurite, malachite, chrysocolla, cuprite, copper, mimetite, quartz.

Distribution: In the Bou Skour mine, Djebel Sarhro, Morocco. At Mutoshi, Katanga Province, Congo (Shaba Province, Zaire). From the Luisito mine, Anora, Córdoba Province, Spain. At Schneeberg, Saxony; in the Clara mine, near Oberwolfach, Black Forest, Germany. In France, from the Cap Garonne mine, near le Pradet, Var, and Chessy, near Lyon, Rhône. In Wheal Alfred, Cornwall, England. At the Gwaithyrafon mine, Cwmsymlog, Wales. On Sardinia, Italy, from the Santa Lucia and Sa Duchessa mines, near Iglesias. At Hayasi, Setoda, Ikuchi Island, Hiroshima Prefecture, Japan. From Broken Hill, New South Wales, Australia. In the USA, from the Tintic district, Juab Co., Utah; in the Mohawk mine, Clark Mountains, San Bernardino Co., California; and at Granite Gap, San Simon district, Hidalgo Co., New Mexico. A few other localities are known but may require confirmation as dominantly yttrian.

Name: To honor Jules Agard, geologist, Bureau de Recherches Géologiques et Minières, Orléans, France, and dominant *yttrium*.

Type Material: Serv. Geol. Maroc, Rabat, Morocco; National School of Mines, Paris, France; The Natural History Museum, London, England, 1978,24.

References: (1) Dietrich, J.E., M. Orliac, and F. Permingeat (1969) L'agardite, une nouvelle espèce minérale, et la problème du chlorotile. Bull. Soc. fr. Minéral., 92, 420–434 (in French with English abs.). (2) (1970) Amer. Mineral., 55, 1447–1448 (abs. ref. 1). (3) Aruga, A. and A. Nakai (1985) Structure of Ca-rich agardite, $(Ca_{0.40}Y_{0.31}Fe_{0.09}Ce_{0.06}La_{0.04}Nd_{0.01})Cu_{6.19}[(AsO_4)_{2.42}(HAsO_4)_{0.49}](OH)_{6.38} \cdot 3H_2O$. Acta Cryst., C41, 161–163. (4) Olmi, F., C. Sabelli, and G. Brizzi (1988) Agardite-(Y), gysinite-(Nd) and other rare minerals from Sardinia. Mineral. Record, 19, 305–310. (5) Olmi, F., C. Sabelli, and R. Trosti Ferroni (1991) A contribution to the crystal chemistry of mixite group minerals from Sardinia (Italy). Neues Jahrb. Mineral., Monatsh., 487–499.

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Agrellite **$NaCa_2Si_4O_{10}F$**

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals elongated ‖ [001], to 10 cm; platy aggregates.

Physical Properties: *Cleavage:* Excellent on {110} and {1$\bar{1}$0}, poor on {010}. Hardness = 5.5 D(meas.) = 2.902 D(calc.) = 2.887 Fluoresces bright pink under LW UV and duller pink under SW UV.

Optical Properties: Transparent to translucent. *Color:* White to grayish or greenish white. *Luster:* Pearly on cleavages.
Optical Class: Biaxial (–). $\alpha = 1.567$ $\beta = 1.579$ $\gamma = 1.581$ 2V(meas.) = n.d. 2V(calc.) = 47°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.759(2)$ $b = 18.946(3)$ $c = 6.986(1)$ $\alpha = 89.88(2)°$ $\beta = 116.65(2)°$ $\gamma = 94.32(2)°$ Z = 4

X-ray Powder Pattern: Villedieu Township, Canada.
3.19 (vs), 3.14 (vs), 3.44 (s), 3.33 (s), 2.58 (s), 2.31 (s), 2.04 (ms)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	57.79	60.92	CaO	25.70	28.43
TiO_2	0.01		SrO	0.16	
ZrO_2	0.18		BaO	0.06	
Al_2O_3	1.32		Na_2O	7.90	7.86
RE	2.57		K_2O	0.22	
Fe_2O_3	0.11		F	4.45	4.82
MnO	0.25		H_2O^+	0.4	
MgO	0.02		$-O = F_2$	1.87	2.03
			Total	99.27	100.00

(1) Villedieu Township, Canada; by wet chemical analysis, spectrophotometry, and flame photometry, total Fe as Fe_2O_3, H_2O by the Penfield method. (2) $NaCa_2Si_4O_{10}F$.

Occurrence: In pegmatite lenses and pods and in mafic gneisses in a regionally metamorphosed agpaitic alkalic rock complex (Villedieu Township, Canada).

Association: Hiortdahlite, mosandrite, miserite, britholite, vlasovite, calcite, fluorite, clinohumite, gittinsite, norbergite, zircon, biotite, phlogopite, galena (Villedieu Township, Canada); miserite, aegirine, eudialyte, quartz (Wausau, Wisconsin, USA).

Distribution: In Canada, from the Sheffield Lake complex, Kipawa River, Villedieu Township, Quebec. In the USA, in the Wausau complex, Marathon Co., Wisconsin. In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. From the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: To honor Professor Stuart Olof Agrell (1913–1996), eminent petrologist, Cambridge University, Cambridge, England.

Type Material: Canadian Museum of Nature, Ottawa; University of Toronto, Toronto; Royal Ontario Museum, Toronto, Canada, M34496; Harvard University, Cambridge, Massachusetts, 117050; National Museum of Natural History, Washington, D.C., USA, 127007; Cambridge University, Cambridge, England; The Natural History Museum, London, England, 1979,431.

References: (1) Gittins, J., M.G. Brown, and B.D. Sturman (1976) Agrellite, a new rock-forming mineral in regionally metamorphosed agpaitic alkalic rocks. Can. Mineral., 14, 120–126. (2) (1977) Amer. Mineral., 62, 173–174 (abs. ref. 1). (3) Ghose, S. and C. Wan (1979) Agrellite, $Na(Ca,RE)_2Si_4O_{10}F$: a layer structure with silicate tubes. Amer. Mineral., 64, 563–572.

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Agrinierite $(K_2, Ca, Sr)U_3O_{10}\cdot 4H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. Crystals tabular on {001}, pseudohexagonal in section. *Twinning:* Sector twinning with composition plane {110}.

Physical Properties: *Cleavage:* {001}, good. Hardness = n.d. D(meas.) = 5.7 D(calc.) = [5.55]

Optical Properties: Transparent to translucent. *Color:* Orange. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Z = b$. α = n.d. $\beta = 2.01$ $\gamma = 2.06$ 2V(meas.) = 55°

Cell Data: *Space Group:* $Cmmm$, $Cm2m$, $Cmm2$, or $C222$. $a = 14.04$ $b = 24.07$ $c = 14.13$ Z = [16]

X-ray Powder Pattern: Margnac mine, France.
7.08 (vvs), 3.128 (vvs), 3.485 (vs), 3.153 (vs), 3.516 (s), 2.023 (s), 6.05 (ms)

Chemistry:

	(1)
UO_3	85.15
CaO	2.20
SrO	2.05
BaO	0.00
K_2O	3.35
H_2O^+	7.45
Total	100.20

(1) Margnac mine, France; by electron microprobe, H_2O by TGA; corresponding to $(Ca_{0.40}K_{0.36}Sr_{0.20})_{\Sigma=0.96}U_{3.00}O_{10}\cdot 4.17H_2O$.

Occurrence: In the oxidation zone of a uranium deposit.

Association: Uranophane, "gummite".

Distribution: From the Margnac mine, Compreignac, Haute-Vienne, France.

Name: For Henri Agrinier (1928–1971), an engineer in the Mineralogy Laboratory of the French Atomic Energy Commission, Paris, France.

Type Material: University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 137454.

References: (1) Cesbron, F., W.L. Brown, P. Bariand, and J. Geffroy (1972) Rameauite and agrinierite, two new hydrated complex uranyl oxides from Margnac, France. Mineral. Mag., 38, 781–789. (2) (1973) Amer. Mineral., 58, 805 (abs. ref. 1).

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Aguilarite Ag_4SeS

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Crystal Data: Orthorhombic. *Point Group:* n.d. In skeletal pseudododecahedral crystals, commonly elongated in the direction of a pseudocubic or pseudo-octahedral edge, to 3 cm; also massive and in intergrowths with acanthite or naumannite.

Physical Properties: *Fracture:* Hackly. *Tenacity:* Sectile. Hardness = 2.5
VHN = 20.5–23.8, 22.7 average (25 g load). D(meas.) = 7.40–7.53 D(calc.) = [7.65]

Optical Properties: Opaque. *Color:* Bright lead-gray on fresh surfaces; dull iron-black on exposed surfaces. *Luster:* Metallic. *Anisotropism:* Very weak or isotropic.
R_1–R_2: (400) 34.8–35.1, (420) 34.7–35.2, (440) 34.6–35.2, (460) 34.7–35.3, (480) 34.8–35.3, (500) 34.8–35.4, (520) 34.6–35.6, (540) 34.1–35.5, (560) 33.5–35.2, (580) 32.8–34.6, (600) 32.1–33.8, (620) 31.5–33.9, (640) 31.0–32.4, (660) 30.6–31.8, (680) 30.2–31.4, (700) 30.0–31.0

Cell Data: *Space Group:* n.d. $a = 4.33$ $b = 7.09$ $c = 7.76$ $Z = 2$

X-ray Powder Pattern: Guanajuato, Mexico.
2.43 (100), 2.88 (50), 1.48 (40), 2.23 (30), 1.73 (30), 2.67 (20), 2.59 (20)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	79.6	79.41	78.9	79.50
Cu		0.50		
Se	15.2	13.96	15.6	14.59
S	6.4	5.93	5.5	5.91
Total	101.2	99.80	100.0	100.00

(1) Silver City, Idaho, USA. (2) Guanajuato, Mexico. (3) San Carlos mine, Guanajuato, Mexico; by electron microprobe. (4) Ag_4SeS.

Polymorphism & Series: Inverted from a higher temperature cubic form.

Occurrence: An uncommon, relatively low-temperature, mineral in hydrothermal deposits rich in silver and selenium, but manifestly deficient in sulfur.

Association: Acanthite, naumannite, silver, stephanite, proustite, pearceite, calcite, quartz.

Distribution: In Mexico, from Guanajuato, in the San Carlos mine [TL] and others; at the Chontalpan mine, Taxco, Guerrero. In the USA, in Idaho, from Silver City, Owyhee Co., and at the 4th of July mine, Yankee Fork, Custer Co.; from the Comstock Lode, Virginia City, Storey Co., Nevada; in Washington, at the L-D mine, Wenatchee, Chelan Co. and the Knob Hill mine, Republic, Ferry Co.; and from Cuchillo, Winston district, Sierra Co., New Mexico. At the Maritoto mine, northeast of Paeroa, New Zealand. From the Woluma goldfield, New South Wales, Australia. In the Sanru mine, Hokkaido, Japan.

Name: After Ponciano Aguilar (1853–1935), Superintendent of the San Carlos mine, Guanajuato, Mexico, where the material was originally found.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 178. (2) Earley, J.W. (l950) Description and synthesis of the selenide minerals. Amer. Mineral., 35, 337–364. (3) Petruk, W., D.R. Owens, J.M. Stewart, and E.J. Murray (l974) Observations on acanthite, aguilarite and naumannite. Can. Mineral., 12, 365–369. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 2.

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Aheylite $(Fe^{2+}, Zn)Al_6(PO_4)_4(OH)_8 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. As crystals, interlocked in felted and matted aggregates to form botryoidal, spherulitic masses; radiating, prismatic groups, to 5 mm.

Physical Properties: *Fracture:* Hackly to splintery. *Tenacity:* May be brittle.
Hardness = 5–5.5 D(meas.) = 2.84 D(calc.) = 2.90

Optical Properties: Transparent in thin flakes. *Color:* Very pale blue, pale green, to blue-green. *Streak:* White. *Luster:* Porcelaneous to subvitreous.
Optical Class: Biaxial (+). $n = \sim 1.63$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 7.400(1)$ $b = 9.896(1)$ $c = 7.627(1)$
$\alpha = 110.87°$ $\beta = 115.00°$ $\gamma = 69.96°$ Z = 1

X-ray Powder Pattern: Huanuni mine, Bolivia.
3.670 (100), 2.888 (67), 6.146 (43), 3.27 (37), 3.436 (36), 2.914 (34), 3.398 (25)

Chemistry:

	(1)	(2)
P_2O_5	35.4	35.23
Al_2O_3	38.1	37.96
FeO	4.14	8.92
ZnO	4.02	
H_2O^+	18.5	17.89
H_2O^-	0.08	0.00
Total	100.24	100.00

(1) Huanuni mine, Bolivia; by ICP, H_2O^- by gravimetry, H_2O^+ by Karl Fischer titration, average of four analyses; corresponds to $(Fe^{2+}_{0.46}Zn_{0.40})_{\Sigma=0.86}Al_6(PO_4)_{3.72}(PO_3OH)_{0.28}(OH)_8 \cdot 4.10H_2O$.
(2) $FeAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$.

Mineral Group: Turquoise group.

Occurrence: A late stage hydrothermal mineral in a base-metal-tin deposit (Huanuni mine, Bolivia).

Association: Variscite, sphalerite, vivianite, wavellite, cassiterite, pyrite, quartz (Huanuni mine, Bolivia).

Distribution: In the Huanuni mine, Oruro, Bolivia. From the Bali Lo copper prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia.

Name: To honor Allen V. Heyl (1918–), economic geologist, U.S. Geological Survey.

Type Material: n.d.

References: (1) Foord, E.E. and J.E. Taggart, Jr. (1998) A reexamination of the turquoise group: the mineral aheylite, planerite (redefined), turquoise and coeruleolactite. Mineral. Mag., 62, 93–111.

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Ahlfeldite $NiSe^{4+}O_3 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals, to 1 mm, elongated along [001] or flattened parallel {110}, showing {110}, {011}, {032}, {103}, {$\overline{1}$01}; in crystalline crusts and spherical aggregates.

Physical Properties: *Cleavage:* On {110} and {103}, fair. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 3.37(2) D(calc.) = 3.51

Optical Properties: Transparent. *Color:* Pale green, apple-green, olive-green; brown, brownish pink, becoming pink with increasing cobalt content. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = pale green; Y = pale pink; Z = pink. *Orientation:* $Y = b$; $Z \wedge c = -16°$. *Dispersion:* $r < v$, strong. $\alpha = 1.709(1)$ $\beta = 1.752(1)$ $\gamma = 1.787(2)$ 2V(meas.) = 85°

Cell Data: *Space Group:* $P2_1/n$. $a = 7.53(1)$ $b = 8.76(2)$ $c = 6.43(1)$ $\beta = 99°05(15)'$ Z = 4

X-ray Powder Pattern: Pacajake mine, Bolivia; close to cobaltomenite. 5.69 (100), 3.426 (80), 2.992 (75), 2.190 (75), 3.772 (60), 2.719 (60), 2.354 (50)

Chemistry:

	(1)	(2)
SeO_2	50.01	50.03
CoO	3.55	16.89
NiO	30.24	16.84
H_2O	16.2	16.24
Total	100.0	100.00

(1) Pacajake mine, Bolivia; by electron microprobe, H_2O by evolved H_2O analyzer; corresponds to $(Ni_{0.90}Co_{0.10})_{\Sigma=1.00}Se_{1.00}O_3 \cdot 2.00H_2O$. (2) $(Ni, Co)SeO_3 \cdot 2H_2O$ with Ni:Co = 1:1.

Polymorphism & Series: Forms a series with cobaltomenite.

Occurrence: A rare alteration product of nickel-bearing selenides and sulfides.

Association: Penroseite, chalcomenite, olsacherite, cerussite, anglesite (Pacajake mine, Bolivia); chalcomenite, olsacherite, lepidocrocite, goethite (El Dragón mine, Bolivia).

Distribution: In Bolivia, from the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, and the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí.

Name: To honor Friedrich E. Ahlfeld (1892–1982) German–Bolivian mining engineer and mineralogist.

Type Material: The Natural History Museum, London, England, 1972,347.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 635. (2) Aristarain, L.F. and C.S. Hurlbut, Jr. (1969) Ahlfeldite from Pacajake Bolivia; a restudy. Amer. Mineral., 54, 448–456. (3) Sturman, B.D. and J.A. Mandarino (1974) The ahlfeldite-cobaltomenite series. Can. Mineral., 12, 304–307. (4) Wildner, M. (1990) Crystal structure refinements of synthetic cobaltomenite ($CoSeO_3 \cdot 2H_2O$) and ahlfeldite ($NiSeO_3 \cdot 2H_2O$). Neues Jahrb. Mineral., Monatsh., 353–362.

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Aikinite $PbCuBiS_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic to acicular, to 1 m, striated ‖ [001], rarely radiating; also massive.

Physical Properties: *Cleavage:* Indistinct on {010}. *Fracture:* Uneven. Hardness = 2.0–2.5 VHN = n.d. D(meas.) = 7.07 D(calc.) = 7.255

Optical Properties: Opaque. *Color:* Blackish lead-gray, tarnishes brown or copper-red, may have a yellowish green coating; in polished section, cream-white. *Streak:* Grayish black. *Luster:* Metallic. *Pleochroism:* Cream-white to pure white or pale brown. *Anisotropism:* Distinct.
R_1–R_2: (400) 39.1–43.5, (420) 39.2–44.0, (440) 39.3–44.5, (460) 39.4–44.9, (480) 39.4–45.3, (500) 39.5–45.7, (520) 39.4–46.0, (540) 39.3–46.2, (560) 39.2–46.4, (580) 39.0–46.3, (600) 38.9–46.1, (620) 38.9–45.8, (640) 38.6–45.4, (660) 38.3–44.9, (680) 38.1–44.4, (700) 37.9–43.9

Cell Data: *Space Group: Pnma.* $a = 11.638(3)$ $b = 4.039(1)$ $c = 11.319(2)$ $Z = 4$

X-ray Powder Pattern: Beresovsk, Russia.
3.68 (100), 3.19 (80), 2.88 (70), 3.59 (60), 2.59 (50), 1.989 (40), 4.08 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb	35.15	35.19	35.98	Bi	36.25	37.52	36.29
Cu	11.11	10.59	11.03	S	16.56	16.70	16.70
Fe		0.17		Total	99.07	100.17	100.00

(1) Beresovsk, Russia. (2) Loch Shin monzogranite, near Lairg, Scotland; by electron microprobe, average of eight analyses; corresponds to $Pb_{0.98}Cu_{0.96}Bi_{1.04}S_{3.00}$. (3) $PbCuBiS_3$.

Occurrence: Uncommon in hydrothermal veins.

Association: Gold, pyrite, galena, tennantite, bismuthinite, enargite, chalcopyrite, quartz.

Distribution: There are numerous minor localities. In Russia, from the Beresovsk district, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains [TL], exceptional crystal sprays; very large crystals at Djida, Buryat, Siberia. From Dobšiná (Dobschau), Slovakia. In France, at the Gardette mine, near Bourg d'Oisans, Isère. In the USA, in Utah, at the Sells mine, Alta, Salt Lake Co.; in Nevada, near Cucomungo Spring and near the Sylvania Mountains, Esmeralda Co.; at the Old Lout mine, Poughkeepsie Gulch, near Ouray, San Juan Co., and in the Sunnyside mine, Eureka Co., Colorado; from the Chantilly quarry, near Arcola, Loudoun Co., Virginia. At Tasco and Huitzuco, Guerrero, Mexico.

Name: For Dr. Arthur Aikin (1773–1854), English chemist and mineralogist, a founder and long-time Secretary of the Geological Society of London, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 412–413. (2) Ohmasa, M. and W. Nowacki (1970) A redetermination of the crystal structure of aikinite [BiS_2|S|$Cu^{IV}Pb^{VII}$]. Zeits. Krist., 132, 71–86. (3) Kohotsu, I. and B.J. Wuensch (1971) The crystal structure of aikinite, $PbCuBiS_3$. Acta Cryst., 27, 1245–1252. (4) Mumme, W.G., E. Welin, and B.J. Wuensch (1976) Crystal chemistry and proposed nomenclature for sulfosalts intermediate in the system bismuthinite–aikinite (Bi_2S_3–$CuPbBiS_3$). Amer. Mineral., 61, 15–20. (5) Harris, D.G. and T.T. Chen (1976) Crystal chemistry and re-examination of nomenclature of sulfosalts in the aikinite–bismuthinite series. Can. Mineral., 14, 194–205. (6) Lowry, D., W.E. Stephens, and D.A. Herd (1994) Bismuth sulfosalts within quartz veining hosted by the Loch Shin monzogranite, Scotland. Mineral. Mag., 58, 39–47. (7) Topa, D., E. Makovicky, and W.H. Paar (2002) Composition ranges and exolution pairs for the members of the bismuthinite–aikinite series from Felbertal, Austria. Can. Mineral., 40, 849–869. (8) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 135. (9) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 3.

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Ajoite $(K,Na)Cu_7AlSi_9O_{24}(OH)_6 \cdot 3H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As sprays of bladed prismatic crystals, to 0.4 mm; commonly fibrous.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = n.d. D(meas.) = 2.96 D(calc.) = 2.951

Optical Properties: Translucent. *Color:* Bluish green.
Optical Class: Biaxial (+). *Pleochroism:* X = very light bluish green; $Y = Z$ = brilliant bluish green. *Orientation:* $X = b$; $Z \wedge c = 15°$. $\alpha = 1.550(1)$ $\beta = 1.583(1)$ $\gamma = 1.641(1)$ 2V(meas.) = 80(1)° 2V(calc.) = 76.4°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 13.637(5)$ $b = 14.507(4)$ $c = 13.620(2)$ $\alpha = 107.16(2)°$ $\beta = 105.45(2)°$ $\gamma = 110.57(2)°$ Z = 3

X-ray Powder Pattern: Ajo, Arizona, USA.
12.25 (100), 2.455 (12), 4.08 (10), 3.061 (10), 3.381 (8), 2.832 (8), 2.258 (8)

Chemistry:

	(1)
SiO_2	41.2
Al_2O_3	3.81
FeO	0.11
MnO	0.02
CuO	42.2
CaO	0.04
Na_2O	0.84
K_2O	2.50
H_2O	8.35
Total	99.07

(1) Ajo, Arizona, USA; Si, Al, and Cu by electron microprobe, corresponding to $(K_{0.70}Na_{0.36}Ca_{0.01})_{\Sigma=1.07}(Cu_{6.97}Fe_{0.02})_{\Sigma=6.99}Al_{0.98}Si_{9.00}O_{24}(OH)_{6.00} \cdot 3.09H_2O$.

Occurrence: In oxidized copper-rich base-metal deposits.

Association: Shattuckite, conichalcite, quartz, muscovite, pyrite (Ajo, Arizona, USA); creaseyite, fluorite (Potter-Cramer property, Arizona, USA); shattuckite, duhamelite, sillénite (Munihuaza, Mexico); quartz, papagoite (Messina, South Africa).

Distribution: In the USA, in Arizona, from the New Cornelia mine, Ajo, Pima Co.; at the Moon Anchor mine and Potter-Cramer property, near Wickenburg, Maricopa Co.; and a prospect in Copper Creek, Pinal Co. From Munihuaza, near Alamos, Sonora, Mexico. At Messina, Transvaal, South Africa.

Name: For the type occurrence at Ajo, Arizona, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 113220.

References: (1) Schaller, W.T. and A.C. Vlisidis (1958) Ajoite, a new hydrous aluminum copper silicate. Amer. Mineral., 43, 1107–1111. (2) Kato, T. and Y. Miúra (1976) Cell dimension of ajoite. Mineral. J. (Japan), 8, 234–239. (3) (1980) Mineral. Abs., 31, 415 (abs. ref. 2). (4) Chao, G.Y. (1981) Ajoite: new data. Amer. Mineral., 66, 201–203.

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Akaganéite β–$\mathbf{Fe^{3+}O(OH,Cl)}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tiny spindlelike quasi-single crystals are up to 5 μm in length; in bundles of such rods; commonly fine-grained massive to powdery.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.52]

Optical Properties: Semitransparent. *Color:* Yellowish brown.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $I2/m$. $a = 10.561(4)$ $b = 3.031(1)$ $c = 10.483(4)$ $\beta = 90.63(4)^\circ$ Z = 8

X-ray Powder Pattern: Synthetic FeO(OH).
3.333 (100), 2.5502 (55), 7.467 (40), 2.2952 (35), 1.6434 (35), 5.276 (30), 2.6344 (25)

Chemistry:

	(1)	(2)	(3)
SiO_2	3.10		
Al_2O_3	1.21		
Fe_2O_3	78.23	69.0 – 76.0	89.86
FeO	0.82		
NiO		0.4 – 5.6	
Na_2O	0.62		
K_2O	0.19		
H_2O^+	10.20		10.14
H_2O^-	4.96		
Cl		3.6 – 6.3	
Total	99.33		100.00

(1) Akagané mine, Japan; Si and Al are probably impurities; other samples from the locality contain significant Cl. (2) Campo del Cielo Fe–Ni meteorite; by electron microprobe, ranges of 14 analyses, total Fe as Fe_2O_3; with O^{2+} and $(OH)^{1-}$ for charge balance, the average corresponds to $(Fe^{3+}_{0.95}Ni_{0.05})_{\Sigma=1.00}O_{0.79}[(OH)_{1.21}Cl_{0.16}]_{\Sigma=1.37}$. (3) FeO(OH).

Occurrence: Apparently formed from pyrrhotite by ferric-sulfate-bearing solutions (Akagané mine, Japan); an important constituent in some soils, and certain geothermal brines and in sea-floor nodules; also formed as a corrosion product of some meteorites.

Association: Pyrrhotite (Akagané mine, Japan); hibbingite (Hibbing, Minnesota, USA).

Distribution: From the Akagané mine, Iwate Prefecture, Japan. Found at the Las Animas mine, La Mur, Trincheras, Sonora, Mexico. In the USA, from Black Rock, Humboldt Co., Nevada; north of the Santa Niño mine, Santa Cruz Co., Arizona; at Questa, Taos Co., New Mexico; and in the Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota. At the Clara mine, near Oberwolfach, Black Forest, Germany. From Warham Marshes, Norfolk, England. At Richelle, Belgium. In brines from the Atlantis II Deep, Red Sea. Additional localities may be expected, as the mineral has the appearance of "limonite".

Name: For the Akagané mine, Japan, its original locality.

Type Material: n.d.

References: (1) Mackay, A.L. (1962) β–ferric oxyhydroxide–akaganéite. Mineral. Mag., 33, 270–280. (2) Buchwald, V.F. and R.S. Clarke, Jr. (1989) Corrosion of Fe–Ni alloys by Cl-containing akaganéite (β–FeOOH): the Antarctic meteorite case. Amer. Mineral., 74, 656–667. (3) Post, J.E. and V.F. Buchwald (1991) Crystal structure refinement of akaganéite. Amer. Mineral., 76, 272–277. (4) Murad, E. (1979) Mössbauer and X-ray data on β–FeOOH (akaganéite). Clay Minerals, 14, 273–284.

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Akatoreite $\mathbf{Mn_9^{2+}Al_2Si_8O_{24}(OH)_8}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Rarely as sheaves, to 1 cm, of radiating prisms, elongated and striated ‖ [100]; fibrous, fine granular, massive. *Twinning:* On $\{0\overline{2}1\}$; twin axis ⊥ $\{0\overline{2}1\}$, lamellar in thin section.

Physical Properties: *Cleavage:* Good on {010}, poor on $\{0\overline{1}2\}$. Hardness = 6
D(meas.) = 3.48 D(calc.) = 3.47

Optical Properties: Transparent. *Color:* Yellow-orange to orange-brown. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* X = colorless; Y = pale yellow; Z = light canary-yellow. *Orientation:* $X \wedge \{010\} = 58°$; $Y \wedge \{010\} = 30°$. $\alpha = 1.698(1)$ $\beta = 1.704(1)$ $\gamma = 1.720(1)$ 2V(meas.) = 65.5°

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.337(2)$ $b = 10.367(2)$ $c = 7.629(1)$ $\alpha = 104.46(1)°$ $\beta = 93.81(2)°$ $\gamma = 104.18(1)°$ Z = 1

X-ray Powder Pattern: Akatore Creek, New Zealand.
4.665 (100), 3.310 (90), 2.214 (80), 9.681 (60), 3.466 (50), 3.063 (50), 2.866 (50)

Chemistry:

	(1)	(2)
SiO_2	36.4	36.9
TiO_2	0.03	0.1
Al_2O_3	8.3	6.2
FeO	1.0	0.9
MnO	47.7	44.2
MgO	0.3	0.8
CaO	0.2	0.2
H_2O	6.21	[10.7]
Total	100.14	[100.0]

(1) Akatore Creek, New Zealand; by electron microprobe, corresponding to $(Mn_{8.61}Fe_{0.19}Mg_{0.09}Ca_{0.05})_{\Sigma=8.94}Al_{2.09}Si_{7.75}O_{23.17}(OH)_{8.83}$. (2) Norberg, Sweden; by electron microprobe, average of eight analyses, H_2O by difference; corresponds to $(Mn_{8.29}Mg_{0.27}Fe_{0.19}Ca_{0.05})_{\Sigma=8.80}Al_{1.64}Si_{8.16}O_{23.17}(OH)_8$.

Occurrence: In a manganiferous metachert and carbonate lens in schists (Akatore Creek, New Zealand); in manganiferous potassium-rich felsic metavolcanics (Norberg, Sweden).

Association: Rhodochrosite, pyroxmangite, rhodonite, spessartine, quartz, tinzenite, apatite, todorokite, alabandite, hübnerite (Akatore Creek, New Zealand); ganophyllite, rhodochrosite, pyrolusite (Norberg, Sweden).

Distribution: In New Zealand, three km south of Akatore Creek, east Otago, South Island. From Norberg, Sweden.

Name: For the locality near Akatore Creek, New Zealand.

Type Material: University of Otago, Dunedin; Geological Survey of New Zealand, Lower Hutt, New Zealand; National Museum of Natural History, Washington, D.C., USA, 137285, 142541.

References: (1) Read, P.B. and A. Reay (1971) Akatoreite, a new manganese silicate from Eastern Otago, New Zealand. Amer. Mineral., 56, 416–426. (2) Ounchanum, P. and S. Morad (1987) Paragenesis of akatoreite and ganophyllite in the manganiferous rocks of the Häste field, Norberg ore district, central Sweden. Neues Jahrb. Mineral., Abh., 157, 225–244. (3) Burns, P.C. and F.C. Hawthorne (1993) Edge-sharing $Mn^{2+}O_4$ tetrahedra in the structure of akatoreite, $Mn_9^{2+}Al_2Si_8O_{24}(OH)_8$. Can. Mineral., 31, 321–329.

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Akdalaite $4Al_2O_3 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 622 or 6. As hexagonal crystals, to 0.8 mm, tabular to equant; in lenslike aggregates.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 7–7.5 VHN = 1085 D(meas.) = 3.68(2) D(calc.) = 3.673

Optical Properties: Translucent. *Color:* White; in thin section, pale greenish yellow. *Luster:* Vitreous to porcelaneous.
Optical Class: Uniaxial (–). $\omega = 1.747(3)$ $\epsilon = 1.741(3)$

Cell Data: *Space Group:* $P6_122$ or $P6_1$. $a = 12.87(1)$ $c = 14.97(1)$ Z = 18

X-ray Powder Pattern: Solnech deposit, Kazakhstan.
2.11 (10), 1.418 (10), 1.393 (10), 2.494 (9), 2.35 (9), 0.9931 (9), 2.32 (8)

Chemistry:

	(1)	(2)
SiO_2	4.74	
Al_2O_3	87.26	95.77
Fe_2O_3	0.97	
ZnO	0.90	
BeO	0.81	
MgO	0.97	
CaO	0.41	
F	0.68	
H_2O^+	4.23	4.23
$-O = (F, Cl)_2$	0.28	
Total	100.69	100.00

(1) Solnech deposit, Kazakhstan; after deduction of muscovite and fluorite, corresponds to $(Al_{1.91}Be_{0.04}Mg_{0.03}Fe^{3+}_{0.01}Zn_{0.01})_{\Sigma=2.00}(O_{2.91}H_{0.07}F_{0.02})_{\Sigma=3.00} \cdot 0.25H_2O$. (2) $4Al_2O_3 \cdot H_2O$.

Occurrence: In veinlets cutting amesite-fluorite-muscovite rock and fluorite-magnetite-diopside-vesuvianite skarn.

Association: Muscovite, fluorite, amesite, magnetite, diopside, vesuvianite, andradite.

Distribution: In the Solnech fluorite deposit, two km west of the Kara-Oba Mo–W deposit, Bet-Pak-Dal Desert, central Kazakhstan.

Name: For the Kazakh name, *Akdala*, for the vicinity of Kara-Oba, Kazakhstan.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Shpanov, E.P., G.A. Sidorenko, and T.I. Stolyarova (1970) Akdalaite, a new hydrous modification of alumina. Zap. Vses. Mineral. Obshch., 99, 333–339 (in Russian). (2) (1971) Amer. Mineral., 56, 635 (abs. ref. 1).

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Åkermanite $Ca_2MgSi_2O_7$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Crystals short prismatic to thin tabular, which may resemble squashed, octahedrally-modified cubes; granular, massive. *Twinning:* On {100} and {001}, cruciform.

Physical Properties: *Cleavage:* Distinct on {001}, poor on {110}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.944 D(calc.) = 2.922

Optical Properties: Transparent to translucent. *Color:* Colorless, yellowish gray, green, brown; in thin section, colorless to yellow. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (+). *Absorption:* Weak; $E > O$. $\omega = 1.630–1.632$ $\epsilon = 1.639–1.648$

Cell Data: *Space Group:* $P\bar{4}2_1m$ (synthetic). $a = 7.8288(8)$ $c = 5.0052(5)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.87 (100), 3.09 (30), 1.764 (30), 2.039 (20), 2.488 (18), 3.73 (14), 5.55 (12)

Chemistry:

	(1)	(2)	(3)
SiO_2	46.55	44.07	44.08
TiO_2		0.05	
Al_2O_3	0.96	0.33	
Fe_2O_3		0.00	
FeO	0.12	0.47	
MnO	0.00	0.11	
ZnO		1.56	
MgO	13.30	12.87	14.78
CaO	39.30	40.09	41.14
Na_2O		< 0.05	
Total	100.23	[99.55]	100.00

(1) Vesuvius, Italy. (2) Cascade Mountain, New York, USA; by electron microprobe; original total given as 99.52%. (3) $Ca_2MgSi_2O_7$.

Polymorphism & Series: Forms a series with gehlenite.

Mineral Group: Melilite group.

Occurrence: A product of contact metamorphism of siliceous limestones and dolostones, and in rocks of the sanidinite facies. Also forms from alkalic magmas rich in calcium.

Association: Monticellite, wollastonite, spurrite, larnite, merwinite, "fassaite," grossular, diopside, forsterite.

Distribution: Occurrences are typically of intermediate series members; relatively pure examples have been found at Monte Somma and Vesuvius, Campania, and Monte Cavalluchio, Sacrofano, near Rome, Lazio, Italy. From Crestmore, Riverside Co., California; on Cascade Mountain, Adirondack Mountains, Essex Co., New York; and from the Tres Hermanas district, Luna Co., New Mexico, USA. On Dufresne Hill, Oka, Quebec, Canada. From near Kilchoan, Ardnamurchan, Argyllshire, Scotland. At Scawt Hill, near Larne, Co. Antrim, Ireland. In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For Anders Richard Åkerman (1837–1922), Swedish metallurgist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 474–477. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 285–334. (3) Ervin, G. and E.F. Osborn (1949) X-ray data on synthetic melilites. Amer. Mineral., 34, 717–722. (4) Valley, J.W. and E.J. Essene (1980) Akermanite in the Cascade Slide xenolith and its significance for regional metamorphism in the Adirondacks. Contr. Mineral. Petrol., 74, 143–152. (5) Swainson, I.P., M.T. Dove, W.S. Schmahl, and A. Putnis (1992) Neutron powder diffraction study of the åkermanite–gehlenite solid solution series. Phys. Chem. Minerals, 19, 185–195.

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Akhtenskite MnO_2

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As microscopic crystals, flaky to platy on {001}, in parallel aggregates, sometimes in rows at 120°, probably due to replacement of an earlier hexagonal mineral; as flaky polycrystalline aggregates.

Physical Properties: *Cleavage:* {001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = [4.78]

Optical Properties: [Opaque.] *Color:* Pale gray to black.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.83$–2.85 $c = 4.47$–4.88 Z = [1]

X-ray Powder Pattern: Mt. Zarod, Russia; calculated from an electron diffraction pattern.
2.45, 2.15, 1.65, 1.42

Chemistry: Sufficient material for direct chemical analysis cannot be separated; energy-dispersive analysis shows Mn as the only cationic species; Mn^{4+} and O were established by X-ray photoelectronic spectroscopy, as was the absence of OH and H_2O.

Polymorphism & Series: Trimorphous with pyrolusite and ramsdellite.

Occurrence: In mixtures in "psilomelane" with other manganese oxides in an iron oxide deposit, probably bacterially altered from a previous mineral (Akhtensk deposit, Russia); in incrustations of ferromanganese minerals on oceanic basalt on a guyot (Mt. Zarod, Russia).

Association: Cryptomelane, nsutite, pyrolusite, todorokite, goethite (Akhtensk deposit, Russia); vernadite, manganite, Fe–Mn oxides (Mt. Zarod, Russia).

Distribution: In the Akhtensk brown ironstone deposit, north of Magnitka, Southern Ural Mountains; on Mt. Zarod, Sikhote-Alin Mountains, Primorskiy Kray, Russia.

Name: For the Akhtensk deposit, Russia, where it was first noted.

Type Material: Mining Institute, St. Petersburg, Russia, 307/5.

References: (1) Chukhrov, F.V., A.I. Gorshkov, and V.S. Drits (1987) Advances in the crystal chemistry of manganese oxides. Zap. Vses. Mineral. Obshch., 16, 210–221 (in Russian). (2) Chukhrov, F.V., A.I. Gorshkov, A.V. Sivtsov, V.V. Berezovskaya, Y.P. Dikov, G.A. Dubinina, and N.N. Varinov (1989) Akhtenskite – the natural analog of ϵ-MnO_2. Izv. Akad. Nauk SSSR, Ser. Geol., 9, 75–80 (in Russian). (3) (1990) Amer. Mineral., 75, 931 (abs. refs. 1 and 2).

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Aklimaite $Ca_4[Si_2O_5(OH)_2](OH)_4 \cdot 5H_2O$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As spherules of columnar or lath-shaped crystals to 5 mm; crystals flattened on (001) and elongated along [010].

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* n.d. *Tenacity:* Brittle. Hardness = 3-4 D(meas.) = 2.20(1) D(calc.) = 2.274

Optical Properties: Transparent. *Color: C*olorless or light-pinkish. *Streak:* n.d. *Luster:* Vitreous.
Optical Class: Biaxial (-). α = 1.548(2) β = 1.551(3) γ = 1.553(2)
2V(obs) > 70° 2V(calc) = 78° *Orientation*: Z = *b*.

Cell Data: *Space Group: C2/m*. *a* = 16.907(5) *b* = 3.6528(8) *c* = 13.068(4) β = 117.25(4)° *Z* = 2

X-ray Powder Pattern: Upper Chegem Caldera, Northern Caucasus, Russia.
11.64 (100), 2.948 (32), 3.073 (20), 2.320 (12), 2.901 (11), 8.30 (10), 2.576 (10)

Chemistry:

	(1)
Na_2O	0.06
K_2O	0.02
CaO	45.39
MnO	0.01
FeO	0.02
SiO_2	24.23
SO_3	0.04
F	3.22
H_2O	27.40
$-O = F_2$	1.36
Total	99.03

(1) Upper Chegem Caldera, Northern Caucasus, Russia; average of 9 electron microprobe analyses, absence of CO_2 confirmed by IR, H_2O and OH^- calculated from structural analysis; corresponding to $(Ca_{4.02}Na_{0.01})_{\Sigma=4.03}[Si_{2.00}O_{5.07}(OH)_{1.93}][(OH)_{3.16}F_{0.84}]_{\Sigma=4.00} \cdot 5H_2O$.

Occurrence: In a metasomatically altered limestone xenolith in ignimbrite.

Association: Larnite, members of the calcium humite-group, hydrogarnets, bultfonteinite, afwillite, ettringite.

Distribution: Upper Chegem (Verkhnechegemskaya) Caldera, near Mount Lakargi, Kabardino-Balkaria, Northern Caucasus, Russia.

Name: Derived from a Turkish women's name, *Aklima*, which means *bright by the mind*, in allusion to the mineral's light color and to the challenge of studying complex crystal structures with imperfect material. The name also honors the Turkish population in the Lakargi region.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia.

References: (1) Zadov, A.E., I.V. Pekov, N.V. Zubkova, V.M. Gazeev, N.V. Chukanov, V.O. Yapaskurt, P.M. Kartashov, E.V. Galuskin, I.O. Galuskina, N.N. Pertzev, A.G. Gurbanov, and D.Yu. Pushcharovsky (2012) Aklimaite, $Ca_4[Si_2O_5(OH)_2](OH)_4 \cdot 5H_2O$, a new natural hydrosilicate from Lakargi area (the North Caucazus, Russia). Zap. Ross. Mineral. Obshch., 141(2), 21-31 (in Russian, English abstract). (2) Zubkova, N.V., I.V. Pekov, D.Yu Pushcharovsky, A.E. Zadov, and N.V. Chukanov (2012) The crystal structure of aklimaite, $Ca_4[Si_2O_5(OH)_2](OH)_4 \cdot 5H_2O$. Zeitschrift für Kristallographie, 228, 452-455. (3) (2013) Amer. Mineral., 98, 811 (abs. refs. 1 & 2).

Akrochordite $(Mn^{2+},Mg)_5(AsO_4)_2(OH)_4 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are prismatic to lathlike, elongated along [201], generally splayed or tapered, to 2 mm; may be in radial aggregates and subparallel sheaves. Typically as wartlike or spherical aggregates of minute crystals.

Physical Properties: *Cleavage:* On {010}, perfect; a second, perpendicular to the first. Hardness = 3.5 D(meas.) = 3.19–3.35 D(calc.) = 3.26–3.29

Optical Properties: Translucent. *Color:* Yellowish red-brown, pale to dark brown, pale pink, colorless. *Luster:* Dull.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = \sim 45°$. *Dispersion:* $r < v$, moderately strong. $\alpha = 1.672$ $\beta = 1.676$ $\gamma = 1.683$ 2V(meas.) = Medium.

Cell Data: *Space Group:* $P2_1/c$. $a = 5.682(2)$ $b = 17.627(5)$ $c = 6.832(1)$ $\beta = 99.49(2)°$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
4.40 (10), 8.79 (8), 2.750 (5), 3.62 (4), 5.31 (3.5), 3.112 (3.5), 3.062 (3.5)

Chemistry:

	(1)	(2)	(3)
P_2O_5	0.42		
As_2O_5	33.51	32.5	31.6
Mn_2O_3	0.50		
FeO	0.46	1.5	0.2
MnO	38.98	39.8	49.5
ZnO		0.5	1.5
MgO	6.94	7.6	0.8
CaO	0.99	0.5	0.8
Na_2O	1.18		
K_2O	0.55		
H_2O	16.78	[17.6]	[15.6]
Total	100.31	[100.0]	[100.0]

(1) Långban, Sweden. (2) Do.; by electron microprobe, H_2O by difference. (3) Sterling Hill, New Jersey, USA; by electron microprobe, H_2O by difference.

Occurrence: A rare mineral in hausmannite ore from a metamorphosed Fe–Mn orebody (Långban, Sweden); in a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA).

Association: Pyrochroite, barite, hausmannite, eveite, brandtite (Långban, Sweden); sarkinite, chlorophoenicite, carbonates (Sterling Hill, New Jersey, USA).

Distribution: From Långban, Värmland, Sweden. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: From the Greek for *wart*, for its typical habit.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162614, R5396.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 927. (2) Moore, P.B. (1967) Contributions to Swedish mineralogy. I. Studies on the basic arsenates of manganese: retzian, hemafibrite, synadelphite, arsenoclasite, arseniopleite, and akrochordite. Arkiv. Mineral. Geol., 4(5), 425–444. (3) Dunn, P.J. (1981) Akrochordite, a second occurrence: Sterling Hill, New Jersey. Mineral. Mag., 44, 235–236. (4) Moore, P.B., P.K. Sen Gupta, and E.O. Schlemper (1989) Akrochordite, $(Mn,Mg)_5(OH)_4(H_2O)_4(AsO_4)_2$: a sheet structure with amphibole walls. Amer. Mineral., 74, 256–262.

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Aksaite $MgB_6O_7(OH)_6 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are elongated along [001] and flattened {100}, with {100}, {010}, {021} and rarely {001}, to 1.5 cm; prism faces are striated parallel to [100].

Physical Properties: *Cleavage:* Probable on {100} and {010}. Hardness = ∼2.5
D(meas.) = 2.066 D(calc.) = 1.972

Optical Properties: Semitransparent. *Color:* Colorless, white to pale gray.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.473(1)$ $\beta = 1.508(1)$ $\gamma = 1.528(1)$ 2V(meas.) = 88°

Cell Data: *Space Group: Pbca* (synthetic). $a = 12.540(6)$ $b = 24.327(11)$ $c = 7.480(3)$
Z = 8

X-ray Powder Pattern: Ak-saĭ, Kazakhstan.
6.36 (10), 4.68 (9), 3.54 (9), 3.19 (9), 6.00 (8), 2.78 (8), 3.09 (7)

Chemistry:

	(1)	(2)	(3)
B_2O_3	61.4	61.13	61.57
R_2O_3		0.56	
MgO	13.8	13.44	11.88
H_2O	23.73	23.73	26.55
insol.		0.56	
Total	98.93	99.42	100.00

(1–2) Ak-saĭ, Kazakhstan; probably admixed with preobrazhenskite. (3) $MgB_6O_7(OH)_6 \cdot 2H_2O$.

Occurrence: In fine-grained halite in a salt dome.

Association: Kieserite, anhydrite, preobrazhenskite, boracite, ginorite, halurgite, strontioborite, metaborite, halite.

Distribution: From the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, Kazakhstan.

Name: From the locality, Ak-saĭ ("White Glen"), Kazakhstan.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160056.

References: (1) Blazko, L.P., V.V. Kondrat'eva, and Y.Y. Yarzhemskii (1962) Aksaite – a new hydrous magnesium borate. Zap. Vses. Mineral. Obshch., 91, 447–454 (in Russian). (2) (1963) Amer. Mineral., 48, 209–210 (abs. ref. 1). (3) (1963) Mineral. Abs., 16, 65–66 (abs. ref. 1). (4) Clark, J.R. and R.C. Erd (1963) The probable chemical formula of aksaite. Amer. Mineral., 48, 930–935. (5) Dal Negro, A. and L. Ungaretti (1971) The crystal structure of aksaite. Amer. Mineral., 56, 1553–1566. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 22.

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Aktashite $Cu_6Hg_3As_4S_{12}$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* 3. Rarely in crystals resembling trigonal pyramids, to 0.2 mm, which may be zoned with gruzdevite; as xenomorphic grains and granular aggregates.

Physical Properties: *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle.
Hardness = ∼3.5 VHN = 300–346, 313 average (50 g load). D(meas.) = 5.5 D(calc.) = 5.72
Opaque. *Color:* Gray-black; white in reflected light. *Streak:* Black. *Luster:* Metallic.
Anisotropism: Weak, in shades of blue.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R3$. $a = 13.730(3)$ $c = 9.329(1)$ $Z = 3$

X-ray Powder Pattern: Gal-Khaya deposit, Russia.
3.10 (10), 1.903 (10), 1.621 (10), 2.69 (7), 1.236 (4), 1.345 (3), 4.04 (2)

Chemistry:

	(1)	(2)	(3)
Cu	23.38	23.2	22.86
Zn		0.15	
Hg	32.54	35.4	36.09
As	18.20	18.9	17.97
Sb	2.55	0.41	
S	23.80	23.6	23.08
Total	100.47	101.66	100.00

(1) Aktash deposit, Russia; by electron microprobe, average of two analyses. (2) Gal-Khaya deposit, Russia; by electron microprobe. (3) $Cu_6Hg_3As_4S_{12}$.

Polymorphism & Series: Forms a series with gruzdevite.

Occurrence: Uncommon, of hydrothermal origin in complex polymetallic As–Hg-bearing deposits.

Association: Stibnite, chalcostibite, mercurian tetrahedrite, tennantite, luzonite, enargite, cinnabar, chalcopyrite, pyrite, sphalerite, realgar, orpiment, dickite, quartz, calcite.

Distribution: In Russia, from the Aktash mercury deposit, Kosh-Agach district, Kurai Range, Altai Mountains [TL]; in the Gal-Khaya deposit, Sakha; at the Lukhumi arsenic deposit, central Caucasus Mountains; from the Vorontsovskoye gold deposit, Serov district, Northern Ural Mountains. At the Chauvai Sb–Hg deposit, Fergana Valley, Alai Range, southern Kyrgyzstan. In the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. At the Getchell mine, Potosi district, Humbolt Co., Nevada, USA. In the Hemlo gold deposit, Thunder Bay district, Ontario, Canada. From the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France.

Name: For its occurrence at the Aktash deposit, Russia.

Type Material: Central Siberian Geological Museum, Novosibirsk, Russia, III-14/1; National School of Mines, Paris, France.

References: (1) Vasil'ev, V.I. (1968) New ore minerals of the mercury deposits of Gornyi Altai and their parageneses. In: Problems of the metallogeny of mercury. Izdat. "Nauka" Moscow, 111–129 (in Russian). (2) (1971) Amer. Mineral., 56, 358 (abs. ref. 1). (3) Gruzdev, V.S., N.M. Chernitsova, and N.G. Shumakove (1972) Aktashite, $Cu_6Hg_3As_5S_{12}$, new data. Doklady Acad. Nauk SSSR, 206, 694–697 (in Russian). (4) (1973) Amer. Mineral., 58, 562 (abs. ref. 3). (5) Kaplunnik, L.N., E.A. Pobedimskaya, and N.V. Belov (1980) Crystal structure of aktashite ($Cu_6Hg_3As_4S_{12}$). Doklady Acad. Nauk SSSR, 251, 96–98 (in Russian).

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Alabandite $Mn^{2+}S$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals cubic or octahedral, to 1 cm. Commonly massive, granular. *Twinning:* Lamellar ‖ {111}.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4 VHN = 164–174, 167 average (100 g load). D(meas.) = 3.95–4.04 D(calc.) = 4.053

Optical Properties: Opaque, but translucent in very thin fragments. *Color:* Iron-black, tarnishing brown; in polished section, gray-white; deep green to brown and red in thin slivers. *Luster:* Submetallic.
Optical Class: Isotropic. $n = 2.70$ (Li).
R: (400) 26.1, (420) 25.9, (440) 25.5, (460) 24.8, (480) 24.2, (500) 23.7, (520) 23.2, (540) 22.9, (560) 22.7, (580) 22.5, (600) 22.3, (620) 22.1, (640) 22.0, (660) 21.9, (680) 21.8, (700) 21.8

Cell Data: *Space Group:* $Fm3m$. $a = 5.2236$ Z = 4

X-ray Powder Pattern: Synthetic.
2.612 (100), 1.847 (50), 1.509 (20), 1.1682 (16), 1.0662 (16), 3.015 (14), 1.306 (8)

Chemistry:

	(1)	(2)	(3)
Mn	63.03	57.09	63.15
Fe		6.86	
Co		0.03	
S	36.91	36.83	36.85
Total	99.94	100.81	100.00

(1) Arizona, USA. (2) Sotkamo, Finland. (3) MnS.

Polymorphism & Series: Dimorphous with rambergite.

Occurrence: May be in large quantities in epithermal polymetallic sulfide vein and especially in low-temperature manganese deposits. An uncommon constituent of a number of meteorites.

Association: Galena, chalcopyrite, sphalerite, pyrite, acanthite, tellurium, rhodochrosite, calcite, rhodonite, quartz.

Distribution: Selected localities include: from Alabanda, 30 km south-southeast of Aydın, Aydın Province, Turkey [TL]. At Baia-de-Arieş (Offenbánya), Săcărîmb (Nagyág), and Cavnic (Kapnikbánya), Romania. From Adervielle, Hautes-Pyrénées, France. At Gersdorf, Saxony, Germany. From manganese mines in Val Graveglia, Liguria, Italy. At Nsuta, Ghana. In the Yakumo and Inakuraishi mines, Hokkaido; the Taisei mine, Akita Prefecture; and many other localities in Japan. From Broken Hill, New South Wales, Australia. In Peru, at Morococha, Junin. In the Preciosa mine, Tlalchichuca, Puebla, and at Onovas, Sonora, Mexico. In the USA, in the Lucky Cuss mine, Tombstone, Cochise Co., Arizona; the Queen of the West mine, Summit Co., Colorado; at Schellbourne, White Pine Co., Nevada; and from Butte, Silver Bow Co., Montana.

Name: For the originally reported locality at Alabanda in Turkey.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 207–208. (2) Törnroos, R. (1982) Properties of alabandite; alabandite from Finland. Neues Jahrb. Mineral., Abh., 144, 107–123. (3) (1955) NBS Circ. 539, 4, 11. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 4.

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Alacránite AsS

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Crystal Data: Monoclinic *Point Group:* $2/m$. Crystals are pinacoidal, prismatic, and flattened on [100], striated ‖ [001] on {100}, other faces dull or tarnished, to 1 mm; as subhedral flattened and prismatic grains.

Physical Properties: *Cleavage:* Imperfect on {100}. *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 1.5 VHN = 69 (20 g load). D(meas.) = 3.43(3) D(calc.) = 3.503

Optical Properties: Transparent to translucent. *Color:* Orange to pale gray with rose-yellow internal reflections; yellow-orange in transmitted light. *Streak:* Yellow-orange. *Luster:* Adamantine, vitreous, resinous, greasy.
Optical Class: Biaxial (+). $\alpha = 2.39(1)$ $\gamma = 2.52(2)$
R_1–R_2: (400) 13.0–14.0, (425) 13.2–14.6, (450) 13.3–14.8, (475) 13.4–14.8, (500) 13.3–14.5, (525) 13.1–14.3, (550) 13.2–14.5, (575) 13.4–14.7, (600) 13.5–14.8, (625) 13.6–14.9, (650) 13.7–15.0, (675) 13.8–15.0, (700) 13.9–15.1

Cell Data: *Space Group:* $C2/c$. $a = 9.943(1)$ $b = 9.366(1)$ $c = 8.908(1)$ $\beta = 102.007°$ $Z = 16$

X-ray Powder Pattern: Uzon caldera, Russia.
3.064 (100), 5.91 (90), 2.950 (90), 5.11 (80), 4.05 (70), 3.291 (50)

X-ray Powder Pattern: Synthetic.
3.01 (100), 2.89 (100), 5.78 (80), 3.20 (80), 3.93 (70), 3.08 (70), 2.82 (60)

Chemistry:

	(1)	(2)
As	67.35	70.03
S	32.61	29.97
Total	99.96	100.00

(1) Uzon caldera, Russia; by electron microprobe, average of four analyses; corresponding to $As_{0.88}S_{1.00}$. (2) AsS.

Polymorphism & Series: Trimorphous with pararealgar and realgar.

Occurrence: In hydrothermal As–S veins (Alacrán mine, Chile); in the condensation zone of a hydrothermal Hg–Sb–As system as cement in a sandy gravel (Uzon caldera, Russia); formed at low temperatures in a polymetallic hydrothermal deposit on a submarine seamount (Conical Seamount, Papua New Guinea).

Association: Realgar, orpiment, arsenic, sulfur, stibnite, pyrite, greigite, arsenopyrite, arsenolamprite, sphalerite, acanthite, barite, quartz, calcite (Alacrán mine, Chile); realgar, orpiment, uzonite, stibnite, cinnabar, pyrite, sulfur (Uzon caldera, Russia); realgar, pyrite, sphalerite, galena, chalcopyrite, amorphous silica (Conical Seamount, Papua New Guinea).

Distribution: From the Alacrán Ag–As–Sb mine, Pampa Larga district, Copiapó, Chile [TL]. In the Uzon caldera, Kamchatka, Russia. At Tiefengraben, Reinerzau, Black Forest, Germany. On Conical Seamount, ten km south-southeast of Lihir Island, Papua New Guinea.

Name: For the occurrence in the Alacrán deposit, Chile.

Type Material: Il'menskii Preserve Museum, Miass; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Popova, V.I., V.A. Popov, A. Clark, V.O. Polyakov, and S.E. Borisovskii (1986) Alacranite – a new mineral. Zap. Vses. Mineral. Obshch., 115, 360–368 (in Russian). (2) (1988) Amer. Mineral., 73, 189 (abs. ref. 1). (3) Migdisov, A.A. and A.Y. Bychkov (1998) The behavior of metals and sulphur during the formation of hydrothermal mercury–antimony–arsenic mineralization, Uzon caldera, Kamchatka, Russia. J. Volcan. and Geothermal Res., 84, 153–171. (4) Burns, P.C. and J.B. Percival (2001) Alacranite, As_4S_4: a new occurrence, new formula, and determination of the crystal structure. Can. Mineral., 39, 809–818. (5) Roland, G. (1972) ??title. [Xray??copy??ck] Can. Mineral., 11, 520–??. (6) Bonazzi, P., L. Bindi, F. Olmi, and S. Menchetti (2003) How many alacranites exist? A structural study of non-stoichiometric As_8S_{9-x} crystals. Eur. J. Mineral., 15, 283–288. [must see - MFG accepts??]

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Alamosite $PbSiO_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals fibrous ‖ [010]; as radiating aggregates and balls, to 7.5 cm.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 4.5 D(meas.) = 6.488(3) D(calc.) = [6.30]

Optical Properties: Transparent to translucent. *Color:* Colorless to white, cream, or light gray. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Orientation:* $Y = b$. *Dispersion:* $r < v$, strong, weak inclined. $\alpha = 1.945$–1.947 $\beta = 1.955$–1.961 $\gamma = 1.959$–1.968 2V(meas.) = 65°

Cell Data: *Space Group:* $P2/n$. $a = 12.247$ $b = 7.059$ $c = 11.236$ $\beta = 113.12°$ Z = 12

X-ray Powder Pattern: Tsumeb, Namibia.
3.34 (100), 3.56 (95), 3.53 (75), 2.300 (75), 3.23 (70), 2.987 (70), 3.25 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	21.11	20.01	21.21
Al_2O_3		0.09	
FeO	0.09	0.18	
MnO		0.02	
PbO	78.13	78.95	78.79
CaO	trace	0.09	
insol.	0.61		
Total	99.94	99.34	100.00

(1) Alamos, Mexico. (2) Tsumeb, Namibia; by electron microprobe. (3) $PbSiO_3$.

Occurrence: As a rare secondary mineral in the oxidized zone of lead-bearing base metal deposits.

Association: Wulfenite, leadhillite, cerussite (Alamos, Mexico); leadhillite, anglesite, melanotekite, fleischerite, kegelite, hematite (Tsumeb, Namibia); diaboleite, phosgenite, cerussite, wulfenite, willemite (Tiger, Arizona, USA); melanotekite, shattuckite, wickenburgite (Rawhide mine, Arizona, USA).

Distribution: From Mexico, in Sonora, at Alamos, and the San Pascual mine, near Zimapán, Hidalgo. In the USA, from Arizona, in the Mammoth-St. Anthony mine, at Tiger, Pinal Co., the Lucky Cuss mine, Tombstone, Cochise Co., and the Rawhide mine, Artillery Mountains, Maricopa Co. As exceptional crystal groups from Tsumeb, Namibia.

Name: For the Mexican type locality at Alamos.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 84859, 85509.

References: (1) Palache, C. and H.E. Merwin (1909) Alamosite, a new lead silicate from Mexico. Amer. J. Sci., 27, 399–401. (2) Mackay, A.L. (1952) The unit cell and space-group of alamosite ($PbSiO_3$). Mineral. Mag., 29, 933–945. (3) Boucher, M.L. and D.R. Peacor (1968) The crystal structure of alamosite, $PbSiO_3$. Zeits. Krist., 126, 98–111. (4) Medenbach, O. and K. Schmetzer (1975) Alamosit ($PbSiO_3$) von Tsumeb — ein neuer Fundpunkt. Neues Jahrb. Mineral., Abh., 123, 138-147 (in German).

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Alarsite $AlAsO_4$

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Crystal Data: Hexagonal. *Point Group:* 32. Subhedral grains, to 0.3 mm, in aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 336–480, average 440 (20 g load). D(meas.) = 3.32(1) D(calc.) = 3.34

Optical Properties: Semitransparent. *Color:* Colorless, with pale tints of yellow, green, blue due to inclusions; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.596(1)$ $\epsilon = 1.608(1)$

Cell Data: *Space Group:* [$P3_121$ or $P3_221$] (by analogy to synthetic $AlAsO_4$). $a = 5.031(1)$ $c = 11.226(6)$ Z = 3

X-ray Powder Pattern: Tolbachik volcano, Russia.
3.442 (100), 4.06 (31), 4.36 (20), 1.873 (16), 2.359 (15), 1.4202 (11), 2.514 (8)

Chemistry:

	(1)	(2)
As_2O_5	66.71	69.27
Al_2O_3	31.98	30.73
Fe_2O_3	0.60	
CuO	0.54	
Total	99.83	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of 20 analyses, total Fe as Fe_2O_3; corresponds to $(Al_{1.04}Fe_{0.01}Cu_{0.01})_{\Sigma=1.06}As_{0.96}O_4$. (2) $AlAsO_4$.

Occurrence: A fumarolic mineral.

Association: Fedotovite, klyuchevskite, lammerite, nabokoite, atlasovite, langbeinite, hematite, tenorite.

Distribution: Occurs at the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: For ALuminum and ARSenic in the composition.

Type Material: Mining Institute, St. Petersburg, Russia.

References: (1) Semenova, T.F., L.P. Vergasova, S.K. Filatov, and V.V. Ananev (1994) Alarsite $AlAsO_4$: a new mineral from volcanic exhalations. Doklady Acad. Nauk SSSR, 338, 501–505 (in Russian). (2) (1995) Amer. Mineral., 80, 1328 (abs. ref. 1).

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Albite $\mathbf{Na_{1.0-0.9}Ca_{0.0-0.1}Al_{1.0-1.1}Si_{3.0-2.9}O_8}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals commonly tabular ∥ {010}, may be curved, to 3 cm; divergent aggregates, granular, cleavable massive. *Twinning:* Common around [010] or ⊥ {010}, giving polysynthetic striae on {001} or {010}; many other laws, contact, simple and multiple.

Physical Properties: *Cleavage:* Perfect on {001}, very good on {010}, imperfect on {110}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.60–2.65 D(calc.) = 2.609–2.621

Optical Properties: Transparent to translucent. *Color:* White to gray, bluish, greenish, reddish; may be chatoyant. *Streak:* White. *Luster:* Vitreous, typically pearly on cleavages. *Optical Class:* Biaxial (+) (low); (–) (high). *Dispersion:* $r < v$, weak (low). $\alpha = 1.526–1.530$ $\beta = 1.531–1.533$ $\gamma = 1.534–1.541$ 2V(meas.) = 85°–90° (low); 52°–54° (high).

Cell Data: *Space Group:* $C\overline{1}$ (low). $a = 8.137(1)$ $b = 12.785(1)$ $c = 7.1583(4)$ $\alpha = 94.26(1)°$ $\beta = 116.60(1)°$ $\gamma = 87.71(1)°$ Z = 4, or *Space Group:* $C\overline{1}$ (high). $a = 8.149$ $b = 12.880$ $c = 7.106$ $\alpha = 93.37°$ $\beta = 116.30°$ $\gamma = 90.28°$ Z = 4

X-ray Powder Pattern: Amelia, Virginia, USA (low).
3.196 (100), 3.780 (25), 6.39 (20), 3.684 (20), 4.030 (16), 3.663 (16), 2.933 (16)

Chemistry:

	(1)	(2)	(3)
SiO_2	68.71	68.74	66.04
Al_2O_3	19.63	19.44	21.26
CaO	0.22		2.13
Na_2O	11.72	11.82	10.57
K_2O	0.03		
Total	100.31	100.00	100.00

(1) Alp Rischuna, Switzerland. (2) $NaAlSi_3O_8$. (3) $Na_{0.90}Ca_{0.10}Al_{1.10}Si_{2.90}O_8$.

Polymorphism & Series: Low- and high-temperature structural modifications are recognized.

Mineral Group: Feldspar group, plagioclase series.

Occurrence: A major constituent of granites and granite pegmatites, alkalic diorites, basalts, and in hydrothermal and alpine veins. A product of potassium metasomatism and in low-temperature and low-pressure metamorphic facies and in some schists. Detrital and authigenic in sedimentary rocks.

Association: Quartz, orthoclase, muscovite, biotite, "hornblende."

Distribution: Widespread; a few localities for good crystals are: in Switzerland, from St. Gotthard, Ticino and Tavetsch, Graubünden. From Roc Tourné, near Modane, Savoie, France. On Mt. Greiner, Zillertal, Tirol, Austria. At Baveno, Piedmont, and in the Pfitschtal, Trentino-Alto Adige, Italy. From Mursinka, Ural Mountains, and Miass, Ilmen Mountains, Southern Ural Mountains, Russia. In the USA, at Haddam and Middletown, Middlesex Co., Connecticut; Amelia, Amelia Co., Virginia; from Diana, Lewis Co., and Dekalb, Macomb, and Pierrepont, St. Lawrence Co., New York. On Prince of Wales Island, Alaska; in the Pala and Mesa Grande districts, San Diego Co., California. At Bathurst, and Wicklow Township, Hastings Co., Ontario, Canada. From Virgem da Lapa and Morro Velho, Minas Gerais, Brazil.

Name: From the Latin, *albus*, for *white*, its characteristic color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 325–333. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 94–165. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 352–360. (4) Armbruster, T., H.B. Bürgi, M. Kunz, E. Gnos, S. Brönnimann, and C. Lienert (1990) Variation of displacement parameters in structure refinements of low albite. Amer. Mineral., 75, 135–140.

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Albrechtschraufite $Ca_4Mg(UO_2)_2(CO_3)_6F_2 \cdot 17H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystalline.

Physical Properties: Hardness = 2–3 D(meas.) = 2.6 D(calc.) = 2.67 Radioactive.

Optical Properties: Semitransparent. *Color:* Yellow-green.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 13.562(3)$ $b = 13.406(3)$ $c = 11.636(3)$
$\alpha = 115.75(2)^\circ$ $\beta = 107.66(2)^\circ$ $\gamma = 92.86(2)^\circ$ Z = 2

X-ray Powder Pattern: n.d.

Chemistry: (1) Jáchymov, Czech Republic; composition merely stated to be $MgCa_4F_2[(UO_2)(CO_3)_3]_2.17H_2O$.

Occurrence: On a museum specimen of schröckingerite.

Association: Schröckingerite, uraninite, dolomite.

Distribution: From Jáchymov (Joachimsthal), Czech Republic.

Name: To honor Professor Albrecht Schrauf (1837–1897), Austrian crystallographer, University of Vienna, Vienna, Austria.

Type Material: Natural History Museum, Vienna, Austria, A.a.6740.

References: (1) Mereiter, K. (1984) The crystal structure of albrechtschraufite, $MgCa_4F_2[(UO_2)(CO_3)_3]_2.17H_2O$. Acta Cryst., C40, 247. (2) Ondruš, P., F. Veselovský, J. Loušek, R. Skála, I. Vavřín, J. Frýda, J. Čejka, and A. Gabašová (1997) Secondary minerals of the Jáchymov (Joachimsthal) ore district. J. Czech Geol. Soc., 42(4), 3–76, esp. p. 11.

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Aldermanite $Mg_5Al_{12}(PO_4)_8(OH)_{22}\cdot 32H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As talclike flakes, to 0.1 mm.

Physical Properties: Hardness = ∼2 D(meas.) = n.d. D(calc.) = 2.0–2.15

Optical Properties: Translucent. *Color:* Colorless in transmitted light. *Luster:* Pearly. *Optical Class:* Biaxial; very low birefringence. $n = 1.500(5)$

Cell Data: *Space Group:* n.d. $a = 15.000(7)$ $b = 8.330(6)$ $c = 26.60(1)$ $Z = 2$

X-ray Powder Pattern: Moculta quarry, Australia.
13.40 (100), 7.98 (80), 5.55 (60), 2.841 (50), 5.70 (30), 4.96 (30), 2.660 (30)

Chemistry:

	(1)	(2)
P_2O_5	25.9	26.34
Al_2O_3	28.4	28.38
MgO	8.4	9.35
CaO	1.2	
H_2O	36.1	35.93
Total	100.0	100.00

(1) Moculta quarry, Australia; by electron microprobe, average of several analyses, H_2O by loss on ignition; corresponds to $(Mg_{4.53}Ca_{0.47})_{\Sigma=5.00}Al_{12.12}(PO_4)_{7.94}(OH)_{22.5}\cdot 31H_2O$. (2) $Mg_5Al_{12}(PO_4)_8(OH)_{22}\cdot 32H_2O$.

Occurrence: As a secondary mineral in cavities in a brecciated metamorphosed sedimentary phosphate deposit, formed by the alteration of fluellite (Moculta quarry, Australia).

Association: Fluellite.

Distribution: At the Moculta phosphate quarry, northeast of Angaston, South Australia.

Name: Honors Arthur Richard Alderman (1901–1980), Professor of Geology and Mineralogy, University of Adelaide, Adelaide, Australia.

Type Material: C.S.I.R.O. Division of Mineral Chemistry, Melbourne, M636; Museum Victoria, Melbourne, Australia, M34778.

References: (1) Harrowfield, I.R., E.R. Segnit, and J.A. Watts (1981) Aldermanite, a new magnesium aluminium phosphate. Mineral. Mag., 44, 59–62. (2) (1981) Amer. Mineral., 66, 1099 (abs. ref. 1).

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Aleksandrovite $KLi_3Ca_7Sn_2[Si_6O_{18}]_2F_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As lamellae, to 70 μm, and as zoned crystals to 0.8 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 4-4.5 VHN = 300 (50 g load). D(meas.) = 3.05(2) D(calc.) = 3.07(2) Fluoresces light-blue under SW UV.

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous, pearly on cleavage surfaces.
Optical Class: Biaxial (-). α = 1.629(2) β = 1.635(4) γ = 1.638(2) 2V(meas.) = n.d. 2V(calc.) = –70.3° *Dispersion*: Strong, $r > v$. *Elongation*: Positive.

Cell Data: *Space Group*: *C*2/*c*. a = 17.01(2) b = 9.751(6)) c = 21.00(2) β = 112.45(8)° Z = 4

X-ray Powder Pattern: Darai-Pioz glacier, Tajikistan.
3.234 (100), 2.894 (42), 2.425 (42), 3.206 (34), 3.712 (33), 3.039 (28), 1.950 (25)

Chemistry:

	(1)		(1)
SiO_2	48.01	CaO	25.52
Al_2O_3	0.07	SrO	0.39
TiO_2	2.86	Na_2O	0.20
SnO_2	12.84	K_2O	2.91
ZrO_2	1.27	Li_2O	3.01
Nb_2O_5	0.11	F	1.71
Fe_2O_3	0.27	H_2O	[0.39]
Ce_2O_3	0.04	$–O = F_2$	0.72
MgO	0.05	Total	99.10

(1) Darai-Pioz glacier, Tajikistan; average of 17 electron microprobe analyses, H_2O calculated from stoichiometry, Li calculated from Li/K and Li/Ca ratios; corresponding to $(K_{0.93}Na_{0.10})_{\Sigma=1.03}Li_{3.02}(Ca_{6.82}Sr_{0.06}Mn_{0.04}Mg_{0.02})_{\Sigma=6.94}(Sn_{1.28}Ti_{0.54}Zr_{0.15}Fe_{0.05}Nb_{0.01})_{\Sigma=2.03}(Si_{11.98}Al_{0.02})_{\Sigma=12}O_{36.00}[F_{1.35}(OH)_{0.65}]_{\Sigma=2.00}$.

Occurrence: In a zoned microcline-calcite vein with aegirine-hedenbergite, quartz, and albite in a glacial moraine boulder. The region contains carbonatites and an alkaline massif.

Association: Miserite, baratovite, katayamalite, Zr and hydroxyl analogues of alexandrovite, fluorite, Sn-titanite, bazirite, pabstite, Sn-sogdianite, sugilite, turkestanite, fluorapatite.

Distribution: From the Darai-Pioz glacier, at the junction of the Turkestan, Zeravshan, and Alay Mountain Ranges, Tajikistan.

Name: Honors the Russian geochemist, geologist, and mineralogist Stanislav Mikhailovich Aleksandrov (b. 1932) for his contributions to the geology, geochemistry, and mineralogy of tin.

Type Material: A.E. Fersman Mineral Museum, Academy of Sciences, Moscow, Russia (3825/1).

References: (1) Pautov, L.A., A.A. Agakhanov, V.Yu. Karpenko, and F.G. Gafurov (2010) Aleksandrovite $KLi_3Ca_7Sn_2[Si_6O_{18}]_2F_2$ - a new tin mineral. Novye dannye o mineralakh, 45, 5-16 (in Russian). New data on minerals, 45, 5-16 (in English). (2) (2012) Amer. Mineral., 97, 1523 (abs. ref. 1).

Aleksite $PbBi_2Te_2S_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Platy grains, to 1 mm.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. VHN = 40–65, 51 average (20 g load). D(meas.) = n.d. D(calc.) = 7.57

Optical Properties: Opaque. *Color:* In polished section, very pale gray with slight greenish tint. *Anisotropism:* Weak.
R: (400) — , (420) — , (440) — , (460) 51.4, (480) 51.8, (500) 52.7, (520) 52.8, (540) 53.2, (560) 53.1, (580) 53.4, (600) 53.9, (620) 53.9, (640) 54.2, (660) 54.5, (680) 54.4, (700) 54.9

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 4.2423(25)$ $c = 79.73(5)$ $Z = 6$

X-ray Powder Pattern: Alekseev mine, Russia.
3.09 (100), 2.12 (60), 2.25 (40), 1.348 (40), 1.307 (40), 3.63 (30), 1.974 (30)

Chemistry:

	(1)	(2)	(3)
Pb	20.3	20.5	21.94
Bi	46.0	45.5	44.25
Te	27.3	27.3	27.02
S	6.3	6.3	6.79
Total	99.9	99.6	100.00

(1) Alekseev mine, Russia; by electron microprobe, leading to $Pb_{0.94}Bi_{2.11}Te_{2.06}S_{1.89}$. (2) Do.; leading to $Pb_{0.95}Bi_{2.10}Te_{2.06}S_{1.89}$. (3) $PbBi_2Te_2S_2$.

Occurrence: Of hydrothermal origin in sulfide-quartz veins (Alekseev mine, Russia).

Association: Galena, gold, altaite, tetradymite, tsumoite, rucklidgeite, quartz (Alekseev mine, Russia).

Distribution: From the Alekseev gold mine, Sutam district, Stanovoi Range, southeast Sakha, Russia [TL]. In the San-notake district, Fukuoka Prefecture, Japan. At the St. David's mine, Dolgellau district, Wales. In the Ardino deposit, Bulgaria. From near Tybo, Nye Co., Nevada, USA. In the Barringer mine, Timmins, Ontario, Canada. From the Corrego Criminoso gold mining district, Goias, Brazil.

Name: For the Alekseev mine, Russia.

Type Material: Gosudarst University, Moscow; Moscow University, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79060.

References: (1) Lipovetskii, A.G., Y.S. Borodaev, and E.N. Zav'yalov (1978) Aleksite, $PbBi_2Te_2S_2$, a new mineral. Zap. Vses. Mineral. Obshch., 107, 315–321 (in Russian). (2) (1979) Amer. Mineral., 64, 652 (abs. ref. 1). (3) Bevins, R.E. and C.J. Stanley (1990) Aleksite, a lead bismuth sulfotelluride; a second world occurrence from the Dolgellau gold belt, Wales. J. Russell Soc., 3(2), 67–69. [get article or look in Bevins Min Wales??-need mine name??more data,another analysis - can combine Russ anal 1–2 note??] (4) Bayliss, P. (1991) ??title??. Amer. Mineral., 76, 257–??.[must??SG,cell]

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Alflarsenite $NaCa_2Be_3Si_4O_{13}(OH)\cdot 2H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As minute bladed crystals, flattened on (010) and elongate on [100], exhibiting forms {010}, {0 $\bar{1}$ 0}, {001}; {2 0 $\bar{1}$ }; as spherules.
Twinning: On {001}.

Physical Properties: *Cleavage*: None observed. *Fracture*: Uneven.
Tenacity: Very brittle. Hardness = ~ 4 D(meas.) = n.d. D(calc.) = 2.605

Optical Properties: Translucent to transparent. *Color*: Colorless to white; very pale beige in aggregates. *Streak*: White. *Luster*: Vitreous.
Orientation: Z = *b*.
Optical Class: Biaxial (+). $\alpha = 1.578(1)$ $\beta = 1.580(1)$ $\gamma = 1.583(1)$ 2V(meas.) = 82(5)° 2V(calc.) = 79° *Orientation:* Z = b; X $\wedge$ a = 45(2)°.

Cell Data: *Space Group*: $P2_1$. $a = 7.1222(4)$ $b = 19.8378(11)$ $c = 9.8071(5)$ $\beta = 111.287(1)°$ $Z = 4$

X-ray Powder Pattern: Tvedalen, Larvik, Vestfold, south Norway.
9.095 (100), 2.915 (92), 3.972 (76), 2.964 (70), 6.279 (42), 3.205 (37), 2.757 (33)

Chemistry:

	(1)	(2)
SiO_2	47.04	47.73
BeO	14.74	14.90
Al_2O_3	0.04	
BaO	0.03	
CaO	22.14	22.07
SrO	0.66	
Na_2O	6.06	6.15
K_2O	0.10	
H_2O	8.86	8.95
Total	99.67	100.00

(1) Tvedalen, Larvik, Vestfold, south Norway; average of 17 electron microprobe and ICP analyses, H_2O from stoichiometry, OH confirmed by IR, corresponding to $(Na_{0.99}Sr_{0.03}K_{0.01})_{\Sigma=1.03}Ca_{2.01}Be_{2.99}Si_{3.98}O_{13}(OH)\cdot 2H_2O$. (2) $NaCa_2Be_3Si_4O_{13}(OH)\cdot 2H_2O$.

Mineral Group: Zeolite group.

Occurrence: A late-stage hydrothermal mineral in a syenitic pegmatite in larvikite.

Association: Calcite, analcime, K-feldspar.

Distribution: Tuften larvikite quarry, Tvedalen, Larvik, Vestfold, south Norway.

Name: Honors Alf Olav Larsen (b. 1952), Norwegian self-taught mineralogist who has contributed to the description of six new mineral species.

Type Material: Department of Geology, Natural History Museum, University of Oslo, Norway (catalog number 42108); Canadian Museum of Nature, Ottawa (catalog number CMNMC 86066).

References: (1) Raade, G., J.D. Grice, and M.A. Cooper (2009) Alflarsenite, a new beryllium-silicate zeolite from a syenitic pegmatite in the Larvik plutonic complex, Oslo Region, Norway. Eur. J. Mineral., 21, 893–900. (2) Grice, J.D., G. Raade, and M.A. Cooper (2010) Alflarsenite; structure and relationship to other Be-Si and zeolite framework structures. Can. Mineral., 48, 255-266.
(3) (2010) Amer. Mineral., 95, 1121 (abs. ref. 1).

Alforsite $Ba_5(PO_4)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals are subhedral, to 0.2 mm, in very fine-grained masses.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.73–4.80 Intense violet cathodoluminescence.

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Uniaxial (–). $\omega = 1.70(1)$ $\epsilon = 1.70(1)$

Cell Data: *Space Group:* $P6_3/m$ (synthetic). $a = 10.284(2)$ $c = 7.651(3)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.06 (100), 2.13 (40), 2.03 (30), 1.928 (30), 1.566 (30), 1.336 (30), 1.077 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	0.1	< 0.05	
P_2O_5	22.7	21.0	21.14
MnO	< 0.1	< 0.1	
PbO	0.8	< 0.1	
CaO	4.6	0.7	
SrO	2.7	2.0	
BaO	67.7	[71.7	76.13
F	0.7	< 0.1	
Cl	3.6	3.5	3.52
$-O = (F, Cl)_2$	[1.2]	0.8	0.79
Total	[101.7]	[98.1]	100.00

(1) Big Creek, California, USA; by electron microprobe, corresponding to $(Ba_{4.05}Ca_{0.75}Sr_{0.24}Pb_{0.03})_{\Sigma=5.07}[(PO_4)_{2.94}(SiO_4)_{0.01}]_{\Sigma=2.95}(Cl_{0.93}F_{0.14})_{\Sigma=1.07}$. (2) Incline, California, USA; by electron microprobe, Ba by difference, originally given as > 1.3%; corresponding to $(Ba_{4.68}Sr_{0.19}Ca_{0.13})_{\Sigma=5.00}[(PO_4)_{2.98}(SiO_4)_{0.01}]_{\Sigma=2.99}(Cl_{0.99}F_{0.05})_{\Sigma=1.04}$. (3) $Ba_5(PO_4)_3Cl$.

Mineral Group: Apatite group.

Occurrence: In lenses and bands of barium silicate metasediments developed under hornblende-pyroxene hornfels facies near the contact with granite or granodiorite.

Association: Celsian, witherite, sanbornite, gillespite, fresnoite, fluorapatite, walstromite, titantaramellite, quartz, tourmaline, pyrite.

Distribution: From Big Creek and Rush Creek, Fresno Co., and on Trumbull Peak, near Incline, Mariposa Co., California, USA. From the La Madrelena mine, Tres Pozos, Baja California, Mexico.

Name: To honor Dr. John T. Alfors (1930–), geologist, California Division of Mines, for his work on the type locality.

Type Material: National Museum of Natural History, Washington, D.C., USA, 147511.

References: (1) Newberry, N.G., E.J. Essene, and D.R. Peacor (1981) Alforsite, a new member of the apatite group: the barium analogue of chlorapatite. Amer. Mineral., 66, 1050–1053.
(2) Hata, M., F. Marumo, S. Iwai, and H. Aoki (1979) Structure of barium chlorapatite. Acta Cryst., 35, 2382–2384.

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Alfredstelznerite $Ca_4(H_2O)_4[B_4O_4(OH)_6]_4(H_2O)_{15}$

Crystal Data: Orthorhombic. *Point Group*: *mm*2. Crystals, acicular elongated along [001], to 5 mm; form {010} dominant, with {h k 0}, {100}, {h k l}, {$\bar{h}$ k l}; as sprays of acicular crystals.

Physical Properties: *Cleavage*: Perfect on {010}. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = 2 D(meas.) = 1.77(1) D(calc.) = 1.775

Optical Properties: Transparent, translucent on dehydration. *Color*: Colorless; white in aggregates. *Streak*: White. *Luster*: Vitreous; silky in aggregates.
Optical Class: Biaxial (+). α = 1.476(3) β = 1.478(3) γ = 1.494(3) 2V(calc) = 39°
Orientation: X = b; Y = c; Z = a.

Cell Data: *Space Group*: *Pca*2_1. a = 12.161(2) b = 40.477(8) c = 10.1843(17) Z = 4

X-ray Powder Pattern: Santa Rosa Mine, Sijes, Salta Province, Argentina.
10.501 (100), 5.226 (70), 3.837 (70), 3.118 (70 broad), 4.623 (60 broad), 2.612 (60), 2.538 (60)

Chemistry:

	(1)	(2)
B_2O_3	50.8	41.57
CaO	20.9	16.74
H_2O	51.1	41.69
Total	122.8	100.00

(1) Santa Rosa Mine, Sijes, Salta Province, Argentina; electron microprobe analyses, H_2O from structure analysis and IR spectrum, corresponding to $Ca_{4.07}(H_2O)_4[B_{3.99}O_4(OH)_6]_4(H_2O)_{15}$.
(2) $Ca_4(H_2O)_4[B_4O_4(OH)_6]_4(H_2O)_{15}$.

Occurrence: A secondary mineral in a cavity in fractured mudstone in a playa-hosted borate deposit.

Association: Colemanite, hydroboracite, ulexite, inyoite, gypsum, anhydrite.

Distribution: Santa Rosa Mine, Sijes, Salta Province, Argentina.

Name: Honors Dr. Alfred Wilhelm Stelzner (1840–1895), first professor of geology at the University of Córdoba and founder of the Mineralogical Museum.

Type Material: Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Argentina (catalog no. MS003266).

References: (1) Galliski, M.A., M.A. Cooper, M.F. Márquez-Zavalía, and F.C. Hawthorne (2010) Alfredstelznerite: a new species of calcium borate hydrate from the Santa Rosa Mine, Salta, northwestern Argentina. Can. Mineral., 48, 123–128. (2) Cooper, M.A., F.C. Hawthorne, M.A. Galliski, and M.F. Márquez-Zavalía (2010) The crystal structure of alfredstelznerite, $Ca_4(H_2O)_4[B_4O_4(OH)_6]_4(H_2O)_{15}$, a complex hydroxy-hydrated calcium borate mineral. Can. Mineral., 48, 129–138. (3) (2010) Amer. Mineral., 95, 1194-1595 (abs. refs. 1 and 2).

Algodonite Cu_6As

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As incrustations of minute highly distorted crystals; commonly massive and granular.

Physical Properties: *Fracture:* Subconchoidal. Hardness = 4 VHN = 245–302 (100 g load). D(meas.) = 8.38 D(calc.) = 8.72

Optical Properties: Opaque. *Color:* Steel-gray to silver-white, tarnishes dull on exposure; in polished section, bright cream-white. *Luster:* Bright metallic. *Anisotropism:* Weak.
R_1–R_2: (400) 51.5–49.3, (420) 52.3–50.5, (440) 52.8–52.4, (460) 53.4–54.6, (480) 54.2–56.4, (500) 55.7–58.4, (520) 57.5–60.5, (540) 58.9–62.3, (560) 60.0–63.8, (580) 60.8–64.8, (600) 61.1–65.5, (620) 61.6–66.1, (640) 61.9–66.5, (660) 62.3–66.7, (680) 62.8–66.9, (700) 63.4–67.1

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.600$ $c = 4.228$ $Z = 2$

X-ray Powder Pattern: Mohawk mine, Michigan, USA.
1.989 (100), 2.11 (40), 2.25 (20), 1.299 (20), 1.194 (20), 1.110 (20), 0.837 (20)

Chemistry:

	(1)	(2)	(3)
Cu	83.11	83.53	83.58
Ag	trace		
As	16.44	16.55	16.42
Total	99.55	100.08	100.00

(1) Rancagua, Chile. (2) Champion mine, Michigan, USA. (3) Cu_6As.

Occurrence: Uncommon in hydrothermal deposits, intimately associated with other copper arsenides.

Association: Copper (typically arsenian), silver, domeykite, koutekite.

Distribution: In Chile, from the Algodones silver mine, near Coquimbo [TL], and the Cerro de las Seguas, Rancagua, O'Higgins Province. At Corocoro, Bolivia. In the Kokito II mine, Neuquén Province, Argentina. In the USA, in Michigan, from Keweenaw Co., at the Mohawk, Pewabic, Seneca, Ahmeek, and Champion mines, and at Painesdale, Houghton Co., also from Baraga Co.; in Colorado, from the Cashin mine, Montrose Co. At Långban, Värmland, Sweden. In France, from the Roua copper mines, about 50 km north of Nice, Alpes-Maritimes. At Tsumeb, Namibia. In the Talmessi mine, 35 km west of Anarak, Iran.

Name: For the Algodones mine, Chile.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 171. (2) Williams, S.A. (1963) Crystals of rammelsbergite and algodonite. Amer. Mineral., 48, 421–422. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 14. (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 393–398. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 8.

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Aliettite

$[Mg_3Si_4O_{10}(OH)_2]\cdot[(Ca_{0.5},Na)_{0.33}(Al,Fe,Mg)_{2-3}(Al,Si)_4O_{10}(OH)_2\cdot nH_2O]$

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Crystal Data: n.d. *Point Group:* n.d. Irregular, tabular to platy crystals, < 2 μm, with curled edges when viewed under the electron microscope; as microscopic rounded aggregates.

Physical Properties: Hardness = Soft. D(meas.) = n.d. D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* Colorless, pale yellow or green.
Optical Class: n.d. $n = 1.558$–1.567

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Taro Valley, Italy.
24.8 (100), 12.4 (67), 3.10 (12), 8.27 (6), 4.96 (2), 3.54 (2), 2.48 (0.5)

Chemistry:

	(1)
SiO_2	53.15
Al_2O_3	3.48
Fe_2O_3	3.48
MnO	0.03
MgO	27.40
CaO	1.10
Na_2O	1.18
H_2O	10.18
Total	100.00

(1) Taro Valley, Italy; by AA and XRF.

Polymorphism & Series: Talc-saponite mixed-layer mineral.

Mineral Group: Smectite group.

Occurrence: An alteration product in serpentinized ophiolites and residual in soils derived therefrom; in altered dolostones.

Association: Talc, chlorite, serpentine, calcite.

Distribution: In Italy, in Emilia-Romagna, at Monte Chiaro, Taro Valley; Frassinoro, Modena; and Ferriere, Nure Valley. From Kinshasa, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Professor Andrea Alietti (1923–), of the University of Modena, Modena, Italy, who first studied the structure of the mineral.

Type Material: n.d.

References: (1) Alietti, A. (1958) Some interstratified clay minerals of the Taro Valley. Clay Minerals Bull., 3, 207–211. (2) Veniale, F. and H.W. van der Marel (1969) Identification of some 1:1 regular interstratified trioctahedral clay minerals. Proc. Int. Clay Conf., Tokyo, 1, 233–244. (3) (1972) Amer. Mineral., 57, 598 (abs. ref. 2). (4) Alietti, A. and J. Mejsner (1980) Structure of a talc/saponite mixed-layer mineral. Clays and Clay Minerals, 28, 388–390. (5) Bailey, S.W. (1982) Nomenclature for regular interstratifications. Amer. Mineral., 67, 394–398.

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Allactite $Mn_7(AsO_4)_2(OH)_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As terminated prisms elongated on [010], or bladed and tabular on {100}, with many forms, yielding complex wedgelike terminations. In divergent or subparallel aggregates, to 6 mm; may be in druses.

Physical Properties: *Cleavage:* Distinct, {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.83 D(calc.) = 3.94

Optical Properties: Translucent. *Color:* Brown, dark to light purplish red, brownish red, colorless to white. *Streak:* Gray to faint brown. *Luster:* Vitreous, slightly greasy on fracture surfaces.
Optical Class: Biaxial (–). *Pleochroism:* X = blood-red; Y = pale yellow; Z = sea-green. *Orientation:* $Y = b$; $X \wedge c = 51°$. *Dispersion:* $r > v$, strong. α = 1.755–1.761 β = 1.772–1.786 γ = 1.774–1.787 2V(meas.) = ∼0°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.03$ $b = 12.12$ $c = 5.51$ $\beta = 114°4'$ Z = 2

X-ray Powder Pattern: Nordmark, Sweden. (ICDD 17-748).
3.06 (100), 3.71 (65), 3.28 (55), 3.23 (50), 2.929 (50), 4.95 (45), 3.39 (45)

Chemistry:

	(1)	(2)	(3)
As_2O_5	29.10	25.4	28.79
FeO		0.4	
MnO	58.64	62.0	62.19
ZnO		2.3	
MgO	1.34	0.2	
CaO	2.01	0.6	
H_2O	8.97	[9.0]	9.02
Total	100.06	[99.9]	100.00

(1) Långban, Sweden. (2) Franklin, New Jersey, USA; by electron microprobe, total Mn as MnO, H_2O calculated from stoichiometry. (3) $Mn_7(AsO_4)_2(OH)_8$.

Occurrence: As a rare secondary mineral in veinlets through metamorphosed manganese deposits (Sweden); in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Synadelphite, hematolite, hausmannite, pyrochroite, fluorite (Moss mine, Sweden); pyroaurite, leucophoenicite, hodgkinsonite, adelite, franklinite, willemite, friedelite, caryopilite, sphalerite, fluorite, barite, calcite, serpentine, chlorite (Franklin, New Jersey, USA).

Distribution: In Sweden, from the Moss and Brattfors mines, Nordmark, and at Långban, Värmland. From Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: From the Greek, *to change*, a reference to the strong pleochroism.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 785–787. (2) Moore, P.B. (1968) Crystal chemistry of the basic manganese arsenate minerals: II. The crystal structure of allactite. Amer. Mineral., 53, 733–741. (3) Dunn, P.J. (1983) Allactite from Franklin and Sterling Hill, New Jersey. Mineral. Record, 14, 251–252. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 656–657.

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Allanite-(Ce) $(Ca, Ce)_2(Al, Fe^{2+}, Fe^{3+})_3(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic; may be metamict. *Point Group:* $2/m$. Crystals tabular ∥ {100}, or prismatic to acicular ∥ [010], to 90 cm; granular, massive. *Twinning:* Polysynthetic, common on {100}.

Physical Properties: *Cleavage:* Imperfect on {001}; poor on {100} and {110}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.5–4.2 D(calc.) = 4.11 May be radioactive.

Optical Properties: Translucent to opaque. *Color:* Brown to black; brown or green in thin section. *Streak:* Gray. *Luster:* Vitreous, resinous to submetallic. *Optical Class:* Biaxial (+) or (–); isotropic when metamict. *Pleochroism:* X = pale olive-green, reddish brown; Y = dark brown, brownish yellow; Z = dark reddish brown, greenish brown. *Orientation:* $Y = b$; $X \wedge c = 1°–47°$; $Z \wedge a = 26°–72°$. *Dispersion:* $r > v$, strong. $n = 1.54–1.72$, metamict. $\alpha = 1.690–1.791$ $\beta = 1.700–1.815$ $\gamma = 1.706–1.828$ 2V(meas.) = 40°–123°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.932$ $b = 5.770$ $c = 10.1575$ $\beta = 114.69°$ Z = 2

X-ray Powder Pattern: Luangwe Bridge area, Zambia; non-metamict.
2.920 (100), 2.714 (66), 3.53 (43), 2.627 (41), 2.182 (36), 2.886 (28), 2.158 (23)

Chemistry:

	(1)		(1)		(1)
SiO_2	29.79	Ce_2O_3	12.8	MgO	0.64
TiO_2	0.02	RE_2O_3	4.78	CaO	10.10
Al_2O_3	12.75	Fe_2O_3	10.64	H_2O^+	1.64
Y_2O_3	0.04	FeO	9.02	H_2O^-	0.10
La_2O_3	7.2	MnO	0.85	Total	100.37

(1) Luangwe Bridge area, Zambia; wet chemical and spectrographic analysis; $RE_2O_3 = Pr_2O_3$ 1.0%, Nd_2O_3 3.10%, Sm_2O_3 0.60%, Gd_2O_3 0.06%, Er_2O_3 0.02%. Analyses have been made of materials rich in La and Y but they are not otherwise described.

Mineral Group: Epidote group.

Occurrence: An accessory in some granites and granite pegmatites, syenites, more rarely in gabbroic pegmatites. Rarely in schists, gneisses, and some contact metamorphosed limestones; a clastic component of sediments.

Association: Epidote, muscovite, fluorite.

Distribution: Widespread; some localities affording good crystals or rich material follow. From Qáqarssuatsiaq, Alluk, south Greenland. At Ytterby and Finbo, Sweden. From Kragerö, Arendal, and on Hitterö Island, Flekkefjord, Norway. From Sillböle, Stansvik, and Vaarala, Finland. At Miass, Ilmen Mountains, Southern Ural Mountains, Russia. From the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France. In the USA, at Pacoima Canyon, Los Angeles Co., California; in the Baringer Hill pegmatite, 26 km west of Burnet, and on the Rode Ranch, Llano Co., Texas. In Canada, from Olden Township, Frontenac Co., Quebec; in the McDonald mine, Hybla, Ontario; and at Hoidas Lake, near Nisikkatch Lake, Saskatchewan. From near Telixtlahuaca, Oaxaca, Mexico. In the Mary Kathleen mine, Queensland, and at Broken Hill, New South Wales, Australia. From Ribuae, Mozambique.

Name: For Thomas Allan (1777–1833), Scottish mineralogist who discovered the species.

Type Material: University of Copenhagen, Copenhagen, Denmark, 5, 6; The Natural History Museum, London, England, 94377.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 522–526. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 151–179. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 302–308. (4) Dollase, W.A. (1971) Refinement of the crystal structures of epidote, allanite and hancockite. Amer. Mineral., 56, 447–464.

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Allargentum Ag_6Sb

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Crystal Data: Hexagonal. *Point Group:* n.d. In complex intergrowths with silver, and as very small grains.

Physical Properties: Hardness = n.d. VHN = 172–203, 189 average. D(meas.) = 10.0 (synthetic). D(calc.) = 10.12

Optical Properties: Opaque. *Color:* Silver. *Luster:* Metallic. *Anisotropism:* Weak. *Bireflectance:* Strong.
R_1–R_2: (400) 67.0–68.8, (420) 66.5–68.2, (440) 66.0–67.6, (460) 65.9–67.3, (480) 67.1–68.6, (500) 67.4–68.7, (520) 68.9–70.4, (540) 69.5–70.9, (560) 70.2–71.6, (580) 70.5–71.8, (600) 71.0–72.3, (620) 71.7–73.0, (640) 72.1–73.4, (660) 72.6–73.9, (680) 73.1–74.3, (700) 73.8–74.9.

Cell Data: *Space Group:* n.d. $a = 2.952$ $c = 4.773$ $Z = 2$

X-ray Powder Pattern: Cobalt, Canada.
2.370 (100), 2.252 (60), 2.548 (40), 1.353 (40), 1.756 (30), 0.943 (30), 1.473 (20)

Chemistry:

	(1)	(2)	(3)
Ag	84.3	83.09	84.17
Hg	0.3		
Ni		0.05	
Sb	15.3	15.82	15.83
As		0.08	
Total	99.9	99.04	100.00

(1) Cobalt, Canada; by electron microprobe, average of 15 analyses. (2) Wasserfall, France; by electron microprobe. (3) Ag_6Sb.

Occurrence: In high-grade Ag–Sb ores.

Association: Silver containing antimony and mercury, dyscrasite, breithauptite, domeykite, kutínaite, stephanite.

Distribution: In Canada, in Ontario, from the Hi-Ho mine, Cobalt [TL], and abundant in many mines of the Cobalt district; also in the Red Lake area. At the Calliope mine, Ouray district, Ouray Co., Colorado, USA. From the Consols and Junction mines, Broken Hill, New South Wales, and North Arm, Queensland, Australia. At Wasserfall, about 20 km northwest of Belfort, Haute-Saône, France. From Rejská, near Kutná Hora, and at Příbram, Czech Republic. In Germany, at Hartenstein, Saxony. From Hällefors, Bergslagen metallic province, Sweden. In the Aktepe district, near Tahkent, Uzbekistan.

Name: From the Greek for *another* and the Latin *argentum*, silver.

Type Material: Canadian Museum of Nature, Ottawa, 61343–61345, 61519; The Natural History Museum, London, England; National Museum of Natural History, Washington, D.C., USA, 135409.

References: (1) Petruk, W.L., L.J. Cabri, D.C. Harris, J.M. Stewart, and L.A. Clark (1970) Allargentum, redefined. Can. Mineral., 10, 163–172. (2) (1971) Amer. Mineral., 56, 638 (abs. ref. 1). (3) Picot, P. and F. Ruhlmann (1978) Présence d'arséniures de cuivre de haute température dans le granite des Ballons (Vosges méridionales). Bull. Minéral., 101, 563–569 (in French with English abs.). (4) Cipriani, C., M. Corazza, and G. Mazzetti (1996) Reinvestigation of natural silver antimonides. Eur. J. Mineral., 8, 1347–1350.

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Alleghanyite $Mn_5^{2+}(SiO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals rounded, slender; in stout plates, some deeply striated. As fan-shaped aggregates; commonly irregular, massive. *Twinning:* On {001}, lamellar, common; also on {105}, {305}.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5
D(meas.) = 4.020 D(calc.) = [4.20]

Optical Properties: Transparent to translucent. *Color:* Pinkish to reddish brown, deep pink, grayish pink; in thin section, pink or buff in thick plates. *Luster:* Vitreous to dull.
Optical Class: Biaxial (–). *Pleochroism:* Pinks in thicker sections. *Orientation:* $Z = b$.
Dispersion: $r > v$. $\alpha = 1.756$ $\beta = 1.780$ $\gamma = 1.792$ 2V(meas.) = 72°

Cell Data: *Space Group:* $P2_1/c$. $a = 8.275$ $b = 4.850$ $c = 10.720$ $\beta = 104.64°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
1.799 (10), 2.860 (8), 2.598 (6), 3.127 (5), 2.725 (5), 2.425 (5), 2.357 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	24.90	24.65	24.38	MgO	2.16	0.78	
TiO_2	0.00	0.14		CaO	0.74	0.11	
Al_2O_3	trace	0.00		F		2.20	
Fe_2O_3	0.00			H_2O		[2.60]	3.66
FeO	1.40	0.84		$-O = F_2$		0.93	
MnO	70.35	70.15	71.96	Total	99.55	[100.54]	100.00

(1) Bald Knob, North Carolina, USA. (2) Do.; by electron microprobe; H_2O calculated from stoichiometry. (3) $Mn_5(SiO_4)_2(OH)_2$.

Polymorphism & Series: Dimorphous with ribbeite; forms a series with chondrodite.

Mineral Group: Humite group.

Occurrence: Hydrothermally deposited, in lenses in a manganese-bearing vein (Bald Knob, North Carolina, USA); in veins crosscutting franklinite ore near pegmatites in a metamorphosed stratiform Zn–Mn deposit (Franklin, New Jersey, USA).

Association: Spessartine, rhodonite, galaxite (Bald Knob, North Carolina, USA); kolicite, holdenite, magnussonite, adelite, kraisslite, chlorophoenicite, franklinite, willemite, barite, calcite (Sterling Hill, New Jersey, USA).

Distribution: In the USA, from Bald Knob, near Sparta, Alleghany Co., North Carolina; crystals from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in the Germolis prospect, Fiddleton, Amador Co., and at Alum Rock Park, Santa Clara Co., California; at Eureka, Hinsdale Co., and the Sunnyside mine, San Juan Co., Colorado. In the Benallt mine, Rhiw, Lleyn Peninsula, Wales. From Långban, and in the Brattfors mine, Nordmark, Värmland, Sweden. In the Hanawa mine, Iwate Prefecture; the Kaso mine, Tochigi Prefecture; the Taguchi mine, Shidara, Aichi Prefecture; and the Rito mine and Hamayokokawa mine, Nagano Prefecture, Japan. In Kyrgyzstan, on Inyl'chek Ridge, Tien Shan.

Name: For the occurrence in Alleghany Co., North Carolina, USA.

Type Material: n.d.

References: (1) Ross, C.S. and P.F. Kerr (1932) The manganese minerals of a vein near Bald Knob, North Carolina. Amer. Mineral., 17, 1–18. (2) Rogers, A.F. (1935) The chemical formula and crystal system of alleghanyite. Amer. Mineral., 20, 25–35. (3) Rentzeperis, P.J. (1970) The crystal structure of alleghanyite, $Mn_5[(OH)_2|(SiO_4)_2]$. Zeits. Krist., 132, 1–18. (4) Winter, G.A., E.J. Essene, and D.R. Peacor (1983) Mn-humites from Bald Knob, North Carolina: mineralogy and phase equilibria. Amer. Mineral., 68, 951–959. (5) Dunn, P.J. (1985) Manganese humites and leucophoenicites from Franklin and Sterling Hill, New Jersey: parageneses, compositions, and implications for solid solution limits. Amer. Mineral., 70, 379–387.

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Alloclasite $(Co, Fe)AsS$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals are prismatic ‖ [010], to 5 mm, in columnar to radiating aggregates; commonly massive.

Physical Properties: *Cleavage:* Perfect on {101}, distinct on {010}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 5 VHN = 818–940 (100 g load). D(meas.) = 5.91–5.95 D(calc.) = 6.188

Optical Properties: Opaque. *Color:* Steel-gray to silver-white. *Streak:* Nearly black. *Luster:* Bright metallic.
R_1–R_2: (400) 49.5–48.2, (420) 48.7–48.3, (440) 48.2–48.6, (460) 47.8–48.8, (480) 47.6–49.2, (500) 47.6–49.7, (520) 47.8–50.1, (540) 48.0–50.4, (560) 48.1–50.5, (580) 48.4–50.6, (600) 48.6–50.7, (620) 48.8–50.7, (640) 49.0–50.5, (660) 49.1–50.3, (680) 49.1–50.1, (700) 49.2–49.9

Cell Data: *Space Group:* $P2_1$. $a = 4.661$ $b = 5.602$ $c = 3.411$ $\beta = 90°2(5)'$ Z = 2

X-ray Powder Pattern: Oraviţa, Romania.
2.750 (100), 2.469 (90), 1.817 (70), 2.401 (50), 3.58 (30), 2.802 (30), 1.707 (30)

Chemistry:

	(1)	(2)	(3)
Co	25.1	23.6	23.3
Fe	6.7	9.1	7.7
Ni	1.0		
As	47.5	45.5	47.3
S	19.9	20.9	20.7
Total	100.2	99.1	99.0

(1) Elizabeth mine, Romania; by electron microprobe, corresponding to $(Co_{0.76}Fe_{0.21}Ni_{0.03})_{\Sigma=1.00}As_{1.13}S_{1.11}$. (2) North Rhine-Westphalia, Germany; by electron microprobe, corresponding to $(Co_{0.71}Fe_{0.29})_{\Sigma=1.00}As_{1.08}S_{1.15}$. (3) Dogatani mine, Japan; by electron microprobe, corresponding to $(Co_{0.74}Fe_{0.26})_{\Sigma=1.00}As_{1.20}S_{1.23}$.

Polymorphism & Series: Dimorphous with glaucodot.

Occurrence: In calcite or quartz veins of apparently low-temperature, late-stage hydrothermal origin. Also in silicified, recrystallized metamorphic rock.

Association: Gold, silver, glaucodot, cobaltite, cobaltian arsenopyrite, emplectite, bismuthinite, sphalerite, calcite, quartz.

Distribution: In Romania, from Oraviţa (Oravicza)[TL], as in the Elizabeth mine. At Bieber, near Hanau, Hesse, Germany. From the San Juan de Plan mine, Gistain Valley, Huesca, Spain. In the Silverfields mine, Cobalt, and the Siscoe Metals mine, Miller Lake, Gowganda, Ontario, Canada. In the USA, in the Kibblehouse quarry, Perkiomenville, Montgomery Co., Pennsylvania. From Bou Azzer, Morocco. At the Scar Crag mine, Braithwaite, Cumbria, England. In the Lautaret Pass, Hautes-Alpes, France. From the Dogatani mine, [??Prefecture-ck Min Japan], Japan. In Australia, at Mount Isa, Queensland, and in the Moonta mines, Yorke Peninsula, South Australia.

Name: From the Greek for *other*, and *to break*, because its cleavage was believed to be different from marcasite, which it resembles.

Type Material: n.d.

References: (1) Kingston, P.W. (1971) On alloclasite, a Co–Fe sulpharsenide. Can. Mineral., 10, 838–846. (2) (1972) Amer. Mineral., 57, 1561 (abs. ref. 1). (3) Scott, J.D. and W. Nowacki (1976) The crystal structure of alloclasite, CoAsS, and the alloclasite–cobaltite transformation. Can. Mineral., 14, 561–566. (4) Petruk, W., D.C. Harris, and J.M. Stewart (1971) Characteristics of the arsenides, sulpharsenides and antimonides. Can. Mineral., 11, 149–186. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 9.

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Allophane $Al_2O_3 \cdot 1.3-2.0(SiO_2) \cdot 2.5-3.0(H_2O)$

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Crystal Data: Amorphous (?). *Point Group:* n.d. Rarely observed as ring-shaped particles, with diameters of 50 Å, which in three dimensions may represent sections through hollow spherules or polyhedra. As hyaline crusts and masses; stalactites and flowstones.

Physical Properties: *Fracture:* Conchoidal to earthy. *Tenacity:* Brittle. Hardness = 3
D(meas.) = 2.75 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* White, pale blue to sky-blue, green, brown.
Luster: Vitreous to earthy, waxy.
Optical Class: Isotropic. n = 1.468–1.512 (air-dried).

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	21.39	28.31	29.17	CaO	1.96	trace	trace
TiO_2		0.40	0.42	Na_2O		1.91	1.48
Al_2O_3	35.20	34.41	33.81	K_2O		0.29	0.16
Fe_2O_3		0.56	0.56	H_2O^+	40.86	10.60	11.20
MgO		0.08	0.04	H_2O^-		23.20	23.00
				Total	99.41	99.76	[99.84]

(1) Allentown, Lehigh Co., Pennsylvania, USA; CaO as $(Ca, Mg)CO_3$. (2) Iijima, Japan.
(3) Kanuma, Japan; original total given as 99.81%.

Occurrence: A weathering product of volcanic ash. In hydrothermally altered igneous rocks, from the breakdown of feldspars, and in hydrothermal veins, typically related to copper deposits. In sedimentary rocks, including chalk and coal beds.

Association: Quartz, cristobalite, imogolite, gibbsite, vermiculite, chrysocolla, "limonite".

Distribution: Of widespread occurrence. From Gräfenthal, near Saalfeld, Thuringia, and at Schneeberg and Schwarzenberg, Saxony, Germany. From Jáchymov (Joachimsthal), Czech Republic. In the Calabona mine, Alghero, and the Rosas mine, Sulsis, Sardinia, Italy. At Laurium, Greece. From near Woolwich, Kent, and Wheal Hamblyn, Devon, England. At the Chessy copper mine, near Lyons, Rhône, France. In the USA, from Bisbee, and the Maid of Sunshine mine, Gleeson, Cochise Co., Arizona; from Kelly, Socorro Co., New Mexico; at Cerro Gordo, Inyo Co., California; and at Friedensville, Lehigh Co. and Cornwall, Lebanon Co., Pennsylvania. In the Mbobo Mkulu Cave, Transvaal, South Africa. From Japan, in the Misotsuchi volcanic ash bed at Iijima, Nagano Prefecture, and the Kanumatsuchi bed at Kanuma, Tochigi Prefecture. At Mt. Shank, South Australia.

Name: From the Greek for *other* and *to appear*, referring to a change of appearance under the blowpipe.

Type Material: Mining Academy, Freiberg, Germany, 26104.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 693–694. (2) Kitagawa, Y. (1974) Dehydration of allophane and its structural formula. Amer. Mineral., 59, 1094–1098. (3) Henmi, T. and K. Wada (1976) Morphology and composition of allophane. Amer. Mineral., 61, 379–390. (4) Wada, S.I. and K. Wada (1977) Density and structure of allophane. Clay Minerals Bull., 12, 289–298. (5) Bailey, S.W. (1980) Summary of recommendations of AIPEA nomenclature committee on clay minerals. Amer. Mineral., 65, 1–7.

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Alloriite $Na_5K_{1.5}Ca(Si_6Al_6O_{24})(SO_4)\cdot(OH)_{0.5}\cdot H_2O$

Crystal Data: Hexagonal. *Point Group*: 3*m*. Crystals hexagonal equant, tabular on {0001}, or prismatic, to 2 mm, displaying {0001}, {10$\bar{1}$ 0}, {10$\bar{1}$ 3}, {10$\bar{1}$ 4}, {11$\bar{2}$ 0}.

Physical Properties: *Cleavage*: Imperfect on {10$\bar{1}$ 0}. *Fracture*: Conchoidal.
Tenacity: Brittle. Hardness = 5 D(meas.) = 2.35(1) D(calc.) = 2.358

Optical Properties: Transparent. *Color*: Colorless to pale violet. *Streak*: White.
Luster: Vitreous.
Optical Class: Uniaxial (+). ω = 1.497(2) ε = 1.499(2) *Pleochroism*: *E* = pale pink, *O* = pale pinkish yellow. *Absorption: E > O.*

Cell Data: *Space Group*: *P*31*c*. a = 12.892(3) c = 21.340(5) Z = 4

X-ray Powder Pattern: Mt. Cavalluccio, Sacrofano caldera, Latium, Italy.
3.33 (100), 4.85 (90), 3.76 (80), 11.3 (70), 3.68 (70), 2.694 (70), 4.03 (60)

Chemistry:

	(1)	(2)
Na_2O	13.55	14.75
K_2O	6.67	6.72
CaO	6.23	5.34
Al_2O_3	26.45	29.11
SiO_2	34.64	34.31
SO_3	8.92	7.62
Cl	0.37	
H_2O	2.1	2.14
CO_2	0.7	
$-O=Cl_2$	0.08	
Total	99.55	99.99

(1) Mt. Cavalluccio, Sacrofano caldera, Latium, Italy; electron microprobe analysis, water by Penfield method, CO_2 by selective sorption, anionic groups confirmed by IR, corresponding to $Na_{19.16}K_{6.21}Ca_{4.87}(Si_{25.26}Al_{22.74}O_{96})(SO_4)_{4.88}(CO_3)_{0.70}Cl_{0.46}(OH)_{0.76}\cdot 4.73H_2O$ (for Z = 1).
(2) $Na_5K_{1.5}Ca(Si_6Al_6O_{24})(SO_4)\cdot(OH)_{0.5}\cdot H_2O$ (for Z = 4).

Mineral Group: Cancrinite group.

Occurrence: Lining the walls of small miarolitic cavities in a sanidine-syenite volcanic bomb.

Association: Sanidine, biotite, andradite, apatite.

Distribution: Mt. Cavalluccio, Campagnano di Roma, Sacrofano caldera, Rome Province, Latium, Italy.

Name: Honors Roberto Allori (b. 1933), an amateur mineralogist who has studied the Latium region.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 3459/1.

References: (1) Chukanov N V, Rastsvetaeva R K, Pekov I V, Zadov A E (2007) Alloriite, $Na_5K_{1.5}Ca(Si_6Al_6O_{24})(SO_4)\cdot(OH)_{0.5}\cdot H_2O$, a new mineral of the cancrinite group. Zapiski Rossiiskogo Mineralogicheskogo Obshchetstva, 136, 82-89; (2007) Geology of Ore Deposits, Vol. 49, 752–757 (in English). (2) Rastsvetaeva, R.K., A.G. Ivanova, N.V. Chukanov, and I.A. Verin (2007) Crystal structure of alloriite. Dokl. Akad. Nauk, 415(2), 242–246 (in Russian); Dokl. Earth Sci., 415, 815–819 (in English). (3) (2009) Amer. Mineral., 94, 399 (abs. ref. 2).

Alluaivite $Na_{19}(Ca, Mn^{2+})_6(Ti, Nb)_3Si_{26}O_{74}Cl \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Irregular accumulations, to 1 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–6
D(meas.) = 2.76(5) D(calc.) = 2.78 Vivid orange-red fluorescence in UV.

Optical Properties: Transparent. *Color:* Colorless to weak brownish pink. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.618(2)$ $\epsilon = 1.626(2)$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 14.046(2)$ $c = 60.60(2)$ Z = 6

X-ray Powder Pattern: Mt. Alluaiv, Russia; could be mistaken for eudialyte.
2.960 (10), 2.825 (10), 7.14 (8), 1.762 (8), 4.30 (7), 2.148 (7), 3.36 (5)

Chemistry:

	(1)		(1)
SiO_2	53.3	SrO	1.0
TiO_2	6.0	BaO	0.6
ZrO_2	0.2	Na_2O	18.6
La_2O_3	0.2	K_2O	0.2
Ce_2O_3	0.8	Cl	0.8
Nb_2O_5	3.9	H_2O	1.7
MnO	3.6	$-O = Cl_2$	0.2
CaO	8.6	Total	99.3

(1) Mt. Alluaiv, Russia; by electron microprobe, average of three grains, H_2O by coulometry; corresponding to $(Na_{17.47}Sr_{0.28}Ce_{0.14}K_{0.12}Ba_{0.11}La_{0.03})_{\Sigma=18.15}(Ca_{4.46}Mn_{1.47})_{\Sigma=5.93}(Ti_{2.18}Nb_{0.85}Zr_{0.05})_{\Sigma=3.08}Si_{25.82}O_{73.26}Cl_{0.66} \cdot 2.75H_2O$.

Occurrence: In ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Eudialyte, nepheline, sodalite, potassic feldspar, arfvedsonite, aegirine.

Distribution: On Mt. Alluaiv, in the Lovozero massif, Kola Peninsula, Russia.

Name: For its occurrence on Mt. Alluaiv, Kola Peninsula, Russia.

Type Material: Mining Museum, St. Petersburg Mining Institute, 1993/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; The Natural History Museum, London, England, 1994,1.

References: (1) Khomyakov, A.P., G.N. Netschelyustov, and R.K. Rastsvetaeva (1990) Alluaivite $Na_{19}(Ca, Mn)_6(Ti, Nb)_3Si_{26}O_{74}Cl \cdot 2H_2O$ – a new titanosilicate of eudialyte-like structure. Zap. Vses. Mineral. Obshch., 119(1), 117–120 (in Russian). (2) (1991) Amer. Mineral., 76, 1728 (abs. ref. 1).

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Alluaudite $(Na, Ca)Mn^{2+}(Fe^{3+}, Mn^{2+}, Fe^{2+}, Mg)_2(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals platy to fibrous, to 1 cm; usually radiating fibrous, in nodular aggregates; granular, massive. *Twinning:* Polysynthetic, with $\{\bar{1}01\}$ as composition plane, seen in thin section.

Physical Properties: *Cleavage:* {010}, {110}, and $\{1\bar{1}0\}$, good. Hardness = 5–5.5 D(meas.) = 3.45 D(calc.) = 3.62

Optical Properties: Subtranslucent to opaque. *Color:* Dirty yellow to brownish yellow, grayish green; surficially dull greenish black, brownish black, black, when altered; yellow to yellow-green in transmitted light. *Streak:* Dirty yellow.
Optical Class: Biaxial (+). *Pleochroism:* X = pale olive-green, straw-yellow to greenish yellow; Z = pale olive-greenish to brownish yellow. *Dispersion:* $r > v$, moderate, crossed. *Absorption:* $Z \gg X$. $\alpha = 1.782(5)$ $\beta = 1.802(2)$ $\gamma = 1.835(1)$ 2V(meas.) = 79.2°

Cell Data: *Space Group:* $C2/c$. $a = 12.004(2)$ $b = 12.533(4)$ $c = 6.404(1)$ $\beta = 114°22(5)'$ Z = 4

X-ray Powder Pattern: Chanteloube, France.
2.73 (10), 6.36 (8), 3.51 (7), 2.74 (7), 3.08 (5), 5.52 (4), 2.53 (3)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	42.15	45.15	MnO	15.34	13.42	F		0.72
Al_2O_3		2.94	MgO	0.47	3.55	H_2O	3.55	
Fe_2O_3	31.48	14.13	CaO	1.40	2.07	$-O = F_2$		0.30
Mn_2O_3	0.88		Li_2O	0.09		insol.	0.58	
FeO		9.40	Na_2O	3.90	8.57	Total	99.84	99.65

(1) Buranga pegmatite, Rwanda; neglecting H_2O, corresponds to $(Na_{0.63}Mn^{2+}_{0.19}Ca_{0.12}Li_{0.03})_{\Sigma=0.97}(Mn^{2+}_{0.95}Mg_{0.05})_{\Sigma=1.00}(Fe^{3+}_{1.96}Mg_{0.04})_{\Sigma=2.00}(PO_4)_3$. (2) Rapid Creek, Canada; by electron microprobe, Fe^{2+}:Fe^{3+} from stoichiometry; corresponds to $(Na_{0.80}Ca_{0.18}Fe^{2+}_{0.02})_{\Sigma=1.00}Na_{0.50}(Mn^{2+}_{0.89}Fe^{2+}_{0.11})_{\Sigma=1.00}(Fe^{3+}_{0.84}Fe^{2+}_{0.48}Mg_{0.42}Al_{0.27})_{\Sigma=2.01}[(PO_4)_{2.96}F_{0.06}]_{\Sigma=3.02}$.

Polymorphism & Series: Forms a series with ferroalluaudite.

Mineral Group: Alluaudite group.

Occurrence: Very common in granite pegmatites, formed by sodium metasomatism of triphylite–lithiophilite, heterosite–purpurite, or ferrisicklerite; in phosphatic nodules in shales.

Association: Triphylite, arrojadite, satterlyite, wicksite, wolfeite, pyrite.

Distribution: Numerous occurrences: in the La Vilate quarry, near Chanteloube, Haute-Vienne, France. At Dolní Bory, near Velkého Meziříčí, Czech Republic. From the Varuträsk pegmatite, Västerbotten, Sweden. In England, at the Tremearne pegmatite, Breage, Cornwall. From the G.E. Smith mine, near Newport, Sullivan Co., New Hampshire; at many localities in the Black Hills, Pennington and Custer Cos., South Dakota, USA. From Rapid Creek, Yukon Territory, Canada. At Sidi-Bou-Othmane, Morocco. From the Buranga pegmatite, near Gatumba, Rwanda. In Zimbabwe, at Mterikati, Miami. In Namibia, at the Tsaobismund pegmatite, 60 km south of Karibib.

Name: Honoring François Alluaud, mining engineer of Limoges, France, who discovered the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 674–675. (2) Fisher, D.J. (1955) Alluaudite. Amer. Mineral., 40, 1100–1109. (3) Moore, P.B. (1971) Crystal chemistry of the alluaudite structure type: contribution to the paragenesis of pegmatite phosphate giant crystals. Amer. Mineral., 56, 1955–1975. (4) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (5) Robinson, G.W., J. Van Velthuizen, H.G. Ansell, and B.D. Sturman (1992) Mineralogy of the Rapid Creek and Big Fish River area, Yukon Territory. Mineral. Record, 23(4), 1–47, esp. 34–36.

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Almandine $Fe_3^{2+}Al_2(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Typically well-formed dodecahedra or trapezohedra, to 1 m; also in rounded grains and massive.

Physical Properties: *Cleavage:* Parting on {110}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 7–7.5 D(meas.) = 4.318 D(calc.) = 4.313

Optical Properties: Transparent to translucent. *Color:* Deep red, brownish red, red-violet, black; may be sectored. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Isotropic; anomalously biaxial. *Dispersion:* Weak. $n = 1.830$

Cell Data: *Space Group: Ia3d.* a = 11.526 Z = 8

X-ray Powder Pattern: Cavendish Township, Peterborough Co., Ontario, Canada. (ICDD 9-427).
2.569 (100), 1.540 (50), 2.873 (40), 1.599 (40), 4.04 (30), 1.866 (30), 1.660 (30)

Chemistry:

	(1)	(2)
SiO_2	37.39	36.21
TiO_2	0.16	
Al_2O_3	20.72	20.49
Fe_2O_3	0.83	
FeO	36.37	43.30
MnO	0.86	
MgO	3.85	
CaO	0.41	
Total	100.59	100.00

(1) Falun, Sweden; corresponds to $(Fe^{2+}_{2.49}Mn_{0.14}Ca_{0.05})_{\Sigma=2.68}(Al_{1.94}Fe^{3+}_{0.05}Ti_{0.01})_{\Sigma=2.00}(Si_{2.99}Al_{0.01})_{\Sigma=3.00}O_{12}$. (2) $Fe_3Al_2(SiO_4)_3$.

Polymorphism & Series: Forms two series, with pyrope, and with spessartine.

Mineral Group: Garnet group.

Occurrence: The most common garnet, typically in mica schists and gneisses, from regionally metamorphosed argillaceous sediments and pelites; also in contact metamorphic hornfels. In granites and eclogites; in sedimentary rocks; as a detrital mineral.

Association: Biotite, cordierite, chlorite, staurolite, andalusite, kyanite, sillimanite, hematite, plagioclase, amphibole, pyroxene.

Distribution: Widespread. Some localities for fine crystals include: in the Zillertal, Tirol, Austria. At Falun, Sweden. In Norway, from near Bodø. From the Akhmatovsk deposit, near Zlatoust, Ural Mountains, Russia. In the USA, from Roxbury, Litchfield Co., and Southbury, New Haven Co., Connecticut; at Auburn, Androscoggin Co., and Topsham, Sagadahoc Co., Maine; from Westfield and Russell, Hampden Co., Massachusetts; and at Hanover, Grafton Co., New Hampshire. From Avondale, Chester Co., Pennsylvania; a large commercial deposit at the Barton mine, North Creek, Warren Co., New York; at Michigamme, Marquette Co., Michigan; from Salida, Chaffee Co., Colorado; and at Ft. Wrangell, Stikine River, Alaska. In Brazil, at Pernambuco, Bahia. From the Miami district, Zimbabwe. At Broken Hill and Thackaringa, New South Wales, and in the Harts Range, Northern Territory, Australia. From Yamanoo, Ibaragi Prefecture, and the Ishikawa district, Fukushima Prefecture, Japan.

Name: For Alabanda in Turkey, a cutting center in antiquity.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 437–447. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 468–698, esp. 537–589. (3) Novak, G.A. and G.V Gibbs (1971) The crystal chemistry of the silicate garnets. Amer. Mineral., 56, 791–825.

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Alstonite $BaCa(CO_3)_2$

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Crystal Data: Triclinic, pseudo-orthorhombic. *Point Group:* $\overline{1}$ or 1. Steep pseudohexagonal dipyramids bounded by pseudohexagonal prisms, to 6 mm, striated strongly $\perp$ pseudohexagonal [0001] and commonly exhibiting a medial re-entrant $\parallel$ pseudohexagonal [0001]. *Twinning:* Common on pseudo-orthorhombic $\{1\overline{1}0\}$ and $\{310\}$, forming pseudohexagonal groups.

Physical Properties: *Cleavage:* On pseudo-orthorhombic $\{110\}$, imperfect. *Fracture:* Uneven. Hardness = 4–4.5 D(meas.) = 3.707(4) D(calc.) = 3.69 Fluoresces yellow under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to snow-white; also pale gray, pale cream, pink to pale rose-red, which may fade on exposure to light; colorless in transmitted light, showing six or twelve domains. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, weak. $\alpha = 1.526$ $\beta = 1.671$ $\gamma = 1.672$ 2V(meas.) = 6°

Cell Data: *Space Group:* $C\overline{1}$ or $C1$. $a = 30.14$ $b = 17.40$ $c = 6.12$ $\alpha = 90°$ $\beta = 90°$ $\gamma = 90°$ Z = 24

X-ray Powder Pattern: Alston, England; essentially identical to paralstonite. 3.55 (100), 2.507 (35), 2.050 (23), 1.941 (19), 1.846 (15), 2.835 (10), 1.589 (8)

Chemistry:

	(1)	(2)
CO_2	29.41	29.59
CaO	17.60	18.85
SrO	4.25	
BaO	48.54	51.56
Total	99.80	100.00

(1) Alston, England. (2) $CaBa(CO_3)_2$.

Polymorphism & Series: Trimorphous with barytocalcite and paralstonite.

Occurrence: Typically in low-temperature hydrothermal Pb–Zn deposits; rare in carbonatites.

Association: Calcite, barite, ankerite, siderite, benstonite, galena, sphalerite, pyrite, quartz.

Distribution: In England, from the Bromley Hill Pb–Zn mine, near Alston, Cumbria, in the Fallowfield lead mine, near Hexham, Northumberland, and at New Brancepeth, Durham. From Mine BK-3, Llantrisant, 10 km north of Cardiff, Wales. From the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. Found in the Tajno borehole, 70 km north of Bialystok, Poland. From the Garaoulère Zn–Pb orebody, Pierrefitte, Pyrénées, France. In the USA, at the Minerva No. 1 mine, Cave-in-Rock, Hardin Co., Illinois. From the Wittingham Coal Measures, Hunter Valley, New South Wales, Australia.

Name: For the original locality near Alston, England.

Type Material: Mining Academy, Freiberg, Germany, 15818.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 218–219. (2) Sartori, F. (1975) New data on alstonite. Lithos, 8, 199–207. (3) Alabaster, C. (1990) Alstonite and barytocalcite from Llantrisant, South Wales and barytocalcite from Holwell, Mendip Hill, England. J. Russell Soc., 3(1), 1–6. (4) Young, B., L. Greenbank, and P.H.A. Nancarrow (1990) Alstonite *in situ* at Brownley Hill mine, Nenthead, Cumbria. Mineral. Mag., 54, 515–516.

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Altaite PbTe

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rarely in very small cubes and octahedra; massive, as cleavages, to 1 cm; granular, myrmekitic in other sulfides.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Subconchoidal. *Tenacity:* Sectile. Hardness = 3 VHN = 47–53, 51 average. D(meas.) = 8.19 D(calc.) = 8.27

Optical Properties: Opaque. *Color:* Tin-white with yellowish tint, tarnishes bronze; in polished section, white with a delicate greenish hue. *Luster:* Metallic.
R: (400) 59.6, (420) 62.6, (440) 65.2, (460) 67.5, (480) 69.3, (500) 70.6, (520) 71.2, (540) 71.1, (560) 70.1, (580) 68.7, (600) 66.8, (620) 65.1, (640) 63.4, (660) 61.9, (680) 60.6, (700) 59.4

Cell Data: *Space Group:* $Fm3m$. a = 6.439 Z = 4

X-ray Powder Pattern: Kirkland Lake, Ontario, Canada.
3.23 (100), 2.29 (80), 1.443 (50), 1.314 (40), 1.859 (30), 1.610 (20), 1.074 (20)

Chemistry:

	(1)	(2)	(3)
Pb	61.52	62.4	61.91
Cu		0.4	
Bi		0.2	
Te	38.48	37.2	38.09
Total	100.00	100.2	100.00

(1) Red Cloud mine, Colorado, USA. (2) Campbell mine, Bisbee, Arizona, USA; by electron microprobe. (3) PbTe.

Occurrence: Typically in hydrothermal vein Au–Te-bearing deposits.

Association: Gold, silver, antimony, tellurium, tellurantimony, galena, pyrite, hessite, nagyágite, tetrahedrite, sylvanite, petzite, calaverite, arsenopyrite, sphalerite, chalcopyrite, jamesonite, boulangerite, bournonite, aguilarite, pyrrhotite, siderite, cerussite, quartz.

Distribution: Occurrences are too numerous to fully list. Selected localities are: in the Zavodinskii mine, near Ziryanovsk, Altai Mountains, Kazakhstan [TL], hundreds of kg. At the Bereznyakov gold deposit, Southern Ural Mountains, Russia. From Săcărîmb (Nagyág), Romania. At Kalgoorlie, Western Australia. In the Fiji Islands, in the Tuvatu Au–Ag–Te deposit, Viti Levu. From the Bulawan deposit, Negros Occidental, Phillipines. At several mines in the Kirkland Lake area, Ontario, Canada. In the USA, in the Foote mine, Kings Mountain, Cleveland Co., North Carolina; the Red Cloud mine, Gold Hill, Boulder Co., Colorado; the Mayflower mine, Tobacco Root Mountains, Madison Co., Montana; the Hilltop mine, near Las Cruces, Doña Ana Co., New Mexico; the Stanislaus mine, Carson Hill district, Calaveras Co., California; and the Minnamax Cu–Ni–sulfide deposit, Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota. From the San Francisco mine, 145 km north of Hermosillo, Sonora, Mexico.

Name: After the locality in the Altai Mountains, Kazakhstan.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 205–207. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 48. (3) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 121–125. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 10.

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Althausite $Mg_2(PO_4)(OH,F,O)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rare crude crystals are elongated along [001], flattened on {010}, showing {010}, {110}, {131}, to 3 cm; generally as cleavable masses.

Physical Properties: *Cleavage:* On {001}, perfect; on {101}, distinct. Hardness = 3.5–4 D(meas.) = 2.97(2) D(calc.) = 2.91

Optical Properties: Translucent. *Color:* Pale gray, reddish brown. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.588(2)$ $\beta = 1.592(2)$ $\gamma = 1.598(2)$ 2V(meas.) = ∼70° 2V(calc.) = 78.5°

Cell Data: *Space Group: Pnma.* $a = 8.258(2)$ $b = 6.054(2)$ $c = 14.383(5)$ Z = 8

X-ray Powder Pattern: Tingelstadtjern quarry, Norway.
3.593 (100), 3.316 (90), 3.024 (80), 2.786 (60), 2.641 (60), 3.418 (40), 2.894 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	43.59	45.14	44.4	CaO	4.50		
SiO_2	0.11			Na_2O	0.22		
TiO_2	< 0.02			F	2.86	2.99	3.04
Al_2O_3	0.53			Cl	0.19		
Fe_2O_3	1.37			H_2O^+	1.87	2.10	
FeO			0.8	H_2O^-	0.07		
MnO	0.07			$-O = (F,Cl)_2$	1.24	1.26	
MgO	45.38	51.03	50.5	Total	99.52	[100.00]	98.7

(1) Tingelstadtjern quarry, Norway. (2) Do.; recalculated after deduction of apatite and excluding minor constituents; then corresponding to $Mg_{2.00}(PO_4)_{1.00}[(OH)_{0.37}F_{0.25}O_{0.19}]_{\Sigma=0.81}$. (3) Overntjern quarry, Norway; by electron microprobe, total Fe as FeO.

Polymorphism & Series: Dimorphous with holtedahlite.

Occurrence: In serpentine–magnesite deposits (Norway).

Association: Apatite, magnetite, xenotime, holtedahlite, szaibelyite, talc, magnesite (Tingelstadtjern quarry, Norway); apatite, enstatite, talc, magnesite (Overntjern quarry, Norway); fluorapatite, wolfeite, topaz, muscovite, sphalerite, quartz, chalcopyrite, pyrrhotite, siderite, arsenopyrite, chlorite, vivianite, panasqueiraite, thadeuite (Panasqueira, Portugal).

Distribution: From the Tingelstadtjern and Overntjern quarries, Modum, Norway. In the Panasqueira Sn–W deposit, Portugal.

Name: To honor Professor Egon Althaus (1933–), Karlsruhe University, Karlsruhe, Germany.

Type Material: Mineralogical-Geological Museum, Oslo University, Oslo, Norway, 22044, 22045.

References: (1) Raade, G. and M. Tysseland (1975) Althausite, a new mineral from Modum, Norway. Lithos, 8, 215–219. (2) (1976) Amer. Mineral., 61, 502 (abs. ref. 1). (3) Rømming, C. and G. Raade (1980) The crystal structure of althausite, $Mg_4(PO_4)_2(OH,O)(F,\square)$. Amer. Mineral., 65, 488–498. (4) Raade, G. (1990) Hydrothermal syntheses of $Mg_2(PO_4)OH$ polymorphs. Neues Jahrb. Mineral., Monatsh., 289–300.

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Althupite $ThAl(UO_2)_7O_2(PO_4)_4(OH)_5 \cdot 15H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As thin tabular crystals, flattened on {100} and terminated by {011} and {021}, to 0.1 mm, and in parallel groups.

Physical Properties: Hardness = n.d. D(meas.) = 3.9(1) D(calc.) = 3.98 Radioactive.

Optical Properties: Transparent. *Color:* Yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = very pale yellow; $Y = Z$ = darker yellow.
Orientation: $X \simeq a$; $Z \wedge c = 15°$. *Dispersion:* $r < v$, strong. $\alpha = 1.620(3)$ $\beta = 1.661(2)$ $\gamma = 1.665(2)$ 2V(meas.) = 31(3)° 2V(calc.) = 34°

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.953(3)$ $b = 18.567(4)$ $c = 13.504(3)$ $\alpha = 72.64(2)°$ $\beta = 68.20(2)°$ $\gamma = 84.21(2)°$ Z = 2

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
10.2 (100), 5.09 (70), 5.80 (50), 4.41 (50), 2.896 (50), 6.67 (40), 4.91 (40)

Chemistry:

	(1)	(2)
UO_3	68.22	68.66
P_2O_5	9.86	9.73
ThO_2	10.25	9.05
Al_2O_3	1.75	1.75
H_2O	[9.92]	10.81
Total	[100.00]	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, average of 10 analyses, H_2O by difference; corresponds to $Th_{1.16}Al_{0.88}(UO_2)_{7.12}O_2(P_{1.07}O_4)_4(OH)_5 \cdot 15H_2O$.
(2) $ThAl(UO_2)_7O_2(PO_4)_4(OH)_5 \cdot 15H_2O$.

Occurrence: A secondary mineral in the uraniferous zone of an altered granite pegmatite.

Association: Beryl, columbite, ranunculite, upalite, phuralumite, threadgoldite, mundite, triangulite, meta-autunite.

Distribution: At the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: For the major cations in the composition, ALuminum, THorium, Uranium, Phosphorus.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG6178.

References: (1) Piret, P. and M. Deliens (1987) Les phosphates d'uranyle et d'aluminium de Kobokobo IX. L'althupite $AlTh(UO_2)[(UO_2)_3O(OH)(PO_4)_2]_2(OH)_3 \cdot 15H_2O$, nouveau minéral; propriétés et structure cristalline. Bull. Minéral., 110, 65–72 (in French with English abs.).
(2) (1988) Amer. Mineral., 73, 189–190 (abs. ref. 1).

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Aluminite $Al_2(SO_4)(OH)_4 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As needles and fibers, to 0.1 mm, commonly in reniform, nodular, or spherulitic masses, and as veinlets.

Physical Properties: *Fracture:* Earthy, in aggregates. *Tenacity:* Friable. Hardness = 1–2 D(meas.) = 1.66–1.82 D(calc.) = 1.794

Optical Properties: Translucent, opaque if massive. *Color:* White to grayish white; colorless in transmitted light. *Luster:* Dull to earthy.
Optical Class: Biaxial (+). *Orientation:* X = elongation. $\alpha = 1.459–1.460$ $\beta = 1.464$ $\gamma = 1.470$ 2V(meas.) = $\sim 90°$

Cell Data: *Space Group:* $P2_1/c$. $a = 7.440(1)$ $b = 15.583(2)$ $c = 11.700(2)$ $\beta = 110.18(2)°$ Z = 4

X-ray Powder Pattern: Gánt, Hungary.
7.93 (100), 9.01 (90), 3.7224 (72), 4.760 (71), 3.7419 (70), 5.033 (63), 4.868 (63)

Chemistry:

	(1)	(2)
SO_3	23.37	23.26
Al_2O_3	29.87	29.63
H_2O	46.76	47.11
Total	[100.00]	100.00

(1) Newhaven, England; recalculated to 100% after deduction of a small amount of gypsum.
(2) $Al_2(SO_4)(OH)_4 \cdot 7H_2O$.

Occurrence: Typically in clays or lignites, formed by the reaction of sulfate-bearing solutions from the decomposition of marcasite or pyrite at moderate temperatures with aluminous silicates; as a volcanic sublimate; in sulfur deposits; rarely in caves.

Association: Basaluminite, gibbsite, epsomite, gypsum, celestine, dolomite, goethite.

Distribution: In Germany, from Morl, near Halle, Saxony-Anhalt. In the Czech Republic, at Milevsko (Mühlhausen), near Kralupy, Kuchelbad, Miletic, and Velvary. From Gánt, Vértes Mountains, and at Nagyegyháza, Hungary. In France, at Mont Vernon, near Épernay, Marne, and in the Auteuil district, Paris. At Newhaven, Sussex, England. On Vesuvius, Campania, Italy. In Ukraine, from the Beregovo district, near Mukachevo; in the Rozdol deposit; and at the Gornostayevka sulfur prospect, Kerch Peninsula. In Russia, at Vodino, near Samara, and on Mount Sokolovaya, near Saratov. Found near Zaglik, Azerbaijan. In the Mbobo Mkulu Cave, near Ngodwana, Transvaal, South Africa. Found in the Salt Range, Punjab, India. In the USA, from Joplin, Jasper Co., Missouri; in the Green River Formation, Emery Co., Utah; at Creston, southwest of Rawlins, Carbon Co., Wyoming; in Cottonwood Cave, Guadalupe Mountains, Eddy Co., New Mexico.

Name: For *aluminum* in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 600–601. (2) Sabelli, C. and R.T. Ferroni (1978) The crystal structure of aluminite. Acta Cryst., 34, 2407–2412. (3) Farkas, L. and Werner, P.-E. (1980) Powder diffraction studies on aluminite and meta-aluminite. Zeits. Krist., 151, 141–152. (4) Hollingworth, S.E. and F.A. Bannister (1950) Basaluminite and hydrobasaluminite, two new minerals from Northamptonshire. Mineral. Mag., 29, 1–17.

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Aluminum Al

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Typically granular massive, may be platy or scaly, to 1 mm.

Physical Properties: *Tenacity:* Malleable. Hardness = 2–3 D(meas.) = 2.707 D(calc.) = 2.697

Optical Properties: Opaque. *Color:* Grayish white. *Luster:* Metallic.
Optical Class: Isotropic.
R: n.d.

Cell Data: *Space Group:* $Fm3m$ (synthetic). $a = 4.0494$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.338 (100), 2.024 (47), 1.221 (24), 1.431 (22), 0.9289 (8), 0.9055 (8), 0.8266 (8)

Chemistry:

	(1)	(2)
Al	99.99 – 100.0	97.81
Total		

(1) Tolbachik volcano, Russia; by electron microprobe. (2) Getang, China; by electron microprobe.

Occurrence: In a gabbro-dolerite massif (Billeekh intrusion, Russia); in aluminum-rich rocks; in high-temperature hydrothermal Sn–W deposits and their alteration zones; in volcanic ash.

Association: Cu, Zn, Sn, Pb, Cd, Fe, Sb, moissanite (Billeekh intrusive, Russia); magnetite, ilmenite, hematite, pyrite, iron (Tolbachik volcano, Russia); Cu, S, jarosite (Getang, China).

Distribution: In Russia, in Siberia, from the Billeekh [TL], Tsepochechnyi, and Ust-Khann'ya intrusives, Vilyui River Basin; in the Nizhefokinskii intrusion, Norilsk district; from the Ukachilkan tin deposit, northeastern Sakha; and at the Tolbachik fissure volcano, Kamchatka Peninsula. In a mud volcano on Bulla Island, Caspian Sea. At Kyzylcheku, Karamazar, Tajikistan. From Getang, Guizhou Province, and in the Lianhuashan tungsten deposit, Guangdong Province, China.

Name: Named *aluminum* by Humphry Davy, who discovered the element.

Type Material: Geological Museum, Academy of Sciences, Yakutsk, Russia.

References: (1) Oleynikov, B.V, A.V. Okrugin, and N.V. Leskova (1978) Petrological significance of the occurrence of native aluminum in mafic rocks. Doklady Acad. Nauk SSSR, 243, 191–194 (in Russian). (2) (1980) Amer. Mineral., 65, 205 (abs. ref. 1). (3) Jiang Xinshun, Li Wenkang, Zhang Shuxin, and Meng Fanyi (1985) Discovery of native aluminum in the oxidation zone in Getang, Anlong County, Guizhou Province. Bull. Chinese Acad. Geol. Sci., 11, 79–86 (in Chinese with English abs.). (4) Glavatskikh, S.F. (1990) Native metals and intermetallic compounds in the exhalation products of the Great Tolbachik fissure eruption (Kamchatka). Doklady Acad. Nauk SSSR, 313, 433–437 (in Russian). (5) (1953) NBS Circ. 539, 1, 11. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 25.

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Aluminocopiapite $Al_{2/3}Fe_4^{3+}(SO_4)_6(OH)_2 \cdot 20H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As minute scales and efflorescences.

Physical Properties: *Tenacity:* "Fragile". Hardness = [2–3] (by analogy to copiapite group members). D(meas.) = n.d. D(calc.) = 2.163 Somewhat soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Pale lemon-yellow to deep yellow. *Optical Class:* Biaxial (+). *Pleochroism:* Y = colorless; Z = greenish yellow. $\alpha = 1.525$ $\beta = 1.535$–1.540 $\gamma = 1.585$–1.590 2V(meas.) = Moderate.

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.30(1)$ $b = 18.80(2)$ $c = 7.31(1)$ $\alpha = 91.5(2)°$ $\beta = 102.3(2)°$ $\gamma = 98.7(1)°$ Z = 1

X-ray Powder Pattern: Forty Mile River, Alaska, USA [magnesian aluminocopiapite]. 9.2 (10), 18.1 (8), 5.58 (8), 6.17 (7), 3.58 (5), 3.50 (5), 5.32 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	40.59	39.18	39.64	MgO	0.28	1.94	
Al_2O_3	3.08	3.12	2.80	CaO	0.03		
Fe_2O_3	25.62	23.16	26.35	Na_2O	0.15		
FeO	1.03	0.17		K_2O	0.01		
MnO	0.08			H_2O	[29.13]	30.40	31.21
CoO		0.16		insol.		1.40	
CuO		0.05		Total	[100.00]	[99.58]	100.00

(1) 1-B mine, Canada; calculated from original elemental analysis, H_2O by difference; corresponds to $(Al_{0.70}Fe^{2+}_{0.18}Mg_{0.09}Na_{0.06}Mn_{0.01}Ca_{0.01})_{\Sigma=1.05}(Fe^{3+}_{3.95}Al_{0.05})_{\Sigma=4.00}(SO_4)_{6.24}(OH)_{2.26} \cdot 18.79H_2O$.
(2) Forty Mile River, Alaska, USA; original total given as 99.69%, corresponds to $(Mg_{0.59}Al_{0.32}Fe^{2+}_{0.03}Co_{0.03}Cu_{0.01})_{\Sigma=0.98}(Fe^{3+}_{3.57}Al_{0.43})_{\Sigma=4.00}(SO_4)_{6.02}(OH)_{2.22} \cdot 19.67H_2O$.
(3) $Al_{2/3}Fe^{3+}_4(SO_4)_6(OH)_2 \cdot 20H_2O$.

Mineral Group: Copiapite group.

Occurrence: A secondary mineral typically formed by the oxidation of pyrite in shales and coal; may be a fumarolic reaction product.

Association: Pyrite.

Distribution: In the USA, from "Temple Rock", [probably the Temple Mountain district, Emery Co.,] Utah; at Island Mountain, Trinity Co., and the Champion mine, White Mountains, Mono Co., California; in the Coeur d'Alene mine, Central City district, Gilpin Co., Colorado; from the Mosquito Fork of the Forty Mile River, Eagle A-3 quadrangle, Alaska. In the 1-B mine and the Emery seam at Glace Bay, Sydney Coalfield, Cape Breton, Nova Scotia, Canada. At Cerritos Bayos, southwest of Calama, Antofagasta, Chile. In Italy, from the Cetine mine, 20 km southwest of Siena, Tuscany, and at the Grotto de Faraglione, Port de Levante, Vulcano, Lipari Islands. In the Dolcoath mine, Camborne, Cornwall, England. From Morl, near Halle, Saxony-Anhalt, Germany.

Name: For its content of *aluminum* and relation to the *copiapite* group.

Type Material: National Museum of Natural History, Washington, D.C., USA, 93834, 103544.

References: (1) Berry, L.G. (1947) Composition and optics of copiapite. Univ. Toronto Studies, Geol. Ser., 51, 21–34 [aluminocopiapite]. (2) (1947) Amer. Mineral., 32, 483 (abs. ref. 1). (3) Zodrow, E.L. (1980) Hydrated sulfates from Sydney Coalfield, Cape Breton Island, Nova Scotia, Canada: the copiapite group. Amer. Mineral., 65, 961–967. (4) Bayliss, P. and A. Atencio (1985) X-ray powder diffraction data and cell parameters for copiapite-group minerals. Can. Mineral., 23, 53–56.

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Aluminocoquimbite $AlFe(SO_4)_3 \cdot 9H_2O$

Crystal Data: Hexagonal. *Point Group:* $\bar{3}\,2/m$. As intergrown tabular or short hexagonal prismatic crystals, to 0.5 mm.

Physical Properties: *Cleavage:* Imperfect, {101}. *Fracture:* n.d. Hardness = n.d. D(meas.) = 2.03(1) D(calc.) = 2.044

Optical Properties: Transparent. *Color:* Colorless to pale pink. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.53$ $\varepsilon = 1.56$

Cell Data: *Space Group:* $P\bar{3}\,1\,2/c$. $a = 10.7065(7)$ $c = 17.3077$ $Z = 4$

X-ray Powder Pattern: Aeolian Islands (Vulcano), Italy.
9.251 (100), 5.310 (83), 3.152 (43), 4.087 (33), 1.765 (20), 2.112 (17), 8.710 (13)

Chemistry:

	(1)
Fe_2O_3	13.96
Al_2O_3	10.30
SO_3	44.24
H_2O	[31.50]
Total	100.00

(1) Aeolian Islands (Vulcano), Italy; electron microprobe analysis, H_2O by difference, corresponding to $Al_{1.07}Fe_{0.92}S_{2.92}H_{18.49}O_{21}$.

Occurrence: A precipitate from volcanic vapors in a fumarole (< 100° C).

Association: Alunogen, coquimbite, krausite, tamarugite, yavapaiite, voltaite, pertlikite, pickeringite, metavoltine.

Distribution: Alum Grotto, Aeolian Islands (Vulcano), Italy.

Name: For its high *aluminum* content and relation to *coquimbite*.

Type Material: Department of Structural Chemistry and Inorganic Sterochemistry, University of Milan, Italy (2009-03).

References: (1) Demartin, F., C. Castellano, C.M. Gramaccioli, and I. Campostrini (2010) Aluminocoquibite, $AlFe(SO_4)_3 \cdot 9H_2O$, a new aluminum iron sulfate form Gortta Dell'Allume, Vulcano, Aeolian Islands, Italy. Can. Mineral., 48, 1465-1468. (2) (2013) Amer. Mineral., 98, 279 (abs. ref. 1).

Aluminum Al

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Typically granular massive, may be platy or scaly, to 1 mm.

Physical Properties: *Tenacity:* Malleable. Hardness = 2–3 D(meas.) = 2.707 D(calc.) = 2.697

Optical Properties: Opaque. *Color:* Grayish white. *Luster:* Metallic.
Optical Class: Isotropic.
R: n.d.

Cell Data: *Space Group:* $Fm3m$ (synthetic). $a = 4.0494$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.338 (100), 2.024 (47), 1.221 (24), 1.431 (22), 0.9289 (8), 0.9055 (8), 0.8266 (8)

Chemistry:

	(1)	(2)
Al	99.99 – 100.0	97.81
Total		

(1) Tolbachik volcano, Russia; by electron microprobe. (2) Getang, China; by electron microprobe.

Occurrence: In a gabbro-dolerite massif (Billeekh intrusion, Russia); in aluminum-rich rocks; in high-temperature hydrothermal Sn–W deposits and their alteration zones; in volcanic ash.

Association: Cu, Zn, Sn, Pb, Cd, Fe, Sb, moissanite (Billeekh intrusive, Russia); magnetite, ilmenite, hematite, pyrite, iron (Tolbachik volcano, Russia); Cu, S, jarosite (Getang, China).

Distribution: In Russia, in Siberia, from the Billeekh [TL], Tsepochechnyi, and Ust-Khann'ya intrusives, Vilyui River Basin; in the Nizhefokinskii intrusion, Norilsk district; from the Ukachilkan tin deposit, northeastern Sakha; and at the Tolbachik fissure volcano, Kamchatka Peninsula. In a mud volcano on Bulla Island, Caspian Sea. At Kyzylcheku, Karamazar, Tajikistan. From Getang, Guizhou Province, and in the Lianhuashan tungsten deposit, Guangdong Province, China.

Name: Named *aluminum* by Humphry Davy, who discovered the element.

Type Material: Geological Museum, Academy of Sciences, Yakutsk, Russia.

References: (1) Oleynikov, B.V, A.V. Okrugin, and N.V. Leskova (1978) Petrological significance of the occurrence of native aluminum in mafic rocks. Doklady Acad. Nauk SSSR, 243, 191–194 (in Russian). (2) (1980) Amer. Mineral., 65, 205 (abs. ref. 1). (3) Jiang Xinshun, Li Wenkang, Zhang Shuxin, and Meng Fanyi (1985) Discovery of native aluminum in the oxidation zone in Getang, Anlong County, Guizhou Province. Bull. Chinese Acad. Geol. Sci., 11, 79–86 (in Chinese with English abs.). (4) Glavatskikh, S.F. (1990) Native metals and intermetallic compounds in the exhalation products of the Great Tolbachik fissure eruption (Kamchatka). Doklady Acad. Nauk SSSR, 313, 433–437 (in Russian). (5) (1953) NBS Circ. 539, 1, 11. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 25.

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Alumoåkermanite $(Ca,Na)_2(Al,Mg,Fe^{2+})(Si_2O_7)$

Crystal Data: Tetragonal. *Point Group*: $\bar{4}\,2m$. Crystals, tabular, to 1.5 mm.

Physical Properties: *Cleavage*: none discernable. *Fracture*: Uneven.
Tenacity: Brittle. Hardness = 4.5-5 D(meas.) = 2.96(2) D(calc.) = 3.00

Optical Properties: Transparent. *Color*: Light brown. *Streak*: White. *Luster*: Vitreous.
Optical Class: Uniaxial (-). ω = 1.635(1) ε = 1.626(1)

Cell Data: *Space Group*: $P\bar{4}\,2_1m$. a = 7.7620(7) c = 5.0311(5) Z = 2

X-ray Powder Pattern: Oldoinyo Lengai volcano, northern Tanzania.
2.859 (100), 2.4563 (32), 3.075 (25), 1.7569 (19), 1.8303 (13) 1.7364 (13), 1.3859 (13)

Chemistry:

	(1)
SiO_2	43.73
TiO_2	0.09
Al_2O_3	8.32
Fe_2O_3	2.14
FeO	4.55
MnO	0.22
MgO	4.36
CaO	30.24
SrO	0.91
Na_2O	5.70
K_2O	0.10
Total	100.36

(1) Oldoinyo Lengai volcano, northern Tanzania; average of 8 electron microprobe analyses, corresponding to $(Ca_{1.48}Na_{0.50}Sr_{0.02}K_{0.01})_{\Sigma=2.01}(Al_{0.44}Mg_{0.30}Fe^{2+}_{0.17}Fe^{3+}_{0.07}Mn_{0.01})_{\Sigma=0.99}(Si_{1.99}Al_{0.01}O_7)$.

Mineral Group: Melilite group.

Occurrence: As phenocrysts in olivine-free melilite-nephelinitic ashes and lapilli-tuffs produced by a carbonatite volcano.

Association: Nepheline, aegirine-augite.

Distribution: From Oldoinyo Lengai volcano, northern Tanzania.

Name: For its composition and relationship to other members of the melilite group.

Type Material: Mineralogical Museum, Department of Mineralogy, St. Petersburg State University, St. Petersburg, Russia (OL218, catalog no. 1/19407); the Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (OL244, catalog no. 3823/1).

References: (1) Wiedenmann, D., A.N. Zaitsev, S.N. Britvin, S.V. Krivovichev, and J. Keller (2009) Alumoåkermanite, $(Ca,Na)_2(Al,Mg,Fe^{2+})(Si_2O_7)$, a new mineral from the active carbonatite-nephelinite-phonolite volcano Oldoinyo Lengai, northern Tanzania. Mineral. Mag., 73, 373–384.
(2) (2010) Amer. Mineral., 95, 1357 (abs. ref. 1).

Alumohydrocalcite $CaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As fibers and needles, to 2.5 mm; commonly in radial aggregates and spherulites, feltlike crystal linings, and powdery to chalky masses.

Physical Properties: *Cleavage:* {100} perfect; {010} imperfect. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.21–2.24 D(calc.) = 2.213 Decomposes in boiling H_2O to calcite and hydrous aluminum oxide.

Optical Properties: Transparent to opaque. *Color:* Chalky white to pale blue, pale yellow, cream, gray; pale rose or brownish pink to dark violet in chromian varieties; colorless in transmitted light. *Luster:* Vitreous to pearly, earthy.
Optical Class: Biaxial (–). *Orientation:* $X = b$; extinction inclined 6°–10°. α = 1.485–1.502 β = 1.553–1.563 γ = 1.570–1.585 2V(meas.) = 64° 2V(calc.) = 50°–55°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$ (chromian). $a = 6.498(3)$ $b = 14.457(4)$ $c = 5.678(3)$ $\alpha = 95.83(5)°$ $\beta = 93.23(3)°$ $\gamma = 82.24(3)°$ Z = 2

X-ray Powder Pattern: Bergisch-Gladbach, Germany.
6.25 (100), 6.50 (70), 3.23 (60), 2.039 (50), 2.519 (40), 7.21 (30), 2.860 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	24.2	26.4	26.19	CaO	17.8	16.5	16.68
Al_2O_3	31.3	22.0	30.33	H_2O	26.7	26.6	26.80
Cr_2O_3		8.3		Total	100.0	99.8	100.00

(1) Bergisch-Gladbach, Germany; $(CO_3)^{2-}$, $(OH)^{1-}$, and H_2O confirmed by IR. (2) Mount Hamilton area, California, USA; chromian, CO_2 by Leco carbon analyzer, H_2O by CEC moisture analyzer; corresponds to $Ca_{1.00}(Al_{1.57}Cr_{0.43})_{\Sigma=2.00}(CO_3)_2(OH)_4 \cdot 3H_2O$.
(3) $CaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$.

Occurrence: Formed at low temperature by the action of carbonated waters on allophane or dickite in dolomites and limestones; chromian varieties are typically formed near altering chromite from serpentinites.

Association: Allophane, dickite, gibbsite, gypsum, aragonite, barite, Fe–Mn oxides.

Distribution: From a Cu–V orebody near Potekhina village, 40 km northeast of Sorsk, Khakassia district, Siberia, Russia. In Germany, in a dolomite quarry near Bergisch-Gladbach, from the Kalem quarry, near Birresborn, Eifel, and at Ramsbeck, North Rhine-Westphalia. Near Ladomirov, Slovakia. From Bicske-Csordakút, Hungary. In England, at Scarborough, North Yorkshire; Weston Favell, Northamptonshire; and in the Woodleaze quarry, Tytherington, Avon. At Montcada, Barcelona Province, Spain. From Chitral, North-West Frontier Province, Pakistan. Chromian varieties occur at: the Ruben mine, Kohlendorf, Nowa Ruda (Neurode), Silesia, Poland. In the Akenobe mine, Hyogo Prefecture, Japan. From east of Mount Hamilton, Santa Clara Co., California, USA. Several other poorly defined localities are known.

Name: From *aluminum*; water, *hydro*; and calcium carbonate, *calcite*, in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 77088.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 280–281. (2) Kautz, K. (1968) Ein Vorkommen von Alumohydrocalcit und Allophan bei Bergisch-Gladbach. Neues Jahrb. Mineral., Monatsh., 350–358 (in German with English abs.). (3) Kautz, K. (1969) Elektronenbeugung und Infrarot-Untersuchungen an Alumohydrocalcit. Neues Jahrb. Mineral., Monatsh., 130–137 (in German with English abs.). (4) Paar, W. (1979) Ein Vorkommen von Alumohydrocalcit von Chitral, Westpakistan, und neue Beobachtungen an chromhaltigem Alumohydrocalcit von Nowej Rudy, Polen (= Neurode, Schlesien). Aufschluss, 28, 269–272 (in German). (5) Roberts, A.C. and M. Bonardi (1983) The X-ray crystallography of a chromian alumohydrocalcite from the Akenobe mine, Hyogo Prefecture, Japan. Geol. Surv. Can. Paper 83-1A, 477–479. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 25.

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Alumoklyuchevskite $K_3Cu_3AlO_2(SO_4)_4$

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Crystal Data: Monoclinic. *Point Group:* 2. Long prismatic to needlelike crystals, with equant cross section, elongated parallel [010], to 1 mm; in aggregates.

Physical Properties: *Cleavage:* {*h*0*l*}, perfect. Hardness = 2.3 VHN = 42
D(meas.) = 3.1(1) D(calc.) = 2.95 Turns white on exposure to air, possibly from hydration.

Optical Properties: Transparent. *Color:* Dark green.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = pale green; Y = grayish green; Z = dark green. *Orientation:* $Y = b$; $X \perp b$; $Y \perp b$. $\alpha = 1.542(1)$ $\beta = 1.548(1)$ $\gamma = 1.641(1)$
2V(meas.) = n.d. 2V(calc.) = 30°

Cell Data: *Space Group:* $I2$. $a = 18.423(5)$ $b = 5.139(1)$ $c = 18.690(7)$ $\beta = 101.72(2)°$
Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia; similar to klyuchevskite.
9.04 (100), 9.15 (84), 7.20 (52), 3.781 (37), 3.757 (33), 2.786 (21), 4.509 (15)

Chemistry:

	(1)	(2)
SO_3	40.70	42.63
Al_2O_3	4.65	6.79
Fe_2O_3	3.70	
CuO	31.19	31.77
K_2O	18.68	18.81
Total	98.92	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of 26 analyses; corresponds to $K_{3.07}Cu_{3.04}(Al_{0.71}Fe_{0.36})_{\Sigma=1.07}O_2(S_{0.98}O_4)_4$. (2) $K_3Cu_3AlO_2(SO_4)_4$.

Occurrence: Deposited by fumarolic gases.

Association: Fedotovite, tenorite, lammerite, averievite, piypite, langbeinite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: For *aluminum* in its composition and its relation to *klyuchevskite*.

Type Material: St. Petersburg Mining Institute, St. Petersburg, Russia, 2072/1.

References: (1) Gorskaya, M.G., L.P. Vergasova, S.K. Filatov, D.V. Rolich, and V.V. Ananiev (1995) Alumoklyuchevskite, $K_3Cu_3AlO_2(SO_4)_4$, a new oxysulfate of K, Cu and Al from volcanic exhalations, Kamchatka, Russia. Zap. Vses. Mineral. Obshch., 124(1), 95–100 (in English).
(2) (1996) Amer. Mineral., 81, 249–254 (abs. ref. 1).

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Alumopharmacosiderite $KAl_4(AsO_4)_3(OH)_4 \cdot 6.5H_2O$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. As fine-grained polycrystalline aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.676

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Isotropic. $n = 1.565(2)$

Cell Data: *Space Group:* $P\overline{4}3m$. $a = 7.745(1)$ Z = [1]

X-ray Powder Pattern: Guanaco, Chile.
7.77 (100), 2.739 (60), 4.48 (50), 3.16 (50), 3.87 (40), 2.335 (40), 2.452 (30)

Chemistry:

	(1)	(2)
As_2O_5	44.3	46.03
Al_2O_3	24.0	27.23
Fe_2O_3	3.9	
CuO	trace	
K_2O	7.5	6.29
H_2O	20.3	20.45
Total	100.0	100.00

(1) Guanaco, Chile; by electron microprobe, average of four analyses, total Fe as Fe_2O_3, H_2O determined separately; after normalization to 79.7%, corresponds to $K_{1.24}(Al_{3.69}Fe^{3+}_{0.38})_{\Sigma=4.07}(AsO_4)_3(OH)_4 \cdot 6.5H_2O$. (2) $KAl_4(AsO_4)_3(OH)_4 \cdot 6.5H_2O$.

Occurrence: With other oxidized arsenates on a museum specimen.

Association: Ceruleite, olivenite, schlossmacherite, mansfieldite, quartz.

Distribution: From the [Emma Luisa gold mine,] Guanaco district, about 100 km east-northeast of Taltal, Antofagasta, Chile.

Name: As the ALUMinum analog of *pharmacosiderite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149527.

References: (1) Schmetzer, K., W. Horn, and H. Bank (1981) Alumopharmakosiderit, $KAl_4[(OH)_4|(AsO_4)_3] \cdot 6,5H_2O$, ein neues Mineral. Neues Jahrb. Mineral., Monatsh., 97–102 (in German with English abs.). (2) (1981) Amer. Mineral., 66, 1099 (abs. ref. 1).

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals euhedral to subhedral, to 1 mm, elongated with rhombic to rectangular cross-section. As rims and parallel oriented intergrowths on simpsonite, also rims around natrotantite, which in turn rims simpsonite crystals.

Physical Properties: Hardness = n.d. VHN = 1650–1690 (100 g load). D(meas.) = n.d. D(calc.) = 7.48 Bright blue cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Colorless to white.
Luster: Adamantine to greasy.
Optical Class: Biaxial (–). $\alpha = > 2.0$ $\beta = > 2.0$ $\gamma = > 2.0$ 2V(meas.) = 66(2)°
Anisotropism: Observed.
R_1–R_2: (486) 15.6–14.7, (589) 15.4–14.6, (656) 15.9–15.1

Cell Data: *Space Group: Pbcn.* a = 4.473–4.477 b = 11.308–11.309 c = 4.767–4.775
Z = 4

X-ray Powder Pattern: Kola Peninsula, Russia.
3.13 (10), 2.89 (8), 3.64 (7b), 5.66 (5), 2.439 (5), 1.837 (5), 1.649 (5)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	0.80	0.0	0.0
Ta_2O_5	81.13	80.9	81.6
SnO_2		1.0	0.2
Al_2O_3	18.47	18.9	18.6
Total	100.40	100.8	100.4

(1) Kola Peninsula, Russia; by electron microprobe, corresponding to $Al_{0.98}(Ta_{0.99}Nb_{0.02})_{\Sigma=1.01}O_4$. (2) Bikita, Zimbabwe; by electron microprobe, corresponding to $Al_{1.00}Ta_{0.98}Sn_{0.02}O_4$. (3) Alto do Giz pegmatite, Brazil; by electron microprobe, corresponding to $Al_{0.99}Ta_{1.00}O_4$.

Occurrence: In albitized areas of highly fractionated rare element-enriched granite pegmatites.

Association: Simpsonite, natrotantite, microlite, cesstibtantite, sosedkoite, albite (Kola Peninsula, Russia); simpsonite, manganoan tapiolite, manganotantalite, zirconian hafnon, apatite, albite, muscovite (Bikita, Zimbabwe); simpsonite, manganotantalite, microlite, parabariomicrolite (Alto do Giz pegmatite, Brazil).

Distribution: From an undisclosed locality [Leshaia pegmatite, Vuoriyarvi carbonatite complex] on the Kola Peninsula, Russia. In the Mdara mine, Bikita, Zimbabwe. From the Alto do Giz pegmatite, near Parelhas, Rio Grande do Norte, Brazil.

Name: For ALUMinum and TANTalum in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, Russia.

References: (1) Voloshin, A.V., Y.P. Men'shikov, and Y.A. Pakhomovskii (1981) Alumotantite and natrotantite, new tantalum minerals in granitic pegmatites. Zap. Vses. Mineral. Obshch., 110, 338–345 (in Russian). (2) (1982) Amer. Mineral., 67, 413 (abs. ref. 1). (3) Ercit, T.S., F.C. Hawthorne, and P. Černý (1992) The crystal structure of alumotantite: its relation to the structures of simpsonite and the $(Al, Ga)(Ta, Nb)O_4$ compounds. Can. Mineral., 30, 653–662.

Alumotungstite $(W, Al)(O, OH)_3(?)$

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Crystal Data: Cubic; may be rhombohedral, pseudocubic. *Point Group:* $4/m\ \bar{3}\ 2/m$ (probable). As octahedra, to 250 μm, may be flattened with a hexagonal outline, and as rounded groups of octahedra; zoned with a separable outer shell. In microcrystalline patches; intimately intergrown with yttrotungstite or ferritungstite. *Twinning:* Interpenetrant octahedra may represent twins on {111}.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [4.52]

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Isotropic; commonly weakly anisotropic. $n = 1.935(5)$; birefringence 0.02.

Cell Data: *Space Group:* $Fd3m$ (probable). $a = 10.20$ $Z = 16$

X-ray Powder Pattern: Kramat Pulai mine, Malaysia; some lines are finely split; may be confused with ferritungstite, with which it is commonly intergrown.
5.86 (vvs), 3.07 (vs), 2.93 (vs), 1.80 (s), 1.96 (ms), 1.72 (ms), 1.54 (ms)

Chemistry:

	(1)
WO_3	88.0
SiO_2	0.24
Al_2O_3	8.3
Fe_2O_3	0.06
CaO	0.77
Total	[97.4]

(1) Kramat Pulai mine, Malaysia; by electron microprobe, here calculated to oxides from original analysis W 69.8%, Al 4.4%, Si 0.11%, Fe 0.04%, Ca 0.55%, K trace, Y not detected.

Occurrence: In fine-grained aggregates of yttrotungstite (Kramat Pulai mine, Perak, Malaysia); lining cavities relict after ferberite, which has replaced scheelite, in fine-grained graphitic schists and contained quartz veins (Uganda and Rwanda).

Association: Yttrotungstite (Kramat Pulai mine, Malaysia); ferritungstite, cerotungstite, anthoinite, ferberite (Uganda and Rwanda).

Distribution: At the Kramat Pulai mine, Kinta district, Perak, Malaysia. From the Nyamulilo and Kirwa mines, Kigezi district, Uganda. At Gifurwe, Rwanda.

Name: For its ALUMinum content, by analogy to ferriTUNGSTITE.

Type Material: The Natural History Museum, London, England, 1927,1157.

References: (1) Davis, R.J. and G.W. Smith (1971) Yttrotungstite. Mineral. Mag., 38, 261–285. (2) Davis, R.J., J.G. Francis, and S.J.B. Reed [alumotungstite]. In: M. Fleischer (1977) U.S. Geol. Surv. Open-File Report 81-1169. (3) Sahama, T.G. (1981) The secondary tungsten minerals, a review. Mineral. Record, 12, 81–87.

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Alunite $KAl_3(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$ or $3m$. Crystals typically pseudocubic $\{01\overline{1}2\}$ or tabular $\{0001\}$ with flat vicinal rhombohedra, to 1 cm; fibrous to columnar, porcelaneous, commonly granular to dense massive.

Physical Properties: *Cleavage:* On $\{0001\}$, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.6–2.9 D(calc.) = 2.82 Strongly pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless if pure; may be white, pale shades of gray, yellow, red, to reddish brown. *Streak:* White. *Luster:* Vitreous, somewhat pearly on $\{0001\}$.
Optical Class: Uniaxial (+). $\omega = 1.572$ $\epsilon = 1.592$

Cell Data: *Space Group:* $R\overline{3}m$ or $R3m$ (synthetic). $a = 6.981(1)$ $c = 17.331(4)$ Z = 3

X-ray Powder Pattern: Marysvale, Utah, USA.
2.89 (100), 2.99 (94), 2.293 (76), 1.926 (66), 4.96 (50), 1.503 (34), 5.77 (26)

Chemistry:

	(1)	(2)
SO_3	38.34	38.66
P_2O_5	0.58	
SiO_2	0.22	
Al_2O_3	37.18	36.92
Na_2O	0.33	
K_2O	10.46	11.37
H_2O	12.99	13.05
Total	100.10	100.00

(1) Marysvale, Utah, USA. (2) $KAl_3(SO_4)_2(OH)_6$.

Polymorphism & Series: Forms a series with natroalunite.

Mineral Group: Alunite group.

Occurrence: Formed between 15 °C and 400 °C by the action of sulfate, which may be generated from pyrite or solfataric action, on aluminous rocks, commonly accompanied by kaolinitization and silicification.

Association: Kaolinite, halloysite, diaspore, pyrite, gypsum, quartz.

Distribution: Many localities, some with deposits of immense size. From Tolfa, 14 km east-northeast of Civitavecchia, Lazio, Italy. At Mukacheve (Muzijeva) and from Beregavo, near Mukachevo, Ukraine. At Rodalquilar, Almeria Province, Spain. From Décazeville, Aveyron, France. In the USA, in a very large deposit near Marysvale, Ohio district, Piute Co., Utah; in Colorado, at South River, Mineral Co., Red Mountain, Hinsdale Co., in the Rosita Hills, Custer Co., and approximately 100 million t in the Calico Peak porphyry, Rico district, Dolores Co.; at Meiklejohn Mountain, near Beatty, Nye Co., Nevada; in Lassen Volcanic National Park, Shasta Co., California. From Hickory's Pond, near Placentia Bay, Newfoundland, Canada. At Hilton, Bernborough, and other localities in the Mount Isa district, Queensland; from Bullah Delah, New South Wales, Australia.

Name: A contraction of the earlier name *aluminilite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 556–560. (2) Parker, R.L. (1962) Isomorphous substitution in natural and synthetic alunite. Amer. Mineral., 47, 127–136. (3) Stoffregen, R.E. and C.N. Alpers (1992) Observations on the unit-cell dimensions, H_2O contents, and δD values of natural and synthetic alunite. Amer. Mineral., 77, 1092–1098. (4) Menchetti, S. and C. Sabelli (1976) Crystal chemistry of the alunite series: crystal structure refinement of alunite and synthetic jarosite. Neues Jahrb. Mineral., Monatsh., 406–417.

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Alunogen $Al_2(SO_4)_3 \cdot 17H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals rare, as thin plates or prismatic [001] or {010} with a six-sided outline about [010], very complex, with about 60 forms noted. Commonly fibrous, to 5 mm, forming delicate masses, crusts, and efflorescences. *Twinning:* On {010}.

Physical Properties: *Cleavage:* {010}, perfect; probable on {100} and {$\overline{3}13$}.
Hardness = 1.5–2 D(meas.) = 1.72–1.77 D(calc.) = 1.79 Soluble in H_2O; taste alumlike, acid and sharp.

Optical Properties: Transparent. *Color:* Colorless in crystals, aggregates white, or pale yellow or red from impurities; colorless in transmitted light. *Luster:* Vitreous to silky.
Optical Class: Biaxial (+). *Orientation:* $X \simeq b$; $Z \wedge c = 42°$. α = 1.459–1.475
β = 1.461–1.478 γ = 1.470–1.485 2V(meas.) = 31°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.420(6)$ $b = 26.97(2)$ $c = 6.062(5)$ $\alpha = 89°57(5)'$
$\beta = 97°34(5)'$ $\gamma = 91°53(5)'$ Z = 2

X-ray Powder Pattern: Nová Baňa, Slovakia.
4.489 (100), 4.390 (81), 3.969 (81), 4.329 (76), 13.46 (54), 3.897 (52), 3.675 (45)

Chemistry:

	(1)	(2)
SO_3	37.74	37.04
Al_2O_3	16.59	15.73
H_2O	44.64	47.23
insol.	0.94	
Total	99.91	100.00

(1) Pintado Canyon, Guadalupe Co., New Mexico, USA. (2) $Al_2(SO_4)_3 \cdot 17H_2O$.

Occurrence: Forms by reaction of sulfates from decomposing sulfides with aluminous minerals in shales and slates; in gossan or altered wall rock of pyritic deposits in arid regions; in coal seams; in relatively low-temperature fumaroles.

Association: Pyrite, marcasite, halotrichite, pickeringite, epsomite, alum, melanterite, gypsum.

Distribution: Many localities, at some in large amounts. From near Nová Baňa (Königsberg), Slovakia. In Italy, on Vesuvius, and from Solfatara di Pozzuoli, Campi Flegrei, and at Miseno, near Naples, Campania; on Vulcano, Lipari Islands. In France, at Sain-Bel, Rhône; in coal at Ronchamp, Haute-Saône. At Libros, near Teruel, Teruel Province, Spain. From the Stamm Asser mine, near Schwartzenberg, and at Bräunsdorf, near Freiberg, Saxony, Germany. From the Avacha and other volcanoes, Kamchatka Peninsula, Russia. In Chile, at Francisco de Vergara, Antofagasta, and from Cerros Pintados, near Iquique, Tarapacá. On Mount Pelée, Martinique. In the USA, abundant at Smoky Mountain, Jackson Co., North Carolina; at Alum Cave Bluff, Sevier Co., Tennessee; extensive deposits in the Alum Mountain district, Grant Co., New Mexico; at The Geysers, Sonoma Co., California; good crystals from the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah; from the Mount St. Augustine volcano, Alaska. In Canada near Vernon, British Columbia; and Scotia mine, Cumberland Co., Nova Scotia. At geothermal areas of Tengchong, Yunnan Province, China. Found in the Heritage Range, Ellsworth Mountains, Antarctica. From near Joadja, New South Wales, Australia.

Name: From the Latin for *alum* and the Greek for *to make*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 537–540. (2) Cesbron, F. and M. Sadrzadeh (1972) Nouvelles données sur l'alunogène $Al_2(SO_4)_3 \cdot 18H_2O$. Bull. Soc. fr. Minéral., 96, 385–387 (in French). (3) Fang, J. H. and P.D. Robinson (1976) Alunogen, $Al_2(H_2O)_{12}(SO_4)_3 \cdot 5H_2O$: its atomic arrangement and water content. Amer. Mineral., 61, 311–317.

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Alvanite $(Zn, Ni)Al_4(VO_3)_2(OH)_{12}\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In hexagonal platelets, micalike, with forms {001}, {010}, {100}, and {101}. *Twinning:* Polysynthetic, ∥ {010}.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 3–3.5 D(meas.) = 2.49 D(calc.) = 2.492

Optical Properties: Semitransparent. *Color:* Pale bluish green to bluish black. *Streak:* White. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (–). *Orientation:* $X \wedge \{010\} = 14°$. *Dispersion:* $r < v$, strong. $\alpha = 1.658$ $\beta =$ n.d. $\gamma = 1.714$ 2V(meas.) = 80°–85°

Cell Data: *Space Group:* $P2_1/n$. $a = 17.808(8)$ $b = 5.132(3)$ $c = 8.881(4)$ $\beta = 92.11(3)°$ Z = 2

X-ray Powder Pattern: Kazakhstan.
4.46 (100), 8.91 (90), 7.85 (80), 5.02 (50), 1.973 (40), 3.287 (35), 2.957 (35)

Chemistry:

	(1)	(2)		(1)	(2)
V_2O_5	24.2	27.5	NiO	2.7	4.2
V_2O_4	3.8		ZnO	0.5	7.6
SiO_2	1.8		MgO	0.5	
Al_2O_3	39.5	34.2	CaO	0.5	
Fe_2O_3	trace		H_2O^+	25.4	
V_2O_3	0.0		H_2O^-	0.5	
FeO		0.3	H_2O		[26.2]
			Total	99.4	[100.0]

(1) Kazakhstan; several values are averages of two determinations. (2) Do.; by electron microprobe, H_2O by difference; corresponding to $(Zn_{0.57}Ni_{0.34}Fe_{0.02})_{\Sigma=0.93}Al_{4.09}V_{1.84}O_{20.50}H_{17.69}$.

Occurrence: In the oxidation zone of a vanadiferous clay-anthraxolite horizon.

Association: Mica, roscoelite (?).

Distribution: In several mines of the Kurumsak and Balasauskandyk districts, northwestern Kara-Tau Mountains, Kazakhstan.

Name: For ALuminum and VANadium in the composition.

Type Material: Mining Institute, St. Petersburg, 1249/2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 65614.

References: (1) Ankinovich, E.A. (1959) New vanadium minerals – satpaevite and al'vanite [alvanite]. Zap. Vses. Mineral. Obshch., 88, 157–164 (in Russian). (2) (1959) Amer. Mineral., 44, 1325–1326 (abs. ref. 1). (3) Pertlik, F. and P.J. Dunn (1990) Crystal structure of alvanite, $(Zn, Ni)Al_4(VO_3)_2(OH)_{12}\cdot 2H_2O$, the first example of an unbranched zweier-single chain vanadate in nature. Neues Jahrb. Mineral., Monatsh., 385–392. (4) Dunn, P.J., A.C. Roberts, and F. Pertlik (1990) Alvanite from Kazakhstan, U.S.S.R.: new crystallographic and chemical data. Mineral. Mag., 54, 609–611.

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Amakinite $(Fe^{2+}, Mg)(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. Rhombohedra $\{10\overline{1}1\}$ modified by $\{10\overline{1}2\}$, $\{10\overline{1}4\}$, $\{11\overline{2}3\}$, $\{20\overline{2}5\}$, $\{0001\}$, to 2 cm; typically in irregular grains.

Physical Properties: *Cleavage:* Poor, observed in some grains. *Fracture:* Irregular. Hardness = 3.5–4 D(meas.) = 2.925–2.98 D(calc.) = [2.74] Weakly magnetic.

Optical Properties: Semitransparent. *Color:* Pale green to yellow-green; rapidly turns brown when exposed to air, due to formation of $Fe(OH)_3$.
Optical Class: Uniaxial (+). $\omega = 1.707(2)$ $\epsilon = 1.722(2)$

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. $a = 6.917(3)$ $c = 14.52(1)$ $Z = 12$

X-ray Powder Pattern: Lucky Eastern pipe, Russia.
2.30 (10), 1.728 (9), 2.80 (8), 1.530 (8), 5.49 (7), 1.551 (7), 1.386 (7)

Chemistry:

	(1)	(2)
SiO_2	0.43	
TiO_2	0.00	
Al_2O_3	0.32	2.50
Fe_2O_3	31.58	
Cr_2O_3	0.00	
FeO	30.40	55.84
MnO	3.63	2.94
MgO	10.10	11.60
CaO	trace	
H_2O^+	23.04	26.13
H_2O^-	0.09	0.49
CO_2	0.32	
Total	99.91	99.50

(1) Lucky Eastern pipe, Russia; corresponds to $(Fe_{0.73}Mg_{0.22}Mn_{0.05})_{\Sigma=1.00}(OH)_2$. (2) Do.

Mineral Group: Brucite group.

Occurrence: Noted in drill core, in thin veins and pockets in kimberlite.

Association: Serpentine, carbonate.

Distribution: In the Udachnaya-Vostochnaya kimberlite pipe, Daldyn-Alakit region, western Sakha, Russia.

Name: For the Amakin Expedition, which prospected the Sakhan diamond deposits.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69547.

References: (1) Kozlov, I.T. and P.P. Levshov (1962) Amakinite, a new mineral of the brucite-pyrochroite group. Zap. Vses. Mineral. Obshch., 91, 72–77 (in Russian). (2) (1962) Amer. Mineral., 47, 1218 (abs. ref. 1). (3) Sviridov, V.F. and T.A. Yakovlevskaya (1973) New data on amakinite from the kimberlitic pipe "Udachnaya". Izv. Akad. Nauk SSSR, Ser. Geol., 10, 144–147 (in Russian). (4) Lutz, H.D., H. Möller, and M. Schmidt (1994) Lattice vibration spectra. Part LXXXII. Brucite-type hydroxides $M(OH)_2$ (M=Ca, Mn, Co, Fe, Cd) – IR and Raman spectra, neutron diffraction of $Fe(OH)_2$. J. Molecular Structure, 328, 121–132.

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Amarantite $Fe_2^{3+}O(SO_4)_2 \cdot 7H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals, to 2 cm, elongated along [001], with dominant {100} and {010}, and square cross section; also flattened [100] and striated on {001}; more than 60 forms recorded; typically in radiating or matted aggregates of needles; columnar or bladed.

Physical Properties: *Cleavage:* Perfect on {010} and {100}. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.189–2.286 D(calc.) = 2.14 Decomposes in H_2O, leaving an insoluble residue.

Optical Properties: Transparent. *Color:* Amaranth-red to brownish red and red-orange. *Streak:* Lemon-yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale yellow; Z = reddish brown. *Orientation:* X (82°,72°); Y (178°,68°); Z (–44°,29°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. *Dispersion:* $r < v$, horizontal. $\alpha = 1.516$ $\beta = 1.598$ $\gamma = 1.621$ 2V(meas.) = 30°–36°

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.976(1)$ $b = 11.678(2)$ $c = 6.698(2)$ $\alpha = 95.65(2)°$ $\beta = 90.36(1)°$ $\gamma = 97.20(2)°$ Z = 2

X-ray Powder Pattern: Sierra Gorda [district], Chile.
11.25 (FFF), 8.69 (FFF), 3.57 (FF), 3.05 (FF), 3.11 (F), 5.16 (mF), 4.98 (mF)

Chemistry:

	(1)	(2)
SO_3	36.18	35.91
Fe_2O_3	35.92	35.81
H_2O	28.13	28.28
Total	100.23	100.00

(1) Paposa, Chile. (2) $Fe_2O(SO_4)_2 \cdot 7H_2O$.

Occurrence: A secondary mineral formed especially in arid climates.

Association: Hohmannite, fibroferrite, chalcanthite, copiapite, coquimbite, sideronatrite.

Distribution: In Chile, in Antofagasta, from the Union mine, Reventon district, near Paposo, at the Compania mine, east of Sierra Gorda; from Quetena, west of Calama, Alcaparrosa, near Cerritos Bayos, southwest of Calama, and at Chuquicamata; at Tierra Amarilla, southeast of Copiapó, Atacama. In the USA, in the Santa Maria Mountains, Riverside Co., California. At Saghand, Yazd, Iran.

Name: From the Greek for *amaranth*, an imaginary purplish red undying flower, for its color.

Type Material: BAF, 44700.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 611–613. (2) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French). (3) Süsse, P. (1968) The crystal structure of amarantite, $Fe_2(SO_4)_2O \cdot 7H_2O$. Zeits. Krist., 127, 261–275.

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Amarillite $NaFe^{3+}(SO_4)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Equant, complexly faceted crystals, thick tabular or rarely prismatic ‖ [001], with common forms {001}, {100}, {110}, {$\bar{1}$01}, and {111}; as groupings of parallel individuals, to 2 mm.

Physical Properties: *Cleavage:* {110}, good, but difficult. *Fracture:* Conchoidal. Hardness = 2.5–3 D(meas.) = 2.19–2.20 D(calc.) = 2.22 Soluble in H_2O; taste astringent.

Optical Properties: Transparent. *Color:* Pale yellow with a greenish tint. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = -39°$; $Z \wedge c = 51°$. *Dispersion:* $r < v$. $\alpha = 1.532(2)$ $\beta = 1.555(3)$ $\gamma = 1.591(2)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $C2/c$. $a = 8.4190(61)$ $b = 10.8409(40)$ $c = 12.4717(50)$ $\beta = 95.495(47)°$ Z = 4

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SO_3	43.59	42.24
Fe_2O_3	21.39	21.06
Na_2O	7.14	8.18
H_2O	28.45	28.52
Total	100.57	100.00

(1) Tierra Amarilla, Chile. (2) $NaFe(SO_4)_2 \cdot 6H_2O$.

Occurrence: Formed in the oxidation zones of sulfide deposits.

Association: Coquimbite, other sulfates.

Distribution: From Tierra Amarilla, southeast of Copiapó, Atacama, Chile. At the Xitieshan Pb–Zn mine, south of Mt. Qilianshan, Chaidamu, Qinghai Province, China.

Name: For the locality at Tierra Amarilla, Chile.

Type Material: National School of Mines, Paris, France, 133.69.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 468–469. (2) Li Jia-Ju, Zhou Jing-Liang, and Dong Wei (1990) The structure of amarillite. Chinese Science Bulletin, 35(24), 2073–2075 (in English).

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Amblygonite $LiAl(PO_4)(F,OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crude crystals, typically equant with complex form development, to 1.5 m; massive. *Twinning:* On several laws, with microscopic polysynthetic twinning common.

Physical Properties: *Cleavage:* {100}, perfect; {110}, good; {$0\overline{1}1$}, distinct; {001} imperfect [morphological orientation of ref. (1)]. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.04–3.11 D(calc.) = [3.13]

Optical Properties: Transparent to translucent. *Color:* Milk-white, pale yellow, beige, salmon-pink, pale green, pale blue, gray, may be colorless; colorless in transmitted light. *Luster:* Vitreous to greasy, pearly on good cleavages.
Optical Class: Biaxial (–). *Orientation:* Euler angles $\phi = 55.5°$; $\psi = 30.0°$; $\theta = 18.2°$ [for amblygonite 92%]. *Dispersion:* $r > v$. $\alpha = 1.577$–1.591 $\beta = 1.592$–1.605 $\gamma = 1.596$–1.613 2V(meas.) = 107°–129.5°

Cell Data: *Space Group:* $C\overline{1}$. $a = 6.644(2)$ $b = 7.744(2)$ $c = 6.910(1)$ $\alpha = 90.35(2)°$ $\beta = 117.33(2)°$ $\gamma = 91.01(2)°$ Z = 4

X-ray Powder Pattern: Chursdorf, Germany.
3.151 (vvsb), 4.642 (vs), 2.955 (vs), 3.237 (ms), 1.935 (ms), 3.300 (m), 2.384 (m)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	48.44	48.31	F	13.06	6.47
Al_2O_3	33.90	34.70	H_2O	0.00	3.07
Li_2O	10.12	10.17	$-O = F_2$	5.50	2.72
			Total	100.02	100.00

(1) [Chursdorf, Germany]; by electron microprobe, corresponds to $Li_{1.00}Al_{0.98}(PO_4)_{1.01}F_{1.02}$.
(2) $LiAl(PO_4)(F,OH)$ with F:OH = 1:1.

Polymorphism & Series: Forms a series with montebrasite.

Mineral Group: Amblygonite group.

Occurrence: An uncommon accessory mineral in zoned granite pegmatites; in high-temperature tin veins and greisens.

Association: Lacroixite, apatite, lithiophilite, spodumene, lepidolite, petalite, pollucite, tourmaline (pegmatites); cassiterite, topaz, mica (greisens).

Distribution: Much less common than montebrasite. The few localities for analyzed material include: from Chursdorf and Arnsdorf, near Penig, Saxony, Germany. On Utö Island, near Stockholm, Sweden. In the USA, at Hebron, Oxford Co., Maine; large crystals in San Domingo Wash, northeast of Wickenburg, Maricopa Co., Arizona. From the Tanco pegmatite, Bernic Lake, Manitoba, Canada. At Coolgardie, Western Australia. From near Karibib, Namibia. In the Muiâne pegmatite, Alto Ligonha district, Mozambique.

Name: From the Greek for *blunt* and *angle*, for its ∼90° cleavage angle.

Type Material: Mining Academy, Freiberg, Germany, 20336.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 823–827. (2) Moss, A.A., E.E. Fejer, and P.G. Embrey (1969) On the X-ray identification of amblygonite and montebrasite. Mineral. Mag., 37, 414–422. (3) Černá, I., P. Černý, and R.B. Ferguson (1973) The fluorine content and some physical properties of the amblygonite-montebrasite minerals. Amer. Mineral., 58, 291–301. (4) Greiner, D.J. and F.D. Bloss (1987) Amblygonite-montebrasite optics: response to $(OH)^-$ orientation and rapid estimation of F from 2*V*. Amer. Mineral., 72, 617–624. (5) Groat, L.A., M. Raudsepp, F.C. Hawthorne, T.S. Ercit, B.L. Sherriff, and J.S. Hartman (1990) The amblygonite-montebrasite series: characterization by single-crystal structure refinement, infrared spectroscopy, and multinuclear MAS-NMR spectroscopy. Amer. Mineral., 75, 992–1008.

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Ameghinite $NaB_3O_3(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [010], may be bent or curved, showing {001}, {010}, {100}, {110}, {011}, {101}, {$\overline{1}$01}, {310}, to 5 mm; as cluster of crystals and nodular masses.

Physical Properties: *Cleavage:* {100}, very good; {001} and {010}, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.030(6) D(calc.) = 2.037 Soluble in H_2O; pale blue fluorescence and phosphorescence under SW and LW UV.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 9°$. *Dispersion:* $r < v$, weak. $\alpha = 1.429(1)$ $\beta = 1.528(1)$ $\gamma = 1.538(1)$ 2V(meas.) = 33°

Cell Data: *Space Group:* $C2/c$. $a = 18.428(3)$ $b = 9.882(2)$ $c = 6.326(2)$ $\beta = 104°23(6)'$ Z = 8

X-ray Powder Pattern: Tincalayu deposit, Argentina.
3.064 (100), 3.147 (76), 2.548 (29), 3.352 (17), 2.914 (17), 4.951 (13), 2.655 (11)

Chemistry:

	(1)	(2)
B_2O_3	59.3	60.91
Na_2O	19.5	18.08
H_2O^+	20.7	
H_2O^-	0.6	
H_2O		21.01
Total	100.1	100.00

(1) Tincalayu deposit, Argentina; corresponds to $Na_{1.11}B_{3.00}O_3(OH)_{4.05}$. (2) $NaB_3O_3(OH)_4$.

Occurrence: Formed in massive borax in a borate-rich playa.

Association: Tincalconite, borax, ezcurrite, rivadavite.

Distribution: From the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina.

Name: Honors two brothers, Carlos Ameghino (1865–1936) and Florentino Ameghino (1854–1911), Argentine geologists.

Type Material: Natural History Museum, Paris, France; Harvard University, Cambridge, Massachusetts, 109054; National Museum of Natural History, Washington, D.C., USA, 137297.

References: (1) Aristarain, L.F. and C.S. Hurlbut, Jr. (1967) Ameghinite, $Na_2O•3B_2O_3•4H_2O$, a new borate from Argentina. Amer. Mineral., 52, 935–945. (2) Dal Negro, A., J.M.M. Pozas, and L. Ungaretti (1975) The crystal structure of ameghinite. Amer. Mineral., 60, 879–883.

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Amesite $Mg_2Al(SiAl)O_5(OH)_4$

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Crystal Data: Triclinic. *Point Group:* 1. As tapering pseudohexagonal prisms elongated along [001], to 2 mm; also tabular. *Twinning:* Common as six-fold sector twins on {001} and polysynthetic twins ∥ {010} prism edges.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 2.78 D(calc.) = 2.70

Optical Properties: Transparent. *Color:* Colorless, white, pink to lilac, or pale green. *Streak:* White with pale green tint. *Luster:* Pearly to somewhat metallic on cleavage surfaces. *Optical Class:* Biaxial (+). *Dispersion:* $r < v$. $\alpha = 1.5967(5)$ $\beta = 1.5986(5)$ $\gamma = 1.615(1)$ 2V(meas.) = 18°

Cell Data: *Space Group:* $C1$. $a = 5.307(1)$ $b = 9.195(2)$ $c = 14.068(3)$ $\alpha = 90.09(2)°$ $\beta = 90.25(2)°$ $\gamma = 89.96(2)°$ Z = [4]

X-ray Powder Pattern: Saranovskoye deposits, Russia; $2H_2$.
7.0 (100), 3.51 (100), 2.476 (80), 1.925 (70), 1.528 (60), 2.600 (40), 1.462 (35)

Chemistry:

	(1)	(2)	(3)
SiO_2	20.95	22.39	21.56
Al_2O_3	35.21	33.73	36.58
FeO	8.28	7.49	
MnO	trace	0.34	
MgO	22.88	23.69	28.93
CaO	0.58		
H_2O	13.02	[12.36]	12.93
Total	100.92	[100.00]	100.00

(1) Chester, Massachusetts, USA. (2) Pensacola Mountains, Antarctica; by electron microprobe, H_2O by difference. (3) $Mg_2Al(SiAl)O_5(OH)_4$.

Polymorphism & Series: $2H_1$, $2H_2$, 6R polytypes.

Mineral Group: Kaolinite-serpentine group.

Occurrence: A product of low-grade metamorphism of Al, Mg-rich rocks.

Association: Vesuvianite, chlorite (Pensacola Mountains, Antarctica); magnetite, rutile, diaspore (Chester, Massachusetts, USA); grossular, calcite, diopside, clinozoisite (Black Lake, Canada).

Distribution: At the Emery mine, Chester, Hampden Co., Massachusetts, USA. From the Lake Asbestos mine, Black Lake, Quebec, Canada. In Antarctica, in the Dufek mafic massif, Pensacola Mountains. From the Postmasburg manganese deposits, Cape Province, South Africa. From Russia, at the Saranovskoye chromite deposits, Northern Ural Mountains. At Hällefors, Sweden. On Mt. Sobotka, Silesia, Poland.

Name: Honors James Ames, a mine owner.

Type Material: National Museum of Natural History, Washington, D.C., USA, 80715.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 655.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 164–169. (3) Steadman, R. and P. M. Nuttall (1962) The crystal structure of amesite. Acta Cryst., 15, 510. (4) Hall, S.H. and S.W. Bailey (1976) Amesite from Antarctica. Amer. Mineral., 61, 497–499. (5) Hall, S.H. and S.W. Bailey (1979) Cation ordering pattern in amesite. Clays and Clay Minerals, 27, 241–247. (6) Anderson, C.S. and S.W. Bailey (1981) A new cation ordering pattern in amesite–$2H_2$. Amer. Mineral., 66, 185–195. (7) Wiewióra, A., J.A. Rausell-Colom, and T. García-González (1991) The crystal structure of amesite from Mount Sobotka: a nonstandard polytype. Amer. Mineral., 76, 647–652.

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Amicite $K_2Na_2Al_4Si_4O_{16}\cdot 5H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* 2. As well-formed pseudotetragonal pyramidal crystals, to 5 mm, showing {011} and {110}, or more rarely {111} and {110}.

Physical Properties: Hardness = ∼4.5 D(meas.) = 2.06–2.23 D(calc.) = 2.146–2.178

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Streak:* White. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 12°$. $\alpha = 1.485$ $\beta = 1.490$ $\gamma = 1.494$ 2V(meas.) = 82°

Cell Data: *Space Group:* $I2$. $a = 10.226$–10.26 $b = 10.422$–10.44 $c = 9.884$–9.92 $\beta = 88°19'-91°30'$ Z = [2]

X-ray Powder Pattern: Hegau, Germany.
2.722 (100), 4.220 (90), 3.141 (80), 7.295 (55), 2.704 (50), 3.238 (45), 5.108 (40)

Chemistry:

	(1)	(2)
SiO_2	36.38	34.81
Al_2O_3	29.46	29.53
Fe_2O_3	trace	
MgO	trace	
CaO	0.22	
SrO	0.03	
BaO	trace	
Na_2O	8.22	8.98
K_2O	12.96	13.64
H_2O	12.80	13.04
Total	100.07	100.00

(1) Hegau, Germany; by electron microprobe; corresponds to $K_{1.88}Na_{1.80}Ca_{0.02}Al_{3.93}Si_{4.12}O_{16}\cdot 4.84H_2O$. (2) $K_2Na_2Al_4Si_4O_{16}\cdot 5H_2O$.

Mineral Group: Zeolite group.

Occurrence: In veinlets cutting melilite-nephelinite volcanic rocks and pyroclastics (Hegau, Germany); in natrolite veinlets cutting ijolite-urtite pegmatites and apatite-nepheline rocks (Kola Peninsula, Russia).

Association: Merlinoite, aragonite, calcite (Hegau, Germany); natrolite (Kola Peninsula, Russia).

Distribution: In the Höwenegg quarry, Hegau, Baden-Württemberg, Germany. From the Kukisvumchorr apatite deposit, Khibiny massif, Kola Peninsula, Russia. In a quarry near Cuidad Real, ?? Province, Spain.

Name: To honor Giovan Battista Amici (1786–1863), physicist, optician, and inventor of microscope optical elements.

Type Material: University of Modena, Modena, Italy; The Natural History Museum, London, England; National Museum of Natural History, Washington, D.C., USA, 145843.

References: (1) Alberti, A., G. Hentschel, and G. Vezzalini (1979) Amicite, a new zeolite. Neues Jahrb. Mineral., Monatsh., 481–488. (2) Alberti, A. and G. Vezzalini (1979) The crystal structure of amicite, a zeolite. Acta Cryst., 35, 2866–2869. (3) (1980) Amer. Mineral., 65, 808 (abs. refs. 1 and 2). (4) Khomyakov, A.P., G.E. Cherepivskaya, T.A. Kurova, and V.V. Kaptsov (1982) First occurrence of amicite ($K_2Na_2Al_4Si_4O_{16}\cdot 5H_2O$) in the USSR. Doklady Acad. Nauk SSSR, 263, 978–980 (in Russian). (5) (1982) Chem. Abs., 97, 9281 (abs. ref. 4).

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Aminoffite $Ca_3Be_2Si_3O_{10}(OH)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As small, euhedral, pyramidal crystals, to 1 mm. *Twinning:* Commonly twinned, polysynthetically on {001}.

Physical Properties: *Cleavage:* Poor on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.94 D(calc.) = 2.86 Strongly piezoelectric.

Optical Properties: Transparent. *Color:* Colorless to light yellowish. *Luster:* Vitreous. *Optical Class:* Uniaxial (–); may be abnormally biaxial. $\omega = 1.647$ $\epsilon = 1.637$

Cell Data: *Space Group:* $P4_2/n$. $a = 9.865(2)$ $c = 9.930(2)$ $Z = 4$

X-ray Powder Pattern: Långban, Sweden.
2.614 (100), 2.84 (90), 4.02 (80), 2.141 (80), 6.97 (70), 4.40 (70), 3.48 (70)

Chemistry:

	(1)	(2)
SiO_2	42.49	43.28
Al_2O_3	4.41	
Fe_2O_3	0.31	
MnO	0.19	
BeO	6.20	12.01
CaO	40.27	40.39
H_2O	6.45	4.32
Total	[100.32]	100.00

(1) Långban, Sweden; original total given as 100.33%. (2) $Ca_3Be_2Si_3O_{10}(OH)_2$.

Occurrence: In cavities in massive magnetite (Långban, Sweden); in fluorite veins at the contact between marbles and "hornblende" granites associated with hastingsite nepheline syenites (Dugdinsk massif, Russia); in fluorite veins in tinguaite and nephelinite dikes (Bayankolsk dike field, Russia).

Association: Magnetite, goethite (Långban, Sweden); fluorite (Russia).

Distribution: From Långban, Värmland, Sweden. In Russia, found in the Bayankolsk dike field, Tuva, and in the Dugdinsk massif; also in the Lake Baikal area, eastern Siberia. From Hall's Grampians, eight km northwest of Emmaville, New South Wales, Australia.

Name: To honor Dr. Gregori Aminoff (1883–1947), Swedish mineralogist and expert on Långban mineralogy, associated with the Riksmuseum, Stockholm, Sweden.

Type Material: Harvard University, Cambridge, Massachusetts, 94627, 106916, 106917; National Museum of Natural History, Washington, D.C., USA, 137291, R7823; The Natural History Museum, London, England, 1984,423.

References: (1) Hurlbut, C.S. (1937) Aminoffite, a new mineral from Långban, Sweden. Geol. Fören. Förhandl. Stockholm, 59, 290–292. (2) (1938) Amer. Mineral., 23, 293 (abs. ref. 1). (3) Mandarino, J.A. (1964) X-ray powder data for aminoffite. Amer. Mineral., 49, 212–214. (4) Moore, P.B. (1968) Relation of the manganese-calcium silicates, gageite and harstigite: a correction. Amer. Mineral., 53, 1418–1420. (5) Coda, A., G. Rossi, and L. Ungaretti (1967) The crystal structure of aminoffite. Atti Rend. Accad. Lincei, 43(3–4), 225–232. (6) (1968) Chem. Abs., 69, 71315 (abs. ref. 5). (7) (1967) Str. Rep., 32, 466–467 (abs. ref. 5).

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Ammonioalunite $(NH_4)Al_3(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $3m$. As rhombohedral crystals, to 20 μm, forming granular masses.

Physical Properties: *Cleavage:* On [{0001}, perfect.] (by analogy with the alunite group). Hardness = 2–3 D(meas.) = 2.4 D(calc.) = 2.58

Optical Properties: Semitransparent. *Color:* Grayish white; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.590(5)$ $\epsilon = 1.602(5)$

Cell Data: *Space Group:* $R\overline{3}m$ or $R3m$. $a = 7.013(1)$ $c = 17.855(5)$ $Z = 3$

X-ray Powder Pattern: The Geysers, California, USA.
3.023 (100), 5.04 (93), 2.996 (50), 1.917 (32), 2.353 (31), 1.753 (21) 3.514 (19)

Chemistry:

	(1)	(2)	(3)
SO_3	35.96	41.35	40.73
SiO_2	11.6		
Al_2O_3	33.0	37.95	38.90
$(NH_4)_2O$	5.39	6.20	6.62
Na_2O	0.17	0.20	
K_2O	0.19	0.22	
H_2O	12.24	14.08	13.75
Total	98.6	[100.00]	100.00

(1) The Geysers, California, USA; by inductively coupled Ar-plasma spectrometry, S by a Leco S analyzer, K by AA, and H and N by a CHN analyzer. (2) Do.; analysis (1) recalculated after deduction of amorphous SiO_2; corresponds to $[(NH_4)_{0.92}Na_{0.02}K_{0.02}]_{\Sigma=0.96}Al_{2.88}(SO_4)_{2.00}(OH)_{5.60}\bullet 0.23H_2O$. (3) $(NH_4)Al_3(SO_4)_2(OH)_6$.

Mineral Group: Alunite group.

Occurrence: Formed in hot springs under very acid conditions, rich in ammonium and sulfate, poor in potassium, below 100 °C.

Association: Ammoniojarosite, amorphous SiO_2.

Distribution: From The Geysers, Sonoma Co., California, USA.

Name: As the *ammonium* analog of *alunite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145596.

References: (1) Altaner, S.P., J.J. Fitzpatrick, M.D. Krohn, P.M. Bethke, D.O. Hayba, J.A. Goss, and Z.A. Brown (1988) Ammonium in alunites. Amer. Mineral., 73, 145–152.

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Ammonioborite $(NH_4)_3B_{15}O_{20}(OH)_8 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Microscopic plates, grouped in parallel; commonly as fine-grained granular masses.

Physical Properties: Hardness = n.d. D(meas.) = 1.765(4) D(calc.) = 1.76 Slowly soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White; colorless in transmitted light. *Optical Class:* Biaxial (+). *Orientation:* $Z \wedge$ elongation $\simeq 7°$–$13°$; $Y = b$. *Dispersion:* $r < v$, slight. $\alpha = 1.470$ $\beta = 1.487$ $\gamma = 1.540$ 2V(meas.) = $\sim 60°$

Cell Data: *Space Group:* $C2/c$. $a = 25.27(5)$ $b = 9.65(3)$ $c = 11.56(3)$ $\beta = 94°17(5)'$ Z = 4

X-ray Powder Pattern: Synthetic.
3.16 (100), 3.09 (100), 5.70 (60), 2.876 (60), 3.01 (50), 8.98 (40), 5.44 (30).

Chemistry:

	(1)	(2)
B_2O_3	74.2	70.15
$(NH_4)_2O$	9.8	10.49
H_2O	[16.0]	19.36
Total	[100.0]	100.00

(1) Larderello, Italy; H_2O by difference. (2) $(NH_4)_3B_{15}O_{20}(OH)_8 \cdot 4H_2O$.

Occurrence: In boric acid-rich fumarolic lagoons.

Association: Sassolite, larderellite.

Distribution: From Larderello, Val di Cecina, Tuscany, Italy.

Name: For its composition, *ammonium borate*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 93756, 94172, R6167.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 366–367. (2) Clark, J.R. and C.L. Christ (1959) Studies of borate minerals (VII): X-ray studies of ammonioborite, larderellite, and the potassium and ammonium pentaborate tetrahydrates. Amer. Mineral., 44, 1150–1158. (3) Merlino, S. and F. Sartori (1971) Ammonioborite: new borate polyion and its structure. Science, 171, 377–379.

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Ammoniojarosite $(NH_4)Fe_3^{3+}(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $3m$. Microscopic tabular crystals, some with hexagonal outlines, rhombohedral or short prismatic; in granular lumps and irregular nodules.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.112

Optical Properties: Semitransparent. *Color:* Pale ocherous yellow; in transmitted light, pale yellow to nearly colorless. *Luster:* Dull, may be waxy to earthy.
Optical Class: Uniaxial (–). $\omega = 1.800(5)$ $\epsilon = 1.750(5)$

Cell Data: *Space Group:* $R\overline{3}m$ or $R3m$. $a = 7.028$ $c = 17.00$ $Z = 3$

X-ray Powder Pattern: Synthetic.
3.114 (100), 3.097 (100), 5.123 (58), 1.988 (30), 1.832 (30), 2.318 (21), 5.811 (14).

Chemistry:

	(1)	(2)
SO_3	34.49	33.38
Al_2O_3	0.02	
Fe_2O_3	49.30	49.93
MgO	0.13	
CaO	0.05	
$(NH_4)_2O$	4.23	5.43
Na_2O	0.22	
K_2O	1.56	
H_2O	9.86	11.26
insol.	0.76	
Total	100.62	100.00

(1) Utah, USA; corresponds to $[(NH_4)_{0.75}K_{0.16}Mg_{0.06}Na_{0.04}]_{\Sigma=1.01}Fe_{2.87}(SO_4)_{2.00}(OH)_6$.
(2) $(NH_4)Fe_3^{3+}(SO_4)_2(OH)_6$.

Mineral Group: Alunite group.

Occurrence: Formed in black lignitic shales containing pyrite (Utah, USA).

Association: Tschermigite, epsomite, jarosite (Utah, USA); gypsum (Buffalo, Wyoming, USA); aluminite, natrojarosite (Zlatá Baňa district, Slovakia).

Distribution: In the USA, from an undefined locality on the "west side of the Kaibab fault, Kane Co., Utah"; from near Buffalo, Johnson Co. and about 5 km south of Wamsutter, Sweetwater Co., Wyoming; at the Sulphur Bank mine, Lake Co. and The Geysers, Sonoma Co., California. From Cebadillas, Potosí, Bolivia. In the Zlatá Baňa district, Slanské Mountains, Slovakia. From Le Kaymar, Aveyron, France. At the Hüttelkogel quarry, near Voightsberg, Austria.

Name: As the *ammonium* analog of *jarosite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95654.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 562–563. (2) Odum, J.K., P.L. Hauff, and R.A. Farrow (1982) A new occurrence of ammoniojarosite in Buffalo, Wyoming. Can. Mineral., 20, 91–95. (3) Smith, W.L. and J.E. Lampert (1973) Crystal data for ammoniojarosite. $NH_4Fe_3(OH)_6(SO_4)_2$. J. Appl. Cryst., 6, 490–491.

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Ammonioleucite $(NH_4, K)AlSi_2O_6$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As minute aggregates replacing analcime crystals. *Twinning:* Common, repeated on {110}.

Physical Properties: Hardness = n.d. D(meas.) = 2.29(5) D(calc.) = 2.24

Optical Properties: Translucent. *Color:* White. *Luster:* Resinous to vitreous. *Optical Class:* Uniaxial (+). $n = 1.518(2)$

Cell Data: *Space Group:* $I4_1/a$. $a = 13.214(1)$ $c = 13.713(2)$ $Z = 16$

X-ray Powder Pattern: Fujioka, Japan.
5.43 (100), 3.30 (80), 5.53 (50), 3.43 (40), 2.955 (20), 2.859(20), 2.839 (10)

Chemistry:

	(1)
SiO_2	62.67
Al_2O_3	22.43
K_2O	4.43
$(NH_4)_2O$	8.70
H_2O	1.77
Total	[100.00]

(1) Fujioka, Japan; by electron microprobe; after subtraction of elements attributed to dolomite and analcime contamination, recalculated to 100.00%; corresponds to $[(NH_4)_{0.68}K_{0.19}]_{\Sigma=0.87}Al_{0.89}Si_{2.12}O_6$.

Occurrence: In veinlets, fractures, and cavities in hydrothermally altered crystalline schist, as powdery pseudomorphous replacements of analcime crystals.

Association: Analcime, dolomite.

Distribution: In the Tatarazawa quarry, Fujioka, Gumma Prefecture, Japan.

Name: For *ammonia* in its chemical composition and its relation to *leucite*.

Type Material: National Science Museum, Tokyo, Japan; National Museum of Natural History, Washington, D.C., USA, 165991.

References: (1) Hori, H., K. Nagashima, M. Yamada, R. Miyawaki, and T. Marubashi (1986) Ammonioleucite, a new mineral from Tatarazawa, Fujioka, Japan. Amer. Mineral., 71, 1022–1027.

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Ammoniomagnesiovoltaite $(NH_4)_2Mg_5Fe^{3+}{}_3Al(SO_4)_{12}•18H_2O$

Crystal Data: Isometric. *Point Group*: 4/*m* $\bar{3}$ 2/*m*. As crusts of intergrown equant crystals to 0.05 mm, displaying {111}, {100} and minor {110}.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 2-3 D(meas.) = 2.55(1) [value ascribed to analytical error] D(calc.) = 2.351 Dissolves in water.

Optical Properties: Translucent. *Color*: Pale yellow to yellow-brown. *Streak*: White. *Luster*: Vitreous.
Optical Class: Isotropic. n = 1.60(1)

Cell Data: *Space Group*: *Fd*$\bar{3}$ *c*. a = 27.260(2) Z = 16

X-ray Powder Pattern: Synthetic $(NH_4)_2Mg_5Fe^{3+}{}_3Al(SO_4)_{12}•18H_2O$.
5.59 (100), 3.420 (72), 3.562 (66), 1.7836 (25), 1.5582 (25), 6.85 (24), 3.059 (22)

Chemistry:

	(1)	(2)
SO_3	47.56	52.52
Al_2O_3	3.31	2.79
FeO (total)	16.99	
Fe_2O_3	[12.28]	13.09
FeO	[5.94]	
MnO	1.18	
MgO	7.02	11.02
K_2O	0.05	
$(NH_4)_2O$	3.11	2.85
H_2O	[17.72]	17.73
Total	98.17	100.00

(1) Köves Hill, Pécs-Vasas, Southern Hungary; average of 5 electron microprobe analyses, H_2O calculated from stoichiometry, $(NH_4)_2O$ by spectrophotometry, presence of H_2O, $(SO_4)^{2-}$, $(NH4)^+$ confirmed by IR spectroscopy, Fe^{2+} and Fe^{3+} determined assuming $(Mg+Fe^{2+}+Mn^{2+})/(Fe^{3+}+Al)$ = 5/4; corresponding to $[(NH_4)_{2.18}K_{0.02}]_{\Sigma=2.20}(Mg_{3.19}Fe^{2+}{}_{1.51}Mn_{0.30})_{\Sigma=5.00}(Fe^{3+}{}_{2.81}Al_{1.19})_{\Sigma=4.00}S_{10.87}O_{44.70}•18H_2O$. (2) $(NH_4)_2Mg_5Fe^{3+}{}_3Al(SO_4)_{12}•18H_2O$.

Mineral Group: Voltaite group.

Occurrence: As efflorescences formed by the chemical reactions as ground water interacts with organic matter from coal and oxidizing pyrite and marcasite on a burning coal dump.

Association: Tschermigite, sabieite, kieserite, pickeringite, hexahydrite.

Distribution: From near Köves Hill, Pécs-Vasas, Mecsek Mountains, Southern Hungary.

Name: As an analog of *voltaite* with essential ammonium and magnesium in the composition.

Type Material: In Hungary at the Herman Ottó Museum, Miskolc, (# 2008.233) and at the Department of Mineralogy and Petrology, Hungarian Natural History Museum, Budapest (Gyn.1590).

References: (1) Szakáll, S., I. Sajó, B. Fehér, and S. Bigi (2012) Ammoniomagnesiovoltaite, a new voltaite-related mineral species from Pécs-Vasas, Hungary. Can. Mineral., 50(1), 65-72. (2) (2014) Amer. Mineral., 99, 2150 (abs. ref. 1).

Amstallite **$CaAl(Si,Al)_4O_8(OH)_4 \cdot (H_2O,Cl)$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular prismatic crystals, to 1 cm, elongated and commonly striated ‖ [001], with cross sections appearing rhombohedral or hexagonal.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–5 D(meas.) = 2.40(5) D(calc.) = 2.38

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$; $Y \wedge c = 10°$. *Dispersion:* $r < v$, weak. $\alpha = 1.533$ $\beta = 1.534$ $\gamma = 1.538$ 2V(meas.) = 57(2)° 2V(calc.) = 59°

Cell Data: *Space Group:* $C2/c$. $a = 18.830(2)$ $b = 11.517(2)$ $c = 5.190(1)$ $\beta = 100.86(1)°$ Z = 4

X-ray Powder Pattern: Amstall, Austria.
9.75 (100), 3.603 (100), 3.816 (90), 5.43 (70), 4.714 (60), 3.175 (60), 4.069 (40)

Chemistry:

	(1)
SiO_2	49.41
Al_2O_3	22.84
CaO	13.80
Cl	1.75
H_2O	12.40
$-O = Cl_2$	0.39
Total	99.81

(1) Amstall, Austria; by electron microprobe, corresponds to $Ca_{0.98}Al_{1.78}Si_{3.26}O_{12.80}Cl_{0.20}H_{5.46}$.

Occurrence: In open fissures cutting pegmatitic schlieren, in hydrothermally altered graphite-bearing metamorphic rocks.

Association: Apatite, rutile, siderite, albite, laumontite, calcite, vivianite.

Distribution: In the Amstall graphite quarry, Amstall, Austria.

Name: For the type locality at Amstall, Austria.

Type Material: Institute of Mineralogy and Crystallography, Vienna University; Natural History Museum, Vienna, Austria.

References: (1) Quint, R. (1987) Description and crystal structure of amstallite, $CaAl(OH)_2[Al_{0.8}Si_{3.2}O_8(OH)_2] \cdot [(H_2O)_{0.8}Cl_{0.2}]$, a new mineral from Amstall, Austria. Neues Jahrb. Mineral., Monatsh., 253–262. (2) (1988) Amer. Mineral., 73, 1492–1493 (abs. ref. 1).

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Analcime $NaAlSi_2O_6 \cdot H_2O$

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Crystal Data: Cubic; tetragonal, orthorhombic, or monoclinic, pseudocubic, with degree of ordering. *Point Group:* $4/m\ \bar{3}\ 2/m$; $4/m\ 2/m\ 2/m$, $2/m\ 2/m\ 2/m$, or $2/m$. Crystals commonly trapezohedra {211}, to 25 cm. Also granular, compact, massive, typically showing concentric structure. *Twinning:* Polysynthetic on {001}, {110}.

Physical Properties: *Cleavage:* Very poor on {100}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.24–2.29 D(calc.) = 2.271 Weakly piezoelectric; weakly electrostatic when rubbed or heated.

Optical Properties: Transparent to translucent. *Color:* White, colorless, gray, pink, greenish, yellowish; in thin section, colorless. *Luster:* Vitreous.
Optical Class: Isotropic; anomalously biaxial (–). n = 1.479–1.493 2V(meas.) = 0°–85°

Cell Data: *Space Group:* $Ia3d$; $I4_1/acd$, $Ibca$, or $I2/a$. a = 13.723–13.733 Z = 16 (cubic).

X-ray Powder Pattern: Låven Island, Langesundsfjord, Norway.
3.43 (10), 5.61 (8), 2.925 (8), 1.743 (6), 2.693 (5), 2.505 (5), 1.903 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	54.19	54.58	54.58	Na_2O	11.08	13.50	14.08
Al_2O_3	23.12	23.05	23.16	K_2O	1.62	0.00	
MgO	0.10	0.10		H_2O^+	8.20	8.70	8.18
CaO	1.54	0.45		Total	99.85	100.38	100.00

(1) Cyclopean Islands, Italy. (2) Mazé, Niigata Prefecture, Japan. (3) $NaAlSi_2O_6 \cdot H_2O$.

Polymorphism & Series: Forms a series with pollucite.

Mineral Group: Zeolite group.

Occurrence: In the groundmass or vesicles of silica-poor intermediate and mafic igneous rocks, typically basalts and phonolites, from late-stage hydrothermal solutions, or disseminated due to deuteric alteration. In lake beds, altered from pyroclastics or clays, or as a primary precipitate; authigenic in sandstones and siltstones.

Association: Zeolites, prehnite, calcite, quartz, glauconite.

Distribution: Some localities for outstanding specimens follow. In Italy, at Aci Castello, Cyclopean Islands, and from Val di Fassa and Alpe di Siusi, Trentino-Alto Aldige. Large crystals from Kotchechovmo, Krasnoyarski Territory, Russia. At Breidhdalsheidhi, Iceland. In the Dean quarry, St. Keverne, Lizard Peninsula, Cornwall, England. Around Glasgow, Dumbartonshire, Scotland. In the USA, from the Lake Superior district, Houghton Co., Michigan; at Cornwall, Lebanon Co., Pennsylvania; from Bergen Hill, Hudson Co., and West Paterson, Passaic Co., New Jersey; on Table Mountain, Jefferson Co., Colorado; in the Price Creek quarry, Benton Co., Oregon. From the Bay of Fundy district, Nova Scotia; large crystals from Mont Saint-Hilaire, Quebec, Canada. From Flinders, Victoria, Australia.

Name: From the Greek for *weak*, alluding to the weak electrostatic charge developed when heated or rubbed.

Type Material: Natural History Museum, Paris, France, 13.77, H4154.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 595–598. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 338–350. (3) Saha, P. (1959) Geochemical and X-ray investigations of natural and synthetic analcites. Amer. Mineral., 44, 300–313. (4) Černý, P. (1974) The present status of the analcime-pollucite series. Can. Mineral., 12, 334–341. (5) Coombs, D.S. (1955) X-ray investigations on wairakite and non-cubic analcime. Mineral. Mag., 30, 699. (6) Mazzi, F. and E. Galli (1978) Is each analcime different? Amer. Mineral., 63, 448–460. (7) Pechar, F. (1988) The crystal structure of natural monoclinic analcime ($NaAlSi_2O_6 \cdot H_2O$). Zeits. Krist., 184, 63–69.

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Anandite $(Ba,K)(Fe^{2+},Mg)_3(Si,Al,Fe)_4O_{10}(S,OH)_2$

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Crystal Data: Monoclinic or orthorhombic. *Point Group:* $2/m$, m, or $2/m\ 2/m\ 2/m$. Poorly developed prism faces give a hexagonal outline to cleavage flakes.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 3–4 D(meas.) = 3.94 D(calc.) = 3.94

Optical Properties: Nearly opaque. *Color:* Black. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* Y = green; Z = brown. *Orientation:* $Y = b$; $Z \wedge a = 8°–16°$. *Dispersion:* Strong. $\alpha = 1.85(1)$ β = n.d. $\gamma = > 1.88$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 5.412(5)$ $b = 9.434(5)$ $c = 19.953(10)$ $\beta = 94°52(10)'$ Z = 2, or *Space Group:* $Pnmn$. $a = 5.439(1)$ $b = 9.509(2)$ $c = 19.878(6)$ Z = 2

X-ray Powder Pattern: Wilagedera iron prospect, Sri Lanka.
3.320 (100), 4.995 (85), 2.490 (80), 9.92 (60), 2.716 (50), 2.681 (45), 3.430 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	25.20	24.59	Na_2O	0.10	0.06
TiO_2	0.28	0.08	K_2O	0.93	0.24
Al_2O_3	4.85	0.80	F		0.12
Fe_2O_3	6.98		Cl		0.91
FeO	33.10	41.73	H_2O^+	1.98	
MnO	0.66	0.92	H_2O^-	0.12	
MgO	3.39	2.89	S	2.96	4.25
CaO	0.16	0.00	$-O = S,(F,Cl)_2$	1.48	2.38
BaO	20.35	23.05	Total	99.58	97.26

(1) Wilagedera iron prospect, Sri Lanka. (2) Do.; by electron microprobe; Mössbauer spectroscopy indicates Fe^{2+}:Fe^{3+} = 1.19.

Polymorphism & Series: 2O, $2M_1$, 1M polytypes.

Mineral Group: Mica group.

Occurrence: As monomineralic veinlets and lenses in a banded magnetite deposit capped by banded magnetite-barite rock. The ore zone and associated interbedded calc-schists and gneisses are of metasedimentary origin, of approximately granulite facies grade.

Association: Magnetite, chalcopyrite, pyrite, pyrrhotite, barite.

Distribution: At the Wilagedera iron prospect, North Western Province, Sri Lanka.

Name: Honoring Dr. Ananda Kentush Coomaraswamy (1877–1947), the first Director of the Mineral Survey of Ceylon (Sri Lanka).

Type Material: n.d.

References: (1) Pattiaratchi, D.B., E. Saari, and T.G. Sahama (1967) Anandite, a new barium iron silicate from Wilagedera, North Western Province, Ceylon. Mineral. Mag., 36, 1–4. (2) Filut, M.A., A.C. Rule, and S.W. Bailey (1985) Crystal structure refinement of anandite-2*Or*, a barium- and sulfur-bearing trioctahedral mica. Amer. Mineral., 70, 1298–1308.

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Anapaite $Ca_2Fe^{2+}(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are tabular on {110}, modified by {001}, {010}, {100}, {1$\overline{1}$1}, {$\overline{1}\overline{1}$1}, {011}, to 1 cm. Commonly in rosettes and subparallel aggregates and crusts of crystals; fibrous, and in nodules.

Physical Properties: *Cleavage:* On {001}, perfect; on {010}, distinct. Hardness = 3.5
D(meas.) = 2.816 D(calc.) = 2.811

Optical Properties: Transparent. *Color:* Green to pale green; colorless to pale green in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* *X* (-119°,81°); *Y* (147°,70°); *Z* (-6°,21°) [using (ϕ,ρ)].
Dispersion: $r > v$, weak. $\alpha = 1.602(3)$ $\beta = 1.613(3)$ $\gamma = 1.649(3)$ 2V(meas.) = 54(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.447(1)$ $b = 6.816(1)$ $c = 5.898(1)$ $\alpha = 101.64(3)°$ $\beta = 104.24(3)°$ $\gamma = 70.76(4)°$ Z = 1

X-ray Powder Pattern: San Giovani, Italy. (ICDD 34-148).
3.764 (100), 2.883 (75), 3.158 (70), 3.391 (55), 3.188 (45), 6.39 (35), 4.551 (35)

Chemistry:

	(1)	(2)
P_2O_5	35.51	35.66
FeO	18.07	18.05
CaO	27.77	28.18
H_2O	18.47	18.11
Total	99.82	100.00

(1) Taman Peninsula, Russia. (2) $Ca_2Fe(PO_4)_2 \cdot 4H_2O$.

Occurrence: In oolitic iron ore, and in the stems of fossil trees (Anapa, Russia); in lacustrine sediments.

Association: Fairfieldite, vivianite, siderite.

Distribution: In Russia, at an iron mine on Cape Zheleznyi Rog Cape, near Anapa, Taman Peninsula. As fine specimens at Kerch, Crimean Peninsula, Ukraine. In the Castelnuovo and Allori mines, Santa Barbara lignite district, near San Giovani, Tuscany, Italy. At Messel, Hesse, Germany. In the Cerdanya basin, east to southwest of Belver, Catalonia Province, Spain. In the USA, from Lewis Well, near Corcoran, Kings Co., California; at the MacArthur mine, near Yerington, Lyon Co., Nevada; in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire.

Name: For its first discovery near Anapa, Russia.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 731–732. (2) Catti, M., G. Ferraris, and G. Ivaldi (1979) Refinement of the crystal structure of anapaite, $Ca_2Fe(PO_4)_2 \cdot 4H_2O$: hydrogen bonding and relationships with the bihydrated phase. Bull. Minéral., 102, 314–318.

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Anatacamite $Cu_2(OH)_3Cl$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Triangular tabular crystals, to 2 mm, exhibit {$11\bar{1}$}, {$1\bar{1}1$}, {100}, and {$\bar{1}11$}. *Twinning*: Pseudo-merohedral twinning.

Physical Properties: *Cleavage*: Good on {$11\bar{1}$}. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 4-4.5 VHN = 350 (50 g load). D(meas.) = n.d. D(calc.) = 3.725

Optical Properties: Transparent. *Color*: Emerald-green. *Streak*: Pale green. *Luster*: Vitreous. *Optical Class*: Biaxial. n = 1.80 (calculated) *Pleochroism*: None.

Cell Data: *Space Group*: $P\bar{1}$. a = 9.1646(9) b = 9.2029(8) c = 9.2102(8) α = 95.858(6)° β = 96.290(7)° γ = 96.507(2)° Z = 8

X-ray Powder Pattern: La Vendida mine, Sierra Gorda mining district, near Antofagasta, Chile. 5.432 (100), 2.747 (94), 2.257 (56), 2.889 (31), 1.702 (29), 1.812 (21)

Chemistry:

	(1)	(2)
CuO	74.24	74.49
ZnO	0.02	
NiO	0.99	
Cl	16.98	16.65
H_2O	[12.74]	12.62
-O=Cl	3.84	3.76
Total	101.13	100.00

(1) La Vendida mine, Sierra Gorda mining district, near Antofagasta, Chile; electron microprobe analysis, H_2O calculated from stoichiometry; corresponding to $Cu_{1.97}Ni_{0.03}(OH)_{2.99}Cl$.
(2) $Cu_2(OH)_3Cl$.

Polymorphism & Series: Polymorphous with atacamite, botallackite and clinoatacamite.

Occurrence: In the oxidation zone of a polymetallic sulfide deposit

Association: Atacamite, belloite, as well as alunite, clinoatacamite, chalcanthite, coquimbite, eriochalcite, jarosite, kröhnkite, magnesioaubertite, tamarugite, voltaite.

Distribution: La Vendida mine (an abandoned open pit copper mine), Sierra Gorda mining district, northeast of Antofagasta, Chile.

Name: For its triclinic symmetry and polymorphism with *atacamite*.

Type Material: Mineralogical Museum, University of Hamburg, Germany (MD 199).

References: (1) Malcherek, T. and J. Schlüter (2010) Anatacamite from La Vendida mine, Sierra Gorda, Atacama desert, Chile: a triclinic polymorph of $Cu_2(OH)_3Cl$. Neues Jahrbuch für Mineralogie Abhandlungen, 187, 307-312. (2) (2014) Amer. Mineral., 99, 551 (abs. ref. 1).

Anatase TiO_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals typically acute dipyramidal {011}, often highly modified; obtuse pyramidal or tabular on {001}; less commonly prismatic on [001], with {110}, {010}, to 3.75 cm. *Twinning:* Rare, on {112}.

Physical Properties: *Cleavage:* Perfect on {001} and {011}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 VHN = 616–698 (100 g load). D(meas.) = 3.79–3.97 D(calc.) = [3.89]

Optical Properties: Transparent when light colored, to nearly opaque when deeply colored. Pyramidal crystals may appear opaque because of total reflection. *Color:* Brown, pale yellow or reddish brown, indigo, black; pale green, pale lilac, gray, rarely nearly colorless; brown, yellow-brown, pale green, blue in transmitted light. *Streak:* White to pale yellow. *Luster:* Adamantine to splendent, metallic.
Optical Class: Uniaxial (–); anomalously biaxial in deeply colored crystals. *Pleochroism:* Weak; stronger in deeply colored crystals. *Absorption:* Commonly $E > O$; may be $O < E$. $\omega = 2.5612$ $\epsilon = 2.4880$ 2V(meas.) = Small.
R_1–R_2: (400) 23.7–23.8, (420) 22.4–22.5, (440) 21.7–21.6, (460) 21.1–21.0, (480) 20.7–20.4, (500) 20.2–20.0, (520) 19.9–19.6, (540) 19.6–19.3, (560) 19.4–19.0, (580) 19.2–18.8, (600) 19.0–18.5, (620) 18.8–18.4, (640) 18.7–18.2, (660) 18.6–18.1, (680) 18.5–18.0, (700) 18.4–17.8

Cell Data: *Space Group:* $I4_1/amd$ (synthetic). $a = 3.7845$ $c = 9.5143$ Z = 4

X-ray Powder Pattern: Synthetic.
3.52 (100), 1.892 (35), 2.378 (20), 1.6999 (20), 1.6665 (20), 1.4808 (14), 2.431 (10)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
TiO_2	98.98	98.36	Al_2O_3	0.15		CaO	0.15	
SnO_2		0.20	Fe_2O_3	0.10	1.11	LOI	0.77	
						Total	100.15	99.67

(1) Rio Cipo, Minas Gerais, Brazil. (2) Brazil.

Polymorphism & Series: Trimorphous with brookite and rutile.

Occurrence: Usually secondary, derived from other titanium-bearing minerals. In Alpine veins, derived from the enclosing gneisses or schists by hydrothermal solutions. In igneous and metamorphic rocks; in pegmatites; from a carbonatite. A common detrital mineral.

Association: Brookite, rutile, titanite, ilmenite, titanian magnetite, hematite, quartz.

Distribution: A very wide-spread mineral; only a few occurrences can be noted. In Alpine veins at many localities throughout the Swiss, French, and Italian and Tirolian Alps: large crystals from Binn, Valais, and at Cavradi, Tavetsch, Graubünden, Switzerland. From LaGrave, Hautes-Alpes, and Bourg d'Oisans, Isère, France. In Norway, at Kragerø; fine crystals from Hardangervidda, Ullensvang; Slidre, Valdres; and Gudbrandsdalen. From the Khodrovy Mountains, Sakha, Russia. In the Virtuous Lady mine, Devonshire, England. At Fron Oleu, near Tremadog, Gwynned, Wales. In several carbonatite deposits, aggregating 500 million tons, in Minas Gerais and Pará, Brazil. In the USA, at many localities in Burke Co., North Carolina; Buckingham Co., Virginia; from Quincy, Norfolk Co., Massachusetts; at Placerville, Eldorado Co., California. In Canada, at Sherbrooke Township, Nova Scotia, and in Henvey Township, Ontario.

Name: From the Greek meaning *extension*, for the greater length of the usual pyramid compared with other tetragonal minerals.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 583–588. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 40–43. (3) Howard, C.J., T.M. Sabine, and F. Dickson (1992) Structural and thermal parameters for rutile and anatase. Acta Cryst., 47, 462–468. (4) (1969) NBS Mono. 25, 7, 82.

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Ancylite-(Ce) $Sr(Ce,La)(CO_3)_2(OH)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are typically pseudo-octahedral {111}, modified by {120}, with curved faces, or short prismatic [001], to 6 mm; as groups of crystals and forming crusts.

Physical Properties: *Fracture:* Splintery. *Tenacity:* Tough. Hardness = 4–4.5
D(meas.) = 3.82–4.30 D(calc.) = 4.15

Optical Properties: Translucent. *Color:* Pale yellow-orange, pink, yellowish brown to brown, gray; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to dull on crystal faces, greasy on fracture surfaces.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$.
$\alpha = 1.615–1.654$ $\beta = 1.695–1.733$ $\gamma = 1.730–1.772$ 2V(meas.) = 70(5)°

Cell Data: *Space Group: Pmcn.* $a = 4.97–5.03$ $b = 8.49–8.53$ $c = 7.24–7.29$ Z = 2

X-ray Powder Pattern: Narssârssuk, Greenland; nearly identical to ancylite-(La).
4.34 (100), 3.71 (100), 2.96 (100), 2.35 (80), 2.09 (70), 2.02 (70), 5.57 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	23.28	23.44	22.99	FeO	0.35	0.19	
ThO_2	0.20	0.53		CaO	1.52	1.35	
La_2O_3		13.08		SrO	21.03	23.97	27.07
$(La,Dy)_2O_3$	24.04			BaO		0.59	
Ce_2O_3	22.22	23.40	42.88	F		2.15	
Pr_2O_3		1.94		H_2O	6.52		7.06
Nd_2O_3		5.35		$-O = F_2$		0.90	
Sm_2O_3		0.29		insol.	0.60		
Gd_2O_3		0.14		Total	99.76	[95.52]	100.00

(1) Narssârssuk, Greenland. (2) Khibiny massif, Kola Peninsula, Russia; by electron microprobe, original total 99.51%; corresponds to $(Sr_{0.86}Ca_{0.09}Ba_{0.01}Fe_{0.01})_{\Sigma=0.97}(Ce_{0.53}La_{0.30}Nd_{0.12}Pr_{0.04}Sm_{0.01}Th_{0.01})_{\Sigma=1.01}(CO_3)_2(OH)\cdot H_2O$. (3) $SrCe(CO_3)_2(OH)\cdot H_2O$.

Occurrence: An uncommon accessory mineral in some nepheline syenites and carbonatites.

Association: Parisite-(Ce), synchysite-(Y), cordylite-(Ce), eudidymite, aegirine, microcline.

Distribution: From Narssârssuk, Greenland. In Canada, large crystals at Mont Saint-Hilaire, in the Miron quarry, Montreal, and from near Saint-Amable, Quebec; at the Ice River complex, near Field, British Columbia; in the Desmont mine, Wilberforce, Ontario. In the USA, in the Sheep Creek vein, Ravalli Co., and the "vermiculite prospects", Bearpaw Mountains, Hill Co., Montana; at Gem Park, Fremont Co., Colorado. In Russia, from the Lovozero, Khibiny, and other massifs, Kola Peninsula. From Langesundsfjord, Norway. At Weishan, Shandong Province, China. In the Jacupiranga mine, São Paulo, Brazil. At the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire).

Name: From the Greek for *curved*, in allusion to the characteristically curved crystals.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 291–293. (2) Keidel, F.A., A. Montgomery, C.W. Wolfe, and R.P. Christian (1971) Calcian ancylite [calcioancylite-(Ce)] from Pennsylvania: new data. Mineral. Record, 2, 18–25, 36. (3) Dal Negro, A., G. Rossi, and V. Tazzoli (1975) The crystal structure of ancylite, $(RE)_x(Ca,Sr)_{2-x}(CO_3)_2(OH)_x(2-x)H_2O$. Amer. Mineral., 60, 280–284. (4) Zaitsev, A.N., F. Wall, and M.J. Le Bas (1998) REE-Sr-Ba minerals from the Khibina carbonatites, Kola Peninsula, Russia: their mineralogy, paragenesis, and evolution. Mineral. Mag., 62, 225–250. (5) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 6.

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Ancylite-(La) $Sr(La,Ce)(CO_3)_2(OH)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are dipyramidal {111}, with {120}, {101}, platy or short prismatic, faces typically curved, to 2 mm; in druses and uncommonly as skeletal or dendritic aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 3.69(5) D(calc.) = n.d.

Optical Properties: Translucent. *Color:* Colorless, pale yellowish gray, yellowish brown, yellow; colorless to pale yellow in thin section. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Dispersion:* $r < v$. $\alpha = 1.640(3)$ $\beta = [1.717]$ $\gamma = 1.731(3)$ 2V(meas.) = 70(5)°

Cell Data: *Space Group:* [*Pmcn*] [by analogy to ancylite-(Ce)]. $a = 5.072(3)$ $b = 8.589(3)$ $c = 7.276(3)$ Z = 2

X-ray Powder Pattern: Mt. Kukisvumchorr, Kola Peninsula, Russia; nearly identical to ancylite-(Ce).
2.955 (100), 4.36 (92), 3.705 (90), 2.664 (89), 3.738 (88), 2.358 (87), 2.092 (80)

Chemistry:

	(1)	(2)
CO_2	22.59	23.07
La_2O_3	25.75	42.69
Ce_2O_3	16.23	
Pr_2O_3	0.10	
Nd_2O_3	0.70	
CaO	1.69	
SrO	24.22	27.16
BaO	0.64	
H_2O	7.37	7.08
Total	99.29	100.00

(1) Mt. Kukisvumchorr, Kola Peninsula, Russia; by electron microprobe, average of seven analyses, H_2O by the Penfield method; corresponds to $(Sr_{0.89}Ca_{0.11}Ba_{0.02})_{\Sigma=1.02}(La_{0.60}Ce_{0.38}Nd_{0.02})_{\Sigma=1.00}(CO_3)_{1.96}(OH)_{1.12}\cdot H_2O$. (2) $SrLa(CO_3)_2(OH)\cdot H_2O$.

Occurrence: A rare mineral in nepheline syenites in differentiated alkalic massifs.

Association: Aegirine, astrophyllite, loparite-(Ce), donnayite-(Y), belovite-(Ce), kukharenkoite-(Y), nenadkevichite, "biotite", eudialyte, catapleiite, apophyllite, fluorapatite, calcite. (Mt. Kukisvumchorr, Kola Peninsula, Russia).

Distribution: On Marchenko Peak, northern part of Mt. Kukisvumchorr, Khibiny massif, Kola Peninsula, Russia. In Canada, from near Saint-Amable, Quebec.

Name: For its relation to *ancylite*-(Ce) and its dominant content of *lanthanum*.

Type Material: St. Petersburg Mining Institute, St. Petersburg, 2092/1; Geological Museum, Kola Scientific Center, Apatity, Russia.

References: (1) Yakovenchuk, V.N., Y.P. Men'shikov, Y.A. Pakhomovskii, and G.Y. Ivanyuk (1997) Ancylite-(La), $Sr(La,Ce)(CO_3)_2(OH)\cdot H_2O$ – a new carbonate from a hydrothermal vein at Kukisvumchorr Mountain (Khibiny massif) and its comparison with ancylite-(Ce). Zap. Vses. Mineral. Obshch., 126(1), 96–108 (in Russian with English abs.). (2) (1998) Amer. Mineral., 83, 652 (abs. ref. 1). (3) Dal Negro, A., G. Rossi, and V. Tazzoli (1975) The crystal structure of ancylite, $(RE)_x(Ca,Sr)_{2-x}(CO_3)_2(OH)_x(2-x)H_2O$. Amer. Mineral., 60, 280–284.

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Andalusite Al_2SiO_5

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As euhedral crystals or columnar aggregates having nearly square cross sections, commonly elongated ‖ [001], to 20 cm. Also fibrous, compact, massive. *Twinning:* On {101}, rare.

Physical Properties: *Cleavage:* Good on {110}, poor on {100}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6.5–7.5 D(meas.) = 3.13–3.16 D(calc.) = 3.149

Optical Properties: Transparent to nearly opaque with inclusions. *Color:* Pink, violet, yellow, green, white, gray; in thin section, colorless to pink or green. *Streak:* White. *Luster:* Vitreous to subvitreous.
Optical Class: Biaxial (–) or (+). *Pleochroism:* Weak; X = reddish pink; $Y = Z$ = greenish yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, strong. $\alpha = 1.632$ $\beta = 1.636$ $\gamma = 1.643$ 2V(meas.) = 71°–86°

Cell Data: *Space Group: Pnnm.* $a = 7.7980(7)$ $b = 7.9031(10)$ $c = 5.5566(5)$ Z = 4

X-ray Powder Pattern: Minas Gerais, Brazil.
5.542 (100), 4.527 (90), 2.773 (90), 2.170 (90), 3.924 (60), 3.524 (60), 2.466 (50)

Chemistry:

	(1)	(2)
SiO_2	36.74	37.08
TiO_2	0.01	
Al_2O_3	62.70	62.92
Fe_2O_3	0.36	
FeO	0.05	
CuO	0.02	
MgO	0.03	
K_2O	0.07	
H_2O^+	0.15	
H_2O^-	0.01	
Total	100.14	100.00

(1) Goat Mountain, Shoshone Co., Idaho, USA. (2) Al_2SiO_5.

Polymorphism & Series: Trimorphous with kyanite and sillimanite; forms a series with kanonaite.

Occurrence: A result of contact metamorphism of argillaceous sediments, also in regionally metamorphosed schists. Rare in granites and pegmatites, which however afford the largest crystals. Detrital in some sandstones.

Association: Kyanite, sillimanite, cordierite, corundum, garnet, tourmaline, mica.

Distribution: Widespread; some localities for good crystals follow. From Hornachuelos, near Córdoba, Córdoba Province, Spain. On the Lisens Alp, Selraintal, Tirol, Austria. At Gefrees, Bodenmais, and elsewhere in Bavaria, Germany. From the Claggau quarry, Co. Galway, Ireland. In the USA, from Lancaster, Worcester Co., Massachusetts; Leiperville, Delaware Co., Pennsylvania; around Custer, Custer Co., South Dakota; in California, from Fresno, Fresno Co., near Ogilby, Cargo Muchacho Mountains, Imperial Co., and near Daltons Ranch, Madera Co. From Mt. Howden, Bimbowrie, South Australia. At Nawalapitiya, Sri Lanka. Gem crystals from the Santa Teresa district, Espírito Santo, Brazil.

Name: For an occurrence in the Andalusia region, Spain.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 496–498. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 759–779. (3) Skinner, B.J., S.P. Clark, Jr., and D.E. Appleman (1961) Molar volumes and thermal expansions of andalusite, kyanite, and sillimanite. Amer. J. Sci., 259, 651–668. (4) Winter, J.K. and S. Ghose (1979) Thermal expansion and high-temperature crystal chemistry of the Al_2SiO_5 polymorphs. Amer. Mineral., 64, 573–586. (5) Gunter, M. and F.D. Bloss (1982) Andalusite-kanonaite series: lattice and optical parameters. Amer. Mineral., 67, 1218–1228.

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Andersonite $Na_2Ca(UO_2)(CO_3)_3 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}m$. As rhombohedra, pseudocubic or flattened and with complex form development, to 1 cm; typically in crystalline crusts, granular.

Physical Properties: Hardness = n.d. D(meas.) = 2.8 D(calc.) = 2.86 Radioactive; soluble in H_2O; fluoresces bright pale green to yellow-green under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Bright green to yellow-green. *Optical Class:* Uniaxial (+). *Pleochroism: O* = colorless; *E* = pale yellow. $\omega = 1.520$ $\epsilon = 1.540$

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic). $a = 17.902(4)$ $c = 23.734(4)$ Z = 18

X-ray Powder Pattern: Hillside mine, Arizona, USA.
13.0 (10), 7.97 (10), 5.68 (10), 5.22 (10), 3.71 (8), 3.00 (7), 4.35 (6)

Chemistry:

	(1)	(2)
SO_3	1.6	
CO_2	19.6	20.50
UO_3	43.4	44.40
MgO	0.5	
CaO	8.9	8.70
Na_2O	9.3	9.62
H_2O	[16.7]	16.78
Total	[100.0]	100.00

(1) Hillside mine, Arizona, USA; after deduction of gypsum 3.4%, H_2O by difference; corresponds then to $Na_{2.00}(Ca_{0.92}Mg_{0.08})_{\Sigma=1.00}(UO_2)_{1.01}(CO_3)_{2.97} \cdot 5.92H_2O$. (2) $Na_2Ca(UO_2)(CO_3)_3 \cdot 6H_2O$.

Occurrence: An uncommon secondary mineral, formed in the oxidized zone of uranium-bearing hydrothermal polymetallic deposits; may be post-mine, coating walls of mine tunnels.

Association: Schröckingerite, bayleyite, shwartzite, boltwoodite, liebigite, gypsum.

Distribution: In the USA, in Arizona, from the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co., and in the Cameron area, Coconino Co.; in Utah, in Grand Co., from the Parco No. 23 mine and Skinny No. 1 mine, southeast of Thompsons, with large crystals at the Bumblebee mine, Seven Mile Canyon, and elsewhere; in Emery Co., at the Delta mine; in San Juan Co., large crystals from the Atomic King No. 2 mine, south of Moab, and nearby mines in Cane Wash, and at the Repete mine. In Colorado, from the Deremo-Snyder mine, San Miguel Co.; large crystals found in the Ambrosia Lake district, McKinley Co., New Mexico; at Jim Thorpe, Carbon Co., Pennsylvania. From Myrthengraben, Semmering Pass, Austria. In the Geevor mine, St. Just, Cornwall, England. At Stripa, Västmanland, Sweden. From Rozna and Jáchymov (Joachimsthal), Czech Republic. In the Huemul mine, Malargüe district, Mendoza Province, Argentina.

Name: Honors Charles Alfred Anderson (1902–1990), geologist with the U.S. Geological Survey, who collected the first samples.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106112–106115.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 239. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 115–117. (3) Coda, A., A. Della Giusta, and V. Tazzoli (1981) The structure of synthetic andersonite, $Na_2Ca[UO_2(CO_3)_3] \cdot xH_2O$ ($x \simeq 5.6$). Acta Cryst., 37, 1496–1500. (4) Axelrod, J.M., F.S. Grimaldi, C. Milton, and K.J. Murata (1951) The uranium minerals from the Hillside mine, Yavapai County, Arizona. Amer. Mineral., 36, 1–22.

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Andesine $Na_{0.7-0.5}Ca_{0.3-0.5}Al_{1.3-1.5}Si_{2.7-2.5}O_8$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals rare, to 2 cm; commonly massive, cleavable, or granular. *Twinning:* Commonly twinned after Albite, Pericline, and Carlsbad laws. Also twinned after a law similar to the Manebach law.

Physical Properties: *Cleavage:* Perfect on {001}, less perfect on {010}; {110} also observed. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.66–2.68 D(calc.) = 2.68

Optical Properties: Transparent to translucent. *Color:* White, gray, green, yellow, flesh-red. *Streak:* White. *Luster:* Subvitreous to pearly.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, weak. $\alpha = 1.545–1.556$ $\beta = 1.548–1.558$ $\gamma = 1.552–1.563$ 2V(meas.) = 78°–90° (low); 73°–80° (high).

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.151(3)$ $b = 12.829(5)$ $c = 14.206(7)$ $\alpha = 93.62(3)°$ $\beta = 116.21(2)°$ $\gamma = 89.70(2)°$ Z = 8

X-ray Powder Pattern: Crestmore, Riverside Co., California, USA (low).
3.21 (100), 3.18 (90), 4.04 (80), 3.76 (70), 3.65 (70), 3.14 (70), 2.93 (70b)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	57.59	60.76	55.59	Na_2O	6.39	8.12	5.73
Al_2O_3	25.84	24.82	28.30	K_2O	0.55		
Fe_2O_3	0.92			H_2O^+	0.32		
MgO	trace			H_2O^-	0.05		
CaO	8.45	6.30	10.38	Total	100.11	100.00	100.00

(1) Beaver Bay, Lake Co., Minnesota, USA. (2) $Na_{0.70}Ca_{0.30}Al_{1.30}Si_{2.70}O_8$. (3) $Na_{0.50}Ca_{0.50}Al_{1.50}Si_{2.50}O_8$.

Polymorphism & Series: Low and high temperature variants differing in structural detail are recognized.

Mineral Group: Feldspar group, plagioclase series.

Occurrence: Widespread in igneous rocks of intermediate silica content, as syenites and andesites. Characteristic of granulite to amphibolite facies metamorphism, commonly as antiperthite; as detrital grains in sedimentary rocks.

Association: Quartz, potassic feldspar, biotite, "hornblende," magnetite.

Distribution: A widespread mineral, although crystals are not common. In the andesite lavas of the Andes Mountains, South America, as at Marmato, Columbia. Around St. Raphaël, Estérel Mountains, Var, and near Chagey, Haute-Saône, France. At Bodenmais, Bavaria, Germany. On Mt. Arcuentu, Sardinia, Italy. From Vapnefjord, Iceland. At Sannidal and Arendal, Norway. In the USA, at Sanford, York Co., Maine. In Japan, at Kaneda, Miyagi Prefecture; Naka, Iwojima Island; Kuzuhara, Toyama Prefecture; and a number of other places. From Minsen, Korea. At Cape Grant, Victoria, Australia.

Name: For the Andes Mountains of South America where it is abundant in the lavas.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 325–327, 333–334. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 94–165. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 352–360. (4) Goodyear, J. and W.J. Duffin (1954) The identification and determination of plagioclase feldspars by the X-ray powder method. Mineral. Mag., 30, 306–326. (5) Steurer, W. and H. Jagodzinski (1988) The incommensurately modulated structure of an andesine. Acta Cryst., 44, 344–351.

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Andorite $PbAgSb_3S_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals stout prismatic, to 3 cm; also thick and thin tabular on {100}, striated ‖ [001]; massive. *Twinning:* Reported on {110}.

Physical Properties: *Fracture:* Smooth conchoidal. *Tenacity:* Brittle. Hardness = 3–3.5 VHN = n.d. D(meas.) = 5.35 D(calc.) = [5.40]

Optical Properties: Opaque. *Color:* Dark steel-gray, may tarnish yellow or iridescent; in polished section, white. *Streak:* Black. *Luster:* Metallic.
R_1–R_2: (400) 38.8–41.8, (420) 38.6–42.0, (440) 38.4–42.2, (460) 37.9–42.2, (480) 37.5–42.1, (500) 37.1–41.9, (520) 36.7–41.5, (540) 36.4–41.2, (560) 36.1–40.8, (580) 35.8–40.4, (600) 35.5–39.9, (620) 35.3–39.5, (640) 35.0–39.1, (660) 34.7–38.6, (680) 34.3–38.1, (700) 33.9–37.6

Cell Data: *Space Group: Pmma.* $a = 13.01$ $b = 19.19$ $c = 4.27$ Z = [4]

X-ray Powder Pattern: Takla Lake, Canada.
3.30 (100), 2.90 (80), 3.45 (40), 2.76 (40), 3.74 (30), 2.06 (30), 1.888 (30)

Chemistry:

	(1)	(2)	(3)
Pb	24.10	22.25	23.75
Ag	10.94	10.90	12.36
Cu	0.68	0.96	
Zn		0.31	
Fe	0.30	0.75	
Sb	41.31	40.75	41.87
S	22.06	24.26	22.02
Total	99.39	100.18	100.00

(1) Oruro, Bolivia. (2) Baia Sprie, Romania. (3) $PbAgSb_3S_6$.

Occurrence: In low-temperature polymetallic hydrothermal veins.

Association: Stibnite, sphalerite, barite, fluorite, siderite, quartz (Baia Sprie, Romania); cassiterite, arsenopyrite, stannite, zinkenite, tetrahedrite, pyrite, alunite, quartz (Itos mine, Bolivia); pyrargyrite, stephanite, sphalerite, rhodochrosite, quartz (Morey, Nevada, USA).

Distribution: In Romania, from Baia Sprie (Felsőbánya) [TL]. In the Czech Republic, at Třebsko, near Příbram. In the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia. From the Les Farges mine, near Ussel, Corrèze; and at Bournac, Montagne Noire, Finistère, France. In the USA, at the Keyser and Morey mines, Morey district, Nye Co., Nevada; in the Thompson mine, Darwin district, Inyo Co., California; and at Bear basin, King Co., Washington. From near Takla Lake, British Columbia, and near Nansen Creek, Yukon Territory, Canada. In Bolivia, in the Itos and San José mines, Oruro; at the Tatasi mine, and Cerro Rico, Potosí. In Australia, from the Meerschaum mine, north of Omeo, Victoria.

Name: For Andor von Semsey (1833–1923), Hungarian nobleman, who was also an amateur mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 457–459. (2) Donnay, J.D.H. and G. Donnay (1954) Syntaxic intergrowths in the andorite series. Amer. Mineral., 39, 161–171. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 155–156. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 12.

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Andorite $PbAgSb_3S_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals stout prismatic, to 3 cm; also thick and thin tabular on {100}, striated ‖ [001]; massive. *Twinning:* Reported on {110}.

Physical Properties: *Fracture:* Smooth conchoidal. *Tenacity:* Brittle. Hardness = 3–3.5 VHN = n.d. D(meas.) = 5.35 D(calc.) = [5.40]

Optical Properties: Opaque. *Color:* Dark steel-gray, may tarnish yellow or iridescent; in polished section, white. *Streak:* Black. *Luster:* Metallic.
R_1–R_2: (400) 38.8–41.8, (420) 38.6–42.0, (440) 38.4–42.2, (460) 37.9–42.2, (480) 37.5–42.1, (500) 37.1–41.9, (520) 36.7–41.5, (540) 36.4–41.2, (560) 36.1–40.8, (580) 35.8–40.4, (600) 35.5–39.9, (620) 35.3–39.5, (640) 35.0–39.1, (660) 34.7–38.6, (680) 34.3–38.1, (700) 33.9–37.6

Cell Data: *Space Group: Pmma.* $a = 13.01$ $b = 19.19$ $c = 4.27$ Z = [4]

X-ray Powder Pattern: Takla Lake, Canada.
3.30 (100), 2.90 (80), 3.45 (40), 2.76 (40), 3.74 (30), 2.06 (30), 1.888 (30)

Chemistry:

	(1)	(2)	(3)
Pb	24.10	22.25	23.75
Ag	10.94	10.90	12.36
Cu	0.68	0.96	
Zn		0.31	
Fe	0.30	0.75	
Sb	41.31	40.75	41.87
S	22.06	24.26	22.02
Total	99.39	100.18	100.00

(1) Oruro, Bolivia. (2) Baia Sprie, Romania. (3) $PbAgSb_3S_6$.

Occurrence: In low-temperature polymetallic hydrothermal veins.

Association: Stibnite, sphalerite, barite, fluorite, siderite, quartz (Baia Sprie, Romania); cassiterite, arsenopyrite, stannite, zinkenite, tetrahedrite, pyrite, alunite, quartz (Itos mine, Bolivia); pyrargyrite, stephanite, sphalerite, rhodochrosite, quartz (Morey, Nevada, USA).

Distribution: In Romania, from Baia Sprie (Felsőbánya) [TL]. In the Czech Republic, at Třebsko, near Příbram. In the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia. From the Les Farges mine, near Ussel, Corrèze; and at Bournac, Montagne Noire, Finistère, France. In the USA, at the Keyser and Morey mines, Morey district, Nye Co., Nevada; in the Thompson mine, Darwin district, Inyo Co., California; and at Bear basin, King Co., Washington. From near Takla Lake, British Columbia, and near Nansen Creek, Yukon Territory, Canada. In Bolivia, in the Itos and San José mines, Oruro; at the Tatasi mine, and Cerro Rico, Potosí. In Australia, from the Meerschaum mine, north of Omeo, Victoria.

Name: For Andor von Semsey (1833–1923), Hungarian nobleman, who was also an amateur mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 457–459. (2) Donnay, J.D.H. and G. Donnay (1954) Syntaxic intergrowths in the andorite series. Amer. Mineral., 39, 161–171. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 155–156. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 12.

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Andradite $Ca_3Fe_2^{3+}(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly well-crystallized dodecahedra, trapezohedra, or combinations, to 5 cm. Also granular to massive.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 3.8–3.9 D(calc.) = 3.859

Optical Properties: Transparent to translucent. *Color:* Yellow, greenish yellow to emerald-green, dark green; brown, brownish red, brownish yellow; grayish black, black; may be sectored. *Streak:* White. *Luster:* Adamantine to resinous, dull.
Optical Class: Isotropic; typically weakly anisotropic. $n = 1.887$

Cell Data: *Space Group: Ia3d.* $a = 12.056$ Z = 8

X-ray Powder Pattern: Synthetic.
2.696 (100), 3.015 (60), 1.6112 (60), 2.462 (45), 1.9564 (25), 1.6728 (25), 1.1195 (25)

Chemistry:

	(1)	(2)
SiO_2	34.91	35.47
TiO_2	trace	
Al_2O_3	0.69	
Fe_2O_3	30.40	31.42
MgO	0.58	
CaO	33.20	33.11
H_2O^-	0.19	
Total	99.97	100.00

(1) Reškovic stream, Serbia, Yugoslavia; corresponds to $(Ca_{3.01}Mg_{0.07})_{\Sigma=3.08}(Fe^{3+}_{1.94}Al_{0.02})_{\Sigma=1.96}(Si_{2.95}Al_{0.05})_{\Sigma=3.00}O_{12}$. (2) $Ca_3Fe_2(SiO_4)_3$.

Polymorphism & Series: Forms two series, with grossular, and with schorlomite.

Mineral Group: Garnet group.

Occurrence: In skarns from contact metamorphosed impure limestones or calcic igneous rocks; in chlorite schists and serpentinites; in alkalic igneous rocks, then typically titaniferous.

Association: Vesuvianite, chlorite, epidote, spinel, calcite, dolomite, magnetite.

Distribution: Widespread; fine examples from; in Italy, at Frascati, Alban Hills, Lazio; the Val Malenco, Lombardy; the Ala Valley, Piedmont; and Larcinaz, Val d'Aosta. At Dognecea (Dognaczka) and Oraviţa (Oravicza), Banat, Romania. From Ocna de fier, Romania (Vaskö, Hungary). At Zermatt, Valais, Switzerland. From Arendal, Norway. In the Wessels mine, near Kuruman, Cape Province, South Africa. In Russia, gem crystals from the Bobrovka River, Nizhni Tagil district, and the Sissertsk district, Ural Mountains; at Sineretschenskoje, north of Vladivostock. In the USA, from Stanley Butte, Graham Co., Arizona; on Garnet Hill, Calaveras Co., and around the Gem mine, San Benito Co., California; at Franklin and Sterling Hill, Sussex Co., New Jersey; from Magnet Cove, Hot Spring Co., Arkansas; and on Prince of Wales Island, Alaska. In Mexico, found near Charco de Peña, about 75 km east of Lázaro Cárdenas, Chihuahua.

Name: After J.B. d'Andrada e Silva (1763–1838), Brazilian mineralogist who described a variety.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 437–447. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 468–698, esp. 617–641. (3) Novak, G.A. and G.V Gibbs (1971) The crystal chemistry of the silicate garnets. Amer. Mineral., 56, 791–825. (4) (1960) NBS Circ. 539, 9, 22.

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Andremeyerite $BaFe_2^{2+}Si_2O_7$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As crystals, < 0.2 mm, with {100} and {010} dominant, also {011} and {120}. *Twinning:* Multiple twinning on {100}.

Physical Properties: *Cleavage:* Perfect on {100} and {010}. Hardness = 5.5 VHN = 440 D(meas.) = 4.15 D(calc.) = 4.14

Optical Properties: Transparent to translucent. *Color:* Pale emerald-green. *Optical Class:* Biaxial (+). *Pleochroism:* X = pale bluish green; $Y = Z$ = colorless with faint brownish tint. *Orientation:* $Z = b$; $X \wedge c = 2°$ at 670 nm to 61° at 470 nm. *Dispersion:* Very strong. *Absorption:* $X > Y \simeq Z$. $\alpha = 1.740(5)$ $\beta = 1.740(5)$ $\gamma = 1.760(5)$ 2V(meas.) = 0°–80°

Cell Data: *Space Group:* $P2_1/c$. $a = 7.488(1)$ $b = 13.785(1)$ $c = 7.085(1)$ $\beta = 118.23(1)°$ Z = 4

X-ray Powder Pattern: Mt. Nyiragongo, Congo.
3.055 (100), 3.122 (80), 3.288 (60), 2.472 (55), 4.63 (40), 2.811 (40), 3.198 (20)

Chemistry:

	(1)	(2)
SiO_2	32.46	28.81
Al_2O_3	1.00	
FeO	31.55	34.44
MnO	1.33	
MgO	0.75	
CaO	0.52	
BaO	32.55	36.75
Na_2O	0.10	
K_2O	0.65	
Total	100.91	100.00

(1) Mt. Nyiragongo, Congo; by electron microprobe. (2) $BaFe_2Si_2O_7$.

Occurrence: In vesicles of melilite-leucite-nephelinite; may represent crystallization of an associated green glass.

Association: Nepheline, leucite, clinopyroxene, kirschsteinite, melilite, apatite, magnetite, götzenite, troilite, glass.

Distribution: From the rim of Mt. Nyiragongo volcano, Kivu Province, Congo (Zaire).

Name: To honor André Marie Meyer (1890–?), Belgian geologist with the Geological Survey of the Belgian Congo, who first collected the mineral.

Type Material: University of Helsinki, Helsinki, Finland.

References: (1) Sahama, T.G., J. Siivola, and P. Rehtijärvi (1973) Andremeyerite, a new barium iron silicate from Nyiragongo, Zaire. Bull. Geol. Soc. Finland, 45, 1–8. (2) (1974) Amer. Mineral., 59, 381 (abs. ref. 1). (3) Cannillo, E.C., F. Mazzi, and G. Rossi (1988) Crystal structure of andremeyerite, $BaFe(Fe,Mn,Mg)Si_2O_7$. Amer. Mineral., 73, 608–612.

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Anduoite $(Ru, Os)As_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As euhedral to anhedral grains, to 100 μm, or in granular aggregates.

Physical Properties: *Cleavage:* At least one noted. *Tenacity:* Brittle. Hardness = n.d. VHN = 1077.9 (50 g load). D(meas.) = n.d. D(calc.) = 8.692

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, white with a pink tint. *Streak:* Grayish black. *Luster:* Dull metallic. *Pleochroism:* Noticeable in air, from pinkish grayish white to pinkish white; distinct in oil. *Anisotropism:* Marked in air, from brownish yellow to grayish green, pale red to pale green; pronounced in oil, from reddish yellow, greenish yellow to purplish gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* *Pnnm* or *Pnn*2. $a = 5.41$ $b = 6.206$ $c = 3.01$ Z = 2

X-ray Powder Pattern: Anduo, Tibet, China.
1.920 (100), 1.501 (90), 1.095 (90), 1.133 (80), 1.210 (70), 1.187 (70), 2.000 (50)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Ru	34.47	30.35	30.65	Cu	0.10	0.00	0.00
Os	6.20	7.27	8.37	Ni	0.00	0.00	0.95
Pt	0.00	0.82	0.65	As	56.65	56.57	56.91
Pd	0.00	0.52	0.61	Sb	0.01	0.00	0.00
Rh	0.00	1.02	1.54	S	0.09	0.26	0.12
Ir	2.08	1.86	0.54	Total	99.60	98.67	100.34

(1) Anduo, Tibet, China; by electron microprobe, average of six analyses, corresponding to $(Ru_{0.89}Os_{0.08}Ir_{0.03}Cu_{0.03})_{\Sigma=1.03}(As_{1.98}S_{0.01})_{\Sigma=1.99}$. (2) Kapinitov deposit, Ukraine; by electron microprobe, average of four analyses, corresponding to $(Ru_{0.80}Os_{0.10}Ir_{0.03}Rh_{0.03}Pd_{0.01}Pt_{0.01})_{\Sigma=0.98}(As_{2.01}S_{0.02})_{\Sigma=2.03}$. (3) Maja e Sukës deposit, Albania; by electron microprobe, corresponding to $(Ru_{0.79}Os_{0.11}Rh_{0.04}Ni_{0.04}Pd_{0.02}Ir_{0.01})_{\Sigma=1.01}(As_{1.98}S_{0.01})_{\Sigma=1.99}$.

Polymorphism & Series: Forms a series with omeiite.

Occurrence: Of magmatic origin, as very rare inclusions in chromian spinel in chromitite bodies enclosed variously by augite peridotite, serpentinized dunite, harzburgite, and pyroxenite.

Association: Chromian spinel, pyrite, pyrrhotite, marcasite, magnetite, chalcopyrite, molybdenite, galena, millerite, violarite. Other platinum group minerals present are ruthenarsenite, sperrylite, ruthenian iridarsenite, irarsenite, irarsite, osarsite, osmiridium, ruthenian osmiridium, laurite, rutheniridosmine (Anduo, Tibet, China); chromian spinel, sperrylite, hollingworthite (Maja e Sukës deposit, Albania).

Distribution: From the Anduo chromite deposit, northern Tibet, China. At the Kapitanov chromite deposit, near Zvenyhorodka, Ukraine. From the Maja e Sukës chromite deposit, Tropoja massif, Albania.

Name: For the Chinese locality at Anduo.

Type Material: Chinese Geological Museum (City ?).

References: (1) Yu, T. and Chou, H. (1979) Anduoite, a new ruthenium arsenide. Kexue Tongbao, 15, 704–708 (in Chinese with English abs.). (2) (1980) Amer. Mineral., 65, 808–809 (abs. ref. 1). (3) Gornostayev, S.S., M. Ohnenstetter, A. Neziraj, D. Ohnenstetter, K.V.O. Laajoki, S.E. Popovchenko, and P.K. Korninko (2001) New occurrences of anduoite, $(Ru, Os)As_2$, from chromite deposits of Ukraine and Albania. Can. Mineral., 39, 591–606. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 95–96.

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Angarfite $NaFe^{3+}_5(PO_4)_4(OH)_4 \cdot 4H_2O$

Crystal Data: Orthorhombic. *Point Group*: 222. Crystals prismatic to needle-like, elongate on [001], with poorly formed chisel-like terminations, to 2 mm.

Physical Properties: *Cleavage*: Poor on {010}. *Fracture*: Splintery. *Tenacity*: Brittle, slightly flexible splinters. Hardness = 2.5 D(meas.) = 2.76(3) D(calc.) = 2.771

Optical Properties: Transparent. *Color*: Orange-brown to red-brown. *Streak*: Pale brown. *Luster*: Vitreous.
Optical Class: Biaxial (+). α = 1.688(1) β = 1.696(1) γ = 1.708(2) 2V(meas.) = 80(3)° 2V(calc.) = 79° *Orientation*: $X = b$, $Y = c$, $Z = a$. *Pleochroism*: X = tan, Y = medium red-brown, Z = dark red-brown. *Absorption*: $X < Y < Z$. *Dispersion*: Strong, $r > v$.

Cell Data: *Space Group*: $C222_1$. a = 12.788(3) b = 17.894(4) c = 8.195(2) Z = 4

X-ray Powder Pattern: Angarf-Sud pegmatite, Tazenakht, Souss-Massa-Draâ region, Morocco. 9.016 (100), 3.355 (51), 10.463 (43), 6.459 (42), 1.463 (36), 1.926 (33), 3.026 (29)

Chemistry:

	(1)
Na_2O	2.69
MgO	4.76
Mn_2O_3	1.79
Fe_2O_3	37.36
P_2O_5	34.68
H_2O	[14.63]
Total	95.91

(1) Angarf-Sud pegmatite, Tazenakht, Souss-Massa-Draâ region, Morocco; average of 5 electron microprobe analyses, H_2O calculated from structure analysis; corresponding to $Na_{0.71}(Fe^{3+}_{3.83}Mg_{0.97}Mn^{3+}_{0.19})_{\Sigma=4.99}(P_{1.00}O_4)_4(OH)_{2.71}(H_2O)_{1.29} \cdot 4H_2O$.

Occurrence: Occurs in phosphate nodules in the intermediate zone of a granitic pegmatite by the reaction of Na-bearing hydrothermal solutions with primary triphylite.

Association: Triphylite, lipscombite–barbosalite, jahnsite-(NaFeMg), bederite.

Distribution: Angarf-Sud pegmatite, Tazenakht, Ouarzazate Province, Souss-Massa-Draâ region, Morocco.

Name: For the pegmatite body from which the first specimens were collected.

Type Material: Natural History Museum of Los Angeles County, California, USA (63428 and 63429).

References: (1) Kampf, A.R., S.J. Mills, R.M. Housley, G. Favreau, J.-C. Boulliard, and V. Bourgoin (2012) Angarfite, $NaFe_5^{3+}(PO_4)_4(OH)_4 \cdot 4H_2O$, a new mineral species from the Angarf-Sud Pegmatite, Morocco: Description and crystal structure. Can. Mineral., 50, 781-791. (2) (2014) Amer. Mineral., 99, 1511 (abs. ref. 1).

Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals are tabular, with a number of forms, to 1 cm, generally in crystalline and globular incrustations.

Physical Properties: *Cleavage:* On {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 4.867 D(calc.) = 4.862

Optical Properties: Semitransparent. *Color:* Dark brown. *Streak:* Reddish brown. *Luster:* Adamantine to semimetallic.
Optical Class: Biaxial (+). *Pleochroism:* Strong; deep blood-red to reddish brown.
Absorption: $X < Z$. $\alpha = 2.13$ $\beta = \sim 2.2$ $\gamma = 2.40$ 2V(meas.) = Medium large.
Anisotropism: Strong.

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.461(5)$ $b = 6.594(3)$ $c = 5.036(3)$ $\alpha = 106.21(5)°$ $\beta = 98.35(5)°$ $\gamma = 108.86(5)°$ Z = 1

X-ray Powder Pattern: Cerro Pululus, Argentina.
3.152 (10), 2.997 (7), 2.856 (5), 2.489 (5), 2.072 (5), 2.960 (4), 2.955 (4)

Chemistry:

	(1)	(2)
As_2O_5	32.2	41.85
SiO_2	5.81	
SnO_2	2.92	
Al_2O_3	2.82	
Fe_2O_3	55.8	58.15
Total	99.55	100.00

(1) Cerro Pululus, Argentina; contains Fe_2O_3 in excess, as hematite; about 3% Sb found in a separate determination; Fe_2O_3:As_2O_5 = 2.49 but found = 2 by XRF in comparison with synthetic material. (2) $Fe_4O_3(AsO_4)_2$.

Occurrence: Probably of exhalative origin, in tin ore.

Association: Cassiterite, hematite.

Distribution: From the Vela Yareta tin mine, on Cerro Pululus, east of Laguna Vilama, Jujuy Province, Argentina.

Name: To honor Dr. Victorio Angelelli (1908–), Argentinian mining geologist, Director of the Argentinian Geological Survey.

Type Material: n.d.

References: (1) Ramdohr, P., F. Ahlfeld, and F. Berndt (1959) Angelellit, ein natürliches triklines Eisen-Arsenat, $2Fe_2O_3 \cdot As_2O_5$. Neues Jahrb. Mineral., Monatsh., 145–151 (in German). (2) Weber, K. (1959) Eine kristallgraphische Untersuchung des Angelellits, $2Fe_2O_3 \cdot As_2O_5$. Neues Jahrb. Mineral., Monatsh., 152–158 (in German). (3) (1959) Amer. Mineral., 44, 1322–1323 (abs. refs. 1 and 2). (4) Moore, P. B. and T. Araki (1978) Angelellite, $Fe_4^{3+}O_3(As^{5+}O_4)_2$: a novel cubic close-packed oxide structure. Neues Jahrb. Mineral., Abh., 132, 91–100 (in German with English abs.).

Anglesite $PbSO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are typically elongated with rhomboidal cross-section, prismatic with large {210}, vertically striated, or large {011} with {101} and {102}; tabular on {001} or {100}; equant {111} and {211}, may exhibit 20 other minor forms, to 0.5 m. Also nodular, stalactitic, granular, massive, banded around a core of galena.

Physical Properties: *Cleavage:* {001}, good; {210}, distinct; {010}, less distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 6.38 D(calc.) = 6.36 May fluoresce yellow under UV.

Optical Properties: Transparent to opaque. *Color:* Colorless to white, commonly tinted gray; orange, yellow, green, blue, rarely violet; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine, resinous to vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, strong.
$\alpha = 1.877$ $\beta = 1.883$ $\gamma = 1.894$ 2V(meas.) = 68°–75°

Cell Data: *Space Group: Pnma.* $a = 8.482(2)$ $b = 5.398(2)$ $c = 6.959(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.001 (100), 4.26 (87), 3.333 (86), 2.067 (76), 3.220 (71), 3.813 (57), 2.028 (48)

Chemistry: (1) Modern analyses are lacking; identification depends on coincidence of X-ray and optical properties with those of the synthetic compound.

Mineral Group: Barite group.

Occurrence: Common in the oxidized zone of lead deposits, where it may constitute an important ore.

Association: Cerussite, leadhillite, lanarkite, caledonite, linarite, brochantite, malachite, mimetite, pyromorphite, wulfenite, massicot, gypsum, sulfur, galena.

Distribution: A few localities for well-crystallized specimens include: from Parys Mountain, Anglesey, Wales. In England, at Matlock and Cromford, Derbyshire, and Caldbeck Fells, Cumbria. From Leadhills, Lanarkshire, and Wanlockhead, Dumfriesshire, Scotland. At Bleiberg, Carinthia, Austria. From Mežica (Mies), Slovenia. In Germany, at Müsen, Littlefeld, Siegen, and other places in Siegerland. From Monteponi and Montevecchio, near Iglesias, Sardinia. In Russia, at Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, and at Nerchinsk, Siberia. From Sidi-Amor-ben-Salem, Tunisia. Fine crystals at the Touissit mine, near Oujda, Morocco. Very large crystals from Tsumeb, and in the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia. In the USA, from the Wheatley mine, Phoenixville, Chester Co., Pennsylvania; in Idaho, from the Bunker Hill mine, Coeur d'Alene district, in the Hypotheek mine, south of Kingston, and the Last Chance and Tyler mines, Wardner, Shoshone Co.; in the Eureka Hill mine, Tintic district, Juab Co., Utah; from the Grand Reef mine, Graham Co., Arizona. In Mexico, from Los Lamentos, Chihuahua; in the Amelia mine, Santa Rosalia, Baja California; at San Felipe Canyon, Aconchi, Sonora. In Australia, large crystals from Broken Hill, New South Wales, and at Dundas, Tasmania.

Name: For its occurrence on the island of Anglesey, Wales.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 420–424. (2) Miyake, M., I. Minato, H. Morikawa, and S. Iwai (1978) Crystal structures and sulphate force constants of barite, celestite, and anglesite. Amer. Mineral., 63, 506–510. (3) Jacobsen, S.D., J.R. Smyth, R.J. Swope, and R.T. Downs (1998) Rigid-body character of the SO_4 groups in celestine, anglesite, and barite. Can. Mineral., 36, 1053–1060. (4) (1954) NBS Circular 539, 3, 67.

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Anhydrite $CaSO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals tabular on {010}, {100}, or {001} or equant with large pinacoidal faces; elongated along [100] or [001], to 15 cm, with about 40 forms recorded. Typically granular, nodular, parallel or divergent fibrous, massive. *Twinning:* Simple or repeatedly on {011}, common; contact twins rare on {120}.

Physical Properties: *Cleavage:* On {010}, perfect; on {100} nearly perfect; on {001} good to imperfect, yielding pseudocubic fragments. *Fracture:* Uneven to splintery. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 2.98(1) D(calc.) = 2.95

Optical Properties: Transparent to translucent. *Color:* Colorless to pale blue or violet if transparent; white, mauve, rose, pale brown or gray from included impurities; colorless in transmitted light. *Streak:* White to pale gray. *Luster:* Pearly on {010}, vitreous to greasy on {001}; vitreous on {100}.
Optical Class: Biaxial (+). *Pleochroism:* For violet varieties; X = colorless to pale yellow or rose; Y = pale violet or rose; Z = violet. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, strong. *Absorption:* $Z > Y > X$. $\alpha = 1.567$–1.574 $\beta = 1.574$–1.579 $\gamma = 1.609$–1.618 2V(meas.) = 42°–44°

Cell Data: *Space Group: Amma.* $a = 6.993(2)$ $b = 6.995(2)$ $c = 6.245(1)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.499 (100), 2.849 (29), 2.3282 (20), 2.2090 (20), 1.8692 (16), 1.6483 (15), 1.7500 (11)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	58.37	58.81	CaO	41.13	41.19
CO_2	0.17		FeS_2	0.02	
$(Al,Fe)_2O_3$	0.06		Total	99.75	100.00

(1) Yonaibata mine, Hukusima Prefecture, Japan; after deduction of CO_2 as calcite, corresponds to $Ca_{0.99}S_{1.00}O_4$. (2) $CaSO_4$.

Occurrence: A major component in sedimentary evaporite deposits and in the cap rocks above salt domes, commonly formed by dehydration of gypsum; in igneous rocks, fumarolic deposits, and in seafloor hydrothermal chimneys, also an alteration product in hydrothermal mineral deposits.

Association: Gypsum, halite, sylvite, polyhalite, dolomite, calcite, magnesite, celestine, sulfur.

Distribution: Numerous occurrences worldwide. In Austria, from Hall, Tirol, at Ischl and Hallein, Salzburg, and Aussee, Styria. In Germany, in Saxony-Anhalt, from Stassfurt-Leopoldshall and Douglashall, near Westeregeln; at Wathlingen, near Celle, Lower Saxony, and elsewhere. Gemmy crystals from the Simplon Tunnel, Valais, Switzerland. In Italy, from the Campiano mine, Boccheggiano district, Tuscany; on Vesuvius, Campania. From the Faraday mine, Bancroft, Ontario, Canada. In the USA, from Paterson, Passaic Co., New Jersey; in the Fairfax quarry, Centreville, Fairfax Co., Virginia; large deposits in the Carlsbad potash district, Eddy Co., New Mexico; at the Boiling Salt Dome, Wharton Co., Texas. From Naica, Chihuahua, Mexico. In the Salt Range, Punjab, India. On Mt. Pinatubo, Philippines. At Morococha, Peru.

Name: From the Greek for *without water*, in contast to hydrous calcium sulfate minerals.

Type Material: Mining Academy, Freiberg, Germany, 16538.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 424–428. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 74–94. (3) Hawthorne, F.C. and R.B. Ferguson (1975) Anhydrous sulphates. II. Refinement of the crystal structure of anhydrite. Can. Mineral., 13, 289–292. (4) Kirfel, A. and G. Will (1980) Charge density in anhydrite, $CaSO_4$, from X-ray and neutron diffraction measurements. Acta Cryst., 36, 2881–2890. (5) McMurdie, H.F., M.-C. Morris, E.H. Evans, B. Paretzkin, W. Wong-Ng, and C.R.Hubbard (1986) Standard X-ray diffraction powder patterns from the JCPDS research associateship. Powder Diffraction, 1, 267.

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Anilite Cu_7S_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic or platy crystals, to 5 mm. *Twinning:* Very common; the twin operations are symmetry operations that act on a pseudocubic subcell, producing "neighboring twins" in which individuals are difficult to distinguish.

Physical Properties: *Tenacity:* Sectile. Hardness = ∼3 VHN = n.d. D(meas.) = n.d. D(calc.) = 5.68

Optical Properties: Opaque. *Color:* Bluish gray. *Streak:* Black. *Luster:* Metallic. R_1–R_2: n.d.

Cell Data: *Space Group: Pnma.* $a = 7.89$ $b = 7.84$ $c = 11.01$ $Z = 4$

X-ray Powder Pattern: Ani mine, Japan. Many of the reported associations of digenite and djurleite, identified by powder diffraction, could be anilite and djurleite, as anilite transforms to digenite during grinding.
1.956 (100), 2.77 (65), 3.20 (57), 2.16 (39), 1.677 (35), 2.54 (31), 2.59 (29)

Chemistry:

	(1)	(2)	(3)
Cu	79.2	80.1	77.6
S	21.7	22.7	22.4
Total	100.9	102.8	100.0

(1–2) Ani mine, Japan; by electron microprobe. All specimens contained some djurleite, $Cu_{31}S_{16}$. (3) Cu_7S_4.

Occurrence: In a drusy quartz vein (Ani mine, Japan); in a Kuroko ore deposit (Matsumine mine, Japan).

Association: Djurleite, covellite (Ani mine, Japan); yarrowite, spionkopite, djurleite, wittichenite, tennantite, chalcopyrite, bornite (Yarrow Creek, Canada); in red beds (Timna Formation, Israel; near Zurich, Switzerland).

Distribution: In Japan, in Akita Prefecture, from the Ani mine [TL], and in the Matsumine mine. At Neudorf, Harz Mountains, Germany. Found northeast of Zurich, Switzerland. From the Lubin and Rudna copper mines, near Legnica, Zechstein copper district, Lower Silesia, Poland. At Bor, Serbia. In the Castletown mine, Lochgilphead, Scotland. From near Nizhni Tagil, Ural Mountains, Russia. In the Timna Formation, southern Israel. In the Estrella mine, Atacama, Chile. From Yarrow Creek, southwestern Alberta, Canada. At Wallaroo, South Australia.

Name: For the Ani mine, Japan.

Type Material: National Science Museum, Tokyo, Japan.

References: (1) Morimoto, N., K. Koto, and Y. Shimazaki (1969) Anilite, Cu_7S_4, a new mineral. Amer. Mineral., 54, 1256–1268. (2) Koto, K. and N. Morimoto (1970) The crystal structure of anilite. Acta Cryst., 26, 915–924.

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Ankangite $Ba(Ti, V^{3+}, Cr^{3+})_8O_{16}$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals, euhedral to subhedral, prismatic, with {100} and {110}, to 1 mm.

Physical Properties: *Cleavage:* Interrupted ⊥ elongation, possibly a parting. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. VHN = 874 (50 g load). D(meas.) = 4.44 D(calc.) = 4.389

Optical Properties: Opaque. *Color:* Black; in reflected light, light rose-reddish gray. *Streak:* Grayish black. *Luster:* Vitreous to adamantine. *Optical Class:* Uniaxial. *Pleochroism:* O = pinkish gray; E = light pink. *Orientation:* $E = c$. *Anisotropism:* Distinct. *Bireflectance:* Weak to distinct.
R_1–R_2: (589) 12.8–20.1

Cell Data: *Space Group:* $I4/m$. $a = 10.139(4)$ $c = 2.961(2)$ $Z = 1$

X-ray Powder Pattern: Ankang Co., China.
3.202 (10), 2.476 (7), 1.589 (7), 3.580 (5), 2.233 (5), 1.892 (5), 1.685 (5)

Chemistry:

	(1)
TiO_2	54.0891
V_2O_3	22.3242
Cr_2O_3	2.0792
BaO	20.5927
Total	99.0852

(1) Ankang Co., China; by electron microprobe, V^{3+} verified by X-ray photoelectron spectroscopy; corresponding to $Ba_{1.09}(Ti_{5.48}V_{2.41}Cr_{0.22})_{\Sigma=8.11}O_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: In a quartz vein.

Association: Barite, barytocalcite, roscoelite, diopside.

Distribution: From the Shiti barite deposit, Ankang Co., Shaanxi Province, China.

Name: For Ankang Co., Shaanxi Province, China, where it occurs.

Type Material: n.d.

References: (1) Xiong Ming, Ma Zhesheng, and Peng Zhizhong (1989) A new mineral – ankangite. Chinese Science Bull., 34(7), 592–596. (2) (1991) Amer. Mineral., 76, 2020 (abs. ref. 1). (3) Wu, X.J., Li, F.H., and H. Hashimoto (1990) Electron microscope study of the incommensurately modulated structure of ankangite. Acta Cryst., 46, 111–117. (4) Shi Nicheng, Ma Zhesheng, and Liu Wei (1991) Crystal structure determination of ankangite with one-dimensional incommensurate modulation. Acta. Petrolog. Mineral., 10(8), 233–245 (in Chinese with English abs.). (5) (1992) Amer. Mineral., 77, 1119 (abs. ref. 4).

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Ankerite $Ca(Fe^{2+}, Mg, Mn^{2+})(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Crystals rhombohedral $\{10\overline{1}1\}$, with curved or saddle-shaped faces; prismatic to tabular $\{11\overline{2}0\}$ with $\{0001\}$, or pseudo-octahedral with equal development of $\{10\overline{1}1\}$ and $\{0001\}$, to 5 cm; columnar, stalactitic, granular, massive. *Twinning:* Simple twins with $\{0001\}$, $\{10\overline{1}0\}$, or $\{11\overline{2}0\}$ as twin plane.

Physical Properties: *Cleavage:* On $\{10\overline{1}1\}$, perfect. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.93–3.10 D(calc.) = 3.11

Optical Properties: Translucent to transparent. *Color:* Brown, yellow, white; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to pearly. *Optical Class:* Uniaxial (–). *Dispersion:* Strong. $\omega = 1.690–1.750$ $\epsilon = 1.510–1.548$

Cell Data: *Space Group:* $R\overline{3}$. $a = 4.8312(2)$ $c = 16.1663(3)$ $Z = 3$

X-ray Powder Pattern: Minntac mine, Mountain Iron, St. Louis Co., Minnesota, USA. (ICDD 41-586).
2.906 (100), 1.7974 (6), 2.203 (5), 1.818 (5), 2.024 (4), 3.714 (3), 2.414 (3)

Chemistry:

	(1)		(1)
CO_2	[42.30]	MgO	7.73
FeO	17.56	CaO	27.49
MnO	4.92	Total	[100.00]

(1) Sokoman Formation, Canada; by electron microprobe, total Fe as FeO, total Mn as MnO, CO_2 by difference; corresponding to $Ca_{0.98}(Fe_{0.49}Mg_{0.38}Mn_{0.14})_{\Sigma=1.01}(CO_3)_{2.00}$.

Polymorphism & Series: Forms two series, with dolomite and with kutnohorite.

Mineral Group: Dolomite group.

Occurrence: Formed in low-grade metamorphosed ironstones and sedimentary banded iron formations; in carbonatites; authigenic, diagenetic, or the product of hydrothermal alteration of carbonate sediments and in hydrothermal sulfide veins.

Association: Siderite, dolomite.

Distribution: Many localities, but only a few have fine crystals or abundant material; regarded as a variety of dolomite by many older authors. In Austria, in Styria, from the Erzberg, Eisenerz, and at Gollrad; Steiermark. In the Brosso mine, northwest of Ivrea, Torino, Italy. From the Oldham area, Lancashire, England. In the USA, at the Roxbury iron mine, Litchfield Co., Connecticut; in the Jeffrey quarry, near Little Rock, Pulaski Co., Arkansas; from the Eagle mine, Gilman district, Eagle Co., and many other places in Colorado. At Muzo, Boyacá Province, Colombia. Large crystals from the Tui mine, North Island, New Zealand. Abundant worldwide in iron formation, with studied material from: the Mesabi Range, Minnesota, USA. In the Sokoman Iron Formation, Howells River area, Quebec, Canada. From the Dales Gorge Member, Hamersley Group, Western Australia.

Name: Honors Professor Matthias Joseph Anker (1772–1843), Austrian mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 208–217. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 219–231. (3) Klein, C.J. and R.P. Fink (1976) Petrology of the Sokoman Iron Formation in the Howells River area, at the western edge of the Labrador Trough. Econ. Geol., 71, 453–487. (4) Reeder, R.J. and W.A. Dollase (1989) Structural variation in the dolomite-ankerite solid-solution series: an X-ray, Mössbauer, and TEM study. Amer. Mineral., 74, 1159–1167. (5) Rosenberg, P.E. (1991) Structural variation in the dolomite-ankerite solid-solution series: an X-ray, Mössbauer, and TEM study – discussion. Amer. Mineral., 76, 659–662.

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Ankinovichite $(Ni,Zn)Al_4(VO_3)_2(OH)_{12}•2H_2O$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As prismatic to bladed crystals to 0.5 mm. V-shaped twins noted.

Physical Properties: *Cleavage:* Perfect (010). *Fracture:* n.d. *Tenacity:* Brittle. Hardness = 2.5-3 VHN = 68 D(meas.) = 2.48(2) D(calc.) = 2.476

Optical Properties: Transparent. *Color:* Colorless to bluish light green. *Streak:* n.d. *Luster:* Vitreous.
Optical Class: Biaxial (+). α = 1.653(2) β = 1.677(2) γ = 1.706(3) 2V(meas.) = 86(2)° 2V(calc.) = 86° *Dispersion:* Strong, $r < v$. *Pleochroism:* None.

Cell Data: Space Group: $P2_1/n$. a = 17.8098(8) b = 5.1228(2) c = 8.8665(4) β = 92.141(1)° Z = 2

X-ray Powder Pattern: Mount Kara-Chagyr, Krygyzstan.
8.89 (100), 7.83 (100), 1.970 (80), 1.904 (70), 3.266 (50), 1.605 (50), 3.354 (40)

Chemistry:

	(1)
Al_2O_3	33.82
SiO_2	0.59
V_2O_5	28.41
FeO	0.14
NiO	8.43
CuO	0.27
ZnO	2.24
H_2O	23.30
Total	97.20

(1) Mount Kara-Chagyr, Krygyzstan; electron microprobe analysis, H_2O by Penfield method, VO_4 confirmed by IR spectroscopy, corresponding to $(Ni_{0.68}Zn_{0.17}Cu_{0.02}Fe_{0.01})_{\Sigma=0.88}Al_4(VO_3)_{1.88}Si_{0.06}(OH)_{12.12}(H_2O)_{2.67}$.

Occurrence: A low-temperature hydrothermal or weathering-derived mineral. As overgrowths on alvanite in vanadium-bearing schists (Kurumsak); also occurs in fractures and as cement in schist fragments within a serpentinite matrix (Mount Kara-Chagyr).

Association: Alvanite, volborthite, carnotite, goethite (Kurumsak); allophone, kolovratite, volborthite, nickelalumite, metatyuyamunite, roscoelite, tangeite, gypsum (Mount Kara-Chagyr).

Distribution: Kurumsak, Chemkent Oblast, Kara-Tau Range, southern Kazakhstan, and Mount Kara-Chagyr, Isfayramsay River, Osh Oblast, Krygyzstan.

Name: Honors mineralogist Ekaterina Aleksandrovna Ankinovich (1911-1991) and geologist Stepan Gerasimovich Ankinovich (1912-1985).

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia; 6798.

References: (1) Karpenko, V.Yu., L.A. Pautov, E.V. Sokolova, F.G. Hawthorne, A.A. Agakhanov, T.V. Dikaya, and G.K. Bekenova (2004) Ankinovichite, the nickel analogue of alvanite, a new mineral from Kurumsak (Kazakhstan) and Kara-Chagyr (Krygyzstan). Zapiski Vseross. Mineral. Obshch. 133(2), 59-70 (in Russian, English abstract). (2) (2005) Amer. Mineral., 90, 1951-1952 (abs. ref. 1).

Annabergite $Ni_3(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals, typically poorly formed, elongated along [001], flattened on [010], with {001}, {010}, {100}, several modifying forms, to 5 mm; usually as fibrous veinlets, crystalline crusts, or earthy.

Physical Properties: *Cleavage:* {010}, perfect; {100}, {$\bar{1}$02}, indistinct. *Tenacity:* Sectile; thin {010} laminae flexible. Hardness = 1.5–2.5 D(meas.) = 3.07 D(calc.) = 3.146

Optical Properties: Transparent to translucent. *Color:* Apple-green, pale green, pale rose or pale pink, white, gray; may be zoned. *Streak:* Pale green to white. *Luster:* Subadamantine, pearly on cleavages, may be dull, earthy.
Optical Class: Biaxial (+), may be biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 36°$.
Dispersion: $r > v$. $\alpha = 1.622$ $\beta = 1.658$ $\gamma = 1.687$ 2V(meas.) = 84°

Cell Data: *Space Group:* $C2/m$. $a = 10.179(2)$ $b = 13.309(3)$ $c = 4.725(1)$ $\beta = 105.00(1)°$ Z = 2

X-ray Powder Pattern: Locality unknown. (ICDD 11-625).
6.58 (100), 2.98 (30), 3.18 (26), 7.82 (25), 4.33 (20), 2.71 (18), 2.67 (14)

Chemistry:

	(1)	(2)		(1)	(2)
As_2O_5	37.25	38.43	NiO	33.82	37.47
SiO_2	0.41		MgO	0.21	
FeO	0.56		H_2O	24.83	24.10
CoO	3.40		Total	100.48	100.00

(1) Cobalt, Canada. (2) $Ni_3(AsO_4)_2 \cdot 8H_2O$.

Polymorphism & Series: Forms a series with erythrite.

Mineral Group: Vivianite group.

Occurrence: An uncommon secondary mineral, formed by the alteration of Co–Ni-bearing arsenides and sulfides, in the oxidized zone of hydrothermal mineral deposits.

Association: Erythrite, retgersite, gersdorffite, nickeline, maucherite, nickel-skutterudite.

Distribution: Many localities, but typically in small amounts. In Germany, from Annaberg and Schneeberg, Saxony; at Richelsdorf, Hesse. From Dobšiná (Dobschau), Slovakia. At Leogang, Salzburg, Austria. In the Sierra Cabrera, Almería Province, and at Molvizar, Granada Province, Spain. In England, in the Dolcoath mine, Cornwall; from the Coniston mines, Coniston, Cumbria. At Strathclyde and Galloway, Leadhills-Wanlockhead district, Scotland. Fine examples from the Kamariza, Plaka, and Verzekos mines, and along the road to Laurium, Greece. From the Bou Azzer district, Morocco. In the Tchah Shurch, and at the Talmessi mine, Anarak district, Iran. At the La Sorpresa mine, Tapacari, Cochabamba, Bolivia. In the Gloria mine, Alisito, Sinaloa, Mexico. In the USA, at the Ore Hill mine, Pacoima Canyon, Los Angeles Co., and in the Kalkar quarry, Santa Cruz, Santa Cruz Co., California; from the Nickel and Lovelock mines, Table Mountain district, Churchill Co., Nevada; at the Snowbird mine, Mineral Co., Montana; and in the Alhambra mine, Grant Co., New Mexico. At Cobalt, Ontario, Canada. In the 132 North deposit, Widgiemooltha district, Western Australia, and at several localities in the Flinders Ranges, South Australia. From the Horai mine, Hyogo Prefecture, and at Kuchisaka, Osaka Prefecture, Japan.

Name: For its originally noted occurrence at Annaberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 746–750. (2) Jambor, J.L. and J.E. Dutrizac (1995) Solid solutions in the annabergite – erythrite – hörnesite synthetic system. Can. Mineral., 33, 1063–1071. (3) Wildner, M., G. Giester, C.L. Lengauer, and C.A. McCammon (1996) Structure and crystal chemistry of vivianite-type compounds: crystal structures of erythrite and annabergite with a Mössbauer study of erythrite. Eur. J. Mineral., 8, 187–192.

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Annite $\mathbf{KFe_3^{2+}AlSi_3O_{10}(OH,F)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular crystals and cleavage fragments with pseudohexagonal outlines, to 15 cm. Commonly as foliated masses. *Twinning:* Contact twins with composition surface {001} and twin axis [310].

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible. Hardness = 2.5–3 D(meas.) = 3.3 D(calc.) = [3.36]

Optical Properties: Translucent to transparent. *Color:* Brown, black. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = brown; $Y = Z$ = dark brown. *Orientation:* $Y = b$. *Dispersion:* $r < v$, weak. $\alpha = 1.624$ $\beta = 1.672$ $\gamma = 1.672$ 2V(meas.) = 0°–5°

Cell Data: *Space Group:* $C2/m$. $a = 5.3860(9)$ $b = 9.3241(7)$ $c = 10.2683(9)$ $\beta = 100.63(1)°$ Z = 2

X-ray Powder Pattern: Synthetic; 1M.
10.264 (100), 3.380 (80), 2.654 (70), 2.465 (40), 1.556 (40), 2.199 (20), 1.692 (20)

Chemistry:

	(1)	(2)	(3)
SiO_2	34.90	32.56	35.21
TiO_2	0.00	1.48	
Al_2O_3	10.90	17.24	9.96
FeO	36.19	34.25	42.11
MnO	1.77	0.03	
MgO	3.40	0.86	
CaO	0.15	0.0	
Na_2O	0.00	0.28	
K_2O	8.10	8.20	9.20
F	2.22		
Cl	0.24		
H_2O			3.52
Total	[97.87]	94.90	100.00

(1) Moina skarn, Tasmania; by electron microprobe, original total given as 97.78%. (2) Kawai mine, Japan; by electron microprobe. (3) $KFe_3AlSi_3O_{10}(OH)_2$.

Polymorphism & Series: 1M polytype.

Mineral Group: Mica group.

Occurrence: In magnesium-poor igneous and metamorphic rocks.

Association: /Fluorite, zircon (Rockport, Massachusetts, USA).

Distribution: In the USA, from Cape Ann, east of Rockport, Essex Co., Massachusetts, and on Pikes Peak, El Paso Co., Colorado. From Mont Saint-Hilaire, Quebec, Canada. In the Moina tungsten skarn deposit, 40 km southwest of Devonport, Tasmania. From the Kawai mine, Ena, Gifu Prefecture, Japan. In Russia, at Katugin, Siberia, and Sludorudnik, Ural Mountains. From Flowerdale, near Gairloch, Scotland.

Name: For the first-noted occurrence at Cape Ann, Massachusetts, USA.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 634.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 55–84. (3) Eugster, H.P. and D.R. Wones (1962) Stability relations of the ferruginous biotite, annite. J. Petrol., 3, 82–125. (4) Hazen, R.M. and C.W. Burnham (1973) The crystal structures of one-layer phlogopite and annite. Amer. Mineral., 58, 889–900. (5) Kwak, T.A.P. and P.W. Askins (1981) Geology and genesis of the F-Sn-W(-Be-Zn) skarn (wrigglite) at Moina, Tasmania. Econ. Geol., 76, 439–467.

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Anorpiment As_2S_3

Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As drusy crusts of wedge-shaped crystals, to 0.2 mm, exhibiting {010}, {110}, {$\bar{1}$ 10},{001}, {021} and {$0\bar{2}$ 1}.

Physical Properties: *Cleavage:* Perfect and easy on {001}. *Fracture:* Irregular.
Tenacity: Sectile. Hardness = 1.5 D(meas.) = 3.33 D(calc.) = 3.346

Optical Properties: Transparent. *Color:* Greenish-yellow. *Streak:* Yellow.
Luster: Resinous on crystal faces, pearly on cleavage surfaces.
Optical Class: Biaxial (-). *n > 2* 2V = 35–40° *Orientation:* Acute bisectrix (*X*) is approximately perpendicular to the {001} cleavage. *Dispersion:* None. *Pleochroism*: None.

Cell Data: *Space Group: P*$\bar{1}$. *a* = 5.7577(2) *b* = 8.7169(3) *c* = 10.2682(7) α = 78.152(7)° β = 75.817(7)° γ = 89.861(6)° *Z* = 4

X-ray Powder Pattern: Palomo mine, Castrovirreyna Province, Huancavelica Department, Peru. 2.552 (100), 4.867 (97), 2.469 (96), 3.609 (82), 4.519 (77), 2.880 (75), 3.702 (46)

Chemistry:

	(1)	(2)
As	58.21	60.91
S	38.72	39.09
Total	96.94	100.00

(1) Palomo mine, Castrovirreyna Province, Huancavelica Department, Peru; average of 4 electron microprobe analyses, corresponding to $As_{1.96}S_{3.04}$. (2) As_2S_3.

Polymorphism & Series: Dimorphous with orpiment.

Occurrence: A very low-temperature hydrothermal mineral.

Association: Dufrénoysite, muscovite, orpiment, pyrite, realgar.

Distribution: At the Palomo mine, Castrovirreyna Province, Huancavelica Department, Peru.

Name: Alludes to the mineral's triclinic (*an*orthic) symmetry and dimorphous relation to *orpiment*.

Type Material: Natural History Museum of Los Angeles County, USA, # 63514 & 63544; Mineral Museum of the University of Arizona, Tucson, USA, #19326.

References: (1) Kampf, A.R., R.T. Downs, R.M. Housley, R.A. Jenkins, and J. Hyršl (2011) Anorpiment, As_2S_3, the triclinic dimorph of orpiment. Mineral. Mag,, 75(6), 2857–2867. (2) (2013) Amer. Mineral., 98, 1078 (abs. ref. 1).

Anorthite $Na_{0.1-0.0}Ca_{0.9-1.0}Al_{1.9-2.0}Si_{2.1-2.0}O_8$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals commonly short, prismatic on [001], rarely on [010], to 2 cm; lamellar, coarse granular, massive. *Twinning:* Commonly polysynthetic on the Albite law; also after the Pericline, Carlsbad, Manebach, and Baveno laws.

Physical Properties: *Cleavage:* Perfect on {001}, less so on {010}, imperfect on {110}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.74–2.76 D(calc.) = 2.760

Optical Properties: Transparent to translucent. *Color:* White, grayish, reddish; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r < v$, weak. $\alpha = 1.573–1.577$ $\beta = 1.580–1.585$ $\gamma = 1.585–1.590$ 2V(meas.) = 78°–83°

Cell Data: *Space Group:* $P\bar{1}$ (low). $a = 8.1768$ $b = 12.8768$ $c = 14.1690$ $\alpha = 93.17°$ $\beta = 115.85°$ $\gamma = 92.22°$ Z = 8

X-ray Powder Pattern: Monte Somma, Italy (low).
3.19 (100), 3.18 (91), 3.21 (63), 3.26 (52), 4.04 (48), 3.12 (39), 3.62 (33)

Chemistry:

	(1)	(2)	(3)
SiO_2	45.88	45.62	43.19
TiO_2	0.04		
Al_2O_3	34.31	35.02	36.65
Fe_2O_3	0.83		
CaO	18.28	18.24	20.16
Na_2O	0.82	1.12	
K_2O	0.11		
H_2O^+	0.14		
Total	100.41	100.00	100.00

(1) Crookdene, Northumberland, England. (2) $Na_{0.10}Ca_{0.90}Al_{1.90}Si_{2.10}O_8$. (3) $CaAl_2Si_2O_8$.

Polymorphism & Series: Trimorphous with dmisteinbergite and svyatoslavite; low- and high-temperature structural modifications are recognized.

Mineral Group: Feldspar group, plagioclase series.

Occurrence: A rare constituent of mafic plutonic and volcanic rocks. In some granulite facies metamorphic rocks; in metamorphosed carbonate rocks; with corundum deposits. Known from meteorites.

Association: Olivine, pyroxene, corundum.

Distribution: A widely distributed rock-forming mineral. Classic occurrences include: from Monte Somma and Vesuvius, Campania; on Mt. Monzoni, Val di Fassa, Trentino-Alto Adige; and from the Cyclopean Islands, Italy. At Tunaberg, Södermanland, Sweden. From near Lojo, Finland. At Bogoslovsk and Barsowka, Ural Mountains, Russia. On Miyakejima Island, Tokyo Prefecture; at Toshinyama, Tochigi Prefecture; the Zao volcano, Yamagata Prefecture; Otaru, Hokkaido; and other places in Japan. In the USA, on Great Sitkin Island, Aleutian Islands, Alaska; from Grass Valley, Nevada Co., California. On Amitok Island, Labrador, Newfoundland, Canada.

Name: From the Greek for *oblique*, for its triclinicity.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 325–327, 337–341. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 94–165. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 352–360. (4) Kempster, C.J.E., H.D. Megaw, and E.W. Radoslovich (1962) The structure of anorthite, $CaAl_2Si_2O_8$. I. Structure analysis. Acta Cryst., 15, 1005–117. (5) Megaw, H.D., C.J.E. Kempster, and E.W. Radoslovich (1962) The structure of anorthite, $CaAl_2Si_3O_8$. II. Description and discussion. Acta Cryst., 15, 117–135.

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Anorthoclase $(Na, K)AlSi_3O_8$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Short prismatic crystals; also tabular, rhombic, flattened along [010], to 5 cm. *Twinning:* Baveno, Carlsbad, and Manebach laws; polysynthetic albite and pericline law twinning produce a grid pattern on {100}.

Physical Properties: *Cleavage:* Perfect on {001}, less perfect on {010}; partings on {100}, {110}, {$\overline{1}$10}, and {$\overline{2}$01}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 2.57–2.60 D(calc.) = 2.57

Optical Properties: Transparent. *Color:* Colorless, also white, pale creamy yellow, red, green. *Streak:* White. *Luster:* Vitreous, may be pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z \wedge b \simeq 5°$. *Dispersion:* $r > v$, weak.
$\alpha = 1.524$–1.526 $\beta = 1.529$–1.532 $\gamma = 1.530$–1.534 2V(meas.) = 42°–52°

Cell Data: *Space Group:* $C\overline{1}$. $a = 8.287$ $b = 12.972$ $c = 7.156$ $\alpha = 91.05°$ $\beta = 116.26°$ $\gamma = 90.15°$ Z = 4

X-ray Powder Pattern: Grande Caldeira, Azores. (ICDD 9-478).
3.211 (100), 3.243 (90), 4.106 (16), 2.162 (16), 6.49 (14), 3.768 (14), 3.726 (14)

Chemistry:

	(1)
SiO_2	62.79
Al_2O_3	22.12
Fe_2O_3	0.36
FeO	0.41
CaO	3.76
Na_2O	7.35
K_2O	2.98
H_2O^+	0.19
H_2O^-	0.07
Total	100.03

(1) Mt. Erebus, Ross Island, Antarctica; corresponds to $(Na_{0.64}Ca_{0.18}K_{0.17})_{\Sigma=0.99}(Al_{0.98}Fe^{2+}_{0.02}Fe^{3+}_{0.01})_{\Sigma=1.01}(Si_{2.81}Al_{0.19})_{\Sigma=3.00}O_8$.

Mineral Group: Feldspar (alkali) group; intermediate between low sanidine and high albite.

Occurrence: In high-temperature sodic volcanic and hypabyssal rocks.

Association: Typically in a fine-grained groundmass or weathered out as loose crystals.

Distribution: Rather abundant worldwide. Some localities for well-characterized material include: on Pantelleria and Ustica Islands, Italy. At Larvik, Norway. From Berkum, North Rhine-Westphalia, Germany. On Grande Caldeira Island, Azores. At Ropp, Nigeria. On Mt. Kenya, Kenya. From Kilimanjaro, Tanzania. At Chilposan, near Minchon, North Korea. From Ogaya, Toyama Prefecture, and Madarajima, Saga Prefecture, Japan. At Kakanui, New Zealand. From Mt. Anakie and Mt. Franklin, Daylesford, Victoria, Australia. Large crystals from Mt. Erebus, Ross Island, Antarctica. At Boron, Kern Co., California, USA.

Name: From the Greek for *oblique* and *fracture*, descriptive of the cleavage.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 324–325. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 6–93. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 342–344. (4) Carmichael, I.S.E. and W.S. MacKenzie (1964) The lattice parameters of high-temperature triclinic sodic feldspars. Mineral. Mag., 33, 949–962. (5) Harlow, G.E. (1982) The anorthoclase structures: the effects of temperature and composition. Amer. Mineral., 67, 975–996.

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Antarcticite $CaCl_2 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* 32. As aggregates of acicular crystals, to 15 cm, with generally poor terminations.

Physical Properties: *Cleavage:* {0001}, perfect; one prismatic, good to perfect. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 1.715(10) D(calc.) = 1.700 Highly hygroscopic.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.550$ $\epsilon = 1.490$–1.500

Cell Data: *Space Group:* $P321$. $a = 7.89$–7.907 $c = 3.95$ $Z = 1$

X-ray Powder Pattern: Antarctica.
3.44 (24), 2.80 (23), 2.16 (23), 2.60 (22), 3.98 (18), 2.28 (13), 6.92 (9)

Chemistry:

	(1)	(2)	(3)
Na	0.34	0.30	
K	0.008		
Fe		0.003	
Mg	0.41	0.015	
Ca	17.5	17.25	18.29
Al		0.002	
Si		0.003	
Cl	32.7	33.14	32.37
H_2O^+	49.2	49.27	49.34
Total	100.1	99.98	100.00

(1) Don Juan Pond, Antarctica; corresponding to $Ca_{1.00}Mg_{0.04}Na_{0.03}Cl_{2.11} \cdot 6.25H_2O$. (2) Bristol Dry Lake, California, USA. (3) $CaCl_2 \cdot 6H_2O$.

Occurrence: A precipitate from highly saline brines under very arid conditions (Don Juan Pond, Antarctica; Bristol Dry Lake, California, USA); in stratified fresh to brackish to salt water columns in onshore "blue holes" (North Andros Island, Bahamas); an abundant component of inclusions in quartz in a zoned mafic pegmatoid (Bushveld complex, South Africa).

Association: Halite, gypsum, celestine (Bristol Dry Lake, California, USA).

Distribution: From Don Juan Pond, Wright Valley, and elsewhere around Mt. Erebus, Victoria Land, Antarctica. At Bristol Dry Lake, San Bernardino Co., California, USA. On North Andros Island, Bahamas. From the Bushveld complex, on Driekop Farm, Transvaal, South Africa.

Name: For its occurrence on the continent of Antarctica.

Type Material: n.d.

References: (1) Torii, T. and J. Ossaka (1965) Antarcticite: a new mineral, calcium chloride hexahydrate, discovered in Antarctica. Science, 149, 975–977. (2) (1965) Amer. Mineral., 50, 2095 (abs. ref. 1). (3) Dunning, G.E. and J.F. Cooper, Jr. (1969) A second occurrence of antarcticite, from Bristol Dry Lake, California. Amer. Mineral., 54, 1018–1025. (4) Agron, P.A. and W.R. Busing (1986) Calcium and strontium dichloride hexahydrates by neutron diffraction. Acta Cryst., C42, 141–143. (5) Schiffries, C.M. (1990) Liquid-absent aqueous fluid inclusions and phase equilibria in the system $CaCl_2$–$NaCl$–H_2O. Geochim. Cosmochim. Acta, 54, 611–619. (6) Eckstein, Y., M. Manecki, M. Matyjasik, and E. Rosenthal (1994) Hydrochemical stratification and processes in three "blue holes" on North Andros Island, Bahamas. Geol. Soc. Amer. Prog. and Abs., 26, 360 (abs.).

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Anthoinite $WAlO_3(OH)_3(?)$

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Crystal Data: Triclinic. *Point Group:* n.d. As crystals, to only a few mm, platy on {010}; commonly in powdery or chalky masses, and pseudomorphs after large scheelite crystals.

Physical Properties: *Cleavage:* One direction, perfect. Hardness = 1 (massive). D(meas.) = 4.78–4.87 D(calc.) = 4.84

Optical Properties: Translucent. *Color:* White, when free of iron. *Luster:* Dull. *Optical Class:* Biaxial. n = 1.81–1.82; birefringence noted under high magnification. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 9.21$ $b = 11.36$ $c = 8.26$ $\alpha = 94°45'$ $\beta = 90°$ $\gamma = 92°35'$ Z = [8]

X-ray Powder Pattern: Nyamulilo mine, Uganda; shows preferred orientation. 5.63 (100), 4.19 (83), 3.058 (71b), 3.97 (69), 2.462 (61), 4.33 (37), 4.12 (35)

Chemistry:

	(1)	(2)	(3)
WO_3	73.23	74.84	74.83
SiO_2	0.73	0.08	
Al_2O_3	16.41	16.03	16.45
Fe_2O_3	0.69	0.07	
CaO	0.25		
H_2O^+	8.70	9.06	8.72
H_2O^-		0.06	
Total	100.01	100.14	100.00

(1) Mt. Misobo mine, Congo; average of two analyses. (2) Bugarama mine, Rwanda; corresponds to $W_{1.00}Al_{0.97}O_{2.90}(OH)_{3.10}$. (3) $WAlO_3(OH)_3$.

Occurrence: In placers with cassiterite and wolframite and in quartz veins with ferberite, which appears to replace it (Mt. Misobo mine, Congo); in altered skarn (Kara mine, Tasmania).

Association: Ferberite, scheelite (Mt. Misobo mine, Congo); mpororoite, scheelite (Kara mine, Tasmania); raspite, ferberite, ferritungstite (Gifurwe mines, Rwanda): ferberite, scheelite, ferritungstite, russellite, mpororoite (Kalzas Mountain, Canada).

Distribution: From the Mt. Misobo tungsten mine, Kalima-Maniema district, and the Mierge mine, Kivu Province, Congo (Zaire). In the Bugarama and Gifurwe mines, Rwanda. In very large crystals from Bengo-Biri, Kalima, Congo Republic. In the Nyamulilo mine, Kigezi district, and the Bjordal mine, Kabole, Uganda. At the Kara mine, southwest of Burnie, Tasmania, Australia. From the Flo property, Kalzas Mountain, 67 km southeast of Mayo, Yukon Territory, Canada.

Name: For Raymond Anthoine (1884–?), Belgian mining engineer.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM2426.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1097–1098. (2) Niggli, E. and E. Jäger (1957) Untersuchungen an Anthoinit. Neues Jahrb. Mineral., Abh., 91, 35–40 (in German). (3) Sahama, T.G., O. von Knorring, and M. Lehtinen (1970) New data for anthoinite. Bull. Geol. Soc. Finland, 42, 95–99. (4) Sahama, T.G. (1981) The secondary tungsten minerals, a review. Mineral. Record, 12, 81–87. (5) Matsubara, S., A. Kato, and K. Nagashima (1984) Mpororoite and anthoinite from the Kara mine, Tasmania. Mineral. Mag., 48, 397–400.

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Anthonyite $Cu(OH,Cl)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, commonly curved along [001], to 1 cm; as crusts.

Physical Properties: *Cleavage:* {100}, good. *Tenacity:* Sectile, crystals bending easily on the {100} cleavage. Hardness = 2 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Lavender.
Optical Class: Biaxial (–). *Pleochroism:* X = rich lavender; $Y = Z$ = deep smoky blue.
Orientation: $Y = b$; $Z \wedge b = 13°$. *Absorption:* $Y = Z > X$. $\alpha = 1.526$ $\beta = 1.602$ $\gamma = 1.602$
2V(meas.) = 3°

Cell Data: *Space Group:* n.d. a = n.d. b = n.d. c = n.d. $\beta = 112°38'$ Z = n.d.

X-ray Powder Pattern: Centennial mine, Michigan, USA.
5.84 (10), 4.14 (7), 3.99 (6), 3.44 (6), 2.87 (6), 3.18 (4), 3.07 (4)

Chemistry:

	(1)
Cu	41.3
AgCl	0.24
Cl	6.3
$H_2O^+ + OH$	35.5
H_2O^+	16.4
Total	99.74

(1) Centennial mine, Michigan, USA; Cu by electrolysis, H_2O:OH from charge balance, corresponding to $Cu_{1.00}[(OH)_{1.72}Cl_{0.28}]_{\Sigma=2.00} \cdot 2.80H_2O$.

Occurrence: In cavities and fractures in basalt, formed by the action of chlorine-bearing connate waters on copper (Centennial mine, Michigan, USA).

Association: Tremolite, quartz, epidote, monazite, copper, cuprite, paratacamite (Centennial mine, Michigan, USA).

Distribution: In the Centennial mine, Calumet, Houghton Co., Michigan and the Cole mine, Bisbee, Cochise Co., Arizona, USA. From Villa Hermosa, Sonora, Mexico. In Germany, at Richelsdorf, Hesse, in slag. From Laurium, Greece, in slag.

Name: For Professor John Williams Anthony (1920–1992), American mineralogist, University of Arizona, Tucson, Arizona, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 142653, 162617.

References: (1) Williams, S.A. (1963) Anthonyite and calumetite, two new minerals from the Michigan copper district. Amer. Mineral., 48, 614–619.

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Anthophyllite $(Mg,Fe^{2+})_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals rare, to 25 cm; as bladed aggregates of unterminated prismatic crystals. Commonly lamellar or fibrous, asbestiform.

Physical Properties: *Cleavage:* Perfect on {210}, intersecting at 54.5° and 125.5°; distinct on {010} and {100}. *Tenacity:* Brittle; fibers are elastic. Hardness = 5.5–6 D(meas.) = ∼2.9–3.5 D(calc.) = 3.09

Optical Properties: Transparent to translucent. *Color:* Gray, brownish gray, yellowish brown, clove-brown, brownish green, emerald-green; in thin section, colorless to pale green or yellow. *Streak:* White or grayish. *Luster:* Vitreous, pearly on cleavage.
Optical Class: Biaxial (+) or (–). *Pleochroism:* When Fe-rich, moderate; X = clove-brown, yellowish brown, grayish brown; Y = clove-brown, brown-gray, brownish; Z = clove-brown to dark brown, grayish blue to green, lilac. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$ or $r < v$, weak to moderate. *Absorption:* $Z > Y = X$ or $Z = Y > X$. α = 1.603–1.679 β = 1.617–1.685 γ = 1.627–1.690 2V(meas.) = ∼80°

Cell Data: *Space Group: Pnma.* a = 18.544(2) b = 18.026(2) c = 5.282(1) Z = 4

X-ray Powder Pattern: Georgia, USA.
3.05 (100), 3.24 (60), 8.26 (55), 2.84 (40), 2.54 (40), 3.65 (35), 8.9 (30)

Chemistry:

	(1)		(1)		(1)
SiO_2	58.08	FeO	10.18	Na_2O	0.05
TiO_2	0.04	MnO	0.20	K_2O	0.01
Al_2O_3	0.30	MgO	27.99	H_2O	[2.20]
Fe_2O_3	0.65	CaO	0.17	Total	[99.87]

(1) Ochsenkogel, Gleinalpe, Austria; by electron microprobe, Fe^{2+}:Fe^{3+} by wet chemical analysis, H_2O calculated from stoichiometry; corresponding to $(Mg_{5.71}Fe^{2+}_{1.17}Fe^{3+}_{0.07}Ca_{0.02}Mn_{0.02}Na_{0.01})_{\Sigma=7.00}(Si_{7.95}Al_{0.05})_{\Sigma=8.00}O_{22}(OH)_{2.00}$.

Polymorphism & Series: Forms a series with magnesio-anthophyllite and ferro-anthophyllite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: 0.1 $Mg/(Mg + Fe^{2+})$ 0.89; $(Ca + Na)_B < 1.34$; Li < 1.0; Si ≥ 7.0.

Occurrence: From medium- or high-grade metamorphism, in amphibolites, gneisses, metaquartzites, iron formations, granulites, and schists derived from argillaceous sediments, ultramafic, or mafic igneous rocks; a retrograde reaction product.

Association: Cordierite, talc, chlorite, sillimanite, mica, olivine, "hornblende," gedrite, magnesio-cummingtonite, garnet, staurolite, plagioclase.

Distribution: From Kongsberg and Snarum, Norway. At Schneeberg, Saxony, Germany. From Norberg, Sweden. At Heřmanov, Czech Republic. In Greenland, from Fiskenæsset. In the USA, from Chesterfield, Hampshire Co., Massachusetts; the Carleton talc mine, near Chester, Windsor Co., Vermont; near Media, Delaware Co., Pennsylvania; the Day Book deposit, near Spruce Pine, Mitchell Co., North Carolina; in California, at the Winchester quarry, Riverside Co., and near Coffee Creek, Carrville, Trinity Co.; in the Copper Queen mine, Prairie Divide, Park Co., Colorado. From Munglinup, Western Australia.

Name: From the Latin *anthophyllum*, meaning *clove*, in allusion to the mineral's color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 384–385. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 211–229. (3) Rabbitt, J.C. (1948) A new study of the anthophyllite series. Amer. Mineral., 33, 263–323. (4) Beatty, S. (1950) X-ray diffraction patterns of asbestos. Amer. Mineral., 35, 579–589. (5) Walitzi, E.M., F. Walter, and K. Ettinger (1989) Verfeinerung der Kristallstruktur von Anthophyllit vom Ochsenkogel/Gleinalpe, Österreich. Zeits. Krist., 188, 237–244 (in German). (6) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 223–225.

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Antigorite $(Mg, Fe^{2+})_3Si_2O_5(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* m. Minute crystals, typically platy along [001], rarely elongated along [010]; some plates have rectangular outline due to cleavage; commonly bladed or fibrous. *Twinning:* May exhibit two- or three-fold twins rotated 60° about an axis ⊥ [001].

Physical Properties: *Cleavage:* Perfect on {001}, observed on {100} and {010}. *Fracture:* Conchoidal or splintery. Hardness = 2.5–3.5 D(meas.) = 2.65 D(calc.) = 2.61

Optical Properties: Translucent to opaque. *Color:* Green, blue-green, white; colorless to pale green in thin section. *Streak:* White. *Luster:* Resinous, greasy, silky, waxy, earthy. *Optical Class:* Biaxial (–). *Orientation:* $X = c$. *Dispersion:* $r > v$. $\alpha = 1.558$–1.567 $\beta = 1.565$ $\gamma = 1.562$–1.574 2V(meas.) = 37°–61°

Cell Data: *Space Group:* Cm. $a = 43.53(1)$ $b = 9.259(3)$ $c = 7.263(7)$ $\beta = 91°8.4(1.6)'$ Z = 16

X-ray Powder Pattern: Griffen Range, Westland, New Zealand.
7.29 (100), 2.525 (100), 3.61 (80), 2.458 (60), 2.172 (60), 1.694 (60), 6.43 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	41.65	44.50	43.37
Al_2O_3	0.10	1.41	
Fe_2O_3	2.88		
FeO	0.16	0.35	
MnO	0.05		
MgO	41.06	41.56	43.63
H_2O	14.22	12.36	13.00
Total	100.12	100.18	100.00

(1) Nikka Vord quarries, Unst, Scotland. (2) State Line pits, Rock Springs, Cecil Co., Maryland, USA; Cr_2O_3 0.06% and NiO 0.095% additionally. (3) $Mg_3Si_2O_5(OH)_4$.

Polymorphism & Series: Polymorphous with clinochrysotile, lizardite, orthochrysotile, and parachrysotile.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Commonly replaces ultramafic rocks, pervasively or in crosscutting veinlets. As a replacement of siliceous dolostone along contacts with diabase sills.

Association: Chromite, magnetite, chrysotile, olivine.

Distribution: Widespread; less common however than lizardite. Some localities for well-studied material include: in the Val Antigorio, Piedmont, Italy. From Prägraten, Tirol, Austria. At Glen Urquhart, Inverness-shire, Scotland. From Hsiu-Yen Hsien, Liaoning Province, China. In the Nishisonnogi area, Nagasaki Prefecture, and the Sasagure area, Fukuoka Prefecture, Japan. From Woodsreef, New South Wales, Australia. In the USA, at Texas, Lancaster Co., Pennsylvania; around Baltimore, Baltimore Co., Maryland; from Brewster, Putnam Co., New York; and at Buck Creek, Clay Co., North Carolina. At Asbestos, Quebec, and Timmins, Ontario, Canada.

Name: For the occurrence at Val Antigorio, Italy.

Type Material: Swiss Federal Institute of Technology, Zurich, Switzerland, Wi4868.

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Antimonpearceite $(Ag,Cu)_{16}(Sb,As)_2S_{11}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are thin, tabular, pseudohexagonal, to 2 cm across, in subparallel and rosettelike groups. *Twinning:* On {110}.

Physical Properties: *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = n.d. D(meas.) = 6.33–6.35 D(calc.) = 6.40

Optical Properties: Opaque. *Color:* Black. *Streak:* Black. *Luster:* Submetallic.
R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/m$. $a = 12.81$ $b = 7.41$ $c = 11.91$ $\beta = 90°$ Z =

X-ray Powder Pattern: Synthetic.
2.83 (100), 2.96 (90), 3.11 (70), 2.49 (60), 2.38 (50), 1.86 (50), 2.31 (40)

Chemistry:

	(1)	(2)
Ag	68.39	62.54
Cu	5.13	8.90
Fe		0.05
As	0.50	1.43
Sb	10.64	9.65
S	15.43	17.62
Total	100.09	100.19

(1) Guanajuato, Mexico; corresponds to $(Ag_{14.49}Cu_{1.84})_{\Sigma=16.33}(Sb_{2.00}As_{0.15})_{\Sigma=2.15}S_{11.00}$.
(2) Sonora, Mexico; corresponds to $(Ag_{11.60}Cu_{2.80})_{\Sigma=14.41}(Sb_{1.59}As_{0.38})_{\Sigma=1.97}S_{11.00}$.

Occurrence: Uncommon in epithermal precious metal veins.

Association: Acanthite, amethyst.

Distribution: In Mexico, from Guanajuato [TL] and an unknown locality in Sonora [TL]. In the USA, at the North Lily mine, Tintic district, Juab Co., Utah. From the Clara mine, near Oberwolfach, Black Forest, Germany. At Serra S'Ilixi, Sarrabus, Sardinia, Italy. In the Barquilla deposit, Salamanca Province, Spain. From the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia. In the Pentire vein system, St. Minver, Cornwall, England. From the Seikoshi mine, Shizuoka Prefecture, Japan. Several additional poorly located occurrences are known.

Name: For its compositional relation to pearceite.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 90546, 93159.

References: (1) Frondel, C. (1963) Isodimorphism of the polybasite and pearceite series. Amer. Mineral., 48, 565–572. (2) Harris, D.C., E.W. Nuffield, and M.H. Frohberg (1965) Studies of polybasite, pearceite, antimonpearceite, and arsenpolybasite. Can. Mineral., 8, 172–184. (3) Sugaki, A., A. Kitakaze, and T. Yoshimoto (1983) Synthesized minerals of polybasite and pearceite series. Synthetic sulfide minerals (XII). Sci. Rep. Tohoku Imperial Univ., 3rd series, 15(3), 461–469.

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Antimonselite Sb_2Se_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral acicular crystals in radiating aggregates, to 1 mm; as very fine granular aggregates.

Physical Properties: Hardness = 3.3 VHN = 120 D(meas.) = 5.969 D(calc.) = 5.88–5.928

Optical Properties: Opaque. *Color:* Black, white in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Biaxial. *Pleochroism:* Distinct; white to very pale gray. *Anisotropism:* Distinct. *Bireflectance:* Distinct.
R_1–R_2: (400) — , (420) 43.8–44.7, (440) 42.4–43.2, (460) 40.8–42.9, (480) 40.1–42.1, (500) 40.5–42.6, (520) 42.2–44.6, (540) 39.3–42.1, (560) 39.0–41.7, (580) 39.1–42.0, (600) 38.3–41.8, (620) 39.6–42.4, (640) 39.7–42.8, (660) 42.7–45.2, (680) 45.5–47.6, (700) 47.6–50.0

Cell Data: *Space Group: Pbnm.* a = 11.588–11.593 b = 11.744–11.747 c = 3.3984–3.955 Z = 4

X-ray Powder Pattern: Near Kaiyang, China.
2.870 (100), 3.70 (70), 2.625 (60), 3.17 (50), 1.746 (35), 3.25 (30), 1.930 (30)

Chemistry:

	(1)	(2)	(3)
Hg	2.35		
Fe	0.03		
Cu	0.61		
Se	48.91	50.35	
As	0.19	0.03	
Sb	47.32	49.25	50.69
S	0.13	0.26	49.31
Total	99.54	99.89	100.00

(1) Near Kaiyang, China; by electron microprobe, average of 14 analyses; corresponds to $(Sb_{1.87}Hg_{0.06}Cu_{0.05}As_{0.01})_{\Sigma=1.99}(Se_{2.99}S_{0.02})_{\Sigma=3.01}$. (2) Bentou deposit, China; by electron microprobe, corresponding to $Sb_{1.88}(Se_{2.96}S_{0.04})_{\Sigma=3.00}$. (2) Sb_2Se_3.

Occurrence: In uraniferous calcite veins in a hydrothermal U–Hg–Mo polymetallic deposit (near Kaiyan, China).

Association: Pyrite, sphalerite, galena, ferroselite, clausthalite, uraninite, cinnabar, hematite, calcite (near Kaiyan, China); gold, clausthalite, selenian famatinite, selenian gersdorffite, trüstedtite, selenian stibnite, quartz, barite (Qiongmo deposit, China).

Distribution: In China, from near Kaiyang, Guizhou Province [TL]; in the Bentou uranium deposit, not otherwise located in Hunan Province; and from the Qiongmo gold deposit, western Qinling Mountains, Shaanxi Province.

Name: For ANTIMONy and SELenium in the composition.

Type Material: Chinese Museum of Geology, Guizhou(?), China.

References: (1) Chen Luming, Zhang Qifa, Li Deren, and Wang Guanxin (1993) Antimonselite – a new mineral. Acta Mineral. Sinica, 13(1), 7–11 (in Chinese with English abs.). (2) (1994) Amer. Mineral., 79, 387 (abs. ref. 1). (3) Min Maoshong, Li Deren, Shi Nicheng, Liu Quanlin, and Cao Yawen (1995) Some new data on antimonselite. Acta Mineral. Sinica, 15(3), 303–304 (in Chinese with English abs.). (4) Min Maozhong, Zhai Jianping, Wang Xiangyun, Shen Baopei, Wen Guangdou, and Fan Tao (1998) Refinement of the crystal structure for a new mineral – antimonselite. Chinese Science Bulletin, 43(5), 413–416 (in English).

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Antimony Sb

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Prominent $\{01\overline{1}2\}$ yields pseudocubic crystals, to 1 cm; also rounded and hoppered; commonly massive or cleavable lamellar, also radiated; may be botryoidal or reniform with granular texture. *Twinning:* On $\{01\overline{1}4\}$, commonly forming complex groups, fourlings, sixlings; also polysynthetic twins.

Physical Properties: *Cleavage:* Perfect on {0001}, distinct on $\{10\overline{1}1\}$, imperfect on $\{10\overline{1}4\}$, indistinct on $\{11\overline{2}0\}$. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–3.5 VHN = 50–69 (100 g load). D(meas.) = 6.61–6.72 D(calc.) = 6.697

Optical Properties: Opaque. *Color:* Tin-white. *Streak:* Gray. *Luster:* Metallic. *Pleochroism:* Very feeble. *Anisotropism:* Weak in air, lively in oil.

R_1–R_2: (400) 71.6–74.1, (420) 72.3–75.1, (440) 72.9–75.8, (460) 73.6–76.6, (480) 74.2–77.3, (500) 74.6–77.8, (520) 74.7–77.9, (540) 74.5–78.0, (560) 74.0–77.7, (580) 73.3–77.1, (600) 72.3–76.6, (620) 71.4–76.0, (640) 70.3–75.3, (660) 69.2–74.8, (680) 68.4–74.4, (700) 67.7–74.2

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic). $a = 4.3084(2)$ $c = 11.274(0.5)$ $Z = 6$

X-ray Powder Pattern: Synthetic.
3.109 (100), 2.248 (70), 1.368 (70), 1.416 (60), 2.152 (60), 1.261 (40), 1.878 (40)

Chemistry:

	(1)
Sb	99.2
As	0.2
Total	99.4

(1) Gottes Segnen mine, St. Andreasberg, Germany; by electron microprobe. [??Gottes Sergen mine in latest criddle??ck]

Mineral Group: Arsenic group.

Occurrence: In hydrothermal Sb–Ag veins.

Association: Silver, stibnite, allemontite, sphalerite, pyrite, galena, quartz.

Distribution: Numerous localities. In the USA, from South Riverside, Riverside Co.; in kg masses from Erskine Creek, Kern Co., California. From Příbram, Czech Republic. At St. Andreasberg, Harz Mountains, Germany. In France, from Allemont, Isère. At Sarrabus, Sardinia, Italy. From Sala, Västmanland, and in the Vena mines, near Askersund, Örebro, Sweden. At Kalliolampi, Nurmo, and near Seinajöki, Finland. At Broken Hill, New South Wales, Australia. From Huasco, Tarapacá, Chile. In Canada, at South Ham, Wolfe Co., Quebec. At Arechuybo, Chihuahua, Mexico.

Name: From the Latin *antimonium*; possibly of Arabic origin; the chemical symbol from the Latin *stibium*, *mark*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 132–133. (2) Barrett, C.S., P. Cucka, and K. Haefner (1963) The crystal structure of antimony at 4.2, 78 and 298 °K. Acta Cryst., 16, 451–453. (3) (1954) NBS Circ. 539, 3, 14. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 14.

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Antlerite $Cu_3(SO_4)(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are thick tabular {010}, equant or short prismatic [001], with dominant {110}, another twenty-odd forms, to 2 cm; commonly fibrous and in cross-fiber veinlets, feltlike, granular or powdery lumps and aggregates.

Physical Properties: *Cleavage:* {010}, perfect; {100}, poor. *Tenacity:* Brittle.
Hardness = 3.5 D(meas.) = 3.88 D(calc.) = 3.93

Optical Properties: Translucent. *Color:* Emerald-green, blackish green, pale green.
Streak: Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow-green; Y = blue-green; Z = green.
Orientation: $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, very strong. $\alpha = 1.726$ $\beta = 1.738$ $\gamma = 1.789$ 2V(meas.) = 53°

Cell Data: *Space Group: Pnam.* a = 8.244(2) $b = 11.987(3)$ $c = 6.043(1)$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 7-407).
4.86 (100), 2.566 (85), 3.60 (75), 2.683 (75), 6.01 (25), 5.40 (25), 2.503 (25)

Chemistry:

	(1)	(2)
SO_3	22.32	22.57
CuO	66.34	67.27
H_2O	10.52	10.16
insol.	0.88	
Total	100.06	100.00

(1) Chuquicamata, Chile; average of two analyses. (2) $Cu_3(SO_4)(OH)_4$.

Occurrence: Uncommon, typically formed in the oxidized zone of copper deposits under highly acid conditions, especially in arid regions.

Association: Brochantite, atacamite, chalcanthite, kröhnkite, natrochalcite, linarite, gypsum.

Distribution: In the USA, in Arizona, from the Antler mine, near Yucca Station, Mohave Co., large crystals at several mines in Bisbee, Cochise Co., from the Grandview mine, Grand Canyon, Coconino Co., in Copper Basin, between Skull Valley and Prescott, and at Jerome, Yavapai Co.; from the Blanchard mine, near Bingham, Hansonburg district, Socorro Co., New Mexico; in the Darwin district, Inyo Co., California; from the Northern Light mine, near Black Mountain, Mountain View district, Mineral Co. and other minor occurrences in Nevada; at Kennicott, Alaska. From Puerto de Gomez, Chihuahua, Mexico. An important copper ore at Chuquicamata, Antofagasta, and from Remolinos, Atacama, Chile. At Ober-Planitz, near Zwickau, Saxony, Germany. From Caldbeck Fells, Cumbria, and at several mines in Cornwall, England. From Capdella, Lerida, Spain. A number of additional poorly characterized localities are known.

Name: For the Antler mine, Arizona, USA, where the first specimens were collected.

Type Material: NMNH, 47698.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 544–546. (2) Hawthorne, F.C., L.A. Groat, and R.K. Eby (1989) Antlerite, $Cu_3SO_4(OH)_4$, a heteropolyhedral wallpaper structure. Can. Mineral., 27, 205–209.

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Anyuiite $Au(Pb,Sb)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Rounded, elongated to platy polymetallic grains, to 0.9 mm, with rhombic to square outline; typically fine-grained granular massive.

Physical Properties: *Tenacity:* Plastic, malleable. Hardness = n.d. VHN = 142–153, 146 average (20 g load); 101–104, 101 average (20 g load) antimonian. D(meas.) = n.d. D(calc.) = 13.49

Optical Properties: Opaque. *Color:* Silvery gray, becoming dull lead-gray on oxidation; in reflected light, pale silvery gray with faint creamy tint, becoming dark gray with blue-black overtones. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Weak, silvery gray to gray. *Bireflectance:* Barely noticable.
R_1–R_2: (400) —, (420) 50.3–56.7, (440) 52.9–59.0, (460) 55.0–60.7, (480) 56.2–62.0, (500) 57.7–62.4, (520) 58.3–63.2, (540) 59.3–63.9, (560) 59.9–64.6, (580) 60.7–65.1, (600) 61.4–65.6, (620) 62.1–66.0, (640) 62.1–66.1, (660) 63.0–66.2, (680) 63.4–66.5, (700) 63.7–66.8

Cell Data: *Space Group:* $I4/mcm$ (by analogy to synthetic $AuPb_2$). $a = 7.39(2)$ $c = 5.61(3)$ $Z = 4$

X-ray Powder Pattern: Bol'shoi Anyui River basin, Russia.
5.22 (60), 2.33 (30), 3.74 (20), 2.59 (20), 1.55 (20), 1.130 (20), 2.82 (10)

Chemistry:

	(1)	(2)	(3)
Ag	0.35		
Au	32.6	34.3	36.7
Pb	64.8	59.0	52.9
Sb	0.3	5.8	10.2
Total	98.05	99.1	99.8

(1) Bol'shoi Anyui River basin, Russia; by electron microprobe, corresponding to $(Au_{1.05}Ag_{0.02})_{\Sigma=1.07}(Pb_{1.98}Sb_{0.02})_{\Sigma=2.00}$. (2) Do.; corresponding to $Au_{1.05}(Pb_{1.71}Sb_{0.29})_{\Sigma=2.00}$. (3) Do.; corresponding to $Au_{1.10}(Pb_{1.51}Sb_{0.49})_{\Sigma=2.00}$.

Occurrence: In placer concentrates derived from small ultramafic-gabbroid masses in a dunite-harzburgite formation (Bol'shoi Anyui River basin, Russia); in gold concentrates from placers (Hunchun River, China).

Association: Lead, gold, ilmenite, titanian magnetite, chrome spinel, hematite, pyrite, chalcopyrite, apatite (Bol'shoi Anyui River basin, Russia); gold, lead, hunchinite, pyrite, pyrrhotite, magnetite, ilmenite (Hunchun River, China).

Distribution: From tributaries of the Bol'shoi Anyui River, Chukot Peninsula, far northeastern Siberia, Russia [TL]. In the Sandogou placers, along the Hunchun River, Jilin Province, China.

Name: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

Type Material: For its occurrence in the Bol'shoi Anyui River basin.

References: (1) Razin, L.V. and G.A. Siderenko (1989) Anyuiite $AuPb_2$ – A new intermetallic of gold and lead. Mineral. Zhurnal, 11(4), 88–90 (in Russian). (2) (1991) Amer. Mineral., 76, 299 (abs. ref. 1). (3) ?? (??) see below?? (4) (1990) Amer. Mineral., 75, 931 (abs. ref. 3).

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Apachite $Cu_9Si_{10}O_{29}\cdot 11H_2O$

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Crystal Data: Monoclinic, probable. *Point Group:* n.d. As minute, twisted or curved beaded spherules of radial fibers, composed of crystals; in seams, exhibiting a silky, fibrous structure on broken surfaces.

Physical Properties: Hardness = 2 D(meas.) = 2.80(2) D(calc.) = [3.26]

Optical Properties: Transparent to translucent. *Color:* Faïence-blue; in thin section, rich blue. *Luster:* Nonmetallic, silky.
Optical Class: Biaxial (–). *Orientation:* $Y \simeq$ length. $\alpha = 1.610$ $\beta = 1.650$ $\gamma = 1.650$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 12.89$ $b = 6.055$ $c = 19.11$ $\beta = 90.42°$ Z = [2]

X-ray Powder Pattern: Christmas, Arizona, USA.
12.89 (100), 3.168 (70), 7.663 (50), 10.62 (40), 9.556 (40), 4.491 (40), 4.174 (40)

Chemistry:

	(1)	(2)
SiO_2	40.8	39.66
FeO	0.3	
CuO	43.6	47.26
MgO	1.7	
CaO	1.8	
H_2O	13.8	13.08
Total	102.0	100.00

(1) Christmas, Arizona, USA; average of two analyses; after recalculation to 100%, corresponds to $(Cu_{7.87}Mg_{0.61}Ca_{0.46}Fe_{0.06})_{\Sigma=9.00}Si_{9.75}O_{28.5}\cdot 11H_2O$. (2) $Cu_9Si_{10}O_{29}\cdot 11H_2O$.

Occurrence: A retrograde metamorphic or mesogene mineral, formed at the expense of a prograde calc-silicate and sulfide assemblage in tactites; typically in fractures or crackled zones cutting garnet-diopside rock, replacing both these silicates and calcite.

Association: Kinoite, gilalite, stringhamite, junitoite, clinohedrite, xonotlite, apophyllite, calcite, tobermorite.

Distribution: In the Christmas copper mine, Gila Co., Arizona, USA.

Name: For the Apache Indians who inhabit the region in Arizona, USA, where it occurs.

Type Material: University of Arizona, Tucson, Arizona, USA; The Natural History Museum, London, England, 1980,532.

References: (1) Cesbron, F.P. and S.A. Williams (1980) Apachite and gilalite, two new copper silicates from Christmas, Arizona. Mineral. Mag., 43, 639–641. (2) (1980) Amer. Mineral., 65, 1065 (abs. ref. 1).

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Aphthitalite $(K, Na)_3Na(SO_4)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As crystals, tabular on {0001}, with trigonal appearance, to 7 cm; also in distorted pseudo-orthorhombic habits. In bladed aggregates, imperfectly mammillary, and in crusts. *Twinning:* On {0001} or repeated on $\{11\overline{2}0\}$, producing tabular pseudohexagonal composites.

Physical Properties: *Cleavage:* On $\{10\overline{1}0\}$, fair; on {0001}, poor. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.66–2.71 D(calc.) = 2.697 Soluble in H_2O, taste saline and bitter.

Optical Properties: Transparent to opaque. *Color:* White, colorless; gray, blue, green due to inclusions and impurities; colorless in transmitted light. *Luster:* Vitreous to resinous. *Optical Class:* Uniaxial (+), may be anomalously biaxial. ω = 1.487–1.493 ϵ = 1.492–1.503 2V(meas.) = Small.

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 5.677$ $c = 7.3331$ Z = 1

X-ray Powder Pattern: Synthetic $K_3Na(SO_4)_2$.
2.839 (100), 2.940 (75), 2.042 (45), 4.09 (30), 3.67 (20), 2.443 (16), 2.330 (14)

Chemistry:

	(1)	(2)
SO_3	47.46	48.17
Na_2O	10.67	9.32
K_2O	41.87	42.51
Total	[100.00]	100.00

(1) Eddy Co., New Mexico, USA; recalculated to 100% after deduction of NaCl 2.15% and insoluble 0.06%, from an original total of 99.88%. (2) $K_3Na(SO_4)_2$.

Occurrence: An uncommon incrustation around volcanic fumaroles; a component of evaporite deposits; in guano deposits, then typically ammonian.

Association: Thénardite, jarosite, sylvite, hematite (fumaroles); blödite, syngenite, mirabilite, picromerite, borax, halite (evaporites); syngenite, whitlockite, monetite, niter, gypsum (guano).

Distribution: From Italy, in Campania, at Vesuvius and Monte Somma, in the Cesano geothermal field, east of Lake Bracciano, Lazio, and on Etna, Sicily. At Douglashall, near Westeregeln, Saxony-Anhalt, Germany. At Stebnyk and Kalusz, Ukraine. In the Boulby potash mine, northwest of Whitby, Yorkshire, England. Large crystals from Kuh-E-Namak, Qom salt dome, Iran. In the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China. In the USA, from Searles Lake, San Bernardino Co., California; in the Carlsbad potash district, Eddy Co., New Mexico; on Kilauea, Hawaii; and on the Mount St. Augustine volcano, Alaska. From Paricutín volcano, near Uruapan, Michoacán, Mexico. On the Merapi volcano, Indonesia. In the Murra-el-elevyn, Petrogale, and Toppin Hill Caves, Western Australia.

Name: From the Greek for *unalterable* and *salt*, in allusion to its stability in air.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 400–403. (2) Moore, P.B. (1973) Bracelets and pinwheels: a topological-geometrical approach to the calcium orthosilicate and alkali sulfate structures. Amer. Mineral., 58, 32–42. (3) Okada, K. and J. Ossaka (1980) Structures of potassium sodium sulphate and tripotassium sodium disulphate. Acta Cryst., 36, 919–921. (4) (1968) NBS Mono. 25, 6, 52.

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Apjohnite $Mn^{2+}Al_2(SO_4)_4 \cdot 22H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As fibrous to acicular crystals, to 3 cm; asbestiform, in crusts, massive.

Physical Properties: Hardness = 1.5 D(meas.) = 1.78–1.81 D(calc.) = 1.836 Soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless to white, also tinted pale red, green, or yellow. *Luster:* Silky in aggregates.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c \simeq 30°$. $\alpha = 1.478$ $\beta = 1.482$ $\gamma = 1.482$
2V(meas.) = Small.

Cell Data: *Space Group:* $P2_1/c$. $a = 6.198(2)$ $b = 24.347(4)$ $c = 21.266(4)$
$\beta = 100.28(3)°$ Z = 4

X-ray Powder Pattern: Terlano, Italy.
3.515 (100), 4.82 (90), 3.792 (33), 4.33 (27b), 3.967 (23), 4.13 (22), 6.07 (20)

Chemistry:

	(1)	(3)
SO_3	33.51	36.00
Al_2O_3	10.65	11.46
MnO	6.60	7.98
MgO	0.36	
H_2O	48.15	44.56
Total	99.27	100.00

(1) Maputo Bay, Mozambique. (2) Terlano, Italy; AA partial analysis not given, corresponding to $(Mn_{0.64}Mg_{0.28}Zn_{0.06}Fe_{0.02})_{\Sigma=1.00}Al_2(SO_4)_4 \cdot 22H_2O$. (3) $MnAl_2(SO_4)_4 \cdot 22H_2O$.

Mineral Group: Halotrichite group.

Occurrence: As efflorescences.

Association: Halotrichite, pickeringite, gunningite, copiapite, epsomite.

Distribution: From Maputo (Delagoa) Bay, near Maputo (Lourenço Marques), Mozambique. At Terlano, Bolzano, Trentino-Alto Adige, Italy. From Smolník (Szomolnok), 16 km northeast of Rožňava, Slovakia. At Jáchymov (Joachimsthal), Czech Republic. In the USA, in Alum Cave, Sevier Co., Tennessee; at Alum Point, Salt Lake Co., Utah; from Creede, Mineral Co., Colorado; in Nevada, at the Twentieth Century mine, Nye Co., and long fibers at the Urania mine, Cactus Peak district; in the Dolores Tunnel mine, Old Placers district, Santa Fe Co., New Mexico.

Name: Honors Dr. James Apjohn (1796–1886), Professor of Chemistry and Mineralogy, Trinity College, Dublin, Ireland.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 527–528. (2) Menchetti, S. and C. Sabelli (1976) The halotrichite group: the crystal structure of apjohnite. Mineral. Mag., 40, 599–608.

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Aplowite $(Co, Mn^{2+}, Ni)SO_4 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As finely granular efflorescences.

Physical Properties: Hardness = ∼3 D(meas.) = 2.33 D(calc.) = 2.36 Soluble in H_2O; dehydrates in air.

Optical Properties: Semitransparent. *Color:* Bright pink; light pink in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.528$ $\beta =$ n.d. $\gamma = 1.536$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/n$. $a = 5.94$ $b = 13.56$ $c = 7.90$ $\beta = 90°31'$ Z = 4

X-ray Powder Pattern: Magnet Cove mine, Canada.
4.46 (10), 5.44 (9), 3.95 (8), 2.95 (7), 3.39 (6), 3.22 (5), 6.78 (4)

Chemistry: (1) Magnet Cove mine, Canada; partial X-ray spectrographic analysis corresponds to $(Co_{0.50}Mn_{0.25}Ni_{0.22}Cu_{0.01}Fe_{0.01}Zn_{0.01})_{\Sigma=1.00}SO_4 \cdot 4H_2O$.

Mineral Group: Rozenite group.

Occurrence: As efflorescences with sulfides (probably cobaltian and nickelian pyrite) on siderite–barite matrix from a hydrothermal Pb–Zn–Cu orebody associated with a large barite deposit.

Association: Moorhouseite, siderite, barite.

Distribution: From the Magnet Cove barite mine, four km southwest of Walton, Nova Scotia, Canada.

Name: Honors Albert Peter Low (1861–1942), Canadian geologist, former Director of the Geological Survey of Canada.

Type Material: National School of Mines, Paris, France; Canadian Geological Survey, Ottawa, Canada, 12145.

References: (1) Jambor, J.L. and R.W. Boyle (1965) Moorhouseite and aplowite, new cobalt minerals from Walton, Nova Scotia. Can. Mineral., 8, 166–171. (2) (1965) Amer. Mineral., 50, 809 (abs. ref. 1).

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Apuanite $Fe^{2+}Fe^{3+}_4Sb^{3+}_4O_{12}S$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Very rarely as crystals, prismatic, thick tabular on {001} and bounded by {110}, {112}, and {114}; commonly massive.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = n.d. VHN = 240–480 (20 g load). D(meas.) = 5.33 D(calc.) = [5.22]

Optical Properties: [Opaque.] *Color:* Black. *Luster:* Metallic.
Optical Class: Uniaxial.
R_1–R_2: (470) 19.1–20.8, (546) 21.9–19.6, (589) 21.6–18.4, (650) 19.6–16.9

Cell Data: *Space Group:* $P4_2/mbc$. $a = 8.372(5)$ $c = 17.974(10)$ $Z = 4$

X-ray Powder Pattern: Buca della Vena mine, Italy.
3.168 (100), 1.922 (47), 2.957 (43), 1.647 (30), 2.646 (23), 2.434 (17), 5.90 (15)

Chemistry:

	(1)	(2)
Fe_2O_3	26.88	32.25
As_2O_3	3.48	
Sb_2O_3	53.82	58.87
FeO	7.04	7.26
ZnO	0.62	
S	2.70	3.24
$-O = S$	1.35	1.62
Total	93.19	100.00

(1) Buca della Vena mine, Italy; by electron microprobe, Fe^{2+}:Fe^{3+} from crystal-structure analysis; corresponds to $Fe^{2+}_{1.04}Zn_{0.08}Fe^{3+}_{3.57}(Sb^{3+}_{3.91}As^{3+}_{0.37})_{\Sigma=4.28}O_{12}S_{0.89}$. (2) $Fe^{2+}Fe^{3+}_4Sb_4O_{12}S$.

Occurrence: In an iron deposit in barite formed by low-grade metasomatic processes at the contact between phyllites and dolostones.

Association: Versiliaite, barite, magnetite, hematite, pyrite.

Distribution: In the Buca della Vena mine, northeast of Stazzema, Apuan Alps, Tuscany, Italy.

Name: For the Apuan Alps, Italy, where it was found.

Type Material: University of Pisa, Pisa, Italy, 3202; National School of Mines, Paris, France.

References: (1) Mellini, M., S. Merlino, and P. Orlandi (1979) Versiliaite and apuanite, two new minerals from the Apuan Alps, Italy. Amer. Mineral., 64, 1230–1234. (2) Mellini, M. and S. Merlino (1979) Versiliaite and apuanite: derivative structures related to schafarzikite. Amer. Mineral., 64, 1235–1242. (3) Mellini, M., M. Amouric, A. Baronnet, and G. Mercuriot (1981) Microstructures and nonstoichiometry in schafarzikite-like minerals. Amer. Mineral., 66, 1073–1079.

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Aqualite $(H_3O)_8(Na,K,Sr)_5Ca_6Zr_3Si_{26}O_{66}(OH)_9Cl$

Crystal Data: Hexagonal. *Point Group*: 3. Crystals, equant, to 3 cm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 4-5 D(meas.) = 2.58(2) D(calc.) = 2.66 Fluoresces pale yellow in LW UV.

Optical Properties: Transparent. *Color*: Pale pink. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (+). ω = 1.569(1) ε = 1.571(1) *Pleochroism*: *E* = colorless to pink; *O* = pink.

Cell Data: *Space Group*: *R3*. *a* = 14.078(3) *c* = 31.24(1) Z = 3

X-ray Powder Pattern: Inagli massif, Sakha Republic, Russia.
4.39 (100), 2.987 (100), 2.850 (79), 10.50 (44), 6.63 (43), 7.06 (42), 3.624 (41)

Chemistry:

	(1)		(1)
Na_2O	2.91	Ce_2O_3	0.54
K_2O	1.93	Al_2O_3	0.34
CaO	11.14	SiO_2	52.70
SrO	1.75	ZrO_2	12.33
BaO	2.41	TiO_2	0.78
FeO	0.56	Nb_2O_5	0.15
MnO	0.30	Cl	1.50
La_2O_3	0.17	H_2O	9.93
Nd_2O_3	0.36	$-O=Cl_2$	0.34
		Total	99.46

(1) Inagli massif, Sakha Republic, Russia; average of 5 electron microprobe analyses, H_2O by Penfield method, IR confirms H_3O^+, corresponding to $[(H_3O)_{7.94}Na_{2.74}K_{1.20}Sr_{0.49}Ba_{0.46}Fe_{0.23}Mn_{0.12}]_{\Sigma=13.18}Ca_{5.79}REE_{0.19})_{\Sigma=5.98}(Zr_{2.92}Ti_{0.08})_{\Sigma=3}(Si_{25.57}Ti_{0.21}Al_{0.19}Nb_{0.03})_{\Sigma=26}[O_{66.46}(OH)_{5.54}]_{\Sigma=72.0}[(OH)_{2.77}Cl_{1.23}]_{\Sigma=4.0}$.

Mineral Group: Eudialyte group.

Occurrence: In a hydrothermally altered perakaline pegmatite in an alkaline massif.

Association: Natrolite, microcline, eckermanite, aegirine, batisite, innelite, lorenzenite, thorite, galena.

Distribution: Inagli massif, ~30 km ESE of Aldan, Sakha Republic (former Yakutsk), Russia.

Name: From the Latin *aqua* in allusion to the role of "water" in its composition.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (catalog no. 2668/1).

References: (1) Khomyakov, A.P., G.N. Nechelyustov, and R.K. Rastsvetaeva (2007) Aqualite, $(H_3O)_8(Na,K,Sr)_5Ca_6Zr_3Si_{26}O_{66}(OH)_9Cl$, a new eudialyte-group mineral from the Inagli alkaline massif, Sakha-Yakutsk, Russia, and the problem of oxonium in hydrated eudialyte. Zap. Ross. Mineral. Obshch., 136(2), 39–55 (in Russian, English abstract); (2007) Geology of Ore Deposits, 49, 739–751 (in English). (2) (2009) Amer. Mineral., 94, 1075-1076 (abs. ref. 1).

Aragonite $CaCO_3$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$. Isolated crystals short to long prismatic along [010], also acicular with chisellike terminations, dipyramidal, thick tabular with forms {001}, {110} and {010}, to 30 cm; as columnar crystal aggregates and crusts, globular, reniform, pisolitic, coralloidal, stalactitic, internally fibrous or banded. *Twinning:* Common by repeated contact twinning on {110}, yielding pseudohexagonal columnar trillings; also polysynthetic lamellae and striations ‖ [001].

Physical Properties: *Cleavage:* {010}, distinct; {110} and {011}, imperfect. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.95 D(calc.) = 2.930 Cathodoluminescent, fluorescent red or yellow under LW and SW UV, phosphorescent.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, also gray, pale shades of yellow, blue, violet, green, red; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, resinous on fracture surfaces.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, weak.
$\alpha = 1.530$ $\beta = 1.681$ $\gamma = 1.685$ 2V(meas.) = 18°

Cell Data: *Space Group: Pmcn.* $a = 4.9611(4)$ $b = 7.9672(6)$ $c = 5.7407(4)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.396 (100), 1.977 (65), 3.273 (52), 2.700 (46), 2.372 (38), 2.481 (33), 2.341 (31)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	43.95	43.97	CaO	55.96	56.03
MgO	0.03		insol.	0.13	
			Total	100.07	100.00

(1) Matsushiro, Japan. (2) $CaCO_3$.

Polymorphism & Series: Trimorphous with calcite and vaterite.

Mineral Group: Aragonite group.

Occurrence: Converts to calcite over geologic time. A primary precipitate in warm marine waters, as oolites and carbonate mud, a principal detrital sedimentary component as the hard parts of many marine micro-organisms, shells and skeletons; also from evaporite deposits; in sinter at hot springs and dripstone in caves; characteristic of high-pressure, low-temperature (blueschist facies) metamorphism; as amygdules in basalt and andesite; a secondary component in altered ultramafic rocks.

Association: Gypsum, sulfur, celestine (evaporite deposits); pumpellyite, lawsonite, glaucophane, quartz (blueschist); calcite, dolomite, hydromagnesite, brucite, magnesite (altered ultramafics).

Distribution: Many localities, but fine crystals are uncommon. From Molina, Guadalajara Province, Spain. Fine crystals from Racalmuto, Cianciana, and Agrigento, Sicily, Italy. At Dognácska and Špania Dolina (Herrengrund), Slovakia. From Tarnowitz, Silesia, Poland. At the Erzberg, near Eisenerz, Styria, and from Leogang, Salzburg, Austria. On the Spitzberg, Hořenz, near Bílina, Czech Republic. From Frizington and Cleator Moor, Cumbria, England. Fine examples at the Touissit mine, near Oujda, and from Tazouta, near Sefrou, Morocco. Large crystals from Tsumeb, Namibia. In the USA, in caves at Bisbee, Cochise Co., Arizona; large crystals from near Lake Arthur, Chavez Co., also near Santa Rosa, Guadalupe Co., New Mexico; in the Passaic mine, Sterling Hill, Ogdensburg, Sussex Co., New Jersey.

Name: For its first-noted occurrence in the Aragon region, Spain.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 182–193. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 108–135. (3) Jarosch, D. and G. Heger (1986) Neutron diffraction refinement of the crystal structure of aragonite. Tschermaks Mineral. Petrog. Mitt., 35, 127–131. (4) (1954) NBS Circ. 539, 3, 53.

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Arakiite

$$(Zn, Mn^{2+}(Mn^{2+}, Mg)_{12}(Fe^{3+}, Al)_2(As^{3+}O_3)(As^{5+}O_4)_2(OH)_{23}$$

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Crystal Data: Tetragonal. *Point Group:* $\overline{4}2m$. As crystals composed of pyramids and prisms, to 2 mm, and in crusts.

Physical Properties: Hardness = Soft. D(meas.) = 2.23 D(calc.) = 2.34 (from cell-dimension charts). Soluble in H_2O.

Optical Properties: Translucent. *Color:* Buff to colorless. *Streak:* White. *Optical Class:* Uniaxial (–). $\omega = 1.513$ $\epsilon = 1.470$

Cell Data: *Space Group:* $I\overline{4}2d$ (synthetic KH_2PO_4). $a = 7.451(1)$ $c = 6.792(15)$ $Z = 4$

X-ray Powder Pattern: Synthetic KH_2PO_4. (ICDD 35–807).
3.724 (100), 2.908 (83), 1.953 (51), 2.635 (23), 2.340 (15), 5.086 (14), 3.008 (14)

Chemistry:

	(1)
K_2O	10.8
NH_3	3.46
Total	

(1) Petrogale Cave, Western Australia; partial analysis, corresponding to $[K_{0.74}(NH_4)_{0.26}]_{\Sigma=1.00}H_2PO_4$.

Occurrence: As a component of stalactites and crusts on the walls of caves containing bat guano deposits.

Association: Biphosphammite, aphthitalite, halite, syngenite, stercorite, oxammite, weddellite, whitlockite, guanine, newberyite, calcite, mundrabillaite.

Distribution: In Petrogale Cave, near Madura Motel, Eucla, and in Murra-el-elevyn Cave, Cocklebiddy, Western Australia.

Name: Honors Dr. Michael Archer (1945–), Curator of Mammals, Queensland Museum, Brisbane, Australia, who discovered the first specimens.

Type Material: Western Australian Museum, Perth, Australia, MDC5901.

References: (1) Bridge, P.J. (1977) Archerite, $(K, NH_4)H_2PO_4$, a new mineral from Madura, Western Australia. Mineral. Mag., 41, 33–35. (2) (1977) Amer. Mineral., 62, 1057 (abs. ref. 1). (3) West, J. (1930) A quantitative X-ray analysis of the structure of potassium dihydrogen phosphate (KH_2PO_4). Zeits. Krist., 74, 306–332.

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Aramayoite $Ag_3Sb_2(Bi,Sb)S_6$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As thin plates parallel to (010), showing striations along {100} and {001}, to 1 cm. *Twinning:* About [$\overline{1}$01] with the composition plane near {$\overline{1}$01}.

Physical Properties: *Cleavage:* Perfect on {010}, fair on {100}, poor on {001}. *Tenacity:* Sectile, thin flakes are flexible but not elastic. Hardness = 2.5 VHN = n.d. D(meas.) = 5.602 D(calc.) = 5.88

Optical Properties: Nearly opaque. *Color:* Iron-black, with thin edges showing deep blood-red; white in reflected light. *Streak:* Black to red-brown. *Luster:* Brilliant metallic. *Pleochroism:* Distinct in oil. *Anisotropism:* Very high in oil.
R_1–R_2: (400) 38.9–43.4, (420) 38.8–42.5, (440) 38.5–41.9, (460) 38.4–41.6, (480) 38.2–41.1, (500) 38.0–40.9, (520) 37.8–40.5, (540) 37.5–40.2, (560) 37.3–40.0, (580) 37.1–40.1, (600) 37.0–40.1, (620) 36.7–39.9, (640) 36.6–39.5, (660) 36.2–39.1, (680) 36.1–39.0, (700) 36.3–39.8

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.813(2)$ $b = 8.268(2)$ $c = 8.880(2)$ $\alpha = 100.32(2)°$ $\beta = 104.07(2)°$ $\gamma = 90.18(2)°$ Z = 2

X-ray Powder Pattern: Animas mine, Bolivia; similar to baumstarkite.
2.806 (100), 3.21 (40), 1.940 (30), 3.43 (20), 2.048 (20), 1.705 (20), 1.402 (20)

Chemistry:

	(1)	(2)
Ag	34.74	34.3
Cu	0.53	
Fe	trace	
Sb	29.95	30.6
Bi	13.75	14.1
As		0.2
S	20.87	20.8
Total	99.84	100.0

(1) Animas mine, Bolivia; corresponding to $(Ag_{2.97}Cu_{0.07})_{\Sigma=3.04}Sb_{2.00}(Bi_{0.61}Sb_{0.27})_{\Sigma=0.98}S_{6.00}$.
(2) Do.; by electron microprobe, average of nine analyses, corresponding to $Ag_{2.94}Sb_{2.00}(Bi_{0.62}Sb_{0.32}As_{0.02})_{\Sigma=0.96}S_{6.00}$.

Occurrence: Rare, typically in vein-controlled hydrothermal Sn–Ag ores.

Association: Tetrahedrite, miargyrite, stannite, pyrite, quartz.

Distribution: From the Animas mine, Chocaya, Potosí, Bolivia [TL]. At Herminia, Julcani district, and in the San Genaro mine, Huancavelica, Peru. From the Armonia mine, El Quevar, Salta Province, and in the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. From Portugalete, Bolivia. At the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. From the Flathead mine, about 13 km north of Niarada, Flathead Co., Montana, USA. At Monts de Blond and Le Bourneix, Hautes-Vienne, and Sainte-Marie-aux-Mines, Haut-Rhin, France. From Altenberg, fSalzburg, Austria.

Name: For Felix Avelino Aramayo (1846–1929), former Managing Director of the Compagnie Aramayo de Mines en Bolivie.

Type Material: The Natural History Museum, London, England, 1926,292, 1940,10; Royal Ontario Museum, Toronto, Canada, M15125; National Museum of Natural History, Washington, D.C., USA, 95553.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 427–428. (2) Graham, A.R. (1951) Matildite, aramayoite, miargyrite. Amer. Mineral., 36, 436–449. (3) Effenberger, H., W.H. Paar, D. Topa, A.J. Criddle, and M. Fleck (2002) The new mineral baumstarkite and a structural reinvestigation of aramayoite and miargyrite. Amer. Mineral., 87, 753–764.

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Arangasite $Al_2(PO_4)(SO_4)F•7.5H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As elongated lamellar crystals, to 200 μm. Typically in parallel or divergent aggregates, forming dense chalklike masses to 3 cm.

Physical Properties: *Cleavage*: Imperfect basal. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 1-2 D(meas.) = 2.01(1) D(calc.) = 2.001

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Dull to silky. *Optical Class*: Biaxial (+) [by analogy to sanjuanite]. α = 1.493(5) β = n.d. γ = 1.485(5) *Pleochroism*: None. *Orientation*: $Z \perp$ to elongation, $X \parallel$ to elongation.

Cell Data: *Space Group*: *P*2/*a*. a = 7.073(1) b = 9.634(2) c = 10.827(2) β = 100.40(1)° Z = 2

X-ray Powder Pattern: Alyaskitovy deposit, Arangas Creek, eastern Sakha (Yakutia), Russia. 9.64 (100), 4.201 (51), 10.64 (29), 5.325 (25), 3.142 (18), 3.482 (14), 3.216 (14)

Chemistry:

	(1)	(2)	(3)
Al_2O_3	25.36	26.64	25.54
P_2O_5	18.50	17.20	17.78
SO_3	20.95	19.10	20.06
F	5.22	4.58	4.76
$–O=F_2$		1.93	2.00
H_2O		34.24	33.86
Total		99.83	100.00

(1) Alyaskitovy deposit, eastern Sakha (Yakutia), Russia; average of 6 electron microprobe analyses, presence of H_2O, $(SO_4)^{2-}$, $(PO_4)^{3-}$ confirmed by IR spectroscopy. (2) Alyaskitovy deposit, eastern Sakha (Yakutia), Russia; average of 2 wet chemical analyses, H_2O by the Penfield method; corresponding to $Al_{2.08}(P_{0.97}O_4)(S_{0.95}O_4)F_{0.96}•7.48H_2O$. (3) $Al_2(PO_4)(SO_4)F•7.5H_2O$.

Occurrence: In cavities in quartz–muscovite–tourmaline–sulfide veins and adjacent rock, as a secondary mineral from near-surface oxidation and weathering of a strongly greisenized Li–F two-mica, leucogranite porphyry containing Sn and W mineralization.

Association: Phosphorscorodite, fluellite, gypsum, colquiriite, strengite, mansfieldite, sinkankasite.

Distribution: From the Alyaskitovy cassiterite-silicate-sulfide deposit, lower reaches of Arangas Creek, a tributary of the Elga River, Indigirka River basin, eastern Sakha (Yakutia), Russia.

Name: For *Arangas* Creek, located near the site from which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 4254/1).

References: (1) Gamyanin, G.N., N.V. Zayakina, and L.T. Galenchikova (2013) Arangasite, $Al_2(PO_4)(SO_4)F·7.5H_2O$, a new mineral from Alyaskitovoye deposit (Eastern Yakutia, Russia). Zap. Ross. Mineral. Obshch., 142(5), 21-30 (in Russian, English abstract). Geol. Ore Deposits, 56(7), 560-566 (in English). (2) (2014) Amer. Mineral., 99, 2150-2151 (abs. ref. 1). (3) Yakubovich, O. V., I. M. Steele, V. V. Chernyshev, N. V. Zayakina, G. N. Gamyanin, and O. V. Karimova (2014) The crystal structure of arangasite, $Al_2F(PO_4)(SO_4)·9H_2O$ determined using low-temperature synchrotron data. Mineral. Mag., 78(4), 889-903.

Aravaipite $Pb_3AlF_9 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. As plates, to 3 mm, flattened on {010}. *Twinning:* Polysynthetic on {010}, universal.

Physical Properties: *Cleavage:* Perfect micaceous {010}; {100}, {001}, {101}, {$10\overline{1}$}, good. *Fracture:* Irregular. *Tenacity:* Flexible. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 6.37 Slightly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). *Orientation:* Euler angles $\phi = 67°$; $\psi = 60°$; $\theta = 76°$.
Dispersion: $r < v$, strong. $\alpha = 1.678(2)$ $\beta = 1.690(2)$ $\gamma = 1.694(2)$ 2V(meas.) = 70(3)° 2V(calc.) = 66°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 5.842(2)$ $b = 25.20(5)$ $c = 5.652(2)$ $\alpha = 93.84(4)°$ $\beta = 90.14(4)°$ $\gamma = 85.28(4)°$ Z = 4

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
3.134 (100), 12.5 (80), 3.65 (70), 3.50 (60), 3.33 (60), 2.916 (40), 2.822 (40)

Chemistry:

	(1)	(2)
Pb	73.8	74.22
Al	3.6	3.22
F	21.0	20.41
H_2O	[3.0]	2.15
Total	[101.4]	100.00

(1) Grand Reef mine, Arizona, USA; by electron microprobe, H_2O estimated from IR; corresponds to $Pb_{2.90}Al_{1.09}F_9 \cdot 1.36H_2O$. (2) $Pb_3AlF_9 \cdot H_2O$.

Occurrence: In the oxidized zone of an epithermal Pb–Cu–Ag deposit hosted by a silicified rhyolite-schist breccia.

Association: Grandreefite, pseudograndreefite, laurelite, fluorite, galena, anglesite, linarite, caledonite, quartz.

Distribution: From the Grand Reef mine, near Klondyke, Aravaipa district, Graham Co., Arizona, USA.

Name: For the Aravaipa mining district, Arizona, USA, where the mineral occurs.

Type Material: Natural History Museum, Los Angeles, California, 33608; National Museum of Natural History, Washington, D.C., USA, 166058.

References: (1) Kampf, A.R., P.J. Dunn, and E.E. Foord (1989) Grandreefite, pseudograndreefite, laurelite, and aravaipaite: four new minerals from the Grand Reef mine, Graham County, Arizona. Amer. Mineral., 74, 927–933. (2) Kampf, A.R. and E.E. Foord (1996) Calcioaravaipaite, a new mineral, and associated lead fluoride minerals from the Grand Reef mine, Graham County, Arizona. Mineral. Record, 27, 293–300.

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Arcanite K_2SO_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As thin cyclically twinned pseudohexagonal tablets, to 1 cm; typically in crusts and coatings. *Twinning:* On {110}, cyclic.

Physical Properties: *Cleavage:* On {010} and {001}, good. Hardness = n.d. D(meas.) = 2.66 D(calc.) = [2.667] Soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* White to colorless, yellow. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, moderate. $\alpha = 1.494$ $\beta = 1.495$ $\gamma = 1.497$ 2V(meas.) = 67°20′

Cell Data: *Space Group:* *Pnam* (synthetic). $a = 7.746(3)$ $b = 10.071(4)$ $c = 5.763(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
2.903 (100), 3.001 (77), 2.886 (53), 4.176 (28), 2.422 (25), 2.089 (25), 2.082 (25)

Chemistry:

	(1)	(2)
SO_3	45.37	45.95
Na_2O	< 0.01	
K_2O	47.50	54.05
$(NH_4)_2O$	5.14	
Total	98.01	100.00

(1) Chincha Islands, Peru; original total given as 97.87%; corresponds to $[K_{1.78}(NH_4)_{0.35}]_{\Sigma=2.13}SO_{4.00}$. (2) K_2SO_4.

Polymorphism & Series: Forms a series with mascagnite.

Occurrence: In a pine railroad tie (Santa Ana mine, California, USA); in hydrothermally altered rock in a geothermal field (Cesano geothermal field, Italy); derived from bird guano on islands and bat guano in caves.

Association: Syngenite (Cesano geothermal field, Italy); swaknoite, mundrabillaite, dittmarite (Arnhem Cave, Namibia).

Distribution: From the Santa Ana tin mine, Trabuco Canyon, Orange Co., California, USA. On the Chincha Islands, off the coast of Peru. At the Cesano geothermal field, Latium, Italy. From the Arnhem, Arun Aas, Baobab, Gâuan Aas, Né-rab-aas, Temple of Doom, and Uisib Caves, Namibia. In the Lobatse Cave, Botswana. From Timbavati Cave, South Africa. In the Murra-el-elevyn Cave, Cocklebiddy, Western Australia.

Name: From the Latin *arcanum duplicatum*, for *double secret*, a medieval alchemical name.

Type Material: University of California, Berkeley, California; Harvard University, Cambridge, Massachusetts, USA, 100763.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 399–400. (2) McGinnety, J.A. (1972) Redetermination of the structures of potassium sulphate and potassium chromate: the effect of electrostatic crystal forces upon observed bond lengths. Acta Cryst., 28, 2845–2858. (3) Arnold, H., A. Kurtz, A. Richter-Zinnius, J. Bethke, and G. Heger (1981) Struktur und Umwandlung des Arcanits, β-K_2SO_4. Zeits. Krist., 154, 246–247 (in German). (4) Groat, L.A. and F.C. Hawthorne (1985) Taylorite discredited (=ammonian arcanite). Can. Mineral., 23, 259–260. (5) (1954) NBS Circ. 539, 62.

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As crystals composed of pyramids and prisms, to 2 mm, and in crusts.

Physical Properties: Hardness = Soft. D(meas.) = 2.23 D(calc.) = 2.34 (from cell-dimension charts). Soluble in H_2O.

Optical Properties: Translucent. *Color:* Buff to colorless. *Streak:* White. *Optical Class:* Uniaxial (–). $\omega = 1.513$ $\epsilon = 1.470$

Cell Data: *Space Group:* $I\bar{4}2d$ (synthetic KH_2PO_4). $a = 7.451(1)$ $c = 6.792(15)$ $Z = 4$

X-ray Powder Pattern: Synthetic KH_2PO_4. (ICDD 35–807).
3.724 (100), 2.908 (83), 1.953 (51), 2.635 (23), 2.340 (15), 5.086 (14), 3.008 (14)

Chemistry:

	(1)
K_2O	10.8
NH_3	3.46
Total	

(1) Petrogale Cave, Western Australia; partial analysis, corresponding to $[K_{0.74}(NH_4)_{0.26}]_{\Sigma=1.00}$ H_2PO_4.

Occurrence: As a component of stalactites and crusts on the walls of caves containing bat guano deposits.

Association: Biphosphammite, aphthitalite, halite, syngenite, stercorite, oxammite, weddellite, whitlockite, guanine, newberyite, calcite, mundrabillaite.

Distribution: In Petrogale Cave, near Madura, and in Murra-el-elevyn Cave, about 200 km east of Balladonia, Western Australia.

Name: Honors Dr. Michael Archer (1945–), Curator of Mammals, Queensland Museum, Brisbane, Australia, who discovered the first specimens.

Type Material: Government Chemical Laboratories, Perth, Australia, MDC 5901.

References: (1) Bridge, P.J. (1977) Archerite, $(K,NH_4)H_2PO_4$, a new mineral from Madura, Western Australia. Mineral. Mag., 41, 33–35. (2) (1977) Amer. Mineral., 62, 1057 (abs. ref. 1). (3) West, J. (1930) A quantitative X-ray analysis of the structure of potassium dihydrogen phosphate (KH_2PO_4). Zeits. Krist., 74, 306–332.

Arctite **$Na_5Ca_7Ba(PO_4)_6F_3$**

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As crystals, to 3 cm.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = ∼5 D(meas.) = 3.13 D(calc.) = 3.19

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous, pearly on the perfect cleavage.
Optical Class: Uniaxial (–), may be anomalously biaxial. $\omega = 1.578(2)$ $\epsilon = 1.577(2)$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.094$ $c = 41.320$ Z = 1

X-ray Powder Pattern: Vuonnemiok River, Kola Peninsula, Russia.
2.746 (100), 3.43 (32), 13.80 (25), 3.06 (25), 2.804 (25), 3.54 (21), 2.719 (21)

Chemistry:

	(1)	(2)
P_2O_5	33.83	36.72
SiO_2	3.60	
ZrO_2	3.25	
Fe_2O_3	0.20	
CaO	31.80	33.85
BaO	12.00	13.22
Na_2O	9.72	13.36
K_2O	1.64	
F	5.25	4.92
H_2O	0.50	
$-O = F_2$	2.20	2.07
S	0.22	
Total	99.81	100.00

(1) Vuonnemiok River, Kola Peninsula, Russia; K, Fe, Zr, S, Si, and some F attributed to impurities. (2) $Na_5Ca_7Ba(PO_4)_6F_3$.

Occurrence: A late-stage pneumatolytic mineral in pegmatitic veinlets in a differentiated alkalic massif.

Association: Natrosilite, vuonnemite, lomonosovite, zirsinalite, natisite, rasvumite, villiaumite, aegirine, thenardite, umbite, paraumbite, kostylevite, wadeite.

Distribution: In the valley of the Vuonnemiok River, [on Mt. Koashva,] Khibiny massif, Kola Peninsula, Russia.

Name: For the locality in the Arctic region.

Type Material: Mining Institute, St. Petersburg, 120/1; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5708/2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82132; The Natural History Museum, London, England, 1994,2.

References: (1) Khomyakov, A.P., A.V. Bykova, and T.A. Kurova (1981) Arctite, $Na_2Ca_4(PO_4)_3F$, a new mineral. Zap. Vses. Mineral. Obshch., 110, 506–508 (in Russian). (2) (1982) Amer. Mineral., 67, 621 (abs. ref. 1). (3) (1982) Mineral. Abs., 33, 168 (abs. ref. 1). (4) Sokolova, E.V., N.A. Yamnova, Y.K. Yegorov-Tismenko, and A.P. Khomyakov (1984) Crystal structure of a new phosphate of Na, Ca, and Ba $(Na_5Ca)Ca_6Ba[PO_4]_6F_3$, Doklady Acad. Nauk SSSR, 274, 78–83 (in Russian). (5) Khomyakov, A.P. (1995) Mineralogy of hyperagpaitic alkaline rocks. Clarendon Press, Oxford, 165.

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Arcubisite Ag_6CuBiS_4

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Crystal Data: n.d. *Point Group:* n.d. In anhedral grains of 0.05 mm average diameter.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* In polished section, pale gray with faint olive-brown tint. *Luster:* Metallic. *Anisotropism:* Distinct in air, strong in oil, cream to bluish green.
R_1–R_2: (400) — , (420) — , (440) 33.6–33.4, (460) 33.5–33.8, (480) 33.1–33.6, (500) 32.5–33.9, (520) 32.1–33.2, (540) 32.1–33.7, (560) 31.8–33.7, (580) 31.4–33.9, (600) 31.2–33.7, (620) 31.0–34.1, (640) 31.0–33.5, (660) 30.9–33.4, (680) — , (700) —

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)	(4)
Ag	64.7	64.0	61.0	59.1
Cu	6.2	5.4	4.3	6.8
Pb	0.8	1.4	1.3	3.1
Fe	1.1	0.8	1.1	0.6
Bi	16.9	16.8	16.0	17.0
Te	1.5	1.8	1.9	2.3
S	11.6	12.6	11.8	13.7
Total	102.8	102.8	97.4	102.6

(1–4) Ivigtut, Greenland; by electron microprobe, the average leading to $Ag_{6.01}Cu_{0.95}Bi_{0.84}Pb_{0.07}Fe_{0.13}Te_{0.18}S_{4.01}$.

Occurrence: In a cryolite deposit.

Association: Galena, hessite, aikinite, matildite, berryite, tellurian canfieldite, acanthite, bismuth, quartz, fluorite, cryolite.

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland [TL].

Name: For the major metallic elements in the mineral: ARgentum, *silver*; CUprum, *copper*; BISmuth and Sulfur.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1973,114.

References: (1) Karup-Møller, S. (1976) Arcubisite and mineral B—two new minerals from the cryolite deposit at Ivigtut, South Greenland. Lithos, 9, 253–257. (2) (1978) Amer. Mineral., 63, 424 (abs. ref. 1).

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Ardaite $Pb_{19}Sb_{13}S_{35}Cl_7$

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Crystal Data: Monoclinic. *Point Group:* n.d. As aggregates of acicular crystals, to 2 μm, as isolated inclusions in sulfides and sulfosalts.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = [6.44]

Optical Properties: Opaque. *Color:* Grayish green or bluish green. *Luster:* Metallic. *Pleochroism:* Distinct. *Anisotropism:* Distinct.

R_1–R_2: (400) —, (420) —, (440) 31.3–33.2, (460) —, (480) 32.1–34.4, (500) —, (520) 32.3–35.1, (540) —, (560) —, (580) 31.7–34.7, (600) —, (620) 31.1–33.9, (640) —, (660) 30.6–32.8, (680) —, (700) 30.3–31.8

Cell Data: *Space Group:* n.d. $a = 21.09$ $b = 22.11$ $c = 8.05$ $\beta = 103.02°$ Z = 2

X-ray Powder Pattern: Synthetic.
3.43 (100), 2.83 (80), 3.13 (40), 1.90 (30), 4.24 (20), 3.90 (20), 2.36 (20)

Chemistry:

	(1)	(2)	(3)	(4)
Pb	56.50	57.94	57.14	59.37
Ag	0.04	0.00		
Fe	0.00	0.31		
Sb	22.48	21.44	22.97	20.94
S	15.56	15.44	16.29	15.62
Cl	3.78	4.39	3.60	4.06
Total	98.36	99.52	100.00	100.00

(1) Madjarovo, Bulgaria; by electron microprobe, average of six analyses. (2) Gruvåsen, Sweden; by electron microprobe, average of 17 analyses. (3) $Pb_{19}Sb_{13}S_{35}Cl_7$. (4) $Pb_{10}Sb_6S_{17}Cl_4$.

Occurrence: Very rare in polymetallic ore deposits.

Association: Galena, nadorite, chlorian robinsonite, chlorian semseyite, pyrostilpnite, argentian tetrahedrite, anglesite (Madjarovo, Bulgaria); sphalerite, pyrrhotite, chalcopyrite, magnetite, scheelite, stannite, pyrargyrite, silver, antimony, arsenopyrite, nisbite, graphite (Gruvåsen, Sweden).

Distribution: From Madjarovo, eastern Rhodope Mountains, Bulgaria [TL]. In the Dressfall mine, Gruvåsen, Bergslagen metallic province, Sweden.

Name: For the Arda River, Bulgaria, which runs through the Madjarovo deposit.

Type Material: n.d.

References: (1) Breskovska, V.V., N.N. Mozgova, N.S. Bortnikov, A.I. Gorshkov, and A.I. Tsepin (1982) Ardaite — a new lead–antimony chlorosulphosalt. Mineral. Mag., 46, 357–61. (2) (1983) Amer. Mineral., 68, 642 (abs. ref. 1). (3) Burke, E.A.J., C. Kieft, and M.A. Zakrzewski (1981) The second occurrence of ardaite: Gruvåsen, Bergslagen, Sweden. Can. Mineral., 19, 419–422.

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Ardealite $Ca_2(HPO_4)(SO_4)\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group: m.* Crystals platy and very thin, minute; as thin crusts and fine-grained powdery, pulverulent to clayey masses, generally intimately intermixed with brushite and gypsum.

Physical Properties: Hardness = n.d. D(meas.) = 2.34(1) D(calc.) = [2.32]

Optical Properties: Semitransparent. *Color:* Pale yellow, yellow, brownish yellow, colorless. *Optical Class:* Biaxial (–). $\alpha = 1.531(2)$ $\beta = 1.539(2)$ $\gamma = 1.546(2)$ 2V(meas.) = 86°

Cell Data: *Space Group: Cc* (synthetic). $a = 5.721(5)$ $b = 30.992(5)$ $c = 6.250(4)$ $\beta = 117.26(6)°$ Z = 4

X-ray Powder Pattern: La Guangola Cave, Italy.
7.73 (100), 3.08 (55), 3.87 (36), 1.810 (27), 2.813 (25), 2.849 (24), 3.93 (21)

Chemistry:

	(1)	(2)	(3)
SO_3	21.25	22.75	23.26
P_2O_5	21.85	21.31	20.61
CaO	31.61	31.14	32.58
H_2O^+	25.14	24.86	23.55
insol.	0.39		
Total	100.24	100.06	100.00

(1) Cioclovina Cave, Romania; H_2O by the Penfield method. (2) La Guangola Cave, Italy; average of three analyses. (3) $Ca_2(HPO_4)(SO_4)\cdot 4H_2O$.

Occurrence: In limestone caves, as an early stage of the breakdown of bat guano, in reaction with calcite.

Association: Brushite, gypsum, carbonate-hydroxylapatite, newberyite, taranakite.

Distribution: From the Cioclovina Cave, Transylvania, Romania. In Italy, in the La Guangola Cave, near Altamura, Apulia. At the Magurata and Bacho Kuo Caves, Bulgaria. From the Baobab and Uisib Caves, Namibia. In the Moora Pave Cave, Jurien Bay, Western Australia. At the Onino-Iwaya Cave, Hiroshima Prefecture, Japan. From the Niah Great Cave, Sarawak, Malaysia.

Name: From *Ardeal*, the old Romanian name for Transylvania.

Type Material: The Natural History Museum, London, England, 1933,87.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1010–1011. (2) Sakae, T., H. Nagata, and T. Sudo (1978) The crystal structure of synthetic calcium phosphate-sulfate hydrate, $Ca_2HPO_4SO_4\cdot 4H_2O$, and its relation to brushite and gypsum. Amer. Mineral., 63, 520–527. (3) Balenzano, F., L. Dell'Anna, M. Di Pierro, and S. Fiore (1984) Ardealite, $CaHPO_4CaSO_4\cdot 4H_2O$: a new occurrence and new data. Neues Jahrb. Mineral., Monatsh., 461–467.

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Ardennite-(V) $Mn_4[Al_4(Al, Mg)][Si_5As]O_{22}(OH)_6$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As acicular crystals; tabular, elongated along [010], to 1 mm; also as parallel aggregates.

Physical Properties: *Cleavage*: None observed. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 6-7 D(meas.) = n.d. D(calc.) = 3.55

Optical Properties: Transparent. *Color*: Yellow. *Streak*: White. *Luster*: Vitreous. *Optical Class:* Biaxial. $\alpha > 1.765(5)$ $\beta < 1.775(5)$ $\gamma = 1.775(5)$ *Orientation: Z = b*. *Pleochroism*: Very weak; *X* = *Y* = pale yellow; *Z* = yellowish.

Cell Data: *Space Group*: *Pnmm*. $a = 8.760(3)$ $b = 5.838(2)$ $c = 18.56(2)$ $Z = 2$

X-ray Powder Pattern: Sparone, Piedmont, Italy.
2.609 (100), 2.948 (90), 1.585 (75), 2.033 (55), 1.477 (45), 1.525 (39), 2.329 (38)

Chemistry:

	(1)
P_2O_5	0.38
As_2O_5	0.37
V_2O_5	4.60
SiO_2	31.21
TiO_2	0.21
Al_2O_3	22.60
Fe_2O_3	1.64
Cr_2O_3	0.34
MgO	4.44
MnO_{total}	23.28
CaO	4.24
Na_2O	0.02
F	0.17
H_2O_{calc}	5.70
O = -F	0.07
Total	99.20

(1) Sparone, Piedmont, Italy; electron microprobe analysis, Mn calculated to fill appropriate structural sites, H_2O calculated for charge balance; corresponding to $[Mn^{2+}_{3.221}Ca_{0.774}Na_{0.006}]_{\Sigma=4.001}$ $[Al_{4.456}Mg_{1.127}Fe^{3+}_{0.210}Mn^{3+}_{0.137}Cr_{0.046}Ti_{0.027}]_{\Sigma=6.003}$ $[Si_{5.000}][V_{0.518}Si_{0.315}Al_{0.080}P_{0.055}As_{0.033}]_{\Sigma=1.001}$ $O_{21.433}(OH)_{6.475}F_{0.092}$.

Occurrence: In a quartz veinlet in piemontite-bearing mica schist.

Association: Quartz, piemontite, hematite, muscovite.

Distribution: At Sparone, Locana Valley (TO), Piedmont, Italy.

Name: As the vanadium analog of *aredennite*, first described from Salmchäteau, Ardennes Mountains, Belgium.

Type Material: Museum of Natural History, University of Pisa, Italy (15525), and Regional Museum of Natural History, Turin, Italy (M/U 15544).

References: (1) Barresi, A.A., P. Orlandi, M. Pasero (2007) History of ardennite and the new mineral ardennite-(V). Eur. J. Mineral., 19, 581-587. (2) (2008) Amer. Mineral., 93, 702 (abs. ref. 1).

Ardennite $\mathbf{Mn_4^{2+}(Al,Mg)_6(SiO_4)_2(Si_3O_{10})[(As,V)O_4](OH)_6}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Individual crystals rare, prismatic, with prism faces strongly striated and pyramidal faces smooth; as radiating fibrous groups, to 4 cm.

Physical Properties: *Cleavage:* Perfect on {010}, distinct on {110}; parting on {001}. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 3.69–3.75 D(calc.) = 3.74

Optical Properties: Nearly opaque, translucent in thin fragments. *Color:* Yellow to yellowish brown; in thin section, yellow to brown. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = dark brownish yellow; Y = golden yellow; Z = pale yellow. *Orientation:* $Z = b$ or c. α = n.d. β = 1.74–1.78; birefringence = 0.15–0.20. γ = n.d. 2V(meas.) = 0°–70°

Cell Data: *Space Group: Pnmm.* $a = 8.7126(8)$ $b = 18.5124(11)$ $c = 5.8108(8)$ Z = 2

X-ray Powder Pattern: Salmchâteau, Belgium.
2.574 (100), 2.911 (70), 4.21 (60), 3.15 (60), 2.871 (60), 1.448 (60), 3.76 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	27.85	29.70	MnO	25.70	18.93
TiO_2		0.04	CuO	0.26	0.01
Al_2O_3	23.55	22.99	MgO	2.30	5.49
Fe_2O_3	0.86	2.77	CaO	1.17	4.41
As_2O_5	13.25	10.11	H_2O^+	5.10	5.44
V_2O_5	0.89	0.04	H_2O^-	0.02	
FeO	0.00		Total	100.95	99.93

(1) Salmchâteau, Belgium. (2) Haute-Maurienne, France; by electron microprobe, confirmed by XRF and wet analysis, H_2O by coulometry; corresponds to $(Mn^{2+}_{2.75}Ca_{0.81}Mg_{0.43})_{\Sigma=3.99}(Al_{4.65}Mg_{0.98}Fe^{3+}_{0.36})_{\Sigma=5.99}(As_{0.91}O_4)Si_{5.10}O_{18}(OH)_6$.

Occurrence: In pegmatites and quartz veins in schist (Salmchâteau, Belgium); in highly oxidized Mn, Al-rich metasediments (Andros Island, Greece).

Association: Quartz, albite, pyrolusite, piemontite, spessartine, braunite, hematite.

Distribution: At Salmchâteau, near Ottré, and at Bihain, Belgium. From Ala, Piedmont, Italy. At Bonneval-sur-Arc, Haute-Maurienne, Isère, France. In the Merehead quarry, Shepton Mallet, Somerset, England. On Evvia and Andros Islands, Cyclades Islands, Greece. At the Kajlidongri manganese mine, Jhabua district, Madhya Pradesh, India. Along the Asemi-gawa River, Kochi Prefecture, Japan.

Name: For the initial occurrence at Salmchâteau, in the Ardennes Mountains, Belgium.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 542–543. (2) Moore, P.B. (1965) Cell data of orientite and its relation to ardennite and zoisite. Can. Mineral., 8, 262–265. (3) Donnay, G. and R. Allmann (1968) Si_3O_{10} groups in the crystal structure of ardennite. Acta Cryst., 24, 845–855. (4) Allman, R. and G. Donnay (1971) Structural relations between pumpellyite and ardennite. Acta Cryst., 27, 1871–1875. (5) Pasero, M. and T. Reinecke (1991) Crystal chemistry, HRTEM analysis and polytypic behavior of ardennite. Eur. J. Mineral., 3, 819–830.

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Arfvedsonite $NaNa_2[(Fe^{2+},Mg)_4Fe^{3+}]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly as elongated prisms, showing {110}, striated and unterminated, to 0.60 m; may be tabular on {010}. As prismatic aggregates and radiating fibrous clusters. *Twinning:* Simple or lamellar twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, with intersections of 56° and 124°; parting on {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = ∼3.3–3.5 D(calc.) = [3.33]

Optical Properties: Translucent to opaque. *Color:* Black, deep green on thin edges; strongly colored in thin section. *Streak:* Deep bluish gray, gray-green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Strong, in blue-greens, yellow-browns, or gray-violets. *Orientation:* $Z = b$; $X \wedge c = 5°–30°$; $Y \wedge a = 20°–45°$. *Dispersion:* $r > v$, very strong. *Absorption:* $X > Y > Z$. α = ∼1.67–1.700 β = ∼1.68–1.710 γ = ∼1.69–1.715 2V(meas.) = 0°–90°

Cell Data: *Space Group:* $C2/m$. $a = 10.007(2)$ $b = 18.077(2)$ $c = 5.332(1)$ $\beta = 104.101(7)°$ Z = 2

X-ray Powder Pattern: Nunarsuatsiak, Tunugdliarfik, Greenland. (ICDD 14-633). 3.161 (100), 2.732 (80), 8.51 (70), 3.423 (45), 2.604 (35), 2.185 (35), 2.550 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.99	51.34	CaO	0.93	1.02
TiO_2	0.77	1.34	Na_2O	6.94	8.68
Al_2O_3	1.66	0.45	K_2O	3.67	1.60
Fe_2O_3	7.52	3.70	F	0.21	
FeO	26.56	26.74	H_2O	1.64	[1.89]
MnO	0.94	1.78	$-O = F_2$	[0.09]	
MgO	0.45	1.77	Total	[100.19]	[100.31]

(1) Red Wine complex, Labrador, Newfoundland, Canada; by electron microprobe, averaged with wet chemical analysis, original total given as 100.18%; corresponding to $(K_{0.71}Na_{0.29})_{\Sigma=1.00}(Na_{1.84}Ca_{0.16})_{\Sigma=2.00}(Fe^{2+}_{3.60}Fe^{3+}_{0.92}Al_{0.15}Mn_{0.13}Mg_{0.11}Ti_{0.09})_{\Sigma=5.00}(Si_{7.83}Al_{0.17})_{\Sigma=8.00}O_{22}$
(2) Kangerdlugssuaq Fjord, Greenland; by electron microprobe, H_2O calculated from stoichiometry.

Polymorphism & Series: Forms a series with magnesio-arfvedsonite.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) \geq 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) \geq 0.5$; $(Na + K)_A \geq 0.5$; $Na_B \geq 1.34$; $Mn_C < 2.5$.

Occurrence: Common in alkalic granites and other alkalic plutonic rocks and pegmatites.

Association: Nepheline, albite, aegirine, riebeckite, katophorite, magnesio-katophorite, quartz.

Distribution: Notable occurrences are: in Greenland, in the Ilímaussaq intrusion, from Kangerdlugssuaq Fjord, at Narssârssuk, and in the Ivigtut cryolite deposit. Around the Langesundsfjord, Norway. At Buchans, Newfoundland, and Mont Saint-Hilaire, Quebec, Canada. In the USA, from St. Peters Dome, near Pikes Peak, El Paso Co., Colorado; on Hurricane Mountain, Intervale, Carroll Co., New Hampshire; at Magnet Cove, Hot Spring Co., Arkansas; near Burnsville, Yancey Co., North Carolina. From the Lovozero massif, Kola Peninsula, Russia. At Bitola, Macedonia. On Mbolwe Hill, Mkushi River area, Central Province, Zambia. From Mt. Malosa, Zomba district, Malawi. In Australia, from Mittagong, New South Wales.

Name: To honor the Swedish chemist, Johan A. Arfvedson (1792–1841).

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 401–403. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 364–374. (3) Hawthorne, F.C. (1976) The crystal chemistry of the amphiboles: V. The structure and chemistry of arfvedsonite. Can. Mineral., 14, 346–356. (4) Layne, G.D. and J.C. Rucklidge (1982) Astrophyllite from Kangerdlugssuaq, East Greenland. Mineral. Mag., 45, 149–156. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 243–245.

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Argentojarosite $AgFe_3^{3+}(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. Typically as scaly masses of minute {0001} crystals with hexagonal outlines, or in pulverulent crusts.

Physical Properties: *Cleavage:* On {0001}, distinct. *Fracture:* [Uneven to conchoidal.] (by analogy to jarosite). *Tenacity:* [Brittle.] Hardness = n.d. D(meas.) = 3.66 D(calc.) = 3.660

Optical Properties: Transparent to translucent. *Color:* Yellow to brown; yellow in transmitted light. *Luster:* Adamantine.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellow; E = pale yellow. ω = 1.882–1.888 ϵ = 1.785–1.790

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.347(10)$ $c = 16.580(53)$ $Z = 3$

X-ray Powder Pattern: Synthetic.
3.062 (100), 5.98 (50), 3.681 (30), 2.524 (30), 2.218 (30), 1.979 (25), 3.127 (20)

Chemistry:

	(1)	(2)
SO_3	28.15	28.11
Fe_2O_3	43.07	42.06
PbO	0.61	
Ag_2O	18.00	20.34
K_2O	0.42	
H_2O	9.81	9.49
insol.	0.29	
Total	100.35	100.00

(1) Tintic Standard mine, Utah, USA. (2) $AgFe_3(SO_4)_2(OH)_6$.

Mineral Group: Alunite group.

Occurrence: An uncommon secondary mineral in the oxidized portions of silver- and sulfide-bearing mineral deposits.

Association: Anglesite, barite, quartz (Tintic Standard mine, Utah, USA).

Distribution: In the USA, an ore mineral in the Tintic Standard mine, near Dividend, East Tintic district, Utah Co., Utah; in the Philadelphia mine, Organ district, Doña Ana Co., New Mexico; from the Cactus Queen mine, Kern Co., California. At the Santa Ana mine, Caborca, Sonora, Mexico. In England, in the West Turf Pits mine, Grassington Moor, Yorkshire; from the Treore mine, St. Teath, and at Wheal Ludcott, St. Ives, Cornwall. From the Rio Tinto, Huelva and La Union mines, Murcia, Spain.

Name: As the silver, *argentum*, analog of *jarosite*.

Type Material: The Natural History Museum, London, England, 1957,357; National Museum of Natural History, Washington, D.C., USA, 104272–104274, 94707, R6309.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 565. (2) May, A., J.J. Sjoberg, and E.G. Baglin (1973) Synthetic argentojarosite: physical properties and thermal behavior. Amer. Mineral., 58, 936–941.

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Argentopentlandite $Ag(Fe,Ni)_8S_8$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As euhedral crystals with well developed octahedral faces; as patches in other sulfides; massive.

Physical Properties: *Cleavage:* Well developed on {111}. Hardness = n.d. VHN = 132–154 (50 g load). D(meas.) = n.d. D(calc.) = 4.66

Optical Properties: Opaque. *Color:* Bronze-brown; cinnamon-brown in polished section. *Luster:* Metallic.
R: (400) 20.4, (420) 21.0, (440) 21.9, (460) 22.9, (480) 24.2, (500) 25.6, (520) 27.2, (540) 28.8, (560) 30.4, (580) 31.9, (600) 33.3, (620) 34.6, (640) 35.8, (660) 36.8, (680) 37.8, (700) 38.6

Cell Data: *Space Group: Fm3m.* a = 10.521(3) Z = 4

X-ray Powder Pattern: Vuonos, Finland.
3.170 (10), 1.858 (10), 2.018 (4), 1.072 (3), 6.06 (2), 5.25 (2), 3.71 (2)

Chemistry:

	(1)	(2)		(1)	(2)
Ag	13.3	12.1	Cu		0.6
Fe	34.7	35.6	S	31.4	31.5
Ni	21.3	20.0	Total	100.7	99.8

(1) Oktyabr mine, Russia; by electron microprobe, corresponds to $Ag_{1.01}(Fe_{5.08}Ni_{2.97})_{\Sigma=8.05}S_{8.00}$.
(2) Talnotry mine, Scotland; by electron microprobe, corresponds to $Ag_{0.91}(Fe_{5.19}Ni_{2.78})_{\Sigma=7.97}S_{8.00}$.

Mineral Group: Pentlandite group.

Occurrence: In pyrite and cubanite-chalcopyrite hydrothermal veins in ultramafic rocks and in skarn; in hydrothermal veins in acidic volcanics; rare in carbonatites.

Association: Pyrite, pyrrhotite, mackinawite, cubanite, chalcopyrite, stannite, galena, sphalerite, calcite, quartz.

Distribution: In Russia, in the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia [TL], and the Khovu-Aksy Co–Ni deposit, Tuva [TL]. In the Vuonos, Miihkali, Hietajärvi, and Outokumpu deposits, Finland. In Scotland, at the Talnotry mine, Newton Stewart, Kirkcudbrightshire. From El Charcón, Murcia Province, Spain. At Koronuda, Macedonia, Greece. From Bottino, Tuscany, Italy. In the Loolekop carbonatite, Phalaborwa, Transvaal, South Africa. From Bird River, and the Agassiz gold deposit, Lynn Lake region, Manitoba, Canada. In the USA, from near Silver City, Ontonogan Co., Michigan. From Windaira, Western Australia. In the Juimao tin mine, Guangxi Province, China.

Name: For the similarity in composition to pentlandite.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74159.

References: (1) Sishkin, M.N., G.A. Mitenkov, V.A. Mikhailova, N.S. Rudashevskii, A.F. Sidarov, A.M. Karpenkov, A.V.Kondrat'ev, and I.A. Bud'ko (1971) Pentlandite variety rich in silver. Zap. Vses. Mineral. Obshch., 100, 184–191 (in Russian). (2) (1973) Mineral. Abs., 24, 71 (abs. ref. 1). (3) Rudashevskii, N.S., G.A. Mintkenov, A.M. Karpenkov, and N.N. Shiskin (1977) Silver-containing pentlandite — the independent mineral species argentopentlandite. Zap. Vses. Mineral. Obshch., 106, 688–691 (in Russian). (4) (1979) Mineral. Abs., 30, 71 (abs. ref. 3). (5) Vuorelainen, Y., T.A. Häkli, and H. Papunen (1972) Argentian pentlandite from some Finnish sulfide deposits. Amer. Mineral., 57, 137–145. (6) Scott, S.D. and E. Gasparini (1973) Argentian pentlandite $(Fe,Ni)_8AgS_8$, from Bird River, Manitoba. Can. Mineral., 12, 165–168. (7) Hall, S.R. and J.M. Stewart (1973) The crystal structure of argentian pentlandite $(Fe,Ni)_8AgS_8$, compared with the refined structure of pentlandite $(Fe,Ni)_9S_8$. Can. Mineral., 12, 169–177. (8) Morales-Ruano, S. and P.F. Hach-alí (1996) Hydrothermal argentopentlandite at El Charcón, southeastern Spain: mineral chemistry and conditions of formation. Can. Mineral., 34, 939–947. (9) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 16.

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Argentopyrite $AgFe_2S_3$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$.
As thick tabular pseudohexagonal prisms, may have rough pyramidal terminations {011}.
Twinning: Pseudohexagonal twins common ‖ [001] by interpenetration of {120}; lamellar twinning is also present.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4
VHN = 225–242 (100 g load). D(meas.) = 4.25 D(calc.) = 4.27

Optical Properties: Opaque. *Color:* Bright gray-white when fresh, commonly tarnished iridescent in greens, blues, yellows, purples, and browns; grayish to yellowish white in reflected light. *Luster:* Metallic. *Anisotropism:* Strong, deep blue to pale blue-gray.
R_1–R_2: (400) 20.5–29.4, (420) 21.6–30.2, (440) 22.7–30.8, (460) 23.8–31.6, (480) 24.6–32.2, (500) 25.3–32.8, (520) 25.8–33.5, (540) 26.3–34.1, (560) 26.8–34.8, (580) 27.4–35.6, (600) 28.1–36.3, (620) 28.7–36.9, (640) 29.4–37.5, (660) 30.0–38.0, (680) 30.4–38.4, (700) 30.9–38.7

Cell Data: *Space Group: Pmmn.* $a = 6.639(4)$ $b = 11.463(6)$ $c = 6.452(3)$ $Z = 4$

X-ray Powder Pattern: Měděnec, Czech Republic.
3.320 (10), 3.316 (9), 1.807 (7), 5.746 (5), 3.104 (5), 1.927 (5), 3.603 (4)

Chemistry:

	(1)	(2)	(3)
Ag	32.89	34.55	34.17
Fe	35.89	35.03	35.37
Cu	0.19	0.17	
As		0.05	
S	30.71	30.15	30.46
Total	99.68	99.95	100.00

(1) St. Andreasberg, Germany. (2) Měděnec, Czech Republic; by electron microprobe, corresponding to $Ag_{1.02}Cu_{0.01}Fe_{2.00}S_{3.00}$. (3) $AgFe_2S_3$.

Polymorphism & Series: Dimorphous with sternbergite.

Occurrence: Rare in silver-bearing hydrothermal veins.

Association: Arsenic, proustite, pyrargyrite, pyrostilpnite, xanthoconite, sternbergite, stephanite, pyrite, nickel-skutterudite, dolomite, calcite, quartz.

Distribution: In the Czech Republic, at Jáchymov (Joachimsthal) [TL], Příbram, and in the Krušné hory Mountains, at Měděnec. From St. Andreasberg, Harz Mountains; Marienberg, Schneeberg, Johanngeorgenstadt, and Freiberg, Saxony; and at the Anton mine, Wieden, Black Forest, Germany. At the Tynebottom mine, Garrigill, near Alston, Cumbria, England. From Broken Hill, New South Wales, Australia. In the Omidani mine, Hyogo Prefecture, Japan. At Colquechaca, Potosí, Bolivia. In the Silvana mine, Sandon, British Columbia, Canada.

Name: For its composition and physical similarity to pyrite.

Type Material: Royal Ontario Museum, Toronto, Canada, M13001.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 248. (2) Murdoch, J. and L.G. Berry (1954) X-ray measurements on argentopyrite. Amer. Mineral., 39, 475–485. (3) Czamanske, G.K. and R.R. Larsen (1969) The chemical identity and formula of argentopyrite and sternbergite. Amer. Mineral., 54, 1198–1201. (4) Šrein, V., T. Řídkošil, P. Kašpar, and J. Šourek (1986) Argentopyrite and sternbergite from polymetallic veins of the skarn deposit Měděnec, Krušné hory Mts., Czechoslovakia. Neues Jahrb. Mineral., Abh., 154, 207–222. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 17.

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Argentotennantite $(Ag, Cu)_{10}(Zn, Fe)_2(As, Sb)_4S_{13}$

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Crystal Data: Cubic. *Point Group:* $[\bar{4}3m]$ (by analogy to tetrahedrite–tennantite). As small grains, to 0.1 mm; and surrounding tennantite.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3.4 VHN = 285–320, 305 average. D(meas.) = n.d. D(calc.) = 5.05

Optical Properties: Opaque. *Color:* Gray-blue; pale gray to greenish gray with a faint bluish tint in polished section. *Streak:* Reddish brown to black. *Luster:* Resinous.
R: (400) 30.9, (420) 30.9, (440) 30.8, (460) 30.7, (480) 30.5, (500) 30.4, (520) 30.4, (540) 30.4, (560) 30.4, (580) 30.3, (600) 29.9, (620) 29.4, (640) 28.8, (660) 28.4, (680) 28.2, (700) 27.8

Cell Data: *Space Group:* $[I\bar{4}3m]$ (by analogy to tetrahedrite–tennantite). $a = 10.584(3)$. Z = [2]

X-ray Powder Pattern: Kvartsitoviye Gorki deposit, Kazakhstan.
3.06 (100), 1.869 (80), 1.595 (40), 2.65 (30), 2.073 (20), 1.230 (20), 1.214 (20)

Chemistry:

	(1)	(2)
Ag	33.54	22.5
Cu	15.60	22.6
Fe	1.13	2.83
Zn	5.44	4.22
Pb	0.18	
Cd	0.10	
Sb	12.59	14.7
As	8.80	9.1
S	22.66	22.9
Total	100.04	99.85

(1) Kvartsitoviye Gorki deposit, Kazakhstan; by electron microprobe, corresponding to $(Ag_{5.67}Cu_{4.48})_{\Sigma=10.15}(Zn_{1.52}Fe_{0.37}Pb_{0.01}Cd_{0.01})_{\Sigma=1.91}(As_{2.14}Sb_{1.89})_{\Sigma=4.03}S_{12.90}$.
(2) Silvermines, Ireland; by electron microprobe, corresponding to $(Cu_{6.32}Ag_{3.70})_{\Sigma=10.02}(Zn_{1.15}Fe_{0.90})_{\Sigma=2.05}(As_{2.15}Sb_{2.13})_{\Sigma=4.28}S_{12.66}$.

Polymorphism & Series: Forms a series with freibergite.

Mineral Group: Tetrahedrite group.

Occurrence: In a polymetallic deposit (Kvartsitoviye Gorki deposit, Kazakhstan); in a stratiform Pb–Zn orebody (Silvermines, Ireland).

Association: Tennantite–tetrahedrite, freibergite, stibnite, mercurian gold, pyrite, galena, siderite, ankerite, quartz (Kvartsitoviye Gorki deposit, Kazakhstan); geocronite, proustite–pyrargyrite, galena (Silvermines, Ireland).

Distribution: In the Kvartsitovye Gorki [Quartzite Hills] deposit, Akmola district, northern Kazakhstan [TL]. At Silvermines, Co. Tipperary, Ireland.

Name: For the chemical composition and by analogy to tennantite.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84396.

References: (1) Spiridonov, E.M., N.F. Sokolova, A.K. Gapeev, D.M. Dashevskaya, T.L. Evstigneeva, T.N. Chvileva, V.G. Demidov, E.P. Balashov, and V.I. Shul'ga (1986) A new mineral — argentotennantite. Doklady Acad. Nauk SSSR, 290, 206–210 (in Russian). (2) (1988) Amer. Mineral., 73, 439 (abs. ref. 1). (3) Zakrzewski, M.A. (1989) Mmbers of the freibergite-argentotennantite series and associated minerals from Silvermines, County Tipperary, Ireland. Mineral. Mag., 53, 293–298.

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Argutite GeO_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$ (synthetic). As subhedral crystals, to 20 μm, showing {111}, {100}, and {101}, included in sphalerite. *Twinning:* Occasionally twinned on {101}.

Physical Properties: Hardness = [6–7] (about the same as associated cassiterite). D(meas.) = n.d. D(calc.) = [6.28]

Optical Properties: Semitransparent. *Color:* Light gray in reflected light. *Optical Class:* Uniaxial. *Anisotropism:* Distinct.
R: (400) 14.8, (420) 13.7, (440) 12.6, (460) 11.6, (480) 11.2, (500) 11.0, (520) 11.0, (540) 11.0, (560) 11.0, (580) 10.9, (600) 10.9, (620) 10.9, (640) 10.9, (660) 10.9, (680) 11.0, (700) 11.0

Cell Data: *Space Group:* $P4_2/mmm$ (synthetic). $a = 4.3975(7)$ $c = 2.8625(8)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.11 (100), 2.399 (60), 1.620 (50), 1.3045 (20), 1.5546 (18), 1.3004 (18), 2.199 (16)

Chemistry:

	(1)
GeO_2	95.82
MnO_2	0.17
FeO	1.20
ZnO	3.03
Total	100.22

(1) Argut deposit, France; by electron microprobe, average of seven analyses; corresponds to $(Ge_{0.94}Zn_{0.04}Fe_{0.02})_{\Sigma=1.00}O_{1.94}$.

Mineral Group: Rutile group.

Occurrence: In a zinc deposit formed in metamorphosed lower Paleozoic sediments.

Association: Sphalerite, cassiterite, siderite, briartite.

Distribution: From the Argut deposit, central Pyrénées, Haute-Garonne, France.

Name: For the occurrence in the Argut deposit, France.

Type Material: n.d.

References: (1) Johan, Z., E. Oudin, and P. Picot (1983) Analogues germanifères et gallifères des silicates et oxydes dans les gisements de zinc des Pyrénées centrales, France; argutite et carboirite, deux nouvelles espèces minérales. Tschermaks Mineral. Petrog. Mitt., 31, 97–119 (in French with English abs.). (2) (1984) Amer. Mineral., 69, 406 (abs. ref. 1). (3) Yamanaka, T. and K. Ogata (1991) Structure refinement of GeO_2 polymorphs at high pressures and temperatures by energy-dispersive spectra of powder diffraction. J. Appl. Cryst., 24, 111–118. (4) (1958) NBS Mono. 25, 8, 28.

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Argyrodite Ag_8GeS_6

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $mm2$. Pseudo-octahedra, dodecahedra, cubes, or as combinations of these forms, in crystals as large as 18 cm. Also radiating crystal aggregates, botryoidal crusts, or massive. *Twinning:* Pseudospinel law {111}; repeated interpenetration twins of pseudododecahedra on {111}.

Physical Properties: *Fracture:* Uneven to slightly conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = n.d. D(meas.) = 6.29 D(calc.) = 6.32

Optical Properties: Opaque. *Color:* Steel-gray with a red tint, tarnishes black; in polished section, gray-white with a violet tint. *Streak:* Gray-black. *Luster:* Strong metallic. *Pleochroism:* Very weak. *Anisotropism:* Weak.
R_1–R_2: (400) 28.9–29.5, (420) 27.9–28.5, (440) 27.1–27.7, (460) 26.3–26.9, (480) 25.8–26.3, (500) 25.3–25.8, (520) 25.0–25.4, (540) 24.7–25.2, (560) 24.6–25.0, (580) 24.5–24.9, (600) 24.4–24.9, (620) 24.5–24.8, (640) 24.6–24.9, (660) 24.5–24.9, (680) 24.6–25.0, (700) 24.7–25.0

Cell Data: *Space Group:* $Pna2_1$. $a = 15.149(1)$ $b = 7.476(2)$ $c = 10.589(1)$ $Z = 4$

X-ray Powder Pattern: Machacamarca, Bolivia.
3.02 (100), 1.863 (50), 2.66 (40), 3.14 (30), 2.44 (30), 2.03 (30), 1.784 (20)

Chemistry:

	(1)	(2)	(3)
Ag	75.78	74.20	76.51
Fe		0.68	
Ge	3.65	4.99	6.44
Sn	3.60	3.36	
Sb	trace	trace	
S	16.92	16.45	17.05
Total	99.95	99.68	100.00

(1) Chocaya, Bolivia. (2) Aullagas, Bolivia. (3) Ag_8GeS_6.

Polymorphism & Series: Forms a series with canfieldite.

Occurrence: In low-temperature polymetallic deposits with silver sulfosalts (Freiberg, Germany); in high-temperature Sn–Ag deposits (Bolivia).

Association: Canfieldite, stephanite, acanthite, pyrargyrite, polybasite, aramayoite, diaphorite, marcasite, pyrite, galena, sphalerite, cassiterite, siderite.

Distribution: In Germany, in Saxony, from the Himmelsfürst [TL] and other mines, Erbisdorf, near Freiberg. In the Fournial mine, Massiac region, Cantal, France. At the Vale das Gatas tungsten mine, near Vila Real, northern Portugal. From Silvermines, Co. Tipperary, Ireland. At a number of localities in Bolivia, including Aullagas, Colquechaca, Potosí, Oruro, Porco, Chocaya, and Machacamarca. At the Dolly Varden mine, Alice Arm, British Columbia, Canada. From Rico, Dolores Co., Colorado, USA. In the Wolyu mine, Youngdong district, South Korea. From Shuiji, Fujian Province, and in the Baiguoyuan deposit, Hubei Province, China.

Name: From the Greek for *silver-containing*.

Type Material: Mining Academy, Freiberg, Germany, 7058.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 356–358. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 122. (3) Eulenberger, G. (1977) Die Kristallstruktur der Tieftemperaturmodifikation von Ag_8GeS_6 — Synthetischer Argyrodite. Monatshefte für Chem., 108, 901–913 (in German with English abs.). (4) Wang, N. (1978) New data for Ag_8SnS_6 (canfieldite) and Ag_8GeS_6 (argyrodite). Neues Jahrb. Mineral., Monatsh., 269–272. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 19.

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Arhbarite $Cu_2(AsO_4)(OH)\cdot 6H_2O$

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Crystal Data: n.d. *Point Group:* n.d. As needlelike individual crystals, in spherulitic or disklike aggregates, to 0.5 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark blue. *Streak:* Sky-blue.
Luster: Vitreous.
Optical Class: Biaxial. *Pleochroism:* X' = turquoise-blue; Z' = deep turquoise-blue.
Orientation: Extinction ∼45° to elongation. $\alpha = 1.720(5) \parallel$ length. β = n.d. $\gamma = 1.740(5) \perp$ length. 2V(meas.) = ∼90°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Arhbar mine, Morocco.
4.57 (100), 4.51 (90), 3.72 (60), 2.603 (50), 2.474 (50), 3.25 (40), 2.891 (40)

Chemistry:

	(1)	(2)
As_2O_5	29.19	29.38
FeO	0.04	
CoO	0.03	
CuO	41.00	40.68
ZnO	0.01	
H_2O	[29.73]	29.94
Total	[100.00]	100.00

(1) Arhbar mine, Morocco; by electron microprobe, average of three analyses, H_2O by difference.
(2) $Cu_2(AsO_4)(OH)\cdot 6H_2O$.

Occurrence: A rare secondary mineral in polymetallic hydrothermal ore deposits.

Association: Dolomite, hematite, löllingite, pharmacolite, erythrite, talc, mcguinnessite (Arhbar mine, Morocco); chrysocolla, brochantite, olivenite, iodargyrite, dolomite (Emma Louisa mine, Chile).

Distribution: From the Arhbar mine, Bou Azzer district, Morocco. In the [Emma Luisa gold mine,] Guanaco district, about 100 km east-northeast of Taltal, Antofagasta, Chile.

Name: For the Arhbar (Aghbar) mine, Morocco, in which the mineral was first found to occur.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160383.

References: (1) Schmetzer, K., G. Tremmel, and O. Medenbach (1982) Arhbarit, $Cu_2[OH|AsO_4]\cdot 6H_2O$, ein neues Mineral von Bou-Azzer, Marokko. Neues Jahrb. Mineral., Monatsh., 529–533 (in German with English abs.). (2) (1983) Amer. Mineral., 68, 1038 (abs. ref. 1).

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Aristarainite $Na_2MgB_{12}O_{16}(OH)_8 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular {100} or elongated [010] crystals, to 0.4 mm, comprised of {100}, {001}, {110}, {210}, and several less common forms. As rosettelike aggregates and efflorescent crusts.

Physical Properties: *Cleavage:* {001} and {100}, perfect; {110}, fair. *Fracture:* Splintery ∥ [010]. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.027(5) D(calc.) = 2.005 Moderate cream-white fluorescence under SW UV; weak phosphorescence.

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = -38°$; $Z \wedge a = 46°$. *Dispersion:* $r > v$, weak. $\alpha = 1.484(1)$ $\beta = 1.498(1)$ $\gamma = 1.523(1)$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P2_1/a$. $a = 18.886(4)$ $b = 7.521(2)$ $c = 7.815(1)$ $\beta = 97.72(1)°$ Z = 2

X-ray Powder Pattern: Tincalayu deposit, Argentina.
7.74 (100), 2.579 (19), 3.037 (13), 3.869 (12), 5.40 (11), 2.400 (10), 3.782 (9)

Chemistry:

	(1)	(2)
B_2O_3	59.5	62.90
MgO	5.65	6.07
Na_2O	7.3	9.33
K_2O	1.05	
H_2O	25.7	21.70
insol.	0.5	
Total	99.7	100.00

(1) Tincalayu deposit, Argentina; with $(OH)^{1-}$ calculated for charge balance, corresponds to $(Na_{1.65}K_{0.16})_{\Sigma=1.81}Mg_{0.98}B_{12.00}O_{16.00}(OH)_{7.76} \cdot 6.14H_2O$. (2) $Na_2MgB_{12}O_{16}(OH)_8 \cdot 4H_2O$.

Occurrence: In a playa evaporite sequence (Tincalayu deposit, Argentina); at a desert borax spring (Eagle Borax Spring, California, USA).

Association: Borax, kernite, rivadavite, ezcurrite, ameghinite, mcallisterite, kurnakovite, searlesite, probertite, ginorite, tincalconite, ulexite, halite, magnesite (Tincalayu deposit, Argentina); thénardite, blödite, mcallisterite, santite, hexahydrite, halite, gypsum (Eagle Borax Spring, California, USA).

Distribution: From the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. In the USA, on the South Meridian claim and at Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., California.

Name: Honors Professor Lorenzo Francisco Aristarain (1926–), Argentine mineralogist specializing in borate deposits, La Plata University, Buenos Aires, Argentina.

Type Material: Natural History Museum, Paris, France; Harvard University, Cambridge, Massachusetts, 109679; National Museum of Natural History, Washington, D.C., USA, 136046, 137296.

References: (1) Hurlbut, Jr., C.S. and R.C. Erd (1974) Aristarainite, $Na_2O \cdot MgO \cdot 6B_2O_3 \cdot 10H_2O$, a new mineral from Salta, Argentina. Amer. Mineral., 59, 647–651. (2) Ghose, S. and Che'ng Wan (1977) Aristarainite: $Na_2Mg[B_6O_8(OH)_4]_2 \cdot 4H_2O$: a sheet structure with chains of hexaborate polyanions. Amer. Mineral., 62, 979–989.

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Armalcolite $(Mg, Fe^{2+})Ti_2O_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As subhedral to anhedral grains, to 300 μm.

Physical Properties: Hardness = [< 5] (less than ilmenite). D(meas.) = 4.94 D(calc.) = 4.64

Optical Properties: Opaque. *Color:* Gray to tan in reflected light. *Luster:* Metallic. *Optical Class:* Biaxial. *Pleochroism:* Observed. *Anisotropism:* Strong; pale gray to dark bluish-gray.
R_1–R_2: (450) 14.1–15.2, (470) 14.0–15.0, (500) 13.8–14.7, (520) 13.7–14.5, (546) 13.4–14.4, (586) 13.3–14.3, (620) 13.2–14.2, (640) 13.0–14.1

Cell Data: *Space Group: Bbmm.* a = 9.743(30) b = 10.023(20) c = 3.738(30) Z = 2

X-ray Powder Pattern: Tranquillity Base, Moon.
3.468 (100), 1.958 (80), 2.763 (25), 2.454 (25), 2.235 (15), 2.199 (15), 2.414 (10)

Chemistry:

	(1)	(2)		(1)	(2)
TiO_2	72.0	76.2	FeO	14.7	10.7
Al_2O_3	1.48	1.65	MnO	0.07	0.83
V_2O_5	0.07		MgO	8.7	9.4
Cr_2O_3	1.94	0.34	CaO	0.32	0.1
			Total	99.28	99.2

(1) Tranquillity Base, Moon; by electron microprobe, total Fe as FeO; corresponds to $(Mg_{0.46}Fe^{2+}_{0.44}Al_{0.06}Cr_{0.06}Ca_{0.01})_{\Sigma=1.03}Ti_{1.92}O_5$. (2) Disko Island, Greenland; by electron microprobe, total Fe as FeO; corresponds to $(Mg_{0.49}Fe^{2+}_{0.32}Al_{0.07}Mn_{0.02}Cr_{0.01})_{\Sigma=0.91}Ti_{2.02}O_5$.

Occurrence: Formed typically at low pressures and high temperatures; in Ti-rich basalts and microbreccias of lunar samples; in salic volcanics; rarely in granite pegmatite; in ultramafic rocks, lamproites, kimberlites; in terrestrial impact craters; in inclusions in a carbonaceous chondrite.

Association: Ilmenite, Fe–Ti oxides, iron, graphite (Disko Island, Greenland); phlogopite, analcime, diopside (Smoky Butte, Montana, USA); rutile, ilmenite (Kimberley, South Africa).

Distribution: From Mare Tranquillitatis at Tranquillity Base; the Taurus-Littrow site; and the Descartes site, Moon. In the Knippa quarry, near Uvalde, Uvalde Co., Texas, and at Smoky Butte, near Jordan, Garfield Co., Montana, USA. From the El Toro cinder cone, near San Luis Potosí, Mexico. In the Nördlinger Reis crater, Bavaria, Germany. From Jumilla, Murcia Province, and Cancarix, Albacete Province, Spain. On Disko Island, Greenland. From the Jagersfontein, Bultfontein, and Dutoitspan diamond mines, Kimberley, Transvaal, South Africa. In the Mwenezi area, Zimbabwe. From several undefined localities in Russia, and elsewhere.

Name: An acronym derived from the last names of Neil Alden ARMstrong (1930–), Edwin Eugene ALdrin (1930–), and Michael COLlins (1930–), the Apollo XI astronauts who collected the type samples.

Type Material: Lunar Science Institute, Houston, Texas, USA.

References: (1) Anderson, A.T., T.E. Bunch, E.N. Cameron, S.E. Haggerty, F.R. Boyd, L.W. Finger, O.B. James, K. Keil, M. Prinz, P. Ramdohr, and A. El Goresy (1970) Armalcolite: a new mineral from the Apollo 11 samples. Geochim. Cosmochim. Acta, 34, Supp. 1, 55–63. (2) (1970) Amer. Mineral., 55, 2136 (abs. ref. 1). (3) Pedersen, A.K. (1981) Armalcolite-bearing Fe–Ti oxide assemblages in graphite-equilibrated salic volcanic rocks with native iron from Disko, central west Greenland. Contr. Mineral. Petrol., 77, 307–324. (4) Bowles, J.F.W. (1988) Definition and range of composition of naturally occurring minerals with the pseudobrookite structure. Amer. Mineral., 73, 1377–1383. (5) Hayob, J.L. and E.J. Essene (1995) Armalcolite in crustal paragneiss xenoliths, central Mexico. Amer. Mineral., 80, 810–822.

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Armangite $Mn^{2+}_{26}As^{3+}_{18}O_{50}(CO_3)(OH)_4$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As tiny short hexagonal prisms, terminated by a trigonal pyramid. *Twinning:* On $\{11\overline{2}0\}$.

Physical Properties: *Cleavage:* {0001}, fair to poor. Hardness = ∼4 D(meas.) = [4.43] (calculated from material with 12% admixed carbonate). D(calc.) = 4.406

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black to pale brown; yellow to brown in transmitted light. *Streak:* Brown.
Optical Class: Uniaxial (–). $\omega = 2.01$ $\epsilon = 1.99$

Cell Data: *Space Group:* $P\overline{3}$. $a = 13.491(2)$ $c = 8.855(1)$ $Z = 1$

X-ray Powder Pattern: Långban, Sweden. (ICDD 19-780).
2.762 (100), 2.94 (70), 2.428 (70), 1.759 (60), 3.92 (50), 1.676 (50), 1.459 (50)

Chemistry:

	(1)	(2)	(3)
As_2O_3	42.92	48.82	48.06
Sb_2O_3	0.40	0.46	
FeO	2.19	2.49	
MnO	45.06	47.06	49.78
PbO	0.32	0.36	
MgO	0.49		
CaO	2.83		
H_2O	0.71	0.81	0.97
CO_2	5.08		1.19
insol.	0.20		
Total	100.20	[100.00]	100.00

(1) Långban, Sweden; average of three analyses. (2) Do.; recalculated to 100% after deduction of insoluble and $(Ca, Mn, Mg)CO_3$ 3.69%; essential CO_3 however was found by crystal-structure analysis and confirmed qualitatively by electron microprobe. (3) $Mn_{26}As_{18}O_{50}(CO_3)(OH)_4$.

Occurrence: On a museum specimen collected from a metamorphosed Fe–Mn deposit.

Association: Calcite, dolomite, barite, hematite, fluorite, manganarsite, hausmannite.

Distribution: From Långban, Värmland, Sweden.

Name: For ARsenic and MANGanese in the composition.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, Flink U71; National Museum of Natural History, Washington, D.C., USA, R5795.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1031–1032. (2) Moore, P.B. and T. Araki (1979) Armangite, $Mn^{2+}_{26}[As^{3+}_6(OH)_4O_{14}][As^{3+}_6O_{18}]_2[CO_3]$, a fluorite derivative structure. Amer. Mineral., 64, 748–757.

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Armenite $BaCa_2Al_6Si_9O_{30}\cdot 2H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$. Sheaves of prismatic crystals, with individuals to 2.5 cm. *Twinning:* Complex, showing sectored triplets; may be lamellar.

Physical Properties: *Cleavage:* Perfect prismatic, one pinacoidal distinct; partings along sector boundaries. Hardness = 7–8 D(meas.) = 2.74–2.76 D(calc.) = 2.787

Optical Properties: Translucent. *Color:* Colorless, fawn, greyish green. *Luster:* Vitreous. *Optical Class:* Biaxial (–), with uniaxial (–) domains. *Orientation:* $X = c$; $Z = b$. $\alpha = 1.550$–1.551 $\beta = 1.557$–1.559 $\gamma = 1.559$–1.562 2V(meas.) = 60°–65° 2V(calc.) = 57.8°

Cell Data: *Space Group: Pnna.* $a = 13.874(2)$ $b = 18.660(2)$ $c = 10.698(1)$ Z = 4

X-ray Powder Pattern: Kongsberg, Norway. (ICDD 20-112).
3.86 (100), 3.41 (90), 2.91 (90), 6.94 (80), 2.78 (80), 4.25 (65), 9.31 (55)

Chemistry:

	(1)	(2)	(3)
SiO_2	46.18	47.6	47.10
Al_2O_3	27.52	27.0	26.64
CaO	9.99	9.50	9.77
SrO	0.04	0.62	
BaO	12.37	12.05	13.35
Na_2O	0.16	0.36	
K_2O	0.13	0.15	
H_2O^+	3.41		
H_2O^-	0.11		
H_2O		2.90	3.14
CO_2		0.31	
Total	99.91	100.49	100.00

(1) Kongsberg, Norway. (2) Rémigny, Canada; by electron microprobe; average of 38 analyses on six samples; corresponds to $(Ba_{0.89}Na_{0.10}K_{0.04})_{\Sigma=1.03}(Ca_{1.92}Sr_{0.07}Na_{0.03})_{\Sigma=2.02}$ $Al_{3.02}(Al_3Si_9O_{30})\cdot 2[(H_2O)_{0.91}(CO_2)_{0.04}]$. (3) $BaCa_2Al_6Si_9O_{30}\cdot 2H_2O$.

Mineral Group: Milarite group (?).

Occurrence: In calcite veins (Kongsberg, Norway); in manganese-metasomatized diorite included in later granodiorite (Rémigny, Canada).

Association: Axinite, pyrrhotite, quartz (Kongsberg, Norway); albite, manganiferous zoisite, piemontite, prehnite, epidote, muscovite (Rémigny, Canada); celsian, bytownite (Broken Hill, Australia).

Distribution: From the Armen mine, near Kongsberg, Norway. In the Su Zurfuru mine, Fluminese, Sardinia, Italy. Large crystals from the Wasenalp, near Simplon, Valais, Switzerland. At Coire Loch Kander, 11 km south-southeast of Braemar, Scotland. From Chvaletice, Czech Republic. At Rémigny, Quebec, Canada. From 16 km northeast of North Bend, King Co., Washington, USA. At Broken Hill and Pernamoota, 30 km north of Broken Hill, New South Wales, Australia.

Name: For the Armen mine, Kongsberg, Norway.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1947,290.

References: (1) Neumann, H. (1939) Armenite, a new mineral. Preliminary note. Norsk. Geol. Tidsskr., 19, 312–313. (2) (1941) Amer. Mineral., 26, 235 (abs. ref. 1). (3) Puoliot, G., P. Trudel, G. Valiquette, and P. Samson (1984) Armenite-thulite-albite veins at Rémigny, Quebec: the second occurrence of armenite. Can. Mineral., 22, 453–464. (4) Armbruster, T. and M. Czank (1992) H_2O ordering and superstructures in armenite, $BaCa_2Al_6Si_9O_{30}\cdot 2H_2O$: a single-crystal X-ray and TEM study. Amer. Mineral., 77, 422–430.

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Armstrongite $CaZrSi_6O_{15}\cdot 2.5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As crystals, to 2 cm, and aggregates. *Twinning:* Polysynthetic, by rotation about [100].

Physical Properties: *Cleavage:* Perfect on {001}, good on {100}. *Tenacity:* Very brittle. Hardness = 4.6 VHN = 310–330 D(meas.) = 2.562–2.593 D(calc.) = 2.71

Optical Properties: Semitransparent. *Color:* Dark to pale brown. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 5°$–$7°$. *Dispersion:* $r < v$. $\alpha = 1.563$ $\beta = 1.569$ $\gamma = 1.573$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 14.04$ $b = 14.16$ $c = 7.81$ $\beta = 109°33'$ Z = 4

X-ray Powder Pattern: Khan-Bogdinskii massif, Mongolia.
4.26 (100), 3.05 (100), 6.60 (90), 3.80 (90), 7.05 (50), 2.995 (50), 1.947 (50)

Chemistry:

	(1)	(2)
SiO_2	60.12	61.64
TiO_2	0.12	
ZrO_2	19.80	21.07
Al_2O_3	0.60	
$(Y,RE)_2O_3$	0.55	
Fe_2O_3	1.31	
MgO	0.19	
CaO	9.15	9.59
Na_2O	0.18	
K_2O	0.14	
H_2O	7.90	7.70
P_2O_5	0.20	
Total	100.26	100.00

(1) Khan-Bogdinskii massif, Mongolia. (2) $CaZrSi_6O_{15}\cdot 2.5H_2O$.

Occurrence: In schlieren of alkalic granite pegmatite, at the contact of arfvedsonite granite with xenoliths of felsic volcanic rocks.

Association: Quartz, microcline, albite, aegirine, arfvedsonite, monazite, synchesite, titanite, other titanosilicates.

Distribution: In the Khan-Bogdinskii granitic massif, Gobi, Mongolia. In the Strange Lake complex, southeast of Lac Brisson, Quebec and Labrador, Newfoundland, Canada.

Name: Honoring Neil Alden Armstrong (1930–), American astronaut, first man to walk on the Moon.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Vladykin, N.V., V.I. Kovalenko, A.A. Kashaev, A.N. Sapozhnikov, and V.A. Pisarskaya (1973) A new mineral of calcium and zirconium, armstrongite. Doklady Acad. Nauk SSSR, 209, 1185–1188 (in Russian). (2) (1974) Amer. Mineral., 59, 208 (abs. ref. 1). (3) Kashaev, A.A. and A.N. Sapozhnikov (1978) Crystal structure of armstrongite. Kristallografiya (Sov. Phys. Crystal.), 23, 956–961 (in Russian).

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Arrojadite $\mathbf{KNa_4Ca(Fe^{2+},Mn^{2+})_{14}Al(PO_4)_{12}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As cleavable masses, to 15 cm.

Physical Properties: *Cleavage:* On {100}, good; on {102}, poor. *Fracture:* Uneven to subconchoidal. Hardness = 5 D(meas.) = 3.527 D(calc.) = 3.586

Optical Properties: Translucent. *Color:* Dark green, bottle-green, yellowish green. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = colorless to pale green; Z = pale yellow-green. *Orientation:* $X = b$; $Y \wedge c = 18°$–$21.5°$. *Dispersion:* $r < v$, strong.
$\alpha = 1.662$–1.664 $\beta = 1.668$–1.670 $\gamma = 1.672$–1.675 2V(meas.) = 80°–86°

Cell Data: *Space Group:* $A2/a$. $a = 24.692(4)$ $b = 10.031(2)$ $c = 16.453(2)$ $\beta = 105.72(9)°$ Z = 4

X-ray Powder Pattern: South Dakota, USA; close to dickinsonite. (ICDD 34-149).
3.042 (100), 2.714 (85), 3.222 (45), 2.774 (30), 2.852 (25), 2.751 (25), 2.550 (25)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	40.00	39.67	Na_2O	6.40	5.77
Al_2O_3	2.66	2.37	K_2O	1.74	2.19
FeO	28.22	23.42	F	0.80	
MnO	15.78	23.13	H_2O	0.91	0.84
MgO	1.04		$-O = F_2$	0.34	
CaO	2.46	2.61	insol.	0.11	
Li_2O	0.09		Total	99.87	100.00

(1) Nickel Plate mine, South Dakota, USA. (2) $KNa_4Ca(Fe,Mn)_{14}Al(PO_4)_{12}(OH)_2$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with dickinsonite.

Occurrence: A high-temperature (≈ 800 °C) primary mineral in granite pegmatites.

Association: Graftonite, cassiterite, spodumene, beryl, muscovite (Nickel Plate mine, South Dakota, USA).

Distribution: In Brazil, from the Serra Branca pegmatite, 13 km south of Pedra Lavrada, Picuí, Paraíba; in the Énio pegmatite mine, northeast of Galiléia, and the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais. In the USA, in New Hampshire, from the G.E. Smith mine, Newport, Sullivan Co., and at the Rice, Nancy #2, and Palermo #1 mines, near North Groton, Grafton Co.; in South Dakota, from the Nickel Plate and White Cap mines, near Keystone, Pennington Co., and in the Victory mine, four km northeast of Custer, Custer Co. From the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In the Mangualde pegmatite, near Mesquitela, Portugal. From Glenbuchat, Aberdeenshire, Scotland. In the Norrö pegmatite, on Rånö Island, Sweden. At Sidi-Bou-Kritcha, Morocco. In Zimbabwe, from Ruwanzi Ranch, Karoi East, Miami, and on the Star Twin, Pearl and Chiwya claims, Urungwe district. In the Buranga pegmatite, near Gatumba, Rwanda.

Name: To honor Miguel Arrojado Ribeiro Lisbôa (1872–1932), Brazilian geologist.

Type Material: The Natural History Museum, London, England, 1927,1145; National Museum of Natural History, Washington, D.C., USA, 105948, 105949.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 679–681. (2) Moore, P.B., T. Araki, S. Merlino, M. Mellini, and P.F. Zanazzi (1981) The arrojadite-dickinsonite series, $KNa_4Ca(Fe,Mn)^{2+}_{14}Al(OH)_2(PO_4)_{12}$: crystal structure and crystal chemistry. Amer. Mineral., 66, 1034–1049. (3) Merlino, S., M. Mellini, and P.F. Zanazzi (1981) Structure of arrojadite, $KNa_4CaMn_4Fe_{10}Al(PO_4)_{12}(OH,F)_2$. Acta Cryst., 37, 1733–1736.

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Arrojadite $\mathbf{KNa_4Ca(Fe^{2+},Mn^{2+})_{14}Al(PO_4)_{12}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As cleavable masses, to 15 cm.

Physical Properties: *Cleavage:* On {100}, good; on {102}, poor. *Fracture:* Uneven to subconchoidal. Hardness = 5 D(meas.) = 3.527 D(calc.) = 3.586

Optical Properties: Translucent. *Color:* Dark green, bottle-green, yellowish green. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = colorless to pale green; Z = pale yellow-green. *Orientation:* $X = b$; $Y \wedge c = 18°$–$21.5°$. *Dispersion:* $r < v$, strong.
$\alpha = 1.662$–1.664 $\beta = 1.668$–1.670 $\gamma = 1.672$–1.675 2V(meas.) = 80°–86°

Cell Data: *Space Group:* $A2/a$. $a = 24.692(4)$ $b = 10.031(2)$ $c = 16.453(2)$ $\beta = 105.72(9)°$ Z = 4

X-ray Powder Pattern: South Dakota, USA; close to dickinsonite. (ICDD 34-149).
3.042 (100), 2.714 (85), 3.222 (45), 2.774 (30), 2.852 (25), 2.751 (25), 2.550 (25)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	40.00	39.67	Na_2O	6.40	5.77
Al_2O_3	2.66	2.37	K_2O	1.74	2.19
FeO	28.22	23.42	F	0.80	
MnO	15.78	23.13	H_2O	0.91	0.84
MgO	1.04		$-O = F_2$	0.34	
CaO	2.46	2.61	insol.	0.11	
Li_2O	0.09		Total	99.87	100.00

(1) Nickel Plate mine, South Dakota, USA. (2) $KNa_4Ca(Fe,Mn)_{14}Al(PO_4)_{12}(OH)_2$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with dickinsonite.

Occurrence: A high-temperature (≈ 800 °C) primary mineral in granite pegmatites.

Association: Graftonite, cassiterite, spodumene, beryl, muscovite (Nickel Plate mine, South Dakota, USA).

Distribution: In Brazil, from the Serra Branca pegmatite, 13 km south of Pedra Lavrada, Picuí, Paraíba; in the Énio pegmatite mine, northeast of Galiléia, and the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais. In the USA, in New Hampshire, from the G.E. Smith mine, Newport, Sullivan Co., and at the Rice, Nancy #2, and Palermo #1 mines, near North Groton, Grafton Co.; in South Dakota, from the Nickel Plate and White Cap mines, near Keystone, Pennington Co., and in the Victory mine, four km northeast of Custer, Custer Co. From the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In the Mangualde pegmatite, near Mesquitela, Portugal. From Glenbuchat, Aberdeenshire, Scotland. In the Norrö pegmatite, on Rånö Island, Sweden. At Sidi-Bou-Kritcha, Morocco. In Zimbabwe, from Ruwanzi Ranch, Karoi East, Miami, and on the Star Twin, Pearl and Chiwya claims, Urungwe district. In the Buranga pegmatite, near Gatumba, Rwanda.

Name: To honor Miguel Arrojado Ribeiro Lisbôa (1872–1932), Brazilian geologist.

Type Material: The Natural History Museum, London, England, 1927,1145; National Museum of Natural History, Washington, D.C., USA, 105948, 105949.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 679–681. (2) Moore, P.B., T. Araki, S. Merlino, M. Mellini, and P.F. Zanazzi (1981) The arrojadite-dickinsonite series, $KNa_4Ca(Fe,Mn)^{2+}_{14}Al(OH)_2(PO_4)_{12}$: crystal structure and crystal chemistry. Amer. Mineral., 66, 1034–1049. (3) Merlino, S., M. Mellini, and P.F. Zanazzi (1981) Structure of arrojadite, $KNa_4CaMn_4Fe_{10}Al(PO_4)_{12}(OH,F)_2$. Acta Cryst., 37, 1733–1736.

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Arsenbrackebuschite $Pb_2(Fe^{3+}, Zn)(AsO_4)_2(OH, H_2O)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tiny flat plates or laths, to 0.5 mm; also very fine-grained, massive. *Twinning:* Complex, observed.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 4–5 D(meas.) = n.d. D(calc.) = 6.54

Optical Properties: Semitransparent. *Color:* Honey-yellow, yellow, brown, green. *Streak:* Pale brownish. *Luster:* Resinous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Honey-yellow to bright yellow. n = 2.0–2.1

Cell Data: *Space Group:* $P2_1/m$. $a = 7.763(1)$ $b = 6.046(1)$ $c = 9.022(1)$ $\beta = 112.5(1)^\circ$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.012 (100d), 3.268 (90), 2.777 (60), 2.313 (30), 2.133 (30), 4.92 (25), 3.68 (25)

Chemistry:

	(1)
P_2O_5	0.17
As_2O_5	30.5
Fe_2O_3	6.5
FeO	
ZnO	3.1
PbO	59.4
H_2O	n.d.
Total	99.67

(1) Tsumeb, Namibia; by electron microprobe, total Fe as Fe_2O_3.

Mineral Group: Brackebuschite group.

Occurrence: In fissures in dolomite breccia in the oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia); in a hydrothermal polymetallic barite–fluorite deposit (Clara mine, Germany).

Association: Beudantite, anglesite, mimetite, bayldonite, stolzite (Clara mine, Germany).

Distribution: From Tsumeb, Namibia. In the Clara mine, near Oberwolfach, Black Forest, Germany. From Brixlegg, Tirol, Austria. At the Hornet mine, Hachita, Grant Co., New Mexico, USA.

Name: As the arsenate analog of *brackebuschite*.

Type Material: Institute for Geosciences, University of Mainz, Mainz; Institute for Mineralogy and Crystallography, University of Stuttgart, Stuttgart, Germany.

References: (1) Abraham, K., K. Kautz, E. Tillmanns, and K. Walenta (1978) Arsenbrackebuschite, $Pb_2(Fe, Zn)(OH, H_2O)[AsO_4]_2$, a new arsenate mineral. Neues Jahrb. Mineral., Monatsh., 193–196. (2) Hofmeister, W. and E. Tillmanns (1976) Strukturelle Beziehungen zwischen Arsenbrackebuschit und Tsumcorit. Fortschr. Mineral., 54, 38 (in German). (3) (1978) Amer. Mineral., 63, 1282 (abs. refs. 1 and 2). (4) Hofmeister, W. and E. Tillmanns (1978) Strukturelle Untersuchungen an Arsenbrackebuschit. Tschermaks Mineral. Petrog. Mitt., 25, 153–163 (in German with English abs.).

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Arsendescloizite $PbZn(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. As roselike aggregates of tabular {001} crystals, to 0.5 mm, with forms {001}, {011}, {101}, and {111}; may be mammillary.

Physical Properties: Hardness = 4–5 D(meas.) = 5.67 D(calc.) = 6.57

Optical Properties: Transparent. *Color:* Pale yellow to pale green. *Streak:* White. *Luster:* Subadamantine.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.990(5)$ $\beta = 2.030(5)$ $\gamma = 2.035(5)$ 2V(meas.) = 30(5)°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 6.075(2)$ $b = 9.358(2)$ $c = 7.634(2)$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
3.23 (10), 2.88 (10), 2.60 (8), 1.559 (8), 4.23 (6), 2.09 (6), 1.656 (6)

Chemistry:

	(1)	(2)	(3)
As_2O_5	26.5	28.11	26.82
FeO	0.3		
CuO		1.76	
ZnO	18.5	19.00	18.99
PbO	52.3	43.45	52.09
CaO		5.11	
H_2O	2.9	2.58	2.10
Total	100.5	100.01	100.00

(1) Tsumeb, Namibia; by electron microprobe, H_2O by TGA; corresponding to $Pb_{1.06}(Zn_{1.03}Fe_{0.02})_{\Sigma=1.05}(AsO_4)(OH)_{1.4}$. (2) Gejiu mine, China. (3) $PbZn(AsO_4)(OH)$.

Mineral Group: Adelite group.

Occurrence: A secondary mineral in oxidized hydrothermal polymetallic deposits.

Association: Tennantite, chalcocite, willemite, mimetite, quartz, goethite (Tsumeb, Namibia).

Distribution: From Tsumeb, Namibia. In the Gejiu Pb–Zn deposit, not otherwise located, China. From the Toroku mine, Miyazaki Prefecture, Japan. At the Ojuela mine, Mapimí, Durango, Mexico. From the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada, USA. At the Michael mine, Weiler, near Lahr, Black Forest, Germany.

Name: As the arsenate analog of *descloizite*.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany, NM08; National Museum of Natural History, Washington, D.C., USA, 148303.

References: (1) Keller, P. and P.J. Dunn (1982) Arsendescloizite, a new mineral from Tsumeb. Mineral. Record, 13, 155–157. (2) (1983) Amer. Mineral., 68, 280 (abs. ref. 1). (3) Zhao, B. (1985) Arsendescloizite discovered for the first time in China. Acta Mineralogica Sinica, 5, 282–284 (in Chinese).

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Arsenic As

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. Commonly granular, massive, and in concentric layers; may be reticulated, reniform, stalactitic; rarely columnar or acicular; also as rhombohedra, to 1 mm. *Twinning:* Rare on twin plane $\{10\overline{1}4\}$; pressure twinning on $\{01\overline{1}2\}$ develops delicate lamellae.

Physical Properties: *Cleavage:* Perfect on {0001}, fair on $\{10\overline{1}4\}$. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5 VHN = 72–173 (100 g load). D(meas.) = 5.63–5.78 D(calc.) = 5.778

Optical Properties: Opaque. *Color:* Tin-white, tarnishes to dark gray. *Streak:* Tin-white. *Luster:* Nearly metallic. *Pleochroism:* Feeble. *Anisotropism:* Distinct, yellowish brown and light gray to yellowish gray.
R_1–R_2: (400) 56.0–57.5, (420) 55.1–56.8, (440) 54.2–56.2, (460) 53.3–55.8, (480) 52.7–55.7, (500) 52.4–55.7, (520) 52.0–55.7, (540) 51.7–55.7, (560) 51.5–55.6, (580) 51.2–55.4, (600) 51.0–55.2, (620) 50.8–55.0, (640) 50.6–54.9, (660) 50.5–54.8, (680) 50.4–54.7, (700) 50.4–54.6

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic). $a = 3.7598(1)$ $c = 10.5475(2)$ $Z = 6$

X-ray Powder Pattern: Synthetic.
2.771 (100), 3.52 (30), 1.879 (30), 2.05 (20), 1.556 (10), 1.768 (10), 1.757 (7)

Chemistry:

	(1)	(2)
As	98.14	99.1
Sb	1.65	0.2
S	0.16	
insol.	0.15	
Total	100.10	99.3

(1) Mount Royal, near Montreal, Quebec, Canada. (2) Sainte-Marie-aux-Mines, France; by electron microprobe.

Polymorphism & Series: Dimorphous with arsenolamprite.

Mineral Group: Arsenic group.

Occurrence: In hydrothermal veins and deposits that contain other arsenic minerals; may be in Co–Ag sulfide veins.

Association: Arsenolite, cinnabar, realgar, orpiment, stibnite, galena, sphalerite, pyrite, barite.

Distribution: Numerous localities are known, most of only minor interest. In Germany, from Freiberg, Schneeberg, Johanngeorgenstadt, Marienberg, and Annaberg, Saxony; Wolfsberg and St. Andreasberg, Harz Mountains; and Wieden, Black Forest. In the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, France. At Jáchymov (Joachimsthal), Příbram, and Cínovec (Zinnwald), Czech Republic. In Romania, from Săcărîmb (Nagyág), Hunyad, and Cavnic (Kapnikbánya). At Sterling Hill, Ogdensburg, Sussex Co., New Jersey and Washington Camp, Santa Cruz Co., Arizona, USA. In the Huallapón mine, Pasto Bueno, Ancash Province, Peru. At Bidi, Sarawak Province, Borneo. In the Akatani mine, Fukui Prefecture, Japan. From the Dajishan tungsten deposits, Jianxi Province, China.

Name: From the Latin *arsenicum*, earlier Greek *arrenikos*, or *arsenikos*, *masculine*, an allusion to its potent properties.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 128–130. (2) Schiferl, D. and C.S. Barrett (1969) The crystal structure of arsenic at 4.2, 788 and 299 °K. J. Appl. Cryst., 2, 30–36. (3) (1954) NBS Circ. 539, 3, 6. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 21.

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Arseniopleite $NaCaMn^{2+}(Mn^{2+},Mg)_2(AsO_4)_3$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Rarely as elongated or lenticular crude crystals; more commonly granular, massive.

Physical Properties: *Cleavage:* On pseudo-$\{10\bar{1}1\}$. *Fracture:* Conchoidal. Hardness = 3–4 D(meas.) = 4.17–4.22 D(calc.) = 4.17

Optical Properties: Opaque to translucent. *Color:* Brownish red to cherry-red, yellow, dark green, gray; orange, light apricot-orange, or brownish orange in transmitted light. *Streak:* Yellowish brown. *Luster:* Dull.
Optical Class: Uniaxial (+), or nearly so. $\omega = 1.794(3)$ $\epsilon = 1.803(3)$ 2V(meas.) = Small, anomalous.

Cell Data: *Space Group:* $P2_1/c$. $a = 11.31$ $b = 13.06$ $c = 6.86$ $\beta = [99°]$ $Z = 4$

X-ray Powder Pattern: Sjö mine, Sweden.
2.825 (10), 2.676 (6), 2.993 (4.5), 1.693 (4.5), 6.52 (4), 3.27 (4), 2.793 (4)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5		0.2	CaO	8.11	6.1
As_2O_5	44.98	51.8	BaO		0.2
Sb_2O_5	trace		Na_2O		5.53
Fe_2O_3	3.68	3.5	Cl	trace	
MnO	28.25	26.3	H_2O^+		0.05
PbO	4.48	3.3	H_2O^-		0.01
MgO	3.10	2.5	H_2O	5.67	
			Total	98.27	99.49

(1) Sjö mine, Sweden. (2) Do.; by electron microprobe, total Fe as Fe_2O_3, As as As_2O_5, by microchemical test, total Mn as MnO, Na by flame photometry, H_2O by the Penfield method; corresponds to $Na_{1.07}(Ca_{0.71}Pb_{0.10}Mn^{2+}_{0.09}Na_{0.09}Ba_{0.01})_{\Sigma=1.00}Mn^{2+}(Mn^{2+}_{1.31}Mg_{0.40}Fe^{3+}_{0.28})_{\Sigma=1.98}[(AsO_4)_{2.93}(PO_4)_{0.02}]_{\Sigma=2.95}$.

Mineral Group: Alluaudite group.

Occurrence: As fracture fillings and thin veins in banded dolostone (Sjö mine, Sweden); in a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Rhodonite, tephroite, hedyphane, dolomite, calcite (Sjö mine, Sweden); calcite, berzeliite, kutnohorite, sarkinite, gonyerite, katoptrite (Långban, Sweden).

Distribution: From the Sjö mine, Örebro, and at Långban, Värmland, Sweden.

Name: From *arsenic* and the Greek for *more*, as it added to the number of related minerals previously described.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 844. (2) Moore, P.B. (1968) Contributions to Swedish mineralogy. I. Studies on the basic arsenates of manganese: retzian, hemafibrite, synadelphite, arsenoclasite, arseniopleite, and akrochordite. Arkiv. Mineral. Geol., 4(5), 425–444. (3) Dunn, P.J. and D.R. Peacor (1987) New data on the relation between caryinite and arseniopleite. Mineral. Mag., 51, 281–284. (4) Ercit, T.S. (1993) Caryinite revisited. Mineral. Mag., 57, 721–727.

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Arseniosiderite $Ca_2Fe_3^{3+}O_2(AsO_4)_3 \cdot 3H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Euhedral crystals very rare, to 2 mm; usually as flattened fibers, in radial aggregates, and felted to granular masses.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 4.5 D(meas.) = 3.58–3.60 D(calc.) = [3.78]

Optical Properties: Opaque, translucent through thin edges. *Color:* Golden yellow, yellowish brown, reddish brown, brownish black, black. *Streak:* Ocher-yellow. *Luster:* Submetallic to silky.
Optical Class: Biaxial (–); pseudouniaxial (–). *Pleochroism:* Strong; X = nearly colorless to pale brownish or brownish red; $Y = Z$ = brownish red to dark reddish brown. *Absorption:* $Y = Z \gg X$. $\alpha = 1.792$–1.815 $\beta = 1.870$–1.898 $\gamma = 1.870$–1.898 2V(meas.) = Small.

Cell Data: *Space Group:* $[A2/a]$ (by analogy to robertsite and mitridatite). $a = 17.76(4)$ $b = 19.53(1)$ $c = 11.30(1)$ $\beta = 96.0°$ Z = 12

X-ray Powder Pattern: Mapimí, Mexico.
8.84 (10), 2.772 (8), 5.62 (5), 2.945 (5), 3.28 (4), 3.22 (4), 2.213 (4)

Chemistry:

	(1)	(2)
As_2O_5	42.67	45.94
Fe_2O_3	32.71	31.92
FeO	0.12	
PbO	0.28	
MgO	0.61	
CaO	14.44	14.94
H_2O	9.34	7.20
insol.	0.40	
Total	100.57	100.00

(1) Mapimí, Mexico. (2) $Ca_2Fe_3O_2(AsO_4)_3 \cdot 3H_2O$.

Occurrence: A rare secondary mineral formed by the oxidation of earlier arsenic-bearing minerals, typically scorodite or arsenopyrite.

Association: Beudantite, carminite, scorodite, dussertite, pharmacolite, pitticite, adamite, erythrite, arsenopyrite, löllingite.

Distribution: From Romanèche, Saône-et-Loire, France. At Hüttenberg, Carinthia, Austria. In Germany, at Schneeberg, Saxony, and at Wittichen and Neubulach, Black Forest. In England, at Carrock and Caldbeck Fells, Cumbria; from the Penberthy Croft mine, St. Hilary, Cornwall; in the Huckworthy Bridge mine, Sampford Spiney, Devon. From the Kamariza mine, Laurium, Greece. At Tsumeb, Namibia. In the USA, from Sterling Hill, Ogdensburg, Sussex Co., New Jersey; at the Mohawk mine, San Bernardino Co., and in the Kalkar quarry, Santa Cruz, Santa Cruz Co., California; from the Gold Hill mine, Tooele Co., and the Mammoth and other mines, Tintic district, Juab Co., Utah. In Mexico, from the Jesus Maria mine, Mazapil district, Zacatecas; in the Ojuela mine, Mapimí, Durango; and at the Las Animas mine, La Mur, Sonora. In the Negra mine, near Cosca, north of Ollague, Bolivia. Found at the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia. A few other localities are known, several requiring confirmation.

Name: For essential *arsenic* in the composition, and *sideros*, Greek for *iron*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 953–955. (2) Moore, P.B. and J. Ito (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. II. Redefinition of overite, an isotype of segelerite. III. Isotypy of robertsite, mitridatite, and arseniosiderite. Amer. Mineral., 59, 48–59. (3) Moore, P.B. and T. Araki (1977) Mitridatite, $Ca_6(H_2O)_6[Fe_9^{III}O_6(PO_4)_9] \cdot 3H_2O$. A noteworthy octahedral sheet structure. Inorg. Chem., 16, 1096–1106. (4) Dunn, P.J. (1979) Contributions to the mineralogy of Franklin and Sterling Hill, New Jersey. Mineral. Record, 10, 160–165.

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Arsenoclasite $Mn_5^{2+}(AsO_4)_2(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals rare, to 5 mm; granular or massive.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 5–6 D(meas.) = 4.16 D(calc.) = 4.21

Optical Properties: Translucent. *Color:* Red, dark orange-brown. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.787$ $\beta = 1.810$ $\gamma = 1.816$ 2V(meas.) = 53°26′

Cell Data: *Space Group:* $P2_12_12_1$. $a = 18.29(2)$ $b = 5.75(1)$ $c = 9.31(2)$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
2.933 (100), 2.739 (75), 4.55 (70), 2.835 (70), 3.057 (60), 1.631 (50), 4.92 (45)

Chemistry:

	(1)	(2)	(3)
SO_3		0.23	
P_2O_5		1.37	
As_2O_5	36.96	34.10	37.04
Al_2O_3		0.17	
FeO	trace	0.03	
MnO	55.01	55.74	57.16
CuO	0.57	0.05	
ZnO		0.11	
PbO		0.15	
MgO	0.87		
BaO	0.11		
H_2O	5.90	[5.85]	5.80
Total	99.42	[97.80]	100.00

(1) Långban, Sweden. (2) Iron Monarch quarry, Australia; by electron microprobe, H_2O calculated for $2H_2O$; corresponding to $Mn_{4.74}Al_{0.02}[(As_{0.90}P_{0.06}S_{0.01})_{\Sigma=0.97}O_4]_2(OH)_4$. (3) $Mn_5(AsO_4)_2(OH)_4$.

Occurrence: A rare fissure mineral in a metamorphosed Fe–Mn orebody (Långban, Sweden); in a sedimentary Fe–Mn deposit (Iron Monarch quarry, Australia).

Association: Sarkinite, adelite, allactite, calcite, dolomite, hausmannite (Långban, Sweden); gatehouseite, shigaite, hematite, hausmannite, barite, manganoan ferroan calcite (Iron Monarch quarry, Australia).

Distribution: At Långban, Värmland, Sweden. Crystallized from the Iron Monarch quarry, Iron Knob, South Australia.

Name: From *arsenic* and the Greek for *breaking*, for its excellent cleavage.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; The Natural History Museum, London, England, 1931,59.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 801–802. (2) Moore, P.B. (1967) Contributions to Swedish mineralogy: I. Studies on the basic arsenates of manganese: retzian, hemafibrite, synadelphite, arsenoclasite, arseniopleite, and akrochordite. Arkiv Mineral. Geol., 4(5), 425–444. (3) Moore, P.B. and J. Molin-Case (1971) Crystal chemistry of the basic manganese arsenates: V. Mixed manganese coordination in the atomic arrangement of arsenoclasite. Amer. Mineral., 56, 1539–1552. (4) (1972) Amer. Mineral., 57, 593 (erratum to ref. 3). (5) Pring, A. and W.D. Birch (1993) Gatehouseite, a new manganese hydroxy phosphate from Iron Monarch, South Australia. Mineral. Mag., 57, 309–313.

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Arsenocrandallite $(Ca,Sr)Al_3[(As,P)O_4]_2(OH)_5 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$ or $3m$. As spherulitic aggregates, to 0.1 mm, in reniform crusts.

Physical Properties: *Fracture:* Conchoidal. Hardness = ~5.5 D(meas.) = 3.25(1) D(calc.) = 3.30

Optical Properties: Semitransparent. *Color:* Blue-green to green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic or nearly so; very low birefringence. $n = 1.625(1)$

Cell Data: *Space Group:* $R\overline{3}m$ or $R3m$. $a = 7.06$–7.08 $c = 17.22$–17.27 $Z = 3$

X-ray Powder Pattern: Neubulach, Germany.
2.99 (10), 3.55 (9), 5.84 (8), 1.769 (6), 1.919 (5), 2.23 (4), 5.02 (3)

Chemistry:

	(1)
P_2O_5	10.7
As_2O_5	22.9
SiO_2	3.2
Al_2O_3	28.7
Fe_2O_3	1.2
Bi_2O_3	2.4
CuO	1.8
ZnO	0.3
CaO	6.9
SrO	6.0
BaO	4.3
H_2O	11.7
Total	100.1

(1) Neubulach, Germany; by electron microprobe, total Fe as Fe_2O_3, H_2O taken as loss on ignition; corresponds to $(Ca_{0.61}Sr_{0.29}Ba_{0.14}Bi_{0.05})_{\Sigma=1.09}(Al_{2.79}Cu_{0.11}Fe^{3+}_{0.07}Zn_{0.02})_{\Sigma=2.99}$ $[(AsO_4)_{0.99}(PO_4)_{0.75}(SiO_4)_{0.26}]_{\Sigma=2.00}(OH)_{4.63} \cdot H_2O$.

Mineral Group: Crandallite group.

Occurrence: A secondary mineral on specimens from a mine dump (Neubulach, Germany).

Association: Brochantite, chalcophyllite, parnauite, barian pharmacosiderite, bulachite, arseniosiderite, mansfieldite, tetrahedrite–tennantite, azurite, malachite, barite, goethite, quartz (Neubulach, Germany); arsenogoyazite, beudantite, olivenite (Centennial Eureka mine, Utah, USA).

Distribution: From Neubulach, and in the Clara mine, near Oberwolfach, Black Forest, Germany. At the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: For *arsenic* in the composition, and relation to *crandallite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150251.

References: (1) Walenta, K. (1981) Mineralien der Beudantit-Crandallitgruppe aus dem Schwarzwald: Arsenocrandallit und sulfatfreier Weilerit. Schweiz. Mineral. Petrog. Mitt., 61, 23–35 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 854 (abs. ref. 1).

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Arsenoflorencite-(Ce) $(Ce, La)Al_3(AsO_4, PO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As scalenohedral crystals, showing $\{10\overline{1}1\}$ and $\{10\overline{1}2\}$, composed of misoriented domains; generally as subhedral grains, to 0.5 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 170 (10 g load). D(meas.) = 4.096 D(calc.) = 4.091

Optical Properties: Transparent to translucent. *Color:* Colorless, creamy white, light brown; light gray in reflected light.
Optical Class: Uniaxial (+). $\omega = 1.739$ $\epsilon = 1.745$

Cell Data: *Space Group:* $[R\overline{3}m]$ [by analogy to florencite-(Ce)]. $a = 7.029$ $c = 16.517$ Z = 3

X-ray Powder Pattern: Near Kimba, Australia.
2.963 (10), 3.513 (6), 1.905 (5), 2.201 (4), 1.753 (4), 2.752 (3), 1.627 (3)

Chemistry:

	(1)
SO_3	1.21
P_2O_5	4.68
As_2O_5	27.02
Al_2O_3	28.75
La_2O_3	8.62
Ce_2O_3	12.97
Pr_2O_3	3.35
Nd_2O_3	2.40
Sm_2O_3	0.38
Gd_2O_3	1.38
SrO	1.99
H_2O	9.36
Total	102.11

(1) Near Kimba, Australia; by electron microprobe, average of three analyses, H_2O calculated from $(OH)^-$ for charge balance; corresponding to $(Ce, La, Pr, Sr, Nd, Gd, Sm)_{\Sigma=1.12}Al_{3.00}[(As, P, Al, S)_{\Sigma=1.00}O_4]_2(OH)_{5.91}$. Arsenoflorencites with dominant La and Nd are known but are not fully described.

Mineral Group: Crandallite group.

Occurrence: As detrital grains in heavy mineral concentrates.

Association: Alunite, florencite-(Ce), quartz.

Distribution: In Australia, from the vicinity of Kimba, Eyre Peninsula, South Australia, and from the Northern Territory–Queensland border near the Gulf of Carpentaria.

Name: As the *arsenic* analog of florencite and for the dominant rare earth element, *cerium*.

Type Material: Museum Victoria, Melbourne, M38084, M38085; South Australian Museum, Adelaide, Australia, G14965; The Natural History Museum, London, England, 1986,481; National Museum of Natural History, Washington, D.C., USA, 163782.

References: (1) Nickel, E.H. and J.E. Temperly (1987) Arsenoflorencite-(Ce): a new arsenate mineral from Australia. Mineral. Mag., 51, 605–609. (2) (1988) Amer. Mineral., 73, 1492–1493 (abs. ref. 1).

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Arsenogorceixite $BaAl_3(AsO_4)(AsO_3OH)(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As rhombohedral crystals, flattened to pseudo-octahedral, showing $\{10\overline{1}1\}$ and $\{0001\}$, to 0.2 mm; in spherulitic aggregates of radiating crystals.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼4 D(meas.) = 3.65(5) D(calc.) = 3.71

Optical Properties: Transparent. *Color:* Colorless, white, yellow, pale yellow, pale blue. *Luster:* Vitreous.
Optical Class: Uniaxial, nearly isotropic. $n = 1.645(2)$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $[R\overline{3}m]$ (by analogy to the crandallite group). $a = 7.10(3)$ $c = 17.39(4)$ Z = 3

X-ray Powder Pattern: Clara mine, Germany.
3.02 (10), 5.84 (8), 3.55 (8), 2.30 (6), 1.930 (6), 1.774 (5), 1.515 (5)

Chemistry:

	(1)	(2)
P_2O_5	5.9	
As_2O_5	27.2	38.36
Al_2O_3	27.8	25.53
FeO	0.7	
CaO	0.2	
SrO	0.9	
BaO	24.9	25.59
F	2.5	
H_2O	[10.9]	10.52
$-O = F_2$	1.0	
Total	[100.0]	100.00

(1) Clara mine, Germany; by electron microprobe, total Fe as FeO, H_2O by difference; corresponding to $(Ba_{0.92}Sr_{0.05}Fe_{0.05}Ca_{0.02})_{\Sigma=1.04}Al_{3.09}[(AsO_4)_{1.34}(PO_4)_{0.47}]_{\Sigma=1.81}$ $[(OH)_{5.19}F_{0.73}]_{\Sigma=5.92} \bullet 0.83H_2O$. (2) $HBaAl_3(AsO_4)_2(OH)_6$.

Mineral Group: Crandallite group.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal polymetallic barite–fluorite deposit (Clara mine, Germany).

Association: Arsenogoyazite, brochantite, agardite, malachite, barian pharmacosiderite, olivenite, fluorite, barite, "limonite", quartz (Clara mine, Germany); mimetite, adamite, beudantite, tsumcorite (Michael mine, Germany).

Distribution: Found in the Clara mine, near Oberwolfach, and the Michael mine, Weiler, near Lahr, Black Forest, Germany. From the Bali Lo copper prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia.

Name: For its *arsenic* content and relation to *gorceixite*.

Type Material: n.d.

References: (1) Walenta, K. and P.J. Dunn (1993) Arsenogorceixit von der Grube Clara im mittleren Schwarzwald. Aufschluss, 44, 250–254 (in German with English abs.). (2) (1996) Amer. Mineral., 81, 249 (abs. ref. 1).

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Arsenogoyazite $(Sr, Ca, Ba)Al_3(AsO_4, PO_4)_2(OH, F)_5 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $3m$. Crystals indistinctly rhombohedral, may show {0001}, to 30 μm, aggregated into reniform crusts with a radial structure.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼4 D(meas.) = 3.35(5) D(calc.) = 3.33

Optical Properties: Translucent. *Color:* Pale green to gray-green, white to yellowish.
Luster: Vitreous.
Optical Class: Isotropic, or nearly so; weak birefringence. $n = 1.64(3)$

Cell Data: *Space Group:* $R\overline{3}m$ or $R3m$. $a = 7.10$ $c = 17.16$ Z = 3

X-ray Powder Pattern: Clara Mine, Germany.
3.03 (10), 3.56 (8), 5.84(7), 1.933 (5), 2.31 (4), 2.27 (4), 1.777 (4)

Chemistry:

	(1)
P_2O_5	8.9
As_2O_5	25.3
Al_2O_3	30.9
FeO	0.2
CaO	2.8
SrO	10.1
BaO	6.5
F	3.6
H_2O	[13.2]
$-O = F_2$	1.5
Total	[100.0]

(1) Clara Mine, Germany; by electron microprobe, total Fe as FeO, H_2O by difference; corresponds to $(Sr_{0.49}Ca_{0.25}Ba_{0.21}Fe^{2+}_{0.01})_{\Sigma=0.96}Al_{3.04}[AsO_4)_{1.10}(PO_4)_{0.63}]_{\Sigma=1.73}$ $[(OH)_{4.05}F_{0.95}]_{\Sigma=5.00} \cdot 2.07H_2O$.

Mineral Group: Crandallite group.

Occurrence: A secondary mineral in a hydrothermal polymetallic barite–fluorite deposit (Clara mine, Germany).

Association: Olivenite, cornwallite, malachite, brochantite, barian pharmacosiderite, arsenogorceixite, cualstibite, quartz, barite (Clara mine, Germany); arsenocrandallite, beudantite, olivenite (Centennial Eureka mine, Utah, USA).

Distribution: From the Clara Mine, near Oberwolfach, Black Forest, Germany. In the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: For *arsenic* in the composition, and its relation to *goyazite*.

Type Material: University of Stuttgart, Stuttgart, Germany; National Museum of Natural History, Washington, D.C., USA, 150232.

References: (1) Walenta, K. and P.J. Dunn (1984) Arsenogoyazit, ein neues Mineral der Crandallitgruppe aus dem Schwarzwald. Schweiz. Mineral. Petrog. Mitt., 64, 11–19 (in German with English abs.). (2) (1986) Amer. Mineral., 71, 845–846 (abs. ref. 1).

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Arsenohauchecornite $Ni_{18}Bi_3AsS_{16}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$, 422, $\bar{4}2m$, or $4mm$. Tabular crystals, to 2 cm; in irregular masses.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 516–655 (50 g load). D(meas.) = 6.35 D(calc.) = 6.52

Optical Properties: Opaque. *Color:* Bronze. *Luster:* Metallic, brilliant on fresh surfaces. R_1–R_2: (470) 41.6–43.0, (546) 46.2–47.1, (589) 48.2–49.2, (650) 50.8–51.6

Cell Data: *Space Group:* $I4/mmm$, $I422$, $I\bar{4}m2$, $I\bar{4}2m$, or $I4mm$. $a = 10.2711(2)$ $c = 10.8070(4)$ Z = 2

X-ray Powder Pattern: Vermilion mine, Sudbury, Canada.
2.875 (100), 2.393 (66), 2.298 (59), 3.253 (56), 4.343 (53), 3.637 (48), 1.862 (48)

Chemistry:

	(1)	(2)
Ni	44.9	46.52
Fe	1.4	
Co	0.3	
Bi	26.5	27.60
As	4.4	3.30
Sb	0.1	
Te	0.0	
S	22.0	22.58
Total	99.6	100.00

(1) Vermilion mine, Sudbury, Canada; by electron microprobe, corresponding to $(Ni_{17.8}Fe_{0.6}Co_{0.2})_{\Sigma=18.6}Bi_{3.0}As_{1.4}S_{16.0}$. (2) $Ni_{18}Bi_3AsS_{16}$.

Mineral Group: Hauchecornite group.

Occurrence: In hydrothermal Ni–Co–Cu sulfide veins.

Association: Chalcopyrite, pyrrhotite, gersdorffite, pyrite, gold, nickeline, galena, copper, sperrylite, michenerite, froodite (Vermilion mine, Canada).

Distribution: From the Vermilion mine, Sudbury, Ontario, Canada [TL]. At Karagaily, central Kazakhstan. In the Tsumo mine, near Hiroshima City, Shimane Prefecture, Japan.

Name: Alludes to its chemical relation to the hauchecornite group.

Type Material: Royal Ontario Museum, Toronto, Canada, M29206–M29208.

References: (1) Gait, R.I., and D.C. Harris (1980) Arsenohauchecornite and tellurohauchecornite: new minerals in the hauchecornite group. Mineral. Mag., 43, 877–878. (2) (1981) Amer. Mineral., 66, 436–437 (abs. ref. 1). (3) Gait, R.I. and D.C. Harris (1972) Hauchecornite – antimonian, arsenian and tellurian varieties. Can. Mineral., 11, 819–825. (4) Grice, J.D. and R.B. Ferguson (1989) The crystal structure of arsenohauchecornite. Can. Mineral., 27, 137–142.

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Arsenohopeite $Zn_3(AsO_4)_2 \cdot 4H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As a polycrystalline grain to 1 mm.

Physical Properties: *Cleavage*: Perfect on {010}, good on {100}, poor on 01} (by analogy with hopeite). *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3 D(meas.) = n.d. D(calc.) = 3.42

Optical Properties: Transparent. *Color*: Colorless to blue, colorless in transmitted light. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (-). α = 1.598(2) β = 1.606(2) γ = 1.613(2) 2V(meas.) = n.d. 2V(calc.) = 86°

Cell Data: *Space Group*: *Pnma*. a = 10.804(2) b = 19.003(4) c = 5.112(1) Z = 4

X-ray Powder Pattern: Calculated pattern.
9.502 (100), 2.926 (95), 4.937 (50), 4.110 (48), 5.196 (31), 3.567 (31), 4.490 (28)

Chemistry:

	(1)	(2)
ZnO	44.92	44.72
Fe_2O_3	0.92	
MnO	0.51	
MgO	0.20	
CuO	0.02	
As_2O_5	45.84	42.09
H_2O	[14.21]	13.19
Total	106.62	100.00

(1) Tsumeb, Namibia; average of 8 electron microprobe analyses; H_2O calculated and confirmed by Raman spectroscopy, high Total attributed to dehydration under the electron beam; corresponding to $(Zn_{2.80}Fe_{0.06}Mn_{0.04}Mg_{0.03})_{\Sigma=2.93}(As_{1.01}O_4)_2 \cdot 4H_2O$. (2) $Zn_3(AsO_4)_2 \cdot 4H_2O$.

Occurrence: A rare secondary mineral formed by alteration of tennantite-rich ore in the oxidized zone of a dolostone-hosted, polymetallic, hydrothermal ore deposit.

Association: Köttigite, adamite, leiteite, schneiderhöhnite.

Distribution: Tsumeb, Namibia.

Name: For the relationship to *hopeite* $[Zn_3(PO_4)_2 \cdot 4H_2O]$, as its arsenate analogue.

Type Material: Natural History Museum, Vienna, Austria (N 8167).

References: (1) Neuhold, F., U. Kolitsch, H.-J. Bernhardt, and C.L. Lengauer (2012) Arsenohopeite, a new zinc arsenate mineral from the Tsumeb mine, Namibia. Mineral. Mag., 76, 603-612. (2) (2012) Amer. Mineral., 97, 1524 (abs. ref. 1).

Arsenolamprite As

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ (synthetic). As needles, to 8 mm, foliated, radial aggregates of plates, and massive.

Physical Properties: *Cleavage:* Perfect, in one direction. Hardness = 2 VHN = n.d. D(meas.) = 5.3–5.5 D(calc.) = 5.577

Optical Properties: Opaque. *Color:* Gray-white, altering to a dull black coating. *Streak:* Black. *Luster:* Metallic, brilliant. *Anisotropism:* Weak.
R_1–R_2: (400) —, (420) 42.8–56.8, (440) 43.6–55.4, (460) 44.3–54.0, (480) 44.7–52.8, (500) 44.8–51.6, (520) 44.6–50.5, (540) 44.0–49.6, (560) 43.1–48.7, (580) 42.7–48.0, (600) 42.6–47.4, (620) 42.7–46.8, (640) 43.0–46.3, (660) 43.4–45.8, (680) 43.8–45.5, (700) 44.4–45.0

Cell Data: *Space Group: Bmab* (synthetic). $a = 3.63$ $b = 4.45$ $c = 10.96$ $Z = 8$

X-ray Powder Pattern: Alacrán mine, Chile.
5.76 (10), 2.72 (10), 2.745 (8), 1.875 (7), 1.730 (7), 3.48 (6), 2.230 (5)

Chemistry: Nearly pure As, with up to 3% Bi.

Polymorphism & Series: Dimorphous with arsenic.

Occurrence: As plates and veinlets in carbonate rocks (Černý Důl mine, Czech Republic); in calcite veins (Mackenheim, Germany).

Association: Arsenic, bismuth, silver, sternbergite, emplectite, safflorite, löllingite, pyrite, galena, orpiment, realgar, calcite.

Distribution: In Germany, from the Palmbaum mine, Marienberg, Saxony [TL]; from Schweisweiler, Rhineland-Palatinate; at Mackenheim, Odenwald, and Wittichen, Black Forest. From the Černý Důl mine, Krkonoše (Giant Mountains), and Jáchymov (Joachimsthal), Czech Republic. At Sainte-Marie-aux-Mines, Haut-Rhin, France. In Switzerland, at the Lengenbach quarry, Binntal, Valais. From the Alacrán Ag–As–Sb mine, Pampa Larga district, Copiapó, Chile. In the Goldstrike mine, Lynn district, Eureka Co., Nevada, USA.

Name: From its composition and the Greek for *brilliant*, in allusion to its reflectance.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 130. (2) Johan, Z. (1959) Arsenolamprit – die rhombische Modifikation des Arsens aus Černý Důl (Schwarzenthal) im Riesengebirge. Chem. Erde, 20, 71–80 (in German). (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 370. (4) Smith, P.M., A.J. Leadbetter, and A.J. Apling (1975) The structures of orthorhombic and vitreous arsenic. Philos. Mag., 31, 57–64. (5) Picot, P. and Z. Johan (1982) Atlas of ore minerals. B.R.G.M., Orleans, France, and Elsevier, Amsterdam, Holland, 77. (6) Hintze, C. (1886) Ueber Arsenolamprit. Zeits. Krist., 11, 606–608. (in German).

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Arsenolite As_2O_3

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly as tiny octahedra, sometimes modified by the dodecahedron, in aggregates or crusts; botryoidal, stalactitic, earthy to pulverulent.

Physical Properties: *Cleavage:* {111}. *Fracture:* Conchoidal. Hardness = 1.5
D(meas.) = 3.87(1) D(calc.) = 3.88 Taste astringent, sweetish; a very toxic substance.

Optical Properties: Transparent. *Color:* White, pale blue, pink to pale yellow if impure with realgar or orpiment; colorless in transmitted light. *Streak:* White to pale yellowish white. *Luster:* Vitreous to silky.
Optical Class: Isotropic; may be anomalously anisotropic. $n = 1.755$

Cell Data: *Space Group:* $Fd3m$ (synthetic). $a = 11.074$ $Z = 16$

X-ray Powder Pattern: Synthetic.
3.195 (100), 6.39 (63), 2.541 (38), 2.7687 (28), 1.957 (27), 1.551 (22), 1.670 (21)

Chemistry: There are no analyses of natural material.

Occurrence: An oxidation product of other arsenic-bearing sulfides in hydrothermal veins; may be formed in mine fires or in burning coal seams.

Association: Claudetite, realgar, orpiment, erythrite.

Distribution: In Germany, from Wittichen, Black Forest; at Lauta, near Marienberg, Johanngeorgenstadt, and Annaberg, Saxony. In the Czech Republic, at Jáchymov (Joachimsthal) and Kuttenberg. At Saint-Etienne, Loire, and elsewhere in France. From the Dolcoath mine, Cambourne, the Phoenix United mines, Linkinhorne, and elsewhere in Cornwall, England. In the Plaka mine, Laurium, Greece. In Italy, at Sondalo, Sondrio, and Borgofranco, Torino. In the USA, from Manhattan, Nye Co., in the Ophir mine, Comstock Lode, Storey Co., at the Getchell mine, Humboldt Co., and from Simon, Mineral Co., Nevada; in the United Verde mine, Jerome, Yavapai Co., Arizona; and at the Armagosa mine, San Bernardino Co., California. In Canada, at Lake Wanapitei, Sudbury, Ontario, and on Watson Creek, British Columbia.

Name: For ARSENic in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 543–544. (2) Pertlik, F. (1978) Structure refinement of cubic As_2O_3 (arsenolite) with single crystal data. Czech. J. Phys., B28(2), 170–176. (3) (1978) Chem. Abs., 88, 573 (abs. ref. 2). (4) Treacy, D.J. and P.C. Taylor (1981) Nuclear quadripole resonance in two crystalline forms of As_2O_3, arsenolite and claudetite I. Solid State Communications, 40(2), 135–138.
(5) (1953) NBS Circ. 539, 1, 51.

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Arsenopalladinite $Pd_8(As,Sb)_3$

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Crystal Data: Triclinic. *Point Group:* 1. As rounded grains, to 1.8 mm.

Physical Properties: *Tenacity:* Malleable. Hardness = n.d. VHN = 379–449 (100 g load). D(meas.) = 10.40 D(calc.) = 11.028

Optical Properties: Opaque. *Color:* White, with yellowish creamy tint, in polished section. *Luster:* Metallic. *Anisotropism:* Strong, red and golden brown to blue-gray in air, khaki-brown to blue-gray and bright steel-gray in oil.

R_1–R_2: (400) 43.9–44.5, (420) 44.7–45.8, (440) 45.7–46.5, (460) 46.8–47.8, (480) 48.1–49.4, (500) 49.4–50.8, (520) 50.8–52.4, (540) 52.1–53.9, (560) 53.2–55.1, (580) 54.4–56.4, (600) 55.4–57.3, (620) 56.4–58.1, (640) 57.0–58.8, (660) 57.7–59.2, (680) 58.2–59.8, (700) 58.8–60.0

Cell Data: *Space Group:* $P1$. $a = 7.43$ $b = 13.95$ $c = 7.35$ $\alpha = 92°53'$ $\beta = 119°30'$ $\gamma = 87°51'$ Z = 6

X-ray Powder Pattern: Itabira, Brazil.
2.13 (100), 2.34 (60), 1.41 (40), 1.24 (30), 1.21 (30), 2.28 (20), 2.19 (20)

Chemistry:

	(1)
Pd	77.56
Cu	0.02
As	17.08
Sb	5.15
Total	99.81

(1) Itabira, Brazil; by electron microprobe, average of 13 grains; corresponds to $Pd_{8.10}(As_{2.53}Sb_{0.47})_{\Sigma=3.00}$.

Occurrence: In gold concentrates.

Association: Hematite, palladian gold, atheneite, stillwaterite, palladseite, isomertieite, quartz (Itabira district, Brazil); gpold, palladium, palladesite (Cauê mine, Brazil); stillwaterite, braggite, vysotaskite, sperrylite, hollingworthite (Siikakama intrusion, Finland).

Distribution: In Brazil, from Minas Gerais, in the Itabira district [TL], and at the Caue iron mine. In the Stillwater complex, Montana, USA. From the Merensky Reef, Bushveldt complex, Transvaal, South Africa. In the Siikakämä and Konttijarvi intrusions, northern Finland.

Name: For the composition.

Type Material: The Natural History Museum, London, England, 1934,72, 1977,258; Royal Ontario Museum, Toronto, Canada, M34726; National Museum of Natural History, Washington, D.C., USA, 142504.

References: (1) Clark, A.M., A.J. Criddle, and E.E. Fejer (1974) Palladium arsenide–antimonides from Itabira, Minas Gerais, Brazil. Mineral. Mag., 39, 528–543. (2) (1974) Amer. Mineral., 59, 1332 (abs. ref. 1). (3) Cabri, L.J., A.M. Clark, and T.T. Chen (1977) Arsenopalladinite from Itabira, Brazil and from the Stillwater Complex, Montana. Can. Mineral., 15, 70–73. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 22.

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Arsenopyrite FeAsS

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals, to 30 cm, flat tabular to blocky to prismatic, striated ‖ [001]. Also compact, granular, columnar. *Twinning:* Common on {100} and {001}; as contact or penetration twins on {101}; on {012} to produce star-shaped trillings or cruciform twins.

Physical Properties: *Cleavage:* Distinct on {101}; {010} in traces. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–6 VHN = 1081 on (001) section (100 g load). D(meas.) = 6.07(15) D(calc.) = 6.18

Optical Properties: Opaque. *Color:* Silver-white to steel-gray; in polished section, white with faint yellow tint. *Luster:* Metallic. *Pleochroism:* Weak, in white or bluish tint and faint reddish yellow. *Anisotropism:* Strong, red-violet.
R_1–R_2: (400) 50.3–51.8, (420) 50.3–51.8, (440) 51.3–51.8, (460) 50.6–51.8, (480) 51.0–51.9, (500) 51.4–51.9, (520) 51.8–51.9, (540) 52.2–51.9, (560) 52.5–51.9, (580) 53.0–51.8, (600) 53.4–51.6, (620) 53.6–51.5, (640) 53.6–51.3, (660) 53.6–51.3, (680) 53.4–51.2, (700) 53.2–51.0

Cell Data: *Space Group:* $P2_1/c$. $a = 5.744(2)$ $b = 5.675(1)$ $c = 5.785(2)$ $\beta = 112.17(2)^\circ$ Z = 4

X-ray Powder Pattern: Freiberg, Germany.
2.677 (100), 2.662 (100), 2.418 (95), 2.412 (95), 2.440 (90), 1.814 (90), 1.824 (70)

Chemistry:

	(1)	(2)	(3)
Fe	34.53	32.48	34.30
Co	0.09	1.16	
Bi	0.79		
As	44.34	48.72	46.01
S	20.22	18.80	19.69
Total	99.97	101.16	100.00

(1) O'Brien mine, Cobalt, Canada. (2) Franklin, New Jersey, USA. (3) FeAsS.

Mineral Group: Arsenopyrite group.

Occurrence: Of hydrothermal origin, typically one of the earliest minerals to form. Found in pegmatites, high-temperature gold-quartz and tin veins, and in contact metamorphic sulfide deposits; less commonly of low-temperature hydrothermal origin. Also in gneisses, schists and other metamorphic rocks.

Association: Pyrrhotite, pyrite, chalcopyrite, galena, gold, scheelite, cassiterite, many other species.

Distribution: The most abundant and widespread arsenic mineral; only a few localities for large and fine crystals can be mentioned. In Germany, from Altenberg, Ehrenfriedersdorf, and Freiberg, Saxony. In the Stari Trg mine, Trepča, Serbia. From Panasqueira, Portugal. At Sala, Tunaberg, Stollberg, Boliden, and Nordmark, Sweden. From Stratonik, Greece. In England, from a number of mines in Cornwall, and in Devonshire, at Tavistock. In the USA, from Franconia, Grafton Co., New Hampshire and Franklin, Sussex Co., New Jersey. From Hidalgo del Parral and Santa Eulalia, Chihuahua, Mexico. In Canada, in the Cobalt district, Ontario. In Japan, large crystals in the Obira mine, Bungo, Oita Prefecture; the Ashio mine, Tochigi Prefecture; and many other localities.

Name: A contraction of *arsenical pyrites*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 316–322. (2) Fuess, H., T. Kratz, J. Töpel-Schadt, and G. Miehe (1987) Crystal structure refinement and electron microscopy of arsenopyrite. Zeits. Krist., 179, 335–346. (3) Morimoto, N. and L.A. Clark (1961) Arsenopyrite crystal-chemical relations. Amer. Mineral., 46, 1448–1469. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 23.

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Arsenosulvanite $Cu_3(As,V)S_4$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As grains, which may be subhedral, to 0.15 mm.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5 VHN = 412–488
D(meas.) = 4.01–4.2 D(calc.) = 4.39

Optical Properties: Opaque. *Color:* Bronze-yellow to pale brownish yellow.
Luster: Metallic.
Optical Class: Isotropic. *Pleochroism:* Yellowish brown.
R: (400) 23.5, (420) 24.9, (440) 26.3, (460) 27.4, (480) 28.6, (500) 29.8, (520) 30.7, (540) 31.7, (560) 32.4, (580) 32.7, (600) 32.4, (620) 31.8, (640) 31.4, (660) 31.1, (680) 30.9, (700) 30.4

Cell Data: *Space Group:* $P\bar{4}3m$. $a = 5.257(3)$ $Z = 1$

X-ray Powder Pattern: Bor, Serbia.
3.054 (10), 1.865 (9), 1.591 (8), 2.638 (6), 1.210 (6), 1.076 (6), 1.318 (5)

Chemistry:

	(1)	(2)		(1)	(2)
Cu	48.84	50.6	Ge		0.62
As	12.80	13.2	S	33.14	32.22
V	4.16	3.4	insol.	1.01	
			Total	99.95	100.04

(1) Mongolia; corresponds to $Cu_{2.97}(As_{0.66}V_{0.32})_{\Sigma=0.98}S_{4.00}$. (2) Bor, Serbia; by electron microprobe, average of five grains; corresponds to $Cu_{3.17}(As_{0.70}V_{0.27}Ge_{0.03})_{\Sigma=1.00}S_{4.00}$.

Polymorphism & Series: Forms a series with sulvanite.

Occurrence: In quartz-calcite veins cutting bituminous limestone (Mongolia); in a porphyry copper deposit (Bor, Serbia; Oyu Togoi deposit, Mongolia).

Association: Pyrite, enargite, luzonite, tennantite, tetrahedrite, sulvanite, chalcocite, covellite, bornite, chalcopyrite, galena, sphalerite, ankerite, hematite, quartz, calcite.

Distribution: From the Lebedinoye gold deposit, near Aldan, southern Sakha, Russia [TL]. At an undefined locality in Mongolia, later found in the Oyu Togoi porphyry Cu–Au deposit. In the Tilva Mika deposit, Bor, eastern Serbia. At Baia Borşa, Romania. From the Kafan copper deposit, Armenia. In the Osarizawa mine, Akita Prefecture, and the Hayakawa Cu–Pb–Zn deposit, Hokkaido, Japan. At Bisbee, Cochise Co., Arizona, and in the Geis Au–Ag–Te deposit, Judith Mountains, Fergus Co., Montana, USA.

Name: For the chemical relation with sulvanite.

Type Material: n.d.

References: (1) Betekhtin, A.G. (1941) The new mineral arsenosulvanite. Zap. Vses. Mineral. Obshch., 70, 161–164 (in Russian with English abs.). (2) Mikheev, V.I. (1941) The structure of arsenosulvanite. Zap. Vses. Mineral. Obshch., 70, 165–184 (in Russian with English abs.). (3) (1955) Amer. Mineral., 40, 368–369 (abs. refs. 1 and 2). (4) Khoroshilova, L.A., O.V. Frank-Kamenetskaya, I. Rozhdestvenskaya, and V.A. Frank-Kamenetskaya (1984) The crystalline structure of arsenosulvanite. In: Yushkin, N.P. and A.M. Askhabov, Eds. Mineralogical, crystallography and the properties of minerals. Trudy Institut Geologii, 46, 78–83 (in Russian). (5) Cvetković, L. and L. Karanović (1993) Occurrence of arsenosulvanite at the Bor copper deposit, Eastern Serbia, Yugoslavia. Neues Jahrb. Mineral., Monatsh., 289–296. (6) Spry, P.G., S. Merlino, S. Wang, X. Zhang, and P.R. Busek (1994) New occurrences and refined crystal chemistry of colusite, with comparisons to arsenosulvanite. Amer. Mineral., 79, 750–762. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 26.

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Arsenpolybasite $(Ag, Cu)_{16}(As, Sb)_2S_{11}$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Thin pseudohexagonal crystals, tabular on {001}, to 6 cm. *Twinning:* Twin plane {110}, repeated.

Physical Properties: *Cleavage:* Imperfect on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–3 VHN = n.d. D(meas.) = 6.18–6.23 D(calc.) = n.d.

Optical Properties: Opaque, translucent in thin fragments. *Color:* Black; dark red in transmitted light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Biaxial (–). *Pleochroism:* In reflected light, weak. *Orientation:* $X = c$; $Y = a$. *Dispersion:* Very strong. $n = > 2.72$ (Li). 2V(meas.) = 22° *Anisotropism:* Moderate.
R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/m$. $a = 26.08$ $b = 15.04$ $c = 23.84$ $\beta = 90°$ Z = 16

X-ray Powder Pattern: Synthetic $(Ag_{14.32}Cu_{1.68})_{\Sigma=16.00}As_2S_{11}$.
3.010 (100), 1.8414 (60), 3.081 (40), 2.839 (35), 2.0935 (30), 6.38 (25), 6.02 (25)

Chemistry:

	(1)
Ag	71.20
Cu	3.26
Fe	0.38
As	6.87
Sb	0.80
S	17.37
Total	99.88

(1) Freiberg, Germany; corresponding to $(Ag_{14.09}Cu_{1.10}Fe_{0.14})_{\Sigma=15.33}(As_{1.96}Sb_{0.14})_{\Sigma=2.10}S_{11.57}$.

Occurrence: Formed in silver-bearing hydrothermal veins of low to medium temperature.

Association: Pyrargyrite, stephanite, tetrahedrite, acanthite, silver, gold, pyrite, quartz, calcite, dolomite.

Distribution: At the Neuer Morgenstern mine, Freiberg, Saxony, Germany [TL]. In Chile, at Quespisiza. From Creede, Mineral Co., Colorado, USA. In the Santo Niño Ag–Pb–Zn vein, Fresnillo district, Zacatecas, Mexico.

Name: For the chemical composition and close relation to polybasite.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 82633, 110527.

References: (1) Frondel, C. (1963) Isodimorphism of the polybasite and pearceite series. Amer. Mineral., 48, 565–572. (2) Harris, D.C., E.W. Nuffield, and M.H. Frohberg (1965) Studies of polybasite, pearceite, antimonpearceite, and arsenpolybasite. Can. Mineral., 8, 172–184. (3) Sugaki, A., A. Kitakaze, and T. Yoshimoto (1983) Synthesized minerals of polybasite and pearceite series. Sci. Rep. Tohoku Univ., 15, 461–469.

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Arsentsumebite $Pb_2Cu(AsO_4)(SO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As distorted crystals, to 2 mm, in aggregates and crusts. *Twinning:* Complex, observed.

Physical Properties: *Fracture:* [Uneven] (by analogy to tsumebite). *Tenacity:* [Brittle.] Hardness = [3.5] D(meas.) = 6.46 D(calc.) = 6.39

Optical Properties: Semitransparent. *Color:* Grass-green to apple-green. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* X = pale pistachio-green; $Y = Z$ = bottle-green. $\alpha = 1.970$ $\beta = 1.992$ $\gamma = 2.011$ 2V(meas.) = 88°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.85$ $b = 5.92$ $c = 7.84$ $\beta = 112.6°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia; close to tsumebite. (ICDD 25-456). 3.25 (100), 4.80 (65), 2.76 (60), 3.64 (46), 2.96 (40), 3.01 (32), 2.094 (30)

Chemistry:

	(1)	(2)
SO_3	9.36	10.97
P_2O_5	0.55	
As_2O_5	13.45	15.74
CuO	10.61	10.90
PbO	61.91	61.16
H_2O	1.58	1.23
Total	97.46	100.00

(1) Tsumeb, Namibia; by electron microprobe, As_2O_5 originally given as As_2O_3, H_2O by CHN analyzer. (2) $Pb_2Cu(AsO_4)(SO_4)(OH)$.

Mineral Group: Brackebuschite group.

Occurrence: A rare mineral in the oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia); in a hydrothermal polymetallic barite–fluorite deposit (Clara mine, Germany).

Association: Malachite, cerussite, azurite, smithsonite, mimetite, bayldonite, conichalcite, duftite, quartz, iron oxide (Tsumeb, Namibia).

Distribution: From Tsumeb, Namibia. In the Clara mine, near Oberwolfach, Black Forest, Germany. At Moldava, 20 km northwest of Teplice, Czech Republic. From the Buckhorn mine, Red Cloud district, Lincoln Co., New Mexico, USA. From the From the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia, and at Broken Hill, New South Wales, Australia.

Name: As the *arsenate* analog of *tsumebite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 134586.

References: (1) Bideaux, R.A., M.C. Nichols, and S.A. Williams (1966) The arsenate analog of tsumebite, a new mineral. Mineral. Soc. Amer. Annual Meeting. Amer. Mineral., 51, 258–259 (abs.). (2) Schlüter, J., G. Gebhard, and G. Wappler (1994) Tsumebit oder Arsentsumebit aus Tsumeb? Lapis, 19(10), 31–34, 86 (in German).

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Arsenuranospathite $HAl(UO_2)_4(AsO_4)_4 \cdot 40H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* n.d. As crusts of wedgelike bladed or acicular crystals, to 0.3 mm, exhibiting {100}, {010}, {001}, and rarely {110}.

Physical Properties: *Cleavage:* Perfect on {001}; good on {100} and {010}. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 2.54 Weak greenish fluorescence under SW UV. Radioactive. Dehydrates readily in air.

Optical Properties: Transparent to translucent. *Color:* Pale yellow, yellowish brown. *Streak:* White.
Optical Class: Biaxial (–). *Orientation:* $X = c$; Z = elongation; length positive.
Dispersion: $r > v$. $\alpha = \ll 1.538$ $\beta = \simeq 1.538$ $\gamma = 1.542(3)$ $2V(meas.) = \sim 52°$

Cell Data: *Space Group:* $P4_2/n$ (pseudocell). $a = 7.16$ $c = 30.37$ Z = 2

X-ray Powder Pattern: Menzenschwand, Germany.
14.62 (10), 7.62 (10), 3.49 (9), 5.03 (8), 3.59 (5), 3.24 (4), 2.25 (3)

Chemistry: (1) Menzenschwand, Germany; Al, As, and U confirmed by microchemical and spectrochemical techniques, formula established by analogy to uranospathite and similarity of X-ray pattern to synthetic material.

Occurrence: A very rare secondary mineral in uranium deposits.

Association: Zeunerite, uranophane, studtite, uranospinite, ianthinite, metakirchheimerite, "uranocircite"–heinrichite, barite, "limonite".

Distribution: In Germany, in the Black Forest, at Menzenschwand and on the dump of the Sophia mine, near Wittichen. From the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France.

Name: As the *arsenate* analog of *uranospathite*.

Type Material: n.d.

References: (1) Walenta, K. (1978) Uranospathite and arsenuranospathite. Mineral. Mag., 42, 117–128. (2) (1979) Amer. Mineral., 64, 465 (abs. ref. 1).

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Arsenuranylite $Ca(UO_2)_4(AsO_4)_2(OH)_4 \cdot 6H_2O(?)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As fine scales and lichenlike incrustations of elongated crystals, to 0.5 mm.

Physical Properties: *Cleavage:* One, perfect. Hardness = 2–3 D(meas.) = n.d. D(calc.) = 4.25 Radioactive.

Optical Properties: Semitransparent. *Color:* Deep orange; yellow in transmitted light. *Optical Class:* Biaxial (–). $\alpha = 1.737$ $\beta = 1.761$ $\gamma = 1.771$–1.778 2V(meas.) = n.d.

Cell Data: *Space Group: Bmmb.* $a = 15.40$ $b = 17.40$ $c = 13.768$ Z = 6

X-ray Powder Pattern: Cherkasar deposit, Uzbekistan.
7.72 (10), 3.85 (10), 8.41 (8), 3.13 (8), 3.42 (7), 1.778 (7), 1.729 (7)

Chemistry:

	(1)	(2)
UO_3	68.64	72.68
As_2O_5	16.68	14.60
CaO	3.48	3.56
H_2O	9.15	9.16
Total	97.95	100.00

(1) Cherkasar deposit, Uzbekistan; corresponding to $Ca_{1.00}(UO_2)_{3.89}(AsO_4)_{2.34} \cdot 8.10H_2O$.
(2) $Ca(UO_2)_4(AsO_4)_2(OH)_4 \cdot 6H_2O$.

Occurrence: In the oxidized zone of a uranium deposit containing arsenic-bearing sulfides (Cherkasar deposit, Uzbekistan).

Association: Paraschoepite, schoepite, metazeunerite, nováčekite, uranospinite (Cherkasar deposit, Uzbekistan).

Distribution: From the Cherkasar uranium deposit, 30 km northwest of Pap, Chatkal Range, Uzbekistan. At Menzenschwand, Black Forest. Germany.

Name: For ARSENic and URANium in its composition and probable relation to *phosphuranylite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64434.

References: (1) Belova, L.N. (1958) Arsenuranylite – the arsenic analogue of phosphuranylite. Zap. Vses. Mineral. Obshch., 87, 598–602 (in Russian). (2) (1959) Amer. Mineral., 44, 208 (abs. ref. 1). (3) (1960) Mineral. Abs., 14, 344 (addendum to abs. ref. 1). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 30.

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Arsiccioite $AgHg_2TlAs_2S_6$

Crystal Data: Tetragonal. *Point Group*: $\bar{4}$ 2 *m*. As irregular grains, to 1 mm, between barite crystals.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle.
VHN = 111-132, 124 average (50 g load). Hardness = 2-2.5 D(meas.) = n.d. D(calc.) = 5.989

Optical Properties: Opaque. *Color*: Red, yellowish white in reflected light, internal reflections weak, deep red. *Streak*: Orange. *Luster*: Metallic to submetallic. *Pleochroism*: None.
Anisotropism: Weak, gray to bluish.
Optical Class: n.d.
R_1-R_2: (471.1) 29.0-29.4, (548.3) 27.6-28.3, (586.6) 26.1-26.5, (652.3) 24.2- 24.6

Cell Data: *Space Group*: $I\bar{4}$ 2*m*. *a* = 10.1386(6) *c* = 11.3441(5) Z = 4

X-ray Powder Pattern: Monte Arsiccio mine, Apuan Alps, Tuscany, Italy.
3.025 (vs), 2.518 (s), 4.195 (m), 3.542 (m), 2.636 (m), 5.04 (w), 2.126 (w)

Chemistry:

	(1)
Cu	0.78
Ag	8.68
Zn	0.47
Fe	0.04
Hg	35.36
Cd	0.20
Tl	18.79
As	10.77
Sb	4.75
S	18.08
Se	0.07
Total	97.99

(1) Monte Arsiccio mine, Italy; average of 5 electron microprobe analyses; corresponding to $(Ag_{0.87}Cu_{0.13}Fe_{0.01})_{\Sigma=1.01}(Hg_{1.91}Zn_{0.08}Cd_{0.02})_{\Sigma=2.01}Tl_{1.00}(As_{1.56}Sb_{0.42})_{\Sigma=1.98}S_{6.12}Se_{0.01}$.

Polymorphism & Series: Forms a series with routhierite.

Occurrence: In a lens of microcrystalline barite near the contact between schist and pyrite-rich dolostone. The assemblage interpreted as crystallized from a sulfide melt during greenschist-facies metamorphism.

Association: Protochabournéite, cinnabar, laffittite, pyrite, realgar, Hg-bearing sphalerite, stibnite, barite.

Distribution: From near the junction of the Sant'Olga tunnel and Farioli shaft, Monte Arsiccio mine, near Sant'Anna di Stazzema, Apuan Alps, Tuscany, Italy.

Name: For the mine that produced the first specimens.

Type Material: Natural History Museum, University of Pisa, Italy (# 19659), and the Natural History Museum, Università degli Studi di Firenze, Florence, Italy (# 3132/I).

References: (1) Biagioni, C., E. Bonaccorsi, Y. Moëlo, P. Orlandi, L. Bindi, M. D'Orazio, and S. Vezzoni (2014) Mercury-arsenic sulfosalts from the Apuan Alps (Tuscany, Italy). II. Arsiccioite, $AgHg_2TlAs_2S_6$, a new mineral from the Monte Arsiccio mine: occurrence, crystal structure and crystal chemistry of the routhierite isotypic series. Mineral. Mag., 78(1), 101-117. (2) (2014) Amer. Mineral., 99, 1806 (abs. ref. 1).

Arthurite $\mathbf{CuFe_2^{3+}(AsO_4,PO_4,SO_4)_2(O,OH)_2 \cdot 4H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic to acicular crystals, to 5 mm; usually as spherical aggregates and thin crusts.

Physical Properties: Hardness = n.d. D(meas.) = ∼3.2 D(calc.) = 3.29

Optical Properties: Transparent to translucent. *Color:* Apple-green to bluish green; pale olive-green in transmitted light.
Optical Class: Biaxial (+), may be biaxial (–). *Pleochroism:* X = colorless to pale green; Y = gray-green; Z = olive-green. *Orientation:* $Y = b$; $Z \wedge c = 10°$. *Absorption:* $Z > Y > X$.
$\alpha = 1.736$ $\beta = 1.767$ $\gamma = 1.796$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.189(2)$ $b = 9.649(2)$ $c = 5.598(1)$
$\beta = 92.16(2)°$ Z = 2

X-ray Powder Pattern: Hingston Down Consols mine, England.
4.28 (vvs), 4.81 (vvs), 6.97 (vvs), 10.08 (vs), 2.801 (vs), 2.912 (s), 3.44 (ms)

Chemistry:

	(1)	(2)
SO_3	[3.2]	3.2
P_2O_5	[5.5]	5.5
As_2O_5	31.3	36.5
Fe_2O_3	29.7	27.6
CuO	15.3	17.5
H_2O	15.0	[9.7]
Total	[100.0]	[100.0]

(1) Hingston Down Consols mine, England; H_2O by loss on ignition; after deduction of quartz 27.4%, and addition of SO_3 and P_2O_5 from analysis (2); then corresponds to $Cu_{1.02}Fe_{1.98}[(As_{0.69}P_{0.20}S_{0.11})_{\Sigma=1.00}O_4]_2(O,OH)_2 \cdot 4H_2O$. (2) Do.; by electron microprobe, H_2O by difference.

Mineral Group: Arthurite group.

Occurrence: A rare secondary mineral in the oxidized zone of some copper deposits, formed by alteration of arsenopyrite or enargite.

Association: Pharmacosiderite, scorodite, conichalcite, chenevixite, chalcophyllite, brochantite, quartz.

Distribution: In England, in Cornwall, from the Hingston Down Consols mine, Calstock, the Gunheath china clay pit, St. Austell, and the Cligga Head mine, Perranzabuloe. From the Clara mine, near Oberwolfach, Black Forest, Germany. In the Bendada pegmatite, near Guarda, Portugal. From Rodalquilar, Almería Province, Spain. At the Potrerillos mine, Atacama, Chile. Fine crystals from the Majuba Hill mine, Antelope district, Pershing Co., Nevada; at the Black Pine mine, near Philipsburg, Granite Co., Montana; from Gold Hill, Tooele Co., Utah, USA. In the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia.

Name: Honors Sir Arthur Edward Ian Montagu Russell (1878–1964) and Arthur William Gerald Kingsbury (1906–1968) for their substantial contributions to British mineralogy.

Type Material: The Natural History Museum, London, England, 1964,74–75 and 1964,80.

References: (1) Davis, R.J. and M.H. Hey (1964) Arthurite, a new copper–iron arsenate from Cornwall. Mineral. Mag., 33, 937–941. (2) (1965) Amer. Mineral., 50, 522 (abs. ref. 1). (3) Davis, R.J. and M.H. Hey (1969) The cell-contents of arthurite redetermined. Mineral. Mag., 37, 520–521. (4) Keller, P. and H. Hess (1978) Die kristallstruktur von Arthurit, $CuFe_2^{3+}[(H_2O)_4|(OH)_2|(AsO_4)_2]$. Neues Jahrb. Mineral., Abh., 133, 291–302 (in German with English abs.).

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Artinite $Mg_2(CO_3)(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically acicular along [010], to 2.5 cm, forming cross-fiber veinlets, botyroidal crusts, and spherical or bow tie aggregates of divergent crystals.

Physical Properties: *Cleavage:* {100}, perfect; {001}, good. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.02–2.03 D(calc.) = 2.047

Optical Properties: Transparent. *Color:* White; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, silky to satiny in aggregates. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 30°$. $\alpha = 1.488(1)$ $\beta = 1.534(1)$ $\gamma = 1.556(1)$ 2V(meas.) = 70°

Cell Data: *Space Group:* $C2/m$. $a = 16.561(5)$ $b = 6.298(3)$ $c = 6.220(3)$ $\beta = 99°9(10)'$ Z = 1

X-ray Powder Pattern: Locality not stated. (ICDD 6-484).
2.736 (100), 5.34 (65), 3.69 (50), 2.210 (40), 8.18 (30), 2.672 (20), 2.271 (20)

Chemistry:

	(1)	(2)
CO_2	22.36	22.38
MgO	40.97	40.98
H_2O	36.62	36.64
Total	99.95	100.00

(1) Monte Ramazzo, Italy. (2) $Mg_2(CO_3)(OH)_2 \cdot 3H_2O$.

Occurrence: A low-temperature mineral in weathered or altered ultramafic rocks, typically serpentinites, likely occurring worldwide.

Association: Brucite, hydromagnesite, pyroaurite, chrysotile, aragonite, calcite, dolomite, magnesite.

Distribution: Well-studied or good specimen material, from: in Italy, in Lombardy, from the Franscia asbestos mine, at Torre Santa Maria and Rocca Castellaccio, Val Lanterna, all in Val Malenco; at Emarese and Cogne, Val d'Aosta, Piedmont; from Viu, near Fubina, Val di Lanzo; and on Mont Ramazzo, north of Borzoli, Liguria. From Kraubath, Styria, Austria. Near Javornica, Bulgaria. In the USA, in California, from northwest of Coalinga, Fresno Co. and into San Benito Co., as fine examples at the Clear Creek mine, west of San Benito Mountain, and elsewhere in the New Idria district; at the Gabbs mine, Gabbs district, Nye Co., Nevada; from Spring Street, Staten Island, New York; at Signal Hill, Hoboken, Hudson Co., New Jersey; in the Belvidere Mountain quarry, Orleans Co., Vermont. In Japan, from Nakauri, Aichi Prefecture, at Hirotani, Fukuoka Prefecture, and along the Utonai River, Hokkaido. From the Ijim massif, Sayan Mountains, Siberia, Russia.

Name: Honors Professor Ettore Artini (1866–1928), Italian mineralogist, University of Milan and Director of the Natural History Museum, Milan, Italy.

Type Material: Natural History Museum, Milan, Italy, 13215, 13217, 22182, 22191.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 263–264. (2) de Wolff, P.M. (1952) The crystal structure of artinite, $Mg_2(OH)_2CO_3 \cdot 3H_2O$. Acta Cryst., 5, 286–287. (3) Jagodzinski, H. Kristallstruktur und Fehlordnung des Artinits $Mg_2[CO_3(OH)_2].3H_2O$. (1965) Tschermaks Mineral. Petrog. Mitt., 10, 297–330 (in German with English abs.). (4) Akao, M. and S. Iwai (1977) The hydrogen bonding of artinite. Acta Cryst., 33, 3951–3953.

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Artroeite $PbAlF_3(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals bladed, flat tabular on $\{10\overline{1}\}$, elongated along [010], to 1 mm, with forms {100}, {010}, {001}, $\{10\overline{1}\}$, {011}, $\{11\overline{1}\}$, and {121}. *Twinning:* Common, by rotation about [010] with composition plane {100}.

Physical Properties: *Cleavage:* Perfect on {100}, good on {010}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 5.36(2) D(calc.) = 5.43

Optical Properties: Semitransparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X \wedge c = 10°$; $Y \wedge a = 42°$; $Z \wedge b = 50°$. *Dispersion:* $r > v$, strong. $\alpha = 1.629(1)$ $\beta = 1.682(2)$ $\gamma = 1.691(2)$ 2V(meas.) = 41(2)° 2V(calc.) = 42°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.270(2)$ $b = 6.821(3)$ $c = 5.057(2)$ $\alpha = 90.68(2)°$ $\beta = 107.69(2)°$ $\gamma = 104.46(2)°$ Z = 2

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
4.42 (100), 2.595 (70), 2.190 (65), 2.030 (50), 3.221 (40), 2.015 (40), 4.05 (35)

Chemistry:

	(1)	(2)
PbO	67.5	68.64
Al_2O_3	15.6	15.68
F	16.1	17.52
H_2O	6.0	5.54
$-O = F_2$	6.8	7.38
Total	98.4	100.00

(1) Grand Reef mine, Arizona, USA; by electron microprobe, average of ten analyses, H_2O by TGA; corresponds to $Pb_{1.00}Al_{1.01}F_{2.80}(OH)_{2.20}$. (2) $PbAlF_3(OH)_2$.

Occurrence: In the oxidized zone of an epithermal Cu–Pb–Ag deposit.

Association: Calcioaravaipaite, quartz, anglesite, fluorite, galena, linarite, muscovite.

Distribution: From the Grand Reef mine, near Klondyke, Aravaipa district, Graham Co., Arizona, USA.

Name: Honors Dr. Arthur Roe (1912–1993), American chemist and collector of microscopic minerals, Tucson, Arizona, USA.

Type Material: Natural History Museum, Los Angeles, California, USA, 39338.

References: (1) Kampf, A.R. and E.E. Foord (1995) Artroeite, $PbAlF_3(OH)_2$, a new mineral from the Grand Reef mine, Graham Co., Arizona: description and crystal structure. Amer. Mineral., 80, 179–183. (2) Kampf, A.R. and E.E. Foord (1996) Calcioaravaipaite, a new mineral, and associated lead fluoride minerals from the Grand Reef mine, Graham County, Arizona. Mineral. Record, 27, 293–300.

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Artsmithite $Hg_4^{1+}Al(PO_4)_{2-x}(OH)_{1+3x}$ (x = 0.26)

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are short prismatic, to 5 μm, in granular aggregates.

Physical Properties: Hardness = 1.5–2 D(meas.) = n.d. D(calc.) = 2.85

Optical Properties: Translucent. *Color:* Turquoise-blue to sky-blue. *Luster:* Earthy. *Optical Class:* Biaxial. *Pleochroism:* X = blue; Z = colorless. $\alpha = 1.632(5)$ (α'). β = n.d. $\gamma = 1.680(5)$ (γ'). 2V(meas.) = n.d.

Cell Data: *Space Group:* $[I2/m]$ (by analogy to vivianite). $a = 9.889(15)$ $b = 13.225(11)$ $c = 4.645(4)$ $\beta = 102.41(11)^\circ$ Z = 2

X-ray Powder Pattern: Santa Catherina meteorite.
6.624 (100), 7.878 (26), 4.818 (24), 3.152 (24), 2.922 (23), 3.805 (21), 2.672 (17)

Chemistry:

	(1)	(2)
P_2O_5	27.60	27.83
FeO	4.53	
CoO	0.39	
NiO	40.18	43.92
H_2O	[27.30]	28.25
Total	[100.00]	100.00

(1) Santa Catherina meteorite; by electron microprobe, total Fe as FeO, H_2O by difference; corresponds to $(Ni_{2.78}Fe^{2+}_{0.33}Co_{0.03})_{\Sigma=3.14}(PO_4)_{2.01}O_{0.12}\bullet 7.84H_2O$. (2) $Ni_3(PO_4)_2\bullet 8H_2O$.

Mineral Group: Vivianite group.

Occurrence: A weathering product of a nickel-rich iron meteorite.

Association: Reevesite, honessite, akaganéite, hematite, goethite, magnetite.

Distribution: In the Santa Catherina iron meteorite.

Name: To honor Hans Henning Arup (1928–), Director of the Danish Corrosion Center, Copenhagen, Denmark.

Type Material: Division of Meteorites, National Museum of Natural History, Washington, D.C., USA, 659, 804, 877.

References: (1) Buchwald, V.F. (1990) A new mineral, arupite, $Ni_3(PO_4)_2\bullet 8H_2O$, the nickel analog of vivianite. Neues Jahrb. Mineral., Monatsh., 76–80. (2) (1990) Amer. Mineral., 75, 1209 (abs. ref. 1).

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are short prismatic, to 5 μm, in granular aggregates.

Physical Properties: Hardness = 1.5–2 D(meas.) = n.d. D(calc.) = 2.85

Optical Properties: Translucent. *Color:* Turquoise-blue to sky-blue. *Luster:* Earthy. *Optical Class:* Biaxial. *Pleochroism:* X = blue; Z = colorless. $\alpha = 1.632(5)$ (α'). β = n.d. $\gamma = 1.680(5)$ (γ'). 2V(meas.) = n.d.

Cell Data: *Space Group:* $[I2/m]$ (by analogy to vivianite). $a = 9.889(15)$ $b = 13.225(11)$ $c = 4.645(4)$ $\beta = 102.41(11)°$ $Z = 2$

X-ray Powder Pattern: Santa Catherina meteorite.
6.624 (100), 7.878 (26), 4.818 (24), 3.152 (24), 2.922 (23), 3.805 (21), 2.672 (17)

Chemistry:

	(1)	(2)
P_2O_5	27.60	27.83
FeO	4.53	
CoO	0.39	
NiO	40.18	43.92
H_2O	[27.30]	28.25
Total	[100.00]	100.00

(1) Santa Catherina meteorite; by electron microprobe, total Fe as FeO, H_2O by difference; corresponds to $(Ni_{2.78}Fe^{2+}_{0.33}Co_{0.03})_{\Sigma=3.14}(PO_4)_{2.01}O_{0.12} \cdot 7.84H_2O$. (2) $Ni_3(PO_4)_2 \cdot 8H_2O$.

Mineral Group: Vivianite group.

Occurrence: A weathering product of a nickel-rich iron meteorite.

Association: Reevesite, honessite, akaganéite, hematite, goethite, magnetite.

Distribution: In the Santa Catherina iron meteorite.

Name: To honor Hans Henning Arup (1928–), Director of the Danish Corrosion Center, Copenhagen, Denmark.

Type Material: Division of Meteorites, National Museum of Natural History, Washington, D.C., USA, 659, 804, 877.

References: (1) Buchwald, V.F. (1990) A new mineral, arupite, $Ni_3(PO_4)_2 \cdot 8H_2O$, the nickel analog of vivianite. Neues Jahrb. Mineral., Monatsh., 76–80. (2) (1990) Amer. Mineral., 75, 1209 (abs. ref. 1).

Arzakite $Hg_3S_2(Br,Cl)_2$

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Crystal Data: Monoclinic (perhaps triclinic). *Point Group:* $2/m$, 2, or m. As complex intergrowths with lavrentievite, to 0.2 mm. *Twinning:* Noted.

Physical Properties: *Cleavage:* Perfect in two directions parallel to elongation. *Fracture:* Rough. *Tenacity:* Brittle. Hardness = 2.0–2.5 VHN = 85–90 (10 g load). D(meas.) = n.d. D(calc.) = 7.69

Optical Properties: Transparent. *Color:* Colorless to yellow, pale bog-brown, reddish brown, deepening on exposure to light; grayish to yellowish brown in thin section; gray in reflected light, with pale yellow to pale brown internal reflections. *Luster:* Vitreous to adamantine. *Streak:* Grayish yellow.
Optical Class: Biaxial. *Pleochroism:* Weak. *Orientation:* Extinction parallel to cleavage. *Bireflectance:* Very weak, grayish white to gray.
R_1–R_2: (546) 16.5–17.0, (590) 15.2–16.7, (620) 14.8–16.0, (656) 14.5–16.0

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. $a = 8.99(4)$ $b = 5.24(1)$ $c = 18.45(8)$ $\beta = 92.28(15)^\circ$ $Z = 5$

X-ray Powder Pattern: Arzak deposit, Russia; differs only by intensities from lavrentievite. 2.63 (10), 3.02 (6), 3.41 (5), 3.99 (4), 2.313 (4), 1.594 (4), 5.05 (3)

Chemistry:

	(1)	(2)
Hg	76.74	77.02
S	7.80	8.21
Br	12.06	10.23
Cl	3.29	4.54
Total	99.89	100.00

(1) Arzak deposit, Russia; by electron microprobe, average of five grains; corresponding to $Hg_{3.08}S_{1.96}(Br_{1.22}Cl_{0.75})_{\Sigma=1.97}$. (2) $Hg_3S_2(Br,Cl)_2$ with Br:Cl = 1:1.

Polymorphism & Series: Forms a series with lavrentievite.

Occurrence: In the oxidized zone of a hydrothermal deposit.

Association: Lavrentievite, cinnabar, corderoite, quartz, kaolinite.

Distribution: From the Arzak deposit, Pii-Khem district, Uyuk Range, Tuva, Siberia, Russia [TL].

Name: For the occurrence in the Arzak deposit, Russia.

Type Material: Mining Institute, St. Petersburg, 1677/1; Central Siberian Geological Museum, Novosibirsk, Russia, VI-24/1.

References: (1) Vasil'ev, V.L., N.A. Pal'chik, and O.K. Grechishchev (1984) Lavrentievite and arzakite, new natural sulfohalogenides of mercury. Geol. i Geofiz., 7, 54–63 (in Russian). (2) (1985) Amer. Mineral., 70, 873–874 (abs. ref. 1). (3) (1984) Chem. Abs., 101, 174794 (abs. ref. 1). (4) Vasil'ev, V.I., Y.G. Lavrent'ev, and N.A. Pal'chik (1986) New data on arzakite and lavrentievite. Doklady Acad. Nauk SSSR, 290, 948–951 (in Russian).

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Asbecasite $\mathbf{Ca_3(Ti,Sn^{4+})As_6^{3+}Si_2Be_2O_{20}}$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As rhombohedral crystals, up to 5 mm, flattened on {0001}, with $\{01\bar{1}2\}$.

Physical Properties: *Cleavage:* Rhombohedral. Hardness = 6.5–7 D(meas.) = 3.70 D(calc.) = 3.71

Optical Properties: Transparent. *Color:* Lemon-yellow or citron-yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–); anomalously biaxial. $\omega = 1.86$ $\epsilon = 1.83$ 2V(meas.) = 0°–17°

Cell Data: *Space Group:* $P3c1$. a = 8.36(2) $c = 15.30(3)$ Z = 2

X-ray Powder Pattern: Cherbadung, Switzerland.
3.231 (100), 2.404 (70), 1.929 (60), 1.571 (50), 1.154 (50), 1.746 (50), 4.030 (50)

Chemistry:

	(1)
SiO_2	12.3
TiO_2	6.3
SnO_2	2.1
Al_2O_3	1.2
As_2O_3	58.7
Tl_2O_3	1.0
BeO	2.3
CaO	15.4
Total	99.3

(1) Cherbadung, Switzerland; purity confirmed by electron microprobe; corresponds approximately to $Ca_{2.67}(Ti_{0.67}Sn_{0.13}Tl_{0.04})_{\Sigma=0.84}As^{3+}_{6.67}Si_{2.00}Al_{0.27}Be_{1.00}O_{20}$.

Occurrence: On cleft faces in orthogneiss (Cherbadung, Switzerland).

Association: Magnetite, hematite, titanite, apatite, anatase, malachite, azurite, tennantite, molybdenite (Cherbadung, Switzerland).

Distribution: On the east flank of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Italy. On the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais, Switzerland.

Name: For elements in the composition, *As, Be, Ca, Si.*

Type Material: Natural History Museum, Basel, Switzerland, SG750; The Natural History Museum, London, England, 1966,222; National Museum of Natural History, Washington, D.C., USA, 143117.

References: (1) Graeser, S. (1966) Asbecasit und cafarsit, zwei neue Mineralien aus dem Binnatal (Kt. Wallis). Schweiz. Mineral. Petrog. Mitt., 46, 367–375 (in German with English abs.). (2) (1967) Amer. Mineral., 52, 1583–1584 (abs. ref. 1). (3) Cannillo, E., G. Giuseppetti, and C. Taadini (1970) The crystal structure of asbecasite. Atti Rend. Accad. Lincei, 46, 457–467. (4) (1970) Amer. Mineral., 55, 1818 (abs. ref. 3). (5) Graeser, S. and A.G. Roggiani (1976) Occurrence and genesis of rare arsenate and phosphate minerals around Pizzo Cervandone, Italy/Switzerland. Rend. Soc. Ital. Mineral. Petrol., 32, 279–288. (6) Downs, J.W. and G.V. Gibbs (1981) The role of the BeOSi bond in the structures of beryllosilicate minerals. Amer. Mineral., 66, 819–826.

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Asbolane $(Ni, Co)_xMn^{4+}(O, OH)_4 \cdot nH_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. Platelets, to several μm, in thin lamellar aggregates; massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: [Opaque.] *Color:* Brownish black.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 2.832$ $c = 9.34$, or $a = 3.04$ $c = 9.34$ Z = n.d.

X-ray Powder Pattern: Lipov deposit, Russia.
4.82 (s), 2.445 (mw), 9.6 (w), 1.7 (vw), 1.419 (vw)

Chemistry:

	(1)
SiO_2	0.6
Al_2O_3	0.1
Fe_2O_3	0.9
Co_2O_3	1.0
MnO	66.7
NiO	17.9
H_2O	[12.8]
Total	[100.0]

(1) New Caledonia; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference. (2) Lipov deposit, Russia; TEM energy-dispersive analysis, supported by TGA and IR, not given, is stated to correspond to $(Ni_{0.28}Co_{0.12}Ca_{0.05})_{\Sigma=0.45}MnO_{1.5}(OH)_2 \cdot 0.64H_2O$.

Occurrence: As a weathering product in silicic rocks (Russia); in siliceous schists (Kara-Chagyra, Uzbekistan); widespread in residual soils above ultramafic rocks (New Caledonia).

Association: Goethite.

Distribution: From Kamsdorf, Thuringia, Germany. In the Lipov and Tyulenev deposits, Middle Ural Mountains, and the Buranov deposit, Southern Ural Mountains, Russia. At Kara-Chagyra, Uzbekistan. In the San Luis mine, Chulchucani, Potosi, Bolivia. Found at a number of places in New Caledonia. Probably from additional localities, but careful characterization is required.

Name: From the Greek for *to soil like soot*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 566, 568 [asbolite, asbolan]. (2) Chukhrov, F.V., A.I. Gorshkov, I.V. Vitovskaya, V.A. Drits, A.V. Sivtsov, and Y.S. Rudnitskaya (1980) Crystallochemical nature of Co-Ni-asbolan. Izv. Akad. Nauk SSSR, Ser. Geol., no. 6, 73–81 (in Russian). (3) Chukhrov, F.V., A.I. Gorshkov, I.V. Vitovskaya, V.A. Drits, A.V. Sivtsov, and Y.P. Dikov (1980) Crystallochemical nature of Ni-asbolan. Izv. Akad. Nauk SSSR, Ser. Geol., no. 9, 108–120 (in Russian). (4) (1981) Mineral. Abs., 32, 322 (abs. ref. 2). (5) (1982) Amer. Mineral., 67, 417–418 (abs. refs. 2 and 3). (6) Llorca, S. and P. Monchoux (1991) Supergene cobalt minerals from New Caledonia. Can. Mineral., 29, 149–161. (7) Manceau, A., A.I. Gorshkov, and V.A. Drits (1992) Structural chemistry of Mn, Fe, Co, and Ni in manganese hydrous oxides: part II. Information from EXAFS spectroscopy and electron and X-ray diffraction. Amer. Mineral., 77, 1144–1157.

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Aschamalmite $Pb_6Bi_2S_9$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As prismatic, lathlike crystals, to 5 cm; also as thick, slightly bent plates.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. VHN = 150–181 (25 g load). D(meas.) = n.d. D(calc.) = 7.33

Optical Properties: Opaque. *Color:* Lead-gray; creamy white in reflected light. *Luster:* Metallic. *Anisotropism:* Moderate, from gray to red-brown.
R_1–R_2: (470) 45.1–48.1, (546) 43.4–46.3, (589) 42.9–46.3, (650) 42.9–46.3

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 13.71$ $b = 4.09$ $c = 31.43$ $\beta = 91.0°$ Z = 4

X-ray Powder Pattern: Ascham Alm, Austria.
3.426 (100), 3.378 (88), 2.941 (54), 2.926 (54), 2.861 (48), 3.525 (42), 2.067 (42)

Chemistry:

	(1)	(2)
Pb	62.95	63.76
Bi	22.56	21.44
S	14.89	14.80
Total	100.40	100.00

(1) Ascham Alm, Austria; by electron microprobe, corresponding to $Pb_{5.89}Bi_{2.05}S_{9.00}$.
(2) $Pb_6Bi_2S_9$.

Occurrence: In alpine veins, cutting gneiss.

Association: Cosalite, galena, quartz, albite, orthoclase, calcite, chlorite.

Distribution: From near Ascham Alm, Untersulzbachtal, Salzburg, Austria [TL]. At Granite Gap, Hidalgo Co., New Mexico, USA.

Name: For its occurrence at Ascham Alm, Austria.

Type Material: Museum of Natural History, Vienna, Austria; Division of Mineral Chemistry, C.S.I.R.O., Port Melbourne, Victoria, Australia; National Museum of Natural History, Washington, D.C., USA, 160379.

References: (1) Mumme, W.G., G. Niedermayr, P.R. Kelly, and W.H. Paar (1983) Aschamalmite, $Pb_{5.92}Bi_{2.06}S_9$, from Untersulzbach Valley in Salzburg, Austria – "monoclinic heyrovskyite". Neues Jahrb. Mineral., Monatsh., 433–444. (2) (1984) Amer. Mineral., 69, 810 (abs. ref. 1).

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Ashanite $(Nb, Ta, U, Fe, Mn)_4O_8$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Single crystals are mentioned but the habit is not stated.

Physical Properties: *Fracture:* Conchoidal to subconchoidal. Hardness = 5.8–6.6 VHN = 570–851 D(meas.) = 6.61(1) D(calc.) = 6.60

Optical Properties: Opaque, translucent on thin edges. *Color:* Dark brown to pitch-black; brownish red in thin section; pale bluish gray in reflected light. *Streak:* Brown. *Luster:* Semimetallic to pitchlike.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = pale brownish red; Z = dark brownish red. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Absorption:* $Z > X$. $\alpha = 2.31$ $\beta = 2.35$ $\gamma = 2.40$ 2V(meas.) = 70°–75°
R_1–R_2: (440) 12.1–12.1, (460) 11.4–11.5, (480) 11.2–11.3, (500) 11.0–11.0, (520) 11.0–11.0, (540) 10.9–10.9, (560) 10.9–10.8, (580) 10.8–10.8, (600) 10.8–10.7, (620) 10.7–10.7, (640) 10.7–10.6, (660) 10.6–10.6, (680) 10.6–10.6, (700) 10.6–10.6

Cell Data: *Space Group: Pcan.* $a = 5.869$ $b = 4.873$ $c = 5.216$ Z = 1

X-ray Powder Pattern: Altai Mountains, China.
2.95 (10), 3.65 (5), 2.54 (3), 2.51 (3), 2.38 (3), 1.729 (3), 2.874 (2)

Chemistry:

	(1)
U_3O_8	23.81
Nb_2O_5	36.76
Ta_2O_5	23.41
RE_2O_3	1.40
FeO	8.25
MnO	7.77
Total	101.40

(1) Altai Mountains, China; corresponds to $(Nb_{1.61}Fe_{0.66}Mn_{0.63}Ta_{0.61}U_{0.51}RE_{0.07})_{\Sigma=4.09}O_{7.98}$.

Occurrence: In the central part of a pegmatite in albitized two-mica granite.

Association: Tantalum-rich columbite, thorium-rich monazite, ishikawaite.

Distribution: From an undefined locality in the Altai Mountains, Sinkiang Uighur Autonomous Province, northwestern China.

Name: From Altai and SHAN, Chinese for *mountains*, for the occurrence in the Altai Mountains, China.

Type Material: n.d.

References: (1) Zhang Rubo, Tian Huixin, Peng Zhizhong, Ma Zhesheng, Han Fengming, and Jing Zebei (1980) A new mineral – ashanite, $(Nb, Ta, U, Fe, Mn)_4O_8$. Kexue Tongbao, 25, 510–514 (in English). (2) (1981) Amer. Mineral., 66, 217 (abs. ref. 1).

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Ashburtonite $HPb_4Cu_4Si_4O_{12}(HCO_3)_4(OH)_4Cl$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Prismatic along [001], to 0.4 mm, showing {110}, {100}, {001}, and {301}.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = > 4.07 D(calc.) = 4.69

Optical Properties: Transparent. *Color:* Blue. *Streak:* Light blue. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.786(3)$ $\epsilon = 1.800(4)$

Cell Data: *Space Group:* $I4/m$. $a = 14.1852(8)$ $c = 6.0759(8)$ $Z = 2$

X-ray Powder Pattern: Anticline prospect, Western Australia.
10.2 (100), 4.495 (100), 3.333 (100), 3.013 (90), 5.644 (70), 2.611 (50), 2.805 (30)

Chemistry:

	(1)
SiO_2	14.07
CuO	18.66
PbO	52.17
Cl	2.28
H_2O	[4.22]
CO_2	[10.31]
$-O = Cl_2$	0.51
Total	[101.20]

(1) Anticline prospect, Western Australia; by electron microprobe, average of four analyses, OH and CO_2 confirmed present by infrared spectroscopy, H_2O and CO_2 calculated from stoichiometry; corresponds to $Pb_{3.99}Cu_{4.01}HSi_{4.00}O_{12.03}(HCO_3)_{4.00}(OH)_{4.00}Cl_{1.10}$.

Occurrence: In a weathered shear zone cutting shales and graywackes, as an alteration of galena and probably chalcopyrite.

Association: Diaboleite, duftite, beudantite, caledonite, plattnerite, cerussite, malachite, brochantite.

Distribution: From the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia.

Name: For its occurrence near the Ashburton Downs pastoral lease and homestead, Western Australia.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 58391; Museum Victoria, Melbourne, Australia, M40712.

References: (1) Grice, J.D., E.H. Nickel, and R.A. Gault (1991) Ashburtonite, a new bicarbonate-silicate mineral from Ashburton Downs, Western Australia: description and structure determination. Amer. Mineral., 76, 1701–1707.

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Ashcroftine-(Y) $K_5Na_5(Y,Ca)_{12}Si_{28}O_{70}(CO_3)_8(OH)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As fibrous prismatic crystals, to 2 cm, striated ‖ [001]; in divergent sprays; as a fine, crystalline powder.

Physical Properties: *Cleavage:* Perfect on {100}, distinct on {001}. *Tenacity:* Flexible. Hardness = 5 D(meas.) = 2.61 D(calc.) = [2.59]

Optical Properties: Transparent to translucent. *Color:* Pale pink, white, pinkish brown, pinkish purple, deep violet-brown. *Streak:* White. *Luster:* Vitreous, may be silky. *Optical Class:* Uniaxial (+). $\omega = 1.536–1.537$ $\epsilon = 1.545–1.549$

Cell Data: *Space Group:* $I4/mmm$. $a = 24.01(1)$ $c = 17.52(1)$ Z = 4

X-ray Powder Pattern: Narssârssuk, Greenland.
17.027 (100), 12.043 (90), 7.615 (60), 3.114 (50), 2.687 (50), 5.379 (35), 6.014 (30)

Chemistry:

	(1)	(2)
SiO_2	38.09	42.69
Y_2O_3	26.61	34.37
MnO	0.79	
MgO	0.87	
CaO	5.72	
Na_2O	3.62	3.93
K_2O	5.65	5.97
H_2O^+	4.8	4.11
H_2O^-	6.40	
CO_2	7.2	8.93
Total	99.75	100.00

(1) Narssârssuk, Greenland; Y_2O_3 originally determined as Al_2O_3. (2) $K_5Na_5Y_{12}Si_{28}O_{70}(CO_3)_8(OH)_2 \cdot 8H_2O$.

Occurrence: In cavities in augite syenite (Narssârssuk, Greenland); in igneous breccia and pegmatites in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Calcite, elpidite, albite, quartz, aegirine, orthoclase, zinnwaldite, graphite (Narssârssuk, Greenland); aegirine, bastnäsite, lorenzenite, brookite, elpidite, leucosphenite, cordylite, narsarsukite (Mont Saint-Hilaire, Canada).

Distribution: From Narssârssuk, Greenland. At Mont Saint-Hilaire, Quebec, Canada. From Cava del 'Osa, near Rome, Lazio, Italy.

Name: To honor Frederick Noel Ashcroft (1878–1949), benefactor to the British Museum (Natural History), London, England.

Type Material: The Natural History Museum, London, England, 1924,867; University of Copenhagen, Copenhagen, Denmark; Harvard University, Cambridge, Massachusetts, 110266; National Museum of Natural History, Washington, D.C., USA, 95320, R4333.

References: (1) Hey, M.H. and F.A. Bannister (1933) Studies on the zeolites. Part IV. Ashcroftine (kalithomsonite of S.G. Gordon). Mineral. Mag., 23, 305–308. (2) Moore, P.B., J.M. Bennett, and S.J. Louisnathan (1969) Ashcroftine is not a zeolite! Mineral. Mag., 37, 515–517. (3) Moore, P.B., P.K. Sen Gupta, E.O. Schlemper, and S. Merlino (1987) Ashcroftine, ca. $K_{10}Na_{10}(Y,Ca)_{24}(OH)_4(CO_3)_{16}(Si_{56}O_{140}) \cdot 16H_2O$, a structure with enormous polyanions. Amer. Mineral., 72, 1176–1189. (4) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 30.

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Ashoverite $Zn(OH)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$, $\bar{4}2m$, or $4mm$. Crystals are square plates, to about 0.5 mm, which thin markedly toward their edges; commonly in stellate groups of crystals intersecting at angles of 60°–70°.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. D(meas.) = 3.3 D(calc.) = 3.44 Fluoresces bluish white under SW UV.

Optical Properties: Translucent. *Color:* Colorless to milky in the center of crystals. *Streak:* White. *Luster:* Dull to vitreous.
Optical Class: Uniaxial (+). $\omega = 1.629(2)$ $\epsilon = 1.639(2)$

Cell Data: *Space Group:* $I4_1/amd$, $I\bar{4}2d$, or $I4_1md$. $a = 6.825(2)$ $c = 33.36(4)$ Z = 32

X-ray Powder Pattern: Near Ashover, England.
2.902 (100), 1.819 (33), 1.702 (21), 1.470 (19), 3.031 (13), 1.0063 (13), 3.332 (11)

Chemistry:

	(1)	(2)
ZnO	84.46	81.88
PbO	2.06	
CdO	0.71	
CaO	0.15	
H_2O	14.9	18.12
Total	102.28	100.00

(1) Near Ashover, England; by electron microprobe, average of eight analyses; H_2O by CHN analyzer, thought to lose H_2O under the electron beam; on recalculation to 2(OH,O) corresponds to $(Zn_{1.18}Pb_{0.01}Cd_{0.01})_{\Sigma=1.20}[(OH)_{1.60}O_{0.40}]_{\Sigma=2.00}$. (2) $Zn(OH)_2$.

Polymorphism & Series: Trimorphous with sweetite and wülfingite.

Occurrence: In an oxidized vein in limestone (near Ashover, England).

Association: Sweetite, wülfingite, fluorite (near Ashover, England).

Distribution: In a limestone quarry 200–300 m northwest of Milltown, near Ashover, Derbyshire, England. From Jüliushutte, Astfeld, Harz Mountains, Germany, in slag.

Name: For the locality at Ashover, England, where it was first found.

Type Material: The Natural History Museum, London, England, 1982,5.

References: (1) Clark, A.M., E.E. Fejer, G. Cressey, and P.C. Tandy (1988) Ashoverite, a new mineral, and other polymorphs of $Zn(OH)_2$ from Milltown, Ashover, Derbyshire. Mineral. Mag., 52, 699–702. (2) (1990) Amer. Mineral., 75, 431 (abs. ref. 1). (3) Schnorrer-Köhler, G. (1988) Mineralogische Notizen IV. Aufschluss, 39, 153–168 (in German).

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Asisite $Pb_7SiO_8Cl_2$

Crystal Data: Tetragonal. *Point Group*: 4/m 2/m 2/m. Platy, to about 0.5 mm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. VHN = 146-186 (50 g load). D(meas.) = n.d. D(calc.) = 8.041

Optical Properties: Transparent. *Color:* Yellow to yellow-green. *Streak:* Light yellow to white. *Luster:* Adamantine.
Optical Class: Uniaxial (-). ω = 2.39 ε = 2.32 *Anisotropism*: Weak in oil, gray; not noticeable in air.
R_1-R_2: (400) 20.6-20.7, (420) 19.8-19.8, (440) 19.0-19.15, (460) 18.5-18.65, (480) 18.1-18.2, (500) 17.7-17.9, (520) 17.4-17.55, (540) 17.15-17.3, (560) 16.9-17.0, (580) 16.7-16.8, (600) 16.6-16.7, (620) 16.5-16.5, (640) 16.3-16.4, (660) 16.2-16.3, (680) 16.1-16.2, (700) 16.0-16.1

Cell Data: *Space Group*: *I4/mmm*. a = 3.897(2) c = 22.81(2) Z = 1
A tetragonal supercell of 14×14×23 Å, is created by strong ordering of Si within the PbO sheet structure, yielding $Pb_{12}(SiO_4)O_8Cl_4$ with Z = 8.

X-ray Powder Pattern: Kombat mine, Namibia.
2.957 (100), 2.752 (60), 1.627 (60), 1.602 (50), 3.46 (40), 1.984 (40), 1.747 (40)

Chemistry:

	(1)
SiO_2	2.0
PbO	93.7
Cl	4.4
$-O = Cl_2$	1.0
Total	99.1

(1) Kombat mine, Namibia; by electron microprobe, average of three analyses, corresponding to $Pb_7Si_{0.55}O_{7.07}Cl_{2.02}$.

Occurrence: In manganese silicate lenses nearby a sulfide ore body.

Association: Hematophanite, barite, jacobsite, hematite, copper, molybdophyllite, chlorite.

Distribution: In the Kombat mine, 49 km south of Tsumeb, Namibia.

Name: For the Asis Farm, location of the Kombat mine, which in the Nama language means drinking place.

Type Material: Canadian Geological Survey, Ottawa, Canada, 64565; The Natural History Museum, London, England, 1986,304.

References: (1) Rouse, R.C., D.R. Peacor, P.J. Dunn, A.J. Criddle, C.J. Stanley, and J. Innes (1988) Asisite, a silicon-bearing lead oxychloride from the Kombat mine, South West Africa (Namibia). Amer. Mineral., 73, 643-650. (2) Welch, M.D. (2004) Pb-Si ordering in sheet-oxychloride minerals: the super-structure of asisite, nominally $Pb_7SiO_8Cl_2$. Mineral Mag., 68, 247–254.

Åskagenite-(Nd) $Mn^{2+}NdAl_2Fe^{3+}(Si_2O_7)(SiO_4)O_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals prismatic, sometimes flattened with rectangular cross-sections, to 4 cm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 6 D(meas.) = 3.737(5) (for metamict material) D(calc.) = 4.375 (sample heated at 600° C) Slightly radioactive.

Optical Properties: Translucent. *Color*: Black, brown in thin fragments. *Streak*: Brown. *Luster*: Resinous.
Optical Class: Isotropic. n = 1.712(2)

Cell Data: *Space Group*: $P2_1/m$. a = 8.78(1) b = 5.710(6) c = 10.02(1) β = 114.6(2)° Z = 2

X-ray Powder Pattern: Near Åskagen quarry, Sweden. (amorphous until heated to 600° C)
2.897 (100), 2.850 (73), 2.687 (73), 1.630 (59), 3.22 (50), 2.121 (48), 3.50 (46)

Chemistry:

	(1)		(1)
CaO	0.27	ThO_2	0.72
Y_2O_3	2.27	MnO	7.98
La_2O_3	0.44	FeO	[7.75]
Ce_2O_3	7.99	Fe_2O_3	[9.16]
Pr_2O_3	1.76	Al_2O_3	15.85
Nd_2O_3	11.21	SiO_2	29.51
Sm_2O_3	3.01	H_2O	0.55
Yb_2O_3	0.21	Total	98.75

(1) Near Åskagen quarry, Värmland, Sweden; average of 4 electron microprobe analyses, H_2O by the Alimarin method, Fe^{+3}/Fe^{+2} calculated from Mössbauer spectrum, Mn^{+2} confirmed by XANES spectroscopy; corresponding to $(Mn^{2+}_{0.69}Fe^{2+}_{0.26}Ca_{0.03})_{\Sigma=0.98}(Nd_{0.41}Ce_{0.30}Y_{0.12}Sm_{0.10}Pr_{0.07}La_{0.02}Th_{0.02}Yb_{0.01})_{\Sigma=1.05}(Al_{1.90}Fe^{3+}_{0.70}Fe^{2+}_{0.40})_{\Sigma=3.00}Si_{2.99}O_{12.63}(OH)_{0.37}$.

Mineral Group: Epidote group.

Occurrence: In a granite pegmatite.

Association: Potassic feldspar, quartz, bastnäsite, thorite, Nd-dominant analogue of allanite-(Ce), brookite, gadolinite-(Y), allophane.

Distribution: Near Åskagen quarry, mining village Torskebäcken, about 12 km east of Filipstad, Värmland, Sweden.

Name: For the quarry that produced the first specimen and indicating the predominance of Nd over other REE in the A2 structural site.

Type Material: Technische Universität, Bergakademie, Freiberg, Germany (82194 and 82218).

References: (1) Chukanov, N.V., J. Göttlicher, S. Möckel, Z. Sofer, K.V. Van, and D.I. Belakovskiy (2010) Åskagenite-(Nd), $Mn^{2+}NdAl_2Fe^{3+}(Si_2O_7)(SiO_4)O_2$, a new mineral of the epidote supergroup. Novye dannye o mineralakh, 45, 17-22 (in Russian). New data on minerals, 45, 17-22 (in English). (2) (2012) Amer. Mineral., 97, 1524 (abs. ref. 1).

Aspedamite $\square_{12}(Fe^{3+},Fe^{2+})_3Nb_4[Th(Nb,Fe^{3+})_{12}O_{42}]\{(H_2O),(OH)\}_{12}$

Crystal Data: Cubic. *Point Group*: $2/m\,\bar{3}$. As dodecahedral crystals with cube modifications to 50 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Hackly. *Tenacity*: Brittle. Hardness = 3-4
D(meas.) = n.d. D(calc.) = 4.070

Optical Properties: Transparent. *Color*: Brownish orange to deep red. *Streak*: Very pale orange. *Luster*: Adamantine.
Optical Class: Isotropic. *n*(calc.) = 2.084

Cell Data: *Space Group*: *Im*3. a = 12.9078(6) Z = 2

X-ray Powder Pattern: Herrebøkasa quarry, Aspedammen, Østfold county, Norway.
9.107 (100), 2.635 (36), 2.889 (33), 1.726 (29), 3.233 (28), 3.454 (18), 4.567 (15)

Chemistry:

	(1)		(1)
SiO	20.78	Nb_2O_5	65.64
ThO_2	5.64	Ta_2O_5	1.78
TiO_2	2.15	La_2O_3	0.52
Fe_2O_3	10.56	Ce_2O_3	1.62
FeO	[2.73]	Nd_2O_3	0.44
MnO	0.82	H_2O	[7.20]
CaO	0.28	Total	100.32
K_2O	0.16		

(1) Herrebøkasa quarry, Aspedammen, Østfold county, Norway; average of 10 electron microprobe analyses, H_2O calculated from structure analysis, presence of OH and H_2O confirmed by Raman spectroscopy, FeO calculated from structure analysis; corresponding to $K_{0.09}Ca_{0.13}Ce_{0.26}La_{0.08}Nd_{0.07}Fe^{2+}_{1.00}Mn_{0.30}Fe^{3+}_{3.48}Th_{0.56}Ti^{4+}_{0.71}Si_{0.34}Nb_{12.98}Ta_{0.21}O_{42}(H_2O)_9(OH)_3$.

Occurrence: In a complex granitic pegmatite on altered monazite.

Association: Monazite.

Distribution: Herrebøkasa quarry, 2 km north-northeast of Aspedammen, Østfold county, Norway.

Name: For the village near which the first specimens were collected.

Type Material: Department of Natural History, Royal Ontario Museum, Toronto, Canada (M56117).

References: (1) Cooper, M.A., Y.A. Abdu, N.A. Ball, P. Černý, F.C. Hawthorne, and R. Kristiansen (2012) Aspedamite, ideally $\square_{12}(Fe^{3+},Fe^{2+})_3Nb_4[Th(Nb,Fe^{3+})_{12}O_{42}]\{(H_2O),(OH)\}_{12}$, a new heteropolyniobite mineral species from the Herrobøkasa quarry, Aspedammen, Østfold, Southern Norway: Description and crystal structure. Can. Mineral., 50, 793-804. (2) (2014) Amer. Mineral., 99, 1511-1512 (abs. ref. 1).

Asselbornite $(Pb,Ba)(UO_2)_6(BiO)_4(AsO_4)_2(OH)_{12}\cdot 3H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$, 432, $2/m\ \overline{3}$ or 23. Crystals are cubes modified by tetrahedra or pseudotetrahedra, to 0.3 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.6 Radioactive.

Optical Properties: Translucent. *Color:* Brown to lemon-yellow; yellow in transmitted light. *Luster:* Greasy to adamantine.
Optical Class: Isotropic. $n = \sim 1.9$

Cell Data: *Space Group:* $Im3m$, $I432$, $Im3$ or $I23$. a = 15.66 Z = 4

X-ray Powder Pattern: Schneeberg, Germany.
4.185 (100), 3.196 (80), 4.520 (70), 3.691 (60), 5.536 (40), 2.609 (40), 3.501 (35)

Chemistry:

	(1)	(2)
UO_3	56.00	57.77
P_2O_5	1.11	1.36
As_2O_5	6.42	6.23
Bi_2O_3	33.27	32.55
PbO	5.88	3.61
BaO	1.84	2.29
Total	104.52	103.81

(1) Schneeberg, Germany; by electron microprobe, average of eight analyses of the central part of a crystal; H_2O 5.6% by TGA, the loss of which is assumed to account for the high total; corresponds to $(Pb_{0.77}Ba_{0.35})_{\Sigma=1.12}(UO_2)_{5.78}(BiO)_{4.18}[(AsO_4)_{1.63}(PO_4)_{0.46}]_{\Sigma=2.09}(OH)_{12}\cdot 3H_2O$.
(2) Do.; by electron microprobe, average of eight analyses of the exterior part of a crystal; corresponds to $(Pb_{0.48}Ba_{0.45})_{\Sigma=0.93}(UO_2)_{5.87}(BiO)_{4.07}[(AsO_4)_{1.57}(PO_4)_{0.57}]_{\Sigma=2.14}(OH)_{12}\cdot 3H_2O$.

Occurrence: On a museum specimen initially, later at the locality.

Association: Uranospinite, uranophane, uranosphaerite, quartz.

Distribution: In the Walpurgis vein, Weisser Hirsch mine, Neustädtel-Schneeberg, Saxony, Germany.

Name: For Eric Asselborn (1954–), surgeon and mineral collector, of Dijon, France, in whose collection the mineral was first found.

Type Material: Museum of Natural History, Geneva, Switzerland, 435/50; National Museum of Natural History, Washington, D.C., USA, 142229.

References: (1) Sarp. H., J. Bertrand, and J. Deferne (1983) Asselbornite, $(Pb,Ba)(UO_2)_6(BiO)_4[(As,P)O_4]_2(OH)_{12}\cdot 3H_2O$, a new uranium, lead and barium hydrous arsenate. Neues Jahrb. Mineral., Monatsh., 417–423. (2) (1984) Amer. Mineral., 69, 565 (abs. ref. 1).

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Astrocyanite-(Ce) $Cu_2(Ce,Nd,La)_2(UO_2)(CO_3)_5(OH)_2 \cdot 1.5H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\overline{6}m2$, $6mm$, or 622. Tabular {0001} crystals, to 1 mm, isolated or forming flat rosettes.

Physical Properties: *Cleavage:* On {0001}. Hardness = 2–3 D(meas.) = 3.80 D(calc.) = 3.95 Radioactive.

Optical Properties: Translucent to opaque. *Color:* Pale blue, bright blue, blue-green. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = blue; E = nearly colorless. *Orientation:* $E \perp \{0001\}$. $\omega = 1.688(2)$ $\epsilon = 1.638(2)$

Cell Data: *Space Group:* $P6/mmm$, $P\overline{6}m2$, $P\overline{6}2m$, $P6mm$, or $P622$. $a = 14.96(2)$ $c = 28.86(4)$ Z = 12

X-ray Powder Pattern: Kamoto-East mine, Congo.
6.73 (100), 3.72 (90), 4.16 (60), 4.30 (50), 13.3 (40), 2.488 (40), 2.154 (40)

Chemistry:

	(1)
UO_3	28.16
Ce_2O_3	11.83
Nd_2O_3	9.74
La_2O_3	3.38
Pr_2O_3	2.48
Sm_2O_3	2.00
Y_2O_3	0.15
CuO	15.55
CaO	0.61
CO_2	21.40
H_2O	[4.70]
Total	[100.00]

(1) Kamoto-East mine, Congo; by electron microprobe, average of six analyses, CO_2 by CHN, H_2O by difference; corresponds to $Cu_{2.02}Ca_{0.11}(Ce_{0.74}Nd_{0.60}La_{0.22}Pr_{0.16}Sm_{0.12}Y_{0.01})_{\Sigma=1.85}(UO_2)_{1.02}(CO_3)_{5.02} \cdot 2.70H_2O$.

Occurrence: In the oxidation zone of the uranium-bearing portion of a Cu–Co deposit.

Association: Uraninite, uranophane, kamotoite-(Y), françoisite-(Nd), shabaite-(Nd), schuilingite-(Nd), masuyite.

Distribution: From the Kamoto-East Cu–Co mine, five km west of Kolwezi, Katanga Province, Congo (Shaba Province, Zaire).

Name: From the Greek *astro* and *kyanos*, alluding to the starlike habit and blue color, and for *cerium* as the dominant rare-earth element.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC3513.

References: (1) Deliens, M. and P. Piret (1990) L'astrocyanite-(Ce), $Cu_2(TR)_2(UO_2)(CO_3)_5(OH)_2 \cdot 1,5H_2O$, nouvelle espèce minérale de Kamoto, Shaba, Zaïre. Eur. J. Mineral., 2, 407–411 (in French with English abs.). (2) (1991) Amer. Mineral., 76, 665 (abs. ref. 1).

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Astrophyllite $(K,Na)_3(Fe^{2+},Mn)_7Ti_2Si_8O_{24}(O,OH)_7$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals tabular ⊥ {001}, bladed or acicular, some faces commonly striated, to 10 cm; groups may be stellate.

Physical Properties: *Cleavage:* Perfect on {001}, poor on {100}. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 3.2–3.4 D(calc.) = n.d.

Optical Properties: Opaque to translucent in thin leaves. *Color:* Bronze-yellow to gold-yellow, brown to reddish brown. *Streak:* Golden. *Luster:* Submetallic, pearly, greasy. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = deep orange-red; Y = orange-yellow; Z = lemon-yellow. *Orientation:* $X \simeq c$; $Y \simeq b$; $Z \simeq a$. *Dispersion:* $r > v$, strong. *Absorption:* $X > Y > Z$. α = 1.678–1.695 β = 1.703–1.726 γ = 1.733–1.758 2V(meas.) = 66°–84°

Cell Data: *Space Group:* $A\overline{1}$. $a = 5.36$ $b = 11.76$ $c = 21.08$ $\alpha = 85°8'$ $\beta = 90°0'$ $\gamma = 103°13'$ Z = 2

X-ray Powder Pattern: Låven Island, Norway; nearly identical with kupletskite. (ICDD 14-194).
10.6 (100), 3.51 (80), 2.77 (60), 2.64 (60), 2.57 (60), 9.82 (30), 1.76 (30)

Chemistry:

	(1)		(1)
SiO_2	36.64	MnO	5.68
TiO_2	10.76	CaO	0.98
ZrO_2	0.66	Na_2O	2.52
Nb_2O_5	0.77	K_2O	5.13
FeO	31.50	H_2O	[4.92]
		Total	[99.56]

(1) Kangerdlugssuaq Fjord, Greenland; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $(K_{1.40}Na_{1.04}Ca_{0.22})_{\Sigma=2.66}(Fe_{5.62}Mn_{1.03})_{\Sigma=6.65}(Ti_{1.73}Nb_{0.07}Zr_{0.07})_{\Sigma=1.87}Si_{7.82}O_{24}(OH)_{7.00}$.

Polymorphism & Series: Forms a series with kupletskite.

Mineral Group: Astrophyllite group.

Occurrence: In nepheline syenites, alkali granites, and their pegmatites; less commonly in fenites and other metasomatized rocks; in nepheline syenite gneisses and paragneisses.

Association: Albite, aegirine, arfvedsonite, nepheline, natrolite, zircon, biotite, leucophanite, eudialyte, catapleiite, djerfisherite, rasvumite, delhayelite, kupletskite.

Distribution: Some prominent localities include: on Låven Island and near Brevik, Langesundsfjord, Norway. In Greenland, at Narssârssuk, in the Ilímaussaq intrusion, and elsewhere. In Spain, south of La Guia, and at Monte Galiñeiro, Vigo, Pontevedra Province. In the USA, in Colorado, at St. Peters Dome, near Pikes Peak, El Paso Co., and in Maine, near Biddeford, York Co. From Mont Saint-Hilaire, Quebec, and the Red Wine complex, Labrador, Newfoundland, Canada. On Rouma Isle, Los Islands, Guinea. From Pilansberg, Transvaal, South Africa. In the Khan-Bogdinskii granitic massif, Gobi, Mongolia. From Mts. Yukspor and Eveslogchorr, Khibiny massif; in the Lovozero massif, Kola Peninsula; and other less-well-defined localities in Russia.

Name: From the Greek for *star* and *leaf*, for the stellate and foliated micaceous habit.

Type Material: Mining Academy, Freiberg, Germany, 26244.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 719–720. (2) Woodrow, P.J. (1967) The crystal structure of astrophyllite. Acta Cryst., 22, 673–678. (3) Layne, G.D., J.C. Rucklidge, and C.K. Brooks (1982) Astrophyllite from Kangerdlugssuaq, East Greenland. Mineral. Mag., 45, 149–156. (4) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 31–32. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 530.

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Atacamite $Cu_2Cl(OH)_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As slender crystals, to 10 cm, prismatic along [001]; striated ‖ [001], on {010} ‖ $[1\bar{1}0]$; commonly tabular ⊥ {010} or pseudo-octahedral with {110} and {011}. Fibrous, sandy granular to compact, massive. *Twinning:* Twin plane {110}, composition plane {110}, rare; about [544], more common. Doublets, triplets, both contact and penetration, and complex groups result from twinning.

Physical Properties: *Cleavage:* {010}, perfect; {101}, fair. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 3.745–3.776 D(calc.) = 3.756

Optical Properties: Transparent to translucent. *Color:* Bright green, dark emerald-green to blackish green; shades of green in transmitted light. *Streak:* Apple-green. *Luster:* Adamantine to vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale green; Y = yellow-green; Z = grass-green. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, strong. $\alpha = 1.831$ $\beta = 1.861$ $\gamma = 1.880$ 2V(meas.) = n.d. 2V(calc.) = 74°56′

Cell Data: *Space Group: Pnam.* $a = 6.030(2)$ $b = 9.120(2)$ $c = 6.865(2)$ Z = 4

X-ray Powder Pattern: Inca de Oro mine, Copiapó, Chile.
5.48 (100), 5.03 (70), 2.278 (69), 1.6060 (57), 2.759 (55), 2.836 (51), 2.779 (51)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Cu	14.82	14.53	14.88	CaO		0.23	
CuO	56.01	55.33	55.87	Cl	16.55	16.22	16.60
CoO		0.21		H_2O	12.69	13.15	12.65
				Total	100.07	99.67	100.00

(1) Collahurasi, Chile. (2) Boleo, Mexico. (3) $Cu_2Cl(OH)_3$.

Polymorphism & Series: Polymorphous with botallackite, clinoatacamite, and paratacamite.

Occurrence: An oxidation product of other copper minerals, especially under arid, saline conditions; in fumarolic deposits; a weathering product of sulfides in subsea black smoker deposits; an alteration of bronze and copper objects of antiquity.

Association: Cuprite, brochantite, linarite, caledonite, malachite, chrysocolla, paratacamite, botallackite.

Distribution: In small amounts from many copper deposits worldwide. In Chile, originally from an undefined locality in the Atacama Desert; now known from many places, as at Copiapó, Carrizal, Tierra Amarilla, and Remolinos, Atacama; Collahurasi, Tarapacá; an ore mineral at Chuquicamata, Antofagasta. From Boleo, Baja California, Mexico. In the USA, in Arizona, at Bisbee, Cochise Co., in large amounts in the Santa Cruz porphyry deposit, in the Mammoth-St. Anthony mine, Tiger, and in the San Manuel mine, Pinal Co.; from the Tintic district, Juab Co., Utah. In South Australia, large crystals from Moonta, in the Burra district, and from Mt. Howden. At Vesuvius, Campania, and Etna, Sicily, Italy. From Laurium, Greece, in slag. At the Turinsk copper mine, Bogoslovsk, Ural Mountains, Russia. From Kara-Kamys, Kazakhstan. In England, at Roughtongill, Caldbeck Fells, Cumbria; and in the Penberthy Croft mine, St. Hilary, and at Botallack, St. Just, Cornwall. From Tsumeb, Namibia. Along the Mid-Atlantic Ridge, in the TAG Hydrothermal Field.

Name: For the undefined occurrence in the Atacama Desert, Chile.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 110816.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 69–73. (2) Larsen, A.L. and R.B. Tripp (1972) New X-ray data on natural atacamite. U.S. Geol. Surv. Prof. Paper 800B, 119–120. (3) Parise, J.B. and B.G. Hyde (1986) The structure of atacamite and its relationship to spinel. Acta Cryst., C42, 1277–1280.

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Atelestite $Bi_2O(AsO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular to prismatic crystals, to 2 mm, with $\{10\overline{1}\}$, $\{010\}$, $\{100\}$, $\{20\overline{1}\}$, $\{11\overline{1}\}$, $\{110\}$, $\{21\overline{1}\}$. Also as mammillary crystalline or smooth spherical aggregates.

Physical Properties: *Cleavage:* $\{100\}$, indistinct. *Fracture:* Subconchoidal. Hardness = 4.5–5 D(meas.) = 7.14 D(calc.) = 6.95

Optical Properties: Transparent to translucent. *Color:* Sulfur-yellow, pale yellow, yellowish green, black; in transmitted light, pale yellow to colorless. *Luster:* Resinous to adamantine. *Optical Class:* Biaxial (+). *Dispersion:* $r < v$, strong. $\alpha = 2.14(1)$ $\beta = 2.15(1)$ $\gamma = 2.18(1)$ 2V(meas.) = 44(2)°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.831(2)$ $b = 7.430(2)$ $c = 7.000(2)$ $\beta = 107.08(2)°$ Z = 4

X-ray Powder Pattern: Neuhilfe mine, Germany.
3.239 (100b), 3.116 (40), 2.725 (30), 6.62 (20), 4.233 (20), 2.526 (20), 2.201 (20)

Chemistry:

	(1)	(2)	(3)
P_2O_5		1.63	
As_2O_5	14.12	16.52	19.48
Bi_2O_3	82.41	80.08	78.99
Fe_2O_3	0.51		
H_2O	1.92	1.54	1.53
Total	98.96	99.77	100.00

(1) Neuhilfe mine, Germany. (2) Do.; corresponds to $Bi_{2.00}O[(AsO_4)_{0.84}(PO_4)_{0.13}]_{\Sigma=0.97}(OH)_{0.99}$. (3) $Bi_2O(AsO_4)(OH)$.

Occurrence: As a rare secondary mineral in the oxidized zone of bismuth- and arsenic-bearing mineral deposits.

Association: Bismutite, eulytite, erythrite, bismutostibiconite, beyerite, preisingerite, walpurgite, mixite, conichalcite, torbernite, quartz.

Distribution: In Germany, in Saxony, at the Neuhilfe, the Weisser Hirsch, and the Junge Kalbe mines, Neustädtel-Schneeberg; from Gadernheim, near Bensheim, Hesse; and at Neubulach and the Schmiedestollen, near Wittichen, Black Forest. From near Smrkovec, Slavkovský Les Mountains, about 10 km north-northeast of Mariánské Lázně (Marienbad), Czech Republic. In the USA, in Utah, at the Mammoth mine, Tintic district, Juab Co., on Gold Hill, Tooele Co., and from the Northern Spy mine, Utah Co.

Name: Derivation not explicitly stated. Probably from the Greek for *incomplete*, as the composition was undetermined when the mineral was first described.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 792–793. (2) Fischer, E. (1956) Über Morphologie und chemische Zusammensetzung von Atelestit. Heidelberger Beiträge zur Mineralogie und Petrographie, 5, 113–117 (in German). (3) Culver, K.B. and L.G. Berry (1963) Flinkite and atelestite. Can. Mineral., 7, 547–553. (4) Mereiter, K. and A. Preisinger (1986) Kristallstrukturdaten der Wismutminerale Atelestit, Mixit und Pucherit. Anzeiger Österreichischen Akademie der Wissenschaften math.-naturwiss. Kl. 123, 79–81 (in German).

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Atelisite-(Y) $Y_4Si_3O_8(OH)_8$

Crystal Data: Tetragonal. *Point Group*: $\bar{4}$ 2*m*. As dipyramidal crystals to 0.3 mm, displaying {101}, {100}, and rarely {001}.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.26

Optical Properties: Transparent. *Color*: Colorless to pale brown. *Streak*: Colorless. *Luster*: Vitreous.
Optical Class: Uniaxial (+). ω = 1.727 ε > 1.8

Cell Data: *Space Group*: $I\bar{4}$ 2*d*. a = 6.947(4) c = 6.133(3) Z = 1

X-ray Powder Pattern: Stetind quarry, Tysfjord, Nordland, Norway.
3.474 (100), 2.601 (73), 1.786 (68), 4.598 (57), 1.838 (26), 2.772 (25), 1.737 (24)

Chemistry:

	(1)
SiO_2	18.73
Y_2O_3	45.67
Yb_2O_3	11.81
Gd_2O_3	2.09
Tb_2O_3	0.54
Dy_2O_3	2.61
Ho_2O_3	0.62
Er_2O_3	4.72
H_2O	[12.2]
Total	98.99

(1) Stetind quarry, Tysfjord, Norway; average of 20 electron microprobe analyses, presence of OH^- confirmed by Raman spectroscopy, H_2O calculated for charge balance; corresponding to $(Y_{3.11}Yb_{0.46}Er_{0.19}Dy_{0.11}Gd_{0.09}Ho_{0.01}Tb_{0.02})_{\Sigma=3.99}(Si_{2.4}[H_4+]_{0.605})_{\Sigma=3.01}O_8(OH)_8$.

Occurrence: A late, hydrothermal mineral in dissolution cavities in fluorite in niobium-yttrium-fluorine (NYF) type, quartz-microcline pegmatite.

Association: Xenotime-(Y), calcioancylite-(Nd), La-dominant calcioancylite.

Distribution: From the Stetind quarry, Tysfjord, Nordland, Norway.

Name: From Greek "*atels*", meaning deficient, in allusion to the Si-deficiency of the mineral.

Type Material: Museum of the University of Hamburg, Germany (NO-004).

References: (1) Malcherek, T., B. Mihailova, J. Schlüter, and T. Husdal (2012) Atelisite-(Y), a new rare earth defect silicate of the KDP structure type. European Journal of Mineralogy, 24(6), 1053-1060. (2) (2014) Amer. Mineral., 99, 2151-2152 (abs. ref. 1).

Athabascaite Cu_5Se_4

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Crystal Data: Orthorhombic. *Point Group:* n.d. As crystal laths, to 100 μm; also massive.

Physical Properties: Hardness = n.d. VHN = 78 (15 g load). D(meas.) = n.d. D(calc.) = 6.59

Optical Properties: Opaque. *Color:* Pale gray to white. *Luster:* Metallic. *Pleochroism:* Distinct, pale gray to blue-gray. *Anisotropism:* Strong, creamy white to dark blue. R_1–R_2: (400) 21.2–25.1, (420) 19.9–25.2, (440) 19.6–25.3, (460) 19.3–25.4, (480) 19.0–25.5, (500) 18.6–25.6, (520) 18.3–25.6, (540) 17.8–25.5, (560) 17.4–25.4, (580) 16.9–25.1, (600) 16.3–25.0, (620) 15.5–24.5, (640) 15.0–24.2, (660) 14.2–23.7, (680) 13.4–23.1, (700) 12.5–22.4

Cell Data: *Space Group:* n.d. $a = 8.227$ $b = 11.982$ $c = 6.441$ Z = 4

X-ray Powder Pattern: Martin Lake mine, Canada.
3.235 (100), 1.997 (80), 3.015 (60), 1.893 (50), 1.664 (40), 3.44 (30), 1.817 (30)

Chemistry:

	(1)	(2)	(3)
Ag		0.43	
Cu	51.1	50.96	50.15
Se	49.7	46.64	49.85
S		2.12	
Total	100.8	100.15	100.00

(1) Martin Lake mine, Canada; by electron microprobe; corresponds to $Cu_{5.11}Se_{4.00}$.
(2) Chaméane mine, France; by electron microprobe; corresponds to $(Cu_{4.88}Ag_{0.02})_{\Sigma=4.90}$ $(Se_{3.60}S_{0.40})_{\Sigma=4.00}$. (3) Cu_5Se_4.

Occurrence: As inclusions in and replacements of umangite, as stringers and veinlets in carbonate veins cutting basalt (Martin Lake mine, Canada).

Association: Umangite, clausthalite, eucairite, berzelianite, sulfatian berzelianite, klockmannite, eskebornite, tyrrellite, copper, silver, uraninite, hematite, pyrite, calcite, barite, quartz, feldspar (Martin Lake mine, Canada); berzelianite, eucairite, crookesite, tyrrellite, ferroselite, bukovite, kruťaite, calcite, dolomite (Petrovice, Czech Republic); umangite, berzelianite (Sierra de Umango, Argentina).

Distribution: At the Martin Lake mine, northeast of Martin Lake, Saskatchewan, Canada [TL]. In the Petrovice uranium deposit, near Ždăr; the Předbořice uranium deposit, near Krásna Hora; and on Koksín Hill, near Mitov, Czech Republic. At the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France. From Skrikerum, near Tryserum, Kalmar, Sweden. At Sierra de Umango, La Rioja Province, Argentina.

Name: For Lake Athabasca, northern Saskatchewan, Canada.

Type Material: National Museum of Canada, Ottawa; Royal Ontario Museum, Toronto, Canada, M29432.

References: (1) Harris, D.C., L.J. Cabri, and S. Kaiman (1970) Athabascaite: a new copper selenide mineral from Martin Lake, Saskatchewan. Can. Mineral., 10, 207–215. (2) (1971) Amer. Mineral., 56, 632 (abs. ref. 1). (3) Johan, Z., P. Picot, and F. Ruhlmann (1982) Evolution paragénétique de la minéralisation uranifère de Chaméane (Puy-de-Dôme) France: chaméanite, geffroyite et giraudite, trois séléniures nouveaux de Cu, Fe, Ag, and As. Tschermaks Mineral. Petrog. Mitt., 29, 151–167 (in French with English abs.).

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Atheneite $(Pd,Hg)_3As$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As tiny blebs; crystal outlines seldom displayed, grain boundaries being commonly embayed.

Physical Properties: Hardness = n.d. VHN = 419–442, 431 average (100 g load).
D(meas.) = 10.2 D(calc.) = 10.16

Optical Properties: Opaque. *Color:* In reflected light, white with bluish tint compared to arsenopalladinite. *Luster:* Metallic. *Pleochroism:* Very weak, in pale yellow to pale bluish gray. *Anisotropism:* Distinct.
R_1–R_2: (400) 46.1–48.3, (420) 47.4–49.8, (440) 48.5–50.9, (460) 49.7–52.4, (480) 50.8–53.6, (500) 51.9–54.8, (520) 53.0–55.8, (540) 54.0–56.7, (560) 54.8–57.3, (580) 55.7–57.8, (600) 56.4–58.3, (620) 57.0–58.5, (640) 57.4–58.6, (660) 57.6–58.7, (680) 57.9–59.0, (700) 58.2–59.1

Cell Data: *Space Group:* $P6/mmm$. $a = 6.798$ $c = 3.483$ $Z = 2$

X-ray Powder Pattern: Itabira, Brazil.
2.423 (vvs), 2.246 (vs), 1.371 (s), 1.302 (s), 1.259 (s), 1.871 (ms), 1.034 (ms)

Chemistry:

	(1)	(2)
Pd	66.0	67.15
Pt		1.96
Hg	14.9	13.79
Au	0.5	0.47
Fe		0.08
Cu	0.1	< 0.07
As	19.0	17.48
Sb	0.1	
Total	100.6	100.93

(1) Itabira, Brazil; by electron microprobe; corresponds to $(Pd_{2.66}Hg_{0.32}Cu_{0.01}Au_{0.01})_{\Sigma=3.00}As_{1.09}$.
(2) Serra Pelada, Brazil; by electron microprobe, corresponds to $(Pd_{2.67}Hg_{0.29}Pt_{0.04}Au_{0.01}Fe_{0.01})_{\Sigma=3.02}As_{1.09}$.

Occurrence: In concentrates from gold washings.

Association: Arsenopalladinite, palladseite, isomertieite, hematite (Itabira, Brazil).

Distribution: In Brazil, from Itabira [TL], and in the Cauê and Conceição iron mines, Minas Gerais, and in the Serra Pelada Au–Pd–Pt deposit, Pará. In the Merensky Reef, Bushveldt complex, Transvaal, South Africa. Found around Zlatoust, Ural Mountains, Russia.

Name: After the Greek goddess *Pallas Athene*, in allusion to its palladium content.

Type Material: The Natural History Museum, London, England, 1934,72, 1977,259; National Museum of Natural History, Washington, D.C., USA, 142504.

References: (1) Clark, A.M., A.J. Criddle, and E.E. Fejer (1974) Palladium arsenide–antimonides from Itabira, Minas Gerais, Brazil. Mineral. Mag., 39, 528–543. (2) (1974) Amer. Mineral., 59, 1330 (abs. ref. 1). (3) Cabral, A.R., B. Lehmann, R. Kwitko-Ribeiro, and C.H. Cravo Costa (2002) Palladium and platinum minerals from the Serra Pelada Au–Pd–Pt deposit, Carajás mineral province, northern Brazil. Can. Mineral., 40, 1451–1463. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 28.

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Atlasovite $KCu_6Fe^{3+}BiO_4(SO_4)_5Cl$

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Crystal Data: Tetragonal (by analogy to nabokoite). *Point Group:* $4/m\ 2/m\ 2/m$. Eight-sided crystals are tabular with prominent {001} modified by {110}, {012} and {014}, to 1 mm; typically intergrown with nabokoite.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 2–2.5 D(meas.) = 4.20(5) D(calc.) = 4.12

Optical Properties: Transparent. *Color:* Dark brown; pale gray with yellow internal reflections in reflected light. *Streak:* Pale brown. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* O = red-brown; E = pale yellow. $\omega = 1.783(3)$ $\epsilon = 1.776(3)$

Cell Data: *Space Group:* $P4/ncc$. $a = 9.86(2)$ $c = 20.58(2)$ $Z = 4$

X-ray Powder Pattern: Tolbachik volcano, Russia.
10.41 (10), 10.75 (9), 2.446 (8), 3.431 (7), 2.890 (7), 4.57 (5), 7.14 (4)

Chemistry:

	(1)	(2)
SO_3	32.21	31.65
TeO_2	1.29	
V_2O_3	0.68	
Bi_2O_3	12.82	18.42
Fe_2O_3	6.26	6.31
CuO	38.15	37.73
ZnO	1.02	
PbO	2.35	
K_2O	3.85	3.72
Cs_2O	0.01	
Cl	2.92	2.80
$-O = Cl_2$	0.66	0.63
Total	100.90	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of four analyses, total Fe as Fe_2O_3; corresponding to $K_{1.01}(Cu_{5.90}Zn_{0.15})_{\Sigma=6.05}(Fe_{0.97}V_{0.11})_{\Sigma=1.08}(Bi_{0.68}Pb_{0.12}Te_{0.10})_{\Sigma=0.90}O_{4.19}(SO_4)_{4.95}Cl_{1.01}$. (2) $KCu_6FeBiO_4(SO_4)_5Cl$.

Polymorphism & Series: Forms a series with nabokoite.

Occurrence: As a volcanic sublimate.

Association: Nabokoite, anglesite, dolerophanite, euchlorine, chloroxiphite, atacamite, piypite, chalcocyanite, alarsite, fedotovite, lammerite, klyuchevskite, langbeinite, hematite, tenorite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: For Vladimir Vasil'evich Atlasov (1661/1664–1711), Russian traveller who first explored the Kamchatka Peninsula.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Popova, V.I., V.A. Popov, N.S. Rudashevskiy, S.F. Glavatskikh, V.O. Polyakov, and A.F Bushmakin (1987) Nabokoite $Cu_7TeO_4(SO_4)_5 \cdot KCl$ and atlasovite $Cu_6Fe^{3+}Bi^{3+}O_4(SO_4)_5 \cdot KCl$. New minerals of volcanic exhalations. Zap. Vses. Mineral. Obshch., 116, 358–367 (in Russian with English abs.). (2) (1988) Amer. Mineral., 73, 927–928 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, 30.

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Atokite $(Pd,Pt)_3Sn$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As small grains, less than 100 μm in diameter, rarely showing {100}.

Physical Properties: Hardness = n.d. VHN = 357 (25 g load). D(meas.) = n.d. D(calc.) = 14.19

Optical Properties: Opaque. *Color:* In polished section, pale cream. *Luster:* Metallic. *Pleochroism:* None to slight. *Anisotropism:* Slight, due to strain.
R_1–R_2: (480) 57.4–60.8, (546) 59.2–65.1, (589) 60.4–63.5, (656) 62.2–65.8

Cell Data: *Space Group:* $Fm3m$. $a = 3.991$ $Z = 4$

X-ray Powder Pattern: Merensky Reef, South Africa.
2.295 (100), 1.202 (100), 1.408 (90), 0.9153 (90), 0.8145 (90), 1.992 (80), 0.8922 (80)

Chemistry:

	(1)
Pt	43.74
Pd	38.35
Sn	18.65
Total	100.74

(1) Merensky Reef, South Africa; by electron microprobe, corresponding to $(Pd_{1.46}Pt_{0.91})_{\Sigma=3.00}Sn_{0.81}$.

Polymorphism & Series: Forms a series with rustenburgite.

Occurrence: As very sparse grains in concentrates of ore (Merensky Reef, South Africa).

Association: Unspecified platinum tellurides (Merensky Reef, South Africa); keithconnite, palladoarsenide (Stillwater complex, Montana, USA).

Distribution: From the Atok [TL] and Rustenburg mines, on the Merensky Reef, Bushveld complex, Transvaal, South Africa. From the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia, Russia. In Montana, in the Stillwater complex, and the Revais Creek district, [??Flathead Ind Res, check mining districts??] ?? Co., USA.

Name: For its occurrence in the Atok mine, South Africa.

Type Material: n.d.

References: (1) Mihálik, P., S.A. Hiemstra, and J.P.R. de Villiers (1975) Rustenburgite and atokite, two new platinum-group minerals from the Merensky Reef, Bushveld Igneous Complex. Can. Mineral., 13, 146–150. (2) (1976) Amer. Mineral., 61, 340 (abs. ref. 1).

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Attakolite $\mathbf{(Ca,Sr)Mn^{2+}(Al,Fe^{3+})_4[H(Si,P)O_4](PO_4)_3(OH)_4}$.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Indistinctly crystalline, massive. *Twinning:* Possible twin lamellae are observed in thin section.

Physical Properties: Hardness = 5 D(meas.) = 3.09–3.23 D(calc.) = [3.35]

Optical Properties: Transparent. *Color:* White to pale red; colorless in thin section. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z = c$; $X \wedge a = 24°$. *Dispersion:* $r < v$ to $r \gg v$, strong. $\alpha = 1.650$–1.655 $\beta = 1.654$–1.664 $\gamma = 1.661$–1.675 2V(meas.) = 75°–84° 2V(calc.) = 74°

Cell Data: *Space Group:* $C2/m$. $a = 17.188(4)$ $b = 11.477(8)$ $c = 7.322(5)$ $\beta = 113.83(4)°$ Z = 4

X-ray Powder Pattern: Västanå mine, Sweden.
3.09 (10), 3.13 (8), 4.34 (7), 2.97 (6), 6.61 (4), 5.68 (4), 3.51 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	9.35	5.9	Na_2O	0.03	
Al_2O_3	26.97	26.8	F	0.10	
Fe_2O_3	0.60	3.9	Cl	0.06	
FeO	1.31		H_2O^+	5.92	[10.5]
MnO	7.10	9.7	H_2O^-	0.20	
PbO	0.03		CO_2	0.57	
MgO	0.29		P_2O_5	32.59	33.6
CaO	11.40	6.6	SO_3	0.13	
SrO	3.30	3.0	$-O = (F,Cl)_2$	0.06	
			Total	99.89	[100.0]

(1) Västanå mine, Sweden; contaminated with calcite 1.30% and svanbergite 0.76%. (2) Do.; by electron microprobe, total Fe as Fe_2O_3 on crystallo-chemical grounds, H_2O by difference; corresponds to $(Ca_{0.81}Sr_{0.20})_{\Sigma=1.01}Mn_{0.95}(Al_{3.65}Fe^{3+}_{0.34})_{\Sigma=3.99}[H(Si_{0.68}P_{0.28})_{\Sigma=0.96}O_4](PO_4)_3(OH)_4$.

Occurrence: In an iron deposit.

Association: Berlinite, lazulite, trolleite, apatite, svanbergite, pyrophyllite, hematite, calcite, quartz.

Distribution: From the Västanå mine, near Näsum, Skåne, Sweden.

Name: From the Greek for *salmon*, for the pale red color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 847. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 845. (3) Gabrielson, O. and P. Gejer. (1966) The mineral attakolite. Arkiv Mineral. Geol., 3(30), 537–543. (4) (1966) Amer. Mineral., 51, 534 (abs. ref. 3). (5) Grice, J.D. and P.J. Dunn (1992) Attakolite: new data and crystal-structure determination. Amer. Mineral., 77, 1285–1291.

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Attikaite $Ca_3Cu_2Al_2(AsO_4)_4(OH)_4 \cdot 2H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m* or *mm*2. As bent, scaly crystals flattened on [001] to 0.080 mm; in spherical aggregates to 0.3 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Tenacity*: Flexible. Hardness = 2-2.5 D(meas.) = 3.2(2) D(calc.) = 3.356

Optical Properties: Transparent. *Color*: Pale blue to greenish blue; colorless in transmitted light. *Streak*: Very pale blue. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.642(2)$ $\beta = \gamma = 1.644(2)$ 2V(meas.) = 10(8)° 2V(calc.) = 0°
Orientation: $X = c$.

Cell Data: *Space Group*: *Pban*, *Pbam*, or *Pba*2. $a = 10.01(1)$ $b = 8.199(5)$ $c = 22.78(1)$
$Z = 4$

X-ray Powder Pattern: Christiana no. 132 mine, Kamareza, Laurion District, Attika, Greece.
22.8 (100), 5.01 (90), 2.780 (70), 11.36 (60), 3.38 (50), 2.503 (50), 2.682 (30)

Chemistry:

	(1)
MgO	0.17
CaO	17.48
FeO	0.12
CuO	16.28
Al_2O_3	10.61
P_2O_5	0.89
As_2O_5	45.45
SO_3	1.39
H_2O	7.61
Total	100.00

(1) Christiana no. 132 mine, Kamareza, Laurion District, Attika, Greece; average of 4 electron microprobe analyses, H_2O by difference, IR confirms OH and H_2O, corresponding to $Ca_{2.94}Cu^{2+}_{1.93}Al_{1.97}Mg_{0.04}Fe^{2+}_{0.02}[(As_{3.74}S_{0.16}P_{0.12})_{\Sigma=4.02}O_{16.08}](OH)_{3.87} \cdot 2.05H_2O$.

Occurrence: In the oxidized portions of polymetallic sulfide-quartz veins.

Association: Arsenocrandallite, arsenogoyazite, conichalcite, olivenite, philipsbornite, azurite, malachite, carminite, beudantite, goethite, quartz, allophane.

Distribution: Christiana no. 132 mine, Kamareza, Laurion District, Attiki Prefecture (Attika), Greece.

Name: For the place of its first occurrence, the historically significant region, Attika, Greece.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (catalog no. 3435/1).

References: (1) Chukanov, N.V., I.V. Pekov, and A.E. Zadov (2007) Attikaite, $Ca_3Cu_2Al_2(AsO_4)_4(OH)_4 \cdot 2H_2O$, a new mineral. Zap. Ross. Mineral. Obshch., 136(2), 17–24 (in Russian, English abstract); (2007) Geology of Ore Deposits, 49, 720–726 (in English).
(2) (2009) Amer. Mineral., 94, 1076 (abs. ref. 1).

Aubertite $CuAl(SO_4)_2Cl \cdot 14H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As crusts of corroded grains.

Physical Properties: *Cleavage:* {010}, perfect. Hardness = n.d. D(meas.) = 1.815 D(calc.) = 1.85 Soluble in H_2O.

Optical Properties: Translucent. *Color:* Azure-blue.
Optical Class: Biaxial (–). *Orientation:* Optic axis nearly $\perp$ {010}. *Dispersion:* $r > v$, moderate. $\alpha = 1.462$ $\beta = 1.482$ $\gamma = 1.495$ 2V(meas.) = 71°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.282(3)$ $b = 13.192(5)$ $c = 6.260(3)$ $\alpha = 91.85(3)°$ $\beta = 94.70(3)°$ $\gamma = 82.46(3)°$ Z = 1

X-ray Powder Pattern: Quetena, Chile.
4.50 (100), 4.247 (69), 3.952 (58), 6.25 (45), 5.59 (44), 3.690 (42), 3.130 (42)

Chemistry:

	(1)	(2)
SO_3	28.30	28.07
Al_2O_3	9.16	8.94
CuO	11.80	13.95
CaO	0.18	
Na_2O	0.13	
K_2O	0.05	
Cl	6.70	6.22
H_2O	45.40	44.22
$-O = Cl_2$	1.51	1.40
Total	100.21	100.00

(1) Quetena, Chile; by spectrophotometric methods, H_2O by the Penfield method; corresponds to $Cu_{0.82}Al_{1.00}(SO_4)_{1.97}Cl_{1.05} \cdot 14.04H_2O$. (2) $CuAl(SO_4)_2Cl \cdot 14H_2O$.

Occurrence: In the oxidized zone of a copper deposit.

Association: Copiapite, botryogen, amarantite, parabutlerite, metahohmannite.

Distribution: From Quetena, west of Calama, Antofagasta, Chile.

Name: Honors J. Aubert (1929–), French geophysicist who collected the first specimens.

Type Material: University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France.

References: (1) Cesbron, F., D. Ginderow, M.-C. Sichère, and H. Vachey (1979) L'aubertite, un nouveau chloro-sulfate hydraté de cuivre et d'aluminium. Bull. Minéral., 102, 348–350 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 205–206 (abs. ref. 1). (3) Ginderow, D. and F. Cesbron (1979) Structure cristalline de l'aubertite, $AlCuCl(SO_4)_2 \cdot 14H_2O$. Acta Cryst., 35, 2499–2502 (in French with English abs.).

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Augelite $Al_2(PO_4)(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thick tabular crystals, {001}, to 13 cm, may be prismatic, even acicular ‖ [001], showing many forms, dominantly {110}, {001}, {$\bar{2}$01}, {$\bar{1}$11}, with {110} striated ‖ [001]; may be massive.

Physical Properties: *Cleavage:* {110}, perfect; {$\bar{2}$01}, good; {001} and {$\bar{1}$01}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 2.696 D(calc.) = 2.704

Optical Properties: Transparent. *Color:* Colorless to white, may be yellowish to pale rose, greenish; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, pearly on perfect {110} cleavage.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = -56°$; $Z \wedge c = 34°$. $\alpha = 1.5736$ $\beta = 1.5759$ $\gamma = 1.5877$ 2V(meas.) = 50°49′ 2V(calc.) = 47°56′

Cell Data: *Space Group:* $C2/m$. $a = 13.124(6)$ $b = 7.988(5)$ $c = 5.066(3)$ $\beta = 112.25(2)°$ Z = 4

X-ray Powder Pattern: Big Fish River area, Canada. (ICDD 34-151).
3.344 (100), 3.517 (55), 4.007 (30), 4.706 (25), 4.673 (25), 3.490 (25), 1.869 (18)

Chemistry:

	(1)	(2)	(3)
P_2O_5	35.04	34.68	35.50
SiO_2		0.07	
TiO_2		0.08	
Al_2O_3	49.15	50.33	50.99
Fe_2O_3	0.89		
MnO	0.31		
CaO	1.09		
H_2O	12.85		13.51
Total	99.33		100.00

(1) Västanå mine, Sweden; after deduction of quartz impurity. (2) Mt. Perry, Australia; by electron microprobe, partial analysis; corresponding to $Al_{2.01}(PO_4)_{0.99}(OH)_3$. (3) $Al_2(PO_4)(OH)_3$.

Occurrence: Formed by hydrogen metamorphism of phosphate-bearing rocks in peraluminous sediments; in some high-temperature hydrothermal ore deposits.

Association: Attakolite, svanbergite, lazulite, hematite, trolleite, berlinite (Västanå mine, Sweden); lazulite, rutile, pyrophyllite, barite (Champion mine, California, USA); arsenopyrite, stannite, pyrite, andorite, cassiterite, zinkenite (Bolivia).

Distribution: From the Västanå mine, near Näsum, Skåne, and at Hålsjöberg, Värmland, Sweden. At Mbale, Uganda. In the Buranga pegmatite, near Gatumba, Rwanda. In the USA, large crystals from the Champion mine, White Mountains, Mono Co., California; in New Hampshire, at the Palermo #1 mine, near North Groton, Grafton Co., and the G.E. Smith mine, Newport, Sullivan Co.; in the Hugo and Ingersoll mines, near Keystone, Pennington Co., South Dakota; in the White Picacho district, Maricopa and Yavapai Cos., Arizona. From the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In Bolivia, from the Socavón mine, San José, and Itos mines, Oruro; at Llallagua, Machacamarca, Tatasi, and Portugalete, Potosí. From Mt. Perry, 75 km southwest of Bundaberg, Queensland, Australia. Additional localities are known.

Name: From the Greek for *luster*, for its pearly luster on the cleavage.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 871–872. (2) Araki, T., J.J. Finney, and T. Zoltai (1968) The crystal structure of augelite. Amer. Mineral., 53, 1096–1103. (3) Duggan, M.B., M.T. Jones, D.N.G. Richards, and J.L. Kamprad (1990) Phosphate minerals in altered andesite from Mount Perry, Queensland, Australia. Can. Mineral., 28, 125–131.

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Augite $(Ca, Na)(Mg, Fe, Al, Ti)(Si, Al)_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Stubby prismatic crystals, square or octagonal in section, to 10 cm; elongated ‖ [001], acicular, skeletal, dendritic. Exsolution lamellae and overgrowths common. *Twinning:* Simple or multiple on {100}, common; also on {001}.

Physical Properties: *Cleavage:* Good on {110}, (110) ∧ $(1\bar{1}0)$ ~87°; partings on {100} and {010}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.19–3.56 D(calc.) = 3.31

Optical Properties: Transparent to opaque. *Color:* Black, brown, greenish, violet-brown; in thin section, colorless to gray; clear cores zoned to dark rims common, also oscillatory and sector zoning. *Streak:* Gray-green. *Luster:* Vitreous, resinous to dull.
Optical Class: Biaxial (+). *Pleochroism:* X = pale green, pale brown, green, greenish yellow; Y = pale brown, pale yellow-green, violet; Z = pale green, grayish green, violet. *Orientation:* $Y = b$; $Z \wedge c = -35°$ to $-50°$; $X \wedge a = -20°$ to $-35°$. *Dispersion:* $r > v$, weak to moderate. *Absorption:* Weak; $Y > Z > X$. $\alpha = 1.671–1.735$ $\beta = 1.672–1.741$ $\gamma = 1.703–1.774$ 2V(meas.) = 25°–61°

Cell Data: *Space Group:* $C2/c$. $a = 9.699$ $b = 8.844$ $c = 5.272$ $\beta = 106.97°$ Z = 4

X-ray Powder Pattern: Locality unknown. (ICDD 24-203).
2.994 (100), 3.324 (75), 2.949 (65), 2.516 (65), 2.566 (55), 2.134 (35), 2.895 (34)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	51.83	45.30	MgO	16.00	11.20
TiO_2	0.49	4.33	CaO	19.21	22.24
Al_2O_3	3.07	6.72	Na_2O	0.27	0.78
Fe_2O_3	1.38	3.98	K_2O	0.02	0.18
FeO	7.21	5.15	H_2O^+	0.47	0.15
MnO	0.17	0.19	H_2O^-	0.11	0.05
			Total	100.23	100.27

(1) Stillwater complex, Montana, USA; corresponds to $(Ca_{0.76}Fe^{2+}_{0.22}Na_{0.02})_{\Sigma=1.00}(Mg_{0.88}Al_{0.05}Fe^{3+}_{0.04}Ti_{0.01}Mn_{0.01})_{\Sigma=0.99}(Si_{1.92}Al_{0.08})_{\Sigma=2.00}O_6$. (2) Stöffel, Germany; corresponds to $(Ca_{0.91}Na_{0.07}Fe^{2+}_{0.04})_{\Sigma=1.02}(Mg_{0.66}Fe^{3+}_{0.13}Fe^{2+}_{0.09}Ti_{0.08}Al_{0.04})_{\Sigma=1.00}(Si_{1.69}Al_{0.31})_{\Sigma=2.00}O_6$.

Mineral Group: Pyroxene group.

Occurrence: Essential in mafic igneous rocks, basalt, gabbro; common in ultramafic rocks; in some high-grade metamorphic rocks and metamorphosed iron formations.

Association: Orthoclase, sanidine, labradorite, olivine, leucite, amphiboles, pyroxenes.

Distribution: Widespread; only a few classic localities, much studied or providing fine examples, are listed. From Arendal, Norway. In Italy, from Vesuvius, Campania; around Frascati, Alban Hills, Lazio; on Mt. Monzoni, Val di Fassa, Trentino-Alto Adige; at Traversella, Piedmont; and on Mt. Etna, Sicily. Around the Laacher See, Eifel district, Germany. At Ústí nad Lábem (Aussig), Bílina, and Vlčí Hora, near Černošín, Czech Republic. On the Azores and Cape Verde Islands. In Canada, from Renfrew and Haliburton Cos., Ontario; at Otter Lake, Pontiac Co., Quebec; and many other localities. In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; and at Diana, Lewis Co., and Fine, St. Lawrence Co., New York. From Tomik, Gilgit district, Pakistan. At Kangan, Andhra Pradesh, India.

Name: From the Greek for *luster*, apparently based on the appearance of its cleavage surface.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 352–364, esp. 360–362. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 294–398. (3) Clark, J.R., D.E. Appleman, and J.J. Papike (1969) Crystal-chemical characterization of clinopyroxenes based on eight new structure refinements. MSA Spec. Paper 2, 31–50. (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 196–198.

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Auriacusite $Fe^{3+}Cu^{2+}AsO_4O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As acicular needles, elongated on [001], to 0.1 mm; in fibrous mats.

Physical Properties: *Cleavage*: Perfect on {010}. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = ~ 3 D(meas.) = n.d. D(calc.) = 4.447

Optical Properties: Transparent. *Color*: Brownish golden-yellow; ocherous yellow mats. *Streak*: Brownish yellow. *Luster*: Silky.
Optical Class: Biaxial (+). α = 1.830(5) β = 1.865(5) γ = 1.910(5) 2V(meas.) = 83.3(3)° 2V(calc.) = 84.6° *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* Strong; $r < v$, probable.

Cell Data: *Space Group*: *Pnnm*. a = 8.6235(7) b = 8.2757(7) c = 5.9501(5) Z = 4

X-ray Powder Pattern: Black Pine mine, Granite County, Montana, USA.
4.884 (100), 2.991 (92), 2.476 (85), 2.416 (83), 2.669 (74), 4.218 (69), 1.582 (54)

Chemistry:

	(1)	(2)
Ag_2O	0.03	
PbO	0.16	
CuO	19.93	29.00
ZnO	0.80	
Fe_2O_3	31.36	29.11
Sb_2O_5	12.71	
P_2O_5	0.04	
V_2O_5	0.00	
As_2O_5	17.32	41.89
SiO_2	0.76	
SeO_3	0.04	
TeO_3	0.53	
SO_3	0.50	
Cl	0.04	
-O=Cl	0.01	
Total	84.21	100.00

(1) Black Pine mine, Granite County, Montana, USA; average of 14 electron microprobe analyses, corresponding to $(Fe^{3+}_{1.33}Cu^{2+}_{0.85}Zn_{0.03})_{\Sigma=2.21}(As_{0.51}Sb_{0.27}Si_{0.04}S_{0.02}Te_{0.01})_{\Sigma=0.85}O_5$.
(2) $Fe^{3+}Cu^{2+}AsO_4O$.

Polymorphism & Series: Forms a series with olivenite.

Group: Olivenite group.

Occurrence: A secondary mineral in the weathering zone of a polymetallic sulfarsenide deposit.

Association: Segnitite, brochantite, malachite, tetrahedrite, pyrite.

Distribution: Black Pine mine, 14.5 km NW of Philipsburg, Granite County, Montana, USA.

Name: From the Latin *auri* (golden yellow) and *acus* (needle), in reference to its color and habit.

Type Material: Mineral Sciences Department, Natural History Museum of Los Angeles County, California, USA (catalog no. 62374); Canadian Museum of Nature, Ottawa, Canada (catalog no. CMNMC 86090).

References: (1) Mills, S.J., A.R. Kampf, G. Poirier, M. Raudsepp, and I.M. Steele (2010) Auriacusite, $Fe^{3+}Cu^{2+}AsO_4O$, the first M^{3+} member of the olivenite group, from the Black Pine mine, Montana, USA. Mineral. Petrol., 99, 113–120. (2) (2010) Amer. Mineral., 95, 1595 (abs. ref. 1).

Aurichalcite $(Zn, Cu)_5(CO_3)_2(OH)_6$

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Crystal Data: Monoclinic, pseudo-orthorhombic by twinning. *Point Group:* $2/m$. As acicular to lathlike crystals with prominent {010}, commonly striated ‖ [001], with wedgelike terminations, to 3 cm. Typically in tufted divergent sprays or spherical aggregates, may be in thick crusts; rarely columnar, laminated or granular. *Twinning:* Observed in X-ray patterns.

Physical Properties: *Cleavage:* On {010} and {100}, perfect. *Tenacity:* "Fragile". Hardness = 1–2 D(meas.) = 3.96 D(calc.) = 3.93–3.94

Optical Properties: Transparent to translucent. *Color:* Pale green, greenish blue, sky-blue; colorless to pale blue, pale green in transmitted light. *Luster:* Silky to pearly. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = colorless; $Y = Z$ = blue-green. *Orientation:* $X = b$; $Y \simeq a$; $Z \simeq c$. *Dispersion:* $r < v$; strong. α = 1.654–1.661 β = 1.740–1.749 γ = 1.743–1.756 2V(meas.) = Very small.

Cell Data: *Space Group:* $P2_1/m$. a = 13.82(2) b = 6.419(3) c = 5.29(3) $\beta = 101.04(2)°$ Z = 2

X-ray Powder Pattern: Mapimí, Mexico.
6.78 (10), 2.61 (8), 3.68 (7), 2.89 (4), 2.72 (4), 1.827 (4), 1.656 (4)

Chemistry:

	(1)
CO_2	16.22
CuO	19.87
ZnO	54.01
CaO	0.36
H_2O	9.93
Total	100.39

(1) Utah; corresponds to $(Zn_{3.63}Cu_{1.37})_{\Sigma=5.00}(CO_3)_2(OH)_6$.

Occurrence: In the oxidized zones of copper and zinc deposits.

Association: Rosasite, smithsonite, hemimorphite, hydrozincite, malachite, azurite.

Distribution: Widespread in small amounts. Localities noteworthy for good specimens include: from the Loktevskii mine, upper Loktevka River, west Altai Mountains, Russia. At Monteponi, and in the Rosas mine, Sulcis, Sardinia, Italy. From Laurium, Greece. At Chessy, near Lyon, Rhône, France. In the USA, in Arizona, fine examples from Bisbee, Cochise Co., in the Silver Hill mine, Pima Co., and at the 79 mine, Gila Co.; from Cerro Gordo, Inyo Co., California; at the Kelly and Graphic mines, Magdalena, Socorro Co., New Mexico. In Utah, from the Tintic district, Juab Co., at the Hidden Treasure mine, Tooele Co., in the Apex mine, near St. George, Washington Co., and from Big Cottonwood Canyon, Salt Lake Co.; at Leadville, Lake Co., Colorado. In Mexico, rich specimens from the Ojuela mine, Mapimí, Durango, Mexico. At the Tchah Khuni mine, Anarak district, Iran. From Tsumeb, Namibia. At Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire).

Name: From the Latin for *golden copper*, brass, for the copper and zinc content of the mineral.

Type Material: The Natural History Museum, London, England, 31118.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 249–250. (2) Jambor, J.L. and G. Pouliot (1965) X-ray crystallography of aurichalcite and hydrozincite. Can. Mineral., 8, 385–389. (3) Harding, M.M., B.M. Kariuki, R. Cernik, and G. Cressey (1994) The structure of aurichalcite, $(Cu, Zn)_5(OH)_6(CO_3)_2$, determined from a microcrystal. Acta Cryst., 50, 673–676. (4) Charnock, J.M., P.F. Schofield, C.M.B. Henderson, G. Cressey, and B.A. Cressey (1996) Cu and Zn ordering in aurichalcite. Mineral. Mag., 60, 887–896.

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Auricupride Cu_3Au

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, as rims less than 100 μm, irregular patches, and platy aggregations.

Physical Properties: Hardness = ∼3.5 VHN = 54 (10 g load). D(meas.) = 11.5 D(calc.) = [13.77]

Optical Properties: Opaque. *Color:* Yellow with a reddish tint; in reflected light, violet-rose. *Luster:* Highly metallic.
R: n.d.

Cell Data: *Space Group: Pm3m.* a = 3.753(5) (synthetic). Z = [1]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Au	53.11	50.82
Cu	45.96	49.18
Total	99.07	100.00

(1) Karabash deposit, Russia; by electron microprobe. (2) Cu_3Au.

Occurrence: In serpentinites as the product of low-temperature ordering and unmixing of Au–Cu solid solution alloys (Karabash deposit, Russia); in reduction halos in Permian red beds (near Zurich, Switzerland).

Association: Gold, copper, other Au–Cu alloys.

Distribution: In Russia, from the Karabash gold deposit, Soimon Valley, Southern Ural Mountains [TL] and at the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia. From Laksia and Pefkos, Cyprus. Found northwest of Zurich, Switzerland. In the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile.

Name: For the composition.

Type Material: n.d.

References: (1) Lozhechkin, M.P. (1939) New data on chemical composition of copper-bearing gold. Doklady Acad. Nauk SSSR, 24, 454–457 (in Russian) (2) Ramdohr, P. (1950) Auricuprid. Fortschr. Mineral., 28, 69 (in German). (3) Ramdohr, P. (1967) The wide-spread paragenesis of ore minerals originating during serpentinization (with some data on new and insufficiently described minerals). Geol. Rudn. Mestorozhd., 2, 32–43 (in Russian). (4) (1968) Amer. Mineral., 53, 350 (abs. ref. 3). (5) Novgorodova, M.I., A.I. Tsepin, A.I. Gorshkov, I.M. Kudrevich, and L.N. Vyal'sov (1977) New data on the crystal chemistry and properties of natural intermetallic compounds of the copper-gold system. Zap. Vses. Mineral. Obshch., 106, 540–552 (in Russian). (6) (1977) Chem. Abs., 87, 209755 (abs. ref. 5). (7) Novgorodova, M.I. and A.I. Tsepin (1976) Phase composition of cupriferous gold. Doklady Acad. Nauk SSSR, 227, 184–187 (in Russian). (8) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 32–33.

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Aurivilliusite $Hg^{2+}Hg^{1+}OI$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As irregular patchy coatings, to 0.5 mm. Twinning noted in quantitative reflectance study.

Physical Properties: *Cleavage:* Distinct on{100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness < 5 D(meas.) = n.d. D(calc.) = 8.96

Optical Properties: Opaque. *Color:* Dark gray-black, exhibits an unusual 'red light' coalescing phenomenon in reflected light. *Streak:* Dark red-brown. *Luster:* Metallic. Extremely light-sensitive.
Optical Class: n.d. n = 2.35-2.38

Cell Data: *Space Group: C*2/*c* (synthetic analog). a = 17.580(6) b = 6.979(1) c = 6.693(3) β = 101.71(4)° Z = 8

X-ray Powder Pattern: New Idria district, San Benito County, California, USA.
3.275 (100), 2.993 (80), 2.873 (80), 8.547 (70), 2.404 (50b), 1.878 (50), 4.796 (30)

Chemistry:

	(1)	(2)
HgO	40.10	39.81
Hg_2O	38.62	38.34
I	22.76	23.32
Br	0.22	
Cl	0.06	
-O = I,Br,Cl	1.46	1.47
Total	100.30	100.00

(1) New Idria district, San Benito County, California, USA; average of 5 electron microprobe analyses, Hg^{2+} and Hg^{1+} partitioned as in the synthetic analog; corresponding to $Hg^{2+}_{1.00}Hg^{1+}_{1.00}O_{1.01}(I_{0.97}Br_{0.01}Cl_{0.01})_{\Sigma=0.99}$. (2) $Hg^{2+}Hg^{1+}OI$.

Occurrence: A rare mineral of uncertain paragenesis in a suite of Hg-bearing oxy-halide phases.

Association: Native mercury, cinnabar, edgarbaileyite.

Distribution: From a prospect pit near the former Clear Creek mercury mine, New Idria district, San Benito County, California, USA.

Name: Honors Dr. Karin Aurivillius (1920–1982) University of Lund, Sweden, who synthesized and determined the crystal structures of many Hg compounds.

Type Material: Systematic Reference Series, Geological Survey of Canada, Ottawa, Canada; NMC 68087.

References: (1) Roberts, A.C., J.A.R. Stirling, A.J. Criddle, G.E. Dunning, and J. Spratt (2004) Aurivilliusite, $Hg^{2+}Hg^{1+}OI$, a new mineral species from the Clear Creek claim, San Benito County, California, USA. Mineral. Mag., 68, 241-245. (2) (2005) Amer. Mineral., 90, 518 (abs. ref. 1).

Aurorite $(Mn^{2+}, Ag, Ca)Mn_3^{4+}O_7 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ or 3. As small, irregular masses and platy or scaly grains, to 8 μm.

Physical Properties: Hardness = < 3 D(meas.) = n.d. D(calc.) = [3.81]

Optical Properties: Opaque, transparent on very thin edges. *Color:* Black; pale brown in transmitted light at the edges of very thin, platy grains.
Optical Class: Biaxial. $n = > 2$ 2V(meas.) = n.d. *Anisotropism:* Yellow-gray to brownish gray. *Bireflectance:* Strong; cream-white to medium black.
R_1–R_2: (400) 10.4–36.5, (420) 10.3–35.3, (440) 10.2–34.0, (460) 9.99–32.4, (480) 9.67–30.6, (500) 9.49–29.2, (520) 9.31–27.8, (540) 9.16–26.6, (560) 9.11–25.6, (580) 8.93–24.9, (600) 8.88–24.5, (620) 8.87–24.0, (640) 8.85–23.7, (660) 8.84–23.4, (680) 8.82–22.9, (700) 8.80–22.7

Cell Data: *Space Group:* $R\overline{3}$ or $R3$. $a = 7.514(4)$ $c = 20.734(5)$ $Z = 2$

X-ray Powder Pattern: Aurora mine, Nevada, USA; nearly indistinguishable from chalcophanite and jianshuiite.
6.94 (10), 3.46 (7), 4.06 (5), 2.54 (5), 2.23 (5), 1.429 (5), 2.45 (4)

Chemistry:

	(1)	(2)		(1)	(2)
As_2O_5	trace		MgO	0.12	
MnO_2	[59.99]	[70.5]	CaO	2.50	2.8
SiO_2	0.11		SrO	n.d.	
Al_2O_3	0.15	0.5	BaO	3.07	2.9
Fe_2O_3	0.07		Na_2O	0.07	
FeO		0.2	K_2O	1.11	0.4
MnO	[7.89]	[3.4]	Ag_2O	7.50	6.0
NiO	0.03		S	n.d.	
CuO	1.06		Cl	n.d.	
ZnO	0.25	0.3	H_2O	[14.78]	[13.0]
PbO	1.30		Total	[100.00]	[100.0]

(1) Aurora mine, Nevada, USA; by electron microprobe; Mn 44.02%, partitioned as MnO_2 59.99% by analogy to chalcophanite, the remainder reported as MnO; H_2O by difference; then corresponding to $(Mn^{2+}_{0.48}Ag_{0.28}Ca_{0.19}K_{0.10}Ba_{0.06}Cu_{0.06}Pb_{0.02}Mg_{0.01}Zn_{0.01})_{\Sigma=1.21}$ $Mn^{4+}_{2.97}O_7 3.53H_2O$. (2) Do.; by electron microprobe; method of partitioning Mn not stated, H_2O by difference.

Occurrence: In veinlets filling microfractures in manganoan calcite (Aurora mine, Nevada, USA).

Association: Manganoan calcite, argentian todorokite, cryptomelane, pyrolusite, chlorargyrite, silver, quartz (Aurora mine, Nevada, USA).

Distribution: In the USA, from the Aurora mine, Hamilton, White Pine Co., and at Yucca Mountain, Nye Co., Nevada; at Morenci, and in the Ash Peak mine, near Duncan, Greenlee Co., from the Sheep Tanks district, La Paz Co., and in the King of Arizona mine, Kofa district, Yuma Co., Arizona. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey. In the Kawazu mine, Shizuoka Prefecture, Japan.

Name: For the occurrence at the Aurora mine, Nevada, USA.

Type Material: n.d.

References: (1) Radtke, A.S., C.M. Taylor, and D.F. Hewett (1967) Aurorite, argentian todorokite, and hydrous silver-bearing lead manganese oxide. Econ. Geol., 62, 186–206. (2) (1967) Amer. Mineral., 52, 1581 (abs. ref. 1). (3) Grice, J.D., B. Gartrell, R.A. Gault, and J. Van Velthuizen (1994) Ernienickelite, $NiMn_3O_7 \cdot 3H_2O$, a new mineral species from the Siberia complex, Western Australia: comments on the chalcophanite group. Can. Mineral., 32, 333–337. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 29.

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Aurostibite $AuSb_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As sparse elongate grains, to 3.5 cm.

Physical Properties: *Tenacity:* Brittle. Hardness = 3 VHN = 280–292
D(meas.) = 9.98 (synthetic). D(calc.) = 9.91

Optical Properties: Opaque. *Color:* Gray, with a bornitelike tarnish; in polished section, galenalike with pinkish tinge. *Luster:* Metallic.
R: (400) 56.4, (420) 57.2, (440) 57.9, (460) 58.6, (480) 59.1, (500) 59.6, (520) 60.0, (540) 60.3, (560) 60.6, (580) 61.0, (600) 61.3, (620) 61.5, (640) 61.6, (660) 61.5, (680) 61.4, (700) 61.2

Cell Data: *Space Group:* $Pa3$. $a = 6.633$ $Z = 4$

X-ray Powder Pattern: Giant Yellowknife mine, Canada.
1.999 (100), 3.32 (50), 0.865 (50), 2.97 (40), 0.783 (40), 2.34 (40), 2.71 (30)

Chemistry:

	(1)	(2)
Au	44.1	44.72
Ag	< 0.1	
Sb	55.9	55.28
Total	100.0	100.00

(1) Hillgrove deposit, Australia; by electron microprobe, average of 15 analyses; corresponding to $Au_{1.00}Sb_{2.05}$. (2) $AuSb_2$.

Mineral Group: Pyrite group.

Occurrence: In hydrothermal gold-quartz veins, in portions deficient in sulfur and containing other antimony minerals.

Association: Gold, freibergite, stibnite, jamesonite, chalcostibite, bournonite, boulangerite, arsenopyrite, pyrite, chalcopyrite, sphalerite, galena, tetrahedrite.

Distribution: In Canada, from the Giant Yellowknife mine, Yellowknife, Northwest Territories [TL]; the Chesterville mine, Larder Lake and the Hemlo gold deposit, Thunder Bay district, Ontario. At Krásná Hora, near Milesov, Czech Republic. From the Viges Au–Sb deposit, Creuse, France. In the Langsele deposit, Skellefte district, Sweden. At the Kallisalo gold deposit, Seinajoki district, western Finland. From Sulitjelma, northern Norway. In the Bestyube goldfield, northern Kazakhstan. In Australia, at the Costerfield Au–Sb mine and the Nagambie gold deposit, Victoria, and in the Hillgrove Sb–Au deposit, 25 km east of Armidale, New South Wales. From the Woxi gold deposit, Hebei Province, China. In the Lone Hand and Jessie gold mines, Gwanda district; and the Indrarama Au–Sb mine, Sebakwe area, Que-Que, Zimbabwe. From the Mobale mine, Kivu Province, Congo (Zaire). At the Ashanti gold deposit, Obuasi, Ghana. Additional localities are known.

Name: In reference to its composition.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada.

References: (1) Graham, A.R. and S. Kaiman (1952) Aurostibite, $AuSb_2$; a new mineral in the pyrite group. Amer. Mineral., 37, 461–469. (2) Naz'mova, G.N., E.M. Spiridonov and Y.S. Shalayev (1975) Aurostibite from the Bestyube deposit, northern Kazakhstan. Doklady Acad. Nauk SSSR, 222, 687–689 (in Russian). (3) Ashley, P.M., N.D.J. Cook, and R.L. Hill (1990) Occurrence and significance of aurostibite in Sb–Au ore from Hillgrove, New South Wales, Australia. Neues Jahrb. Mineral., Monatsh., 537–551. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 30.

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Austinite $CaZn(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. As enantiomorphous bladed crystals exhibiting {011}, {111}, {1$\bar{1}$1}, {010} and several other forms, sometimes forming scepters. Also as radially fibrous crusts and nodules. *Twinning:* Left- and right-handed individuals joined on (100), with (010) and (001) coincident.

Physical Properties: *Cleavage:* Good on {011}. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 4.13 D(calc.) = [4.31]

Optical Properties: Translucent to transparent. *Color:* Colorless, white to pale yellowish white, green. *Luster:* Subadamantine to silky in aggregates.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, weak.
$\alpha = 1.759(3)$ $\beta = 1.763(3)$ $\gamma = 1.783(3)$ 2V(meas.) = ∼45°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.505$–7.509 $b = 9.037$–9.046 $c = 5.921$–5.934 Z = 4

X-ray Powder Pattern: Gold Hill, Utah, USA.
3.171 (10), 2.801 (10), 2.637 (10), 1.616 (9), 1.509 (7), 2.529 (6), 5.781 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	0.1	0.90		CaO	19.2	21.33	21.45
As_2O_5	42.7	42.85	43.96	H_2O	3.6	[3.45]	3.45
FeO		0.49		insol.	2.4		
CuO		0.88		Total	100.5	[100.00]	100.00
ZnO	32.5	30.10	31.14				

(1) Gold Hill, Utah, USA; insoluble is quartz, some adamite adhering. (2) Kamariza mine, Greece; by electron microprobe, H_2O by difference; corresponding to $Ca_{1.00}(Zn_{0.96}Cu_{0.03}Fe_{0.01})_{\Sigma=1.00}[(As_{0.97}P_{0.03})_{\Sigma=1.00}O_4](OH)$. (3) $CaZn(AsO_4)(OH)$.

Polymorphism & Series: Forms a series with conichalcite.

Mineral Group: Adelite group.

Occurrence: A rare secondary mineral in the oxidized zone of some arsenic-rich base-metal deposits.

Association: Adamite, talmessite, "limonite", quartz (Gold Hill, Utah, USA).

Distribution: In the USA, in the Western Utah mine, Gold Hill, Tooele Co., Utah; at the Mohawk mine, Clark Mountains, San Bernardino Co., California; from the Table Mountain mine, Galiuro Mountains, Pinal Co., Arizona; at Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in the Tucker's tunnel uranium deposit, near Durango, Hinsdale Co., Colorado. From the Ojuela mine, Mapimí, Durango, Mexico. At the Lili mine, near Lomitos, Bolivia. From the Kamariza mine, Laurium, Greece. At Tsumeb and Guchab, Otavi district, Namibia. In the Puttapa zinc mine, near Beltana, South Australia.

Name: To honor Professor Austin Flint Rogers (1877–1957), American mineralogist, Stanford University, Palo Alto, California, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 809–810. (2) Williams, S.A. and J. de Azevedo (1967) Austinite from Gold Hill, Utah. Amer. Mineral., 52, 1224–1226. (3) Radcliffe, D. and W.B. Simmons, Jr. (1971) Austinite: chemical and physical properties in relation to conichalcite. Amer. Mineral., 56, 1359–1365. (4) Giuseppetti, G. and C. Tadini (1988) The crystal structure of austinite, $CaZn(AsO_4)(OH)$, from Kamareza, Laurion (Greece). Neues Jahrb. Mineral., Monatsh., 159–166. (5) Clark, L.A., J.J. Pluth, I. Steele, J.V. Smith, and S.R. Sutton (1997) Crystal structure of austinite, $CaZn(AsO_4)OH$. Mineral. Mag., 61, 677–683.

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Autunite $Ca(UO_2)_2(PO_4)_2 \cdot 10–12H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As thin to moderately thick crystals, tabular on {001} and with rectangular or octagonal outline, to 2 cm; commonly in subparallel growths, foliated or scaly aggregates, and in crusts. *Twinning:* On {110}, interpenetrant, rare.

Physical Properties: *Cleavage:* Perfect on {001}; {100}, indistinct. Hardness = 2–2.5 D(meas.) = 3.05–3.2 (varies with hydration). D(calc.) = 3.14 (for $10.5H_2O$). Strong yellow-green fluorescence in UV. Dehydrates in air. Radioactive.

Optical Properties: Transparent to translucent. *Color:* Lemon-yellow to sulfur-yellow, greenish yellow to pale green; may be dark green to greenish black. *Streak:* Pale yellow. *Luster:* Vitreous, pearly on {001}.
Optical Class: Uniaxial (–), commonly anomalously biaxial (–). *Pleochroism:* $X =$ colorless to pale yellow; $Y = Z =$ yellow to dark yellow. *Orientation:* $Z = c$; $Y = \{110\}$. *Dispersion:* $r > v$, strong. $\omega = 1.575$ $\epsilon = 1.572$ $\alpha = 1.553–1.555$ $\beta = 1.575$ $\gamma = 1.577–1.578$ 2V(meas.) = 10°–53°

Cell Data: *Space Group:* $I4/mmm$. $a = 6.989$ $c = 20.63$ Z = 2

X-ray Powder Pattern: Les Oudots mine, France. (ICDD 41–1353).
3.569 (100), 10.35 (85), 5.185 (65), 2.074 (60), 3.502 (40), 2.187 (40), 4.930 (35)

Chemistry:

	(1)	(2)
UO_3	60.84	58.00
P_2O_5	13.40	14.39
CaO	5.31	5.69
H_2O	20.33	21.92
Total	99.88	100.00

(1) Autun, France. (2) $Ca(UO_2)_2(PO_4)_2 \cdot 12H_2O$.

Mineral Group: Autunite group.

Occurrence: A secondary mineral derived from primary uranium-bearing minerals under oxidizing conditions, in hydrothermal veins, granite pegmatites, etc.

Association: Meta-autunite, torbernite, phosphuranylite, saléeite, uranophane, uranophane-beta, sabugalite.

Distribution: Widespread, many minor localities, but few for outstanding specimens. In France, at L'Ouche d'Jau, Saint-Symphorien-de-Marmagne, and the Les Oudots mine, Autun district, Saône-et-Loire; from the Margnac mine, Compreignac, Haute-Vienne; large crystals from the Gagnol mine, Lachaux, Puy-de-Dôme. From Sabugal, Urgeiriça, and elsewhere in Portugal. At Peveragno, near Cúneo, Piedmont, Italy. Large crystals from Bergen, Vogtland, Germany. From a number of localities in Cornwall, England. Fine groups from the Dahl (Daybreak) mine, near Mt. Spokane, east of Elk, Spokane Co., Washington, USA. At Malacacheta, Minas Gerais, Brazil. Large crystals from Mt. Painter, Flinders Ranges, South Australia.

Name: For Autun, France, near to which the first specimens to be analyzed were collected.

Type Material: Natural History Museum, Paris, France, H6307.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 984–987. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Survey Bull. 1064, 160–170. (3) Takano, Y. (1961) X-Ray study of autunite. Amer. Mineral., 46, 812–822.

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Avdoninite $K_2Cu_5Cl_8(OH)_4 \cdot H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*, *m* or 2. As crusts; crystals, poorly formed, short-prismatic to thick tabular, to 0.2 mm; with {001}, {100}.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Stepped. *Tenacity*: Brittle. Hardness = 3 D(meas.) = 3.03(3) D(calc.) = 3.066

Optical Properties: Transparent. *Color*: Bright green. *Streak*: Pale green. *Luster*: Vitreous. *Optical Class*: Biaxial. $\alpha = 1.669(2)$ $\beta = 1.688(2)$ $\gamma = 1.707(5)$ 2V = 90(2)°
Orientation: $Y = c$; $X = b$ (?).

Cell Data: *Space Group*: *P*2/*m*, *Pm*, or *P*2. $a = 24.34(2)$ $b = 5.878(4)$ $c = 11.626(5)$ $\beta = 93.3(1)°$ $Z = 4$

X-ray Powder Pattern: Tolbachik Volcano, Kamchatka Region, Russia.
11.63 (100), 5.80 (27), 5.88 (20), 2.518 (19), 5.73 (17), 2.321 (17), 3.052 (15)

Chemistry:

	(1)
K_2O	11.94
CuO	51.43
Cl	37.07
H_2O	6.9
$-O=Cl_2$	8.37
Total	98.97

(1) Tolbachik Volcano, Kamchatka Region, Russia; average of 4 electron microprobe analyses, H_2O by Penfield method, IR confirms OH and H_2O, corresponding to $K_{1.96}Cu_{5.00}Cl_{8.09}(OH)_{3.87} \cdot 1.03H_2O$.

Occurrence: A product of precipitation from fumarolic gases (Tolbachik Volcano, Russiaa); also reported as an alteration on massive sulfide ore exposed at the Earth's surface.

Association: Euchlorite, paratacamite, belloite, langbeinite, atacamite.

Distribution: Yadovitaya ("Poisonous") fumaroles, Second Cinder Cone, Northern Breach of the Tolbachik Large Fissure Eruption, Tolbachik Volcano, Kamchatka Region, Russia; also reported from the Blyava deposit, Orenburg oblast and dumps at the Degtyarka deposit, Sverdlovsk oblast, Russia.

Name: Honors Ural mineralogist Vladimir Nikolaevich Avdonin (1925–), senior scientist of the Ural Geological Museum, Ural State Mining University, Russia.

Type Material: Mineralogical Museum of the Department of Mineralogy, St. Petersburg State University, St. Petersburg, Russia (catalog no. 19175).

References: (1) Chukanov, N.V., M.N. Murashko, A.E. Zadov, and A.F. Bushmakin (2006) Avdoninite, $K_2Cu_5Cl_8(OH)_4 \cdot H_2O$, a New Mineral Species from Volcanic Exhalations and the Technogenic Zone at Volcanic-Hosted Massive Sulfide Deposits. Zap. Ross. Mineral. Obshch., 135(3), 38–42 (in Russian, English abstract); (2007) Geology of Ore Deposits, 49, 505–508 (in English). (2) (2009) Amer. Mineral., 94, 1076 (abs. ref. 1).

Averievite $Cu_5O_2(VO_4)_2 \cdot CuCl_2 \cdot (Cs,K,Rb)Cl$

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Crystal Data: Hexagonal. *Point Group:* 3. As pseudohexagonal crystals, to 0.3 mm, with $\{10\bar{1}0\}$, $\{01\bar{1}0\}$, $\{0001\}$, $\{000\bar{1}\}$.

Physical Properties: *Cleavage:* On $\{10\bar{1}0\}$, good. *Tenacity:* Brittle. Hardness = ∼4 VHN = 258 (20 g load). D(meas.) = 3.54 (thought low due to adhesion of air bubbles). D(calc.) = 4.01(1)

Optical Properties: Opaque. *Color:* Black. *Streak:* Black. *Luster:* Metallic to resinous. *Optical Class:* Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group: P*3. $a = 6.375(1)$ $c = 8.399(1)$ Z = 1

X-ray Powder Pattern: Tolbachik volcano, Russia.
2.315 (10), 3.43 (7), 2.810 (4), 1.598 (4), 2.131 (3), 3.048 (2), 1.871 (2)

Chemistry:

	(1)
MoO_3	1.51
V_2O_5	23.84
Fe_2O_3	0.62
CuO	62.01
K_2O	0.98
Rb_2O	0.82
Cs_2O	3.35
Cl	7.56
$-O = Cl_2$	1.70
Total	98.99

(1) Tolbachik volcano, Russia; by electron microprobe, average of 17 analyses, total Fe as Fe_2O_3; with chloride compounds in open structural channels, corresponds to $Cu_{5.00}O_{2.19}[(V_{0.94}Mo_{0.04}Fe_{0.02})_{\Sigma=1.00}O_{3.89}]_2 \cdot Cu_{0.56}Cl_{1.12} \cdot (Cs_{0.17}K_{0.15}Rb_{0.06})_{\Sigma=0.38}Cl_{0.40}$.

Occurrence: In volcanic fumaroles.

Association: Piypite, alumoklyuchevskite, fedotovite, alarsite, nabokoite, tenorite, lammerite, langbeinite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: To honor Valerii Viktorovich Aver'ev [Averiev] (1929–1968), volcanologist, Institute of Volcanology, Petropavlovsk-Kamchatskii, Russia.

Type Material: Mining Museum, St. Petersburg Mining Institute, St. Petersburg, Russia, 2102/2.

References: (1) Vergasova, L.P., G.L. Starova, S.K. Filatov, and V.V. Anan'ev (1998) Averievite $Cu_5(VO_4)_2O_2 \cdot nMX$ – a new mineral of volcanic exhalations. Doklady Acad. Nauk, 359, 804–807 (in Russian). (2) Starova, G.L., S.V. Krivovichev, V.S. Fundamensky, and S.K. Filatov (1997) The crystal structure of averievite, $Cu_5O_2(VO_4)_2 \cdot nMX$: comparison with related compounds. Mineral. Mag., 61, 441–446. (3) (1999) Amer. Mineral., 84, 685 (abs. ref. 1–2).

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Avicennite Tl_2O_3

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As crystals, less than 1 mm, some showing subhedral octahedral faces; as porous grains, and as a coating on carlinite.

Physical Properties: *Fracture:* Conchoidal to hackly, uneven. *Tenacity:* Very brittle. Hardness = 1.5–2.5 VHN = 46–80 (15 and 25 g loads). D(meas.) = 8.9 D(calc.) = 10.34

Optical Properties: Opaque. *Color:* Grayish black with brownish black tint; pale to medium gray under reflected light. *Streak:* Grayish black, black with a brownish tint. *Luster:* Metallic. *Optical Class:* Isotropic.
R: (400) 11.5, (470) 12.5, (500) 13.0, (546) 12.7, (589) 12.3, (650) 10.6, (700) 11.5

Cell Data: *Space Group:* $Ia3$. a = 10.5468(3) Z = 16

X-ray Powder Pattern: Carlin mine, Nevada, USA.
3.044 (100), 1.864 (38), 2.637 (37), 1.590 (30), 4.307 (17), 2.068 (7), 2.486 (6)

Chemistry: (1) Near Dzhuzumli, Tajikistan; Tl 79.52% by microchemical methods, corresponding to Tl_2O_3 88.86%, Fe_2O_3 4.46% an impurity. (2) Carlin mine, Nevada, USA; by electron microprobe, average of three analyses, Tl 89.6% corresponding to Tl_2O_3 100.1%.

Occurrence: In the weathered zone of a hematite-calcite vein cutting banded marmorized and silicified limestones near a granite-gneiss contact (near Dzhuzumli, Tajikistan); formed by oxidation of carlinite in carbonaceous gold ores in silicified limestones and quartz (Carlin mine, Nevada, USA).

Association: Hematite, "limonite", ferruginous clay minerals (near Dzhuzumli, Tajikistan); carlinite, hematite, quartz (Carlin mine, Nevada, USA); parapierrotite (Lookout Pass, Utah, USA).

Distribution: From near the village of Dzhuzumli, Mt. Zirabulaksk region, Samarkand district, western Uzbekistan. In the USA, from the Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co., Nevada, and near Lookout Pass, Tooele Co., Utah.

Name: For the medieval Uzbek (Persian) scholar and physician, Abū 'Alī al-Husayn ibn 'Abd Allāh ibn Sīnā (Avicenna) (930–1037), who lived in Bukhara, Tajikistan.

Type Material: n.d.

References: (1) Karpova, K.N., E.A. Kon'kova, E.D. Larkin, and V.F. Savel'ev (1958) Avicennite, a new mineral. Dokl. Akad. Nauk Uzbekistan SSR, 2, 23–26 (in Russian). (2) (1959) Amer. Mineral., 44, 1324–1325 (abs. ref. 1). (3) Kon'kova, E.A. and V.F. Savel'ev (1960) A new thallium mineral – avicennite. Zap. Vses. Mineral. Obshch., 89, 316–320 (in Russian). (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 604–605. (5) Radtke, A.S., F.W. Dickson, and J.F. Slack (1978) Occurrence and formation of avicennite, Tl_2O_3, as a secondary mineral at the Carlin gold deposit, Nevada. J. Res. U.S. Geol. Surv., 6, 241–246.

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Avogadrite $(K, Cs)BF_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As minute octagonal crystals, tabular to platy on {001}, may be elongated along [010] or [100]; as dense crusts.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.507–3.305 Somewhat soluble in H_2O, with a bitter taste.

Optical Properties: Translucent. *Color:* Colorless to white, yellowish to reddish when impure; colorless in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.3239$ (synthetic KBF_4). $\beta = 1.3245$ $\gamma = 1.3247$ 2V(meas.) = Very large.

Cell Data: *Space Group: Pnma* (synthetic KBF_4). $a = 8.6588(5)$ $b = 5.4800(4)$ $c = 7.0299(8)$ $Z = 4$

X-ray Powder Pattern: Synthetic KBF_4. (ICDD 16-378).
3.41 (100), 3.26 (80), 3.06 (75), 2.068 (55), 3.51 (45), 2.801 (40), 2.091 (35)

Chemistry:

	(1)	(2)	(3)
K	15.2	31.05	
Cs	7.0		60.49
B	12.0	8.59	4.92
F		60.36	34.59
Total		100.00	100.00

(1) Vesuvius, Italy; partial analysis determined on H_2O extracts from mixtures of sublimates, B given as B_2O_3 38.8% in the original analysis. (2) KBF_4. (3) $CsBF_4$.

Polymorphism & Series: Cubic above 273 °C.

Occurrence: Formed as a sublimation product around volcanic fumaroles.

Association: Sassolite, malladrite, hieratite (Vesuvius, Italy).

Distribution: From Vesuvius, Campania, and on Vulcano, Lipari Islands, Italy. At volcanoes on the Kamchatka Peninsula, Russia.

Name: For Amedeo Avogadro (1776–1856), Professor of Physics at the University of Turin, Turin, Italy.

Type Material: Natural History Museum, Paris, France, 126.148.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 97–98. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 65–66. (3) Brunton, G. (1969) The crystal structure of KBF_4. Acta Cryst., 25, 2161–2162.

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Awaruite Ni_2Fe to Ni_3Fe

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Massive; as pebbles, grains and flakes; rare crystals, to 4 mm. In meteorites as rims or regular intergrowths with kamacite.

Physical Properties: *Tenacity:* Malleable and flexible. Hardness = 5.5–6 VHN = 320–380 (low Ni); 265–290 (high Ni) (50 g load). D(meas.) = 7.8–8.65 D(calc.) = [6.37–8.53] Strongly magnetic.

Optical Properties: Opaque. *Color:* Silver-white to grayish white. *Luster:* Metallic.
R: (400) 54.4, (420) 56.0, (440) 57.6, (460) 59.1, (480) 60.4, (500) 61.4, (520) 62.4, (540) 63.1, (560) 63.8, (580) 64.4, (600) 64.8, (620) 65.2, (640) 65.5, (660) 65.7, (680) 66.1, (700) 66.4

Cell Data: *Space Group: Fm3m.* a = 3.545–3.560 Z = 1[*wehad*4, *ckICDD* = 1??*ckuseempprog*??*changednow*]

X-ray Powder Pattern: Awarua Bay, New Zealand.
2.044 (10), 1.772 (6), 1.069 (4), 1.253 (3), 1.023 (1), 0.814 (1), 0.792 (1)

X-ray Powder Pattern: Oregon, USA. ("josephinite").
2.06 (100), 1.073 (40), 1.783 (30), 1.259 (20), 1.027 (10)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	76.60	67.63	67.77	75.93
Fe	21.45	31.02	32.23	24.07
Co	1.19	0.70		
Cu	0.66			
S	0.06	0.22		
P	0.04			
SiO_2	0.00	0.43		
Total	100.00	100.00	100.00	100.00

(1) South Fork, Smith River, California, USA. (2) Gorge River, New Zealand. (3) Ni_2Fe. (4) Ni_3Fe.

Occurrence: In river placers, from serpentinized peridotites and ophiolites; rare in meteorites.

Association: Gold, magnetite (placers); copper, heazlewoodite, pentlandite, violarite, chromite, millerite (peridotites); kamacite, allabogdanite, schreibersite, graphite (meteorites).

Distribution: From the Red Hills and the Gorge River draining them, near Awarua Bay [TL], south Westland, New Zealand. At Coolac, New South Wales, and in the Lord Brassey mine, Tasmania, Australia. From the Bobrovka River, Nizhni Tagil, Ural Mountains, Russia. In the Feragen ultramafic body, Sør-Trøndelag, Norway. From Vadu Dobrii, Poiana Ruscă Mountains, Romania. In the Elvo River, Piedmont, Italy. From Poschiavo, Bergell, Switzerland. In the USA, from Josephine and Jackson Cos., Oregon; South Fork, Smith River, Del Norte Co., California; and in the Line Pit mine, Cecil Co., Maryland. From the Lillooet district, Fraser River, British Columbia; and at Holle Canyon, Pelly River, Yukon Territory, Canada. From Oko, Kochi Prefecture, Japan. In the Sakhakot-Qila complex, Malakand Agency, Pakistan. A number of additional localities are known, many as widely dispersed occurrences in large ultramafic bodies.

Name: For the locality near Awarua Bay, New Zealand.

Type Material: Geological Survey of New Zealand, Lower Hutt, New Zealand, P21969.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 117–119. (2) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 356–357. (3) Challis, G.A. (1975) Native nickel from the Jerry River, south Westland, New Zealand; an example of natural refining. Mineral. Mag., 40, 247–251. (4) Ahmed, Z. and J.C. Bevan (1981) Awaruite, iridian awaruite, and a new Ru–OsIr–Ni–Fe alloy from the Sakhakot-Qila Complex, Malakand Agency, Pakistan. Mineral. Mag., 44, 225–230. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 13. (6) Williams, K.L. (1960) ??title?? Amer. Mineral., 45, 450–453. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 31.

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Azoproite $(Mg, Fe^{2+})_2(Fe^{3+}, Ti, Mg)BO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic crystals, often striated and skeletal, to 2 cm, typically poorly terminated, with a diamond-shaped outline on {001}.

Physical Properties: *Cleavage:* On {010}, good, may be a parting; on {001}, distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼5.5 D(meas.) = 3.63(2) D(calc.) = [3.63] Paramagnetic.

Optical Properties: Translucent to nearly opaque; transparent in thin section. *Color:* Black. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = pale bluish green; Y = dark green; Z = brownish red. *Absorption:* $Z > Y > X$. $\alpha = 1.799(2)$ $\beta = 1.822(3)$ $\gamma = 1.855(5)$ 2V(meas.) = $> 70°$ 2V(calc.) = 80°

Cell Data: *Space Group: Pbam.* $a = 9.26(1)$ $b = 12.25(1)$ $c = 3.01(1)$ Z = 4

X-ray Powder Pattern: Tazheran massif, Russia.
2.52 (10d), 5.07 (8), 2.16 (6), 2.02 (6), 2.77 (5b), 2.11 (5), 1.900 (5)

Chemistry:

	(1)
TiO_2	15.40
B_2O_3	19.07
Fe_2O_3	16.01
FeO	5.16
MnO	0.11
MgO	45.01
Na_2O	trace
Total	100.76

(1) Tazheran massif, Russia; after deduction of calcite, spinel, forsterite, corresponds to $(Mg_{1.82}Fe^{2+}_{0.13})_{\Sigma=1.95}(Fe^{3+}_{0.37}Ti_{0.36}Mg_{0.25})_{\Sigma=0.98}B_{1.02}O_{5.00}$.

Mineral Group: Ludwigite group.

Occurrence: An uncommon late-stage mineral in the border zone in magnesian contact-metamorphic rocks associated with syenites; the deposit is estimated to contain 350 kT B_2O_3.

Association: Calcite, ludwigite, brucite, clinohumite, baddeleyite, tazheranite, perovskite, geikielite, forsterite.

Distribution: From the Tazheran alkalic massif, west of Lake Baikal, eastern Siberia, Russia.

Name: A Russian acronym honoring the Study of Deep Zones of the Earth's Crust (AZOPRO in Russian) sponsored in 1969 by the International Geological Association.

Type Material: Mining Institute, St. Petersburg, 1481/1–1481/3; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72890–72892; Natural History Museum, Paris; National School of Mines, Paris, France, V16383.

References: (1) Konev, A.A., V.S. Lebedeva, A.A. Kashayev and Z.F. Ushchapovskaya (1970) Azoproite, a new mineral of the ludwigite group. Zap. Vses. Mineral. Obshch., 99, 225–231 (in Russian). (2) (1971) Amer. Mineral., 56, 360 (abs. ref. 1).

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Azurite $Cu_3(CO_3)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are typically complex, with over 100 forms recorded, to 30 cm. Tabular on {001}, less commonly so on {102} or {$\bar{1}$02}; short to long prismatic along [001], with prominent {110} and {100}, or along [010], with wedgelike terminations. As rhomboidal, lenticular, or spherical subparallel aggregates, which may form rosettes; also as internally radial stalactitic or columnar aggregates; botryoidal, drusy, earthy, massive. *Twinning:* Rare; twin planes {$\bar{1}$01}, {$\bar{1}$02}, {001}.

Physical Properties: *Cleavage:* On {011}, perfect but interrupted; on {100}, fair; on {110}, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 3.773(3) D(calc.) = 3.78

Optical Properties: Transparent to translucent. *Color:* Azure-blue, Berlin blue, very dark to pale blue; pale blue in transmitted light. *Streak:* Pale blue. *Luster:* Vitreous to subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* In shades of blue. *Orientation:* $X = b$; $Z \wedge c = -12°36'$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > Y > X$. $\alpha = 1.730$ $\beta = 1.754$–1.758 $\gamma = 1.835$–1.838 2V(meas.) = 67°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.0109(5)$ $b = 5.8485(6)$ $c = 10.345(2)$ $\beta = 92.43(3)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.516 (100), 2.224 (70), 5.15 (55), 3.674 (50), 2.510 (35), 2.287 (35), 5.08 (30)

Chemistry:

	(1)	(2)
CO_3	25.46	25.54
CuO	69.08	69.23
H_2O	5.46	5.23
Total	100.00	100.00

(1) Chessy, France. (2) $Cu_3(CO_3)_2(OH)_2$.

Occurrence: In the oxidized zones of copper deposits associated with carbonate rocks; may constitute an ore of copper.

Association: Malachite, chrysocolla, brochantite, antlerite, cuprite, cerussite, smithsonite, calcite, dolomite.

Distribution: Widespread, with many localities producing good crystals. From Chessy, near Lyon, Rhône, France. At Alghero and elsewhere on Sardinia, Italy. In the Zmeinogorsk (Schlangenberg) and Zolotuskinskii mines, Altai Mountains, Russia. Large crystals at the Touissit mine, near Oujda, Morocco. An ore at the Chingola mine, Nchanga, Zambia. Extraordinary examples from Tsumeb, Namibia. In the USA, in Arizona, fine examples from the Copper Queen and other mines of the Warren district, Bisbee, Cochise Co.; at Morenci, Greenlee Co.; in the Mammoth-St. Anthony mine, Pinal Co.; from the New Cornelia mine, Ajo, Pima Co.; at the Kelly and Graphic mines, Magdalena, Socorro Co., New Mexico; in Utah, in the Apex mine, St. George, Washington Co., and at the Big Indian mine, near La Sal, San Juan Co. Fine crystals from the El Cobre mine, Concepcion del Oro, and at the San Carlos mine, Mazapil, Zacetecas, Mexico. In Australia, many localities, as in New South Wales, at Broken Hill, also fine crystals from the Girilambone mine, north of Nyngan. In China, from the Yang Chweng mine, Shilu, Guangdong Province, China.

Name: From the Persian *lazhward*, for its characteristic blue color.

Type Material: Natural History Museum, Paris, France, 103.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 264–269. (2) Gattow, G. and J. Zemann (1958) Neubestimmung der Kristallstruktur von Azurit, $Cu_3(OH)_2(CO_3)_2$. Acta Cryst., 11, 866–872 (in German). (3) (1960) NBS Circ. 539, 10, 30. (4) Dana, E.S. (1883) Dana's system of mineralogy, (5th edition), 715–716.

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Babefphite $BaBe(PO_4)F$

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Crystal Data: Triclinic, pseudotetragonal. *Point Group:* 1. As anhedral, equant to flattened grains, to 1.5 mm; may be in aggregates.

Physical Properties: *Tenacity:* Very brittle. Hardness = [3.5] VHN = 140–200
D(meas.) = 4.31 D(calc.) = 4.325

Optical Properties: Transparent. *Color:* White. *Luster:* Vitreous to greasy.
Optical Class: Biaxial; pseudouniaxial (+). *Orientation:* Negative elongation. $\omega = 1.629(2)$
$\epsilon = 1.632(2)$

Cell Data: *Space Group:* $P1$. $a = 6.889(3)$ $b = 16.814(7)$ $c = 6.902(3)$ $\alpha = 90.01(3)^\circ$
$\beta = 89.99(3)^\circ$ $\gamma = 90.32(3)^\circ$ Z = 8

X-ray Powder Pattern: Aunik deposit, Russia.
3.190 (10), 2.163 (10), 1.516 (10), 2.760 (8), 2.440 (7), 2.033 (7), 1.135 (7b)

Chemistry:

	(1)	(2)
P_2O_5	26.55	27.26
Fe_2O_3	0.3	
BeO	11.63	9.61
CaO	0.00	
BaO	56.50	58.90
F	7.27	7.30
H_2O	[0.64]	
$-O = F_2$	3.05	3.07
Total	[99.84]	100.00

(1) Aunik deposit, Russia; by microchemical analysis, with $(OH)^{1-}$ for charge balance, corresponds to $Ba_{0.99}Be_{1.20}(PO_4)_{1.00}[F_{1.02}(OH)_{0.36}]_{\Sigma=1.38}$. (2) $BaBe(PO_4)F$.

Occurrence: In eluvium directly above rare-metal skarn deposits associated with alkaline intrusions.

Association: Zircon, ilmenorutile, fluorite, phenakite, scheelite, bertrandite, albite, microcline, quartz.

Distribution: Occurs in the Aunik fluorite-rare metals deposit, Buryatia, Siberia, Russia.

Name: For BArium, BEryllium, Fluorine, and PHosphorous in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72021.

References: (1) Nazarova, A.S., N.N. Kuznetsova, and D.P. Shashkin (1966) Babefphite, a barium-beryllium fluoride-phosphate. Doklady Acad. Nauk SSSR, 167, 895–897 (in Russian). (2) (1966) Amer. Mineral., 51, 1547 (abs. ref. 1). (3) Simonov, M.A., Y.K. Yegorov-Tismenko, and N.V. Belov (1980) Use of modern X-ray equipment to solve fine problems of structural mineralogy by the example of the crystal structure of babefphite $BaBe(PO_4)F$. Kristallografiya (Sov. Phys. Crystal.), 25, 28–30.

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Babingtonite $Ca_2(Fe^{2+},Mn)Fe^{3+}Si_5O_{14}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Stubby, prismatic, striated crystals, to 3 cm; also platy and as subparallel aggregates.

Physical Properties: *Cleavage:* Perfect on {001}, good on {010} and {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.34–3.37 D(calc.) = 3.26

Optical Properties: Opaque to faintly translucent. *Color:* Dark greenish black. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = deep green; Y = lilac-brown; Z = pale to deep brown. *Dispersion:* $r > v$, strong. $\alpha = 1.700(3)$ $\beta = 1.710(3)$ $\gamma = 1.725(3)$ 2V(meas.) = 50(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.50(1)$ $b = 12.18(1)$ $c = 6.68(1)$ $\alpha = 86°3(5)'$ $\beta = 93°59(5)'$ $\gamma = 112°19(5)'$ Z = 2

X-ray Powder Pattern: Baveno, Italy.
2.75 (100), 2.87 (80), 3.12 (70), 2.17 (60), 2.95 (60b), 2.47 (50), 6.69 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	52.80	52.44	52.41
TiO_2	0.29	0.00	
Al_2O_3	2.41	0.23	
Fe_2O_3	13.17	14.43	13.93
FeO	7.68	10.12	12.53
MnO	1.89	1.03	
MgO	0.92	0.65	
CaO	19.19	19.67	19.56
Na_2O	0.48	0.08	
H_2O	0.91	1.27	1.57
Total	99.74	[99.92]	100.00

(1) Arendal, Norway. (2) Holyoke, Hampden Co., Massachusetts, USA; original total given as 99.82%. (3) $Ca_2Fe^{2+}Fe^{3+}Si_5O_{14}(OH)$.

Polymorphism & Series: Forms a series with manganbabingtonite.

Occurrence: In veins cutting granite pegmatite and diorite; in cavities and vugs in mafic volcanic rocks and gneisses; in skarns.

Association: Prehnite, calcite, epidote, albite, orthoclase, garnet, quartz, "hornblende," zeolites.

Distribution: Known from a number of localities, most minor; some providing good crystals are: in Norway, at the Brastad mine, Oyestad, near Arendal. From Gronsjöberg, Dalarma, Sweden. In Germany, at Herbornseelbach, Hesse. From Baveno, Piedmont, Italy. In the Khandivali quarry, near Bombay, Maharashtra, India. At Mitani, Kochi Prefecture, Japan. From Noril'sk, western Siberia, Russia. In the USA, in Massachusetts, exceptional crystals from Lane's quarry, Westfield, Hampden Co.; in the Cheapside and Deerfield quarries, East Deerfield, Franklin Co.; also at Winchester Highlands, Uxbridge, Norfolk Co. At Paterson, Passaic Co., and Mine Hill, Morris Co., New Jersey; from the Goose Creek quarry, Leesburg, Loudoun Co., Virginia; and at Lenoir, Caldwell Co., North Carolina.

Name: For Dr. William Babington (1756–1833), Irish physician and mineralogist.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 381–382. (2) Washington, H.S. and H.E. Merwin (1923) On babingtonite. Amer. Mineral., 8, 215–223. (3) Palache, C. and F.A. Gonyer (1932) On babingtonite. Amer. Mineral., 17, 295–299. (4) Kosoi, A.L. (1975) The structure of babingtonite. Kristallografiya (Sov. Phys. Crystal.), 20, 730–739 (in Russian). (5) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Survey of Canada, Paper 60-4, 11.

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Babkinite $Pb_2Bi_2(S,Se)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $\overline{3}$. As thin tablets, in aggregates, to 2 mm across.

Physical Properties: *Cleavage:* Perfect, on {001}. Hardness = ∼2. VHN = 71–91, 82 average, ⊥ to cleavage; 90–112, 100 average, ∥ to cleavage (10 g load). D(meas.) = n.d. D(calc.) = 8.096

Optical Properties: Opaque. *Color:* Silvery gray; in reflected light, white with yellowish tint. *Streak:* Gray. *Luster:* Metallic.
Optical Class: Uniaxial. *Pleochroism:* Weak in pale bluish brown tints. *Anisotropism:* Distinct. *Bireflectance:* Negligible.
R: (400) 51.3, (420) 50.7, (440) 49.6, (460) 48.7, (480) 48.6, (500) 48.5, (520) 47.8, (540) 47.5, (560) 48.2, (580) 47.0, (600) 46.5, (620) 46.5, (640) 46.1, (660) 46.5, (680) 46.2, (700) 46.7

Cell Data: *Space Group:* $P\overline{3}1m$ or $P\overline{3}$. $a = 4.191(2)$ $c = 39.60(3)$ $Z = 3$

X-ray Powder Pattern: Nevskoye deposit, Russia.
3.04 (10), 2.096 (8), 1.298 (7), 1.806 (6), 1.233 (6), 3.42 (5), 1.725 (5)

Chemistry:

	(1)
Ag	0.13
Pb	42.58
Sb	0.08
Bi	42.02
Se	10.60
S	5.80
Total	101.21

(1) Nevskoye deposit, Russia; by electron microprobe, average of 23 analyses; corresponds to $(Pb_{1.99}Ag_{0.01})_{\Sigma=2.00}(Bi_{1.95}Sb_{0.01})_{\Sigma=1.96}(S_{1.75}Se_{1.30})_{\Sigma=3.05}$.

Occurrence: In a hydrothermal deposit in sediments, near their contact with a granite intrusion.

Association: Arsenopyrite, stannite, tetrahedrite, wittite, laitakarite, selenian cosalite, cassiterite, wolframite.

Distribution: From the Nevskoye W–Sn deposit, 25 km northwest of Omsukchan, Magadan region, Russia.

Name: To honor Petr Vasil'evich Babkin (1929–1977), Russian geologist, Northeast Geological Administration of Mingeo, Magadan, Russia, who first studied the Nevskoye deposit.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p806/1.

References: (1) Bryzgalov, I.A., E.M. Spiridonov, I.V. Petrova, and M.S. Sakharova (1996) Babkinite $Pb_2Bi_2(S,Se)_3$ – a new mineral. Doklady Acad. Nauk SSSR, 346, 656–659 (in Russian). (2) (1996) Amer. Mineral., 81, 1513–1518 (abs. ref. 1).

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Baddeleyite ZrO_2

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly tabular on {100} and somewhat elongated on [010], or short to long prismatic along [001], to 6 cm; rarely equant; prism faces striated ‖ [001]; radially fibrous with concentric banding in botryoidal masses. *Twinning:* Ubiquitous; on {100} and {110}, both may be polysynthetic; rare on {201}.

Physical Properties: *Cleavage:* {001} nearly perfect, {010} and {110} less perfect. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 5.40–6.02 D(calc.) = [5.83] Blue-green cathodoluminescence.

Optical Properties: Transparent; in dark-colored specimens, only in thin fragments. *Color:* Colorless to yellow, green, greenish or reddish brown, brown, iron-black; colorless to brown in transmitted light. *Streak:* White to brownish white. *Luster:* Greasy to vitreous; nearly submetallic in black crystals.
Optical Class: Biaxial (–). *Pleochroism:* X = yellow, reddish brown, oil-green; Y = oil-green, reddish brown; Z = brown, light brown. *Orientation:* $X \wedge c = 13°$; $Y = b$. *Dispersion:* $r > v$, rather strong. *Absorption:* $X > Y > Z$. $\alpha = 2.13(1)$ $\beta = 2.19(1)$ $\gamma = 2.20(1)$
2V(meas.) = 30(1)° 2V(calc.) = 28°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 5.1505(1)$ $b = 5.2116(1)$ $c = 5.3173(1)$ $\beta = 99.230(1)°$ Z = 4

X-ray Powder Pattern: Phalaborwa, South Africa.
3.15 (10), 2.835 (9), 2.62 (5), 1.817 (5), 3.66 (4), 3.51 (4), 1.847 (4)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	0.19	0.08	HfO_2		0.93	CaO	0.06	
TiO_2		0.56	Fe_2O_3	0.82		LOI	0.28	
ZrO_2	98.90	97.8	FeO		1.3	Total	100.25	100.67

(1) Balangoda, Sri Lanka. (2) Axel Heiberg Island, Canadian Arctic Archipelago; by electron microprobe, average of 35 analyses.

Occurrence: An accessory mineral in carbonatites and kimberlites; in syenites, diabases, gabbros, anorthosites; detrital in gem gravels. In lunar basalt, tektites, and meteorites.

Association: Ilmenite, zirkelite, apatite, magnetite, perovskite (Jacupiranga mine, Brazil); fluorite, nepheline, pyrochlore, allanite (Monte Somma, Italy).

Distribution: At Rakwana and Balangoda, Sri Lanka. From Monte Somma, Campania, Italy. In Russia, large crystals from the Kovdor massif, and in the Gulinskii massif, the Vuoriyarvi carbonatite complex, and the Imandrovsky layered intrusion, Kola Peninsula; in the Lukkulaisvaara layered intrusion, Karelia. At the Jacupiranga mine, São Paulo, and at Poços de Caldas, Minas Gerais, Brazil. From Bozeman, Gallatin Co., Montana, USA. In the Bingo deposit, Kivu Province, Congo (Zaire). From Catanda, Angola. At Benfontein, and in large crystals from Phalaborwa, Transvaal, South Africa. Other minor occurrences are known.

Name: For Joseph Baddeley, who first called attention to the Sri Lankan material.

Type Material: The Natural History Museum, London, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 608–610. (2) Heimstra, S.A. (1955) Baddeleyite from Phalaborwra, Eastern Transvaal. Amer. Mineral., 40, 275–282. (3) Keil, K. and P.E. Fricker (1974) Baddeleyite (ZrO_2) in gabbroic rocks from Axel Heiberg Island, Canadian Arctic Archipelago. Amer. Mineral., 59, 249–253. (4) Scatena-Wachel, D.E. and A.P. Jones (1984) Primary baddeleyite (ZrO_2) in kimberlite from Benfontein, South Africa. Mineral. Mag., 48, 257–261. (5) Heaman, L.M. and A.N. LeCheminant (1993) Paragenesis and U–Pb systematics of baddeleyite (ZrO_2). Chem. Geol., 110, 95–126. (6) Howard, C.J., R.J. Hill, and B.E. Reichert (1988) Structures of the ZrO_2 polymorphs at room temperature by high-resolution neutron powder diffraction. Acta Cryst., 44, 116–120.

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Bafertisite $\mathbf{Ba(Fe^{2+},Mn^{2+})_2TiOSi_2O_7(OH,F)_2}$

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Crystal Data: Monoclinic. *Point Group: m.* Crystals of simple rhombic habit, elongated along [100] and flattened on {001}. As aggregates of acicular crystals, to 1.5 cm. *Twinning:* Ubiquitous on {001}, polysynthetic.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ∼5 D(meas.) = 3.96–4.25 D(calc.) = 3.8

Optical Properties: Semitransparent. *Color:* Bright red, yellowish red to light brown, straw-brown to tan.
Optical Class: Biaxial (–). *Pleochroism:* X = yellow-red to reddish brown; Y = yellow; Z = pale yellow to greenish yellow. *Orientation:* $Y = b$; $X \wedge a = 5.5°$. *Absorption:* $X > Z$.
$\alpha = 1.805$–1.808 $\beta = 1.835$ $\gamma = 1.860$–1.862 2V(meas.) = 54°–86°

Cell Data: *Space Group: Cm.* $a = 10.60$ $b = 13.64$ $c = 12.47$ $\beta = 119°30'$ Z = 8

X-ray Powder Pattern: Baiyun-Obo deposit, China.
2.65 (100), 2.11 (40), 1.72 (40), 2.52 (30), 2.23 (30), 2.07 (30), 1.75 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	23.68	25.18	BaO	29.98	26.59
TiO_2	15.39	14.27	K_2O	0.12	0.33
Al_2O_3	0.29	1.00	Na_2O	0.49	0.38
Fe_2O_3	1.08	3.67	F		3.50
Nb_2O_5	0.84	0.32	Cl	0.63	
FeO	22.56	10.82	H_2O^+	1.65	2.16
MnO	1.62	12.77	H_2O^-	1.14	
MgO	0.50		$-O = (F,Cl)_2$	0.14	1.47
CaO	0.37	0.30	Total	100.20	99.82

(1) Baiyun-Obo deposit, China. (2) Burpala massif, Russia; corresponding to $Ba(Mn_{0.90}Fe^{2+}_{0.76}Fe^{3+}_{0.33})_{\Sigma=1.99}TiOSi_2O_7(OH,F)_2$.

Polymorphism & Series: Forms a series with hejtmanite.

Occurrence: In hydrothermal veins (Baiyun-Obo deposit, China); in a dike of microcline granite-aplite (Burpala massif, Russia).

Association: Aegirine, fluorite, barite, bastnäsite (Baiyun-Obo deposit, China).

Distribution: In China, from the Baiyun-Obo mine, near Pao-t'ou, Inner Mongolia. From the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, Russia. At an undefined locality in Kazakhstan. In the Fountain quarry, near Fountain, Pitt Co., North Carolina, USA.

Name: For elements in the composition, BArium, iron (FERrum), TItanium, and SIlicon.

Type Material: n.d.

References: (1) Peng Ch'i-Jui (1959) The discovery of several new minerals of rare elements. Ti Chih K'o Hsueh, 10, 289 (in Chinese). (2) (1960) Amer. Mineral., 45, 754 (abs. ref. 1) (3) Semenov, E.I. and P'ei-Shan Chang (1959) New mineral bafertisite. Sci. Record (Peking), 3, 652–655 (in Russian). (4) (1960) Amer. Mineral., 45, 1317 (abs. ref. 3). (5) Kuan Ya-Hsien, V.I. Simonov, and N.V. Belov (1963) Crystal structure of bafertisite $BaFe_2TiO[Si_2O_7](OH)_2$. Doklady Acad. Nauk SSSR, 149, 1416–1419 (in Russian). (6) (1963) Chem. Abs., 59, 3386 (abs. ref. 5). (7) Yakovlevskaya, T.A. and D.A. Mineev (1965) Crystals and the optical orientation of bafertisite. Trudy Mineral. Muzeya Akad. Nauk SSSR, 16, 293–294 (in Russian). (8) (1965) Chem. Abs., 63, 9158 (abs. ref. 7). (9) Ganzeev, A.A., A.F. Efimov, and G.V. Lyubomilova (1971) Manganiferous bafertisite from the Burpala massif (northern Baikal) Trudy Mineral. Muzeya Akad. Nauk SSSR, 20, 195-197 (in Russian). (10) (1972) Amer. Mineral., 57, 1005 (abs. ref. 9).

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Baghdadite $Ca_3(Zr,Ti)Si_2O_9$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals stumpy prismatic, to 250 μm. *Twinning:* Contact twins, individuals having [010] in common.

Physical Properties: *Fracture:* Conchoidal. Hardness = ~6 VHN = 725–783, 750 average (50 g load). D(meas.) = n.d. D(calc.) = 3.48 Cathodoluminescence, dull gray with greenish tint.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.652$ $\beta = 1.658$ $\gamma = 1.670$ 2V(meas.) = ~72°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.42$ $b = 10.16$ $c = 7.36$ $\beta = 91.1°$ Z = 4

X-ray Powder Pattern: Dupezeh Mountain, Iraq.
2.84 (100), 2.98 (85), 3.23 (80), 3.04 (75), 2.88 (70), 7.30 (45), 1.702 (40)

Chemistry:

	(1)
SiO_2	29.26
TiO_2	2.11
ZrO_2	27.00
Al_2O_3	0.03
Fe_2O_3	0.11
MgO	0.05
CaO	41.44
Na_2O	0.02
Total	100.02

(1) Dupezeh Mountain, Iraq; by electron microprobe, average of 26 analyses of four crystals; estimated to contain HfO_2 ~0.16%; corresponds to $Ca_{3.00}(Zr_{0.89}Ti_{0.11})_{\Sigma=1.00}(Si_{1.98}Fe_{0.01})_{\Sigma=1.99}O_9$.

Occurrence: In a melilite skarn in contact with banded diorite, in roof pendant xenoliths of calc-silicate marbles and hornfels.

Association: Åkermanite, perovskite, schorlomite, monticellite, wollastonite, foshagite, calcite, phlogopite, spinel, cuspidine, baddeleyite, pyrrhotite, djerfisherite, valleriite (melilite skarn); andesine, kaersutite, titanian augite, ilmenite, titanian magnetite, xonotlite (banded diorite).

Distribution: On Dupezeh Mountain, near Hero Town, Qala-Diza region, northeastern Iraq.

Name: For Baghdad, the capital of Iraq.

Type Material: n.d.

References: (1) Al-Hermezi, H.M., D.M. McKie, and A.J. Hall (1986) Baghdadite, a new calcium zirconium silicate mineral from Iraq. Mineral. Mag., 50, 119–123. (2) (1987) Amer. Mineral., 72, 222 (abs. ref. 1).

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Bahianite $Al_5Sb_3^{5+}O_{14}(OH)_2$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As water-worn, bean-shaped pebbles, to 10 cm, with polycrystalline or radial-fibrous structure; also as curved and striated crystals, diamond-shaped or rectangular, lining pockets in the pebbles. *Twinning:* As pseudohexagonal multiple contact twins, chrysoberyllike.

Physical Properties: *Cleavage:* {100}, perfect. *Fracture:* Uneven. Hardness = 9 VHN = 1605 (100 g load). D(meas.) = 4.78–5.29; 5.46 for a crystal. D(calc.) = 5.26

Optical Properties: Transparent to translucent. *Color:* Tan, cream, orange-brown, brown; crystals colorless, tan, pale violet; yellow internal reflections in transmitted light. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Dispersion:* $r > v$. $\alpha = 1.81(1)$ $\beta = 1.87(1)$ $\gamma = 1.92(1)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $C2/m$. $a = 9.406(6)$ $b = 11.541(8)$ $c = 4.410(3)$ $\beta = 90.94(3)^\circ$ Z = 2

X-ray Powder Pattern: Paramirim region, Brazil.
3.241 (100), 3.194 (100), 2.156 (80), 4.712 (70), 2.457 (70), 2.411 (70), 1.648 (70)

Chemistry:

	(1)	(2)	(3)
WO_3	1.20	0.3	
Sb_2O_5	57.28	61.9	64.00
SiO_2	1.03	3.5	
TiO_2		0.2	
Al_2O_3	35.37	30.6	33.62
Fe_2O_3	1.04	1.3	
BeO	0.75	0.75	
MgO		0.1	
H_2O	2.77	0.85	2.38
Total	99.44	99.50	100.00

(1) Paramirim region, Brazil; by electron microprobe, average of four analyses, total Fe as Fe_2O_3, H_2O by the Penfield method; corresponds to $Al_{5.49}Be_{0.24}Si_{0.14}Fe^{3+}_{0.10}W_{0.04}Sb_{2.80}O_{14}(OH)_{2.44}$.
(2) Do. (3) $Al_5Sb_3O_{14}(OH)_2$.

Occurrence: In potholes as stream-worn pebbles and as residual concentrates above weathered volcanic rock.

Association: Quartz, andalusite, kyanite, diaspore, phenakite, eskolaite, cassiterite, gold.

Distribution: About eight km southeast of the village of Paramirim das Crioulas, and elsewhere in the region around Rio do Picos das Almas, Serra das Almas, south-central Bahia, Brazil.

Name: For the occurrence in Bahia, Brazil.

Type Material: Harvard University, Cambridge, Massachusetts, 119088; National Museum of Natural History, Washington, D.C., USA, 133875, 135922.

References: (1) Moore, P.B, C. do P. Barbosa, and R.V. Gaines (1978) Bahianite, $Sb_3Al_5O_{14}(OH)_2$, a new species. Mineral. Mag., 42, 179–182. (2) (1979) Amer. Mineral., 64, 464 (abs. ref. 1). (3) Moore, P.B. and T. Araki (1976) Bahianite, $Al_6Sb_3^{5+}O_{14}(O,OH)_2$, a novel hexagonal close-packed oxide structure. Neues Jahrb. Mineral., Abh., 126, 113–125. (4) Cassedanne, J.P. (1985) Bahianite from Brazil. Mineral. Record, 16, 111–115.

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Baileychlore $(Zn, Fe^{2+}, Al, Mg)_6(Si, Al)_4O_{10}(OH)_8$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As fine-grained transverse fibers of very small size.

Physical Properties: *Cleavage:* Perfect micaceous. Hardness = < 5 D(meas.) = 3.18(2) D(calc.) = 3.195

Optical Properties: Transparent. *Color:* Green, zoned.
Optical Class: Biaxial. *Pleochroism:* Weak; green to yellow-green. $\alpha = 1.582$ β = n.d. $\gamma = 1.614$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C\overline{1}$ or $C1$ (uncertainty due to random stacking of chlorite layers). $a = 5.346(3)$ $b = 9.257(4)$ $c = 14.40(7)$ $\beta = 97.12(5)^\circ$ Z = [2]

X-ray Powder Pattern: Red Dome deposit, Australia.
7.14 (100), 14.3 (90), 1.542 (60), 2.660 (50), 3.573 (40), 2.450 (35b), 4.600 (30)

Chemistry:

	(1)
SiO_2	32.0
Al_2O_3	12.4
FeO	12.9
MnO	0.15
ZnO	30.5
MgO	4.6
CaO	1.0
H_2O	n.d.

(1) Red Dome deposit, Australia; by electron microprobe; excluding CaO, corresponds to $(Zn_{2.50}Fe_{1.20}Al_{1.17}Mg_{0.76}Mn_{0.01})_{\Sigma=5.64}(Si_{3.55}Al_{0.45})_{\Sigma=4.00}O_{10}(OH)_8$.

Mineral Group: Chlorite group.

Occurrence: As rims on colloform calcite veins, within a strongly oxidized collapse karst-breccia containing skarn clasts.

Association: Andesine, garnet, vesuvianite, zincian chamosite, goethite, hematite, chalcocite, copper, malachite, calcite.

Distribution: From the Red Dome deposit, 15 km west-northwest of Chillagoe, Queensland, Australia.

Name: For Professor Sturges W. Bailey (1919–1994), Department of Geology and Geophysics, University of Wisconsin, Madison, Wisconsin, USA.

Type Material: Geological Museum, University of Wisconsin, Madison, Wisconsin, 6000/1; National Museum of Natural History, Washington, D.C., USA, 164430; South Australian Museum, Adelaide, Australia, 13592.

References: (1) Rule, A.C. and F. Radke (1988) Baileychlore, the Zn end member of the trioctahedral chlorite series. Amer. Mineral., 73, 135–139.

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Bakerite $Ca_4B_4(BO_4)(SiO_4)_3(OH)_3 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely as single crystals, to 0.2 mm, stout, rhombic prisms having oblique terminations or as thin diamond-shaped tablets. As botryoidal and drusy crusts and nodules; most commonly as dense fine-grained aggregates or massive.

Physical Properties: Hardness = 4.5 D(meas.) = 2.88 D(calc.) = 2.94

Optical Properties: Translucent to opaque from clay inclusions. *Color:* Colorless to white. *Luster:* Vitreous to porcelaneous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 44°$. $\alpha = 1.624$ $\beta = 1.635$ $\gamma = 1.654$
2V(meas.) = 87°–88°

Cell Data: *Space Group:* $P2_1/c$. a = 4.83 $b = 7.60$ $c = 9.60$ $\beta = 90°2'$ Z = [1]

X-ray Powder Pattern: Sterling Borax mine, California, USA.
3.11 (100), 2.85 (60), 2.236 (60), 3.74 (50), 2.51 (50), 2.18 (50), 2.99 (40)

Chemistry:

	(1)	(2)
SiO_2	27.90	28.90
B_2O_3	27.58	27.91
CaO	35.14	35.97
H_2O^+	8.60	7.22
H_2O^-	0.30	
rem.	0.65	
Total	100.17	100.00

(1) Corkscrew Canyon, Death Valley, California, USA; remainder is oxides of trivalent elements.
(2) $Ca_4B_4(BO_4)(SiO_4)_3(OH)_3 \cdot H_2O$.

Mineral Group: Gadolinite group.

Occurrence: As irregular veins in altered volcanic rock (Baker Canyon, Death Valley, California, USA).

Association: Natrolite, thomsonite (Baker Canyon, Death Valley, California, USA); danburite, calcite, stilbite, datolite, quartz (Charcas, Mexico).

Distribution: In the USA, in California, the mineral probably never occurred at the type locality given as "16 miles northeast of Daggett" which is Borate, 14 km east of Yermo, San Bernardino Co.; it more likely was from later authenticated localities in the Black Mountains, west of Furnace Creek, Death Valley, Inyo Co.; also in the Sterling Borax mine, Tick Canyon, Los Angeles Co. Found near Tory Hill, Bancroft, Ontario, Canada. At Charcas, San Luis Potosí, Mexico. From Sivas, Turkey. In Italy, from near Sestri Levante, Liguria.

Name: To honor Richard C. Baker, of Nutfield, Surrey, England, Mining Director of the Pacific Coast Borax Co., who discovered the mineral.

Type Material: The Natural History Museum, London, England, 86511; Harvard University, Cambridge, Massachusetts, 92735; National Museum of Natural History, Washington, D.C., USA, 94820.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 363. (2) Kramer, H. and R.D. Allen (1956) A restudy of bakerite, priceite, and veatchite. Amer. Mineral., 41, 689–700. (3) Murdoch, J. (1962) Bakerite crystals. Amer. Mineral., 47, 919–923. (4) Pemberton, H.E. (1971) Type locality for bakerite. Amer. Mineral., 56, 1109–1110.

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Baksanite $Bi_6Te_2S_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Granular, dropletlike and in spherical aggregates, to 13 mm.

Physical Properties: *Cleavage:* Perfect, on {0001}. *Tenacity:* Flexible, but not elastic. Hardness = 1.5–2 VHN = 62 (5 g load). D(meas.) = 8.1(1) D(calc.) = 8.07

Optical Properties: Opaque. *Color:* Steel-gray; in reflected light, bright white. *Streak:* Black. *Luster:* Metallic.
Optical Class: Uniaxial. *Anisotropism:* Distinct, in yellowish gray tints. *Bireflectance:* Weak. R_1–R_2: (400) 46.3–50.1, (420) 47.5–50.2, (440) 48.9–50.5, (460) 48.1–52.2, (480) 48.2–52.0, (500) 47.7–52.4, (520) 47.7–52.2, (540) 48.1–52.4, (560) 48.7–52.6, (580) 48.6–52.1, (600) 49.0–51.6, (620) 49.3–51.0, (640) 49.2–51.1, (660) 49.2–50.8, (680) 48.7–51.1, (700) 48.5–51.2

Cell Data: *Space Group:* $P\overline{3}m1$. a = 4.249(2) c = 62.82(5) Z = 3

X-ray Powder Pattern: Tyrnyauz deposit, Russia.
3.09 (100), 4.50 (46), 2.255 (38), 2.126 (25), 3.58 (22), 3.30 (20), 3.53 (15)

Chemistry:

	(1)	(2)
Pb	2.15	
Te	14.33	15.90
Se	0.00	
Sb	0.12	
Bi	76.40	78.11
S	6.64	5.99
Total	99.64	100.00

(1) Tyrnyauz deposit, Russia; by electron microprobe, average of 20 analyses; corresponds to $(Bi_{5.78}Pb_{0.16}Sb_{0.02})_{\Sigma=5.96}Te_{1.77}S_{3.27}$. (2) $Bi_6Te_2S_3$.

Occurrence: In altered magnetite–andradite skarn.

Association: Gold, bismuthinite, ingodite, joséite, andradite, calcite, chlorite, stilpnomelane.

Distribution: From the Tyrnyauz W–Mo deposit, left bank of the Baksan River Valley, northern Caucasus Mountains, Russia [TL].

Name: For the Baksan River Valley, in which the mineral occurs.

Type Material: Mining Institute, St. Petersburg, 2082/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p1112/1.

References: (1) Pekov, I.V., E.N. Zav'yalov, S.V. Fedyushchenko, D.K. Shcherbachev, Y.S. Borodayev, and G.D. Dorokhova (1996) Baksanite, $Bi_6(Te_2S_3)$, a new mineral from Tyrny'auz (northern Caucasus). Doklady Acad. Nauk SSSR, 347, 787–791 (in Russian). (2) (1997) Amer. Mineral., 82, 1038 (abs. ref. 1).

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Balangeroite $(Mg, Fe^{2+}, Fe^{3+}, Mn^{2+})_{42}Si_{16}O_{54}(OH)_{40}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous, both loose and compact; asbestiform, elongated along [001], to several cm.

Physical Properties: *Cleavage:* One or more on $\{hk0\}$ are very good. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.96–3.10 D(calc.) = 3.098

Optical Properties: Transparent only in thin section. *Color:* Brown. *Luster:* Vitreous, greasy.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; dark brown ∥ [001]; yellow-brown ⊥ [001]. $\alpha = 1.680(5) \perp [001]$. β = n.d. $\gamma = \sim 1.680 \parallel [001]$. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2/n$. $a = 19.40$ $b = 9.65$ $c = 19.40$ $\beta = 91.1°$ Z = [2]

X-ray Powder Pattern: Balangero mine, Italy.
2.714 (100), 6.77 (80), 2.674 (75), 3.378 (45), 9.59 (40), 3.278 (40), 2.516 (40)

Chemistry:

	(1)
SiO_2	28.37
TiO_2	0.03
Al_2O_3	0.27
Fe_2O_3	8.89
Cr_2O_3	0.03
FeO	16.95
MnO	3.59
MgO	31.81
CaO	0.13
H_2O	[9.93]
Total	[100.00]

(1) Balangero mine, Italy; by electron microprobe, average of 16 analyses; Fe^{2+}:Fe^{3+} = 2.12 was deduced from wet chemical analysis, H_2O by difference; corresponds to $(Mg_{26.74}Fe^{2+}_{7.99}Fe^{3+}_{3.77}Mn^{2+}_{1.71}Al_{0.18}Ca_{0.08}Cr_{0.01}Ti_{0.01})_{\Sigma=40.49}Si_{16}O_{55.81}(OH)_{37.35}$.

Occurrence: In schistose serpentinite in proximity to a large ultramafic massif.

Association: Chrysotile, magnetite, Fe–Ni alloy, olivine, chlorite, titanian clinohumite, diopside, antigorite, calcite, aragonite, "opal", "chalcedony", clay minerals.

Distribution: In the Balangero (San Vittore) mine and at Ponte del Diavolo, Lanzo Valley, and from Santa Maria della Neve, Fiano, Piedmont, Italy.

Name: For the Balangero mine, Piedmont, Italy.

Type Material: Mineralogy Institute, Turin University, Turin, Italy, 14873.

References: (1) Compagnoni, R., G. Ferraris, and L. Fiori (1983) Balangeroite, a new fibrous silicate related to gageite from Balangero, Italy. Amer. Mineral., 68, 214–219. (2) Ferraris, G., M. Mellini, and S. Merlino (1987) Electron-diffraction and electron-microscopy study of balangeroite and gageite: crystal structures, polytypism, and fiber texture. Amer. Mineral., 72, 382–391.
(3) Belluso, E. and G. Ferraris (1991) New data on balangeroite and carlosturanite from alpine serpentinites. Eur. J. Mineral., 3, 559–566.

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Balipholite $BaMg_2LiAl_3(Si_2O_6)_2(OH,F)_8$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals needlelike and fibrous, elongated ‖ [001], up to 1 mm; as radiating or parallel sheaflike aggregates.

Physical Properties: *Cleavage:* Perfect on {010}, distinct on {100} and {110}.
Hardness = n.d. D(meas.) = 3.32–3.35 D(calc.) = [3.32]

Optical Properties: Transparent to translucent. *Color:* Pale yellowish white; in thin section, colorless. *Luster:* Silky.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. α = 1.5807–1.5810 β = 1.5954–1.5958 γ = 1.5984–1.6008 2V(meas.) = 68°–72°

Cell Data: *Space Group: Ccca.* $a = 13.60$ $b = 20.24$ $c = 5.16$ Z = [4]

X-ray Powder Pattern: Hsianghualing area, China.
10.12 (100), 3.39 (91), 4.05 (78), 2.605 (31), 2.390 (28)

Chemistry:

	(1)		(1)
SiO_2	33.44	CaO	0.28
TiO_2	0.11	BaO	19.07
Al_2O_3	23.43	Li_2O	2.00
Fe_2O_3	0.32	Na_2O	0.26
FeO	0.58	K_2O	0.47
MnO	0.05	H_2O^+	10.30
BeO	0.01	P_2O_5	0.03
MgO	9.68	Total	100.03

(1) Hsianghualing area, China; corresponding to $(Ba_{0.88}K_{0.07}Na_{0.06}Ca_{0.03})_{\Sigma=1.04}(Mg_{1.69}Al_{0.17}Fe^{2+}_{0.06}Fe^{3+}_{0.03})_{\Sigma=1.95}Li_{0.95}Al_{3.00}(Si_{3.93}Al_{0.07})_{\Sigma=4.00}O_{11.96}(OH)_{8.07}$.

Occurrence: In a miarolitic cavity.

Association: Zinnwaldite, quartz.

Distribution: From the Hsianghualing area, Linwu, Hunan Province, China.

Name: For BArium and LIthium in the composition, and the Chinese for *fibrous*.

Type Material: n.d.

References: (1) X-ray Laboratory, Wuhan Geologic College, Geology Team 654, Hunan Geology Bureau, and Geology Laboratory, Hunan Geology Bureau (1975) A new lithium-bearing mineral in China: balipholite, $BaMg_2LiAl_3[Si_2O_6]_2(OH)_8$. Scientia Geologia Sinica, 1, 100 (in Chinese with English title). (2) (1976) Amer. Mineral., 61, 338 (abs. ref. 1). (3) (1975) Mineral. Abs., 26, 325 (abs. ref. 1). (4) Wuhan Geologic College; Hunan Geologic Bureau (1977) Balipholite $BaMg_2LiAl_3[Si_2O_6]_2(OH,F)_8$ and its crystal structure. Ti Chih K'o Hsueh, 65–82 (in Chinese). (5) (1977) Chem. Abs., 87, 120592 (abs. ref. 4).

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Balkanite $Cu_9Ag_5HgS_8$

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Crystal Data: Orthorhombic. *Point Group:* 222, $mm2$, or $2/m\ 2/m\ 2/m$. As rodlike prismatic crystals, to 0.2 mm, elongated and striated ‖ [001], and in grains, to 3 mm. *Twinning:* Lamellar in several directions, common.

Physical Properties: Hardness = ∼3.5 VHN = 79.4–91.6 (100 g load). D(meas.) = 6.318 (synthetic). D(calc.) = 6.421

Optical Properties: Opaque. *Color:* Steel-gray; pale gray in polished section. *Luster:* Metallic. *Anisotropism:* Strong.
R_1–R_2: (400) — , (420) — , (440) 35.4–30.6, (460) 35.6–31.0, (480) 35.4–31.0, (500) 35.0–30.2, (520) 34.0–28.9, (540) 34.0–28.0, (560) 33.4–27.2, (580) 32.8–26.5, (600) 32.4–26.0, (620) 32.1–25.6, (640) 31.8–25.1, (660) 31.5–24.9, (680) — , (700) —

Cell Data: *Space Group:* $P222$, $Pmm2$, or $Pmmm$. $a = 10.62(2)$ $b = 9.42(2)$ $c = 3.92(4)$ $Z = 1$

X-ray Powder Pattern: Sedmochislenitsi deposit, Bulgaria.
2.98 (10), 2.55 (10), 1.955 (9), 2.61 (8), 2.45 (8), 1.985 (8), 3.09 (7)

Chemistry:

	(1)	(2)
Cu	37.4	37.1
Ag	33.1	33.3
Hg	14.0	13.8
S	17.2	16.9
Total	101.7	101.1

(1) Sedmochislenitsi deposit, Bulgaria; by electron microprobe, corresponding to $Cu_{8.78}Ag_{4.58}Hg_{1.04}S_{8.00}$. (2) Do.; corresponding to $Cu_{8.76}Ag_{4.69}Hg_{1.04}S_{8.00}$.

Occurrence: In high-grade copper ores in a stratiform Pb–Zn–Cu deposit (Sedmochislenitsi deposit, Bulgaria).

Association: Bornite, chalcocite, chalcopyrite, djurleite, digenite, tennantite, stromeyerite, mckinstryite, wittichenite, bismuth, rammelsbergite, mercurian silver, cinnabar, pyrite, calcite, barite, aragonite.

Distribution: In the Sedmochislenitsi mine, Vratsa district, western part of the Stara Planina (Balkan Mountains), Bulgaria [TL]. From Manhattan, Nye Co., Nevada, USA. From about 20 km southwest of Agua Prieta, Sonora, Mexico.

Name: For the medieval and popular name of the Stara Planina (Balkan Mountains), the main mountain range giving its name to the Balkan Peninsula.

Type Material: Mineralogical Museum of the Higher Institute of Mining and Geology, 619; Museum of the University of Sofia "Kliment Ohridsky", Sofia, 1351; National Museum of Natural History, Sofia, Bulgaria, 2339.

References: (1) Atanassov, V.A. and G.N. Kirov (1973) Balkanite, $Cu_9Ag_5HgS_8$, a new mineral from the Sedmochislenitsi mine, Bulgaria. Amer. Mineral., 58, 11–15.

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Balliranoite $(Na,K)_6Ca_2(Si_6Al_6O_{24})Cl_2(CO_3)$

Crystal Data: Hexagonal. *Point Group*: 6. Crystals, prismatic on {10$\bar{1}$ 0} and striated along [0001], to 2 mm; as grains to 1 cm.

Physical Properties: *Cleavage*: Perfect on {10$\bar{1}$ 0}. *Fracture*: n.d.
Tenacity: Brittle. Hardness = 5 D(meas.) = 2.48(1) D(calc.) = 2.486(12)

Optical Properties: Transparent. *Color*: Colorless. *Streak*: n.d.
Luster: Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.523(2)$ $\varepsilon = 1.525(2)$

Cell Data: *Space Group*: $P6_3$. $a = 12.695(2)$ $c = 5.325(1)$ $Z = 1$

X-ray Powder Pattern: Monte Somma–Vesuvio volcanic complex, Campania, Italy.
4.797 (100), 3.281 (73), 2.662 (58), 3.669 (57), 2.446 (31), 2.120 (18), 2.754 (16)

Chemistry:

	(1)
SiO_2	32.38
Al_2O_3	27.28
CaO	12.70
Na_2O	13.05
K_2O	3.08
Cl	7.43
SO_3	1.96
CO_2	3.24
H_2O	0.19
$-O=Cl_2$	1.68
Total	99.63

(1) Monte Somma–Vesuvio volcanic complex, Campania, Italy; average of 5 analyses, CO_2 by selective sorption, H_2O by Penfield method and confirmed by IR, corresponding to $Na_{4.70}Ca_{2.53}K_{0.73}(Si_{6.02}Al_{5.98}O_{23.995})Cl_{2.34}(CO_3)_{0.82}(SO_4)_{0.27}\cdot 0.12\ H_2O$.

Mineral Group: Cancrinite group.

Occurrence: A product of metasomatic reaction between alkaline magma and limestone.

Association: Orthoclase, phlogopite, clinohumite, calcite, diopside, pargasite, haüyne, apatite.

Distribution: Monte Somma–Vesuvio volcanic complex, Campania, Italy.

Name: Honors the Italian crystallographer Paolo Ballirano (b. 1964), Department of Earth Sciences, University of Rome, for contributions to the crystal chemistry of cancrinite group minerals.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (catalog no. 3756/1).

References: (1) Chukanov, N.V., N.V. Zubkova, I.V. Pekov, L.V. Olysych, E. Bonaccorsi, and D.Y. Pushcharovski (2010) Balliranoite, $(Na,K)_6Ca_2(Si_6Al_6O_{24})Cl_2(CO_3)$, a new cancrinite-group mineral from Monte Somma–Vesuvio volcanic complex, Italy. Eur. J. Mineral., 22, 113–119. (2) (2010) Amer. Mineral., 95, 1595-1596 (abs. ref. 1).

Balyakinite $CuTeO_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As minute short prismatic crystals, and as grains, to 0.5 mm.

Physical Properties: Hardness = n.d. VHN = 80–125, 105 average (10 g load).
D(meas.) = 5.6 D(calc.) = 5.64

Optical Properties: Semitransparent. *Color:* Grayish green, bluish green, blue to pale blue; in reflected light, gray, bluish gray. *Streak:* Pale bluish green.
Optical Class: Biaxial (–). *Pleochroism:* Weak; in greens. *Orientation:* $X = a$; $Y = b$; $Z = c$.
$\alpha = 2.11$ $\beta = 2.18$ $\gamma = 2.22$ 2V(meas.) = $> 80°$ *Anisotropism:* Slight.

Cell Data: *Space Group: Pmcn.* $a = 7.604(6)$ $b = 5.837(4)$ $c = 12.705(6)$ Z = 8

X-ray Powder Pattern: Russia.
2.85 (10), 2.84 (8), 3.09 (5), 1.711 (5), 4.34 (4), 3.18 (4), 2.28 (3.5)

Chemistry:

	(1)	(2)
TeO_2	67.54	66.74
SeO_2	0.03	
Sb_2O_3	1.12	
FeO	0.08	
CuO	33.42	33.26
PbO	0.62	
Ag_2O	0.26	
Total	103.07	100.00

(1) Russia; by electron microprobe, calculated from average of three elemental analyses; corresponding to $(Cu_{1.01}Ag_{0.01}Pb_{0.01})_{\Sigma=1.03}(Te_{1.02}Sb_{0.02})_{\Sigma=1.04}O_{2.93}$. (2) $CuTeO_3$.

Occurrence: A rare mineral formed in the oxidation zone as an alteration product of Cu–Te sulfides.

Association: Tetrahedrite, chalcopyrite, tellurite, bilibinskite, bogdanovite, teineite, quartz (Aginsk deposit, Russia).

Distribution: In Russia, from the Pionersk deposit, eastern Sayan, and the Aginsk gold telluride deposit, Kamchatka, Far Eastern Region.

Name: To honor Tat'yana Stepanovna Balyakina (1906–1986), Geology Instructor, Moscow University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80669.

References: (1) Spiridonov, E.M. (1980) Balyakinite, $CuTeO_3$, a new mineral from the oxidation zone. Doklady Acad. Nauk SSSR, 253, 1448–1450 (in Russian). (2) (1981) Amer. Mineral., 66, 436 (abs. ref. 1). (3) Lindqvist, O. (1972) The crystal structure of $CuTeO_3$. Acta Chem. Scand., 26, 1423–1430.

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Bambollaite $Cu(Se, Te)_2$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m$ or $4/m\ 2/m\ 2/m$. Fine granular aggregates and lenses, intimately intermixed with klockmannite.

Physical Properties: *Fracture:* Fine conchoidal. Hardness = n.d. VHN = n.d. D(meas.) = 5.64 (synthetic). D(calc.) = [5.02]

Optical Properties: Opaque. *Color:* In polished section, creamy white. *Anisotropism:* Slight. R_1–R_2: n.d.

Cell Data: *Space Group:* $P4_2/n$ or perhaps $I4_1/amd$. a = 5.466 c = 5.632 Z = [2]

X-ray Powder Pattern: Moctezuma mine, Mexico.
3.19 (100), 1.961 (70), 1.653 (50), 1.931 (40), 1.689 (30), 1.270 (20), 1.121 (20)

Chemistry:

	(1)
Cu	25.1
Se	44.5
Te	31.0
Total	100.6

(1) Synthetic material matching the X-ray powder pattern of the natural mineral; by electron microprobe, corresponding to $Cu_{1.00}(Se_{1.43}Te_{0.62})_{\Sigma=2.05}$.

Occurrence: In oxidized Au–Te ore in subparallel quartz veins in a hydrothermally altered tuff.

Association: Klockmannite, tellurium, selenium, chalcomenite, tellurite, paratellurite, illite, calcite, quartz.

Distribution: In the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico [TL].

Name: For the Spanish nickname "La Bambolla" of the mine where it occurs, which roughly translates into "hot air" in allusion to exaggerated tales of rich gold ore.

Type Material: Royal Ontario Museum, Toronto, Canada, M27177; National Museum of Natural History, Washington, D.C., USA, 128391.

References: (1) Harris, D.C. and E.W. Nuffield (1972) Bambollaite, a new copper telluro-selenide. Can. Mineral., 11, 738–742. (2) (1973) Amer. Mineral., 58, 805 (abs. ref. 1).

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Bamfordite $Fe^{3+}Mo_2O_6(OH)_3 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As tabular, diamond-shaped crystals, to 0.05 mm, showing {001}, {100}, {010}, {110}, {$1\overline{1}0$}, in aggregates.

Physical Properties: *Cleavage:* {100}, traces. *Tenacity:* Compact to friable in aggregates. Hardness = 2–3 D(meas.) = 3.620(8) D(calc.) = 3.616

Optical Properties: Transparent. *Color:* Bright apple-green with slight yellowish tinge. *Streak:* Greenish yellow. *Luster:* Vitreous, earthy in aggregates.
Optical Class: Biaxial (–). *Pleochroism:* Pale to moderate; in yellowish greens. *Orientation:* $Y \simeq$ a; $c \wedge Z' = 7°$; length-slow. $\alpha = 1.91(1)$ $\beta = 2.03(1)$ $\gamma = 2.11(1)$ 2V(meas.) = ∼90° 2V(calc.) = 74°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.889(5)$ $b = 7.545(5)$ $c = 9.419(5)$ $\alpha = 71.46(4)°$ $\beta = 83.42(4)°$ $\gamma = 72.78(4)°$ Z = 2

X-ray Powder Pattern: Bamford Hill, Australia.
3.319 (100), 3.232 (90), 5.620 (70), 4.095 (70), 4.711 (50), 2.614 (50), 1.956 (50)

Chemistry:

	(1)	(2)
MoO_3	68.93	69.75
WO_3	1.90	
P_2O_5	0.39	
Fe_2O_3	18.93	19.34
H_2O	9.9	10.91
Total	100.05	100.00

(1) Bamford Hill, Australia; by electron microprobe, H_2O by CHN analyzer; with $(OH)^{1-}$ calculated for charge balance, corresponds to $Fe_{1.00}(Mo_{2.01}W_{0.03}P_{0.02})_{\Sigma=2.06}O_6(OH)_{3.34} \cdot 0.64H_2O$.
(2) $FeMo_2O_6(OH)_3 \cdot H_2O$.

Occurrence: Formed in miarolitic cavities and vugs by oxidation of molybdenite under strongly acidic conditions in a W–Mo–Bi deposit.

Association: W–Mo–Bi oxides, "clay", muscovite, quartz.

Distribution: On Bamford Hill, 85 km west-southwest of Cairns, Queensland, Australia.

Name: For its occurrence on Bamford Hill, Australia.

Type Material: South Australian Museum, Adelaide, 20653; Museum of Victoria, Melbourne, Australia, M7424.

References: (1) Birch, W.D., A. Pring, E.M. McBriar, B.M. Gatehouse, and C.A. McCammon (1998) Bamfordite, $Fe^{3+}Mo_2O_6(OH)_3 \cdot H_2O$, a new hydrated iron molybdenum oxyhydroxide from Queensland, Australia. Amer. Mineral., 83, 172–177.

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Banalsite $BaNa_2Al_4Si_4O_{16}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Very rarely showing traces of crystal faces; coarsely crystalline to compact, massive.

Physical Properties: *Cleavage:* Good on {110} and {001}. Hardness = 6.5
D(meas.) = 3.065 D(calc.) = 3.073

Optical Properties: Translucent to transparent in thin flakes. *Color:* White.
Luster: Vitreous, pearly on cleavage.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.5695$ $\beta = 1.5710$
$\gamma = 1.5775$ 2V(meas.) = 41(3)°

Cell Data: *Space Group: Ibam.* $a = 8.496(2)$ $b = 9.983(2)$ $c = 16.755(3)$ Z = 4

X-ray Powder Pattern: Benallt mine, Wales; close to stronalsite.
3.53 (100), 5.20 (90), 8.50 (80), 3.21 (80), 2.90 (80), 2.09 (80), 3.77 (70)

Chemistry:

	(1)	(2)
SiO_2	34.74	36.44
Al_2O_3	31.20	30.92
MnO	0.03	
MgO	1.00	
CaO	0.81	
BaO	21.99	23.25
Na_2O	8.43	9.40
K_2O	0.66	
H_2O	1.08	
Total	99.94	100.00

(1) Benallt mine, Wales. (2) $BaNa_2Al_4Si_4O_{16}$.

Mineral Group: Feldspar group.

Occurrence: In veinlets through manganese ore and in lenses in metamorphosed mudstone (Benallt mine, Wales).

Association: Tephroite, alleghanyite, jacobsite, barite, calcite (Benallt mine, Wales).

Distribution: In the Benallt mine, Rhiw, Lleyn Peninsula, Wales. At Långban, Värmland, Sweden. From the Kalahari manganese field, Cape Province, South Africa.

Name: Derived from the chemical symbols for the major constituents, *Ba, Na, Al, Si.*

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1944,420–423; Harvard University, Cambridge, Massachusetts, 108656; National Museum of Natural History, Washington, D.C., USA, 105854.

References: (1) Campbell Smith, W., F.A. Bannister, and M.H. Hey (1944) A new barium-feldspar from Wales. Nature, 154, 336–337. (2) (1945) Amer. Mineral., 30, 85 (abs. ref. 1). (3) Campbell Smith, W., F.A. Bannister, and M.H. Hey (1944) Banalsite, a new barium-feldspar from Wales. Mineral. Mag., 27, 33–47. (4) Haga, N. (1973) The crystal structure of banalsite, $BaNa_2Al_4Si_4O_{16}$, and its relation to the feldspar structure. Mineral. J. (Japan), 7, 262–281. (5) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Bandylite $CuB(OH)_4Cl$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As crystals, typically tabular on {001} or pyramidal, to 5 mm; dominant forms are {001}, {111}, {201}, and {110}; also as radial clusters, almost lichenlike, in joints in the rock.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Very flexible; easily deformed. Hardness = 2.5 D(meas.) = 2.810 D(calc.) = 2.81 Soluble in H_2O; alters to eriochalcite on exposure to air.

Optical Properties: Transparent. *Color:* Deep blue with greenish portions; cendre blue to Italian blue, becoming greener with atacamite inclusions; blue in transmitted light. *Streak:* Pale blue. *Luster:* Vitreous, pearly on cleavage surfaces; dull when altered.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = deep cendre blue; E = pale greenish yellow. $\omega = 1.691–1.692$ $\epsilon = 1.640–1.641$

Cell Data: *Space Group:* $P4/n$. $a = 6.19$ $c = 5.61$ Z = 2

X-ray Powder Pattern: Quetena, Chile.
5.59 (10), 3.08 (8), 2.54 (8), 1.952 (7), 4.35 (6), 1.655 (6), 4.13 (5.5)

Chemistry:

	(1)	(2)
Cu	34.94	35.73
B_2O_4	23.35	24.07
Fe_2O_3	0.35	
MgO	0.05	
CaO	0.05	
Na_2O	0.40	
Cl	19.47	19.94
H_2O	19.60	20.26
SO_3	0.05	
insol.	1.84	
Total	100.10	100.00

(1) Quetena, Chile. (2) $CuB(OH)_4Cl$.

Occurrence: Of secondary origin, in a leached zone above massive iron sulfates (Quetena, Chile).

Association: Atacamite, eriochalcite (Quetena, Chile); starkeyite (near Taltal, Chile).

Distribution: In Chile, from Quetena, west of Calama, and near Taltal, Antofagasta.

Name: For Dr. Mark Chance Bandy (1900–1963), American mining engineer, mineralogist, and mineral collector, who first collected the mineral.

Type Material: Harvard University, Cambridge, Massachusetts, 94625, 97381; National Museum of Natural History, Washington, D.C., USA, C5459.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 373–374. (2) Collin, R.L. (1951) The crystal structure of bandylite, $CuCl_2 \cdot CuB_2O_4 \cdot 4H_2O$. Acta Cryst., 4, 204–209. (3) Ross, V. and J.O. Edwards (1959) Tetrahedral boron in teepleite and bandylite. Amer. Mineral., 44, 875–877.

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Bannermanite $(Na, K)_x V_x^{4+} V_{6-x}^{5+} O_{15}$ (x = 0.7)

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As incrustations of subhedral to euhedral lathlike crystals, flattened on {001} and elongated along [010], up to 250 μm.

Physical Properties: *Cleavage:* {100}, perfect; {010}, fair. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.5(2) D(calc.) = 3.55

Optical Properties: Opaque, transparent on thin edges. *Color:* Black; light brown on thin edges in transmitted light. *Streak:* Dark gray-black. *Luster:* Submetallic. *Optical Class:* Biaxial. *Orientation:* [010] $\parallel$ Y or Z; length-slow. *Absorption:* $Y > X$ or $Z > X$. n = [2.2] (rule of Gladstone and Dale).

Cell Data: *Space Group:* $C2/m$. $a = 15.413(7)$ $b = 3.615(2)$ $c = 10.066(8)$ $\beta = 109.29(8)^\circ$ Z = 2

X-ray Powder Pattern: Izalco volcano, El Salvador. (ICDD 35-713).
7.24 (100), 3.367 (100), 3.068 (80), 2.911 (80), 9.47 (70), 3.491 (70), 2.725 (60)

Chemistry:

	(1)
V_2O_5	95.98
Na_2O	3.03
K_2O	1.26
Total	100.27

(1) Izalco volcano, El Salvador; by electron microprobe, average of six analyses, V^{4+}:V^{5+} from charge balance; corresponds to $(Na_{0.56}K_{0.15})_{\Sigma=0.71}V_{0.71}^{4+}V_{5.29}^{5+}O_{15}$.

Occurrence: In vanadium-bearing sublimates in fumaroles on a basaltic volcanic cone.

Association: Shcherbinaite, stoiberite, ziesite, fingerite, chalcocyanite, chalcanthite.

Distribution: From Izalco volcano, El Salvador.

Name: To honor Dr. Harold MacColl Bannerman (1897–1976), American economic geologist, U.S. Geological Survey and Dartmouth College, Hanover, New Hampshire, USA.

Type Material: Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire; Harvard University, Cambridge, Massachusetts, 126482; National Museum of Natural History, Washington, D.C., USA, 148832, 160385.

References: (1) Hughes, J.M. and L.W. Finger (1983) Bannermanite, a new sodium-potassium vanadate isostructural with β–$Na_xV_6O_{15}$. Amer. Mineral., 68, 634–641. (2) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 511–512, 519.

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Bannisterite

$KCa(Mn^{2+}, Fe^{2+}, Zn, Mg)_{20}$
$(Si, Al)_{32}O_{76}(OH)_{16}\cdot 4-12H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic bladed crystals and aggregates, to 20 cm; as anhedral plates bounded by cleavage surfaces.

Physical Properties: *Cleavage:* Perfect on {001}; a second prismatic cleavage is noted microscopically. Hardness = 4 D(meas.) = 2.83–2.84 D(calc.) = 2.84

Optical Properties: Translucent. *Color:* Light to dark brown, black. *Luster:* Resinous. *Optical Class:* Biaxial (–). *Pleochroism:* X = nearly colorless; $Y = Z$ = pale yellow to brown. *Orientation:* $Y = b$; $Z \simeq a$. *Dispersion:* $r < v$, weak to moderate. $\alpha = 1.544$–1.574 $\beta = 1.586$–1.611 $\gamma = 1.589$–1.612 2V(meas.) = Small to medium.

Cell Data: *Space Group:* $A2/a$. $a = 22.20$–22.32 $b = 16.32$–16.40 $c = 24.69$–24.70 $\beta = 94°17'-94°21'$ Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
12.33 (100), 3.436 (20), 4.103 (15b), 2.638 (15), 3.077 (12), 2.606 (11), 4.593 (10)

Chemistry:

	(1)	(2)
SiO_2	45.4	46.3
Al_2O_3	3.84	4.2
Fe_2O_3	2.1	1.44
FeO	16.5	5.67
MnO	19.9	23.4
ZnO	0.0	4.6
MgO	0.47	3.1
CaO	1.55	1.3
Na_2O	0.51	0.09
K_2O	0.92	1.04
H_2O	7.82	9.3
Total	99.0	100.4

(1) Broken Hill, Australia; determinations by a combination of electron microprobe, AA, and flame photometry. (2) Franklin, New Jersey, USA; by electron microprobe; Fe^{2+} and Fe^{3+} by wet methods, K and Na by flame photometry, H_2O by DTA-TGA; corresponds to $(K_{0.82}Na_{0.11})_{\Sigma=0.93}$ $Ca_{0.86}(Mn_{12.21}Fe^{2+}_{2.92}Mg_{2.85}Zn_{2.09}Fe^{3+}_{0.66})_{\Sigma=20.73}(Si_{28.53}Al_{3.05})_{\Sigma=31.58}O_{76}(OH)_{16}\cdot 12.2H_2O$.

Occurrence: In metamorphosed Mn-Zn orebodies.

Association: Manganoan and zincian amphiboles, rhodonite, sphalerite, quartz, calcite, barite (Franklin, New Jersey, USA); rhodonite, sphalerite, fluorite, galena, apophyllite, quartz (Broken Hill, Australia).

Distribution: In the Benallt mine, Rhiw, Lleyn Peninsula, Wales. From Franklin, Sussex Co., New Jersey, USA. At Nyberget, Sweden. In the Ananai mine, Kochi Prefecture, Japan. From Broken Hill, New South Wales, Australia.

Name: Honoring Dr. Frederick Allen Bannister (1901–), formerly Keeper of Minerals, British Museum (Natural History), London, England.

Type Material: The Natural History Museum, London, England, 1967,321; Harvard University, Cambridge, Massachusetts, 91862, 91863, 108571, 128253; National Museum of Natural History, Washington, D.C., USA, 145728–145730.

References: (1) Smith, M.L. and C. Frondel (1968) The related layered minerals ganophyllite, bannisterite, and stilpnomelane. Mineral. Mag., 36, 893–913. (2) (1969) Amer. Mineral., 54, 577 (abs. ref. 1). (3) Plimer, I.R. (1977) Bannisterite from Broken Hill, Australia. Neues Jahrb. Mineral., Monatsh., 504–508. (4) Dunn, P.J., P.B. Leavens, J.A. Norberg, and R.A. Ramik (1981) Bannisterite: new chemical data and empirical formulae. Amer. Mineral., 66, 1063–1067. (5) Heaney, P.J., J.E. Post, and H.T. Evans, Jr. (1992) The crystal structure of bannisterite. Clays and Clay Minerals, 40, 129–144.

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Baotite **$Ba_4(Ti,Nb)_8Si_4O_{28}Cl$**

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Crystal Data: Tetragonal. *Point Group:* $4/m$ As crystals, to 10 cm; as subhedral crystals and grains.

Physical Properties: *Cleavage:* Fair on {110}. *Fracture:* Hackly. *Tenacity:* Brittle. Hardness = 6 VHN = 769 D(meas.) = 4.42–4.71 D(calc.) = 4.69

Optical Properties: Translucent to transparent. *Color:* Light brown to black. *Luster:* Nearly semimetallic to vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* Strong; O = colorless; E = dark brownish to light greenish yellow. *Absorption:* $E > O$. $\omega = 1.94$ $\epsilon = 2.16$

Cell Data: *Space Group:* $I4_1/a$. $a = 19.2$–20.022 $c = 5.908$–6.006 Z = 16

X-ray Powder Pattern: Ravalli Co., Montana, USA.
1.335 (100), 1.422 (25), 3.139 (10), 1.763 (9.5), 3.516 (9), 2.234 (9), 1.351 (9)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	14.17	15.74	CaO	0.41	0.22
TiO_2	29.33	41.48	BaO	37.55	40.21
Al_2O_3	1.62	0.10	Na_2O	0.20	
Fe_2O_3	3.07	0.22	K_2O	0.13	
Cr_2O_3	0.05		Cl	2.01	1.69
Nb_2O_5	11.50	0.07	H_2O	0.52	
MgO	0.20		$-O = Cl_2$	0.45	
			Total	100.31	99.73

(1) Baiyun-Obo mine, China; corresponds to $(Ba_{3.82}Ca_{0.11})_{\Sigma=3.93}(Ti_{5.84}Nb_{1.35}Fe_{0.60}Al_{0.18})_{\Sigma=7.97}(Si_{3.68}Al_{0.32})_{\Sigma=4.00}O_{28}Cl_{0.88}$. (2) Šebkovice, Czech Republic; by electron microprobe, corresponding to $(Ba_{4.00}Ca_{0.06})_{\Sigma=4.06}(Ti_{7.91}Fe_{0.04}Al_{0.02}Nb_{0.01})_{\Sigma=7.98}(Si_{3.99}Al_{0.01})_{\Sigma=4.00}O_{28}Cl_{0.73}$.

Occurrence: In quartz veins cutting quartzite near alkalic granite and syenite (Baiyun-Obo mine, China); in a carbonate vein cutting "hornblende" gneiss intruded by diabase sills and small pegmatites (Ravalli Co., Montana, USA).

Association: Quartz, calcite, aegirine, galena, pyrite, alkalic amphiboles (Baiyun-Obo mine, China); calcite, dolomite, ancylite, aeschynite, monazite, sodic amphiboles, barite (Ravalli Co., Montana, USA); benitoite, bario-orthojoaquinite, fresnoite, natrolite (Gem mine, California, USA).

Distribution: In China, from the Baiyun-Obo mine, near Pao-t'ou, Inner Mongolia. In the USA, on Sheep Creek, Ravalli Co., Montana, and at the Gem mine, San Benito Co., California. From Šebkovice, Czech Republic. At Karlstein and Jarolden, Waldviertel region, Austria. In the Garaoulère mine, Pierrefitte, Hautes-Pyrénées, France.

Name: For the locality, Pao-t'ou (Baotou in Russian), China.

Type Material: National School of Mines, Paris, France.

References: (1) Peng Ch'i-Jui (1959) The discovery of several new minerals of rare elements. Ti Chih K'o Hsueh, 10, 289 (in Chinese). (2) (1960) Amer. Mineral., 45, 754 (abs. ref. 1). (3) Semonov, V.I. (1960) Baotite, a mineral with a metasilicate ring (Si_4O_{12}). Kristallografiya (Sov. Phys. Crystal.), 5, 544–546 (in Russian). (4) Heinrich, E.W., W.H. Boyer, and F.A. Crowley (1962) Baotite (pao-t'ou-k'uang) from Ravalli County, Montana. Amer. Mineral., 47, 987–993. (5) Nekrasov, Y.K., V.I. Ponomarev, V.I. Simonov, and D.M. Kheiker (1969) Refinement of the atomic structure of baotite and the isomorphic relationships in this mineral. Kristallografiya (Sov. Phys. Crystal.), 14, 602–609 (in Russian). (6) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 566–567. (7) Němec, D. (1987) Baotite – a rock-forming mineral of Ba-rich hyperpotassic dyke rocks. Neues Jahrb. Mineral., Monatsh., 31–42.

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Barahonaite-(Fe) $(Ca, Cu, Na, Fe^{3+}, Al)_{12}Fe^{3+}_2(AsO_4)_8(OH)_x \cdot nH_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*, 2 *or m*. As thin tabular composite crystals forming rosettes, to 0.2 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle.
Hardness = 2-3 (possibly). D(meas.) = n.d. D(calc.) = 2.93-3.11

Optical Properties: Transparent to translucent. *Color*: Greenish-yellow. *Streak*: White to pale yellow. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.664(2)$ $\beta \approx \gamma$ $\gamma = 1.677(2)$ 2V(meas.) = 45–80°

Cell Data: *Space Group*: n.d. $a = 10.161(7)$ $b = 22.39(2)$ $c = 10.545(10)$ $\beta = 93.3(1)°$ Z = 2

X-ray Powder Pattern: Dolores prospect, Murcia province, Spain.
22.0 (100), 11.2 (70), 2.763 (30), 5.068 (20), 3.345 (20), 2.659 (20), 2.541 (20)

Chemistry:

	(1)
Na_2O	2.07
MgO	0.14
CaO	12.96
CuO	12.41
Al_2O_3	1.71
Fe_2O_3	13.78
SiO_2	0.33
P_2O_5	0.42
As_2O_5	41.18
SO_3	0.29
Cl	0.91
-O=Cl	0.21
H_2O	14.01
Total	100.00

(1) Dolores prospect, Murcia province, Spain; average of 7 electron microprobe analyses, H_2O by difference; anionic groups confirmed by IR, corresponding to $(Ca_{4.95}Cu_{3.34}Na_{1.43}Mg_{0.07}Fe^{3+}_{1.70}Al_{0.72})_{\Sigma=12.21}Fe^{3+}_{2.00}[(As_{0.96}P_{0.02}S_{0.01}Si_{0.01})O_4]_8[(OH)_{6.82}Cl_{0.55}]_{\Sigma=7.37} \cdot 13.2H_2O$.

Polymorphism & Series: Complete solid solution with barahonaite-(Al).

Occurrence: A secondary mineral in the oxidized zone of a sulfide deposit.

Association: Arsenocrandallite, arsenogoyazite, conichalcite, cobaltarthurite, chlorargyrite, olivenite, azurite, cornwallite, pharmacosiderite, zálesíite, lavendulan.

Distribution: Dolores prospect, near Pastrana, Murcia province, northern Spain.

Name: Honors Antonio Barahona (b 1937) of Madrid who provided the original specimens.

Type Material: Canadian Museum of Nature, Ontario, 85716.

References: (1) Viñals, J., J.L. Jambor, M. Raudsepp, A.C. Roberts, J.D. Grice, M. Kokinos, and W.S. Wise (2008) Barahonaite-(Al) and barahonaite-(Fe), new Ca-Cu arsenate mineral species from Murcia province, Southeastern Spain, and Gold Hill, Utah. Can. Mineral., 46, 205–217. (2) (2008) Amer. Mineral., 93, 1941-1942 (abs. ref. 1).

Barahonaite-(Al) $(Ca, Cu, Na, Fe^{3+}, Al)_{12}Fe^{3+}_2(AsO_4)_8(OH)_x \cdot nH_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*, 2 *or m*. As coatings of curved, thin tabular composite crystals forming rosettes, to 0.2 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 2-3 (possibly). D(meas.) = 3.03 D(calc.) = 2.93-3.11

Optical Properties: Transparent to translucent. *Color*: Pale blue. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.616(2)$ $\beta \approx \gamma$ $\gamma = 1.622(2)$ 2V(meas.) = 45–80°

Cell Data: *Space Group*: n.d. $a = 9.964(3)$ $b = 22.43(1)$ $c = 10.555(6)$ $\beta = 92.76(6)°$ Z = 2

X-ray Powder Pattern: Dolores prospect, Murcia province, Spain.
22.0 (100), 11.16 (70), 4.983 (50), 3.333 (45), 2.493 (35), 3.003 (30), 3.655 (25), 2.654 (25)

Chemistry:

	(1)
Na_2O	1.65
MgO	0.00
CaO	15.71
CuO	14.59
Al_2O_3	9.52
Fe_2O_3	0.10
SiO_2	0.14
P_2O_5	0.35
As_2O_5	41.16
SO_3	1.24
Cl	0.06
-O=Cl	0.01
H_2O	14.49
Total	100.00

(1) Dolores prospect, Murcia province, Spain; average of 6 electron microprobe analyses, H_2O by difference; anionic groups confirmed by IR, corresponding to $(Ca_{5.75}Cu_{3.77}Na_{1.09}\ Al_{1.84}Fe^{3+}_{0.03})_{\Sigma=12.48}Al_{2.00}[(As_{0.94}S_{0.04}P_{0.01}Si_{0.01})O_4]_8\ [(OH)_{7.95}Cl_{0.04}]_{\Sigma=7.99} \cdot 12.5H_2O$.

Polymorphism & Series: Complete solid solution with barahonaite-(Fe).

Occurrence: A secondary mineral in the oxidized zone of a sulfide deposit.

Association: Arsenocrandallite, arsenogoyazite, conichalcite, cobaltarthurite, chlorargyrite, olivenite, azurite, cornwallite, pharmacosiderite, jarosite, zálesíite, lavendulan.

Distribution: Dolores prospect, near Pastrana, Murcia province, northern Spain; Gold Hill Mine, Toole County, Utah, USA.

Name: For its mineralogical and compositional relationship with barahonaite-(Fe).

Type Material: Canadian Museum of Nature, Ontario, 85719.

References: (1) Viñals, J., J.L. Jambor, M. Raudsepp, A.C. Roberts, J.D. Grice, M. Kokinos, and W.S. Wise (2008) Barahonaite-(Al) and barahonaite-(Fe), new Ca-Cu arsenate mineral species from Murcia province, Southeastern Spain, and Gold Hill, Utah. Can. Mineral., 46, 205–217. (2) (2008) Amer. Mineral., 93, 1941-1942 (abs. ref. 1).

Barartite $(NH_4)_2SiF_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Minute crystals, flattened on {0001}, may be elongated ⊥ [0001]. Arborescent, mammillary; commonly included within cryptohalite. *Twinning:* Dartlike or paddlewheel twins, with twin plane inclined to {0001}.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = ∼2.5 D(meas.) = 2.152 (synthetic). D(calc.) = 2.144 Soluble in H_2O, with a saline taste.

Optical Properties: Transparent. *Color:* White; colorless in thin section. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.406(1)$ $\epsilon = 1.391(3)$

Cell Data: *Space Group:* $C\overline{3}m$ (synthetic). $a = 5.77$ $c = 4.78$ Z = 1

X-ray Powder Pattern: Kehley's Run mine, Pennsylvania, USA.
4.84 (100), 2.42 (45), 2.09 (40), 2.22 (35), 3.45 (30), 5.00 (20), 4.20 (20)

Chemistry: Analyses of natural material have not been made.

Polymorphism & Series: Dimorphous with cryptohalite, the higher-temperature form.

Occurrence: Above a burning coal seam (Barari, India); a sublimation product at fumaroles (Vesuvius, Italy); a sublimation product in burning anthracite piles (Pennsylvania, USA).

Association: Cryptohalite, sal ammoniac, sulfur.

Distribution: In India, at the Bararee colliery, Barari, Jharia coalfield, West Bengal. From Vesuvius, Campania, Italy. In the Clara mine, near Oberwolfach, Black Forest, Germany. From the Kehley's Run mine, Shenandoah, Schuylkill Co., Pennsylvania, USA.

Name: For the occurrence at Barari, India, from which it was first characterized.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 106–107. (2) Lapham, D.M., J.H. Barnes, W.F. Downey, Jr. and R.B. Finkelman (1980) Mineralogy associated with burning anthracite deposits of eastern Pennsylvania. Pennsylvania Geol. Surv. Min. Res. Report, 4th ser., 78, 45–47.

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Baratovite $KLi_3Ca_7(Ti,Zr)_2Si_{12}O_{36}F_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As platy deposits, to 5 cm; in patchy granular aggregates. *Twinning:* On {001}, common.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.92 D(calc.) = 2.91 Brilliant bluish white fluorescence under SW UV.

Optical Properties: Transparent to translucent. *Color:* White. *Luster:* Vitreous, pearly in part.
Optical Class: Biaxial (+). *Orientation:* $X \wedge \perp \{001\} \simeq 50°$. *Dispersion:* $r > v$, strong.
$\alpha = 1.670$ $\beta = 1.670$–1.671 $\gamma = 1.673$–1.677 2V(meas.) = 32°–60°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 16.941(3)$ $b = 9.746(2)$ $c = 20.907(3)$ $\beta = 112.50(10)°$ Z = 4

X-ray Powder Pattern: Dara-i-Pioz massif, Tajikistan.
3.22 (100), 2.41 (20), 1.92 (17), 3.02 (5), 3.54 (4), 1.60 (4), 1.49 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	50.46	52.31	Li_2O	2.05	3.25
TiO_2	9.55	10.99	Na_2O	0.70	0.22
ZrO_2	2.28		K_2O	2.96	2.89
Fe_2O_3	0.50	0.29	F	1.05	0.34
Nb_2O_5	0.72		H_2O		1.21
MnO	0.12	0.22	$-O = F_2$	0.44	0.14
CaO	30.36	28.25	Total	100.31	99.83

(1) Dara-i-Pioz massif, Tajikistan; corresponds to $(K_{0.90}Na_{0.28})_{\Sigma=1.18}Li_{1.96}Ca_{7.75}(Ti_{1.71}Zr_{0.26})_{\Sigma=1.97}Si_{12}O_{37.00}F_{0.79}$. (2) Iwagi Islet, Japan; by electron microprobe, Li by flame photometry, H_2O by gravimetry, and F by specific ion electrode; corresponding to $(K_{0.85}Na_{0.10})_{\Sigma=0.95}Li_{3.00}(Ca_{6.94}Mn_{0.04})_{\Sigma=6.98}(Ti_{1.90}Fe^{3+}_{0.05})_{\Sigma=1.95}Si_{12}O_{35.78}[(OH)_{1.85}F_{0.25}]_{\Sigma=2.10}$.

Occurrence: An accessory mineral in quartz-albite-aegirine veinlets and in albitites in syenites (Dara-i-Pioz massif, Tajikistan); a fine-grained accessory mineral in a small aegirine syenite stock in coarse-grained biotite granite (Iwagi Islet, Japan).

Association: Miserite, ekanite, titanite, quartz, albite, aegirine (Dara-i-Pioz massif, Tajikistan); albite, aegirine, pectolite, sugilite, allanite, titanite, andradite, zircon, apatite (Iwagi Islet, Japan).

Distribution: From the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. On Iwagi Islet, Ehime Prefecture, Japan.

Name: For Rauf Baratovich Baratov (1921–), Soviet petrologist, Institute of Geology, Dushanbe, Tajikistan.

Type Material: Mineralogical Museum, University of St. Petersburg, St. Petersburg, 16250–16252; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76077, 77839, vis5062.

References: (1) Dusmatov, V.D., E.I. Semenov, A.P. Khomyakov, A.V. Bykova, and N.K. Dzharfarov (1975) Baratovite, a new mineral. Zap. Vses. Mineral. Obshch., 104, 580–582 (in Russian). (2) (1976) Amer. Mineral., 61, 1053 (abs. ref. 1). (3) Menchetti, S. and C. Sabelli (1979) The crystal structure of baratovite. Amer. Mineral., 64, 383–389. (4) Murakami, N., T. Kato, and F. Hirowatari (1983) Katayamalite, a new Ca-Li-Ti silicate mineral from Iwagi Islet, southwest Japan. Mineral. J. (Japan), 11, 261–268. (5) (1984) Amer. Mineral., 69, 811–812 (abs. ref. 4). (6) Baur, W.H. and D. Kassner (1992) Katayamalite and baratovite are structurally identical. Eur. J. Mineral., 839–841.

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Barberiite NH_4BF_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals rare, pseudohexagonal, tabular to platy on {001}, typically elongated along [010] or [100], to 300 μm; commonly in globular aggregates, to 2 mm.

Physical Properties: Hardness = n.d. VHN = 13.0–15.4, 14.2 average (25 g load). D(meas.) = 1.89(3) D(calc.) = 1.90 Very soluble in H_2O; decomposes in humid air.

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial, (+) or (–). n = [1.3081] 2V(meas.) = 90(2)°

Cell Data: *Space Group: Pnma.* $a = 9.0615(7)$ $b = 5.6727(6)$ $c = 7.2672(6)$ Z = 4

X-ray Powder Pattern: Vulcano, Italy.
3.183 (100), 3.540 (90), 2.898 (80), 4.472 (75), 2.163 (70), 2.536 (65), 2.282 (65)

Chemistry:

	(1)	(2)
Na	0.4	
K	2.2	
NH_4	16.6	17.21
BF_4	79.8	82.79
F	0.3	
Cl	0.6	
Br	0.1	
Total	100.0	100.00

(1) Vulcano, Italy; by ion chromatography, after deduction of some NH_4, F, Cl, and Br as sal ammoniac, corresponds to $[(NH_4)_{0.96}K_{0.06}Na_{0.02}]_{\Sigma=1.04}BF_4$. (2) NH_4BF_4.

Occurrence: Formed by fumarolic activity, stable at ground temperatures between 200 °C and 600 °C.

Association: Malladrite, realgar, bismuthinite, cannizzarite, galenobismuthite, sphalerite, sulfur, sal ammoniac, sassolite.

Distribution: From the Fossa crater, Vulcano, Lipari Islands, Italy.

Name: To honor Franco Barberi, Professor of Vulcanology, University of Pisa, Pisa, Italy, who promoted studies of Vulcano.

Type Material: Bari University, Bari, Italy (4/nm).

References: (1) Garavelli, A. and F. Vurro (1994) Barberiite, NH_4BF_4, a new mineral from Vulcano, Aeolian Islands, Italy. Amer. Mineral., 79, 381–384. (2) Caron, A.P. and J.L. Ragle (1971) Refinement of the structure of orthorhombic ammonium tetrafluoroborate, NH_4BF_4. Acta Cryst., 27, 1102–1107.

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Barbertonite $Mg_6Cr_2(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. As plates, flattened on {0001}, in fibrous matted masses, and as cross-fiber veinlets.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Flexible but not elastic. Hardness = 1.5–2 D(meas.) = 2.10(5) D(calc.) = 2.11 Greasy feel.

Optical Properties: Transparent. *Color:* Intense violet to rose-pink; violet to pale rose-pink in transmitted light. *Streak:* Very pale violet to white. *Luster:* Waxy to pearly. *Optical Class:* Uniaxial (–); may be biaxial due to strain. *Pleochroism:* Weak; O = dark rose-pink to violet; E = pale rose-pink to violet. $\omega = 1.557(3)$ $\epsilon = 1.529(3)$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 6.17$ $c = 15.52$ Z = 1

X-ray Powder Pattern: n.d.

Chemistry: Intimately intermixed with stichtite; analyses of pure material are therefore lacking. The species is supported by X-ray diffraction patterns showing group membership.

Polymorphism & Series: Dimorphous with stichtite.

Mineral Group: Manasseite group.

Occurrence: An alteration product of chromite in serpentinite.

Association: Stichtite, chromite, antigorite.

Distribution: From the Kaapsehoop asbestos mine, Kaapse Hoop, Barberton district, Transvaal, South Africa. In the Adelaide Ag–Pb mine, Dundas, Tasmania, Australia. At Hoo Field, Cunningsburgh, Shetland Islands, Scotland.

Name: For the Barberton district, South Africa, where it was first found.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 92549.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 659. (2) Frondel, C. (1941) Constitution and polymorphism of the pyroaurite and sjögrenite groups. Amer. Mineral., 26, 295–315. (3) Taylor, H.W.F. (1973) Crystal structures of some double hydroxide minerals. Mineral. Mag., 39, 377–389.

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Barbosalite $Fe^{2+}Fe_2^{3+}(PO_4)_2(OH)_2$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. As stout prismatic to pseudocubic crystals, may have a mosaic texture, to 0.25 mm; generally as microcrystalline to powdery coatings. *Twinning:* Contact twins with (001) as composition surface.

Physical Properties: Hardness = 6 D(meas.) = 3.60–3.62 D(calc.) = 3.71

Optical Properties: Translucent to nearly opaque. *Color:* Dark blue, blue-green. *Streak:* Dark blue. *Luster:* Vitreous to earthy. *Optical Class:* Biaxial (+). *Pleochroism:* $X = Y$ = dark blue-green; Z = dark olive-green. *Dispersion:* $r > v$, strong. *Absorption:* Strong; $X = Y > Z$. $\alpha = 1.76$–1.78 $\beta = 1.77$–1.81 $\gamma = 1.835$–1.84 2V(meas.) = 64°.

Cell Data: *Space Group:* $P2_1/c$. $a = 7.25$ $b = 7.46$ $c = 7.49$ $\beta = 120°15'$ Z = 2

X-ray Powder Pattern: Sapucaia mine, Brazil.
3.361 (10), 3.313 (8), 4.84 (6), 3.239 (6), 3.160 (6), 2.327 (4), 1.309 (4)

Chemistry:

	(1)	(2)
Fe_2O_3	40.92	40.79
FeO	18.38	18.35
MnO	0.30	
P_2O_5	36.07	36.26
H_2O	[4.33]	4.60
Total	[100.00]	100.00

(1) Criminoso mine, Brazil; by electron microprobe, Fe^{2+}:Fe^{3+} from stoichiometry, H_2O by difference. (2) $Fe^{2+}Fe_2^{3+}(PO_4)_2(OH)_2$.

Mineral Group: Lazulite group.

Mineral Group: Dimorphous with lipscombite.

Occurrence: In complex granitic pegmatites, formed by oxidation and hydration of primary phosphates.

Association: Tavorite, huréaulite, heterosite, triphylite, vivianite, roscherite, rockbridgeite.

Distribution: In Brazil, in Minas Gerais, at the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, and in good crystals from the Criminoso pegmatite mine, about 35 km north of São Jose da Safira, Agua Boa. In the USA, at the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from the Bull Moose and Tip Top mines, near Custer, Custer Co., South Dakota; at the Williams pegmatite, Coosa Co., Alabama. In Australia, from Wilson's quarry, Thackaringa district, 40 km southwest of Broken Hill, New South Wales, and in the Wiperaminga Hill West quarry, Boolcoomata, South Australia. From the Buranga pegmatite, near Gatumba, Rwanda. At the Angarf-Sud pegmatite, Tazenakht Plain, Morocco. In the Mangualde pegmatite, near Mesquitela, Portugal.

Name: Honors Aluizio Licinio de Miranda Barbosa (1916–), Professor of Geology, School of Mines, Ouro Preto, Brazil.

Type Material: National Museum, Rio de Janeiro, Brazil; The Natural History Museum, London, England, 1965,209; National Museum of Natural History, Washington, D.C., USA, 106842.

References: (1) Lindberg, M.L. and W.T. Pecora (1955) Tavorite and barbosalite, two new phosphate minerals from Minas Gerais, Brazil. Amer. Mineral., 40, 952–966. (2) Lindberg. M.L. and C.L. Christ (1959) Crystal structures of the isostructural minerals lazurite, scorzalite and barbosalite. Acta Cryst., 12, 695–697. (3) Smith, M.L.L. (1969) Twinning in barbosalite from the Sapucaia pegmatite mine, Minas Gerais, Brazil. U.S. Geol. Surv. Prof. Paper 650-D, 75–79. (4) Dunn, P.J., P.B. Leavens, B.D. Sturman, R.V. Gaines, and C. do Prado Barbosa (1979) Hureaulite and barbosalite from Lavra do Criminoso, Minas Gerais, Brazil. Mineral. Record, 10, 147–151.

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Barentsite $H_2Na_7Al(CO_3)_4F_4$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $\overline{1}$ or 1. Granular, to 5 mm.

Physical Properties: *Cleavage:* {001} and {110}, perfect. *Tenacity:* Brittle. Hardness = 3 VHN = 86–172, 100–165 averages. D(meas.) = 2.56 D(calc.) = 2.55 Alters surficially to a white powder in air; slowly decomposed by H_2O.

Optical Properties: Transparent. *Color:* Colorless if fresh. *Luster:* Vitreous, pearly on cleavages; dull when altered.
Optical Class: Biaxial (–). *Orientation:* $X \simeq \{001\}$; $X \wedge a \simeq 45°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.358(2)$ $\beta = 1.479(2)$ $\gamma = 1.530(2)$ 2V(meas.) = 62°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 6.472(2)$ $b = 6.735(2)$ $c = 8.806(2)$
$\alpha = 92.50(2)°$ $\beta = 97.33(2)°$ $\gamma = 119.32(2)°$ Z = 1

X-ray Powder Pattern: Mt. Restin'yun, Kola Peninsula, Russia.
2.778 (100), 2.658 (100), 2.887 (84), 2.169 (70), 2.316 (50), 1.870 (42), 2.543 (30)

Chemistry:

	(1)	(2)
CO_2	31.45	34.79
Al_2O_3	10.5	10.08
Na_2O	44.1	42.87
F	14.0	15.02
H_2O	3.59	3.56
$-O = F_2$	5.9	6.32
Total	97.74	100.00

(1) Mt. Restin'yun, Kola Peninsula, Russia; by electron microprobe, average of three analyses, H_2O and CO_3 by microchemical methods; CO_3^{2-} and $(OH)^{1-}$ confirmed by IR; corresponds to $H_{1.96}Na_{6.99}Al_{1.01}(CO_3)_{3.51}F_{3.62}$. (2) $H_2Na_7Al(CO_3)_4F_4$.

Occurrence: Rare in hydrothermal veinlets in alkalic pegmatites in a differentiated alkalic massif.

Association: Shortite, villiaumite, cryolite, neighborite, bonshtedtite, natrite, albite.

Distribution: From Mt. Restin'yun, Khibiny massif, Kola Peninsula, Russia.

Name: To honor Willem Barents (1550–1597), the famous Dutch seafarer, for whom the Barents Sea, northeast of the Kola Peninsula, was named.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity; Mining Institute, St. Petersburg, 2046/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82753.

References: (1) Khomyakov, A.P., T.A. Kurova, G.N. Nechelyustov, and G.O. Piloyan (1983) Barentsite, $Na_7AlH_2(CO_3)_4F_4$, a new mineral. Zap. Vses. Mineral. Obshch., 112, 474–479 (in Russian). (2) (1984) Amer. Mineral., 69, 565 (abs. ref. 1). (3) Trinh Le Thu, Y.A. Pobedimskaya, V.S. Fundamenskiy, T.N. Nadezhina, and A.P. Khomyakov (1983) Crystal structure of barentsite. Doklady Acad. Nauk SSSR, 273, 699–704 (in Russian).

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Bariandite $Al_3(V^{5+},V^{4+})_{40}O_{100}\cdot 45H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* m or $2/m$. Crystals elongated ‖ [010], forming fibers, platy on {001}, to 3 mm; in sheeted aggregates of parallel fibers, such layers sometimes stacked.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = n.d. D(meas.) = ∼2.7 D(calc.) = 2.50

Optical Properties: Nearly opaque. *Color:* Black to dark green; in reflected light shows green internal reflections.
Optical Class: Biaxial. *Pleochroism:* Greenish brown ‖ [010], bottle-green ⊥ [010] in transmitted light; strong in brownish gray under reflected light. $n = > 1.85$ 2V(meas.) = n.d.

Cell Data: *Space Group:* Cc or $C2/c$. $a = 11.70(3)$ $b = 3.63(1)$ $c = 20.06(5)$ $\beta = 101°30(20)'$ Z = 2

X-ray Powder Pattern: Mounana mine, Gabon.
14.20 (FFF), 3.480 (F), 3.430 (F), 5.72 (mF), 2.852 (mF), 1.939 (mF), 1.827 (mF)

Chemistry:

	(1)
V_2O_5	63.26
V_2O_4	14.19
Al_2O_3	3.75
Fe_2O_3	0.17
H_2O	18.11
Total	[99.48]

(1) Mounana mine, Gabon; original total given as 100.08%; corresponds to $Al_{0.68}[(V^{5+},V^{4+})_{7.90}Fe^{3+}_{0.02}]_{\Sigma=7.92}O_{20}\cdot 9.14H_2O$.

Occurrence: In the oxidation zone of a uranium mineral deposit (Mounana mine, Gabon); in the oxidation zone of a vanadium deposit (Minasragra, Peru).

Association: Duttonite, lenoblite (Mounana mine, Gabon); roscoelite, gypsum (Minasragra, Peru).

Distribution: From the Mounana uranium mine, Franceville, Gabon. At Minasragra, 46 km from Cerro de Pasco, Peru.

Name: To honor Dr. Pierre Bariand (1933–), Curator of Mineralogy, University of Paris, Paris, France.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1970,151.

References: (1) Cesbron, F. and H. Vachey (1971) La bariandite, nouvel oxyde hydraté de vanadium (IV) et (V). Bull. Soc. fr. Minéral., 94, 49–54 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1555 (abs. ref. 1). (3) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 515, 517.

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Baricite $(Mg, Fe^{2+})_3(PO_4)_2 \cdot 8H_2O$

Crystal Data: Monoclinic. *Point Group:* $2/m$. As thick plates, parallel to {010}, to 12 cm.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Flexible in thin flakes. Hardness = 1.5–2 D(meas.) = 2.35–2.42 D(calc.) = 2.448

Optical Properties: Translucent. *Color:* Colorless to pale blue, varies with iron oxidation. *Streak:* White to pale blue, darkening after several days. *Luster:* Vitreous, pearly on {010}. *Optical Class:* Biaxial (+). *Pleochroism:* X = blue; $Y = Z$ = colorless. *Orientation:* $X = b$; $Z \wedge c = 28°$–$30°$. *Dispersion:* $r < v$, weak. $\alpha = 1.547$–1.554 $\beta = 1.553$–1.564 $\gamma = 1.582$–1.595 2V(meas.) = 55°–60° 2V(calc.) = 60°

Cell Data: *Space Group:* $C2/m$. $a = 10.075$ $b = 13.416$–13.434 $c = 4.622$–4.670 $\beta = 104°22'$–$104°52'$ Z = 2

X-ray Powder Pattern: Yukon Territory, Canada.
6.71 (100), 2.699 (70), 2.956 (60), 2.526 (50), 3.196 (40), 2.418 (35), 2.217 (30)

Chemistry:

	(1)	(2)	(3)
P_2O_5	31.28	31.45	31.25
Fe_2O_3	2.77	0.20	
FeO	19.90	15.10	23.72
MnO		2.95	
MgO	15.36	16.40	13.31
H_2O	28.96	30.75	31.72
Total	[98.27]	[96.85]	100.00

(1) Yukon Territory, Canada; Fe^{2+}:Fe^{3+} = 7.98:1 by TGA, H_2O by TGA; corresponding to $(Mg_{1.64}Fe^{2+}_{1.21}Fe^{3+}_{0.15})_{\Sigma=3.00}(PO_4)_2(OH)_{0.15} \cdot 7.85H_2O$. (2) Marlborough Province, New Zealand; Fe^{2+}:Fe^{3+} from (1); correcting from average of three microprobe analyses for Mn and Ca, then corresponding to $(Mg_{2.04}Fe^{2+}_{0.86}Mn_{0.21}Ca_{0.04}Fe^{3+}_{0.01})_{\Sigma=3.16}(PO_4)_{2.04} \cdot 7.90H_2O$. (3) $(Mg, Fe^{2+})_3(PO_4)_2 \cdot 8H_2O$ with Mg:Fe^{2+} = 1:1.

Mineral Group: Vivianite group.

Occurrence: As fracture fillings in sideritic iron formation (Yukon Territory, Canada); as a folded ribbonlike mass in sediment from a raised beach (Marlborough Province, New Zealand).

Association: Siderite, vivianite, lazulite, whiteite, collinsite, childrenite, quartz (Yukon Territory, Canada).

Distribution: From the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In Marlborough Province, New Zealand.

Name: Honors Dr. Ljudevit Barić, former Director of the Mineralogical Museum and Professor of Mineralogy, University of Zagreb, Zagreb, Croatia.

Type Material: Mineralogical and Petrological Musuem, Zagreb, Croatia; Royal Ontario Museum, Toronto, Canada, M34169, M35430; National Museum of Natural History, Washington, D.C., USA, 135698, 137303, 145736.

References: (1) Sturman, B.D. and J.A. Mandarino (1976) Baricite, the magnesium analogue of vivianite, from Yukon Territory, Canada. Can. Mineral., 14, 403–406. (2) (1976) Amer. Mineral., 61, 1053 (abs. concerning ref. 1). (3) Rodgers, K.A. (1987) Baraćite [= baricite], a further occurrence. Neues Jahrb. Mineral., Monatsh., 183–192.

Bari-olgite $Ba(Na,Sr,REE)_2Na[PO_4]_2$

Crystal Data: Hexagonal. *Point Group:3*. As irregular, equant or flattened crystals, sometimes with a hexagonal outline, to 1.5 cm. Dominant forms are trigonal prisms.

{100}, {$\bar{1}$ 00} and trigonal pyramids {101}, {$\bar{1}$ 01}, {10$\bar{1}$ }, {$\bar{1}$ 0$\bar{1}$ }. Resembles quartz.

Physical Properties: *Cleavage:* Imperfect on (00*l*) and (*hk*0). *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5-5 D(meas.) = 3.986 D(calc.) = 4.000
Fluoresces bright pink-orange in SW UV and weak pink-red in LW UV.

Optical Properties: Transparent. *Color:* Light green, colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (-). ε = 1.623(3) ω = 1.628(2) *Pleochroism:* None.

Cell Data: Space Group: *P3*. *a* = 5.541(2) *c* = 7.020(3) Z = 1

X-ray Powder Pattern: Palitra (Palette) pegmatite, Kola Peninsula, Russia.
2.839 (100), 2.774 (100), 3.964 (60), 1.984 (40), 1.611 (26), 7.044 (22), 2.344 (20)

Chemistry:

	(1)
Na_2O	14.78
K_2O	0.87
CaO	0.32
SrO	16.57
BaO	31.17
MnO	0.39
La_2O_3	2.41
Ce_2O_3	1.90
Pr_2O_3	0.10
Nd_2O_3	0.16
SiO_2	0.08
P_2O_5	31.77
Total	100.52

(1) Palitra (Palette) pegmatite, Kola Peninsula, Russia; electron microprobe analysis, corresponding to $(Na_{2.14}K_{0.08}Ca_{0.03}Mn_{0.02}Sr_{0.72}Ba_{0.91}La_{0.07}Ce_{0.05})_{\Sigma=4.02}P_{2.01}O_8$.

Polymorphism & Series: Forms a series with olgite.

Occurrence: A late-stage crystallization product of a dry melt supersaturated in Na and F at temperatures of 300-350° C.

Association: Intermixed with manaksite, natrosilite, villiaumite; also aegirine, analcime, chkalovite, natrolite, serandite, sodalite, ussingite, vuonnemite.

Distribution: At the Palitra (Palette) pegmatite, Mt. Kedykverpakhk, Lovozero alkaline massif, Kola Peninsula, Russia.

Name: Reflects the dominant presence of BARI um in the composition and the relation to *olgite*.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia; 2908/1.

References: (1) Pekov, I.V., N.V., Chukanov, I.M., Kulikova, N.V.,Zubkova, O.D., Krotova, N.I., Sorokina, and D.S. Pushcharovsky (2004) A new mineral, bari-olgite $Ba(Na,Sr,REE)_2Na[PO_4]_2$, and its crystal structure. Zapiski Vseross. Mineral. Obshch. 133(1), 41-49 (in Russian, English abstract). (2) (2005) Amer. Mineral., 90, 768-769 (abs. ref. 1).

Bariomicrolite $Ba(Ta,Nb)_2(O,OH)_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As intergrowths with microlite; may be partially metamict.

Physical Properties: *Fracture:* [Uneven] (by analogy to microlite). *Tenacity:* [Brittle.] Hardness = 4.5–5 VHN = 485–498 D(meas.) = 5.68–5.80 D(calc.) = 5.51

Optical Properties: [Opaque.] *Color:* [Yellowish to orangish.] *Luster:* [Dull to resinous.] *Optical Class:* Isotropic.
R: 12.8–13.6

Cell Data: *Space Group:* $Fd3m$. a = 10.570(5) Z = 8

X-ray Powder Pattern: Chi-Chico, Brazil.
3.034 (100), 6.04 (80), 3.18 (65), 2.631 (60), 1.865 (60), 1.591 (45), 1.079 (40)

Chemistry:

	(1)		(1)		(1)
U_3O_8	1.68	As_2O_3	0.12	CaO	0.47
Ta_2O_5	71.59	Sb_2O_3	0.01	SrO	0.09
Nb_2O_5	5.87	Bi_2O_3	0.03	BaO	4.85
SiO_2	1.2	Ce_2O_3	0.45	Na_2O	< 0.5
TiO_2	1.21	FeO	0.93	Li_2O	< 0.1
ZrO_2	< 0.1	MnO	0.09	Ag_2O	0.01
ThO_2	0.19	CuO	0.06	Tl_2O	1.56
SnO_2	2.05	PbO	0.90	H_2O^+	6.9
Al_2O_3	0.42	MgO	< 0.1	Total	100.68

(1) Chi-Chico, Brazil; after deduction of microlite 3.68%, tantalite 0.26%, cassiterite 0.12%, quartz, and feldspar (with thallium considered a contaminant introduced during separation), corresponds to $(Ba,Fe,U,...)_{\Sigma=0.31}(Ta,Nb,Ti,Sn)_{\Sigma=2.00}O_{5.32}(H_2O)_2$.

Mineral Group: Pyrochlore group, microlite subgroup; $Ba_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Ta_B \geq Nb_B$.

Occurrence: In a concentrate from alluvium derived from a pegmatite.

Association: Microlite, tantalite, cassiterite, quartz, feldspar.

Distribution: Found at Chi-Chico, São João del Rei, Minas Gerais, Brazil.

Name: Assigned by the IMA Committee on pyrochlore nomenclature for the predominant *barium* content and relation to *microlite* in the pyrochlore group.

Type Material: n.d.

References: (1) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410, esp. 406–407 [rijkeboerite = bariomicrolite]. (2) van der Veen, A.H. (1963) A study of pyrochlore [rijkeboerite = bariomicrolite]. Verhandel. Kon. Nederlands Geol. Mijnbouwkundig Genootschap, Geol. Ser., 22, 188 p. (3) (1963) Amer. Mineral., 48, 1415 (abs. ref. 2).

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Bario-orthojoaquinite $(Ba,Sr)_4Fe^{2+}_2Ti_2Si_8O_{26}\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As pseudotetragonal crystals, steep dipyramidal {111} and truncated by {001}, to 8 mm; pyramidal faces are curved and striated; as aggregates.

Physical Properties: *Cleavage:* {001}, good. Hardness = 5.5 D(meas.) = 3.96 D(calc.) = 3.96

Optical Properties: Transparent to translucent. *Color:* Yellow-brown. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = very pale yellow; Y = pale yellow; Z = yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, strong. *Absorption:* $Z \gg Y > X$.
$\alpha = 1.735$ $\beta = 1.737$ $\gamma = 1.800$ 2V(meas.) = 10°–15°

Cell Data: *Space Group:* $Ccmm$, $Cc2m$, or $Ccm2$. $a = 10.477(5)$ $b = 9.599(1)$ $c = 22.59(1)$ Z = [4]

X-ray Powder Pattern: Gem mine, California, USA.
2.997 (100), 2.953 (95), 2.824 (90), 5.64 (70), 2.935 (70), 4.30 (62), 3.203 (50)

Chemistry:

	(1)
SiO_2	35.15
TiO_2	11.33
Al_2O_3	0.57
RE_2O_3	0.00
FeO	9.47
MnO	0.62
CaO	0.17
SrO	3.34
BaO	38.56
Na_2O	0.12
H_2O	1.3
Total	100.63

(1) Gem mine, California, USA; by electron microprobe, corresponds to $(Ba_{3.44}Sr_{0.44}Al_{0.15}Ca_{0.04})_{\Sigma=4.07}(Fe^{2+}_{1.80}Mn_{0.12}Na_{0.05})_{\Sigma=1.97}(Ti_{1.94}Al_{0.06})_{\Sigma=2.00}Si_{8.00}O_{26}\cdot 0.93H_2O$.

Mineral Group: Joaquinite group.

Occurrence: In a block of highly fractured basalt subjected to high-pressure metamorphism and serpentinization.

Association: Benitoite, baotite, fresnoite, natrolite.

Distribution: At the Gem mine, San Benito Co., California, USA.

Name: For its BARIum content, ORTHOrhombic symmetry, and membership in the *joaquinite* group.

Type Material: University of California, Santa Barbara, California; Harvard University, Cambridge, Massachusetts, 119525; National Museum of Natural History, Washington, D.C., USA, 149428.

References: (1) Wise, W.S. (1982) Strontiojoaquinite and bario-orthojoaquinite: two new members of the joaquinite group. Amer. Mineral., 67, 809–816.

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Bariopharmacoalumite $Ba_{0.5}Al_4(AsO_4)_3(OH)_4 \cdot 4H_2O$

Crystal Data: Isometric. *Point Group:* $\bar{4}$ 3*m*. As encrustations of isolated or interpenetrating cubes, to 0.5 mm.

Physical Properties: *Cleavage:* Imperfect, {001}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3.5 VHN = 165-327 (245.75 mN load). D(meas.) = n.d. D(calc.) = 2.580

Optical Properties: Transparent to translucent. *Color:* Colorless to pale yellow, deep blue internal reflections in reflected light. *Streak:* White.
Luster: Adamantine.
Optical Class: Isotropic. *n* = [1.573]

Cell Data: *Space Group: P*$\bar{4}$ 3*m.* *a* = 7.742(4) *Z* = 1

X-ray Powder Pattern: Cap Garonne, Var, France.
7.759 (100), 5.485 (27), 3.878 (27), 4.454 (18), 3.159 (16), 2.738 (16), 3.456 (14)

Chemistry:

	(1)
K_2O	0.07
BaO	11.35
CuO	0.35
Al_2O_3	27.89
Fe_2O_3	0.19
As_2O_5	47.28
H_2O	14.58
Total	101.71

(1) Cap Garonne, Var, France; average of 16 electron microprobe analyses, H_2O and OH^- confirmed by crystal structure analysis, corresponding to $(Ba_{0.54}Cu_{0.03}K_{0.01})_{\Sigma=0.58}(Al_{3.99}Fe_{0.02})_{\Sigma=4.01}(AsO_4)_{3.00}(OH)_{3.85}O_{0.15} \cdot 4H_2O$.

Group & Series: Pharmacosiderite supergroup; pharmacoalumite group.

Occurrence: A secondary mineral coating fractures and cavities in tetrahedrite-tennantite bearing rocks undergoing near-surface weathering.

Association: Mansfieldite, philipsbornite, beudantite, carminite, duftite, mimetite, scorodite, olivenite, arsentsumebite, lavendulan, foretite (Cap Garonne mines, France); bariopharmacosiderite, quartz, chalcedony, goethite (Mina Grande, Chile).

Distribution: From the Cap Garonne mines, near Le Pradet, Var, France; at Mina Grande, Chile; from the Gambatesa mine, Val Graveglia, Liguria, Italy.

Name: Recognizes the species as the barium dominant analogue of *pharmacoalumite*.

Type Material: Natural History Museum, London, England (BM 2010,82).

References: (1) Mills, S.J., M.S. Rumsey, G. Favreau, J. Spratt, M. Raudsepp, and M. Dini (2011) Bariopharmacoalumite, a new mineral species from Cap Garonne, France, and Mina Grande, Chile. Mineral. Mag., 75, 135–144. (2) (2013) Amer. Mineral., 98, 279-280 (abs. ref. 1).

Bariopyrochlore $(Ba,Sr)_2(Nb,Ti)_2(O,OH)_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As crude to anhedral crystals, to 1 mm, showing cube and octahedron faces; granular, porous due to alteration or recrystallization.

Physical Properties: *Cleavage:* {111}, very poor. *Fracture:* Conchoidal. *Tenacity:* [Brittle] (by analogy to the pyrochlore group). Hardness = 4.5–5 VHN = 550 (100 g load). D(meas.) = 3.85–4.15 D(calc.) = 4.01

Optical Properties: Translucent to opaque with inclusions. *Color:* Yellowish gray, light olive-gray to very pale orange; white with many fine, colorless inclusions; internal reflections are colorless to white, occasionally brownish to reddish. *Luster:* [Vitreous to resinous.] *Optical Class:* Isotropic. n = 2.07–2.11

Cell Data: *Space Group:* $Fd3m$. a = 10.562(6) Z = 8

X-ray Powder Pattern: Panda Hill, Tanzania.
3.044 (100), 6.09 (80), 1.864 (70), 1.590 (70), 1.0164 (60), 3.18 (50), 1.210 (50)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_3	69.06	65.60	FeO	0.44		PbO		0.23
Ta_2O_5	0.23	0.57	MgO		0.57	Na_2O	0.28	0.23
TiO_2	3.87	4.63	CaO	0.86	1.37	K_2O	0.15	0.23
ThO_2	0.62	0.92	BaO	12.88	15.31	F	trace	
ΣCe_2O_3	2.06	2.17	SrO	6.60	trace	H_2O^+	4.11	8.17
						Total	[101.16]	[100.00]

(1) Panda Hill, Tanzania; by spectrographic methods, Na and K by flame photometry, H_2O by the Penfield method; then corrected for zircon 0.42%, phlogopite 0.27%, orthoclase 0.42%, apatite 0.92%, cassiterite 0.32%, quartz 0.33%, rutile 0.15%, CuO 0.01%, PbO 0.01%, and CO_2 0.01%; corresponds to $(Ba_{0.30}Sr_{0.22}Ca_{0.05}Ce_{0.04}Na_{0.03}Fe_{0.02}K_{0.01}Th_{0.01})_{\Sigma=0.68}(Nb_{1.83}Ti_{0.17})_{\Sigma=2.00}O_{5.61}(H_2O)_{0.80}$. (2) Mrima Hill, Kenya; H_2O by loss on ignition; after deduction of gorceixite 9.8%, barite 0.6%, quartz 1.1%, hematite 1.0%, Al_2O_3 0.2%, corresponds to $(Ba_{0.36}Ca_{0.09}Mg_{0.05}Ce_{0.05}Na_{0.03}K_{0.02}Th_{0.01})_{\Sigma=0.61}(Nb_{1.78}Ti_{0.21}Ta_{0.01})_{\Sigma=2.00}O_{5.52}(H_2O)_{1.64}$.

Mineral Group: Pyrochlore group and subgroup; $Ba_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: At the contact zone of a highly weathered, biotite-rich rock in a roof pendant in a carbonatite (Panda Hill, Tanzania); in weathered carbonatite (Araxá,Brazil); in an alkalic aegerine-albite-microcline metasomatite in nepheline syenite (Stettin, Wisconsin, USA).

Association: Biotite, kaolinized feldspar, fluorite, quartz, apatite, zircon, chlorite, plagioclase, rutile, hematite, "limonite" (Panda Hill, Tanzania); aegirine, zircon (Wisconsin, USA).

Distribution: From the Mbeya carbonatite, Panda Hill, near Mbeya, Tanzania. In the Mrima Hill carbonatite, Kenya. From the Bingo deposit, Kivu Province, Congo (Zaire). In a deposit of several hundred million tons at Araxá, Minas Gerais, and in the Catalão II carbonatite, Goiás, Brazil. From Dehnel's pit, Stettin, Marathon Co., Wisconsin, USA. At an undefined locality in Primorskiy Kray, Russia. Known from a few other carbonatites.

Name: Assigned by the IMA Committee on pyrochlore nomenclature for the predominant *barium* content and membership in the *pyrochlore* group.

Type Material: n.d.

References: (1) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410, esp. 407 [pandaite = bariopyrochlore]. (2) Jäger, E., E. Niggli, and A.H. van der Veen (1959) A hydrated barium-strontium pyrochlore [bariopyrochlore] in a biotite rock from Panda Hill, Tanganyika. Mineral. Mag., 32, 10–25. (3) (1959) Amer. Mineral., 44, 1324 (abs. ref. 2). (4) Harris, P.M. (1965) Pandaite [bariopyrochlore] from the Mrima Hill niobium deposit (Kenya). Mineral. Mag., 35, 277–290.

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Bariosincosite $BaV_2^{4+}O_2(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thick plates, parallel to {010}, to 12 cm.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Flexible in thin flakes. Hardness = 1.5–2 D(meas.) = 2.35–2.42 D(calc.) = 2.448

Optical Properties: Translucent. *Color:* Colorless to pale blue, varies with iron oxidation. *Streak:* White to pale blue, darkening after several days. *Luster:* Vitreous, pearly on {010}. *Optical Class:* Biaxial (+). *Pleochroism:* X = blue; $Y = Z$ = colorless. *Orientation:* $X = b$; $Z \wedge c = 28°$–$30°$. *Dispersion:* $r < v$, weak. $\alpha = 1.547$–1.554 $\beta = 1.553$–1.564 $\gamma = 1.582$–1.595 2V(meas.) = 55°–60° 2V(calc.) = 60°

Cell Data: *Space Group:* $C2/m$. $a = 10.075$ $b = 13.416$–13.434 $c = 4.622$–4.670 $\beta = 104°22'$–$104°52'$ $Z = 2$

X-ray Powder Pattern: Yukon Territory, Canada.
6.71 (100), 2.699 (70), 2.956 (60), 2.526 (50), 3.196 (40), 2.418 (35), 2.217 (30)

Chemistry:

	(1)	(2)	(3)
P_2O_5	31.28	31.45	31.25
Fe_2O_3	2.77	0.20	
FeO	19.90	15.10	23.72
MnO		2.95	
MgO	15.36	16.40	13.31
H_2O	28.96	30.75	31.72
Total	[98.27]	[96.85]	100.00

(1) Yukon Territory, Canada; Fe^{2+}:Fe^{3+} = 7.98:1 by TGA, H_2O by TGA; corresponding to $(Mg_{1.64}Fe^{2+}_{1.21}Fe^{3+}_{0.15})_{\Sigma=3.00}(PO_4)_2(OH)_{0.15} \cdot 7.85H_2O$. (2) Marlborough Province, New Zealand; Fe^{2+}:Fe^{3+} from (1); correcting from average of three microprobe analyses for Mn and Ca, then corresponding to $(Mg_{2.04}Fe^{2+}_{0.86}Mn_{0.21}Ca_{0.04}Fe^{3+}_{0.01})_{\Sigma=3.16}(PO_4)_{2.04} \cdot 7.90H_2O$. (3) $(Mg, Fe^{2+})_3(PO_4)_2 \cdot 8H_2O$ with Mg:Fe^{2+} = 1:1.

Mineral Group: Vivianite group.

Occurrence: As fracture fillings in sideritic iron formation (Yukon Territory, Canada); as a folded ribbonlike mass in sediment from a raised beach (Marlborough Province, New Zealand).

Association: Siderite, vivianite, lazulite, whiteite, collinsite, childrenite, quartz (Yukon Territory, Canada).

Distribution: From the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In Marlborough Province, New Zealand.

Name: Honors Dr. Ljudevit Barić, former Director of the Mineralogical Museum and Professor of Mineralogy, University of Zagreb, Zagreb, Croatia.

Type Material: Mineralogical and Petrological Musuem, Zagreb, Croatia; Royal Ontario Museum, Toronto, Canada, M34169, M35430; National Museum of Natural History, Washington, D.C., USA, 135698, 137303, 145736.

References: (1) Sturman, B.D. and J.A. Mandarino (1976) Baricite, the magnesium analogue of vivianite, from Yukon Territory, Canada. Can. Mineral., 14, 403–406. (2) (1976) Amer. Mineral., 61, 1053 (abs. concerning ref. 1). (3) Rodgers, K.A. (1987) Baraćite [= baricite], a further occurrence. Neues Jahrb. Mineral., Monatsh., 183–192.

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Barnesite $(Na,Ca)_2V_6^{5+}O_{16}\cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As small clusters of subparallel to radiating bladed to fibrous crystals, elongated along [010], to 0.5 mm; in spherical aggregates, and as botryoidal to velvety coatings.

Physical Properties: *Cleavage:* {001}, perfect; {100}, {010}, fair. *Tenacity:* Fragile [*sic*], prone to smearing. Hardness = 3 D(meas.) = 3.09–3.15 D(calc.) = 3.23

Optical Properties: Semitransparent. *Color:* Brilliant dark red; brownish red on exposure. *Luster:* Adamantine, less brilliant after exposure.
Optical Class: Biaxial (–). *Pleochroism:* X = yellow; Y = yellow-orange; Z = red. *Orientation:* $Y = a$; $Z = b$; $X \wedge c \sim 5°$. $\alpha = 1.797$–1.80 $\beta = 2.01$–2.04 $\gamma = 2.04$–2.08 2V(meas.) = 60°

Cell Data: *Space Group:* $P2/m$. $a = 12.17(4)$ $b = 3.602(10)$ $c = 7.78(4)$ $\beta = 95°2(24)'$
Z = 1

X-ray Powder Pattern: Cactus Rat mines, Utah, USA.
7.90 (100), 3.12 (70), 3.45 (35), 12.2 (25), 2.27 (25), 1.800 (25), 2.92 (18)

Chemistry:

	(1)	(2)	(3)
V_2O_5	82.40	76.60	82.46
V_2O_4		6.26	
SiO_2	0.40		
CaO		3.84	
Na_2O	9.10	5.38	9.37
H_2O^+		5.20	
H_2O^-		2.72	
H_2O	7.73		8.17
Total	99.63	[100.00]	100.00

(1) Cactus Rat mines, Utah, USA. (2) Kazakhstan; recalculated to 100% after deduction of 9.14% impurities; corresponds to $(Na_{1.13}Ca_{0.45})_{\Sigma=1.58}(V_{5.51}^{5+}V_{0.49}^{4+})_{\Sigma=6.00}[O_{15.55}(OH)_{0.45}]_{\Sigma=16.00}\cdot 2.69H_2O$. (3) $Na_2V_6O_{16}\cdot 3H_2O$.

Occurrence: In small cavities and fractures and as interstitial filling in sandstone in the oxidized zone of a vanadiferous uranium deposit, possibly formed as an oxidation product of hewettite (Cactus Rat mines, Utah, USA); in weathered black schist (Kazakhstan).

Association: Metahewettite, thenardite (Cactus Rat mines, Utah, USA); bokite (The Fish, Nevada, USA); hewettite, metahewettite, jarosite, alunite, gypsum, barite (Kazakhstan).

Distribution: From the Cactus Rat mine group, Yellow Cat district, 24 km southeast of Thompson, Grand Co., Utah and The Fish, Eureka Co., Nevada, USA. In several mines of the Kurumsak and Balasauskandyk districts, northwestern Kara-Tau Mountains, Kazakhstan.

Name: To honor Dr. William H. Barnes (1903–), National Research Council of Canada, Ottawa, Canada, authority on the crystallography of many vanadium minerals.

Type Material: n.d.

References: (1) Weeks, A.D., D.R. Ross, and R.F. Marvin (1963) The occurrence and properties of barnesite, $Na_2V_6O_{16}\cdot 3H_2O$, a new hydrated sodium vanadate mineral from Utah. Amer. Mineral., 48, 1187–1195. (2) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 514–515. (3) Akinovich, E.A. and N.I. Podlipaeva (1986) A Ca-variety of barnesite from rocks of a carbonaceous-siliceous vanadium-bearing formation in southern Kazakhstan. Zap. Vses. Mineral. Obshch., 115, 345–351.

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Barquillite $\mathbf{Cu_2(Cd, Fe^{2+})GeS_4}$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Platy crystals, to 50 μm, commonly in rosettelike aggregates.

Physical Properties: Hardness = 4–4.5 VHN = 180–300 D(meas.) = n.d. D(calc.) = 4.53

Optical Properties: Opaque. *Color:* In reflected light, gray with a violet tint.
Luster: Metallic.
Optical Class: Uniaxial. *Pleochroism:* Very Weak. *Anisotropism:* Very weak.
Bireflectance: Very weak.
R: (400) 24.8, (420) 24.8, (440) 24.7, (460) 24.4, (480) 24.2, (500) 23.8, (520) 23.5, (540) 23.3, (560) 23.2, (580) 23.0, (600) 23.1, (620) 23.1, (640) 23.3, (660) 23.5, (680) 23.3, (700) 22.9

Cell Data: *Space Group:* $I\bar{4}2m$ (by analogy to briartite). $a = 5.45(4)$ $c = 10.61(1)$ $Z = 2$

X-ray Powder Pattern: Barquilla deposit, Spain.
3.10 (100), 1.92 (80), 1.89 (70), 1.64 (60), 1.60 (20), 2.73 (10)

Chemistry:

	(1)
Ag	0.26
Cu	30.67
Zn	0.09
Cd	20.38
Fe	2.20
Mn	0.43
Sn	0.17
Ge	14.99
Ga	0.05
Sb	0.09
Bi	0.16
S	29.42
Total	98.91

(1) Barquilla deposit, Spain; by electron microprobe, average of 34 analyses of nine grains, corresponds to $(Cu_{2.10}Ag_{0.01})_{\Sigma=2.11}(Cd_{0.79}Fe_{0.17}Mn_{0.03}Zn_{0.01})_{\Sigma=1.00}(Ge_{0.90}Sn_{0.01})_{\Sigma=0.91}S_{3.98}$.

Mineral Group: Stannite group.

Occurrence: Very rare, in a hydrothermal Sn–Ge–Cd–Cu–Fe vein deposit.

Association: Tetrahedrite, greenockite, chalcopyrite, bornite, mawsonite, stannite, stannoidite, mohite, digenite.

Distribution: From the Barquilla deposit, southwest Salamanca Province, Spain [TL].

Name: For the village of Barquilla, Spain, near the type locality.

Type Material: Museo Geominero, Madrid, MGM-3000; Department of Geology, Salamanca; Area of Crystallography and Mineralogy, Badajoz, Spain; Institute for Mineralogy, Ruhr University, Bochum, Germany; Laboratory of Crystallography, Nancy, France.

References: (1) Murciego, A., M.I. Pascua, J. Babkine, Y. Dusausoy, O. Medenbach, and H.-J. Bernhardt (1999) Barquillite, $Cu_2(Cd, Fe)GeS_4$, a new mineral from the Barquilla deposit, Salamanca, Spain. Eur. J. Mineral., 11, 111–117. (2) (??) Amer. Mineral., ??, ??–?? (abs. ref. 1).

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Barrerite $(Na,K,Ca)_2Al_2Si_7O_{18}\cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As well-formed, laminar crystals, to 5 mm, with {010}, {011}, and {111}; {001} is common, but of poor quality.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = n.d. D(meas.) = 2.13(1) D(calc.) = 2.11

Optical Properties: Transparent to translucent. *Color:* White to slightly pink.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.4791(5)$ $\beta = 1.4851(5)$ $\gamma = 1.4891(5)$ 2V(meas.) = n.d. 2V(calc.) = 78(8)°

Cell Data: *Space Group: Amma.* $a = 13.643(2)$ $b = 18.200(3)$ $c = 17.842(2)$ Z = 8

X-ray Powder Pattern: Capo Pula, Sardinia, Italy; cannot be distinguished from stellerite. 9.10 (> 100), 4.054 (100), 3.028 (80), 3.004 (25), 4.659 (20), 2.773 (20), 1.8192 (17)

Chemistry:

	(1)
SiO_2	58.82
Al_2O_3	14.75
Fe_2O_3	0.04
MnO	trace
MgO	0.24
CaO	1.66
SrO	trace
BaO	trace
Na_2O	5.97
K_2O	1.76
H_2O	16.40
Total	99.64

(1) Capo Pula, Sardinia, Italy; by AA, SiO_2 by gravimetry, Al_2O_3 by complexometric titration, H_2O by TGA; corresponds to $(Na_{1.36}K_{0.26}Ca_{0.21}Mg_{0.04})_{\Sigma=1.87}Al_{2.05}Si_{6.93}O_{18}\cdot 6.44H_2O$.

Mineral Group: Zeolite group.

Occurrence: On the walls of large fractures in deeply weathered andesitic and rhyolitic lavas.

Association: Heulandite.

Distribution: Found near Capo Pula, below South Efisio Tower, Nora, Sardinia, Italy.

Name: For Richard Maling Barrer (1910–), New Zealand-born British teacher and student of the chemistry of zeolites.

Type Material: University of Modena, Modena, Italy; National Museum of Natural History, Washington, D.C., USA, 128521.

References: (1) Passaglia, E. and D. Pongiluppi (1974) Sodian stellerite from Capo Pula, Sardegna. Lithos, 7, 69–73. (2) Passaglia, E. and D. Pongiluppi (1975) Barrerite, a new natural zeolite. Mineral. Mag., 40, 208. (3) (1976) Amer. Mineral., 61, 1053 (abs. refs. 1 and 2). (4) Galli, E. and A. Alberti (1975) The crystal structure of barrerite. Bull. Soc. fr. Minéral., 98, 331–340.

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Barringerite $(Fe, Ni)_2P$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}m2$. As bands, 10–15 μm wide and several hundred μm long, consisting of individual grains less than 1 μm in diameter, along the contact between schreibersite and troilite.

Physical Properties: Hardness = > 7 VHN = 1097 (20 g load). D(meas.) = n.d. D(calc.) = 6.92

Optical Properties: [Opaque.] *Color:* White, similar to kamacite; bluish compared to schreibersite, in reflected light.
Optical Class: Uniaxial. *Anisotropism:* Noticeable; white to blue.
R: (Slightly higher than that of schreibersite; lower than that of kamacite).

Cell Data: *Space Group:* $P\overline{6}2m$. $a = 5.87(7)$ $c = 3.44(4)$ $Z = 3$

X-ray Powder Pattern: Synthetic Fe_2P.
2.237 (100), 1.28 (100), 1.21 (100), 1.10 (100), 2.048 (95), 1.920 (90), 1.694 (80)

Chemistry:

	(1)	(2)	(3)
Fe	44.3	75.1	76.22
Cr			0.73
Ni	33.9	0.04	2.85
Co	0.25	0.21	
P	21.8	22.8	20.21
Total	100.25	98.15	100.01

(1) Ollague meteorite; average of several analyses by electron microprobe, corresponding to $(Fe_{1.16}Ni_{0.84}Co_{0.01})_{\Sigma=2.01}P$. (2) Y-793274 meteorite; by electron microprobe. (3) China; corresponding to $(Fe_{2.09}Ni_{0.07}Cr_{0.02})_{\Sigma=2.18}P$.

Occurrence: Along the contacts between schreibersite and troilite in a Fe–Ni meteorite (Ollague); as a single grain in a brecciated lunar meteorite of mixed mare and highland origin (Y-793274 meteorite); in the oxidation zone of a platinum-bearing Cu–Ni sulfide deposit (China).

Association: Kamacite, olivine, schreibersite, troilite (Ollague meteorite); plagioclase, glass (Y-793274 meteorite) schreibersite, wüstite, lawrencite (Canyon Diablo meteorite).

Distribution: In the Imilac (Ollague) pallasite meteorite [an extraterrestrial origin has been questioned]. In the Yamato-793274 meteorite, from the Moon. In the Canyon Diablo iron meteorite. Found in an unspecified mineral deposit in China.

Name: To honor Daniel Moreau Barringer (1860–1929), early proponent of the meteor impact origin of Meteor Crater, near Canyon Diablo, Arizona, USA.

Type Material: Nininger collection, Center for Meteorite Studies, Arizona State University, Tempe, Arizona, USA.

References: (1) Buseck, P.R. (1969) Phosphide from meteorites: barringerite, a new iron-nickel mineral. Science, 165, 169–171. (2) (1970) Amer. Mineral., 55, 317 (abs. ref. 1). (3) Chen Kegiao, Jin Zaimiao, and Peng Zhizhong (1983) The discovery of iron barringerite, (Fe_2P) in China. Scientia Geol. Sinica, 199–202 (in Chinese with English abs.). (4) (1984) Amer. Mineral., 69, 407 (abs. ref. 3). (5) (1984) Mineral. Abs., 35, 186–187 (abs. ref. 3). (6) Brandstätter, F., C. Koeberl, and G. Kurat (1991) The discovery of iron barringerite in lunar meteorite Y-793274. Geochim. Cosmochim. Acta, 55, 1173–1174. (7) Carlsson, B., M. Gölin, and S. Rundqvist (1973) Determination of the homogeneity range and refinement of the crystal structure of Fe_2P. J. Solid State Chem., 8, 57–67. (8) Fujii, H., S. Komura, T. Takeda, T. Okamoto, Y. Ito, and J. Akimitsu (1979) Polarized neutron diffraction study of Fe_2P single crystal. J. Phys. Soc. Japan, 46, 1616–1621.

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Barringtonite $MgCO_3 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As needles and radiating fibers, to 0.03 mm, in nodular incrustations.

Physical Properties: *Cleavage:* Good on {100}, {010}; on {001}, probable. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.825

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (+). *Orientation:* Length-slow. $\alpha = 1.458$ $\beta = 1.473$ $\gamma = 1.501$
2V(meas.) = 68°–80° 2V(calc.) = 73°44′

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.155$ $b = 6.202$ $c = 6.092$ $\alpha = 94°00'$ $\beta = 95°32'$ $\gamma = 108°42'$ Z = [4]

X-ray Powder Pattern: Barrington Tops, Australia.
8.682 (vs), 3.093 (vs), 2.936 (vs), 6.087 (s), 5.816 (s), 2.495 (s), 2.309 (s)

Chemistry:

	(1)	(2)	(3)
CO_2	34.8	36.5	36.57
MgO	31.8	33.5	33.49
H_2O	33.4	30.0	29.94
Total	[100.0]	[100.0]	100.00

(1) Barrington Tops, Australia; corresponds to $Mg_{1.00}C_{1.00}O_3 \cdot 2.35H_2O$ (2) Do.; corresponds to $Mg_{1.00}C_{1.00}O_3 \cdot 2.00H_2O$ (3) $MgCO_3 \cdot 2H_2O$.

Occurrence: Formed by leaching of magnesium from olivine basalt under a waterfall by meteoric water.

Association: Nesquehonite.

Distribution: In Australia, under Rainbow Falls, Sempill Creek, Barrington Tops, New South Wales.

Name: For its occurrence near Barrington, Australia.

Type Material: n.d.

References: (1) Nashar, B. (1965) Barringtonite – a new hydrous magnesium carbonate from Barrington Tops, New South Wales, Australia. Mineral. Mag., 34, 370–372. (2) (1965) Amer. Mineral., 50, 2103–2104 (abs. ref. 1).

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Barroisite $[NaCa][(Mg,Fe^{2+})_3Al_2](Si_7Al)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As rims on, or cores of, other mixed-species amphibole crystals.

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = n.d. D(calc.) = 3.21

Optical Properties: Semitransparent. *Color:* Green; dark green in thin section.
Luster: [Vitreous.]
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $[C2/m.]$ $a = 9.759(1)$ $b = 17.921(2)$ $c = 5.290(1)$ $\beta = 104.49(1)°$ Z = [2]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	53.26	49.32	MgO	17.84	7.93
TiO_2	0.24	0.22	CaO	7.41	5.94
Al_2O_3	7.90	9.05	Na_2O	3.84	4.30
Cr_2O_3	0.04		K_2O	0.39	0.21
FeO	5.80	19.97	F	0.04	
MnO	0.03	0.35	Cl	0.03	
NiO	0.11		$-O = (F,Cl)_2$	0.03	
			Total	96.90	97.29

(1) Nordfjord, Norway; by electron microprobe, Fe^{2+}:Fe^{3+} by diffraction; corresponds to $Na_{1.04}Ca_{1.10}(Mg_{3.82}Al_{0.70}Fe^{2+}_{0.42}Fe^{3+}_{0.20}K_{0.07}Ti_{0.03})_{\Sigma=5.24}(Si_{7.40}Al_{0.60})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Anglesey, Wales; by electron microprobe, corresponds to $Na_{1.07}Ca_{0.93}(Mg_{1.73}Fe^{2+}_{1.58}Fe^{3+}_{0.86}Al_{0.77}Mn_{0.04}K_{0.04}Ti_{0.02})_{\Sigma=5.04}(Si_{7.21}Al_{0.79})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with ferro-barroisite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.5$; $(Na + K)_A < 0.5$; $0.67 \quad Na_B \quad 1.33$; $(Ca + Na)_B \geq 1.34$; $Si < 7.5$.

Occurrence: In blueschist facies metamorphic rocks.

Association: Omphacite, glaucophane, crossite, actinolite, calcite.

Distribution: Along Cleary Creek, 20 km north of Fairbanks, and on the northwest side of Kodiak Island, Alaska, USA. In Wales, on Anglesey, near Llanfairpwllgwyngyll. From the Nybö eclogite pod, Nordfjord, Norway.

Name: n.d.

Type Material: n.d.

References: (1) Murgoci, G. (1922) Sur les propriétés des amphiboles bleues. Compt. Rendus Acad. Sci. Paris, 175, 373 (in French). (2) Murgoci, G. (1922) Sur le classification des amphiboles bleues et de certaines hornblendes. Compt. Rendus Acad. Sci. Paris, 175, 426 (in French). (3) Heritsch, H., P. Paulitsch, and E.M. Walitzi (1957) Die Struktur von Karinthin und einer barroisitischen Hornblende. Tschermaks Mineral. Petrog. Mitt., 6, 215–225 (in German). (4) Ungaretti, L., D.C. Smith, and G. Rossi (1981) Crystal-chemistry by X-ray structure refinement and electron microprobe analysis of a series of sodic-calcic to alkali-amphiboles from the Nybö eclogite pod, Norway. Bull. Minéral., 104, 400–412. (5) Gibbons, W. and M. Gyopari (1986) A greenschist protolith for blueschist in Anglesey, U.K. In: B.W. Evans and E.H. Brown, Eds., Blueschists and eclogites, Geol. Soc. Amer. Memoir 164, 217–228.

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Barstowite $Pb_4(CO_3)Cl_6 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated, to 2 cm, commonly in subparallel aggregates.

Physical Properties: *Cleavage:* Prismatic, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3 VHN = 108–117, 111 average (100 g load). D(meas.) = 5.71(23) D(calc.) = 5.77

Optical Properties: Transparent to opaque. *Color:* Colorless to white; in reflected light shows abundant colorless internal reflections. *Streak:* White. *Luster:* Adamantine.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d. *Anisotropism:* Weak to moderate. *Bireflectance:* Moderate, gray to dark gray.
R_1–R_2: (400) 14.2–14.8, (420) 14.0–14.6, (440) 13.8–14.4, (460) 13.7–14.1, (480) 13.4–13.9, (500) 13.2–13.7, (520) 13.1–13.5, (540) 12.9–13.4, (560) 12.8–13.2, (580) 12.7–13.1, (600) 12.6–13.0, (620) 12.5–12.9, (640) 12.5–12.9, (660) 12.4–12.8, (680) 12.3–12.8, (700) 12.3–12.7

Cell Data: *Space Group:* $P2_1/m$. a = 4.2043(8) b = 9.199(2) c = 16.663(3) β = 91.82(1)° Z = 2

X-ray Powder Pattern: Bounds Cliff, England.
4.02 (10), 2.296 (8), 2.377 (6), 4.16 (5), 2.108 (4), 3.79 (3), 3.045 (3)

Chemistry:

	(1)	(2)
CO_2	4.10	3.93
PbO	81.30	79.75
Cl	18.67	19.00
H_2O	1.61	1.61
$-O = Cl_2$	4.21	4.29
Total	101.47	100.00

(1) Bounds Cliff, England; by electron microprobe, Pb and Cl average of three analyses, C and H by CHN analyzer, presence of $(CO_2)^{2-}$ and H_2O confirmed by IR; original elemental analysis here converted to oxides; corresponds to $Pb_{4.02}(CO_3)_{1.03}[Cl_{5.82}(OH)_{0.16}]_{\Sigma=5.98} \cdot 0.90H_2O$.
(2) $Pb_4(CO_3)Cl_6 \cdot H_2O$.

Occurrence: A rare reaction product of sea water with a metal-bearing vein exposed at sea level (Bounds Cliff, England); produced by the action of sea water on lead-bearing slag (Laurium, Greece; Baratti Beach, Italy); a corrosion product of lead object (Mahdia, Tunisia).

Association: Phosgenite, galena, jamesonite, cerussite, pyrite, sphalerite, chalcopyrite, dolomite, quartz (Bounds Cliff, England).

Distribution: From Bounds Cliff, St. Endellion, Cornwall, England. Large crystals at Laurium, Greece, in slag. At Baratti Beach, Tuscany, Italy, in slag. In the Kairakty polymetallic barite deposit, central Kazakhstan. From a shipwreck near Mahdia, Tunisia.

Name: Honors Richard William Barstow (1947–1982), mineral collector and dealer of Cornwall, England.

Type Material: The Natural History Museum, London, England, 1990,25 and E.1353.

References: (1) Stanley, C.J., G.C. Jones, A.D. Hart, P. Keller, and D. Lloyd (1991) Barstowite, $3PbCl_2 \cdot PbCO_3 \cdot H_2O$, a new mineral from Bounds Cliff, St Endellion, Cornwall. Mineral. Mag., 55, 121–125. (2) (1992) Amer. Mineral., 77, 670 (abs. ref. 1). (3) Kutzke, H., H. Klapper, S. Merlino, M. Pasero, N. Perchiazzi, and G. Eggert (2000) The crystal structure of barstowite, $Pb_4Cl_6(CO_3) \cdot H_2O$, determined on crystals from Etruscan slag and from a Late-Hellenistic shipwreck. Zeits. Krist., 215, 110–113.

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Bartelkeite $PbFe^{2+}Ge_3O_8$

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Crystal Data: Monoclinic. *Point Group:* 2 or $2/m$. Crystals, to 1 mm, tabular on $\{10\overline{1}\}$ or acicular on {101}; {111} and {010} also observed.

Physical Properties: *Cleavage:* {101}, distinct. Hardness = ∼4 D(meas.) = n.d. D(calc.) = 4.97

Optical Properties: Transparent. *Color:* Colorless, white to very pale greenish. *Streak:* White. *Luster:* Subadamantine. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $X \wedge a \simeq 55°$. *Dispersion:* $r < v$. $\alpha = 1.885(4)$ $\beta = 1.910(4)$ $\gamma = 1.913(4)$ 2V(meas.) = ∼35(5)°

Cell Data: *Space Group:* $P2_1$ or $P2_1/m$. $a = 5.431(3)$ $b = 13.689(7)$ $c = 5.892(3)$ $\beta = 111.79(4)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
2.91 (10), 4.42 (8), 2.87 (8), 2.75 (7), 2.20 (7), 4.74 (6), 5.08 (5)

Chemistry:

	(1)
GeO_2	53.7
FeO	12.1
PbO	34.0
Total	99.8

(1) Tsumeb, Namibia; by electron microprobe, Fe^{2+} valence determined microchemically; corresponding to $Pb_{0.97}Fe^{2+}_{0.99}Ge_{3.02}O_8$.

Occurrence: A very rare mineral in cavities in oxidized primary germanium ore from a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Germanite, reniérite, tennantite, galena.

Distribution: From Tsumeb, Namibia.

Name: For Wolfgang Bartelke (1949–), German mineral collector and specialist in the minerals of Tsumeb, Namibia.

Type Material: University of Stuttgart, Stuttgart, Germany, NM07; National Museum of Natural History, Washington, D.C., USA, 148302.

References: (1) Keller, P., H. Hess, and P.J. Dunn (1981) Bartelkeit, $PbFe^{2+}Ge_3O_8$, ein neues Germanium Mineral von Tsumeb, Namibia. Chem. Erde, 40, 201–206 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 413 (abs. ref. 1).

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Bartonite $K_3Fe_{10}S_{14}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Anhedral masses, intergrown with pyrrhotite; rare elongated single crystals, to 50 μm long.

Physical Properties: *Cleavage:* {112}, distinct. *Fracture:* Conchoidal. Hardness = 3.5 VHN = 94–120, 104 average (15 g load). D(meas.) = 3.305 D(calc.) = 3.286 Weakly magnetic.

Optical Properties: Opaque. *Color:* Blackish brown; in polished section, yellowish green-gray to yellowish green-brown. *Streak:* Black. *Luster:* Submetallic. *Pleochroism:* Very weak. R_1–R_2: (400) 21.7–18.3, (420) 16.7–14.4, (440) 17.7–17.2, (460) 18.4–18.6, (480) 19.4–19.5, (500) 19.7–20.6, (520) 20.3–21.4, (540) 20.9–21.8, (560) 21.9–22.7, (580) 22.7–23.2, (600) 23.4–23.7, (620) 23.9–24.3, (640) 24.7–25.1, (660) 25.0–25.5, (680) 25.2–26.1, (700) 26.4–26.5

Cell Data: *Space Group:* $I4/mmm$. $a = 10.424(1)$ $c = 20.626(1)$ $Z = 2$

X-ray Powder Pattern: Coyote Peak, California, USA.
2.998 (100), 5.99 (77), 1.833 (40), 9.31 (27), 3.139 (27), 2.379 (25), 1.841 (25)

Chemistry:

	(1)	(2)
K	9.54	10.43
Na	0.05	
Fe	51.2	49.66
Cu	0.62	
Ni	0.19	
Co	0.11	
S	38.4	39.91
Cl	0.02	
Total	100.13	100.00

(1) Coyote Peak, California, USA; by electron microprobe, corresponding to $(K_{2.78}Na_{0.07})_{\Sigma=2.85}(Fe_{10.46}Cu_{0.10}Ni_{0.04}Co_{0.02})_{\Sigma=10.62}S_{13.46}$. (2) $K_3Fe_{10}S_{14}$.

Occurrence: In clots with other sulfides and silicates in an alkalic diatreme which intruded Franciscan rocks.

Association: Rasvumite, djerfisherite, erdite, pyrrhotite, pyrite, sphalerite, löllingite, magnetite, nepheline, phlogopite.

Distribution: From Coyote Peak, near Orick, Humboldt Co., California, USA [TL].

Name: For Paul Booth Barton, Jr. (1930–), ore petrologist with the U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149498.

References: (1) Czamanske, G.K., R.C. Erd, B.F. Leonard, and J.R. Clark (1981) Bartonite, a new potassium iron sulfide mineral. Amer. Mineral., 66, 369–375. (2) Evans, H.T., Jr. and J.R. Clark (1981) The crystal structure of bartonite, a potassium iron sulfide, and its relationship to pentlandite and djerfisherite. Amer. Mineral., 66, 376–384.

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Barylite $BaBe_2Si_2O_7$

Crystal Data: Orthorhombic. *Point Group*: mm2. As thin tabular to prismatic crystals displaying square cross sections, to 2 cm; granular, massive.

Physical Properties: *Cleavage:* Good on {001} and {100}, imperfect on {010}. *Tenacity:* Brittle. Hardness = 7 VHN = 734 D(meas.) = 4.066(2) D(calc.) = [4.00] May fluoresce vivid blue.

Optical Properties: Translucent. *Color:* Colorless, white, blue. *Luster:* Vitreous to greasy. *Optical Class*: Biaxial (-) or (+). *Orientation: X = b*; *Y = c*; Z = *a*. *Dispersion: r > v*; moderate. α = 1.695(2) β = 1.702(2) γ = 1.708(2) 2V(meas.) = 60°-70°

Cell Data: *Space Group*: $Pn2_1a$. *a* = 9.835(2) *b* = 11.654(3) *c* = 4.673(2) Z = 4

X-ray Powder Pattern: Seal Lake, Canada.
3.35 (vs), 2.93 (ms), 2.45 (ms), 3.04 (m), 2.99 (m), 5.84 (mw), 4.56 (mw)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	35.51	36.42	37.54	BeO	16.01	15.77	[15.46]
Al_2O_3	0.05			MgO	0.21	0.29	
Fe_2O_3	0.04			CaO	0.42		
FeO		0.19	trace	BaO	47.43	46.49	46.75
ZnO		trace		H_2O	0.57	0.40	
PbO		0.11		Total	100.24	99.67	[99.75]

(1) Långban, Sweden. (2) Franklin, New Jersey, USA. (3) Narssârssuk, Greenland; by electron microprobe, BeO from stoichiometry; corresponds to $Ba_{0.99}Be_{2.00}Si_{2.02}O_{7.03}$.

Polymorphism & Series: Dimorphous with clinobarylite.

Occurrence: In a banded vein in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA); in an “amazonite" pocket (Park Co., Colorado, USA); in narrow veins in chertlike silica and albite in fenitized gneisses (Seal Lake, Canada); in calcite veins cutting amphibole gneisses (Vishnevye Mountains, Russia); in nepheline syenite pegmatite (Narssârssuk, Greenland).

Association: Hedyphane (Långban, Sweden); hedyphane, willemite (Franklin, New Jersey, USA); microcline, barite, fluorite (Park Co., Colorado, USA); eudialyte (Seal Lake, Canada); bastnäsite, aeschynite, barite, strontianite, thorogummite, harmotome, fluorite, quartz (Vishnevye Mountains, Russia).

Distribution: At Långban, Värmland, Sweden. In Norway, on Arø Island, Langesundsfjord, and at Bratthagen, 10 km northwest of Larvik, Lågendal. From Narssârssuk, Greenland. In the USA, at Franklin, Sussex Co., New Jersey, with exceptional crystals from an undisclosed locality in Park Co., Colorado. In Canada, at Seal Lake and Letitia Lake, Labrador, Newfoundland, and Mont Saint-Hilaire, Quebec. In Russia, from the Vishnevy-Ilmen Mountains, Southern Ural Mountains. In the Pokrovo-Kireevsk structure, Kazakhstan.

Name: From the Greek for *heavy*, for its high density.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 562. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 92. (3) Heinrich, E.W. and R.W. Deane (1962) An occurrence of barylite near Seal Lake, Labrador. Amer. Mineral., 47, 758-763. (4) Robinson, P.D. and J.H. Fang (1977) Barylite, $BaBe_2Si_2O_7$: its space group and crystal structure. Amer. Mineral., 62, 167-169. (5) Petersen, O.V. and O. Johnson (1980) First occurrence of the rare mineral barylite in Greenland. Tschermaks Mineral. Petrog. Mitt., 27, 35-39. (6) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 87-89.

Barysilite $Pb_8Mn(Si_2O_7)_3$

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Crystal Data: Hexagonal. *Point Group:* $3\overline{2}/m$. As platy, subparallel crystals in lamellar and ball-like aggregates, to 3 mm; granular, massive.

Physical Properties: *Cleavage:* {0001}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 6.55–6.71 D(calc.) = [6.54]

Optical Properties: Semitransparent. *Color:* Pink to colorless; tarnishes on exposure. *Luster:* Pearly on cleavage.
Optical Class: Uniaxial (–). $\omega = 2.033–2.07$ $\epsilon = 2.015–2.05$

Cell Data: *Space Group:* $R\overline{3}c$. $a = 9.821$ $c = 38.38$ $Z = 6$

X-ray Powder Pattern: Långban, Sweden.
2.957 (100), 2.765 (80), 2.675 (80), 3.88 (60), 3.16 (60), 4.57 (50), 3.22 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	16.84	17.1	16.26
Al_2O_3	0.59		
FeO	0.23		
MnO	3.33	3.7	3.20
ZnO	0.30		
PbO	77.35	78.4	80.54
MgO	0.78		
CaO	0.21	0.6	
H_2O^+	0.07		
Total	99.70	99.8	100.00

(1) Franklin, New Jersey, USA. (2) Do.; by electron microprobe. (3) $Pb_8Mn(Si_2O_7)_3$.

Occurrence: In iron ores (Harstigen mine, Sweden); as thin films and veinlets in a metamorphosed zinc orebody (Franklin, New Jersey, USA).

Association: Garnet, willemite, axinite, hardystonite (Franklin, New Jersey, USA).

Distribution: In the Harstigen mine, near Persberg, and Långban and Jakobsberg, Värmland, Sweden. From Franklin, Sussex Co., New Jersey, USA.

Name: From the Greek for *heavy* and for SILicon in its composition.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 114630.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 421. (2) Shannon, E.V. and H. Berman (1926) Barysilite from Franklin Furnace, New Jersey. Amer. Mineral., 11, 130–132. (3) Glasser, F.P. (1964) New data on barysilite. Amer. Mineral., 49, 1485–1488. (4) Lajzérowicz, J. (1965) Étude par diffraction des rayons X et absorption infra-rouge de la barysilite, $MnPb_8 \cdot 3Si_2O_7$, et composés isomorphes. Acta Cryst., 20, 357–363 (in French with English abs.). (5) Billhardt, H.W. (1969) Synthesis of lead pyrosilicate and other barysilite-like compounds. Amer. Mineral., 54, 510–521. (6) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727.

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Barite $BaSO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Commonly in well-formed crystals, to 85 cm, with over 70 forms noted. Thin to thick tabular {001}, {210}, {101}, {011}; also prismatic along [001], [100], or [010], equant. As crested to rosettelike aggregates of tabular individuals, concretionary, fibrous, nodular, stalactitic, may be banded; granular, earthy, massive.

Physical Properties: *Cleavage:* {001}, perfect; {210}, less perfect; {010}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 4.50 D(calc.) = 4.47 May be thermoluminescent, may fluoresce and phosphoresce cream to spectral colors under UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, yellow, brown, gray, pale shades of red, green, blue, may be zoned, or change color on exposure to light; colorless or faintly tinted in transmitted light. *Streak:* White. *Luster:* Vitreous to resinous, may be pearly. *Optical Class:* Biaxial (+). *Pleochroism:* Weak. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, weak. *Absorption:* $Z > Y > X$. $\alpha = 1.636$ $\beta = 1.637$ $\gamma = 1.648$ 2V(meas.) = 36°–40°

Cell Data: *Space Group: Pnma.* $a = 8.884(2)$ $b = 5.457(3)$ $c = 7.157(2)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.445 (100), 3.103 (95), 2.121 (80), 2.106 (75), 3.319 (70), 3.899 (50), 2.836 (50)

Chemistry:

	(1)	(2)
SO_3	34.21	34.30
CaO	0.05	
BaO	65.35	65.70
Total	99.61	100.00

(1) Svárov, Czech Republic. (2) $BaSO_4$.

Polymorphism & Series: Forms a series with celestine.

Mineral Group: Barite group.

Occurrence: A gangue mineral in low-temperature hydrothermal veins; in residual deposits from weathered barite-bearing limestones; an accessory mineral in igneous rocks; in carbonatites; a primary component of submarine volcanogenic massive sulfide deposits and sea-floor chimneys.

Association: Fluorite, calcite, dolomite, rhodochrosite, gypsum, sphalerite, galena, stibnite.

Distribution: The most common barium mineral; many localities, even for fine crystals. From Alston Moor, Frizington, Cleator Moor, and elsewhere in Cumbria, England. At Baia Sprie (Felsőbánya) and Cavnic (Kapnikbánya), Romania. From Příbram, Czech Republic. In Germany, from the Beihilfe mine, near Freiberg, and the Pöhla mine, Schwarzemberg, Saxony; in the Clara mine, near Oberwolfach, Black Forest, and at many other places. In the Rock Candy mine, north of Grand Forks, British Columbia, Canada. In the USA, from the Book Cliffs, near Grand Junction, Mesa Co., at Stoneham, Weld Co., in the Bulldog Mountain mine, Creede District, Mineral Co., and elsewhere in Colorado; at Elk Creek and Box Elder Creek, Meade and Pennington Cos., South Dakota; from Palos Verdes, Los Angeles Co., California; in the Magma mine, Superior, Gila Co., Arizona; very fine crystals from the Miekle mine, Elko Co., Nevada. At the El Solar mine, Taxco, Guerrero, Mexico. Immense crystals from the Elandsrand gold mine, Carletonville, South Africa.

Name: From the Greek for *weight*, in allusion to the high specific gravity.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 408–415. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 3–29. (3) Miyake, M., I. Minato, H. Morikawa, and S. Iwai (1978) Crystal structures and sulphate force constants of barite, celestite, and anglesite. Amer. Mineral., 63, 506–510. (4) Jacobsen, S.D., J.R. Smyth, R.J. Swope, and R.T. Downs (1998) Rigid-body character of the SO_4 groups in celestine, anglesite, and barite. Can. Mineral., 36, 1053–1060. (5) (1972) NBS Mono. 25, 10, 12.

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Barytocalcite $BaCa(CO_3)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically as elongated crystals, short to long prismatic and striated parallel [101], to 5 cm, or equant, showing large {100}, {$\bar{1}$11}, {$\bar{1}$31}, {210}, minor {001},{110}, {101}; may be massive, cleavable.

Physical Properties: *Cleavage:* On {210}, perfect; on {001}, imperfect. *Fracture:* Uneven to subconchoidal. Hardness = 3.5–4 D(meas.) = 3.66–3.71 D(calc.) = 3.72 Pale yellowish to red fluorescence under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale gray, bright to pale green, pale yellow; colorless in transmitted light. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 64°$; $Y \wedge c = -26°$. *Dispersion:* $r > v$, weak. $\alpha = 1.525$ $\beta = 1.684$ $\gamma = 1.686$ 2V(meas.) = 15°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.092(1)$ $b = 5.2344(6)$ $c = 6.544(1)$ $\beta = 106.05(1)°$ Z = 2

X-ray Powder Pattern: Alston, England. (ICDD 15-285).
3.125 (100), 3.140 (90), 4.018 (40), 4.345 (25), 2.157 (25), 2.512 (20), 2.379 (20)

Chemistry:

	(1)	(2)
CO_2	29.95	29.59
MgO	0.50	
CaO	18.75	18.85
SrO	1.81	
BaO	48.92	51.56
Total	99.93	100.00

(1) Vuoriyarvi massif, Russia; corresponds to $Ba_{0.92}Ca_{1.03}Sr_{0.08}Mg_{0.03}(CO_3)_{2.00}$.
(2) $BaCa(CO_3)_2$.

Polymorphism & Series: Trimorphous with alstonite and paralstonite.

Occurrence: A relatively uncommon accessory mineral in metallic veins, formed by reaction of hydrothermal fluids with limestone; however it may be the dominant barium-bearing species; rarely in carbonatites and Alpine veins.

Association: Barite, calcite, strontianite, siderite, alstonite, benstonite, witherite, norsethite, fluorite, sphalerite, pyrrhotite, quartz.

Distribution: In England, from the Bleagill mine, Alston, Cumbria, and at Holwell, Mendip Hills, Somerset. From Llantrisant, Wales. In the Himmelsfürst mine, Freiberg, Saxony, Germany. At Stříbro, Czech Republic. In the Vuoriyarvi carbonatite complex, and from the Khibiny massif, Kola Peninsula, Russia. At the Ediacara mine, west of Beltana, and from north of Angaston, Mount Lofty Ranges, South Australia. From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. On the Rough claims, north of Sifton Pass, British Columbia, and at the Jason Pb–Zn deposits, Macmillan Pass, Yukon Territory, Canada. In the USA, from the Westvaco trona mine, about 30 km west of Green River, Sweetwater Co., Wyoming; in the Pigeon Roost mine, 5 km northeast of Glenwood, Montgomery Co., Arkansas; at the Juanita mine, Magdalena district, Socorro Co., New Mexico.

Name: For *barium* with calcium and carbonate (*calcite*) in its composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 220–221. (2) Dickens, B. and J.S. Bowen (1971) The crystal structure of $BaCa(CO_3)_2$ (barytocalcite). J. Res. Nat. Bur. Stnd., A – Phys. and Chem., 75A(3), 197–203. (3) Kapustin, Y.L. (1971) Mineralogy of carbonatites. Nauka Publishers, Moscow, 152–153 (in English).

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Barytolamprophyllite

$$(Na,K)_3(Ba,Fe^{2+},Ca)_2(Ti,Fe^{3+})_3O_2(Si_2O_7)_2(F,OH,O)_2$$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As foliated aggregates of cleavable pseudorhombohedra.

Physical Properties: *Cleavage:* Perfect on {100}, less so on {011}, imperfect on {010}. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 3.62–3.66 D(calc.) = [3.82]

Optical Properties: Semitransparent. *Color:* Dark brown. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = light yellow; Z = brown. *Orientation:* $Z \wedge c = 6°–7°$. *Dispersion:* $r > v$, distinct. *Absorption:* $Z > Y > X$. α = 1.742–1.743 β = [1.754] γ = 1.776–1.778 2V(meas.) = 29°–30°

Cell Data: *Space Group:* $C2/m$ or $C2$. $a = 19.833$ $b = 7.089$ $c = 5.393$ $\beta = 96.66°$ Z = 2

X-ray Powder Pattern: Kola Peninsula, Russia. (ICDD 34-313).
2.801 (100), 2.153 (90), 1.482 (90), 1.601 (80), 3.447 (70), 1.790 (70), 3.294 (50)

Chemistry:

	(1)		(1)
SiO_2	28.53	BaO	17.24
TiO_2	26.60	Na_2O	9.52
Al_2O_3	1.12	K_2O	3.10
Fe_2O_3	2.72	F	1.60
FeO	2.63	Cl	0.51
MnO	1.75	H_2O^+	0.70
MgO	1.00	P_2O_5	0.06
CaO	1.70	$-O = (F,Cl)_2$	0.78
SrO	1.47	Total	[99.47]

(1) Kola Peninsula, Russia; original total given as 99.34%; corresponds to $(Na_{2.47}K_{0.53})_{\Sigma=3.00}(Ba_{1.05}Fe^{2+}_{0.28}Ca_{0.24}Mn_{0.20}Mg_{0.20}Sr_{0.12})_{\Sigma=2.09}(Ti_{2.68}Fe^{3+}_{0.28})_{\Sigma=2.96}(Si_{3.82}Al_{0.18})_{\Sigma=4.00}O_{14}[F_{0.68}(OH)_{0.62}O_{0.57}Cl_{0.14}]_{\Sigma=2.01}$.

Occurrence: In ijolite (Lovozero massif, Russia).

Association: Aegirine, nepheline, potassic feldspar, cancrinite, apatite (Lovozero massif, Russia); amphibole, eudialyte, natrolite, pectolite (Gardiner complex, Greenland).

Distribution: From Mts. Kukisvumchorr, Rasvumchorr, and Koashva, Khibiny massif, Kola Peninsula, and in the Murun massif, southwest of Olekminsk, Yakutia, Russia. At Kahlenberg, Graulai, and Üdersdorf, Eifel district, Germany. From Coyote Peak, near Orick, Humboldt Co., California, USA. In the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland.

Name: For the BARium in its composition and its relation to *lamprophyllite*.

Type Material: Beijing University, Beijing, China.

References: (1) Tze-Chung Peng [Zhizhong Peng] and Chien-hung Chang [Jianhong Zhang] (1965) New varieties of lamprophyllite–barytolamprophyllite and orthorhombic lamprophyllite. Scientia Sinica, 14, 1827–1840 (in English). (2) (1966) Amer. Mineral., 51, 1549 (abs. ref. 1). (3) Zhizhong Peng, Jianhong Zhang, and Jinfu Shu (1984) The crystal structure of barytolamprophyllite. Kexue Tongbao, 29, 237–241 (in English). (4) (1984) Chem. Abs., 101, 26260 (abs. ref. 3).

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Basaluminite $Al_4(SO_4)(OH)_{10}\cdot 4-5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Microcrystalline, as crystals with rhombic outlines, to about 2 μm; commonly in compact masses.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = 2.08–2.12 D(calc.) = 2.12

Optical Properties: Semitransparent. *Color:* White to pale yellow, pale brown. *Optical Class:* [Biaxial.] *Orientation:* Negative elongation. n = 1.515–1.540, 1.525 average. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. a = 14.857(3) b = 10.011(3) c = 11.086(3) β = 122.28(3)° Z = 4

X-ray Powder Pattern: Chickerell, England.
9.36 (100), 4.681 (27), 4.273 (20), 5.91 (13), 1.888 (12), 3.687 (10), 2.720 (10)

Chemistry:

	(1)	(2)	(3)
SO_3	17.15	18.10	17.25
Al_2O_3	42.85	44.75	43.94
CaO		0.20	
H_2O	[40.00]	35.60	38.81
insol.		0.72	
Total	[100.00]	99.37	100.00

(1) Irchester, England; average of two analyses, after deduction of Fe_2O_3 and allophane, H_2O by difference, corresponds to $Al_{3.92}(SO_4)_{1.00}(OH)_{9.76}\cdot 5.48H_2O$. (2) Chickerell, England; corresponds to $Al_{3.88}(SO_4)_{1.00}(OH)_{9.64}\cdot 3.92H_2O$. (3) $Al_4(SO_4)(OH)_{10}\cdot 5H_2O$.

Occurrence: Typically a weathering product of clays, as the result of acid released from the oxidation of pyrite; probably always a dehydration product of hydrobasaluminite; as coatings on joint surfaces and veinlets in ironstone (Irchester, England); in chalk (Clifton Hill, England); a reaction rim surrounding carbonate concretions (Chickerell, England); on fractures in garnet–sillimanite laterite (Kanogami, Japan).

Association: Hydrobasaluminite, hydroargillite, meta-aluminite, allophane, gibbsite, gypsum, aragonite.

Distribution: In England, from the Lodge pit, Irchester, Northamptonshire; on Clifton Hill, Brighton, Sussex; at the Crook Hill brickyard, Chickerell, near Weymouth, Dorset. From Moel Goedog, near Harlech, Merioneth, Wales. Found north of Ballybunion, Co. Kerry, Ireland. At Épernay, Marne, France. In the Vodino and Chekur-Koyashe sulfur deposits, along the middle Volga, and at the Kaluginsk deposits, Middle Ural Mountains, Russia. In the USA, from Shoals, Martin Co., Indiana; in the Flemming coal bed, Crawford Co., Kansas; at the Fuemrole mine, Temple Mountain, Emery Co., Utah; near Fort Foote, Prince Georges Co., Maryland; in Arizona, in the Lavender pit, Bisbee, Cochise Co. From Kanogami, Fukushima Prefecture, Japan. Several additional localities are known.

Name: As a BASic sulfate of ALUMINum.

Type Material: The Natural History Museum, London, England, 1950,56–61; Harvard University, Cambridge, Massachusetts, USA, 101819.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 586. (2) Clayton, T. (1980) Hydrobasaluminite and basaluminite from Chickerell, Dorset. Mineral. Mag., 43, 931–937.

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Bassanite $2CaSO_4 \cdot H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* 2. As needlelike crystals, to 0.1 mm, typically in parallel aggregates. *Twinning:* About [010], twin plane {101}, may be sectored (synthetic).

Physical Properties: Hardness = n.d. D(meas.) = 2.69–2.76 D(calc.) = 2.731

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Biaxial (+). *Orientation:* Positive elongation, parallel extinction,
$\alpha = 1.550–1.559$ $\beta = 1.560$ $\gamma = 1.577–1.584$ 2V(meas.) = 10°–15°

Cell Data: *Space Group:* $I2$ (synthetic). $a = 12.0317(4)$ $b = 6.9269(2)$ $c = 12.6712(3)$
$\beta = 90.27(1)°$ Z = 12

X-ray Powder Pattern: Synthetic.
3.006 (100), 2.807 (86), 6.00 (70), 1.847 (56), 3.469 (54), 2.139 (22), 3.042 (15)

Chemistry:

	(1)	(2)
SO_3	54.19	55.16
CaO	37.75	38.63
H_2O	6.37	6.21
Total	98.31	100.00

(1) Danby Lake, California, USA. (2) $2CaSO_4 \cdot H_2O$.

Occurrence: Altered from gypsum in leucite tephrite blocks; fumarolic (Vesuvius, Italy); in dry or perennially dry lake beds (California, Australia); in caves, interlayered with gypsum.

Association: Gypsum, anhydrite, celestine, calcite, gibbsite.

Distribution: From Vesuvius, Campania, Italy. At Wadi Mestaoua, east of Foum Tataouine, Tunisia. In the USA, in caves in Big Bend National Park, Brewster Co., Texas; in California, from Danby [dry] Lake, San Bernardino Co., at a dry lake near Ballarat, Inyo Co., and in the S.A.M. Corporation sulfur mine, near Taft, Kern Co. Found near Nappan, Nova Scotia, Canada. In the Hutt and Leeman [pond-playa] lagoons, north of Perth, Western Australia. From South Victoria Land, Antarctica. Probably more widespread than the above listing of localities would indicate.

Name: To honor Francesco Bassani (1853–1916), Professor of Paleontology, University of Naples, Naples, Italy.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 476. (2) Allen, R.D. and H. Kramer (1953) Occurrence of bassanite in two desert basins in southeastern California. Amer. Mineral., 38, 1266–1268. (3) Bezou, C., A. Nonat, J.-C. Mutin, A.N. Christensen, and M.S. Lehmann (1995) Investigation of the crystal structure of $\gamma-CaSO_4$, $CaSO_4 \cdot 0.5H_2O$, and $CaSO_4 \cdot 0.6H_2O$ by powder diffraction methods. J. Solid State Chem., 117, 165–176. (4) (1981) NBS Mono. 25, 22–23.

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Bassetite $Fe^{2+}(UO_2)_2(PO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Crystals, with square or rectangular outline, to 3 mm, are thin tablets, flattened on [010], showing {111}, {101}, {110}, {001}, {010}; typically in parallel or fanlike groups. *Twinning:* Two or more individuals at ∼90° with [001] of one individual ∥ [100] of the other; common.

Physical Properties: *Cleavage:* {010}, perfect; {100} and {001}, distinct. Hardness = 2.5 D(meas.) = 3.40–3.63 D(calc.) = 3.63 Radioactive.

Optical Properties: Transparent; in transmitted light, seen as sectored due to twinning. *Color:* Olive-green, olive-brown, yellowish brown, bronzy yellow, yellow. *Luster:* Vitreous, bronzy on {010}.
Optical Class: Biaxial (–) (probable). *Pleochroism:* $X = Y$ = yellow; Z = dark olive-brown to brownish black. *Orientation:* $X = b$; Y ∧ c = 18.5°. *Dispersion:* $r > v$, strong. $\alpha = 1.603(2)$ $\beta = 1.610(2)$ $\gamma = 1.617(2)$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/m$ (synthetic). $a = 6.98(4)$ $b = 17.07(4)$ $c = 7.01(7)$ $\beta = 90°32(5)'$ Z = 2

X-ray Powder Pattern: Cornwall, England.
4.89 (10), 3.46 (10), 8.59 (6), 2.20 (6), 4.24 (3), 4.05 (3), 2.96 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3	61.99	62.71	61.51	H_2O	14.49	14.20	15.50
P_2O_5	15.21	15.43	15.26	insol.	0.63		
FeO	7.60	7.78	7.73	Total	100.20	100.12	100.00
CuO	0.28						

(1) Wheal Basset, Cornwall, England. (2) Arcu su Linnarbu, Italy. (3) $Fe(UO_2)_2(PO_4)_2 \cdot 8H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: A rare secondary mineral in the oxidized zone of some uranium-bearing hydrothermal mineral deposits.

Association: Uranospathite, torbernite, uraninite, pyrite (Basset mines, England); meta-autunite, torbernite (Arcu su Linnarbu, Italy); saléeite, metanováčekite (Sue mine, Arizona, USA).

Distribution: In England, from the Basset group of mines, Illogan, and the South Terras mine, St. Stephen-in-Brannel, Cornwall. At Arcu su Linnarbu, Capoterra, near Cagliari, Sardinia, Italy. From Daverdisse, Belgium. At the Los Ratones and Pedro Alvaro vanadium mines, Salamanca Province, Spain. From the La Crouzille mine, Haute-Vienne, France. In the USA, on Overland Mountain, Jamestown district, Boulder Co., Colorado; in Utah, from the Denise No. 1 mine and in the Fuemrol mine, Temple Mountain, Emery Co., Utah; in Arizona, at the Sue and Red Bluff mines, Sierra Ancha Mountains, and widespread in the Dripping Springs quartzite in the northwestern part of Gila Co.; from the Merry Widow mine, Grant Co., New Mexico.

Name: For the Basset mine group, Cornwall, England, from which it was first described.

Type Material: Mineralogical Museum, Cambridge, 1297; [Museum of Practical Geology, Ludlam collection L1936, L1941, L1946] now in The Natural History Museum, London, England; National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 994–995. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 200–204. (3) Vochten, R., E. De Grave, and J. Pelsmaekers (1984) Mineralogical study of bassetite in relation to its oxidation. Amer. Mineral., 69, 967–978. (4) Vochten, R. and G. Brizzi (1987) Bassetite and other uranium minerals from Arcu su Linnarbu, Capoterra, Cagliari, Sardinia. Mineral. Record, 18, 181–184.

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Bassoite $SrV_3O_7 \cdot 4H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As grains to 400 μm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 4-4.5 VHN = 150 (100 g load). D(meas.) = n.d. D(calc.) = 2.940

Optical Properties: Opaque. *Color*: Black. *Streak*: Black. *Luster*: Submetallic. *Optical Class*: Anisotropic. *Bireflectance*: Weak. *Pleochroism*: Very weak, gray to dark green. R_1-R_2: (471.1) 18.5-19.0, (548.3) 17.2-17.8, (586.6) 16.8-17.5, (652.3) 16.2-16.8

Cell Data: *Space Group*: $P2_1/m$. a = 5.313(3) b = 10.495(3) c = 8.568(4) β = 91.14(5)° Z = 2

X-ray Powder Pattern: Calculated pattern.
8.5663 (100), 3.4049 (17), 2.8339 (15), 2.6550 (15), 1.8666 (15), 6.6363 (14), 3.4399 (14)

Chemistry:

	(1)	(2)
SrO	23.66	24.41
CaO	0.27	
Na_2O	0.07	
VO_2	58.56	58.61
H_2O	[16.99]	16.98
Total	99.55	100.00

(1) Molinello mine, Val Graveglia, Italy; average of 7 electron microprobe analyses, H_2O calculated from stoichiometry and confirmed by Mössbauer spectroscopy; corresponding to $(Sr_{0.97}Ca_{0.02}Na_{0.01})_{\Sigma=1.01}V_{3.00}O_7 \cdot 4H_2O$. (2) $SrV_3O_7 \cdot 4H_2O$.

Occurrence: In a metamorphosed bedded chert and Mn ore deposit.

Association: Rhodonite, quartz, braunite.

Distribution: At the Molinello manganese mine, Val Graveglia, eastern Liguria, northern Apennines, Italy.

Name: Honors Riccardo Basso (b. 1947), Professor of Mineralogy and Crystallography, University of Genoa, Italy.

Type Material: Dipartimento per lo Studio del Territorio e delle sue Risorse, Università di Genova, Italy, (M0480).

References: (1) Bindi, L., C. Carbone, R. Cabella, and G. Lucchetti (2011) Bassoite, $SrV_3O_7 \cdot 4H_2O$, a new mineral from Molinello mine, Val Graveglia, eastern Liguria, Italy. Mineral. Mag., 75, 2677-2686. (2) (2012) Amer. Mineral., 97, 1525 (abs. ref. 1).

Bastnäsite-(Ce) $(Ce, La)(CO_3)F$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}2c$. Commonly in tabular to equant crystals, with {0001} and {$10\bar{1}0$}, may be modified by {$11\bar{2}0$}, {$10\bar{1}1$}, {$10\bar{1}2$}, {$10\bar{1}3$}, {$11\bar{2}2$}, horizontally striated, may be elongated, commonly in syntaxic intergrowth with röntgenite-(Ce), synchysite-(Ce), parisite-(Ce), or cordylite-(Ce), to 20 cm; granular, massive.

Physical Properties: *Cleavage:* On {$10\bar{1}0$}, indistinct; {0001}, a parting, distinct to perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 4.9–5.2 D(calc.) = 5.12 (for $Ce(CO_3)F$). Strongly piezoelectric; dark red cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Wax-yellow, honey-yellow, reddish brown; in transmitted light, pale yellow to colorless. *Luster:* Vitreous to greasy, pearly on basal partings.
Optical Class: Uniaxial (+). *Pleochroism:* Faint. *Absorption:* $O < E$. $\omega = 1.717$–1.722 $\epsilon = 1.818$–1.823

Cell Data: *Space Group:* $P\bar{6}2c$. a = 7.118(1) c = 9.762(1) Z = 6

X-ray Powder Pattern: Stove Mountain, Colorado, USA.
2.88 (100), 3.56 (71), 2.06 (50), 1.892 (50), 4.90 (35), 2.01 (35), 1.675 (24)

Chemistry:

	(1)	(3)		(1)	(3)
P_2O_5	0.60		F	6.23	8.69
CO_2	20.20	20.14	$-O = F_2$	2.61	3.66
La_2O_3	36.30	37.28	Total	101.22	100.00
Ce_2O_3	40.50	37.55			

(1) Madagascar. (2) Gallinas Mountains, New Mexico, USA; analysis not given, corresponds to $(Ce_{0.48}La_{0.37}Nd_{0.10}Pr_{0.04}Sm_{0.01})_{\Sigma=1.00}(CO_3)F$. (3) $(Ce, La)(CO_3)F$ with Ce:La = 1:1.

Polymorphism & Series: 4H, 6R, 3R polytypes; forms a series with hydroxylbastnäsite-(Ce).

Occurrence: The most abundant RE-bearing mineral, typically hydrothermal, although primary igneous occurrences are known. In granite and alkali syenites and pegmatites; in carbonatites; in contact-metamorphic deposits; rarely as a detrital mineral in placers.

Association: Allanite-(Ce), cerianite-(Ce), synchysite-(Ce), parisite-(Ce), cerite-(Ce), fluocerite-(Ce), fluorite.

Distribution: In Sweden, from the Bastnäs mine, near Riddarhyttan, Västmanland. At the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France. In a large deposit at Karkin, near Eskiçehir, Eskiçehir Province, Turkey. Fine crystals from Shinwaro, Kunar Province, Afghanistan. On Zegi Mountain, Fata, Pakistan. Large crystals from Andakatany, Ambatofangehana, and elsewhere in Madagascar. At Karonge, Burundi. On Wigu Hill, Tanzania. From Nkombwa Hill, Zambia. In the USA, from near Stove Mountain, in the St. Peters Dome area, and at Crystal Park, near Pikes Peak, El Paso Co., Colorado; at the Red Cloud fluorite mine, Gallinas Mountains, Lincoln Co., New Mexico; in a large deposit at Mountain Pass, San Bernardino Co., California; from Granite Mountain, near Little Rock, Pulaski Co., Arkansas; in the Trout Brook Valley, near Ticonderoga, Essex Co., New York. At Mont Saint-Hilaire, Quebec, Canada. A major ore mineral in the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. There are numerous minor localities.

Name: For its first-noted occurrence in the Bastnäs mine, Sweden, and content of *cerium*.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 23:0476.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 289–291. (2) Ni, Y., J.M. Hughes, and A.N. Mariano (1993) The atomic arrangement of bastnäsite-(Ce), $Ce(CO_3)F$, and structural elements of synchysite-(Ce), röntgenite-(Ce), and parisite-(Ce). Amer. Mineral., 78, 415–418. (3) Jansen, G.J., G.B. Magnin, Jr., and B. Levin (1959) Synthesis of bastnaesite. Amer. Mineral., 44, 180–181.

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Bastnäsite-(La) $(La, Ce)(CO_3)F$

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Crystal Data: [Hexagonal.] [by analogy to bastnäsite-(Ce)]. *Point Group:* $\overline{6}2c$. Fine-grained massive.

Physical Properties: Hardness = [4–4.5] D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark brown.
Optical Class: Uniaxial (+). ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* [$P\overline{6}2c$] [by analogy to bastnäsite-(Ce)]. a = n.d. c = n.d. Z = n.d.

X-ray Powder Pattern: Probably nearly identical to bastnäsite-(Ce).

Chemistry:

	(2)	(3)
CO_2	n.d.	20.14
La_2O_3	55.04	37.28
Ce_2O_3	n.d.	37.55
Pr_2O_3	4.35	
Nd_2O_3	11.49	
Sm_2O_3	n.d.	
CaO	1.72	
H_2O	n.d.	
F	n.d.	8.69
$-O = F_2$	n.d.	3.66
Total		100.00

(1) Belaya Zima deposit, Russia; analysis not given but stated to correspond to $(La_{0.44}Ce_{0.41}Nd_{0.14})_{\Sigma=0.99}(CO_3)F$. (2) Near Odegi, Nigeria; partial analysis by electron microprobe, corresponding to $(La_{0.71}Nd_{0.14}Ca_{0.09}Pr_{0.06})_{\Sigma=1.00}(CO_3)F$. (3) $(La, Ce)(CO_3)F$ with La:Ce = 1:1.

Occurrence: In late ankerite carbonatites (Belaya Zima deposit, Russia).

Association: Fluocerite, cerianite-(Ce) (near Odegi, Nigeria).

Distribution: From the Belaya Zima RE–Nb deposit, eastern Sayan, Siberia, Russia. Found near Odegi, Afu Hills, Nigeria.

Name: For its relation to *bastnäsite*-(Ce) and dominant *lanthanum* in its composition.

Type Material: n.d.

References: (1) Vainshtein, E.E., L.K. Pozharitskaya, and N.V. Turanskaya (1961) Behavior of rare earths in the process of carbonatite formation. Geokhimiya, 11, 1031–1034 (in Russian). (2) Styles, M.T. and B.R. Young (1983) Fluocerite and its alteration products from the Afu Hills, Nigeria. Mineral. Mag., 47, 41–46.

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Bastnäsite-(Y) $Y(CO_3)F$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}2c$. Irregular grains, to 4 μm, aggregated into compact pseudomorphs after large gagarinite-(Y) crystals.

Physical Properties: Hardness = [4–4.5] [by analogy to bastnäsite-(Ce)].
D(meas.) = 3.9–4.0 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Brick-red to carmine-red; pale brown in transmitted light.
Optical Class: Uniaxial (+). n = 1.66–1.67 ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* [$P\bar{6}2c$] [by analogy to bastnäsite-(Ce)]. a = 6.57(20 c = 9.48(2)
Z = 6

X-ray Powder Pattern: Verkhne-Espe massif, Kazakhstan.
2.78 (10), 1.948 (10), 3.43 (7.5), 1.976 (7.5), 1.822 (7.5), 1.260 (5), 1.608 (4)

Chemistry:

	(1)
CO_2	18.99
SiO_2	3.00
ThO_2	0.72
RE_2O_3	60.00
Al_2O_3	0.40
Fe_2O_3	3.3
CaO	4.09
K_2O	0.40
F	7.28
H_2O^+	0.74
H_2O^-	4.36
$-O = F_2$	3.10
Total	[100.18]

(1) Verkhne-Espe massif, Kazakhstan; original total given as 100.12%, RE = Y 40.1%, La 1.4%, Ce 7.0%, Pr 1.8%, Nd 6.2%, Sm 5.3%, Eu 0.6%, Gd 6.8%, Tb 1.6%, Dy 11.0%, Ho 2.6%, Tm 1.1%, Yb 5.3%, Lu 1.7%; after deduction of microcline 2.4%, hematite 3.3%, fluorite 3%, and quartz 1.5%, corresponds to $[(Y_{0.36}Dy_{0.10}Er_{0.07}RE_{0.37})_{0.90}Ca_{0.09}Th_{0.01}]_{\Sigma=1.00}(CO_3)_{1.00}[F_{0.73}(OH)_{0.19}]_{\Sigma=0.92}$.

Occurrence: A rare secondary mineral in a microcline–quartz pegmatite vein.

Association: Gagarinite-(Y), fluorite, microcline, hematite, quartz.

Distribution: In the Verkhne-Espe alkaline massif, Tarbagatai Range, Kazakhstan.

Name: As a *bastnäsite* species with dominant *yttrium*.

Type Material: Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis1961 and vis1962.

References: (1) Mineev, D.A., T.I. Lavrischeva, and A.V. Bykova (1970) Yttrian bastnaesite – an alteration product of gagarinite. Zap. Vses. Mineral. Obshch., 99, 328–332. (2) (1972) Amer. Mineral., 57, 594 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 36.

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Batiferrite $BaFe_2^{2+}Fe_8^{3+}Ti_2O_{19}$

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Crystal Data: n.d. *Point Group:* n.d. As dense, fine-grained aggregates.

Physical Properties: Hardness = 5 VHN = 372–380 (100 g load). ?? D(meas.) = 5.283–5.420 ?? D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Reddish brown.
Optical Class: Biaxial (–). α = 1.911–1.916 β = n.d. γ = 1.920–1.932 2V(meas.) = 81°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Oktyabr deposit, Russia.
3.09 (10), 3.41 (7), 1.98 (6), 1.948 (6), 1.908 (6), 1.723 (6), 1.667 (6)

Chemistry:

	(1)	(2)	(3)
UO_3	63.74	67.37	66.88
SiO_2	0.48	0.97	3.54
CO_2	3.20	0.60	0.39
PbO	0.53	0.55	0.74
CaO	2.62	0.40	0.47
BaO	21.21	21.14	17.43
H_2O	8.24	8.19	10.07
Total	100.02	99.22	99.52

(1–3) Oktyabr deposit, Russia; respectively corresponding to $BaO \cdot 1.94UO_3 \cdot 4H_2O$; $BaO \cdot 1.75UO_3 \cdot 3.4H_2O$; and $BaO \cdot 2UO_3 \cdot 4.8H_2O$.

Occurrence: In the oxidation zone of a U–Mo deposit, replacing "pitchblende" and replaced by uranophane.

Association: Uraninite, uranophane, calciouranoite, metacalciouranoite, protasite.

Distribution: From the Oktyabr U–Mo deposit, 12 km southeast of Krasnokamensk, Strel'tsov district, eastern Transbaikal, Russia.

Name: For BArium, URANium, and Oxygen in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76547, 76548.

References: (1) Rogova, V.P., L.N. Belova, G.N. Kiziyarov, and N.N. Kuznetsova (1973) Bauranoite and metacaltsuranoite [metacalciouranoite] – new minerals of the group of hydrous uranium oxides. Zap. Vses. Mineral. Obshch., 102, 75–81 (in Russian). (2) (1973) Amer. Mineral., 58, 1111 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 37.

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Batisite $(Na,K)_2BaTi_2(Si_2O_7)_2$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $mm2$ or $2/m\ 2/m\ 2/m$. As complex elongated crystals, to 10 cm.

Physical Properties: *Cleavage:* Fair on {100}, {010}, and {001}; parting on {110}. *Tenacity:* Brittle. Hardness = ∼6 VHN = 764 D(meas.) = 3.432 D(calc.) = 3.49 Some samples are piezoelectric.

Optical Properties: Transparent in thin slivers. *Color:* Dark brown. *Streak:* Rose-brown. *Luster:* Vitreous to slightly oily.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Y = yellowish brown; Z = reddish brown. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, strong. $\alpha = 1.730(1)$ $\beta = 1.735(1)$ $\gamma = 1.791(1)$ 2V(meas.) = 7°

Cell Data: *Space Group:* $Ima2$ or $Imam$. a = 10.40–10.50 b = 13.85–13.91 c = 8.08–8.10 Z = 4

X-ray Powder Pattern: Inagli massif, Russia; nearly identical to shcherbakovite.
2.91 (100), 3.39 (50), 2.16 (50), 1.68 (50), 2.09 (40), 3.20 (30), 2.62 (30)

Chemistry:

	(1)		(1)
SiO_2	39.00	CaO	0.27
TiO_2	22.00	SrO	0.03
ZrO_2	1.90	BaO	22.00
Al_2O_3	0.90	Na_2O	8.40
Fe_2O_3	1.80	K_2O	2.60
Nb_2O_5	0.36	H_2O^+	0.50
MnO	0.09	LOI	0.10
MgO	trace	Total	99.95

(1) Inagli massif, Russia; corresponds to $(Na_{1.66}K_{0.34})_{\Sigma=2.00}(Ba_{0.88}Ca_{0.03}Mn_{0.01})_{\Sigma=0.92}(Ti_{1.68}Fe^{3+}_{0.14}Al_{0.11}Zr_{0.09})_{\Sigma=2.02}Si_{3.97}[O_{13.66}(OH)_{0.34}]_{\Sigma=14.00}$.

Occurrence: In aegirine-arfvedsonite-microcline pegmatites in dunites (Inagli massif, Russia).

Association: Microcline, nepheline, aegirine, arfvedsonite, lorenzenite, uranian thorite, eudialyte, apatite, orthoclase (Inagli massif, Russia).

Distribution: From the Inagli massif, 30 km west of Aldan; the Murun massif, southwest of Olekminsk, Yakutia; and on Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia. At Liley, near Üdersdorf, Graulai, and Altburg, Eifel district, Germany.

Name: For *Ba, Ti, Si* in the composition.

Type Material: Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; Moscow Geological Survey Institute, Moscow; Vernadsky State Geological Museum, Moscow, 46244; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 61316, vis3299.

References: (1) Kravchenko, S.M. and E.V. Vlasova (1959) Rare-metal mineralization associated with nepheline syenites of the alkalic province of Central Aldan. Doklady Acad. Nauk SSSR, 128, 1046–1049 (in Russian). (2) (1960) Amer. Mineral., 45, 908–909 (abs. ref. 1). (3) Kravchenko, S.M., E.V. Vlasova, and N.G. Pinevich (1960) Batisite, a new mineral. Doklady Acad. Nauk SSSR, 133, 657–660 (in Russian). (4) (1960) Amer. Mineral., 45, 1317 (abs. ref. 3). (5) Nikitin, A.V. and N.V. Belov (1962) Crystal structure of batisite $Na_2BaTi_2Si_4O_{14}$ = $Na_2BaTi_2O_2[Si_4O_{12}]$. Doklady Acad. Nauk SSSR, 146, 1401–1403 (in Russian). (6) (1963) Chem. Abs., 58, 5116 (abs. ref. 5). (7) Schmahl, W., E. Tillmanns, and K. Abraham (1981) Struktur und Kristallchemie von Batisite aus der Westeifel. Fortschr. Mineral., 59(1), 174–176 (in German). (8) Schmahl, W.W. and E. Tillmanns (1987) Isomorphic substitutions, straight Si–O–Si geometry, and disorder of tetrahedral tilting in batisite, $(Ba,K)(K,Na)Na(Ti,Fe,Nb,Zr)Si_4O_{14}$. Neues Jahrb. Mineral., Monatsh., 107–118.

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Batisivite $V_8Ti_6[Ba(Si_2O)]O_{28}$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As equant to elongate grains, to 0.2 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle.
Hardness = 7-7.5 D(meas.) = n.d. D(calc.) = 4.624 VHN = 1200-1470 (30 g load).

Optical Properties: Opaque. *Color*: Black; weak cream white in reflected light. *Streak*: Black.
Luster: Resinous. *Bireflectance*: Weak to moderate. *Anisotropism*: Weak.
Optical Class: n.d.
R_1-R_2: (440) 16.92-17.40, (460) 16.68-17.20, (540) 16.80-17.49, (580) 16.93-17.60, (640) 17.15-17.78, (700) 17.44-18.10

Cell Data: *Space Group*: $P\bar{1}$. a = 7.521(1) b = 7.643(1) c = 9.572(1) α = 110.20° β = 103.34(1)° γ = 98.28(1)° Z = 1

X-ray Powder Pattern: Slyudyanka Complex, southern Baikal region, Russia.
2.85 (100), 1.582 (100), 1.433 (100), 3.10 (80), 2.63 (80), 2.13 (80), 1.781 (80)

Chemistry:

	(1)	(2)
BaO	11.42	11.34
MgO	0.08	
Fe_2O_3	1.48	
Cr_2O_3	12.29	
Nb_2O_5	0.26	
Al_2O_3	1.81	
SiO_2	6.16	8.88
VO_2	8.20	
V_2O_3	26.27	44.33
TiO_2	31.76	35.45
Total	99.73	100.00

(1) Slyudyanka Complex, southern Baikal region, Russia; average of 237 electron microprobe analyses, VO_2:V_2O_3 calculated, absence of OH confirmed by Raman spectroscopy, corresponding to $(V^{3+}_{4.77}V^{4+}_{0.75}Cr_{2.20}Fe_{0.25}Nb_{0.03})_{\Sigma=8.00}(Ti_{5.41}V^{4+}_{0.59})_{\Sigma=6.00}[Ba_{1.01}Mg_{0.02}(Si_{1.40}Al_{0.48}O_{0.94})]O_{28}$.
(2) $V_8Ti_6[Ba(Si_2O)]O_{28}$.

Mineral Group: Derbylite group.

Occurrence: An accessory mineral, frequently intergrown with schreyerite in quartz bands, in a Cr-V-rich quartz-diopside metamorphic rock.

Association: Cr-V-bearing diopside and tremolite, calcite, schreyerite, berdesinskiite, V-bearing titanite, ankangite, chromite-coulsonite series spinels, Fe-bearing members of the eskolaite-karelianite series, uraninite, chernykhite-roscoelite series micas, Cr-bearing goldmanite, dravite-vanadiumdravite tourmalines, albite, barite, zircon, unnamed U-Ti-V-Cr oxide phases.

Distribution: Slyudyanka Complex, southern Baikal region, Russia.

Name: For its major cations (Ba, Ti, Si, V).

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow.

References: (1) Reznitsky, L.Z., E.V. Sklyarova, T. Armbruster, E.V. Galuskin, Z.F. Ushchapovskaya, Yu.S. Polekhovsky, N.S. Karmanov, A.A. Kashaev, and I.G. Barash (2008) Batisivite, $V_8Ti_6[Ba(Si_2O)]O_{28}$, a new mineral species from the derbylite group. Geol. Ore Deposits, 50, 565–573 (original Russian text: Zapiski Rossiiskogo Mineral. Obsch., 2007, 5, 55–67).
(2) Armbruster, T., M. Kadiyski, L.Z. Reznitsky, E.V. Sklyarov, and E.V. Galuskin (2008) Batisivite, the first silicate related to the derbylite-hemloite group. Eur. J. Mineral., 20, 975–981.
(3) (2009) Amer. Mineral., 94, 1077 (abs. ref. 1). (4) (2009) Amer. Mineral., 94, 650 (abs. ref. 2).

Baumhauerite $Pb_3As_4S_9$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$ ($2/m$ pseudocell). Crystals are short prismatic parallel to [010], tabular on {100}; striated on {100} parallel to [010], as well as on {010} parallel to [001]; crystals may be rounded, to 2.5 cm. Also as aggregates of rounded grains. *Twinning:* Polysynthetic, on {100}.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Conchoidal. Hardness = 3 VHN = 177–184, average 181. D(meas.) = 5.33–5.44 D(calc.) = [5.42]

Optical Properties: Opaque. *Color:* Lead-gray to steel-gray, may tarnish to iridescence; in polished section, white with deep red internal reflections. *Streak:* Chocolate-brown. *Luster:* Metallic. *Anisotropism:* Strong, dark brown, pale brown, pale brownish gray; may be colorful in green, violet, blue-green or yellow.
R_1–R_2: (400) 38.0–42.1, (420) 37.6–41.9, (440) 37.2–41.6, (460) 36.8–41.2, (480) 36.4–40.7, (500) 36.0–40.4, (520) 35.5–39.8, (540) 35.1–39.2, (560) 34.6–38.6, (580) 34.2–37.9, (600) 33.7–37.2, (620) 33.2–36.5, (640) 32.5–35.7, (660) 31.8–34.9, (680) 31.1–34.2, (700) 30.5–33.5

Cell Data: *Space Group:* $P\overline{1}$ ($P2_1/m$ pseudocell). $a = 22.80(1)$ $b = 8.357(5)$ $c = 7.894(5)$ $\alpha = 90°3(2)'$ $\beta = 97°16(4)'$ $\gamma = 89°55(2)'$ $Z = 4$

X-ray Powder Pattern: Binntal, Switzerland (close to baumhauerite-*2a*).
3.00 (100), 2.94 (100), 2.76 (100), 4.11 (80), 3.43 (80), 3.25 (80), 3.56 (80)

Chemistry:

	(1)	(2)	(3)
Pb	47.9	53.85	51.38
Tl	0.4		
As	27.2	23.22	24.77
Sb	0.6		
S	23.9	22.94	23.85
Total	100.0	100.01	100.00

(1) Binntal, Switzerland; by electron microprobe, average of two analyses; corresponds to $Pb_{2.79}As_{4.38}S_{9.00}$. (2) Mooseck, Austria; by electron microprobe, corresponds to $Pb_{3.35}As_{3.98}S_{9.00}$. (3) $Pb_3As_4S_9$.

Occurrence: In sugary dolostone (Binntal, Switzerland).

Association: With baumhauerite-*2a*, other lead sulfarsenides, realgar, pyrite, dolomite (Binntal, Switzerland).

Distribution: In the Lengenbach quarry, Binntal, Valais, Switzerland [TL]. From Mooseck, near Golling, Salzburg, Austria. In the Seravezza marble quarries, 20 km southwest of Carrara, Tuscany, Italy. In Canada, at Madoc, and in the Hemlo gold deposit, Thunder Bay district, Ontario. From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and at the Zuni mine, Silverton, Colorado, USA. From Novoye, Kaidarkan, Kyrgyzstan.

Name: For Professor Heinrich Adolph Baumhauer (1848–1926), German mineralogist, University of Fribourg, Switzerland.

Type Material: The Natural History Museum, London, England, 1926,1654.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 460–462. (2) Engel, P. and W. Nowacki (1969) Die Kristallstruktur von Baumhauerit. Zeits. Krist., 129, 178–202 (in German). (3) Pring, A., W.D. Birch, D. Sewell, S. Graeser, A. Edenharter, and A. Criddle (1990) Baumhauerite-*2a*: a silver-bearing mineral with a baumhauerite-like supercell from Lengenbach, Switzerland. Amer. Mineral., 75, 915–922. (4) Pring, A. (2001) The crystal chemistry of the sartorite group minerals from Lengenbach, Binntal, Switzerland – a HRTEM study. Schweiz. Mineral. Petrog. Mitt., 81, 69–87. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 154.

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Baumhauerite-*2a* $Pb_{11}Ag(As,Sb)_{18}S_{36}$

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Crystal Data: Monoclinic. *Point Group:* n.d. As domains intergrown with baumhauerite.

Physical Properties: *Cleavage:* One perfect, probably {100}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = 156–165, average 159. D(meas.) = n.d. D(calc.) = 5.31–5.37

Optical Properties: Opaque. *Color:* Steel-gray. *Streak:* Dark reddish brown. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Moderate; brownish gray, greenish gray, very pale bluish gray, pale greenish gray.
R_1–R_2: (400) 38.9–41.9, (420) 38.4–41.6, (440) 37.8–41.3, (460) 37.3–40.9, (480) 36.8–40.5, (500) 36.2–40.2, (520) 35.6–39.6, (540) 34.9–39.0, (560) 34.2–38.1, (580) 33.5–37.3, (600) 32.8–36.4, (620) 32.1–35.6, (640) 31.4–34.7, (660) 30.6–34.0, (680) 30.1–33.3, (700) 29.6–32.6

Cell Data: *Space Group:* n.d. $a = 44.74(4)$ $b = 8.477(4)$ $c = 7.910(6)$ $\beta = 93.37(5)°$ Z = n.d. ??1??

X-ray Powder Pattern: Binntal, Switzerland (close to baumhauerite).
3.01 (100), 2.75 (90), 2.28 (90), 4.22 (80), 2.95 (70), 2.73 (70), 3.68 (60)

Chemistry:

	(1)	(2)
Pb	46.3	44.35
Ag	1.4	0.25
Hg		0.3
Tl		1.85
As	26.9	20.15
Sb	0.5	5.45
S	24.3	24.55
Total	99.4	96.90

(1) Binntal, Switzerland; by electron microprobe, corresponding to $Pb_{10.62}Ag_{0.62}(As_{17.06}Sb_{0.20})_{\Sigma=17.26}S_{36.00}$. (2) Quiruvilca, Peru; by electron microprobe, corresponding to $Pb_{10.06}Ag_{0.12}Hg_{0.07}(As_{12.65}Sb_{2.10}Tl_{0.43})_{\Sigma=15.18}S_{36.00}$.

Occurrence: In sugary dolomite (Binntal, Switzerland).

Association: Baumhauerite, other lead sulfarsenides, realgar, pyrite, dolomite (Binntal, Switzerland).

Distribution: In the Lengenbach quarry, Binntal, Valais, Switzerland [TL]. From the La Libertad mine, Quiruvilca, ??, Peru.

Name: For its similarity to baumhauerite.

Type Material: Museum of Victoria, Melbourne, M30980, South Australian Museum, Adelaide, Australia, G15547; The Natural History Museum, London, England, 1926,1654; Natural History Museum, Basel, Switzerland, L7228.

References: (1) Pring, A., W.D. Birch, D. Sewell, S. Greaser, A. Edenharter, and A. Criddle (1990) Baumhauerite-*2a*: a silver-bearing mineral with a baumhauerite-like supercell from Lengenbach, Switzerland. Amer. Mineral., 75, 915–922. (2) Robinson, G. and D. Harris (1987) A baumhauerite-like mineral from Quiruvilca, Peru. Mineral. Record, 18, 199–201. [must??]

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Baumstarkite $AgSbS_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Equant crystals, to 3 mm, showing {001}, {10$\overline{1}$}, {201}, {010}, {01$\overline{1}$}, {100}. *Twinning:* Common on {001}.

Physical Properties: *Cleavage:* Perfect on {001}; less perfect on {100}. *Fracture:* Even. *Tenacity:* Sectile, somewhat flexible. Hardness = ∼2.5 VHN = 71–98, 89 average (25 g load). D(meas.) = 5.33 D(calc.) = 5.39

Optical Properties: Opaque, transparent on thin edges. *Color:* Iron-black, grayish black on fresh surfaces; deep blood-red in transmitted light, may show red internal reflections; gray to white in reflected light. *Streak:* Grayish black. *Luster:* Metallic. *Anisotropism:* Bright white to gray with a brownish tint to very dark blue; dull greenish yellow to brown to mauve to dark blue on twinned grains. *Bireflectance:* Weak to moderate; gray to white.

R_1–R_2: (400) 33.2–41.0, (420) 32.7–40.8, (440) 32.2–40.2, (460) 31.6–39.6, (480) 31.1–39.5, (500) 30.4–38.8, (520) 30.0–38.1, (540) 29.4–37.4, (560) 28.6–36.8, (580) 28.1–36.4, (600) 27.6–35.7, (620) 2.07–34.6, (640) 26.4–33.6, (660) 25.9–32.7, (680) 25.4–32.4, (700) 25.2–31.3

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.766(2)$ $b = 8.322(2)$ $c = 8.814(2)$ $\alpha = 100.62(2)°$ $\beta = 104.03(2)°$ $\gamma = 90.22(2)°$ Z = 2

X-ray Powder Pattern: San Genaro mine, Peru; similar to aramayoite.
2.798 (100), 3.425 (8), 2.841 (8), 3.224 (6), 1.3994 (6), 2.013 (5), 1.971 (5)

Chemistry:

	(1)	(2)
Ag	36.3	36.72
As	0.7	
Sb	40.2	41.45
S	22.0	21.83
Total	99.4	100.00

(1) San Genaro mine, Peru; by electron microprobe, average of 22 analyses; corresponding to $Ag_{0.99}(Sb_{0.97}As_{0.03})_{\Sigma=1.00}S_{2.01}$. (2) $AgSbS_2$.

Polymorphism & Series: Trimorphous with cuboargyrite and miargyrite.

Occurrence: Of hydrothermal hypogene origin.

Association: Miargyrite, pyrargyrite, stannite, kesterite, andorite, diaphorite, robinsonite, galena, chalcopyrite, sphalerite, pyrite.

Distribution: From the San Genaro mine, Huancavelica, Peru [TL].

Name: To honor Manfred Baumstark (1954–), German mineralogist, who provided the type material.

Type Material: Mineralogical Institute, University of Salzburg, Salzburg, Austria, 14524 and 14525; The Natural History Museum, London, England, 2000,32 and 2000,33.

References: (1) Effenberger, H., W.H. Paar, D. Topa, A.J. Criddle, and M. Fleck (2002) The new mineral baumstarkite and a structural reinvestigation of aramayoite and miargyrite. Amer. Mineral., 87, 753–764.

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Bauranoite $BaU_2O_7 \cdot 4-5H_2O$

Crystal Data: n.d. *Point Group:* n.d. As dense, fine-grained aggregates.

Physical Properties: Hardness = 5 VHN = 372–380 (100 g load). D(meas.) = 5.283–5.420 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Reddish brown.
Optical Class: Biaxial (–). α = 1.911–1.916 β = n.d. γ = 1.920–1.932 2V(meas.) = 81°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Russia.
3.09 (10), 3.41 (7), 1.98 (6), 1.948 (6), 1.908 (6), 1.723 (6), 1.667 (6)

Chemistry:

	(1)	(2)	(3)
UO_3	63.74	67.37	66.88
SiO_2	0.48	0.97	3.54
PbO	0.53	0.55	0.74
CaO	2.62	0.40	0.47
BaO	21.21	21.14	17.43
H_2O	8.24	8.19	10.07
CO_2	3.20	0.60	0.39
Total	100.02	99.22	99.52

(1–3) Russia; respectively corresponding to $BaO \cdot 1.94UO_3 \cdot 4H_2O$; $BaO \cdot 1.75UO_3 \cdot 3.4H_2O$; and $BaO \cdot 2UO_3 \cdot 4.8H_2O$.

Occurrence: In the oxidation zone of a U–Mo deposit, replacing "pitchblende" and replaced by uranophane.

Association: Uraninite, uranophane, calciouranoite, metacalciouranoite, protasite.

Distribution: From an undisclosed locality [Streltsovskoe U–Mo deposit, eastern Transbaikal] in Russia.

Name: For BArium and URANium in the composition.

Type Material: n.d.

References: (1) Rogova, V.P., L.N. Belova, G.N. Kiziyarov, and N.N. Kuznetsova (1973) Bauranoite and metacaltsuranoite [metacalciouranoite] – new minerals of the group of hydrous uranium oxides. Zap. Vses. Mineral. Obshch., 102, 75–81 (in Russian). (2) (1973) Amer. Mineral., 58, 1111 (abs. ref. 1).

Bavenite $Ca_4Be_2Al_2Si_9O_{26}(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As radiating crystal groups, to 6 cm; as bladed crystals and rosettes of thin plates; also fine feltlike masses of needles, compact fibrous, chalklike massive. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Perfect on {001}, fair on {100}. Hardness = 5.5–6 D(meas.) = 2.71–2.74 D(calc.) = 2.69–2.79 Weakly piezoelectric.

Optical Properties: Translucent to transparent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. α = 1.578–1.586 β = 1.579–1.585 γ = 1.583–1.593 2V(meas.) = 22°–58°

Cell Data: *Space Group:* $Am2a$. $a = 19.39(2)$ $b = 23.19(2)$ $c = 5.005(9)$ Z = 4

X-ray Powder Pattern: Baveno, Italy.
3.74 (100), 3.35 (90), 3.24 (80), 3.13 (70), 3.05 (70), 2.56 (60), 4.19 (50)

Chemistry:

	(1)	(2)
SiO_2	57.64	57.83
Al_2O_3	6.46	10.90
BeO	7.66	5.35
CaO	23.96	23.99
H_2O^+	3.56	
H_2O^-	0.32	1.93
Total	99.60	100.00

(1) Mesa Grande district, California, USA; corresponds to $Ca_{4.11}Be_{2.95}Al_{1.22}Si_{9.22}O_{26}\bullet 1.90H_2O$.
(2) $Ca_4Be_2Al_2Si_9O_{26}(OH)_2$.

Occurrence: As druses in miarolitic cavities in granite and associated pegmatites, formed by alteration of beryl and other beryllium-bearing minerals. Also in hydrothermal veins and skarns.

Association: Beryl, helvite, phenakite, bertrandite, quartz, epidote, stilbite, albite, orthoclase, titanite, chlorite, clinozoisite, tremolite.

Distribution: From Baveno and Val d'Ossola, Piedmont, Italy. At Strzegom (Striegau), Silesia, Poland. From the Czech Republic, at Jeclov, Věžná, and near Drahonín. At Takelund, southeast of Halden, Østfold, Norway. In Switzerland, from the Muotta Nera, Piz Lai Blau, Val Nalps and at Val Casaccia, Val Cristallina, Graubünden. In the USA, from the Himalaya mine, Mesa Grande district, and in the Rincon district, San Diego Co., California; at the Foote mine, Kings Mountain, Cleveland Co., North Carolina; from the Rutherford mine, Amelia, Amelia Co., Virginia; and elsewhere. In the Londonderry quarry, near Coolgardie, Western Australia. From Batystau, central Kazakhstan. In Russia, as large crystals at Akoudertia, Siberia; Malyshero, Ural Mountains; and a number of other less-well-defined localities.

Name: For the original occurrence at Baveno, Italy.

Type Material: Municipal Museum of Natural History, Milan, Italy; Natural History Museum, Paris, France, 108.1881, 108.1882

References: (1) Artini, E. (1901) Di una nuova specie minerale trovata nel granito di Baveno. Atti Rend. Accad. Lincei, 10, 139–145 (in Italian). (2) Fleischer, M.F. and G. Switzer (1953) The bavenite problem. Amer. Mineral., 38, 988–993. (3) Switzer, G. and L.E. Reichen (1960) Re-examination of pilinite and its identification with bavenite. Amer. Mineral., 45, 757–762. (4) Berry, L.G. (1963) The composition of bavenite. Amer. Mineral., 48, 1166–1168. (5) Cannillo, E. and A. Coda (1966) The crystal structure of bavenite. Acta Cryst., 20, 301–309. (6) Loiacono, G.M., G. Kostecky, and J.S. White, Jr. (1982) Resolution of space group ambiguities in minerals. Amer. Mineral., 67, 846–847.

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Bayerite $Al(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As very fine fibers; also as flaky and tabular crystals, to 0.1 mm; in radiating hemispherical aggregates and crusts.

Physical Properties: Hardness = n.d. D(meas.) = 2.53 D(calc.) = 2.54

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Biaxial (+). *Orientation:* Extinction negative, parallel to fiber length.
α = 1.565–1.574 β = n.d. γ = 1.580–1.584 2V(meas.) = Small.

Cell Data: *Space Group:* $P2_1/a$; $P2_1/n$ (synthetic). $a = 5.0626(2)$ $b = 8.6719(2)$ $c = 9.4254(3)$ $\beta = 90.26(1)^\circ$ Z = 8

X-ray Powder Pattern: Hatrurim Formation, Israel.
4.73 (s), 2.21 (s), 4.36 (ms), 1.720 (m), 3.19 (w), 2.70 (vw), 2.16 (vw)

Chemistry: No chemical analysis appears to have been published.

Polymorphism & Series: Polymorphous with doyleite, gibbsite, and nordstrandite.

Occurrence: Probably precipitated from high-aluminum gels on carbonates at pH > 5.8 (Hatrurim Formation, Israel); as weathered crusts on amphiboles and pyroxenes (Dnieper region, Russia); in bauxites.

Association: Calcite, gypsum, portlandite, ettringite, vaterite, thaumasite (Hatrurim Formation, Israel).

Distribution: In the Hatrurim Formation, Israel. From an undefined area in the Dnieper region, and in the Listvennoye deposit, Yenisei Ridge, Siberia, Russia. In the San Elias mine, San Luis Province, Argentina. On Raoul Island, Kermadec Group, South Pacific.

Name: The artificial compound is thought to have been named for the 19th-century German metallurgist Karl J. Bayer; the name was then applied to the natural mineral.

Type Material: n.d.

References: (1) Gross, S. and L. Heller (1963) A natural occurrence of bayerite. Mineral. Mag., 33, 723–724. (2) (1964) Amer. Mineral., 49, 819 (abs. ref. 1). (3) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 14–15. (4) Khorosheva, D.P. (1968) Bayerite from the bauxite horizon of the middle Dnieper region. Doklady Acad. Nauk SSSR, 182, 123–126 (in Russian). (5) Schoen, R. and C.E. Roberson (1970) Structures of aluminum hydroxide and geochemical implications. Amer. Mineral., 55, 43–77. (6) McHardy, W.J. and A.P. Thomson (1971) Conditions for the formation of bayerite and gibbsite. Mineral. Mag., 38, 358–368. (7) Zigan, F., W. Joswig, and N. Burger (1978) Die Wasserstoffpositionen im Bayerit, $Al(OH)_3$. Zeits. Krist., 148, 255–273 (in German with English abs.).

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Bayldonite $PbCu_3O(AsO_3OH)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare as crystals, to 1 cm. Usually as mammillary crusts, powdery, fine-grained massive. *Twinning:* As pseudoscalenohedral trillings with composition plane $(\bar{3}11)$.

Physical Properties: *Fracture:* Conchoidal to irregular. Hardness = 4.5 D(meas.) = 5.24–5.65 D(calc.) = 5.707

Optical Properties: Translucent. *Color:* Siskin-green, apple-green, yellow-green, grass-green; dark green to black in crystals; may show sector twinning in thin section. *Luster:* Resinous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y \wedge$ elongation $\simeq 45°$. *Dispersion:* $r < v$, strong. $\alpha = 1.95(1)$ $\beta = 1.97$ $\gamma = 1.99(1)$ 2V(meas.) = Large. 2V(calc.) = 89°

Cell Data: *Space Group:* $C2/c$. $a = 10.147(2)$ $b = 5.892(1)$ $c = 14.081(2)$ $\beta = 106.05(1)°$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
3.148 (100), 2.932 (78), 3.231 (72), 4.516 (65), 2.723 (60), 2.658 (55), 2.260 (54)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3		1.00		PbO	30.13	32.60	30.67
P_2O_5		0.20		H_2O	4.58	4.20	4.95
As_2O_5	31.76	30.09	31.59	rem.	2.65		
CuO	30.88	31.70	32.79	Total	100.00	99.79	100.00

(1) St. Day, Cornwall, England; after deduction of remnant Fe_2O_3, CaO, and loss on ignition, corresponds to $Pb_{1.03}Cu_{2.97}O(As_{1.06}O_3OH)_2(OH)_{2.22}$. (2) Kayrakty, Kazakhstan; $(OH)^{1-}$ confirmed by IR, corresponding to $Pb_{1.00}Cu_{3.00}O[(As_{0.98}P_{0.01})_{\Sigma=0.99}O_3OH]_2(OH)_{1.77}$. (3) $Cu_3PbO(AsO_3OH)_2(OH)_2$.

Occurrence: A rare secondary mineral in the oxidized zone of some polymetallic deposits.

Association: Mimetite, olivenite, azurite, malachite, tsumebite, cuprian adamite, duftite, keyite, schulténite, philipsbornite (Tsumeb, Namibia); beudantite, anglesite, cerussite, malachite, azurite, barite (Kayrakty, Kazakhstan).

Distribution: In England, in Cornwall, from the Penberthy Croft mine, St. Hilary; at Wheal Carpenter, near Gwinear; from Wheal Gorland, Gwennap; and at Wheal Alfred, Phillack; from many mines at Caldbeck Fells, Cumbria. In the Tynagh mine, near Loughrea, Co. Galway, Ireland. In France, at the Cap Garonne mine, near le Pradet, Var; La Rabasse, Hérault; Les Ardillats, Rhône; and elsewhere. Large crystals from Tsumeb, Namibia. At Kayrakty, Kazakhstan. In Australia, from Broken Hill, New South Wales; in the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia; at the Mt. Malvern mine, near Clarendon, South Australia. In the USA, from the Killie mine, Spruce Mountain district, Elko Co., Nevada; in Arizona, at Bisbee, Cochise Co., and from the Frijole prospect, Santa Rita Mountains, Pima Co.; in the Black Pine mine, near Philipsburg, Granite Co., Montana.

Name: Honors John Bayldon, English physician who collected the original specimens.

Type Material: The Natural History Museum, London, England, 1921,433.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 929–930. (2) Cesbron, F. and H. Vachey (1974) The unit cell and twin of bayldonite. Mineral. Mag., 39, 716–718. (3) Sumín de Portilla, V., M. Portillo Quevedo and V.I. Stepanov (1981) The structure of bayldonite: chemical analysis, differential thermal analysis, and IR spectroscopy. Amer. Mineral., 66, 148–153. (4) Ghose, S. and C. Wan (1979) Structural chemistry of copper and zinc minerals. VI. Bayldonite, $(Cu,Zn)_3Pb(AsO_4)_2(OH)_2$: a complex layer structure. Acta Cryst., 35, 819–823.

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Bayleyite $Mg_2(UO_2)(CO_3)_3 \cdot 18H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are well-formed, short prismatic along [001], to 0.1 mm; typically in globular aggregates and crusts of divergent crystals.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–2.5 D(meas.) = 2.05 D(calc.) = 2.06 Radioactive. Soluble in H_2O; may rapidly dehydrate; weak fluorescence of uncertain yellow-green to pale greenish under LW and SW UV.

Optical Properties: Semitransparent. *Color:* Sulfur-yellow. *Luster:* Vitreous, dulling with dehydration.
Optical Class: Biaxial (–). *Pleochroism:* X = pale pink; $Y = Z$ = pale yellow to greenish yellow. *Orientation:* $Z = b$; $X \wedge c = 8°$–$15°$. $\alpha = 1.454$–1.455 $\beta = 1.490$–1.492 $\gamma = 1.500$–1.502 2V(meas.) = 30° 2V(calc.) = 45°–57°

Cell Data: *Space Group:* $P2_1/a$. $a = 26.65(5)$ $b = 15.31(5)$ $c = 6.53(2)$ $\beta = 93°04'$ Z = 4

X-ray Powder Pattern: Hillside mine, Arizona, USA.
7.66 (10), 13.1 (9), 3.83 (6), 2.69 (5), 2.21 (5), 6.53 (4), 5.85 (4b)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	35.28	34.76	Na_2O	0.21	
SO_3	0.02		K_2O	0.10	
CO_2	16.72	16.04	H_2O	37.91	39.40
MgO	9.76	9.80	Total	[100.00]	100.00

(1) Hillside mine, Arizona, USA; recalculated from an original total of 100.78%, after deduction of gypsum 8.45% and insoluble 0.45%; corresponds to $Mg_{2.00}(UO_2)_{1.02}(CO_3)_{3.15} \cdot 17.43H_2O$.
(2) $Mg_2(UO_2)(CO_3)_3 \cdot 18H_2O$.

Occurrence: As a coating or efflorescence with other secondary uranium minerals, which may be post-mining, typically in sediment-hosted uranium-bearing deposits.

Association: Schröckingerite, andersonite, swartzite, gypsum (Hillside mine, Arizona, USA); schröckingerite, gypsum (Hideout mine, Utah, USA); tyuyamunite, uranophane, liebigite, carnotite (Powder River Basin, Wyoming, USA).

Distribution: In the USA, in Arizona, from the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co., and in the Cole shaft, Bisbee, Cochise Co.; at Ambrosia Lake, Grants district, McKinley Co., New Mexico; in Utah, from the Hideout No. 1 (Tiger) mine, Deer Flats, White Canyon district, on the Coral claim, Elk Ridge, at the Mi Vida mine, San Juan Co., and from the Delta Group mine, San Rafael Swell, Emery Co.; in Colorado, at the Garfield and Rifle mines, north of Rifle, Garfield Co., from the J.J. mine, Montrose Co., and well-crystallized in the Schwartzwalder mine, Jefferson Co.; in Wyoming, from the Pumpkin Buttes area, Powder River Basin, Niobrara Co. In the Rabbit Lake uranium mine, Saskatchewan, Canada. From near Azegour, Morocco. In the Huemul mine, Malargüe district, Mendoza Province, Argentina. From the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, France. In the Hatrurim Formation, Israel.

Name: To honor Professor William Shirley Bayley (1861–1943), American mineralogist and geologist, University of Illinois, Urbana, Illinois, USA, and the U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106101–106104.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 237–238. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 112–115. (3) Weeks, A.D. and M.E. Thompson (1954) Identification and occurrence of uranium and vanadium minerals from the Colorado Plateaus. U.S. Geol. Surv. Bull. 1009-B, 25–26. (4) Axelrod, J.M., F.S. Grimaldi, C. Milton, and K.J. Murata (1951) The uranium minerals from the Hillside mine, Yavapai County, Arizona. Amer. Mineral., 36, 1–22. (5) Z.Y. Zhang, K.D. Luo, and Z.R. Chen (1985) The crystal structure of bayleyite. Scientica Sinica, Series B, 28(4), 344–350.

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Baylissite $K_2Mg(CO_3)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. In fine-grained crusts of anhedral crystals. *Twinning:* Polysynthetic, probably universal.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–3 D(meas.) = 2.06(1) (synthetic). D(calc.) = 2.04 Decomposes in H_2O and in a humid atmosphere.

Optical Properties: Transparent to translucent. *Color:* Colorless.
Optical Class: Biaxial (+). $\alpha = 1.462(2)$ $\beta = [1.483]$ $\gamma = 1.531(2)$. 2V(meas.) = $\sim 64°$

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 11.404(4)$ $b = 6.228(2)$ $c = 6.826(2)$ $\beta = 99.66(2)°$ Z = 2

X-ray Powder Pattern: Gerstenegg-Sommerloch tunnel, Switzerland.
2.98 (10b), 3.12 (8), 2.47 (8), 2.56 (7), 2.06 (7), 6.33 (6), 4.20 (4)

Chemistry: (1) Identity determined by microchemical determination of the presence of K and Mg, in conjunction with optical and X-ray data similar to the synthetic compound.

Occurrence: A secondary mineral in fractures in aplite granite and granodiorite.

Association: Grimselite, schröckingerite, calcite, monohydrocalcite.

Distribution: In the Gerstenegg-Sommerloch cable tunnel, north of the Grimsel Pass, Bern, Switzerland.

Name: Honoring Noel Stanley Bayliss, Professor of Chemistry, University of Western Australia, Nedlands, Western Australia, who characterized the synthetic compound.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany.

References: (1) Walenta, K. (1976) Baylissit, ein neues Karbonatmineral aus den Schweizer Alpen. Schweiz. Mineral. Petrog. Mitt., 56, 187–194 (in German with English abs.). (2) (1977) Mineral. Abs., 28, 208 (abs. ref. 1). (3) Bucat, R.B., J.M. Patrick, A.H. White, and A.C. Willis (1977) Crystal structure of baylissite, $K_2Mg(CO_3)_2, 4H_2O$. Australian J. Chem., 30, 1379–1382.

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Bazhenovite $CaS_5 \cdot CaS_2O_3 \cdot 6Ca(OH)_2 \cdot 20H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed or platy crystals, to 5 mm, showing {110}, {011}, {101}, and {111}, flattened on {010}, elongated along [001]; in aggregates, to 1 cm.

Physical Properties: *Cleavage:* {010}, very good. *Fracture:* Uneven. *Tenacity:* Brittle but elastic. Hardness = 2 D(meas.) = 1.83(1) D(calc.) = 1.845 Soluble in H_2O, hydrolyzes in air, with sulfur evident in the residue.

Optical Properties: Transparent in thin crystals, translucent in aggregates. *Color:* Orange to yellow. *Streak:* Pale yellow. *Luster:* Vitreous, pearly on intergrowths of parallel plates. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = deep yellow-green; Y = greenish yellow; Z = pale greenish yellow. *Orientation:* $X = b$; $Y = a$; $Z \wedge c = 30°$. *Absorption:* $X > Z > Y$. $\alpha = 1.595(2)$ $\beta = 1.619(2)$ $\gamma = 1.697(3)$ 2V(meas.) = n.d. 2V(calc.) = 60°20′.

Cell Data: *Space Group:* $P2_1/c$. $a = 8.45(1)$ $b = 17.47(1)$ $c = 8.24(1)$ $\beta = 119.5°$ Z = 1

X-ray Powder Pattern: Chelyabinsk coal basin, Russia.
8.76 (10), 4.39 (10), 1.996 (7), 2.91 (6), 2.81 (5), 2.62 (5), 2.28 (5)

Chemistry:

	(1)	(2)
Fe	1.34	
Ca	28.12	27.58
O	[9.08]	12.20
S	19.56	
S^s		6.11
S^p		7.25
S^t		6.20
OH		9.46
H_2O	41.9	31.20
Total	[100.00]	100.00

(1) Chelyabinsk coal basin, Russia; H_2O by TGA. (2) Analysis (1) after deduction of Fe as impurity, portlandite 1%, adsorbed H_2O 1%, recasting S as S^s = sulfide S, S^p = polysulfide S, S^t = thiosulfate S; then corresponding to $Ca(S^p_{2.63}S^s_{2.22})_{\Sigma=4.85} \cdot Ca(S^t_{2.25}O_{3.00}) \cdot Ca_{6.00}(OH)_{12.20} \cdot 20.14H_2O$.

Occurrence: Among the melt products of old, burning coal dumps.

Association: Siderite, pyrite, iron, sulfur, oldhamite, portlandite, periclase, troilite, pyrrhotite, fluorite.

Distribution: In the Chelyabinsk coal basin, Southern Ural Mountains, Russia.

Name: For Alfre Georgievich Bazhenov (1931–), geochemist and petrologist, and Lyudmila Fedorovna Bazhenova (1938–), analytical chemist, of the Il'menskii Preserve, Miass, Russia.

Type Material: Mining Institute, St. Petersburg, 1956/1; Il'menskii Preserve Museum, Miass, Russia, 5873–5875; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Chesnokov, B.V., V.O. Polyakov, and A.F. Bushmakin (1987) Bazhenovite $CaS_5 \cdot CaS_2O_3 \cdot 6Ca(OH)_2 \cdot 20H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 116, 737–743 (in Russian). (2) (1989) Amer. Mineral., 74, 500 (abs. ref. 1). (3) (1988) Mineral. Abs., 39, 495–496 (abs. ref. 1).

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Bazirite $BaZrSi_3O_9$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Crystals rarely entirely euhedral, prismatic with partially developed pyramidal terminations, more commonly anhedral to subhedral, < 1 mm. Also as clusters of crystals.

Physical Properties: *Cleavage:* Pyramidal, probably $\{10\bar{1}4\}$; poor on $\{10\bar{1}0\}$; strong parting $\|$ {0001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.82 Moderately strong pale bluish fluorescence under SW UV; strong blue cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Colorless.
Optical Class: Uniaxial (+). $\omega = 1.675$–1.681 $\epsilon = 1.685$–1.688

Cell Data: *Space Group:* $P\bar{6}c2$. a = 6.737–6.769 $c = 9.997$–10.020 Z = 2

X-ray Powder Pattern: Rockall Island, Scotland.
3.80 (100), 2.800 (100), 5.85 (35), 3.38 (35), 2.93 (30), 2.012 (30), 2.213 (25)

Chemistry:

	(1)	(2)	(3)
SiO_2	39.71	39.59	39.46
TiO_2	0.17	0.51	
ZrO_2	26.38	26.12	26.98
SnO_2	0.06	0.11	
BaO	33.69	34.12	33.56
Total	100.01	100.45	100.00

(1–2) Rockall Island, Scotland; by electron microprobe. (3) $BaZrSi_3O_9$.

Occurrence: A late-stage interstitial mineral in aegirine-riebeckite granite (Rockall Island, Scotland); in granular celsian-bearing rocks near contacts with granite (Big Creek, California, USA).

Association: Elpidite, aegirine, albite, cristobalite, leucophosphite, monazite, quartz, apatite, eudialyte, magnetite, pyrochlore, xenotime, barite, titanite (Rockall Island, Scotland); taramellite, celsian, diopside, actinolite (Big Creek, California, USA).

Distribution: On Apex Ridge, Rockall Island, in the North Atlantic Ocean, 294 km west of St. Kilda Island, Outer Hebrides, Scotland. At the Esquire No. 8 claim, Big Creek, Fresno Co., California, USA.

Name: For BArium and ZIRconium in the composition.

Type Material: The Natural History Museum, London, England, MI 36445.

References: (1) Young, B.R., J.R. Hawkes, R.J. Merriman, and M.T. Styles (1978) Bazirite, $BaZrSi_3O_9$, a new mineral from Rockall Island, Inverness-shire, Scotland. Mineral. Mag., 42, 35–40. (2) (1979) Amer. Mineral., 64, 241 (abs. ref. 1). (3) Alfors, J.T. and A. Pabst (1984) Titanian taramellites in western North America. Amer. Mineral., 69, 358–373. (4) Hawthorne, F.C. (1987) The crystal chemistry of the benitoite group minerals and structural relations in (Si_3O_9) ring structures. Neues Jahrb. Mineral., Monatsh., 16–30.

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Bazzite $Be_3(Sc,Fe)_2Si_6O_{18}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Hexagonal prisms, to 2 cm, commonly barrel-like and in subparallel aggregation.

Physical Properties: Hardness = 6.5–7 VHN = 851–897 D(meas.) = 2.77–2.85 D(calc.) = n.d. Electromagnetic.

Optical Properties: Semitransparent. *Color:* Light to dark sky-blue. *Optical Class:* Uniaxial (–). *Pleochroism:* O = pale greenish yellow; E = intense sky-blue. ω = 1.622–1.637 ϵ = 1.602–1.622

Cell Data: *Space Group:* $P6/mcc$. $a = 9.521(5)$ $c = 9.165(5)$ Z = 2

X-ray Powder Pattern: Synthetic $Be_3(Sc_{1.75}Fe^{3+}_{0.25})_{\Sigma=2.00}Si_6O_{18}$. 3.306 (100), 8.27 (89), 2.960 (75), 4.006 (48), 4.578 (24), 2.577 (17), 1.761 (15)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	58.80	58.00	MgO	0.82	0.10
Al_2O_3	0.25	0.80	Li_2O	0.00	0.24
Fe_2O_3	2.21	5.70	Na_2O	2.82	1.60
Sc_2O_3	14.44	14.50	K_2O	0.22	0.13
FeO	3.68		Rb_2O	0.037	0.25
MnO	1.58	1.43	Cs_2O	0.31	2.93
BeO	12.90	14.50	H_2O^+	2.60	1.10
			Total	100.67	101.28

(1) Central Kazakhstan; corresponds to $Be_{3.06}(Sc_{1.26}Fe^{2+}_{0.31}Fe^{3+}_{0.17}Mn_{0.13}Mg_{0.12}Al_{0.03})_{\Sigma=2.02}(Si_{5.93}Be_{0.07})_{\Sigma=6.00}O_{18}\bullet 0.87H_2O$, with $(Na_{0.55}K_{0.03}Cs_{0.01})_{\Sigma=0.59}$ in the channels. (2) Heftetjern, Norway; by electron microprobe, average of three analyses; total Fe as Fe_2O_3, Be and Li by AA on bulk sample; corresponds to $Be_{3.1}(Sc_{1.24}Fe_{0.42}Mn_{0.12}Al_{0.10}Mg_{0.02})_{\Sigma=1.90}(Na_{0.30}Cs_{0.12}Li_{0.05}Rb_{0.02}K_{0.01})_{\Sigma=0.50}(Si_{5.7}Be_{0.3})_{\Sigma=6.00}O_{18}\bullet 0.36H_2O$.

Occurrence: In miarolitic cavities in granite (Baveno, Italy); in alpine veins (Switzerland); in granite pegmatite (Heftetjern, Norway).

Association: Quartz, orthoclase, muscovite, laumontite, albite (Baveno, Italy); quartz, hematite, calcite, chlorite, albite, fluorite (Switzerland); beryl, bavenite (Heftetjern, Norway).

Distribution: From Baveno, Piedmont, Italy. In Switzerland, at Val Strem and elsewhere in Graubünden; on the Witenalp; at Wiler, Reusstal; and on Stollen Oberaar, Grimsel Pass. Near Heiligenblut, Carinthia, Austria. Large crystals from Heftetjern, Tørdal, Norway. At an undisclosed locality in central Kazakhstan. On Mts. Antero and White, Chaffee Co., Colorado, USA.

Name: To honor Alessandro E. Bazzi, discoverer of the material from Baveno, Italy.

Type Material: Municipal Museum of Natural History, Milan; University of Milan, Milan, Italy; The Natural History Museum, London, England, 1925,534; Natural History Museum, Paris, France, 115.132.

References: (1) Artini, E. (1915) Due minerali di Baveno contenenti terre rare: weibyeite e bazzite. Atti Rend. Accad. Lincei, 24, 313–319 (in Italian). (2) (1921) Mineral. Abs., 1, 204 (abs. ref. 1). (3) Bergerhoff, G. (1955) Über die Kristallstruktur des Bazzit und ihre Beziehungen zu der des Beryll. Tschermaks Mineral. Petrog. Mitt., 35, 410–421 (in German with English abs.). (4) Peyronel, G. (1956) The crystal structure of Baveno bazzite. Acta Cryst., 9, 181–186. (5) Chistyakova, M.B., V.A. Moleva, and Z.P. Razmanova (1966) Bazzite found for the first time in the USSR. Doklady Acad. Nauk SSSR, 169, 1421–1424 (in Russian). (6) (1967) Amer. Mineral., 52, 563–564 (abs. ref. 5). (7) Frondel, C. and J. Ito (1968) Synthesis of the scandium analogue of beryl. Amer. Mineral., 53, 943–953. (8) Juve, G. and S. Bergstøl (1990) Caesian bazzite in granite pegmatite in Tørdal, Telemark, Norway. Mineral. Petrol., 43, 131–136.

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Bearsite $Be_2(AsO_4)(OH)\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As tangled fibrous aggregates of prismatic crystals, to 1 mm, elongated ‖ [001] with longitudinal striations, displaying the forms {100}, {130}, and {131}; as fine incrustations.

Physical Properties: Hardness = n.d. D(meas.) = < 2.0 D(calc.) = 2.20

Optical Properties: Transparent to translucent. *Color:* White.
Optical Class: Biaxial (–). *Orientation:* $Z \wedge c = 8°–10°$. $\alpha = 1.490(1)$ $\beta = \sim 1.502$ $\gamma = 1.502(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $[C2/m$ or $Cc]$ (by analogy to moraesite). $a = 8.55(2)$ $b = 36.90(2)$ $c = 7.13(2)$ $\beta = 97°49(30)'$ Z = 12

X-ray Powder Pattern: Bota-Burum deposit, Kazakhstan; nearly identical to moraesite. 6.95 (10), 3.31 (8), 4.23 (6), 3.02 (6), 2.88 (5), 2.145 (5), 1.956 (5)

Chemistry:

	(1)	(2)
As_2O_5	> 25.5	46.71
SiO_2	1.64	
Al_2O_3	6.06	
Fe_2O_3	1.08	
BeO	16.75	20.33
MgO	0.61	
CaO	1.40	
H_2O	> 29.0	32.96
Total		100.00

(1) Bota-Burum deposit, Kazakhstan; partial analysis by microchemical methods. Identity depends on the correspondence of the X-ray powder pattern with moraesite.
(2) $Be_2(AsO_4)(OH)\cdot 4H_2O$.

Occurrence: As a secondary mineral formed during the oxidation of an arsenic-bearing metal sulfide deposit associated with a felsite porphyry containing beryl.

Association: Pharmacosiderite, arseniosiderite, scorodite–mansfieldite, conichalcite, tyrolite, sodium uranospinite, metazeunerite, arsenopyrite, molybdenite, galena, pyrite, sphalerite, realgar, orpiment, uraninite, beryl.

Distribution: Found in the Bota-Burum uranium deposit, 15 km south of Alakol' Lake, Chu-Ili Mountains, Kazakhstan.

Name: For BEryllium and ARSenic in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Kopchenova, E.B. and G.A. Sidorenko (1962) Bearsite – an arsenic analogue of moraesite. Zap. Vses. Mineral. Obshch., 91, 442–446 (in Russian). (2) (1963) Amer. Mineral., 48, 210–211 (abs. ref. 1).

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Bearthite $Ca_2Al(PO_4)_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely as aggregates of partly euhedral, flat prismatic crystals, to 1 mm; typically as smaller, usually corroded, anhedral grains.

Physical Properties: *Cleavage:* One poor prismatic, possible. *Fracture:* Uneven.
Hardness = < 5 D(meas.) = n.d. D(calc.) = 3.25

Optical Properties: Transparent. *Color:* Pale yellow; in transmitted light, colorless, commonly cloudy with inclusions. *Streak:* White.
Optical Class: Biaxial (+). *Orientation:* $X = b$. *Dispersion:* $r < v$, distinct. $\alpha = 1.660$–1.662 $\beta = 1.671$–1.672 $\gamma = 1.690$–1.696 2V(meas.) = 64°–65°

Cell Data: *Space Group:* $P2_1/m$. $a = 7.231(3)$ $b = 5.734(2)$ $c = 8.263(4)$ $\beta = 112.57(8)°$ Z = 2

X-ray Powder Pattern: Stockhorn, Switzerland; calculated due to poor Gandolphi pattern.
3.05 (100), 2.867 (61), 2.568 (39), 2.754 (27), 4.58 (22), 2.634 (21), 2.444 (19)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	44.32	41.64	45.19	MgO	0.12	1.64	
SiO_2	0.30	0.26		CaO	33.04	29.32	35.71
Al_2O_3	15.91	13.00	16.23	SrO	3.53	2.30	
La_2O_3	0.03	1.52		F	0.48	0.60	
Ce_2O_3	0.04	3.15		Cl	0.02	0.00	
Nd_2O_3		0.82		H_2O			2.87
FeO	0.03	0.19		$-O = (F, Cl)_2$	0.20	0.25	
				Total	97.62	94.19	100.00

(1) Stockhorn, Switzerland; by electron microprobe, average of four analyses, $(OH)^{1-}$ shown present by Raman IR and crystal-structure analysis, added here for charge balance; corresponding to $(Ca_{1.87}Sr_{0.11})_{\Sigma=1.98}(Al_{0.99}Mg_{0.01})_{\Sigma=1.00}[(P_{1.98}Si_{0.02})_{\Sigma=2.00}O_4]_2[(OH)_{0.85}F_{0.08}]_{\Sigma=0.93}$. (2) Val Po, Italy; by electron microprobe; corresponding to $(Ca_{1.77}Sr_{0.08}Ce_{0.06}La_{0.03}Nd_{0.02})_{\Sigma=1.96}(Al_{0.86}Mg_{0.14}Fe_{0.01})_{\Sigma=1.01}[(P_{1.98}Si_{0.02})_{\Sigma=2.00})O_4]_2[(OH)_{0.79}F_{0.10}]_{\Sigma=0.89}$. (3) $Ca_2Al(PO_4)_2(OH)$.

Mineral Group: Brackebuschite group.

Occurrence: In synmetamorphic quartz segregations and as an accessory mineral in high-pressure metamorphic rocks. Experimental study indicates that the stability of bearthite is restricted to very Ca-poor or P-rich rocks under moderate to high-temperature conditions.

Association: Lazulite, apatite, kyanite, coesite, pyrope, paragonite, muscovite, almandine, rutile, augelite, wardite, goyazite, hydroxylherderite, quartz, albite, talc.

Distribution: Found on the western ridge of the Stockhorn, Zermatt Valley, Valais, Switzerland. In Italy, in the Dora Maira massif, between the Po and Varaita Valleys, Piedmont, and around Passo di Vizze, Alto Adige. In Austria, near the Höllkogel, 12 km south-southwest of Mürzzuschlag, Styria. From the Västanå mine, near Näsum, Skåne, Sweden.

Name: Honors Professor Peter Bearth (1902–1989), for his pioneering petrologic studies of the high-pressure terranes of the western Alps.

Type Material: Mineralogic-Petrographic Institute, University of Basel, Basel, Switzerland, PB100f; National School of Mines, Paris, 84DM54, 85DM45, 85DM70; Natural History Museum, Paris, France.

References: (1) Chopin, C., F. Brunet, W. Gebert, O. Medenbach, and E. Tillmanns (1993) Bearthite, $Ca_2Al[PO_4]_2(OH)$, a new mineral from high-pressure terranes of the western Alps. Schweiz. Mineral. Petrog. Mitt., 73, 1–9. (2) (1993) Amer. Mineral., 78, 1314 (abs. ref. 1). (3) Brunet, F. and C. Chopin (1995) Bearthite, $Ca_2Al(PO_4)_2OH$: stability, thermodynamic properties and phase relations. Contr. Mineral. Petrol., 121, 258–266.

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Beaverite-(Zn) $Pb(Fe_2Zn)(SO_4)_2(OH)$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ 2/*m*. As a powdery coating of hexagonal plates.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 4.25

Optical Properties: Transparent. *Color*: Brownish yellow to yellow. *Streak*: Yellow ochre.
Luster: Vitreous to subadamantine.
Optical Class: n.d. $n > 1.800$ *Pleochroism*: Pale to dark yellow.

Cell Data: *Space Group*: $R\bar{3}\,m$. $a = 7.3028(2)$ $c = 17.0517(4)$ Z = 3

X-ray Powder Pattern: Mikawa mine, Niigata Prefecture, Japan.
5.930 (100), 3.072 (61), 3.110 (43), 3.651 (39), 2.273 (39), 2.273 (33), 1.826 (33)

Chemistry:

	(1)
PbO	31.94
Fe2O3	22.46
ZnO	10.15
CuO	3.59
l2O3	0.78
SO3	23.95
H2O	[7.22]
Total	100.00

(1) Mikawa mine, Niigata Prefecture, Japan; average of dozens of electron microprobe analyses, H_2O by difference, OH and SO_4 confirmed by FT-IR spectroscopy; corresponding to $Pb_{0.95}(Fe_{1.88}Al_{0.10})(Zn_{0.83}Cu_{0.30})(SO_4)_2[(OH)_{5.36}O_{0.38}]$.

Mineral Group: Alunite group.

Occurrence: A secondary mineral in the oxidized zone of a hydrothermal Cu-Pb-Zn ore deposit.

Association: Anglesite, galena, pyrite, sphalerite, quartz.

Distribution: At the Mikawa mine, Mikawa, Aga-machi, Higashikanbara-gun, Niigata Prefecture, Japan.

Name: As the Zn-analogue of *beaverite*-(Cu), $[Pb(Fe_2Cu)(SO4)_2(OH)_6]$.

Type Material: National Museum of Nature and Science, Tokyo, Japan (NSM-M28910).

References: (1) Sato, E., I. Nakai, , Y. Terada, Y. Tsutsumi, K. Yokoyama, R. Miyawaki, and S. Matsubara (2011) Beaverite-(Zn), $Pb(Fe_2Zn)(SO_4)_2(OH)$, a new member of the alunite group, from Mikawa Mine, Niigata Prefecture, Japan. Mineral. Mag., 75, 375-377. (2) (2012) Amer. Mineral., 97, 1525 (abs. ref. 1).

Beaverite $Pb(Fe^{3+}, Cu, Al)_3(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As rhombohedral crystals or hexagonal plates, to 0.5 mm, typically aggregated into earthy or friable masses and powdery coatings.

Physical Properties: Hardness = [∼3] D(meas.) = 4.36 D(calc.) = 4.31

Optical Properties: Semitransparent. *Color:* Canary-yellow, brownish yellow, pale brown. *Optical Class:* Uniaxial (–); strong birefringence. *Pleochroism:* O = dark yellow; E = pale yellow. $\omega = 1.83$–1.87 $\epsilon = 1.85$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.205(5)$ $c = 16.994(32)$ $Z = 3$

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
5.87 (100), 3.054 (97), 3.61 (45), 2.280 (28), 3.066 (26), 2.932 (25), 1.807 (22)

Chemistry:

	(1)	(2)
SO_3	23.60	25.15
Al_2O_3	4.03	1.00
Fe_2O_3	19.13	20.38
CuO	10.74	13.95
PbO	32.50	33.08
H_2O	10.00	6.45
Total	[100.00]	100.01

(1) Horn Silver mine, Utah, USA; recalculated after deduction of 10.05% insoluble, then corresponding to $Pb_{0.99}(Fe^{3+}_{1.62}Cu_{0.92}Al_{0.54})_{\Sigma=3.08}(SO_4)_{2.00}(OH)_6$. (2) Grand Reef mine, Arizona, USA; by electron microprobe, average of three analyses; corresponds to $Pb_{0.94}(Fe^{3+}_{1.62}Cu_{1.12}Al_{0.12})_{\Sigma=2.86}(SO_4)_{2.00}(OH)_6$.

Mineral Group: Alunite group.

Occurrence: An uncommon secondary mineral in the oxidized zone of Pb–Cu deposits.

Association: Olivenite, conichalcite, duftite, beudantite, osarizawaite, hidalgoite, corkite, carminite, bindheimite, plumbojarosite, bayldonite, brochantite, chrysocolla, galena.

Distribution: In the USA, rich masses from the Horn Silver mine, near Frisco, San Francisco district, Beaver Co., at the Centennial Alta mine, Little Cottonwood Canyon district, Salt Lake Co., from the Hidden Treasure mine, Ophir district, Tooele Co., and elsewhere in Utah; in the Boss mine, Goodsprings district, Clark Co., Nevada; at Tombstone, Cochise Co., and from the Grand Reef mine, Graham Co., Arizona; in the Blanchard mine, near Bingham, Socorro Co., New Mexico. From a number of mines in Caldbeck and Carrock Fells, Cumbria, England. In the Cap Garonne mine, near le Pradet, Var, France. In Japan, at the Osarizawa mine, Kazuno, and the Kosaka mine, Akita Prefecture. From Tsumeb, Namibia. At Kipushi, Shaba Province, Congo (Zaire). In the Whim Creek copper mine, Pilbara district, Western Australia. At the Tui mine, Mount Te Aroha, New Zealand. Most occurrences are minor; a number of others are known.

Name: For Beaver Co., Utah, USA, from which the mineral was first recognized.

Type Material: Natural History Museum, Paris, France, 11244; The Natural History Museum, London, England, 1912,615; National Museum of Natural History, Washington, D.C., USA, 86986, R6314.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 568. (2) Morris, R.C. (1962) Osarizawaite from Western Australia. Amer. Mineral., 47, 1079–1093. (3) Breidenstein, B., J. Schlüter, and G. Gebhard (1992) On beaverite: new occurrence, chemical data, and crystal structure. Neues Jahrb. Mineral., Monatsh., 213–220.

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Bechererite $Zn_7Cu[SiO(OH)_3]SO_4(OH)_{13}$

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Crystal Data: Hexagonal. *Point Group:* 3. Steep trigonal hemimorphic crystals, to 0.25 mm, with $\{12\bar{3}0\}$, $\{24\bar{6}1\}$, $\{62\bar{8}1\}$, and $\{000\bar{1}\}$.

Physical Properties: *Cleavage:* On {0001}. *Tenacity:* Brittle. Hardness = 2–3
D(meas.) = 3.45(5) D(calc.) = 3.51

Optical Properties: Semitransparent. *Color:* Colorless, pale blue, ice-green, pale green.
Streak: White. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.705(1)$ $\epsilon = 1.611(1)$

Cell Data: *Space Group:* $P3$. $a = 8.319(2)$ $c = 7.377(1)$ Z = 1

X-ray Powder Pattern: Tonopah-Belmont mine, Arizona, USA.
7.37 (100), 2.556 (50), 3.282 (30), 2.724 (30), 3.623 (25), 1.572 (20), 2.191 (15)

Chemistry:

	(1)
SO_3	9.5
SiO_2	6.1
CuO	8.6
ZnO	60.6
H_2O	[15.2]
Total	[100.0]

(1) Tonopah-Belmont mine, Arizona, USA; by electron microprobe, average of five analyses, H_2O by difference; corresponds to $Zn_{6.93}Cu_{1.01}[Si_{0.95}O(OH)_3]S_{1.10}O_4(OH)_{13}$.

Occurrence: A very rare secondary mineral in the oxidized zone of a hydrothermal base-metal deposit (Tonopah-Belmont mine, Arizona, USA); a post-mine mineral (Frongoch mine, Wales).

Association: Rosasite, willemite, hydrozincite, smithsonite, paratacamite, boleite (Tonopah-Belmont mine, Arizona, USA); susannite, hemimorphite, namuwite, cerussite (Frongoch mine, Wales).

Distribution: From the Tonopah-Belmont mine, Osborne district, Maricopa Co., Arizona, USA. In Wales, in Dyfed, at the Frongoch mine and from the Nantycagl (Eaglebrook) and Esgair Hir mines, Ceulanymaesmawr. At Broken Hill, New South Wales, Australia;

Name: To honor Dr. Karl Becherer (1926–), University of Vienna, Vienna, Austria, for his work on the related mineral spangolite.

Type Material: Institute for Mineralogy and Crystallography, University of Vienna, 8B/10-030#1; Natural History Museum, Vienna, Austria, M6789.

References: (1) Giester, G. and B. Rieck (1996) Bechererite, $(Zn,Cu)_6Zn_2(OH)_{13}[(S,Si)(O,OH)_4]_2$, a novel mineral species from the Tonopah-Belmont mine, Arizona. Amer. Mineral., 81, 244–248. (2) Hoffmann, C., T. Armbruster, and G. Giester (1997) Acentric structure ($P3$) of bechererite, $Zn_7Cu(OH)_{13}[SiO(OH)_3SO_4]$. Amer. Mineral., 82, 1014–1018. (3) Green, D.I, S.A. Rust, and J.S. Mason (1996) Frongoch mine, Dyfed. UK J. of Mines & Minerals, 17, 29–38.

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Becquerelite $Ca(UO_2)_6O_4(OH)_6 \cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals usually tabular on {001} having pseudohexagonal outline, also prismatic, elongated along [010] into thick laths; {010} is usually striated ‖ [100], to 3 cm; also as coatings and fine-grained aggregates.

Physical Properties: *Cleavage:* {001} perfect; {101}, {010}, and {110} imperfect. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 5.09–5.2 D(calc.) = 5.10 Radioactive.

Optical Properties: Transparent. *Color:* Amber-yellow, golden to lemon-yellow, yellow-orange, brownish yellow; yellow in transmitted light. *Streak:* Yellow. *Luster:* Adamantine to greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless to pale yellow; $Y = Z$ = yellow to deep yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, marked. $\alpha = 1.725$–1.735 $\beta = 1.815$–1.825 $\gamma = 1.825$–1.830 2V(meas.) = 32(3)°

Cell Data: *Space Group:* $Pn2_1a$. $a = 13.8378(8)$ $b = 12.3781(12)$ $c = 14.9238(9)$ Z = 4

X-ray Powder Pattern: Shaba Province, Congo.
7.50 (10), 3.22 (9), 3.75 (8), 3.56 (8), 2.58 (7), 4.71 (6), 1.943 (5)

Chemistry:

	(1)	(2)	(3)
UO_3	86.57	86.4	87.10
CaO	2.78	3.2	2.84
H_2O	10.16	[10.4]	10.06
Total	99.51	[100.0]	100.00

(1) Shinkolobwe, Congo. (2) Congo; by electron microprobe, average of two analyses, H_2O by difference; corresponding to $Ca_{1.15}(UO_2)_6O_4(OH)_6 \cdot 8.6H_{1.97}O$. (3) $Ca(UO_2)_6O_4(OH)_6 \cdot 8H_2O$.

Occurrence: A weathering product of uraninite in the oxidized portions of uranium deposits and, more rarely, in pegmatites.

Association: Uraninite, schoepite, soddyite, curite, fourmarierite, dewindtite, ianthinite, wölsendorfite, rutherfordine, masuyite, kasolite (Shinkolobwe, Congo); johannite, uranopilite, zippeite (Happy Jack mine, Utah, USA).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Schlema-Harlenstein, Saxony, and Wölsendorf, Bavaria, Germany. From Mitterberg, Salzburg, Austria. In the Geevor mine, St. Just, Cornwall, England. From the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France. In the USA, in the Monument No. 2 and Cato Sells mines, Apache Co., Arizona; in Utah, at the Delta, Consolidated, and Lucky Strike No. 2 mines, San Rafael Swell, Emery Co., from Seven Mile Canyon, Grand Co., in the Posey and Frey No. 4 mines, Red Canyon district, the Big Buck mine, Big Indian district, and the Happy Jack and Hideout mines, White Canyon district, San Juan Co.; at Pumpkin Buttes, Campbell Co., Wyoming; from Paguate, Valencia Co., New Mexico; and a few others of the Colorado Plateau uranium deposits. In Canada, from the Lake Athabaska district, and the LaRonge uranium mines, near Nistowiack Lake, Saskatchewan. In the South Alligator Valley, Northern Territory, Australia.

Name: For French physicist Antoine Henri Becquerel (1852–1908), who discovered radioactivity in 1896.

Type Material: Natural History Museum, Paris, France, 122.135.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 625–627. (2) Protas, J. (1957) Propriétés et synthèse d'un oxyde hydraté d'uranium et de calcium de Shinkolobwe, Katanga. Compt. Rendus Acad. Sci. Paris, 244, 91–93 (in French). (3) (1957) Amer. Mineral., 42, 920 (abs. ref. 2). (4) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 62–68. (5) Pagoaga, M.K., D.E. Appleman, and J.M. Stewart (1987) Crystal structures and crystal chemistry of the uranyl oxide hydrates becquerelite, billietite, and protasite. Amer. Mineral., 72, 1230–1238.

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Bederite $Na_xCa_2(Mn^{2+},Mg,Fe^{2+})_4(Fe^{3+},Mg,Al)_2(PO_4)_6 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Ellipsoidal masses, to 5 cm. *Twinning:* Small optical domains resemble "tartan" twinning in microcline.

Physical Properties: *Cleavage:* {100}, good. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.48(1) D(calc.) = 3.50

Optical Properties: Semitransparent. *Color:* Dark brown to black; brown to olive-green in thin fragments. *Streak:* Dark olive-green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = olive-green; Z = brown. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, strong. *Absorption:* $X = Y > Z$. $\alpha = 1.729(3)$ $\beta = 1.738(3)$ $\gamma = 1.741(3)$ 2V(meas.) = 54° 2V(calc.) = 60°

Cell Data: *Space Group: Pcab.* $a = 12.559(2)$ $b = 12.834(1)$ $c = 11.714(2)$ Z = 4

X-ray Powder Pattern: El Peñón pegmatite, Argentina.
2.768 (100), 2.927 (78), 3.006 (67), 2.814 (35), 2.110 (33), 6.419 (31), 2.856 (31)

Chemistry:

	(1)
P_2O_5	41.76
Al_2O_3	0.82
Fe_2O_3	12.00
FeO	2.25
MnO	20.59
ZnO	0.40
MgO	3.45
CaO	10.91
SrO	0.43
Na_2O	0.63
H_2O	3.52
Total	96.76

(1) El Peñón pegmatite, Argentina; by electron microprobe, average of nine analyses; Fe^{2+}:Fe^{3+} from crystal-structure analysis, total Mn as MnO, H_2O by the Penfield method; corresponds to $(Na_{0.21}Ca_{0.03})_{\Sigma=0.24}(Ca_{1.96}Sr_{0.04})_{\Sigma=2.00}(Mn^{2+}_{2.98}Mg_{0.65}Fe^{2+}_{0.32}Zn_{0.05})_{\Sigma=4.00}(Fe^{3+}_{1.54}Mg_{0.23}Al_{0.17})_{\Sigma=1.94}(PO_4)_{6.03} \cdot 2H_2O$.

Occurrence: Of rare occurrence in a complex granite pegmatite in mica schist.

Association: Muscovite, quartz, potassic feldspar.

Distribution: From the El Peñón pegmatite, El Quemado district, Nevados de Palermo, Salta Province, Argentina.

Name: Honors Roberto Beder (1888–1930), Swiss-Argentinian mineralogist.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81556.

References: (1) Galliski, M.A., M.A. Cooper, F.C. Hawthorne, and P. Černý (1999) Bederite, a new pegmatite phosphate mineral from Nevados de Palermo, Argentina: description and crystal structure. Amer. Mineral., 84, 1674–1679.

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Béhierite $(Ta, Nb)BO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are pseudo-octahedral {011}, to 7 mm; may be intergrown with schiavinatoite.

Physical Properties: *Cleavage:* On {110} and {010}, distinct. *Fracture:* Subconchoidal. Hardness = 7–7.5 D(meas.) = 7.86(5) D(calc.) = 7.91

Optical Properties: Translucent. *Color:* Grayish pink. *Streak:* White.
Luster: Adamantine.
Optical Class: Uniaxial (+), high birefringence. $\omega = > 2.00$ $\epsilon = > 2.00$

Cell Data: *Space Group:* $I4_1/amd$. $a = 6.206(5)$ $c = 5.472(5)$ $Z = 4$

X-ray Powder Pattern: Manjaka, Madagascar; very close to schiavinatoite.
4.10 (100), 3.10 (71), 2.327 (71), 2.478 (50), 1.600 (50), 1.939 (35)

Chemistry:

	(1)	(2)
B_2O_3	[15.77]	16.44
Nb_2O_5	21.73	31.38
Ta_2O_5	63.95	52.18
Total	[101.45]	100.00

(1) Antsongombato, Madagascar; by electron microprobe, B_2O_3 calculated from stoichiometry; corresponds to $(Ta_{0.64}Nb_{0.36})_{\Sigma=1.00}BO_4$. The original X-ray fluorescence analysis of type material from Manjaka, Madagascar is stated to have shown Ta:Nb:Zr = 18:1:0.4. (2) $(Ta, Nb)BO_4$ with Ta:Nb = 1:1.

Occurrence: Very rare, in granite pegmatites.

Association: Elbaite, pollucite, manganoan apatite, lepidolite, quartz, albite (Manjaka, Madagascar); schiavinatoite, rhodizite, elbaite–liddicoatite, quartz, feldspar (Antsongombato, Madagascar).

Distribution: From Manjaka and Antsongombato, south of Betafo, Madagascar. In the Animikie Red Ace pegmatite, near Pine River, Florence Co., Wisconsin, USA.

Name: To honor Jean Béhier (1903–1965), French mineralogist, Geological Survey of Madagascar, who discovered the mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA, 139602.

References: (1) Mrose, M.E. and H.J. Rose (1962) Behierite $(Ta, Nb)BO_4$, a new mineral from Manjaka, Madagascar. Geol. Soc. Amer., Annual Meeting Abs. with Prog., 235 (abs.). (2) (1962) Amer. Mineral., 47, 414 (abs. ref. 1). (3) Demartin, F., V. Diella, C.M. Gramaccioli, and F. Pezzotta (2001) Schiavinatoite, $(Nb, Tb)BO_4$, the Nb analogue of behierite. Eur. J. Mineral., 13, 159–165.

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Behoite $Be(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals pseudo-octahedral, {011} and {110}, or sphenoidal, to 7 mm; faces show striae and etch pits; subhedral, as rounded crystal aggregates and crusts. *Twinning:* Probably polysynthetically twinned, observed optically.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼4 D(meas.) = 1.92(1) D(calc.) = [1.93]

Optical Properties: Translucent to opaque, rarely transparent. *Color:* Colorless or white, rarely pale pink to pale gray; may show anomalous blue and brown interference colors in transmitted light. *Luster:* Vitreous; greasy to dull.
Optical Class: Biaxial (–). *Orientation:* [$X = b$; $Y = a$; $Z = c$] (by analogy to isotypic synthetic ϵ-$Zn(OH)_2$). *Dispersion:* $r < v$, strong. $\alpha = 1.533(3)$ $\beta = 1.544(3)$ $\gamma = 1.548(3)$ 2V(meas.) = 82°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 4.62(2)$ $b = 7.05(2)$ $c = 4.55(3)$ Z = 4

X-ray Powder Pattern: Rode Ranch pegmatite, Texas, USA.
2.39 (vs+), 3.88 (vs), 3.83 (vs), 2.95 (m), 2.79 (m), 1.99 (m), 1.96 (m)

Chemistry: Emission spectroscopy shows Be as the only major element.

Polymorphism & Series: Polymorphous with clinobehoite.

Occurrence: In granite pegmatite as a near-surface alteration product of gadolinite (Rode Ranch pegmatite, Texas, USA); in altered volcanic tuff (Honeycomb Hills, Utah, USA); in pegmatite veins and miarolitic cavities in nepheline syenite (Mont Saint-Hilaire, Canada).

Association: Gadolinite, bastnäsite, tengerite, quartz, albite, microcline, montmorillonite, fluorite, calcite (Rode Ranch pegmatite, Texas, USA).

Distribution: In the USA, from the Rode Ranch pegmatite, Llano Co., and the Clear Creek pegmatite, Burnet Co., Texas, and in the Honeycomb Hills, Juab Co., Utah. In Canada, at Mont Saint-Hilaire, Quebec. In the Saga larvikite quarry, Tvedalen, near Larvik, Norway.

Name: For beryllium, Be, and hydroxyl, OH, in its composition.

Type Material: n.d.

References: (1) Ehlmann, A.J. and R.S. Mitchell (1970) Behoite, beta-$Be(OH)_2$, from the Rode Ranch pegmatite, Llano County, Texas. Amer. Mineral., 55, 1–9. (2) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 299.

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Beidellite $(Ca_{0.5}, Na)_{0.3}Al_2(Si, Al)_4O_{10}(OH)_2 \cdot nH_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As thin plates, laths, and ribbons, to 30 μm; in veinlets filling fractures and as claylike masses.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 1–2 D(meas.) = 2–3 depending on hydration. D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* White, reddish brown, brownish gray. *Luster:* Waxy to vitreous.
Optical Class: Biaxial (–). $\alpha = 1.494$ $\beta = 1.536$ $\gamma = 1.536$ 2V(meas.) = 9°–16°

Cell Data: *Space Group:* $C2/m$. $a = 5.179$ $b = 8.970$ $c = 17.57$ $\beta =$ [$\sim 90°$]
Z = n.d.

X-ray Powder Pattern: Black Jack mine, Idaho, USA; glycolated, diffuse pattern.
17.6 (100), 4.42 (100), 3.95 (100), 3.54 (100), 2.50 (100), 1.498 (100), 2.57 (80)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	45.32	45.83	CaO	2.76	1.41
TiO_2		0.46	Na_2O	0.10	0.16
Al_2O_3	27.84	22.79	K_2O	0.12	0.09
Fe_2O_3	0.70	5.71	H_2O^+	14.48	9.79
FeO		0.28	H_2O^-	8.16	12.55
MgO	0.16	0.86	Total	99.64	99.93

(1) Black Jack mine, Idaho, USA; corresponds to $(Ca_{0.23}Na_{0.02}K_{0.01})_{\Sigma=0.26}(Al_{1.96}Fe^{3+}_{0.04}Mg_{0.02})_{\Sigma=2.02}(Si_{3.46}Al_{0.54})_{\Sigma=4.00}O_{10}(OH)_2$. (2) Velka Kopan, Ukraine; corresponds to $(Ca_{0.12}Na_{0.02}K_{0.01})_{\Sigma=0.15}(Al_{1.62}Fe^{3+}_{0.33}Mg_{0.10}Ti_{0.03}Fe^{2+}_{0.02})_{\Sigma=2.10}(Si_{3.54}Al_{0.46})_{\Sigma=4.00}O_{10}(OH)_2$.

Mineral Group: Smectite group.

Occurrence: A constituent of bentonitic clays; an alteration product in hydrothermal mineral deposits, especially porphyry Cu-Mo systems; in soils derived from mafic rocks.

Association: Plagioclase, quartz, orthoclase, montmorillonite, kaolin, allophane, muscovite.

Distribution: Of worldwide occurrence, but pure and well-characterized materials are uncommon. In the USA, from Beidell, Saguache Co., and at Wagon Wheel Gap, Mineral Co., Colorado; in the Black Jack mine, Carson district, Owyhee Co., Idaho; from Arizona, at Morenci, Greenlee Co., Ajo, Pima Co., in the San Manuel mine, Pinal Co., and in the Globe-Miami district, Gila Co.; at Boron, Kern Co., California. In the Princess mine, Namiquipa, Chihuahua, Mexico. From Sibert, Rhône, France. At Unterrupsroth, Bavaria, Germany. From Velka Kopan, Khust, Ukraine.

Name: For Beidell, Colorado, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R4762 (Black Jack mine, Idaho, USA); R4761 (Beidell, Colorado, USA, material determined to be a mixture in part).

References: (1) Larsen, E.S. and E.T. Wherry (1925) Beidellite, a new mineral name. J. Wash. Acad. Sci., 15, 465–466. (2) Ross, C.S. and E.V. Shannon (1925) The chemical and optical properties of beidellite. J. Wash. Acad. Sci., 15, 467–468. (3) (1926) Amer. Mineral., 11, 167 (abs. refs. 1 and 2). (4) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 226–245. (5) Weir, A.H. and R. Greene-Kelly (1962) Beidellite. Amer. Mineral., 47, 137–146.

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Belakovskiite $Na_7(UO_2)(SO_4)_4(SO_3OH)(H_2O)_3$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As fibers to 22 mm. Soluble in water.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle, flexible and elastic. Hardness = 2 D(meas.) = n.d. D(calc.) = 2.953

Optical Properties: Transparent. *Color*: Pale yellowish green. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Biaxial (+). $\alpha = 1.500$ $\beta = 1.511$ $\gamma = 1.523$ *Orientation*: $X \approx a$.

Cell Data: *Space Group*: $P\bar{1}$. $a = 5.4581(3)$ $b = 11.3288(6)$ $c = 18.4163(13)$ $\alpha = 104.786(7)°$ $\beta = 90.092(6)°$ $\gamma = 96.767(7)°$ $Z = 2$

X-ray Powder Pattern: Blue Lizard Mine, Utah, USA.
5.19 (100), 3.057 (59), 4.66 (58), 3.568 (37), 8.96 (35), 8.46 (29), 1.8320 (29)

Chemistry:

	(1)
Na_2O	21.67
UO_3	30.48
SO_3	40.86
H_2O	[6.45]
Total	99.4

(1) Blue Lizard Mine, Utah, USA; average of 9 electron microprobe analyses, H_2O calculated from structural analysis; corresponding to $Na_{6.83}(U_{1.04}O_2)(SO_4)_4(S_{0.99}O_3OH)(H_2O)_3$.

Occurrence: A secondary efflorescence on sandstone in the oxidation zone of a Colorado Plateau type uraninite deposit.

Association: Blödite, ferrinatrite, kröhnkite, meisserite, metavoltine.

Distribution: From the Blue Lizard Mine, Red Canyon, White Canyon district, San Juan Co., Utah, USA.

Name: Honors Dmitry Ilych Belakovskiy (b. 1957), a prominent Russian mineralogist and Curator of the A.E. Fersman Mineralogical Museum, Moscow, Russia.

Type Material: Natural History Museum of Los Angeles County, California, USA (# 64055) and the A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (4410/1).

References: (1) Kampf, A.R., J. Plášil, A.V. Kasatkin, and J. Marty (2014) Belakovskiite, $Na_7(UO_2)(SO_4)_4(SO_3OH)(H_2O)_3$, a new uranyl sulphate mineral from the Blue Lizard mine, San Juan County, Utah, USA. Mineral. Mag., 78(3), 639-649. (2) (2015) Amer. Mineral., 100, 658 (abs. ref. 1).

Belendorffite Cu_7Hg_6

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $3m$. Massive, a nugget.

Physical Properties: Hardness = n.d. VHN = 45–206, 125 average (25 g load).
D(meas.) = 13.2(1) D(calc.) = 13.15

Optical Properties: Opaque. *Color:* Silvery, tarnishing rapidly to blackish brown; in reflected light, bright white with a yellowish tint. *Streak:* Silvery. *Luster:* Metallic.
Optical Class: Uniaxial. *Anisotropism:* Very weak.
R: (400) 66.2, (420) 67.0, (440) 67.6, (460) 68.3, (480) 69.7, (500) 70.2, (520) 71.0, (540) 71.9, (560) 72.8, (580) 73.4, (600) 74.1, (620) 74.7, (640) 75.3, (660) 76.0, (680) 76.4, (700) 76.9

Cell Data: *Space Group:* $R3m$ (by analogy to synthetic). $a = 9.4024(4)$ $c = ??$
alpha=90.425°??must convert to a and c??; $Z = 4R??$

X-ray Powder Pattern: Landsberg, Germany.
2.523 (100), 2.227 (100), 2.221 (100), 2.208 (100), 2.983 (80), 2.966 (80), 6.68 (60)

Chemistry:

	(1)	(2)
Cu	25.61	26.98
Hg	74.06	73.02
Total	99.67	100.00

(1) Landsberg, Germany; by electron microprobe, average of ten analyses, probably contains some mercury; corresponds to $Cu_{6.78}Hg_{6.22}$. (2) Cu_7Hg_6.

Polymorphism & Series: Dimorphous with kolymite.

Occurrence: In a mercury deposit.

Association: Mercury.

Distribution: From Landsberg, near Obermoschel, Rhineland-Palatinate, Germany [TL].

Name: In honor of Klaus Belendorff (1956–), mineral collector of Münster, Germany, who first noted the mineral.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany.

References: (1) Bernhardt, H.-J. and K. Schmetzer (1992) Belendorffite, a new copper amalgam dimorphous with kolymite. Neues Jahrb. Mineral., Monatsh., 21–28. (2) (1992) Amer. Mineral., 77, 1305–1309 (abs. ref. 1). (3) Lindahl, T. and S. Westman (1969) The structure of the rhombohedral gamma brass like phase in the copper-mercury system. Acta Chem. Scand., 23, 1181–1190.

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Belkovite $\mathbf{Ba_3(Nb,Ti)_6(Si_2O_7)_2O_{12}}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. As crystals, prismatic to barrel-shaped, with triangular cross section and stepped faces, showing the forms $\{11\bar{2}0\}$ and $\{0001\}$, to 1 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Moderately brittle. Hardness = 6–7 VHN = 900–1030, average 970 (40 g load). D(meas.) = 4.16(3) D(calc.) = 4.25

Optical Properties: Transparent. *Color:* Brown to brownish red. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (+); anomalously biaxial. $\omega = 1.928(2)$ $\epsilon = 2.002(5)$
2V(meas.) = 0°–10°

Cell Data: *Space Group:* $P\bar{6}2m$. $a = 8.966(3)$ $c = 7.799(3)$ $Z = 1$

X-ray Powder Pattern: Vuoriyarvi complex, Russia.
2.937 (100), 3.888 (51), 7.81 (35), 1.948 (26), 2.750 (25), 3.481 (24), 2.154 (22)

Chemistry:

	(1)
SiO_2	17.80
TiO_2	5.60
ZrO_2	1.20
Al_2O_3	0.14
Fe_2O_3	1.78
Nb_2O_5	42.20
Ta_2O_5	0.15
CaO	0.05
SrO	0.00
BaO	30.30
Na_2O	0.20
K_2O	0.55
Total	99.97

(1) Vuoriyarvi complex, Russia; by electron microprobe, corresponding to $(Ba_{2.74}K_{0.16}Na_{0.09}Ca_{0.01})_{\Sigma=3.00}(Nb_{4.41}Ti_{0.97}Fe^{3+}_{0.31}Zr_{0.13}Al_{0.04}Ta_{0.01})_{\Sigma=5.87}Si_{4.12}O_{24.90}$.

Occurrence: Of secondary origin, formed by alteration of barium-rich pyrochlore during dolomitization of calcite carbonatites in pyroxenites.

Association: Magnetite, pyrochlore, phlogopite, chlorite, pyrite, pyrrhotite, dolomite, carbonate-apatite, barite, alstonite, nenadkevichite.

Distribution: In the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia.

Name: For Igor Vladimirovich Bel'kov (1917–1989), Soviet mineralogist, Director, Kola Scientific Center, Apatity, Russia, who explored the Kola Peninsula.

Type Material: Mining Institute, St. Petersburg, 2036/1; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 6014; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p584.

References: (1) Voloshin, A.V., V.V. Subbotin, Y.A. Pakhomovskii, A.Y. Bakhchisaraitsev, N.A. Yamnova, and D.Y. Pushcharovskii (1990) Belkovite $Ba_3(Nb,Ti)_6(Si_2O_7)_2O_{12}$ new mineral from carbonatite of the Vuoriyarvi massif (Kola Peninsula). Doklady Acad. Nauk SSSR, 315, 1218–1220 (in Russian). (2) Voloshin, A.V., V.V. Subbotin, Y.A. Pakhomovskii, A.Y. Bakhchisaraitsev, N.A. Yamnova, and D.Y. Pushcharovskii (1991) Belkovite — a new barium–niobium silicate from carbonatites of the Vuoriyarvi massif (Kola Peninsula, USSR). Neues Jahrb. Mineral., Monatsh., 23–31. (3) (1991) Amer. Mineral., 76, 1728 (abs. ref. 2).

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Bellbergite $(K, Ba, Sr)_2Sr_2Ca_2(Ca, Na)_4Al_{18}Si_{18}O_{72}\cdot 30H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\overline{6}m2$, or $6mm$. Rarely as hexagonal dipyramidal crystals, consisting of $\{10\overline{1}2\}$, to 0.3 mm; commonly subparallel intergrowths elongated along [0001].

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼5 D(meas.) = 2.20(2) D(calc.) = 2.19

Optical Properties: Transparent. *Color:* Colorless to white; crystals zoned, with transparent ends and white sides. *Streak:* [White.] *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.522(2)$ $\epsilon = 1.507(2)$

Cell Data: *Space Group:* $P6_3/mmc$, $P6_3mc$, or $P\overline{6}2c$. $a = 13.244(1)$ $c = 15.988(2)$ Z = 1

X-ray Powder Pattern: Bellerberg volcano, Germany.
3.80 (100), 6.58 (80), 2.95 (70), 2.21 (70), 2.70 (50), 2.50 (50), 1.83 (50)

Chemistry:

	(1)
SiO_2	34.41
Al_2O_3	27.90
CaO	9.31
SrO	7.63
BaO	1.22
Na_2O	0.70
K_2O	1.95
H_2O	[16.88]
Total	[100.00]

(1) Bellerberg volcano, Germany; by electron microprobe, H_2O by difference; corresponds to $K_{1.33}Na_{0.72}Ca_{5.32}Sr_{2.36}Ba_{0.26}Al_{17.55}Si_{18.36}O_{72}\cdot 30H_2O$.

Mineral Group: Zeolite group.

Occurrence: In leucite tephrite lava at contacts between lava and calcium-rich xenoliths.

Association: Sanidine, clinopyroxene, pyrrhotite, thompsonite, ettringite, willhendersonite, gismondine, jasmundite, mayenite, srebrodolskite, calcic olivine, portlandite.

Distribution: From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany.

Name: For its occurrence at the Bellerberg (also Bellberg) volcano, Germany.

Type Material: University of Vienna, Vienna, Austria.

References: (1) Rüdinger, B., E. Tillmanns, and G. Hentschel (1993) Bellbergite – a new mineral with the zeolite structure type EAB. Mineral. Petrol., 48, 147–152.

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Bellidoite Cu_2Se

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As anhedral grains, to 0.3 mm in diameter.

Physical Properties: Hardness = < 3 VHN = 33–41 (100 g load). D(meas.) = n.d. D(calc.) = [7.01]

Optical Properties: Opaque. *Color:* Creamy white in reflected light. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Very weak, in gray colors.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P4_2/n$. $a = 11.52$ $c = 11.74$ Z = [32]

X-ray Powder Pattern: Habrí, Czech Republic.
2.06 (100), 3.38 (80), 1.763 (70), 2.25 (50), 6.80 (30), 3.50 (10), 2.32 (10)

Chemistry:

	(1)	(2)
Cu	61.5	61.62
Se	38.0	38.38
Total	99.5	100.00

(1) Habrí, Czech Republic; by electron microprobe. (2) Cu_2Se.

Polymorphism & Series: Dimorphous with berzelianite.

Occurrence: Formed at medium to low temperatures with other hydrothermal selenides and sulfides.

Association: Berzelianite, umangite, eskebornite, klockmannite, djurleite, digenite, siderite, calcite.

Distribution: From Habrí, near Tisnova, Czech Republic. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina.

Name: For Eleodoro Bellido Bravo, Director of Servicio de Geología y Minería, Peru.

Type Material: n.d.

References: (1) De Montreuil, L. A. (1975) Bellidoite, a new copper selenide. Econ. Geol., 70, 384–387. (2) (1975) Amer. Mineral., 60, 736 (abs. ref. 1). (3) Paar, W.H., D. Topa, A.C. Roberts, A.J. Criddle, G. Amann, and R.J. Sureda (2002) The new mineral species brodtkorbite, Cu_2HgSe_2, and the associated selenide assemblage from Tuminico, Sierra de Cacho, La Rioja, Argentina. Can. Mineral., 40, 225–237.

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Bellingerite $Cu_3(IO_3)_6 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Complex euhedral crystals, to 2 mm, elongated along [010] and flattened on [100], show {100}, {010}, {001}, {102}, {201}, {20$\overline{1}$}, {011}, {02$\overline{1}$}, and 20 other forms; {100} striated parallel [010]. *Twinning:* On {$\overline{1}$10}, common, but may not show re-entrants.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = ∼4 D(meas.) = 4.89(1) D(calc.) = 4.932 Slightly soluble in hot H_2O.

Optical Properties: Semitransparent. *Color:* Pale green; pale bluish green in transmitted light. *Streak:* Very pale green.
Optical Class: Biaxial (+). *Pleochroism:* X = Y = pale bluish green; Z = blue-green. *Orientation:* X (70°,–70°); Y (38°,175°); Z (59°,34°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. *Dispersion:* $r > v$, strong. *Absorption:* $Z > X = Y$. $\alpha = 1.890$ $\beta = 1.90$ $\gamma = 1.99$ 2V(meas.) = Medium.

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.2560(23)$ $b = 7.9503(15)$ $c = 7.8559(17)$ $\alpha = 105.096(16)°$ $\beta = 92.945(22)°$ $\gamma = 96.952(21)°$ Z = 1

X-ray Powder Pattern: Chuquicamata, Chile. (ICDD 19-393).
3.72 (100), 3.35 (90), 3.17 (90), 3.82 (70), 3.07 (65), 3.13 (60), 3.57 (55)

Chemistry:

	(1)	(2)
I_2O_5	18.65	18.70
CuO	77.55	78.48
H_2O	3.22	2.82
Total	99.42	100.00

(1) Chuquicamata, Chile; corresponds to $Cu_{3.00}(IO_3)_{5.94} \cdot 2.28H_2O$. (2) $Cu_3(IO_3)_6 \cdot 2H_2O$.

Occurrence: A rare secondary mineral in veinlets in a porphyry copper deposit.

Association: Leightonite, gypsum.

Distribution: From Chuquicamata, Antofagasta, Chile.

Name: To honor Herman C. Bellinger (1867–1940), General Manager of the Chile Exploration Company, who submitted the first specimens.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 95026.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 313–315. (2) Ghose, S. and C. Wan (1974) Structural chemistry of copper and zinc minerals. II. Stereochemistry of copper(II) and iodine(V) in bellingerite, $3Cu(IO_3)_2.2H_2O$. Acta Cryst., 30, 965–974. (3) Berman, H. and C.W. Wolfe (1940) Bellingerite, a new mineral from Chuquicamata, Chile. Amer. Mineral., 25, 505–512.

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Belovite-(Ce) **$NaSr_3(Ce,La)(PO_4)_3(F,OH)$**

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As acicular to prismatic crystals, to 3 cm, with $\{10\overline{1}0\}$ and {0001} prominent, in radiating to sheaflike aggregates; also granular.

Physical Properties: *Cleavage:* Prismatic and pinacoidal, imperfect. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 4.19 D(calc.) = [4.13]

Optical Properties: Semitransparent to translucent. *Color:* Honey-yellow, greenish yellow; in transmitted light, colorless to slightly yellow. *Luster:* Vitreous, greasy on fracture surfaces. *Optical Class:* Uniaxial (–). $\omega = 1.653–1.660$ $\epsilon = 1.634–1.640$

Cell Data: *Space Group:* $P\overline{3}$. $a = 9.692(3)$ $c = 7.201(1)$ Z = 2

X-ray Powder Pattern: Mt. Punkaruaiv, Kola Peninsula, Russia; close to belovite-(La). 2.90 (100), 3.17 (70), 2.79 (70), 2.009 (70), 1.470 (60), 2.32 (50), 2.151 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	1.12	0.03	Sm_2O_3		0.06
P_2O_5	28.88	29.53	MgO	0.16	
ThO_2		0.10	CaO	5.23	0.78
SiO_2	0.20	0.22	SrO	33.60	38.95
Fe_2O_3	0.60		BaO	0.96	1.05
RE_2O_3	24.00		Na_2O	3.60	3.91
La_2O_3		8.39	K_2O	0.20	
Ce_2O_3		12.15	F		1.84
Pr_2O_3		0.68	H_2O	0.89	1.50
Nd_2O_3		1.64	$-O = F_2$		0.78
			Total	99.44	[100.05]

(1) Mt. Punkaruaiv, Kola Peninsula, Russia; Ce:La = 1:0.6. (2) Kola Peninsula, Russia; by electron microprobe, original total given as 100.06%; corresponds to $Na_{0.93}(Sr_{2.77}Ca_{0.10}Ba_{0.04})_{\Sigma=2.91}(Ce_{0.55}La_{0.39}Nd_{0.07}Pr_{0.03})_{\Sigma=1.04}[(P_{1.03}Si_{0.01})_{\Sigma=1.04}O_{4.04}]_3[F_{0.71}(OH)_{0.35}]_{\Sigma=1.06}$.

Mineral Group: Apatite group.

Occurrence: As a secondary mineral in pegmatites in differentiated alkalic massifs.

Association: Ussingite, natrolite, chkalovite, epistolite, tugtupite, mangan-neptunite, murmanite, gaidonnayite, nordite-(La), lamprophyllite, fluorcaphite, lomonosovite, deloneite-(Ce), sitinakite, aegirine, eudialyte, sodalite, microcline, nepheline.

Distribution: Found in Russia, on Mts. Punkaruaiv, Lepkhe-Nelm, Sengischorr, Karnasurt, Kedykvyrpakhk, and Alluaiv, Lovozero massif; and on Mts. Kukisvumchorr and Koashva, Khibiny massif, Kola Peninsula.

Name: Honoring Russian crystallographer and academician Nikolai Vasil'evich Belov (1891–1982), former Head of the Crystallography and Crystallochemistry Department, Moscow Lomonosov State University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 56440.

References: (1) Borodin, L.S. and M.E. Kazakova (1954) Belovite – a new mineral from an alkaline pegmatite. Doklady Acad. Nauk SSSR, 96, 613–616 (in Russian). (2) (1955) Amer. Mineral., 40, 367–368 (abs. ref. 1). (3) Nadezhina, T.N., D.Y. Pushcharovskiy, and A.P. Khomyakov (1987) Specification of the crystal structure of belovite. Mineral. Zhurnal, 9(2), 45–48 (in Russian with English abs.). (4) Pekov, I.V., N.V. Chukanov, O.V. Yeletskaya, A.P. Khomyakov, and Y.P. Men'shikov (1995) Belovite-(Ce): new data, refined formula, and and its relationship to other minerals of the apatite group. Zap. Vses. Mineral. Obshch., 124(2), 98–110 (in Russian with English abs.).

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Belovite-(La) $NaSr_3(La,Ce)(PO_4)_3(F,OH)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Prismatic crystals, to 3 cm, with large $\{10\overline{1}0\}$, $\{10\overline{1}1\}$, $\{10\overline{1}\overline{1}\}$, $\{0001\}$, modified by $\{11\overline{2}0\}$, $\{11\overline{2}1\}$, $\{11\overline{2}\overline{1}\}$; may be granular.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = ∼5 VHN = 450 (30 g load). D(meas.) = 4.19 D(calc.) = 4.05

Optical Properties: Transparent. *Color:* Greenish yellow to bright yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.653$ $\epsilon = 1.635$–1.636

Cell Data: *Space Group:* $P\overline{3}$. $a = 9.647(1)$ $c = 7.170(1)$ Z = 2

X-ray Powder Pattern: Mt. Kukisvumchorr, Kola Peninsula, Russia; close to belovite-(Ce). 2.897 (100), 2.884 (100), 3.59 (87), 3.30 (65), 2.790 (54), 1.910 (36), 1.796 (36)

Chemistry:

	(1)		(1)
SO_3	0.03	Gd_2O_3	0.01
P_2O_5	28.30	Y_2O_3	0.01
SiO_2	0.24	CaO	0.50
ThO_2	0.43	SrO	40.09
La_2O_3	13.08	BaO	2.35
Ce_2O_3	8.15	Na_2O	4.09
Pr_2O_3	0.30	F	2.04
Nd_2O_3	0.30	H_2O	0.22
Sm_2O_3	0.03	$-O = F_2$	0.86
		Total	99.31

(1) Mt. Kukisvumchorr, Kola Peninsula, Russia; by electron microprobe, H_2O by the Penfield method; corresponds to $Na_{0.98}(Sr_{2.86}Ba_{0.12}Ca_{0.06})_{\Sigma=3.04}(La_{0.59}Ce_{0.37}Pr_{0.01}Nd_{0.01}Th_{0.01})_{\Sigma=0.99}[(P_{2.95}Si_{0.03})_{\Sigma=2.98}O_{3.99}]_3[F_{0.80}(OH)_{0.18}]_{\Sigma=0.98}$.

Mineral Group: Apatite group.

Occurrence: In natrolite veinlets in pegmatites in a differentiated alkalic massif.

Association: Gaidonnayite, gerasimovskite, lamprophyllite, murmanite, aegirine, pectolite, microcline, natrolite.

Distribution: Found in the Kirov apatite mine, Mt. Kukisvumchorr, and on Mt. Eveslogchorr, Khibiny massif, Kola Peninsula, Russia.

Name: For *lanthanum* dominant over cerium and its relation to *belovite*-(Ce).

Type Material: Mining Institute, St. Petersburg, 3026/24; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p1523.

References: (1) Pekov, I.V., I.M. Kulikova, Y.K. Kabalov, O.V. Yeletskaya, N.V. Chukanov, Y.P. Men'shikov, and A.P. Khomyakov (1996) Belovite-(La) $Sr_3Na(La,Ce)[PO_4]_3(F,OH)$ – a new rare earth mineral in the apatite group. Zap. Vses. Mineral. Obshch., 125(3), 101–109 (in Russian with English abs.). (2) (1997) Amer. Mineral., 82, 620 (abs. ref. 1).

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Crystal Data: Orthorhombic or monoclinic. *Point Group:* n.d. In platy aggregates, or massive, to 20 cm.

Physical Properties: *Cleavage:* Perfect in one direction, parallel to the plates. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 2.32–2.40 D(calc.) = n.d.

Optical Properties: Opaque, translucent in thin section. *Color:* White, light yellow to brownish yellow; black when manganese-rich. *Luster:* Vitreous to oily, pearly on cleavage surfaces.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = brown to dark brown; Y = light brown to yellow-brown; Z = light brown. *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.740$ $\beta = \sim 1.772$–1.778 $\gamma = 1.775$–1.780 2V(meas.) = 21°–25°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kola Peninsula, Russia; after heating at 900 °C.
1.690 (10), 3.21 (8), 2.48 (6), 1.361 (5), 2.90 (3), 2.18 (3), 1.633 (2)

Chemistry:

	(1)	(2)		(1)	(2)
$(Nb, Ta)_2O_5$	7.16	7.51	MgO	0.00	0.14
SiO_2	3.96	2.80	CaO	6.72	6.40
TiO_2	48.76	48.19	Na_2O	0.55	0.23
ZrO_2	6.64	6.56	K_2O	trace	0.20
Al_2O_3	0.46	0.24	H_2O^+	8.35	7.20
Fe_2O_3	n.d.	1.85	H_2O^-	17.21	18.50
MnO	0.00	0.04	Total	99.81	99.86

(1–2) Kola Peninsula, Russia.

Occurrence: Included in aegirine and microcline, in nepheline syenite pegmatite in an alkalic massif, in part probably as a replacement of murmanite.

Association: Aegirine, microcline, nepheline, zeolites, eudialyte, lorenzenite, lamprophyllite, titanium oxides.

Distribution: From [Mt. Karnasurt,] Lovozero massif, Kola Peninsula, Russia.

Name: For Dmitry Stepanovich Belyankin (1876–1953), prominent Russian mineralogist and petrographer.

Type Material: n.d.

References: (1) Gerasimovskii, V.I. and M.E. Kazakova (1950) Belyankinite – a new mineral. Doklady Acad. Nauk SSSR, 71, 925–927 (in Russian). (2) (1952) Amer. Mineral., 37, 882 (abs. ref. 1). (3) E.I. Semenov (1957) Oxides and hydroxides of titanium and niobium in the Lovozero alkalic massif. Inst. mineral., geokhim., and crystallokhim. redkikh elementov, Trudy, 1, 41–59 (in Russian). (4) (1958) Amer. Mineral., 43, 1220–1221 (abs. ref. 3). (5) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 390–392 (in English).

Bementite $Mn_5^{2+}Si_4O_{10}(OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* 222. Radiated or stellate with minute foliated structure; compact, hornlike forms; massive granular; in intricate intergrowths with other minerals.

Physical Properties: *Cleavage:* Perfect on {100}, {010}, {001}. *Fracture:* Conchoidal. Hardness = 4.5–6 D(meas.) = 2.98–3.02 D(calc.) = [3.07]

Optical Properties: Translucent. *Color:* Pale yellow to yellowish brown. *Luster:* Waxy, pearly on perfect cleavage.
Optical Class: Biaxial (–). *Pleochroism:* Weak, in yellows. *Orientation:* $X \perp \{001\}$. $\alpha = 1.624$ $\beta = 1.650$ $\gamma = 1.650$ 2V(meas.) = $\sim 0^\circ$

Cell Data: *Space Group:* $P2_12_12_1$. $a = 14.5$ $b = 17.5$ $c = 29.1$ Z = [16]

X-ray Powder Pattern: Franklin, New Jersey, USA.
3.66 (100), 7.25 (90), 3.58 (90), 2.436 (14), 3.43 (9), 3.30 (6), 3.09 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	39.00	38.36	37.03
Al_2O_3		0.96	
Fe_2O_3		0.71	
FeO	[3.75]	4.94	
MnO	42.12	39.22	54.64
ZnO	2.86	2.93	
MgO	3.83	3.35	
CaO	trace	0.62	
H_2O^+	8.44	8.01	8.33
H_2O^-		0.60	
Total	[100.00]	99.70	100.00

(1) Franklin, New Jersey, USA; FeO lost, estimated by difference. (2) Do. (3) $Mn_5Si_4O_{10}(OH)_6$.

Occurrence: Layered parallel to the walls of secondary veins of calcite in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA); intimately intergrown with other manganese minerals (Olympic Peninsula, Washington, USA).

Association: Calcite, willemite (Franklin, New Jersey, USA); hausmannite, jacobsite, braunite, alleghanyite, barite, grossular, johannsenite, calcite (Olympic Peninsula, Washington, USA); hausmannite, rhodochrosite, inesite (Hale Creek, California, USA).

Distribution: In the USA, at Franklin, Sussex Co., New Jersey; in Washington, on the Olympic Peninsula, an ore mineral at a number of small deposits in Clallan, Jefferson, and Mason Cos.; from Ray, Pinal Co., Arizona; at Hale Creek, Trinity Co., California; and from the Black Diablo mine, Black Diablo district, Pershing Co., Nevada. In the Treburland mine, Altarnun, Cornwall, and near Chillaten, Devon, England. From Langbån, Värmland, Sweden. In Russia, at a number of poorly-defined localities. In the Tokuzawa mine, Fukushima Prefecture; the Ichinomata mine, Kumamoto Prefecture; and at Kunimiyama, Kochi Prefecture, Japan. In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For Clarence Sweet Bement (1843–1923), American mineral collector of Philadelphia, Pennsylvania, USA.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 704. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 117–118. (3) Kato, T. (1963) New data on the so-called bementite. J. Min. Soc. Japan, 6, 93–103 (in Japanese). (4) (1964) Amer. Mineral., 49, 446–447 (abs. ref. 3).

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Benauite $\mathbf{SrFe_3^{3+}(PO_4,SO_4)(PO_3OH)(OH)_6}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As poorly formed, platy to scaly crystals, flattened on {0001}, to 1 mm, in radial aggregates.

Physical Properties: *Cleavage:* On {0001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼3.5 D(meas.) = 3.65(5) D(calc.) = 3.648

Optical Properties: Transparent to translucent. *Color:* Yellow to brown. *Streak:* Yellowish. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–), anomalously biaxial, with blue interference colors.
Pleochroism: O = yellow; E = nearly colorless. $\omega = 1.872(5)$ $\epsilon = 1.862(5)$ 2V(meas.) = 20°

Cell Data: *Space Group:* $[R\overline{3}m]$ (probable, by analogy to beudantite). $a = 7.28(2)$ $c = 16.85(4)$ Z = [3]

X-ray Powder Pattern: Clara mine, Germany.
5.88 (10), 3.06 (9), 3.65 (6), 2.25 (6), 2.96 (5), 2.81 (5), 2.53 (5)

Chemistry:

	(1)		(1)
SO_3	6.79	PbO	2.79
P_2O_5	18.53	CaO	0.07
As_2O_5	0.78	SrO	12.35
Al_2O_3	0.26	BaO	4.32
Fe_2O_3	40.85	K_2O	0.07
CuO	0.03	H_2O	[13.09]
ZnO	0.07	Total	[100.00]

(1) Clara mine, Germany; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; stated to correspond to $(Sr_{0.67}Ba_{0.16}Pb_{0.07}Ca_{0.01}K_{0.01})_{\Sigma=0.92}(Fe^{3+}_{2.90}Al_{0.03})_{\Sigma=2.93}[(PO_4)_{1.48}(SO_4)_{0.48}(AsO_4)_{0.04}]_{\Sigma=2.00}(OH,H_2O)_{8.3}$.

Mineral Group: Crandallite group.

Occurrence: A secondary mineral in the oxidized zone of a hydrothermal polymetallic barite–fluorite deposit.

Association: Kidwellite, fluorite, goethite.

Distribution: From the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: For the Benauer Berg, Germany, near which the Clara mine is situated.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany; Museum Victoria, Melbourne, Australia.

References: (1) Walenta, K., W.D. Birch, and P.J. Dunn (1996) Benauite, a new mineral of the crandallite group from the Clara mine in the central Black Forest, Germany. Chem. Erde, 56, 171–176. (2) (1997) Amer. Mineral., 82, 430 (abs. ref. 1).

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Benavidesite $Pb_4(Mn,Fe)Sb_6S_{14}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals, to 200 μm long, or rounded grains, to 50 μm. *Twinning:* Polysynthetic twinning is common parallel to crystal elongation.

Physical Properties: Hardness = n.d. VHN = 77–116 (15 g load). D(meas.) = n.d. D(calc.) = 5.60

Optical Properties: Opaque. *Color:* Lead-gray; white with a greenish tint under reflected light, with rare dull red internal reflections. *Streak:* Dark gray with a brownish tint. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong, with tints of brown and blue. R_1–R_2: (400) 40.7–42.0, (420) 39.6–42.0, (440) 39.3–42.0, (460) 39.5–42.4, (480) 39.9–43.0, (500) 39.7–42.9, (520) 39.5–42.7, (540) 39.0–42.4, (560) 38.9–42.2, (580) 38.7–41.8, (600) 38.3–41.3, (620) 37.9–40.8, (640) 37.5–40.9, (660) 36.8–39.5, (680) 36.1–38.7, (700) 35.6–37.8

Cell Data: *Space Group:* $P2_1/a$. $a = 15.74$ $b = 19.14$ $c = 4.06$ $\beta = 91.50°$ $Z = 2$

X-ray Powder Pattern: Uchuc-Chacua deposit, Peru.
3.45 (100), 2.829 (40), 4.10 (30), 2.737 (30), 3.85 (20), 3.169 (20), 3.098 (20)

Chemistry:

	(1)	(2)
Pb	39.9	39.9
Cu		0.1
Zn		0.1
Mn	2.2	1.8
Fe	0.8	1.1
Sb	34.8	33.0
Bi		2.6
S	21.1	21.7
Total	98.8	100.3

(1) Uchuc-Chacua deposit, Peru; by electron microprobe, corresponding to $Pb_{4.06}(Mn_{0.84}Fe_{0.30})_{\Sigma=1.14}Sb_{6.00}S_{13.80}$. (2) Sätra mine, Sweden; by electron microprobe, average of five analyses, corresponding to $Pb_{4.09}(Mn_{0.69}Fe_{0.42}Cu_{0.03}Zn_{0.03})_{\Sigma=1.17}(Sb_{5.74}Bi_{0.26})_{\Sigma=6.00}S_{14.38}$.

Polymorphism & Series: Forms a series with jamesonite.

Occurrence: In a metamorphosed iron sulfide deposit associated with submarine felsic volcanism (Sätra mine, Sweden); in telescoped polymetallic mineralization associated with dacitic intrusions (Uchuc-Chacua deposit, Peru).

Association: Galena, manganoan sphalerite, pyrite, pyrrhotite, alabandite, uchucchacuaite, quartz, bustamite, rhodonite, calcite (Uchuc-Chacua deposit, Peru); galena, freibergite, gudmundite, manganoan sphalerite, bismuth, spessartine (Sätra mine, Sweden); pyrite, calcite (Dachang district, China).

Distribution: From the Uchuc-Chacua deposit, Cajatambo Province, Peru [TL]. In the Sätra mine, Doverstorp, Bergslagen metallic province, Sweden [TL]. In the Dachang district, Guangxi Autonomous Region, China.

Name: To honor the contributions of Alberto Benavides (1920–), Peruvian mining engineer, to the development of mining in Peru.

Type Material: National School of Mines, Paris, France (Uchuc-Chacua deposit, Peru); Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands (Sätra mine, Sweden).

References: (1) Oudin, E., P. Picot, F. Pillard, Y. Moëlo, E.A.J. Burke, and M.A. Zakrzewski (1982) La bénavidésite, $Pb_4(Mn,Fe)Sb_6S_{14}$, un noveau minéral de la série de la jamesonite. Bull. Minéral., 105, 166–169 (in French with English abs.). (2) (1983) Amer. Mineral., 68, 280 (abs. ref. 1). (3) L.L.Y. Chang, X. Li, and C. Zhang. The jamesonite – benavidesite series. Can. Mineral., 25, 667–672.

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Benitoite $BaTiSi_3O_9$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}2m$. Flat pyramidal crystals, tabular on {0001}, triangular or hexagonal in outline, to 6 cm. *Twinning:* By rotation about [0001].

Physical Properties: *Cleavage:* Poor on $\{10\bar{1}1\}$. *Fracture:* Conchoidal. Hardness = 6–6.5 D(meas.) = 3.65 D(calc.) = 3.68 Blue fluorescence under SW UV; intense blue cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Sapphire-blue, white to colorless, pink; commonly bicolored. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* O = colorless; E = purple, indigo, greenish blue.
ω = 1.756–1.757 ϵ = 1.802–1.804

Cell Data: *Space Group:* $P\bar{6}2c$. $a = 6.6410(7)$ $c = 9.7597(10)$ $Z = 2$

X-ray Powder Pattern: San Benito Co., California, USA. (ICDD 26-1036).
3.71 (100), 2.72 (90), 2.86 (75), 5.73 (65), 2.169 (60), 3.30 (50), 3.13 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	43.68	42.62	43.60
TiO_2	20.09	19.44	19.32
BaO	36.33	37.27	37.08
Na_2O		0.14	
Total	100.10	99.47	100.00

(1) San Benito Co., California, USA. (2) Do.; by electron microprobe. (3) $BaTiSi_3O_9$.

Occurrence: In natrolite veins cutting glaucophane schist in a serpentine body (San Benito Co., California, USA); in a magnesio-riebeckite-quartz-phlogopite-albite dike cutting serpentinite (Ohmi, Japan).

Association: Neptunite, joaquinite, natrolite (San Benito Co., California, USA); ohmilite, bario-orthojoaquinite, leucosphenite (Ohmi, Japan).

Distribution: In the USA, in California, at the Gem mine, Mina Numero Uno, the Victor and Junilla claims, and on Santa Rita Peak, San Benito Co.; from Big Creek–Rush Creek, Fresno Co.; and on Trumbull Peak, near Incline, Mariposa Co.; in the Diamond Jo quarry, Magnet Cove, Hot Spring Co., Arkansas From Ohmi, Niigata Prefecture, Japan. At Broken Hill, New South Wales, Australia.

Name: For the occurrence in San Benito Co., California, USA.

Type Material: n.d.

References: (1) Louderback, G.D. (1907) Benitoite, a new California gem mineral. Univ. Calif., Bull. Dept. Geol., 5, 149–153. (2) Louderback, G.D. (1909) Benitoite, its paragenesis and mode of occurrence. Univ. Calif., Bull. Dept. Geol., 5, 331–380. (3) Fischer, K. (1969) Verfeinerung der Kristallstruktur von Benitoit $BaTi[Si_3O_9]$. Zeits. Krist., 129, 222–243 (in German with English abs.). (4) Laird, J. and A.L. Albee (1972) Chemical composition and physical, optical and structural properties of benitoite, neptunite and joaquinite. Amer. Mineral., 57, 85–102. (5) Wise, W.S. and R.H. Gill (1977) Minerals of the Benitoite Gem mine. Mineral. Record, 8, 442–452. (6) Laurs, B.M., W.R. Rohtert, and M. Gray (1997) Benitoite from the New Idria District, San Benito County, California. Gems & Gemology, 33, 166–187.

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Benjaminite $(Ag, Cu)_3(Bi, Pb)_7S_{12}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive and as laths, to 6 mm, which are complex intergrowths of several closely related phases. *Twinning:* Polysynthetic, common.

Physical Properties: *Cleavage:* Fair, parallel to the elongation. Hardness = 3.3–3.5 VHN = 186–232 (50 g load). D(meas.) = n.d. D(calc.) = 6.68

Optical Properties: Opaque. *Color:* Gray on fresh fracture, tarnishing dull or yellow to coppery red; in polished section, creamy white to very pale brownish. *Luster:* Metallic, with greasy appearance. *Anisotropism:* Strong.

R_1–R_2: (400) 44.2–47.2, (420) 44.8–47.8, (440) 45.2–48.6, (460) 45.2–49.0, (480) 45.0–49.2, (500) 44.8–49.2, (520) 44.5–49.0, (540) 44.0–48.6, (560) 43.6–48.0, (580) 43.3–47.6, (600) 43.1–47.2, (620) 43.0–46.8, (640) 42.8–46.3, (660) 42.7–45.9, (680) 42.6–45.6, (700) 42.5–45.2

Cell Data: *Space Group:* $C2/m$. $a = 13.25(2)$ $b = 4.05(1)$ $c = 20.25(3)$ $\beta = 103.14(07)^\circ$ Z = 2

X-ray Powder Pattern: Camsell River, Canada. Easily mistaken for pavonite. 2.851 (100), 3.539 (80), 3.427 (80), 2.813 (60), 2.022 (60), 2.007 (60), 3.302 (50)

Chemistry:

	(1)	(2)		(1)	(2)
Ag	12.6	14.2	Bi	65.1	64.8
Cu	1.4	0.0	Sb		0.0
Pb	3.7	0.6	S	16.4	18.0
			Total	99.2	97.6

(1) Round Mountain, Nevada, USA; by electron microprobe, average of four analyses; corresponding to $(Ag_{2.74}Cu_{0.52})_{\Sigma=3.26}(Bi_{7.31}Pb_{0.42})_{\Sigma=7.73}S_{12.00}$. (2) AW mine, Australia; by electron microprobe, corresponding to $Ag_{2.82}(Bi_{6.62}Pb_{0.06})_{\Sigma=6.68}S_{12.00}$.

Occurrence: In a quartz vein near the contact of a soda-granite and an intrusive rhyolite (Outlaw mine, Nevada); with arsenides (Camsell River, Canada); in a veinlet in calcite (Cobalt, Canada); in a molybdenite pipe deposit (AW mine, Australia).

Association: Aikinite, chalcopyrite, pyrite, covellite, muscovite, molybdenite, quartz (Outlaw mine, Nevada); safflorite, skutterudite, rammelsbergite, arsenopyrite, nickeline, matildite, bismuthinite, chalcopyrite, pyrite, sphalerite, galena, bismuth, silver (Camsell River, Canada); molybdenite, bismuth, bismuthinite (AW mine, Australia).

Distribution: In the USA, from the Outlaw mine, about 17 km north of Manhattan, Round Mountain district, Nye Co., Nevada [TL]; in the Alaska mine, Poughkeepsie Gulch, near Ouray, San Juan Co., Colorado. From the Terra Company mine, Camsell River, Northwest Territories; and in the Canadian Keely mine, Cobalt, Ontario, Canada. In the Porvenir mine, Cerro Bonete, Potosí, Bolivia. At the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. From the AW mine, south of Tenterfield, New South Wales, Australia. In the Nanten and Daimaru veins, Ikuno deposits, Hyogo Prefecture, Japan. At the Svishti Plaz gold deposit, central Balkan Mountains, Bulgaria. In the Waschgang Au–Cu deposit, Goldberg Mountains, Upper Carinthia, Austria.

Name: Honors Dr. Marcus Benjamin (1857–1932), U.S. National Museum, marine taxonomist and long-time editor of U.S.N.M. publications.

Type Material: Royal Ontario Museum, Toronto, Canada, 13805; Harvard University, Cambridge, Massachusetts, 85749; National Museum of Natural History, Washington, D.C., USA, 95058.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 441–442. (2) Nuffield, E.W. (1953) Benjaminite. Amer. Mineral., 38, 550–552. (3) Nuffield, E.W. (1975) Benjaminite — a re-examination of the type material. Can. Mineral., 13, 394–401. (4) Harris, D.C. and T.T. Chen (1975) Benjaminite, reinstated as a valid species. Can. Mineral., 13, 402–407. (5) Herbert, H.K. and W.G. Mumme (1981) Unsubstituted benjaminite from the AW mine, NSW: a discussion of metal substitutions and stability. Neues Jahrb. Mineral., Monatsh., 69–80. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 40.

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Benleonardite $Ag_8(Sb,As)Te_2S_3$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$, $\overline{4}2m$, $4mm$, 422, $4/m$, $\overline{4}$, or 4. As crusts and fracture fillings composed of grains and laths, to 100 μm. *Twinning:* According to some simple law.

Physical Properties: Hardness = n.d. VHN = 105–125, 117 average (25 g load). D(meas.) = n.d. D(calc.) = 7.76

Optical Properties: Opaque. *Color:* In polished section, very pale blue. *Anisotropism:* Moderate to strong, in tints of brown, blue, and gray. R_1–R_2: (400) 35.6–36.8, (420) 35.7–36.6, (440) 35.8–36.2, (460) 35.7–35.6, (480) 35.5–34.9, (500) 35.1–34.1, (520) 34.7–33.2, (540) 34.1–32.2, (560) 33.5–31.4, (580) 32.9–30.7, (600) 32.4–30.0, (620) 32.0–29.5, (640) 31.6–29.1, (660) 31.4–28.7, (680) 31.1–28.4, (700) 30.8–28.1

Cell Data: *Space Group:* $P4/mmm$, $P\overline{4}m2$, $P\overline{4}2m$, $P4mm$, $P422$, $P4/m$, $P\overline{4}$, or $P4$. $a = 6.603(5)$ $c = 12.726(6)$ Z = 2

X-ray Powder Pattern: Moctezuma mine, Mexico. 2.936 (100), 12.7 (70), 2.608 (35), 2.158 (35), 3.188 (30), 2.863 (25), 2.328 (20)

Chemistry:

	(1)	(2)	(3)
Ag	64.5	62.99	64.59
Cu	0.1	1.65	
Sb	7.3	5.33	9.11
As	1.4	1.70	
Te	18.7	19.06	19.10
S	8.0	8.33	7.20
Total	100.0	99.06	100.00

(1) Moctezuma mine, Mexico; by electron microprobe, average of 14 analyses, corresponding to $Ag_{7.80}Cu_{0.02}(Sb_{0.78}As_{0.24})_{\Sigma=1.02}Te_{1.90}S_{3.25}$. (2) Gies deposit, Montana, USA; by electron microprobe, average of four analyses; corresponding to $Ag_{7.53}Cu_{0.33}(Sb_{0.56}As_{0.29})_{\Sigma=0.85}Te_{1.93}S_{3.35}$. (3) $Ag_8SbTe_2S_3$.

Occurrence: In fractures in an intensely silicified rhyolitic vitrophyre (Moctezuma mine, Mexico); in a limestone-hosted disseminated Au–Ag–Te deposit (Mayflower mine, Montana, USA); in an epithermal Au–Ag-Te vein system along the contact between alkaline intrusives and sediments (Gies mine, Montana, USA).

Association: Silver, acanthite, hessite, cervelleite, pyrite, sphalerite, dolomite, quartz (Moctezuma mine, Mexico); tetrahedrite, hessite, gold, sphalerite (Mayflower mine, Montana, USA); hessite, tetrahedrite (Gies mine, Montana, USA).

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico [TL]. In the Mayflower mine, Tobacco Root Mountains, Madison Co., and the Gies mine, Judith Mountains, Fergus Co., Montana, USA. From the Emperor mine, Vatukoula, and the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands.

Name: For Dr. Benjamin Franklin Leonard (1921–), of the U.S. Geological Survey, Denver, Colorado, USA.

Type Material: The Natural History Museum, London, England, 1985,354 and E.1611; National Museum of Natural History, Washington, D.C., USA, 165226.

References: (1) Stanley, C.J., A.J. Criddle, and J.E. Chisholm (1986) Benleonardite, a new mineral from the Bambolla mine, Moctezuma, Sonora, Mexico. Mineral. Mag., 50, 681–686. (2) (1988) Amer. Mineral., 73, 439 (abs. ref. 1). (3) Spry, P.G. and S.E. Thieben (1996) Two new occurrences of benleonardite, a rare silver–tellurium sulphosalt, and a possible new occurrence of cervelleite. Mineral. Mag., 60, 871–876.

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Benstonite $(Ba,Sr)_6Ca_6Mg(CO_3)_{13}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Rhombohedral crystals, to 1 cm; typically as cleavable masses with a fine mosaic structure.

Physical Properties: *Cleavage:* On $\{31\overline{4}2\}$, good. Hardness = 3–4 D(meas.) = 3.596–3.66 D(calc.) = 3.695 Fluoresces red or yellow under LW UV, SW UV, and X-rays; strong red phosphorescence.

Optical Properties: Translucent. *Color:* Snow-white, ivory, very pale yellow, pale yellowish brown.
Optical Class: Uniaxial (–). $\omega = 1.690(1)$ $\epsilon = 1.527(1)$

Cell Data: *Space Group:* $R\overline{3}$. $a = 18.280(9)$ $c = 8.652(8)$ Z = 3

X-ray Powder Pattern: Magnet Cove, Arkansas, USA.
3.08 (95), 3.92 (38), 2.536 (28), 2.127 (23), 1.905 (17), 4.19 (16), 3.53 (10)

Chemistry:

	(1)	(2)
CO_2	31.35	30.61
MnO	0.35	
MgO	1.69	2.16
CaO	19.52	18.00
SrO	4.02	
BaO	43.05	49.23
Total	99.98	100.00

(1) Magnet Cove, Arkansas, USA; corresponds to $(Ba_{5.27}Sr_{0.73})_{\Sigma=6.00}Ca_{6.00}(Mg_{0.79}Ca_{0.12}Mn_{0.09})_{\Sigma=1.00}(CO_3)_{13.00}$. (2) $Ba_6Ca_6Mg(CO_3)_{13}$.

Occurrence: In a barite deposit (Magnet Cove, Arkansas, USA); in Alpine veins cutting a carbonatite (Bayan Obo deposit, China).

Association: Barite, calcite, quartz (Magnet Cove, Arkansas, USA); calcite, alstonite, fluorite, sphalerite (Cave-in-Rock, Illinois, USA); huntite, barytocalcite, strontianite, pyrite, phlogopite, monazite, daqingshanite (Bayan Obo deposit, China).

Distribution: In the USA, from the Baroid barite mine about four km east-northeast of Magnet Cove, Hot Spring Co., Arkansas, and in the Minerva No. 1 mine, near Cave-in-Rock, Hardin Co., Illinois. From the Jason Pb–Zn deposits, Macmillan Pass, Yukon Territory, Canada. At Långban, Värmland, Sweden. From Rosh Pinah, Namibia. In the Murun massif, southwest of Olekminsk, Sakha, Russia. From the Jogipatti carbonatite, near Samalpatti, Tamil Nadi, India. In the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China.

Name: Honoring Orlando J. Benston (1901–1966), metallurgist for the Baroid Division, National Lead Co., Malvern, Arkansas, USA, who supplied the first specimens.

Type Material: Victor Goldschmidt University, Göttingen, Germany, S21351; National Museum of Natural History, Washington, D.C., USA, 120234, 120236.

References: (1) Lippmann, F. (1962) Benstonite, $Ca_7Ba_6(CO_3)_{13}$, a new mineral from the barite deposit in Hot Spring County, Arkansas. Amer. Mineral., 47, 585–598. (2) White, J.S., Jr. and E. Jarosewich (1970) Second occurrence of benstonite. Mineral. Record, 1, 140–141. (3) Effenberger, H. (1979) Kristallstruktur und chemische Formel des Benstonits, $Ba_6Ca_6Mg(CO_3)_{13}$. Neues Jahrb. Mineral., Abh., 136, 326–337 (in German with English abs.).

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Bentorite $\mathbf{Ca_6(Cr,Al)_2(SO_4)_3(OH)_{12}\cdot 26H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As stout hexagonal prisms, $\{10\bar{1}0\}$, $\{10\bar{1}1\}$, $\{0001\}$, to 0.25 mm; commonly in fibrous masses, granular aggregates, and thin films. *Twinning:* On $\{10\bar{1}0\}$ as composition plane.

Physical Properties: *Cleavage:* $\{10\bar{1}0\}$, perfect; $\{0001\}$, distinct. Hardness = 2
D(meas.) = 2.025 D(calc.) = 2.021

Optical Properties: Transparent. *Color:* Bright violet. *Streak:* Very pale violet.
Luster: Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* O = nearly colorless; E = pale violet.
Absorption: $O < E$. $\omega = 1.478(2)$ $\epsilon = 1.484(2)$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 22.35$ $c = 21.41$ Z = 8

X-ray Powder Pattern: Hatrurim Formation, Israel.
9.656 (100), 5.592 (40), 1.942 (20), 3.60 (10), 3.23 (10), 2.772 (10), 3.89 (8)

Chemistry:

	(1)
SO_3	14.99
CO_2	6.70
SiO_2	2.50
Al_2O_3	1.01
Fe_2O_3	0.10
Cr_2O_3	7.48
MgO	0.00
CaO	29.90
H_2O	37.70
Total	100.38

(1) Hatrurim Formation, Israel; by AA, SO_3 by gravimetric analysis, CO_2 and H_2O by TGA; after deduction of CaO and CO_2 as calcite and CaO, SiO_2, H_2O as truscottite, the remainder (about 80%) corresponds to $Ca_{5.88}(Cr_{1.61}Al_{0.32}Fe^{3+}_{0.02})_{\Sigma=1.95}(S_{1.02}O_4)_{3.00}(OH)_{11.97}\cdot 28.06H_2O$.

Mineral Group: Ettringite group.

Occurrence: In low-temperature hydrothermal veins in black calcite–spurrite marble.

Association: Calcite, thaumasite, truscottite, vaterite, jennite, tobermorite, brownmillerite, mayenite, melnikovite, "chlorite".

Distribution: In a marble quarry in the Hatrurim Formation, near the Arad-Sodom road, Negev Desert, Israel.

Name: To honor Professor Y.K. Bentor, University of California, San Diego, California, USA, for his contributions to geology and mineralogy in Israel.

Type Material: Geochemistry Department, Geological Survey of Israel, Jerusalem, Israel, SG644; Fairleigh-Dickinson University, Madison, New Jersey, USA.

References: (1) Gross, S. (1980) Bentorite. A new mineral from the Hatrurim Area, west of the Dead Sea, Israel. Israel J. of Earth Sci., 29, 81–84. (2) (1981) Amer. Mineral., 66, 639 (abs. ref. 1).

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Benyacarite

$(H_2O, K)_2(Mn^{2+}, Fe^{2+})_2$
$(Fe^{3+}, Ti, Al)_2Ti(PO_4)_4(O, F)_2 \cdot 14H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 2 mm, tabular on {010}, equant {111}, with {001}, more rarely {100}.

Physical Properties: *Cleavage:* Perfect on {010}; parting on {101}. *Fracture:* Uneven. *Tenacity:* Very brittle. Hardness = 2.5–3 D(meas.) = n.d. D(calc.) = 2.37

Optical Properties: Transparent to translucent. *Color:* Greenish yellow, may be pale brown, almost colorless; pale yellow to colorless in thin section. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.612(3)$ $\beta = 1.621(3)$ $\gamma = 1.649(3)$ 2V(meas.) = 60(3)°

Cell Data: *Space Group: Pbca.* $a = 10.561(5)$ $b = 20.585(8)$ $c = 12.516(2)$ Z = 4

X-ray Powder Pattern: El Criollo pegmatite, Argentina.
6.26 (100), 3.13 (100), 10.29 (90), 7.51 (80), 3.76 (50), 5.16 (40), 3.96 (40)

Chemistry:

	(1)		(1)
P_2O_5	28.1	CaO	0.1
TiO_2	12.3	Na_2O	0.2
Al_2O_3	0.7	K_2O	1.6
Fe_2O_3	11.0	F	1.5
FeO	2.8	H_2O	[28.9]
MnO	11.2	$-O = F_2$	[0.6]
MgO	0.3	Total	[98.1]

(1) El Criollo pegmatite, Argentina; by electron microprobe, FeO:Fe_2O_3 and H_2O assumed from crystal-structure determination; corresponding to $[(H_2O)_{0.78}K_{0.32}Na_{0.06}]_{\Sigma=1.16}(Mn^{2+}_{1.50}Fe^{2+}_{0.42}Mg_{0.07}Ca_{0.01})_{\Sigma=2.00}(Fe^{3+}_{1.36}Ti_{0.56}Al_{0.14})_{\Sigma=2.06}Ti_{1.00}(PO_4)_4(O_{1.20}F_{0.80})_{\Sigma=2.00} \cdot 14H_2O$.

Occurrence: A rare secondary mineral in a complex zoned granite pegmatite.

Association: Phosphosiderite, strengite, pachnolite, apatite, torbernite.

Distribution: From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina. In Germany, at Hagendorf, and on the Kreuzberg, Pleystein, Bavaria. From Folgosinho, near Gouveia, Portugal.

Name: To honor María Angélica R. de Benyacar (1928–), National Atomic Energy Commission, Buenos Aires, Argentina, for her mineralogical studies.

Type Material: Department of Earth Sciences, University of Milan, Milan, Italy.

References: (1) Demartin, F., T. Pilati, H.D. Gay, and C.M. Gramaccioli (1993) The crystal structure of a mineral related to paulkerrite. Zeits. Krist., 208, 57–71. (2) (1994) Amer. Mineral., 79, 763 (abs. ref. 1). (3) Demartin, F., H.D. Gay, C.M. Gramaccioli, and T. Pilati (1997) Benyacarite, a new titanium-bearing phosphate mineral species from Cerro Blanco, Argentina. Can. Mineral., 35, 707–712.

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Beraunite $Fe^{2+}Fe_5^{3+}(PO_4)_4(OH)_5 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly as crystals, tabular on {100}, elongated along [010], to 1 cm; striated on {100} ‖ [010]. In coarse radially fibrous aggregates, globular or discoidal, and in crusts. *Twinning:* On {100}, may be interpenetrant.

Physical Properties: *Cleavage:* On {100}, good. Hardness = 3–4 D(meas.) = 2.8–3.08 D(calc.) = 2.894 (greenish black); 2.970 (orange).

Optical Properties: Translucent. *Color:* Dull greenish to greenish brown when fresh, may be color banded; reddish brown to hyacinth-red, blood-red on exposure. *Streak:* Olive-drab when fresh; yellow, brownish yellow on exposure. *Luster:* Vitreous, pearly on cleavages, resinous on fractures.
Optical Class: Biaxial (+), may be biaxial (–). *Pleochroism:* X = pale flesh-pink, yellow, blue-green; Y = pale flesh-pink, yellow, pale olive-green; Z = carnelian-red, reddish brown, olive-green. *Orientation:* $Z = b$; $Y \wedge c = 1.5°$–$5°$. *Dispersion:* $r > v$, marked, may be $r < v$. $\alpha = 1.707$–1.775 $\beta = 1.735$–1.786 $\gamma = 1.738$–1.820 2V(meas.) = Moderate to large.

Cell Data: *Space Group:* $C2/c$ (greenish black) with $a = 20.953(5)$ $b = 5.171(1)$ $c = 19.266(4)$ $\beta = 93.34(2)°$ Z = 4, or *Space Group:* $C2/c$ (orange) with $a = 20.646(5)$ $b = 5.129(7)$ $c = 19.213(5)$ $\beta = 93.67(7)°$ Z = 4

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
10.37 (10), 4.825 (6), 3.082 (6), 9.58 (5), 7.229 (5), 4.418 (5), 3.187 (4), 3.747 (3)

Chemistry:

	(1)	(2)
P_2O_5	30.17	31.26
Al_2O_3	0.02	
Fe_2O_3	54.41	43.97
FeO	1.92	7.91
H_2O	13.45	16.86
Total	99.97	100.00

(1) Middletown, New Jersey, USA; partially oxidized. (2) $Fe^{2+}Fe_5^{3+}(PO_4)_4(OH)_5 \cdot 6H_2O$.

Occurrence: A component of bog iron ores; a cement in clays, sands, and bone material; an alteration product of triphylite in granite pegmatites.

Association: Vivianite, dufrénite, rockbridgeite, cacoxenite, wavellite, ferrostrunzite, ferristrunzite, frondelite, huréaulite, mitridatite, stewartite, laueite, leucophosphite, triphylite, "limonite".

Distribution: Many localities are known; some with well-studied material include: in the Hrbek mine, at St. Benigna, near Beroun, Czech Republic. In Germany, from the Eleonore and Rotläufchen iron mines, near Giessen, Hesse; and at Hühnerkobel, near Zwiesel, from Hagendorf, and on the Kreuzberg, Pleystein, Bavaria. From the Gravel Hill mine, Perranzabuloe, Cornwall, England. In the Mangualde pegmatite, near Mesquitela, Portugal. From the Leveäniemi mine, Svappavaara, near Kiruna, Sweden. In the USA, from the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., New Hampshire; at Raccoon Creek, Mullica Hill, Gloucester Co., New Jersey; in the Hesnard mine, three km southwest of Keystone, and the Big Chief mine, one km south of Glendale, Pennington Co., South Dakota; from the Foote mine, near Kings Mountain, Cleveland Co., North Carolina. In the Moculta phosphate quarry, northeast of Angaston, South Australia.

Name: For its occurrence near Beroun (formerly Beraun), Czech Republic.

Type Material: Mining Academy, Freiberg, Germany, 21359.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 959–961. (2) Fanfani, L. and P.F. Zanazzi (1967) The crystal structure of beraunite. Acta Cryst., 22, 173–181. (3) Moore, P.B. (1970) Crystal chemistry of the basic iron phosphates. Amer. Mineral., 55, 135–169. (4) Moore, P.B. and A.R. Kampf (1992) Beraunite: refinement, comparative crystal chemistry, and selected bond valences. Zeits. Krist., 201, 263–281.

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Berborite $Be_2(BO_3)(OH)\cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 3, $3m$, or 6. As crystals showing {0001}, {$10\bar{1}1$}, {$11\bar{2}1$}, with half-a-dozen less common forms, typically hemihedral, or prismatic along [0001], to 1.5 cm. *Twinning:* Noted, complex.

Physical Properties: *Cleavage:* Perfect on {0001}. *Fracture:* Irregular. Hardness = 3 VHN = 85 D(meas.) = 2.03–2.06 D(calc.) = 2.04

Optical Properties: Transparent to translucent. *Color:* Colorless to white, may be zoned. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.5804$–1.5817 $\epsilon = 1.485$–1.4928

Cell Data: *Space Group:* $P3$ (1T), with $a = 4.4328(8)$ $c = 5.337(1)$ Z = 1, or *Space Group:* $P3c1$ (2T), with $a = 4.4348(4)$ $c = 10.664(1)$ Z = 2, or *Space Group:* $P6_3$ (2H), with $a = 4.4403(8)$ $c = 10.655(2)$ Z = 2

X-ray Powder Pattern: Saga quarry, Norway (1T).
5.35 (100), 2.666 (50), 3.120 (45), 2.046 (20), 3.840 (5), 2.218 (5), 1.780 (5)

Chemistry:

	(1)	(3)
B_2O_3	23.5	31.12
BeO	39.3	44.72
H_2O		24.16
LOI	33.2	
Total	96.0	100.00

(1) Luppikko deposit, Russia; hambergite and fluorite estimated 2%–3%. (2) Saga quarry, Norway; stated to have Be:B = 1.99–2.02:1.00. (3) $Be_2(BO_3)(OH)\cdot H_2O$.

Polymorphism & Series: 1T, 2T, 2H polytypes.

Occurrence: In serpentinized dolostone associated with W–Sr–B–Be-bearing skarns (Pitkäranta district, Russia); in vugs with natrolite (Saga quarry, Norway).

Association: Hambergite, schoenfliesite, helvite, apatite, cassiterite, fluorite, calcite, dolomite, magnetite, sphalerite, vesuvianite, chondrodite, diopside, smithsonite, goethite (Pitkäranta district, Russia); natrolite, thomsonite (Saga quarry, Norway).

Distribution: From the Luppikko deposit, Pitkäranta district, Lake Ladoga, Karelia, Russia. In the Saga and Tuften larvikite quarries, Tvedalen, and at Brønnebukta, Siktesøya Island, Langesundsfjord, Norway.

Name: For BERyllium and BORate in the composition.

Type Material: Mineralogical Museum, St. Petersburg, 15180; Mining Institute, St. Petersburg, 1003/1–1003/5; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69274.

References: (1) Nefedov, E.I. (1967) Berborite, a new mineral. Doklady Acad. Nauk SSSR, 174, 189–192 (in Russian). (2) (1968) Amer. Mineral., 53, 348–349 (abs. ref. 1). (3) Schlatti, M. (1968) Hydrothermalsynthese und Strukturtyp des Berylliumborates $^{2}_{\infty}$ $Be_2BO_3OH.H_2O$. Tschermaks Mineral. Petrog. Mitt., 12, 463–469 (in German with English abs.). (4) Giuseppetti, G., F. Mazzi, C. Tadini, A.O. Larsen, A. Åsheim, and G. Raade (1990) Berborite polytypes. Neues Jahrb. Mineral., Abh., 162, 101–116.

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Berdesinskiite $V_2^{3+}TiO_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As grains, rarely up to 70 μm, and as rims around schreyerite.

Physical Properties: Hardness = [6–6.5] (polishing hardness close to that of rutile). D(meas.) = n.d. D(calc.) = 4.536

Optical Properties: Opaque. *Color:* Black; reddish brown under reflected polarized light. *Luster:* Metallic.
Optical Class: Biaxial. *Bireflectance:* Weak.
R_1–R_2: (400) 16.6–17.1, (420) 17.1–17.5, (440) 17.4–18.0, (460) 17.9–18.4, (480) 18.3–18.9, (500) 18.8–19.4, (520) 19.2–19.8, (540) 19.5–20.3, (560) 19.8–20.8, (580) 20.0–21.1, (600) 20.3–21.3, (620) 20.4–21.4, (640) 20.5–21.5, (660) 20.6–21.6, (680) 20.4–21.6, (700) 20.2–21.5

Cell Data: *Space Group:* [$C2/c$ or Cc; $P2_1/c$; $P2/c$ or Pc] (by analogy to synthetic V_2TiO_5). $a = 10.11(1)$ $b = 5.084(4)$ $c = 7.03(1)$ $\beta = 111.46(6)°$ Z = 4

X-ray Powder Pattern: Near Lasamba Hill, Kenya; line intensities not given.
4.721, 4.492, 3.316, 2.895, 2.676, 2.543, 2.447

Chemistry:

	(1)	(2)
TiO_2	34.13	34.77
Al_2O_3	0.76	
V_2O_3	64.35	65.23
Cr_2O_3	1.39	
MnO	0.01	
Total	100.64	100.00

(1) Near Lasamba Hill, Kenya; by electron microprobe, average of five analyses; corresponding to $(V_{1.96}Cr_{0.05}Al_{0.03})_{\Sigma=2.04}Ti_{0.98}O_5$. (2) V_2TiO_5.

Occurrence: In strongly weathered gneiss with quartzite in a gem kornerupine deposit of Precambrian age.

Association: Schreyerite, rutile, kornerupine, diopside, epidote, graphite, quartz, biotite, tourmaline.

Distribution: From six km southeast of Lasamba Hill, Kwale district, south of Voi, Kenya.

Name: For Professor Waldemar Berdesinski (1911–1990), crystallographer, University of Heidelberg, Heidelberg, Germany.

Type Material: Universities of Bochum, Hamburg, and Heidelberg, Germany; National Museum of Natural History, Washington, D.C., USA, 147362.

References: (1) Bernhardt, H.-J., K. Schmetzer, and O. Medenbach (1983) Berdesinskiite, V_2TiO_5, a new mineral from Kenya and additional data for schreyerite, $V_2Ti_3O_9$. Neues Jahrb. Mineral., Monatsh., 110–118. (2) (1983) Amer. Mineral., 68, 1038 (abs. ref. 1).

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Bergenite $(Ba,Ca)_2(UO_2)_3(PO_4)_2(OH)_4 \cdot 5.5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thin tabular to needlelike crystals, to 3 mm.

Physical Properties: Hardness = n.d. D(meas.) = ∼4.1 D(calc.) = 4.98 Radioactive; pale green fluorescence under SW UV.

Optical Properties: Semitransparent. *Color:* Yellow to greenish yellow. *Streak:* Pale yellow. *Optical Class:* Biaxial (–). $\alpha = 1.660$ β = n.d. $\gamma = 1.722$ 2V(meas.) = 60°

Cell Data: *Space Group:* $P2_1/c$. $a = 23.32$ $b = 17.19$ $c = 20.63$ $\beta = 93.0°$ Z = 18

X-ray Powder Pattern: Streuberg, Germany.
7.73 (100), 3.837 (80), 3.054 (60), 2.874 (50), 2.826 (50), 8.54 (40), 3.742 (40), 3.415 (40)

Chemistry:

	(1)	(2)
UO_3	62.54	62.4
P_2O_5	10.98	11.4
CaO	2.44	2.5
BaO	13.98	13.2
H_2O	[10.06]	[10.5]
Total	[100.00]	[100.0]

(1) Streuberg, Germany; by electron microprobe, average of five analyses, H_2O by difference; corresponds to $(Ba_{1.22}Ca_{0.58})_{\Sigma=1.80}(UO_2)_{2.93}(PO_4)_{2.07}(OH)_4 \cdot 5.5H_2O$. (2) Do.; by electron microprobe, H_2O by difference.

Occurrence: On a mine dump (Streuberg, Germany).

Association: "Uranocircite", torbernite, autunite, dewindtite, barian uranophane (Streuberg, Germany).

Distribution: In Germany, from the Streuberg, near Bergen, Saxony, and at Menzenschwand, Black Forest.

Name: For the first-noted occurrence of the mineral near Bergen, Germany.

Type Material: n.d.

References: (1) Bültemann, H.W. and G.H. Moh (1959) Bergenit, ein neues Mineral der Phosphuranylit-Gruppe. Neues Jahrb. Mineral., Monatsh., 232–233 (in German). (2) (1960) Amer. Mineral., 45, 909 (abs. ref. 1). (3) Piret, P. and M. Deliens (1981) Nouvelles données sur la bergenite holotype. Bull. Minéral., 104, 16–18 (in French with English abs.).

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Bergslagite $CaBe(AsO_4)(OH)$

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Crystal Data: Monoclinic or triclinic, pseudomonoclinic. *Point Group:* $2/m$ or $\overline{1}$. As elongated, flattened crystals, to 1 cm, showing {100} and {001}; in crusts.

Physical Properties: *Fracture:* Uneven. Hardness = 5 D(meas.) = 3.40(2) D(calc.) = 3.40 Fluoresces pale shades of yellowish brown, greenish, or bluish under SW UV.

Optical Properties: Translucent. *Color:* Colorless, white or gray, dark gray-brown, brownish black; may be green or pink. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Orientation:* $X \simeq a$; $Y = b$; $Z \simeq c$. *Dispersion:* $r \gg v$.
$\alpha = 1.659$–1.660 $\beta = 1.678$–1.681 $\gamma = 1.690$–1.694 2V(meas.) = ∼70° 2V(calc.) = 74°–78°

Cell Data: *Space Group:* $P2_1/c$. $a = 4.8818(9)$ $b = 7.809(1)$ $c = 10.127(1)$ $\beta = 90.16(1)°$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.200 (10), 3.519 (8), 4.879 (7), 3.905 (7), 3.046 (7), 2.917 (7), 2.409 (6)

Chemistry:

	(1)	(2)
As_2O_5	51.58	56.06
SiO_2	2.48	
BeO	13.0	12.20
CaO	28.57	27.35
H_2O	6.0	4.39
Total	101.63	100.00

(1) Långban, Sweden; by electron microprobe, average of ten analyses, BeO from average of three determinations, by AA, emission spectroscopy, and the Weisz Ring-Oven technique, H_2O by TGA; corresponds to $Ca_{0.99}Be_{1.02}[(AsO_4)_{0.87}(SiO_4)_{0.08}]_{\Sigma=0.95}(OH)_{1.30}$. (2) $CaBe(AsO_4)(OH)$.

Occurrence: In thin veins in pieces of hematite ore found on mine dumps from a metamorphosed Fe–Mn orebody (Långban, Sweden); in rhyolite (Sailauf, Germany).

Association: Manganoan diopside, manganberzeliite, tilasite, svabite, hematite, calcite, barite (Långban, Sweden); hematite, muscovite (Sailauf, Germany).

Distribution: From Långban, Värmland, Sweden. In Switzerland, in the Falotta mine, Oberhalbstein, and in the Fianel mine, Val Ferrera, Graubünden; on the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais. At Sailauf, northeast of Aschaffenburg, Spessart Mountains, Bavaria, Germany.

Name: For the occurrence at Långban, which is in the *Bergslagen* region of Sweden.

Type Material: University of Copenhagen, Copenhagen, Denmark; National Museum of Natural History, Washington, D.C., USA, 162582.

References: (1) Hansen, S., L. Fälth, O.V. Petersen, and O. Johnsen (1984) Bergslagite, a new mineral species from Långban, Sweden. Neues Jahrb. Mineral., Monatsh., 257–262. (2) Hansen, S., L. Fälth, and O. Johnsen (1984) Bergslagite, a mineral with tetrahedral berylloarsenate sheet anions. Zeits. Krist., 166, 73–80. (3) (1985) Amer. Mineral., 70, 436 (abs. refs. 1 and 2). (4) Kolitsch, U. (1996) Bergslagit aus dem Rhyolith-Steinbruch bei Sailauf im Spessart. Mineralien Welt, 7(5), 45–46 (in German).

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Berlinite $AlPO_4$

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Crystal Data: Hexagonal. *Point Group:* 32. Granular, to 6 mm, massive.
Twinning: Subparallel twinning lamellae.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼6.5 D(meas.) = 2.64–2.66 D(calc.) = 2.618 May fluoresce dark red under UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, pale gray, may be pale rose; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.524(1)$ $\epsilon = 1.532(1)$

Cell Data: *Space Group:* $P3_121$ (synthetic). $a = 4.941(2)$ $c = 10.940(3)$ Z = 3

X-ray Powder Pattern: Synthetic.
3.369 (100), 4.28 (25), 1.835 (16), 2.471 (12), 2.306 (12), 1.393 (12), 1.389 (12)

Chemistry:

	(1)	(2)
P_2O_5	58.43	58.20
SiO_2	0.13	
Al_2O_3	41.88	41.80
Fe_2O_3	0.04	
Total	100.48	100.00

(1) Mt. Perry, Australia; by electron microprobe, total Fe as Fe_2O_3. (2) $AlPO_4$.

Occurrence: A rare high-temperature hydrothermal or metasomatic mineral.

Association: Augelite, attakolite, kyanite, pyrophyllite, scorzalite, lazulite, gatumbaite, burangaite, amblygonite, phosphosiderite, purpurite, apatite, muscovite, quartz, hematite (granite pegmatites); alunite, aragonite, collophane, crandallite, francoanellite, gypsum, huntite, hydromagnesite, leucophosphite, nesquehonite, niter, nitrocalcite (Paddy's River mine, Australia).

Distribution: In the Västanå mine, near Näsum, Skåne, and at Hålsjöberg, Värmland, Sweden. In Rwanda, in the Buranga and Rusororo pegmatites, Gatumba district. In Australia, on Mt. Perry, 75 km southwest of Bundaberg, Queensland, and at Paddy's River mine, Australian Capital Territory. From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil.

Name: Honoring Professor Nils Johan Berlin (1812–1891), pharmacologist, University of Lund, Lund, Sweden.

Type Material: Wroclaw University, Wroclaw, Poland, II–9574; Harvard University, Cambridge, Massachusetts, USA, 101252.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 696–697. (2) Gallagher, M.J. and J.F. Gerards (1962) Berlinite from Rwanda. Mineral. Mag., 33, 613–615. (3) Duggan, M.B., M.T. Jones, D.N.G. Richards, and J.L. Kamprad (1990) Phosphate minerals in altered andesite from Mount Perry, Queensland, Australia. Can. Mineral., 28, 125–131. (4) Sowa, H., J. Macavei, and H. Schultz (1990) The crystal structure of berlinite $AlPO_4$ at high pressure. Zeits. Krist., 192, 119–136. (5) (1960) NBS Circ. 539, 10, 3.

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Bermanite $Mn^{2+}Mn^{3+}_2(PO_4)_2(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are tabular on {010}, with additional forms, to 5 mm; as sheaflike aggregates and rosettes; generally as thin films or druses on fractures. *Twinning:* Polysynthetic about [101] with composition plane $\{\overline{1}01\}$ or about $[\overline{1}01]$ with composition plane {101}, common; as reflection twins, on {001} about [100], or with two more individuals twinned on $\{\overline{3}01\}$ about [100] producing composite fourlings.

Physical Properties: *Cleavage:* Perfect on {001}; imperfect on {110}. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.84–2.85 D(calc.) = 2.87

Optical Properties: Translucent. *Color:* Reddish brown, darkening on exposure; yellowish brown to brownish red, with red internal reflections, in transmitted light. *Luster:* Vitreous to slightly resinous, dull.
Optical Class: Biaxial (–). *Pleochroism:* X = light red; Y = pale yellow; Z = deep red. *Orientation:* $X = b$; $Y \wedge a = 32.5°$; $Y \wedge c = -36.5°$. *Dispersion:* $r < v$, strong. *Absorption:* $Z > X > Y$. α = 1.685–1.690 β = 1.725–1.729 γ = 1.748–1.751 2V(meas.) = 72°–75°

Cell Data: *Space Group:* $P2_1$. a = 5.425–5.446 b = 19.206–19.25 c = 5.425–5.428 β = 110.29°−110.40° Z = 2

X-ray Powder Pattern: 7U7 Ranch, Arizona, USA.
9.63 (100), 2.905 (36), 4.82 (28), 3.263 (23), 3.673 (19), 5.10 (16), 3.062 (11)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	31.4	30.80	Mn_2O_3	30.6	34.26	CaO	0.75	
Al_2O_3	0.19		MnO	12.8	15.39	H_2O	20.2	19.55
Fe_2O_3	3.20		MgO	1.05		Total	100.19	100.00

(1) 7U7 Ranch, Arizona, USA; corresponding to $(Mn^{2+}_{0.82}Mg_{0.12}Ca_{0.06})_{\Sigma=1.00}(Mn^{3+}_{1.75}Fe^{3+}_{0.18}Al_{0.02})_{\Sigma=1.95}(PO_4)_2(OH)_2 \cdot 3.99H_2O$. (2) $Mn^{2+}Mn^{3+}_2(PO_4)_2(OH)_2 \cdot 4H_2O$.

Occurrence: A late-stage hydrothermal mineral replacing primary phosphate phases, usually triplite or lithiophilite, in complex granite pegmatites.

Association: Triplite, strengite, leucophosphite, huréaulite, lithiophilite, stewartite, sicklerite, rockbridgeite, phosphosiderite, strunzite, switzerite, paulkerrite.

Distribution: In the USA, from the 7U7 Ranch, 40 km west of Hillside, Bagdad district, Yavapai Co., Arizona; in the Williams pegmatite, Coosa Co., Alabama; at the Stewart Lithia mine, Pala, San Diego Co., California; from the White Elephant, Bull Moose, Linwood, and Tip Top mines, near Custer, Custer Co., South Dakota; in the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., New Hampshire. At the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina. From the McMahon quarry, near Olary, and in the Wiperaminga Hill West quarry, Boolcoomata, South Australia. From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. At the Buranga pegmatite, near Gatumba, Rwanda. In the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire). From the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. At Hagendorf, Bavaria, Germany. Other minor localities have been noted.

Name: In honor of Dr. Harry Berman (1902–1944), Professor of Mineralogy, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 97863–97865, 119698; National Museum of Natural History, Washington, D.C., USA, 120405.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 967–968. (2) Hurlbut, C.S., Jr. and L.F. Aristarain (1968) Bermanite, and its occurrence in Córdoba, Argentina. Amer. Mineral., 53, 416–431. (3) Kampf, A.R. and P.B. Moore (1976) The crystal structure of bermanite, a hydrated manganese phosphate. Amer. Mineral., 61, 1241–1248.

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Bernalite $Fe(OH)_3 \cdot nH_2O$ (n = 0.0 to 0.25)

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$. As flattened pyramidal crystals and pseudo-octahedra, to 3 mm, with slightly concave faces. *Twinning:* Polysynthetic, crosshatched, observed in thin section, probably pinacoidal.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 3.32(2) D(calc.) = 3.35

Optical Properties: Transparent to opaque due to goethite inclusions. *Color:* Dark bottle-green to yellow-green; in thin section, yellowish bottle-green. *Streak:* Apple-green. *Luster:* Vitreous to adamantine when fresh; resinous on crystal surfaces. *Optical Class:* Biaxial. n = 1.92–1.94 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pmmn$, probable, or $Immm$, possible. a = 7.544(2) b = 7.560(4) c = 7.558(2) Z = 8

X-ray Powder Pattern: Broken Hill, Australia.
3.784 (100), 1.692 (17), 2.393 (16), 2.676 (15), 1.892 (10), 1.545 (9), 2.023 (6)

Chemistry:

	(1)
SiO_2	2.99
Fe_2O_3	65.53
ZnO	1.13
PbO	2.70
H_2O	25.2
CO_2	1.0
Total	98.55

(1) Broken Hill, Australia; by electron microprobe, average of eight analyses, Fe^{3+} confirmed by Mössbauer spectroscopy, H_2O and CO_2 by CHN analyzer; corresponds to $(Fe^{3+}_{0.93}Si_{0.06}Zn_{0.01})_{\Sigma=1.00}[(OH)_{2.95}O_{0.04}]_{\Sigma=2.99} \cdot [(H_2O)_{0.04}(CO_2)_{0.03}Pb_{0.01}]_{\Sigma=0.08}$.

Occurrence: On a museum specimen from a metamorphosed Pb–Zn deposit, probably from the surface oxidation zone.

Association: Goethite, coronadite.

Distribution: From the Proprietary mine, Broken Hill, New South Wales, Australia.

Name: To honor John Desmond Bernal (1901–1971), eminent British crystallographer and historian of science.

Type Material: Museum Victoria, Melbourne; South Australian Museum, Adelaide, Australia, G17627.

References: (1) Birch, W.D., A. Pring, A. Reller, and H.W. Schmalle (1993) Bernalite, $Fe(OH)_3$, a new mineral from Broken Hill, New South Wales: description and structure. Amer. Mineral., 78, 827–834. (2) McCammon, C.A., A. Pring, H. Keppler, and T. Sharp (1995) A study of bernalite, $Fe(OH)_3$, using Mössbauer spectroscopy, optical spectroscopy and transmission electron microscopy. Phys. Chem. Minerals, 22, 11–20.

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Bernardite $Tl(As,Sb)_5S_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are thick tabular, partly corroded and striated, with prominent {100}, {012}, {210}, and {201}, {$\overline{2}$01}, {010}, to 4 mm.

Physical Properties: *Fracture:* Subconchoidal to uneven. Hardness = ∼2 D(meas.) = 4.5(1) D(calc.) = 4.105

Optical Properties: Semitransparent. *Color:* Black. *Streak:* Red. *Luster:* Dull. *Optical Class:* Biaxial.
R_1–R_2: (400) 29.6–32.3, (420) 28.9–31.8, (440) 28.1–31.3, (460) 27.4–30.6, (480) 26.8–29.9, (500) 26.0–28.9, (520) 25.4–27.8, (540) 25.0–26.7, (560) 24.5–25.8, (580) 24.0–25.1, (600) 23.6–24.4, (620) 23.3–23.9, (640) 23.1–23.4, (660) 22.9–23.0, (680) 22.8–22.8, (700) 22.8–22.5

Cell Data: *Space Group:* $P2_1/c$. $a = 15.647(4)$ $b = 8.038(3)$ $c = 10.750(3)$ $\beta = 91.27(3)^\circ$ Z = 4

X-ray Powder Pattern: Alšar, Macedonia (calculated).
3.06 (100), 4.28 (74), 4.46 (65), 3.07 (65), 3.68 (63), 2.68 (59), 3.72 (55)

Chemistry:

	(1)	(2)	(3)
Tl	23.3	22.7	24.46
As	43.7	35.2	44.84
Sb	0.1	10.4	
S	31.5	29.8	30.70
Total	98.6	98.1	100.00

(1) Alšar, Macedonia; by electron microprobe, corresponding to $Tl_{0.93}(As_{4.75}Sb_{0.01})_{\Sigma=4.76}S_{8.00}$.
(2) Do.; by electron microprobe, corresponding to $Tl_{0.96}(As_{4.04}Sb_{0.74})_{\Sigma=4.78}S_{8.00}$. (3) $TlAs_5S_8$.

Occurrence: In a hydrothermal deposit with other As–Tl sulfide minerals.

Association: Realgar, orpiment, hutchinsonite, wallisite, hatchite, lorandite, edenharterite, erniggliite, stalderite (Binntal, Switzerland).

Distribution: From Alšar (Allchar), near Rošden, Macedonia [TL]. At the Lengenbach quarry, Binntal, Valais, Switzerland.

Name: In honor of Dr. Jan H. Bernard, mineralogist, Geological Survey of Czechoslovakia, who first noted the mineral.

Type Material: Národni Museum, Prague, Czech Republic; Natural History Museum, Vienna; Institute for Mineralogy and Crystallography, University of Vienna, Austria.

References: (1) Pašava, J., F. Pertlik, E.F. Stumpfl, and J. Zemann (1989) Bernardite, a new thallium arsenic sulphosalt from Allchar, Macedonia, with a determination of the crystal structure. Mineral. Mag., 53, 531–538. (2) (1990) Amer. Mineral., 75, 1209 (abs. ref. 1).

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Berndtite SnS_2

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ (2T) and $6mm$ (4H). Tabular hexagonal crystals, to 0.01 mm, in powdery aggregates.

Physical Properties: *Cleavage:* {0001}, marked. Hardness = Very soft. VHN = n.d. D(meas.) = 4.5 (synthetic). D(calc.) = [4.55]

Optical Properties: Translucent to transparent. *Color:* Pale yellow; in polished section, gray, with intense brownish to yellow-orange internal reflections. *Luster:* Resinous. *Streak:* Golden yellow. *Pleochroism:* Strong. *Anisotropism:* Dark greenish gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P\overline{3}m1$ (2T), with $a = 3.639$ $c = 5.868$ Z = 1, or
Space Group: $P6_3mc$ (4H), with $a = 3.650$ $c = 11.811$ Z = 2

X-ray Powder Pattern: Synthetic.
5.89 (100), 2.784 (55), 3.162 (30), 1.824 (30), 2.155 (25), 1.743 (20), 1.669 (8)

Chemistry: Sn and S are major constituents.

Polymorphism & Series: Stacking polytypes 2T and 4H are known.

Mineral Group: Melonite group.

Occurrence: A secondary mineral in tin sulfide ores (Cerro de Potosí, Bolivia); a secondary mineral in a tin-bearing pegmatite (Lagares-do-Estanho tin pegmatite); in a high-temperature deposit, hydrothermally altered (Arandis, Namibia).

Association: Stannite, pyrite, cassiterite, sulfur.

Distribution: From Cerro [Rico], Potosí, Bolivia [2T TL]. In Portugal, at Panasqueira [4H TL] and from the Lagares-do-Estanho tin pegmatite. In the Stiepelmann mine, Arandis, Namibia. From Forestville, Northumberland Co., Pennsylvania, USA.

Name: For Dr. Fritz Berndt, German mineralogist, Corporatión Minera de Bolivia, Oruro, Bolivia.

Type Material: National Museum of Natural History, Washington, D.C., USA, 114486, C5354A.

References: (1) Moh, G.H. and F. Berndt (1964) Two new natural tin sulfides, Sn_2S_3 and SnS_2. Neues Jahrb. Mineral., Monatsh., 94–95. (2) (1965) Amer. Mineral., 50, 2107 (abs. ref. 1). (3) Moh, G.H. (1966) Das binäre System Zinn-Schwefel und seine Minerale. Fortschr. Mineral. (abs.) 42, 211. (4) Clark, A.H. (1972) On the natural occurrence of tin sulfides (berndtite). Naturwissenschaften, 59, 361. (5) Hazen, R.M. and L.W. Finger (1978) The crystal structures and compressibilities of layer minerals at high pressure. I. SnS_2, berndtite. Amer. Mineral., 63, 289–292.

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Berryite $Pb_3(Cu,Ag)_5Bi_7S_{16}$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$ or 2. Lathlike aggregates of several not quite parallel individuals, to a maximum length of 1 mm; granular, massive. *Twinning:* Repeated.

Physical Properties: *Cleavage:* Poor. Hardness = n.d. VHN = 131–152 (100 g load), 171 (100 g load). D(meas.) = 6.7, corrected for admixed quartz. D(calc.) = [6.83]

Optical Properties: Opaque. *Color:* White to pale gray in polished section.
Pleochroism: Weak to distinct. *Anisotropism:* Distinct to strong, from pale gray to red-brown and green.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P\ 2_1/m$ or $P2_1$. $a = 12.72$ $b = 4.02$ $c = 58.07$ $\beta = 102.5°$
Z = [4]

X-ray Powder Pattern: Nordmark, Sweden.
3.47 (10), 2.89 (8), 2.80 (7), 2.18 (4), 3.70 (2), 2.86 (2), 3.23 (1)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb	21.6	20.8	20.9	Bi	49.2	47.5	49.5
Ag	4.9	6.8	7.4	S	[17.2]	[17.2]	17.0
Cu	7.1	7.8	5.3	Total	[100.0]	[100.1]	100.1

(1) Ivigtut, Greenland; by electron microprobe, sulfur by difference, recalculated to be near 100%; corresponds to $Pb_{3.15}(Cu_{3.40}Ag_{1.35})_{\Sigma=4.75}Bi_{7.10}S_{16.20}$. (2) Do.; corresponds to $Pb_{2.95}(Cu_{3.60}Ag_{1.80})_{\Sigma=5.40}Bi_{6.65}S_{15.65}$. (3) Owen Lake, Canada; by electron microprobe, average of several grains; corresponds to $Pb_{3.09}(Cu_{2.55}Ag_{2.10})_{\Sigma=4.55}Bi_{7.25}S_{16.25}$.

Occurrence: In quartz veins with other sulfides and sulfosalts, and in siderite-rich cryolite (Ivigtut, Greenland).

Association: Emplectite, aikinite, cuprobismutite, cupropavonite (Colorado, USA); galena, chalcopyrite, sphalerite, quartz (Nordmark, Sweden); galena, cosalite, ourayite, matildite, aikinite (Ivigtut, Greenland); aikinite, matildite, benjaminite, quartz, barite (Tary Ekan deposit, Kazakhstan).

Distribution: In the USA, in Colorado, from the Missouri mine, Park Co. [TL], the Mike mine, Silverton district, San Juan Co., and Cinnamon Gulch, Northeast Montezuma district, Clear Creek Co.; at the Outlaw mine, Round Mountain, Manhattan, Nye Co., Nevada. From near Owen Lake, south of Houston, British Columbia, Canada. In the Ivigtut cryolite deposit, southwestern Greenland. At Nordmark, Värmland, Sweden. From the Catarama mine, Baia Borşa district, Baia Mare (Nagybánya), Romania. In the Svishti Plaz gold deposit, central Balkan Mountains, Bulgaria. From two km west of Lairg, Scotland. In the Adrasman, Kaptar-Hana, and Tary Ekan deposits, eastern Karamazar, Tajikistan. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. At the Funiushan copper skarn deposit, near Nanjing, Jiangsu Province, China. Several additional localities are known.

Name: In honor of Professor Leonard Gascoigne Berry (1914–1982), Canadian mineralogist, Queen's University, Kingston, Ontario, Canada, who obtained the first X-ray powder pattern of the mineral.

Type Material: University of Copenhagen, Copenhagen, Denmark; National Museum of Natural History, Washington, D.C., USA, 92902.

References: (1) Nuffield, E.W. and D.C. Harris (1966) Studies of mineral sulpho-salts: XX—berryite, a new species. Can. Mineral., 8, 407–413. (2) Karup-Møller, S. (1966) Berryite from Greenland. Can. Mineral., 8, 414–423. (3) (1967) Amer. Mineral., 52, 928 (abs. refs. 1 and 2). (4) Harris, D.C. and D.R. Owen (1973) Berryite, a Canadian occurrence. Can. Mineral., 11, 1016–1018. (5) Vendrell-Saz, M., S. Karup-Møller, and A. Lopez-Soler (1978) Optical and microhardness study of some Ag–Cu–Pb–Bi sulphides. Neues Jahrb. Mineral., Abh., 132, 101–112.

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Berthierine $(Fe^{2+}, Fe^{3+}, Al, Mg)_{2-3}(Si, Al)_2O_5(OH)_4$

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Crystal Data: Monoclinic; in part hexagonal or orthorhombic. *Point Group:* m. Commonly as microcrystalline oolitic aggregates.

Physical Properties: Hardness = Soft. D(meas.) = n.d. D(calc.) = [3.06]

Optical Properties: Transparent. *Color:* Dark olive-green, yellowish green.
Optical Class: [Biaxial.] n = 1.62–1.65 2V(meas.) = n.d.

Cell Data: *Space Group:* Cm. a = 5.25–5.41 b = 9.10–9.33 c = 7.06–7.27 $\beta = 104.5°$
Z = [2]

X-ray Powder Pattern: Stanion Lane pit, Corby, England; 1H.
7.105 (100), 3.546 (100), 2.520 (100), 2.147 (70), 1.560 (70), 1.775 (60), 1.478 (60)

X-ray Powder Pattern: Ayrshire, Scotland; mixed 1M and 1H.
7.04 (100), 3.513 (100), 2.514 (90), 1.552 (70), 2.137 (60), 2.673 (40), 2.399 (40)

Chemistry:

	(1)	(2)
SiO_2	20.84	26.01
TiO_2	0.51	
Al_2O_3	28.02	12.33
Fe_2O_3	5.38	5.32
FeO	32.29	37.07
MnO		0.04
MgO	2.02	6.13
CaO		0.48
H_2O	10.70	10.33
Total	99.76	97.71

(1) Belgorod district, Kursk, Russia; corresponds to $(Fe^{2+}_{1.48}Al_{0.96}Fe^{3+}_{0.22}Mg_{0.16})_{\Sigma=2.82}(Si_{1.15}Al_{0.85})_{\Sigma=2.00}O_{5.04}(OH)_{3.93}$. (2) Kaňk, Czech Republic; corresponds to $(Fe^{2+}_{1.81}Mg_{0.53}Al_{0.36}Fe^{3+}_{0.23})_{\Sigma=2.93}(Si_{1.52}Al_{0.48})_{\Sigma=2.00}O_{5.00}(OH)_{4.00}$.

Polymorphism & Series: 1M and 1H polytypes.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Common in unmetamorphosed marine sediments; in lateritic and polar soils.

Association: Glauconite, chlorite-vermiculite interstratified with mica-smectite, siderite, calcite.

Distribution: Widespread; a few localities for studied material are: at Hayange, Meurthe-et-Moselle, France. In several mines in the Weardale fluorite district, Durham; in the Stanion Lane pit, Corby, Northamptonshire; on the Worth Farm and in the Philpots quarry, West Sussex, England. From the Belgorod district and the Voronezh anticline, Kursk, Russia. In the Chichibu mine, Saitama Prefecture, Japan. On Ellef Ringnes Island, Northwest Territories; from near Picton, Ontario; and at Mont Saint-Hilaire, Quebec, Canada.

Name: Honors the French geologist, Pierre Berthier (1782–1861).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 658.
(2) Brindley, G.W. (1951) The crystal structure of some chamosite minerals. Mineral. Mag., 29, 502–530. (3) Brindley, G.W. and R.F. Youell (1953) Ferrous chamosite and ferric chamosite. Mineral. Mag., 37, 57–70. (4) Brindley, G.W. (1982) Chemical composition of berthierines – a review. Clays and Clay Minerals, 30, 153–155.

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Berthierite $FeSb_2S_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Prismatic crystals elongated and striated ‖ [001], to 1 cm, typically unterminated; fibrous, plumose or radial, brushes to 6 cm; granular, massive.

Physical Properties: *Cleavage:* Prismatic, indistinct. *Tenacity:* Brittle. Hardness = 2–3 VHN = n.d. D(meas.) = 4.64 D(calc.) = 4.68

Optical Properties: Opaque. *Color:* Dark steel-gray, commonly tarnished iridescent or pinchbeck-brown; in polished section, gray. *Streak:* Dark brownish gray. *Luster:* Metallic. *Pleochroism:* Marked. *Anisotropism:* Strong.
R_1–R_2: (400) 32.6–46.2, (420) 32.2–45.9, (440) 31.8–45.5, (460) 31.2–45.0, (480) 30.7–44.4, (500) 30.4–43.8, (520) 30.2–43.1, (540) 30.3–42.5, (560) 30.4–41.9, (580) 30.8–41.4, (600) 31.1–40.8, (620) 31.4–40.3, (640) 31.4–39.9, (660) 31.4–39.4, (680) 31.4–38.9, (700) 31.3–38.4

Cell Data: *Space Group: Pnam.* $a = 11.401(2)$ $b = 14.148(3)$ $c = 3.758(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
2.601 (100), 2.621 (93), 3.663 (92), 2.862 (78), 3.181 (77), 2.999 (52), 3.628 (51)

Chemistry:

	(1)	(2)
Fe	13.43	13.06
Mn	trace	
Sb	56.06	56.95
S	29.46	29.99
insol.	0.33	
Total	99.28	100.00

(1) Herja, Romania; corresponds to $Fe_{1.05}Sb_{2.01}S_{4.00}$. (2) $FeSb_2S_4$.

Occurrence: In low-temperature hydrothermal antimony veins, in portions deficient in sulfur.

Association: Stibnite, arsenopyrite, pyrite, barite, calcite, quartz.

Distribution: Localities are numerous. In France, from Chazelles, Auvergne [TL], Pontgibaud, Puy-de-Dôme, and Valcros, Provence. At Herja (Kisbánya), Baia Mare (Nagybánya) district, and Baia Sprie (Felsőbánya), Romania. From Příbram and Kutná Hora, Czech Republic. At Bräunsdorf, near Freiberg, Saxony, Germany. From Ribnova, southern Rhodope Mountains, Bulgaria. In the Niccioleta mine, Tuscany, Italy. In Mexico, from San Martin, Concepción del Oro, Zacatecas; and from mines near Triunfo, Baja California. At Chashan, Guangxi Province, China. [ck??Japan??]

Name: For Pierre Berthier (1782–1861), French chemist.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 481–482. (2) Barton, P.B., Jr. (1971) The Fe–Sb–S system. Econ. Geol., 66, 121–132. (3) Lemoine, P., D. Carré, and F. Robert (1991) Structure du sulfure de fer et d'antimoine, $FeSb_2S_4$ (berthiérite). Acta Cryst., C47, 938–940 (in French with English abs.). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 43.

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Bertossaite $(Li, Na)_2CaAl_4(PO_4)_4(OH, F)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Massive.

Physical Properties: *Cleavage:* On {100}, good. *Fracture:* Uneven to subconchoidal. Hardness = 6 D(meas.) = 3.10 D(calc.) = 3.10

Optical Properties: Semitransparent. *Color:* Pale pink; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, moderately strong. $\alpha = 1.624(3)$ $\beta = 1.636(3)$ $\gamma = 1.642(3)$ 2V(meas.) = Moderately large. 2V(calc.) = 53°

Cell Data: *Space Group: Imcb.* $a = 11.48(1)$ $b = 15.73(2)$ $c = 7.23(1)$ Z = 4

X-ray Powder Pattern: Buranga pegmatite, Rwanda. (ICDD 41-1450).
3.059 (100), 3.104(84), 2.411 (63), 3.295 (60), 2.881 (57), 2.577 (40), 4.32 (33)

Chemistry: (1) Buranga pegmatite, Rwanda; an analysis was not published - based on other properties it is stated to be the calcium analog of palermoite, $(Sr, Ca)(Li, Na)_2Al_4(PO_4)_4(OH)_4$.

Occurrence: Thought to be formed during a late calcium-rich phase of mineralization in a lithium-bearing granite pegmatite.

Association: Amblygonite, lazulite-scorzalite, augelite, brazilianite, apatite, crandallite, trolleite, samuelsonite, quartz.

Distribution: In the Buranga pegmatite, near Gatumba, Rwanda.

Name: Honoring Antonio Bertossa, Director of the Geological Survey of Rwanda.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMB11232; National Museum of Natural History, Washington, D.C., USA, 141000.

References: (1) von Knorring, O. and M.E. Mrose (1966) Bertossaite, $(Li, Na)_2(Ca, Fe, Mn)Al_4(PO_4)_4(OH, F)_4$, a new mineral from Rwanda, Africa. Can. Mineral., 8, 668 (abs.).
(2) (1967) Amer. Mineral., 52, 1583 (abs. ref. 1).

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Bertrandite $Be_4Si_2O_7(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals thin tabular, commonly prismatic to needlelike, to 5 cm; in radial aggregates. *Twinning:* Common on {011} or {021}; twins heart-shaped or V-shaped with axes crossing at angles of about 60° and 120°.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {100}, {010}, and {110}. Hardness = 6–7 D(meas.) = 2.59–2.60 D(calc.) = [2.61] Pyroelectric.

Optical Properties: Transparent. *Color:* Colorless to slightly yellow. *Luster:* Vitreous, pearly on {001}.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$. *Dispersion:* $r < v$, weak.
$\alpha = 1.583–1.591$ $\beta = 1.598–1.605$ $\gamma = 1.608–1.614$ 2V(meas.) = ∼75°

Cell Data: *Space Group:* $Cmc2_1$. $a = 8.7135(4)$ $b = 15.268(1)$ $c = 4.5683(3)$ Z = 4

X-ray Powder Pattern: Mica Creek, Mt. Isa, Queensland, Australia.
4.38 (100), 3.19 (90), 2.54 (80), 2.28 (60), 2.22 (50), 3.94 (40), 1.305 (40)

Chemistry:

	(1)	(2)
SiO_2	49.26	50.44
Al_2O_3	trace	
Fe_2O_3	1.40	
BeO	42.0	42.00
H_2O	6.90	7.56
Total	99.56	100.00

(1) Barbin, France. (2) $Be_4Si_2O_7(OH)_2$.

Occurrence: In fissures in granites and associated pegmatites and in miarolitic cavities in greisens; commonly an alteration product of beryl, more rarely as a primary mineral.

Association: Beryl, phenakite, herderite, tourmaline, muscovite, fluorite, quartz.

Distribution: In small amounts at numerous localities. A few affording pure material or larger crystals include: in France, near Nantes, in the Barbin quarries at Petit-Port, Loire-Atlantique. At Val Vigezzo, Piedmont, Italy. From Písek, Czech Republic. In the USA, in the Strickland quarry, Portland, Middlesex Co., Connecticut; in Virginia, at Amelia, Amelia Co.; in Colorado, on Mt. Antero, Chaffee Co. and elsewhere. At Spor Mountain, Juab Co., Utah, a large commercial deposit; in the Pala district, San Diego Co., California. In a large deposit at Sierra de Aguachile, Acuña, Coahuila, Mexico. Large crystals at the Golconda mine, near Governador Valadares, Minas Gerais, Brazil. From Klein Spitzkopje, Namibia. In the Tae Hwa mine, Chung Cheong Buk Do, South Korea. From Akchatau, Kara-Oba, and Kounrad, Kazakhstan.

Name: Honoring Emile Bertrand (1844–1909), French mineralogist.

Type Material: National School of Mines, Paris, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 545–546.
(2) Vernon, R.H. and K.L. Williams (1960) Bertrandite from Mica Creek, Queensland. Amer. Mineral., 45, 1300–1303. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 89–93. (4) Henderson, W.A. (1975) The bertrandites of Connecticut. Mineral. Record, 6, 114–123. (5) Downs, J.W. and F.K. Ross (1987) Neutron-diffraction study of bertrandite. Amer. Mineral., 72, 979–983.

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Beryl $Be_3Al_2Si_6O_{18}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals prismatic to tabular, with $\{10\bar{1}0\}$, $\{0001\}$, and $\{11\bar{2}0\}$; may be complexly terminated by pyramids, to 18 m and 180 t. Also radial, trapiche, columnar; granular to compact. *Twinning:* On $\{hk\bar{i}l\}$ forms, rarely.

Physical Properties: *Cleavage:* Imperfect on $\{0001\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 7.5–8 VHN = 1190–1450, 1300 average. D(meas.) = 2.63–2.97 increasing with alkali content; 2.7 average. D(calc.) = 2.640

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale blue to sky-blue, bluish green through green to greenish yellow or yellow, rose to peach, deep pink to raspberry-red; may be zoned; commonly colorless in thin section. *Streak:* White. *Luster:* Vitreous, resinous. *Optical Class:* Uniaxial (–). *Pleochroism:* Weak to distinct; O = colorless, yellowish green, light blue, yellowish red; E = sea-green, blue, purplish red. ω = 1.567–1.610 ϵ = 1.565–1.599; increasing with alkali content.

Cell Data: *Space Group:* $P6/mcc$. a = 9.205–9.274 c = 9.187–9.249 Z = 2

X-ray Powder Pattern: Royalston, Massachusetts, USA.
2.867 (100), 3.254 (95), 7.98 (90), 4.60 (50), 3.99 (45), 3.015 (35), 2.523 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	65.59	63.29	67.07	Na_2O	0.26	1.23	
Al_2O_3	18.25	17.76	18.97	Cs_2O		3.79	
FeO	1.16			Rb_2O		0.05	
BeO	13.46	10.79	13.96	LOI	0.70	1.10	
Li_2O		1.30		Total	99.42	99.31	100.00

(1) Mursinka, Russia; by electron microprobe. (2) Nuristan district, Laghman Province. Afghanistan; by electron microprobe. (3) $Be_3Al_2Si_6O_{18}$.

Occurrence: In granites and granite pegmatites, rarely in nepheline syenites. Also in mafic metamorphic rocks, low- to high-temperature hydrothermal veins and in vugs in rhyolite.

Association: Quartz, feldspar, muscovite, lepidolite, spodumene, amblygonite, tourmaline, topaz, cassiterite, columbite, tantalite.

Distribution: Prominent localities for fine specimens include: in Russia, in the Mursinka-Alabashka area, near Yekaterinburg (Sverdlovsk), Ural Mountains, and from Nerchinsk south to Borzya, Adun-Chilon Mountains, Siberia. At Volhynia, Ukraine. In the Muiâne pegmatite, Alto Ligonha district, Mozambique. From Madagascar, especially around Mt. Bity, south of Antsirabe, with giant crystals from the Malakialina district. In the Rafin-Gabas Hills, near Jos, Nigeria. In the Sandawana-Belingwe area, Mweza Range, Zimbabwe. Exceptional green crystals from the Muzo and Chivor districts, Boyacá Province, Colombia. In Brazil, from Minas Gerais, in large districts around Teófilo Otoni, Governador Valadares, Conselheiro Pena, and Itabira. Around Mingora, Swat district; from Dassu and the Skardu district; at Kunar and Nagar, near Karimabad, Hunza district, Pakistan. In Afghanistan, around Khenj, Panjshir Valley. In the USA, from the Pala and Rincon districts, San Diego Co., California; at Hiddenite, Alexander Co., North Carolina; fine red crystals in the Wah Wah Mountains, Beaver Co., Utah; on Mt. Antero, Chaffee Co., Colorado; and in the Sawtooth Mountains area, Idaho.

Name: From the Greek *beryllos*, original significance unknown.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 405–409. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 372–409. (3) Sinkankas, J. (1981) Emeralds and other beryls. Chilton, Radnor, Pennsylvania, USA, 665 pp. (4) Aurisicchio, C., G. Fioravanti, O. Grubessi, and P.F. Zanazzi (1988) Reappraisal of the crystal chemistry of beryl. Amer. Mineral., 73, 826–837.

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Beryllite $Be_3SiO_4(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic or monoclinic. *Point Group:* n.d. As fine spherulites, to 3 mm; as drusy segregations and fibrous crusts; powdery masses and coatings on other minerals.

Physical Properties: Hardness = 1 in aggregate. D(meas.) = 2.196 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* White. *Luster:* Silky.
Optical Class: Biaxial (–). $\alpha = 1.50–1.544$ $\beta = 1.553(2)$ $\gamma = 1.52–1.562$ 2V(meas.) = $< 45°$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Lovozero massif, Russia.
4.01 (100), 2.34 (100), 3.64 (90), 1.351 (80), 3.39 (70), 3.19 (70), 2.90 (70)

Chemistry:

	(1)	(2)
SiO_2	34.10	35.11
TiO_2	trace	
Al_2O_3	1.63	
Fe_2O_3	0.12	
BeO	40.00	43.84
MgO	trace	
CaO	0.50	
Na_2O	2.42	
H_2O^+	18.95	21.05
H_2O^-	3.25	
Total	100.97	100.00

(1) Lovozero massif, Russia. (2) $Be_3SiO_4(OH)_2 \cdot H_2O$.

Occurrence: In the center of a zoned pegmatite cutting arfvedsonite-bearing nepheline syenite (Lovozero massif, Russia); in analcime-rich veins (Ilímaussaq intrusion, Greenland).

Association: Albite, epididymite, bertrandite, natrolite, sodalite (Lovozero massif, Russia); analcime, sørensenite, chkalovite, epididymite, tugtupite (Ilímaussaq intrusion, Greenland).

Distribution: From the Natrolite Stock pegmatite, Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. At Kvanefjeld and on the Taseq slope, in the Ilímaussaq intrusion, southern Greenland.

Name: In allusion to the BERYLLium in its composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 57361.

References: (1) Kuz'menko, M.V. (1954) Berillite [beryllite] – a new mineral. Doklady Acad. Nauk SSSR, 99, 51–454 (in Russian). (2) (1955) Amer. Mineral., 40, 787–788 (abs. ref. 1). (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 96–98. (4) Andersen, S. (1967) On beryllite and bertrandite from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland, 181(4), 11–26.

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Beryllonite $NaBePO_4$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Tabular on {010} to short prismatic ‖ [010]; crystals may have many forms, especially ‖ [100] and [010]; some faces typically etched to dullness, to 25 cm; also in spherical aggregates, fibrous, massive. *Twinning:* On {101}, contact and penetration twins; on {110} and {100} polysynthetic and pseudohexagonal stellate twins.

Physical Properties: *Cleavage:* {010}, perfect; {100}, good, interrupted; {101}, indistinct; {001}, in traces. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.77–2.84 D(calc.) = 2.805

Optical Properties: Transparent to translucent. *Color:* Colorless, white to pale yellow; in transmitted light, colorless. *Luster:* Vitreous to adamantine, may be pearly on {010}. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, weak. $\alpha = 1.552$ $\beta = 1.558$ $\gamma = 1.561$ 2V(meas.) = 67°56′

Cell Data: *Space Group:* $P2_1/n$. $a = 8.178(3)$ $b = 7.818(2)$ $c = 14.114(6)$ $\beta = 90.00(2)°$ Z = 12

X-ray Powder Pattern: Stoneham, Maine, USA.
2.84 (10), 3.65 (9), 2.28 (7), 3.92 (6), 2.37 (6), 4.44 (4), 1.965 (4)

Chemistry:

	(1)	(2)
P_2O_5	55.86	55.89
BeO	19.84	19.70
Na_2O	23.64	24.41
LOI	0.08	
Total	99.42	100.00

(1) Stoneham, Maine, USA; composite average of six partial analyses. (2) $NaBePO_4$.

Occurrence: As a rare secondary mineral in granitic and alkalic pegmatites.

Association: Herderite, triplite, beryl, apatite, cassiterite, columbite, eosphorite, morinite, väyrynenite, lithiophilite, elbaite, pollucite, petalite, lepidolite, albite, orthoclase, quartz.

Distribution: In the USA, in Maine, found on Sugarloaf Mountain, near Stoneham, at the Dunton quarry and the Bell Pit, Newry, Oxford Co., and other minor occurrences. In Canada, occurs at Mont Saint-Hilaire, Quebec. Found at the Viitaniemi pegmatite, Eräjärvi, Finland. From the Norrö pegmatite, on Rånö Island, Sweden. In England, in the Meldon aplite, Okehampton, Devonshire. Large crystals from Paprock, Laghman Province, Afghanistan. Occurs in the Énio pegmatite mine, northeast of Galiléia; at the Lavra da Ilha pegmatite, in the Jequitinhonha River, three km north of Taquaral; and from the Almerindo mine, Linópolis, Minas Gerais, Brazil.

Name: For one of the major constituents in the composition, BERYLLium.

Type Material: Yale University, New Haven, Connecticut, USA, 3.1946.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 677–679. (2) Giuseppetti, G. and C. Tadini (1973) Refinement of the crystal structure of beryllonite, $NaBePO_4$. Tschermaks Mineral. Petrog. Mitt., 20, 1–12. (3) Mrose, M. (1952) Hurlbutite, $CaBe_2(PO_4)_2$, a new mineral. Amer. Mineral., 37, 931–940. (4) King, V.T. and E.E. Foord (1994) Mineralogy of Maine, 57–59.

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Berzelianite Cu_2Se

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As thin dendritic crusts; fine grained and disseminated as powdery inclusions.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Somewhat malleable. Hardness = 2.7 VHN = 21–24 (100 g load). D(meas.) = 6.71 D(calc.) = [7.28]

Optical Properties: Opaque. *Color:* Silver-white, tarnishing. *Streak:* Shining. *Luster:* Metallic. *Anisotropism:* Isotropic, may be slightly anisotropic.
R: (400) 25.8, (420) 28.9, (440) 30.0, (460) 30.7, (480) 31.1, (500) 31.0, (520) 30.2, (540) 28.7, (560) 27.0, (580) 25.5, (600) 24.1, (620) 22.9, (640) 21.8, (660) 20.7, (680) 19.7, (700) 18.7

Cell Data: *Space Group:* $Fm3m$ (synthetic). $a = 5.694(7)$ $Z = 4$

X-ray Powder Pattern: Skrikerum, Sweden.
2.03 (100), 3.33 (90), 1.729 (80), 1.171 (40), 1.434 (30), 1.317 (20), 1.105 (20)

Chemistry:

	(1)	(2)
Cu	57.21	61.62
Ag	3.51	
Se	39.22	38.38
Total	99.94	100.00

(1) Skrikerum, Sweden. (2) Cu_2Se.

Polymorphism & Series: Dimorphous with bellidoite.

Occurrence: With other selenides in hydrothermal veinlets in dolostone (Clausthal, Germany); in iron ores (Lerbach, Germany); with other selenides in calcite veins in serpentine (Skrikerum, Sweden); in a gold-quartz-orthoclase deposit (Redjang-Lebong, Sumatra).

Association: Eucairite, clausthalite, tiemannite, umangite, klockmannite, aguilarite, crookesite, athabascaite, stromeyerite, polybasite, pearceite, gold, uraninite, pyrite, marcasite, calcite.

Distribution: At Skrikerum, near Tryserum, Kalmar, Sweden [TL]. From Lerbach, Tilkerode, Zorge, Clausthal, and St. Andreasberg, Harz Mountains; at Niederschlema, Saxony; and the Mullenbach uranium deposit, Black Forest, Germany. In the Czech Republic, in the Habrí and Bukov mines, near Tisnova; at the Petrovice uranium deposit, near Ždár; and the Předbořice uranium deposit, near Krásna Hora. From the Kyzylalmasay gold deposit, [??where in?? or drop] Uzbekistan. In the Sierra de Umango, and at Tuminico, Sierra de Cacho, La Rioja Province, Argentina. From the Elefante prospect, near the Serra Pelada Au–Pd–Pt deposit, Pará, Brazil. At Redjang-Lebong, Sumatra. From Kalgoorlie and in the Copper Hills prospect, East Pilbara region, Western Australia, and at El Sharana, Northern Territory, Australia. In the Pinky Fault uranium deposit, Lake Athabasca, Saskatchewan, Canada. From the Durant vein, Aurora district, Mineral Co., Nevada, USA.

Name: For Jöns Jacob Berzelius (1779–1848), Swedish chemist, who discovered selenium.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 182–183. (2) Earley, J.W. (1950) Description and synthesis of the selenide minerals. Amer. Mineral., 35, 337–364. (3) Yamamoto, K. and S. Kashida. (1991) X-ray study of the average structures of Cu_2Se and $Cu_{1.8}S$ in the room temperature and the high temperature phases. J. Solid State Chem., 93, 202–211. (4) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 65–67. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 44.

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Berzeliite $NaCa_2(Mg, Mn^{2+})_2(AsO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Very rare trapezohedra {211}, with small modifying faces {001}, {011}, {012}, to 4 mm; commonly as rounded grains or massive.

Physical Properties: *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle.
Hardness = 4.5–5 D(meas.) = 4.08 D(calc.) = 4.068

Optical Properties: Transparent to translucent. *Color:* Colorless, yellow, honey-yellow to yellow-orange, yellowish red, brownish orange; in transmitted light, colorless to orange.
Streak: Nearly white to yellow-orange. *Luster:* Resinous.
Optical Class: Isotropic; may show weak anomalous birefringence. n = 1.707–1.748

Cell Data: *Space Group: Ia3d.* a = 12.355(2) Z = 8

X-ray Powder Pattern: Långban, Sweden. (ICDD 19-165).
2.754 (100), 1.712 (70), 1.648 (70), 5.03 (60), 3.09 (60), 2.632 (60), 2.517 (60)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	1.23	1.48		CaO	19.27	18.76	18.72
As_2O_5	56.72	54.92	57.54	Na_2O	4.56	4.70	5.17
V_2O_5	0.23	0.09		K_2O	0.08		
SiO_2	0.66	0.57		Cl		0.03	
FeO	trace	0.03		H_2O^+	0.37	0.24	
MnO	2.83	9.59	11.84	H_2O^-	0.34	0.12	
PbO	0.35	0.19		$-O = Cl_2$		0.01	
MgO	13.60	9.30	6.73	Total	100.24	100.01	100.00

(1) Långban, Sweden; corresponds to $(Na_{0.84}K_{0.01})_{\Sigma=0.85}(Ca_{1.97}Pb_{0.01})_{\Sigma=1.98}(Mg_{1.94}Mn_{0.23})_{\Sigma=2.17}[(As_{0.94}P_{0.03}Si_{0.02}V_{0.01})_{\Sigma=1.00}O_4]_3$. (2) Do.; corresponds to $Na_{0.89}Ca_{1.96}(Mg_{1.35}Mn_{0.79})_{\Sigma=2.14}[(As_{0.93}P_{0.04}Si_{0.02})_{\Sigma=0.99}O_4]_3$. (3) $NaCa_2(Mg, Mn)_2(AsO_4)_3$ with Mg:Mn = 1:1.

Polymorphism & Series: Forms a series with manganberzeliite.

Occurrence: In metamorphosed Fe–Mn orebodies.

Association: Hausmannite, rhodonite, tephroite, hedyphane, caryinite, manganoan biotite, långbanite, braunite, hematite, dolomite, barite, calcite.

Distribution: In Sweden, found at Långban and Nordmark, Värmland, and in the Sjö mine, near Grythyttan, Örebro.

Name: In honor of the noted Swedish chemist and mineralogist, Jöns Jacob Berzelius (1779–1848).

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 681–683. (2) Blix, R. and F.E. Wickman (1958) A contribution to the knowledge of the mineral berzeliite. Arkiv Mineral. Geol., 2(33), 417–424. (3) Hawthorne, F.C. (1976) Refinement of the crystal structure of berzeliite. Acta Cryst., 32, 1581–1583.

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Fergusonite-beta-(Ce) $(Ce, La, Nd)NbO_4$

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Crystal Data: Monoclinic, metamict. *Point Group:* 2. As prismatic crystals terminated by dipyramids; as anhedral grains, to 1 mm.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 6
D(meas.) = 5.34–5.44 D(calc.) = 5.99

Optical Properties: Semitransparent. *Color:* Red to reddish brown. *Streak:* Pale rose.
Luster: Vitreous to greasy; adamantine.
Optical Class: Isotropic. $n = 2.155$

Cell Data: *Space Group:* $I2$. $a = 5.19$ $b = 11.34$ $c = 5.48$ $\beta = 84°57'$ Z = 4

X-ray Powder Pattern: "Northern China"; after heating at 1000 °C for 1 hour.
3.24 (10), 3.058 (10), 1.965 (10), 1.910 (8), 1.706 (8), 1.677 (8), 1.608 (8)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8		1.01	RE_2O_3	46.88	51.12
UO_3	0.07		Fe_2O_3		0.66
Nb_2O_5	42.98	41.78	FeO	0.95	
Ta_2O_5	0.09	1.00	MnO	0.03	
SiO_2	0.03		CaO	1.26	1.20
TiO_2	0.12	0.05	H_2O^+	n.d.	
ThO_2	8.01	0.88	H_2O^-	trace	
UO_2	0.03		Total	100.45	97.70

(1) "Northern China"; RE = La 24.0%, Ce 42.7%, Pr 7.24%, Nd 21.5%, Sm 2.69%, Eu 0.49%, Gd 1.04%, Dy 0.36%. (2) Chernigovsky region, Ukraine; RE = La 15.0%, Ce 40.8%, Pr 4.9%, Nd 19.2%, Sm 1.55%, Eu 0.31%, Gd 0.50%, Tb 0.12%, Dy 0.25%, Ho 0.05%, Yb 0.12%, Lu 0.02%, Y 17.18%; corresponding to $(RE_{0.98}Ca_{0.06}U_{0.01}Th_{0.01})_{\Sigma=1.06}(Nb_{0.94}Fe_{0.03}Ta_{0.01})_{\Sigma=0.98}O_4$.

Polymorphism & Series: Dimorphous with fergusonite-(Ce).

Occurrence: In magnesian skarn around carbonatite-derived dolomitic marble ("Northern China"); in carbonatite (Chernigovsky region, Ukraine).

Association: Diopside, phlogopite, cerian apatite, calcite ("Northern China"); olivine, phlogopite, calcite, magnetite, monazite (Chernigovsky region, Ukraine).

Distribution: From an undisclosed locality [eastern Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia] in "Northern China". In the Chernigovsky region, Ukraine.

Name: In allusion to its dimorphous relation to *fergusonite-(Ce)*.

Type Material: n.d.

References: (1) Kuo Chi-Ti, Wang I-Hsien, Wang Hsien-Chueh, Wang Chung-Kang, and Hou Hung-Chuan (1973) Studies on minerals of the fergusonite group [brocenite = fergusonite-beta-(Ce)]. Geochimica, 2, 86–92 (in Chinese). (2) (1975) Amer. Mineral., 60, 485 (abs. ref. 1). (3) Chashka, A.I., E.Y. Marchenko, V.A. Khovostova, and A.V. Bykova (1976) Brocenite [fergusonite-beta-(Ce)] – the first finding in the USSR. Zap. Vses. Mineral. Obshch., 105, 457–463 (in Russian). (4) Peishan Zhang and Pejie Tao (1987) Characteristics of the fergusonite- and aeschynite-group minerals in China. Zhongguo Xitu Xuebao, 5(1), 1–7 (in Chinese). (5) (1987) Chem. Abs., 107, 241 (abs. ref. 4).

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Fergusonite-beta-(Nd) $(Nd, Ce)NbO_4$

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Crystal Data: Monoclinic, metamict. *Point Group:* n.d. As prismatic dipyramidal crystals, to 0.25 mm, also as irregular grains.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = [5.5–6.5] [by analogy to fergusonite-(Y)]. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Brownish red, red, yellowish brown, or yellowish red. *Streak:* Pale brown. *Luster:* Vitreous to greasy.
Optical Class: Isotropic to weakly anisotropic. $n = 2.0$

Cell Data: *Space Group:* n.d. $a = 5.07$ $b = 5.62$ $c = 5.41$ $\beta = 93.0°$ Z = [2]

X-ray Powder Pattern: Bayan Obo, China; untreated material.
3.2064 (10), 3.0253 (10), 1.8832 (9), 2.7976 (5), 2.6961 (5), 2.0648 (5), 1.9549 (5)

Chemistry:

	(1)		(1)
Nb_2O_5	41.00	Al_2O_3	0.12
Ta_2O_5	0.11	RE_2O_3	55.00
SiO_2	0.29	FeO	0.27
TiO_2	0.17	MnO	0.30
ThO_2	1.09	MgO	0.07
ZrO_2	0.19	CaO	0.29
UO_2	1.46	Total	100.36

(1) Bayan Obo, China; RE_2O_3 = La_2O_3 2.05%, Ce_2O_3 14.62%, Pr_2O_3 4.28%, Nd_2O_3 21.25%, Sm_2O_3 4.53%, Eu_2O_3 0.21%, Gd_2O_3 1.37%, Tb_2O_3 0.71%, Dy_2O_3 0.98%, Ho_2O_3 0.56%, Er_2O_3 0.51%, Tm_2O_3 0.36%, Yb_2O_3 0.45%, Lu_2O_3 0.29%, Y_2O_3 2.83%; corresponds to $(Nd_{0.38}Ce_{0.27}Pr_{0.08}Sm_{0.08}Y_{0.08}La_{0.04}Gd_{0.02}Dy_{0.02}Tb_{0.01}Ho_{0.01}Er_{0.01}Tm_{0.01}Yb_{0.01})_{\Sigma=1.02}(U, Th, Ca, Fe)_{\Sigma=0.06}(Nb, Ta, Ti)_{\Sigma=0.96}O_4$.

Polymorphism & Series: Dimorphous with fergusonite-(Nd).

Occurrence: In sodium-metasomatised carbonatite-derived dolomitic marble.

Association: Riebeckite, ferroan dolomite, biotite, magnetite, monazite, bastnäsite, aeschynite-(Nd), ilmenite, pyrite, fergusonite-(Ce), fergusonite-(Nd).

Distribution: From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China.

Name: In allusion to its dimorphous relation to *fergusonite-(Nd)*.

Type Material: n.d.

References: (1) Sun Weijun, Ma Fengjun, and Zhuang Shijie (1983) Fergusonite-beta-Nd. Scientia Geologica Sinica, 78–81 (in Chinese with English abs.). (2) (1984) Amer. Mineral., 69, 406–407 (abs. ref. 1).

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Fergusonite-beta-(Y) $YNbO_4$

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Crystal Data: Monoclinic; typically metamict. *Point Group:* n.d. Crystals prismatic, to 0.2 mm in cross section.

Physical Properties: Hardness = [5.5–6.5] [by analogy to fergusonite-(Y)]. D(meas.) = 5.65 D(calc.) = [5.63]

Optical Properties: Semitransparent. *Color:* Light yellow.
Optical Class: [Isotropic when metamict.] n = n.d.

Cell Data: *Space Group:* n.d. $a = 5.12$ $b = 10.89$ $c = 5.20$ $\beta = 88°10'$ Z = [4]

X-ray Powder Pattern: n.d.

Chemistry: (1) "Central Asia"; X-ray spectrographic analysis showed major Y, Nb, U; Fe ∼2.5%; Ta, Th ∼1%; Ca, Zr ∼0.5%; Ti ∼0.2%; Pb ∼0.1%.

Polymorphism & Series: Dimorphous with fergusonite-(Y).

Occurrence: In microcline-bearing granite stocks.

Association: Microcline, quartz.

Distribution: From an undisclosed locality [Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China] in "Central Asia".

Name: In allusion to its dimorphous relation to *fergusonite-(Y)*.

Type Material: n.d.

References: (1) Gorshevskaya, S.A., G.A. Sidorenko, and I.E. Smorchkov (1961) A new modification of fergusonite: β-fergusonite [fergusonite-beta-(Y)]. Geol. Mestorozhdenii Redkikh Elementov, 9, 28–29 (in Russian). (2) (1961) Amer. Mineral., 46, 1516–1517 (abs. ref. 1). (3) Weitzel, H. and H. Schröcke (1980) Kristallstrukturverfeinerungen von Euxenit, $Y(Nb_{0.5}Ti_{0.5})_2O_6$, und M-Fergusonit, $YNbO_4$. Zeits. Krist., 152, 69–82 (in German with English abs.). (4) Trunov, V.K., V.A. Efremov, Y.A. Velikopodnyi, and I.M. Averina (1981) The structure of $YNbO_4$ crystals at room temperature. Kristallografiya (Sov. Phys. Crystal.), 26, 67–71 (in Russian). (5) Kinzhibalo, L.N., V.K. Trunov, A.A. Evdokimov, and V.G. Krongauz (1982) Refinement of the crystal structure of fergusonite. Kristallografiya (Sov. Phys. Crystal.), 27, 43–48 (in Russian). (6) Peishan Zhang and Pejie Tao (1987) Characteristics of the fergusonite- and aeschynite-group minerals in China. Zhongguo Xitu Xuebao, 5(1), 1–7 (in Chinese). (7) (1987) Chem. Abs., 107, 241 (abs. ref. 6).

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Betafite $(Ca, U)_2(Ti, Nb, Ta)_2O_6(OH)$

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Crystal Data: Cubic; typically metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals commonly octahedra modified by {110}, {100}, {113}, {233}, and {230}; some crystals elongated ‖ [001] or [111]; to 15 cm.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 3–5 VHN = 354–412 (Norway); 249–287 (Madagascar). D(meas.) = 3.7–4.9 D(calc.) = [3.79–4.01] Radioactive.

Optical Properties: Translucent to opaque. *Color:* Red; greenish brown, dark brown to black when metamict, commonly superficially altered yellow; almost colorless in transmitted light.
Luster: Waxy, greasy to adamantine, semimetallic.
Optical Class: Isotropic. $n = 1.910$–2.197
R: (400) 13.5, (420) 13.2, (440) 13.0, (460) 12.8, (480) 12.6, (500) 12.4, (520) 12.3, (540) 12.2, (560) 12.0, (580) 11.9, (600) 11.7, (620) 11.6, (640) 11.6, (660) 11.6, (680) 11.5, (700) 11.5

Cell Data: *Space Group:* $Fd3m$ (heat-reconstituted metamict material). $a = 10.20$–10.42 $Z = 8$

X-ray Powder Pattern: Antanifotsy, Madagascar; after heating at 1000 °C.
2.98 (10), 1.82 (8), 1.55 (6), 3.99 (3), 2.49 (3), 1.154 (3), 3.19 (2)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
UO_3	26.60	27.15	ThO_2	1.30	1.12	MgO	0.40	trace
Nb_2O_5	34.80	34.80	Al_2O_3	2.10	1.50	CaO	3.45	3.12
Ta_2O_5		1.00	Fe_2O_3	2.87	0.50	K_2O		0.38
TiO_2	18.30	16.20	ΣY_2O_3	0.90		H_2O	7.60	12.50
SnO_2	0.30	0.37	ΣCe_2O_3	0.60	1.00	Total	99.22	99.64

(1) Ambolotara, Madagascar; corresponds to $(U_{0.32}Ca_{0.21}Mg_{0.03}Y_{0.03}Ce_{0.01})_{\Sigma=0.60}(Nb_{0.90}Ti_{0.79}Al_{0.14}Fe_{0.12}Th_{0.03}Sn_{0.01})_{\Sigma=1.99}[O_{4.09}(OH)_{2.91}]_{\Sigma=7.00}$. (2) Ambalahazo, Madagascar; corresponds to $(U_{0.30}Ca_{0.18}K_{0.03}Ce_{0.02})_{\Sigma=0.53}(Nb_{0.84}Ti_{0.65}Al_{0.09}Fe_{0.02}Th_{0.01}Sn_{0.01}Ta_{0.01})_{\Sigma=1.63}[O_{2.56}(OH)_{4.44}]_{\Sigma=7.00}$.

Mineral Group: Pyrochlore group, betafite subgroup; $U_A > 20\%$; $2Ti_B \geq (Nb + Ta)_B$.

Occurrence: Typically a primary mineral in granite pegmatites; rare in carbonatites.

Association: Thorite, allanite, zircon, beryl, titanite, magnetite, biotite, microcline, quartz.

Distribution: In Madagascar, large crystals at a number of localities, including: from Ambolotara, west of Betafo; Ambatolampikely; Ambatofotsy; Ambatomboahangy; Ambalahazo; Tomboarivo; and Antanifotsy. In Norway, at Höysjåen, near Kragerø; Landsverk quarry, near Evje; and Ljosland. From Slyudyanka, near Lake Baikal, Siberia, Russia. In the Silver Crater mine, Wilberforce, Ontario, and elsewhere in Canada. In the USA, in the Brown Derby pegmatite, Gunnison Co., Colorado; in the Pidlite pegmatite, Mora Co., New Mexico; and from the Cady Mountains, San Bernardino Co., California.

Name: For the locality near Betafo, Madagascar.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 803–805. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 511–519. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 320–325. (4) Hogarth, D.D. (1961) A study of pyrochlore and betafite. Can. Mineral., 6, 610–633. (5) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (6) Junge, W., J. Knoth, and R. Rath (1983) Chemische und optische Untersuchungen von komplexen Titan-Niob-Tantalaten (Betafiten). Neues Jahrb. Mineral., Abh., 147, 169–183 (in German with English abs.).

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Roselite-beta $Ca_2Co(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As granular aggregates.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 3.5–4 D(meas.) = 3.71 D(calc.) = 3.77

Optical Properties: Semitransparent. *Color:* Dark rose-red. *Luster:* Vitreous. *Optical Class:* Biaxial (–) [*sic*]. *Pleochroism:* X = pink; Y = pale pink; Z = nearly colorless. *Dispersion:* $r < v$, strong, crossed. $\alpha = 1.723$ $\beta = 1.737$ $\gamma = 1.756$ 2V(meas.) = 80°–90°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.88$ $b = 7.67$ $c = 5.58$ $\alpha = 112°19'$ $\beta = 71°21'$ $\gamma = 119°41'$ Z = 1

X-ray Powder Pattern: Schneeberg, Germany; nearly identical to talmessite. 2.75 (10), 3.08 (9), 3.59 (6), 3.98 (4), 3.22 (4), 1.894 (4), 1.719 (4)

Chemistry:

	(1)	(2)
As_2O_5	49.66	50.74
FeO	0.32	
CoO	13.28	16.54
NiO	1.43	
MgO	0.92	
CaO	26.29	24.76
H_2O	8.41	7.96
Total	100.31	100.00

(1) Schneeberg, Germany. (2) $Ca_2Co(AsO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with roselite.

Mineral Group: Fairfieldite group.

Occurrence: A rare secondary mineral in cobalt-bearing hydrothermal mineral deposits.

Association: Roselite, calcite, pyrite, quartz (Schneeberg, Germany); erythrite, arthurite, conichalcite, chenevixite, scorodite, cobaltaustinite, heterogenite (Dome Rock mine, Australia).

Distribution: From Schneeberg, Saxony, and at the Bauhaus district, Richelsdorf Mountains, Hesse, Germany. At Bou Azzer, Morocco. From Tsumeb, Namibia. In the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia. From the San Jose del Carmen mine, Copiapó, Atacama, Chile.

Name: As a monoclinic dimorph of *roselite*.

Type Material: The Natural History Museum, London, England, 1956,196; Harvard University, Cambridge, Massachusetts, USA, 105301.

References: (1) Frondel, C. (1955) Neomesselite and beta-roselite: two new members of the fairfieldite group. Amer. Mineral., 40, 828–833. (2) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésiens naturels. Bull. Soc. fr. Minéral., 87, 169–211 (in French).

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Betekhtinite $Cu_{10}(Fe,Pb)S_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Needles, to 3.5 cm in length, and in irregular masses.

Physical Properties: *Cleavage:* In three directions. Hardness = 3–3.5 VHN = n.d. D(meas.) = 5.96–6.05 D(calc.) = 6.14

Optical Properties: Opaque. *Color:* Black; in polished section, bright cream parallel to elongation, stronger yellowish cream perpendicular, dulls on exposure. *Anisotropism:* Strong, distinctly colored.
R_1–R_2: (400) 34.0–35.4, (420) 33.7–34.6, (440) 33.4–33.8, (460) 33.2–33.3, (480) 32.9–33.0, (500) 32.8–32.6, (520) 32.6–32.3, (540) 32.5–32.1, (560) 32.3–32.0, (580) 32.0–31.8, (600) 31.8–31.8, (620) 31.6–31.9, (640) 31.4–32.2, (660) 31.4–32.4, (680) 31.2–32.4, (700) 31.2–32.4

Cell Data: *Space Group: Immm.* $a = 14.67$ $b = 22.80$ $c = 3.85$ Z = 4

X-ray Powder Pattern: Dzhezkazgan, Kazakstan.
1.832 (100), 2.93 (90), 3.08 (80), 1.946 (70), 1.766 (70), 2.35 (60), 2.01 (60)

Chemistry:

	(1)	(2)
Cu	61.39	58.88
Pb	19.20	17.47
Ag		0.79
Fe	1.83	2.81
S	17.25	20.16
Total	99.67	100.11

(1) Mansfeld, Germany. (2) Dzhezkazgan, Kazakhstan.

Occurrence: In veins cutting the black cupriferous shale (Mansfeld, Germany).

Association: Bornite, chalcocite, chalcopyrite, galena, silver, celestine, anhydrite, calcite.

Distribution: In Germany, in the Mansfeld Kupferschiefer at Eisleben, Saxony-Anhalt [TL], and at Waschenbach, Odenwald, Germany. In the Radka deposit, Pazardzhik, and the Propada deposit, Malko-Tarnovo district, Bulgaria. From near Lairg, Sutherlandshire, Scotland. On the Mürtschenalp, Switzerland. From Långban, Värmland, Sweden. In the Bulancak deposit, Giresun, Turkey. At Tsumeb, Namibia. Rich specimens from Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). At the St. Cloud mine, Sierra Co., New Mexico, USA. In the La Leona mine, Santa Cruz Province, Argentina. At the Yoshino mine, Yamagata Prefecture, Japan. From Mt. Lyell, Tasmania, Australia. Richly crystallized at Dzhezkazgan, Kazakhstan. Probably yet to be recognized in many other mineral deposits.

Name: For Anatolii Georgievich Betekhtin (1897–1962), Russian mineralogist and economic geologist.

Type Material: Mineral Museum, Humboldt University, Berlin, Germany.

References: (1) Schüller, A. and E. Wohlmann (1955) Betechtinit, ein neues Blei-Kupfer-Sulfid aus dem Mansfelder Rücken. Geologie, 4, 535–555 (in German). (2) (1956) Amer. Mineral., 41, 371–372 (abs. ref. 1). (3) Dornberger-Schiff, K. von and E. Höhne (1959) Die Kristallstruktur des Betechtinit $Pb_2(Cu,Fe)_{21}S_{15}$. Acta Cryst., 12, 646–651 (in German). (4) Schüller, A. (1960) Zur Kenntnis des Betechtinit, $(Cu,Fe)_{10}PbS_{>6}$. Neues Jahrb. Mineral., Monatsh., 121–131 (in German).

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Betpakdalite $Ca_2MgFe_3^{3+}As_2^{5+}Mo_8^{6+}O_{36}(OH)\cdot 23H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are short prismatic, with $\{hk0\}$ and $\{h0l\}$, or pseudo-octahedra, to 0.2 mm; in crystalline aggregates, powdery, as thin coatings, massive. *Twinning:* Many crystals are "oriented intergrowths of two or three individuals."

Physical Properties: *Cleavage:* {001}, very good. Hardness = ∼3 D(meas.) = 2.98–3.05 D(calc.) = 2.90

Optical Properties: Transparent. *Color:* Bright lemon-yellow with a pale greenish, rarely brownish, tint; greenish yellow in transmitted light. *Luster:* Dull to waxy. *Optical Class:* Biaxial (+). *Pleochroism:* Distinct; X = pale yellow; Y = greenish yellow; Z = bluish green. *Orientation:* $Y = b$; $X \wedge c = 12°$. *Dispersion:* Inclined, extreme. *Absorption:* $Z > Y > X$. α = 1.782–1.809 β = 1.797–1.821 γ = 1.850–1.857 2V(meas.) = n.d. 2V(calc.) = 53°–88°

Cell Data: *Space Group:* $C2/m$. a = 19.531(2) b = 11.061(1) c = 15.257(2) β = 131.57(1)° Z = 2

X-ray Powder Pattern: Kara-Oba deposit, Kazakhstan.
8.75 (10), 3.63 (9), 1.532 (8), 1.480 (8), 2.95 (7), 1.732 (7), 1.191 (7)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
MoO_3	50.26	52.9	52.42	H_2O^+	3.20		
As_2O_5	13.94	10.0	10.46	H_2O^-	15.80		
Fe_2O_3	12.30	11.2	10.90	H_2O		[19.4]	19.27
MgO		1.8	1.84	insol.	0.80		
CaO	4.18	5.3	5.11	Total	100.48	[100.6]	100.00

(1) Kara-Oba deposit, Kazakhstan. (2) Tsumeb, Namibia; by electron microprobe, total Fe as Fe_2O_3, H_2O calculated for stoichiometry; corresponds to $Ca_{2.1}Mg_{1.0}Fe_{3.1}Mo_{8.00}As_{1.9}O_{36}(OH)\cdot 23H_2O$. (3) $Ca_2MgFe_3Mo_8As_2O_{36}(OH)\cdot 23H_2O$.

Occurrence: Filling cracks in leached pyrite in the oxidized zone of a mineral deposit (Kara-Oba deposit, Kazakhstan); on vein quartz (Krupka, Czech Republic); in a deep oxidation zone of a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Ferrimolybdite, gypsum, jarosite, hydromica, "limonite", "opal" (Kara-Oba deposit, Kazakhstan); molybdenite, molybdite, quartz (Krupka, Czech Republic); scorodite, powellite, adamite, gerdtremmelite, wulfenite, hidalgoite, chalcocite, digenite, kaolinite, quartz, hematite (Tsumeb, Namibia).

Distribution: In the Kara-Oba Mo–W deposit, Bet-Pak-Dal Desert, central Kazakhstan. At Krupka, Krušné hory Mountains, Czech Republic. From Vaulry, Haute-Vienne, France. At Tsumeb, Namibia. From Elsmore, New South Wales, Australia.

Name: For the original occurrence in the Bet-Pak-Dal Desert, Kazakhstan.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 62532, 62533.

References: (1) Yermilova, L.P. and V.M. Senderova (1961) Betpakdalite – a new mineral from the oxidation zone of the Karaoba wolframite deposit. Zap. Vses. Mineral. Obshch., 90, 425–430 (in Russian). (2) (1962) Amer. Mineral., 47, 172–173 (abs. ref. 1). (3) Čech, F. (1962) The yellow molybdic ochre from Krupka in the Krusne Mountains. Casopis Mineral. Geol. 7, 195–197. (4) (1962) Chem. Abs., 57, 3093–3094 (abs. ref. 3). (5) Schmetzer, K., B. Nuber, and G. Tremmel (1984) Betpakdalit aus Tsumeb, Namibia: Mineralogie, Kristallchemie und Struktur. Neues Jahrb. Mineral., Monatsh., 393–403 (in German with English abs.). (6) Moore, P.B. (1992) Betpakdalite unmasked, and a comment on bond valences. Aust. J. Chem., 45, 1335–1354. (7) (1993) Amer. Mineral., 78, 849 (abs. ref. 6). (8) Cooper, M.A. and F.C. Hawthorne (1999) The crystal structure of betpakdalite and a new chemical formula $Mg(H_2O)_6Ca_2(H_2O)_{13}[Mo_8^{6+}As_2^{5+}Fe_3^{3+}O_{36}(OH)](H_2O)_4$. Can. Mineral., 37, 61–66.

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Beudantite $PbFe_3^{3+}(AsO_4)(SO_4)(OH)_6$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}\ 2/m$. As tabular crystals, pseudocubes, or pseudo-octahedra, to 5 mm; also microcrystalline massive.

Physical Properties: *Cleavage:* Good on {0001}. Hardness = 3.5–4.5 D(meas.) = 4.48(2) D(calc.) = 4.49

Optical Properties: Transparent to translucent. *Color:* Yellow, greenish yellow, red, dark green, brown, black; crystals may exhibit biaxial sectoring. *Streak:* Grayish yellow to green. *Luster:* Vitreous, resinous, may be frosted.
Optical Class: Uniaxial (–), commonly anomalously biaxial. *Pleochroism:* O = yellow to red-brown; E = colorless to yellow. $\omega = 1.957$ $\epsilon = 1.943$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.315$–7.339 $c = 17.034$–17.036 Z = 3

X-ray Powder Pattern: Washington mine, Montana, USA.
3.078 (100), 2.865 (80), 2.290 (70), 5.725 (50), 3.108 (50), 5.089 (45), 1.979 (35)

Chemistry:

	(1)	(2)
SO_3	11.15	11.25
As_2O_5	16.02	16.15
Fe_2O_3	33.48	33.65
CuO	0.22	
ZnO	0.11	
PbO	31.22	31.36
H_2O	[7.80]	7.59
Total	[100.00]	100.00

(1) Washington mine, Montana, USA; by electron microprobe, H_2O by difference, corresponding to $(Pb_{0.99}Cu_{0.02}Zn_{0.01})_{\Sigma=1.02}Fe_{2.98}(AsO_4)_{0.99}(SO_4)_{0.99}(OH)_{6.07}$. (2) $PbFe_3(AsO_4)(SO_4)(OH)_6$.

Mineral Group: Beudantite group.

Occurrence: A secondary mineral in the oxidized zone of polymetallic deposits.

Association: Carminite, scorodite, mimetite, dussertite, arseniosiderite, pharmacosiderite, olivenite, bayldonite, duftite, anglesite, cerussite, azurite.

Distribution: Many localities are known. In Germany, at the Louise mine, Horhausen, and the Schöne Aussicht mine, near Dernbach, Rhineland-Palatinate; at Reichenbach, near Bensheim, Hesse; from the Clara mine, near Oberwolfach, and elsewhere in the Black Forest. In France, from the Cap Garonne mine, near le Pradet, Var, and Blond, near Vauly, Haute-Vienne. In England, at many mines in Caldbeck Fells, Cumbria, and in Cornwall. In Greece, from Laurium, pure masses in the Kamariza mine, and in the slags. Superb crystals at Tsumeb, Namibia. In Mexico, from the Ojuela mine, Mapimí, Durango, and at La Mur, Trincheras, Sonora. From the Mohawk mine, Clark Mountains, San Bernardino Co., California; abundant at Bisbee, Cochise Co., Arizona, USA. In the Belvedere Au–Pb mine, near Mt. McGrath, Western Australia.

Name: Honors François Sulpice Beudant (1787–1850), French mineralogist, University of Paris, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1001–1002. (2) Walenta, K. (1966) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 3. Folge. Tschermaks Mineral. Petrog. Mitt., 11, 121–164, esp. 122–129 (in German). (3) Szymański, J.T. (1988) The crystal structure of beudantite, $Pb(Fe,Al)_3[(As,S)O_4]_2(OH)_6$. Can. Mineral., 26, 923–932. (4) Giuseppetti, G. and C. Tadini (1989) Beudantite: $PbFe_3(SO_4)(AsO_4)(OH)_6$, its crystal structure, tetrahedral site disordering and scattered Pb distribution. Neues Jahrb. Mineral., Monatsh., 27–33.

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Beusite $(Mn^{2+}, Fe^{2+}, Ca, Mg)_3(PO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As rough prismatic crystals, to 30 cm; usually in laminated or granular intergrowths with lithiophilite, perhaps by exsolution.

Physical Properties: *Cleavage:* Good on {010}; fair on {100}. Hardness = 5
D(meas.) = 3.60–3.70 D(calc.) = [3.60]

Optical Properties: Translucent. *Color:* Pale reddish brown. *Streak:* Pale pink or brown. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = -36°$. *Dispersion:* $r > v$, strong.
$\alpha = 1.685–1.708$ $\beta = 1.688–1.711$ $\gamma = 1.700–1.723$ 2V(meas.) = 25°–45°

Cell Data: *Space Group:* $P2_1/c$. $a = 8.797(3)$ $b = 11.758(4)$ $c = 6.170(2)$
$\beta = 99.31(2)°$ Z = 4

X-ray Powder Pattern: Los Aleros pegmatite, Argentina.
3.49 (100b), 2.863 (100b), 2.708 (60), 3.13 (40), 1.926 (40b), 3.01 (35), 2.89 (30)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	40.2	41.6	CaO	4.64	16.1
SiO_2	1.5		Li_2O	0.14	
FeO	14.2	19.8	H_2O^+	0.8	
MnO	35.5	23.1	H_2O^-	0.17	
MgO	2.56	0.0	Total	99.71	100.6

(1) Los Aleros pegmatite, Argentina; after deduction of SiO_2, Li_2O, and H_2O as impurities, corresponds to $(Mn_{1.77}Fe_{0.70}Ca_{0.29}Mg_{0.22})_{\Sigma=2.98}(PO_4)_2$. (2) Yellowknife district, Canada; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(Mn_{1.10}Ca_{0.98}Fe_{0.94})_{\Sigma=3.02}(PO_4)_{1.99}$.

Polymorphism & Series: Forms a series with graftonite.

Occurrence: A late-stage accessory mineral in complex granite pegmatites. As euhedral inclusions in troilite nodules in an iron meteorite.

Association: Lithiophilite or triphylite (pegmatites); troilite, sarcopside (iron meteorite).

Distribution: In Argentina, large crystals from the Los Aleros pegmatite, and at the Amanda and San Salvador pegmatites, San Luis Province. In Canada, near upper Ross Lake, Yellowknife district, Northwest Territories, and at the Gotcha claim, on an island in Cross Lake, Manitoba. In the USA, in the Storm Mountain and Crystal Snow pegmatites, Crystal Mountain district, Larimer Co., Colorado. From the Eräjärvi area, Orivesi, Finland. At the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. From Kyrk-Bulak, Turkestan Range, Kirgizia. In the El Sampal type IIIA iron meteorite.

Name: Honors Dr. Alexey Alexandrovich Beus, Professor of Mineralogy and Geochemistry, Moscow Polytechnical Institute, for his work on minerals of this group.

Type Material: Harvard University, Cambridge, Massachusetts, 109052, 134312, 134313; National Museum of Natural History, Washington, D.C., USA, 137294.

References: (1) Hurlbut, C.S., Jr. and L.F. Aristarain (1968) Beusite, a new mineral from Argentina, and the graftonite–beusite series. Amer. Mineral., 53, 1799–1814. (2) Wise, M.A. and P. Černý (1990) Beusite-triphylite intergrowths from the Yellowknife pegmatite field, Northwest Territories. Can. Mineral., 28, 133–139. (3) Wise, M.A., F.C. Hawthorne, and P. Černý (1990) Crystal structure of Ca-rich beusite from the Yellowknife pegmatite field, Northwest Territories. Can. Mineral., 28, 141–146. (4) Steele, I.M., E. Olsen, J. Pluth, and A.M. Davis (1991) Occurrence and crystal structure of Ca-free beusite in the El Sampal IIIA iron meteorite. Amer. Mineral., 76, 1985–1989.

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Beyerite $(Ca,Pb)Bi_2O_2(CO_3)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are thin rectangular plates, with large {001}, modified by {111}, to 0.5 mm, in rosettes and subparallel aggregates; commonly compact earthy, in thin films, and massive.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–3 D(meas.) = 6.56 D(calc.) = [6.61]

Optical Properties: Transparent to opaque. *Color:* Bright yellow, lemon-yellow, pale yellow, grayish green, gray, white; pale yellow to colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–); may be anomalously biaxial. $\omega = 2.13(2)$ $\epsilon = 1.99(2)$

Cell Data: *Space Group:* $I4/mmm$. $a = 3.78(1)$ $c = 21.77(5)$ Z = 2

X-ray Powder Pattern: Schneeberg, Germany.
2.851 (10), 2.721 (9), 1.755 (8), 1.530 (8), 1.688 (7), 3.632 (6), 3.354 (6)

Chemistry:

	(1)	(2)
CO_2	13.89	14.43
Bi_2O_3	75.29	76.38
PbO	1.77	
CaO	9.05	9.19
Total	[100.00]	100.00

(1) Mica Lode pegmatite, Colorado, USA; recalculated from an original total of 99.83%, neglecting CuO 1.10%, MnO 0.12%, and insoluble 0.79%, corresponds to $(Ca_{0.99}Pb_{0.04})_{\Sigma=1.03}$ $Bi_{2.00}O_2(CO_3)_{1.95}$. (2) $CaBi_2O_2(CO_3)_2$.

Occurrence: A rare secondary mineral in hydrothermal mineral deposits and granite pegmatites, formed by alteration of bismuth-bearing sulfides and sulfosalts.

Association: Bismutite, bismutostibiconite, atelestite, preisingerite, pucherite, eulytite, namibite, clinobisvanite, bismutotantalite, bismuthinite, bismuth.

Distribution: In Germany, from Schneeberg, Saxony; in the Black Forest, in the Clara mine, near Oberwolfach, from Neubulach, and at Hechtsberg, near Hausach. In the Eliáš and Rovnost mines, Jáchymov (Joachimsthal), Czech Republic. From the Bisundi pegmatite, Bhilwara district, Rajasthan, India. At the Chinorsayskiy granodiorite massif, Tajikistan. In the USA, in California, from the Stewart mine, Pala district, and in the Mesa Grande district, San Diego Co., and the Jensen quarry, Riverside Co.; at the Harding mine, Dixon, Taos Co., New Mexico; in pegmatites in the White Picacho district, Maricopa and Yavapai Cos., and on the Gettysburg claims, Copperopolis, Yavapai Co., Arizona; from the School Section and Mica Lode pegmatites, Eight Mile Park area, Fremont Co., and the Meyers Ranch pegmatite, Park Co., Colorado; at the Boss mine, Goodsprings district, Clark Co., Nevada. From the Northern Spy mine, Tintic district, Juab Co., Utah. In the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada. In Argentina, from the San Elías mine, San Luis Province.

Name: To honor Adolph Beyer (1743–1805), mining engineer and mineralogist, Schneeberg, Germany, who first recognized bismutite.

Type Material: Harvard University, Cambridge, Massachusetts, 91593, 111598; National Museum of Natural History, Washington, D.C., USA, 94017, C2251, R2756.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 281–282. (2) Heinrich, E.W. (1947) Beyerite from Colorado. Amer. Mineral., 32, 660–669. (3) Lagerkrantz, A. and G. Sillén (1948) On the crystal structure of $Bi_2O_2CO_3$ (bismutite) and $CaBi_2O_2(CO_3)_2$ (beyerite). Arkiv Kemi, 25(20), 21 p.

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Bezsmertnovite $Au_4Cu(Te, Pb)$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As tabular or irregular grains, up to 0.2 x 0.05 mm.

Physical Properties: Hardness = n.d. VHN = 310–374, 353 (10 g load). D(meas.) = n.d. D(calc.) = 16.3

Optical Properties: Opaque. *Color:* In polished section, bright yellow-orange, resembling gold but having lower reflectivity. *Anisotropism:* Weak, in neutral gray shades.
R: (400) — , (420) 15.1, (440) 15.1, (460) 15.7, (480) 17.5, (500) 21.2, (520) 29.0, (540) 37.5, (560) 45.6, (580) 52.4, (600) 55.7, (620) 57.4, (640) 58.3, (660) 58.7, (680) 58.6, (700) 58.2

Cell Data: *Space Group:* n.d. $a = 4.036$ $b = 4.025$ $c = 4.061$ Z = n.d. [*needsckZandcell*??]

X-ray Powder Pattern: Kamchatka, Russia.
2.33 (10), 1.744 (8-9), 2.61 (8), 3.30 (7), 1.144 (4), 1.405 (4), 1.073 (4)

Chemistry:

	(1)	(2)
Au	72.3	72.6
Ag	3.77	4.05
Cu	6.27	6.28
Fe	0.72	0.92
Pb	8.95	9.54
Te	7.16	7.15
Total	99.2	100.54

(1) Kamchatka, Russia; by electron microprobe, average of seven analyses of three samples, corresponding to $(Au_{3.65}Ag_{0.35})_{\Sigma=4.00}(Cu_{0.98}Fe_{0.13})_{\Sigma=1.11}(Te_{0.56}Pb_{0.43})_{\Sigma=0.99}$. (2) Do.; by electron microprobe, corresponding to $(Au_{3.63}Ag_{0.37})_{\Sigma=4.00}(Cu_{0.97}Fe_{0.16})_{\Sigma=1.15}(Te_{0.55}Pb_{0.45})_{\Sigma=1.00}$.

Occurrence: In the cementation zone of a volcanogenic gold telluride deposit, rarely as rims around grains of gold.

Association: Bilibinskite, bogdanovite, gold, tellurides of Cu, Fe and Pb.

Distribution: From the Aginsk gold telluride deposit, Kamchatka, Far Eastern Region, Russia.

Name: For Dr. Marianna Sergeevna Bezsmertnaya (1914–1991), Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, and Dr. Vladimir Vasil'evich Bezsmertnyi (1912–), All-Union Pedagogy Institute, Moscow, Russia, Soviet geologists and researchers on ore deposits.

Type Material: Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79408.

References: (1) Spiridonov, E.M. and T.N. Chvileva (1979) Bezsmertnovite, $Au_4Cu(Te, Pb)$; a new mineral from the zone of oxidation of deposits of the Far East. Doklady Acad. Nauk SSSR, 249, 185–189 (in Russian). (2) (1981) Amer. Mineral., 66, 878 (abs. ref. 1). (3) Bochek, L.I., Y.A. Malinovskiy, S.M. Sandomirskaya, and N.G. Chuvikina (1982) Bilibinskite and bezsmertnovite, new hybrid minerals of the intermetallic compound-oxide type rather than intermetallic compounds of gold. Doklady Acad. Nauk SSSR, 266, 1255–1259 (in Russian). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 46.

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Bianchite $(Zn, Fe^{2+})(SO_4)\cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Indistinct crystals, typically in crusts. *Twinning:* Common in artificial material.

Physical Properties: Hardness = ∼2.5 D(meas.) = 2.03–2.07 D(calc.) = 2.00 Soluble in H_2O.

Optical Properties: Transparent. *Color:* White to yellowish with oxidation of the iron; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = -26°$. *Dispersion:* $r > v$, weak.
$\alpha = 1.465$ $\beta = 1.494$ $\gamma = 1.495$ 2V(meas.) = 10°–20°

Cell Data: *Space Group:* $C2/c$. $a = 10.096$ $b = 7.201$ $c = 24.492$ $\beta = 98°16'$ Z = 8

X-ray Powder Pattern: Boleslaw, Poland. (ICDD 12-16).
4.42 (100), 4.03 (90), 2.965 (80), 2.911 (80), 5.47 (70), 3.61 (60), 5.85 (50)

Chemistry:

	(1)	(2)
SO_3	30.13	29.70
FeO	8.84	
ZnO	20.01	30.20
H_2O	39.92	40.10
insol.	1.02	
Total	99.92	100.00

(1) Raibl mine, Italy. (2) $ZnSO_4 \cdot 6H_2O$.

Mineral Group: Hexahydrite group.

Occurrence: A post-mine mineral, typically in efflorescences on mine walls, an alteration product of oxidizing sulfides.

Association: Goslarite, melanterite, hydrozincite, gypsum (Raibl mine, Italy).

Distribution: From the Cave del Predil, Raibl mine, south of Tarvisio, Friuli-Venezia Giulia, Italy. At Bleiberg, Carinthia, Austria. From Boleslaw, near Olkusz, Poland. At Wittichen, Black Forest, Germany. In the Borieva mine, Madan region, Bulgaria. From Glomsrudkollen, near Vikersund, Norway. At the Paddy's River mine, Australian Capital Territory. In the USA, from Bisbee, Cochise Co., Arizona; in the Silver Plume district, Clear Creek Co., Colorado; at Sterling Hill, Sussex Co., New Jersey; in the Ueberroth zinc mine, Friedensville, Lehigh Co., Pennsylvania.

Name: To honor Angelo Bianchi (1892–1970), Italian mineralogist, University of Padova, Padova, Italy.

Type Material: University of Padova, Padova, Italy, 1039/1774; The Natural History Museum, London, England, 1933,90; National Museum of Natural History, Washington, D.C., USA, R6735.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 495–496.

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Bicchulite $Ca_2Al_2SiO_6(OH)_2$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As an extremely fine powder.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.813 (synthetic).

Optical Properties: Semitransparent. *Color:* White or gray; colorless in thin section.
Luster: Powdery, earthy.
Optical Class: Isotropic. $n = 1.625$

Cell Data: *Space Group:* $I\bar{4}3m$. $a = 8.82–8.83$ $Z = 4$

X-ray Powder Pattern: Fuka, Japan.
2.786 (100), 2.753 (95), 3.60 (90), 2.597 (50), 1.559 (50), 3.04 (40), 2.96 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	28.51	23.77	20.56
TiO_2	0.09	0.92	
Al_2O_3	21.79	23.59	34.89
Fe_2O_3	2.66	6.72	
FeO	0.25	0.20	
MnO	0.03	0.02	
MgO	2.72	2.00	
CaO	35.26	36.89	38.38
Na_2O	0.25	0.14	
K_2O	0.18	0.11	
H_2O^+	8.03	4.79	6.17
H_2O^-	0.43	0.40	
P_2O_5	0.02	0.02	
Total	100.22	99.57	100.00

(1) Fuka, Japan; mixed with vesuvianite. (2) Do.; contaminated by small amounts of gehlenite, vesuvianite, and hydrogrossular. (3) $Ca_2Al_2SiO_6(OH)_2$.

Polymorphism & Series: Dimorphous with kamaishilite.

Occurrence: In skarns in limestones, formed through alteration of gehlenite subjected to later retrograde hydration reactions.

Association: Vesuvianite, hydrogrossular, gehlenite, melilite, calcite.

Distribution: From Fuka, near Bicchu, Okayama Prefecture, and in the Akagané mine, Iwate Prefecture, Japan. At Carneal, Co. Antrim, Ireland.

Name: For Bicchu, the town encompassing the Japanese type locality.

Type Material: Department of Earth Sciences, Okayama University, Okayama, Japan, ONM-01; Institute of Geological Sciences, London, England.

References: (1) Henmi, C., I. Kusachi, K. Henmi, P.A. Sabine, and B.R. Young (1973) A new mineral bicchulite, the natural analogue of gehlenite hydrate, from Fuka, Okayama Prefecture, Japan, and Carneal, County Antrim, Northern Ireland. Mineral. J. (Japan), 7, 243–251.
(2) (1974) Amer. Mineral., 59, 1330 (abs. ref. 1). (3) Sahl, K. and N.D. Chatterjee (1977) The crystal structure of bicchulite, $Ca_2[Al_2SiO_6](OH)_2$. Zeits. Krist., 146, 35–41. (4) Gupta, A.K. and N.D. Chatterjee (1978) Synthesis, composition, thermal stability, and thermodynamic properties of bicchulite, $Ca_2[Al_2SiO_6](OH)_2$. Amer. Mineral., 63, 58–65. (5) Sahl, K. (1980) Refinement of the crystal structure of bicchulite, $Ca_2[Al_2SiO_6](OH)_2$. Zeits. Krist., 152, 13–21.

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Bideauxite $Pb_2AgCl_3(F,OH)_2$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals, to 7 mm, are dominated by {100}, {111}, {011}, with {113}, {114}, {112}, {116}, and {029}.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle to sectile. Hardness = 3
D(meas.) = 6.274(8) D(calc.) = 6.26

Optical Properties: Transparent. *Color:* Colorless, becoming pale lavender on exposure to light. *Streak:* White. *Luster:* Adamantine, dull after exposure to light.
Optical Class: Isotropic. *Dispersion:* Low. $n = 2.192(15)$

Cell Data: *Space Group:* $Fd3m$. a = 14.1273(6) Z = 16

X-ray Powder Pattern: Tiger, Arizona, USA.
2.718 (10), 3.530 (9), 2.497 (9), 4.259 (7), 4.076 (7), 3.240 (7), 1.839 (6)

Chemistry:

	(1)
Ag	15.74
Pb	62.66
F	3.26
Cl	14.74
OH	[2.78]
Total	[99.18]

(1) Tiger, Arizona, USA; average of two analyses, Ag and Pb by AA, $(OH)^{1-}$ calculated from charge balance; corresponds to $Pb_{2.02}Ag_{0.97}Cl_{2.77}F_{1.14}(OH)_{1.09}$.

Occurrence: Rarely enclosing and replacing boleite, with other oxidized Pb and Cl minerals, from an oxidized base-metal mineral deposit (Tiger, Arizona, USA).

Association: Boleite, diaboleite, matlockite, leadhillite, anglesite, cerussite, dioptase, covellite, quartz (Tiger, Arizona, USA); boleite, atacamite (Iquique, Chile).

Distribution: From the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA. In Chile, at a prospect about 20 km east of Iquique, Tarapacá.

Name: For Richard August Bideaux (1935–), of Oro Valley, Arizona, USA, American mineralogist and mineral collector.

Type Material: National Museum of Natural History, Washington, D.C., USA, 114583.

References: (1) Williams, S.A. (1970) Bideauxite, a new Arizona mineral. Mineral. Mag., 37, 637–640. (2) (1971) Amer. Mineral., 56, 634–635 (abs. ref. 1). (3) Cooper, M.A., F.C. Hawthorne, S. Merlino, M. Pasero, and N. Perchiazzi (1999) Stereoactive lone-pair behavior of Pb in the crystal structure of bideauxite: $Pb_2^{2+}Ag^{+}Cl_3F(OH)$. Can. Mineral., 37, 915–921.

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Bieberite $CoSO_4 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As stalactites and crusts of minute crystals.

Physical Properties: *Cleavage:* On {001}, perfect; on {110}, fair. Hardness = 2
D(meas.) = 1.96 D(calc.) = 1.942 Soluble in H_2O; easily dehydrates to the hexahydrate.

Optical Properties: Translucent. *Color:* Rose-red, flesh-red; in transmitted light, pale rose-red to colorless. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 29°18'$. $\alpha = 1.475$–1.477
$\beta = 1.482$–1.483 $\gamma = 1.488$–1.489 2V(meas.) = $88°01'$

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 14.040$ $b = 6.495$ $c = 10.923$
$\beta = 105.27°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 16-487).
4.87 (100), 3.76 (75), 4.82 (55), 2.725 (25), 3.71 (20), 4.02 (14), 3.25 (14)

Chemistry:

	(1)	(2)
P_2O_5	29.05	28.48
CoO	19.91	26.66
MgO	3.86	
H_2O	46.83	44.86
Total	99.65	100.00

(1) Bieber, Germany. (2) $CoSO_4 \cdot 7H_2O$.

Mineral Group: Melanterite group.

Occurrence: An uncommon oxidation product of cobalt-bearing sulfide–arsenides.

Association: Erythrite, annabergite, pharmacolite, cobaltite, linnaeite.

Distribution: In Germany, from Bieber, near Hanau, Hesse; at Siegen, Westphalia; from Wittichen, Black Forest. At Leogang, and in the Rauris Valley, Salzburg, Austria. In the Penberthy Croft mine, St. Hilary, and at Wheal Alfred, Phillack, Cornwall, England. From Minas de Riotintó, Huelva Province, Spain. At Chalanches, Isère, France. In the Dome Rock copper mine, South Australia. From the Copper King mine, Lomagundi district, Zimbabwe. At Island Mountain, Trinity Co., California; from Ajo, Pima Co., Arizona; and in the Dolly prospect, Emery Co., Utah, USA. From Tres Puntos, near Copiapó, Atacama, Chile.

Name: For its first-noted occurrence at Bieber, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 505–507.

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Biehlite $(Sb^{3+}, As^{3+})_2MoO_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are fibrous, to 1 cm, elongated along [001], in felted masses and irregular aggregates.

Physical Properties: *Tenacity:* Flexible. Hardness = "Soft". D(meas.) = n.d. D(calc.) = 5.23

Optical Properties: Translucent. *Color:* White. *Streak:* White. *Luster:* Silky. *Optical Class:* [Biaxial.] n = [2.13] (by the rule of Gladstone and Dale). α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$. a = 18.076(5) b = 5.920(5) c = 5.083(5) β = 96.97(1)° Z = 4

X-ray Powder Pattern: Tsumeb, Namibia; shows strong preferred orientation. 2.990 (100), 2.960 (100), 5.622 (65), 3.104 (61), 2.104 (42), 3.376 (39), 1.962 (32)

Chemistry:

	(1)
MoO_3	33.76
Sb_2O_3	60.99
As_2O_3	4.95
Total	99.70

(1) Tsumeb, Namibia; by electron microprobe, average of five analyses; corresponds to $(Sb_{1.79}As_{0.21})_{\Sigma=2.00}Mo_{1.00}O_6$.

Occurrence: A rare secondary mineral from an oxidized zone in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Anglesite, wulfenite.

Distribution: From Tsumeb, Namibia.

Name: To honor Dr. Friedrich Karl Biehl (1887–?), mineralogist, Westfälische-Wilhelms University, Münster, Germany, who authored an early dissertation on Tsumeb species.

Type Material: Hamburg University, Hamburg, Germany.

References: (1) Schlüter, J., K.-H. Klaska, G. Adiwidjaja, K. Friese, and G. Gebhard (2000) Biehlite, $(Sb, As)_2MoO_6$, a new mineral from Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 234–240. (2) (2001) Amer. Mineral., 86, 197 (abs. ref. 1).

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Bijvoetite-(Y) $(Y,Dy)_8(UO_2)_{16}(CO_3)_{16}O_8(OH)_8 \cdot 39H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Platy crystals, flattened on {001} and elongated along [110], showing $\{\bar{1}10\}$, $\{\bar{1}30\}$, {010}, {130}, $\{1\bar{1}0\}$, to 3 mm.

Physical Properties: *Cleavage:* On {001}, good. Hardness = 2 VHN = 36
D(meas.) = n.d. D(calc.) = 3.907 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Sulfur-yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* X = colorless; Y = pale yellow; Z = deep yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$; $Z \wedge [110] = 25.1°$. $\alpha = 1.600(2)$ $\beta = 1.650(2)$ $\gamma = 1.722(2)$ 2V(meas.) = 84° 2V(calc.) = 83°

Cell Data: *Space Group:* $C2ma$, $Cm2b$, or $C222_1$. $a = 21.22(3)$ $b = 45.30(7)$ $c = 13.38(2)$ Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
6.70 (100), 8.61 (80), 4.16 (60), 2.996 (60), 3.52 (50), 3.36 (50), 3.111 (40)

Chemistry:

	(1)
UO_3	60.66
CO_2	8.88
Y_2O_3	7.52
Gd_2O_3	2.80
Tb_2O_3	0.96
Dy_2O_3	5.61
H_2O	[13.57]
Total	[100.00]

(1) Shinkolobwe, Congo; by electron microprobe, CO_2 by chromatography, H_2O by difference; corresponds to $(Y_{4.57}Dy_{2.06}Gd_{1.06}Tb_{0.36})_{\Sigma=8.05}(UO_2)_{14.54}(CO_3)_{13.83}O_8(OH)_{9.57} \cdot 38.86H_2O$.

Occurrence: Very rare, in the lower portion of the oxidation zone developed above uraninite-bearing dolomitic rocks.

Association: Lepersonnite-(Gd), sklodowskite, curite, uranophane, becquerelite, rutherfordine, studtite, torbernite, soddyite, kasolite, schoepite, oursinite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Professor Johannes Martin Bijvoet (1892–1980), Dutch crystallographer.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG13781.

References: (1) Deliens, M. and P. Piret (1982) Bijvoetite et lepersonnite, carbonates hydratés d'uranyle et de terres rares de Shinkolobwe, Zaïre. Can. Mineral., 20, 231–238 (in French with English abs.). (2) (1983) Amer. Mineral., 68, 1248 (abs. ref. 1). (3) Y. Li, P.C. Burns, and R.A. Gault (2000) A new rare-earth-element uranyl carbonate sheet in the structure of bijvoeite-(Y). Can. Mineral., 38, 153–162.

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Bikitaite **$LiAlSi_2O_6 \cdot H_2O$**

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Crystal Data: Monoclinic or triclinic, pseudomonoclinic. *Point Group:* 2 or 1. Crystals prismatic, elongated ‖ [010], striations common ‖ [100], in radiating groups, to 10 cm. Also coarse to fine granular.

Physical Properties: *Cleavage:* Perfect on {100}, good on {001}. *Fracture:* Conchoidal. Hardness = 6 D(meas.) = 2.29–2.30 D(calc.) = 2.29

Optical Properties: Transparent. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 28°–29°$. *Dispersion:* $r < v$.
$\alpha = 1.509–1.510$ $\beta = 1.520–1.521$ $\gamma = 1.522–1.523$ 2V(meas.) = 45°

Cell Data: *Space Group:* $P2_1$. $a = 8.613(4)$ $b = 4.962(2)$ $c = 7.600(4)$ $\beta = 114.45(1)°$ Z = 2, or *Space Group:* $P1$. $a = 8.606(1)$ $b = 4.953(1)$ $c = 7.599(1)$ $\alpha = 89.89(2)°$ $\beta = 114.42(2)°$ $\gamma = 89.96(2)°$ Z = 2

X-ray Powder Pattern: Bikita, Zimbabwe.
3.46 (100), 3.37 (100), 4.20 (90), 2.479 (90), 7.87 (80), 6.93 (50), 4.37 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	55.79	58.7	58.87
Al_2O_3	26.68	25.1	24.98
Fe_2O_3	0.07		
MgO	0.33		
Li_2O	6.51	7.27	7.32
Na_2O	0.10		
K_2O	0.17		
H_2O	9.82	8.98	8.83
Total	99.47	100.05	100.00

(1) Bikita, Zimbabwe. (2) Do.; by electron microprobe, Li by AA, H_2O by TGA.
(3) $LiAlSi_2O_6 \cdot H_2O$.

Mineral Group: Zeolite group, probable.

Occurrence: As a late-formed mineral in fractures in lithium-rich pegmatites.

Association: Eucryptite, quartz, petalite, feldspar, calcite, stilbite, allophane (Bikita, Zimbabwe); albite, quartz, fairfieldite (Foote mine, North Carolina, USA).

Distribution: From Bikita, Zimbabwe. In the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA.

Name: For the locality, Bikita, Zimbabwe.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 106822.

References: (1) Hurlbut, C.S., Jr. (1957) Bikitaite, $LiAlSi_2O_6 \cdot H_2O$; a new mineral from Southern Rhodesia. Amer. Mineral., 42, 792–797. (2) Hurlbut, C.S., Jr. (1958) Additional data on bikitaite. Amer. Mineral., 43, 768–770. (3) Phinney, W.C. and D.B. Stewart (1961) Some physical properties of bikitaite and its dehydration and decomposition products. U.S. Geol. Sur. Prof. Paper 424, D353–D357. (4) Leavens, P.B., C.S. Hurlbut, Jr., and J.A. Nelen (1968) Eucryptite and bikitaite from King's [*sic*] Mountain, North Carolina. Amer. Mineral., 53, 1202–1207. (5) Kocman, V., R.I. Gait, and J. Rucklidge (1974) The crystal structure of bikitaite, $Li[AlSi_2O_6] \cdot H_2O$. Amer. Mineral., 59, 71–78. (6) Bissert, G. and F. Liebau (1986) The crystal structure of a triclinic bikitaite, $Li[AlSi_2O_6] \cdot H_2O$, with ordered Al/Si distribution. Neues Jahrb. Mineral., Monatsh., 241–252.

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Bilibinskite $Au_3Cu_2PbTe_2$

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Crystal Data: Cubic (pseudocell). *Point Group:* n.d. Massive.

Physical Properties: Hardness = n.d. VHN = 329–419, 381 average (20 g load).
D(meas.) = 12.7 D(calc.) = [14.44]

Optical Properties: Opaque. *Color:* Pale brown, rose-brown. *Streak:* Gold-brown to brown. *Luster:* Semimetallic.
R: n.d.

Cell Data: *Space Group:* n.d. $a = 4.095$ Z = [0.5]

X-ray Powder Pattern: Aginsk deposit, Russia.
2.37 (100), 1.232 (80), 2.05 (70), 1.448 (60), 3.06 (40), 1.184 (20), 3.00 (10)

Chemistry:

	(1)	(2)
Au	48.4	50.06
Ag	1.54	
Cu	9.35	10.77
Fe	0.19	
Pb	19.2	17.55
Te	21.6	21.62
Se	0.34	
Total	100.6	100.00

(1) Aginsk deposit, Russia; by electron microprobe, average of eight analyses on two samples, leading to $(Au_{2.90}Ag_{0.17})_{\Sigma=3.07}(Cu_{1.74}Fe_{0.04})_{\Sigma=1.78}Pb_{1.10}(Te_{2.00}Se_{0.05})_{\Sigma=2.05}$. (2) $Au_3Cu_2PbTe_2$.

Occurrence: In the zone of weathering of tellurium deposits.

Association: Gold, bogdanovite, bezsmertnovite, belyakinite, other tellurides of Au, Cu, Pb, Fe (Aginsk deposit, Russia); sylvanite, krennerite (Southern Dzhelambet deposit, Kazakhstan).

Distribution: From the Aginsk gold telluride deposit, Kamchatka, Far Eastern Region, Russia [TL]. At the Southern Dzhelambet deposit, central Kazakhstan [TL].

Name: For Soviet geologist Yuri Aleksandrovich Bilibin (1901–1952), Karpkinskii All-Union Research Institute, St. Petersburg, Russia, specialist in gold deposits.

Type Material: Mining Institute, St. Petersburg, 101/1–2; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 78385, vis207.

References: (1) Spiridonov, E.M., M.S. Bezsmertnaya, T.N. Chvileva, and V.V. Bezsmertnyi (1978) Bilibinskite, $Au_3Cu_2PbTe_2$, a new mineral of gold-telluride deposits. Zap. Vses. Mineral. Obshch., 107, 310–315 (in Russian). (2) (1979) Amer. Mineral., 64, 652 (abs. ref. 1). (3) Spiridonov, E.M., M.S. Bezsmertnaya, T.N. Chvileva, and V.V. Bezsmertnyi (1978) Bilibinskite $Au_3Cu_2PbTe_2$ — a new mineral from gold-telluride deposits. Comments. Zap. Vses. Mineral. Obshch., 107, 501 (in Russian). (4) (1978) Chem. Abs., 89, 200512 (abs. ref. 3). (5) Bochek, L.I., Y.A. Malinovskiy, S.M. Sandomirskaya, and N.G. Chuvikina (1982) Bilibinskite and bezsmertnovite, new hybrid minerals of the intermetallic compound-oxide type rather than intermetallic compounds of gold. Doklady Acad. Nauk SSSR, 266, 1255–1259 (in Russian). (6) Spiridonov, E.M. (1991) Composition and structure of the bilibinskite-bogdanovite mineral group. Novye Dannye Mineral., 37, 138–145 (in Russian). (7) (1995) Amer. Mineral., 80, 848–849 (abs. ref. 6).

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Bílinite $Fe^{2+}Fe_2^{3+}(SO_4)_4 \cdot 22H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous crystals, to 0.03 mm, in radial aggregates.

Physical Properties: Hardness = ∼2 D(meas.) = 1.875–1.99 D(calc.) = [1.99] Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White to yellowish; colorless in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (–). *Orientation:* Inclined extinction 33°–39°. α = 1.480–1.482 β = n.d. γ = 1.489–1.493 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 6.208$ $b = 24.333$ $c = 21.255$ $\beta = 100.3°$ Z = 4

X-ray Powder Pattern: Světec, Czech Republic. (ICDD 25-1153).
4.31 (100), 3.51 (100), 4.84 (50), 4.10 (40), 4.96 (30), 3.29 (30), 5.48 (25)

Chemistry:

	(1)	(2)
SO_3	34.87	33.78
Fe_2O_3	15.88	16.84
FeO	6.93	7.58
MgO	0.13	
Na_2O	0.29	
H_2O	41.77	41.80
Total	99.87	100.00

(1) Světec, Czech Republic. (2) $Fe^{2+}Fe_2^{3+}(SO_4)_4 \cdot 22H_2O$.

Mineral Group: Halotrichite group.

Occurrence: An alteration of iron sulfide in lignite (Světec, Czech Republic); a post-mine mineral with other iron sulfates (Nikitov deposits, Ukraine).

Association: Melanterite (Nikitov deposits, Ukraine).

Distribution: From Světec (Schwaz), near Bílina, Czech Republic. In the Nikitov mercury deposits, Ukraine. From the Higgins mine, Bisbee, Cochise Co., Arizona, and at Arco, Butte Co., Idaho, USA. From the Chiricas mine, Malargüe district, Mendoza Province, Argentina.

Name: For its first-noted occurrence near Bílina, Czech Republic.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 529. (2) Bol'shakov, A.P. and L.I. Ptushko (1969) Alteration products of melanterite from Nikitov mercury ore deposits. Zap. Vses. Mineral. Obshch., 3, 288–294 (in Russian).

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Billietite $\mathbf{Ba(UO_2)_6O_4(OH)_6 \cdot 4{-}8H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals pseudohexagonal, tabular on {001}, may be elongated along [110], to 5 mm. *Twinning:* Very common, on {110} and {111}, the latter producing sector-twinned aragonitelike groups.

Physical Properties: *Cleavage:* {001} perfect, {110} and {010} imperfect. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 5.28–5.36 D(calc.) = 5.27–5.40 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow to golden yellow and amber-yellow. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = colorless to pale yellow; $Y = Z$ = greenish yellow to deep golden yellow, amber-brown. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, very strong. $\alpha = 1.725$–1.730 $\beta = 1.780$–1.822 $\gamma = 1.790$–1.829
2V(meas.) = $\sim 36°$

Cell Data: *Space Group:* $Pbn2_1$. $a = 12.0720(22)$ $b = 30.167(4)$ $c = 7.1455(5)$ Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
7.53 (10), 3.77 (9), 3.17 (8), 2.03 (6), 3.54 (5), 2.49 (4), 2.56 (3)

Chemistry:

	(1)	(2)	(3)
UO_3	82.76	84.39	86.00
SiO_2	0.76		
CaO	0.30		
BaO	6.88	7.41	7.68
H_2O	8.97	8.68	6.32
Total	99.67	100.48	100.00

(1–2) Shaba Province, Congo. (3) $Ba(UO_2)_6O_4(OH)_6 \cdot 4H_2O$.

Occurrence: An uncommon alteration product of uraninite.

Association: Uranophane, fourmarierite, metatorbernite, rutherfordine, becquerelite, studtite, soddyite.

Distribution: From Shinkolobwe and in the Musonoi mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). From the La Crouzille mine, and the Margnac mine, Compreignac, Haute-Vienne, and in the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France. In Germany, at Wölsendorf, Bavaria; from Menzenschwand, and at Wittichen, Black Forest; and at Bergen, Vogtland, Saxony. On Mauch Chunk Ridge, Jim Thorpe, Carbon Co., Pennsylvania, and in the Delta mine, Emery Co., Utah, USA.

Name: For Valère Louis Billiet (1903–1945), Belgian crystallographer, University of Ghent, Ghent, Belgium.

Type Material: Harvard University, Cambridge, Massachusetts, 104455; National Museum of Natural History, Washington, D.C., USA, 160496.

References: (1) Vaes, J.F. (1947) Six nouveaux minéraux d'urane provenant de Shinkolobwe (Katanga). Ann. Soc. Géol. Belg., 70, B212–B229, esp. B214–B217 (in French). (2) (1947) Mineral. Abs., 10, 146 (abs. ref. 1). (3) (1948) Amer. Mineral., 33, 384 (abs. ref. 1). (4) Frondel, J.W. and F. Cuttitta (1953) Studies of uranium minerals (XII): the status of billietite and becquerelite. Amer. Mineral., 38, 1019–1024. (5) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 68–72. (6) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates. Amer. Mineral., 45, 1026–1061. (7) Pagoaga, M.K., D.E. Appleman, and J.M. Stewart (1987) Crystal structure and crystal chemistry of the uranyl oxide hydrates becquerelite, billietite, and protasite. Amer. Mineral., 72, 1230–1238.

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Billingsleyite $Ag_7(As,Sb)S_6$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Fine-grained aggregates.

Physical Properties: *Tenacity:* Slightly sectile. Hardness = 2.5 VHN = n.d.
D(meas.) = 5.92(2) D(calc.) = 5.90

Optical Properties: Opaque. *Color:* Dark lead-gray. *Luster:* Metallic.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = \sim 14.82$ $b = \sim 14.82$ $c = 10.48$ $Z = 8$

X-ray Powder Pattern: Tintic, Utah, USA.
3.05 (10), 3.19 (7), 3.53 (6), 2.83 (6), 2.49 (6), 3.34 (5), 6.11 (4)

Chemistry:

	(1)
Ag	75.59
Cu	0.02
Fe	0.06
As	5.73
Sb	1.50
S	16.28
insol.	0.61
Total	99.79

(1) Tintic, Utah, USA; corresponding to $Ag_7(As_{0.86}Sb_{0.14})_{\Sigma=1.00}S_6$.

Occurrence: Believed to have occurred in a body of high-grade silver ore.

Association: Acanthite, tennantite, bismuthinite, galena, pyrite.

Distribution: In the North Lily mine, East Tintic district, Utah Co., Utah, USA [TL].

Name: For Paul Billingsley (1887–1962), mining geologist, who discovered the North Lily mine, and collected the type material.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 110530; National Museum of Natural History, Washington, D.C., USA, R18987.

References: (1) Frondel, C. and R.M. Honea (1968) Billingsleyite, a new silver sulfosalt. Amer. Mineral., 53, 1791–1798.

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Billwiseite $Sb^{3+}_5(Nb,Ta)_3WO_{18}$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As blocky crystals displaying {100}, {011} and {410}, to 0.50 mm. *Twinning:* Common on (100).

Physical Properties: *Cleavage*: {100} indistinct. *Fracture*: Hackly. *Tenacity*: Brittle. Hardness = 5 D(meas.) = n.d. D(calc.) = 6.330

Optical Properties: Transparent. *Color*: Pale yellow with a hint of green, colorless in transmitted light. *Streak*: Colorless to very pale yellow. *Luster*: Vitreous.
Optical Class: Biaxial. *n*(calc.) = 2.3 2V(meas.) = 76(2)° *Orientation*: $X \parallel b$, $Y \wedge c = 72.8°$ (in β acute).

Cell Data: *Space Group*: *C*2/*c*. $a = 5.5482(5)$ $b = 4.9143(5)$ $c = 5.5482(5)$ $\beta = 90.425(2)°$ Z = 4

X-ray Powder Pattern: Stak Nala, Karakoram Mountains, 70 km east of Gilgit, Pakistan.
3.147 (100), 3.500 (53), 1.662 (53), 3.017 (48), 1.906 (47), 1.735 (30), 1.762 (25)

Chemistry:

	(1)
Nb_2O_5	12.03
Ta_2O_5	19.31
Sb_2O_3	48.34
TiO_2	0.99
WO_3	19.96
Total	100.63

(1) Stak Nala, Karakoram Mountains, 70 km east of Gilgit, Pakistan; average of 8 electron microprobe analyses, absence of OH and H_2O confirmed by IR spectroscopy, valence state of Sb determined by crystal structure analysis; corresponding to $Sb^{3+}_{4.87}(Nb_{1.33}Ta_{1.28}Ti_{0.18}W_{1.26})_{\Sigma=4.05}O_{18}$.

Occurrence: In a complex zoned granitic pegmatite of the LCT (Li–Cs–Ta) type.

Association: Lepidolite, B-rich muscovite.

Distribution: At Stak Nala, Karakoram Mountains, 70 km east of Gilgit, Pakistan.

Name: Honors William Stewart Wise (b. 1933), Professor of Geology Emeritus, University of California at Santa Barbara, USA, for his contributions to mineralogy and his inspiration and mentoring of mineralogy students.

Type Material: Department of Natural History, Royal Ontario Museum, Toronto, Canada (M55951).

References: (1) Hawthorne, F.C., M.A. Cooper, N.A. Ball, Y.A. Abdu, P. Černý, F. Cámara and B.M. Laurs (2012) Billwiseite, ideally $Sb^{3+}_5(Nb,Ta)_3WO_{18}$, a new oxide mineral species from the Stak Nala pegmatite, Nanga Parbat-Haramosh Massif, Pakistan: description and crystal structure. Can. Mineral., 50, 805-814. (2) (2014) Amer. Mineral., 99, 1512 (abs. ref. 1).

Bindheimite $Pb_2Sb_2O_6(O,OH)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Fibrous, perhaps due to pseudomorphism; as dense to earthy cryptocrystalline masses and incrustations; rarely opaline.

Physical Properties: *Fracture:* Earthy, conchoidal. Hardness = 4–4.5 D(meas.) = 4.6–8.4 D(calc.) = [6.78–6.88]

Optical Properties: Translucent to opaque. *Color:* Yellow, yellow-brown, brown, white, gray, greenish; colorless to yellow and brown in transmitted light. *Streak:* White, yellowish white. *Luster:* Resinous, dull, earthy.
Optical Class: Isotropic. n = 1.84–1.87

Cell Data: *Space Group:* $Fd3m$. a = 10.37–10.42 Z = 8

X-ray Powder Pattern: Unknown locality.
3.03 (100), 1.85 (80), 1.58 (80), 2.62 (60), 0.884 (50), 1.20 (40), 1.17 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
As_2O_5		0.1		CaO		1.0	
Sb_2O_5	40.35	30.0	41.06	Na_2O		0.2	
Fe_2O_3	5.22	3.0		H_2O	5.31		2.29
Bi_2O_3		9.7		LOI		4.5	
PbO	44.12	41.1	56.65	insol.	3.63	8.0	
				Total	98.63	97.6	100.00

(1) Wamsley mine, Mineral Co., Nevada, USA. (2) Otjimboyo East, Namibia; remnant is SiO_2 6.4%, insoluble 1.6%. (3) $Pb_2Sb_2O_7 \bullet H_2O$.

Mineral Group: Stibiconite group.

Occurrence: Common in the oxidized portions of antimony-bearing lead deposits.

Association: Galena, pyrite, chalcopyrite, tetrahedrite, jamesonite, bournonite, zinkenite, cerussite, plumbojarosite, argentojarosite, minium, massicot, quartz, barite, calcite, dolomite.

Distribution: A widely distributed mineral, but rarely in large amounts. From Nerchinsk, Siberia, Russia. In Austria, at Oberzeiring, Styria, and Hüttenberg, Carinthia. In Italy, at Camerata Cornello, Val Brembana, and at Gorno, Val Seriana, Lombardy. In the Bodannon mine and Wheal Boys, St. Endellion, and elsewhere in Cornwall, and at Caldbeck Fells, Cumbria, England. From Otjimboyo East, Karibib, Namibia. At Hamman N'bail, Qacentina (Constantine), Algeria. From Broken Hill, New South Wales, Australia. In the Chichibu mine, Saitama Prefecture, Japan. At Machacamaraca, Potosi, Bolivia. From the Ojuela mine, Mapimí, Durango, Mexico. In the USA, at the Montezuma and other mines, Arabia district, Pershing Co., Nevada; from the Coeur d'Alene district, Shoshone Co., Idaho; in several mines in the Tintic district, Juab Co., and the Horn Silver mine, San Francisco district, Beaver Co., Utah; at Cerro Gordo, Inyo Co., and elsewhere in California.

Name: For Johann Jacob Bindheim (1750–1825), German chemist who made the first chemical analysis of the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1018–1020. (2) Mason, B. and C.J. Vitaliano (1953) The mineralogy of the antimony oxides and antimonates. Mineral. Mag., 30, 100–112. (3) Bothwell, D.I., R.J. Davis, and A.A. Moss (1960) A bismuth-bearing variety of bindheimite. Mineral. Mag., 32, 664–666.

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Biotite $\mathbf{K(Mg,Fe^{2+})_3(Al,Fe^{3+})Si_3O_{10}(OH,F)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Uncommon in good crystals, tabular or short prismatic, with pseudohexagonal outline, to 3 m. Typically irregular foliated or bent masses; in scaly aggregates or disseminated grains. *Twinning:* On composition plane {001}, twin axis [310].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle to flexible, elastic. Hardness = 2.5–3 D(meas.) = 2.7–3.3 D(calc.) = 3.25

Optical Properties: Semitransparent. *Color:* Dark green, brown, black, reddish brown, light yellow, grayish yellow, brownish green, brown; yellow to reddish brown in thin section. *Streak:* White. *Luster:* Splendent to submetallic, vitreous, pearly on cleavage. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = gray-yellow, yellow-brown, orange-brown; $Y = Z$ = dark brown, dark green, dark red-brown. *Orientation:* $Y = b$; $X \wedge c = 0°$–$3°$; $Z \wedge a = 0°$–$9°$. *Dispersion:* $r < v$, Fe-rich; may be $r > v$, Mg-rich; weak. *Absorption:* $Y \simeq Z \gg X$. $\alpha = 1.565$–1.625 $\beta = 1.605$–1.696 $\gamma = 1.605$–1.696 2V(meas.) = $0°$–$25°$

Cell Data: *Space Group:* $C2/m$. $a = 5.3$ $b = 9.2$ $c = 10.2$ $\beta = 100°$ Z = 2

X-ray Powder Pattern: Edenville, Orange Co., New York, USA.
10.1 (100), 3.37 (100), 2.66 (80), 2.45 (80), 2.18 (80), 2.00 (80), 1.67 (80)

Chemistry:

	(1)		(1)		(1)
SiO_2	36.25	MnO	0.49	K_2O	9.57
TiO_2	3.39	MgO	11.80	Cl	0.06
Al_2O_3	13.90	CaO	0.00	H_2O^+	2.80
Fe_2O_3	6.80	Li_2O	0.03	Total	100.00
FeO	14.81	Na_2O	0.10		

(1) Vercelli, Italy; by electron microprobe, average of six analyses on one grain, Fe^{3+} by a semimicrovolumetric method, H_2O by TGA; corresponds to $(K_{0.94}Na_{0.02})_{\Sigma=0.96}(Mg_{1.35}Fe^{2+}_{0.95}Mn_{0.03})_{\Sigma=2.33}(Fe^{3+}_{0.39}Ti_{0.20}Al_{0.05}Li_{0.01})_{\Sigma=0.65}(Si_{2.79}Al_{1.21})_{\Sigma=4.00}[O_{10.55}(OH)_{1.44}Cl_{0.01}]_{\Sigma=12.00}$, in the general structural formula $K(Mg,Fe^{2+})_{3-2}(Al,Fe^{3+},Ti)_{0-1}(Si_{3-2.5}Al_{1--1.5})_{\Sigma=4}O_{10--11}(OH,F)_{2--1}$.

Polymorphism & Series: 1M, $2M_1$, 3A polytypes.

Mineral Group: Mica group.

Occurrence: An important rock-forming mineral under a wide range of conditions. In regionally metamorphosed schists and gneisses, and in contact metamorphosed rocks; in granites to nepheline syenites; less common in extrusive igneous rocks, from rhyolites to basalts. Characteristic of potassic hydrothermal alteration; in detrital sediments.

Association: Quartz, potassic feldspar, plagioclase, nepheline, muscovite, pyroxenes, amphiboles, andalusite, cordierite, garnet, spinel.

Distribution: Good crystals from: in Italy, at Vesuvius and Monte Somma, Campania, and in the Pfitschtal and on Mt. Monzoni, Val di Fassa, Trentino-Alto Adige. At Brevik and Arendal, Norway. From near Miass, Ilmen Mountains, Southern Ural Mountains, Russia. In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; Monroe, Orange Co., and Russell, St. Lawrence Co., New York; at Easton, Northampton Co., Pennsylvania; from the Pala and Rincon districts, San Diego Co., California. In Canada, in Ontario, at Bancroft, Wakefield, and Otter Lake, Parry Sound; in Quebec, in the Bear Lake mine, Pontiac Co.

Name: For the French mineralogist and physicist, Jean Baptiste Biot (1774–1862).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 627–632. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 55–84. (3) Nagelschmidt, G. (1937) X-ray investigations on clays. Part III. Zeits. Krist., 97, 514–521. (4) Brigatti, M.F. and P. Davoli (1990) Crystal-structure refinements of *1M* plutonic biotites. Amer. Mineral., 75, 305–313.

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Biphosphammite $(NH_4, K)H_2PO_4$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As crystals, to 2 mm, tapering, prismatic, in radiating groups; stalactitic and in crusts; fine granular, powdery.

Physical Properties: Hardness = Very soft. D(meas.) = 2.04(2) D(calc.) = [2.02] for NH_4:K = 1:1.

Optical Properties: Semitransparent. *Color:* White, pale buff, to deep shades of brown; colorless in transmitted light. *Streak:* White to pale buff. *Luster:* Dull, earthy; crystals rarely vitreous.
Optical Class: Uniaxial (–). $\omega = 1.525$ $\epsilon = 1.480$

Cell Data: *Space Group:* $I\bar{4}2d$. $a = 7.4935(5)$ $c = 7.340(3)$ Z = [4]

X-ray Powder Pattern: Murra-el-elevyn Cave, Australia.
3.75 (10), 5.24 (9), 3.02 (9b), 1.993 (8), 2.650 (7), 2.368 (7), 1.593 (6)

Chemistry:

	(1)	(2)
SO_3	5.59	
P_2O_5	51.1	56.52
Na_2O	0.16	
K_2O	14.2	18.76
$(NH_4)_2O$	12.3	10.37
H_2O		14.35
insol.	0.81	
rem.	[16.14]	
Total	[100.3]	100.00

(1) Murra-el-elevyn Cave, Australia; partial analysis, remainder mostly CaO and H_2O; stated to correspond to $[(NH_4)_{0.62}K_{0.38}]_{\Sigma=1.00}H_2PO_4$ 88%, syngenite 11.5%, insolubles in H_2O, 0.81%.
(2) $(NH_4, K)H_2PO_4$ with NH_4:K = 1:1.

Occurrence: An alteration product of phosphammite in guano, due to loss of NH_4 (Guañape Island, Peru); a byproduct of the reaction between the liquid fraction of bat guano and urea (Murra-el-elevyn Cave, Australia).

Association: Phosphammite (Guañape Island, Peru); syngenite (Murra-el-elevyn Cave, Australia).

Distribution: On Guañape Island, south of Trujillo, Peru. In Murra-el-elevyn Cave, Cocklebiddy, and in Petrogale Cave, near Madura, Western Australia. From Gcwihaba Cave, 280 km west of Maun, northwestern Botswana.

Name: As a BIPHOSPHate of AMMonium.

Type Material: Western Australian Museum, Perth, MDC3977.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 807. (2) Pryce, M.W. (1972) Biphosphammite: a second occurrence. Mineral. Mag., 38, 965–967.

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Biringuccite $Na_2B_5O_8(OH)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tiny crystals and microcrystalline clusters, in earthy masses.

Physical Properties: Hardness = n.d. D(meas.) = 2.32(1) (synthetic). D(calc.) = 2.297 Soluble in H_2O.

Optical Properties: Transparent. *Color:* White to pale yellow.
Optical Class: Biaxial (–) (synthetic). *Orientation:* $Y = b$; $Z \wedge a = 5.4(6)°$ $\alpha = 1.496(2)$ $\beta = 1.539(2)$ $\gamma = 1.557(2)$ 2V(meas.) = 62.7° 2V(calc.) = 64.6°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 11.1955(7)$ $b = 6.5607(4)$ $c = 20.7566(9)$ $\beta = 93.891(6)°$ Z = 4

X-ray Powder Pattern: Synthetic.
3.45 (100), 10.32 (80), 3.05 (55), 3.03 (55), 2.589 (45), 5.18 (40), 2.853 (40)

Chemistry: (1) Larderello, Italy; identification depended on the chemical analysis interpreted as a mixture with nasinite, and the correspondence of lines in the mixture's X-ray powder pattern with those of synthetic material.

Occurrence: As scales on piping in a geothermal field.

Association: Nasinite, thénardite, orpiment, quartz.

Distribution: From Larderello, Val di Cecina, Tuscany, Italy.

Name: To honor Vannoccio Biringuccio (1480–1538/9), alchemist and metallurgist, author of the *Pirotechnia*.

Type Material: University of Florence, Florence, Italy, 16802/703; National Museum of Natural History, Washington, D.C., USA, 163785.

References: (1) Cipriani, C. and P. Vannuccini (1961) Hoeferite [= biringuccite] e nasinite: due nuori borati fra i prodotti di Larderello. Pt. I. Atti Rend. Accad. Lincei, 30, 74–83; Pt. II. 235–245 (in Italian). (2) Cipriani, C. A proposito del nome del borato naturale $2Na_2O\cdot 5B_2O_3\cdot 4H_2O$ di Larderello. Atti Rend. Accad. Lincei, 31, 141–142 (in Italian). (3) (1963) Amer. Mineral., 48, 709–711 (abs. refs. 1–2). (4) Corazza, E., S. Menchetti, and C. Sabelli (1974) The crystal structure of biringuccite, $Na_4[B_{10}O_{16}(OH)_2]\cdot 2H_2O$. Amer. Mineral., 59, 1005–1015. (5) Menchetti, S., C. Sabelli, A. Stoppioni, and R. Trosti-Ferroni (1983) Hydrothermal synthesis at 250 °C and X-ray study of resulting products in the $NaOH-B_2O_3-H_2O$ system. Neues Jahrb. Mineral., Abh., 148, 163–180.

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Birnessite $(Na, Ca)_{0.5}(Mn^{4+}, Mn^{3+})_2O_4 \cdot 1.5H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Rarely in platelets, to 50 μm; commonly extremely finely crystalline, spherulitic, cellular.

Physical Properties: Hardness = 1.5 D(meas.) = 3.0 D(calc.) = [3.4]

Optical Properties: Nearly opaque. *Color:* Black; dark brown in transmitted light.
Luster: Dull.
Optical Class: Pseudouniaxial (–); identification by optical properties is impossible. $\omega = \sim 1.73$ $\epsilon = \sim 1.69$

Cell Data: *Space Group:* $C2/m$ (synthetic $\approx Na_{0.58}(Mn^{4+}_{1.42}Mn^{3+}_{0.58})_{\Sigma=2.00}O_4 \cdot 1.5H_2O$).
$a = 5.175(1)$ $b = 2.850(1)$ $c = 7.337(3)$ $\beta = 103.18(2)^\circ$ Z = 1

X-ray Powder Pattern: Marine nodule, Caribbean; all reflections are typically very broad.
7.08 (100), 2.333 (43), 1.711 (29), 3.547 (28), 2.031 (24), 2.468 (17), 1.426 (17)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.9		CaO	0.39	
MnO_2	75.8	61.40	Na_2O	1.9	7.30
Mn_2O_3		18.58	K_2O	1.8	
FeO	0.55		Cl	0.1	
CoO	0.14		H_2O	[10.89]	12.72
NiO	0.80		S	0.2	
CuO	0.33		rem.		
MgO	6.2		Total	[100.0]	100.00

(1) Marine nodule, Caribbean; by electron microprobe, total Mn as MnO_2, H_2O by difference.
(2) $Na_{0.50}(Mn^{4+}_{1.50}Mn^{3+}_{0.50})_{\Sigma=2.00}O_4 \cdot 1.5H_2O$.

Occurrence: A major manganese-bearing mineral of many soils; a common alteration product of manganese-rich mineral deposits; a component of bacterially-precipitated manganese oxides; an important constituent of "desert varnish" and marine manganese nodules.

Association: Rhodonite, rhodochrosite, tephroite, spessartine, alleghanyite, cummingtonite (Cummington, Massachusetts, USA); manganese and iron oxides, calcium carbonate (marine nodules).

Distribution: Increasingly recognized as a common manganese oxide mineral. From Birness, Aberdeenshire, Scotland. In the Treburland mine, Altarnun, and the Penberthy Croft mine, St. Hilary, Cornwall, England. On Groote Eylandt, Northern Territory, and near Noarlunga, Mount Lofty Ranges, South Australia. At the Ioi mine, Ritta, Shiga Prefecture, Japan. In the USA, at Sterling Hill, Sussex Co., New Jersey; from Cummington, Hampshire Co., Massachusetts; in the Kramer borate deposit, Boron, Kern Co., California; at Silver Cliff, Custer Co., Colorado; and elsewhere. From Mont St. Hilaire, Quebec, Canada. A number of oceanic sea floor and sea mount occurrences are now known.

Name: For the type locality at Birness, Scotland.

Type Material: n.d.

References: (1) Jones, L.H.P. and A.A. Milne (1956) Birnessite, a new manganese oxide mineral from Aberdeenshire, Scotland. Mineral. Mag., 31, 283–288. (2) (1957) Amer. Mineral., 42, 440 (abs. ref. 1). (3) Glover, E.D. (1977) Characterization of a marine birnessite. Amer. Mineral., 62, 278–285. (4) Chukhrov, F.V., A.I. Gorshkov, E.S. Rudnitskaya, V.V. Beresovskaya, and A.V. Sivtsov (1980) Manganese minerals in clay: a review. Clays and Clay Minerals, 28, 346–453. (5) Post, J.E. and D.R. Veblen (1990) Crystal structure determinations of synthetic sodium, magnesium, and potassium birnessite using TEM and the Rietveld method. Amer. Mineral., 75, 477–489.

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Bischofite $MgCl_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals short prismatic along [001]; commonly foliated, fibrous, crystalline granular. *Twinning:* May twin polysynthetically under pressure.

Physical Properties: *Fracture:* Conchoidal to uneven. Hardness = 1–2 D(meas.) = 1.591–1.604 D(calc.) = 1.5895 (synthetic). Soluble in H_2O; deliquescent; taste astringent, bitter.

Optical Properties: Semitransparent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = 9.5°$. *Dispersion:* $r > v$, weak.
$\alpha = 1.495$ $\beta = 1.507$ $\gamma = 1.528$ 2V(meas.) = 79°24′

Cell Data: *Space Group:* $C2/m$ (synthetic). $a = 9.8607(2)$ $b = 7.1071(2)$ $c = 6.0737(2)$ $\beta = 93.758(2)°$ Z = 2

X-ray Powder Pattern: Synthetic.
4.095 (100), 2.646 (69), 2.880 (58), 2.732 (39), 2.305 (39), 2.228 (27), 3.553 (26)

Chemistry:

	(1)	(2)	(3)
Mg	11.86	11.5	11.95
Ca		0.9	
Cl	35.04	34.2	34.88
H_2O	[53.10]	[51.4]	53.17
SO_3		2.0	
Total	[100.00]	[100.0]	100.00

(1) Leopoldshall, Germany; H_2O by difference. (2) Stassfurt, Germany; by electron microprobe, H_2O by difference. (3) $MgCl_2 \cdot 6H_2O$.

Occurrence: In saline deposits; probably in part secondary, formed from carnallite.

Association: Carnallite, halite, kieserite.

Distribution: In Germany, from Stassfurt-Leopoldshall, 34 km south of Magdeburg, Saxony-Anhalt; at Vienenburg and Aschersleben, Lower Saxony. From Lake Inder, Kazakhstan.

Name: For Karl Gustav Bischof (1792–1870), German geologist and mineral chemist, University of Bonn, Bonn, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 46–47. (2) Heide, K. and W. Kühn (1965) Bischofit im carnallitschen Stassfurtlager der stillgelegten Kaliwerke Aschersleben/Anhalt (Schachtanlage V). Chem. Erde, 24, 211–214 (in German). (3) Sorrell, C.A. and R.R. Ramey (1974) X-ray powder data and unit cell parameters of $MgCl \cdot 6H_2O$. J. Chem. Engr. Data, 19, 31–32. (4) Agron, P.A. and W.R. Busing (1985) Magnesium dichloride hexahydrate, $MgCl_2 \cdot 6H_2O$, by neutron diffraction. Acta Cryst., C41, 8–10.

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Bismite α–Bi_2O_3

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals microscopic, rare; earthy to pulverulent, compact granular, massive.

Physical Properties: *Fracture:* Uneven to earthy when massive. Hardness = 4.5 D(meas.) = 8.64–9.22 D(calc.) = 10.4

Optical Properties: Transparent in very small fragments. *Color:* Grayish green, greenish yellow to bright yellow. *Streak:* Gray to yellow. *Luster:* Subadamantine to dull, earthy. *Optical Class:* Biaxial. *Dispersion:* High. $n = > 2.42$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 5.851$ $b = 8.169$ $c = 7.513$ $\beta = 112°58'$ Z = 4

X-ray Powder Pattern: Colavi, Bolivia.
3.232 (10), 2.676 (9), 1.670 (8), 1.640 (8), 1.951 (7.5), 1.740 (7.5), 1.167 (7)

Chemistry: Modern analyses of authenticated material are lacking.

Polymorphism & Series: Dimorphous with sphaerobismoite.

Occurrence: An oxidation product of bismuth.

Association: Bismuth, bismutite, cassiterite.

Distribution: From near Colavi, at Tazna, and Llallagua, Bolivia. In the USA, at the Harding mine, Dixon, Taos Co., New Mexico; at the Victor mine, Rincon, and in a number of the pegmatites at Pala, San Diego Co., and near Baker, San Bernardino Co., California; an ore mineral in the Missouri mine, Park Co., Colorado. In the Ebisu mine, Gifu Prefecture, Japan. Numerous localities for bismuth oxides have been reported, but modern confirmation is required, as most have proven to be carbonates, etc.

Name: For BISMuth in its composition.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 97831.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 599–601. (2) Frondel, C. (1943) Mineralogy of the oxides and carbonates of bismuth. Amer. Mineral., 28, 521–535. (3) Corria Neves, J.M., J.E. Lopes Nunes, T.G. Sahama, M. Lehtinen, O. von Knorring (1974) Bismuth and antimony minerals in the granite pegmatites of northern Mozambique. Rev. Cienc. Geol., Ser. A, 7, 1–37. (4) (1975) Chem. Abs., 83, 190 (abs. ref. 3).

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Bismoclite BiOCl

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals minute, scaly or thin rectangular, rarely with corners truncated at 45°; platy, columnar-fibrous, earthy, compact massive.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Very plastic. Hardness = 2–2.5 D(meas.) = 7.36 D(calc.) = 7.784

Optical Properties: Opaque, transparent in fine grains. *Color:* Cream-white, pale gray, yellowish brown; colorless in thin section. *Luster:* Greasy, silky, pearly on cleavage surfaces; dull to earthy when massive.
Optical Class: Uniaxial (–). $\omega = 2.15$ (synthetic). ϵ = n.d.

Cell Data: *Space Group:* $P4/nmm$ (synthetic). $a = 3.887$ $c = 7.354$ Z = 2

X-ray Powder Pattern: Synthetic.
3.44 (100), 2.677 (95), 2.753 (75), 7.38 (40), 1.946 (35), 2.205 (30), 1.574 (30)

Chemistry:

	(1)	(2)	(3)
Fe_2O_3	0.12		
Bi_2O_3	88.49	88.53	92.74
Cl	13.00	12.51	7.06
H_2O^+	0.87	1.58	1.79
H_2O^-		0.20	
insol.	0.77		
$-O = Cl_2$	2.93	2.82	1.59
Total	100.32	[100.00]	100.00

(1) Jakkalswater, South Africa. (2) Goldfield, Nevada, USA; recalculated to 100% after deduction of quartz 34.81%, Fe_2O_3 0.28%. (3) BiO(Cl, OH) with Cl:OH = 1:1.

Occurrence: In an alluvial specimen, found near bismuth-bearing granite pegmatites (Jackals Water, South Africa); in greisen (Bygoo, Australia).

Association: Bismutite, mica (Jackals Water, South Africa); bismuthinite (Bygoo, Australia); bismutite, jarosite, alunite, cerussite (Tintic district, Utah, USA); atacamite, connellite, uranium minerals (near Dalbeattie, Scotland).

Distribution: In South Africa, about 25 km northwest of Jakkalswater, near Steinkopf, Cape Province. From Mt. Holland, Western Australia, and Bygoo, New South Wales, Australia. In the USA, from the Eagle and Blue Bell mines, Tintic district, Juab Co., Utah; in the Grizzly Bear and other mines, Goldfield, Esmeralda Co., Nevada. In the Falcacci mine, Rio Marina, Elba, Italy. From near Dalbeattie, Kirkcudbrightshire, Scotland. At the Croft Gothal mine, Cornwall, England. From Wittichen, Black Forest, Germany. At Tary-Ekan, Karamazan, Tajikistan. From the Kara-Oba Mo–W deposit, Bet-Pak-Dal Desert, central Kazakhstan.

Name: In allusion to its composition, a *bismuth oxychloride*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 60–62. (2) Mountain, E.D. (1937) Two new bismuth minerals from South Africa. Mineral. Mag., 24, 59–64. (3) Keramidas, K.G., G.P. Voutsas, and P.I. Rentzeperis (1993) The crystal structure of BiOCl. Zeits. Krist., 205, 35–40. (4) (1953) NBS Circ. 539, 4, 54–55.

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Bismuth Bi

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals, to 12 cm, but indistinct, commonly in parallel groupings, or hoppered; reticulated, arborescent, foliated, granular. *Twinning:* Polysynthetic, common.

Physical Properties: *Cleavage:* Perfect on {0001}, good on $\{10\overline{1}1\}$, poor on $\{10\overline{1}4\}$. *Tenacity:* Sectile, brittle. Hardness = 2–2.5 VHN = 16–18 (100 g load). D(meas.) = 9.70–9.83 D(calc.) = 9.81

Optical Properties: Opaque. *Color:* Silver-white, with reddish hue, tarnishes iridescent; in polished section, brilliant creamy white, tarnishing yellow. *Streak:* Pale silver. *Luster:* Metallic. *Pleochroism:* Feeble. *Anisotropism:* Distinct.

R_1–R_2: (400) 47.0–58.2, (420) 49.3–58.8, (440) 51.4–59.7, (460) 52.9–60.9, (480) 54.4–62.4, (500) 56.2–63.9, (520) 57.8–65.3, (540) 59.3–66.6, (560) 60.4–67.8, (580) 61.4–69.0, (600) 62.4–69.9, (620) 63.1–70.7, (640) 63.6–71.5, (660) 63.9–72.2, (680) 64.0–72.8, (700) 64.1–73.2

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.546$ $c = 11.860$ $Z = 6$

X-ray Powder Pattern: Synthetic.
3.28 (100), 2.273 (41), 2.37 (40), 1.868 (23), 1.443 (16), 1.491 (11), 1.330 (11)

Chemistry:

	(1)
Bi	98.77
Sb	0.5
As	0.19
S	0.2
Total	99.66

(1) Durango, Mexico.

Mineral Group: Arsenic group.

Occurrence: In hydrothermal veins with ores of Co, Ni, Ag, and Sn; in pegmatites and topaz-bearing Sn–W quartz veins.

Association: Chalcopyrite, arsenopyrite, pyrrhotite, pyrite, cobaltite, nickeline, breithauptite, skutterudite, safflorite, löllingite, bismuthinite, silver, cubanite, molybdenite, sphalerite, galena, scheelite, wolframite, calcite, barite, quartz.

Distribution: From numerous localities, but typically as a minor accessory mineral. From Altenberg, Schneeberg, and Annaberg, Saxony, Germany. At Jáchymov (Joachimsthal), Czech Republic. From near Villanueva de Córdoba, Córdoba Province, Spain. In the Dolcoath and other mines, Cornwall, England. From Uncia, Chorolque, Llallagua, and Tazna, Potosí, Bolivia, economically important. An 11 kg nugget found at Velaque, La Paz, Bolivia. In the Mt. Arthur mine, Queensland, and from Kingsgate, New South Wales, Australia. At Natsukidani, Oita Prefecture, Japan, large crystals. From Cobalt, Ontario, Canada.

Name: From the German *weisse masse*, later *wismuth*, *white mass*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 134–135. (2) (1954) NBS Circ. 539, 3, 20. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 47.

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Bismuthinite Bi_2S_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, up to 12 cm, stout prismatic to acicular, elongated and striated ‖ [001]. Commonly massive with foliated or fibrous texture.

Physical Properties: *Cleavage:* {010}, perfect and easy, {100} and {110}, imperfect. *Tenacity:* Flexible, somewhat sectile. Hardness = 2–2.5 VHN = n.d. D(meas.) = 6.78 D(calc.) = 6.81

Optical Properties: Opaque. *Color:* Lead-gray to tin-white, with a yellowish or iridescent tarnish. *Streak:* Lead-gray. *Luster:* Metallic. *Anisotropism:* Strong, especially in oil.
R_1–R_2: (400) 35.7–46.2, (420) 36.4–47.2, (440) 37.2–47.9, (460) 37.7–48.3, (480) 37.7–48.8, (500) 37.6–49.4, (520) 37.3–49.6, (540) 37.1–49.1, (560) 36.9–48.7, (580) 36.8–48.3, (600) 36.6–47.8, (620) 36.4–47.3, (640) 36.3–46.8, (660) 36.1–46.3, (680) 36.0–45.8, (700) 35.9–45.4

Cell Data: *Space Group: Pbnm.* $a = 11.12$ $b = 11.25$ $c = 3.97$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.569 (100), 3.118 (80), 3.530 (60), 2.812 (50), 3.967 (40), 2.521 (40), 1.953 (40)

Chemistry:

	(1)	(2)	(3)	(4)
Bi	76.94	79.28	79.47	81.3
Pb		1.68		
Cu		0.48	0.57	
Fe		0.74	0.17	
Te			0.94	
Se	8.80			
S	14.15	18.46	18.42	18.7
insol.			0.50	
Total	99.89	100.64	100.07	100.0

(1) Guanajuato, Mexico. (2) Jonquiére, Quebec, Canada. (3) Riddarhyttan, Västmanland, Sweden. (4) Bi_2S_3.

Mineral Group: Forms a series with stibnite.

Occurrence: Typically in low- to high-temperature hydrothermal vein deposits, in tourmaline-bearing copper deposits in granite, in some gold veins formed at high temperatures, and in recent volcanic exhalation deposits.

Association: Bismuth, aikinite, arsenopyrite, stannite, galena, pyrite, chalcopyrite, tourmaline, wolframite, cassiterite, quartz.

Distribution: Widespread. From the Llallagua, Huanuni, Tazna, and Chorolque districts, Potosí, Bolivia. From Guanajuato, Mexico. In the USA, large crystals at the Victoria mine, Dolly Varden district, Elko Co.; in a number of mines in the Goldfield district, Esmeralda Co., and elsewhere in Nevada. From Moravicza and Băiţa (Rézbánya), Romania. At Schneeberg and Altenberg, Saxony, Germany. From a number of mines in Cornwall, England. In the Mt. Biggenden mine, Queensland, Australia. At Fefena, Madagascar. Exceptional crystals from Spind, Farsum, Norway.

Name: From the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 275–278. (2) Kupčik, V. and L. Veselá-Nováková (1970) Zur Kristallstruktur des Bismuthinits, Bi_2S_3. Tschermaks Mineral. Petrog. Mitt., 14, 55–59 (in German). (3) Springer,

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G. (1971) The synthetic solid-solution series Bi_2S_3–$BiCuPbS_3$ (bismuthinite–aikinite). Neues Jahrb. Mineral., Monatsh., 19–24. (4) Mumme, W.G., E. Welin, and B.J. Wuensch (1976) Crystal chemistry and proposed nomenclature for sulfosalts intermediate in the system bismuthinite–aikinite (Bi_2S_3–$CuPbBiS_3$). Amer. Mineral., 61, 15–20. (5) Topa, D., E. Makovicky, and W.H. Paar (2002) Composition ranges and exolution pairs for the members of the bismuthinite–aikinite series from Felbertal, Austria. Can. Mineral., 40, 849–869. (6) (1967) NBS Mono. 25, 5, 13.

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Bismutite $Bi_2O_2(CO_3)$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Very rare in platy crystals, to 0.5 mm; typically radially fibrous to spheroidal, in crusts and earthy to dense massive aggregates.

Physical Properties: *Cleavage:* On {001}, probable. Hardness = 2.5–3.5
D(meas.) = 6.1–7.7; 8.11 D(calc.) = 8.25

Optical Properties: Opaque to transparent in small grains. *Color:* Straw-brown, brown, brownish yellow, pale yellow, pale green, greenish gray, gray, may be dark gray to black in dense pseudomorphs; colorless to pale yellow or pale green in transmitted light. *Streak:* Gray. *Luster:* Vitreous, waxy, may be dull to earthy.
Optical Class: Uniaxial; moderate birefringence. *Orientation:* Positive elongation, parallel extinction. n = 2.12–2.30

Cell Data: *Space Group:* $I4/mmm$. a = 3.867–3.870 c = 13.686–13.697 Z = 2

X-ray Powder Pattern: Marropino mine, Zambezia, Mozambique.
2.953 (100), 2.737 (41), 3.724 (30), 1.6184 (30b), 2.137 (25), 1.7502 (22b), 1.9354 (20)

Chemistry:

	(1)	(2)
CO_2	8.29	8.63
Bi_2O_3	91.68	91.37
H_2O	trace	
Total	99.97	100.00

(1) Guanajuato, Mexico. (2) $Bi_2O_2(CO_3)$.

Occurrence: A relatively common alteration product of other bismuth-bearing minerals in hydrothermal mineral deposits and granite pegmatites.

Association: Bismuth, bismuthinite, tetradymite, many other bismuth-bearing minerals.

Distribution: Some well-confirmed occurrences include: in Germany, from Ullersreuth, Thuringia; at Schneeberg, Johanngeorgenstadt, and elsewhere in Saxony. At Meymac, Corrèze, France. In England, from Wheal Owles, Wheal Coates, the South Crofty mine, the Penberthy Croft mine, and others in Cornwall, and at Caldbeck Fells, Cumbria. From Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. At Tazna and many other places in Bolivia. In the USA, at the Harding mine, Dixon, Taos Co., New Mexico; in the Trout Creek Pass pegmatites, Chaffee Co., Colorado; from the Comstock mine, Dos Cabezos Mountains, Cochise Co., Arizona; at the Mammoth mine, Tintic district, Juab Co., Utah. From Kingsgate, New South Wales, Australia. At many other minor localities.

Name: In allusion to *bismuth* in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 259–262. (2) Lagerkrantz, A. and G. Sillén (1948) On the crystal structure of $Bi_2O_2CO_3$ (bismutite) and $CaBi_2O_2(CO_3)_2$ (beyerite). Arkiv Kemi, 25(20), 21 p. (3) Sahama, T.G. and M. Lehtinen (1968) Bismutite of the granite pegmatites of Zambezia, Mozambique. Bull. Geol. Soc. Finland, 40, 145–150.

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Bismutocolumbite $Bi(Nb,Ta)O_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic crystals, to 2 mm, striated perpendicular to elongation.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 7.56 D(calc.) = [7.66]

Optical Properties: Semitransparent. *Color:* Black; brown in transmitted light. *Streak:* Brown to pale yellow. *Luster:* Submetallic. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 2.38$ $\beta = 2.42$ $\gamma = 2.47$ 2V(meas.) = n.d. 2V(calc.) = 85°

Cell Data: *Space Group:* $Pcnn$. $a = 4.992(3)$ $b = 11.731(3)$ $c = 5.677(5)$ Z = 4

X-ray Powder Pattern: Danburitovaya mine, Russia.
3.164 (100), 2.934 (90), 1.734 (80), 2.842 (45), 2.495 (45), 1.769 (45), 1.899 (40)

Chemistry:

	(1)
Nb_2O_5	27.03
Ta_2O_5	11.67
TiO_2	0.06
SnO_2	0.08
Bi_2O_3	59.85
Sb_2O_3	0.28
PbO	0.13
Total	99.10

(1) Danburitovaya mine, Russia; by electron microprobe, corresponding to $(Bi_{0.99}Sb_{0.01})_{\Sigma=1.00}(Nb_{0.79}Ta_{0.21})_{\Sigma=1.00}O_4$.

Occurrence: In a pegmatite.

Association: Elbaite, bismuth-rich microlite, cassiterite, danburite, quartz.

Distribution: In the Danburitovaya mine, Malkhan Range, central Transbaikal, Russia.

Name: For BISMuth in its composition and relation to minerals of the *columbite–tantalite* series.

Type Material: Mining Institute, St. Petersburg, 2075/1; Il'menskii Preserve Museum, Miass, 3604, 3619; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p767/1.

References: (1) Peretazhko, I.S., V.E. Zagorskiy, A.N. Sapozhnikov, Y.D. Bobrov, and A.D. Rakcheev (1992) Bismutocolumbite $Bi(Nb,Ta)O_4$ – a new mineral from miarolitic pegmatites. Zap. Vses. Mineral. Obshch., 121(3), 130–134 (in Russian). (2) (1994) Amer. Mineral., 79, 570 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 111 (abs. ref. 1).

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Bismutoferrite $BiFe_2^{3+}(SiO_4)_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* m. Minutely crystalline, powdery, earthy, massive.

Physical Properties: *Fracture:* Even to flat conchoidal when massive. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 4.47 D(calc.) = [5.09]

Optical Properties: Semitransparent. *Color:* Yellow, green. *Streak:* Light green. *Optical Class:* Biaxial. $\alpha = 1.93$ $\beta = 1.97$ $\gamma = 2.01$ 2V(meas.) = n.d.

Cell Data: *Space Group:* Cm. $a = 5.21$ $b = 9.02$ $c = 7.74$ $\beta = 100°40'$ Z = 2

X-ray Powder Pattern: Schneeberg, Germany; could be confused with chapmanite. 7.63 (100), 3.87 (100), 2.90 (70), 3.18 (50), 3.58 (35), 2.59 (35), 2.53 (25)

Chemistry:

	(1)	(2)	(3)
SiO_2	23.08	23.9	23.03
Al_2O_3		0.3	
Fe_2O_3	33.33	29.3	30.60
FeO		1.8	
Bi_2O_3	43.26	42.5	44.64
As_2O_3		0.08	
H_2O^+		1.8	1.73
Total	99.67	99.7	100.00

(1) Schneeberg, Germany. (2) Do.; corresponds to $Bi_{0.92}(Fe^{3+}_{1.86}Fe^{2+}_{0.25}Al_{0.03})_{\Sigma=2.14}Si_2O_8(OH)$. (3) $BiFe_2(SiO_4)_2(OH)$.

Occurrence: Probably of hydrothermal origin, in veins cutting shale (Schneeberg, Germany).

Association: Quartz, "chalcedony," bismuth, cobaltite, arsenopyrite, chlorargyrite (Schneeberg, Germany); quartz, bismuth, galena, silver ores (Johanngeorgenstadt, Germany); clinobisvanite (Lodi # 4 claim, California, USA).

Distribution: In Germany, at Schneeberg, Johanngeorgenstadt, and Gersdorf, Saxony. From near Smrkovec, Slavkovský Les Mountains, about 10 km north-northeast of Mariánské Lázně, Czech Republic. In England, at the South Terras mine, St. Stephen-in-Brannel, and the Hingston Down quarry, Calstock, Cornwall, and at Buckbarrow Beck, Carney Fell, Cumbria. From the Lodi # 4 claim, Plumas Co., California, and in the Organ Mountains, Dona Ana Co., New Mexico, USA.

Name: For BISMUTh and iron, (FERRum), in the composition.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 562. (2) Milton, C., J.M. Alexrod, and B. Ingram (1958) Bismutoferrite, chapmanite, and "hypochlorite". Amer. Mineral., 43, 656–670. (3) Zhukhlistov, A.P. and B.B. Zvyagin (1977) Determination of the crystal structures of chapmanite and bismuthoferrite [bismutoferrite] by high-voltage electron diffraction. Kristallografiya (Sov. Phys. Crystal.), 22, 731–738 (in Russian).

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Bismutohauchecornite $Ni_9Bi_2S_8$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As elongated tabular crystals, to 0.3 mm; as grains and massive.

Physical Properties: Hardness = n.d. VHN = 360–392, average 375 (10 g load). D(meas.) = n.d. D(calc.) = [6.25]

Optical Properties: Opaque. *Color:* Bronze-yellow. *Pleochroism:* Moderate. *Anisotropism:* Weak in reflected light.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P4/mmm$. $a = 7.37$ $c = 5.88$ Z = [1]

X-ray Powder Pattern: Oktyabr mine, Russia.
2.80 (10), 1.867 (8), 4.34 (6), 2.40 (6), 2.32 (6), 3.67 (5), 1.808 (4)

Chemistry:

	(1)	(2)	(3)
Ni	43.6	45.85	43.93
Fe	0.2	0.22	
Co	0.8	0.66	
Pb		0.01	
As	0.5	0.72	
Bi	33.9	27.76	34.75
S	21.4	22.46	21.32
Total	100.4	97.68	100.00

(1) Oktyabr mine, Russia; by electron microprobe, corresponding to $(Ni_{8.90}Co_{0.16}Fe_{0.04})_{\Sigma=9.10}(Bi_{1.94}As_{0.08})_{\Sigma=2.02}S_{8.00}$. (2) Zimmer Lake, Canada; by electron microprobe, corresponding to $(Ni_{8.92}Co_{0.13}Fe_{0.04})_{\Sigma=9.09}(Bi_{1.52}As_{0.11})_{\Sigma=1.63}S_{8.00}$. (3) $Ni_9Bi_2S_8$.

Mineral Group: Hauchecornite group.

Occurrence: Of hydrothermal origin; as secondary pore-fillings and replacements of sandstone and conglomerate (Zimmer Lake, Canada); in ultramafic rocks (Liu Zhuang, China).

Association: Chalcocite, galena, pentlandite, altaite (Oktyabr mine, Russia); chalcopyrite, pyrrhotite, millerite (Zimmer Lake, Canada).

Distribution: In the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia, Russia [TL]. From near Zimmer Lake, northern Saskatchewan, Canada. At the Mihara mine, Okayama Prefecture, and the Tsumo mine, Shimane Prefecture, Japan. In China, from Liu Zhuang, Tongbai Co., Henan Province.

Name: For the relation to hauchecornite.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 77168.

References: (1) Kovalenker, V.A., T.L. Evstigneeva, V.D. Begizov, L.N. Vyal'sov, A.V. Smirnov, Y.K. Krakovetskii, and V.S. Balbin (1978) Hauchecornite from copper-nickel ores of the Oktyabr'skoe deposit. Trudy Min. muzeya Akad. Nauk SSSR, 26, 201–205 (in Russian). (2) (1979) Chem. Abs., 90, 158 (abs. ref. 1). (3) Just, J. (1980) Bismutohauchecornite—new name: hauchecornite redefined. Mineral. Mag., 43, 873–876. (4) Watkinson, D.H., J.B. Heslop, and W.D. Ewert (1975) Nickel sulphide-arsenide assemblages associated with uranium mineralization, Zimmer Lake area, northern Saskatchewan. Can. Mineral., 13, 198–204.

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Bismutomicrolite $(Bi, Ca)(Ta, Nb)_2O_6(OH)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As crystals, octahedral, to 2 mm; commonly massive, in veinlets.

Physical Properties: *Fracture:* Uneven. *Tenacity:* [Brittle] (by analogy to the pyrochlore group). Hardness = 5 D(meas.) = ∼6.5 D(calc.) = 6.83–6.97

Optical Properties: Semitransparent. *Color:* Yellow, pink, brown; dark gray to black.
Luster: Dull, resinous.
Optical Class: Isotropic. $n = > 2.00$

Cell Data: *Space Group: Fd3m.* a = 10.430–10.485 Z = 8

X-ray Powder Pattern: Tromba pegmatite, Brazil.
2.997 (vvs), 1.838 (vs), 1.568 (vs), 3.136 (s), 5.94 (ms), 2.595 (ms), 2.004 (ms)

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	5.65	6.65	CaO	1.46	3.35
Ta_2O_5	45.49	63.10	SrO	0.92	
SiO_2	0.36		Na_2O	0.08	
Al_2O_3	0.80		K_2O	0.09	
Fe_2O_3		0.08	Li_2O	0.25	
Bi_2O_3	40.40	25.09	H_2O^+	4.16	1.50
FeO + MnO	0.22		H_2O^-	0.04	
			Total	99.92	[99.77]

(1) Wampewo pegmatite, Uganda. (2) Tromba pegmatite, Brazil; original total given as 99.97%, after deduction of Fe_2O_3 corresponds to $(Bi_{0.64}Ca_{0.36})_{\Sigma=1.00}(Ta_{1.69}Nb_{0.31})_{\Sigma=2.00}O_6(OH)$.

Mineral Group: Pyrochlore group; microlite subgroup: $Bi_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Ta_B \geq Nb_B$.

Occurrence: A late hydrothermal replacement of bismutotantalite in a lithium-bearing pegmatite (Wampewo pegmatite, Uganda).

Association: Waylandite, bismutotantalite (Wampewo Hill, Uganda); bismutite, bismuth (Tromba pegmatite, Brazil).

Distribution: In the Wampewo pegmatite, Gamba Hill, near Kampala, southwest Uganda. In the Tromba pegmatite, Goiás; at Alto Manoel, Baldoino, Paraíba; and at Lavra Ermo, Carnauba dos Danta, Rio Grande del Norte, Brazil. From the Solnetchnaya mine, Malkhan Range, central Tranbaikalia, Russia.

Name: Assigned by the IMA Committee on pyrochlore nomenclature for the predominant *bismuth* content and relation to *microlite* in the pyrochlore group.

Type Material: n.d.

References: (1) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410, esp. 408 [westgrenite = bismutomicrolite]. (2) von Knorring, O. and M.E. Mrose (1963) Westgrenite [bismutomicrolite] and waylandite, two new bismuth minerals from Uganda (abs.). Geol. Soc. Amer. Spec. Paper 73, 256A (abs.). (3) (1963) Amer. Mineral., 48, 216 (abs. ref. 2). (4) Erichsen de Oliveira, O., N. Rocha Baptista, and A. Baptista (1970) Westgrenita [bismutomicrolite] no pegmatito de Tromba, Estado de Goiás. An. Acad. brasil. Ciénc., 42(1), 41–44 (in Portuguese).

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Bismutopyrochlore $(Bi, U, Ca, Pb)_{1+x}(Nb, Ta)_2O_6(OH)\cdot nH_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Always anhedral, forming earthy crusts.

Physical Properties: Hardness = 4–5 D(meas.) = n.d. D(calc.) = 7.38

Optical Properties: Transparent to opaque. *Color:* Yellow to yellow-brown, rarely greenish; brownish in transmitted light.
Optical Class: Isotropic. $n = 2.09(1)$

Cell Data: *Space Group:* $Fd3m$. a = 10.38 Z = 8

X-ray Powder Pattern: Neubulach, Germany.
3.01 (10), 2.60 (7), 1.833 (7), 1.565 (7), 1.190 (5), 1.162 (5), 1.498 (4)

Chemistry:

	(1)
Fe_2O_3	6.9
Bi_2O_3	49.2
Sb_2O_3	43.9
Total	100.0

(1) Clara mine, Germany; by electron microprobe, corresponds to $Bi^{3+}_{1.31}Sb^{5+}_{1.69}Fe^{3+}_{0.54}O_7$.

Mineral Group: Stibiconite group.

Occurrence: A secondary mineral formed as an alteration product of bismuthian tetrahedrite–tennantite.

Association: Tetrahedrite–tennantite, chalcopyrite, beyerite, atelestite, preisingerite, bismutite, malachite, azurite, olivenite.

Distribution: From the Clara mine, near Oberwolfach, at Neubulach, and at Niederohlsbach, Black Forest, Germany. In the Lodi #4 mine, Spring Creek district, Plumas Co., California, USA.

Name: For a *bismuth*-containing member of the *stibiconite* group.

Type Material: n.d.

References: (1) Walenta, K. (1983) Bismutostibiconit, ein neues Mineral der Stibiconitgruppe aus dem Schwarzwald. Chem. Erde, 42, 77–81 (in German with English abs.). (2) (1984) Amer. Mineral., 69, 1190 (abs. ref. 1).

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Bismutostibiconite $Bi(Sb^{5+},Fe^{3+})_2O_7$

Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Always anhedral, forming earthy crusts.

Physical Properties: Hardness = 4–5 D(meas.) = n.d. D(calc.) = 7.38

Optical Properties: Transparent to opaque. *Color:* Yellow to yellow-brown, rarely greenish; brownish in transmitted light.
Optical Class: Isotropic. $n = 2.09(1)$

Cell Data: *Space Group:* $Fd3m$. a = 10.38 Z = 8

X-ray Powder Pattern: Neubulach, Germany.
3.01 (10), 2.60 (7), 1.833 (7), 1.565 (7), 1.190 (5), 1.162 (5), 1.498 (4)

Chemistry:

	(1)
Fe_2O_3	6.9
Bi_2O_3	49.2
Sb_2O_3	43.9
Total	100.0

(1) Clara mine, Germany; by electron microprobe, corresponds to $Bi^{3+}_{1.31}Sb^{5+}_{1.69}Fe^{3+}_{0.54}O_7$.

Mineral Group: Stibiconite group.

Occurrence: A secondary mineral formed as an alteration product of bismuthian tetrahedrite–tennantite.

Association: Tetrahedrite–tennantite, chalcopyrite, beyerite, atelestite, preisingerite, bismutite, malachite, azurite, olivenite.

Distribution: From the Clara mine, near Oberwolfach, at Neubulach, and at Niederohlsbach, Black Forest, Germany.

Name: For a *bismuth*-containing member of the *stibiconite* group.

Type Material: n.d.

References: (1) Walenta, K. (1983) Bismutostibiconit, ein neues Mineral der Stibiconitgruppe aus dem Schwarzwald. Chem. Erde, 42, 77–81 (in German with English abs.). (2) (1984) Amer. Mineral., 69, 1190 (abs. ref. 1).

Bismutotantalite $Bi(Ta,Nb)O_4$

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Crystal Data: Orthorhombic; may be metamict. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As stout crystals, prismatic [001], to 10 cm, commonly irregular or misshapen.

Physical Properties: *Cleavage:* Partings or cleavages on {010}, good; {101}, {100}, distinct. *Fracture:* Subconchoidal. Hardness = 5–5.5 D(meas.) = 8.15–8.89 D(calc.) = 8.73–8.98

Optical Properties: Opaque, transparent in very thin fragments. *Color:* Pale brown to pitch-black; pale smoke-gray to colorless in transmitted light. *Streak:* Yellow, yellow-brown to black. *Luster:* Adamantine to submetallic.
Optical Class: Biaxial (+); isotropic when metamict. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$. $\alpha = 2.388$–2.395 $\beta = 2.403$–2.408 $\gamma = 2.426$–2.428 2V(meas.) = 80°

Cell Data: *Space Group:* $Pcmn$ or $Pcn2_1$. a = 4.97–5.00 $b = 11.80$–11.89 $c = 5.66$–5.69 Z = 4

X-ray Powder Pattern: Acari, Brazil.
3.148 (10), 2.945 (6), 3.555 (3), 1.735 (3), 1.270 (3), 2.819 (2), 2.743 (2)

Chemistry:

	(1)	(2)	(3)	(4)
Nb_2O_5	6.63	1.26	5.6	
Ta_2O_5	40.12	46.45	42.1	48.67
SiO_2		0.16		
Fe_2O_3	0.11	0.94		
Bi_2O_3	52.26	48.98	49.4	51.33
Sb_2O_3	0.04	1.76	1.2	
ZnO		0.38		
MnO	0.12	0.11		
LOI	0.33	0.62		
Total	99.61	100.66		100.00

(1) Gamba Hill, Uganda; contains additionally U_3O_8 0.06%. (2) Acari, Brazil. (3) Muiâne mines, Mozambique; partial analysis by XRF and electron microprobe. (4) $BiTaO_4$.

Occurrence: In granite pegmatite (Uganda and Mozambique); as stream-rounded pebbles (Acari, Brazil).

Association: Muscovite, schorl, cassiterite (Gamba Hill, Uganda).

Distribution: On Gamba Hill, near Kambala, southwest Uganda. In the Muiâne pegmatite, Alto Ligonha district, Mozambique. At Analamisakana, Madagascar. In Brazil, in Rio Grande do Norte, from Acari, near Picuí, Campina Grande, at Carnauba dos Dantas, Saco do Onca, at Parelhas, near Recife, and at Currais Novos; in the Baldino mine, Junco, Paraíba. In Japan, at Nagatareyama, Fukuoka Prefecture. From an undisclosed locality [Kjoktogoi] in the Altai Mountains, Sinkiang Uighur Autonomous Province, China.

Name: For BISMuth in its composition, and relation to *tantalite*.

Type Material: The Natural History Museum, London, England, 1929,160; National Museum of Natural History, Washington, D.C., USA, 96044.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 769–770. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 442–445. (3) Hurlbut, C.S., Jr. (1957) Bismutotantalite from Brazil. Amer. Mineral., 42, 178–183. (4) von Knorring, O. and A. Fadipe (1981) On the mineralogy and geochemistry of niobium and tantalum in some granite pegmatites and alkali granites of Africa. Bull. Minéral., 104, 496–507.

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Bityite $CaLiAl_2(AlBeSi_2)O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals thin and pseudohexagonal, to 1 cm; as lamellae which may form rosettes and as dense, micaceous aggregates.

Physical Properties: *Cleavage:* Perfect micaceous on {001}. *Fracture:* Uneven. Hardness = 4–4.5 VHN = 277–304 D(meas.) = 3.02–3.05 D(calc.) = 3.14

Optical Properties: Transparent to translucent. *Color:* Pearly white, grayish blue, greenish blue, light brown; colorless in thin section, prominently zoned into six sectors. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X \simeq c$; $Y \simeq a$; $Z = b$. $\alpha = 1.651$ $\beta = 1.659$ $\gamma = 1.661$ 2V(meas.) = 35°–52°

Cell Data: *Space Group:* $C2/c$. $a = 4.98$ $b = 8.67$ $c = 18.74$ $\beta = \sim 90°$ Z = 4

X-ray Powder Pattern: Mt. Bity, Madagascar.
2.480 (100), 1.45 (100), 2.043 (90), 3.136 (80), 1.878 (70), 4.29 (60), 2.355 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	31.95	33.37	31.04
Al_2O_3	41.75	36.24	39.51
FeO		0.17	
BeO	2.27	7.30	6.46
MgO	0.13	0.04	
CaO	14.30	14.42	14.48
Li_2O	2.73	2.39	3.86
Na_2O	0.40	0.29	
K_2O	0.16	0.04	
H_2O	6.50	5.72	4.65
Total	100.19	99.98	100.00

(1) Mt. Bity, Madagascar; BeO apparently partially determined as Al_2O_3. (2) Londonderry, Australia. (3) $CaLiAl_2(AlBeSi_2)O_{10}(OH)_2$.

Polymorphism & Series: $2M_1$ polytype.

Mineral Group: Mica group.

Occurrence: A late-stage mineral in lithium-bearing pegmatites.

Association: Tourmaline, albite, lepidolite (Mt. Bity, Madagascar); bavenite, beryl, albite, cassiterite, columbite, tourmaline (Londonderry, Australia); calcite, albite (Strickland quarry, Connecticut, USA).

Distribution: In Madagascar, from Maharitra, on Mt. Bity. In the Namherere mine, Aukole, Uganda. In the USA, from the Strickland quarry, Portland, Middlesex Co., Connecticut, and the Harding pegmatite, Dixon, Taos Co., New Mexico. On the Huron claims, 16 km north of Point du Bois, Manitoba, Canada. At Pizzo Marcio, Val Vigezzo, Piedmont, Italy. From the Maantienvarsi pegmatite dike, Eräjärvi pegmatite area, Orivesi, Finland. At Tittling, near Passau, Bavaria, Germany. At Londonderry, Western Australia.

Name: For the locality, Mt. Bity, Madagascar.

Type Material: Natural History Museum, Paris, France; Harvard University, Cambridge, Massachusetts, USA, 87680.

References: (1) Lacroix, A. (1908) Les minéraux des filons de pegmatite à tourmaline lithique de Madagascar. Bull. Soc. fr. Minéral., 31, 218–247 (in French). (2) (1950) Amer. Mineral., 35, 1091 (discussion of analysis in ref. 1). (3) Strunz, H. (1956) Bityit, ein berylliumglimmer. Zeits. Krist., 107, 325–330 (in German). (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 114–116. (5) Lin, J.-C. and S. Guggenheim (1983) The crystal structure of a Li,Be-rich brittle mica: a dioctahedral-trioctahedral intermediate. Amer. Mineral., 68, 130–142.

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Bixbyite $(Mn^{3+}, Fe^{3+})_2O_3$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As cubes, rarely modified by {112} or {111}, commonly striated, to 6 cm; massive. *Twinning:* On {111}, as penetration twins.

Physical Properties: *Cleavage:* {111}, in traces. *Fracture:* Irregular. Hardness = 6–6.5 VHN = 946–1402 (100 g load). D(meas.) = 4.945 D(calc.) = 5.031

Optical Properties: Opaque. *Color:* Black. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R: (400) 24.7, (420) 24.1, (440) 23.5, (460) 23.0, (480) 22.8, (500) 22.9, (520) 23.3, (540) 23.6, (560) 23.5, (580) 23.2, (600) 22.9, (620) 22.7, (640) 22.4, (660) 22.2, (680) 22.2, (700) 22.1

Cell Data: *Space Group:* $Ia3$. $a = 9.411$ $Z = 16$

X-ray Powder Pattern: Synthetic Mn_2O_3.
2.72 (100), 1.664 (30), 3.84 (25), 2.01 (14), 1.845 (14), 1.4191 (14), 2.35 (12)

Chemistry:

	(1)	(2)	(3)
SiO_2	1.21	0.00	
TiO_2	1.70		
Al_2O_3	2.53	2.02	
Fe_2O_3	47.98	14.86	50.29
Mn_2O_3		82.56	49.71
MnO	42.05		
MgO	0.10	0.07	
O	4.38		
Total	99.95	99.51	100.00

(1) Thomas Range, Utah, USA; average of two analyses. (2) Postmasburg, South Africa; by electron microprobe. (3) $(Mn, Fe)_2O_3$ with Mn:Fe = 1:1.

Occurrence: In lithophysal cavities in rhyolite; in metamorphosed manganese ores.

Association: Topaz, spessartine, beryl, quartz, sanidine, pseudobrookite, hematite (rhyolites); braunite (manganese ores).

Distribution: In the USA, from the Thomas Range, Juab Co., Utah; at a number of places in the Black Range, Sierra and Catron Cos., New Mexico; and near Saddle Mountain, Pinal Co., Arizona. In Mexico, at Cerro de Mercado, Durango; the Barranca del Cobre, Chihuahua; and Tepetate, San Luis Potosi. From Ribes, Gerona Province, Spain. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. At Långban, Värmland, near Murjek, and at Sörhårås, Ultevis, Sweden. From Sitapár, Chindwara district, Central Provinces, and the Kajlidongri mine, Jhabua district, Madhya Pradesh, India. At Cobatla, near Postmasburg, Transvaal; a major ore in the Kuruman district, Cape Province, South Africa. In the Lomagundi district, Zimbabwe. Large crystals from the Otjiwarango district, Namibia. A few additional localities are known.

Name: For Maynard Bixby, mineral dealer of Salt Lake City, Utah, USA, who provided the first specimens.

Type Material: Yale University, New Haven, Connecticut, USA, 1.6369.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 550–551. (2) Montgomery, A. (1934) A recent find of bixbyite and associated minerals in the Thomas Range, Utah. Amer. Mineral., 19, 82–87. (3) Geller, S. (1971) Structures of $\alpha-Mn_2O_3$, $(Mn_{0.983}Fe_{0.017})_2O_3$ and $(Mn_{0.37}Fe_{0.63})_2O_3$ and relation to magnetic ordering. Acta Cryst., 27, 821–828. (4) Moore, P.B. and T. Araki (1976) Braunite: its structure and relationship to bixbyite, and some insights on the genealogy of fluorite derivative structures. Amer. Mineral., 61, 1226–1240. (5) de Villiers, J.P. and P.R. Buseck (1989) Stacking variations and nonstoichiometry in the bixbyite-braunite polysomatic mineral group. Amer. Mineral., 74, 1325–1336. (6) (1959) NBS Circ. 539, 9, 37.

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Bjarebyite $(Ba,Sr)(Mn^{2+},Fe^{2+},Mg)_2Al_2(PO_4)_3(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As multiply-faceted, steeply-terminated, spearhead-shaped crystals, to 3 mm, with as many as 14 forms discernable. Also as etched and striated prismatic crystals, and fibrous, massive.

Physical Properties: *Cleavage:* Perfect on {010} and {100}. Hardness = 4
D(meas.) = 3.90–3.95 D(calc.) = 3.92–4.02

Optical Properties: Translucent. *Color:* Emerald-green, with a faint bluish tint; pistachio to dark green. *Streak:* White. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* Weak, grayish tan to pale yellow-green; also strong, X = colorless to pale brownish yellow; Y = brownish green; Z = apple-green or olive-green.
Orientation: $Y = b$; $Z \wedge c = 7°–8°$. *Dispersion:* $r \gg v$ to $r < v$. $\alpha = 1.692–1.724$
$\beta = 1.695–1.727$ $\gamma = 1.710–1.749$ 2V(meas.) = ∼35°–38° 2V(calc.) = 40°56′

Cell Data: *Space Group:* $P2_1/m$. $a = 8.930(14)$ $b = 12.073(24)$ $c = 4.917(9)$
$\beta = 100.15(13)°$ Z = 2

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
3.090 (10), 8.81 (7), 2.681 (7), 1.495 (5), 4.97 (4), 4.47 (4), 2.910 (4)

Chemistry:

	(1)	(2)
P_2O_5		32.96
Al_2O_3	13.43	13.25
Fe_2O_3		3.30
FeO	8.67	5.94
MnO	9.56	15.98
SrO	1.57	
BaO	23.69	23.87
H_2O		4.70
Total		100.00

(1) Palermo #1 mine, New Hampshire, USA; by electron microprobe, partial analysis, total Fe as FeO, total Mn as MnO; corresponds to $(Ba_{1.1}Sr_{0.1})_{\Sigma=1.2}Al_{1.8}(Mn_{0.9}Fe_{0.9}Mg_{0.2})_{\Sigma=2.0}(PO_4)_3(OH)_3$.
(2) Buranga mine, Rwanda; average of two analyses, corresponding to $Ba_{1.00}(Mn_{1.45}Fe_{0.53})_{\Sigma=1.98}(Al_{1.67}Fe^{3+}_{0.28})_{\Sigma=1.95}(PO_4)_{2.97}(OH)_{2.90}$.

Mineral Group: Bjarebyite group.

Occurrence: A rare late stage reaction product of triphylite and amblygonite in complex granite pegmatites.

Association: Palermoite, augelite, childrenite, montebrasite, scorzalite, whitlockite, carbonate-apatite, siderite (Palermo #1 mine, New Hampshire, USA); bertossaite, lazulite-scorzalite, burangaite, trolleite, apatite, quartz (Buranga mine, Rwanda).

Distribution: From the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, USA. At the Buranga pegmatite, near Gatumba, Rwanda. In the Västanå mine, near Näsum, Skåne, Sweden.

Name: Honors Alfred Gunnar Bjareby (1899–1967), Swedish-American student of New England pegmatite minerals, Boston, Massachusetts, USA, who collected the first specimen.

Type Material: n.d.

References: (1) Moore, P.B., D.H. Lund, and K.L. Keester (1973) Bjarebyite, $(Ba,Sr)(Mn,Fe,Mg)_2Al_2(OH)_3(PO_4)_3$, a new species. Mineral. Record, 4, 282–285. (2) (1974) Amer. Mineral., 59, 873 (abs. ref. 1). (3) Moore, P.B. and T. Araki (1974) Bjarebyite, $Ba(Mn,Fe)_2^{2+}Al_2(OH)_3[PO_4]_3$: Its atomic arrangement. Amer. Mineral., 59, 567–572. (4) von Knorring, O. and A.-M. Fransolet (1975) An occurrence of bjarebyite in the Buranga pegmatite, Rwanda. Schweiz. Mineral. Petrog. Mitt., 55, 9–18. (5) Mandarino, J.A. and B.D. Sturman (1976) Kulanite, a new barium iron aluminum phosphate from the Yukon Territory, Canada. Can. Mineral., 14, 127–131.

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Blatonite $(UO_2)CO_3 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. As distorted acicular crystals, typically in asbestiform bundles, to 1 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Flexible. Hardness = 2–3 D(meas.) = 4.05(2) D(calc.) = 4.02 Radioactive; strongly fluoresces greenish yellow under LW UV.

Optical Properties: Translucent. *Color:* Canary-yellow. *Streak:* White. *Luster:* Silky. *Optical Class:* Uniaxial (+). *Orientation:* Length-fast. $\omega = 1.588(2)$ $\epsilon = 1.612(2)$

Cell Data: *Space Group:* n.d. $a = 15.79(1)$ $c = 23.93(3)$ Z = 36

X-ray Powder Pattern: Jomac mine, Utah, USA.
3.056 (100), 6.56 (77), 6.91 (55), 7.86 (47), 4.76 (40), 4.34 (36), 3.39 (33)

Chemistry:

	(1)	(2)
UO_3	81.98	82.18
CO_2	12.82	12.64
H_2O	5.38	5.18
Total	100.18	100.00

(1) Jomac mine, Utah, USA; by electron microprobe and TGA, $(CO_3)^{2-}$ and $(OH)^{1-}$ confirmed by IR; corresponds to $(UO_2)_{0.99}(CO_3)_{1.00} \cdot 1.03H_2O$. (2) $(UO_2)CO_3 \cdot H_2O$.

Occurrence: In seams of gypsum in the oxidized portions of a roll-front-type uranium deposit in silty conglomerate.

Association: Gypsum, boltwoodite, coconinoite, metazeunerite, rutherfordine, azurite, brochantite, carbonate-cyanotrichite, malachite, manganoan smithsonite.

Distribution: From the Jomac mine, White Canyon district, San Juan Co., Utah, USA.

Name: Honors Dr. Norbert Blaton (1945–), crystallographer and specialist in uranium minerals, Catholic University of Leuven, Leuven, Belgium.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, R.C.4788.

References: (1) Vochten, R. and M. Deliens (1998) Blatonite, $UO_2CO_3 \cdot H_2O$, a new uranyl carbonate monohydrate from San Juan County, Utah. Can. Mineral., 36, 1077–1081. (2) (1999) Amer. Mineral., 84, 990 (abs. ref. 1).

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Blatterite $(Mn^{2+},Mg)_{35}(Mn^{3+},Fe^{3+})_9Sb_3^{5+}(BO_3)_{16}O_{32}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Lathlike crystals, to 5 mm, elongated and striated parallel [001], showing {110}, poorly terminated, may be slightly curved.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, imperfect, a parting. *Tenacity:* Brittle. Hardness = ∼6 VHN = 814–940, 877 average (100 g load). D(meas.) = 4.7(4) D(calc.) = 4.25

Optical Properties: Opaque. *Color:* Black; exhibits red-orange internal reflections. *Streak:* Brown. *Luster:* Metallic to submetallic. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Anisotropism:* Weak to distinct; shades of grayish brown. *Bireflectance:* Buff, creamy buff, pale buff. R_1–R_2: (400) 11.1–12.4, (420) 10.9–12.2, (440) 10.7–12.0, (460) 10.5–11.9, (480) 10.4–11.8, (500) 10.3–11.7, (520) 10.2–11.6, (540) 10.1–11.5, (560) 10.0–11.4, (580) 9.98–11.4, (600) 9.97–11.3, (620) 9.95–11.3, (640) 9.93–11.2, (660) 9.91–11.2, (680) 9.88–11.1, (700) 9.86–11.1

Cell Data: *Space Group: Pnnm.* $a = 37.654(8)$ $b = 12.615(3)$ $c = 6.2472(8)$ Z = 2

X-ray Powder Pattern: Nordmark, Sweden.
2.605 (100), 5.243 (45), 2.721 (40), 2.621 (35), 1.564 (35), 2.520 (30), 5.621 (20)

Chemistry:

	(1)	(2)
B_2O_3	14.4	[14.63]
Sb_2O_5	12.65	12.80
TiO_2		0.19
Al_2O_3		0.33
Fe_2O_3	3.48	1.96
Mn_2O_3	[9.9]	[16.03]
MnO	[46.2]	[38.89]
MgO	13.0	14.89
Total	[99.63]	[99.72]

(1) Nordmark, Sweden; by ICP, total Sb as Sb_2O_5, total Fe as Fe_2O_3, Mn^{2+}:Mn^{3+} calculated for charge balance; then corresponds to $(Mn^{2+}_{22.38}Mg_{12.62})_{\Sigma=35.00}(Mn^{3+}_{4.91}Fe^{3+}_{1.71}Mn^{2+}_{3.12})_{\Sigma=9.74}Sb^{5+}_{3.06}(B_{1.01}O_3)_{16.00}O_{32}$. (2) Långban, Sweden; by electron microprobe, total Sb as Sb_2O_5, total Fe as Fe_2O_3, Mn^{2+}:Mn^{3+} calculated for charge balance; then corresponds to $(Mn^{2+}_{20.87}Mg_{14.06})_{\Sigma=34.93}(Mn^{3+}_{7.73}Fe^{3+}_{0.93}Al_{0.25}Ti_{0.09})_{\Sigma=9.00}Sb^{5+}_{3.01}(BO_3)_{16.00}O_{32}$.

Occurrence: From metamorphosed Fe–Mn orebodies.

Association: Manganosite, pyrochroite, hausmannite, katoptrite, calcite.

Distribution: From [the Brattfors mine,] Nordmark, and at Långban, Värmland, Sweden.

Name: Honoring Fritz Blatter (1943–), German mineral collector, who provided the original material.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; Mineralogical-Geological Museum, University of Oslo, Oslo, Norway; The Natural History Museum, London, England1986,112, E.1168.

References: (1) Raade, G., M.H. Mladeck, V.K. Din, A.J. Criddle, and C.J. Stanley (1988) Blatterite, a new Sb-bearing $Mn^{2+}-Mn^{3+}$ member of the pinakiolite group, from Nordmark, Sweden. Neues Jahrb. Mineral., Monatsh., 121–136. (2) (1989) Amer. Mineral., 74, 1399 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1998) The crystal structure of blatterite, $Sb_3^{5+}(Mn^{3+},Fe^{3+})_9(Mn^{2+},Mg)_{35}(BO_3)_{16}O_{32}$, and structural hierarchy in $Mn^{3+}-$bearing zigzag borates. Can. Mineral., 36, 1171–1193.

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Bleasdaleite $(Ca,Fe^{3+})_2Cu_5(Bi,Cu)(PO_4)_4(H_2O,OH,Cl)_{13}$

Crystal Data: Monoclinic [pseudotetragonal]. *Point Group*: 2/*m*. As thin tabular crystals, to 20 μm, that form scaly crusts, rosettes and hemispherical aggregates to 100 μm.

Physical Properties: *Cleavage*: Well developed on {001}. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 2 D(meas.) = n.d. D(calc.) = 2.77

Optical Properties: Transparent. *Color*: Dark brown. *Streak*: Pale brown. *Luster*: Resinous. *Optical Class*: Biaxial (-). α = 1.718(4) β = 1.748(3) γ = 1.748(3) 2V(calc.) = ~ 0° *Orientation*: *X = c, Y/ Z = a/b*. *Pleochroism:* Medium strong, *X* = pale yellow-brown, *Y* = *Z* = dark yellow-brown. *Absorption*: *X < Y = Z.*

Cell Data: *Space Group*: *C*2/*m*. *a* = 14.200(7) *b* = 13.832(7) *c* = 14.971(10) β = 102.08(8)° Z = 4

X-ray Powder Pattern: Lake Boga, Victoria, Australia.
14.57 (100), 6.95 (40), 6.28 (40), 2.816 (40), 3.469 (30b), 2.507 (30), 2.452 (30)

Chemistry:

	(1)
CaO	7.59
CuO	34.79
Bi_2O_3	15.53
Fe_2O_3	3.04
Al_2O_3	0.13
P_2O_5	21.70
As_2O_5	0.34
Cl	1.01
H_2O	16.10
-O = Cl	0.23
Total	100.00

(1) Lake Boga, Victoria, Australia; electron microprobe analysis, H_2O by difference; corresponding to $(Ca_{1.63}Fe^{3+}_{0.46})_{\Sigma=2.09}Cu_5(Bi_{0.80}Cu_{0.25})_{\Sigma=1.05}[(PO_4)_{3.67}(AsO_4)_{0.04}]_{\Sigma=3.71}[Cl_{0.34}(OH)_{6.15}]\cdot 7.7H_2O$.

Occurrence: A secondary mineral from cavities in weathered uraniferous granitic pegmatite containing partly oxidized copper sulfide minerals.

Association: n.d.

Distribution: From Lake Boga, Swan Hill Rural City, Victoria, Australia.

Name: Honors the Reverend John I. Bleasdale (1822-1884) for of his promotion of mineralogy in Victoria.

Type Material: Museum of Victoria, Melbourne (M44699), and in the South Australian Museum, Adelaide, Australia.

References: (1) Birch, W.D., A. Pring, and U. Kolitsch (1999) Bleasdaleite, $(Ca,Fe^{3+})_2Cu_5(Bi,Cu)(PO_4)_4(H_2O,OH,Cl)_{13}$, a new mineral from Lake Boga, Victoria, Australia. Austral. J. Mineral., 5(2), 69-75. (2) (2000) Amer. Mineral., 85, 1321 (abs. ref. 1).

Blixite $Pb_2Cl(O,OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Massive, in films.

Physical Properties: *Cleavage:* One direction, distinct. Hardness = ∼3 D(meas.) = 7.35 D(calc.) = [7.35]

Optical Properties: Semitransparent. *Color:* Pale yellow, yellow-orange, to grayish yellow. *Streak:* Pale yellow. *Luster:* Vitreous, may be dull.
Optical Class: Biaxial (+). *Orientation:* Extinction ∥ cleavage; OAP ⊥ to cleavage. α = ∼2.05 β = n.d. γ = ∼2.20 2V(meas.) = ∼80°

Cell Data: *Space Group:* n.d. $a = 5.832(3)$ $b = 5.694(5)$ $c = 25.47(2)$ Z = 8

X-ray Powder Pattern: Långban, Sweden.
2.93 (10), 3.88 (8), 1.660 (8), 2.83 (6), 2.12 (6), 2.04 (6), 3.18 (5)

Chemistry:

	(1)	(2)
Fe_2O_3		0.49
CuO		0.15
ZnO		0.06
PbO	69.50	60.32
CaO	0.30	
$PbCl_2$	30.16	37.01
H_2O	0.79	
SO_3		2.07
Total	100.75	100.10

(1) Långban, Sweden; corresponds to $(Pb_{1.95}Ca_{0.02})_{\Sigma=1.97}Cl_{1.02}[O_{1.27}(OH)_{0.41}]_{\Sigma=1.68}$. (2) Elura deposit, Australia; by electron microprobe, average of two analyses, original analyses elemental, here converted to $PbCl_2$ and oxides; S probably in anglesite.

Occurrence: In hausmannite-rich dolomite and manganophyllite skarn in a metamorphosed Fe–Mn orebody (Långban, Sweden); a reaction product in slag immersed in sea water (Laurium, Greece).

Association: Dolomite, hausmannite, copper, manganophyllite (Långban, Sweden); brucite, hydrocerussite (Mendip Hills, England); mendipite, anglesite (Elura deposit, Australia).

Distribution: From Långban, Värmland, Sweden. In the Merehead quarry, Mendip Hills, Somerset, England. At Laurium, Greece, in slag. Found in the Elura Zn–Pb–Ag deposit, 43 km northeast of Cobar, New South Wales, Australia.

Name: For Dr. Ragnar Blix (1898–1985), chemist at the Swedish Museum of Natural History, who performed analyses of many Långban minerals.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 251539; National Museum of Natural History, Washington, D.C., USA, 114720.

References: (1) Gabrielson, O., A. Parwel, and F.E. Wickman (1958) Blixite, a new lead-oxyhalide mineral from Långban. Arkiv Mineral. Geol., 2(32), 411–415. (2) (1960) Amer. Mineral., 45, 908 (abs. ref. 1). (3) Scott, K.M. (1994) Lead oxychlorides at Elura, western NSW, Australia. Mineral. Mag., 58, 336–338.

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Blödite $Na_2Mg(SO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals equant to prismatic [001], with complex development, as with prominent {110}, {210}, {011}, {001}, {111}, {$\overline{2}$11}, and many others, to 10 cm; granular to compact massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 2.218–2.24 D(calc.) = 2.23 Soluble in H_2O, taste slightly saline, bitter.

Optical Properties: Transparent to translucent. *Color:* Colorless, may be dark gray, bluish green, or reddish from inclusions; colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 37°$. $\alpha = 1.483$ $\beta = 1.486$ $\gamma = 1.487$ 2V(meas.) = 71°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.126(2)$ $b = 8.242(1)$ $c = 5.539(1)$ $\beta = 100.84°$ Z = 2

X-ray Powder Pattern: Soda Lake, California, USA.
3.252 (100), 4.555 (95), 3.289 (95), 2.971 (40), 2.732 (40), 4.281 (30), 2.025 (30)

Chemistry:

	(1)	(2)
SO_3	47.61	47.87
Fe_2O_3	0.08	
MgO	12.09	12.06
Na_2O	18.00	18.53
Cl	0.31	
H_2O	21.49	21.54
Total	99.58	100.00

(1) Ischl, Austria. (2) $Na_2Mg(SO_4)_2 \cdot 4H_2O$.

Occurrence: In lacustrine salt deposits and salt efflorescences; probably a product of metamorphism of marine salt deposits; in nitrate deposits; may be a volcanic sublimate.

Association: Halite, kainite, carnallite, polyhalite (marine salt deposits); halite, thénardite, mirabilite (lacustrine salt deposits).

Distribution: From Ischl and Hallstatt, Austria. In the Stassfurt district, Saxony-Anhalt, Germany. From Kaluszyn, Poland. In Italy, at Monte Sambuco, Sicily. In the USA, from the Green River Formation, Garfield and Rio Blanco Cos., Colorado; at the Great Salt Lake, Davis Co., Utah; large crystals from Soda Lake, Carrizo Plain, San Luis Obispo Co., and at Bertram Siding, Salton Sea, Imperial Co., California; from Laguna Salina, Estancia Valley, Torrance Co., New Mexico. At Chuquicamata, Antofagasta, Chile. In the Mayo and Warcha mines, Salt Range, Punjab, India. Additional localities are known, most as widespread surficial efflorescences.

Name: To honor the German chemist Carl August Blöde (1773–1820).

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 447–450. (2) Hawthorne, F.C. (1985) Refinement of the crystal structure of bloedite: structural similarities in the $[^{VI}M(^{IV}T\Phi_4)_2\Phi_n]$ finite-cluster minerals. Can. Mineral., 23, 669–674. (3) (1968) NBS Mono. 25, 63–64.

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Blossite α–$\mathbf{Cu_2V_2^{5+}O_7}$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As equant anhedral crystals, to 150 μm, typically intergrown with other fumarolic copper vanadates.

Physical Properties: Hardness = n.d. D(meas.) = 3.95–3.97 (synthetic). D(calc.) = 4.051

Optical Properties: Opaque. *Color:* Black; white in reflected light, with red-brown internal reflections. *Streak:* Red-brown. *Luster:* Metallic.
Optical Class: Biaxial. n = [2.05] (rule of Gladstone and Dale). *Anisotropism:* Moderate; gray to creamy gray-brown. *Bireflectance:* Weak to moderate; in shades of cream-white.
R_1–R_2: (481) 14.6–15.3, (547) 15.4–16.6, (591) 14.8–16.7, (644) 14.5–15.7

Cell Data: *Space Group:* $Fdd2$. $a = 20.676(6)$ $b = 8.392(3)$ $c = 6.446(2)$ Z = 8

X-ray Powder Pattern: Synthetic α-$Cu_2V_2O_7$. (ICDD 26-566).
3.260 (100), 3.080 (100), 3.220 (80), 2.483 (80), 2.102 (70), 2.096 (70), 1.712 (70)

Chemistry:

	(1)	(2)
V_2O_5	53.28	53.34
CuO	46.49	46.66
Total	99.77	100.00

(1) Izalco volcano, El Salvador; by electron microprobe. (2) $Cu_2V_2O_7$.

Polymorphism & Series: Dimorphous with ziesite.

Occurrence: A very rare sublimate, probably formed between 100–200 °C, from the outer sulfate zone of a fumarole in the crater of a basaltic composite volcano.

Association: Fingerite, stoiberite, mcbirneyite, ziesite.

Distribution: From the summit crater of Izalco volcano, El Salvador.

Name: To honor Dr. F. Donald Bloss (1920–), American mineralogist, Virginia Polytechnic Institute, Blacksburg, Virginia, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 164270.

References: (1) Robinson, P.D., J.M. Hughes, and M.L. Malinconico (1987) Blossite, α-$Cu_2^{2+}V_2^{5+}O_7$, a new fumarolic sublimate from Izalco volcano, El Salvador. Amer. Mineral., 72, 397–400. (2) Calvo, C. and R. Faggiani (1975) α cupric divanadate. Acta Cryst., 31, 603–605.

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Bluelizardite $Na_7(UO_2)(SO_4)_4Cl(H_2O)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As bladed crystals, to 0.4 mm, elongated on [010] and flattened by {001}. Other prominent form are {100}, {001}, and {111}. Crystals form spherical radial divergent (hedgehog-like) aggregates.

Physical Properties: *Cleavage*: Good on {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 2 D(meas.) = n.d. D(calc.) = 3.116 Bright yellow-green fluorescence under LW and SW UV.

Optical Properties: Transparent. *Color*: Pale yellow. *Streak*: Yellowish white. *Luster*: Vitreous. *Optical Class*: Biaxial (–). $\alpha = 1.515$ $\beta = 1.540$ $\gamma = 1.545$ 2V(meas.) = 48(2)° 2V(calc.) = 47.6° *Pleochroism*: None. *Orientation*: $X = b$, $Y \approx a$, $Z \approx c$.

Cell Data: *Space Group*: *C*2/*c*. $a = 21.1507(6)$ $b = 5.3469(12)$ $c = 34.6711(9)$ $\beta = 104.913(3)°$ Z = 8

X-ray Powder Pattern: Blue Lizard U mine, San Juan County, Utah, USA.
5.16 (100), 10.31 (60), 17.08 (52), 3.186 (36), 3.353 (28), 3.484 (27), 4.238 (23)

Chemistry:

	(1)	(2)
Na_2O	24.15	24.46
SO_3	35.84	36.07
UO_3	32.89	32.31
Cl	3.76	4.00
H_2O	[4.05]	4.06
–OH=Cl	0.85	0.90
Total	99.94	100.00

(1) Blue Lizard U mine, Utah, USA; average of 5 electron microprobe analyses, H_2O by structural analysis, presence of SO_4, H_2O, UO_2 confirmed by Raman spectroscopy; corresponding to $Na_{6.94}(U_{1.02}O_2)(SO_4)_{4.00}Cl_{0.94}O_{0.06}(H_2O)_2$. (2) $Na_7(UO_2)(SO_4)_4Cl(H_2O)_2$.

Occurrence: An oxidation product as efflorescence on tunnel walls in sulfide-bearing sandstone in an abandoned underground Colorado Plateau-type uranium mine.

Association: Chalcanthite, copiapite, ferrinatrite, gypsum, kröhnkite, johannite, and a few new unnamed uranyl sulfates of Na and Mg.

Distribution: From the Blue Lizard U mine, Red Canyon, White Canyon district, San Juan County, Utah, USA.

Name: For the mine that produced the first specimens.

Type Material: Natural History Museum of Los Angeles County, California, USA (# 64060, 64061, 64062, 64063).

References: (1) Plášil, J., A.R. Kampf, A.V. Kasatkin, and J. Marty (2014) Bluelizardite, $Na_7(UO_2)(SO_4)_4Cl(H_2O)_2$, a new uranyl sulfate mineral from the Blue Lizard mine, San Juan County, Utah, USA. Journal of Geosciences, 59, 145-158. (2) (2014) Amer. Mineral., 99, 1806-1807 (abs. ref. 1).

Crystal Data: Monoclinic. *Point Group:* $2/m$. As equant anhedral crystals, to 1 cm, and in nodular aggregates.

Physical Properties: *Cleavage:* On {010}, perfect; a parting on {100}. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 3.54(1) D(calc.) = 3.57

Optical Properties: Transparent. *Color:* Green-brown to red-brown. *Streak:* Yellow-brown. *Luster:* Resinous, bronzy on parting planes.
Optical Class: Biaxial (+). *Pleochroism:* Moderate; $X = Y$ = yellow-orange; Z = orange. *Orientation:* $Y = b$; $X \wedge a = 10°$. *Absorption:* $Z > X \simeq Y$. $\alpha = 1.694(1)$ $\beta = 1.698(1)$ $\gamma = 1.715(2)$ 2V(meas.) = 46.4(2)° 2V(calc.) = 52°

Cell Data: *Space Group:* $P2_1/n$. $a = 12.776$–12.843 $b = 12.478$–12.518 $c = 10.966$–11.035 $\beta = 97.21°$–$97.47°$ $Z = 4$

X-ray Powder Pattern: Cross Lake, Canada.
3.054 (100), 2.082 (67), 2.869 (66), 2.508 (53), 2.712 (49), 1.575 (43), 2.902 (37)

Chemistry:

	(1)	(2)	(3)
P_2O_5	45.2	43.8	43.75
Al_2O_3	7.5	4.9	5.24
Fe_2O_3	6.9	7.4	8.20
FeO	0.3	3.6	
MnO	31.7	32.2	36.44
ZnO	0.1	0.3	
MgO	0.3	0.4	
CaO	1.2	0.6	
Na_2O	6.8	6.3	6.37
H_2O	0.3	0.3	
Total	100.3	99.8	100.00

(1) Cross Lake, Canada; by electron microprobe, average of five analyses, red-brown material; Fe^{2+}:Fe^{3+} by Mössbauer spectroscopy; H_2O by TGA; from crystal structure analysis, the semi-empirical formula is $(Na_{2.07}Mn_{0.53}Ca_{0.20})_{\Sigma=2.80}(Mn^{2+}_{3.68}Al_{1.39}Fe^{3+}_{0.81}Mg_{0.07}Fe^{2+}_{0.04}Zn_{0.01})_{\Sigma=6.00}$ $P_{5.99}[O_{23.69}(OH)_{0.31}]_{\Sigma=24.00}$. (2) Do.; by electron microprobe, average of two analyses, green-brown material. (3) $Na_2Mn_5FeAl(PO_4)_6$.

Occurrence: An uncommon primary mineral in the intermediate zone of a granite pegmatite enriched in manganese and fluorine.

Association: Beusite, fillowite, triplite, apatite, alluaudite.

Distribution: From the Gotcha claim, on an island in Cross Lake, Manitoba, Canada.

Name: To honor Emeritus Professor Robert Bury Ferguson (1920–), Canadian mineralogist, University of Manitoba, Winnipeg, Canada, especially for his contributions to pegmatite mineralogy.

Type Material: University of Manitoba, Winnipeg, Manitoba, M6083; Royal Ontario Museum, Toronto, Canada, M42687.

References: (1) Ercit, T.S., A.J. Anderson, P. Černý, and F.C. Hawthorne (1986) Bobfergusonite: a new primary phosphate mineral from Cross Lake, Manitoba. Can. Mineral., 24, 599–604. (2) Ercit, T.S., F.C. Hawthorne, and P. Černý (1986) The crystal structure of bobfergusonite. Can. Mineral., 24, 605–614. (3) (1988) Amer. Mineral., 73, 190 (abs. refs. 1 and 2).

Bobierrite $Mg_3(PO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are usually acicular, fibrous, and lath-shaped, elongated ‖ [001] and flattened on {010}, may be diamond-shaped, to 4 cm; as crystalline aggregates, typically in the form of fans and rosettes, fine-grained, massive.

Physical Properties: *Cleavage:* {010}, perfect. Hardness = 2–2.5 D(meas.) = 2.195 (synthetic). D(calc.) = 2.133

Optical Properties: Transparent. *Color:* Colorless, white, may be blue; in transmitted light, colorless. *Luster:* Nearly vitreous to pearly on cleavages.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 27°$–$29°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.508$–1.512 $\beta = 1.514$–1.520 $\gamma = 1.541$–1.543 2V(meas.) = 71(3)° 2V(calc.) = 73°

Cell Data: *Space Group:* $C2/c$. $a = 4.667(1)$ $b = 27.926(8)$ $c = 10.067(3)$
$\beta = 105.01(2)°$ Z = 4

X-ray Powder Pattern: Synthetic.
6.96 (100), 2.94 (27), 8.04 (18), 2.81 (13), 2.41 (12), 3.02 (10), 2.13 (10)

Chemistry:

	(1)	(2)	(3)
P_2O_5	34.59	34.52	34.88
MgO	29.97	25.12	29.71
CaO		5.71	
H_2O	35.38	34.27	35.41
Total	99.94	99.62	100.00

(1) Mejillones, Chile. (2) Ødegården, Sweden. (3) $Mg_3(PO_4)_2 \cdot 8H_2O$.

Occurrence: Formed from the chemical alteration of guano deposits (Mejillones, Chile; Imperial Canyon lava tubes, Kenya), and an elephant tusk (Edgerton, Minnesota, USA). As a rare alteration product of primary phosphate-bearing minerals (Wodgina, Australia; Bendada pegmatite, Portugal).

Association: Hannayite, schertelite, lithiophilite, sicklerite, purpurite, collinsite, apatite, dolomite, calcite.

Distribution: Found on Mejillones Island, Chile. In Western Australia, found in the Pilbara district, at Wodgina. From Marlborough, New Zealand. In the USA, found near Edgerton, Pipestone Co., Minnesota. At the Ødegården apatite mines, Bamble, Norway. In the Bendada pegmatite, near Guarda, Portugal. Fine large crystals found in the Zheleznyi iron mine, Kovdor massif, Kola Peninsula, Russia. In Kenya, occurs in the Imperial Canyon lava tubes, Northern Chyulu Hills.

Name: In honor of Pierre Adolphe Bobierre (1823–1881), French agricultural chemist, who first described the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 753–754. (2) Frazier, A.W., J.R. Lehr, and J.P. Smith (1963) The magnesium phosphates hannayite, schertelite and bobierrite. Amer. Mineral., 48, 635–641. (3) Kaupstin, Y.L. (1971) Mineralogy of carbonatites. Nauka Publishers, Moscow, 174. (4) Mason, B. and P.J. Dunn (1974) An unusual occurrence of bobierrite at Wodgina, Western Australia. Mineral. Record, 5, 265. (5) Takagi, S., M. Mathew, and W.E. Brown (1986) Crystal structures of bobierrite and synthetic $Mg_3(PO_4)_2 \cdot 8H_2O$. Amer. Mineral., 71, 1229–1233.

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Bobtraillite $(Na,Ca)_{13}Sr_{11}(Zr,Y,Nb)_{14}Si_{42}B_6O_{132}(OH)_{12}\cdot 12H_2O$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ 2/*m*. As blocky to prismatic crystals, elongated along [001] and exhibiting {100} and {001}, to 2 mm, as parallel 2- to 3-member aggregates and rosettes; rarely as plates, flattened along [001].

Physical Properties: *Cleavage*: None. *Fracture*: Uneven to conchoidal. *Tenacity*: Brittle. Hardness = 5.5 D(meas.) = n.d. D(calc.) = 3.16

Optical Properties: Transparent. *Color*: Gray to pale green or brown, rarely black. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (+). ω = 1.627(1) ε = 1.645(1) *Pleochroism*: None.

Cell Data: *Space Group*: $P\bar{3}c_1$. a =19.720(1) c = 9.9788(5) Z = 1

X-ray Powder Pattern: Mont Saint-Hilaire, Quebec, Canada [also a calculated peak at 17.08 (44)]. 2.752 (100), 3.13 (70), 3.96 (51), 3.76 (49), 6.46 (38), 5.43 (33), 1.990 (27)

Chemistry:

	(1)
Na_2O	5.62
CaO	1.11
SrO	17.76
BaO	0.40
$[B_2O_3]$	3.38
Y_2O_3	1.15
SiO_2	40.51
ZrO_2	25.32
HfO_2	0.48
Nb_2O_5	1.32
$[H_2O]$	5.25
Total	102.30

(1) Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada; average of 7 electron microprobe analyses, H_2O calculated and confirmed by IR spectroscopy, B from structural analysis; corresponding to $(Na_{11.20}Ca_{1.22})_{\Sigma=12.42}(Sr_{10.59}Ba_{0.16})_{\Sigma=10.75}(Zr_{12.69}Y_{0.63}Nb_{0.61}Hf_{0.14})_{\Sigma=14.07}Si_{41.64}B_6O_{132}(OH)_{12}\cdot 12H_2O$.

Occurrence: A late hydrothermal mineral in cavities in igneous breccia and nepheline syenite pegmatite.

Association: An unnamed burbankite-group mineral, donnayite-(Y), clinoamphibole, albite, aegirine, pyrrhotite, pyrite, annite, analcime, microcline, a white mica (muscovite?), titanite, clinopyroxene, calcite.

Distribution: Poudrette quarry, Mont Saint-Hilaire, Rouville County, Quebec, Canada.

Name: Honors Dr. Robert ("Bob") James Traill (b. 1921), mineralogist and former head of the Mineralogy Section at the Geological Survey of Canada, Ottawa (1953-1986).

Type Material: Canadian Museum of Nature, Ottawa, Canada (CMNMC 83718).

References: (1) McDonald, A.M. and G.Y. Chao (2005) Bobtraillite, $(Na,Ca)_{13}Sr_{11}(Zr,Y,Nb)_{14}Si_{42}B_6O_{132}(OH)_{12}\cdot 12H_2O$, a new mineral species from Mont Saint-Hilaire, Quebec: Description, structure determination and relationship to benitoite and wadeite. Can. Mineral., 43, 747-758. (2) (2005) Amer. Mineral., 90, 1945 (abs. ref. 1).

Bogdanovite $(Au, Te, Pb)_3(Cu, Fe)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$ (by analogy to $AuCu_3$). In radial crystal aggregates, to 1 mm; massive.

Physical Properties: Hardness = n.d. VHN = 235–270 (Cu-rich), 290–354 (Fe-rich) (20 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Rose-brown to bronze-brown; quickly tarnishes in air to bluish black; unusual color effects in polished section, from purple-raspberry or grayish lilac to gold and yellow. *Luster:* Semimetallic.
R_1–R_2: (400) — , (420) 11.8–15.8, (440) 10.5–15.2, (460) 9.2–14.8, (480) 8.0–14.8, (500) 6.9–16.9, (520) 6.2–22.5, (540) 5.6–29.5, (560) 6.1–34.5, (580) 8.4–37.6, (600) 13.5–39.2, (620) 21.0–40.0, (640) 29.5–39.8, (660) 36.2–39.0, (680) 41.2–37.7, (700) 44.9–35.7

Cell Data: *Space Group:* $Pm3m$. a = 4.0876(15) Z = 1

X-ray Powder Pattern: Russia or Kazakhstan.
2.36 (100), 1.230 (80), 2.045 (60), 1.447 (60), 1.180 (30), 1.092 (25), 0.992 (15)

Chemistry:

	(1)
Au	61.8
Ag	3.39
Cu	11.2
Fe	1.18
Pb	13.1
Te	10.2
Total	100.87

(1) Kazakhstan; by electron microprobe, corresponding to $(Au_{1.83}Te_{0.47}Pb_{0.37}Ag_{0.18})_{\Sigma=2.85}(Cu_{1.03}Fe_{0.12})_{\Sigma=1.15}$. Cu and Fe vary reciprocally from Cu:Fe = 0.91:0.09 to 0.22:0.78.

Occurrence: In the oxidation zone of Au–Te deposits.

Association: Gold, bilibinskite, bezsmertnovite, belyakinite, tellurides of Fe, Cu, Pb (Aginsk deposit, Russia).

Distribution: From the Aginsk gold telluride deposit, Kamchatka, Far Eastern Region, Russia [TL]. At the Southern Dzhelambet deposit, central Kazakhstan [TL]. From Bisbee, Cochise Co., Arizona, USA.

Name: For Soviet geologist Aleksei Alekseevich Bogdanov (1907–1971), Moscow University, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1115/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79408.

References: (1) Spiridonov, E.M. and T.N. Chvileva (1979) Bogdanovite, $Au_5(Cu, Fe)_3(Te, Pb)_2$, a new mineral of the group of intermetallic compounds of gold. Vestnik Moskva Univ., Ser. Geol., 1, 44–52 (in Russian). (2) (1979) Amer. Mineral., 64, 1329 (abs. ref. 1). (3) Bayliss, P. (1990) Revised unit-cell dimensions, space group, and chemical formula of some metallic minerals. Can. Mineral., 28, 751–755. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 53.

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Bøggildite $Sr_2Na_2Al_2(PO_4)F_9$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As columnar crystal aggregates, individual crystals prismatic with nearly square outline, to 12 mm; crystals are striated lengthwise. *Twinning:* Polysynthetic, twin plane {001}, common.

Physical Properties: *Cleavage:* Prismatic, possible. *Fracture:* Even. Hardness = 4–5
D(meas.) = 3.66 D(calc.) = 3.692

Optical Properties: Semitransparent. *Color:* Flesh-red; in transmitted light, colorless to slightly reddish in thicker grains. *Luster:* Vitreous, greasy on fracture surfaces.
Optical Class: Biaxial (+) or biaxial (–). *Orientation:* $Z = b$; $X \wedge a = 36°$. *Dispersion:* Weak.
$\alpha = 1.462(2)$ $\beta = 1.466(2)$ $\gamma = 1.469(2)$ 2V(meas.) = 78°–80°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.251(3)$ $b = 10.464(5)$ $c = 18.577(9)$
$\beta = 107.53(3)°$ Z = 4

X-ray Powder Pattern: Ivigtut, Greenland.
3.162 (100), 3.893 (80), 3.96 (65), 3.127 (65), 2.627 (65), 2.878 (50), 2.865 (50)

Chemistry:

	(1)		(1)
PO_4	17.63	Mg	0.18
Al	10.04	Ca	0.20
Fe	0.06	Na	8.60
Mn	trace	K	0.15
Sr	31.89	Li	trace
Ba	0.35	F	31.70
		Total	100.80

(1) Ivigtut, Greenland; corresponds to $Sr_{2.04}Na_{2.03}Al_{2.01}(PO_4)_{1.00}F_{8.97}$.

Occurrence: A rare mineral within greisen formed at the contact zone of a cryolite ore body.

Association: Fluorite, cryolite, sphalerite, pyrite, zircon, chalcopyrite, galena, molybdenite, albite, muscovite, quartz.

Distribution: Found in the Ivigtut cryolite deposit, southern Greenland.

Name: Honoring the Danish mineralogist Ove Balthasar Bøggild (1872–1956), Professor of Geology, University of Copenhagen, Copenhagen, Denmark.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1857.155a.

References: (1) Pauly, H. (1956) Bøggildite, a new phosphate-fluoride from Ivigtut, South Greenland. Medd. Grønland, 137(6), 1–17. (2) Møller, C.K. (1956) X-ray investigation of bøggildite. Medd. Grønland, 137(6), 1–15. (3) (1956) Amer. Mineral., 41, 959 (abs. refs. 1 and 2). (4) Hawthorne, F.C. (1982) The crystal structure of bøggildite. Can. Mineral., 20, 263–270.

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Boggsite **$Ca_8Na_3(Si,Al)_{96}O_{192}\cdot 70H_2O$**

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, chisel-shaped, bladed, to 0.5 mm, elongated along [010], showing {011}, {010}, {102}, {001}, and {100}. As radial hemispheres, to 2 mm, composed of fine-grained polycrystalline aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼3.5 D(meas.) = 1.998 D(calc.) = 1.994 Altered material fluoresces weak bluish under both LW and SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white, due to alteration. *Streak:* White. *Luster:* Vitreous to dull.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, strong.
$\alpha = 1.480(1)$ $\beta = 1.481(1)$ $\gamma = 1.487(1)$ 2V(meas.) = 25(6)°

Cell Data: *Space Group: Imma.* $a = 20.236(2)$ $b = 23.798(1)$ $c = 12.798(1)$ Z = 1

X-ray Powder Pattern: Near Goble, Oregon, USA.
11.269 (100), 3.855 (86), 3.368 (63), 4.456 (34), 11.884 (33), 4.354 (31), 3.604 (31)

Chemistry:

	(1)
SiO_2	63.01
Al_2O_3	12.60
Fe_2O_3	0.11
MgO	0.07
CaO	5.89
Na_2O	1.23
K_2O	0.10
H_2O	17.0
Total	100.01

(1) Near Goble, Oregon, USA; by electron microprobe, H_2O by C-H-N analysis; corresponds to $(Ca_{7.8}Na_{2.9}K_{0.2}Mg_{0.1})_{\Sigma=11.0}(Si_{77.6}Al_{18.3}Fe_{0.1})_{\Sigma=96.0}O_{192}\cdot 70H_2O$.

Mineral Group: Zeolite group.

Occurrence: In vesicles in one of a series of porphyritic basalt flows intercalated with pyroclastics and minor sediments.

Association: Mordenite, tschernichite, zeolites, apophyllite, calcite, aragonite, "opal."

Distribution: Along Goble Creek, near Goble, Columbia Co., Oregon, USA.

Name: After Robert Maxwell Boggs (1918–), of Seattle, Washington, USA, and his son, Dr. Russell Calvin Boggs (1952–), of Cheney, Washington, USA, mineral collectors.

Type Material: American Museum of Natural History, New York, New York, USA; Royal Ontario Museum, Toronto, Canada.

References: (1) Howard, D.G., R.W. Tschernich, J.V. Smith, and G.L. Klein (1990) Boggsite, a new high-silica zeolite from Goble, Columbia County, Oregon. Amer. Mineral., 75, 1200–1204.
(2) Pluth, J.J. and J.V. Smith (1990) Crystal structure of boggsite, a new high-silica zeolite with the first three-dimensional channel system bounded by both 12- and 10-rings. Amer. Mineral., 75, 501–507.

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Bøgvadite $Na_2SrBa_2Al_4F_{2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As blocky crystals, to 0.15 mm, showing {110}, {010}, and {012}, slightly flattened on {010} and elongated ‖ [100], with rounded and corroded faces.

Physical Properties: *Fracture:* Uneven. Hardness = > 3 VHN = 300(50) (25 g load). D(meas.) = 3.85 D(calc.) = 3.898

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.4326(2)$ $\beta = 1.4360(2)$ $\gamma = 1.4389(2)$ 2V(meas.) = 87(0.5)° 2V(calc.) = 85(6)°

Cell Data: *Space Group:* $Pnmn$ or $Pn2n$. $a = 7.110(3)$ $b = 19.907(10)$ $c = 5.347(3)$ Z = 2

X-ray Powder Pattern: Ivigtut, Greenland.
3.240 (100), 3.194 (50), 2.924 (50), 2.116 (50), 9.968 (40), 6.689 (40), 2.668 (40)

Chemistry:

	(1)	(2)
Na	5.57	5.13
Ba	32.17	30.65
Sr	7.03	9.78
Al	12.45	12.04
F	[42.85]	42.40
Total	[100.07]	100.00

(1) Ivigtut, Greenland; by electron microprobe, average of 11 analyses, F 40%–45%, calculated from stoichiometry; corresponds to $Na_{2.15}Sr_{0.71}Ba_{2.08}Al_{4.09}F_{20}$. (2) $Na_2SrBa_2Al_4F_{2O}$.

Occurrence: In the cryolite deposit.

Association: Jarlite, ralstonite, barite, potassian mica, quartz, a kaolinlike mineral.

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland.

Name: For Richard Bøgvad (1897–1952), formerly Chief Geologist for the company Øresund A/S, which mined the Ivigtut cryolite deposit.

Type Material: n.d.

References: (1) Pauly, H. and O.V. Petersen (1988) Bøgvadite, $Na_2SrBa_2Al_4F_{20}$, a new fluoride from the cryolite deposit, Ivigtut, S. Greenland. Bull. Geol. Soc. Denmark, 37, 21–30. (2) (1991) Amer. Mineral., 76, 1728–1729 (abs. ref. 1).

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Bohdanowiczite $AgBiSe_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Anhedral grains, to 200 by 600 μm. *Twinning:* Polysynthetic.

Physical Properties: Hardness = 3.2 VHN = 63–96 D(meas.) = n.d. D(calc.) = 7.72

Optical Properties: Opaque. *Color:* Pale creamy yellow, pale yellow, pink, tarnishing more golden. *Anisotropism:* Noticeable, distinctly stronger in oil, in yellowish gray tones. R_1–R_2: (470) 51.2–52.9, (546) 49.8–51.5, (589) 50.1–51.5, (650) 50.1–51.6

Cell Data: *Space Group:* $P\overline{3}m1$ (most probable). $a = 8.412(6)$ $c = 19.63(3)$ Z = [6]

X-ray Powder Pattern: Kletno, Poland.
2.91 (100), 2.03 (30), 6.54 (20), 3.40 (20), 3.26 (18), 2.09 (18), 1.630 (6)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	22.31	22.6	22.9	22.7
Pb	1.34		0.0	
Cu	0.25		0.2	
Co	0.01			
Ni	0.02			
Bi	44.89	43.2	44.7	44.0
Se	28.46	32.8	30.8	33.3
S	2.47		1.2	
Total	99.75	98.6	99.8	100.0

(1) Kletno, Poland; by electron microprobe, average of three analyses, corresponding to $(Ag_{0.98}Cu_{0.02})_{\Sigma=1.00}(Bi_{0.97}Pb_{0.03})_{\Sigma=1.00}(Se_{1.66}S_{0.34})_{\Sigma=2.00}$. (2) Near Julianehåb, Greenland; by electron microprobe, corresponding to $(Ag_{1.01}Bi_{1.00}Se_{2.00}$. (3) Kidd Creek mine, Canada; by electron microprobe, coresponding to $(Ag_{0.99}Cu_{0.02})_{\Sigma=1.01}Bi_{1.00}(Se_{1.83}S_{0.17})_{\Sigma=2.00}$. (4) $AgBiSe_2$.

Occurrence: In fluorite and quartz in a strongly cracked zone formed in crystalline limestone adjacent to magnetite-bearing skarns (Kletno, Poland); in reduction halos in red beds (near Zurich, Switzerland).

Association: Clausthalite, tiemannite, umangite, klockmannite, wittichenite, silver, naumannite, bornite, chalcopyrite, chalcocite, uraninite, fluorite, quartz (Kletno, Poland); tennantite, carrollite, cobaltite, bornite, chalcopyrite, chalcocite, naumannite, eucairite, clausthalite (Kidd Creek mine, Canada); hessite, chalcocite, digenite, umangite, naumannite, eucairite, bornite, chalcopyrite, clausthalite, covellite, magnetite, hematite, goethite, malachite, azurite (Julianehåb, Greenland).

Distribution: From Kletno, Sudetes Mountains, Poland [TL]. In the Clara mine, near Oberwolfach, and the Mullenbach uranium deposit, Black Forest, Germany. Found northwest of Zurich, Switzerland. From Ocna de Fier (Morávicza; Vaskő), Romania. At the Kidd Creek mine, near Timmins, Ontario, Canada. In the Frederik VII's mine, 5 km east of Julianehåb, southern Greenland. From near Vanos, Chihuahua, Mexico. At the Iron Monarch quarry, Iron Knob, South Australia.

Name: Honors Professor Karol Bohdanowicz (1864–1947), Polish economic geologist, of Cracow, Poland.

Type Material: Academy of Mining and Metallurgy, Cracow, Poland.

References: (1) Banaś, M., D. Atkin, J.F.W. Bowles, and P.R. Simpson (1979) Definitive data on bohdanowiczite, a new silver bismuth selenide. Mineral. Mag., 43, 131–133. (2) (1979) Amer. Mineral., 64, 1333 (abs. ref. 1). (3) Pringle, G.J. and R.I. Thorpe (1980) Bohdanowiczite, junoite and laitakarite from the Kidd Creek mine, Timmins, Ontario. Can. Mineral., 18, 353–360. (4) Schonwandt, H.K. (1983) Interpretation of ore microstructures from a seleneous Cu-mineralization in South Greenland. Neues Jahrb. Mineral., Abh., 146, 302–332. (5) Geller, S. and J.H. Wernick (1959) Ternary semiconducting compounds with sodium chloride-like structure: $AgSbSe_2$, $AgSbTe_2$, $AgBiS_2$, $AgBiSe_2$. Acta Cryst., 12, 46–54.

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Böhmite AlO(OH)

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely as tabular to stout prismatic crystals, to 2 mm, showing {001}, {110}, {101}, {111}, {221}, and in groups; commonly extremely fine-grained, in pisolitic aggregates or disseminated.

Physical Properties: *Cleavage:* {010}, very good; {100}, well-developed; {001}, poor. Hardness = 3.5 D(meas.) = 3.02–3.05 D(calc.) = [3.08]

Optical Properties: Semitransparent. *Color:* White, pale grayish brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on {010}.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. α = 1.644–1.648 β = 1.654–1.657 γ = 1.661–1.668 2V(meas.) = 74°–88°

Cell Data: *Space Group: Amam.* $a = 3.693(1)$ $b = 12.221(2)$ $c = 2.865(1)$ Z = 4

X-ray Powder Pattern: Huruni Peak, New Zealand.
6.11 (100), 3.15 (60), 2.347 (60), 1.862 (20), 1.850 (20), 1.308 (15), 1.661 (10)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	2.11	0.76	Fe_2O_3	0.58	0.53
TiO_2		0.03	MgO		0.02
Al_2O_3	81.60	83.84	CaO	0.26	0.08
Ga_2O_3	0.05		H_2O	15.31	[15.05]
			Total	99.91	[100.31]

(1) Vishnevy Mountains, Ural Mountains, Russia; corresponds to $Al_{0.98}[O_{0.96}(OH)_{1.04}]_{\Sigma=2.00}$.
(2) Huruni Peak, New Zealand; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $Al_{0.98}Si_{0.01}O(OH)$.

Polymorphism & Series: Dimorphous with diaspore.

Occurrence: Formed from aluminosilicates during tropical weathering, commonly a major constituent of bauxites, laterites, or fireclays; a late product of low-temperature hydrothermal decomposition of corundum, nepheline in nepheline pegmatites, syenites, or ocean-ridge basalts.

Association: Kaolinite, gibbsite, diaspore (bauxites); nepheline, gibbsite, diaspore, natrolite, analcime (nepheline pegmatites).

Distribution: Widespread, but rarely well-crystallized; studied material from: in France, at les Baux, near Arles, Bouches-du-Rhône; at Recoux, Var; and Pérlille and Cadarcet, Ariège. On Montecchio Maggiore, Vicenza, Italy. At Baratka, Hungary. Crystals from the Tvedalen district and elsewhere in the Langesundsfjord area, Norway. In the Mandamus complex, 20 km west of Culverden, New Zealand. In the USA, in the Alberhill clay pits, Riverside Co., California; from the Linwood-Barton district, and at the Laurel Creek mine, Rabun Co., Georgia; on Hogback Mountain, Jackson Co., North Carolina.

Name: For Johannes Böhm (1857–1938), German geologist, who first studied the species.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 645–646. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 111–117. (3) Sahama, T.G., M. Lehtinen, and P. Rehtijärvi (1973) Natural boehmite single crystals from Ceylon. Contr. Mineral. Petrol., 39, 171–174. (4) Shelley, D., D. Smale, and A.J. Tulloch (1977) Boehmite in syenite from New Zealand. Mineral. Mag., 41, 398–400. (5) Larsen, A.O. (1981) Boehmite from syenite pegmatites in the Oslo region, Norway. Mineral. Record, 12, 227–230. (6) Hill, R.J. (1981) Hydrogen atoms in boehmite: a single crystal X-ray diffraction and molecular orbital study. Clays and Clay Minerals, 29, 435–445. (7) Corbató, C.E., R.T. Tettenhorst, and G.G. Christoph (1985) Structure refinement of deuterated boehmite. Clays and Clay Minerals, 33, 71–75.

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Bokite $(Al, Fe^{3+})_{1.3}(V^{5+}, V^{4+}, Fe^{3+})_8O_{20}\cdot 7.4H_2O$

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Crystal Data: Monoclinic, probable. *Point Group:* n.d. Platy to columnar or wedge-shaped grains, to 0.3 mm long, in reniform crusts with radiating structure; in veinlets.

Physical Properties: *Cleavage:* One direction, perfect ‖ elongation, another fair ⊥ to first. Hardness = ∼3 D(meas.) = 2.97–3.10 D(calc.) = [3.41]

Optical Properties: Opaque, translucent in thinnest fragments. *Color:* Black; pale gray in reflected light. *Streak:* Black, may be brownish black. *Luster:* Semimetallic to dull. *Optical Class:* Biaxial. *Pleochroism:* Strong; dirty olive-green to deep reddish brown. *Absorption:* $X > Z$. $\alpha = 2.01(5)$ (α') β = n.d. $\gamma = 2.06(5)$ (γ') 2V(meas.) = n.d. *Anisotropism:* Strong; brownish yellow to gray-blue.

Cell Data: *Space Group:* n.d. $a = 11.838(5)$ $b = 3.643(1)$ $c = 11.142(5)$ $\beta = 110.58(4)°$ Z = [1]

X-ray Powder Pattern: Kurumsak area, Kazakhstan.
10.47 (100), 3.452 (30), 2.907 (12), 2.592 (12), 1.8208 (11), 3.177 (9), 2.760 (9)

Chemistry:

	(1)	(2)		(1)	(2)
V_2O_5	50.30	49.70	BaO	trace	trace
V_2O_4	14.10	14.00	Na_2O	trace	trace
SiO_2	trace	trace	K_2O	0.00	1.50
Al_2O_3	3.90	4.40	H_2O^+	7.70	7.80
Fe_2O_3	15.30	15.40	H_2O^-	6.60	6.60
MgO	trace	trace	SO_3	0.00	0.60
CaO	trace	trace	Total	[97.90]	100.00

(1) Kurumsak area, Kazakhstan; original total given as 98.20%; corresponds to $(Al_{0.72}Fe_{0.60})_{\Sigma=1.32}(V_{6.80}Fe_{1.20})_{\Sigma=8.00}O_{20}\cdot 7.46H_2O$. (2) Do.; with jarosite impurity, corresponds to $K_{0.26}(Al_{0.80}Fe_{0.46})_{\Sigma=1.26}(V_{6.74}Fe_{1.26})_{\Sigma=8.00}O_{20}\cdot 7.44H_2O$.

Occurrence: In carbonaceous vanadiferous shales (Kurumsak area, Kazakhstan); in rich U–V ore in Triassic stream channels and impregnating sandstone (Monument No. 2 mine, Arizona, USA).

Association: Jarosite, kazakhstanite (Kurumsak area, Kazakhstan); navajoite (Monument No. 2 mine, Arizona, USA).

Distribution: From the Balasauskandyk and nearby Kurumsak and Ran districts, northwestern Kara-Tau Mountains, and in the Dzhebagly Mountains, Talass Alatau Range, Kazakhstan. In the USA, in the Monument No. 2 mine, Apache Co., Arizona; at The Fish, Eureka Co., and near Cockalorum Wash, Nye Co., Nevada; and from the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas.

Name: For Ivan Ivanovich Bok (1898–1983), Kazakh geologist, Institute of Geosciences, Alma-Ata, Kazakhstan.

Type Material: National Museum of Natural History, Washington, D.C., USA, 139767.

References: (1) Ankinovich, E.A. (1963) A new vanadium mineral – bokite. Zap. Vses. Mineral. Obshch., 92, 51–59 (in Russian). (2) (1963) Amer. Mineral., 48, 1180–1181 (abs. ref. 1). (3) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 515, 517.

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Boleite $KPb_{26}Ag_9Cu_{24}Cl_{62}(OH)_{48}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals cubic, to 2 cm, rarely modified by {111} and {011}; commonly surficially layered with or overgrown by pseudoboleite with mutually ∥ {001}.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 3–3.5 D(meas.) = 5.054 D(calc.) = 5.082

Optical Properties: Translucent to opaque. *Color:* Deep Prussian blue to indigo; bluish green in transmitted light. *Streak:* Blue, with greenish tint. *Luster:* Weakly vitreous; pearly on cleavage surfaces.
Optical Class: Isotropic. $n = 2.05$

Cell Data: *Space Group:* $Pm3m$. $a = 15.288(2)$ $Z = 1$

X-ray Powder Pattern: Boleo, Mexico; may be totally obscured by the pattern of intergrown pseudoboleite. (ICDD 27-1206).
4.415 (100), 3.821 (80), 2.702 (60), 2.547 (40), 3.505 (35), 2.330 (35), 1.990 (35)

Chemistry:

	(1)	(2)		(1)	(2)
AgCl	12.03	11.79	Cl	17.04	16.86
Pb	49.16	49.26	H_2O	4.35	3.95
CuO	17.17	17.46	insol.	0.21	
K_2O	n.d.	0.68	Total	99.96	100.00

(1) Boleo, Mexico; corresponds to $Pb_{25.88}Ag_{9.16}Cu_{23.54}Cl_{61.58}O_{49.87}H_{52.65}$.
(2) $KPb_{26}Ag_9Cu_{24}Cl_{62}(OH)_{48}$.

Occurrence: A secondary mineral formed through reaction of chloride with primary sulfides in the oxidized zone of Pb–Cu deposits; in smelter slag immersed in and leached by sea water.

Association: Pseudoboleite, cumengeite, atacamite, anglesite, cerussite, phosgenite, gypsum (Boleo, Mexico); pseudoboleite, anglesite, cerussite, atacamite, paratacamite, leadhillite, paralaurionite, caledonite, phosgenite, matlockite, bideauxite (Mammoth-St. Anthony mine, Arizona, USA).

Distribution: In Mexico, exceptional crystals from the Amelia mine, Boleo, near Santa Rosalía, Baja California; also from an undefined locality in Sonora. In the USA, in the Mammoth-St. Anthony mine, Tiger, and the Vekol mine, Pinal Co.; the Apache mine, Gila Co.; and the Rowley mine, Maricopa Co., Arizona; from Philipsburg, Granite Co., Montana. At Laurium, Greece, in slag. In England, from Cornwall, at Tolcarne Beach, Newquay; at Newporth Beach, near Falmouth; and in the Porthilley mine, St. Minver. At Juliushütte, Astfeld, Harz Mountains, Germany, in slag. Found at an undisclosed location in the Kopet-Dag Range, Cheleken Peninsula, Central Asia, Russia. In the Tchah Khuni mine, near Anarak, Iran. From Broken Hill, New South Wales, Australia. In Chile, at Huantajaya, near Iquique, and the Pica district, Cerro de Challocallo, Tarapacá; from Mantos Blancos, and at a number of mines around Caracoles, Sierra Gorda district, southwest of Calama, Antofagasta.

Name: For the occurrence at Boleo, Mexico.

Type Material: National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 78–79. (2) Rouse, R.C. (1973) The crystal structure of boleite – a mineral containing silver atom clusters. J. Solid State Chemistry, 6, 86–92. (3) Winchell, R.E. and R.C. Rouse (1974) The mineralogy of the boleite group. Mineral. Record, 5, 280–287. (4) Cooper, M.A. and F.C. Hawthorne (2000) Boleite: resolution of the formula, $KPb_{26}Ag_9Cu_{24}Cl_{62}(OH)_{48}$. Can. Mineral., 38, 801–809.

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Boltwoodite $HK(UO_2)(SiO_4)\cdot 1.5H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Radiating acicular to fibrous, elongated along [010], to 1 cm.

Physical Properties: *Cleavage:* {010} perfect, {001} imperfect. Hardness = 3.5–4 D(meas.) = ∼4.7 D(calc.) = [4.46] Fluoresces dull green in both SW and LW UV; radioactive.

Optical Properties: Transparent to translucent. *Color:* Pale yellow. *Luster:* Pearly; radial aggregates vitreous to silky; dull to earthy in microcrystalline pseudomorphs.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = colorless; $Y = Z$ = yellow; anomalous blue interference colors. $\alpha = 1.668$–1.670 $\beta = 1.695$–1.696 $\gamma = 1.698$–1.703 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1$. $a = 7.073(2)$ $b = 7.064(1)$ $c = 6.638(1)$ $\beta = 105°45(1)'$ Z = 2

X-ray Powder Pattern: Delta mine, Utah, USA.
6.81 (100), 3.40 (90), 2.95 (80), 3.54 (70), 2.91 (70), 6.40 (50), 5.45 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	14.8	13.27	14.00
Fe_2O_3		0.52	
UO_3	68.5	67.19	66.64
CaO		1.59	
Na_2O	0.4	2.54	
K_2O	9.4	7.83	10.97
H_2O	6.9		8.39
LOI		6.91	
Total	[100.0]	99.85	100.00

(1) Delta mine, Utah, USA; original total given as 99.88%, after deduction of CuO 9.61% and SO_3 2.12% as brochantite, remainder Al_2O_3, V_2O_5, PbO, CaO, MgO 0.34%, insoluble 0.19%, recalculated to 100.0%. (2) Swakopmund, Namibia; loss on ignition taken as H_2O; corresponds to $(H_3O)_{0.55}(K_{0.78}Na_{0.39}Ca_{0.14})_{\Sigma=1.31}(UO_2)(SiO_4)\cdot H_2O$. (3) $HK(UO_2)(SiO_4)\cdot 1.5H_2O$.

Occurrence: In the outer silicate zone of alteration surrounding hydrated uranyl oxides incrusting primary uraninite; also filling fractures at some distance from primary uraninite. From pegmatite and Colorado-Plateau-type sandstone uranium deposits.

Association: Uraninite, becquerelite, fourmarierite, phosphouranylite, gypsum, fluorite.

Distribution: In the USA, from the Delta mine, Emery Co., Utah; the New Method mine, near Amboy, San Bernardino Co., California; in the Marshall Pass district, at the Little Indian No. 36 mine, Gunnison Co. and the Lookout No. 22 mine, Saguache Co., and in Unaweep Canyon, Mesa Co., Colorado; in the Green Monster mine, Goodsprings district, Clark Co., Nevada; and in the Williams quarry, near Easton, Northampton Co., Pennsylvania. Exceptionally developed at the Rössing mine, near Swakopmund, Namibia. From near Dalbeattie, Kirkcudbrightshire, Scotland. At Karago, Rwanda. From Quebrada del Tigre, Córdoba Province, and near Guandacol, La Rioja Province, Argentina. From near Myponga, South Australia. In the Togo mine, Tottori Prefecture, Japan. Other minor occurrences are known.

Name: For Bertram Borden Boltwood (1870–1927), radiochemist of Yale University, New Haven, Connecticut, USA, who devised the U–Pb method of measuring geologic time.

Type Material: National Museum of Natural History, Washington, D.C., USA, 112710.

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References: (1) Frondel, C. and J. Ito (1956) Boltwoodite, a new uranium silicate. Science, 124, 931. (2) (1957) Amer. Mineral., 42, 307 (abs. ref. 1). (3) Honea, R.M. (1961) New data on boltwoodite, an alkali uranyl silicate. Amer. Mineral., 46, 12–25. (4) Kato, T. and Y. Miura (1974) Cell dimensions of boltwoodite. Mineral. J. (Japan), 7, 400–404. (5) Strunz, H. and C. Tennyson (1981) Symmetry and twinning in boltwoodite. Kristallografiya (Sov. Phys. Crystal.), 26, 1288–1292 (in Russian). (6) Stohl, F.V. and D. K. Smith (1981) The crystal chemistry of the uranyl silicate minerals. Amer. Mineral., 66, 610–625.

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Bonaccordite $Ni_2Fe^{3+}BO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are elongated prisms, to 400 μm, may be in rosettelike radiating groups or in veinlets.

Physical Properties: VHN = 1069, 1200 average (15 g load). Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.17

Optical Properties: Opaque. *Color:* Reddish brown; in reflected light, gray with brownish tinge, with strong reddish brown internal reflections.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d. *Anisotropism:* Medium to strong. *Bireflectance:* Distinct, in oil.
R_1–R_2: 14.2–17.6

Cell Data: *Space Group:* [*Pbam*] (by analogy to ludwigite group). $a = 9.213(6)$ $b = 12.229(7)$ $c = 3.001(2)$ Z = 4

X-ray Powder Pattern: Bon Accord, South Africa.
2.548 (100), 2.514 (100), 5.10 (50), 1.898 (50), 4.61 (40), 2.334 (35), 2.025 (35)

Chemistry:

	(1)
SiO_2	0.4
B_2O_3	[13.0]
Fe_2O_3	31.9
MnO	0.04
CoO	1.5
NiO	52.7
MgO	0.5
Total	[100.0]

(1) Bon Accord, South Africa; presumably by electron microprobe, average of nine analyses, total Fe as Fe^{3+}, B by difference, originally given as 13.1%, presence confirmed by wet analysis; corresponding to $(Ni_{1.86}Co_{0.05}Mg_{0.03}Si_{0.02})_{\Sigma=1.96}Fe_{1.05}B_{0.99}O_5$.

Mineral Group: Ludwigite group.

Occurrence: In a small tabular body of nickeliferous serpentinite, probably a contact deposit, along the junction of quartzite and an ultramafic intrusive; it appears to have formed at ~730 °C and < 2 kbar during thermal metamorphism, possibly of a nickel-rich meteorite.

Association: Trevorite, liebenbergite, nepouite, nimite, bunsenite, gaspéite, violarite, millerite.

Distribution: Found three km west of the Scotia talc mine, Bon Accord area, Barberton, Transvaal, South Africa.

Name: For the locality at Bon Accord, South Africa.

Type Material: Royal Ontario Museum, Toronto, Canada, M33443; National Museum of Natural History, Washington, D.C., USA, 132463.

References: (1) De Waal, S.A., E.A. Viljoen, and L.C. Calk (1974) Nickel minerals from Barberton, South Africa: VII. Bonaccordite, the nickel analogue of ludwigite. Trans. Geol. Soc. of South Africa, 77, 375. (2) (1976) Amer. Mineral., 61, 502 (abs. ref. 1).

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Bonattite $CuSO_4 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Minute crystals, in concretions and vermiform aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.663 (synthetic). D(calc.) = 2.68 Soluble in H_2O; dehydrates from chalcanthite.

Optical Properties: Semitransparent. *Color:* Pale blue; colorless in transmitted light. *Optical Class:* Biaxial (+). $\alpha = 1.554$–1.559 $\beta = 1.577$–1.578 $\gamma = 1.615$–1.618 2V(meas.) = 71°–79°

Cell Data: *Space Group:* Cc (synthetic). $a = 5.592(5)$ $b = 13.029(10)$ $c = 7.341(6)$ $\beta = 97°3(7)'$ Z = 4

X-ray Powder Pattern: Capo Calamita, Elba, Italy.
4.40 (100), 3.24 (67), 5.09 (65), 3.65 (54), 3.42 (50), 2.814 (43), 3.00 (39)

Chemistry:

	(1)	(2)
SO_3	36.49	37.47
FeO	0.82	
CuO	35.23	37.23
MgO	0.25	
H_2O	27.33	25.30
Total	100.12	100.00

(1) Capo Calamita, Elba, Italy; corresponds to $CuSO_4 \cdot 3H_2O$ 85.15%, $CuSO_4 \cdot 5H_2O$ 14.85%. Identification rests on correspondence of the X-ray powder pattern and optical data with that of synthetic $CuSO_4 \cdot 3H_2O$. (2) $CuSO_4 \cdot 3H_2O$.

Occurrence: A secondary mineral in a pyrite deposit (Capo Calamita, Elba, Italy).

Association: Chalcanthite, pyrite (Capo Calamita, Elba, Italy); quartz, gypsum, pyrite, poitevinite, scorodite (Avoca claim, Canada).

Distribution: From [Cantiere Macei,] Capo Calamita, Elba, Italy. At the Recsk copper mine, Mátra Mountains, Hungary. On the Avoca claim, Hat Creek, Bonaparte River area, Lillooet district, British Columbia, Canada. At Steamboat Hot Springs, Steamboat Springs district, Washoe Co., Nevada, USA. In the Undu mine, Nukundamu, Vanua Levu, Fiji. From Mina Raua, near Lima, Peru.

Name: To honor Stefano Bonatti (1902–1968), Italian petrologist, University of Pisa, Pisa, Italy.

Type Material: University of Florence, Florence, Italy, 1973/I.

References: (1) Garavelli, C.L. (1957) Bonattite: un nuovo minerale di alterazione del giacimento Elbano di Capo Calamita. Rend. Soc. Ital. Mineral. Petrol., 13, 268 (in Italian). (2) (1958) Amer. Mineral., 43, 180 (abs. ref. 1). (3) Jambor, J.L. (1962) Second occurrence of bonattite. Can. Mineral., 7, 245–252. (4) Zahrobsky, R.F. and W.H. Bauer (1968) On the crystal chemistry of salt hydrates. V. The determination of the crystal structure of $CuSO_4.3H_2O$ (bonattite). Acta Cryst., 24, 508–513.

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Bonshtedtite $Na_3(Fe^{2+},Mg)(PO_4)(CO_3)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$ (probable). As tabular crystals, elongated along [010], with well developed {210}, {$\bar{1}$01}, {$\bar{1}$11} faces, to 5 mm; as fine-grained aggregates.

Physical Properties: *Cleavage:* {010}, {100}, perfect. *Tenacity:* Brittle. Hardness = ∼4 D(meas.) = 2.95–3.16 D(calc.) = 2.95

Optical Properties: Transparent. *Color:* Colorless, with a rose, pale yellow, or pale greenish gray tint; in transmitted light, colorless. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. α = 1.520–1.525 β = 1.568–1.570 γ = 1.591–1.597 2V(meas.) = 68°

Cell Data: *Space Group:* $P2_1/m$ (probable). $a = 8.921$ $b = 6.631$ $c = 5.151$ $\beta = 90°25'$ Z = 2

X-ray Powder Pattern: Vuonnemiok River valley, Russia.
3.318 (100), 2.662 (30), 8.923 (20), 2.578 (20), 2.146 (18), 1.658 (18), 1.851 (15b)

Chemistry:

	(1)	(2)
P_2O_5	26.17	25.80
CO_2	[16.09]	14.70
SiO_2		0.43
FeO	16.66	16.80
MnO	1.65	0.30
MgO	2.54	4.61
CaO	0.03	0.26
Na_2O	35.34	33.00
K_2O	0.03	0.35
LOI		4.33
Total	98.51	100.58

(1) Vuonnemiok River valley, Russia; by electron microprobe, total Fe and Mn as FeO and MnO; giving $Na_{3.00}(Fe_{0.63}Mg_{0.17}Na_{0.12}Mn_{0.06})_{\Sigma=0.98}(PO_4)_{1.01}(CO_3)_{1.00}$. (2) Kovdor massif, Russia; by electron microprobe, total Fe and Mn as FeO and MnO, contains about 1% each of forsterite and shortite; corresponding to $(Na_{2.99}K_{0.02})_{\Sigma=3.01}(Fe_{0.66}Mg_{0.28}Mn_{0.01})_{\Sigma=0.95}(PO_4)_{1.03}(CO_3)_{0.91}$.

Occurrence: In veinlets associated with alkali-carbonate metasomatism of alkalic massifs.

Association: Shortite, thermonatrite, eitelite, neighborite, trona, burbankite, barentsite, siderite, aegirine.

Distribution: Found in drill core from the Vuonnemiok River valley, and on Mts. Suoluaiv, Kukisvumchorr, Partomchorr, and Restin'yun, Khibiny massif, also in drill core from the Kovdor massif, Kola Peninsula, Russia.

Name: To honor Elsa Maksimilianovna Bonshtedt-Kupletskaya (1897–1974), Russian specialist in mineralogy of alkalic massifs.

Type Material: Mining Institute, St. Petersburg, 1198/1; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5713/5, 5723/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81589.

References: (1) Khomyakov, A.P., V.V. Aleksandrov, N.I. Krasnova, V.V. Ermilov, and N.N. Smol'yaninova (1982) Bonshtedtite, $Na_3Fe(PO_4)(CO_3)$, a new mineral. Zap. Vses. Mineral. Obshch., 111, 486–490 (in Russian). (2) (1983) Amer. Mineral., 68, 1038 (abs. ref. 1). (3) Thi, T.T.L., T.N. Pobedimskaya, T.N. Nadezhina, and A.P. Khomyakov (1984) The crystal structures of alkaline carbonates: barentsite, bonshtedtite and donnayite. Acta Cryst., C40, supplement, C257 (abs.).

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Boothite $CuSO_4 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals very rare, complex, typically fibrous or crystalline massive.

Physical Properties: *Cleavage:* {001}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 1.94 D(calc.) = n.d. Soluble in H_2O; dehydrates to chalcanthite.

Optical Properties: Transparent to translucent. *Color:* Blue; pale blue in transmitted light. *Luster:* Vitreous, silky or pearly if fibrous.
Optical Class: Biaxial (–) or (+). *Orientation:* $Y = b$; $X \simeq c$. $\alpha = 1.47$ $\beta = 1.48$ $\gamma = 1.49$ 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SO_3	28.65	28.02
FeO	0.28	
CuO	28.53	27.84
MgO	trace	
H_2O	43.76	44.14
Total	101.22	100.00

(1) Alma mine, California, USA. (2) $CuSO_4 \cdot 7H_2O$.

Mineral Group: Melanterite group.

Occurrence: An alteration product of chalcopyrite (Alma mine, California, USA).

Association: Chalcanthite, melanterite, pisanite (Alma mine, California, USA).

Distribution: In the USA, at the Alma pyrite mine, near Leona Heights, Alameda Co., and from the Penn (Campo Seco) mine, Calaveras Co., California; at the Colusa mine, Butte, Silver Bow Co., Montana. At Sain-Bel, near Lyon, Rhône, France. From the Galaktos district, 15 km southeast of Veria, Greece. At the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: To honor Professor Edward Booth (1857–1917), American chemist, University of California, Berkeley, California, USA.

Type Material: n.d.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 18. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 504–505.

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Boracite $Mg_3B_7O_{13}Cl$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $mm2$. Euhedral crystals, to 2.5 cm, (referred to pseudotetrahedral morphology) show prominent {001}, {110}, {111}, {$\overline{1}$11}, and a dozen other modifying forms; spherulitic, plumose to fibrous, fine granular aggregates. *Twinning:* On {111}, as penetration twins.

Physical Properties: *Fracture:* Conchoidal to uneven. Hardness = 7–7.5 D(meas.) = 2.91–3.10 D(calc.) = 2.97 Very slowly soluble in H_2O; strongly piezoelectric and pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, yellow; bluish green, green to dark green if ferroan; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. α = 1.662–1.658 β = 1.662–1.667 γ = 1.668–1.673 2V(meas.) = 82.5°

Cell Data: *Space Group:* $Pca2_1$. $a = 8.577(6)$ $b = 8.553(8)$ $c = 12.09(1)$ Z = 4

X-ray Powder Pattern: England.
2.044 (100), 3.025 (88), 2.705 (55), 3.492 (45), 2.137 (30), 6.050 (27), 2.468 (21)

Chemistry:

	(1)	(2)
B_2O_3	59.68	62.15
FeO	1.09	
MgO	26.38	25.71
$MgCl_2$	12.17	12.14
LOI	0.55	
Total	99.87	100.00

(1) Lüneburg, Germany; average of two analyses. (2) $Mg_3B_7O_{13}Cl$.

Polymorphism & Series: Dimorphous with trembathite; forms a series with ericaite.

Occurrence: An uncommon component of bedded sedimentary salt and potash deposits of marine origin, the boron probably derived from nearby volcanic activity.

Association: Anhydrite, gypsum, halite, sylvite, carnallite, kainite, hilgardite.

Distribution: In Germany, from Lüneburg, 40 km south-southeast of Hamburg, Lower Saxony; in Saxony-Anhalt, in the Stassfurt-Westeregeln-Bernburg district, at the Douglashall, Berlepsch, Solvayhall, Wilhelmshall and other mines; in Thuringia, from Bischofferode, in the Glückauf mine, Sondershausen, and elsewhere. In France, at Lunéville, Meurthe-et-Moselle. In the Boulby potash mine, northwest of Whitby, Yorkshire, England. In the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, Kazakhstan. Large crystals from Alto Chapare, Cochabamba, Bolivia. In the USA, in the Choctaw salt dome, Iberville Parish, Louisiana, and the Louann Salt Formation, Clarke Co., Alabama. From the Penobsquis and Salt Springs evaporite deposits, near Sussex, New Brunswick, Canada.

Name: For *boron* in the composition.

Type Material: Mining Academy, Freiberg, Germany, 19324.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 378–381. (2) Dowty, E. and J.R. Clark (1973) Crystal structure refinements for orthorhombic boracite, $Mg_3ClB_7O_{13}$, and a trigonal, iron-rich analogue. Zeits. Krist., 138, 64–99. (3) Burns, P.C. (1995) X-ray powder diffraction data for the identification of boracite-group minerals. Powder Diffraction, 10(4), 250–260. (4) Burns, P.C. and M.A. Carpenter (1996) Phase transitions in the series boracite–trembathite–congolite: phase relations. Can. Mineral., 34, 881–892.

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Borax $Na_2B_4O_5(OH)_4 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are commonly short to long prismatic [001] and somewhat flattened on {100}, showing {100}, {110}, {001}, {$\bar{1}$12}, {$\bar{1}$11}, {010}, {021}, to 10 cm, typically distorted; commonly massive. *Twinning:* Rare on {100}.

Physical Properties: *Cleavage:* {100}, perfect; {110}, less perfect; {010}, in traces. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 1.715(5) D(calc.) = 1.70 Soluble in H_2O, slightly sweetish alkaline taste; rapidly dehydrates in air to tincalconite; diamagnetic.

Optical Properties: Translucent to opaque. *Color:* Colorless to white, pale gray, pale blue, pale green; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to resinous, may be earthy.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = -55°35'$. *Dispersion:* $r > v$, strong, crossed. $\alpha = 1.4466$ $\beta = 1.4687$ $\gamma = 1.4717$ 2V(meas.) = n.d. 2V(calc.) = 39°58′

Cell Data: *Space Group:* $C2/c$. $a = 11.8790(2)$ $b = 10.6440(2)$ $c = 12.2012(2)$ $\beta = 106.617(1)°$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.576 (100), 2.565 (95), 4.86 (80), 2.848 (65), 2.833 (60), 5.69 (50), 3.936 (45)

Chemistry: (1) Modern analyses are lacking; natural occurrences produce a nearly pure mineral.

Occurrence: In evaporite deposits, salt lakes, playas, commonly well-crystallized; as an efflorescence on soils in arid regions.

Association: Inyoite, ulexite, colemanite, kernite, kurnakovite, trona, aphthitalite, glauberite, calcite, nitratine, gaylussite, hanksite, halite, gypsum.

Distribution: An ore of boron in some deposits, with numerous minor occurrences. Originally collected from a number of salt lakes in the Ladakh district, Kashmir to north of Lhasa, Tibet, China, along the Qinghai Province-Xizang Plateau. In the Kirka borate deposit, Kütahya Province, Turkey. From the Inder borate deposit, Kazakhstan. In Argentina, large reserves at the Loma Blanca deposit, eight km southwest of Coranzulí, Jujuy Province; in the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province. In the USA, in California, commercial deposits at Borax Lake, Lake Co.; Searles Lake, San Bernardino Co.; in the Kramer borate deposit, Boron, Kern Co.; from Furnace Creek and Resting Springs, Death Valley, Inyo Co.; found in Rhodes Marsh, Teels Marsh, and others in Mineral Co., Nevada; and at Alkali Flat, Doña Ana Co., New Mexico.

Name: From the Arabic for *white*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 339–341. (2) Giese, R.F., Jr. (1968) A refinement of the crystal structure of borax $Na_2B_4O_5(OH)_4 \cdot 8H_2O$. Can. Mineral., 9, 573. (3) Levy, H.A. and G.C. Lisensky (1978) Crystal structures of sodium sulfate decahydrate (Glauber's salt) and sodium tetraborate decahydrate (borax). Redetermination by neutron diffraction. Acta Cryst., 34, 3502–3510. (4) (1979) NBS Mono. 25, 16, 66.

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Borcarite $Ca_4MgB_4O_6(CO_3)_2(OH)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As euhedral crystals, to 5 mm; in subparallel growths, dense massive, and in veins.

Physical Properties: *Cleavage:* Perfect on {100} and {110}; others on {hkl} and {$h0l$}. Hardness = 4–4.5 D(meas.) = 2.77–2.56 D(calc.) = 2.790

Optical Properties: Semitransparent. *Color:* Greenish blue to bluish green, pale brown, may be nearly colorless; colorless in thin section. *Luster:* Vitreous, slightly pearly on cleavages. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 28(4)°$. *Dispersion:* $r < v$, noticeable. $\alpha = 1.590–1.594$ $\beta = 1.632–1.653$ $\gamma = 1.641–1.660$ 2V(meas.) = 30(2)° 2V(calc.) = 20°

Cell Data: *Space Group:* $C2/m$. $a = 17.840(4)$ $b = 8.380(2)$ $c = 4.445(1)$ $\beta = 102.04(3)°$ Z = 2

X-ray Powder Pattern: Snezhnoye deposit, Russia.
7.57 (10), 2.67 (10), 1.886 (10), 2.91 (9), 2.27 (9), 2.21 (9), 1.610 (9)

Chemistry:

	(1)	(2)	(3)
CO_2	15.64	16.65	16.12
B_2O_3	24.77	25.38	25.51
Al_2O_3	0.26		
Fe_2O_3	0.02		
FeO	0.46	1.17	
MgO	7.40	6.02	7.38
CaO	41.31	40.50	41.09
Cl	0.00		
H_2O^+	10.20	10.06	9.90
H_2O^-	0.07	0.20	
Total	100.13	99.98	100.00

(1) Snezhnoye deposit, Russia; average of two analyses. (2) Fuka, Japan; by electron microprobe, B by ICP, CO_2 and H_2O by CHNS analyzer; borate, CO_3^{2-}, and $(OH)^{1-}$ confirmed by IR; corresponds to $Ca_{3.94}(Mg_{0.82}Fe_{0.09})_{\Sigma=0.91}B_{3.98}O_{5.70}(CO_3)_{2.01}(OH)_{6.10}$.
(3) $Ca_4MgB_4O_6(CO_3)_2(OH)_6$.

Occurrence: In kotoite marbles, near the contact with granodiorite (Snezhnoye deposit, Russia); a rare secondary mineral probably formed by reaction of late hydrothermal fluids with brucite (Fuka, Japan).

Association: Szaibélyite, uralborite, sibirskite, kotoite, magnetite, spinel, calcite (Snezhnoye deposit, Russia); olshanskyite, bultfonteinite, takedaite, calcite (Fuka, Japan).

Distribution: In Russia, from the Snezhnoye boron deposit, Izvestkovyi stream, Tas-Khayakhtakh Range, Polar Ural Mountains, and in the Solongo boron deposit, Buryatia, Siberia. At Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For BORate and CARbonate in the composition.

Type Material: Vernadsky Geological Museum, Moscow, 48151; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 68747, 68748.

References: (1) Pertzev, N.N., I.V. Ostrovskaya, and I.B. Nikitina (1965) The new mineral borcarite. Zap. Vses. Mineral. Obshch., 94, 180–186 (in Russian). (2) (1965) Amer. Mineral., 50, 2097 (abs. ref. 1). (3) (1965) Mineral. Abs., 17, 398 (abs. ref. 1). (4) Burns, P.C. and F.C. Hawthorne (1995) Hydrogen bonding in borcarite, an unusual borate-carbonate mineral. Mineral. Mag., 59, 297–304. (5) Kusachi, I., Y. Takechi, C. Henmi, and S. Kobayashi (1997) Borcarite from Fuka, Okayama Prefecture, Japan. Mineral. J. (Japan), 19, 115–122. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 44–45.

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Borishanskiite $Pd_{1+x}(As,Pb)_2$ (x = 0 to 0.2)

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Typically as grains, to 150 μm, enclosed in sulfides.

Physical Properties: *Cleavage:* Three directions observed. *Tenacity:* Brittle. Hardness = n.d. VHN = 241 (20 g load). D(meas.) = n.d. D(calc.) = 10.2

Optical Properties: Opaque. *Color:* Dark steel-gray; pale gray in polished section. *Luster:* Metallic. *Anisotropism:* Barely noticeable to moderate, in yellowish gray tones. R_1–R_2: (430) 51.6–53.2, (460) 54.1–54.6, (490) 55.8–56.2, (520) 56.0–56.4, (550) 56.6–57.0, (580) 57.3–57.8, (610) 58.3–58.7, (640) 59.3–59.8, (670) 60.1–60.6, (700) 61.2–61.7

Cell Data: *Space Group:* $Ccm2_1$. $a = 7.18(2)$ $b = 8.62(2)$ $c = 10.66(2)$ $Z = 16$

X-ray Powder Pattern: Noril'sk region, Russia.
2.65 (100), 2.16 (90), 2.50 (60), 2.25 (60), 1.677 (60), 1.385 (60), 1.169 (60)

Chemistry:

	(1)	(2)
Pd	29.8	31.4
Ag		1.1
Pb	50.4	50.2
As	21.4	19.8
Total	101.6	102.5

(1–2) Talnakh area, Russia; by electron microprobe, corresponding to $Pd_{1.06}(As_{1.08}Pb_{0.92})_{\Sigma=2.00}$ and $(Pd_{1.16}Ag_{0.04})_{\Sigma=1.20}(As_{1.04}Pb_{0.96})_{\Sigma=2.00}$.

Occurrence: In massive and disseminated Cu–Ni sulfide ores.

Association: Nickeline, palladian cuproauride, pentlandite, cubanite, chalcopyrite, magnetite, pyrrhotite, zvyagintsevite, atokite.

Distribution: From Russia, in the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia [TL].

Name: To honor Serafima Samoylovna Borishanskaya (1907–1988), Russian mineralogist, Moscow University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Razin, L.V., L.S. Dubakina, V.I. Meschankina, and V.D. Begizov (1975) Borishanskiite – a new plumboarsenide of palladium from the copper-nickel sulfide ores of the Talnakh differentiated intrusive. Zap. Vses. Mineral. Obshch., 104, 57–61 (in Russian). (2) (1976) Amer. Mineral., 61, 502 (abs. ref. 1).

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Bornemanite $BaNa_4Ti_2NbSi_4O_{17}(F,OH)\cdot Na_3PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As platy aggregates, to 1 cm, of fine leaflets along cleavages and on the surface of lomonosovite and in natrolite.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle; fibers are flexible. Hardness = 3.5–4 VHN = 257–283 D(meas.) = 3.47–3.50 D(calc.) = 3.49

Optical Properties: Translucent to transparent. *Color:* Pale yellow. *Luster:* Pearly. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; $X = Y$ = colorless; Z = brownish. *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.682$–1.683 $\beta = 1.687$–1.695 $\gamma = 1.718$–1.720 2V(meas.) = 40° 2V(calc.) = 66°

Cell Data: *Space Group:* *Ibmm* or *Ibm*2. a = 5.48(5) $b = 7.10(5)$ $c = 48.2(1)$ Z = 4

X-ray Powder Pattern: Lovozero massif, Russia.
24.1 (100), 8.04 (100), 3.44 (100), 3.02 (100), 2.682 (80), 1.610 (80), 1.781 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	23.96	25.00	BaO	12.05	13.00
TiO_2	18.72	18.00	Li_2O	0.10	
ZrO_2	0.20	0.25	Na_2O	19.62	20.00
Al_2O_3	0.55	0.00	K_2O	0.65	0.67
Fe_2O_3		0.30	Rb_2O	0.002	
Nb_2O_5	9.22	8.86	Cs_2O	0.00	
Ta_2O_5		0.66	F	1.52	1.64
FeO	0.17		H_2O^+	2.44	
MnO	2.97	2.48	H_2O^-	0.30	
MgO	0.04	0.06	H_2O		0.70
CaO	0.33	0.77	P_2O_5	6.57	6.80
SrO	0.70	0.68	$-O = F_2$	0.64	0.69
			Total	99.47	99.18

(1–2) Lovozero massif, Russia.

Occurrence: In the natrolite zone of alkalic pegmatites in a differentiated alkalic massif.

Association: Natrolite, lomonosovite.

Distribution: In the Jubilee pegmatite, on Mt. Karnasurt, and on Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: To honor Irina Dmitrievna Borneman-Starynkevich (1891–1988), Russian mineralogist specializing in Khibiny and Lovozero minerals, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1057/3; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3274, 3308; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75318; National School of Mines, Paris, France; The Natural History Museum, London, England, 1994,4; National Museum of Natural History, Washington, D.C., USA, 143813.

References: (1) Men'shikov, Y.P., I.V. Bussen, E.A. Goiko, N.I. Zabavnikova, A.N. Mer'kov, and A.P. Khomyakov (1975) Bornemanite, a new silicophosphate of sodium, titanium, niobium and barium. Zap. Vses. Mineral. Obshch., 104, 322–326 (in Russian). (2) (1976) Amer. Mineral., 61, 338 (abs. ref. 1).

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Bornhardtite $Co^{2+}Co_2^{3+}Se_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive.

Physical Properties: Hardness = ∼4 VHN = n.d. D(meas.) = n.d. D(calc.) = 6.166

Optical Properties: Opaque. *Color:* Rose-red.
R: (400) 41.3, (420) 42.8, (440) 44.3, (460) 45.4, (480) 46.4, (500) 47.2, (520) 47.8, (540) 48.4, (560) 49.2, (580) 49.2, (600) 49.7, (620) 50.2, (640) 50.8, (660) 51.4, (680) 52.0, (700) 52.7

Cell Data: *Space Group: Fd3m.* a = ∼10.2 Z = 8

X-ray Powder Pattern: Trogtal quarry, Germany.
2.7 (100), 2.4 (100), 2.3 (100), 2.2 (100), 2.0 (100), 1.96 (100), 1.42 (100)

Chemistry: No analysis appears ever to have been made.

Mineral Group: Linnaeite group.

Occurrence: Of hydrothermal origin.

Association: Trogtalite, hastite, clausthalite.

Distribution: In Germany, in the Harz Mountains, from the Trogtal quarry, near Lautenthal [TL], and at Tilkerode. In the Pinky Fault uranium deposit, Saskatchewan, Canada. From Cerro de Cacheuta, Mendoza Province, Argentina.

Name: Honors Dr. Wilhelm Bornhardt (1864–1946), German student of ore deposits.

Type Material: n.d.

References: (1) Ramdohr, P. and M. Schmitt (1955) Vier neue natürliche Kobaltselenide vom Steinbruch Trogtal bei Lautenthal im Harz. Neues Jahrb. Mineral., Monatsh., 133–142 (in German). (2) (1956) Amer. Mineral., 41, 164–165 (abs. ref. 1).

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Bornite Cu_5FeS_4

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals pseudocubic, dodecahedral, octahedral, to 6 cm; commonly granular, compact, or massive, disseminated. *Twinning:* On {111}; commonly shows penetration twins.

Physical Properties: *Cleavage:* {111} in traces. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3–3.25 VHN = n.d. D(meas.) = 5.06–5.08 D(calc.) = 5.074

Optical Properties: Opaque. *Color:* Copper-red to pinchbeck-brown on fresh surfaces, rapidly tarnishes iridescent purplish; in polished section, pinkish brown when fresh. *Streak:* Pale grayish black. *Luster:* Metallic. *Pleochroism:* Weak but noticeable. *Anisotropism:* Weak.
R: (400) 19.9, (420) 18.8, (440) 17.9, (460) 17.6, (480) 18.0, (500) 18.8, (520) 20.0, (540) 21.3, (560) 22.9, (580) 24.4, (600) 26.0, (620) 27.5, (640) 28.8, (660) 30.2, (680) 31.6, (700) 32.7

Cell Data: *Space Group: Pbca.* $a = 10.950$ $b = 21.862$ $c = 10.950$ Z = 16

X-ray Powder Pattern: Messina, South Africa.
1.937 (100), 3.18 (60), 2.74 (50), 1.258 (50), 1.119 (50), 3.31 (40), 2.50 (40)

Chemistry:

	(1)	(2)	(3)
Cu	62.99	62.8	63.33
Pb	0.10		
Fe	11.23	11.4	11.12
S	25.58	25.7	25.55
Total	99.90	99.9	100.00

(1) Superior, Arizona, USA. (2) Monte Catini, Tuscany, Italy; by electron microprobe. (3) Cu_5FeS_4.

Occurrence: Associated with and disseminated in mafic igneous rocks, in contact metamorphic skarn deposits, in pegmatites, in medium- to high-temperature hydrothermal deposits, and in sedimentary cupriferous shales; stable below ∼200 °C.

Association: Chalcopyrite, pyrite, other copper and iron sulfides, garnet, calcite, wollastonite, quartz.

Distribution: Important localities for fine crystals include: in the USA, from Butte, Silver Bow Co., Montana, and at Bristol, Hartford Co., Connecticut. In England, from the Carn Brea mine, Illogan, and elsewhere in Cornwall. Large crystals from the Mangula mine, Lomagundi district, Zimbabwe. From the Frossnitz Alpe, eastern Tirol, Austria. At Dzhezkazgan, Kazakhstan. In the N'ouva mine, Talate, Morocco. Widespread as an important ore mineral of copper, for example at the Magma mine, Superior, Pinal Co., and Bisbee, Cochise Co., Arizona; and Kennicott, Alaska, USA. At Ookiep, Namaqualand, Cape Province; and the Messina mine, Transvaal, South Africa. In Australia, from Mt. Lyell, Tasmania, and Olympic Dam, Roxby Downs, South Australia.

Name: Honoring Ignaz Edler von Born (1742–1791), distinguished Austrian mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 195–197. (2) Koto, K. and N. Morimoto (1975) Superstructure investigation of bornite, Cu_5FeS_4, by the modified partial Patterson function. Acta Cryst., 31, 2268–2273. (3) Kanazawa, Y., K. Koto, and N. Morimoto (1978) Bornite Cu_5FeS_4: stability and crystal structure of the intermediate form. Can. Mineral., 16, 397–404. (4) Pierce, L. and P.R. Buseck (1978) Superstructuring in the bornite–digenite series: a high resolution electron microscope study. Amer. Mineral., 63, 1–16. (5) Grguric, B.A., A. Putnis, and R.J. Harrison (1998) An investigation of the phase transitions in bornite (Cu_5FeS_4) using neutron diffraction and differential scanning calorimetry. Amer. Mineral., 83, 1231–1239. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 54.

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Borodaevite $Ag_5(Pb,Fe)Bi_7(Sb,Bi)_2S_{17}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Crystals are elongated, platy; as irregular grains, to 1.2 mm.

Physical Properties: Hardness = n.d. VHN = 165 (20 g load). D(meas.) = n.d. D(calc.) = 7.90

Optical Properties: Opaque. *Color:* Black; white in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Distinct, brown. *Bireflectance:* Very weak.
R_1–R_2: (400) —, (420) 39.9–41.4, (440) 40.4–42.4, (460) 39.8–42.1, (480) 39.7–42.3, (500) 39.5–42.2, (520) 39.1–41.8, (540) 39.0–41.5, (560) 38.4–41.2, (580) 38.2–41.0, (600) 37.6–40.6, (620) 37.3–40.3, (640) 37.2–40.0, (660) 36.5–39.6, (680) 36.6–39.3, (700) 36.1–39.3

Cell Data: *Space Group:* $C2/m$ or Cm. $a = 13.515(7)$ $b = 4.098(3)$ $c = 26.000(8)$ $\beta = 93.00(4)^\circ$ $Z = 2$

X-ray Powder Pattern: Alaskitovoye deposit, Russia.
2.82 (10), 3.37 (9b), 3.24 (9), 3.49 (8b), 1.992 (8), 2.01 (7), 1.967 (6)

Chemistry:

	(1)
Ag	18.23
Pb	3.22
Fe	0.43
Sb	6.42
Bi	53.47
S	17.92
Total	99.69

(1) Alaskitovoye deposit, Russia; by electron microprobe, average of three analyses; corresponds to $Ag_{5.10}Pb_{0.47}Fe_{0.23}Bi_{7.73}Sb_{1.59}S_{16.88}$.

Occurrence: In a hydrothermal Sn–W deposit.

Association: Matildite, gustavite–andorite, aramayoite, galena, pavonite, ramdohrite, owyheeite, benjaminite, molybdenite, hübnerite, triplite, quartz.

Distribution: From the Alaskitovoye Sn–W deposit, near Ust-Nera, Sakha, Russia [TL].

Name: To honor Yuri Sergeevich Borodaev (1923–), Russian mineralogist, Moscow State University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87992.

References: (1) Nenasheva, S.N, A.V. Efimov, A.V. Sivtzov, and N.N. Mozgova (1992) Borodaevite $[Ag_5(Fe,Pb)_1Bi_7]_{13}(Sb,Bi)_2S_{17}$ – a new mineral. Zap. Vses. Mineral. Obshch., 121(4), 113–120 (in Russian). (2) (1994) Amer. Mineral., 79, 763 (abs. ref. 1). (3) Ilinca, G. and E. Makovicky (1997) Note on the definition of borodayevite [*sic*] $[Ag_5(Fe,Pb)Bi_7]_{13}(Sb,Bi)_2S_{17}$. Neues Jahrb. Mineral., Monatsh., 337–353.

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Boromullite $Al_9BSi_2O_{19}$

Crystal Data: Orthorhombic. *Point Group*: *mm*2. As prisms or bundles of prisms, to 0.4 mm; typically as fine intergrowths with or overgrowths on sillimanite, or embaying werdingite.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.081

Optical Properties: Transparent. *Color*: Colorless. *Streak*: n.d. *Luster*: n.d.
Optical Class: Biaxial (+). α = 1.627(1) β = 1.634(1) γ = 1.649(1) 2V(meas.) = 57(2)°
2V(calc.) = 69(12)°

Cell Data: *Space Group*: $Cmc2_1$. a = 5.7168(19) b = 15.023(5) c = 7.675(3) Z = 2

X-ray Powder Pattern: Mount Stafford, central Australia.
3.38 (100), 2.19 (80), 1.512 (80), 2.67 (60), 2.51 (60), 5.37 (50), 2.11(50)

Chemistry:

	(1)
SiO_2	19.01
TiO_2	0.01
B_2O_3	6.52
Al_2O_3	74.10
MgO	0.07
CaO	0.00
MnO	0.01
FeO	0.40
Total	100.12

(1) Mount Stafford, central Australia; average of 11 electron microprobe analyses, corresponding to $Mg_{0.01}Fe_{0.03}Al_{8.88}\ B_{1.14}Si_{1.93}O_{18.94}$.

Occurrence: Product of granulite facies metamorphism of boron-rich peletic rocks.

Association: Sillimanite, werdingite, sekaninaite-cordierite, potassium feldspar, biotite, hercynite, ilmenite, ominelite-grandidierite, plagioclase, alusite, tourmaline, monazite-(Ce), an unspecified apatite-group mineral, zircon.

Distribution: Mount Stafford, ~170 km northwest of Alice Springs, central Australia.

Name: Recognizes boron as an essential constituent and for its relationship to mullite.

Type Material: South Australian Museum, Science Centre, Morgan Thomas Lane, Adelaide, South Australia 5000, Australia; SAM G31520 and SAM G31521.

References: (1) Buick, I.S., E.S. Grew, T. Armbruster, O. Medenbach, M.G. Yates, G.E. Bebout, and G.L. Clarke (2008) Boromullite, $Al_9BSi_2O_{19}$, a new mineral from granulite-facies metapelites, Mount Stafford, central Australia: a natural analogue of a synthetic "boron-mullite". Eur. J. Mineral., 20, 935–950. (2) (2009) Amer. Mineral., 94, 648 (abs. ref. 1).

Boromuscovite $\mathbf{KAl_2(Si_3B)O_{10}(OH,F)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Pseudohexagonal crystals, to 4 μm, aggregated in coatings on other minerals.

Physical Properties: *Cleavage:* Perfect on {001}; poor {010} parting. *Fracture:* Subconchoidal. Hardness = 2.5–3 in aggregate. D(meas.) = 2.81 (on a mixture). D(calc.) = 2.89 ($2M_1$); 2.90 (1M).

Optical Properties: Nearly opaque. *Color:* White to buff or pale cream. *Streak:* White. *Luster:* Dull, earthy to porcelaneous.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = -1°$; $Y \wedge a = 2°$; $Z = b$. *Dispersion:* $r > v$, weak. $\alpha = 1.557(2)$ $\beta = 1.587(2)$ $\gamma = 1.593(2)$ 2V(meas.) = 44(2)° 2V(calc.) = 47.5°

Cell Data: *Space Group:* $[C2/c]$ ($2M_1$ polytype by analogy to muscovite). $a = 5.075(1)$ $b = 8.794(4)$ $c = 19.815(25)$ $\beta = 95.59(3)°$ Z = [2], or *Space Group:* $[C2/c]$ (1M polytype by analogy to muscovite). $a = 5.077(1)$ $b = 8.775(3)$ $c = 10.061(2)$ $\beta = 101.31(2)°$ Z = [4]

X-ray Powder Pattern: Little Three mine, California, USA.
3.569 (100), 4.391 (80), 3.008 (80), 2.505 (80), 9.862 (60), 4.239 (40), 4.007 (40)

Chemistry:

	(1)		(1)
SiO_2	48.1	Na_2O	< 0.05
TiO_2	< 0.01	K_2O	11.0
B_2O_3	7.0	Rb_2O	0.52
Al_2O_3	28.1	Cs_2O	0.05
Fe_2O_3	0.1	F	0.76
MnO	0.08	H_2O^+	4.55
MgO	0.15	H_2O^-	0.22
CaO	0.1	P_2O_5	< 0.05
Li_2O	0.05	$-O = F_2$	0.32
		Total	100.46

(1) Little Three mine, California, USA; by a combination of electron microprobe, XRF, AA, and ICP-atomic emission spectroscopy; corresponding to $(K_{0.89}Rb_{0.02}Ca_{0.01})_{\Sigma=0.92}(Al_{1.93}Li_{0.01}Mg_{0.01})_{\Sigma=1.95}(Si_{3.06}B_{0.77}Al_{0.17})_{\Sigma=4.00}O_{9.82}[(OH)_{2.02}F_{0.16}]_{\Sigma=2.18}$.

Polymorphism & Series: $2M_1$, 1M polytypes.

Mineral Group: Mica group.

Occurrence: A coating on other minerals on the floor of a pegmatite pocket, hydrothermally deposited after rupture of the pocket.

Association: Lepidolite, quartz, microcline, topaz.

Distribution: From the Little Three mine, Ramona district, San Diego Co., California, USA.

Name: Presumably for the BOROn content and relation to *muscovite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 166821.

References: (1) Foord, E.E., R.F. Martin, J.J. Fitzpatrick, J.E. Taggart, Jr., and J.G. Crock (1991) Boromuscovite, a new member of the mica group, from the Little Three mine pegmatite, Ramona district, San Diego County, California. Amer. Mineral., 76, 1998–2002.

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Borovskite Pd_3SbTe_4

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Crystal Data: Cubic. *Point Group:* n.d. Irregular grains, to 0.2 mm, embedded in sulfides.

Physical Properties: Hardness = n.d. VHN = 88.3 (10 g load). D(meas.) = n.d. D(calc.) = [8.25]

Optical Properties: Opaque. *Color:* Dark gray; in polished section, white. *Luster:* Metallic. *Anisotropism:* Isotropic to slightly anisotropic.
R: n.d.

Cell Data: *Space Group:* n.d. $a = 5.794(8)$ $Z = 1$

X-ray Powder Pattern: Khautovaarsk deposit, Russia.
2.902 (100), 2.041 (60), 1.550 (50), 1.297 (40), 1.183 (40), 3.34 (30), 1.603 (30)

Chemistry:

	(1)	(2)
Pd	32.39	33.55
Pt	1.23	
Ni	0.25	
Fe	0.04	
Sb	10.98	12.80
Bi	3.34	
Te	51.97	53.65
Total	100.21	100.00

(1) Khautovaarsk deposit, Russia; by electron microprobe, average of four analyses; corresponding to $(Pd_{2.93}Pt_{0.06}Ni_{0.04}Fe_{0.01})_{\Sigma=3.04}(Sb_{0.87}Bi_{0.15})_{\Sigma=1.02}Te_{3.93}$. (2) Pd_3SbTe_4.

Occurrence: In massive pentlandite-chalcopyrite-pyrrhotite ores of hydrothermal origin.

Association: Pyrrhotite, chalcopyrite, altaite, pentlandite.

Distribution: From the Khautovaarsk Cu–Ni deposit, 20 km south of Suoyarvi, Karelia, Russia [TL].

Name: To honor Igor Borisovich Borovskii (1909–1985), Russian pioneer in microprobe analysis, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, Russia.

References: (1) Yalovoi, A.A., A.F. Siderov, N.S. Rudashevskii, and I.A. Bud'ko (1973) Borovskite – Pd_3SbTe_4 – a new mineral. Zap. Vses. Mineral. Obshch., 102, 427–431 (in Russian). (2) (1974) Amer. Mineral., 59, 873 (abs. ref. 1)

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Bortnikovite Pd_4Cu_3Zn

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As a discontinuous rim, to 50–60 μm, on an isoferroplatinum grain.

Physical Properties: *Cleavage*: None observed. *Fracture*: n.d. *Tenacity*: Poorly malleable. Hardness = n.d. VHN = 353.8 to 382.0 (50 g load). D(meas.) = n.d. D(calc.) = 11.16

Optical Properties: Opaque. *Color*: Steel-white, with a slight cream tint; white with a slight grayish beige tint, in reflected light. *Streak*: n.d.
Luster: Metallic.
Optical Class: n.d.
R: (400) 63.2, (420) 57.0, (440) 54.7, (460) 55.8, (480) 58.0, (500) 59.4, (520) 60.5, (540) 61.4, (560) 62.2, (580) 63.1, (600) 63.7, (620) 64.2, (640) 64.8, (660) 65.9, (680) 66.9, (700) 68.6

Cell Data: *Space Group*: *P*4/*mmm* [probable]. a = 6.00 (2) c = 8.50 (3) Z = 3

X-ray Powder Pattern: Konder River, Khabarovsk region, Russia.
2.13 (100), 1.224 (80), 1.059 (40), 1.501 (30), 1.346 (20), 3.00 (10), 2.67 (10)

Chemistry:

	(1)
Pt	4.06
Pd	58.19
Fe	1.41
Cu	27.26
Zn	8.02
Total	98.94

(1) Konder River, Khabarovsk region, Russia; average 18 electron microprobe analyses corresponding to $(Pd_{3.822}Pt_{0.145})_{\Sigma=3.967}Cu_{2.998}(Zn_{0.857}\ Fe_{0.177})_{\Sigma=1.034}$.

Occurrence: As rims on isoferroplatinum grains in alluvial placer sediment derived from a concentrically zoned, alkaline ultramafic massif.

Association: Isoferroplatinum, titanite, perovskite, V-bearing magnetite, bornite, chlorite.

Distribution: From the Konder River PGM placer deposit, Ayan-Maya district, Khabarovsk region, Russia.

Name: Honors Professor Nikolai Stefanovich Bortnikov, mineralogist and researcher at the Russian Academy of Sciences.

Type Material: Mineralogical Museum, St. Petersburg State University, Russia.

References: (1) Mochalov, A.G., M.D. Tolkachev, Y.S. Polekhovsky, and E.M. Goryacheva (2007) Bortnikovite, Pd_4Cu_3Zn, a new mineral species from the unique Konder placer deposit, Khabarovsk krai, Russia. Geology of Ore Deposits, 49(4), 318–327. (2) (2008) Amer. Mineral., 93, 705 (abs. ref. 2).

Boscardinite $TlPb_4(Sb_7As_2)_{\Sigma=9}S_{18}$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As millimeter-sized masses of intergrown crystals. *Twinning*: Polysynthetic twinning well developed.

Physical Properties: *Cleavage*: n.d. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.355

Optical Properties: Opaque. *Color*: Gray, white in reflected light. *Streak*: Black. *Luster*: Metallic. *Anisotropism*: Distinct, shades of gray.
Optical Class: n.d.
R_1-R_2: (470) 33.8-39.3, (546) 32.1-38.0, (589) 31.2-36.9, (650) 29.7-35.3

Cell Data: *Space Group*: $P\bar{1}$. a = 8.0929(4) b = 8.7610(5) c = 22.4971(11)
α = 90.868(4)° β = 97.247(4)° γ = 90.793(4)° Z = 2

X-ray Powder Pattern: Monte Arsiccio mine,Tuscany, Italy.
2.824 (vs), 2.707 (s), 3.705 (ms), 3.540 (ms), 2.977 (ms), 2.324 (ms), 2.176 (ms)

Chemistry:

	(1)	(2)
Ag	1.48	1.37
Tl	9.72	8.96
Pb	23.36	25.74
Sb	35.25	33.46
As	5.78	6.54
S	22.14	22.08
Se	0.04	0.01
Total	97.77	98.16

(1) Monte Arsiccio mine,Tuscany, Italy; electron microprobe analysis; corresponding to $Ag_{0.36}Tl_{1.23}Pb_{2.92}(Sb_{7.50}As_{2.00})_{\Sigma=9.50}S_{17.88}Se_{0.01}$. (2) Monte Arsiccio mine,Tuscany, Italy; electron microprobe analysis; corresponding to $Ag_{0.33}Tl_{1.13}Pb_{3.20}(Sb_{7.09}As_{2.25})_{\Sigma=9.34}S_{17.76}$.

Occurrence: In a quartz vein cutting dolostone, associated with a barite-pyrite-iron oxide deposit in regionally metamorphosed rocks.

Association: Zinkenite, dolomite.

Distribution: From at the Sant'Olga level, Monte Arsiccio mine, near Sant'Anna di Stazzema, Apuan Alps, Tuscany, Italy.

Name: Honors Matteo Boscardin (b. 1939) for his contribution to the knowledge of the regional mineralogy of Italy.

Type Material: Natural History Museum, University of Pisa, Pisa, Italy (# 19349).

References: (1) Orlandi, P., C. Biagioni, E. Bonaccorsi, Y. Moëlo, and W.H. Paar (2012) Lead-antimony sulfosalts from Tucsany (Italy). XII. Boscardinite, $TlPb_4(Sb_7As_2)_{\Sigma9}S_{18}$, a new mineral species from the Monte Arsiccio mine: occurrence and crystal structure. Can. Mineral., 50(2), 235–251. (2) (2014) Amer. Mineral., 99, 2152 (abs. ref. 1).

Bostwickite $CaMn_6^{3+}Si_3O_{16}\cdot 7H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. As divergent sprays of bladed crystals, commonly composed of tiny microcrystals, to 250 μm; as radial aggregates and hemispherules of such crystals, to 3 mm.

Physical Properties: Hardness = ~1 D(meas.) = 2.93(10) D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark brownish red. *Streak:* Brownish red. *Luster:* Vitreous to submetallic on prism surfaces.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X = Y$ = red-brown; Z = yellow-brown. *Dispersion:* $r < v$, very strong. *Absorption:* $X = Y > Z$. $\alpha = 1.775(5)$ $\beta = 1.798(3)$ $\gamma = 1.800(3)$ 2V(meas.) = 25°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Franklin, New Jersey, USA.
11.3 (100), 2.567 (40), 3.548 (30), 2.898 (30), 2.262 (25), 2.238 (25), 1.470 (25)

Chemistry:

	(1)	(2)
SiO_2	20.1	21.56
Al_2O_3	1.0	
Fe_2O_3	0.5	
Mn_2O_3	56.3	56.65
As_2O_5	1.0	
MgO	0.9	
CaO	5.1	6.71
H_2O	[15.1]	15.08
Total	[100.0]	100.00

(1) Franklin, New Jersey, USA; by electron microprobe, H_2O by difference; corresponds to $(Ca_{0.76}Mg_{0.19})_{\Sigma=0.95}(Mn^{3+}_{5.97}Fe^{3+}_{0.05})_{\Sigma=6.02}(Si_{2.80}Al_{0.16}As^{5+}_{0.07})_{\Sigma=3.03}O_{16}\cdot 7.1H_2O$.
(2) $CaMn_6Si_3O_{16}\cdot 7H_2O$.

Occurrence: In a metamorphosed stratiform zinc deposit, on surfaces of ore and on secondary carbonate minerals.

Association: Franklinite, calcite, fluorite, willemite, kittatinnyite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: For Richard C. Bostwick, collector of Franklin minerals and expert in mineral fluorescence.

Type Material: Harvard University, Cambridge, Massachusetts, 125617–125620; National Museum of Natural History, Washington, D.C., USA, C4222.

References: (1) Dunn, P.J. and P.B. Leavens (1983) Bostwickite, a new calcium manganese silicate hydrate from Franklin, New Jersey. Mineral. Mag., 47, 387–389. (2) (1984) Amer. Mineral., 69, 810 (abs. ref. 1).

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Botallackite $Cu_2Cl(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crusts of minute platy interlaced crystals.

Physical Properties: *Cleavage:* One direction, good, $\perp Z$. Hardness = [Soft.]
D(meas.) = ∼3.6 D(calc.) = [3.60]

Optical Properties: Transparent to translucent. *Color:* Mountain-green, bluish green to green; pale bluish green in transmitted light.
Optical Class: Biaxial (+). *Pleochroism:* Weak; in shades of bluish green. *Dispersion:* $r > v$, strong. $\alpha = 1.775(3)$ $\beta = 1.800(5)$ $\gamma = 1.846(3)$ 2V(meas.) = Moderately large.

Cell Data: *Space Group:* $P2_1/m$. $a = 5.717(1)$ $b = 6.126(1)$ $c = 5.636(1)$
$\beta = 93.07(1)^\circ$ Z = [2]

X-ray Powder Pattern: Botallack mine, England.
5.66 (10), 2.40 (8), 2.57 (7), 2.84 (4), 1.53 (4), 2.68 (3), 1.93 (3)

Chemistry:

	(1)	(2)
CuO	66.25	74.49
Cl	14.51	16.60
H_2O	22.60	12.65
$-O = Cl_2$	3.27	3.74
Total	100.09	100.00

(1) Botallack mine, England. (2) $Cu_2Cl(OH)_3$.

Polymorphism & Series: Polymorphous with atacamite, clinoatacamite, and paratacamite.

Occurrence: In copper-bearing deposits, in areas with high chlorine concentrations or weathered while exposed to seawater; a reaction product of slag immersed in seawater; a weathering product of sulfides in subsea black smoker deposits.

Association: Atacamite, paratacamite (Botallack mine, Cornwall, England; Bisbee, Arizona, USA); gypsum, brochantite, connellite (Dalbeattie, Scotland).

Distribution: In Wheal Cock and West Wheal Owles, the Botallack and Levant mines, St. Just, and a few other places in Cornwall, England. At the Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland. From the Castletown mine, Lochgilphead, Scotland. Found in the Dooneen mine, Allihies, Co. Cork, Ireland. From Juliushütte, Astfeld, Harz Mountains, Germany, in slag. At Laurium, Greece, in slag. In South Africa, from the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, in slag. From Bisbee, Cochise Co., Arizona, USA. Along the Mid-Atlantic Ridge, in the TAG Hydrothermal Field.

Name: For the occurrence in the Botallack mine, Cornwall, England.

Type Material: The Natural History Museum, London, England, 36528; Harvard University, Cambridge, Massachusetts, USA, 100805.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 76–77. (2) Frondel, C. (1950) On paratacamite and some related copper chlorides. Mineral. Mag., 29, 34–45. (3) Hawthorne, F.C. (1985) Refinement of the crystal structure of botallackite. Mineral. Mag., 49, 87–89.

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Botryogen $MgFe^{3+}(SO_4)_2(OH)\cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are short to long prismatic, elongated and striated ‖ [001], complex with $\{\bar{1}01\}$, {010}, {110}, {120}, $\{\bar{1}11\}$, many other forms, to several mm. Commonly in stalactitic, reniform, botryoidal or globular aggregates with internal radiating structure.

Physical Properties: *Cleavage:* {010}, perfect; {110}, good. *Fracture:* Conchoidal, irregular. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 2.14 D(calc.) = 2.23 Decomposed by hot H_2O.

Optical Properties: Transparent to translucent. *Color:* Pale to dark orange. *Streak:* Ocher-yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless to pale brown; Y = cinnamon-brown; Z = golden yellow. *Orientation:* $X = b$; $Z \wedge c = 12°$. *Dispersion:* $r > v$, strong. $\alpha = 1.523$ $\beta = 1.530$ $\gamma = 1.582$ 2V(meas.) = 42°

Cell Data: *Space Group:* $P2_1/n$. $a = 10.47$–10.51 $b = 17.83$–17.85 $c = 7.11$–7.14 $\beta = 100°00'$–$100°20'$ Z = 4

X-ray Powder Pattern: Quetena, Chile.
8.86 (FFF), 2.998 (F), 6.29 (mF), 5.11 (mF), 5.47 (f), 3.86 (f), 3.41 (f)

Chemistry:

	(1)	(2)
SO_3	38.37	38.55
Fe_2O_3	19.51	19.28
MgO	9.35	9.64
H_2O	32.28	32.53
Total	99.51	100.00

(1) Redington mine, California, USA. (2) $MgFe(SO_4)_2(OH)\cdot 7H_2O$.

Occurrence: A secondary mineral, which may be in great abundance, altered from pyrite, especially in arid climates.

Association: Copiapite, amarantite, hohmannite, coquimbite, voltaite, pickeringite, epsomite, gypsum, chalcanthite.

Distribution: From Falun, Sweden. At the Rammelsberg mine, near Goslar, Harz Mountains, Germany. In Chile, in Antofagasta, at Chuquicamata, Quetena, west of Calama, and Alcaparrosa, near Cerritos Bayos, southwest of Calama. From the Santa Elena mine, Quebrada de La Alcaparrosa, San Juan Province, Argentina. In the USA, from the Redington mine, Knoxville, and at the Palisades mine, near Calistoga, Napa Co., California; abundant as a post-mining product at Bisbee, Cochise Co., Arizona; from Cornwall, Lebanon Co., Pennsylvania. At Libiola, Liguria, and Rio Marina, Elba, Italy.

Name: From the Greek for *bunch of grapes* and *to bear*, in allusion to the globular forms exhibited by the original material.

Type Material: Natural History Museum, Vienna, Austria, A.a.185; The Natural History Museum, London, England, 1956,315.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 617–618. (2) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French). (3) Süsse, P. (1968) Die Kristallstruktur des Botryogens. Acta Cryst., 24, 760–767 (in German with English abs.).

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Bottinoite $NiSb_2^{5+}(OH)_{12}\cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$, 32, or $\overline{3}\ 2/m$. Crystals tabular on {0001}, with $\{10\overline{1}0\}$, in roselike and spherulitic aggregates, to 3 mm. *Twinning:* Inability to solve the structure was attributed to possible twinning.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼3
VHN = 94–110, 105 average (10 g load). D(meas.) = 2.83(1) (synthetic). D(calc.) = 2.81

Optical Properties: Transparent. *Color:* Pale blue to blue-green. *Streak:* Very pale blue.
Luster: Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.600(10)$ $\epsilon = 1.605(10)$

Cell Data: *Space Group:* $P31m$, $P3m1$, $P312$, or $P\overline{3}1m$. $a = 16.026(3)$ $c = 9.795(2)$
Z = 6

X-ray Powder Pattern: Bottino mine, Italy.
4.62 (100), 3.36 (100), 2.34 (80), 1.806 (70), 2.09 (60), 1.751 (60), 4.88 (50)

Chemistry:

	(1)	(2)	(3)	(4)
As_2O_5		0.53		
Sb_2O_5	62.6	69.12	52.07	52.65
SiO_2		0.31		
NiO	15.2	15.92	12.04	12.16
H_2O	32.9		35.40	35.19
Total	110.7		99.51	100.00

(1) Bottino mine, Italy; by electron microprobe, average of four analyses, with apparent loss of H_2O in electron beam; H_2O by TGA, $(OH)^{1-}$ and H_2O confirmed by IR. (2) Brownley Hill mine, England; by electron microprobe, average of four partial analyses. (3) Synthetic; by AA, H_2O by TGA; corresponds to $Ni_{0.99}Sb_{1.98}H_{24.13}O_{18}$. (4) $NiSb_2(OH)_{12}\cdot 6H_2O$.

Occurrence: Adjacent to and incrusting ullmannite in oxidized hydrothermal base-metal deposits.

Association: Ullmannite, galena, sphalerite, chalcopyrite, pyrite, quartz, calcite, bindheimite, cerussite, hydrozincite, chrysocolla, malachite, hemimorphite, pyromorphite, wulfenite.

Distribution: In the Bottino mine, near Seravezza, Tuscany, Italy. In England, at the Brownley Hill mine, Nenthead, Cumbria. From the Hendre Felen mine, Ysbyty Ystwyth, Dyfed, and the Mynydd Gorddu mine, Bont gôch, Ceulanymaesmawr, Wales. In Germany, from Dörnberg, Ramsbeck, North Rhein-Westphalia.

Name: For its occurrence in the Bottino mine, Italy.

Type Material: University of Florence, Florence, Italy, 1747/RI.

References: (1) Bonazzi, P., S. Menchetti, A. Caneschi, and S. Magnanelli (1992) Bottinoite, $Ni(H_2O)_6[Sb(OH)_6]_2$, a new mineral from the Bottino mine, Alpi Apuane, Italy. Amer. Mineral., 77, 1301–1304. (2) Clark, A.M. (1993) Bottinoite, a mineral new to Britain. Mineral. Mag., 57, 543–544.

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Boulangerite $Pb_5Sb_4S_{11}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Needlelike crystals, to 1 cm, rarely as tiny rings; fibrous, compact masses. Crystals are seldom terminated; striations ‖ [001] strong.

Physical Properties: *Cleavage:* Distinct on {100}. *Tenacity:* Brittle; flexible in thin crystals. Hardness = 2.5–3 VHN = n.d. D(meas.) = ∼6.2 D(calc.) = 6.21

Optical Properties: Opaque. *Color:* Dull, lead-gray. *Streak:* Brownish. *Luster:* Metallic, may be silky. *Pleochroism:* Weak. *Anisotropism:* Distinct.

R_1–R_2: (400) 40.5–44.0, (420) 40.0–43.7, (440) 39.5–43.5, (460) 39.0–43.2, (480) 38.6–43.0, (500) 38.2–42.7, (520) 37.9–42.4, (540) 37.6–42.0, (560) 37.2–41.6, (580) 36.8–41.1, (600) 36.3–40.3, (620) 35.8–39.6, (640) 35.4–38.8, (660) 35.0–38.0, (680) 34.6–37.3, (700) 34.1–36.6

Cell Data: *Space Group:* $P2_1/a$. $a = 21.612(7)$ $b = 23.543(8)$ $c = 8.084(3)$ $\beta = 100.71(2)^\circ$ Z = 8

X-ray Powder Pattern: Cleveland mine, Stevens Co., Washington, USA. (ICDD 42-1407). 3.725 (100), 2.823 (42), 3.216 (41), 3.023 (32), 2.812 (31), 3.910 (23), 3.009 (21)

Chemistry:

	(1)	(2)	(3)
Pb	55.28	54.25	55.42
Fe	0.39		
Sb	25.40	23.65	25.69
Bi		3.05	
Se		1.16	
S	18.19	17.81	18.89
insol.	0.62		
Total	99.88	99.82	100.00

(1) Cleveland mine, Stevens Co., Washington, USA; corresponding to $Pb_{5.17}Fe_{0.14}Sb_{4.04}S_{11.00}$. (2) Boliden, Sweden; by electron microprobe, corresponding to $Pb_{5.05}(Sb_{3.75}Bi_{0.28})_{\Sigma=4.03}(S_{10.72}Se_{0.28})_{\Sigma=11.00}$. (3) $Pb_5Sb_4S_{11}$.

Occurrence: In hydrothermal veins formed at low to medium temperatures.

Association: Lead sulfosalts, galena, stibnite, sphalerite, pyrite, arsenopyrite, siderite, quartz.

Distribution: Widespread; only a few localities can be given. In France, at Molières, Gard [TL], and from Saint-Pons, Alpes-de-Haute-Provence. In rings from Bottino, Tuscany, Italy. In crystals from Sala, Västmanland; Nasafjell, Lappland; and Boliden, Västerbotten, Sweden. At Wolfsberg, Harz Mountains, at Ober-Lahr, near Altenkirchen, Rhineland-Palatinate, and Waldsassen, Bavaria, Germany. From Trepča, Serbia. At Příbram, Czech Republic. In the USA, in the Coeur d'Alene district, Shoshone Co., and [??where??in] the Wood River district, Blaine Co., Idaho; in the Iron Mountain mine, Superior, Mineral Co., Montana; and at Augusta Mountain, Gunnison Co., Colorado. In Mexico, at the Noche Buena mine, Mazapil, Zacatecas. From Madoc, Ontario, Canada, as rings.

Name: Honors Charles Louis Boulanger (1810–1849), French mining engineer, who called attention to the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 420–422. (2) Mumme, W. (1989) The crystal structure of $Pb_{5.05}(Sb_{3.75}Bi_{0.28})S_{10.72}Se_{0.28}$: boulangerite of near ideal composition. Neues Jahrb. Mineral., Monatsh., 498–512. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, ??.

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Bournonite $PbCuSbS_3$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals short prismatic to tabular, typically striated, as much as 11 cm across; commonly as subparallel aggregates. Also massive, granular to compact. *Twinning:* On {110}, commonly forming cross or cogwheel aggregates.

Physical Properties: *Cleavage:* {010}, imperfect; {100} and {001}, less perfect. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 176–205 (100 g load). D(meas.) = 5.83 D(calc.) = 5.84

Optical Properties: Opaque. *Color:* Steel-gray to iron-black. *Streak:* Steel-gray to iron-black. *Luster:* Brilliant to dull. *Pleochroism:* Very weak. *Anisotropism:* Weak in air. R_1–R_2: (400) 37.0–37.4, (420) 36.8–37.3, (440) 36.5–37.2, (460) 36.1–37.0, (480) 35.6–36.8, (500) 35.2–36.6, (520) 34.8–36.4, (540) 34.3–36.2, (560) 33.8–35.8, (580) 33.4–35.5, (600) 33.0–35.1, (620) 32.7–34.7, (640) 32.3–34.0, (660) 32.0–33.4, (680) 31.4–32.7, (700) 30.8–32.1

Cell Data: *Space Group:* $Pnm2_1$. $a = 8.153(3)$ $b = 8.692(3)$ $c = 7.793(2)$ $Z = 4$

X-ray Powder Pattern: Neudorf, Germany.
2.74 (100), 3.90 (80), 1.765 (60), 2.59 (50), 4.37 (40), 2.99 (40), 2.69 (40)

Chemistry:

	(1)	(2)		(1)	(2)
Pb	42.34	42.40	Sb	24.44	24.91
Cu	12.80	13.01	S	19.58	19.68
Zn	0.04		rem.	0.37	
Fe	0.27		Total	99.84	100.00

(1) Herja (Kisbánya), Romania. (2) $PbCuSbS_3$.

Polymorphism & Series: Forms a series with seligmannite.

Occurrence: In hydrothermal veins formed at medium temperatures.

Association: Galena, tetrahedrite, sphalerite, chalcopyrite, pyrite, stibnite, zinkenite, siderite, quartz, rhodochrosite, dolomite, barite.

Distribution: Numerous localities, even for fine crystals. In England, from Wheal Boys, St. Endellion [TL], and in exceptional crystals from the Herodsfoot mine, Lanreath, Cornwall. At the Mogul mine, Silvermines, Co. Tipperary, Ireland. From the Georg mine, near Horhausen, North Rhine-Westphalia, and at Clausthal, Neudorf, and Wolfsberg, Harz Mountains, Germany. From Příbram, Czech Republic. At Baia Sprie (Felsőbánya), Cavnic (Kapnikbánya), and Săcărîmb (Nagyág), Romania. In France, from Pontgibaud, Puy-de-Dôme; large crystals at St. Laurent Le Minier, Gard; and from Prunières [ck??Gard??also], Isère. In Bolivia, from Chorolque, Colquechaca, Pacuani, Machacamarca, and Oruro; at Cerro Rico, and as fine crystals from the Víboras mine, Machacamarca, Potosí. At the Quiruvilca mine, La Libertad, and from Pachapaque. Peru. At Park City, Summit Co., Utah, USA. In Mexico, in the Noche Buena mine, Mazapil, Zacatecas, and at Naica, Chihuahua. From Broken Hill, New South Wales, Australia. In the Chichibu mine, Saitama Prefecture, and the Nakaze mine, Hyogo Prefecture, Japan. At the Yaogangxian mine, Chenzhou, Hunan Provinve, China.

Name: In honor of Jacques Louis de Bournon (1751–1825), French crystallographer and mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 406–410. (2) Edenharter, A., W. Nowacki, and Y. Takéuchi (1970) I. Verfeinerung der Kristallstruktur von Bournonit $[(SbS_3)_2|Cu_2^{IV}Pb^{VII}Pb^{VIII}]$ und von Seligmannit $[(AsS_3)_2|Cu_2^{IV}Pb^{VII}Pb^{VIII}]$. Zeits. Krist., 131, 397–417 (in German with English abs.). (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 133. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 57.

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Boussingaultite $(NH_4)_2Mg(SO_4)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are short prismatic along [001], showing {001}, {010}, {110}, {111}, a number of other forms. Typically in stalactites, to 20 cm, or as fibrous crusts, massive.

Physical Properties: *Cleavage:* $\{\bar{2}01\}$, perfect (synthetic). Hardness = 2 D(meas.) = 1.722 (synthetic). D(calc.) = 1.718 Soluble in H_2O, with sharply astringent and saline taste.

Optical Properties: Transparent to translucent. *Color:* Colorless, white to yellowish pink; colorless in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c \simeq 12°$. *Dispersion:* $r > v$, perceptible. $\alpha = 1.470$ $\beta = 1.472$ $\gamma = 1.479$ 2V(meas.) = 51°11′

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 9.324(7)$ $b = 12.597(9)$ $c = 6.211(5)$ $\beta = 107.14(2)°$ Z = 2

X-ray Powder Pattern: Synthetic; shows preferred orientation. (ICDD 17-135).
4.22 (100), 2.085 (95), 5.11 (85), 7.20 (70), 3.79 (70), 1.818 (65), 2.189 (55)

Chemistry:

	(1)	(2)
SO_3	43.49	44.40
Al_2O_3	0.04	
Fe_2O_3	0.08	
MgO	11.54	11.18
$(NH_4)_2O$	10.86	14.44
Na_2O	0.60	
K_2O	0.22	
H_2O	31.48	29.98
Total	98.31	100.00

(1) South Mountain, California, USA. (2) $(NH_4)_2Mg(SO_4)_2 \cdot 6H_2O$.

Mineral Group: Picromerite group.

Occurrence: A rare sublimate formed under fumarolic conditions.

Association: n.d.

Distribution: From Travale, Val di Cecina, and Larderello, Tuscany, Italy. At the Schoeller mine, Libušin, near Kladno, Czech Republic. In the USA, in California, from South Mountain, near Santa Paula, Ventura Co.; in substantial quantity in Geyser Creek Canyon, The Geysers, Sonoma Co.; and at Coso Hot Springs, Inyo Co. From Gcwihaba Cave, 280 km west of Maun, northwestern Botswana.

Name: Honoring Professor Jean-Baptiste Joseph Dieudonné Boussingault (1802–1887), French chemist, Lyon University, Lyon, France.

Type Material: Natural History Museum, Paris, 99.494; National School of Mines, Paris, France, 17853.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 455–456. (2) Larsen, E.S. and E.V. Shannon (1920) Boussingaultite from South Mountain, near Santa Paula, California. Amer. Mineral., 5, 127–128. (3) Margulis, T.N. and D.H. Templeton (1962) Crystal structure and hydrogen bonding of magnesium ammonium sulfate hexahydrate. Zeits. Krist., 117, 344–357. (4) Montgomery, H. (1964) The crystal structure of Tutton's salts. II. Magnesium ammonium sulfate hexahydrate and nickel ammonium sulfate hexahydrate. Acta Cryst., 17, 1478–1479.

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Bowieite $(Rh, Ir, Pt)_2S_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As anhedral grains, to 0.5 mm across, and as inclusions in other platinum group minerals.

Physical Properties: *Tenacity:* Very slightly brittle. Hardness = n.d. VHN = 858–1635, 1288 average (100 g load). D(meas.) = n.d. D(calc.) = 6.91–6.96

Optical Properties: Opaque. *Color:* Pale gray to pale gray-brown in reflected light. *Luster:* Metallic. *Anisotropism:* Weak, dark gray to very dark brown.
R_1–R_2: (400) 43.5–44.5, (420) 44.2–45.2, (440) 44.8–45.8, (460) 45.3–46.5, (480) 45.7–46.9, (500) 45.9–47.3, (520) 46.1–47.6, (540) 46.2–47.8, (560) 46.3–48.0, (580) 46.4–48.2, (600) 46.5–48.3, (620) 46.6–48.4, (640) 46.8–48.5, (660) 46.8–48.6, (680) 46.9–48.6, (700) 47.0–48.7

Cell Data: *Space Group: Pbcn.* a = 8.454–8.473 b = 5.995–6.002 c = 6.121–6.143
Z = 4

X-ray Powder Pattern: Goodnews Bay, Alaska, USA.
3.00 (vvs), 0.7877 (vvs), 0.7768 (vvs), 0.7726 (vvs), 1.757 (vs), 2.143 (s), 1.728 (s)

Chemistry:

	(1)	(2)	(3)
Rh	30.8	68.80	29.2
Ir	35.4		44.6
Pt	8.8		
S	25.3	31.05	24.1
Total	100.3	99.85	97.9

(1) Salmon River, Alaska, USA; by electron microprobe; corresponds to $(Rh_{1.14}Ir_{0.70}Pt_{0.17})_{\Sigma=2.01}S_{3.00}$ (2) Gaositai, China; by electron microprobe, corresponds to $Rh_{2.07}S_{3.00}$. (3) Gusevogorskii massif, Russia; by electron microprobe, corresponds to $(Rh_{1.13}Ir_{0.93})_{\Sigma=2.06}S_{3.00}$.

Occurrence: In platinum alloy nuggets recovered from dredging operations (Salmon River, Alaska, USA); in platinum-bearing ultramafic rocks intruded into a granite gneiss-"hornblende" gneiss complex (Gaositai, China).

Association: Platinum-iridium, platinum, osmium, laurite, silicate inclusions (Salmon River, Alaska, USA).

Distribution: From the Salmon River, Goodnews Bay, Alaska, USA [TL]. In the Santiago River, Esmeraldas Province, Ecuador. From the Gusevogorskii massif, Ural Mountains, and the Baimka placer, Chukotka, Far Eastern Region, Russia. At Gaositai, Hebei Province, China. In sediments in the Blagoevgrad graben, southwest Bulgaria. At Milverton, near Fifield, New South Wales, Australia. In the Pirogues River, New Caledonia.

Name: To honor the Scottish scientist, Dr. Stanley Hay Umphray Bowie (1917–), of the Institute of Geological Sciences, London, England.

Type Material: The Natural History Museum, London, England, 1983,70, E813.

References: (1) Desborough, G.A. and A.J. Criddle (1984) Bowieite: a new rhodium–iridium–platinum sulfide in platinum-alloy nuggets, Goodnews Bay, Alaska. Can. Mineral., 22, 543–552. (2) (1989) Amer. Mineral., 74, 9 and 1215 (abs. ref. 1)?? [must see??what are these??] (3) Parthé, E., D. Hohnke, and F. Hulliger (1967) A new structure type with octahedron pairs for Rh_2S_3, Rh_2Se_3 and Ir_2S_3. Acta Cryst., 23, 832–840.

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Boyleite $(Zn, Mg)SO_4 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In thin crusts and earthy aggregates.

Physical Properties: *Fracture:* Uneven. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 2.41 (synthetic $ZnSO_4 \cdot 4H_2O$). Soluble in H_2O; slowly alters to gunningite in a dry atmosphere.

Optical Properties: Semitransparent. *Color:* White. *Streak:* White.
Optical Class: Biaxial (–). $\alpha = 1.522(2)$ $\beta = [1.531]$ $\gamma = 1.536(2)$ 2V(meas.) = ∼70°

Cell Data: *Space Group:* $P2_1/n$ (synthetic $ZnSO_4 \cdot 4H_2O$). $a = 5.95$ $b = 13.60$ $c = 7.96$ $\beta = 90°18'$ Z = 4

X-ray Powder Pattern: Kropbach quarry, Germany.
5.46 (10), 4.47 (10), 6.85 (8), 3.96 (8), 3.39 (7), 2.95 (7), 2.55 (5)

Chemistry:

	(1)
SO_3	38.89
ZnO	33.09
MgO	3.19
H_2O	24.83
Total	[100.00]

(1) Kropbach quarry, Germany; recalculated after deduction of estimated gypsum 11.60%, then corresponding to $(Zn_{0.84}Mg_{0.16})SO_4 \cdot 4H_2O$.

Mineral Group: Rozenite group.

Occurrence: A rare alteration product of sphalerite in a hydrothermal Pb–Zn vein (Kropbach quarry, Germany).

Association: Gypsum, gunningite, sphalerite (Kropbach quarry, Germany); gunningite, coquimbite, zincocopiapite, jarosite, melanterite, römerite, siderotil, voltaite, chalcanthite, hexahydrite, gypsum (Les Vallettes, Switzerland).

Distribution: From the Kropbach quarry, Münstertal, Black Forest, Germany. At Les Vallettes, Valais, Switzerland. From Keno Hill, Yukon Territory, Canada.

Name: Honoring Dr. Robert William Boyle (1920–), Canadian geochemist, Geological Survey of Canada, Ottawa, Canada.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137413.

References: (1) Walenta, K. (1978) Boyleit, ein neues Sulfatmineral von Kropbach im südlichen Schwarzwald. Chem. Erde. 37, 73–79 (in German with English abs.). (2) (1979) Amer. Mineral., 64, 241, 464 (abs. ref. 1).

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Brabantite $CaTh(PO_4)_2$

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Crystal Data: Monoclinic; partially metamict. *Point Group:* $2/m$. Crystals are elongated, in crystalline aggregates, to 1.5 cm; fine granular, massive.

Physical Properties: *Cleavage:* On {100} and {001}. Hardness = ∼5 D(meas.) = 4.72–5.02 (after heating to 900 °C); 5.20 D(calc.) = 5.26 Radioactive.

Optical Properties: Semitransparent. *Color:* Grayish brown to reddish brown on rims, pale yellow, brownish green; brown-gray in thin section. *Luster:* Dull, greasy.
Optical Class: Biaxial (+). $\alpha = 1.691$ $\beta = 1.696$–1.73 $\gamma = 1.725$ 2V(meas.) = 44°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.726(6)$ $b = 6.933(5)$ $c = 6.447(12)$ $\beta = 103°53(16)'$ Z = 2

X-ray Powder Pattern: Brabant Farm, Namibia; close to monazite.
3.06 (100), 2.85 (75), 3.26 (70), 4.15 (30), 1.947 (30), 3.46 (25), 2.14 (25)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3		0.29		$(Ce,Y)_2O_3$		3.05	
P_2O_5	27.68	28.78	30.72	Fe_2O_3	0.05	0.66	
SiO_2	2.27	1.60		MnO	0.32		
UO_2		1.23		MgO	0.56	trace	
TiO_2		0.12		CaO	11.94	13.33	12.14
ThO_2	52.65	51.12	57.14	H_2O	3.07		
Al_2O_3	0.74			Total	99.28	100.18	100.00

(1) Brabant Farm, Namibia; after deduction of H_2O from admixed brockite, corresponds to $(Ca_{1.00}Mg_{0.06}Mn_{0.02})_{\Sigma=1.08}(Th_{0.94}Al_{0.07})_{\Sigma=1.01}[(P_{0.92}Si_{0.09})_{\Sigma=1.01}O_4]_2$. (2) Xinjiang Uygur Autonomous Region, China; corresponds to $Ca_{1.04}(Th_{0.86}RE_{0.08}U_{0.02})_{\Sigma=0.96}[(PO_4)_{1.78}(SiO_4)_{0.12}]_{\Sigma=1.90}$. (2) $CaTh(PO_4)_2$.

Mineral Group: Monazite group.

Occurrence: In a zoned granite pegmatite (Brabant Farm, Namibia); in a rare-metal-bearing pegmatite (Xinjiang Uygur Autonomous Region, China); an accessory mineral in peraluminous granites (Eibenstock, Germany).

Association: Hematite, brockite, thorite, uraninite, muscovite (Brabant Farm, Namibia); hafnian zircon, spodumene, manganocolumbite, albite (Xinjiang Uygur Autonomous Region, China); cheralite, huttonite (Kuttankuli, India).

Distribution: In the Van der Made pegmatite, Brabant Farm, west of Itiro, Karibib district, Namibia. In China, at an undisclosed locality in the Xinjiang Uygur Autonomous Region. From Kuttankuli (Kuttakuzhi), about 42 km east-southeast of Trivandrum, Kerala State, India. Along Cordell Creek, Dugger Community, Guadalupe Co., Texas, USA. In the Eibenstock pluton, in the Erzgebirge, Germany.

Name: For the Brabant Farm, Namibia, location of the pegmatite where the mineral was first found.

Type Material: Institute for Mineralogy and Crystallography, Berlin Technical University, Berlin, Germany.

References: (1) Rose, D. (1980) Brabantite, $CaTh[PO_4]_2$, a new mineral of the monazite group. Neues Jahrb. Mineral., Monatsh., 247–257. (2) Wang Xianjue (1978) A new mineral – lingaitukuang [= brabantite]. Kexue Tongbao, 23, 743–745 (in Chinese). (3) (1981) Amer. Mineral., 66, 878–879 (abs. refs. 1 and 2). (4) Förster, H.-J. (1998) The chemical composition of REE-Y-U-rich accessory minerals in peraluminous granites of the Erzgebirge-Fichtelgebirge region, Germany, Part I: the monazite-(Ce)-brabantite solid solution series. Amer. Mineral., 83, 259–272.

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Bracewellite $Cr^{3+}O(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Very rarely as minute crystals; in crystalline masses; in alluvial grains.

Physical Properties: Hardness = n.d. D(meas.) = 4.45–4.48 D(calc.) = [4.28]

Optical Properties: Semitransparent. *Color:* Deep red to black. *Streak:* Dark brown. *Optical Class:* Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group: Pbnm.* a = 4.492(3) b = 9.860(5) c = 2.974(2) Z = 4

X-ray Powder Pattern: Merume River, Guyana.
4.065 (vvs), 2.648 (vs), 2.404 (vs), 2.458 (w), 2.149 (w), 3.314 (vw), 2.546 (vw)

Chemistry:

	(1)	(2)
Ti_2O_3	0.17	
Al_2O_3	6.2	
Fe_2O_3	15.1	
Cr_2O_3	70.6	89.40
V_2O_3	0.64	
H_2O	6.9	10.60
Total	99.6	100.00

(1) Merume River, Guyana; estimated to contain 30% eskolaite. (2) CrO(OH).

Polymorphism & Series: Trimorphous with grimaldiite and guyanaite.

Occurrence: In fine-grained intergrowth with other chromium oxide-hydroxide minerals.

Association: Eskolaite, grimaldiite, guyanaite, mcconnellite.

Distribution: In the basin of the Merume River, Guyana.

Name: For Smith Bracewell, formerly Director, British Guyana Geological Survey, who first noted the occurrence.

Type Material: The Natural History Museum, London, England, 1979,136.

References: (1) Milton, C., D.E. Appleman, M.H. Appleman, E.C.T. Chao, F. Cuttitta, J.I. Dinnin, E.J. Dwornik, B.L. Ingram, and H.J. Rose, Jr. (1976) Merumite, a complex assemblage of chromium minerals from Guyana. U.S. Geol. Surv. Prof. Paper 887, 1–29. (2) (1977) Amer. Mineral., 62, 593 (abs. ref. 1).

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Brackebuschite $Pb_2(Mn^{3+},Fe^{3+})(VO_4)_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically as acicular crystals, elongated and striated ‖ [010], may be lathlike or wedge-shaped, flattened on {001}, with {100}, {001}, {011}, $\{10\overline{2}\}$, $\{10\overline{3}\}$, others, perhaps without terminal faces, to 1.5 mm; in sprays, dendritic, botryoidal.

Physical Properties: Hardness = n.d. D(meas.) = 6.05 D(calc.) = 6.11

Optical Properties: Translucent to nearly opaque. *Color:* Dark brown to black; reddish brown in transmitted light. *Streak:* Yellow. *Luster:* Submetallic.
Optical Class: Biaxial (+). *Pleochroism:* X = nearly colorless; Y = dark reddish brown; Z = reddish brown. *Orientation:* Y = b; $X \wedge a = 20°$. *Dispersion:* $r > v$, strong. $\alpha = 2.28$ $\beta = 2.36$–2.38 $\gamma = 2.48$–2.49 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.810$–8.880 $b = 6.135$–6.155 $c = 7.650$–7.681 $\beta = 111°30'$–$111°50'$ Z = 2

X-ray Powder Pattern: Venus mine, Argentina.
3.25 (10), 4.95 (8), 2.76 (8), 2.98 (6), 1.720 (6), 3.08 (5), 2.13 (4)

Chemistry:

	(1)		(1)
P_2O_5	0.18	CuO	0.42
V_2O_5	25.32	ZnO	1.29
FeO	4.65	PbO	61.00
MnO	4.77	H_2O	2.03
		Total	99.66

(1) "Sierra de Córdoba," Argentina; corresponds to $Pb_{1.88}(Mn^{3+}_{0.46}Fe^{3+}_{0.45}Zn_{0.11}Cu_{0.04})_{\Sigma=1.06}[(V_{0.96}P_{0.01})_{\Sigma=0.97}O_{3.72}]_2(OH)_{1.55}$. (2) Do.; by electron microprobe, average of 10 analyses, not given but stated to correspond to $(Pb_{1.96}Sr_{0.01}Ca_{0.01})_{\Sigma=1.98}(Fe^{3+}_{0.77}Mn^{3+}_{0.13}Cu_{0.03}Zn_{0.02})_{\Sigma=0.95}(V_{1.02}O_4)_2(OH)$. (3) Do.; by electron microprobe, average of 29 analyses, not given but stated to correspond to $(Pb_{1.89}Sr_{0.02}Ca_{0.03}Ba_{0.01})_{\Sigma=1.95}(Mn^{3+}_{0.96}Fe^{3+}_{0.04}Cu_{0.03}Zn_{0.01})_{\Sigma=1.04}[(V_{1.00}As_{0.01})_{\Sigma=1.01}O_4]_2(OH)$.

Mineral Group: Brackebuschite group.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal Pb–Zn deposits.

Association: Descloizite, vanadinite, wulfenite, cerussite.

Distribution: Found in the Venus, Agua del Rubio, Bienvenida, Pilar, and Algarrobites mines, El Guaico district, Córdoba Province, Argentina. In the USA, from a prospect in the Swisshelm district, Swisshelm Mountains, Cochise Co., and at the Palmetto mine, Santa Cruz Co., Arizona; on the Hack claim, Paradox Valley, Montrose Co., Colorado. From the Kusu vanadium deposit, 85 km southwest of Kinshasa, Bas-Congo Province, Congo (Bas-Zaire Province, Zaire). In the Mounana uranium mine, Franceville, Gabon.

Name: Honoring Ludwig Brackebusch (1849–1906), Professor of Mineralogy, University of Córdoba, Córdoba, Argentina.

Type Material: The Natural History Museum, London, England, 55819; Harvard University, Cambridge, Massachusetts, USA, 96255.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1052–1053. (2) Berry, L.G. and A.R. Graham (1948) X-ray measurements on brackebuschite and hematolite. Amer. Mineral., 33, 489–495. (3) Donaldson, D.M. and W.H. Barnes (1955) The structures of the minerals of the descloizite and adelite groups: III – brackebuschite. Amer. Mineral., 40, 597–613. (4) Fanfani, L. and P.F. Zanazzi (1967) Structural similarities of some secondary lead minerals. Mineral. Mag., 36, 522–529. (5) Symes, R.F. and S.A. Williams (1973) Heyite and brackebuschite compared. Mineral. Mag., 39, 69–73. (6) Foley, J.A., J.M. Hughes, and D. Lange (1997) The atomic arrangement of brackebuschite, redefined as $Pb_2(Mn^{3+},Fe^{3+})(VO_4)_2(OH)$, and comments on Mn^{3+} octahedra. Can. Mineral., 35, 1027–1033.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare minute crystals, flattened on {001}, and in extremely fine-grained masses.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3.5 D(meas.) = 2.720–2.734 D(calc.) = [2.72] Soluble in H_2O, dissolving sodium phosphate.

Optical Properties: Semitransparent. *Color:* Light gray. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 7°$. *Dispersion:* $r < v$. $\alpha = 1.487(2)$ $\beta = 1.546(2)$ $\gamma = 1.560(2)$ 2V(meas.) = 49° 2V(calc.) = 50°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.85(1)$ $b = 6.63(1)$ $c = 5.16(1)$ $\beta = 90°25(5)'$ Z = 2

X-ray Powder Pattern: Westvaco mine, Wyoming, USA.
2.655 (100), 3.312 (71), 8.85 (50), 2.576 (35), 1.839 (30), 3.694 (25), 1.658 (25)

Chemistry:

	(1)	(2)
SO_3	0.55	
P_2O_5	26.34	28.59
SiO_2	0.02	
CO_2	18.39	17.73
Al_2O_3	0.29	
Fe_2O_3	0.62	
MgO	15.44	16.23
Na_2O	37.57	37.45
Cl	0.42	
H_2O^-	0.36	
Total	[100.00]	100.00

(1) John Hay, Jr. Well No. 1, Wyoming, USA; recalculated to 100% after deduction of shortite 0.36% and clay 14.46%. (2) $Na_3Mg(PO_4)(CO_3)$.

Occurrence: A rare mineral in oil shale in the Green River formation.

Association: Shortite, clay minerals, trona, pirssonite, northupite, gaylussite, alstonite, dolomite, quartz.

Distribution: In the John Hay, Jr. Well No. 1, about 30 km west of Green River, and in the Westvaco mine, Green River, Sweetwater Co., Wyoming, USA.

Name: Honoring Dr. Wilmot Hyde Bradley (1899–1979), geologist, U.S. Geological Survey, who studied the Green River formation.

Type Material: National Museum of Natural History, Washington, D.C., USA, 117718.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 295. (2) Fahey, J.J. and M.E. Mrose (1962) Saline minerals of the Green River formation. U.S. Geol. Sur. Prof. Paper 405, 34–35, 48.

Braggite (Pt, Pd, Ni)S

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Crystal Data: Tetragonal. *Point Group:* $4/m$ or 4. As prisms, to 2 cm, and rounded grains. *Twinning:* Rarely observed.

Physical Properties: Hardness = n.d. VHN = 946–1064, 997 average (100 g load). D(meas.) = ∼10 D(calc.) = 9.383

Optical Properties: Opaque. *Color:* White in reflected light. *Luster:* Metallic. *Anisotropism:* Distinct, in purplish and pinkish shades of gray and brown.
R_1–R_2: (400) 41.3–41.8, (420) 41.8–42.4, (440) 42.1–43.0, (460) 42.4–43.4, (480) 42.5–43.8, (500) 42.7–44.1, (520) 42.7–44.2, (540) 42.6–44.2, (560) 42.5–44.2, (580) 42.4–44.2, (600) 42.3–44.1, (620) 42.2–44.1, (640) 41.9–44.0, (660) 41.9–43.9, (680) 41.9–43.8, (700) 41.5–43.8

Cell Data: *Space Group:* $P4_2/m$. $a = 6.367$ $c = 6.561$ $Z = 8$

X-ray Powder Pattern: Potgietersrus district, South Africa; can be confused with vysotskite.
2.86 (100), 2.93 (30), 2.64 (30), 1.852 (30), 1.423 (30), 1.713 (20), 1.595 (2)

Chemistry:

	(1)	(2)		(1)	(2)
Pt	63.2	62.1	Ni	4.4	2.0
Pd	15.4	19.0	S	17.4	16.9
			Total	100.4	100.0

(1) Potgietersrus district, South Africa; by electron microprobe, corresponding to $(Pt_{0.60}Pd_{0.27}Ni_{0.14})_{\Sigma=1.01}S_{1.00}$. (2) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $(Pt_{0.60}Pd_{0.34}Ni_{0.06})_{\Sigma=1.00}S_{1.00}$.

Polymorphism & Series: Forms a series with vysotskite; dimorphous with cooperite.

Occurrence: In layered mafic intrusives, formed at high magmatic temperatures.

Association: Sperrylite, cooperite, laurite, platinum (Potgietersrus district, South Africa); pentlandite, pyrrhotite, chalcopyrite, cubanite, nickelian mackinawite, gold, cooperite, vysotskite, moncheite, isoferroplatinum, kotulskite, keithconnite, palladian tulameenite (Stillwater complex, Montana, USA).

Distribution: One of most common and economically important platinum group minerals. From the Rustenburg and Potgietersrus [TL] districts, in the Merensky Reef, Bushveld complex, Transvaal, South Africa. At the Stillwater complex, Montana, USA. From the Lac des Iles complex, Ontario, Canada. In the Santiago River, Esmeraldas Province, Ecuador. At the Luanga complex, Serra dos Carajas, Para, Brazil. From the Noril'sk region, western Siberia, and in the Lukkulaisvaara layered intrusion, Karelia, Russia. On Rum Island, Inner Hebrides, Scotland. In the Siikakama intrusion and the Kirakkajuppura deposit, Penikat layered complex, northeast of Kemi, Finland. At Little Darling Creek, east of Broken Hill, New South Wales, Australia. On Round Hill, near Orepuki, New Zealand. Additional localities are known.

Name: To honor Sir William Henry Bragg (1862–1942) and Professor William Lawrence Bragg (1890–1971), Cambridge University, Cambridge, England, pioneers in the X-ray investigation of crystals, as this was the first new mineral to be discovered by X-ray methods alone.

Type Material: The Natural History Museum, London, England, 1932,1303–1304; National Museum of Natural History, Washington, D.C., USA, 105857.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 259. (2) Childs, J.D. and Hall, S.R. (1973) The crystal structure of
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braggite, (Pt, Pd, Ni)S. Acta Cryst., 29, 1446–1451. (3) Cabri, L.J., J.H.G. Laflamme, J.M. Stewart, K. Turner, and B.J. Skinner (1978) On cooperite, braggite, and vysotskite. Amer. Mineral., 63, 832–839. (4) Verryn, S.M.C. and R.K.W. Merkle (1994) Compositional variation of cooperite, braggite, and vysotskite from the Bushveld Complex. Mineral. Mag., 58, 223—234. (5) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 100. (6) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 71–72. (7) Criddle, A.J. and C.J. Stanley (1985) Characteristic optical data for cooperite, braggite and vysotskite. Can. Mineral., 23, 149–162.

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Braithwaiteite $NaCu_5(TiSb)O_2(AsO_4)_4[AsO_3(OH)]_2(H_2O)_8$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Crystals tabular, to 1 mm; form {001} dominant, {010} less prominent, {100}, {$10\bar{3}$}, and {203} subordinate.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~ 2 D(meas.) = 3.44(2) D(calc.) = 3.753

Optical Properties: Transparent. *Color*: Sky-blue. *Streak*: Pale blue. *Luster*: Vitreous. *Optical Class*: Biaxial (-). $\alpha = 1.698(2)$ $\beta = 1.757(5)$ $\gamma = 1.783(5)$ 2V (meas.) = 59(2)° 2V (calc.) = 65° *Pleochroism:* Weak; *X* = *Y* = pale blue; *Z* = greenish blue. *Absorption*: X = Y < Z. *Orientation*: X ^ a = 20.5°; Y ^ c = 79.9°; Z ^ b = 12.9°.

Cell Data: *Space Group*: $P\bar{1}$. $a = 7.0308(4)$ $b = 9.8823(5)$ $c = 10.6754(6)$ $\alpha = 106.973(1)°$ $\beta = 104.274(1)°$ $\gamma = 93.839(1)°$ $Z = 1$

X-ray Powder Pattern: Laurani, Bolivia.
9.825(100), 2.947(60), 5.887(50), 4.635(30), 3.354(30), 3.232(30), 2.736(30)

Chemistry:

	(1)	(2)
Sb_2O_5	11.7	10.63
As_2O_5	42.3	45.30
TiO_2	4.5	5.25
FeO	0.2	-
CuO	25.8	26.13
ZnO	trace	-
Na_2O	1.7	2.04
H_2O	10.17	10.65
Total	96.37	100.00

(1) Laurani, Bolivia; average of 4 electron microprobe analyses, low analytical total due to beam damage of sample, H_2O and valances assigned from structure analysis, corresponding to $Na_{0.87}Cu^{2+}_{5.17}Fe_{0.04}(Ti^{4+}_{0.90}Sb^{5+}_{1.15})_{\Sigma=2.05}O_2(As^{5+}_{0.98}O_4)_4[As^{5+}_{0.98}O_3(OH)]_2{\cdot}8H_2O$.
(2) $NaCu_5(TiSb)O_2(AsO_4)_4[AsO_3(OH)]_2(H_2O)_8$.

Occurrence: An uncommon secondary mineral in the weathering zone of a hydrothermal enargite deposit.

Association: Lammerite, lavendulan-lemmereite.

Distribution: Laurani, near Sica Sica, Bolivia.

Name: Honors Richard S.W. Braithwaite (b. 1930), chemist and mineralogist at the University of Manchester, England, for his contributions to the chemistry of secondary Cu-Pb minerals.

Type Material: Canadian Museum of Nature, Ottawa, Ontario (CMNMC 86085).

References: (1) Parr, W.H., M.A. Cooper, F.C. Hawthorne, E. Moffat, M.E. Gunter, A.C. Roberts, and P.J. Dunn (2009) Braithwaiteite, $NaCu_5(TiSb)O_2(AsO_4)_4[AsO_3(OH)]_2(H_2O)_8$, a new mineral species from Laurani, Bolivia, Can. Mineral., 47, 947–953. (2) Hawthorne, F.C., M.A. Cooper, and W.H. Parr (2008) The crystal structure of braithwaiteite. J. Coord. Chem., 61, 15–29.
(3) (2010) Amer. Mineral., 95, 204 (abs. refs. 1and 2).

Braitschite-(Ce) $(Ca,Na)_6(Ce,La,Nd)_2B_{24}O_{42}(OH)_6 \cdot 3H_2O(?)$

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Crystal Data: Hexagonal. *Point Group:* n.d. As hexagonal plates, to 70 μm; in spherical aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.903(2) D(calc.) = 2.837

Optical Properties: Semitransparent. *Color:* Colorless to white, may be pink to red from admixed hematite. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.646(2)$ $\epsilon = 1.647(2)$

Cell Data: *Space Group:* n.d. $a = 12.256(1)$ $c = 7.377(5)$ Z = 1

X-ray Powder Pattern: Cane Creek mine, Utah, USA.
4.283 (100), 3.021 (92), 10.52 (54), 2.8090 (53), 3.168 (45), 3.155 (38), 1.8805 (35)

Chemistry:

	(1)		(1)
B_2O_3	48.2	Dy_2O_3	0.25
Y_2O_3	1.50	Ho_2O_3	0.05
La_2O_3	4.57	Er_2O_3	0.08
Ce_2O_3	7.64	Tm_2O_3	0.02
Pr_2O_3	1.00	Yb_2O_3	0.02
Nd_2O_3	3.67	Lu_2O_3	0.01
Sm_2O_3	0.94	CaO	21.8
Eu_2O_3	0.39	Na_2O	1.68
Gd_2O_3	0.32	H_2O^+	7.75
Tb_2O_3	0.10	Total	[100.0]

(1) Cane Creek mine, Utah, USA; by a wide variety of analytical methods, recalculated to 100% from an original total of 99.91%; after deduction of about 35% admixed quartz, dolomite, hematite, and a chloritelike mineral, corresponds to $(Ca_{6.74}Na_{0.94})_{\Sigma=7.68}(Ce_{0.81}La_{0.49}Nd_{0.38}Y_{0.23}Pr_{0.11}Sm_{0.09}Eu_{0.04}Gd_{0.03}Dy_{0.02}Tb_{0.01}Er_{0.01})_{\Sigma=2.22}B_{24.00}O_{42}(OH)_{4.54} \cdot 5.19H_2O$.

Occurrence: In anhydrite at the contact with sylvite in a thick sequence of marine evaporites, at a depth of about 1 km.

Association: Anhydrite, dolomite, halite, hematite, chalcopyrite.

Distribution: From the Cane Creek potash mine, about 13 km southwest of Moab, and in the CC-1 well, about 1.8 km south of that mine, Grand Co., Utah, USA.

Name: Honors Dr. Otto Braitsch (1921–1966), University of Freiburg, Freiburg, Germany, for his contributions to evaporate mineralogy and geochemistry.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120627.

References: (1) Raup, O.B., A.J. Gude, 3rd, E.J. Dwornik, F. Cuttitta, and H.J. Rose, Jr. (1968) Braitschite, a new hydrous calcium rare-earth borate mineral from the Paradox Basin, Grand County, Utah. Amer. Mineral., 53, 1081–1095.

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Brandtite $Ca_2(Mn^{2+},Mg)(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Stout to slender prismatic crystals, with prominent {100}, {110}, {120}, {010}, {122}, a number of minor forms, to 8 mm; in radiated groups and fibrous spherules. *Twinning:* On {100}, common.

Physical Properties: *Cleavage:* {010}, perfect; {001}, good. Hardness = 3.5
D(meas.) = 3.61–3.67 D(calc.) = 3.63–3.70

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = 6°$; $Z \wedge c = 84°$. *Dispersion:* $r < v$, strong to very strong. $\alpha = 1.707–1.709$ $\beta = 1.711$ $\gamma = 1.722–1.727$ 2V(meas.) = 15°–23°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.897–5.899$ $b = 12.991–12.968$ $c = 5.964–5.684$ $\beta = 108.01–108.05°$ Z = 2

X-ray Powder Pattern: Harstigen mine, Sweden.
3.010 (100), 3.241 (70), 3.373 (55), 3.424 (30), 6.482 (25), 5.151 (20), 3.790 (20)

Chemistry:

	(1)	(2)	(3)
P_2O_5	0.05		
As_2O_5	50.48	49.95	51.19
FeO	0.05		
MnO	14.03	14.85	15.80
PbO	0.96		
MgO	0.90	0.46	
CaO	25.07	24.66	24.98
Cl	0.04		
H_2O	8.09	9.31	8.03
insol.	0.04		
Total	99.71	99.23	100.00

(1) Harstigen mine, Sweden. (2) Vrančice, Czech Republic; by electron microprobe, H_2O by TGA; corresponds to $Ca_{2.01}(Mn_{0.96}Mg_{0.05})_{\Sigma=1.01}(AsO_4)_{1.99} \cdot 2.32H_2O$. (3) $Ca_2Mn(AsO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with parabrandtite.

Mineral Group: Roselite group.

Occurrence: In metamorphosed Fe–Mn orebody (Harstigen mine and Långban, Sweden); in a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA).

Association: Lead, sarkinite, flinkite, caryopilite, galena, barite, calcite (Harstigen mine, Sweden); sarkinite, rhodochrosite, sphalerite, franklinite, willemite, barite, calcite, chalcopyrite, löllingite (Sterling Hill, New Jersey, USA).

Distribution: Found in the Harstigen mine, near Persberg, and at Långban, Värmland, Sweden. From Sailauf, northeast of Aschaffenburg, Bavaria, Germany. In the Falotta mine, Oberhalbstein, Graubünden, Switzerland. At Vrančice, near Příbram, Czech Republic. In the Ushkatyn-III deposit, Atasu district, Kazakhstan. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. In the Veta Negra mine, Pampa Larga district, Tierra Amarilla, southeast of Copiapó, Chile. From the Wessel's mine, near Kuruman, Cape Province, South Africa.

Name: To honor George Brandt (1694–1768), Swedish chemist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 725–727. (2) Dahlman, B. (1952) The crystal structures of kröhnkite, $CuNa_2(SO_4)_2 \cdot 2H_2O$ and brandtite, $MnCa_2(AsO_4)_2 \cdot 2H_2O$. Arkiv. Mineral. Geol., 1(12), 339–366. (3) Hawthorne, F.C. and R.B. Ferguson (1977) The crystal structure of roselite. Can. Mineral., 15, 36–42. (4) Mrázek, Z. (1985) Brandtite and chervetite from Vrančice near Příbram (Bohemia). Časopis pro Mineralogii a Geologii, 30(3), 295–302. (5) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 659–660.

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Brannerite $(U, Ca, Y, Ce)(Ti, Fe)_2O_6$

Crystal Data: Monoclinic; always metamict. *Point Group:* $2/m$. As indistinct prismatic crystals, to 30 cm, some showing an orthogonal prism zone; more typically as rounded, detrital grains and pebbles and as irregular embedded grains and masses.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5–5.5 D(meas.) = 4.2–5.43 D(calc.) = [5.20]; 6.37 (synthetic UTi_2O_6). Radioactive.

Optical Properties: Opaque, transparent in very thin fragments. *Color:* Black, brownish olive-green, yellow-brown to yellow with alteration; yellowish green in transmitted light. *Streak:* Dark greenish brown to yellowish brown. *Luster:* Pitchlike to vitreous when fresh, resinous to dull when altered.
Optical Class: Isotropic. $n = 2.23$–2.30
R: (400) 13.9, (420) 13.5, (440) 13.1, (460) 12.8, (480) 12.7, (500) 12.5, (520) 12.3, (540) 12.2, (560) 12.1, (580) 12.0, (600) 11.9, (620) 11.8, (640) 11.7, (660) 11.7, (680) 11.6, (700) 11.5

Cell Data: *Space Group:* $C2/m$ (synthetic UTi_2O_6). $a = 9.8123(15)$ $b = 3.7697(6)$ $c = 6.9253(9)$ $\beta = 118.957(6)°$ $Z = 2$

X-ray Powder Pattern: Custer Co., Idaho, USA; recrystallized in air at 1000 °C.
3.41 (10), 1.903 (8), 4.73 (6), 3.32 (6), 2.462 (6), 2.276 (6), 1.864 (6)

Chemistry	(1)	(2)		(1)	(2)		(1)	(2)
UO_3	33.5		UO_2	10.3	62.83	BaO	0.3	
SiO_2	0.6		$(Yt, Er)_2O_3$	3.9		SrO	0.1	
TiO_2	39.0	37.17	FeO	2.9		H_2O	2.0	
ZrO_2	0.2		PbO	0.2		CO_2	0.2	
ThO_2	4.1		CaO	2.9		Total	100.2	100.00

(1) Custer Co., Idaho, USA. (2) UTi_2O_6.

Polymorphism & Series: Dimorphous with orthobrannerite (?); forms a series with thorutite.

Occurrence: A primary mineral in granite pegmatite and in granitic gneiss; in silicified pebble conglomerates; in hydrothermal quartz and calcite veins; detrital in placers.

Association: Uraninite, gold, rutile, xenotime, apatite, zircon.

Distribution: In the USA, from Kelly Gulch, Custer Co., Idaho; in the San Bernardino Mountains, San Bernardino Co., and about ten km south of Coleville, Mono Co., California; at the California mine, Chaffee Co., Colorado; from Penn Haven Junction, Carbon Co., Pennsylvania. In Canada, an ore mineral in the Blind River-Elliot Lake district, Ontario, and at Eldorado, Saskatchewan. From Hornachuelos, Fuente Obejuna, and El Cabril, Cordoba, Spain. At Chateâu-Lambert, Voges, France. From Hüttenberg, Carinthia, Austria. Found at Lengenbach, Binntal, Valais, Switzerland. In Morocco, at Bou-Azzer. On the Witwatersrand, Transvaal, South Africa. From Crocker's Well, near Manna Hill, and the Nichols Nob copper mine, Flinders Range, South Australia. A few other localities are known.

Name: To honor Dr. John Casper Branner (1850–1922), American geologist, formerly Professor of Geology and President of Stanford University, Palo Alto, California, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 105793, 114997.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 774–775. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 333–337. (3) Hewett, D.F., J. Stone, and H. Levine (1957) Brannerite from San Bernardino County, California. Amer. Mineral., 42, 30–38. (4) Szymański, J.T. and J.D. Scott (1982) A crystal-structure refinement of synthetic brannerite, UTi_2O_6, and its bearing on rate of alkaline-carbonate leaching of brannerite in ore. Can. Mineral., 20, 271–279.

Brannockite $KLi_3Sn_2Si_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. In very thin hexagonal plates, with {0001} dominant, to 1 mm. *Twinning:* Common, $\perp$ [0001], observable only by X-ray study.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.980 D(calc.) = 3.08 Fluoresces bright bluish white in SW UV.

Optical Properties: Semitransparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.567$ $\epsilon = 1.566$

Cell Data: *Space Group:* $P6/mcc$. a = 10.002(2) $c = 14.263(3)$ Z = 2

X-ray Powder Pattern: Kings Mountain, North Carolina, USA.
4.109 (10), 2.905 (9), 7.141 (8), 4.343 (8), 5.714 (7), 8.693 (6), 2.681 (6)

Chemistry:

	(1)	(2)
SiO_2	65.8	64.70
SnO_2	28.2	27.05
Li_2O	3.75	4.02
Na_2O	0.74	
K_2O	3.72	4.23
Total	102.2	100.00

(1) Kings Mountain, North Carolina, USA; by electron microprobe, Li, Na, and K by flame photometry. (2) $KLi_3Sn_2Si_{12}O_{30}$.

Mineral Group: Milarite group.

Occurrence: In the late hydrothermal portions of a Li-Sn-rich pegmatite, in vugs and on flat fracture surfaces.

Association: Bavenite, pyrite, tetrawickmanite, stannian titanite, albite, quartz.

Distribution: From the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA.

Name: Honoring Dr. Kent Combs Brannock (1923–1973), Kingsport, Tennessee, USA, chemist and mineral collector.

Type Material: National Museum of Natural History, Washington, D.C., USA, 125045.

References: (1) White, J.S., Jr., J.E. Arem, J.A. Nelen, P.B. Leavens, and R.W. Thomssen (1973) Brannockite, a new tin mineral. Mineral. Record, 4, 73–76. (2) (1973) Amer. Mineral., 58, 1111 (abs. ref. 1). (3) Armbruster, T. and R. Oberhänsli (1988) Crystal chemistry of double-ring silicates: structures of sugilite and brannockite. Amer. Mineral., 73, 595–600.

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Brassite $Mg(AsO_3OH)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Cryptocrystalline crusts and powder, intermixed with other arsenates.

Physical Properties: Hardness = n.d. D(meas.) = 2.28(4) D(calc.) = 2.326

Optical Properties: Semitransparent. *Color:* White. *Luster:* Pearly.
Optical Class: Biaxial (+) (synthetic). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.531(2)$ $\beta = 1.546(2)$ $\gamma = 1.562(2)$ 2V(meas.) = n.d. 2V(calc.) = 80°

Cell Data: *Space Group: Pbca* (synthetic). $a = 7.472(1)$ $b = 10.891(1)$ $c = 16.585(5)$ Z = 8

X-ray Powder Pattern: Jáchymov, Czech Republic.
4.97 (10), 3.20 (8), 3.07 (7), 4.14 (6), 3.88 (5), 2.324 (5), 4.54 (4)

Chemistry:

	(1)	(2)
As_2O_5	48.1	48.63
MgO	15.6	17.06
CaO	0.9	
H_2O	[35.4]	34.31
Total	[100.0]	100.00

(1) Jáchymov, Czech Republic; H_2O by difference, corresponds to $(Mg_{0.92}Ca_{0.04})_{\Sigma=0.96}$ $AsO_3OH\cdot 3.70H_2O$. (2) $Mg(AsO_3OH)\cdot 4H_2O$.

Occurrence: A rare reaction product of arsenic-rich solutions with Ca–Mg carbonates.

Association: Pharmacolite, picropharmacolite, weilite, haidingerite, rauenthalite, arsenic, realgar, dolomite.

Distribution: From Jáchymov (Joachimsthal), Czech Republic. At Bieber and Richelsdorf, Hesse, and Wittichen, Black Forest, Germany. In the Ruben mine, Kohlendorf, Nowa Ruda (Neurode), Silesia, Poland. From the Salsigne mine, 15 km north of Carcassone, Aude, France.

Name: Honoring Rèjane Brasse, who first synthesized the compound.

Type Material: National School of Mines, Paris, France, 1963.

References: (1) Fontan, F., M. Orliac, F. Permingeat, R. Pierrot, and R. Stahl (1973) La brassite, $MgHAsO_4\cdot 4H_2O$, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 96, 365–370 (in French with English abs.). (2) (1975) Amer. Mineral., 60, 945 (abs. ref. 1). (3) Protas, J. and R. Gindt (1976) Structure cristalline de la brassite, $MgHAsO_4\cdot 4H_2O$, produit de déshydration de la roesslérite. Acta Cryst., 32, 1460–1466 (in French with English abs.).

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Braunite $Mn^{2+}Mn_6^{3+}SiO_{12}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As pyramidal crystals, to 5 cm, striated on {001} and {201} ‖ [010]; also dense granular, massive. *Twinning:* On {112}.

Physical Properties: *Cleavage:* Perfect on {112}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 920–1079, 1025–1196 (100 g load). D(meas.) = 4.72–4.83 D(calc.) = [4.86] Weakly magnetic.

Optical Properties: Opaque. *Color:* Dark, brownish black to steel-gray; in polished section, greyish white with a brownish tinge. *Streak:* Brownish black to steel-gray. *Luster:* Submetallic. *Anisotropism:* Weak in air to distinct in oil, dark to lighter slate gray.
R_1–R_2: (400) 23.4–25.4, (420) 22.7–24.5, (440) 22.0–23.6, (460) 21.5–22.9, (480) 21.0–22.4, (500) 20.5–21.9, (520) 20.0–21.5, (540) 19.6–21.2, (560) 19.3–20.9, (580) 19.0–20.6, (600) 18.8–20.3, (620) 18.6–20.0, (640) 18.5–19.8, (660) 18.3–19.6, (680) 18.2–19.5, (700) 18.1–19.4.

Cell Data: *Space Group:* $I4_1/acd$. $a = 9.36$–9.45 $c = 18.60$–18.97 $Z = 8$

X-ray Powder Pattern: Thuringia, Germany.
2.72 (100), 1.656 (70), 2.14 (50), 2.35 (40), 1.420 (40), 1.074 (40), 3.49 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	9.89	9.68	9.94	FeO	3.81		
TiO_2		0.09		MnO	78.91	[10.80]	11.73
Al_2O_3		0.35		MgO	0.15	0.13	
Fe_2O_3		2.02		CaO	0.34	0.38	
Mn_2O_3		[75.80]	78.33	O	7.35		
				Total	100.45	[99.25]	100.00

(1) Långban, Sweden; total Mn as MnO. (2) Tirodi, India; by electron microprobe, Mn^{2+} estimated equal to (Si + Al + Ti) − (Mg + Ca). (3) $Mn^{2+}Mn_6^{3+}SiO_{12}$.

Polymorphism & Series: Forms a series with abswurmbachite.

Occurrence: Formed by metamorphism of manganese silicates and oxides; also a product of weathering.

Association: Pyrolusite, jacobsite, hausmannite, bixbyite, rhodonite, spessartine, hematite.

Distribution: Of widespread origin; a few localities for large crystals or pure material are: in Germany, at Öhrenstock and Elgersburg, near Ilmenau, Thuringia, and at Ilfeld, Harz Mountains. From Långban, and Jakobsberg, Värmland, Sweden. In Norway, at Botnedalen. In Italy, at St. Marcel, Val d'Aosta. From Kacharwali, Nagpur district, Maharashtra, and Tirodi, Madhya Pradesh, India. In Brazil, at Miguel Burnier, near Ouro Prêto, Minas Gerais. From mines in the Kalahari manganese field, around Kuruman, Cape Province, South Africa. In the USA, at the Spiller manganese mines, 25 km northeast of Mason, Mason Co., Texas; in the Batesville district, Independence Co., Arkansas; at Cartersville, Bartow Co. Georgia; from Snowmass, Pitkin Co., Colorado; in the Black Diablo mine, Pershing Co., Nevada; and the Fort Seward mine, Humboldt Co., California.

Name: To honor Kammerrath [Advisor of the Chambers] Braun of Gotha, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 551–554. (2) Moore, P.B. and T. Araki (1976) Braunite: its structure and relationship to bixbyite, and some insights on the genealogy of fluorite derivative structures. Amer. Mineral., 61, 1226–1240. (3) Dasgupta, H.C. and R. Manickavasagam (1981) Chemical and X-ray investigation of braunite from the metamorphosed manganiferous sediments of India. Neues Jahrb. Mineral., Abh., 142, 149–160. (4) Bhattacharyya, P.K., S. Dasgupta, M. Fukuoka, and S. Roy (1984) Geochemistry of braunite and associated phases in metamorphosed non-calcareous manganese ores of India. Contr. Mineral. Petrol., 87, 65–71. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 177.

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Brazilianite $NaAl_3(PO_4)_2(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals typically equant, or spearhead-shaped, elongated along [100], with large {011}, {$\bar{1}$11}, also {010}, {110}, {$\bar{3}$01}, {$\bar{1}$01}, other forms, to 20 cm. May be radial fibrous, globular.

Physical Properties: *Cleavage:* On {010}, good. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 2.98 D(calc.) = 2.998

Optical Properties: Transparent. *Color:* Chartreuse-yellow, pale yellow, yellow-green; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = -20°$. *Dispersion:* $r < v$, faint.
$\alpha = 1.602$ $\beta = 1.609$ $\gamma = 1.621$–1.623 2V(meas.) = n.d. 2V(calc.) = 71°–75°

Cell Data: *Space Group:* $P2_1/n$. $a = 11.229(6)$ $b = 10.142(5)$ $c = 7.098(4)$ $\beta = 97°41'$
Z = 4

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
5.04 (10), 2.98 (8), 2.73 (8), 2.68 (8), 2.87 (7), 1.44 (5), 3.77 (4)

Chemistry:

	(1)	(2)
P_2O_5	37.97	39.22
Al_2O_3	43.82	42.26
Na_2O	8.42	8.56
K_2O	0.37	
H_2O	9.65	9.96
Total	100.23	100.00

(1) [Córrego Frio mine,] Brazil. (2) $NaAl_3(PO_4)_2(OH)_4$.

Occurrence: A hydrothermal mineral in phosphate-rich zones of granite pegmatites; also in metamorphosed sedimentary deposits.

Association: Muscovite, albite, apatite, tourmaline ([Córrego Frio mine,] Brazil); whitlockite, apatite, quartz (Palermo #1 mine, New Hampshire, USA); amblygonite, lazulite-scorzalite, augelite, bertossaite, apatite (Buranga pegmatite, Rwanda).

Distribution: In Brazil, from the Córrego Frio and other nearby pegmatite mines, Divino das Laranjeiras, near Linópolis, and from São Geraldo do Baixio, Minas Gerais; on Alto Patrimônio, near Pedro Lavrada, Paraíba; from Boqueirão del Parelhas and Alto do Giz, Rio Grande do Norte. In the USA, at the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., and the G.E. Smith mine, Newport, Sullivan Co., New Hampshire; at the Bell Pit, Newry, Oxford Co., Maine; from the White Picacho district, Maricopa and Yavapai Co., Arizona. In the Big Fish River–Rapid Creek area, Yukon Territory, Canada. From the Buranga pegmatite, near Gatumba, Rwanda. At Millstätter Seenrücken, Carinthia, Austria. From Dolní Bory, near Velkého Meziříčí, Czech Republic. At Giogo di Toirano, Bardineto, Savona, Italy. From Hagendorf, Bavaria, Germany.

Name: For Brazil, the country in which it was first found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 105048.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 841–843. (2) Frondel, C. and M.L. Lindberg (1948) Second occurrence of brazilianite. Amer. Mineral., 33, 135–141. (3) Gatehouse, B.M. and B.K. Miskin (1974) The crystal structure of brazilianite, $NaAl_3(PO_4)_2(OH)_4$. Acta Cryst., 30, 1311–1317.

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Bredigite $Ca_7Mg(SiO_4)_4$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $mm2$. Crystals are squat, barrel- or boat-shaped, with pseudohexagonal cross sections, or as slender prismatic crystals, to 2 mm; also as rounded grains. *Twinning:* Simple contact and cyclical on {110}.

Physical Properties: *Cleavage:* Distinct on {130}. Hardness = n.d. D(meas.) = 3.42 D(calc.) = [3.32]

Optical Properties: Transparent. *Color:* Colorless, gray. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* In thick sections, X = pale violet; $Y = Z$ = colorless to pale green. *Orientation:* $X = b$; $Y = a$; $Z = c$. α = 1.712–1.725 β = 1.716–1.728 γ = 1.725–1.740 2V(meas.) = 10°–34°

Cell Data: *Space Group:* $P2nn$. a = 10.909(9) b = 18.34(1) c = 6.739(9) Z = 4

X-ray Powder Pattern: Scawt Hill, Ireland.
2.730 (100), 2.663 (100), 2.259 (80), 1.923 (80), 2.067 (60), 1.574 (60), 1.554 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	33.08	36.6	35.70
TiO_2	0.34		
Fe_2O_3	0.12		
MnO	3.38		
MgO	6.78	5.1	5.99
CaO	49.23	59.9	58.31
BaO	6.91		
F	0.16		
Total	100.00	[101.6]	100.00

(1) Synthetic, sample separated from slag; recalculated after deducting impurities. (2) Scawt Hill, Ireland; by electron microprobe, original analysis Si 17.1%, Mg 3.1%, Ca 42.8%, here converted to oxides, traces of Na, Al, P, S. (3) $Ca_7Mg(SiO_4)_4$.

Occurrence: In contact metamorphosed limestones and dolostones intruded by diabase (Scawt Hill, Ireland) or syenite monzonite (Marble Canyon, Texas, USA).

Association: Larnite, spurrite, gehlenite, melilite, perovskite, magnetite (Scawt Hill, Ireland).

Distribution: In the USA, at Marble Canyon, Culberson Co., Texas. In Ireland, at Scawt Hill and Ballycraigy, near Larne, Co. Antrim. At Camas Mòr, Isle of Muck, Inverness-shire, and at Camphouse, Ardnamurchan, Argyllshire, Scotland. In the Hatrurim Formation, Israel.

Name: For Max Albrecht Bredig (1902–), physical chemist, who studied the polymorphism of Ca_2SiO_4.

Type Material: The Natural History Museum, London, England, 1956,385.

References: (1) Tilley, C.E. and H.C.G. Vincent (1948) The occurrence of an orthorhombic high-temperature form of Ca_2SiO_4 (bredigite) in the Scawt Hill contact-zone and as a constituent of slags. Mineral. Mag., 28, 255–271. (2) (1948) Amer. Mineral., 33, 786 (abs. ref. 1). (3) Douglas, A.M.B. (1951) X-ray investigation of bredigite. Mineral. Mag., 29, 875–884. (4) Bridge, T.E. (1966) Bredigite, larnite, and γ dicalcium silicates from Marble Canyon. Amer. Mineral., 51, 1766–1774. (5) Moore, P.B. and T. Araki (1976) The crystal structure of bredigite and the genealogy of some alkaline earth orthosilicates. Amer. Mineral., 61, 74–87. (6) Sarkar, S.L. and J.W. Jeffrey (1978) Electron microprobe analysis of Scawt Hill bredigite-larnite rock. J. Amer. Ceramic Soc., 61, 177–178. (7) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 14.

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Breithauptite NiSb

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals rare, thin tabular or needlelike, to 1 mm; arborescent, disseminated, massive. *Twinning:* Twin plane $\{10\bar{1}1\}$.

Physical Properties: *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 5.5 VHN = n.d. D(meas.) = 7.591–8.23 D(calc.) = 8.629

Optical Properties: Opaque. *Color:* Pale copper-red, may be with violet tint. *Streak:* Reddish brown. *Luster:* Metallic. *Pleochroism:* Very distinct. *Anisotropism:* Very noticeable in air and oil.
R_1–R_2: (400) 44.9–49.0, (420) 43.1–48.1, (440) 41.4–47.1, (460) 39.6–46.4, (480) 38.2–45.8, (500) 36.9–45.2, (520) 35.9–45.5, (540) 37.4–47.7, (560) 39.5–49.4, (580) 42.0–51.6, (600) 44.5–53.4, (620) 46.8–55.1, (640) 49.1–56.9, (660) 51.1–58.4, (680) 52.6–59.8, (700) 53.9–61.1

Cell Data: *Space Group:* $P6_3/mmc$. $a = 3.946$ $c = 5.148$ $Z = 2$

X-ray Powder Pattern: Cobalt, Canada.
2.84 (100), 2.06 (70), 1.965 (70), 1.533 (30), 1.074 (30), 1.610 (20), 1.419 (20)

Chemistry:

	(1)	(2)	(3)
Ni	32.09	32.7	32.52
Fe	0.04		
Co	0.59		
Sb	66.62	67.2	67.48
As	0.58		
S	0.00		
Total	99.92	99.9	100.00

(1) Hudson Bay mine, Cobalt, Canada; in part due to nickeline. (2) St. Andreasberg, Germany; by electron microprobe. (3) NiSb.

Mineral Group: Nickeline group.

Occurrence: In hydrothermal calcite veins associated with Co–Ni–Ag ores.

Association: Silver, nickeline, maucherite, cobaltite, ullmannite, tetrahedrite, pyrrhotite, cubanite, chalcopyrite, sphalerite, galena, calcite.

Distribution: In Germany, from St. Andreasberg, Harz Mountains [TL??], and in the Merkur mine, Bad Ems, Rhineland-Palatinate. In France, at Ar, Pyrénées-Atlantiques, and Pierrefitte, Hautes-Pyrénées. On Monte Narba, Sarrabus, Sardinia, Italy. From Tunaberg, Saxberget, and Långsjön, Sweden. At Sulitjelma, Norway. From the Ilímaussaq intrusion, southern Greenland. At Broken Hill, New South Wales, Australia. From the Noril'sk region, western Siberia, Russia. In the Natsume mine, Hyogo Prefecture, Japan. At the Kolar Gold Fields, Karnataka, India. In Canada, from the Cobalt district, near Red Lake; in the Silver Islet mine and the Hemlo gold deposit, Thunder Bay district, Ontario. In the USA, from Coyote Peak, near Orick, Humboldt Co., California. Several additional localities are known.

Name: To honor Saxon mineralogist Johann Friedrich August Breithaupt (1791–1873).

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 238–239. (2) Beran, A. and T. Mohsenzadeh (1982) A reflected light investigation of nickeline, breithauptite and millerite. Tschermaks Mineral. Petrog. Mitt., 30, 267–275. (3) De Jong, W.F. (1925) De structuur van breithauptiet. Physica, 241–243 (in Dutch). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 62.

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Brendelite $(Bi,Pb)_2(Fe^{3+},Fe^{2+})O_2(PO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tabular $\{\overline{2}01\}$, showing also {100}, {010}, {001}, to 0.3 mm, in aggregates.

Physical Properties: Hardness = 4.5 VHN = 270–330, 300 average (15 g load). D(meas.) = n.d. D(calc.) = 6.83

Optical Properties: Translucent to opaque. *Color:* Black; dark brown in transmitted light. *Streak:* Pale brown. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = pale brown to brown; $Y = Z$ = dark brown to opaque. *Orientation:* $Z = b$; $Y \simeq a$. α = [2.06] β = [2.15] γ = [2.19] 2V(meas.) = 70.5°
R_1–R_2: (400) 14.69–16.36, (420) 13.98–15.66, (440) 13.49–15.22, (460) 13.13–14.86, (480) 12.85–14.58, (500) 12.73–14.48, (520) 12.60–14.37, (540) 12.45–14.24, (560) 12.38–14.14, (580) 12.28–14.04, (600) 12.22–13.94, (620) 12.15–13.85, (640) 12.10–13.77, (660) 12.06–13.69, (680) 11.96–13.61, (700) 12.03–13.61

Cell Data: *Space Group:* $C2/m$. a = 12.278(2) b = 3.815(1) c = 6.899(1) β = 111.14(1)° Z = 2

X-ray Powder Pattern: Güldener Falk mine, Germany.
3.011 (100), 3.372 (77), 2.750 (62), 5.726 (54), 3.217 (46), 3.322 (37), 2.863 (34)

Chemistry:

	(1)	(2)
P_2O_5	10.71	10.98
As_2O_5	0.32	0.20
V_2O_5	0.24	0.55
Bi_2O_3	47.10	56.12
Fe_2O_3	9.44	6.32
FeO	3.12	5.58
PbO	26.08	18.12
H_2O	[1.46]	[1.46]
Total	[98.47]	[99.33]

(1) Güldener Falk mine, Germany; by electron microprobe, average of 15 analyses; Fe^{2+}:Fe^{3+} from Mössbauer spectroscopy, H_2O calculated from theory; corresponds to $(Bi_{1.27}Pb_{0.73})_{\Sigma=2.00}(Fe^{3+}_{0.80}Fe^{2+}_{0.23})_{\Sigma=1.03}O_{2.04}[(PO_4)_{0.95}(AsO_4)_{0.02}(VO_4)_{0.02}]_{\Sigma=0.99}(OH)_{0.96}$. (2) Do.; by electron microprobe, average of 25 analyses, Fe^{2+}:Fe^{3+} from Mössbauer spectroscopy, H_2O calculated from theory; corresponds to $(Bi_{1.50}Pb_{0.51})_{\Sigma=2.01}(Fe^{3+}_{0.76}Fe^{2+}_{0.21})_{\Sigma=0.97}O_{2.28}[(PO_4)_{0.96}(VO_4)_{0.04}(AsO_4)_{0.01}]_{\Sigma=1.01}(OH)_{0.72}$.

Occurrence: A very rare secondary mineral found on the dumps of a Bi–Co–Ni–Ag deposit.

Association: Eulytite, bismutite, bismutoferrite.

Distribution: From the Güldener Falk mine, near Schneeberg, Saxony, Germany.

Name: In honor of Christian Friedrich Brendel (1776–1861), expert in mining equipment, Neustädtel-Schneeberg, Germany.

Type Material: State Museum of Mineralogy and Geology, Dresden, Germany.

References: (1) Krause, W., H.-J. Bernhardt, C. McCammon, and H. Effenberger (1998) Brendelite, $(Bi,Pb)_2Fe^{3+,2+}O_2(OH)(PO_4)$, a new mineral from Schneeberg, Germany: description and crystal structure. Mineral. Petrol., 63, 263–277. (2) (1999) Amer. Mineral., 84, 1195 (abs. ref. 1).

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Brenkite $Ca_2(CO_3)F_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Prismatic crystals are flattened {010} and elongated along [001], exhibiting {010}, {110}, {102}, and {021}, to 6 mm; in radial and spherical aggregates.

Physical Properties: Hardness = ∼5 D(meas.) = 3.10(4) D(calc.) = 3.126

Optical Properties: Semitransparent. *Color:* Colorless. *Streak:* White. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.525(5)$ $\beta = 1.590(5)$ $\gamma = 1.593(5)$ 2V(meas.) = 26°–28° 2V(calc.) = 23.5°

Cell Data: *Space Group: Pbcn*. $a = 7.650(2)$ $b = 7.550(2)$ $c = 6.548(2)$ Z = 4

X-ray Powder Pattern: Schellkopf, Germany.
2.794 (100), 3.028 (80), 3.006 (80), 1.835 (80), 2.486 (70), 3.276 (60), 2.265 (60)

Chemistry:

	(1)	(2)
CO_2	24.6	24.70
CaO	62.3	62.95
F	21.3	21.33
$-O = F_2$	9.0	8.98
Total	99.2	100.00

(1) Schellkopf, Germany; C and F average of four analyses, Ca average of two analyses, recalculated to oxides from an elemental analysis. (2) $Ca_2(CO_3)F_2$.

Occurrence: In voids and fissures in a porphryritic selbergite [formerly nosean-phonolite].

Association: Phillipsite, zeophyllite, gismondine, calcite.

Distribution: At the Schellkopf, 0.5 km west of Brenk, Eifel district, Germany.

Name: For Brenk, near the locality in Germany.

Type Material: Johannes Gutenberg University, Mainz, Germany; National Museum of Natural History, Washington, D.C., USA, 137256.

References: (1) Hentschel, G., U. Leufer, and E. Tillmanns (1978) Brenkit, ein neues Kalzium-Fluor-Karbonat vom Schellkopf/Eifel. Neues Jahrb. Mineral., Monatsh., 325–329 (in German with English abs.). (2) (1979) Amer. Mineral., 64, 241 (abs. ref. 1). (3) Leufer, U. and E. Tillmanns (1980) Die Kristallstruktur von Brenkit, $Ca_2F_2CO_3$. Tschermaks Mineral. Petrog. Mitt., 27, 261–266.

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Brewsterite $(Sr, Ba, Ca)Al_2Si_6O_{16} \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly equant or prismatic, striated and elongated along [100], to 1.5 cm. Platy, radial fibrous, and in granular aggregates. *Twinning:* Lamellar ∥ {010}.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.45 D(calc.) = [2.42]

Optical Properties: Transparent. *Color:* White, colorless, yellowish, gray, greenish; colorless in thin section. *Streak:* White. *Luster:* Vitreous to pearly on {010}. *Optical Class:* Biaxial (+). *Orientation:* $Z \perp (010)$; $X \wedge c = 19°–34°$ in various sectors of the crystal. *Dispersion:* $r > v$, weak, crossed. $\alpha = 1.510$ $\beta = 1.512$ $\gamma = 1.523$ 2V(meas.) = 65°

Cell Data: *Space Group:* $P2_1/m$. $a = 6.793(2)$ $b = 17.573(6)$ $c = 7.759(2)$ $\beta = 94.54(3)°$ Z = 2

X-ray Powder Pattern: Strontian, Scotland.
4.53 (10), 6.15 (9), 2.885 (9), 3.209 (8), 3.867 (7), 4.98 (4), 1.989 (4)

Chemistry:

	(1)	(2)
SiO_2	54.42	54.02
Al_2O_3	15.25	15.86
Fe_2O_3	0.08	0.11
CaO	1.19	0.80
SrO	8.99	11.80
BaO	6.80	3.01
Na_2O		0.21
K_2O		0.14
H_2O	13.22	13.72
Total	99.95	99.67

(1) Strontian, Scotland; corresponds to $(Sr_{0.58}Ba_{0.30}Ca_{0.14})_{\Sigma=1.02}Al_{1.98}Si_{6.00}O_{16} \cdot 4.86H_2O$.
(2) Burpala massif, Russia; corresponds to $(Sr_{0.76}Ba_{0.13}Ca_{0.10}Na_{0.04}K_{0.02}Fe_{0.01})_{\Sigma=1.06}Al_{2.06}Si_{5.94}O_{16} \cdot 4.86H_2O$.

Mineral Group: Zeolite group.

Occurrence: Hydrothermally deposited in druses lining cavities in basalts and schists; more rarely in ore deposits.

Association: Zeolites, calcite, quartz.

Distribution: From Strontian, Argyllshire, Scotland. At St. Christophe, Bourg d'Oisans, Isère, and around Barèges, Hautes-Pyrénées, France. In the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, Russia. At Yellow Lake, near Olalla, British Columbia, Canada. Other localities are reported but require confirmation.

Name: Honoring Sir David Brewster (1781–1868), Scottish mineralogist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 576–577. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 206–207. (3) Gottardi, G. and E. Galli (1985) Natural zeolites. Springer, 300–305. (4) Strunz, H. and C. Tennyson (1956) "Polymorphie" in der Gruppe der Blätterzeolithe (Heulandit-Stilbit-Epistilbit: Brewsterit). Neues Jahrb. Mineral., Monatsh., 11, 1–9 (in German). (5) Schlenker, J.L., J.J. Pluth, and J.V. Smith (1977) Refinement of the crystal structure of brewsterite, $Ba_{0.5}Sr_{1.5}Al_4Si_{12}O_{32} \cdot 10H_2O$. Acta Cryst., 33, 2907–2910. (6) Akizuki, M. (1987) Crystal symmetry and order-disorder structure of brewsterite. Amer. Mineral., 72, 645–648. (7) Nawaz, R. (1990) Brewsterite: re-investigation of morphology and elongation. Mineral. Mag., 54, 654–656.

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Brewsterite $(Sr, Ba, Ca)Al_2Si_6O_{16} \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly equant or prismatic, striated and elongated along [100], to 1.5 cm. Platy, radial fibrous, and in granular aggregates. *Twinning:* Lamellar ∥ {010}.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.45 D(calc.) = [2.42]

Optical Properties: Transparent. *Color:* White, colorless, yellowish, gray, greenish; colorless in thin section. *Streak:* White. *Luster:* Vitreous to pearly on {010}. *Optical Class:* Biaxial (+). *Orientation:* $Z \perp (010)$; $X \wedge c = 19°–34°$ in various sectors of the crystal. *Dispersion:* $r > v$, weak, crossed. $\alpha = 1.510$ $\beta = 1.512$ $\gamma = 1.523$ 2V(meas.) = 65°

Cell Data: *Space Group:* $P2_1/m$. $a = 6.793(2)$ $b = 17.573(6)$ $c = 7.759(2)$ $\beta = 94.54(3)°$ Z = 2

X-ray Powder Pattern: Strontian, Scotland.
4.53 (10), 6.15 (9), 2.885 (9), 3.209 (8), 3.867 (7), 4.98 (4), 1.989 (4)

Chemistry:

	(1)	(2)
SiO_2	54.42	54.02
Al_2O_3	15.25	15.86
Fe_2O_3	0.08	0.11
CaO	1.19	0.80
SrO	8.99	11.80
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Na_2O		0.21
K_2O		0.14
H_2O	13.22	13.72
Total	99.95	99.67

(1) Strontian, Scotland; corresponds to $(Sr_{0.58}Ba_{0.30}Ca_{0.14})_{\Sigma=1.02}Al_{1.98}Si_{6.00}O_{16} \cdot 4.86H_2O$.
(2) Burpala massif, Russia; corresponds to $(Sr_{0.76}Ba_{0.13}Ca_{0.10}Na_{0.04}K_{0.02}Fe_{0.01})_{\Sigma=1.06}Al_{2.06}Si_{5.94}O_{16} \cdot 4.86H_2O$.

Mineral Group: Zeolite group.

Occurrence: Hydrothermally deposited in druses lining cavities in basalts and schists; more rarely in ore deposits.

Association: Zeolites, calcite, quartz.

Distribution: From Strontian, Argyllshire, Scotland. At St. Christophe, Bourg d'Oisans, Isère, and around Barèges, Hautes-Pyrénées, France. In the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, Russia. At Yellow Lake, near Olalla, British Columbia, Canada. Other localities are reported but require confirmation.

Name: Honoring Sir David Brewster (1781–1868), Scottish mineralogist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 576–577. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 206–207. (3) Gottardi, G. and E. Galli (1985) Natural zeolites. Springer, 300–305. (4) Strunz, H. and C. Tennyson (1956) "Polymorphie" in der Gruppe der Blätterzeolithe (Heulandit-Stilbit-Epistilbit: Brewsterit). Neues Jahrb. Mineral., Monatsh., 11, 1–9 (in German). (5) Schlenker, J.L., J.J. Pluth, and J.V. Smith (1977) Refinement of the crystal structure of brewsterite, $Ba_{0.5}Sr_{1.5}Al_4Si_{12}O_{32} \cdot 10H_2O$. Acta Cryst., 33, 2907–2910. (6) Akizuki, M. (1987) Crystal symmetry and order-disorder structure of brewsterite. Amer. Mineral., 72, 645–648. (7) Nawaz, R. (1990) Brewsterite: re-investigation of morphology and elongation. Mineral. Mag., 54, 654–656.

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Brewsterite $(Sr, Ba, Ca)Al_2Si_6O_{16} \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly equant or prismatic, striated and elongated along [100], to 1.5 cm. Platy, radial fibrous, and in granular aggregates. *Twinning:* Lamellar ∥ {010}.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.45 D(calc.) = [2.42]

Optical Properties: Transparent. *Color:* White, colorless, yellowish, gray, greenish; colorless in thin section. *Streak:* White. *Luster:* Vitreous to pearly on {010}. *Optical Class:* Biaxial (+). *Orientation:* $Z \perp (010)$; $X \wedge c = 19°–34°$ in various sectors of the crystal. *Dispersion:* $r > v$, weak, crossed. $\alpha = 1.510$ $\beta = 1.512$ $\gamma = 1.523$ 2V(meas.) = 65°

Cell Data: *Space Group:* $P2_1/m$. $a = 6.793(2)$ $b = 17.573(6)$ $c = 7.759(2)$ $\beta = 94.54(3)°$ Z = 2

X-ray Powder Pattern: Strontian, Scotland.
4.53 (10), 6.15 (9), 2.885 (9), 3.209 (8), 3.867 (7), 4.98 (4), 1.989 (4)

Chemistry:

	(1)	(2)
SiO_2	54.42	54.02
Al_2O_3	15.25	15.86
Fe_2O_3	0.08	0.11
CaO	1.19	0.80
SrO	8.99	11.80
BaO	6.80	3.01
Na_2O		0.21
K_2O		0.14
H_2O	13.22	13.72
Total	99.95	99.67

(1) Strontian, Scotland; corresponds to $(Sr_{0.58}Ba_{0.30}Ca_{0.14})_{\Sigma=1.02}Al_{1.98}Si_{6.00}O_{16} \cdot 4.86H_2O$.
(2) Burpala massif, Russia; corresponds to $(Sr_{0.76}Ba_{0.13}Ca_{0.10}Na_{0.04}K_{0.02}Fe_{0.01})_{\Sigma=1.06}Al_{2.06}Si_{5.94}O_{16} \cdot 4.86H_2O$.

Mineral Group: Zeolite group.

Occurrence: Hydrothermally deposited in druses lining cavities in basalts and schists; more rarely in ore deposits.

Association: Zeolites, calcite, quartz.

Distribution: From Strontian, Argyllshire, Scotland. At St. Christophe, Bourg d'Oisans, Isère, and around Barèges, Hautes-Pyrénées, France. In the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, Russia. At Yellow Lake, near Olalla, British Columbia, Canada. Other localities are reported but require confirmation.

Name: Honoring Sir David Brewster (1781–1868), Scottish mineralogist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 576–577. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 206–207. (3) Gottardi, G. and E. Galli (1985) Natural zeolites. Springer, 300–305. (4) Strunz, H. and C. Tennyson (1956) "Polymorphie" in der Gruppe der Blätterzeolithe (Heulandit-Stilbit-Epistilbit: Brewsterit). Neues Jahrb. Mineral., Monatsh., 11, 1–9 (in German). (5) Schlenker, J.L., J.J. Pluth, and J.V. Smith (1977) Refinement of the crystal structure of brewsterite, $Ba_{0.5}Sr_{1.5}Al_4Si_{12}O_{32} \cdot 10H_2O$. Acta Cryst., 33, 2907–2910. (6) Akizuki, M. (1987) Crystal symmetry and order-disorder structure of brewsterite. Amer. Mineral., 72, 645–648. (7) Nawaz, R. (1990) Brewsterite: re-investigation of morphology and elongation. Mineral. Mag., 54, 654–656.

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Brezinaite Cr_3S_4

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Crystal Data: Monoclinic. *Point Group:* $2/m$ Anhedral grains, to 3 mm.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 4.12

Optical Properties: Opaque. *Color:* Brownish gray in polished section; synthetic brezinaite is dull gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I2/m$ (synthetic). $a = 5.96(1)$ $b = 3.425(5)$ $c = 11.270(15)$ $\beta = 91.54(3)°$ Z = 2

X-ray Powder Pattern: Tucson iron meteorite.
2.644 (100), 5.67 (70), 2.056 (70), 1.716 (70), 2.978 (65), 2.606 (60), 5.23 (40)

Chemistry:

	(1)	(2)
Cr	48.3	54.88
Fe	3.9	
V	1.61	
Ti	0.96	
Mn	0.86	
Ni	0.08	
S	45.0	45.12
Total	100.71	100.00

(1) Tucson iron meteorite; by electron microprobe, average of 26 grains, corresponding to $(Cr_{2.65}Fe_{0.20}V_{0.09}Ti_{0.06}Mn_{0.04})_{\Sigma=3.04}S_{4.00}$. (2) Cr_3S_4.

Occurrence: In the metal matrix and contiguous to silicate inclusions (Tucson iron meteorite).

Association: Forsterite, enstatite, aluminous diopside, anorthite, feldspathic glass, kamacite, taenite, schreibersite (Tucson iron meteorite); troilite, carlsbergite, daubréelite (New Baltimore iron meteorite).

Distribution: In the Tucson [TL], New Baltimore, and Gibeon iron meteorites.

Name: In honor of Aristides Brezina (1848–1909), past Director of the Mineralogy-Petrology Section of the Natural History Museum, Vienna, Austria.

Type Material: Meteorite Collection, National Museum of Natural History, Washington, D.C., USA.

References: (1) Bunch, T.E. and L.H. Fuchs (1969) A new mineral: brezinaite, Cr_3S_4, and the Tucson meteorite. Amer. Mineral., 54, 1509–1518. (2) Jellinek, F. (1957) The structure of the chromium sulfides. Acta Cryst., 10, 620. (3) Buchwald, V.F. (1977) The mineralogy of iron meteorites. Phil. Trans. Royal Soc. London, A. 286, 453–491.

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Brianite $Na_2CaMg(PO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As anhedral grains, to 0.2 mm. *Twinning:* Polysynthetic on {100}, showing a lamellar structure in polarized light.

Physical Properties: Hardness = 4.5 D(meas.) = 3.0–3.3 D(calc.) = [3.13]

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (–). *Orientation:* Extinction ∧ lamellae ≈2°–3°. $\alpha = 1.598(1)$ $\beta = 1.605(1)$ $\gamma = 1.608(1)$ 2V(meas.) = 63°–65° 2V(calc.) = 66°

Cell Data: *Space Group:* $P2_1/a$. $a = 13.36(5)$ $b = 5.23(2)$ $c = 9.13(3)$ $\beta = 91.2(2)°$ Z = 4

X-ray Powder Pattern: Dayton meteorite.
2.625 (10), 3.734 (9), 2.679 (9), 1.875 (9), 2.718 (8), 3.344 (7), 2.230 (7)

Chemistry:

	(1)	(2)
P_2O_5	46.9	47.27
FeO	0.5	
MgO	12.6	13.42
CaO	18.8	18.67
Na_2O	22.1	20.64
Total	100.9	100.00

(1) Dayton meteorite; by electron microprobe, average of six grains, total Fe as FeO; corresponds to $Na_{2.16}Ca_{1.01}Mg_{0.95}Fe^{2+}_{0.02}(PO_4)_2$. (2) $Na_2CaMg(PO_4)_2$.

Occurrence: A very rare component in phosphate nodules in an iron meteorite.

Association: Panethite, whitlockite, albite, enstatite, schreibersite, kamacite, taenite, graphite, sphalerite, troilite.

Distribution: In the Dayton finest (very fine-grained) octahedrite meteorite.

Name: In honor of Dr. Brian Harold Mason (1917–), U.S. National Museum, Washington, D.C., USA, for his contributions to the study of meteorites.

Type Material: National Museum of Natural History, Washington, D.C., USA, 1506.

References: (1) Fuchs, L.H., E. Olsen, and E.P. Henderson (1967) On the occurrence of brianite and panethite, two new phosphate minerals from the Dayton meteorite. Geochim. Cosmochim. Acta, 31, 1711–1719. (2) (1968) Amer. Mineral., 53, 508–509 (abs. ref. 1). (3) Moore, P.B. (1975) Brianite, $Na_2CaMg[PO_4]_2$: a phosphate analog of merwinite, $Ca_2CaMg[SiO_4]_2$. Amer. Mineral., 60, 717–718.

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Brianroulstonite $Ca_3[B_5O_6(OH)_6](OH)Cl_2 \cdot 8H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* m. As thin micaceous {010} lamellae, to 0.5 mm, in aggregates. *Twinning:* About [102] on {010}, ubiquitous but observed only by X-ray diffraction.

Physical Properties: *Cleavage:* On {010}, perfect. *Tenacity:* Flexible. Hardness = ∼5
D(meas.) = 1.97(3) D(calc.) = 1.93

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = a$; $Z = b$; $X \wedge c = 30°$. $\alpha = 1.506(2)$ $\beta = 1.527(2)$ $\gamma = 1.532(2)$ 2V(meas.) = 56(1)° 2V(calc.) = 51.4°

Cell Data: *Space Group:* Pa. $a = 17.367(4)$ $b = 8.079(2)$ $c = 8.693(2)$ $\beta = 121.56(2)°$
Z = 2

X-ray Powder Pattern: Penobsquis mine, Canada; admixed with halite.
8.10 (10), 4.04 (4), 3.56 (2), 2.834 (2), 2.535 (2), 2.276 (2), 7.06 (1)

Chemistry:

	(1)	(2)	(3)
B_2O_3	[33.92]	28.76	28.80
CaO	32.85	27.85	27.84
K_2O	0.05		
Cl	13.79	11.69	11.73
H_2O	[40.44]	34.29	34.28
$-O = Cl_2$	3.11	2.59	2.65
Total	[117.94]	[100.00]	100.00

(1) Penobsquis mine, Canada; by electron microprobe, average of four analyses, high total from severe burnup in the electron beam, B_2O_3 and H_2O by stoichiometry from crystal-structure analysis. (2) Analysis (1) recalculated to 100%. (3) $Ca_3[B_5O_6(OH)_6](OH)Cl_2 \cdot 8H_2O$.

Occurrence: Very rare in residues from halite–sylvite evaporites.

Association: Halite, hilgardite, pringleite, trembathite, sellaite, fluorite, hematite, muscovite, penobsquisite, "clay".

Distribution: From the Penobsquis evaporite deposit, near Sussex, New Brunswick, Canada.

Name: Honors Brian V. Roulston (1948–), geologist and specialist in evaporite deposits.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81500.

References: (1) Grice, J.D., R.A. Gault, and J. Van Velthuizen (1997) Brianroulstonite: a new borate mineral with a sheet structure. Can. Mineral., 35, 751–758. (2) (1998) Amer. Mineral., 83, 400 (abs. ref. 1).

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Brianyoungite $Zn_3(CO_3, SO_4)(OH)_4$

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Crystal Data: Monoclinic, pseudo-orthorhombic, or orthorhombic. *Point Group:* $2/m$, 2, or 222. Crystals are thin tapering blades elongated along [010], to 2 μm, aggregated in rosettes.

Physical Properties: *Cleavage:* On {100}, perfect; another perpendicular, probably on {001}. Hardness = n.d. D(meas.) = 3.93–4.09 D(calc.) = 4.11

Optical Properties: Semitransparent. *Color:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+) (probable). $\alpha = 1.635$ $\beta = 1.650$ γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$, $P2_1$, or $P222_1$. $a = 15.724(3)$ $b = 6.256(5)$ $c = 5.427(5)$ $\beta =\sim 90°$ Z = 4

X-ray Powder Pattern: Brownley Hill mine, England.
15.44 (100), 7.88 (100), 2.714 (40), 1.565 (30b), 5.25 (20), 2.577 (20), 2.397 (20)

Chemistry:

	(1)	(2)
SO_3	6.62	6.01
CO_2	9.90	9.91
ZnO	71.47	73.27
H_2O^+	10.70	10.81
Total	98.69	100.00

(1) Brownley Hill mine, England; ZnO by ICP/OES and XRF, SO_3 by ICP/OES, H_2O by CHN analyzer; corresponding to $Zn_{2.93}[(CO_3)_{0.75}(SO_4)_{0.28}]_{\Sigma=1.03}(OH)_{3.97}$. (2) $Zn_3(CO_3, SO_4)(OH)_4$ with CO_3:SO_4 = 3:1.

Occurrence: A rare secondary post-mine mineral in limestone-hosted oxidized Pb–Zn ores (Brownley Hill mine, England).

Association: Gypsum, smithsonite, pyrite, goethite (Brownley Hill mine, England).

Distribution: From England, at the Brownley Hill mine, near Alston, and the Smallcleugh mine, Nenthead, Cumbria. In Belgium, at Altenberg, near Aachen. In Germany, at the Alexander and Bastenberg mines, Ramsbeck, Sauerland; in the Marie mine, Wilnsdorf, Siegerland; at the Friedrichssegen mine, near Bad Ems, and in the Katzental area, near Nothweiler, Rhineland-Palatinate; from the Neue Fröhlichkeit mine, near St. Andreasberg, Harz Mountains; from the mines Gelbe Birke, near Schwartzemberg, Langenau, near Brand-Erbisdorf, Fortuna, near Breitenbrunn, and Reiche Zeiche, Freiberg, Saxony; from Wittmansgereuth, near Saalfeld, Thuringia; and elsewhere. Found at Laurium, Greece. From Broken Hill, New South Wales, Australia.

Name: Honors Brian Young (1947–), field geologist and mineralogist of the British Geological Survey, who provided the first specimens.

Type Material: Royal Museum of Scotland, Edinburgh, Scotland, 1992.17.1–8.

References: (1) Livingstone, A. and P.E. Champness (1993) Brianyoungite, a new mineral related to hydrozincite, from the north of England orefield. Mineral. Mag., 57, 665–670. (2) (1994) Amer. Mineral., 79, 1009 (abs. ref. 1).

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Briartite $Cu_2(Zn,Fe)GeS_4$

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Crystal Data: Tetragonal. *Point Group:* $4mm$ or $\overline{4}m2$. Small grains, to 2 mm, embedded, interstitial, and in networks in other sulfides. *Twinning:* Commonly shows polysynthetic twinning.

Physical Properties: Hardness = 4.5 VHN = n.d. D(meas.) = n.d. D(calc.) = 4.337

Optical Properties: Opaque. *Color:* Gray to gray-blue in reflected light.
Anisotropism: Weak in air, distinct in oil.
R: (400) 23.4, (420) 24.2, (440) 25.0, (460) 25.7, (480) 26.4, (500) 27.0, (520) 27.4, (540) 27.6, (560) 27.5, (580) 27.2, (600) 26.8, (620) 26.0, (640) 25.0, (660) 23.8, (680) 22.5, (700) 21.2

Cell Data: *Space Group:* $I4_1md$ or $I\overline{4}d2$. $a = 5.32$ $c = 10.51$ Z = 2

X-ray Powder Pattern: Kipushi, Congo.
3.06 (FF), 1.888 (m), 1.871 (m), 1.608 (m), 1.591 (m), 2.67 (f), 1.533 (f)

Chemistry:

	(1)	(2)	(3)
Cu	33.1	32.0	32.9
Fe	9.5	5.1	2.6
Zn	6.9	10.8	12.2
Ge	16.0	14.6	13.7
Ga		1.0	2.2
Sn	0.5		
S	32.4	34.8	36.1
Total	98.4	98.3	99.7

(1) Kipushi, Congo; by electron microprobe, corresponding to $Cu_{2.06}(Fe_{0.67}Zn_{0.42})_{\Sigma=1.09}(Ge_{0.87}Sn_{0.02})_{\Sigma=0.89}S_{4.00}$. (2) Do.; by electron microprobe, corresponding to $Cu_{1.86}(Zn_{0.61}Fe_{0.34})_{\Sigma=0.95}(Ge_{0.74}Ga_{0.05})_{\Sigma=0.79}S_{4.00}$. (3) Tsumeb, Namibia; by electron microprobe, corresponding to $Cu_{1.84}(Zn_{0.66}Fe_{0.16})_{\Sigma=0.82}(Ge_{0.67}Ga_{0.11})_{\Sigma=0.78}S_{4.00}$.

Mineral Group: Stannite group.

Occurrence: As rare inclusions in other Ge–Ga-bearing sulfides.

Association: Chalcopyrite, tennantite, reniérite, germanite, galena, sphalerite.

Distribution: From the Prince Leopold mine, Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire) [TL]. At Tsumeb, Namibia. From Kabwe (Broken Hill), Zambia. In the Radka deposit, Pazardzhik, Bulgaria. From the Plan d'Argut zinc deposit, central Pyrénées, Haut-Garonne, France. At Cerro de Toro, Las Alpujarrides, Granada [could be Almería??ck] Province, Spain.

Name: For Gaston Briart, geologist who studied the Kipushi deposit.

Type Material: Catholic University of Louvain, Louvain, Belgium, U309; National School of Mines, Paris, France; The Natural History Museum, London, England, 1967,271.

References: (1) Francotte, J., J. Moreau, R. Ottenburgs, and C. Lévy (1965) La briartite, $Cu_2(Fe,Zn)GeS_4$, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 88, 432–437 (in French). (2) (1966) Amer. Mineral., 51, 1816 (abs. ref. 1). (3) Wintenberger, M. (1979) Etude de la structure cristallographique et magnetique de Cu_2FeGeS_4 et remarque sur la structure magnetique de Cu_2MnSnS_4. Mat. Res. Bull., 14, 1195–1202 (in French with English abs.). (4) Mozgova, N.N., S.N. Nenasheva, Y.S. Borodaev, A.I. Tsepin, and T.A. Kalinina (1994) New data on briartite. Doklady Acad. Nauk SSSR, 335, 780–783 (in Russian).

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Brindleyite $(Ni, Mg, Fe^{2+})_2Al(SiAl)O_5(OH)_4$

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Crystal Data: Monoclinic or hexagonal. *Point Group:* n.d. Crystals platy, with poorly developed individuals, less than 1 μm; massive.

Physical Properties: Hardness = 2.5–3 D(meas.) = 3.17(1) D(calc.) = 3.16

Optical Properties: Semitransparent. *Color:* Dark yellow-green.
Optical Class: Biaxial. $n = 1.635(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. 1M and 3A assumed. $a = 5.286(5)$ $b = 9.133(3)$ $c = 7.31(1)$ $\beta = 104°9(7)'$ Z = 2, or *Space Group:* n.d. 1A assumed. $a = 5.277(1)$ b = n.d. $c = 7.09(1)$ β = n.d. Z = 2

X-ray Powder Pattern: Megara, Greece.
7.07 (100), 3.54 (80), 2.62 (18), 2.47 (18), 2.37 (18), 1.524 (17), 4.54 (10)

Chemistry:

	(1)
SiO_2	27.45
TiO_2	0.99
Al_2O_3	24.09
ΣLa_2O_3	0.35
Cr_2O_3	0.17
FeO	1.15
NiO	30.18
MgO	3.18
CaO	0.07
H_2O	[12.37]
Total	[100.00]

(1) Megara, Greece; by electron microprobe, H_2O by difference.

Polymorphism & Series: 1M plus 3A and 1A polytypes assumed.

Mineral Group: Kaolinite-serpentine group.

Occurrence: As coatings on limestone and as veinlets cutting kaolinitic clays at the base of a bauxite deposit developed on karst; also a significant component of weathered ultramafic rock (Megara, Greece).

Association: Bastnäsite, malachite, bayerite (Megara, Greece).

Distribution: In the Marmara bauxite deposit, Megara, Greece. From Victorio, Grant Co., New Mexico, USA.

Name: To honor Dr. George William Brindley (1905–1983), Professor of Mineral Science, Pennsylvania State University, University Park, Pennsylvania, USA.

Type Material: Department of Mineralogy, University of Belgrade, Belgrade, Yugoslavia; National Museum of Natural History, Washington, D.C., USA, 136982.

References: (1) Maksimovic, Z. and D.L. Bish (1978) Brindleyite, a nickel-rich aluminous serpentine mineral analogous to berthierine. Amer. Mineral., 63, 484–489.

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Britholite-(Ce) $(Ce,Ca)_5(SiO_4,PO_4)_3(OH,F)$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals are hexagonal prisms, to 1 cm; granular, massive.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5 D(meas.) = 4.20–4.69 D(calc.) = 4.65

Optical Properties: Opaque, transparent only in thin flakes. *Color:* Brown, yellow-brown, blue. *Luster:* Adamantine.
Optical Class: Uniaxial (–) or biaxial (–). *Pleochroism:* May be O = brown; E = colorless.
n = 1.77–1.81 2V(meas.) = 44°

Cell Data: *Space Group:* $P6_3/m$. a = 9.61(2) c = 7.03(2) Z = 2

X-ray Powder Pattern: Oka, Canada.
2.836 (vs), 3.480 (s), 2.809 (s), 1.858 (s), 4.116 (m), 3.927 (m), 3.211 (m)

Chemistry:	(1)	(2)	(3)
SiO_2	16.77	12.28	20.89
TiO_2		0.09	
ThO_2		5.62	20.73
UO_2			1.47
Al_2O_3		0.47	0.00
$(Ce,La)_2O_3$	60.54	33.43	
La_2O_3			7.35
Ce_2O_3			18.61
Pr_2O_3			1.64
Nd_2O_3			5.1
Fe_2O_3	0.43	0.14	
MgO	0.13	0.20	
CaO	11.28	28.84	19.92
Na_2O	1.85	0.21	
F	1.33	2.10	
H_2O^+	1.27	0.54	
P_2O_5	6.48	16.96	4.3
$-O = F_2$		0.90	
Total	100.08	99.98	100.01

(1) Naujakasik, Greenland. (2) Oka, Canada. (3) Monte Somma, Italy; by electron microprobe, average of ten analyses; corresponds to $(Ca_{2.77}Ce_{0.88}Th_{0.62}La_{0.35}Nd_{0.24}Pr_{0.08}U_{0.04})_{\Sigma=4.98}(Si_{2.71}P_{0.47})_{\Sigma=3.18}O_{12}(OH)$.

Occurrence: In nepheline syenites, pegmatites, and contact deposits related to them.

Association: Zircon, pyrochlore, titanite, fluorite, diopside, andradite, allanite, vesuvianite.

Distribution: At Naujakasik, in the Ilímaussaq intrusion, southern Greenland. From about three km east of Jamestown, Boulder Co., Colorado, USA. At Oka and Mont Saint-Hilaire, Quebec, Canada. From the Pibnesburg complex, Rustenburg, Transvaal, South Africa. In the San Vito quarry, Monte Somma, Campania, Italy. At Tvedalen, Norway. From Tungpei, not otherwise located in China. In the Ishim complex, northern Kazakhstan. From the Khibiny massif, Kola Peninsula; the Kyshtym district, Ural Mountains; and other less-well-defined localities in Russia.

Name: From the Greek for *weight*, in allusion to its density, and its content of *cerium*.

Type Material: University of Copenhagen, Copenhagen, Denmark; The Natural History Museum, London, England, 85379.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 19–20. (2) Gay, P. (1957) An investigation of some rare-earth silicates: cerite, lessingite, beckelite, britholite and stillwellite. Mineral. Mag., 31, 455–468. (3) Hughson, M.R. and J.G. Sen (1964) A thorian intermediate member of the britholite–apatite series. Amer. Mineral., 49, 937–951. (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 297–300. (5) Deyu Li, Peiling Wang, and Jiancheng Li (1981) The crystal structure of lessingite [britholite-(Ce)], rich in light rare earth of cerium. Guisuanyan Xuebao, 9(4), 422–432. (6) (1982) Chem. Abs., 226893 (abs. ref. 5). (7) Orlandi, P., N. Perchiazzi, and G. Mannucci (1989) First occurrence of britholite-(Ce) in Italy (Monte Somma, Vesuvius). Eur. J. Mineral., 1, 723–725.

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Britholite-(Y) $(Y,Ca)_5(SiO_4,PO_4)_3(OH,F)$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As short prismatic hexagonal crystals, to 1.3 cm; more commonly massive.

Physical Properties: *Cleavage:* Imperfect on {0001}, $\{10\bar{1}0\}$. *Fracture:* Uneven to splintery. Hardness = 6 D(meas.) = 4.35 D(calc.) = [4.44]

Optical Properties: Translucent to transparent. *Color:* Dark reddish brown; in thin section, yellowish brown. *Streak:* Faint brown. *Luster:* Resinous to dull.
Optical Class: Uniaxial (+). $\omega = 1.728$–1.750 $\epsilon = 1.730$–1.752

Cell Data: *Space Group:* $P6_3/m$. $a = 9.43$ $c = 6.81$ $Z = 2$

X-ray Powder Pattern: Suishoyama pegmatite, Japan.
2.813 (100), 2.753 (90), 2.727 (80), 3.13 (50), 3.09 (50), 3.39 (30), 1.885 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	22.70	21.80	MgO	0.10	0.07
TiO_2		0.04	PbO		0.13
UO_2		0.23	CaO	9.58	13.31
ThO_2	0.51	1.55	Na_2O		0.20
Al_2O_3	0.75	0.72	K_2O		0.06
Y_2O_3	46.91	37.47	F	0.50	1.48
ΣCe_2O_3	4.47	6.02	H_2O^+	0.68	
ΣLa_2O_3	5.76	10.92	H_2O^-	0.15	
Fe_2O_3	1.44	0.69	H_2O		1.35
Nb_2O_5		0.06	CO_2	0.10	
FeO	0.79	0.50	P_2O_5	1.73	2.98
MnO	3.67	0.66	$-O = F_2$	0.21	0.62
			Total	[99.63]	99.62

(1) Suishoyama pegmatite, Japan; original total given as 99.58%. (2) "European Russia."

Occurrence: In pegmatites.

Association: Yttrialite, thorogummite, tengerite, allanite.

Distribution: In the Suishoyama pegmatite, near Iisaka, Fukushima Prefecture, and from Shinden, Gifu Prefecture, Japan. From an undefined locality given only as "European Russia."

Name: For its chemical relation to *britholite-(Ce)* and dominant *yttrium* in its composition.

Type Material: n.d.

References: (1) Hata, S. (1938) Abukumalite [britholite-(Y)], a new mineral from pegmatites of Iisaka, Fukushima prefecture. Sci. Pap. Inst. Phys. Chem. Res., Tokyo, 34, 1018–1023.
(2) Omori, K. and S. Hasegawa (1953) Yttrialite and abukumalite [britholite-(Y)] from pegmatite of Suishoyama, Iisaka village, Fukushima, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 37, 21–29. (3) Ito, J. (1968) Silicate apatites and oxyapatites. Amer. Mineral., 53, 890–907.
(4) (1970) Introduction to Japanese minerals. Geol. Sur. of Japan, 62–63.

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Brizziite $NaSbO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Platy hexagonal crystals, to 0.2 mm, flattened on {0001}, in dense aggregates and incrustations. *Twinning:* On {0001}, polysynthetic, common.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Flexible. Hardness = n.d. VHN = 41–70, 57 average (15 g load). D(meas.) = 4.8(2) D(calc.) = 4.95

Optical Properties: Transparent. *Color:* Colorless, light pink or yellow in aggregates. *Streak:* White. *Luster:* Pearly.
Optical Class: Uniaxial (–). $\omega = [1.84]$ $\epsilon = 1.631$

Cell Data: *Space Group:* $R\overline{3}$. $a = 5.301(1)$ $c = 15.932(4)$ Z = 6

X-ray Powder Pattern: Cetine mine, Italy.
1.874 (100), 2.365 (69), 1.471 (69), 2.650 (67), 5.30 (53), 3.00 (50), 1.185 (47)

Chemistry:

	(1)	(2)
Sb_2O_5	83.28	83.92
Na_2O	15.98	16.08
Total	99.26	100.00

(1) Cetine mine, Italy; by electron microprobe, average of 40 analyses on three grains.
(2) $NaSbO_3$.

Occurrence: A weathering product of stibnite in an antimony deposit in highly silicified limestone.

Association: Stibiconite, mopungite, cetineite, sénarmontite.

Distribution: In the Cetine mine, 20 km southwest of Siena, Tuscany, Italy.

Name: Honors Dr. Giancarlo Brizzi (1936–1992), mineral collector who discovered the first specimens.

Type Material: University of Florence, Florence, Italy, 2037/RI.

References: (1) Olmi, F. and C. Sabelli (1994) Brizziite, $NaSbO_3$, a new mineral from the Cetine mine (Tuscany, Italy): description and crystal structure. Eur. J. Mineral., 6, 667–672.
(2) (1995) Amer. Mineral., 80, 630 (abs. ref. 1).

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Brochantite $Cu_4(SO_4)(OH)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are typically thick prismatic to acicular, elongated along [001] or [010], to 5 cm; may be flattened [001]; about 40 forms known; in aggregates, druses, crusts, also massive, granular. *Twinning:* On {100}, common, giving a pseudo-orthorhombic appearance.

Physical Properties: *Cleavage:* On {100}, perfect. *Fracture:* Uneven to conchoidal. Hardness = 3.5–4 D(meas.) = 3.97 D(calc.) = 4.09

Optical Properties: Transparent to translucent. *Color:* Emerald-green, blackish green, pale green; bluish green in transmitted light. *Streak:* Pale green. *Luster:* Vitreous, somewhat pearly on cleavages.
Optical Class: Biaxial (–). *Pleochroism:* Slight; in bluish greens. *Orientation:* $Y = b$; $X \simeq a$; $Z \simeq c$. *Dispersion:* $r < v$, medium. $\alpha = 1.728$ $\beta = 1.771$ $\gamma = 1.800$ 2V(meas.) = 77(2)°

Cell Data: *Space Group:* $P2_1/a$. $a = 13.08$ $b = 9.85$ $c = 6.02$ $\beta = 103°22'$ Z = 4

X-ray Powder Pattern: Locality not stated. (ICDD 13-398).
2.521 (100), 3.90 (85), 2.678 (50), 6.38 (40), 5.36 (40), 3.19 (40), 2.923 (20)

Chemistry:

	(1)	(2)
SO_3	17.54	17.70
CuO	70.29	70.35
H_2O	11.96	11.95
Total	99.79	100.00

(1) Collahuasi, Chile; average of two analyses. (2) $Cu_4(SO_4)(OH)_6$.

Occurrence: Common in the oxidized zone of copper deposits, yet rarely an ore; formed under low acidity, principally in arid regions.

Association: Malachite, azurite, tenorite, cuprite, linarite, caledonite, cerussite, atacamite, chrysocolla, cyanotrichite, iron oxides.

Distribution: In Russia, from the Mednorudyanskoye copper deposit, near Nizhni Tagil, and at Gumeshevsk, southwest of Yekaterinburg (Sverdlovsk), Ural Mountains. At Băiţa (Rézbánya), Romania. From Rosas and Sa Duchessa, Sardinia, Italy. In Germany, at the Clara mine, near Oberwolfach, Black Forest. In England, numerous occurrences in Cornwall, and at Roughton Gill, Cumbria. From Tsumeb, Namibia. At Aïn-Barbar, Constantine, Algeria. In Australia, at Broken Hill, New South Wales. From many occurrences in Chile, as at Chuquicamata and Collahuasi, Antofagasta; from Potrerillos, Atacama; and at Challacollo, Tarapacá. In the USA, in Arizona, large crystals from Bisbee, Cochise Co., and at the Mammoth-St. Anthony mine, Tiger, Pinal Co.; in the Mammoth mine, Tintic, Juab Co., Utah; at Bingham, Socorro Co., New Mexico; from the Cerro Gordo mine, Inyo Co., California; in the Douglas Hill and Mason Pass mines, Yerington district, Lyon Co., Nevada. Many other localities are known.

Name: Honors Professor André Jean François Marie Brochant de Villiers (1772–1840), French geologist and mineralogist, School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 541–544. (2) Cocco, G. and F. Mazzi (1959) La struttura della brochantite. Period. Mineral. 28(2–3), 9–149 (in Italian with English abs.). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 46.

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Brockite $(Ca, Th, Ce)(PO_4)\cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 622 (?). Rarely as stubby hexagonal prisms, to 50 μm; commonly granular radial, in very fine-grained massive aggregates, cryptocrystalline earthy.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = 3.9(2) D(calc.) = [3.81] Radioactive.

Optical Properties: Translucent to opaque. *Color:* Pale yellow on thin edges; red-brown in reflected light, principally from included hematite. *Luster:* Greasy to vitreous. *Optical Class:* Uniaxial (+). *Orientation:* Parallel extinction, positive elongation. $\omega = 1.680(2)$ $\epsilon = 1.695(2)$

Cell Data: *Space Group:* $P6_222$ (?). $a = 6.96(3)$ $c = 6.40(3)$ $Z = 3$

X-ray Powder Pattern: Wet Mountains, Colorado, USA; cannot be distinguished from other members of the rhabdophane group.
3.03 (vsb), 4.37 (s), 2.83 (s), 2.15 (s), 3.47 (m), 1.86 (m), 6.06 (mw)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	24.7	34.6	RE_2O_3	6.9	23.8
CO_2	3.2		CaO	10.2	10.6
UO_2		3.1	SrO	1.4	
ThO_2	44.7	23.9	BaO	1.1	
ZrO_2		4.0	H_2O	7.8	
			Total	[100.0]	100.0

(1) Wet Mountains, Colorado, USA; $RE_2O_3 = Y_2O_3$ 1.27%, CeO_2 1.23%, La_2O_3 0.49%, Pr_6O_{11} 0.06%, Nd_2O_3 1.52%, Sm_2O_3 0.72%, Eu_2O_3 0.30%, Gd_2O_3 0.99%, Tb_4O_7 0.35%, Dy_2O_3 0.64%, Ho_2O_3 0.16%, Er_2O_3 0.19%, Tm_2O_3 0.01%, Yb_2O_3 0.02%, Lu_2O_3 0.01% [= 7.9%]; H_2O and CO_2 by CHN analyzer, recalculated to 100% from an original total of 102.2% after deduction of hematite 4.6% and insoluble 2.0%; corresponds to $(Ca_{0.43}Th_{0.41}RE_{0.11}Sr_{0.03}Ba_{0.02})_{\Sigma=1.00}$ $[(PO_4)_{0.83}(CO_3)_{0.17}]_{\Sigma=1.00}\cdot 0.87H_2O$. (2) Ishikawa, Japan; $RE_2O_3 = Y_2O_3$ 7.5%, La_2O_3 3.8%, Ce_2O_3 7.5%, Nd_2O_3 5.0%; corresponds to $(Ca_{0.39}Th_{0.19}Y_{0.14}Ce_{0.09}Zr_{0.07}Nd_{0.06}La_{0.05})_{\Sigma=0.99}$ $PO_4\cdot H_2O$.

Mineral Group: Rhabdophane group.

Occurrence: A rare accessory mineral in granite and granite pegmatites.

Association: Monazite, bastnäsite, xenotime, thorite, zircon, apatite, rutile, hematite.

Distribution: In the USA, in a prospect pit about 1 km east of the Bassick mine, Querida, Wet Mountains, and at the Hardwick mine and Nightingale shaft, Custer Co., Colorado; in the Bear Lodge Mountains, Crook Co., Wyoming; from the Diamond Creek district, Lemhi Co., Idaho and the Lemhi Pass district, Idaho-Montana; found in Monroe Canyon, Sevier Co., Utah; from the Laughlin Peak area, Colfax Co., New Mexico; in the Rawhide Mountains, Mohave Co., Arizona. At Mont Saint-Hilaire, Quebec, Canada. From Kizilcaoren, Turkey. In Japan, from Atagoyama, Shionhira, Shin-yashikiike, and Ishizuka, Ishikawa district, Fukushima Prefecture, Japan. A few other minor localities are known.

Name: To honor Maurice R. Brock, U.S. Geological Survey, who supplied the first specimen.

Type Material: National Museum of Natural History, Washington, D.C., USA, 121952.

References: (1) Fisher, F.G. and R. Meyrowitz (1962) Brockite, a new calcium thorium phosphate from the Wet Mountains, Colorado. Amer. Mineral., 47, 1346–1355. (2) Staatz, M.H. (1985) Geology and description of the thorium and rare-earth veins in the Laughlin Peak area, Colfax County, New Mexico. U.S. Geol. Survey Prof. Paper 1049-E, 32 pp. (3) Shogi, H. and J. Akai (1994) Brockite from Ishikawa, Fukushima Prefecture, Japan. Science Reports, Niigata University, Series E (Geology and Mineralogy), 9, 89–96.

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Brodtkorbite Cu_2HgSe_2

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As individual anhedral grains, to 100 μm, and in aggregates.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = [2.5–3] VHN = 91–131, average 118 (10 g load). D(meas.) = n.d. D(calc.) = 7.77

Optical Properties: Opaque. *Color:* Dark gray. *Streak:* Dark gray. *Luster:* Metallic. *Optical Class:* Biaxial *Pleochroism:* Weak to moderate; pale pink to pale blue. *Anisotropism:* Weak to strong; mauve-gray to yellowish gray. *Bireflectance:* Weak to strong. R_1–R_2: (400) 30.7–38.1, (420) 30.6–38.2, (440) 30.4–37.9, (460) 29.9–37.3, (480) 29.3–36.6, (500) 28.6–36.0, (520) 28.0–35.6, (540) 27.5–35.2, (560) 27.1–35.0, (580) 26.8–34.8, (600) 26.4–34.5, (620) 26.2–34.3, (640) 26.1–34.2, (660) 26.1–33.9, (680) 26.3–33.6, (700) 26.4–33.3

Cell Data: *Space Group:* $P2_1/n$. $a = 7.492(5)$ $b = 4.177(1)$ $c = 7.239(4)$ $\beta = 114.20(5)^\circ$ $Z = 2$

X-ray Powder Pattern: Tuminico, Argentina.
2,730 (100), 3.991 (70), 2.223 (70), 3.576 (50), 3.534 (50), 3.414 (50), 2.072 (50)

Chemistry:

	(1)	(2)
Cu	26.2	26.17
Hg	40.7	41.31
Se	32.9	32.52
Total	99.8	100.00

(1) Tuminico, Argentina; by electron microprobe, average of seven analyses; corresponds to $Cu_{2.00}Hg_{0.98}Se_{2.02}$. (2) Cu_2HgSe_2.

Occurrence: Uncommon in a telethermal selenium-rich hydrothermal polymetallic deposit, in calcite veins in amphibolites, formed below 112 °C.

Association: Berzelianite, tiemannite, umangite, clausthalite, eucairite, naumannite, hematite, calcite.

Distribution: From Tuminico, Sierra de Cacho, La Rioja Province, Argentina [TL].

Name: To honor Dr. Milka Kronegold de Brodtkorb (1932–), Professor at the Universities of Buenos Aires and La Plata, Argentina, for her contributions to mineralogy and economic geology.

Type Material: Institute of Mineralogy, University of Salzburg, Austria, 14600–14602; The Natural History Museum, London, England, 1998,173.

References: (1) Paar, W.H., D. Topa, A.C. Roberts, A.J. Criddle, G. Amann, and R.J. Sureda (2002) The new mineral species brodtkorbite, Cu_2HgSe_2, and the associated selenide assemblage from Tuminico, Sierra de Cacho, La Rioja, Argentina. Can. Mineral., 40, 225–237. (2) (2002) Amer. Mineral., 87, 1731 (abs. ref. 1).

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Bromargyrite AgBr

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals cubic, with {111} and {011}, to 1 cm; in parallel or subparallel groups; commonly as crusts and coatings, massive. *Twinning:* {111}, rare.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Sectile, ductile, very plastic. Hardness = 2.5 D(meas.) = 6.474 D(calc.) = 6.477 May give off a strong "medicinal" odor when exposed to air.

Optical Properties: Transparent to translucent. *Color:* Pale yellow, greenish brown, bright green. *Streak:* White to yellowish white. *Luster:* Resinous to adamantine, waxy. *Optical Class:* Isotropic. $n = 2.253$

Cell Data: *Space Group:* $Fm3m$. $a = 5.7745$ (synthetic). Z = 4

X-ray Powder Pattern: Synthetic.
2.886 (100), 2.041 (55), 1.667 (16), 1.291 (14), 1.1787 (10), 3.33 (8), 1.444 (8)

Chemistry:

	(1)	(2)
Ag	57.56	65.16
Cl		10.71
Br	42.44	24.13
Total	100.00	100.00

(1) Rancho de San Onofre, Charcas, Mexico. (2) Ag(Br, Cl) with Br:Cl = 1:1.

Polymorphism & Series: Dimorphous with chlorargyrite.

Occurrence: A rare secondary mineral in the oxidation zones of silver deposits, notably in arid regions.

Association: Silver, iodargyrite, smithsonite, Fe–Mn oxides.

Distribution: While a rare mineral, nevertheless known from a number of localities. From Huelgoet, Finistère, France. At the Schöne Aussicht mine, near Dernbach, and at Bad Ems, Rhineland-Palatinate, Germany. In the USA, at Bisbee, Tombstone, and the Commonwealth mine, Pearce, Cochise Co., Arizona; from the Silver City district, Grant Co., and elsewhere in New Mexico; at Silver Cliff, Custer Co., and on Horse Mountain, 13 km south of Eagle, Eagle Co., Colorado. From Charcas, San Luis Potosi; Plateros, Zacatecas; and many other localities in Mexico. At Chañarcillo, south of Copiapó, Atacama, Chile. From Broken Hill, New South Wales, Australia.

Name: For BROMine and the Greek for silver, *argyros*, in its composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 11–15 [bromyrite]. (2) Barclay, C.J. and J.B. Jones (1971) The Broken Hill silver halides. J. Geol. Soc. Australia, 18, 149–157. (3) (1955) NBS Circ. 539, 4, 46–47.

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Bromellite BeO

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Crystal Data: Hexagonal. *Point Group:* 6*mm*. As prismatic crystals, elongated along [0001], to 1 mm, showing pyramidal hemimorphism, with $\{000\overline{1}\}$ and $\{10\overline{1}0\}$ well developed, $\{10\overline{1}1\}$ small; may be tabular ∥ {0001}; in randomly intergrown rosettelike aggregates; cleavage fragments, to 10 cm.

Physical Properties: *Cleavage:* $\{10\overline{1}0\}$, distinct. Hardness = ∼9 D(meas.) = 3.017 D(calc.) = 3.044 Pyroelectric; fluoresces yellowish white in both LW and SW UV.

Optical Properties: Transparent. *Color:* White to creamy white. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.705–1.719$ $\epsilon = 1.733$

Cell Data: *Space Group:* $P6_3mc$ (synthetic). $a = 2.6983(4)$ $c = 4.3776(4)$ Z = 2

X-ray Powder Pattern: Synthetic.
2.061 (100), 2.337 (91), 2.189 (61), 1.349 (29), 1.238 (24), 1.598 (22), 1.1482 (16)

Chemistry:

	(1)	(2)
SiO_2		0.7
Al_2O_3	0.17	1.2
B_2O_3		1.4
Fe_2O_3		0.1
Sb_2O_3	0.29	
MnO	trace	
BeO	98.02	93.2
MgO	0.07	
CaO	1.03	0.1
BaO	0.55	
LOI	0.85	3.4
Total	100.98	100.1

(1) Långban, Sweden. (2) Langesundsfjord, Norway; by AA and D-C arc spectroscopy.

Occurrence: In hydrothermal calcite veins and veinlets in hematite skarn and skarnized limestones (Långban, Sweden); in vugs in natrolite, hydrothermally altered from nepheline, in syenite pegmatite (Langesundsfjord, Norway).

Association: Swedenborgite, richterite, manganophyllite (Långban, Sweden); natrolite, diaspore, chamosite (Langesundsfjord, Norway).

Distribution: From Långban, Värmland, Sweden. In the Saga larvikite quarry, Tvedalen, near Larvik, Norway. From the Izumrudnye district, Yekaterinburg (Sverdlovsk), Ural Mountains, the Pitkäranta district, Lake Ladoga, Karelia, and other less-well-defined localities in Russia.

Name: For Magnus von Bromell (1679–1731), Swedish physician and mineralogist.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 506–507. (2) Hazen, R.M. and L.W. Finger (1986) High-pressure and high-temperature crystal chemistry of beryllium oxide. J. Appl. Phys., 59, 3728–3733. (3) Larsen, A.O., A. Åsheim, and S.A. Berge (1987) Bromellite from syenite pegmatite, southern Oslo region, Norway. Can. Mineral., 25, 425–428. (4) (1953) NBS Circ. 539, 1, 36.

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Brontesite $(NH_4)_3PbCl_5$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. Crystals tabular on {010}, to 0.1 mm; pseudotetragonal, exhibiting forms {110}, {011}, {121}.

Physical Properties: *Cleavage*: None observed. *Fracture*: None observed.
Tenacity: n.d. Hardness = n.d. D(meas.) = 2.72(1) D(calc.) = 2.728

Optical Properties: Translucent. *Color*: Colorless to white. *Streak*: White.
Luster: Vitreous.
Optical Class: Biaxial. n = 1.70(3) *Orientation:* n.d.

Cell Data: *Space Group*: *Pnma*. *a* = 8.434(1) *b* = 15.759(2) *c* = 8.462(1) Z = 4

X-ray Powder Pattern: La Fossa crater, Vulcano, Aeolian Islands, Italy.
3.067 (100), 2.020 (80), 2.710 (78), 1.910 (78), 2.421 (75), 1.491 (75), 1.457 (65)

Chemistry:

	(1)	(2)
K	1.1	
Pb	47.8	47.25
Cl	36.1	40.43
Br	3.7	
NH_4	11.3	12.32
Total	100.0	100.00

(1) La Fossa crater, Vulcano, Sicily, Italy; average of 6 EDS analyses, NH_4 by difference after confirmation by IR and microchemical tests, corresponding to $[(NH_4)_{2.87}K_{0.13}]_{\Sigma=3.00}Pb_{1.09}(Cl_{4.79}Br_{0.21})_{\Sigma=5.00}$. (2) $(NH_4)_3PbCl_5$.

Occurrence: A product of fumarolic activity.

Association: Bismuthinite, godovikovite, demicheleite-(Cl), demicheleite-(Br), alunite.

Distribution: La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy.

Name: For Brontes, one of the Cyclopes and a son of Uranus, helpers of the Greek god of fire whose workshops were alleged to be located at Vulcano.

Type Material: Department of Structural Chemistry and Inorganic Stereochemistry, University of Milan, Italy (reference collection 2008-03).

References: (1) Demartin, F., C.M. Gramaccioli, and I. Campostrini (2009) Brontesite, $(NH_4)_3PbCl_5$, a new product of fumarolic activity from La Fossa crater, Vulcano, Aeolian Islands, Italy, Can. Mineral., 47, 1237–1243. (2) (2010) Amer. Mineral., 95, 1122 (abs. ref. 1).

Brookite TiO_2

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 12 cm, typically tabular on {010} and elongated and striated ‖ [001]; rarely tabular on {001}; commonly pyramidal {111} or pseudohexagonal with {120} and {111}. *Twinning:* On {120}, uncertain.

Physical Properties: *Cleavage:* {120}, indistinct; {001}, in traces. *Fracture:* Subconchoidal to irregular. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 4.08–4.18 D(calc.) = 4.133

Optical Properties: Opaque to translucent, transparent in thin fragments. *Color:* Brown, yellowish brown, reddish brown; dark brown to iron-black; yellowish brown to dark brown in transmitted light. *Streak:* White to grayish white or yellowish white. *Luster:* Metallic adamantine to submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Very weak; yellowish, reddish, orange to brown.
Orientation: $Z = b$. *Dispersion:* $r > v$, very strong, with crossed axial dispersion.
Absorption: $Z > Y > X$. $\alpha = 2.5831$ $\beta = 2.5843$ $\gamma = 2.7004$ 2V(meas.) = 0°–28°, variable with wavelength.

Cell Data: *Space Group: Pcab.* $a = 5.4558$ $b = 9.1819$ $c = 5.1429$ Z = 8

X-ray Powder Pattern: Magnet Cove, Arkansas, USA.
3.51 (100), 2.900 (90), 3.47 (80), 1.893 (30), 1.662 (30), 2.476 (25), 1.691 (20)

Chemistry:

	(1)	(2)
TiO_2	98.59	98.77
Fe_2O_3	1.41	1.48
Total	100.00	100.25

(1) Snowdon, Wales; corresponds to $(Ti_{0.99}Fe_{0.01})_{\Sigma=1.00}O_2$. (2) Magnet Cove, Arkansas, USA; corresponds to $(Ti_{0.99}Fe_{0.01})_{\Sigma=1.00}O_2$.

Polymorphism & Series: Trimorphous with anatase and rutile.

Occurrence: An accessory mineral in alpine veins in gneiss and schist; in contact metamorphic zones and hydrothermal veinlets; a common detrital mineral.

Association: Anatase, rutile, titanite, orthoclase, quartz, hematite, calcite, chlorite, muscovite.

Distribution: A widespread mineral, but only a few localities afford fine crystals. At Fron Oleu, near Tremadog, Gwynned, Wales. From Bourg d'Oisans, Isère, France. In Switzerland, in the Maderanthal and Griessertal, Uri, at Salvan, Valais, and elsewhere. In Austria, found near Prägraten and Virgen, Tirol. From Hardangervidda, Norway. In Russia, at Atliansk, near Miass, Ilmen Mountains, Southern Ural Mountains, and large crystals in the Dodo mine, about 100 km west-northwest of Saranpaul, Subpolar Ural Mountains. In Italy, at Monte Bregaceto, near Genoa, Liguria. In Brazil, in the diamond placers of Bahia and Diamantina, Minas Gerais. In the USA, at Magnet Cove, Hot Spring Co., Arkansas; Ellensville, Ulster Co., New York; and near Powderhorn, Gunnison Co., Colorado.

Name: For Henry James Brooke (1771–1857), English crystallographer and mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 588–593. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 44–47. (3) Meagher, E.P. and G.A. Lager (1979) Polyhedral thermal expansion in the TiO_2 polymorphs: refinement of the crystal structures of rutile and brookite at high temperature. Can. Mineral., 17, 77–85.

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Brownmillerite $Ca_2(Al, Fe^{3+})_2O_5$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As square platelets, to about 60 μm; massive.

Physical Properties: Hardness = n.d. D(meas.) = 3.76 D(calc.) = 3.68–3.73

Optical Properties: Semitransparent. *Color:* Reddish brown.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; $X = Y$ = yellow-brown; Z = dark brown.
Orientation: Y and Z lie in the plane of the platelets; extinction in that plane is diagonal.
$\alpha = < 2.02$ $\beta = > 2.02$ $\gamma = > 2.02$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Ibm2$. $a = 5.584(5)$ $b = 14.60(1)$ $c = 5.374(5)$ Z = 2

X-ray Powder Pattern: Near Mayen, Germany.
2.65 (vs), 7.19 (s), 2.78 (s), 1.93 (s), 2.05 (ms), 3.65 (m), 1.82 (m)

Chemistry:

	(1)	(2)	(3)
TiO_2		1.5	1.9
Al_2O_3	17.2	22.3	13.1
Fe_2O_3	30.5	27.6	41.9
Cr_2O_3		0.1	n.d.
MgO		n.d.	n.d.
CaO	46.2	44.8	43.7
insol.		4.0	
LOI	0.5		
Total	94.4	100.3	100.6

(1) Near Mayen, Germany; by semiquantitative spectroscopy. (2) Hatrurim Formation, Israel; corresponds to $Ca_{1.99}(Al_{1.09}Fe_{0.86}Ti_{0.05})_{\Sigma=2.00}O_5$. (3) Do.; corresponds to $Ca_{1.95}(Fe_{1.31}Al_{0.64}Ti_{0.06})_{\Sigma=2.01}O_5$.

Occurrence: In thermally metamorphosed limestone blocks included in volcanic rocks (near Mayen, Germany); in high-temperature, thermally metamorphosed, impure limestones (Hatrurim Formation, Israel).

Association: Calcite, ettringite, wollastonite, larnite, mayenite, gehlenite, diopside, pyrrhotite, grossular, spinel, afwillite, jennite, portlandite, jasmundite (near Mayen, Germany); melilite, mayenite, wollastonite, kalsilite, corundum (Klöch, Austria); spurrite, larnite, mayenite (Hatrurim Formation, Israel).

Distribution: From the Ettringer-Bellerberg volcano, near Mayen, Eifel district, Germany. Found at Klöch, Styria, Austria. In the Hatrurim Formation, Israel.

Name: The artificial compound was named for Dr. Lorrin Thomas Brownmiller (1902–), Chief Chemist of the Alpha Portland Cement Company, Easton, Pennsylvania, USA, in 1932, the name then transferred to the naturally-occurring mineral.

Type Material: Mineral Museum, University of Cologne, Cologne, Germany, M5026/86; National Museum of Natural History, Washington, D.C., USA, 120045.

References: (1) Hentschel, G. (1964) Mayenit, $12CaO \bullet 7Al_2O_3$, und Brownmillerit, $2CaO \bullet (Al, Fe)_2O_3$, zwei neue Minerale in den Kalksteineinschlüssen der Lava des Ettringer Bellerberges. Neues Jahrb. Mineral., Monatsh., 22–29 (in German with English abs.). (2) (1965) Amer. Mineral., 50, 2106 (abs. ref. 1). (3) Colville, A.A. and S. Geller (1971) The crystal structure of brownmillerite, Ca_2FeAlO_5. Acta Cryst., 27, 2311–2315. (4) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 11–13.

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Brucite $Mg(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\,2/m$. Crystals tabular {0001}, to 19 cm, in platy or foliated masses and rosettes; also fibrous, to 50 cm; granular, massive.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Sectile; separable plates are flexible, fibers are elastic. Hardness = 2.5 D(meas.) = 2.39 D(calc.) = 2.368 Pyroelectric.

Optical Properties: Transparent. *Color:* White, pale green, blue, gray; honey-yellow to brownish red and deep brown in manganoan varieties; colorless in transmitted light.
Streak: White. *Luster:* Waxy, pearly on cleavage surfaces.
Optical Class: Uniaxial (+); anomalously biaxial. ω = 1.56–1.59 ϵ = 1.58–1.60
2V(meas.) = Small.

Cell Data: *Space Group:* $P\bar{3}m1$. . $a = 3.142(1)$ $c = 4.766(2)$
Z = 1

X-ray Powder Pattern: Synthetic.
2.365 (100), 4.77 (90), 1.794 (55), 1.573 (35), 1.494 (18), 1.373 (16), 1.310 (12)

Chemistry:

	(1)	(2)	(3)
Fe_2O_3	0.10	1.95	
FeO		9.57	
MnO	0.84		
MgO	68.29	60.33	69.11
H_2O	30.74	28.60	30.89
Total	99.97	100.45	100.00

(1) Wood's Chrome mine, Pennsylvania, USA; corresponds to $(Mg_{0.99}Fe_{0.01})_{\Sigma=1.00}(OH)_2$.
(2) Asbestos, Canada; after deduction of Fe_2O_3 impurity, corresponds to $(Mg_{0.93}Fe^{2+}_{0.08})_{\Sigma=1.01}(OH)_2$. (3) $Mg(OH)_2$.

Mineral Group: Brucite group.

Occurrence: A common alteration of periclase in marble; a low-temperature hydrothermal vein mineral in metamorphic limestones and chlorite schists; formed during serpentinization of dunites.

Association: Calcite, aragonite, dolomite, magnesite, hydromagnesite, artinite, talc, chrysotile.

Distribution: Many localities, but rarely in crystalline masses. In the USA, at Hoboken, Hudson Co., New Jersey; large crystals from Wood's Chrome mine, near Texas, Lancaster Co., Pennsylvania; at the Tilly Foster mine, Brewster, Putnam Co., New York; a large deposit near Gabbs, Gabbs district, Nye Co., Nevada; at the Crestmore quarry, Riverside Co., California. In Canada, at Asbestos and Wakefield, Quebec. From Mt. Vesuvius, Campania, and at Teulada, Sardinia, Italy. On Unst, Shetland Islands, and at Camas Mòr, Isle of Muck, Scotland. At Långban and Nordmark, Värmland, Sweden. From Asbest, Ural Mountains, Russia. Fine crystals in the Ethyl mine, Mutorashanga, Zimbabwe. From Phalaborwa, Transvaal, South Africa.

Name: For Archibald Bruce (1777–1818), physician and early American mineralogist, Professor at the College of Physicians and Surgeons (later Columbia University), New York, New York, USA, who first described the species.

Type Material: The Natural History Museum, London, England, 1911,730.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 636–639. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 90–92. (3) Catti, M., G. Ferraris, S. Hull, and A. Pavese (1995) Static compression and H disorder in brucite, $Mg(OH)_2$, to 11 GPa: a powder neutron diffraction study. Phys. Chem. Minerals, 22, 200–206. (4) (1956) NBS Circ. 539, 6, 30.

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Brüggenite $Ca(IO_3)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals subhedral, to 1 cm, short prismatic, elongated along [001], with {010} and {011}, other faces irregular, and a diamond-shaped cross-section showing {320}. In radiating clusters and long columnar anhedral crystals, intergrown with nitratine; as crusts.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5
D(meas.) = 4.24(1) D(calc.) = 4.244 Slowly soluble in cold H_2O; readily soluble in hot H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless to bright yellow; colorless to very pale yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = -47°$; $Z = b$. *Dispersion:* $r < v$, moderate to strong. $\alpha = 1.772–1.779$ $\beta = 1.795–1.802$ $\gamma = 1.817–1.824$ 2V(meas.) = 86°–96°

Cell Data: *Space Group:* $P2_1/c$. $a = 8.509(1)$ $b = 10.027(2)$ $c = 7.512(1)$
$\beta = 95°16.00(55)'$ Z = 4

X-ray Powder Pattern: Pampa Pique III, Chile.
3.051 (100), 3.238 (90), 4.235 (80), 3.739 (60), 3.503 (60), 2.522 (60), 1.7768 (60)

Chemistry:

	(1)	(2)
I_2O_5	81.4	81.83
CaO	14.1	13.75
SrO	0.4	
H_2O	4.1	4.42
Total	[100.0]	100.00

(1) Pampa Pique III, Chile; after deduction of 1/3 admixed lautarite, CO_2 0.1%, insoluble 0.3%.
(2) $Ca(IO_3)_2 \cdot H_2O$.

Occurrence: In veins with nitratine and impregnating the enclosing decomposing rhyolite tuff in a small basin filled with nitrate caliche.

Association: Nitratine, anhydrite, lautarite, hydroboracite, halite.

Distribution: At Pampa Pique III, about one km north of Oficina Lautaro, Taltal district, Antofagasta, Chile.

Name: To honor Professor Juan Brüggen (1887–1953), University of Chile, who wrote the first textbook on the geology of Chile.

Type Material: National Museum of Natural History, Washington, D.C., USA, 122445.

References: (1) Ericksen, G.E., M.E. Mrose, and J.W. Marinenko (1974) Mineralogical studies of the nitrate deposits of Chile IV. Brüggenite, $Ca(IO_3)_2 \cdot H_2O$, a new saline mineral. J. Res. U.S. Geol. Sur., 2, 471–478.

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Brugnatellite $Mg_6Fe^{3+}(CO_3)(OH)_{13}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ (probable). Tiny hexagonal or trigonal flakes, may be striated at 60°, flattened on {0001}; in lamellar or foliated masses, forming nodules, crusts, and coatings.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ∼2 D(meas.) = 2.14 D(calc.) = 2.21

Optical Properties: Transparent. *Color:* Flesh-pink to yellowish or brownish white; colorless to pink in transmitted light. *Streak:* White. *Luster:* Pearly.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellowish red; E = colorless. ω = 1.533–1.540 ϵ = 1.505–1.515

Cell Data: *Space Group:* n.d. $a = 5.47$ $c = 15.97$ Z = 1

X-ray Powder Pattern: Torre di Santa Maria, Italy. (ICDD 14-365).
7.93 (100), 3.96 (90), 2.00 (70), 2.35 (60), 2.63 (50), 1.56 (40), 1.53 (40)

Chemistry:

	(1)	(2)	(3)
Fe_2O_3	13.20	14.65	14.39
MnO	1.80	1.98	
MgO	42.79	40.36	43.59
H_2O	33.77	33.50	34.09
CO_2	7.78	8.04	7.93
insol.	1.03	1.15	
Total	100.37	99.68	100.00

(1) Torre di Santa Maria, Italy. (2) Viu, Italy. (3) $Mg_6Fe(CO_3)(OH)_{13}\cdot 4H_2O$.

Occurrence: A hydrothermal alteration product in serpentinite, lining cracks with other magnesium-rich species.

Association: Chrysotile, artinite, hydromagnesite, pyroaurite, magnesite, brucite, aragonite.

Distribution: In Italy, from Torre di Santa Maria, near Ciappanico, Val Malenco, and Monte Motta, Val Lanterna, Lombardy; on Monte Ramazzo, Borzoli, Liguria; at Viu, Val di Lanzo, Piedmont; and elsewhere. From Bou-Offrouh, Morocco. At Swinna Ness, Unst, Shetland Islands, Scotland. From Sannidal, Norway. In Canada, near Bancroft, Ontario, and near Notre-Dame-du-Laus, Quebec. In the Iron Hill carbonatite, Powderhorn-Cebolla district, Gunnison Co., Colorado, USA. From Higashi Kurodaguchi, Inasa, Shizuoka Prefecture; Naradani, Kiyomimura, Gifu Prefecture; Irazuyama, Ehime Prefecture; Sasaguri, Fukuoka Prefecture; Mashiki, Kumamoto Prefecture; and elsewhere in Japan.

Name: For Luigi Vincenzo Brugnatelli (1859–1928), Professor of Mineralogy, University of Pavia, Pavia, Italy.

Type Material: Municipal Museum of Natural History, Milan, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 660–661.

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Brumadoite $Cu_3Te^{6+}O_4(OH)_4{\cdot}5H_2O$

Crystal Data: Monoclinic. *Point Group*: n.d. Crystals platy, to 0.003 mm, form {100} observed; as microcrystalline aggregates or crusts.

Physical Properties: *Cleavage*: None observed. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = 2.60(5) D(calc.) = 4.768

Optical Properties: Transparent to translucent. *Color*: Blue; gray with blue internal reflections in reflected light. *Streak*: Pale blue. *Luster*: Vitreous.
Optical Class: n.d. n = ~ 1.79 *Pleochroism*: Observed.
R: (470) 10.2, (546) 8.9, (589) 8.3, (650) 8.3

Cell Data: *Space Group*: $P2_1/m$ or $P2_1$. a = 8.629(2) b = 5.805(2) c = 7.654(2) β = 103.17° Z = 2

X-ray Powder Pattern: Pedra Preta mine, Serra das Éguas, Brumado, Bahia, Brazil.
8.432 (100), 3.162 (66), 2.385 (27), 1.666 (14), 2.291 (12), 1.916 (11), 1.452 (10)

Chemistry:

	(1)	(2)
TeO_3	30.58	32.50
CaO	0.07	
CuO	43.05	44.16
PbO	1.70	
SiO_2	0.55	
H_2O	24.05	23.34
Total	100.00	100.00

(1) Pedra Preta mine, Serra das Éguas, Brumado, Bahia, Brazil; average of 16 electron microprobe analyses, H_2O by difference, IR confirms OH, and H_2O, Te^{6+} confirmed by microchemical test, corresponding to $(Cu_{2.90}Pb_{0.04}Ca_{0.01})_{\Sigma=2.95}(Te^{6+}_{0.93}Si_{0.05})_{\Sigma=0.98}O_{3.92}(OH)_{3.84}{\cdot}5.24H_2O$.
(2) $Cu_3Te^{6+}O_4(OH)_4{\cdot}5H_2O$.

Occurrence: A late fracture-filling mineral in coarse-grained magnesite.

Association: Magnesite, mottramite, quartz.

Distribution: Pedra Preta mine, Serra das Éguas, Brumado, Bahia, Brazil.

Name: For Brumado, Bahia, Brazil, near the first described locality.

Type Material: Museu de Geociências, Instituto de Geociências, Universidade de São Paulo, São Paulo, SP, Brazil; Museu José Bonifácio de Andrada e Silva, Santos, SP, Brazil (no. M5528); National Mineral Collection, Geological Survey of Canada, Ottawa, Ontario (no. NMC 068161); Natural History Museum, London, England (no. BM 2008,32).

References: (1) Atencio, D., A.C. Roberts, P.A. Matioli, J.A.R. Stirling, K.E. Venance, W. Doherty, C.J. Stanley, R. Rowe, G.J.C. Carpenter, and J.M.V. Coutinho (2008) Brumadoite, a new copper tellurate hydrate, from Brumado, Bahia, Brazil. Mineral. Mag., 72, 1201–1205.
(2) (2009) Amer. Mineral., 94, 1495 (abs. ref. 1).

Brunogeierite $(Ge^{2+}, Fe^{2+})Fe_2^{3+}O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Very rare crystals, to 5 mm; usually as crusts, or as rims incrusting tennantite enclosing reinierite; as inclusions in sphalerite and magnetite.

Physical Properties: Hardness = 5 D(meas.) = n.d. D(calc.) = 5.51 Ferromagnetic.

Optical Properties: Opaque. *Color:* Gray, with brownish internal reflections in reflected light.
Optical Class: Isotropic.
R: (400) 15.5, (420) 15.0, (440) 14.5, (460) 14.1, (480) 13.8, (500) 13.6, (520) 13.4, (540) 13.3, (560) 13.2, (580) 13.1, (600) 13.0, (620) 13.0, (640) 12.9, (660) 12.8, (680) 12.8, (700) 12.8

Cell Data: *Space Group:* $Fd3m$. a = 8.409–8.416 Z = 8

X-ray Powder Pattern: Tsumeb, Namibia.
2.540 (10), 1.484 (9), 1.615 (7), 2.972 (6), 1.095 (6), 1.720 (4), 1.283 (3)

Chemistry:

	(1)	(2)	(3)	(4)
GeO_2	37.0	40.5	42.13	35.69
Fe_2O_3				64.31
FeO	63.8	60.7	57.87	
Total	100.8	101.2	100.00	100.00

(1) Tsumeb, Namibia; by electron microprobe, total Fe as FeO; corresponding to $(Ge_{0.87}Fe^{2+}_{0.13})_{\Sigma=1.00}Fe_2^{3+}O_4$. (2) Do.; total Fe as FeO; corresponding to $(Ge_{0.95}Fe^{2+}_{0.05})_{\Sigma=1.00}$ $Fe_2^{3+}O_4$. (3) $GeFe_2^{3+}O_4$, with Fe reported as Fe^{2+}. (4) $GeFe_2^{3+}O_4$, with Fe reported as Fe^{3+}.

Mineral Group: Spinel group.

Occurrence: In the lower oxidation zone of a dolostone-hosted hydrothermal polymetallic ore deposit, at a depth of 930 meters (Tsumeb, Namibia).

Association: Tennantite, reniérite, zincian stottite (Tsumeb, Namibia); sphalerite, magnetite (France).

Distribution: From Tsumeb, Namibia. In France, from many deposits in the central Pyrénées, as at Cauflens, Ariège; Carboire, Couledoux, Estaing, and Pal Bidao, Haute-Garonne; and elsewhere.

Name: For Dr. Bruno H. Geier (1902–1987), formerly Chief Mineralogist, Tsumeb Corporation, Tsumeb, Namibia.

Type Material: n.d.

References: (1) Ottemann, J. and B. Nuber (1972) Brunogeierit, ein Germanium-Ferritspinell von Tsumeb. Neues Jahrb. Mineral., Monatsh., 263–267 (in German with English abs.).
(2) (1973) Amer. Mineral., 58, 348 (abs. ref. 1). (3) Johan, Z., E. Oudin, and P. Picot (1983) Analogues germanifères et gallifères des silicates et oxydes dans les gisements de zinc des Pyrénées centrales, France; argutite et carboirite, deux nouvelles espèces minérales. Tschermaks Mineral. Petrog. Mitt., 31, 97–119 (in French with English abs.).

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Brushite $Ca(HPO_4)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are needlelike, prismatic to tabular {010}, to 2 cm; may be foliated; usually powdery or earthy.

Physical Properties: *Cleavage:* On {010} and {001}, perfect. Hardness = 2.5 D(meas.) = 2.328 D(calc.) = 2.257 Piezoelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless to pale yellow, ivory-yellow; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = -30°$. *Dispersion:* $r > v$, noticably crossed. $\alpha = 1.539–1.540$ $\beta = 1.546$ $\gamma = 1.551–1.552$ 2V(meas.) = 59°–90°

Cell Data: *Space Group:* $C2/c$. $a = 6.361(3)$ $b = 15.191(4)$ $c = 5.814(2)$ $\beta = 118.45(4)°$ Z = 4

X-ray Powder Pattern: Pig Hole Cave, Virginia, USA.
7.62 (100), 3.80 (31), 1.90 (10), 3.06 (8), 2.53 (6), 4.27 (2), 2.63 (1)

Chemistry:

	(1)	(2)
P_2O_5	41.41	41.24
CaO	32.69	32.59
H_2O	26.36	26.17
Total	100.46	100.00

(1) Aves Island, Venezuela. (2) $Ca(HPO_4)\cdot 2H_2O$.

Occurrence: One of the most common cave minerals, in guano deposits, and in phosphorites, formed at low pH by reaction of phosphate-rich solutions with calcite and clay.

Association: Tanarakite, ardealite, hydroxylapatite, variscite, gypsum.

Distribution: Numerous occurrences. Found on Aves Island, Venezuela, west of Dominica in the Caribbean Sea. From Sombrero Island, West Indies. On Mona Island, Puerto Rico. In the USA, in Pig Hole Cave, Giles Co., Virginia; along Rock Creek, Kankakee Co., Illinois; in Kartchner Cavern, near Benson, Cochise Co., Arizona. Large crystals from Quercy, near Limoges, Haute-Vienne, France. At Schneeberg, Saxony, Germany. From Wheal Cock, St. Just, Cornwall, England. At Oran, Algeria. From the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. In Kyusen-do Cave, Kumamoto Prefecture, Japan. From the Skipton lava tube caves, 40 km southwest of Ballarat, Victoria, Australia. In the Vestfold Hills, East Antarctica.

Name: To honor Professor George Jarvis Brush (1831–1912), American mineralogist, Yale University, New Haven, Connecticut, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 704–706. (2) Murray, J.W. and R.V. Dietrich (1956) Brushite and taranakite from Pig Hole Cave, Giles Co., Virginia. Amer. Mineral., 41, 616–626. (3) Curry, N.A. and D.W. Jones (1971) Crystal structure of brushite, calcium hydrogen orthophosphate dihydrate: a neutron diffraction investigation. J. Chem. Soc, A, 3725–3729. (4) Fiore, S. and R. Laviano (1991) Brushite, hydroxylapatite, and taranakite from Apulian caves (southern Italy): new mineralogical data. Amer. Mineral., 76, 1722–1727.

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Buchwaldite $NaCaPO_4$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. In aggregates of fine needles, as inclusions, to 40 μm, in troilite.

Physical Properties: *Cleavage:* One, platy, or a parting. Hardness = < 3 D(meas.) = n.d. D(calc.) = 3.21

Optical Properties: Semitransparent. *Color:* Colorless to white.
Optical Class: Biaxial (–) [*sic*]. *Orientation:* Parallel extinction. $\alpha = 1.607$ $\beta = 1.610$ $\gamma = 1.616$ 2V(meas.) = $\sim 65°$ 2V(calc.) = $70°45'$

Cell Data: *Space Group:* $Pmn2_1$. $a = 5.167(25)$ $b = 9.259(45)$ $c = 6.737(32)$ Z = 4

X-ray Powder Pattern: Cape York meteorite.
2.72 (100), 3.79 (90), 1.91 (80), 2.63 (60), 2.58 (50), 2.51 (40), 2.19 (40)

Chemistry:

	(1)	(2)
P_2O_5	44.9	44.91
MnO	0.06	
CaO	35.6	35.48
Na_2O	19.5	19.61
Total	100.06	100.00

(1) Cape York meteorite; by electron microprobe. (2) $NaCaPO_4$.

Occurrence: As inclusions in troilite nodules in an iron meteorite.

Association: Troilite, chromite, other unidentified phosphates.

Distribution: In the Agpalilik and other fragments of the Cape York iron meteorite.

Name: To honor Dr. Vagn Fabius Buchwald (1929–), Technical University of Denmark, Lyngby, Denmark, for his contributions to the study of iron meteorites.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Olsen, E., J. Erlichman, T.E. Bunch, and P.B. Moore (1977) Buchwaldite, a new meteoritic phosphate mineral. Amer. Mineral., 62, 362–364.

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Buckhornite $Au^{3+}Pb_2BiTe_2S_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral to subhedral bladed crystals, flattened $\perp$ {100}, to 1.5 mm, may be foillike, warped, bowed, or in helical spirals; commonly aggregated in clusters.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Sectile and flexible. Hardness = n.d. VHN = 46–60, 54 average (10 g load). D(meas.) = n.d. D(calc.) = 8.43

Optical Properties: Opaque. *Color:* Black. *Streak:* Gray. *Luster:* Splendent metallic. *Optical Class:* Biaxial. *Pleochroism:* Distinct; purplish gray to pale blue. *Anisotropism:* Distinct; blue to mauve. *Bireflectance:* Moderate to strong. R_1–R_2: (400) 50.7–52.4, (420) 50.8–53.1, (440) 50.7–53.3, (460) 50.2–53.0, (480) 49.3–52.3, (500) 48.4–51.4, (520) 47.3–50.4, (540) 46.0–49.2, (560) 44.9–48.0, (580) 43.9–46.9, (600) 43.1–46.0, (620) 42.5–45.3, (640) 42.0–44.7, (660) 41.6–44.2, (680) 41.3–43.7, (700) 40.9–43.3

Cell Data: *Space Group: Pmmm.* $a = 4.073$–4.092 $b = 12.245$–12.326 $c = 9.322$–9.374 $Z = 2$

X-ray Powder Pattern: Buckhorn mine, Colorado, USA. 2.763 (vvs), 2.390 (vvs), 3.739 (vs), 3.108 (vs), 2.456 (vs), 2.044 (s), 1.7084 (s)

Chemistry:

	(1)	(2)	(3)
Au	17.0	16.97	16.81
Pb	34.5	37.02	35.37
Cu	0.1		
Te	22.3	22.38	21.78
Sb		3.26	
Bi	18.4	12.41	17.83
S	7.8	8.17	8.21
Total	100.1	100.21	100.00

(1) Buckhorn mine, Colorado, USA; by electron microprobe, average of seven analyses; corresponds to $Au_{1.02}Cu_{0.02}Pb_{1.97}Bi_{1.04}Te_{2.06}S_{2.89}$. (2) Bohuliby mine, Czech Republic; by electron microprobe, average of 38 analyses; corresponds to $Au_{1.03}Pb_{2.13}(Bi_{0.69}Sb_{0.31})_{\Sigma=1.00}Te_{2.05}S_{2.95}$. (3) $AuPb_2BiTe_2S_3$.

Occurrence: In hydrothermal Au–Te-bearing deposits.

Association: Pyrite, aikinite, tetradymite, calaverite, gold, chalcopyrite, covellite, bornite, chalcocite, galena, sphalerite, hematite (Buckhorn mine, Colorado, USA); pyrite, nagyágite, tellurobismuthite, altaite, galena, calaverite, gold (Bohuliby mine, Czech Republic); pyrite, melonite, tetradymite (Golden Sunlight mine, Montana, USA).

Distribution: In the USA, from the Buckhorn Pb–Ag mine, 1.6 km northwest of Jamestown, Boulder Co., Colorado [TL], and at the Golden Sunlight mine, near Whitehall, Jefferson Co., Montana. In the Pepř and Bohuliby mines, Jílové gold deposit, 30 km southeast of Prague, Czech Republic. From the Megradzor district, Armenia.

Name: For its occurrence in the Buckhorn mine, Colorado, USA.

Type Material: The Natural History Museum, London, England, 1991,51, 1991,52, E.1102; Harvard University, Cambridge, Massachusetts, 126786; National Museum of Natural History, Washington, D.C., USA, ??.

References: (1) Francis, C.A., A.J. Criddle, C.J. Stanley, D.E. Lange, S. Shieh, and J.G. Francis (1992) Buckhornite, $AuPb_2BiTe_2S_3$, a new mineral species from Boulder County, Colorado, and new data for aikinite, tetradymite and calaverite. Can. Mineral., 30, 1039–1047. (2) (1993) Amer. Mineral., 78, 1108 (abs. ref. 1). (3) Johan, Z., I. Dódony, P. Morávek, and J. Pašava (1994) La buckhornite, $Pb_2AuBiTe_2S_3$, du gisement d'or de Jílové, République tchèque. Compt. Rendus Acad. Sci. Paris, 318, 1225–1231 (in French with English abs.). (3) Effenberger, ??, ?? (2000) ??title?? Zeits. Krist., 215, 10.

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Buddingtonite $(NH_4)AlSi_3O_8$

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Crystal Data: Monoclinic. *Point Group:* 2 or $2/m$. As crystals similar in habit and interfacial angle to orthoclase, with forms {001}, {010}, {110}, {$\bar{1}$01}, to 0.05 mm. In compact masses pseudomorphous after plagioclase. *Twinning:* Noted.

Physical Properties: *Cleavage:* Good on {001}, distinct on {010}. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 2.32(1) D(calc.) = 2.38

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* Light grey, yellow when impure. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge a = 4°$; $Y \wedge c = 19°$. $\alpha = 1.530(2)$ $\beta = 1.531(2)$ $\gamma = 1.534(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1$ or $P2_1/m$. $a = 8.571$ $b = 13.032$ $c = 7.187$ $\beta = 112°44(1)'$ Z = 4

X-ray Powder Pattern: Sulfur Bank mine, California, USA.
3.81 (100), 6.52 (95), 3.38 (70), 3.23 (70), 4.33 (65), 3.26 (60), 3.01 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	66.89	70.06	Na_2O	0.06	
Al_2O_3	20.09	19.82	K_2O	0.65	
MgO	0.22		$(NH_4)_2O$	8.34	10.12
CaO	0.04		H_2O	3.44	
BaO	0.27		Total	[100.00]	100.00

(1) Sulfur Bank mine, California, USA; probably contains a small amount of reversibly hydrated ammonian montmorillonite accounting for the remaining H_2O content; after deductions for TiO_2, FeS_2, and $H_2O^- = 4\%$, recalculated to 100.00%. (2) $(NH_4)AlSi_3O_8$.

Mineral Group: Feldspar group.

Occurrence: A low-temperature hydrothermal replacement of plagioclase in andesite altered by ammonia-bearing hot springs (Sulfur Bank mine, California, USA); in metasomatized rhyolitic ash-flow tuffs (Cedar Mountains, Nevada, USA); in the sedimentary Phosphoria Formation (Idaho, Wyoming, and Montana, USA).

Association: Plagioclase, sulfur, stibnite, pyrite, marcasite, ammoniojarosite, gypsum, barite, anatase, montmorillonite (Sulfur Bank mine, California, USA); illite, albite, montmorillonite, kaolinite (Phosphoria Formation, Idaho, Wyoming, and Montana, USA).

Distribution: In the USA, at the Sulfur Bank mercury mine, Lake Co., and on Sharon Heights, Menlo Park, Santa Clara Co., California; in the Cedar Mountains, 50 km northwest of Tonopah, Nye Co., Nevada; at a number of exposures of the Meade Peak Member of the Phosphoria Formation in Idaho, Wyoming, and Montana. In the Condor oilshale deposit, near Proserpine, Queensland, Australia. From the Toshichi Spa, Iwate Prefecture, Japan.

Name: To honor Emeritus Professor Arthur Francis Buddington (1890–1980), American geologist, Princeton University, Princeton, New Jersey, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 116974, 132920, 147604.

References: (1) Erd, R.C., D.E. White, J.J. Fahey, and D.E. Lee (1964) Buddingtonite, an ammonium feldspar with zeolitic water. Amer. Mineral., 49, 831–850. (2) Gulbrandsen, R.A. (1974) Buddingtonite, ammonium feldspar, in the Phosphoria Formation, southeastern Idaho. J. Res. U.S. Geol. Sur., 2, 693–697. (3) Voncken, J.H.L., H.L.M. van Roermund, A.M.J. van der Eerden, J.B.H. Jansen, and R.C. Erd (1993) Holotype buddingtonite: an ammonium feldspar without zeolitic H_2O. Amer. Mineral., 78, 204–209.

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Buergerite $\mathbf{NaFe_3^{3+}Al_6(BO_3)_3Si_6O_{18}(O,F,OH)_4}$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals short to long prismatic, in divergent sprays, segmented, up to 4 cm, with forms $\{11\bar{2}0\}$, $\{30\bar{3}0\}$, $\{10\bar{1}1\}$, and $\{02\bar{2}1\}$.

Physical Properties: *Cleavage:* Distinct prismatic. *Tenacity:* Brittle. Hardness = 7
D(meas.) = 3.31(1) D(calc.) = 3.29 Pyroelectric and piezoelectric.

Optical Properties: Translucent. *Color:* Dark brown to almost black with a bronze schiller.
Streak: Yellow-brown. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellow-brown; E = very pale yellow.
$\omega = 1.735(3)$ $\epsilon = 1.655(3)$

Cell Data: *Space Group:* $R3m$. $a = 15.869(2)$ $c = 7.188(2)$ $Z = 3$

X-ray Powder Pattern: Mexquitic, Mexico. (ICDD 25-703).
2.563 (100), 2.952 (64), 3.96 (52), 3.47 (48), 6.33 (45), 2.032 (43), 4.20 (40)

Chemistry:

	(1)
SiO_2	33.86
TiO_2	0.55
B_2O_3	10.86
Al_2O_3	30.79
Fe_2O_3	17.62
FeO	1.27
MnO	0.13
MgO	0.13
CaO	0.69
Na_2O	2.46
K_2O	0.07
F	1.86
H_2O^+	0.40
$-O = F_2$	0.78
Total	99.91

(1) Mexquitic, Mexico; corresponds to $(Na_{0.82}Ca_{0.13}K_{0.02})_{\Sigma=0.97}(Fe^{3+}_{2.29}Al_{0.27}Fe^{2+}_{0.18}Ti_{0.07}Mg_{0.03}Mn_{0.02})_{\Sigma=2.86}Al_{6.00}(B_{1.08}O_3)_3Si_{5.85}O_{18}[O_{2.59}F_{1.02}(OH)_{0.46}]_{\Sigma=4.07}$.

Mineral Group: Tourmaline group.

Occurrence: Of probable pneumatolytic origin, in cavities in a rhyolite.

Association: Quartz, potassic feldspar, plagioclase, biotite, muscovite.

Distribution: From near Mexquitic, San Luis Potosi, Mexico.

Name: To honor Professor Martin Julian Buerger (1903–1986), eminent crystallographer, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

Type Material: Royal Ontario Museum, Toronto, Canada, M25021; American Museum of Natural History, New York City, New York, 35468; National Museum of Natural History, Washington, D.C., USA, 122200.

References: (1) Donnay, G., C.O. Ingamells, and B. Mason (1966) Buergerite, a new species of tourmaline. Amer. Mineral., 51, 198–199. (2) Tippe, A. and W.C. Hamilton (1971) A neutron diffraction study of the ferric tourmaline, buergerite. Amer. Mineral., 56, 101–113. (3) Dunn, P.J. (1976) Buergerite, uniformity of composition. Amer. Mineral., 61, 1029–1030. (4) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 559–602.

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Bukovite $Tl_2Cu_3FeSe_4$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$, $4mm$, or $4/m\ 2/m\ 2/m$. Minute crystals, up to 2 mm, and crystalline, embedded in other selenides; massive.

Physical Properties: *Cleavage:* Good on {001}, imperfect on {100}. Hardness = 2 VHN = 64 (20 g load). D(meas.) = n.d. D(calc.) = 7.40

Optical Properties: Opaque. *Color:* Gray-brown. *Luster:* Metallic. *Pleochroism:* Weak, creamy gray to gray.
R_1–R_2: (400) 23.5–28.3, (420) 24.7–29.0, (440) 25.7–29.7, (460) 26.5–30.5, (480) 26.6–30.6, (500) 27.0–30.7, (520) 27.1–30.6, (540) 26.6–29.9, (560) 26.5–29.4, (580) 26.1–28.8, (600) 26.0–28.8, (620) 26.1–28.8, (640) 26.7–29.1, (660) 27.9–29.7, (680) 28.7–30.3, (700) 29.9–31.3

Cell Data: *Space Group:* $I\bar{4}2m$, $I4mm$ or $I4/mmm$. $a = 3.976(5)$ $c = 13.70(2)$ $Z = 1$

X-ray Powder Pattern: Bukov, Czech Republic.
2.998 (100), 2.600 (90), 1.771 (80), 2.255 (70), 1.987 (70), 1.656 (60), 3.428 (50)

Chemistry:

	(1)	(2)
Tl	42.3	42.1
Cu	21.8	20.3
Fe	6.0	6.0
Se	30.7	31.0
Total	100.8	99.4

(1) Předbořice, Czech Republic; by electron microprobe, corresponding to $Tl_{1.98}Cu_{3.28}Fe_{1.02}Se_{3.72}$.
(2) Bukov, Czech Republic; by electron microprobe; corresponding to $Tl_{2.01}Cu_{3.12}Fe_{1.04}Se_{3.83}$.

Occurrence: In selenium-bearing veins of hydrothermal origin.

Association: Clausthalite, eskebornite, eucairite, chaméanite, umangite, berzelianite, hakite, klockmannite, sabatierite, crookesite, ferroselite, cadmoselite, pyrite, marcasite, chalcopyrite, chalcocite, bornite, uraninite, hematite, goethite, calcite, dolomite, quartz.

Distribution: In the Czech Republic, from Bukov [TL], near Tisnova; in the Petrovice uranium deposit, near Ždăr; and the Předbořice uranium deposit, near Krásna Hora. At Skrikerum, near Tryserum, Kalmar, Sweden. In the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina.

Name: For its occurrence at Bukov, Czech Republic.

Type Material: National School of Mines, Paris, France; Charles University, Prague, Czech Republic.

References: (1) Johan, Z. and M. Kvaček (1971) La bukovite, $Cu_{3+x}Tl_2FeSe_{4-x}$, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 94, 529–533 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1910 (abs. ref. 1). (3) Zemann, J. (1974) Structure type of bukovite. Anz. Oesterr. Akad. Wiss. Math.–Naturwiss. Kl., 110, 126–129 (in German). (4) (1976) Chem. Abs., 84, 20303 (abs. ref. 3). (5) Makovicky, E., Z. Johan, and S. Karup-Møeller (1980) New data on bukovite, thalcusite, chalcothallite and rohaite. Neues Jahrb. Mineral., Abh., 138, 122–146.

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Bukovskýite $Fe_2^{3+}(AsO_4)(SO_4)(OH)\cdot 7H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals, needlelike, elongated along [011], to 0.5 mm, showing {0*kl*} forms, terminated by {100} and {30$\overline{2}$}, may be in radial groups; generally in aggregates, forming nodules.

Physical Properties: *Cleavage:* On {010}, imperfect. *Fracture:* Uneven, earthy. *Tenacity:* Flexible in crystals. Hardness = Soft. D(meas.) = 2.334 D(calc.) = 2.336

Optical Properties: Semitransparent. *Color:* Yellowish green to grayish green. *Streak:* Pale yellowish.
Optical Class: Biaxial; birefringence 0.049–0.056. *Orientation:* Extinction angle = 22°.
α = n.d. β = 1.570–1.582 (β') γ = 1.626–1.631 (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.722(5)$ $b = 14.079(5)$ $c = 10.284(5)$
$\alpha = 93.50(4)°$ $\beta = 115.96(4)°$ $\gamma = 90.27(4)°$ Z = 4

X-ray Powder Pattern: Kaňk, Czech Republic.
9.197 (100), 8.884 (60), 9.625 (43), 3.077 (36), 3.920 (35), 2.458 (23), 5.338 (20)

Chemistry:

	(1)	(2)
SO_3	16.50	16.35
As_2O_5	22.10	23.46
Fe_2O_3	32.42	32.60
H_2O	28.12	27.59
Total	[99.14]	100.00

(1) Kaňk, Czech Republic; original total given as 99.32%, presence of AsO_4, SO_4, and $(OH)^{1-}$ confirmed by IR; assuming H_2O^- 0.69%, corresponds to $Fe_{2.00}(AsO_4)_{0.95}(SO_4)_{1.02}(OH)_{1.00}\cdot 7H_2O$.
(2) $Fe_2(AsO_4)(SO_4)(OH)\cdot 7H_2O$.

Occurrence: A post-mining surficial weathering product of Fe–As sulfides.

Association: Arsenopyrite, pyrite, quartz.

Distribution: Found in dumps of the Kuntery and other mines, Kaňk, 2.5 km north of Kutná Hora, Czech Republic.

Name: To honor Antonín Bukovský (1865–1950), Professor at the secondary school of Kutná Hora, Czech Republic, who first analyzed the mineral.

Type Material: Charles University, 14240; National Museum, Prague, Czech Republic, 53411.

References: (1) Novák, F, P. Povondra, and J. Vtělenský (1967) Bukovskýite, $Fe_2^{3+}(AsO_4)(SO_4)(OH)\cdot 7H_2O$, from Kaňk, near Kutná Hora – a new mineral. Acta Univ. Carolinae, Geol., 4, 297–325. (2) (1969) Amer. Mineral., 54, 576–577 (abs. ref. 1). (3) (1969) Amer. Mineral., 54, 991 (abs. ref. 1). (4) Johan, Z. (1986) Crystal symmetry and unit-cell of bukovskyite, $Fe_2^{3+}(AsO_4)(SO_4)(OH)\cdot 7H_2O$. Neues Jahrb. Mineral., Monatsh., 445–451.

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Bulachite $Al_2(AsO_4)(OH)_3 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. As flattened needles, in bundles and radial aggregates, to 0.75 mm, in crusts.

Physical Properties: Hardness = ∼2 D(meas.) = 2.60(10) D(calc.) = 2.59

Optical Properties: Translucent. *Color:* White to blue-green. *Luster:* Satiny. *Optical Class:* Biaxial (–). *Orientation:* $X \perp$ flattening; $Y \parallel$ transverse axis; $Z \parallel$ length. *Dispersion:* $r > v$. $\alpha = 1.540$–1.548 $\beta = [1.546]$ $\gamma = 1.548$–1.560 2V(meas.) = ∼66°

Cell Data: *Space Group:* $Pmnm$, $Pma2$, $Pmn2_1$, or $P2_122_1$. $a = 15.53$ $b = 17.78$ $c = 7.03$ Z = 10

X-ray Powder Pattern: Neubulach, Germany.
7.78 (10), 3.49 (8), 8.97 (7), 6.55 (7), 5.92 (7), 3.75 (7), 2.73 (6b)

Chemistry:

	(1)	(2)
As_2O_5	39.1	38.57
Al_2O_3	37.2	34.22
H_2O	25.5	27.21
Total	101.8	100.00

(1) Neubulach, Germany; H_2O by TGA, corresponds to $Al_{2.17}As_{1.01}O_{4.05}(OH)_{3.46} \cdot 2.48H_2O$.
(2) $Al_2(AsO_4)(OH)_3 \cdot 3H_2O$.

Occurrence: Initially found on two museum specimens collected on mine dumps.

Association: Arsenocrandallite, malachite, azurite, barian pharmacosiderite, goethite, quartz.

Distribution: At Neubulach, Black Forest, Germany.

Name: For the occurrence at Neubulach, Germany.

Type Material: n.d.

References: (1) Walenta, K. (1983) Bulachit, ein neues Aluminiumarsenatmineral von Neubulach im nördlichen Schwarzwald. Aufschluss, 34, 445–451 (in German). (2) (1985) Amer. Mineral., 70, 214 (abs. ref. 1).

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Bultfonteinite $Ca_2SiO_2(OH,F)_4$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As radiating prismatic acicular crystals and radial spherules, to 2 cm. *Twinning:* Interpenetrating on {100} and {010}; polysynthetic.

Physical Properties: *Cleavage:* Good on {100} and {010}. *Fracture:* Conchoidal. Hardness = 4.5 D(meas.) = 2.73 D(calc.) = 2.74

Optical Properties: Transparent. *Color:* Pale pink to colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z' \wedge c = 27°$–$29°$ on {010}; $Z' \wedge c = 46°$–$48°$ on {100}. *Dispersion:* $r > v$, barely perceptible. $\alpha = 1.587(2)$ $\beta = [1.590]$ $\gamma = 1.597(2)$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.992(4)$ $b = 8.185(2)$ $c = 5.671(1)$ $\alpha = 93°57'$ $\beta = 90°19'$ $\gamma = 89°51'$ Z = 4

X-ray Powder Pattern: Bultfontein mine, Kimberley, South Africa.
1.93 (100), 8.12 (60), 2.92 (60), 2.88 (60), 2.037 (50), 4.06 (40), 3.50 (40)

Chemistry:

	(1)	(2)
SiO_2	26.50	24.06
B_2O_3		0.02
Al_2O_3	0.72	1.37
CaO	54.20	53.59
Na_2O		0.04
F	8.81	7.90
H_2O^+		10.78
H_2O^-		0.75
H_2O	13.36	
CO_2		4.65
P_2O_5		0.02
$-O = F_2$	3.71	3.33
Total	99.88	99.85

(1) Bultfontein mine, Kimberley, South Africa. (2) Fuka, Japan; corresponds to $(Ca_{2.04}(Si_{0.96}Al_{0.06})_{\Sigma=1.02}O_{2.13}[(OH)_{2.87}F_{1.00}]_{\Sigma=3.87}$.

Occurrence: In a large "horse" of diabase and shale fragments in a kimberlite pipe (Bultfontein mine, Kimberley, South Africa); in a contact zone in thermally metamorphosed limestone (Crestmore, California, USA).

Association: Calcite, apophyllite, natrolite (Bultfontein mine, Kimberley, South Africa); afwillite, scawtite (Crestmore, California, USA); oyelite, scawtite, xonotlite (Fuka, Japan).

Distribution: In South Africa, in Cape Province, in the Bultfontein and Dutoitspan diamond mines, Kimberley; the Jagersfontein diamond mine, Orange River Colony; and the N'Chwaning and Wessels manganese mines, near Kuruman. In the USA, at Crestmore, Riverside Co., California. In the Hatrurim Formation, Israel. In Japan, from Fuka, near Bicchu, and in the Mihara mine, Okayama Prefecture.

Name: For the Bultfontein mine, Kimberley, South Africa, where it was first discovered.

Type Material: Cambridge University, Cambridge; The Natural History Museum, London, England, 1928,78.

References: (1) Parry, J., A.F. Williams, and F.E. Wright (1932) On bultfonteinite, a new fluorine-bearing hydrous calcium silicate from South Africa. Mineral. Mag., 23, 145–162. (2) (1933) Amer. Mineral., 18, 32 (abs. ref. 1). (3) McIver, E.J. (1963) The structure of bultfonteinite, $Ca_4Si_2O_{10}F_2H_6$. Acta Cryst., 16, 551–558. (4) Kusachi, I., C. Henmi, and K. Henmi (1984) An oyelite-bearing vein at Fuka, the town of Bitchu, Okayama Prefecture, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 79, 267–275.

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Bunsenite NiO

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals minute octahedra, may be modified by the cube or dodecahedron. *Twinning:* Observed.

Physical Properties: Hardness = 5.5 D(meas.) = 6.898 D(calc.) = 6.806

Optical Properties: Transparent. *Color:* Dark pistachio-green. *Streak:* Brownish black. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 2.37$

Cell Data: *Space Group:* $Fm3m$ (synthetic). $a = 4.1769$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.088 (100), 2.410 (91), 1.476 (57), 0.9838 (21), 0.8517 (17), 1.259 (16), 1.206 (13)

Chemistry: Analyses of natural material are lacking.

Mineral Group: Periclase group.

Occurrence: In a hydrothermal Ni–U vein (Johanngeorgenstadt, Germany); in a small tabular nickel deposit at the contact between quartzite and serpentinized ultramafics; it apparently formed at ∼730 °C and < 2 kbar during thermal metamorphism, possibly of a nickel-rich meteorite (Bon Accord, South Africa).

Association: Bismuth, annabergite, aerugite, xanthiosite (Johanngeorgenstadt, Germany); liebenbergite, trevorite, nickeloan serpentine, nickeloan ludwigite, violarite, millerite, gaspéite, nimite, bonaccordite (Bon Accord, South Africa).

Distribution: At Johanngeorgenstadt, Saxony, Germany. From three km west of the Scotia Talc mine, Bon Accord, Barberton district, Transvaal, South Africa. From Kambalda, 56 km south of Kalgoorlie, Western Australia.

Name: For Professor Robert William Eberhard Bunsen (1811–1899), German chemist of the University of Heidelberg, Heidelberg, Germany, who had observed artificial NiO.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 500–501. (2) (1953) NBS Circ. 539, 1, 47.

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Burangaite $(Na,Ca)(Fe^{2+},Mg)Al_5(PO_4)_4(OH,O)_6 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are prismatic, bladed, elongated along [010], bounded by {$h0l$} forms, and complexly terminated by {311} and {$22\overline{3}$}; may be fibrous.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = 5 D(meas.) = 3.05 D(calc.) = 3.00

Optical Properties: Semitransparent. *Color:* Bluish to blue-green; commonly shows a zoned hourglass structure, centrally blue with colorless margins. *Streak:* Pale blue.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = light blue; Y = dark blue; Z = colorless. *Orientation:* $Z = b$; $X \wedge c = 11°$. *Dispersion:* $r > v$. *Absorption:* $Y > X > Z$. $\alpha = 1.611(2)$ $\beta = 1.635(2)$ $\gamma = 1.643(1)$ 2V(meas.) = 58° 2V(calc.) = 60°

Cell Data: *Space Group:* $C2/c$. $a = 25.099(2)$ $b = 5.0491(7)$ $c = 13.438(1)$ $\beta = 110.88(1)°$ Z = 4

X-ray Powder Pattern: Buranga pegmatite, Rwanda.
11.71 (100), 3.081 (90), 3.115 (70), 4.86 (41), 3.318 (39), 2.044 (32), 1.6746 (28)

Chemistry:

	(1)	(2)
P_2O_5	37.65	39.38
Al_2O_3	34.35	34.11
Fe_2O_3	1.14	1.15
FeO	6.26	5.36
MnO	0.40	0.16
MgO	2.00	1.82
CaO	1.88	0.00
Na_2O	2.93	4.05
H_2O^+	11.60	12.32
insol.	2.06	
Total	100.27	98.35

(1) Buranga pegmatite, Rwanda; corresponds to $(Na_{0.70}Ca_{0.25})_{\Sigma=0.95}(Fe^{2+}_{0.65}Mg_{0.37}Mn_{0.04})_{\Sigma=1.06}(Al_{5.01}Fe^{3+}_{0.11})_{\Sigma=5.12}(PO_4)_{3.95}[(OH)_{5.58}O_{0.62}]_{\Sigma=6.20} \cdot 2H_2O$. (2) Do.; by electron microprobe, Fe^{2+}:Fe^{3+} from O^{2-} excess over FeO, total Mn as MnO, H_2O from stoichiometry; corresponds to $Na_{0.96}(Fe^{2+}_{0.55}Mg_{0.33}Fe^{3+}_{0.10}Mn_{0.02})_{\Sigma=1.00}Al_{4.89}(PO_4)_{4.06}(OH)_6 \cdot 2H_2O$.

Occurrence: In corroded aggregates of other phosphates in a zoned granite pegmatite (Buranga pegmatite, Rwanda).

Association: Scorzalite, bjarebyite, bertossaite, trolleite, samuelsonite, gatumbaite, wardite, brazilianite, apatite, quartz (Buranga pegmatite, Rwanda); berlinite, lazulite, scorzalite, augelite, gatumbaite, trölleite, rutile (Hålsjöberg, Sweden).

Distribution: In the Buranga pegmatite, near Gatumba, Rwanda. At Hålsjöberg, Värmland, Sweden. From the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada, USA.

Name: For the initial occurrence in the Buranga pegmatite, Rwanda.

Type Material: n.d.

References: (1) von Knorring, O., M. Lehtinen, and T.G. Sahama (1977) Burangaite, a new phosphate mineral from Rwanda. Bull. Geol. Soc. Finland, 49, 33–36. (2) (1978) Amer. Mineral., 63, 793 (abs. ref. 1). (3) Selway, J.B., M.A. Cooper, and F.C. Hawthorne (1997) Refinement of the crystal structure of burangaite. Can. Mineral., 35, 1515–1522.

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Burbankite $(Na, Ca)_3(Sr, Ba, Ce)_3(CO_3)_5$

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Crystal Data: Hexagonal. *Point Group:* $6mm$. Long dihexagonal prismatic crystals with shallow pyramidal terminations, striated parallel [001], may be in fibrous spherical aggregates; anhedral granular, to 5 cm.

Physical Properties: *Cleavage:* On $\{10\bar{1}0\}$, distinct to imperfect. Hardness = 3.5–4 D(meas.) = 3.50–3.58 D(calc.) = 3.50–3.54 Piezoelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, grayish yellow, pale yellow, pink, pale greenish. *Luster:* Vitreous.
Optical Class: Uniaxial (–) $\omega = 1.616$–1.635 $\epsilon = 1.597$–1.623

Cell Data: *Space Group:* $P6_3mc$. $a = 10.41$–10.547 $c = 6.250$–6.520 Z = 2

X-ray Powder Pattern: Big Sandy Creek, Montana, USA.
2.630 (10), 3.034 (6), 5.26 (5), 3.719 (5), 2.145 (5), 1.754 (3), 1.662 (3)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	33.24	[33.17]	Dy_2O_3		0.08
Y_2O_3	< 0.03		Tb_2O_3	0.05	
La_2O_3	3.37		Yb_2O_3		0.10
Ce_2O_3	5.39	2.12	CaO	11.47	12.03
Pr_2O_3	0.46		SrO	25.08	32.35
Nd_2O_3	1.26	0.13	BaO	11.47	11.02
Sm_2O_3	0.14		Na_2O	8.34	8.30
Gd_2O_3	0.41		Total	100.68	[99.30]

(1) Big Sandy Creek, Montana, USA; by electron microprobe, corresponds to $(Na_{1.78}Ca_{0.89})_{\Sigma=2.67}(Sr_{1.60}Ba_{0.50}Ca_{0.46}La_{0.14}Ce_{0.22}Nd_{0.05}Pr_{0.02}Gd_{0.01})_{\Sigma=3.00}(CO_3)_5$. (2) Mont Saint-Hilaire, Canada; by electron microprobe, CO_2 from stoichiometry; corresponds to $(Na_{1.78}Ca_{1.07})_{\Sigma=2.85}(Sr_{2.07}Ba_{0.48}Ca_{0.35}RE_{0.10})_{\Sigma=3.00}(CO_3)_5$.

Occurrence: Typically an abundant accessory mineral in carbonatites; in an intrusive alkalic gabbro-syenite complex; may be authigenic.

Association: Ancylite, calkinsite, lanthanite, calcite, "biotite", barite (Big Sandy Creek, Montana, USA); ancylite, carbocernaite, calcite (Mont Saint-Hilaire, Canada).

Distribution: In the USA, from vermiculite prospects at the head of Big Sandy Creek, Rocky Boy's Indian Reservation, about 40 km east of Box Elder, Hill Co., Montana; in the Green River Formation, Utah and Wyoming. In Canada, at Mont Saint-Hilaire, and in the Miron quarry, Montreal, Quebec; at Chipman Lake, Ontario. In the Qaqarssuk carbonatite, near Sukkertoppen, and the Grønnedal-Ika complex, Greenland. Found in Brazil, at Poços de Caldas, Minas Gerais. In Russia, on the Kola Peninsula, from the Vuoriyarvi carbonatite and Khibiny massifs, large crystals; at the Ozernyi carbonatite, southeastern Sakha; Arbarastakh carbonatite, Aldan; and the Nizhnesayanskii carbonatite, east Sayan; and in the Vishnevogorsk complex, Vishnevy-Ilmen Mountains, Southern Ural Mountains. From the Tajno massif carbonatites, 70 km north of Bialystok, Poland. In the Zeerust district, Transvaal, South Africa.

Name: Honors Wilbur Sweet Burbank (1898–1975), geologist of the U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106843.

References: (1) Pecora, W.T. and J.H. Kerr (1953) Burbankite and calkinsite, two new carbonate minerals from Montana. Amer. Mineral., 38, 1169–1183. (2) Chen, T.T. and G.Y. Chao (1974) Burbankite from Mont St. Hilaire, Quebec. Can. Mineral., 12, 342–345. (3) Effenberger, H., F. Kluger, H. Paulus, and E.R. Wölfel (1985) Crystal structure refinement of burbankite. Neues Jahrb. Mineral., Monatsh., 161–170.

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Burckhardtite $Pb_2(Fe^{3+},Mn^{3+})Te^{4+}(AlSi_3)O_{12}(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic (?), pseudohexagonal. *Point Group:* n.d. Rarely as hexagonal crystals, to 50 μm, typically overgrown on dickite; as crystal rosettes, < 0.2 mm.

Physical Properties: *Cleavage:* Perfect micaceous, basal. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 4.96 Paramagnetic.

Optical Properties: Transparent to translucent. *Color:* Carmine to violet-red. *Streak:* Pale red. *Luster:* Adamantine to slightly pearly.
Optical Class: Biaxial (–). *Pleochroism:* X = pale magenta; $Y = Z$ = carmine. $\alpha = 1.82$ $\beta = 1.85$ $\gamma = 1.85$ 2V(meas.) = Small.

Cell Data: *Space Group:* C-centered cell (?). $a = 5.21$ $b = 9.04$ $c = 12.85$ $\beta = 90°$ Z = 2

X-ray Powder Pattern: Moctezuma, Mexico.
3.11 (100), 12.8 (90), 3.70 (90), 2.60 (70), 1.840 (60), 1.590 (50), 2.26 (30b)

Chemistry:

	(1)
SiO_2	20.28
TeO_2	17.03
Al_2O_3	5.44
Fe_2O_3	7.25
Mn_2O_3	1.18
PbO	45.23
H_2O	[3.59]
Total	[100.00]

(1) Moctezuma, Mexico; by electron microprobe, valences of Te, Fe, and Mn inferred from the oxidized state of the deposit, H_2O by difference; corresponds to $Pb_{1.83}(Fe^{3+}_{0.82}Mn^{3+}_{0.14})_{\Sigma=0.96}Te_{0.97}(Si_{3.04}Al_{0.96})_{\Sigma=4.00}O_{12.7} \cdot 1.80H_2O$.

Occurrence: In a breccia, loosely cemented by dickite, in very thin disseminations on quartz fragments.

Association: Moctezumite, zemannite, tellurite, barite, dickite, quartz.

Distribution: In the Moctezuma mine, Moctezuma, Sonora, Mexico.

Name: To honor Mexican geologist Carlos Burckhardt (1869–1935).

Type Material: University of Delaware, Newark, Delaware; Harvard University, Cambridge, Massachusetts, 125476, 119081, 119085; National Museum of Natural History, Washington, D.C., USA, 136509, 144110, 164347, 164348.

References: (1) Gaines, R.V., P.B. Leavens, and J.A. Nelen (1979) Burckhardtite, a new silicate-tellurite from Mexico. Amer. Mineral., 64, 355–358.

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Burgessite $Co_2(H_2O)_4[AsO_3(OH)]_2(H_2O)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, prismatic, to 0.1 mm, forms {011} and {*hol*} observed; typically as rosettes, to 0.8 mm.

Physical Properties: *Cleavage*: Good on {010}; fair on {001}. *Fracture*: Hackly. *Tenacity*: Brittle. Hardness = ~ 3 D(meas.) = 2.93(2) D(calc.) = 2.94

Optical Properties: Transparent. *Color*: Purplish pink with a brown tint. *Streak*: Colorless to pale pink. *Luster*: Vitreous to adamantine.
Optical Class: Biaxial (+). $\alpha = 1.596(2)$ $\beta = 1.604(2)$ $\gamma = 1.628(2)$ 2V(meas.) = 70(2)°
2V(calc.) = 61° *Orientation*: X = *b*; Y ∧ *c* = 29° (in β obtuse); Z ∧ *a* = 20° (in β acute).

Cell Data: *Space Group*: $P2_1/n$. $a = 4.7058(12)$ $b = 9.299(3)$ $c = 12.738(4)$
$\beta = 98.933(8)°$ $Z = 2$

X-ray Powder Pattern: Keeley mine, Timiskaming District, Ontario, Canada.
7.446 (100), 6.267 (44), 2.998 (31), 3.725 (29), 3.260 (25), 2.596 (23), 2.970 (21)

Chemistry:

	(1)
As_2O_5	47.91
P_2O_5	0.03
CoO	27.31
NiO	3.52
ZnO	0.04
CaO	0.18
SO_3	0.13
H_2O	22.65
Total	101.77

(1) Keeley mine, South Lorraine Township, Timiskaming District, Ontario, Canada; average of 8 electron microprobe analyses, H_2O by difference, structure analysis and IR confirm OH and H_2O, corresponding to $(Co_{1.75}Ni_{0.23}Ca_{0.02})_{\Sigma=2.00}(AsO_3OH)_{\Sigma=2.00}(H_2O)_5$.

Occurrence: A secondary mineral along fractures in the weathering zone of a polymetallic sulfarsenate deposit.

Association: Skutterudite, cobaltite, bismuth, arsenolite, bismuthoferrite, erythrite.

Distribution: Keeley mine, South Lorraine Township, Timiskaming District, Ontario, Canada.

Name: For David Burgess (b. 1951), of Newington, Connecticut, USA, who brought the sample to the authors' attention.

Type Material: Canadian Museum of Nature, Ottawa, Ontario (CNMMC 86051).

References: (1) Sejkora, J., F.C. Hawthorne, M.A. Cooper, J.D. Grice, J. Vadak, and J.L. Jambor (2009) Burgessite, $Co_2(H_2O)_4[AsO_3(OH)]_2(H_2O)$, a new arsenate mineral species from the Keeley mine, South Lorrain Township, Ontario, Canada. Can. Mineral., 47, 159–164. (2) Cooper, M.A. and F.C. Hawthorne (2009) The crystal structure of burgessite, $Co_2(H_2O)_4[AsO_3(OH)]_2(H_2O)$, and its relation to erythrite. Can. Mineral., 47, 165–172. (3) (2009) Amer. Mineral., 94, 1495-1496 (abs. refs. 1 and 2).

Burkeite $Na_6(SO_4)_2(CO_3)$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ or 222. Crystals are tabular {100}, with {010}, {110}, {001}, rough and uneven, to 4 mm; as reticulated aggregates, mulberrylike nodules, commonly massive. *Twinning:* On {110}, common, forming X-shapes.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5
D(meas.) = 2.57 D(calc.) = 2.61 Soluble in H_2O.

Optical Properties: Transparent. *Color:* White, pale buff, grayish; colorless in transmitted light. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, distinct.
$\alpha = 1.448$ $\beta = 1.489$ $\gamma = 1.493$ 2V(meas.) = 34°

Cell Data: *Space Group:* $Pmnm$ (supercell). $a = 7.06$–7.09 $b = 9.21$–9.25 $c = 5.17$–5.19
Z = 2

X-ray Powder Pattern: Synthetic.
2.801 (100), 3.526 (80), 3.795 (75), 2.640 (75), 2.583 (75), 2.777 (55), 3.854 (40)

Chemistry:

	(1)	(2)
SO_3	39.96	41.05
CO_2	11.72	11.28
Na_2O	47.89	47.67
Cl	0.09	
H_2O	0.04	
insol.	0.04	
$-O = Cl_2$	[0.02]	
Total	[99.72]	100.00

(1) Searles Lake, California, USA. (2) $Na_6(SO_4)_2(CO_3) = Na_4(SO_4)[(SO_4)_{1-t}(CO_3)_t]$, t=2/3.

Occurrence: An uncommon product of evaporation in dry lakes, but typical of efflorescences on saline soils.

Association: Gaylussite, trona, sulfohalite, borax, northupite, thénardite, calcite, tychite, halite, hanksite (Searles Lake, California, USA).

Distribution: In the USA, in California, from Searles Lake, San Bernardino Co. and Deep Spring Lake, Inyo Co.; at Carbonate Lake, Grant Co., Washington; from Teels Marsh, Esmeralda Co., Nevada; in the Green River Formation, northern Piceance Creek Basin, and at Hortense and Mount Princeton Hot Springs, along Chalk Creek, Chaffee Co., Colorado. At Lake Katwe, western Uganda. From near Loiengalani, Lake Turkana, Kenya. Found near Ak Göl, Great Konya Basin, Konya Province, Turkey. In the Flumen-Monegros district, Huesca Province, Spain. From the McMurdo region and around Mt. Erebus, Victoria Land, Antarctica.

Name: Honors William Edmund Burke (1880–1966), chemical engineer, who first prepared the synthetic compound.

Type Material: National Museum of Natural History, Washington, D.C., USA, 97277, 102866–102872.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 633–634. (2) Giuseppetti, G., F. Mazzi, and C. Tadini (1988) The crystal structure of synthetic burkeite: $Na_4SO_4(CO_3)_t(SO_4)_{1-t}$. Neues Jahrb. Mineral., Monatsh., 203–221. (3) (1974) NBS Mono., 25, 11, 52.

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Burnsite $KCdCu_7O_2(SeO_3)_2Cl_9$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As anhedral equidimensional grains, to 0.1 mm.

Physical Properties: *Cleavage:* On {0001}, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 1–1.5 VHN = 12 D(meas.) = n.d. D(calc.) = 3.85

Optical Properties: Opaque to translucent. *Color:* Dark red. *Streak:* Red.
Luster: Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.920(5)$ $\epsilon = 1.912(5)$ *Bireflectance:* Weak; 0.01.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 8.7805(8)$ $c = 15.521(2)$ Z = 2

X-ray Powder Pattern: Tolbachik volcano, Russia.
7.779 (100), 4.391 (80), 3.814 (80), 3.066 (70), 2.501 (60), 6.823 (50), 2.582 (50)

Chemistry:

	(1)	(2)
SeO_2	19.91	18.47
CuO	46.74	46.35
CdO	10.45	10.69
K_2O	4.3	3.92
Cl	25.46	26.56
$-O = Cl_2$	5.75	5.99
Total	101.11	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, corresponding to $K_{1.08}Cd_{0.97}Cu_{6.98}O_{2.05}(Se_{1.07}O_{3.21})_2Cl_{8.53}$. (2) $KCdCu_7O_2(SeO_3)_2Cl_9$.

Occurrence: A very rare fumarolic sublimate, formed at an estimated 450 °C–500 °C.

Association: Cotunnite, sofiite, ilinskite, georgbokiite, chloromenite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Professor Peter Carman Burns (1966–), Canadian mineralogist and structural crystallographer, University of Notre Dame, Notre Dame, Indiana, USA, for his contributions to structural mineralogy.

Type Material: Mining Museum, Mining Institute, St. Petersburg, Russia.

References: (1) Krivovichev, S.V., L.P. Vergasova, G.L. Starova, S.K. Filatov, S.N. Britvin, A.C. Roberts, and I.M. Steele (2002) Burnsite, $KCdCu_7O_2(SeO_3)_2Cl_9$, a new mineral species from the Tolbachik volcano, Kamchatka Peninsula, Russia. Can. Mineral., 40, 1171–1175.

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Burpalite $Na_2CaZrSi_2O_7F_2$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As tablets, elongated along [001] and flattened on {010}, to 5 mm. In fan-shaped aggregates, commonly intimately intergrown with låvenite.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–6
D(meas.) = 3.33(15) D(calc.) = 3.27 Weak yellow-orange fluorescence in X-rays.

Optical Properties: Transparent to translucent. *Color:* Colorless, yellowish. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak.
$\alpha = 1.627(2)$ $\beta = 1.634(2)$ $\gamma = 1.639(2)$ 2V(meas.) = 82.1° 2V(calc.) = 80.1°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.1173(8)$ $b = 10.4446(6)$ $c = 7.2555(3)$
$\beta = 90.039(7)°$ Z = 4

X-ray Powder Pattern: Burpala massif, Russia; by Gandolfi camera to exclude låvenite domains.
2.962 (vs), 1.886 (ms), 1.556 (ms), 1.787 (s), 3.035 (m), 3.306 (m), 1.678 (m)

Chemistry:

	(1)
SiO_2	31.82
TiO_2	1.06
ZrO_2	31.11
Y_2O_3	0.32
Nb_2O_5	0.22
FeO	0.43
MnO	0.60
CaO	14.52
Na_2O	13.86
F	8.1
H_2O	1.23
$-O = F_2$	3.41
Total	99.86

(1) Burpala massif, Russia; by electron microprobe, average of four analyses, H_2O by Penfield method; corresponds to $(Na_{1.69}Mn_{0.03}Fe_{0.02}Y_{0.01})_{\Sigma=1.75}Ca_{0.98}(Zr_{0.96}Ti_{0.05}Nb_{0.01})_{\Sigma=1.02}Si_{2.00}O_7[F_{1.61}(OH)_{0.26}]_{\Sigma=1.87} \cdot 0.13H_2O$.

Polymorphism & Series: Dimorphous with låvenite.

Occurrence: In a fenitized hornfelsic sandstone in the contact zone of an alkalic intrusive.

Association: Låvenite, albite, nepheline, aegirine, alkalic amphibole, biotite, catapleiite, astrophyllite, fluorite, loparite.

Distribution: In the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, Russia.

Name: For its occurrence in the Burpala massif, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p300; Museum of Natural History, University of Pisa, Pisa, Italy; The Natural History Museum, London, England, 1994,5.

References: (1) Khomyakov, A.P., D.Y. Pushcharovskii, I.M. Kulikova, and V.I. Kuz'min (1988) New representative of the hiortdahlite-lavenite mineralogical group. Vestnik Mosk. Univ. Geol., 43(1), 87–92 (English trans. of Russian). (2) (1990) Amer. Mineral., 75, 436–437 (abs. ref. 1). (3) Merlino, S., N. Perchiazzi, A.P. Khomyakhov [Khomyakov], D.Y. Pushcharovskii, I.M. Kulikova, and V.I. Kuzmin (1990) Burpalite, a new mineral from the Burpalinskii massif, North Transbajkal [Transbaikal], USSR: its crystal structure and OD character. Eur. J. Mineral., 2, 177–185.

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Bursaite $Pb_5Bi_4S_{11}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Prismatic crystals, up to 4 mm, and platy elongated grains; partly in radial or polycrystalline aggregates. *Twinning:* Common, with twin plane ‖ [001], possibly {110}; lamellar.

Physical Properties: *Cleavage:* Tabular [*sic*]; ‖ [100]. Hardness = Polishing hardness less than chalcopyrite, greater than bismuth. VHN = 126–134 D(meas.) = > 6.2 D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Gray; white in polished section. *Luster:* Metallic. *Pleochroism:* Weak, white with blue tint to brown to light gray. *Anisotropism:* Strong, in gray-bluish and yellowish colors.
R_1–R_2: n.d.

Cell Data: *Space Group: Bbmm.* $a = 13.399(20)$ $b = 20.505(10)$ $c = 4.117(5)$ Z = [2]

X-ray Powder Pattern: Uludağ, Turkey.
2.048 (100), 2.998 (78), 3.670 (67), 3.484 (67), 2.696 (67), 2.794 (44), 3.127 (33)

Chemistry:

	(1)	(2)	(3)
Pb	45.0	45.03	46.57
Ag	1.0	1.41	
Bi	38.5	37.43	37.58
Sb		0.61	
S	14.7	15.53	15.85
Total	99.2	100.01	100.00

(1) Uludağ, Turkey; by electron microprobe, corresponding to $(Pb_{4.72}Ag_{0.20})_{\Sigma=4.92}Bi_{4.00}S_{10.82}$.
(2) Shumilovsk deposit, Russia; by electron microprobe, corresponding to $(Pb_{4.83}Ag_{0.29})_{\Sigma=5.12}(Bi_{3.99}Sb_{0.11})_{\Sigma=4.10}S_{10.78}$. (3) $Pb_5Bi_4S_{11}$.

Occurrence: In a contact metamorphic scheelite deposit (Uludağ, Turkey); in sulfide veinlets around a greisen Sn–W deposit in granite (Shumilovsk deposit, Russia); in a volcanogenic massive sulfide deposit (Cofer deposit, Virginia, USA).

Association: Sphalerite, tremolite, pyrite, calcite, garnet, quartz, scheelite, chalcopyrite, bismuth (Uludağ, Turkey); kobellite, tintinaite (Boliden, Sweden); wolframite, cassiterite, bismuthinite, galena, cosalite, heyrovskýite, galenobismutite, cannizzarite, tetradymite, joséite-B, bismuth, quartz (Shumilovsk deposit, Russia).

Distribution: From Uludağ, Bursa Province, Turkey [TL]. At Hůrky, Czech Republic. From Băiţa, Romania. At Boliden, Västerbotten, Sweden. From Vulcano, in the Lipari Islands, Italy. In the Shumilovsk Sn–W deposit, western Transbaikal, and from the Strezhana pyrite-polymetallic deposit, locality not otherwise defined, Russia. In the USA, at Organ, Doña Ana Co., New Mexico; large crystals in the Abril mine, Middle Pass district, Cochise Co., Arizona; from near Austin, Reese River district, Lander Co., Nevada; in the Cofer deposit, Louisa Co., Virginia. From the Huemules deposit, Chubut Province, Argentina.

Name: For the locality in Bursa Province, Turkey.

Type Material: n.d.

References: (1) Tolun, R. (1954–1955) A study on the concentration tests and beneficiation of the Uludağ tungsten ore. Bull. Mineral Research and Exploration Inst. Turkey, Foreign Ed., 46–47, 106–127 (in English). (2) (1956) Amer. Mineral., 41, 671 (abs. ref. 1). (3) Klominsky, J. M. Rieder, C. Kieft, and L. Mraz (1971) Heyrovskýite, $6(Pb_{0.86}Bi_{0.08}(Ag, Cu)_{0.04})S \bullet Bi_2S_3$, from Hůrky, Czechoslovakia, a new mineral of genetic interest. Mineralium Deposita, 6, 133–147. (4) Pokrovskaya, I.V., E.M. Muratov, P.S. Bernshtein, and A.P. Slyusarev (1981) Antimonial bursaite and its paragenesis in the Strezhana deposit. Izv. Akad. Nauk Kaz. SSR, Ser. Geol. 68–76 (in Russian). (5) (1982) Chem. Abs., 96, 22497 (abs. ref. 5). (6) Mozgova, N.N., N.I. Organova, Y.S. Borodaev. E.G. Ryabeva, A.V. Sivtsov, T.I. Getmanskaya, and O.V. Kuzmina (1988) New data on cannizzarite and bursaite. Neues Jahrb. Mineral., Abh., 158, 293–309.

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Burtite $CaSn(OH)_6$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}$ (probable). As pseudo-octahedra, to 2 mm. *Twinning:* Cubic diffraction symmetry observed is likely due to twinning.

Physical Properties: *Cleavage:* Pseudocubic, good. *Tenacity:* Very brittle. Hardness = ∼3 D(meas.) = 3.28(1) D(calc.) = 3.22

Optical Properties: Semitransparent. *Color:* Surficially yellow due to alteration; colorless in transmitted light. *Luster:* Vitreous; surface typically earthy due to alteration.
Optical Class: Uniaxial (+); sections exhibit very weak birefringence and interference figures; typically appears isotropic. $n = 1.633(1)$

Cell Data: *Space Group:* $R\overline{3}$ probable, $R3$, $R32$, $R3m$, $R\overline{3}m$ possible; $Pn3$ actually observed, thought due to twinning. $a = 11.49$ $c = 14.08$ Z = 4

X-ray Powder Pattern: El Hamman, Morocco.
4.06 (vs), 1.814 (s), 1.657 (s), 0.9850 (s), 0.9576 (s), 4.68 (ms), 2.87 (ms)

Chemistry:

	(1)	(2)
SnO_2	56.3	57.78
MgO	0.3	
CaO	20.6	21.50
H_2O(I)	[20.2]	20.72
H_2O(II)	[2.6]	
Total	[100.0]	100.00

(1) El Hamman, Morocco; by electron microprobe; H_2O(I) necessary for stoichiometry, H_2O(II) by difference, excess water possibly trapped in the structure; corresponds to $(Ca_{0.98}Mg_{0.02})_{\Sigma=1.00}Sn_{1.00}(OH)_6 \bullet 0.39H_2O$. (2) $CaSn(OH)_6$.

Mineral Group: Schoenfliesite group.

Occurrence: From a garnetite in a tin-bearing skarn, formed under conditions of relatively low temperature and low X_{CO_2}.

Association: Wickmanite, stokesite, datolite, pectolite, andradite, wollastonite, malayaite, clinopyroxene, löllingite.

Distribution: On the west bank of the Beht River, near El Hamman, central Morocco.

Name: For Dr. Donald McLain Burt (1943–), Professor of Mineralogy, Arizona State University, Tempe, Arizona, USA, authority on mineral equilibria in skarn and greisen deposits, who had predicted the natural occurrence of the compound.

Type Material: Catholic University of Louvain, Louvain, Belgium, EH80016.

References: (1) Sonnet, P.M. (1981) Burtite, calcium hexahydroxostannate, a new mineral from El Hamman, central Morocco. Can. Mineral., 19, 397–401. (2) (1982) Amer. Mineral., 67, 854 (abs. ref. 1). (3) Cohen-Addad, C. (1967) Étude des hydroxystannates $CaSn(OH)_6$ et $ZnSn(OH)_6$ par diffraction des rayons X et résonance magnétique nucléaire. Bull. Soc. fr. Minéral., 90, 32–35 (in French with English abs.).

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Bussyite-(Ce) $(Ce,REE,Ca)_3(Na,H_2O)_6MnSi_9Be_5(O,OH)_{30}(F,OH)_4$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, prismatic on [101], to 10 mm, exhibiting forms {1 1 $\bar{1}$ }, {1 0 $\bar{1}$ }; as crystal sprays. *Twinning:* Fine lamellar, parallel elongation.

Physical Properties: *Cleavage*: Perfect on {1 0 $\bar{1}$ }. *Fracture*: Splintery. *Tenacity*: Brittle. Hardness = 4 D(meas.) = 3.00. D(calc.) = 3.11

Optical Properties: Transparent to translucent. *Color*: Pale pinkish orange. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.574(2)$ $\beta = 1.591(2)$ $\gamma = 1.597(2)$ 2V(meas.) = 63(2)° 2V(calc.) = 61° *Orientation*: X $\wedge$ *c* = 39° (β acute); Y = *b*; Z $\wedge$ *a* = 44.5° (β obtuse).

Cell Data: *Space Group*: *C*2/*c*. $a = 11.654(3)$ $b = 13.916(3)$ $c = 16.583(4)$ $\beta = 95.86(2)°$ Z = 4

X-ray Powder Pattern: Poudrette dike, Mont Saint-Hilaire, Quebec, Canada.
8.120 (100), 2.863 (48), 3.543 (39), 2.668 (33), 6.959 (26), 2.959 (24), 2.749 (23)

Chemistry:

	(1)		(2)
Na_2O	7.63	Sm_2O_3	0.99
K_2O	0.05	Gd_2O_3	1.03
BeO	8.33	Er_2O_3	0.01
CaO	5.35	Yb_2O_3	1.97
MgO	0.03	SiO_2	38.66
MnO	2.49	ThO_2	3.31
Al_2O_3	0.82	F	3.67
Y_2O_3	1.97	S	0.03
La_2O_3	2.65	H_2O	4.12
Ce_2O_3	9.77	-O=F	1.55
Pr_2O_3	1.23	-O=S	0.01
Nd_2O_3	4.54	Total	95.21

(1) Poudrette dike, Mont Saint-Hilaire, Quebec, Canada; average of 26 electron microprobe analyses, H_2O calculated from structural analysis, IR confirms OH and H_2O, corresponding to $(Ce_{0.823}Nd_{0.373}Y_{0.242}Th_{0.173}Pr_{0.103}Sm_{0.079}Gd_{0.078}Eu_{0.008})_{\Sigma=1.89}(Ca_{0.775}La_{0.225})_{\Sigma=1}$ $[Na_{3.000}(H_2O)_{2.500}Ca_{0.544}K_{0.015}]_{\Sigma=6.055}(Mn_{0.485}Na_{0.402}Mg_{0.012})_{\Sigma=0.899}(Si_{8.897}Be_{4.605}Al_{0.222})_{\Sigma=13.724}$ $O_{30}[F_{2.67}(OH)_{1.33}]_{\Sigma=4}$.

Occurrence: A late-stage hydrothermal mineral associated with a nepheline syenite-hosted pegmatite.

Association: Serandite, aegirine, albite, analcime, ancylite-(Ce), calcite, catapleiite, gonnardite, kupletskite, leucophanite, microcline, nenadkevichite, polylithionite, sphalerite.

Distribution: Poudrette pegmatite dike, Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Antoine Alexandre Brutus Bussy (1794-1882), co-discoverer of beryllium.

Type Material: Canadian Museum of Nature, Ottawa, Ontario, Canada (catalog no. CMNMC 85929).

References: (1) Grice, J.D., R. Rowe, G. Poirier, A. Pratt, and J. Francis (2009) Bussyite-(Ce), a new beryllium silicate mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 47, 193–204. (2) (2009) Amer. Mineral., 94, 1496 (abs. ref. 1).

Bustamite $(Mn^{2+}, Ca)_3Si_3O_9$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals prismatic, needlelike, to 2.5 cm, or tabular on {001}; commonly fibrous, cleavable massive. *Twinning:* Composition plane {110}, simple twins, uncommon.

Physical Properties: *Cleavage:* Perfect on {100}, good on {110} and {1$\bar{1}$0}, poor on {010}. Hardness = 5.5–6.5 D(meas.) = 3.32–3.43 D(calc.) = 3.421 Pink color fades on exposure to light.

Optical Properties: Transparent to translucent. *Color:* Pale pink to brownish red; in thin section, colorless to yellowish pink. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Z$ = orange; Y = rose. *Orientation:* $X \wedge a \simeq 15°$; $Y \wedge b \simeq 35°$; $Z \wedge c \simeq 30°$–$35°$. *Dispersion:* $r < v$, weak, strong crossed dispersion. α = 1.640–1.695 β = 1.651–1.708 γ = 1.653–1.710 2V(meas.) = 34°–60°

Cell Data: *Space Group:* $P\bar{1}$. $a = 15.412$ $b = 7.157$ $c = 13.824$ $\alpha = 89°29'$ $\beta = 94°51'$ $\gamma = 102°56'$ Z = 12

X-ray Powder Pattern: Broken Hill, Australia.
2.880 (100), 2.989 (60), 3.19 (50), 1.776 (50), 2.227 (40), 1.665 (40), 2.711 (30)

Chemistry:

	(1)	(2)
SiO_2	48.44	48.31
FeO	0.27	1.87
MnO	25.20	33.04
ZnO	0.53	
MgO	0.65	1.90
CaO	25.20	14.93
LOI	0.34	
Total	100.63	100.05

(1) Franklin, New Jersey, USA; corresponding to $(Ca_{1.66}Mn^{2+}_{1.31}Mg_{0.06}Fe^{2+}_{0.01})_{\Sigma=3.04}Si_{2.97}O_9$.
(2) Långban, Sweden; corresponding to $(Mn^{2+}_{1.74}Ca_{0.99}Mg_{0.18}Fe^{2+}_{0.10})_{\Sigma=3.01}Si_{3.00}O_9$.

Occurrence: In manganese ores formed by metamorphism of manganese-bearing sediments with attendant metasomatism; typically associated with skarns.

Association: Rhodonite, tephroite, calcite, glaucochroite, johannsenite, wollastonite, diopside, grossular.

Distribution: "Type" material, from Tetela de Ocampo, Hidalgo, Mexico, is a mixture; well-studied material from other localities includes: in the USA, at Franklin, Sussex Co., New Jersey. At Långban and in the Harstigen mine, near Persberg, Värmland, Sweden. At the Treburland mine, Altarnun, Cornwall, and in the Railroad quarry, Meldon, near Okehampton, Devon, England. At Camas Malag, Isle of Skye, Scotland. From Băiţa (Rézbánya), Romania. At Campiglia, Tuscany, and Schio, Vicenza, Italy. From the N'Chwaning mine, near Kuruman, Cape Province, South Africa. In Australia, at Broken Hill, New South Wales. From the Obori mine, Yamagata Prefecture; the Noda-Tamagawa mine, Iwate Prefecture; the Kanoiri mine, Tochigi Prefecture; the Mikumo mine, Shiga Prefecture; and the Hijikuzu mine, Iwate Prefecture, Japan.

Name: In honor of General Anastasio Bustamente (1780–1853), of Mexico.

References: (1) Larsen, E.S. and E.V. Shannon (1922) Bustamite from Franklin Furnace, New Jersey. Amer. Mineral., 7, 95–100. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 574–585. (3) Peacor, D.R. and M.J. Buerger (1962) Determination and refinement of the crystal structure of bustamite, $CaMnSi_2O_6$. Zeits. Krist., 117, 331–343. (4) Harada, K., H. Sekino, K. Nagashima, T. Watanabe, and K. Momoi (1974) High-iron bustamite and fluorapatite from the Broken Hill mine, New South Wales, Australia. Mineral. Mag., 39, 601–604. (5) Ohashi, Y. and L.W. Finger (1978) The role of octahedral cations in pyroxenoid crystal chemistry. I. Bustamite, wollastonite, and the pectolite-schizolite-serandite series. Amer. Mineral., 63, 274–288.

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Butlerite $Fe^{3+}(SO_4)(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular on {001} or {100}, may be pseudo-octahedral. *Twinning:* On {101}, very common.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = 2.5 D(meas.) = 2.55 D(calc.) = 2.53

Optical Properties: Semitransparent. *Color:* Deep orange; in transmitted light, pale yellow-orange. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = very pale yellow; Z = pale yellow. *Orientation:* $Z = b$; $X \wedge c = -18°$. α = 1.593–1.604 β = 1.665–1.674 γ = 1.731–1.741 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/m$. a = 6.44–6.50 b = 7.31–7.37 c = 5.84–5.87 $\beta = 108°23(5)'–108°28(20)'$ Z = 2

X-ray Powder Pattern: United Verde mine, Arizona, USA.
4.97 (FF), 3.15 (F), 3.59 (mF), 3.05 (mF), 3.22 (mf), 2.48 (mf), 6.17 (ff)

Chemistry:

	(1)	(2)
SO_3	38.63	39.07
Al_2O_3	0.55	
Fe_2O_3	36.31	38.96
FeO	0.41	
Na_2O	2.73	
H_2O	22.83	21.97
Total	101.46	100.00

(1) United Verde mine, Arizona, USA. (2) $Fe(SO_4)(OH)\cdot 2H_2O$.

Polymorphism & Series: Dimorphous with parabutlerite.

Occurrence: Rarely formed from the oxidation of pyritic ore; may be formed under fumarolic conditions from mine fires.

Association: Parabutlerite, copiapite, fibroferrite, other iron sulfates.

Distribution: In the USA, from the United Verde copper mine, Jerome, Yavapai Co., Arizona; at the Lone Star mine, La Bajada district, Santa Fe Co., New Mexico; in the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah; from near Cimarron, Gunnison Co., Colorado. At the Santa Elena mine, Quebrada de La Alcaparrosa, San Juan Province, Argentina. From Chuquicamata and Quetena, west of Calama, Antofagasta, Chile. At Saghand, Yazd, Iran. From the Xitieshan Pb–Zn mine, south of Mt. Qilianshan, Chaidamu, Qinghai Province, China.

Name: Honors Professor Gurdon Montague Butler (1881–1961), American mining geologist, University of Arizona, Tucson, Arizona, USA.

Type Material: University of Arizona Mineral Museum, Tucson, Arizona, M52; Harvard University, Cambridge, Massachusetts, 90539; National Museum of Natural History, Washington, D.C., USA, 95953.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 608–609. (2) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French). (3) Fanfani, L., A. Nunzi, and P.F. Zanazzi (1971) The crystal structure of butlerite. Amer. Mineral., 56, 751–757.

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Bütschliite $K_2Ca(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As microscopic barrel-shaped crystals, elongated along [0001], in earthy to porcelaneous masses.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.607

Optical Properties: Semitransparent. *Color:* Grayish yellow, brownish gray, may be pale green from admixture.
Optical Class: Uniaxial (–). $\omega = 1.595$ $\epsilon = 1.455$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 5.3822(4)$ $c = 18.156(2)$ Z = 3

X-ray Powder Pattern: Synthetic. (ICDD 25-625).
2.862 (100), 3.02 (35), 1.690 (20), 1.641 (20), 1.044 (20), 0.933 (20), 2.071 (14)

Chemistry: (1) Identification depends primarily on correspondence with the X-ray powder pattern of synthetic material.

Polymorphism & Series: Dimorphous with fairchildite.

Occurrence: Formed in fused wood-ash clinkers in partly burned trees.

Association: Calcite, fairchildite.

Distribution: In the USA, many occurrences in forests from trees struck by lightning. Some studied are: from Kanabownits Canyon, Grand Canyon National Park, Coconino Co., Arizona; in the Kaniksu National Forest, near Coolin, Bonner Co., Idaho; at Long Shop, Montgomery Co., Virginia. From near Eganville and Deseronto, Ontario, Canada.

Name: To honor Johann Adam Otto Bütschli (1848–1920), Professor of Zoology at the University of Heidelberg, Heidelberg, Germany, who studied double salts of potassium and calcium.

Type Material: National Museum of Natural History, Washington, D.C., USA, 105675, 105676.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 230–231. (2) Milton, C. and J. Axelrod (1947) Fused wood-ash stones: fairchildite (n. sp.) $K_2CO_3 \cdot CaCO_3$, buetschliite (n. sp.) $3K_2CO_3 \cdot 2CaCO_3 \cdot 6H_2O$ and calcite, $CaCO_3$, their essential components. Amer. Mineral., 32, 607–624. (3) Effenberger, H. and H. Langhof (1984) On the aplanarity of the CO_3 group in buetschliite, dipotassium calcium carbonate, $K_2Ca(CO_3)_2$: a further refinement of the atomic arrangement. Acta Cryst., C40, 2999–1300.

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Buttgenbachite $Cu_{36}(NO_3)_2Cl_8(OH)_{62}\cdot 4{-}10H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals are hexagonal, acicular and striated ‖ [0001], terminated by $\{20\overline{2}1\}$, to 1 mm; as isolated crystals, radiating groups and felted crystal aggregates.

Physical Properties: Hardness = 3 D(meas.) = 3.36–3.42 D(calc.) = 3.23–3.25

Optical Properties: Translucent. *Color:* Deep azure-blue; blue in transmitted light. *Streak:* Pale greenish blue. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.738$ $\epsilon = 1.752$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 15.739$–15.750 $c = 9.127$–9.161 $Z = 1$

X-ray Powder Pattern: Likasi, Congo; close to connellite.
13.70 (vvs), 7.95 (vvs), 2.75 (vvs), 2.30 (vvs), 1.621 (vs), 3.27 (s), 2.51 (s)

Chemistry:

	(1)	(5)
SO_3	0.00	
N_2O_5	5.40	2.75
CuO	71.56	72.87
Cl	6.02	7.22
H_2O	17.34	18.79
$-O = Cl_2$	[1.36]	1.63
Total	[98.96]	100.00

(1) Likasi, Congo; original total given as 99.04%; corresponds to $Cu_{36.00}(NO_3)_{4.00}Cl_{6.80}(OH)_{61.20}\cdot 7.92H_2O$. (2) Do.; crystal-structure analysis yields $Cu_{36.0}(NO_3)_{2.6}Cl_{6.6}(OH)_{62.8}\cdot 2.1H_2O$. (3) Tombstone, Arizona, USA; crystal-structure analysis yields $Cu_{36.0}(NO_3)_{1.1}Cl_{7.9}(OH)_{63}\cdot 4H_2O$. (4) Bisbee, Arizona, USA; crystal-structure analysis yields $Cu_{36.0}(NO_3)_{1.0}Cl_{8.1}(OH)_{62.9}\cdot 5.5H_2O$. (5) $Cu_{36}(NO_3)_2Cl_8(OH)_{62}\cdot 10H_2O$.

Polymorphism & Series: Forms a series with connellite.

Occurrence: A rare secondary mineral found in the oxidized portions of copper deposits; the nitrate may be of biological origin.

Association: Cuprite, likasite, gerhardtite, malachite, brochantite, silver.

Distribution: From Likasi, Katanga Province, Congo (Shaba Province, Zaire). At the Botallack mine, St. Just, Cornwall, England. In the USA, in Arizona, from the Mildren and Steppe claims, South Comobabi Mountains, Pima Co., in the Toughnut mine, Tombstone, and at Bisbee, Cochise Co; from about seven km north of Coaldale Junction, Esmeralda Co., Nevada; in the Centennial mine, near Calumet, Keweenaw Co., Michigan. At the Great Australia mine, near Cloncurry, Queensland, Australia.

Name: Honors Professor Henri Jean François Buttgenbach (1874–1964), Belgian mineralogist, University of Liège, Liège, Belgium, who long studied Congo minerals.

Type Material: University of Liège, Liège, Belgium, 9.482 and 15.915; The Natural History Museum, London, England, 1933,267.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 572–573. (2) Bannister, F.A., M.H. Hey, and G.F. Claringbull (1950) Connellite, buttgenbachite, and tallingite. Mineral. Mag., 29, 280–286. (3) McLean, W.J. and J.W. Anthony (1972) The disordered, "zeolite-like" structure of connellite. Amer. Mineral., 57, 426–438. (4) Fanfani, L., A. Nunzi, P.F. Zanazzi, and R. Zanzari (1973) The crystal structure of buttgenbachite. Mineral. Mag., 39, 264–270. (5) Hibbs, D.E., P. Leverett, and P.A. Williams (2002) Buttgenbachite from Bisbee, Arizona, USA: a single-crystal X-ray study. Neues Jahrb. Mineral., Monatsh., 225–240. (6) Hibbs, D.E., P. Leverett, and P.A. Williams (2003) A single crystal X-ray study of a sulphate-bearing buttgenbachite, $Cu_{36}Cl_{7.8}(NO_3)_{1.3}(SO_4)_{0.35}(OH)_{62.2}.5H_2O$, and a re-examination of the crystal chemistry of the buttgenbachite – connellite series. Mineral. Mag., 67, 47–60.

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Byelorussite-(Ce) **$NaMn^{2+}Ba_2(Ce,La)_2Ti_2Si_8O_{26}(F,OH)\cdot H_2O$**

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Crystal Data: Orthorhombic. *Point Group:* 222. As crystals, tabular to thin tabular, to 2.5 cm.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {100}, poor on {010}. *Fracture:* Brittle. Hardness = 5.5–6 D(meas.) = 3.92 D(calc.) = 4.09

Optical Properties: Semitransparent. *Color:* Pale yellow to brown. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* In pale yellows. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Absorption:* $Z > Y \simeq X$. $\alpha = 1.743$ $\beta = 1.760(3)$ $\gamma = 1.820(5)$ 2V(meas.) = 58°–62°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 10.57(6)$ $b = 9.69(6)$ $c = 22.38(10)$ Z = [4]

X-ray Powder Pattern: Gomel district, Belarus.
2.783 (100), 3.00 (68), 2.95 (63), 4.42 (59B), 2.91 (52), 2.606 (52), 3.30 (45B)

Chemistry:

	(1)
SiO_2	33.98
TiO_2	11.35
RE_2O_3	23.59
FeO	0.82
MnO	2.58
ZnO	1.58
MgO	0.15
SrO	0.43
BaO	20.58
Na_2O	2.08
K_2O	0.40
F	0.98
H_2O	[1.45]
$-O = F_2$	0.41
Total	[99.56]

(1) Gomel district, Belarus; by electron microprobe, average of four analyses; $RE_2O_3 = La_2O_3$ 8.33%, Ce_2O_3 12.13%, Pr_2O_3 0.58%, Nd_2O_3 2.3%, Sm_2O_3 0.1%, Gd_2O_3 0.15%; corresponds to $(Na_{0.95}K_{0.12})_{\Sigma=1.07}(Mn_{0.52}Zn_{0.27}Fe_{0.16}Mg_{0.05})_{\Sigma=1.00}(Ba_{1.90}Sr_{0.06})_{\Sigma=1.96}RE_{2.03}Ti_{2.01}Si_{8.00}O_{26}[F_{0.73}(OH)_{0.27}]_{\Sigma=1.00}\cdot H_2O$.

Mineral Group: Joaquinite group.

Occurrence: In a salband of a quartz vein in lower Proterozoic metasomatized granosyenites.

Association: Brookite, bastnäsite, montmorillonite, quartz, magnesio-riebeckite, aegirine, albite, leucophanite, titanite.

Distribution: In the Diabazov rare earth–Be deposit, near Zhitkovichi, Gomel district, Belarus.

Name: For the occurrence in Belarus (formerly Byelorussia, USSR), and the *cerium* content.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 88051.

References: (1) Shpanov, E.P., G.N. Netschelyustov, S.V. Baturin, and L.S. Solntseva (1989) Byelorussite-(Ce) – $NaMnBa_2Ce_2Ti_2Si_8O_{26}(F,OH)\cdot H_2O$ – a new mineral of the joaquinite group. Zap. Vses. Mineral. Obshch., 118(5), 100–107 (in Russian). (2) (1991) Amer. Mineral., 76, 665–666 (abs. ref. 1).

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Bystrite $(Na,K)_7Ca(Si_6Al_6)O_{24}S_{1.5}\cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals tabular, to 5 mm; and as irregular grains and aggregates.

Physical Properties: *Cleavage:* $\{10\bar{1}0\}$, good; pinacoidal, weak, perhaps a parting. Hardness = 5 D(meas.) = 2.43(1) D(calc.) = 2.45

Optical Properties: Semitransparent. *Color:* Deep yellow; in thin section, yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* Deep yellow to colorless. *Orientation:* Negative elongation. *Absorption:* $O > E$. $\omega = 1.584$ $\epsilon = 1.660$

Cell Data: *Space Group:* $P31c$. a = 12.855 $c = 10.700$ Z = [2]

X-ray Powder Pattern: Malaya Bystraya deposit, Russia.
3.720 (100), 3.313 (90), 3.919 (80), 4.824 (70), 2.676 (70)

Chemistry:

	(1)
SiO_2	33.37
Al_2O_3	26.74
CaO	5.10
Na_2O	14.42
K_2O	7.63
Cl	0.25
H_2O	1.62
S	12.03
SO_3	0.50
CO_2	0.32
$-O = (S_3, Cl_2)$	2.06
Total	99.92

(1) Malaya Bystraya deposit, Russia; by electron microprobe, S by wet chemical analysis, H_2O by coulometry; corresponding to $(Na_{5.17}K_{1.80})_{\Sigma=6.97}Ca_{1.01}(Si_{6.17}Al_{5.83})_{\Sigma=12.00}O_{24}[S_{4.17}Cl_{0.08}(CO_3)_{0.08}(SO_4)_{0.07}]_{\Sigma=4.40}\cdot H_2O$.

Mineral Group: Cancrinite group.

Occurrence: In a lazurite deposit.

Association: Lazurite, calcite, diopside.

Distribution: In the Malaya Bystraya lazurite deposit, 25 km west of Slyudanka, south of Lake Baikal, Siberia, Russia.

Name: Presumably for the occurrence in the Malaya Bystraya deposit, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Ivanov, V.G. and A.N. Sapozhnikov (1985) Lazurites of the USSR. Nauka, Novosibirsk, 1–172 (in Russian). (2) Sapozhnikov, A.N., V.G. Ivanov, L.F. Piskunova, A.A. Kashaev, L.E. Terentieva, and E.A. Pobedimskaya (1991) Bystrite $Ca(Na,K)_7(Si_6Al_6O_{24})(S_3)_{1.5}\cdot H_2O$ – a new cancrinite-like mineral. Zap. Vses. Mineral. Obshch., 120(3), 97–100 (in Russian). (3) Pobedimskaya, E.A., L.E. Terentieva, A.N. Sapozhnikov, A.A. Kashaev, and G.I. Dorokhova (1991) Crystal structure of bystrite. Doklady Acad. Nauk SSSR, 319, 873–878 (in Russian). (4) (1993) Amer. Mineral., 78, 450 (abs. refs. 1 and 3).

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Byströmite $MgSb_2^{5+}(O,OH)_6$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. In porous massive aggregates of submicroscopic particles; a few grains show square or rectangular outlines under the electron microscope.

Physical Properties: Hardness = ∼7 D(meas.) = 5.5(1); 5.7 when corrected for stibiconite impurity. D(calc.) = 5.80

Optical Properties: Transparent to translucent. *Color:* Blue-gray to yellowish brown when in admixture with stibiconite; colorless in transmitted light. *Streak:* Pale gray.
Optical Class: Uniaxial. n = 1.855–1.915

Cell Data: *Space Group:* $P4_2/mnm$. a = 4.68 c = 9.21 Z = 2

X-ray Powder Pattern: El Antimonio, Mexico.
3.32 (100), 2.57 (90), 1.73 (90), 4.19 (70), 2.34 (50), 4.63 (40), 2.96 (40)

Chemistry:

	(1)	(2)
Al_2O_3	0.08	
Fe_2O_3	0.03	
Sb_2O_5	89.05	90.37
MgO	6.65	7.43
CaO	1.44	
H_2O^+	2.60	2.20
H_2O^-	0.17	
insol.	0.25	
Total	100.27	[100.00]

(1) La Fortuna mine, Sonora, Mexico; H_2O^+ by the Penfield method; known to be slightly contaminated with stibiconite, insoluble is quartz. (2) Do.; corrected for stibiconite impurity; then corresponding to $Mg_{0.65}Sb_{1.97}[O_{5.14}(OH)_{0.86}]_{\Sigma=6.00}$.

Mineral Group: Ferrotapiolite group.

Occurrence: In quartz veins in an oxidized antimony deposit.

Association: Stibiconite, quartz.

Distribution: In the La Fortuna and San Jose mines, El Antimonio, 27 km southwest of Agua Prieta, Sonora, Mexico.

Name: For Dr. Anders Byström (1916–1956), Swedish crystal chemist, who made a structural analysis of the synthetic compound.

Type Material: The Natural History Museum, London, England, 1951,300; National Museum of Natural History, Washington, D.C., USA, 106194.

References: (1) Mason, B. and C.J. Vitaliano (1952) Bystromite, magnesium antimonate, a new mineral. Amer. Mineral., 37, 53–57. (2) Byström, A., B. Hök, and B. Mason (1941) The crystal structure of zinc metantimonate and similar compounds. Arkiv Kemi, Mineral., Geol., 15B, 1–8.

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Bytownite $\mathbf{Na_{0.3-0.1}Ca_{0.7-0.9}Al_{1.7-1.9}Si_{2.3-2.1}O_8}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals, flattened along [010], are rare, to 3 cm; commonly as cleavable masses or anhedral grains in massive aggregates. *Twinning:* Common after the Albite, Carlsbad, and Pericline laws, developed in simple to complex combinations.

Physical Properties: *Cleavage:* Perfect on {001}, good on {010}, imperfect on {110}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.72–2.74 D(calc.) = 2.713–2.726

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray. *Streak:* White. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (–). *Dispersion:* $r < v$, weak. $\alpha = 1.565–1.573$ $\beta = 1.569–1.580$ $\gamma = 1.578–1.585$ 2V(meas.) = 87° to −78° (low); 81° to −83° (high).

Cell Data: *Space Group:* $P\bar{1}$ or $I\bar{1}$ for certain compositions. $a = 8.178$ $b = 12.870$ $c = 14.187$ $\alpha = 93.5°$ $\beta = 115.9°$ $\gamma = 90.63°$ Z = 8

X-ray Powder Pattern: Rustenburg mine, Transvaal, South Africa.
3.20 (100), 4.03 (80), 3.75 (80), 3.17 (80), 3.62 (70), 2.94 (70b), 2.52 (70)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	49.06	50.54	45.62	Na_2O	2.57	3.40	1.12
Al_2O_3	32.14	31.70	35.02	K_2O	0.17		
Fe_2O_3	0.27			H_2O^+	0.13		
MgO	0.20			H_2O^-	0.03		
CaO	15.38	14.36	18.24	Total	99.95	100.00	100.00

(1) Rustenburg mine, Transvaal, South Africa. (2) $Na_{0.30}Ca_{0.70}Al_{1.70}Si_{2.30}O_8$.
(3) $Na_{0.10}Ca_{0.90}Al_{1.90}Si_{2.10}O_8$.

Polymorphism & Series: Low- and high-temperature structural modifications are recognized.

Mineral Group: Feldspar group, plagioclase series.

Occurrence: A rock-forming mineral typical of mafic intrusive igneous rocks, as gabbros and anorthosites; as phenocrysts in basalts; rare in metamorphic rocks.

Association: Pyroxenes, olivine.

Distribution: One of the less frequently identified feldspars, although still very common. "Type" material from Ottawa, Ontario, Canada was later shown to be a mixture. Elsewhere in Canada, from the Shawmere anorthosite, Foleyet Township, Ontario, and on Yamaska Mountain, near Abbotsford, Quebec. On Rhum Island, Scotland. At Eycott Hill, near Keswick, Cumberland, England. From Närödal, Norway. In Greenland, from Fiskenæsset and Storo. In the Bushveld complex, Transvaal, South Africa. In the USA, in the Stillwater complex, Montana; from Cornwall, Lebanon Co., and Phoenixville, Chester Co., Pennsylvania; near Lakeview, Lake Co., Oregon; in the Lucky Cuss mine, Tombstone, Cochise Co., Arizona; and from the Grants district, McKinley Co., New Mexico. From Isa Valley, Western Australia.

Name: For the "type" locality, in Ottawa (formerly Bytown), Ontario, Canada.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 325–327, 334–335. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 94–165. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 352–360. (4) Goodyear, J. and W.J. Duffin (1954) The identification and determination of plagioclase feldspars by the X-ray powder method. Mineral. Mag., 30, 306–326. (5) Fleet, S.G., S. Chandrasekhar, and H.D. Megaw (1966) The structure of bytownite ('body-centered anorthite'). Acta Cryst., 21, 782–801.

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Běhounekite $U(SO_4)_2(H_2O)_4$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. Crystals short prismatic to tabular, to 0.5 mm.

Physical Properties: *Cleavage*: Perfect on {100}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 2 D(meas.) = n.d. D(calc.) = 3.62

Optical Properties: Transparent. *Color*: Green. *Streak*: Gray to greenish gray. *Luster*: Strongly vitreous.
Optical Class: Biaxial(+). α = 1.590(2) β = 1.618(4) γ = 1.659(2) 2V(calc.) = 81°
Pleochroism: Moderate, *Z* = emerald green, *X* = *Y* = pale emerald green. *Absorption*: *Z* > *X* = *Y*.

Cell Data: *Space Group*: *Pnma*. *a* = 14.6464(3) *b* = 11.0786(3) *c* = 5.6910(14) *Z* = 4

X-ray Powder Pattern: Jáchymov ore district, Krušné hory Mts., Czech Republic.
7.330 (100), 6.112 (54), 4.787 (42), 3.080 (41), 5.538 (21), 3.478(20), 3.663 (17)

Chemistry:

	(1)	(2)
Y_2O_3	0.75	
SO_3	31.36	31.88
UO_2	53.40	53.77
H_2O	[14.53]	14.35
Total	100.04	100.00

(1) Jáchymov ore district, Krušné hory Mts., Czech Republic; average of 5 electron microprobe analyses, H_2O calculated from stoichiometry, OH calculated for charge balance, IR and structure analysis show no evidence for OH; corresponding to $(U_{0.99}Y_{0.03})_{\Sigma=1.02}(SO_4)_{1.97}(H_2O)_4(OH)_{0.11}$.
(2) $U(SO_4)_2(H_2O)_4$.

Occurrence: A secondary mineral on highly altered native arsenic in the oxidation zone of a polymetallic sulfarsenide deposit.

Association: Aresenic, arsenolite, kaatialaite, claudetite, gypsum.

Distribution: Geschieber vein (10th level, Svornost/Einigkeit shaft) at the intersection with the Geier vein structure, Jáchymov (St Joachimsthal) ore district, Krušné hory Mts., Western Bohemia, Czech Republic.

Name: Honors Professor František Běhounek (1898-1973), a Czech nuclear physicist.

Type Material: Mineralogical collection, National Museum, Prague, Czech Republic (P1p 2/2010).

References: (1) Plášil, J., K. Fejfarová, M. Novák, M. Dušek, R. Škoda, J. Hloušek, J. Čejka, J. Majzlan, J. Sejkora, V. Machovič, and D. Talla (2011) Běhounekite, $U(SO_4)_2(H_2O)_4$, from Jáchymov (St Joachimsthal), Czech Republic: the first natural U^{4+} sulphate. Mineralogical Magazine, 75, 2739-2753. (2) (2014) Amer. Mineral., 99, 551-552 (abs. ref. 1).

Cabriite Pd_2SnCu

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As grains, to 4 mm, in massive mooihoekite. *Twinning:* Polysynthetic.

Physical Properties: Hardness = n.d. VHN = 258–282, 272 average (50 g load). D(meas.) = 11.1 D(calc.) = 10.7

Optical Properties: Opaque. *Color:* Pink with slight lilac tinge, pinkish brown. *Luster:* Metallic. *Pleochroism:* Detectable. *Anisotropism:* Strong, grayish brown to golden to deep steel-blue colors.
R_1–R_2: (400) 40.5–40.7, (420) 41.1–41.8, (440) 41.7–42.0, (460) 42.8–42.1, (480) 44.4–42.6, (500) 46.1–43.3, (520) 47.8–44.0, (540) 49.5–44.9, (560) 51.3–45.7, (580) 53.3–47.0, (600) 55.6–48.6, (620) 58.2–50.6, (640) 61.2–52.9, (660) 64.1–55.4, (680) 66.8–57.9, (700) 69.1–60.2

Cell Data: *Space Group: Pmmm.* $a = 7.88(5)$ $b = 7.88(5)$ $c = 3.94(2)$ $Z = 4$

X-ray Powder Pattern: Oktyabr mine, Russia.
2.29 (10), 2.17 (9), 1.230 (8), 1.217 (4), 1.840 (3b), 1.434 (3b), 1.182 (3)

Chemistry:

	(1)	(2)	(3)
Pd	52.1	50.7	53.87
Pt	2.6	4.9	
Sn	30.0	28.1	30.05
Cu	16.2	15.5	16.08
Sb		0.8	
Total	100.9	100.0	100.00

(1) Oktyabr mine, Russia; by electron microprobe, corresponds to $(Pd_{1.92}Pt_{0.05})_{\Sigma=1.97}Sn_{0.99}Cu_{1.00}$. (2) Do.; corresponds to $(Pd_{1.92}Pt_{0.10})_{\Sigma=2.02}(Sn_{0.95}Sb_{0.03})_{\Sigma=0.98}Cu_{0.99}$. (3) Pd_2SnCu.

Occurrence: In massive mooihoekite ore, also in galena–chalcopyrite veins.

Association: Mooihoekite, sperrylite, geeversite, putoranite, paolovite, talnakhite, sobolevskite, polarite, froodite, auricupride, silver, cassiterite, stannite, chalcopyrite, valeriite, galena, sphalerite, magnetite.

Distribution: From the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia, Russia [TL]. In the Minnamax Cu–Ni sulfide deposit, Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota, USA. From the Muskox intrusion, Northwest Territories, and at Thetford Mines, Quebec, Canada. In the Onverwacht mine, in the Merensky Reef, Bushveld complex, Transvaal, South Africa.

Name: For Dr. Louis J. Cabri (1934-), Canadian mineralogist at the Canadian Centre for Mineral and Energy Technology, Ottawa, Canada, describer of a number of platinum group minerals.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; Canadian Geological Survey, Ottawa, Canada.

References: (1) Evstigneeva, T.L. and A.D. Genkin (1983) Cabriite, Pd_2SnCu, a new mineral species in the mineral group of palladium, tin and copper compounds. Can. Mineral., 21, 481–487. (2) (1984) Amer. Mineral., 69, 1190 (abs. ref. 1). (3) Wilson, G.C, J.C. Rucklidge, and C. Cermignani (2002) Coarse-grained cabriite from Noril'sk, Russia. Can. Mineral., 40, 473–479. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 68.

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals, may be crudely hexagonal, acicular along [0001], typically in compact concentric spherical to radial aggregates, to 8 mm; in bundles, randomly fibrous; as coatings or an intergranular cement.

Physical Properties: Hardness = 3–4 D(meas.) = 2.2–2.6 D(calc.) = 2.217

Optical Properties: Semitransparent. *Color:* Yellow to brownish yellow or reddish orange, golden yellow, deep orange, rarely greenish; yellow in transmitted light. *Luster:* Silky. *Optical Class:* Uniaxial (+). *Pleochroism:* O = pale yellow; E = canary-yellow to yellow-orange. ω = 1.575–1.585 ϵ = 1.635–1.656

Cell Data: *Space Group:* $P6_3/m$. $a = 27.559(1)$ $c = 10.550(1)$ Z = 2

X-ray Powder Pattern: Avant claim, Arkansas, USA.
11.94 (10), 22.0 (8), 3.3452 (5), 4.897 (4), 6.921 (3), 9.065 (2), 2.7868 (2)

Chemistry:

	(1)	(2)	(3)
P_2O_5	25.71	26.18	26.04
Al_2O_3		2.89	1.10
Fe_2O_3	41.46	40.37	41.36
H_2O	32.81	30.59	31.50
insol.		0.14	
Total	99.98	100.17	100.00

(1) Svatá Dobrotivá (St. Benigna), Czech Republic. (2) Eleonore mine, Germany. (3) $Fe_{24}AlO_6(PO_4)_{17}(OH)_{12}\cdot 75H_2O$.

Occurrence: A common accessory mineral in oxidized magnetite and "limonite" iron ores; in Fe,Mn-bearing novaculites; a rare constituent of iron-rich sediments and soils.

Association: Dufrénite, rockbridgeite, beraunite, strengite, wavellite, magnetite, "limonite".

Distribution: Widespread in small amounts. In the Czech Republic, from the Hrbek mine, Svatá Dobrotivá (St. Benigna); at Třenice; from Zbirov; and at Cerhovice. In Germany, from the Eleonore and Rotläufchen mines, near Giessen, Hesse, and at Hühnerkobel, near Zwiesel, Bavaria. In France, at Rochefort-en-Terre, Morbihan. From Shanagolden, Co. Limerick, Ireland. At Kiruna, Sweden. In the USA, from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from Pennsylvania, at Hellertown, Northampton Co., Moore's Mill, Cumberland Co., and Noble's mine, Lancaster Co. On Indian Mountain, Cherokee Co., Alabama, groups large for the species; in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., from the Avant claim, about three km southwest of Shady, and at Three Oak Gap, Polk Co., Arkansas; in the Vanleer mine, Iron City, Lawrence Co., Tennessee; from the Palmetto mine, southwest of Bartow, Polk Co., Florida.

Name: From the Greek for *a bad guest*, for the phosphorus content that degrades the quality of iron made from the host ores.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 997–999. (2) Fisher, D.J. (1966) Cacoxenite from Arkansas. Amer. Mineral., 51, 1811–1814. (3) Moore, P.B. and J. Shen (1983) X-ray structural study of cacoxenite, a mineral phosphate. Nature, 306, 356–358.

Cadmium Cd

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As smooth flattened grains, up to 0.2 mm.

Physical Properties: *Tenacity:* Malleable. Hardness = n.d. VHN = 68.5–73.5 (10 g load). D(meas.) = 8.65 (synthetic). D(calc.) = [8.65] Diamagnetic.

Optical Properties: Opaque. *Color:* Pale gray; tin-white with a bluish tint in reflected light. *Luster:* Metallic.

R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.979$ $c = 5.617$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.345 (100), 2.809 (65), 2.580 (32), 1.901 (32), 1.516 (26), 1.490 (19), 1.316 (17)

Chemistry:

	(1)	(2)
Cd	99 – 100	95.70 – 96.73
Cr		0.23
Total		

(1) Ust'-Khann'ya intrusive, Russia; by electron microprobe. (2) Verkhoyan'ya, Russia.

Occurrence: In the heavy, non-magnetic fraction of a mechanical concentrate from a gabbro intrusive (Ust'-Khann'ya intrusive, Russia); a product of post-magmatic activity in mineralized aleurolites, sandstones, dolostones, and mudstones (Verkhoyan'ya, Russia).

Association: Moissanite, Fe, Cu, Pb, Sn, Zn, Cu–Zn alloy, Sn–Sb alloy, sulfides, garnet, spinel, kyanite, corundum, rutile (Ust'-Khannin intrusive, Russia); monteponite, otavite, titanite, ilmenite, chalcopyrite, bornite, chalcocite, pyrite, galena (Verkhoyan'ya, Russia).

Distribution: In Russia, from the Ust'-Khann'ya intrusive, lower Khann'ya River, Vilyui River basin, eastern Siberian platform [TL]; and in southern Verkhoyan'ya. In the Burobaiskii massif, eastern Kazakhstan. At the Goldstrike mine, Lynn district, Eureka Co., Nevada, USA.

Name: From the Greek for *calamine*, as the element occurs in slags resulting from smelting smithsonite (formerly calamine) ore.

Type Material: n.d.

References: (1) Oleinikov, B.V., A.V. Okrugin, and N.V. Leskova (1979) Native cadmium in traps of the Siberian Platform. Doklady Acad. Nauk SSSR, 248, 1426–1428 (in Russian). (2) (1980) Amer. Mineral., 65, 1065 (abs. ref. 1). (3) Novgorodova, M.I., D.A. Zhivtsov, A.I. Gorshkov, N.V. Trubkin, and A.I. Tsepin (1982) Native cadmium from southern Verkhoyan'ya. Zap. Vses. Mineral. Obshch., 111, 304–315 (in Russian). (4) (1982) Chem. Abs., 97, 112586 (abs. ref. 3). (5) Hull, A.W. and W.P. Davy (1931) Cadmium, Cd. Strukturbericht 1913–1928, 1, 42 (in German). (6) (1954) NBS Circ. 539, 3, 10.

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Cadmoselite CdSe

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Crystal Data: Hexagonal. *Point Group:* 6*mm*. Crystals, to 0.1 mm, show the base and horizontally striated hexagonal pyramid. Fine xenomorphic disseminations cementing sandstone.

Physical Properties: *Cleavage:* Perfect, apparently prismatic. *Tenacity:* Brittle. Hardness = 4 VHN = 203–222 D(meas.) = 5.47 D(calc.) = 5.807

Optical Properties: Opaque. *Color:* Black; pale gray in reflected light, slightly brown in oil, with brownish internal reflections. *Streak:* Black. *Luster:* Resinous to adamantine. *Anisotropism:* Weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3mc$. $a = 4.271$ $c = 6.969$ $Z = 2$

X-ray Powder Pattern: Ust'Uyuk deposit, Russia.
2.13 (10), 1.816 (8), 3.67 (7), 1.96 (7), 1.196 (7), 1.026 (7), 1.433 (6)

Chemistry:

	(1)	(2)
Cd	49.37	58.74
Zn	2.83	
Fe	1.95	
Se	37.50	41.26
S	[8.35]	
Total	[100.00]	100.00

(1) Ust'Uyuk deposit, Russia; Fe attributed to ferroselite, S by difference; total recalculated to 100% after deduction of insoluble 4.8%. (2) CdSe.

Occurrence: In sedimentary strata, under reducing secondary conditions of medium to high alkalinity (Ust'Uyuk deposit, Russia).

Association: Ferroselite, clausthalite, cadmian sphalerite, selenium, greenockite, pyrite, laumontite, calcite (Ust'Uyuk deposit, Russia).

Distribution: From the Ust'Uyuk V–Se–U deposit, Tuva, Russia. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina.

Name: For the presence of cadmium and selenium.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72553.

References: (1) Bur'yanova, E.Z., G.A. Kovalev, and A.I. Komkov (1957) The new mineral cadmoselite. Zap. Vses. Mineral. Obshch., 86, 626–628 (in Russian). (2) (1958) Amer. Mineral., 43, 623 (abs. ref. 1). (3) Freeman, D.K., S.L. Mair, and Z. Barnea (1977) The structure and Bijvoet ratios of cadmium selwnide. Acta Cryst., 33, 355–359. (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 657–659. (5) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 60–61.

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Cadwaladerite $AlCl(OH)_2 \cdot 4H_2O$

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Crystal Data: Amorphous. *Point Group:* n.d. Granular and in small masses, embedded in halite.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = 1.66 D(calc.) = n.d. Weakly hygroscopic.

Optical Properties: Transparent to translucent. *Color:* Lemon-yellow. *Luster:* Vitreous. *Optical Class:* Isotropic. $n = 1.513$, variable.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Al_2O_3	29.34	30.25
CaO	1.60	
Cl	21.51	21.04
H_2O^+	26.27	53.45
H_2O^-	26.81	
$-O = Cl_2$	5.53	4.74
Total	[100.00]	100.00

(1) Cerro Pintados, Chile; recalculated to 100% after deduction of Na_2O 1.85% as NaCl, K_2O 0.90% as KCl, CaO 0.47% as $CaCl_2$ and with SO_3 0.82% as $CaSO_4 \cdot 2H_2O$. (2) $AlCl(OH)_2 \cdot 4H_2O$.

Occurrence: In a sulfate deposit, embedded in halite.

Association: Halite, gypsum.

Distribution: On mine dumps at Cerro Pintados, 80 km southeast of Iquique, Tarapacá, Chile.

Name: For Charles Meigs Biddle Cadwalader, formerly President of the Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 134143.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 77.

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Cafarsite $\mathbf{Ca_8(Ti,Fe^{2+},Fe^{3+},Mn)_{6-7}(As^{3+}O_3)_{12}\cdot 4H_2O}$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Crystals, to 3 cm, faces smooth to rough, cubo-octahedral, with dodecahedron and {*hk*0}.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5.5–6 D(meas.) = 3.90 D(calc.) = [3.50]

Optical Properties: Opaque to translucent in thin fragments. *Color:* Dark brown; red in transmitted light. *Streak:* Yellow-brown.
Optical Class: Isotropic; marked anisotropism under crossed polars. $n = \geq 2.20$
R: n.d.

Cell Data: *Space Group: Pn*3. $a = 15.984$ $Z = 4$

X-ray Powder Pattern: Pizzo Cervandone, Italy.
2.827 (100), 2.747 (80), 3.140 (60), 1.6857 (60), 3.675 (50), 1.724 (50), 9.17 (40)

Chemistry:

	(1)	(2)
As_2O_5	60.0	
TiO_2	8.5	14.1
SnO_2		0.13
Al_2O_3		0.7
Fe_2O_3	11.0	
As_2O_3		55.0
FeO		7.8
MnO	5.0	2.6
CaO	13.0	16.5
Na_2O		1.1
H_2O	2.4	1.6
Total	99.9	99.53

(1) Cherbadung, Switzerland. (2) Do.; by electron microprobe and AA; As^{3+} detected by an iodine test; corresponds to $(Ca_{6.35}Mn_{0.79}Na_{0.77})_{\Sigma=7.91}(Ti_{3.81}Fe_{2.34}Al_{0.30}Sn_{0.02})_{\Sigma=6.47}$ $As_{12.01}O_{36}\cdot 1.92H_2O$.

Occurrence: On cleft faces in orthogneiss (Cherbadung, Switzerland).

Association: Asbecasite, gasparite-(Ce), chernovite, synchysite (Cherbadung, Switzerland).

Distribution: On the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais, Switzerland. On the east flank of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont, Italy. In the Hemlo gold mine, Ontario, Canada.

Name: For elements in the composition, CAlcium, iron (Ferrum), and ARSenic.

Type Material: Natural History Museum, Basel, Switzerland, SG749; The Natural History Museum, London, England, 1966,434.

References: (1) Graeser, S. (1966) Asbecasit und Cafarsit, zwei neue Mineralien aus dem Binnatal (Kt. Wallis). Schweiz. Mineral. Petrog. Mitt., 46, 367–375 (in German with English abs.) (2) (1967) Amer. Mineral., 52, 1584 (abs. ref. 1). (3) Graeser, S. and A.G. Roggiani (1976) Occurrence and genesis of rare arsenate and phosphate minerals around Pizzo Cervandone, Italy/Switzerland. Rend. Soc. Ital. Mineral. Petrol., 32, 279–288. (4) Edenharter, A., W. Nowacki, and M. Weibel (1977) Zur Struktur und Zusammensetzung von Cafarsit. Cafarsit ein As(III)-Oxid, kein Arsenat. Schweiz. Mineral. Petrog. Mitt., 57, 1–16 (in German with English abs.).

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Cafetite $\mathbf{Ca(Fe^{3+}, Al)_2Ti_4O_{12}\cdot 4H_2O}$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* n.d. Crystals columnar to acicular, elongated along [001], with striated prism faces; forms are {100}, {520}, {210}, several other minor. In fibrous aggregates, radial to tangled masses.

Physical Properties: *Cleavage:* In two directions, prismatic. *Tenacity:* Brittle, needles elastic. Hardness = 4–5 D(meas.) = 3.28 D(calc.) = 3.19 Some data presented here may be that of kassite.

Optical Properties: Semitransparent. *Color:* Pale yellow to colorless. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Orientation:* $Z \wedge c = 2°–4°$. *Dispersion:* Strong. $\alpha = 1.95$ $\beta = 2.08$ $\gamma = 2.11$ 2V(meas.) = 36.5°–39°

Cell Data: *Space Group:* n.d. $a = 31.34(5)$ $b = 12.12(3)$ $c = 4.96(1)$ $\beta = [90°]$ Z = 16

X-ray Powder Pattern: Afrikanda massif, Russia.
7.86 (10), 3.27 (8), 2.562 (8), 1.914 (7), 2.63 (4), 2.108 (4), 1.573 (4)

Chemistry:

	(1)
TiO_2	54.11
Al_2O_3	2.02
Fe_2O_3	22.00
FeO	0.49
MnO	0.20
MgO	1.44
CaO	6.23
Na_2O	0.28
K_2O	0.40
H_2O^+	8.83
H_2O^-	3.46
Total	100.46

(1) Afrikanda massif, Russia; corresponds to $(Ca_{0.67}Mg_{0.21}Na_{0.06}K_{0.05}Mn_{0.02})_{\Sigma=1.01}(Fe^{3+}_{1.68}Al_{0.24}Ti^{4+}_{0.05}Ti^{3+}_{0.03})_{\Sigma=2.00}(Ti_{3.92}Si_{0.09})_{\Sigma=4.01}O_{12}\cdot 4H_2O$.

Occurrence: A late mineral in miarolitic cavities in pegmatites cutting a pyroxenite massif.

Association: Ilmenite, titanomagnetite, titanite, anatase, perovskite, baddeleyite, phlogopite, clinochlore, kassite.

Distribution: In the Afrikanda pyroxenite massif, Kola Peninsula, Russia.

Name: For CAlcium, iron (FErrum), and TITanium in the composition.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, 13420-21; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72024.

References: (1) Kukharenko, A.A., V.V. Kondrat'eva, and V.M. Kovyazina (1959) Cafetite, a new hydrous titanate of calcium and iron. Zap. Vses. Mineral. Obshch., 88, 444–453 (in Russian). (2) (1960) Amer. Mineral., 45, 476 (abs. ref. 1). (3) Evans, H.T., Jr., E.J. Dwornik, and C. Milton (1986) Kassite from the Diamond Jo quarry, Magnet Cove, Hot Springs County, Arkansas: The problem of cafetite and kassite. Amer. Mineral., 71, 1045–1048. (4) Self, P.G. and P.R. Buseck (1991) Structure model for kassite, $CaTi_2O_4(OH)_2$. Amer. Mineral., 76, 283–287.

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Cahnite $Ca_2B(AsO_4)(OH)_4$

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Crystal Data: Tetragonal. *Point Group:* $\overline{4}$. Crystals, sphenoidal pseudotetrahedral or pseudo-octahedral, characteristically twinned and etched, to 18 mm, showing {100}, {110}, {111}, {1$\overline{1}$1}, {311}. *Twinning:* Common on {110}, interpenetrant, characteristically crosslike with a square cross-section.

Physical Properties: *Cleavage:* On {110}, perfect. *Tenacity:* Brittle. Hardness = ∼3
D(meas.) = 3.156 D(calc.) = [3.22] Pale yellow fluorescence under LW and SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white, may be pale yellow or pale green; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Dispersion:* Strong; exhibits anomalous interference colors.
ω = 1.655–1.662 ϵ = 1.656–1.663

Cell Data: *Space Group:* $I\overline{4}$. $a = 7.0952$ $c = 6.104$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
3.56 (100), 1.818 (52), 2.640 (48), 5.02 (20), 4.67 (20), 2.833 (19), 2.336 (17)

Chemistry:

	(1)	(2)
As_2O_5	38.05	38.58
B_2O_3	11.86	11.68
CaO	37.62	37.65
H_2O	12.42	12.09
Total	99.95	100.00

(1) Franklin, New Jersey, USA. (2) $Ca_2B(AsO_4)(OH)_4$.

Occurrence: A late-stage mineral in pegmatites cutting a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA); with zeolites in leucitic lava (Capo di Bove, Italy).

Association: Hedyphane, friedelite, pyrochroite, franklinite, willemite, rhodonite, datolite, axinite, jarosewichite, samfowlerite, flinkite, hodgkinsonite, hetaerolite, hausmannite, groutite, kentrolite, garnet, barite (Franklin, New Jersey, USA); phillipsite, chabazite, calcite (Capo di Bove, Italy); natronambulite, gypsum, barite, calcite (Kombat mine, Namibia); svabite, magnetite, sphalerite, garnet, calcite (Siberia, Russia).

Distribution: From Franklin, Sussex Co., New Jersey, USA. In the Klodeborg mine, Arendal, Norway. At Capo di Bove, and Vallerano, Strada Laurentina, near Rome, Lazio, Italy. In the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia. In the Killik, Hisarcık, and Espey borate mines, near Emet, Kütahya Province, Turkey. In Russia, from the Solongo boron deposit, Buryatia. At Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: To honor Lazard Cahn (1865–1940), mineral collector and dealer, Colorado Springs, Colorado, USA, who first noted the species.

Type Material: Harvard University, Cambridge, Massachusetts, 90010, 90015, 90016, 90019; National Museum of Natural History, Washington, D.C., USA, 95568.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 386–387. (2) Embrey, P.G. (1960) Cahnite from Capo di Bove, Rome. Mineral. Mag., 32, 666–668. (3) Prewitt, C.T. and M.J. Buerger (1961) The crystal structure of cahnite. Amer. Mineral., 46, 1077–1085. (4) Malinko, S.V. (1966) The first find of cahnite in the USSR. Doklady Acad. Nauk SSSR, 166, 695–697 (in Russian). (5) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 660–663.

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Calaverite $AuTe_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Bladed and short to slender prisms elongated ‖ [010], striated ‖ [010], to 1 cm; also massive, granular. *Twinning:* Common on {110}, less common on {031} and {111}.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 197–213 (100 g load). D(meas.) = 9.10–9.40 D(calc.) = 9.31

Optical Properties: Opaque. *Color:* Grass-yellow to silver-white; white in reflected light. *Streak:* Greenish to yellowish gray. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak.
R_1–R_2: (400) 45.7–54.4, (420) 48.4–57.1, (440) 51.1–59.6, (460) 53.6–61.8, (480) 56.0–63.6, (500) 57.9–65.2, (520) 59.4–66.4, (540) 60.6–67.3, (560) 61.3–68.0, (580) 61.8–68.3, (600) 62.2–68.4, (620) 62.5–68.6, (640) 62.7–68.5, (660) 62.8–68.4, (680) 62.9–68.2, (700) 63.0–68.1

Cell Data: *Space Group:* $C2/m$ or $C2$. $a = 7.1947(4)$ $b = 4.4146(2)$ $c = 5.0703(3)$ $\beta = 90.038(4)^\circ$ $Z = 2$

X-ray Powder Pattern: Cripple Creek, Colorado, USA.
3.02 (10), 2.09 (8), 2.20 (4), 2.93 (3), 1.758 (3), 1.689 (3), 1.506 (3)

Chemistry:

	(1)	(2)	(3)
Au	41.66	42.15	43.59
Ag	0.77	0.60	
Te	57.87	57.00	56.41
Total	100.30	99.75	100.00

(1) Cripple Creek, Colorado, USA. (2) Kalgoorlie, Australia. (3) $AuTe_2$.

Polymorphism & Series: Dimorphous with krennerite.

Occurrence: Typically in veins in low-temperature hydrothermal deposits, but also in medium- and high-temperature deposits.

Association: Altaite, coloradoite, krennerite, rickardite, other tellurides, pyrite, arsenopyrite, tetrahedrite, tennantite, sphalerite, stibnite, other sulfides.

Distribution: In the USA, in California, at the Stanislaus [TL], Morgan, and Melones mines, Carson Hill district, Calaveras Co.; at the Spotted Horse mine, Maiden, Fergus Co., and the Mayflower mine, Tobacco Root Mountains, Madison Co., Montana; in Colorado, fine examples in the Cripple Creek district, Teller Co.; the Central City district, Gilpin Co.; Gold Hill, Boulder Co.; and the Bessie G and Mayday mines, La Plata Co. From the San Francisco mine, 145 km north of Hermosillo, Sonora, Mexico. At the El Indio mine, east of La Serena, Coquimbo, Chile. In several mines in the Kirkland Lake area, and in the Hemlo gold deposit, Thunder Bay district, Ontario; and the Robb-Montbray mine, Quebec, Canada. From the Lake View and North Kalgoorlie mines, Kalgoorlie, Western Australia. At Nishizaki, Gifu Prefecture,in the Date mine, Hokkaido, and the Susaki mine, Shizuoka Prefecture, Japan. In the Emperor mine, Vatukoula, and in the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands. At the Bulawan deposit, Negros Occidental, Phillipines. From Klyuchi, eastern Siberia, and in the Bereznyakov gold deposit, Southern Ural Mountains, Russia.

Name: For its occurrence in Calaveras Co., California, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 335–338. (2) Schutte, W.J. and J.L. de Boer (1988) Valence fluctuations in the incommensurately modulated structure of calaverite $AuTe_2$. Acta Cryst., 44, 486–494. (3) Reithmayer, K., W. Steurer, H. Schulz, and J.L. de Boer (1993) High-pressure single-crystal structure study on calavrite, $AuTe_2$. Acta Cryst., 49, 6–11. (4) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 107–110. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 112. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 69.

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Calciborite CaB_2O_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Prismatic crystals, to 1.5 cm, in radial clusters and bundles, intimately intergrown with sibirskite.

Physical Properties: *Fracture:* Uneven to conchoidal. Hardness = ∼3.5 D(meas.) = 2.878 D(calc.) = 2.88 Bright green cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Optical Class:* Biaxial (–). *Orientation:* Extinction angle 22°. $\alpha = 1.595$ $\beta = 1.654$ $\gamma = 1.670$ 2V(meas.) = 54°

Cell Data: *Space Group: Pccn.* $a = 8.38$ $b = 13.81$ $c = 5.00$ Z = 8

X-ray Powder Pattern: Novofrolovskoye deposit, Russia.
3.44 (10), 3.57 (8), 1.976 (7), 1.870 (7), 1.793 (7), 7.10 (6), 3.81 (6)

Chemistry:

	(1)	(2)
As_2O_5	0.30	
SiO_2	0.55	
CO_2	6.07	
B_2O_3	47.58	55.39
Fe_2O_3	0.22	
Al_2O_3	0.18	
MgO	0.81	
CaO	44.08	44.61
H_2O^+	0.17	
H_2O^-	0.50	
Total	100.46	100.00

(1) Novofrolovskoye deposit, Russia; contaminated by calcite, dolomite, and garnet. (2) CaB_2O_4.

Occurrence: From drillcore into a contact metasomatized limestone near a quartz diorite intrusion associated with a copper deposit in skarn.

Association: Sibirskite, calcite, dolomite, garnet, magnetite, pyroxene.

Distribution: From the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains, Russia.

Name: For the essential chemical components, CALCIum and BORon.

Type Material: St. Petersburg Mining Institute, St. Petersburg, 1297/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64943.

References: (1) Petrova, E.S. (1955) Calciborite, a new mineral. Geology of Mining and Chemical Raw Materials, 218–223 (in Russian). (2) (1956) Amer. Mineral., 41, 815 (abs. ref. 1). (3) Malinko, S.V., N.N. Kuznetsova, V.M. Pensionerova, and L.I. Rybakova (1963) New data on calciborite. Zap. Vses. Mineral. Obshch., 92, 684–690 (in Russian). (4) Shashkin, D.P., M.A. Simonov, and N.V. Belov (1971) X-ray diffraction study of natural calcium metaborates. Kristallografiya (Sov. Phys. Crystal.), 16, 231–235 (in Russian). (5) Yegorov-Tismenko, Y.K., M.A. Simonov, and N.V. Belov (1980) Crystal structures of calciborite $Ca_2[BO_3BO]_2$ and synthetic calcium boraluminate $2CaAl[BO_3]O \equiv Ca_2[AlO_3BO]_2$. Doklady Acad. Nauk SSSR, 251, 1122–1123 (in Russian). (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 49.

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Calcioancylite-(Ce) $(Ca,Sr)(Ce,La)_3(CO_3)_4(OH)_3 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* [*m*.] As pseudo-octahedral dipyramidal to prismatic crystals with curved faces, to 2 mm; in subparallel aggregates; may occur as zoned intergrowns with ancylite-(Ce).

Physical Properties: *Fracture:* Splintery. *Tenacity:* Somewhat brittle. Hardness = 4–4.5 D(meas.) = 3.95 D(calc.) = n.d. May be pale pink in daylight, fluorescing pale bluish gray under indoor fluorescent light.

Optical Properties: Transparent to translucent. *Color:* Pink, white, gray; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, greasy on fractures.
Optical Class: Biaxial (–). *Dispersion:* $r < v$, barely perceptible. $\alpha = 1.654(3)$ $\beta = 1.733(3)$ $\gamma = 1.772(3)$ 2V(meas.) = 60°–70°

Cell Data: *Space Group:* [*Pm*] [by analogy to calcioancylite-(Nd)]. a = n.d. b = n.d. c = n.d. β = n.d. Z = n.d.

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
2.94 (100), 4.32 (75), 2.33 (45), 3.66 (40), 2.07 (35), 5.54 (30), 2.00 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	n.d.	n.d.	22.88	Sm_2O_3	0.21	0.65	
La_2O_3	21.85	11.44		CaO	7.55	6.59	7.29
Ce_2O_3	31.07	30.97	63.98	SrO	0.25	6.68	
Pr_2O_3	2.67	2.62		F	0.72		
Nd_2O_3	7.64	9.31		H_2O	n.d.	n.d.	5.85
				Total			100.00

(1) Ilímaussaq intrusion, Greenland; partial analysis, corresponding to $(Ca_{1.04}Sr_{0.02})_{\Sigma=1.06}(Ce_{1.44}La_{1.02}Nd_{0.34}Pr_{0.12})_{\Sigma=2.92}(CO_3)_4(OH)_3 \cdot H_2O$. (2) Afrikanda massif, Russia; partial analysis, corresponding to $(Ca_{0.92}Sr_{0.50})_{\Sigma=1.42}(Ce_{1.46}La_{0.54}Nd_{0.44}Pr_{0.12}Sm_{0.02})_{\Sigma=2.58}(CO_3)_4(OH)_3 \cdot H_2O$. (3) $CaCe_3(CO_3)_4(OH)_3 \cdot H_2O$

Occurrence: A rare mineral, found in late-stage miaroles in granite (Baveno, Italy); in Alpine-cleft type fissures (Cornog, Pennsylvania, USA; Polar Ural Mountains, Russia); in alkaline igneous rocks (Mont Saint-Hilaire, Canada; Ilímaussaq intrusion, Greenland; Kola Peninsula, Russia); and in leucite-bearing lamproite dikes (Baffin Island, Canada).

Association: Potassic feldspar, natrolite, aegirine, catapleiite, perovskite, astrophyllite, titanite, apatite, anatase, synchysite, quartz, calcite, actinolite, pyrite (Cornog, Pennsylvania, USA).

Distribution: From Russia, originally found in a glacial erratic boulder; from the Afrikanda pyroxenite massif, Kola Peninsula, and at Dodo and Puiva, Polar Ural Mountains. From Baveno, Italy. In the Kalcherkogel tunnel, Styria, Austria. Found near Mendig, Eifel, Germany. From Cezlak, west-northwest of Slovenska Bistrica, Slovenia. At Tvedalen, near Larvik, Norway. In Greenland, at Narssârssuk, and near the head of the Lilleelv River, Ilímaussaq intrusion. In the USA, from the Keystone quarry, near Cornog, Chester Co., Pennsylvania, and at the Foote mine, Cleveland Co., North Carolina. From Mont Saint-Hilaire, Quebec, and at Napoleon Bay, Baffin Island, Canada.

Name: For its *calcium* content and from the Greek for *curved* in allusion to the typical rounded and distorted crystal habit; and for the dominant rare earth element, *cerium*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 291–293. (2) Pekov, I.V., O.V. Petersen, and A.V. Voloshin (1997) Calcio-ancylite-(Ce) from Ilímaussaq and Narssârssuk, Greenland, Kola Peninsula and Polar Urals, Russia; ancylite-(Ce) – calcio-ancylite-(Ce) an isomorphous series. Neues Jahrb. Mineral., Abh., 171, 309–322.

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Calcioancylite-(Nd) $Ca(Nd,Ce,Gd,Y)_3(CO_3)_4(OH)_3 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* m. As dipyramidal tabular crystals, to 1 mm, typically in subparallel aggregates.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 4–4.5
D(meas.) = > 4.02 D(calc.) = 4.08

Optical Properties: Transparent. *Color:* Pale pink. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z = c$. *Dispersion:* $r < v$, weak. $\alpha = 1.660(1)$ $\beta = 1.725(1)$ $\gamma = 1.765(1)$ 2V(meas.) = 70° 2V(calc.) = 74°

Cell Data: *Space Group:* Pm. $a = 7.212(2)$ $b = 4.976(2)$ $c = 8.468(2)$ $\beta = 90.04(3)°$
Z = 1

X-ray Powder Pattern: Baveno, Italy.
4.26 (10), 2.905 (9), 2.048 (8), 3.67 (7), 2.320 (7), 1.979 (7), 5.49 (6)

Chemistry:

	(1)		(1)
CO_2	23.47	Gd_2O_3	6.68
La_2O_3	3.16	Dy_2O_3	1.74
Ce_2O_3	14.18	Tm_2O_3	0.83
Pr_2O_3	3.23	Y_2O_3	3.93
Nd_2O_3	20.23	CaO	9.05
Sm_2O_3	7.63	SrO	0.00
Eu_2O_3	0.00	H_2O	[5.87]
		Total	[100.00]

(1) Baveno, Italy; by electron microprobe, CO_2 by elemental microanalyzer, H_2O by difference; corresponding to $Ca_{1.20}(Nd_{0.90}Ce_{0.64}Sm_{0.33}Gd_{0.28}Y_{0.26}Pr_{0.15}La_{0.14}Dy_{0.07}Tm_{0.03})_{\Sigma=2.80}(CO_3)_{3.98}(OH)_{2.84} \cdot 1.01H_2O$.

Occurrence: Coating miarolitic cavities in granite.

Association: Orthoclase, quartz, albite.

Distribution: From the Montecatini quarry, Baveno, Piedmont, Italy.

Name: For *calcioancylite* with dominant *neodymium*.

Type Material: Municipal Natural History Museum, Milan, Italy, M29872.

References: (1) Orlandi, P., M. Pasero, and G. Vezzalini (1990) Calcio-ancylite-(Nd), a new REE-carbonate from Baveno, Italy. Eur. J. Mineral., 2, 413–418. (2) (1991) Amer. Mineral., 76, 1729 (abs. ref. 1).

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Calcioaravaipaite $PbCa_2Al(F,OH)_9$

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Crystal Data: Monoclinic. *Point Group:* 2, m, or $2/m$. Crystals flattened on {100}, elongated ‖ [011], showing {100} and {011}, to 0.7 mm; massive. *Twinning:* On {100}, universal.

Physical Properties: *Cleavage:* {100}, good. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 4.85(5) D(calc.) = 4.71

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 73°$. *Dispersion:* $r > v$, strong. $\alpha = 1.510(1)$ $\beta = 1.528(1)$ $\gamma = 1.531(1)$ 2V(meas.) = 36(2)° 2V(calc.) = 44°

Cell Data: *Space Group:* $A2$, Am, or $A2/m$. a = 23.906(5) $b = 7.516(2)$ $c = 7.699(2)$ $\beta = 92.25°$ Z = 8

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
11.9 (100), 3.51 (85), 3.71 (70), 2.981 (60), 2.943 (60), 2.028 (60), 1.971 (60)

Chemistry:

	(1)
Al_2O_3	10.8
PbO	46.4
CaO	23.5
F	30.9
H_2O	[1.4]
$-O = F_2$	13.0
Total	[100.0]

(1) Grand Reef mine, Arizona, USA; by electron microprobe, average of five analyses, H_2O by difference; corresponds to $Pb_{1.02}Ca_{2.05}Al_{1.04}[F_{7.97}(OH)_{0.76}O_{0.27}]_{\Sigma=9.00}$.

Occurrence: In the oxidized zone of an epithermal Cu–Pb–Ag deposit.

Association: Artroeite, quartz, anglesite, fluorite, galena, linarite, muscovite.

Distribution: From the Grand Reef mine, near Klondyke, Aravaipa district, Graham Co., Arizona, USA.

Name: For its CALCIum content and relation to *aravaipaite*.

Type Material: Natural History Museum, Los Angeles, California, USA, 39338.

References: (1) Kampf, A.R. and E.E. Foord (1996) Calcioaravaipaite, a new mineral, and associated lead fluoride minerals from the Grand Reef mine, Graham County, Arizona. Mineral. Record, 27, 293–300.

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Calciobetafite $Ca_2(Nb,Ti)_2(O,OH)_7$

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Crystal Data: Cubic; may be metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, to 0.2 mm.

Physical Properties: *Fracture:* [Conchoidal to uneven] (by analogy to betafite). *Tenacity:* [Brittle.] Hardness = [3–5.5] D(meas.) = n.d. D(calc.) = [4.12] May be radioactive.

Optical Properties: Semitransparent. *Color:* Reddish brown to black. *Luster:* [Greasy, waxy to adamantine.]
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group:* $Fd3m$. a = 10.2978(5) Z = 8

X-ray Powder Pattern: Monte di Procida, Italy.
2.973 (100), 1.820 (53), 1.552 (45), 2.574 (27), 1.181 (16), 1.151 (13), 1.051 (12)

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	27.5	32.9	Pr_2O_3		0.6
Ta_2O_5		2.4	Nd_2O_3	1.2	1.4
TiO_2	14.3	15.0	FeO	1.9	2.0
ZrO_2	1.1	1.0	CaO	16.0	16.0
ThO_2		4.5	Na_2O	1.7	1.7
UO_2		4.8	F	1.3	
Y_2O_3	0.6	0.6	H_2O	n.d.	n.d.
La_2O_3	0.7	0.7	$-O = F_2$	0.5	
CeO_2	4.0	4.0	Total	69.8	87.6

(1–2) Monte di Procida, Italy; by electron microprobe, the average corresponding to $[(Ca,Na)_{1.52}RE_{0.20}Th_{0.08}U_{0.08}]_{\Sigma=1.88}[(Nb,Ta)_{1.16}Ti_{0.84}(Fe,Mn,Mg,Al)_{0.12}Zr_{0.04}]_{\Sigma=2.16}(O,F)_7$.

Polymorphism & Series: Dimorphous with zirkelite.

Mineral Group: Pyrochlore group, betafite subgroup; $Ca_A > 20\%$; $2Ti_B \geq (Nb + Ta)_B$.

Occurrence: In a subvolcanic rock, locally termed "sanidinite", present in a phreatomagmatic explosion breccia.

Association: Sanidine, plagioclase, polymignite, zirkelite, zirconolite, magnesian hastingsitic amphibole, clinopyroxene, biotite, magnetite, apatite, titanite.

Distribution: From Monte di Procida, Campi Flegrei, near Naples, Campania, Italy. In Canada, at Hybla, Ontario.

Name: For a mineral with the *betafite* structure with high CALCIum content.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150338.

References: (1) Mazzi, F. and R. Munno (1983) Calciobetafite (new mineral of the pyrochlore group) and related minerals from Campi Flegrei, Italy; crystal structures of polymignyte and zirkelite: comparison with pyrochlore and zirconolite. Amer. Mineral., 68, 262–276. (2) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410.

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Calcioburbankite $Na_3(Ca, Ce, Sr)_3(CO_3)_5$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $6mm$, or $\overline{6}2c$. As imperfect prismatic crystals, elongated along [0001], to 2 cm, with dominant $\{10\overline{1}0\}$; also as equant crystals with $\{10\overline{1}0\}$ and $\{0001\}$ and fibrous terminations.

Physical Properties: *Cleavage:* Indistinct on $\{10\overline{1}0\}$. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 3.45(3) D(calc.) = 3.46

Optical Properties: Translucent. *Color:* Bright orange, pale pink. *Streak:* White. *Luster:* Vitreous, silky.
Optical Class: Uniaxial (–). $\omega = 1.636(1)$ $\epsilon = 1.631(1)$

Cell Data: *Space Group:* $P6_3mmc$, $P6_3mc$, or $P\overline{6}2c$. $a = 10.447(3)$ $c = 6.318(3)$ $Z = 2$

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.601 (10), 2.130 (6), 3.01 (5), 2.509 (5), 1.793 (5), 1.674 (5), 1.613 (5)

Chemistry:

	(1)
CO_2	[35.13]
La_2O_3	9.30
Ce_2O_3	14.38
Pr_2O_3	1.26
Nd_2O_3	3.76
Sm_2O_3	0.48
CaO	11.81
SrO	7.65
BaO	0.46
Na_2O	15.17
Total	[99.40]

(1) Mont Saint-Hilaire, Canada; by electron microprobe, CO_2 calculated from stoichiometry, absence of $(OH)^{1-}$ and H_2O confirmed by IR; corresponds to $Na_{3.07}(Ca_{1.32}Ce_{0.55}Sr_{0.46}La_{0.36}Nd_{0.14}Pr_{0.05}Sm_{0.02}Ba_{0.02})_{\Sigma=2.92}(CO_3)_5$.

Occurrence: A rare late stage mineral associated with an intrusive alkalic gabbro-syenite complex.

Association: Ancylite-(Ce), calcite, donnayite-(Y), fluorapatite, natrolite, pyrite, rhodochrosite, rutile, "chlorite" (vent or altered pegmatite); aegirine, calcite, fluorite, galena, leucophanite, mangan-neptunite, microcline, molybdenite-2H and -3R, narsarsukite, pectolite, pyrite, schairerite, shortite, sodalite, sphalerite, thermonatrite, titanite (marble xenoliths).

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: The *calcium* analog of *burbankite*.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 50804.

References: (1) Van Velthuizen, J., R.A. Gault, and J.D. Grice (1995) Calcioburbankite, $Na_3(Ca, REE, Sr)_3(CO_3)_5$, a new mineral species from Mont Saint-Hilaire, Quebec, and its relationship to the burbankite group of minerals. Can. Mineral., 33, 1231–1235. (2) (1996) Amer. Mineral., 81, 1013 (abs. ref. 1).

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Calciocatapleiite $CaZrSi_3O_9 \cdot 2H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. Lamellar crystals and grains, to a few cm. Crystals display three-fold twinning about the *c* axis.

Physical Properties: *Cleavage:* Present. Hardness = 4.5-5 D(meas.) = 2.77 D(calc.) = 2.746

Optical Properties: Opaque, translucent on thin edges. *Color:* Pale yellow to cream.
Luster: Vitreous to dull.
Optical Class: Uniaxial (+). ω = 1.603 ε = 1.639

Cell Data: *Space Group: Pbnn*. *a* = 7.378(1) *b* = 12.779(1) *c* = 10.096(1) *Z* = 4

X-ray Powder Pattern: Burpala massif, Russia; very close to catapleiite.
2.96 (100), 3.96 (80), 3.06 (80), 1.975 (80), 1.835 (80), 6.45 (70), 1.740 (70)

Chemistry:

	(1)
SiO_2	44.49
TiO_2	0.06
ZrO_2	31.00
Al_2O_3	0.60
RE_2O_3	0.28
Fe_2O_3	0.36
CaO	13.82
Na_2O	0.32
K_2O	0.10
H_2O+	9.15
H_2O^-	0.18
Total	100.36

(1) Burpala massif, Russia; leading to $(Ca_{0.98}Na_{0.04})_{\Sigma=1.02}Zr_{1.00}(Si_{2.94}Al_{0.04})_{\Sigma=2.98}O_9 \cdot 2.01H_2O$.

Occurrence: In cavities between crystals of microcline, in syenite pegmatites of a differentiated alkalic massif.

Association: Pyrophanite, pyrochlore, titanian låvenite, loparite-(Ce), kupletskite, RE-apatite, hiortdahlite, calcian seidozerite, leucophane, microcline.

Distribution: In the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, and from the Afrikanda complex, Kola Peninsula, Russia. At the Golden Horn batholith, Okanogan County, Washington, USA. From Strange Lake, Quebec-Labrador and Ice River, British Columbia, Canada. From the Norra Kärr complex, Småland, Sweden. At Cnoc Rhaonastil, Isle of Islay, Scotland, UK.

Name: For its *calcium* content and close relation to *catapleiite*. The change from the original name conforms to International Mineralogical Association guidelines.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; 7203/5.

References: (1) Portnov, A.M. (1964) Calcium catapleiite, a new variety of catapleiite. Doklady Acad. Nauk SSSR, 154, 607-609 (in Russian). (2) (1964) Amer. Mineral., 49, 1153 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 52. (4) Merlino, S., M. Pasero, M. Bellezza, D.Yu. Pushcharovsky, E.R. Gobetchia, N.V. Zubkova, and I.V. Pekov (2004) The crystal structure of calcium catapleiite. Can. Mineral. 42, 1037-1045. (5) (2005) Amer. Mineral., 90, 771 (abs. ref. 4).

Calciocopiapite $CaFe_4^{3+}(SO_4)_6(OH)_2 \cdot 20H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As powdery crusts.

Physical Properties: Hardness = [2–3] (by analogy to copiapite group members).
D(meas.) = n.d. D(calc.) = 2.225

Optical Properties: Semitransparent. *Color:* Grayish yellow to brownish yellow.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $[P\overline{1}]$ (by analogy to copiapite; ICDD 27-77). $a = 7.35$ $b = 18.21$ $c = 7.01$ $\alpha = 85.52°$ $\beta = 103.55°$ $\gamma = 100.62°$ Z = 1

X-ray Powder Pattern: Dashkesan deposit, Azerbaijan.
3.108 (10), 3.027 (10), 2.809 (10), 1.860 (10), 3.458 (9), 1.267 (9), 1.244 (9)

Chemistry:

	(1)	(2)
SO_3	39.00	38.92
Fe_2O_3	26.25	25.88
MgO	0.32	
CaO	4.85	4.54
H_2O	29.30	30.66
insol.	0.40	
Total	100.12	100.00

(1) Dashkesan deposit, Azerbaijan. (2) $CaFe_4(SO_4)_6(OH)_2 \cdot 20H_2O$.

Mineral Group: Copiapite group.

Occurrence: In the oxidized weathering zone of a magnetite–pyrite deposit.

Association: Chalcanthite, malachite, hydrous iron oxides.

Distribution: From the Dashkesan deposit, Middle Caucasus Mountains, Azerbaijan.

Name: As the *calcium* member of the *copiapite* group.

Type Material: n.d.

References: (1) Kashkai, M.A. and R.M. Aliev (1960) The new mineral calciocopiapite (tusiite) of the copiapite group and the general characteristics of this group. Akad. Nauk Azerbaijan SSR, Trudy Azerbaijan Geograph. Obshch, 49–76 (in Russian with English abs.). (2) (1962) Amer. Mineral., 47, 807–808 (abs. ref. 1).

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Calciodelrioite $Ca(VO_3)_2(H_2O)_4$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As terminated, prismatic crystals with {001} and {011} dominant. Typically as needles elongated and striated parallel to [100], forming parallel to sub-parallel intergrowths or divergent sprays to 2 mm or as very tightly intergrown broad blade-like aggregates in flat-lying "star bursts" to 2 mm.

Physical Properties: *Cleavage*: Perfect on {001}, others possible parallel [100]. *Tenacity*: Brittle. *Fracture*: Irregular to splintery. Hardness = 2.5 D(meas.) = n.d. D(calc.) = 2.451-2.503 Soluble in water.

Optical Properties: Transparent. *Color*: Colorless, tan to reddish brown, brown. *Streak*: White. *Luster*: Subadamantine (crystals), silky (aggregates).
Optical Class: Biaxial (+). $\alpha = 1.733(3)$ $\beta = 1.775(3)$ $\gamma = 1.825(3)$ 2V(meas.) = 87.3(9)° 2V(calc.) = 87° *Orientation*: $X = b$, $Z \approx a$. *Pleochorism*: None.

Cell Data: *Space Group*: *I*2/*a*. $a = 14.6389(10)$ $b = 6.9591(4)$ $c = 17.052(2)$ $\beta = 102.568(9)°$ Z = 8

X-ray Powder Pattern: West Sunday mine, Colorado, USA.
6.450 (100), 3.027 (50), 2.560 (28), 3.489 (18), 1.786 (18), 3.215 (17), 4.350 (16)

Chemistry:

	(1)	(2)	(3)
Na_2O	0.34	0.08	
K_2O	0.22	0.02	
CaO	15.83	13.39	18.09
SrO	2.31	6.87	
V_2O_5	58.13	56.96	58.67
H_2O	[23.16]	[22.66]	23.24
Total	99.99	99.98	100.00

(1) West Sunday mine, Colorado, USA; average of 11 electron microprobe analyses, H_2O calculated from structure refinement, results normalized to account for dehydration during analysis; corresponding to $(Ca_{0.88}Sr_{0.07}Na_{0.04}K_{0.01})_{\Sigma=1.00}(V_{1.00}O_3)_2(H_{2.01}O)_4$. (2) West Sunday mine, Colorado, USA; average of 10 electron microprobe analyses, H_2O calculated from structure refinement, results normalized to account for dehydration during analysis; corresponding to $(Ca_{0.76}Sr_{0.21}Na_{0.01})_{\Sigma=0.98}(V_{1.00}O_3)_2(H_{2.01}O)_4$. (3) $Ca(VO_3)_2(H_2O)_4$.

Polymorphism & Series: Forms a series with delrioite; dimorphous with rossite.

Occurrence: A secondary mineral as crystalline crusts on fracture surfaces in the oxidized portions of corvusite- and montroseite-impregnated sandstone.

Association: Gypsum, rossite, metarossite, celestine, huemulite, pascoite (West Sunday mine); delrioite, hendersonite, pascoite, powellite, schindlerite (St. Jude mine); delrioite, huemulite, hummerite, magnesiopascoite, powellite, K- and Mg-bearing decavanadate (Blue Streak mine); huemulite (Little Eva mine).

Distribution: From the West Sunday and St. Jude mines, Slick Rock district, San Miguel County; and at the Blue Streak mine, Bull Canyon, Montrose County, Colorado; and also at the Little Eva mine, Yellow Cat district, Grand County, Utah, USA.

Name: As the calcium (*Ca*) analog of *delrioite.*

Type Material: Natural History Museum of Los Angeles County, California, USA (# 63837, 63838, and 63839).

References: (1) Kampf, A.R., J. Marty, B.P. Nash, J. Plášil, A.V. Kasatkin, and R. Škoda (2012) Calciodelrioite, $Ca(VO_3)_2(H_2O)_4$, the Ca analog of delrioite, $Sr(VO_3)_2(H_2O)_4$. Mineral. Mag., 76(7), 2803-2817. (2) (2014) Amer. Mineral., 99, 2437-2438 (abs. ref. 1).

Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, flattened on [010], to 2 mm, in parallel or radiating groups; foliated, nodular or reniform, massive.

Physical Properties: *Cleavage:* One, perfect, parallel foliation; another, interrupted, perpendicular to the first; a third, also interrupted, oblique to the first. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.51–2.53 D(calc.) = 2.65

Optical Properties: Transparent to translucent, opaque if massive. *Color:* Sulfur-yellow, greenish yellow to siskin-green, yellowish white; yellow in transmitted light. *Streak:* Sulfur-yellow to white. *Luster:* Pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 61.5°$. *Dispersion:* $r < v$, strong.
$\alpha = 1.572–1.604$ $\beta = 1.579–1.610$ $\gamma = 1.583–1.612$ 2V(meas.) = 70°–80°

Cell Data: *Space Group:* $C2/c$. $a = 10.34(2)$ $b = 24.20(2)$ $c = 6.31(2)$ $\beta = 91°30'$
$Z = 2$

X-ray Powder Pattern: Kara-Tau Range, Kazakhstan.
12.10 (10), 2.903 (9), 2.652 (9), 2.592 (9), 1.578 (9b), 3.149 (7), 6.05 (6)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	34.01	34.00	34.8	MgO	2.65	3.20	3.2
SiO_2		0.10		CaO	14.81	17.30	17.8
Al_2O_3	2.90	8.00	6.8	H_2O^+		22.10	
Fe_2O_3	24.34	12.80	15.4	H_2O^-		1.50	
Cr_2O_3		0.50		H_2O	20.56		[22.0]
CuO		0.35		Total	99.27	99.85	[100.0]

(1) The Battenberg, Germany; Fe^{2+}:Fe^{3+} from stoichiometry; corresponds to $(Ca_{3.31}Fe^{2+}_{0.36})_{\Sigma=3.67}(Mg_{0.83}Fe^{2+}_{0.17})_{\Sigma=1.00}(Fe^{3+}_{3.29}Al_{0.71})_{\Sigma=4.00}(PO_4)_6(OH)_{3.34} \cdot 12.61H_2O$. (2) Kara-Tau Range, Kazakhstan; corresponding to $Ca_{3.88}Mg_{1.00}(Fe^{3+}_{2.08}Al_{1.97})_{\Sigma=3.99}(PO_4)_{6.02}(OH)_4 \cdot 12.85H_2O$.
(3) Moculta quarry, Australia; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponding to $Ca_{3.88}Mg_{0.97}(Fe^{3+}_{2.36}Al_{1.63})_{\Sigma=3.99}(PO_4)_6(OH)_{3.67} \cdot 13.11H_2O$.

Mineral Group: Montgomeryite group.

Occurrence: As nodules in a bed of Tertiary clay (The Battenberg, Germany); in phosphatic clay (Moculta quarry, Australia).

Association: Montgomeryite, jarosite, cacoxenite, tinticite, apatite, pyrite (Moculta quarry, Australia).

Distribution: In Germany, on the Battenberg, and from Hagendorf, Bavaria. On Sal Island, Cape Verde Islands. In the Moculta phosphate quarry, northeast of Angaston, South Australia. From an undefined locality in the Kara-Tau Range, Kazakhstan.

Name: For CALCIum and iron, FERRum, in the composition.

Type Material: Type material is claimed to have been analyzed by (2) Mead and Mrose, but no further details are given.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 976–977. (2) Mead, C.W. and M.E. Mrose (1968) Solving problems in phosphate mineralogy with the electron probe. U.S. Geol. Surv. Prof. Paper 600-D, D204–D206. (3) Dunn, P.J., W.L. Roberts, T.J. Campbell, and P.B. Leavens (1983) Red montgomeryite and associated minerals from the Tip Top pegmatite with notes on kingsmountite and calcioferrite. Mineral. Record, 14, 195–197. (4) Ankinovich, E.A., S.G. Ankinovich, A.A. Dara, and F.A. Kurmakaeva (1983) Ferrous montgomeryite of the Kara-Tau. Zap. Vses. Mineral. Obshch., 112, 84–88 (in Russian with English abs.). (5) Henderson, W.A., Jr. and V. Peisley (1985) Calcioferrite from the Moculta quarry near Angaston, South Australia. Mineral. Record, 16, 477–480.

Calciohilairite $CaZrSi_3O_9 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* 32. Equant trigonal crystals, to 2 mm, showing two prisms, $\{11\bar{2}0\}$ and $\{2\bar{1}\bar{1}0\}$, and right and left rhombohedra, $\{10\bar{1}2\}$ and $\{01\bar{1}2\}$.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4 D(meas.) = 2.68(2) D(calc.) = 2.74

Optical Properties: Semitransparent. *Color:* Pale blue or pale beige, white when altered. *Luster:* Vitreous to pearly, dull if altered.
Optical Class: Uniaxial (–). $\omega = 1.622(1)$ $\epsilon = 1.619(1)$

Cell Data: *Space Group: R*32. $a = 20.870(4)$ $c = 16.002(4)$ Z = [24]

X-ray Powder Pattern: Liberty Bell Mountain, Washington, USA.
5.231 (100), 3.013 (30), 3.137 (20), 5.993 (12), 2.607 (9), 2.900 (7), 3.197 (6)

Chemistry:

	(1)	(2)	(3)
SiO_2	38.81	41.16	43.58
TiO_2	0.09	0.04	
ZrO_2	31.64	33.58	29.79
Al_2O_3	2.61	0.05	
FeO	0.03	0.12	
CuO	0.19	0.42	
CaO	11.25	11.62	13.56
Na_2O	0.20	0.13	
H_2O	[15.18]	[12.88]	13.07
Total	[100.00]	[100.00]	100.00

(1–2) Liberty Bell Mountain, Washington, USA; by electron microprobe, H_2O by difference. (3) $CaZrSi_3O_9 \cdot 3H_2O$. (4) Near Saint-Amable, Canada; by electron microprobe, corresponds to $(Ca_{0.99}K_{0.01})_{\Sigma=1.00}(Zr_{0.96}Ti_{0.02}Mn_{0.01})_{\Sigma=0.99}(Si_{3.00}Al_{0.01})_{\Sigma=3.01}O_{8.98}$.

Occurrence: In miarolitic cavities in a peralkalic alaskitic border granite of a batholith (Liberty Bell Mountain, Washington, USA); in miarolitic cavities in a nepheline syenite sill (near Saint-Amable, Canada).

Association: Microcline, quartz, albite, fluorite, chlorite, bastnäsite, zircon, malachite (Liberty Bell Mountain, Washington, USA); nenadkevichite, rhodochrosite, polylithionite, fluorite, aegirine, astrophyllite, eudialyte, microcline, mangan-neptunite, pyrite (near Saint-Amable, Canada).

Distribution: In Washington Pass, on Liberty Bell Mountain, Okanogan Co., Washington, USA. From near Saint-Amable, Quebec, Canada.

Name: For the *calcium* content and relation to *hilairite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 161901, 162182.

References: (1) Boggs, R.C. (1988) Calciohilairite, $CaZrSi_3O_9 \cdot 3H_2O$, the calcium analogue of hilairite from the Golden Horn batholith, northern Cascades, Washington. Amer. Mineral., 73, 1191–1194. (2) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 95.

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Calciotantite $CaTa_4O_{11}$

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Crystal Data: Hexagonal. *Point Group:* 622. As crystals with square, rectangular, or hexagonal outlines, to 2 mm; may be included in microlite.

Physical Properties: Hardness = n.d. VHN = 970 (40 g load). D(meas.) = 7.46 D(calc.) = 7.40 Weak blue cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Adamantine.
Optical Class: Uniaxial.
R_1–R_2: (486) 16.9–16.3, (551) 17.0–16.6, (589) 17.1–16.7, (656) 18.2–18.0

Cell Data: *Space Group:* $P6_322$. $a = 6.245(3)$ $c = 12.323(4)$ $Z = 2$

X-ray Powder Pattern: Mt. Vasin-Myl'k, Russia.
3.02 (10), 1.508 (10), 2.78 (9), 3.15 (7), 1.793 (7), 1.551 (7), 2.47 (6)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	2.84	6.54	
Ta_2O_5	91.09	87.18	94.03
SnO_2		0.55	
PbO		0.09	
CaO	6.05	5.51	5.97
Na_2O	0.05	0.47	
Total	100.03	100.34	100.00

(1) Mt. Vasin-Myl'k, Russia; corresponds to $(Ca_{0.99}Na_{0.01})_{\Sigma=1.00}(Ta_{3.20}Nb_{0.80})_{\Sigma=4.00}O_{11}$.
(2) Do.; by electron microprobe, corresponds to $(Ca_{0.88}Na_{0.14})_{\Sigma=1.02}(Ta_{3.52}Nb_{0.44}Sn_{0.03})_{\Sigma=3.99}O_{10.90}$. (3) $CaTa_4O_{11}$.

Occurrence: In the albite-spodumene zone of granite pegmatites.

Association: Microlite, scheelite, wodginite, apatite (Mt. Vasin-Myl'k, Russia); cassiterite, lithiotantite, microlite, thoreaulite, cesplumtantite (Manono pegmatite, Congo).

Distribution: From Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia. At Ungursai, eastern Kazakhstan. In the Manono pegmatite, Katanga Province, Congo (Shaba Province, Zaire).

Name: For CALCIum and TANTalum in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5702/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81392.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, and F.M. Tyusheva (1982) Calciotantite, $CaTa_4O_{11}$, a new mineral from granitic pegmatites of the Kola Peninsula. Mineral. Zhurnal, 4(3), 75–79 (in Russian with English abs.). (2) (1983) Amer. Mineral., 68, 471 (abs. ref. 1). (3) Voloshin, A.V., Y.A. Pakhomovskii, L.V. Bulgak, and G.A. Perlina (1985) Ungursaite [calciotantite] - a new tantalate of calcium and sodium from granitic pegmatites. Mineral. Zhurnal, 7(4), 88–94 (in Russian with English abs.). (4) Yamnova, N.A., D.Y. Pushcharovskii, and A.V. Voloshin (1988) Identity of ungursaite with calciotantite and synthetic $CaTa_4O_{11}$. Kristallografiya (Sov. Phys. Crystal.), 33, 845–847 (in Russian).

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Calciouranoite $(Ca, Ba, Pb)U_2O_7 \cdot 5H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Prismatic to acicular crystals, radial fibrous in spherulites.

Physical Properties: *Cleavage:* One direction, pinacoidal. Hardness = 4 D(meas.) = 4.62 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* Red-orange, yellow-brown, orange-brown, brown; bright yellow in transmitted light. *Luster:* Greasy to dull.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X = Y$ = deep lemon-yellow; Z = pale yellow to almost colorless. *Absorption:* $X = Y > Z$. $\alpha = 1.76$ $\beta = 1.84$ $\gamma = 1.87$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Oktyabr'skoye U–Mo deposit; * = distinct lines, pattern indistinct otherwise.
4.00, *3.406, *3.050, 2.68, 2.00

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3	68.02	71.78	63.23	BaO	2.68		
As_2O_5	0.63			Na_2O	0.60		0.16
SiO_2	0.32	4.00	0.64	K_2O	5.81	0.06	1.77
Al_2O_3	0.34	0.69	0.20	H_2O^+	7.05	8.00	
Fe_2O_3	0.71		0.10	H_2O^-	5.31	3.03	
PbO	2.37	1.18	1.35	H_2O			7.29
CaO	5.86	6.77	14.90	CO_2			8.82
SrO			1.76	Total	99.70	[95.51]	100.22

(1) Oktyabr'skoye U–Mo deposit; after deduction of quartz impurity, corresponds to $(Ca_{0.74}Ba_{0.13}Pb_{0.07}Na_{0.06})_{\Sigma=1.00}U_{1.7}O_7 \cdot 4.8H_2O$. (2) Do.; original total given as 96.05%, after deduction of quartz impurity, corresponds to $(Ca_{0.95}Pb_{0.06})_{\Sigma=1.01}U_2O_7 \cdot 5H_2O$. (3) Do.; after deduction of calcite 20.25% and uranophane 1–2% corresponds to $(Ca_{0.58}K_{0.18}Sr_{0.16}Pb_{0.06}Na_{0.02})_{\Sigma=1.00}U_{2.12}O_7 \cdot 3.89H_2O$.

Occurrence: In stringers in felsite, deep in the oxidation zone of a U–Mo deposit, in water-saturated ore-bearing faults.

Association: Calcite, uranophane, bauranoite, metacalciouranoite, protasite.

Distribution: From the Oktyabr'skoye U–Mo deposit, 12 km southeast of Krasnokamensk, eastern Transbaikal, Russia.

Name: For CALCIum and URANium in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81272.

References: (1) Rogova, V.P., L.N. Belova, G.N. Kiziyarov, and N.N. Koznetsova (1974) Calciouranoite – a new hydroxide of uranium. Zap. Vses. Mineral. Obshch., 103, 108–109 (in Russian). (2) (1975) Amer. Mineral., 60, 161 (abs. ref. 1). (3) Fedorov, O.V., B.I. Ryzhkov, and G.V. Lyubomilova (1982) Potassium-strontium variety of calciouranoite. Doklady Acad. Nauk SSSR, 262, 209–213 (in Russian).

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Calcite $CaCO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. Well-formed crystals are common, $\{10\overline{1}1\}$, $\{21\overline{3}1\}$, thin to thick tabular $\{0001\}$, with combinations of over 1000 forms noted, to 7 m; granular, stalactitic, in concretions, massive. *Twinning:* On $\{01\overline{1}2\}$, $\{10\overline{1}1\}$, $\{0001\}$, $\{02\overline{2}1\}$ as twin and composition planes.

Physical Properties: *Cleavage:* $\{10\overline{1}1\}$, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.7102(2) D(calc.) = 2.711 May fluoresce red, blue, yellow, and other colors under either SW and LW UV; phosphorescent, cathodoluminescent, thermoluminescent, rarely triboluminescent.

Optical Properties: Transparent to opaque. *Color:* Colorless or white, also gray, yellow, green, many other colors from included minerals; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous; pearly on cleavages and $\{0001\}$.
Optical Class: Uniaxial (–); anomalously biaxial. *Dispersion:* Very strong.
Absorption: $O > E$. $\omega = 1.658$ $\epsilon = 1.486$ 2V(meas.) = 0° to small.

Cell Data: *Space Group:* $R\overline{3}c$. a = 4.9896(2) $c = 17.0610(11)$ Z = 6

X-ray Powder Pattern: Synthetic.
3.035 (100), 2.285 (18), 2.095 (18), 1.913 (17), 1.875 (17), 2.495 (14), 3.86 (12)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	[44.22]	43.97	MgO	1.74	
FeO	0.43		CaO	53.60	56.03
			Total	[99.99]	100.00

(1) Monterey Formation, California, USA, CO_2 calculated from stoichiometry. (2) $CaCO_3$.

Polymorphism & Series: Trimorphous with aragonite and vaterite; forms a series with rhodochrosite.

Mineral Group: Calcite group.

Occurrence: A major rock-forming mineral; in limestones, marbles, chalks, a common cement in clastic sedimentary rocks, and as gangue in hydrothermal veins; in alkalic to mafic igneous rocks; common as speleothems in caves.

Association: Dolomite, celestine, fluorite, barite, pyrite, marcasite, sphalerite (low-temperature veins); zeolites, chalcedony, "chlorite" (vesicles); talc, tremolite, grossular, quartz (metamorphic); nepheline, diopside, apatite, orthoclase (igneous).

Distribution: Abundant worldwide; a few of the many localities include: in Iceland, at the Helgustadanáma mine, Reydarfjord. In England, from Alston Moor, Egremont, and Frizington, Cumbria; Weardale, Durham; at Liskeard, Cornwall. From St. Andreasberg, Harz Mountains, and Freiberg, Saxony, Germany. At Herja (Kisbánya), Baia Mare (Nagybánya) district, Romania. In the USA, from Rossie and Balmat, St. Lawrence Co., New York; at Hancock, Houghton Co., and in the Phoenix mine, Keeweenaw Co., Michigan; in Missouri, from many mines in Reynolds Co., and at Joplin, Jasper Co.; Galena, Cherokee Co., Kansas; and Picher, Ottawa Co., Oklahoma, in the Tri-State district; from the Elmwood mine, near Carthage, Smith Co., Tennessee; at Bisbee, Cochise Co., Arizona. In Mexico, from Santa Eulalia, and in Areponapuchic Canyon, Chihuahua; at many mines at Guanajuato; from Charcas, San Luis Potosi. At Dal'negorsk, Primorskiy Krai, Russia. From Tsumeb, Namibia. In the Mupine mine, Katanga Province, Congo (Shaba Province, Zaire).

Name: From the Latin *calx*, for *burnt lime*, an allusion to an important commercial use.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 142–160. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 108–135. (3) Effenberger, H., K. Mereiter, and J. Zemann (1981) Crystal structure refinements of magnesite, calcite, rhodochrosite, siderite, smithsonite, and dolomite, with discussion of some aspects of the stereochemistry of calcite type carbonates. Zeits. Krist., 156, 233–243. (4) (1953) NBS Circ. 539, II, 51.

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Calcium catapleiite $CaZrSi_3O_9 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $[6/m\ 2/m\ 2/m]$ (by analogy to catapleiite). Lamellar crystals and grains, to a few cm.

Physical Properties: *Cleavage:* Present. Hardness = 4.5–5 D(meas.) = 2.77 D(calc.) = [2.75]

Optical Properties: Opaque, translucent on thin edges. *Color:* Pale yellow to cream. *Luster:* Vitreous to dull.
Optical Class: Uniaxial (+). $\omega = 1.603$ $\epsilon = 1.639$

Cell Data: *Space Group:* $[P6_3/mmc.]$ $a = 7.40$ $c = 10.07$ Z = [2]

X-ray Powder Pattern: Burpala massif, Russia; very close to catapleiite.
2.96 (100), 3.96 (80), 3.06 (80), 1.975 (80), 1.835 (80), 6.45 (70), 1.740 (70)

Chemistry:

	(1)
SiO_2	44.49
TiO_2	0.06
ZrO_2	31.00
Al_2O_3	0.60
RE_2O_3	0.28
Fe_2O_3	0.36
CaO	13.82
Na_2O	0.32
K_2O	0.10
H_2O^+	9.15
H_2O^-	0.18
Total	100.36

(1) Burpala massif, Russia; leading to $(Ca_{0.98}Na_{0.04})_{\Sigma=1.02}Zr_{1.00}(Si_{2.94}Al_{0.04})_{\Sigma=2.98}O_9 \cdot 2.01H_2O$.

Occurrence: In cavities between crystals of microcline, in syenite pegmatites of a differentiated alkalic massif.

Association: Pyrophanite, pyrochlore, titanian låvenite, loparite-(Ce), kupletskite, RE-apatite, hiortdahlite, calcian seidozerite, leucophane, microcline.

Distribution: In the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, Russia.

Name: For its *calcium* content and close relation to *catapleiite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72035.

References: (1) Portnov, A.M. (1964) Calcium catapleiite, a new variety of catapleiite. Doklady Acad. Nauk SSSR, 154, 607–609 (in Russian). (2) (1964) Amer. Mineral., 49, 1153 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 52.

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Calcjarlite $Na(Ca,Sr)_3Al_3(F,OH)_{16}$

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Crystal Data: [Monoclinic] (by analogy to jarlite). *Point Group:* n.d. As elongated tabular crystals in radial aggregates, to 2 mm.

Physical Properties: *Fracture:* Uneven. Hardness = ∼4 D(meas.) = 3.51 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Colorless to white; colorless in thin section.
Luster: Vitreous.
Optical Class: Biaxial (+); rarely (−). *Orientation:* $Z \wedge c = 15°$. $\alpha = 1.425(1)$ $\beta = 1.428(1)$ $\gamma = 1.432(1)$ 2V(meas.) = 72°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Pravaya Noiba River, Russia.
2.96 (10), 3.04 (7), 3.16 (6), 3.51 (5), 2.23 (4), 2.15 (4), 3.44 (3)

Chemistry:

	(1)
Al_2O_3	26.46
MgO	4.21
CaO	17.40
SrO	11.33
BaO	4.46
Na_2O	4.78
K_2O	0.97
F	47.50
H_2O^+	3.10
H_2O^-	0.00
$-O = F_2$	19.95
Total	100.26

(1) Pravaya Noiba River, Russia; corresponds to $(Na_{0.87}K_{0.11})_{\Sigma=0.98}(Ca_{1.75}Sr_{0.61}Mg_{0.58}Ba_{0.16})_{\Sigma=3.10}Al_{2.94}[F_{14.06}(OH)_{1.94}]_{\Sigma=16.00}$.

Occurrence: In a fluorite vein in quartz-mica schists.

Association: Fluorite, thorite, usovite, chamosite, phillipsite, erionite, micas, halloysite.

Distribution: Near the mouth of the second tributary to the Pravaya Noyba River, tributary to the Teya River, Yenisei Ridge, Siberia, Russia.

Name: As a CALCium analog of *jarlite*.

Type Material: Mineralogical Museum, Tomsk Polytechnical Institute, Tomsk; Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, Novosibirsk, Russia.

References: (1) Nozhkin, A.D., V.A. Moleva, and T.P. Chubkova (1970) First find of jarlite in the USSR. Zap. Vses. Mineral. Obshch., 99, 458–462 (in Russian). (2) Povarennykh, A.S. (1973) The new mineral species calcjarlite. Konst. Svoistva Mineral., 7, 131–135 (in Russian). (3) (1972) Mineral. Abs., 23, 316 (abs. ref. 1). (4) (1974) Amer. Mineral., 59, 873 (abs. refs. 1 and 2).

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Calclacite $Ca(C_2H_3O_2)Cl \cdot 5H_2O$

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Crystal Data: Monoclinic (synthetic). *Point Group:* $2/m$. As silky hairlike efflorescences, to 4 cm.

Physical Properties: Hardness = n.d. D(meas.) = 1.5 D(calc.) = 1.55

Optical Properties: Semitransparent *Color:* White. *Luster:* Silky in aggregates. *Optical Class:* Biaxial (+). *Orientation:* $Z = c$; OAP = {100}. $\alpha = 1.468$ $\beta = 1.484$ $\gamma = 1.515$ 2V(meas.) = 80°

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 11.51$ $b = 13.72$ $c = 6.82$ $\beta = 116.7°$ Z = 4

X-ray Powder Pattern: Synthetic.
8.27 (s), 3.24 (s), 2.43 (s), 6.87 (m), 4.16 (m), 2.30 (m), 6.15 (w)

Chemistry:

	(1)	(2)
Ca	17.6	17.84
Cl	15.4	15.78
$C_2H_3O_2$	25.5	26.28
H_2O	39.5	40.10
Total	98.0	100.00

(1) On a museum specimen of calcareous schist. (2) $Ca(C_2H_3O_2)Cl \cdot 5H_2O$.

Occurrence: Forms on calcareous rock and fossil specimens and pottery sherds thorough the action of acetic acid derived from oak storage cabinets.

Association: Unspecified efflorescent salts.

Distribution: Described only from museum specimens.

Name: From the composition, CALcium, chlorine, CL, and ACetate.

Type Material: Royal Institute of Natural Sciences, Brussels, Belgium, N5518.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1107. (2) Van Tassel, R. (1958) On the crystallography of calclacite, $Ca(CH_3COO)Cl \cdot 5H_2O$. Acta Cryst., 11, 745–746.

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Calcurmolite $Ca(UO_2)_3(MoO_4)_3(OH)_2 \cdot 11H_2O$

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Crystal Data: n.d. *Point Group:* n.d. As prismatic crystals, to 1.5 mm, in bundles or radial platy aggregates; as crusts of vermiform spherical aggregates of platy crystals.

Physical Properties: Hardness = 2–3 D(meas.) = n.d. D(calc.) = n.d. Radioactive; strong yellowish green fluorescence under UV.

Optical Properties: Translucent. *Color:* Deep honey-yellow, bright yellow.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale yellow; Z = yellow.
$\alpha = 1.760–1.770$ $\beta = 1.816–1.827$ $\gamma = 1.856–1.863$ 2V(meas.) = n.d. 2V(calc.) = 76°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kadzharan deposit, Armenia.
7.80 (100), 3.21 (80), 3.89 (60), 8.33 (50), 1.99 (50), 1.855 (40), 4.29 (30)

Chemistry:

	(1)	(2)	(3)
MoO_3	23.83	21.62	27.64
UO_3	47.73	65.48	54.93
SiO_2	6.18		
$(Al + Fe)_2O_3$	2.76		
CaO	3.30	3.20	3.59
H_2O	12.90	9.59	13.84
Total	96.70	99.89	100.00

(1) Kyzylsai Mo–U deposit, Kazakhstan; after deduction of impurities, corresponds to $Ca_{1.06}(UO_2)_3(MoO_4)_{2.98}(OH)_2 \cdot 10.88H_2O$. (2) Rabéjac deposit, France; by electron microprobe, H_2O by gas chromatography. (3) $Ca(UO_2)_3(MoO_4)_3(OH)_2 \cdot 11H_2O$.

Occurrence: A secondary mineral in the lower oxidized zone of Mo–U deposits.

Association: Uraninite, uranophane, uranospinite, halloysite, betpakdalite, jarosite, ferrimolybdite (Kadzharan deposit, Armenia); umohoite, uranophane (Rabéjac deposit, France); yingjiangite, studtite, kivuite, tengchongite, autunite (Tongbiguan village, China).

Distribution: From the Kadzharan molybdenum deposit, upper Okhcha River, Kafan district, Armenia. In the Kyzylsai Mo–U deposit, Chu-Ili Mountains, southwestern Balkhash region, Kazakhstan. At Tongbiguan village, Yingjiang Co., Yunnan Province, China. From the Rabéjac and Mas-d'Alary uranium deposits, south of Lodève, Hérault, France.

Name: For the essential chemical components, CALCium, URanium, and MOLybdenum.

Type Material: n.d.

References: (1) Rudnitskaya, L.S. (1958) Calcium uranium molybdate, $Ca(UO_2)_3(MoO_4)_3(OH)_2 \cdot 8H_2O$. Proc. 2nd Internat. Conf. Peaceful Uses of Atomic Energy, Geneva, 2, 286 [kadzharanite = calcurmolite]. (2) Fedorov, O.V. (1963) The second find of calcium uranium molybdate in the USSR. Zap. Vses. Mineral. Obshch., 92, 464–465 (in Russian). (3) Deliens, M. (1992) Etude comparative des calcurmolites de Rabejac (Lodeve, Herault, France) et de l'Union Sovietique. Ann. Soc. Géol. Belg., 115, 91–97 (in French with English abs.). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 52–53.

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Calderite $(Mn^{2+}, Ca)_3(Fe^{3+}, Al)_2(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Granular, massive.

Physical Properties: Hardness = 7 D(meas.) = 4.05 D(calc.) = 4.07

Optical Properties: Semitransparent. *Color:* Dark reddish brown to dark yellowish; yellow to pale greenish yellow in thin section.
Optical Class: Isotropic; shows slight anisotropism. $n = 1.875$–1.934

Cell Data: *Space Group: Ia3d.* $a = 11.81$ $Z = 8$

X-ray Powder Pattern: Otjosondu, Namibia.
2.62 (100), 1.574 (100), 2.92 (90), 2.39 (90), 1.632 (90), 0.968 (90), 1.906 (80)

Chemistry:

	(1)	(2)
SiO_2	35.16	32.4
TiO_2	0.28	
Al_2O_3	9.04	
Fe_2O_3	16.27	31.4
FeO	0.00	
MnO	27.38	29.0
MgO	0.50	
CaO	12.12	8.5
Total	100.75	101.3

(1) Otjosondu, Namibia; by electron microprobe; corresponds to $(Mn_{1.96}Ca_{1.10})_{\Sigma=3.06}(Fe^{3+}_{1.04}Al_{0.87}Mg_{0.06}Ti_{0.02})_{\Sigma=1.99}(Si_{2.97}Al_{0.03})_{\Sigma=3.00}O_{12}$. (2) Wabush district, Canada; by electron microprobe, corresponds to $(Mn_{2.20}Ca_{0.82})_{\Sigma=3.02}Fe^{3+}_{2.02}(Si_{2.90}Al_{0.10})_{\Sigma=3.00}O_{12}$.

Mineral Group: Garnet group.

Occurrence: In a manganese deposit (Otjosondu, Namibia); in an iron formation (Wabush district, Canada).

Association: Pyrolusite, aegirine, rhodonite, hematite, rhodochrosite, quartz, kutnohorite (Wabush district, Canada).

Distribution: From Katkamsandi, Hazaribagh district, Bihar, and at Netra, Balaghat district, Madhya Pradesh, India. At Otjosondu, Namibia. In the Wabush district, near Labrador City, Labrador, Newfoundland, Canada. From the Fianel mine, Val Ferrera, Graubünden, Switzerland.

Name: For James Calder, an early writer on the geology of India; name first applied to a rock, later transferred to its predominant mineral.

Type Material: n.d.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 443.
(2) Vermaas, F.H.S. (1952) Manganese-iron garnet from Otjosondu, South-West Africa. Mineral. Mag., 29, 946–951. (3) Klein, C., Jr. (1966) Mineralogy and petrology of the metamorphosed Wabush Iron Formation, southwestern Labrador. J. Petrol., 7, 246–305.
(4) Dunn, P.J. (1979) On the validity of calderite. Can. Mineral., 17, 569–571. (5) Amthauer, G., K. Katz-Lehnert, D. Lattard, M. Okrusch, and E. Woermann (1989) Crystal chemistry of natural Mn^{3+} -bearing calderite-andradite garnets from Otjosondu, SWA/Namibia. Zeits. Krist., 189, 43–56.

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Caledonite $Pb_5Cu_2(SO_4)_3(CO_3)(OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As striated prismatic [001] crystals, to 2.5 cm, typically flattened on {100} and displaying many forms, including {010}, {100}, {120}, {101}, {131}, {011}, {111}, {121}. In divergent aggregates, rarely fibrous; as massive coatings.

Physical Properties: *Cleavage:* On {010}, perfect; on {100} and {101}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 5.6–5.76 D(calc.) = 5.69 Piezoelectric.

Optical Properties: Translucent to transparent. *Color:* Deep verdigris-green, blue-green; pale bluish green in transmitted light. *Streak:* Pale green. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (–). *Pleochroism:* Weak. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, barely perceptible. $\alpha = 1.818(3)$ $\beta = 1.866(3)$ $\gamma = 1.909(3)$ 2V(meas.) = ∼85°

Cell Data: *Space Group:* $Pnm2_1$. $a = 7.146(3)$ $b = 20.089(7)$ $c = 6.560(5)$ Z = 2

X-ray Powder Pattern: Red Gill mine, England.
3.139 (100), 4.69 (57), 3.031 (55), 1.861 (55), 2.752 (43), 3.152 (36), 2.226 (36)

Chemistry:

	(1)	(2)
SO_3	14.15	14.89
CO_2	3.16	2.73
PbO	69.18	69.17
CuO	9.73	9.86
H_2O	3.78	3.35
Total	[100.00]	100.00

(1) Challacollo, Chile; recalculated to 100% after deduction of insoluble 2.31%; corresponds to $Pb_{5.06}Cu_{2.00}(SO_4)_{2.90}(CO_3)_{1.18}(OH)_{5.96}$. (2) $Pb_5Cu_2(SO_4)_3(CO_3)(OH)_6$.

Occurrence: An uncommon secondary mineral in the oxidized portions of Pb–Cu deposits.

Association: Cerussite, anglesite, leadhillite, brochantite, linarite, azurite, malachite.

Distribution: Widely distributed, although fine specimens are uncommon. In Scotland, from Leadhills, Lanarkshire, and Wanlockhead, Dumfriesshire. At Red Gill and other mines, Caldbeck Fells, Cumbria, England. In the Preobrazhensky mine, Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. Large crystals from Tchah Milleh, Anarak, Iran. In the USA, in Arizona, large crystals in rich masses from the Mammoth-St. Anthony mine, Tiger, Pinal Co., in the Rowley mine, near Theba, Maricopa Co., and elsewhere; from the Mex-Tex mine, near Bingham, Hansonburg district, Socorro Co., New Mexico; large crystals from the Blue Bell mine, near Baker, San Bernardino Co., at the Chance mine, Chidago Canyon, Mono Co., and from Cerro Gordo, Inyo Co., California. At Challacollo, Tarapacá, Chile. From Paddy's River mine, Australian Capital Territory, Australia.

Name: From the Latin *Caledonia*, the Roman name for the Highlands of Scotland, the first known locality.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 630–632. (2) Giacovazzo, C., S. Menchetti, and F. Scordari (1973) The crystal structure of caledonite, $Cu_2Pb_5(SO_4)_3CO_3(OH)_6$. Acta Cryst., 29, 1986–1990. (3) Giacovazzo, C., S. Menchetti, and F. Scordari (1976) X-ray powder data for caledonite. Mineral. Mag., 40, 536.

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Calkinsite-(Ce) $(Ce,La)_2(CO_3)_3 \cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. As platy {010} crystals, to 1 mm. *Twinning:* Commonly twinned on {101}, compound and elongated along [100].

Physical Properties: *Cleavage:* {010}, perfect; {101}, distinct; {001}, a parting (?). Hardness = ~2.5 D(meas.) = 3.28(1) D(calc.) = [3.27]

Optical Properties: Translucent. *Color:* Pale yellow. *Optical Class:* Biaxial (–). *Pleochroism:* X = yellow; $Y = Z$ = colorless. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak. $\alpha = 1.569$ $\beta = 1.657$ $\gamma = 1.686$ 2V(meas.) = 54° 2V(calc.) = 57.2°

Cell Data: *Space Group:* $P2_122_1$. $a = 9.57(2)$ $b = 12.65(8)$ $c = 8.94(2)$ Z = 4

X-ray Powder Pattern: Big Sandy Creek, Montana, USA.
6.54 (10b), 3.27 (5), 4.78 (4), 4.49 (4), 2.931 (3b), 2.128 (3), 2.115 (3)

Chemistry:

	(1)
CO_2	23.93
La_2O_3	19.82
Ce_2O_3	32.05
Pr_2O_3	2.89
Nd_2O_3	7.97
H_2O	13.34
Total	[100.00]

(1) Big Sandy Creek, Montana, USA; recalculated to 100% after deduction of impurities 11.65%, from an original total of 100.47%; corresponds to $(Ce_{1.03}La_{0.67}Nd_{0.26}Pr_{0.10})_{\Sigma=2.06}(CO_3)_{3.00} \cdot 4.09H_2O$.

Occurrence: A weathering product closely associated with burbankite, in calcite veins cutting shonkinite in a composite stock (Big Sandy Creek, Montana, USA).

Association: Burbankite, ancylite, lanthanite, barite, goethite, calcite, "biotite" (Big Sandy Creek, Montana, USA); barite, strontianite, pyrite (Vuoriyarvi massif, Kola Peninsula, Russia); dolomite, khanneshite, carbocernaite, mckelveyite, barite, "chlorite" (Khanneshin complex, Afghanistan).

Distribution: In the USA, from vermiculite prospects at the head of Big Sandy Creek, Rocky Boy's Indian Reservation, about 40 km east of Box Elder, Hill Co., Montana. At the Vuoriyarvi carbonatite massif, Kola Peninsula, Russia. From the Khanneshin carbonatite complex, Afghanistan.

Name: Honors Frank Cathcart Calkins (1878–1974), geologist with the U.S. Geological Survey.

Type Material: n.d.

References: (1) Pecora, W.T. and J.H. Kerr (1953) Burbankite and calkinsite, two new carbonate minerals from Montana. Amer. Mineral., 38, 1169–1183.

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Callaghanite $Cu_2Mg_2(CO_3)(OH)_6 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are pseudo-octahedral to dipyramidal, dominated by {111} and $\{11\overline{1}\}$, modified by {122} and $\{12\overline{2}\}$, to 3 mm; as incrustations and massive in veinlets.

Physical Properties: *Cleavage:* On {111} and $\{11\overline{1}\}$, perfect. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 2.71 D(calc.) = 2.65

Optical Properties: Transparent to translucent. *Color:* Azure-blue. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* In shades of blue. *Orientation:* $Z \wedge a = 18°$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > Y > X$. $\alpha = 1.559$ $\beta = 1.653$ $\gamma = 1.680$
2V(meas.) = 55°

Cell Data: *Space Group:* $C2/c$. $a = 10.0060(7)$ $b = 11.7520(8)$ $c = 8.2132(7)$ $\beta = 107°23'$ Z = 4

X-ray Powder Pattern: Gabbs, Nevada, USA.
7.45 (10), 6.17 (10), 3.87 (9), 3.18 (9), 2.30 (7), 4.80 (6), 3.72 (6)

Chemistry:

	(1)	(2)
CO_2	11.46	11.77
CuO	38.27	42.56
MgO	20.86	21.57
CaO	8.89	
H_2O	20.51	24.10
Total	99.99	100.00

(1) Gabbs, Nevada, USA; after deduction of calcite impurity, with $(OH)^{1-}$ calculated for charge balance, corresponds to $Cu_{1.93}Mg_{2.07}(CO_3)_{0.82}(OH)_{6.36} \cdot 2H_2O$. (2) $Cu_2Mg_2(CO_3)(OH)_6 \cdot 2H_2O$.

Occurrence: Disseminated in the contact zone between diorite and serpentinized dolostone.

Association: Magnesite, dolomite, serpentine, brucite, forsterite.

Distribution: From near Gabbs, Gabbs district, Nye Co., Nevada, USA.

Name: Honors Dr. Eugene Callaghan (1904–1990), Director of the New Mexico Bureau of Mines, Socorro, New Mexico, USA, for his work on magnesite deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, R9406.

References: (1) Beck, C.W. and J.H. Burns (1954) Callaghanite, a new mineral. Amer. Mineral., 39, 630–635. (2) Brunton, G. (1973) Refinement of the callaghanite structure. Amer. Mineral., 58, 551.

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Calomel HgCl

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Of variable and complex habit; crystals commonly tabular on {001}, prismatic ‖ [001], equant pyramidal, to 1 cm; in drusy crusts, earthy, massive. *Twinning:* On {112}, contact and penetration twins, may be repeated.

Physical Properties: *Cleavage:* Good on {110}, uneven; imperfect on {011}. *Fracture:* Conchoidal. *Tenacity:* Sectile, plastic. Hardness = 1.5 D(meas.) = 7.15 D(calc.) = 7.23 Fluoresces brick-red under UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, ash-gray, yellowish gray, brown, color deepening on exposure to light; colorless in transmitted light. *Streak:* Pale yellowish white. *Luster:* Adamantine.
Optical Class: Uniaxial (+). *Pleochroism:* Weak. *Absorption:* $E > O$. $\omega = 1.973$ $\epsilon = 2.656$

Cell Data: *Space Group:* $I4/mmm$ (synthetic). a = 4.4795(5) $c = 10.9054(9)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.170 (100), 4.15 (75), 2.067 (40), 2.727 (30), 1.962 (30), 1.970 (16), 2.824 (12)

Chemistry: Analyses of natural material are not available.

Polymorphism & Series: Forms a series with kuzminite.

Occurrence: An uncommon secondary mineral formed through the alteration of other mercury minerals.

Association: Mercury, amalgam, cinnabar, mercurian tetrahedrite, eglestonite, terlinguaite, montroydite, kleinite, moschelite, kadyrelite, kuzminite, chursinite, kelyanite, calcite, "limonite", clay minerals.

Distribution: From Moschellandsberg [ck?? Landsberg, near Obermoschel??], Rhineland-Palatinate, Germany [TL]. At Alva, Serbia. Large crystals from Almadén, Ciudad Real Province, Spain. Found near Montpellier, Hérault, France. In England, at the Chatsworth mine, Grassington Moor, Yorkshire. From the Kadyrel deposit, Tuva, Siberia, Russia. Rich specimens from El Doktor, Queretaro; Huahuaxtla, Guerrero; Plateros, Zacatecas; and elsewhere in Mexico. In the USA, in California, near Palo Alto, San Mateo Co., and the Redington mine, Napa Co.; from the Sunflower district, Maricopa Co., Arizona; in the McDermitt mine, Humboldt Co., Nevada; abundant at Terlingua, Brewster Co., Texas; and from near Jackfork, Pike Co., Arkansas. Some other minor localities are known.

Name: Of uncertain origin; possibly from the Greek for *beautiful* and *honey*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 25–28. (2) Calos, N.J., C.H.L. Kennard, and R.L. Davis (1989) The structure of calomel, Hg_2Cl_2, derived from neutron powder data. Zeits. Krist., 187, 305–307. (3) (1976) NBS Mono. 25, 13, 30.

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Calumetite $Cu(OH,Cl)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As spherules and sheaves of scaly crystals, subparallel on {001}, with {001} and {110}.

Physical Properties: *Cleavage:* {001}, good. *Tenacity:* Brittle. Hardness = 2
D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Brilliant azure to powder blue; bluish white on the cleavage. *Luster:* Pearly on the cleavage.
Optical Class: Biaxial (–). *Pleochroism:* Feeble; in blues. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Absorption:* $Z \geq Y > X$. $\alpha = 1.666$ $\beta = 1.690$ $\gamma = 1.690$ 2V(meas.) = 2°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Centennial mine, Michigan, USA.
7.50 (10), 2.481 (8), 3.02 (6), 3.76 (5), 3.42 (3), 3.30 (3), 2.341 (3)

Chemistry:

	(1)
AgCl	0.17
Cu	44.1
Cl	5.3
$H_2O^+ + OH$	33.5
H_2O^+	16.9
Total	99.97

(1) Centennial mine, Michigan, USA; Cu by electrolysis, H_2O:OH from charge balance; corresponding to $Cu_{0.99}[(OH)_{1.78}Cl_{0.22}]_{\Sigma=2.00} \cdot 2.35H_2O$.

Occurrence: In cavities and fractures in basalt, formed by the action of chlorine-bearing connate waters on copper, cuprite being regarded as an intermediate product in the alteration (Centennial mine, Michigan, USA).

Association: Tremolite, quartz, epidote, monazite, copper, cuprite, atacamite, buttgenbachite, malachite, paratacamite, anthonyite (Centennial mine, Michigan, USA).

Distribution: In the USA, from the Centennial and other nearby mines, near Calumet, Houghton Co., Michigan. From Laurium, Greece, in slag. In Germany, from Niederfischbach, Siegerland, and at Richelsdorf, Hesse, in slag.

Name: For the town of Calumet, Michigan, USA, near which it was first discovered.

Type Material: National Museum of Natural History, Washington, D.C., USA, 115870.

References: (1) Williams, S.A. (1963) Anthonyite and calumetite, two new minerals from the Michigan copper district. Amer. Mineral., 48, 614–619.

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Calvertite $Cu_5Ge_{0.5}S_4$

Crystal Data: Isometric. *Point Group*: n.d. As anhedral, elongate to elliptical grains, to 100 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular to conchoidal. *Tenacity*: Brittle. Hardness = 4-5 VHN = 268-307 (25 g load). D(meas.) = n.d. D(calc.) = 5.239

Optical Properties: Opaque. *Color*: Black; pale bluish-gray in reflected light. *Streak*: Black. *Luster*: Metallic. *Birefringence:* None. *Pleochroism:* None. *Internal reflections*: None observed. *Optical Class*: Isotropic.
R_{air}-R_{oil}: (400) 28.0-13.5, (420) 27.6-13.3, (440) 27.1-12.8, (460) 26.7-12.3, (480) 25.9-11.5, (500) 25.0-10.8, (520) 24.2-10.1, (540) 23.5-9.5, (560) 22.8-9.1, (580) 22.3-8.8, (600) 22.1-8.6, (620) 21.8-8.5, (640) 21.6-8.5, (660) 21.5-8.5, (680) 21.5-8.4, (700) 21.5-8.4

Cell Data: *Space Group*: *Fm*3*m*, *F*432, or $F\bar{4}3m$. $a = 5.337(1)$ $Z = 1$
Metastable and highly disordered; the ordered equivalent would be $Cu_{10}GeS_8$ with $a = 2 \times 5.337$ Å.

X-ray Powder Pattern: Tsumeb mine, Namibia. (Although matching the pattern for synthetic material, these 4 lines are not definitive as they match strong lines for reinerite, germanocolusite, and germanite).
3.053 (100), 1.869 (90), 1.595 (30), 2.639 (10)

Chemistry:

	(1)
Cu	63.10
Fe	1.66
Zn	0.55
Ge	5.67
As	1.50
Ga	0.36
V	0.05
S	26.63
Total	99.60

(1) Tsumeb mine, Namibia; average of 8 electron microprobe analyses, corresponding to $(Cu_{4.782}Fe_{0.143}Zn_{0.041}Ga_{0.025}V_{0.005})_{\Sigma=4.996}(Ge_{0.382}\ As_{0.096})_{\Sigma=0.478}S_4$.

Occurrence: In a highly oxidized, polymetallic, fractured and brecciated dolomite and sandstone pipe.

Association: Reinerite, tennantite, gallite, chalcocite.

Distribution: Tsumeb mine, Namibia.

Name: Honors Lauriston (Larry) Derwent Calvert (1924–1993) of the National Research Council, Ottawa, Canada for his studies of metallic phases and contributions to the Powder Diffraction File (ICDD).

Type Material: Canadian Museum of Nature, Ottawa (CMNMC 85731), and the Natural History Museum, London, England (BM 2004, 78).

References: (1) Jambor, J.L., A.C. Roberts, L.A. Groat, C.J. Stanley, A.J. Criddle, and M.N. Feinglos (2007) Calvertite, $Cu_5Ge_{0.5}S_4$, a new mineral species from Tsumeb, Namibia. Can. Mineral., 45, 1519–1523. (2) (2008) Amer. Mineral., 93, 1686 (abs. ref. 1).

Calzirtite $Ca_2Zr_5Ti_2O_{16}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Single crystals exhibit a prismatic dipyramidal habit; commonly in complex pseudotrapezohedral trillings, outwardly similar to garnet crystals, or with deep re-entrants, to 5 mm. *Twinning:* Cyclic, on an unknown law.

Physical Properties: *Cleavage:* Two partings at ∼80°. *Tenacity:* Brittle. Hardness = 6–7 VHN = 626–1035 D(meas.) = 4.90–5.01 D(calc.) = [5.15] Wavy red cathodoluminescence.

Optical Properties: Transparent. *Color:* Light brown, dark brown to nearly black, light green to brownish green, reddish brown in thin fragments; light gray in reflected light, internal reflections reddish brown; variegated brown in thin section. *Streak:* Brown. *Luster:* Semimetallic to adamantine, greasy on fractures.
Optical Class: Uniaxial (+). $\omega = 2.19$–2.27 $\epsilon = 2.26$–2.36 *Anisotropism:* Pronounced.

Cell Data: *Space Group:* $I4_1/acd$. $a = 15.094(2)$ $c = 10.043(2)$ $Z = 8$

X-ray Powder Pattern: Ozernyi massif, Russia.
2.945 (10), 1.801 (10), 1.537 (9), 1.170 (7), 2.552 (6), 0.9807 (6), 0.8597 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5	0.10	1.58		Fe_2O_3	1.64	0.75	
SiO_2	0.41	0.80		CaO	11.26	12.22	12.63
TiO_2	16.04	17.62	17.99	H_2O			
$ZrO_2 + HfO_2$	70.56	66.09	69.38	P_2O_5		0.05	
$RE + ThO_2$		0.15		LOI	0.17	0.65	
				Total	100.18	99.91	100.00

(1) Ozernyi massif, Russia; corresponds to $Ca_{1.81}Zr_{5.16}(Ti,Fe)_2O_{16}$. (2) Kugda massif, Russia; Fe_2O_3 includes FeO, ZrO_2 includes HfO_2; corresponds to $(Ca_{1.82}Ce_{0.02})_{\Sigma=1.84}(Zr_{4.79}Ti_{0.28})_{\Sigma=5.07}(Ti_{1.69}Nb_{0.11}Si_{0.11}Fe_{0.09})_{\Sigma=2.00}O_{16.00}$. (3) $Ca_2Zr_5Ti_2O_{16}$.

Occurrence: A characteristic accessory mineral in alkalic and ultramafic complexes associated with carbonatites; typically found in residual soils and alluvium.

Association: Forsterite, pyroxene, calcite, magnetite, phlogopite, niobian perovskite, apatite, rutile, anatase, baddeleyite, zirconolite.

Distribution: In Russia, from the Ozernyi massif, near Lake Gornoye, Aldan, Sakha; in the Guli ultrabasic pluton, and the Kugda, Magan, and Odikhincha massifs, between the Maimecha and Kotui rivers, far northern Siberia; in the Tazheranskii alkalic massif, west of Lake Baikal, eastern Siberia; and the Seblyavr pluton, Kola Peninsula. Found near Chiesa, Val Malenco, Lombardy, Italy. In the Kaiserstuhl, Baden-Württemberg, Germany. From the Jacupiranga carbonatite, São Paulo, Brazil. In the Bukusu carbonatite complex, southeastern Uganda.

Name: For CALcium and ZIRconium in its composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 61743, 62363.

References: (1) Zdorik, T.B., G.A. Sidorenko, and A.V. Bykova (1961) A new calcium titanozirconate – calzirtite. Doklady Acad. Nauk SSSR, 137, 681–684 (in Russian). (2) Pyatenko, Y.A. and Z.V. Pudovkina (1961) The crystal structure of calzirtite – a new derivative of the structural type of CaF_2-CeO_2. Kristallografiya (Sov. Phys. Crystal.), 6, 196–199 (in Russian). (3) (1961) Amer. Mineral., 46, 1515 (abs. refs. 1 and 2). (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 340–341. (5) Bulakh, A.G., G.F. Anastasenko, and L.M. Dakhiya (1967) Calzirtite from carbonatites of northern Siberia. Amer. Mineral., 52, 1880–1885. (6) Zhabin, A.G., Z.V. Pudovkina, and A.V. Bykova (1962) Calzirtite from the carbonatites of the Guly ultrabasic intrusion in Polar Siberia. Doklady Acad. Nauk SSSR, 146, 1399–1400 (in Russian). (7) Sinclair, W., R.A. Eggleton, and G.M. McLaughlin (1986) Structure refinement of calzirtite from Jacupiranga, Brazil. Amer. Mineral., 71, 815–818.

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Cámaraite $Ba_3NaTi_4(Fe^{2+},Mn)_8(Si_2O_7)_4O_4(OH,F)_7$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Crystals, platy on {001}, to 8 x 15 x 2 mm; as star shaped aggregates.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Splintery.
Tenacity: Brittle. Hardness = < 5 D(meas.) = 3.871(1), impure sample. D(calc.) = 4.018

Optical Properties: Translucent. *Color*: Orange-red to brownish-red. *Streak*: Pale yellow.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = light brown; Y = reddish brown; Z = yellow-brown. *Absorption*: Z < X < Y. γ(calc) = 1.866 2V(meas.) = 93(1)°
Orientation: X ^ a = 90.4°; Y ^ b = 86.9°; Z ^ c = 103.9°.

Cell Data: *Space Group*: $C\bar{1}$. a = 10.6965(7) b = 13.7861(9) c = 21.478(2)
α = 99.345(1)° β = 92.315(2)° γ = 89.993(2)° Z = 4

X-ray Powder Pattern: Verkhnee Espe Deposit, Akjailyautas Mountains, eastern Kazakhstan.
2.63 (100), 2.79 (90), 1.721 (70), 3.39 (50), 3.18 (50), 2.101 (50), 2.87 (40)

Chemistry:

	(1)		(1)
SiO_2	25.25	CaO	0.56
TiO_2	15.69	BaO	21.11
ZrO_2	0.33	FeO_{total}	16.54
Al_2O_3	0.13	Na_2O	1.41
Fe_2O_3	2.77	K_2O	0.84
Nb_2O_5	1.57	F	3.11
MnO	9.46	H_2O_{calc}	1.84
ZnO	0.12	$-O = F_2$	1.31
MgO	0.21	Total	99.63

(1) Verkhnee Espe Deposit, Akjailyautas Mountains, eastern Kazakhstan, average of 13 electron microprobe analyses, Fe^{3+}/Fe^{2+} by Mössbauer spectroscopy, H_2O from structure analysis; corresponding to $(Ba_{2.61}K_{0.34})_{\Sigma=2.95}(Na_{0.86}Ca_{0.14})_{\Sigma=1}(Ti_{3.72}Nb_{0.22}Al_{0.05})_{\Sigma=3.99}$ $(Fe^{2+}_{4.36}Fe^{3+}_{0.66}$ $Mn_{2.53}Mg_{0.10}$ $Zr_{0.05}$ $Zn_{0.03}$ $Ca_{0.05})_{\Sigma=7.78}Si_{7.97}O_{35.89}H_{3.88}F_{3.11}$.

Occurrence: A hydrothermal mineral in the extensively recrystallized contact zone of a fenitized granite.

Association: Bafertisite, jinshajiangite, zircon, pyrochlore-group minerals, thorite, monazite, xenotime, fluoroleakeite (as inclusions).

Distribution: Verkhnee Espe Deposit, Akjailyautas Mountains, eastern Kazakhstan.

Name: Honors Fernando Cámara (b. 1967) of Melilla, Spain, in recognition of his contributions to the mineralogy and crystallography of Ti-silicates, amphiboles, and arrojadite-group and cancrinite-group minerals.

Type Material: Fersman Mineralogical Museum, Moscow, Russia (catalog no. 3828/1 and 3828/2).

References: (1) Sokolova, E., Y. Abdu, F.C. Hawthorne, A.V. Stepanov, G.K. Bekenova, and P.E. Kotel'nikov (2009) Cámaraite, $Ba_3NaTi_4(Fe^{2+},Mn)_8(Si_2O_7)_4O_4(OH,F)_7$. I. A new Ti-silicate mineral from the Verkhnee Espe Deposit, Akjailyautas Mountains, Kazakhstan. Mineral. Mag., 73, 847–854. (2) Cámara, F., E. Sokolova, and F. Nieto (2009) Cámaraite, $Ba_3NaTi_4(Fe^{2+},Mn)_8(Si_2O_7)_4O_4(OH,F)_7$. II. The crystal structure and crystal chemistry of a new group-II Ti-disilicate mineral. Mineral. Mag., 73, 855–870. (3) (2010) Amer. Mineral., 95, 1357–1358 (abs. refs. 1 and 2).

Camerolaite $Cu_4Al_2(HSbO_4, SO_4)(CO_3)(OH)_{10}\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Crystals are acicular, elongated along [010], flattened on {100}, showing only {100} and {001}; typically in tufts or radiating aggregates, to 2 mm.

Physical Properties: *Cleavage:* On {100} and {001}, good. *Fracture:* Fibrous. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.1(1) D(calc.) = 2.96

Optical Properties: Transparent. *Color:* Blue-green. *Streak:* Pale green. *Luster:* Silky. *Optical Class:* Biaxial (+). *Pleochroism:* X = colorless; Y = pale green; Z = blue-green. *Orientation:* $X \perp \{100\}$; $Z = b$. *Dispersion:* $r < v$, strong. $\alpha = 1.626(2)$ $\beta = 1.646(2)$ $\gamma = 1.682(2)$ 2V(meas.) = 77(3)° 2V(calc.) = 75°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 10.765(6)$ $b = 2.903(2)$ $c = 12.527(8)$ $\beta = 95.61(4)°$ Z = 1

X-ray Powder Pattern: Cap Garonne mine, France.
4.276 (100), 5.160 (90), 5.62 (50), 3.565 (40), 2.380 (35), 2.326 (35), 2.137 (30)

Chemistry:

	(1)
SO_3	4.75
CO_2	6.26
Sb_2O_3	13.55
Al_2O_3	14.54
CuO	40.56
H_2O	20.00
Total	99.66

(1) Cap Garonne mine, France; by electron microprobe, average of eight analyses, CO_2 and H_2O by CHN analyzer; corresponds to $Cu_{3.56}Al_{1.99}[(HSbO_4)_{0.59}(SO_4)_{0.41}]_{\Sigma=1.00}(CO_3)_{0.99}(OH)_{9.91}\cdot 2.12H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of polymetallic mineral deposits.

Association: Parnauite, cyanotrichite, malachite, quartz (Cap Garonne mine, France); brochantite, chalcophyllite, mimetite, azurite (St.-Luc, Switzerland).

Distribution: In France, from the Cap Garonne mine, near le Pradet, Var, and at Ceilhes, Hérault. From near St.-Luc, Val d'Anniviers, Valais, Switzerland. In the Clara mine, near Oberwolfach, Black Forest, Germany. At Špania Dolina (Herrengrund) and Piesky, Slovakia.

Name: Honors Michel Camerola, mineral collector who collected the first specimen.

Type Material: Natural History Museum, Geneva, Switzerland, 435/84.

References: (1) Sarp, H. and P. Perroud (1991) Camerolaite, $Cu_4Al_2[HSbO_4, SO_4](OH)_{10}(CO_3)\cdot 2H_2O$, a new mineral from Cap Garonne mine, Var, France. Neues Jahrb. Mineral., Monatsh., 481–486. (2) (1992) Amer. Mineral., 77, 1116 (abs. ref. 1). (3) Cuchet, S. (1995) Seconde occurrence de camérolaïte, $Cu_4Al_2[(HSbO_4, SO_4)](OH)_{10}(CO_3)\cdot 2H_2O$, Val d'Anniviers, Valais, Suisse. Schweiz. Mineral. Petrog. Mitt., 75, 283–284 (in French with English abs.).

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Cameronite $AgCu_7Te_{10}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$, $4mm$, or $\overline{4}2m$. As anhedral equidimensional grains, up to about 200 μm in diameter.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = [3.5–4] VHN = 150–173, 163 average (100 g load). D(meas.) = n.d. D(calc.) = 7.144

Optical Properties: Opaque. *Color:* Gray. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Slight, pale gray to pale brownish gray. *Anisotropism:* Distinct, medium gray to slate-gray to brownish gray.
R_1–R_2: (400) 23.6–28.4, (420) 25.6–30.1, (440) 27.4–31.4, (460) 28.9–32.5, (480) 30.1–33.1, (500) 31.0–33.6, (520) 31.6–33.7, (540) 32.1–33.8, (560) 32.5–33.7, (580) 32.8–33.6, (600) 33.0–33.4, (620) 33.1–33.2, (640) 33.3–33.0, (660) 33.4–32.7, (680) 33.5–32.6, (700) 33.6–32.3

Cell Data: *Space Group:* $P4_2/mmc$, $P4_2mc$, or $P\overline{4}2c$. $a = 12.695(2)$ $c = 42.186(6)$ Z = 16

X-ray Powder Pattern: Good Hope mine, Colorado, USA.
3.45 (100), 2.118 (100), 1.804 (60), 1.377(40), 1.222 (40), 1.815 (30), 1.151 (30)

Chemistry:

	(1)	(2)	(3)
Ag	6.34	6.3	5.89
Cu	24.44	24.1	24.33
Te	69.10	69.6	69.78
Total	99.88	100.0	100.00

(1) Good Hope mine, Colorado, USA; by electron microprobe, average of two analyses; corresponding to $Ag_{1.09}Cu_{7.10}Te_{10.00}$. (2) Do.; by electron microprobe, corresponding to $Ag_{1.07}Cu_{6.95}Te_{10.00}$. (3) $AgCu_7Te_{10}$.

Occurrence: One of a number of metallic tellurium-bearing minerals in a hydrothermal deposit.

Association: Tellurium, rickardite, vulcanite, arsenopyrite, pyrite.

Distribution: From the Good Hope mine, Vulcan, Gunnison Co., Colorado, USA [TL].

Name: In honor of Professor Eugene Nathan Cameron (1910–), University of Wisconsin, who first recognized the mineral as a new species.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 64956; The Natural History Museum, London, England, 1984,356, E.1000, R933; National Museum of Natural History, Washington, D.C., USA, 162713.

References: (1) Roberts, A.C., D.C. Harris, A.J. Criddle, and W.W. Pinch (1986) Cameronite, a new copper-silver telluride from the Good Hope mine, Vulcan, Colorado. Can. Mineral., 24, 379–384. (2) (1987) Amer. Mineral., 72, 1023 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 70.

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Camgasite $CaMg(AsO_4)(OH)\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As euhedral to anhedral crystals, to 0.15 mm, prismatic along [010], showing {100}, {010}, and {001}, as radial aggregates in crusts. *Twinning:* Polysynthetic ∥ {010}, seen in thin section.

Physical Properties: *Cleavage:* {100}, {001}, distinct. *Fracture:* Conchoidal. Hardness = ∼2 D(meas.) = 2.4(1) D(calc.) = 2.335

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$. $\alpha = 1.540(2)$ $\beta = [1.548]$ $\gamma = 1.563(2)$ 2V(meas.) = 74°

Cell Data: *Space Group:* $P2_1/m$ (probable). $a = 9.18(3)$ $b = 7.63(2)$ $c = 16.27(5)$ $\beta = 128.0(5)°$ Z = 4

X-ray Powder Pattern: Johann mine, near Wittichen, Germany. 7.28 (10), 6.42 (10), 4.00 (8), 3.28 (8), 3.21 (8), 3.02 (8), 2.96 (8)

Chemistry:

	(1)	(2)
As_2O_5	37.9	37.03
MgO	12.9	12.98
CaO	18.9	18.07
H_2O	[30.3]	31.92
Total	[100.0]	100.00

(1) Johann mine, near Wittichen, Germany; by electron microprobe, H_2O by difference; corresponds to $Ca_{1.06}Mg_{1.01}(AsO_4)_{1.04}(OH)_{1.02}\cdot 4.82H_2O$. (2) $CaMg(AsO_4)(OH)\cdot 5H_2O$.

Occurrence: A secondary mineral in a Co–U-rich zone in a polymetallic mineral deposit.

Association: Monohydrocalcite, gypsum, calcite, rapidcreekite, nováčekite, erythrite, hörnesite.

Distribution: In the Johann mine, near Wittichen, Black Forest, Germany.

Name: For *Ca*, calcium, *Mg*, magnesium, and *As*, arsenic, in the composition.

Type Material: Stuttgart University, Stuttgart, Germany.

References: (1) Walenta, K. and P.J. Dunn (1989) Camgasit, ein neues Calcium-Magnesiumarsenatmineral der Zusammensetzung $CaMg(AsO_4)(OH)\cdot 5H_2O$ von Wittichen im mittleren Schwarzwald. Aufschluss, 40, 369–372 (in German with English abs.). (2) (1991) Amer. Mineral., 76, 2021 (abs. ref. 1).

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Caminite $Mg_7(SO_4)_5(OH)_4 \cdot H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As imperfect dipyramidal crystals, to 500 μm; botyroidal.

Physical Properties: *Cleavage:* {001}, good, possible. Hardness = 2.5 D(meas.) = 2.58–2.79 D(calc.) = [2.14]

Optical Properties: Transparent. *Color:* White or colorless; colorless in transmitted light. *Optical Class:* Uniaxial (–). $\omega = 1.534$ $\epsilon = 1.532$

Cell Data: *Space Group:* $I4_1/amd$ (synthetic). $a = 5.242(1)$ $c = 12.995(3)$ Z = 4

X-ray Powder Pattern: East Pacific Rise.
3.345 (100), 3.220 (80), 1.871 (50), 1.620 (25), 2.062 (20), 2.041 (20), 1.854 (20)

Chemistry:

	(1)	(2)
SO_3	52.7	54.35
MgO	37.3	38.31
CaO	trace	
H_2O	[10.0]	7.34
Total	[100.0]	100.00

(1) East Pacific Rise; by electron microprobe, H_2O by difference. (2) $Mg_7(SO_4)_5(OH)_4 \cdot H_2O$.

Occurrence: Formed by the reaction of sea water with hydrothermal fluids in a midocean ridge submarine chimney vent. Unstable below 130° C., below which it hydrates and redissolves in sea water.

Association: Anhydrite.

Distribution: Along the East Pacific Rise at 21° N.

Name: From the Latin *caminus*, for *chimney*, as the mineral occurs in undersea black-smoker chimneys.

Type Material: n.d.

References: (1) Haymon, R.M. and M. Kastner (1986) Caminite: A new magnesium-hydroxide-sulfate-hydrate mineral found in a submarine hydrothermal deposit, East Pacific Rise, 21°N. Amer. Mineral., 71, 819–825. (2) Keefer, K.D., M.F. Hochella, Jr., and B.H.W.S. De Jong (1981) The structure of the magnesium hydroxide sulfate hydrate $MgSO_4.\frac{1}{3}Mg(OH)_2.\frac{1}{3}H_2O$. Acta Cryst., 37, 1003–1006.

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Campigliaite $Cu_4Mn^{2+}(SO_4)_2(OH)_6 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. In tufts of crystals, elongated along [010], bladed on {100}, to 0.2 mm. *Twinning:* Polysynthetic, with {100} as twin plane, ubiquitous.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = n.d. D(meas.) = 3.0 D(calc.) = 3.063

Optical Properties: Transparent. *Color:* Pale blue; pale greenish blue in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X \simeq a$; $Y \simeq c$; $Z = b$. *Dispersion:* $r < v$, weak.
$\alpha = 1.589$ $\beta = 1.645$ $\gamma = 1.659$ 2V(meas.) = 52°

Cell Data: *Space Group:* $C2$. $a = 21.725(8)$ $b = 6.118(6)$ $c = 11.233(7)$ $\beta = 100.40(5)°$ Z = 4

X-ray Powder Pattern: Temperino mine, Italy.
10.68 (100), 5.34 (60), 3.56 (44), 2.673 (5), 2.768 (2), 2.570 (2), 1.781 (2)

Chemistry:

	(1)	(2)
SO_3	20.15	23.71
MnO	9.95	10.50
CuO	40.60	47.11
ZnO	4.47	
H_2O	[24.83]	18.68
Total	[100.00]	100.00

(1) Temperino mine, Italy; by electron microprobe, average of three analyses, total Mn as MnO, H_2O by difference; corresponds to $(Cu_{3.62}Zn_{0.39})_{\Sigma=4.01}Mn_{0.99}(SO_4)_{1.78}(OH)_{6.44} \cdot 6.55H_2O$.
(2) $Cu_4Mn(SO_4)_2(OH)_6 \cdot 4H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a metallic sulfide skarn deposit.

Association: Gypsum, brochantite, antlerite.

Distribution: From the Temperino mine, Campiglia Marittima, Tuscany, Italy.

Name: For the locality which provided the first specimens, Campiglia Marittima, Italy.

Type Material: Mineralogical Museum, University of Florence, Florence, 214/I; National Museum of Natural History, Washington, D.C., USA, 148483–148485.

References: (1) Menchetti, S. and C. Sabelli (1982) Campigliaite, $Cu_4Mn(SO_4)_2(OH)_6 \cdot 4H_2O$, a new mineral from Campiglia Marittima, Tuscany, Italy. Amer. Mineral., 67, 385–393.

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Canaphite $CaNa_2(P_2O_7)\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group: m.* Crystals are prismatic, elongated along [100] and tabular on {010}, to 0.5 mm, showing {010}, with {100}, and {001}, in radiating clusters; as spherical nodules.

Physical Properties: *Cleavage:* Perfect on {010}; poor on {100} and {001}. Hardness = ∼2 D(meas.) = 2.24 D(calc.) = 2.27

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 25°$. $\alpha = 1.496(2)$ $\beta = 1.504(2)$ $\gamma = 1.506(4)$ 2V(meas.) = 52(5)° 2V(calc.) = 52.9°

Cell Data: *Space Group: Pc.* $a = 5.673(4)$ $b = 8.48(1)$ $c = 10.529(5)$ $\beta = 106.13(6)°$ Z = 2

X-ray Powder Pattern: Haledon, New Jersey, USA.
3.06 (100), 2.608 (90), 8.47 (80), 5.44 (80), 4.36 (70), 5.06 (60), 3.87 (60)

Chemistry:

	(1)	(2)
P_2O_5	43.4	42.75
MgO	0.2	
CaO	17.5	16.89
Na_2O	16.5	18.66
H_2O	21.8	21.70
Total	99.4	100.00

(1) Haledon, New Jersey, USA; by electron microprobe, H_2O by DTA–TGA; corresponds to $Ca_{1.03}Mg_{0.03}Na_{1.74}(P_{2.00}O_7)\cdot 3.96H_2O$. (2) $CaNa_2(P_2O_7)\cdot 4H_2O$.

Occurrence: On a museum micromount specimen presumably from a trap-rock quarry (Haledon, New Jersey, USA); in recent lake-bed sediments (La Cruz Lake, Spain).

Association: Stilbite, quartz (Haledon, New Jersey, USA).

Distribution: Attributed to [Braens quarry,] Haledon [or Great Notch quarry, near Little Falls], Passaic Co., New Jersey, USA. From La Cruz Lake, Cuenca Province, Spain.

Name: For CAlcium, sodium, NAtrium, and PHosphate in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160286.

References: (1) Peacor, D.R., P.J. Dunn, W.B Simmons, and F.J. Wicks (1985) Canaphite, a new sodium calcium phosphate hydrate from the Paterson area, New Jersey. Mineral. Record, 16, 467–468. (2) (1986) Amer. Mineral., 71, 1543–1544 (abs. ref. 1). (3) Rouse, R.C., D.R. Peacor, and R.L. Freed (1988) Pyrophosphate groups in the structure of canaphite, $CaNa_2P_2O_7\cdot 4H_2O$: the first occurrence of a condensed phosphate as a mineral. Amer. Mineral., 73, 168–171. (4) Queralt, I., R. Juliá, and F. Plana (1994) Canaphite: an uncommon condensed phosphate in lake sediments. 16th Meeting, Int. Mineral. Assoc., Pisa, Italy, 343 (abs.).

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Canasite $Na_3K_3Ca_5Si_{12}O_{30}(OH,F)_4$

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Crystal Data: Monoclinic. *Point Group: m.* As crystals, to 10 cm; in platy aggregates, to 20 cm; also granular. *Twinning:* Polysynthetic, the twinning plane at an angle of 8° to the less perfect cleavage.

Physical Properties: *Cleavage:* One, very perfect; another, perfect, at 118° to the first. *Fracture:* Splintery, breaks into long acute-angled or wedge-shaped pieces. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.707 D(calc.) = [2.65]

Optical Properties: Transparent to translucent. *Color:* Greenish yellow to grayish green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge$ less perfect cleavage = 2°. $\alpha = 1.534$ $\beta = 1.538$ $\gamma = 1.543$ 2V(meas.) = 58°

Cell Data: *Space Group: Cm.* $a = 18.836$ $b = 7.244$ $c = 12.636$ $\beta = 111.76(2)°$ Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
3.080 (100b), 2.907 (80), 1.641 (80), 4.69 (70), 4.81 (60), 2.359 (60), 4.20 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	56.08	55.71	K_2O	8.47	10.63
TiO_2	0.10	0.06	F	2.21	2.17
Al_2O_3	0.55	0.20	Cl	0.22	
Fe_2O_3	1.41	0.72	H_2O^+	1.11	1.25
FeO	0.71	0.36	H_2O^-	0.49	0.60
MnO	0.38	0.41	CO_2	0.20	
MgO	0.05	0.26	P_2O_5	0.04	0.08
CaO	20.95	20.39	$-O = (F,Cl)_2$	0.96	0.91
Na_2O	8.01	7.08	Total	100.02	99.01

(1–2) Khibiny massif, Russia. (3) Murun massif, Russia; analysis not given, stated to correspond to $Na_{2.96}K_{2.94}(Ca_{4.69}Fe_{0.17}Mg_{0.08}Mn_{0.07}Al_{0.05}Ti_{0.01})_{\Sigma=5.07}Si_{12}O_{30}[(OH)_{2.27}F_{1.48}O_{0.25}]_{\Sigma=4.00}$.

Occurrence: In pegmatites in a differentiated alkalic massif (Khibiny massif, Russia); in charoitic rocks (Murun massif, Russia).

Association: Fenaksite, lamprophyllite, titanite, eudialyte, nepheline, pyroxene, orthoclase (Khibiny massif, Russia); tinaksite, miserite, charoite (Murun massif, Russia).

Distribution: On Mts. Yukspor and Rasvumchorr, Khibiny massif, Kola Peninsula, and in the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: For CAlcium, sodium, NAtrium, and SIlicon in the chemical composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 801; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 61128029; National Museum of Natural History, Washington, D.C., USA, 136472.

References: (1) Dorfman, M.D., D.D. Rogachev, Z.I. Goroshchenko, and E.I. Uspenskaya (1959) Canasite, a new mineral. Trudy Mineralog. Muzeya Akad. Nauk SSSR, 9, 158–166 (in Russian). (2) (1960) Amer. Mineral., 45, 253–254 (abs. ref. 1). (3) Rozhdestvenskaya, I.V., L.V. Nikishova, I.I. Bannova, and Y.D. Lasebnik (1987) Canasite: the refinement of crystal structure and comparison with that of miserite. Acta Cryst., A43, C159. (4) Rozhdestvenskaya, I.V., L.V. Nikishova, I.I. Bannova, and Y.D. Lasebnik (1987) [Canasite: crystal structure typomorphism.] Mineral. Zhurnal, 10(4), 31–41 (in Russian with English abs.).

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Canavesite $Mg_2(HBO_3)(CO_3)\cdot 5H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* n.d. As fibrous [010], flattened pseudohexagonal crystals, to 3 mm, typically in rosettelike aggregates.

Physical Properties: *Cleavage:* On {*h*0*l*}, one or more sets. *Tenacity:* Slightly flexible. Hardness = n.d. D(meas.) = ∼1.8 D(calc.) = 1.790

Optical Properties: Transparent. *Color:* Colorless to milky white. *Luster:* Vitreous, silky in aggregates.
Optical Class: Biaxial (+). *Orientation:* $Z = b$. *Dispersion:* Very weak. $\alpha = 1.485(4)$ $\beta = 1.494(4)$ $\gamma = 1.505(2)$ 2V(meas.) = Very large.

Cell Data: *Space Group:* n.d. $a = 23.49(2)$ $b = 6.164(6)$ $c = 21.91(2)$ $\beta = 114.91(9)°$ Z = 12

X-ray Powder Pattern: Brosso mine, Italy.
9.54 (100), 8.12 (40), 4.56 (21), 3.110 (19), 7.80 (18), 7.53 (14), 2.233 (14)

Chemistry:

	(1)	(2)
CO_2	18.57	17.02
B_2O_3	12.70	13.47
MgO	31.60	31.18
H_2O	37.44	38.33
Total	100.31	100.00

(1) Brosso mine, Italy; average of two analyses, CO_2 and H_2O by elemental analyzer; corresponding to $Mg_{2.03}(HBO_3)_{0.94}(CO_3)_{1.09}\cdot 4.91H_2O$. (2) $Mg_2(HBO_3)(CO_3)\cdot 5H_2O$.

Occurrence: A rare secondary mineral on tunnel surfaces in an abandoned mine in weathering ludwigite–magnetite skarn.

Association: Ludwigite, magnetite.

Distribution: From the Brosso mine, northwest of Ivrea, Piedmont, Italy.

Name: For the Canavese district, in which the mine that produced the first specimens is located.

Type Material: Municipal Natural History Museum, Milan, 17349, M30079, M30099, M300100, M300102; National Museum of Natural History, Washington, D.C., USA, 148483–148485; University of Florence, Florence; University of Torino, Torino, Italy; National School of Mines, Paris, France; The Natural History Museum, London, England, 1981,468.

References: (1) Ferraris, G., M. Franchini-Angela, and P. Orlandi (1978) Canavesite, a new carboborate mineral from Brosso, Italy. Can. Mineral., 16, 69–73. (2) (1979) Amer. Mineral., 64, 652 (abs. ref. 1).

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Cancrinite $Na_6Ca_2Al_6Si_6O_{24}(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* 6. Rarely as prismatic crystals, terminated by a low pyramid, to 2 cm; commonly massive. *Twinning:* Lamellar, rare.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}0\}$, poor on {0001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.42–2.51. D(calc.) = [2.49]

Optical Properties: Transparent to translucent. *Color:* Colorless, white, light blue to light grayish blue, honey-yellow, orange, reddish; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly, or greasy.
Optical Class: Uniaxial (–) or (+). ω = 1.507–1.528 ϵ = 1.495–1.503

Cell Data: *Space Group:* $P6_3$. a = 12.58–12.76 c = 5.11–5.20 Z = 1

X-ray Powder Pattern: York River, Bancroft, Canada.
3.21 (100), 4.64 (90), 3.64 (70), 2.099 (70), 1.488 (50), 1.447 (50), 10.92 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	34.35	33.64	34.25
TiO_2		0.07	
Al_2O_3	29.35	29.82	29.06
Fe_2O_3	0.03		
MgO	0.01	0.39	
CaO	8.11	8.64	10.66
Na_2O	17.66	15.41	17.67
K_2O	0.10	0.50	
Cl	0.21		
H_2O^+	3.02	4.61	
H_2O^-	0.11		
CO_2	6.60	6.79	8.36
SO_3		0.03	
Total	99.55	99.90	100.00

(1) Dungannon Township, Ontario, Canada. (2) Iron Hill, Colorado, USA.
(3) $Na_6Ca_2Al_6Si_6O_{24}(CO_3)_2$.

Mineral Group: Cancrinite group.

Occurrence: A primary mineral in some alkalic igneous rocks, including pegmatites in nepheline syenites; also as an alteration product of nepheline.

Association: Nepheline, sodalite, natrolite, orthoclase, monticellite, titanian andradite, zircon.

Distribution: At Miass, Ilmen Mountains, Southern Ural Mountains, and on the Kola Peninsula, Russia. From Tvedalen and the Langesundsfjord, Norway. Found near Loch Borolan, Assynt, Scotland. Around the Laacher See, Eifel district, Germany. From Vesuvius, Campania, Italy. In the USA, from Gardiner and Litchfield, Kennebec Co., Maine; Pennsburg, Chester Co., Pennsylvania; at Iron Hill, Gunnison Co., Colorado; and Point of Rocks, Colfax Co., New Mexico. In Canada, from Bancroft, Egan Chute, and Blue Mountain, Ontario; at Mont Saint-Hilaire, Quebec; and a number of other lesser localities.

Name: For Count Egor Frantsevich Kankrin (Georg Cancrin) (1774–1845), German-Russian Minister of Finance of Russia.

Type Material: Humbolt Museum, Berlin, Germany.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 427–428. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 310–320. (3) Foit, F.F., Jr. (1973) Cancrinite with a new superstructure from Bancroft, Ontario. Can. Mineral., 11, 940–951. (4) Grundy, H.D. and I. Hassan (1982) The crystal structure of a carbonate-rich cancrinite. Can. Mineral., 20, 239–251.

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Cancrisilite $Na_7Al_5Si_7O_{24}(CO_3)\cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6mm$. Anhedral, granular, to 3 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5
D(meas.) = 2.40(2) D(calc.) = 2.39 Fluoresces yellow under UV.

Optical Properties: Transparent to translucent. *Color:* Lilac; colorless in thin section.
Streak: White. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.509(2)$ $\epsilon = 1.490(2)$

Cell Data: *Space Group:* $P6_3mc$. $a = 12.575(3)$ $c = 5.105(2)$ $Z = 1$

X-ray Powder Pattern: Lovozero massif, Russia; resembles cancrinite.
3.22 (100), 3.65 (90), 6.30 (70), 4.61 (50), 2.722 (50), 2.597 (20), 2.402 (20)

Chemistry:

	(1)
SiO_2	43.11
Al_2O_3	24.42
Fe_2O_3	0.33
MnO	0.11
CaO	0.68
Na_2O	21.30
K_2O	0.10
H_2O	5.01
CO_2	4.82
SO_3	0.36
Total	100.24

(1) Lovozero massif, Russia, corresponding to $(Na_{6.89}Ca_{0.12}Fe^{3+}_{0.04}Mg_{0.03}K_{0.02})_{\Sigma=7.10}(Si_{7.20}Al_{4.80})_{\Sigma=12.00}O_{24.10}(CO_3)_{1.10}(SO_4)_{0.04}\cdot 2.79H_2O$.

Mineral Group: Cancrinite group.

Occurrence: In ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Potassic feldspar, nepheline, sodalite, arfvedsonite, aegirine, manaksite, eudialyte, lamprophyllite, additional minor minerals.

Distribution: From Mts. Alluaiv and Karnasurt, and in the Chinglusuai River valley, Lovozero massif, Kola Peninsula, Russia.

Name: For the relatively high ratio of silicon to aluminum, and its relation to *cancrinite*.

Type Material: Vernadsky Geological Museum, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p503/1.

References: (1) Khomyakov, A.P., E.I. Semenov, E.A. Pobedimskaya, T.N. Nadezhina, and R.K. Rastsvetaeva (1991) Cancrisilite $Na_7[Al_5Si_7O_{24}]CO_3\cdot 3H_2O$ – a new mineral of the cancrinite group. Zap. Vses. Mineral. Obshch., 120(6), 80–84 (in Russian). (2) (1993) Amer. Mineral., 78, 1314 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 55–56.

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Canfieldite Ag_8SnS_6

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $mm2$. Crystals, to 1 cm, with combinations of pseudo-octahedron and dodecahedron; also botryoidal with drusy surface; as small inclusions. *Twinning:* Commonly on {111}, as pseudospinel law twins, or repeated interpenetration twins of pseudododecahedra.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5 VHN = 90.7–171 (25 g load). D(meas.) = 6.2–6.3 D(calc.) = 6.311

Optical Properties: Opaque. *Color:* Steel-gray with reddish tinge, tarnishes black with blue to purple tint; pale gray with violet tint in reflected light. *Streak:* Gray-black, somewhat shining. *Luster:* Metallic.
R: (400) 33.0, (420) 30.8, (440) 28.9, (460) 28.0, (480) 27.2, (500) 26.5, (520) 25.9, (540) 25.5, (560) 25.2, (580) 25.1, (600) 24.9, (620) 24.9, (640) 24.8, (660) 24.8, (680) 24.8, (700) 24.9

Cell Data: *Space Group:* $Pna2_1$ or $Pnam$ (synthetic). $a = 15.298(2)$ $b = 7.548(1)$ $c = 10.699(1)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.114 (100), 3.085 (90), 1.8960 (90), 2.727 (70), 1.9129 (70), 3.252 (55), 3.232 (55)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Ag	74.10	65.12	73.49	Ge	1.82		
Fe	0.21			Te		8.69	
Sn	6.94	10.57	10.14	S	16.22	13.95	16.37
				Total	99.29	98.33	100.00

(1) Aullagas, Bolivia. (2) Revelstoke, Canada; by electron microprobe. (3) Ag_8SnS_6.

Polymorphism & Series: Forms a series with argyrodite; stable below 172 °C.

Occurrence: In polymetallic veins, formed very late in the paragenetic sequence.

Association: Argyrodite, pyrargyrite, stephanite, acanthite, polybasite, freibergite, stannite, stannoidite, cassiterite, arsenopyrite, jordanite, marcasite, pyrrhotite, sphalerite, galena.

Distribution: In Bolivia, exceptional crystals from the Gallofa vein, Aullagas, near Colquechaca, and at the Guadaloupe mine, Chocaya, Potosí. From the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. In Canada, from about 33 km northeast of Revelstoke, British Columbia. At the Campbell mine, Bisbee, Cochise Co., Arizona, and the Leadville district, Lake Co., Colorado, USA. In the Himmelsfürst mine, Erbisdorf, near Freiberg, Saxony, Germany. From Rejská, near Kutná Hora, and Příbram, Czech Republic. In the Ikuno and Omidani mines, Hyogo Prefecture, and the Ashio mine, Tochigi Prefecture, Japan. At Shuiji, Jianyang Co., Fujian Province, China. From the Karamken Au–Ag deposit, Okhotsk district, and at the Belukhinsk tungsten deposit, eastern Transbaikalia, Russia. Other minor occurrences are known.

Name: Honoring Frederick Alexander Canfield (1849–1926), American mining engineer and mineral collector of Dover, New Jersey, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 356–358. (2) Harris, D.C. and D.R. Owens (1971) A tellurium-bearing canfieldite, from Revelstoke, B.C. Can. Mineral., 10, 895–898. (3) Wang, N. (1978) New data for Ag_8SnS_6 (canfieldite) and Ag_8GeS_6 (argyrodite). Neues Jahrb. Mineral., Monatsh., 269–272. (4) Soeda, A., M. Watanabe, K. Hoshino, and K. Nakashima (1984) Mineralogy of tellurium-bearing canfieldite from the Tsumo mine, SW Japan and its implications for ore genesis. Neues Jahrb. Mineral., Abh., 150, 11–23. (5) Sugaki, A., A. Kitakaze, and H. Kitazawa (1985) Synthesized tin and tin-sulfide minerals; Synthetic sulfide minerals (XIII). Sci. Rep., Tohoku Univ., Ser. 3, 16, 199–211 (in English). (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 71.

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Cannizzarite $Pb_{46}Bi_{54}S_{127}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As very thin single laths, to 2 mm, straight, or commonly warped, with frayed ends; as felted masses and stellate groups. *Twinning:* Stellate trillings and as simple V-shapes.

Physical Properties: *Tenacity:* Somewhat malleable, slightly elastic, easily twisting and bending. Hardness = ∼2 VHN = 132 (20 g load). D(meas.) = 6.7 D(calc.) = 6.95

Optical Properties: Opaque. *Color:* White to silvery gray, tarnishes iridescent. *Luster:* Metallic. *Anisotropism:* Strong, from blue to gray.
R_1–R_2: (400) 49.2–51.3, (420) 49.8–52.4, (440) 50.4–53.5, (460) 50.7–53.7, (480) 50.6–53.3, (500) 50.2–52.8, (520) 49.7–52.2, (540) 49.2–51.6, (560) 48.6–51.0, (580) 48.2–50.4, (600) 47.8–50.0, (620) 47.5–49.5, (640) 47.3–49.2, (660) 47.2–49.0, (680) 47.2–49.0, (700) 47.2–49.2

Cell Data: *Space Group:* $P2_1/m$. $a = 4.13$ $b = 4.09$ $c = 15.48$ $\beta = 98.56°$ $Z = 1$

X-ray Powder Pattern: Vulcano, Italy (shows some preferred orientation).
3.82 (10), 3.01 (6), 2.68 (6), 2.87 (5), 2.22 (5), 2.03 (5), 1.910 (4)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb	36.21	37.51	38.30	Sb	0.02		
Ag		0.17		Te		0.21	
Fe		0.03		Se	4.56		
Bi	44.56	44.96	45.34	S	14.07	16.25	16.36
				Total	99.42	[99.13]	100.00

(1) Vulcano, Italy; by electron microprobe, average of eight analyses; corresponds to $Pb_{44.70}(Bi_{54.54}Sb_{0.02})_{\Sigma=54.56}(S_{112.23}Se_{14.77})_{\Sigma=127.00}$. (2) Mittal-Hohtenn tunnel, Switzerland; by electron microprobe, corresponding to $(Pb_{45.22}Ag_{0.39})_{\Sigma=45.61}Bi_{53.74}(S_{126.59}Te_{0.41})_{\Sigma=127.00}$. (3) $Pb_{46}Bi_{54}S_{127}$.

Occurrence: Associated with deep fumarolic activity (Vulcano, Italy); in sulfide veinlets in a greisen Sn–W deposit in granite (Shumilovsk deposit, Russia).

Association: Lillianite, mozgovaite, kirkiite, barberiite, galenobismutite, bismuthinite, galena, gold, tellurium (Vulcano, Italy); wolframite, cassiterite, bismuthinite, galena, cosalite, heyrovskýite, galenobismutite, bursaite, tetradymite, joséite-B, bismuth, quartz (Shumilovsk deposit, Russia).

Distribution: In Italy, on Vulcano, in the Lipari Islands [TL], and from the Ginevro mine, Elba. From Santa Maria, Val Medel, Graubünden, at Goppenstein, Lotschental, and in the Mittal-Hohtenn tunnel, Valais, Switzerland. From the Felbertal tungsten mine, Salzburg, Austria. In the Shumilovsk Sn–W deposit, west Transbaikal, and the Vysokogorsk deposit, Far Eastern Region, Russia. From the Hobenzan granitic complex, Yamaguchi Prefecrure, Japan. At Landsman Camp, Graham Co., Arizona, USA.

Name: Honors Stanislao Cannizzaro (1826–1910), celebrated Italian chemist, University of Rome, Italy.

Type Material: University of Florence, Florence, Italy, 14398/G; Natural History Museum, 128.28; National School of Mines, Paris, France.

References: (1) Zambonini, F., O. de Fiore, and G. Carobbi (1925) Su un sulfobismuto di piombo di Vulcano. Annali. R. Osserv. Vesuv., Ser. 3, 1, 31–36 (in Italian). (2) Graham, A.R., R.M. Thompson, and L.G. Berry (1953) Studies of mineral sulfo-salts; XVII – cannizzarite. Amer. Mineral., 38, 536–544. (3) Matzat, E. (1979) Cannizzarite. Acta Cryst., 35, 133–136. (4) Borodaev, Y.S., A. Garavelli, C. Garbarino, S.M. Grillo, N.N. Mozgova, N.I. Organova, and N.Y. Trubkin (2000) Rare sulfosalts from Vulcano, Aeolian Islands, Italy. III. Wittite and cannizzarite. Can. Mineral., 38, 23–34. (5) Berlepsch, P., T. Armbruster, E. Makovicky, C. Hejny, D. Topa, and S. Graeser (2001) The crystal structure of (001) twinned xilingolite, $Pb_3Bi_2S_6$, from Mittal-Hohtenn, Valais, Switzerland. Can. Mineral., 39, 1653–1663.

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Cannonite $Bi_2O(SO_4)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As equant to prismatic crystals, elongated along $[\bar{1}02]$, to 200 μm; granular massive.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4 VHN = 183–280, 229 average (100 g load). D(meas.) = 6.5(1) (synthetic). D(calc.) = 6.515

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Adamantine. *Optical Class:* Biaxial. α = [1.91] β = n.d. γ = [1.99] 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. a = 7.700(3) b = 13.839(6) c = 5.686(2) β = 109.11(3)° Z = 4

X-ray Powder Pattern: Tunnel Extension mine, Utah, USA.
3.206 (100), 1.984 (90), 2.924 (70), 3.644 (60), 3.466 (60), 2.782 (50), 3.513 (40)

Chemistry:

	(1)	(2)
SO_3	14.18	14.20
Bi_2O_3	82.53	82.61
H_2O	[3.29]	3.19
Total	[100.00]	100.00

(1) Tunnel Extension mine, Utah, USA; by electron microprobe, average of ten analyses, recalculated from an elemental analysis; H_2O by difference, presence of $(OH)^{1-}$ by analogy to the synthetic compound; then corresponding to $Bi_{1.99}O(S_{0.99}O_4)(OH)_{2.08}$. (2) $Bi_2O(SO_4)(OH)_2$.

Occurrence: An alteration product in a Cu–Bi–Au-sulfide deposit.

Association: Covellite, cuprobismutite, bismuthinite, quartz.

Distribution: In the USA, from the Tunnel Extension mine, Marysvale, Ohio district, Piute Co., Utah.

Name: Honors Benjamin Bartlett Cannon, V (1950–), amateur mineralogist of Seattle, Washington, USA, who recognized the first specimens.

Type Material: The Natural History Museum, London, England, 1992,239, 1992,240, and E.1456; Canadian Geological Survey, Ottawa, Canada, 67428.

References: (1) Stanley, C.J., A.C. Roberts, D.C. Harris, A.J. Criddle, and J.T. Szymański (1992) Cannonite, $Bi_2O(OH)_2SO_4$, a new mineral from Marysvale, Utah, USA. Mineral. Mag., 56, 605–609. (2) (1993) Amer. Mineral., 78, 845 (abs. ref. 1). (3) Golič, L., M. Graunar, and F. Lazarni (1982) *catena*−Di−μ−hydroxo−μ_3−oxo−dibismuth(III) sulphate. Acta Cryst., 38, 2881–2883.

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Caoxite $CaC_2O_4 \cdot 3H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As elongated crystals, tabular on {010}, with polygonal outline, to 0.5 mm; as crystalline spherulites.

Physical Properties: *Cleavage:* On {010}, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.87

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). $\alpha = 1.483(3)$ (α') $\beta = [1.516]$ $\gamma = 1.533(3)$ (γ') 2V(meas.) = 70(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.097(1)$ $b = 7.145(1)$ $c = 8.434(1)$ $\alpha = 76.54(1)°$ $\beta = 70.30(1)°$ $\gamma = 70.75(1)°$ Z = 2

X-ray Powder Pattern: Cerchiara mine, Italy.
5.52 (vs), 2.834 (s), 7.92 (m), 5.26 (m), 4.99 (m), 3.643 (m), 2.758 (m)

Chemistry:

	(1)	(2)
C_2O_3	[39.54]	39.54
CaO	30.03	30.79
H_2O	[29.67]	29.67
Total	[99.24]	100.00

(1) Cerchiara mine, Italy; by electron microprobe, average of five analyses, C_2O_3 and H_2O calculated from the ideal formula; corresponds to $Ca_{0.98}C_{2.01}O_4 \cdot 3.01H_2O$ (2) $CaC_2O_4 \cdot 3H_2O$.

Occurrence: In veinlets cutting metamorphosed Mn–Ba-rich cherts in an obducted ophiolite.

Association: Quartz, barite, manganese oxides.

Distribution: From the Cerchiara mine, near Faggiona, Val di Vara, Liguria, Italy.

Name: An acronym with two meanings, for the essential chemical components, CAlcium and OXalate, or the Centennial Anniversary Of X-rays, an essential analytical tool in modern mineralogy.

Type Material: University of Genoa, Genoa, Italy.

References: (1) Basso, R., G. Lucchetti, L. Zefiro, and A. Palenzona (1997) Caoxite, $Ca(H_2O)_3(C_2O_4)$, a new mineral from the Cerchiara mine, northern Appennines, Italy. Neues Jahrb. Mineral., Monatsh., 84–96. (2) (1998) Amer. Mineral., 83, 185 (abs. ref. 1).

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Capgaronnite $HgS \cdot Ag(Cl, Br, I)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As single crystals, elongated along [001] and flattened on {010}, showing {010}, {100}, {110}, and {*h*0*l*}, to 1 mm; in tufted aggregates. *Twinning:* On {*h*0*l*}, as contact twins.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Irregular. *Tenacity:* Sectile. Hardness = Soft. D(meas.) = n.d. D(calc.) = 6.19

Optical Properties: Translucent to opaque. *Color:* Black. *Streak:* Gray-black. *Luster:* Subadamantine to submetallic.
Optical Class: Biaxial (–) (probable). *Pleochroism:* X = dark brown; Z = gray to purple. *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = \sim 2.2$ β = n.d. $\gamma = \sim 2.3$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_12_12$. $a = 6.803(8)$ $b = 12.87(1)$ $c = 4.528(7)$ $Z = 4$

X-ray Powder Pattern: Cap Garonne mine, France.
2.664 (100), 3.762 (60), 3.637 (60), 6.43 (40), 2.265 (40), 3.283 (30), 2.047 (20)

Chemistry:

	(1)
Ag	23.99
Hg	53.92
S	7.96
Cl	10.58
Br	5.17
I	0.33
Total	101.95

(1) Cap Garonne mine, France; by electron microprobe, average of five analyses; corresponds to $Hg_{0.98}Ag_{0.80}S_{0.90}(Cl_{1.08}Br_{0.23}I_{0.01})_{\Sigma=1.32}$.

Occurrence: Probably formed from oxidation of Hg–Ag-rich tennantite exposed to seawater (Cap Garonne mine, France).

Association: Olivenite, cyanotrichite, brochantite, parnauite, tennantite, strüverite, tourmaline, perroudite.

Distribution: In the Cap Garonne mine, near le Pradet, Var, France. At Chañarcillo, south of Copiapó, Atacama, Chile. From the Broken Hill Proprietary mine, New South Wales, Australia.

Name: For the occurrence in the Cap Garonne mine, France.

Type Material: n.d.

References: (1) Mason, B., W.G. Mumme, and H. Sarp (1992) Capgaronnite, $HgS \cdot Ag(Cl, Br, I)$, a new sulfide-halide mineral from Var, France. Amer. Mineral., 77, 197–200.
(2) Mason, B. (1972) Tocornalite [capgaronnite]. Smithsonian Contribution to Earth Science, 9, 79-80.

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Cappelenite-(Y) $Ba(Y,Ce)_6Si_3B_6O_{24}F_2$

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Crystal Data: Metamict; hexagonal after reconstitution at 725 °C. *Point Group:* 3. As crystals, thick hexagonal prismatic, showing $\{10\bar{1}0\}$, $\{0001\}$, and $\{10\bar{1}3\}$, to 2 cm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 4.407 D(calc.) = [4.50]

Optical Properties: Translucent. *Color:* Greenish brown, pale yellowish. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (–). $n = \sim 1.76$; birefringence rather strong.

Cell Data: *Space Group:* $P3$. $a = 10.67(2)$ $c = 4.680(2)$ $Z = 1$

X-ray Powder Pattern: Metamict.

Chemistry:

	(1)	(2)
SiO_2	14.21	14.51
ThO_2	0.80	
B_2O_3	[17.16]	16.82
Y_2O_3	52.62	54.55
La_2O_3	2.97	
CeO_2	1.29	
CaO	0.67	
BaO	8.02	12.35
Na_2O	0.25	
K_2O	0.20	
F		3.06
LOI	1.81	
$-O = F_2$		1.29
Total	[100.00]	100.00

(1) Lille Arø Island, Langesundsfjord, Norway; B_2O_3 by difference, corresponds to $(Ba_{0.64}La_{0.22}Na_{0.10}K_{0.05})_{\Sigma=1.01}(Y_{5.74}Ca_{0.15}Ce^{4+}_{0.09}Th_{0.04})_{\Sigma=6.02}Si_{2.91}B_{6.07}O_{24}F_2$. (2) $BaY_6Si_3B_6O_{24}F_2$.

Occurrence: In a small vein in nepheline syenite pegmatite.

Association: Wöhlerite, rosenbuschite, thorite, catapleiite, låvenite, nepheline, sodalite.

Distribution: On Lille Arø Island, in the Langesundsfjord, Norway.

Name: For D. Cappelen of Holden, Norway, a collector who discovered the mineral, and its *yttrium* content.

Type Material: University of Oslo, Oslo, Norway; National Museum of Natural History, Washington, D.C., USA, 160547.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 413–414. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 248. (3) Shen, J. and P.B. Moore (1984) Crystal structure of cappelenite, $Ba(Y,RE)_6[Si_3B_6O_{24}]F_2$: a silicoborate sheet structure. Amer. Mineral., 69, 190–195.

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Caracolite $Na_3Pb_2(SO_4)_3Cl$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically as incrustations of prismatic crystals, to 3 mm. *Twinning:* Pseudohexagonal trillings are produced by twinning, which may be polysynthetic.

Physical Properties: Hardness = 4.5 D(meas.) = ∼5.1 D(calc.) = 4.50 Decomposes in H_2O, leaving $PbSO_4$.

Optical Properties: Transparent. *Color:* Colorless, pale gray, may be stained green.
Luster: Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, strong. $\alpha = 1.743(5)$ $\beta = 1.754(5)$ $\gamma = 1.764(5)$ 2V(meas.) = Very large.

Cell Data: *Space Group:* $P2_1/m$. $a = 19.62$ $b = 7.14$ $c = 9.81$ $\beta = 90°$ Z = 4

X-ray Powder Pattern: Beatriz mine, Chile. (ICDD 25-706).
2.927 (100), 1.906 (56), 3.55 (55), 2.876 (45), 2.132 (35), 8.45 (31), 4.03 (31)

Chemistry:

	(1)	(2)
SO_3	16.70	29.76
FeO	0.33	
ZnO	0.29	
PbO		55.32
Pb	50.88	
Cu	2.51	
Na_2O	trace	11.52
Cl	10.18	4.39
insol.	1.84	
$-O = Cl_2$		0.99
Total		100.00

(1) Beatriz mine, Chile; partial analysis of impure material; composition established by crystal-structure analysis of natural and synthetic material. (2) $Na_3Pb_2(SO_4)_3Cl$.

Occurrence: A rare secondary mineral in the oxidized zone of chlorine-rich lead deposits.

Association: Boleite, pseudoboleite, bindheimite, anglesite, galena (Beatriz mine, Chile); atacamite, boleite, osarizawaite–beaverite, paratacamite (Herminia mine, Chile).

Distribution: From the Beatriz, Herminia, Santa Ana, and San Rafael mines, Sierra Gorda district, southwest of Calama, Antofagasta, Chile. In the Auguste-Victoria mine, Marl-Hüls, Ruhr Valley, North Rhine-Westphalia, Germany.

Name: For Caracoles, a town near the Beatriz mine, Chile.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 546–547. (2) Schneider, W. (1969) Bestimmung einer Überstruktur am Caracolit. Neues Jahrb. Mineral., Monatsh., 58–64 (in German with English abs.).

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Carboborite $Ca_2Mg[B(OH)_4]_2(CO_3)_2 \cdot 4H_2O$.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As steep pseudorhombohedral crystals, to 3 mm, with dominant {101} and {110}, modified by {011}, {100}, {121}, and {101}.

Physical Properties: *Cleavage:* {101}, perfect; {110}, distinct; {001}, imperfect. Hardness = 2 D(meas.) = 2.12 D(calc.) = 2.15 Fluoresces white under UV; pale green phosphorescence.

Optical Properties: Translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge a = 10°19'$; $Z \wedge c = 12°$. $\alpha = 1.507(1)$ $\beta = 1.546(1)$ $\gamma = 1.569(1)$ 2V(meas.) = 75°

Cell Data: *Space Group:* $P2_1/n$. $a = 11.011(3)$ $b = 6.674(1)$ $c = 10.692(5)$ $\beta = 116.64(3)°$ Z = 2

X-ray Powder Pattern: China.
5.63 (10), 4.315 (10), 3.136 (8), 2.160 (8), 2.727 (7), 2.437 (6), 4.86 (5)

Chemistry:

	(1)	(2)
SO_3	0.00	
CO_2	10.46	19.38
B_2O_3	15.70	15.33
MgO	9.08	8.87
CaO	24.21	24.69
Na_2O	0.27	
K_2O	trace	
Cl	0.00	
H_2O	39.78	31.73
insol.	1.17	
Total	100.67	100.00

(1) China. (2) $Ca_2Mg[B(OH)_4]_2(CO_3)_2 \cdot 4H_2O$.

Occurrence: In a lacustrine borate deposit.

Association: Ulexite, hydroboracite, gypsum.

Distribution: From China, at an unspecified locality [Dafangshan, Qinghai Plateau, Tibet].

Name: For the essential anionic chemical components, CARBOnate and BORate.

Type Material: n.d.

References: (1) Hsien-Te Hsieh, Tze-Chiang Chien, and Lai-Pao Liu (1964) The new mineral carboborite, $MgCa_2[CO_3|B_2O_5] \cdot 10H_2O$. Scientia Sinica, 13, 813–821 (in Russian). (2) (1965) Amer. Mineral., 50, 262–263 (abs. ref. 1). (3) Ma Zhesheng, Shi Nicheng, Shen Jinchuan, and Peng Zhizhong (1981) The refinement of the crystal structure of carboborite $MgCa_2[CO_3]_2[B(OH)_4]_2 \cdot 4H_2O$. Bull. Minéral., 104, 578–581.

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Carbocernaite $(Ca, Na)(Sr, Ce, Ba)(CO_3)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As tabular crystals with wedgelike terminations, to 4 mm, with dominant {100}, minor {010}, {001}, {021}, {540}, {210}, vicinal {305} and {210}; as grains and exsolution lamellae.

Physical Properties: *Cleavage:* {100}, {021}, and {010}, poor. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 3.53 D(calc.) = 3.64

Optical Properties: Transparent to translucent. *Color:* Colorless; white, yellow, yellowish green, rose, or brown if altered. *Luster:* Vitreous, greasy on fractures. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $z = c$. *Dispersion:* $r > v$, marked. $\alpha = 1.569(2)$ $\beta = 1.679(2)$ $\gamma = 1.708(2)$ 2V(meas.) = n.d. 2V(calc.) = 52°

Cell Data: *Space Group:* $Pb2m$. $a = 6.430$ $b = 7.301$ $c = 5.214$ Z = 2

X-ray Powder Pattern: Vuoriyarvi complex, Kola Peninsula, Russia. 3.00 (10), 2.015 (9), 1.813 (8), 2.60 (7b), 2.29 (7b), 3.66 (5), 2.082 (5)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	33.85	[32.02]	FeO	0.53	
Ce_2O_3	10.27	10.16	MnO		0.69
La_2O_3	8.78	13.26	CaO	16.68	17.15
Pr_6O_{11}	0.99	0.76	SrO	17.77	18.74
Nd_2O_3	2.47	1.82	BaO	5.24	1.64
Sm_2O_3	0.30	0.31	Na_2O	3.15	3.83
Gd_2O_3	0.39		H_2O	1.22	
			Total	101.64	[100.38]

(1) Bayan Obo deposit, China; corresponds to $(Ca_{0.78}Na_{0.26})_{\Sigma=1.04}(Sr_{0.44}RE_{0.40}Ba_{0.10})_{\Sigma=0.94}(CO_3)_2$. (2) Sarnu-Dandali complex, India; by electron microprobe, CO_2 calculated from stoichiometry; corresponds to $(Ca_{0.67}Na_{0.33})_{\Sigma=1.00}(Sr_{0.31}RE_{0.44}Ca_{0.15}Ba_{0.03}Mn_{0.03})_{\Sigma=0.96}(CO_3)_2$.

Occurrence: An uncommon accessory mineral in dolomite–calcite carbonatite associated with an alkaline ultramafic massif (Vuoriyarvi massif, Kola Peninsula, Russia); exsolved from calcite and in a carbonatite dike in fenitized melanephelinite (Sarnu-Dandali complex, India).

Association: "Chlorite", ankerite, alstonite, anatase, quartz (Vuoriyarvi complex, Kola Peninsula, Russia); dolomite, barite, "chlorite", mckelveyite-(Y), calkinsite-(Ce), khanneshite (Khanneshin complex, Afghanistan.).

Distribution: In Russia, from the Vuoriyarvi carbonatite complex and in the Khibiny massif, Kola Peninsula; at the Ozernyi carbonatite, southeastern Sakha. At the Khanneshin carbonatite complex, Afghanistan. In the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, and at Weishan, Shandong Province, China. From the Phan Si Pan Range, Vietnam. At the Sarnu-Dandali alkaline complex, Barmer District, Rajasthan, India. In Canada, at Sturgeon Narrows, Sturgeon Lake, Thunder Bay district, Ontario; from Mont Saint-Hilaire, Quebec.

Name: For the essential chemical components, CARBOnate, CERium, and sodium, NAtrium.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64100.

References: (1) Bulakh, A.G., V.V. Kondrat'eva, and E.N. Baranova (1961) Carbocernaite, a new rare earth carbonate. Zap. Vses. Mineral. Obshch., 90, 42–49 (in Russian). (2) (1961) Amer. Mineral., 46, 1202 (abs. ref. 1). (3) Shi Nicheng, Ma Zhesheng, and Peng Zhizhong (1982) The crystal structure of carbocernaite. Kexue Tongbao, 27, 76–80 (in English). (4) Wall, F., M.J. Le Bas, and R.K. Srivastava (1993) Calcite and carbocernaite exsolution and cotectic textures in a Sr, REE-rich carbonatite dyke from Rajasthan, India. Mineral. Mag., 57, 495–513.

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Carbonate-cyanotrichite $Cu_4Al_2(CO_3,SO_4)(OH)_{12}\cdot 2H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Individual platelets and acicular crystals, to 5 mm, typically in radiating fibrous crusts and spherules.

Physical Properties: Hardness = < 2 D(meas.) = 2.66(1) D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Pale blue to azure-blue. *Luster:* Silky. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = colorless; Z = bright blue. *Orientation:* Negative elongation, parallel extinction. *Dispersion:* $r > v$, strong. $\alpha = 1.616(2)$ β = n.d. $\gamma = 1.677(2)$ 2V(meas.) = 55°–60°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Balasauskandyk deposit, Kazakhstan.
4.21 (100), 10.13 (93), 5.03 (60), 3.33 (58), 2.01 (53), 2.51 (52), 2.77 (45)

Chemistry:

	(1)		(1)
SO_3	4.05	ZnO	0.62
CO_2	5.20	CaO	0.55
SiO_2	2.98	MgO	0.26
V_2O_4	0.16	H_2O^+	22.90
Al_2O_3	18.10	H_2O^-	1.45
CuO	44.40	Total	100.67

(1) Balasauskandyk deposit, Kazakhstan; after deducting quartz 2.98%, dolomite 0.88%, calcite 0.50%, and H_2O^- 0.80%, corresponds to $(Cu,Zn)_{3.70}Al_{2.30}(C_{0.67}S_{0.33})_{\Sigma=1.00}[O_{2.98}(OH)_{1.02}]_{\Sigma=4.00}(OH)_{12}\cdot 2H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of copper-bearing deposits.

Association: Volborthite, malachite, azurite, aurichalcite, pseudomalachite, spangolite, gibbsite, allophane (Balasauskandyk deposit, Kazakhstan); volborthite, tangeite, malachite, brochantite, langite (Menzies Bay, Canada).

Distribution: From the Balasauskandyk, Kurumsak, and other vanadium deposits, Kara-Tau Mountains, Kazakhstan. On Mt. Dzhebagly, Talass Alatau Range, and from Sary-Dzhas, Terskii Alatau Range, Kyrgyzstan. In the USA, from the Engels mine, north of Taylorsville, Plumas Co., California; in several mines at Bisbee, Cochise Co., Arizona; at the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada; from the Jomac mine, White Canyon district, San Juan Co., Utah; at the Emery mine, Chester, Hampton Co., Massachusetts. From Menzies Bay, Vancouver Island, British Columbia, Canada. In France, from the Cap Garonne mine, near le Pradet, Var, and in the Valcroze mine, Alzon, Gard. On the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais, Switzerland. From South Wheal Crebor, Tavistock, Devon, England. In the Wedding Cave mine, Bwlchgwyn, Clwyd, Wales. From the Maharahara mine, near Woodville, New Zealand. A few other minor localities are known.

Name: As the *carbonate*-dominant analog of *cyanotrichite*.

Type Material: Mining Museum, St. Petersburg, 1396/2–3; Vernadsky State Geological Museum, Moscow, 49844; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 65618, 65619.

References: (1) Ankinovich, E.A., I.I. Gekht, and R.I. Zaitseva (1963) A new variety of cyanotrichite – carbonate-cyanotrichite. Zap. Vses. Mineral. Obshch., 92, 458–463 (in Russian). (2) (1964) Amer. Mineral., 49, 441–442 (abs. ref. 1). (3) Read, A.J. (1986) Chalcophyllite and other rare hydroxy-sulfates from Maharahara, New Zealand. Mineral. Record, 17, 199–204. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 56–57.

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Carbonate-fluorapatite $Ca_5(PO_4, CO_3)_3F$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As minute prismatic crystals; in spherulites, to 5 mm, and fibrous crusts; usually cryptocrystalline massive.

Physical Properties: *Cleavage:* Poor on {0001} and $\{10\bar{1}0\}$. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.14–3.27 D(calc.) = 3.10

Optical Properties: Transparent to translucent. *Color:* Colorless, white, green, blue, yellow, brown, black; colorless to brown in thin section. *Luster:* Vitreous to earthy. *Optical Class:* Uniaxial (–), biaxial (–), isotropic when cryptocrystalline. *Orientation:* $X = c$. $n = 1.57$–1.63 [isotropic]. $\omega = 1.622$–1.640 $\epsilon = 1.614$–1.633 [uniaxial]. $\alpha = 1.612$–1.622 $\beta = 1.621$–1.627 $\gamma = 1.622$–1.627 [biaxial]. 2V(meas.) = 0°–25°

Cell Data: *Space Group:* $P6_3/m$. $a = 9.346$ $c = 6.887$ Z = 2

X-ray Powder Pattern: Staffel, Germany (fossil bone).
2.692 (100), 2.790 (55), 2.240 (45), 3.054 (34), 1.783 (25), 3.433 (20), 8.04 (18)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	38.13	40.33	K_2O		0.38
CO_2	3.40	2.70	F	3.71	3.89
Fe_2O_3	0.34		Cl		trace
MgO	0.10	1.35	H_2O	0.47	0.63
CaO	53.94	51.42	insol.	1.83	trace
Na_2O		1.17	$-O = F_2$	1.56	1.64
			Total	100.36	100.23

(1) Wheal Franco, Devon, England; corresponding to $(Ca_{4.99}Mg_{0.01})_{\Sigma=5.00}[(PO_4)_{2.79}(CO_3)_{0.40}]_{\Sigma=3.19}[F_{1.01}(OH)_{0.26}]_{\Sigma=1.27}$. (2) Staffel, Germany (fossil bone); corresponding to $Ca_{4.78}[(PO_4)_{2.70}(CO_3)_{0.28}]_{\Sigma=2.98}[F_{0.92}(OH)_{0.08}]_{\Sigma=1.00}$.

Mineral Group: Apatite group.

Occurrence: Typically of secondary origin. An important constituent of fossil bone, teeth, and marine phosphorite deposits. In carbonatites and nepheline syenite pegmatites. In fractures in phosphate-rich nodules.

Association: Glauconite, quartz, dolomite, clay minerals (phosphorites); beryl, fluorite, calcite, hematite, phlogopite, quartz (pegmatites).

Distribution: High-carbonate fluorapatite has been analyzed from many localities, although none can be considered well-characterized, as the mechanism whereby carbonate is incorporated in the mineral is still controversial. From Wheal Franco, near Tavistock, Devon, England. In Germany, at Dehrn and Staffel, near Limburg, Hesse. In the USA, at the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah; at Point of Rocks, Colfax Co., New Mexico; abundant (billions of tons of ore-grade material) in the Coastal Plain phosphorite deposits of the southeastern USA and western USA Phosphoria Formation. From Mont Saint-Hilaire and near Saint-Amable, Quebec, and along Rapid Creek, Yukon Territory, Canada. At the Zheleznyi iron mine, Kovdor massif, and in many pegmatites in the Lovozero massif, Kola Peninsula, Russia.

Name: For a *fluorapatite* with essential *carbonate*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 879–889. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 297–334. (3) Brophy, G.P. and J.T. Nash (1968) Compositional, infrared, and X-ray analysis of fossil bone. Amer. Mineral., 53, 445–454. (4) Binder, G. and G. Troll (1989) Coupled anion substitution in natural carbon-bearing apatites. Contr. Mineral. Petrol., 101, 394–401.

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Carbonate-hydroxylapatite $Ca_5(PO_4, CO_3)_3(OH)$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Cryptocrystalline; as fibrous or laminated botryoidal crusts.

Physical Properties: *Cleavage:* Poor on {0001} and $\{10\bar{1}0\}$. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.9–3.2 D(calc.) = 2.87 (synthetic).

Optical Properties: Transparent to translucent. *Color:* Colorless, white, yellow, brown. *Luster:* Vitreous, earthy.
Optical Class: Uniaxial (–). $\omega = 1.603$ $\epsilon = 1.598$

Cell Data: *Space Group:* $P6_3/m$ (synthetic). $a = 9.309$ $c = 6.927$ Z = 2

X-ray Powder Pattern: Synthetic $Ca_5(PO_4)_{1.5}CO_3)_{1.5}(OH)$. (ICDD 19-272).
2.78 (100), 2.68 (40), 3.46 (25), 2.231 (16), 1.929 (16), 1.838 (16), 3.04 (10)

Chemistry:

	(1)
SO_3	0.45
P_2O_5	38.7
CO_2	0.87
SiO_2	1.13
La_2O_3	0.14
Ce_2O_3	0.37
CaO	54.8
SrO	0.32
F	0.93
Cl	0.20
OH	2.42
$-O = (F, Cl, OH)_2$	1.57
Total	98.76

(1) The Kaiserstuhl, Germany; by electron microprobe and coulometric analysis, average of six analyses, $(OH)^{1-}$ calculated for stoichiometry; corresponding to $(Ca_{4.97}Sr_{0.02}Ce_{0.01})_{\Sigma=5.00}[(PO_4)_{2.77}(CO_3)_{0.10}(SiO_2)_{0.10}(SO_3)_{0.03}]_{\Sigma=3.00}[(OH)_{0.72}F_{0.25}Cl_{0.03}]_{\Sigma=1.00}$.

Mineral Group: Apatite group.

Occurrence: As cement in phosphatic soils and bioclastic limestones. An accessory mineral in carbonatites and alkaline igneous rocks.

Association: Calcite.

Distribution: Carbonatian hydroxylapatite has been analyzed from many localities, although the species is not well-characterized, as the mechanism whereby carbonate is incorporated is controversial. At the Ødegården apatite mines, Bamble, Norway. From the Kaiserstuhl, Baden-Württemberg, Germany. Found on Tuvalu (Ellice Islands), central Pacific. At Phalaborwa, Transvaal, South Africa. From Magnet Cove, Hot Spring Co., Arkansas, USA.

Name: For a *carbonate*-rich *hydroxylapatite*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 879–889. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 297–334. (3) Sommerauer, J. and K. Katz-Lehnert (1985) A new partial substitution mechanism of CO_3^{2-}/CO_3OH^{3-} and SiO_4^4 for the PO_4^{3-} group in hydroxyapatite from the Kaiserstuhl alkaline complex (SW-Germany). Contr. Mineral. Petrol., 91, 360–368.

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Caresite $Fe_4^{2+}Al_2(CO_3)(OH)_{12}\cdot 3H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$ or 1. As radiating tufts and bundles of crystals, to 2 mm; crystals elongated ‖ [101] and flattened on {001}. Forms observed are {100} and {001}, also (110). *Twinning:* Always, by rotation about [101].

Physical Properties: Hardness = n.d. D(meas.) = 2.86 D(calc.) = 2.89

Optical Properties: Transparent to translucent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X \simeq b$; $Z \wedge c = 10(5)°$. $\alpha = 1.411(2)$ $\beta = 1.416(2)$ $\gamma = 1.422(2)$ 2V(meas.) = 77(2)° 2V(calc.) = 78°

Cell Data: *Space Group:* $C\overline{1}$ or $C1$. $a = 9.48(5)$ $b = 6.98(3)$ $c = 9.30(5)$ $\alpha = 91.14(10)°$ $\beta = 104.85(10)°$ $\gamma = 90.0(10)°$ Z = 4

X-ray Powder Pattern: Hagendorf, Germany.
3.48 (100), 4.56 (70), 3.69 (60), 2.852 (40), 1.460 (40), 2.277 (30), 2.242 (30)

Chemistry:

	(1)	(2)
Ca	29.86	31.05
Al	10.27	10.45
F	52.1	51.52
H_2O	7.0	6.98
Total	99.23	100.00

(1) Hagendorf, Germany; by electron microprobe, average of two analyses, H_2O by DTA–TGA; corresponds to $Ca_{1.90}Al_{0.97}F_7\cdot 0.96H_2O$. (2) $Ca_2AlF_7\cdot H_2O$.

Occurrence: Formed by hydrothermal alteration of triphyllite in a pegmatite.

Association: Rockbridgeite, pyrite, strengite, apatite.

Distribution: Originally noted on a museum specimen, labelled only "Hagendorf", the matrix of which resembles that of pegmatites in the Hagendorf area, Bavaria, Germany. Since found in the Hagendorf-Süd pegmatite.

Name: For Dr. Carl Hintze (1851–1916), Professor of Mineralogy, Univerity of Breslau, Breslau, Germany, noted for his compilation of the famous *Handbuch der Mineralogie*.

Type Material: Royal Ontario Museum, Toronto, Canada, M35498; National Museum of Natural History, Washington, D.C., USA, B20119.

References: (1) Dunn, P.J., D.R. Peacor, and B.D. Sturman (1979) Carlhintzeite, a new calcium aluminum fluoride hydrate from the Hagendorf pegmatites, Bavaria, Germany. Can. Mineral., 17, 103–105. (2) (1980) Amer. Mineral., 65, 205–206 (abs. ref. 1). (3) Mücke, A. (1981) The parageneses of the phosphate minerals of the Hagendorf pegmatite - a general view. Chem. Erde, 40, 217–234.

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Carletonite $KNa_4Ca_4Si_8O_{18}(CO_3)_4(OH,F)\cdot H_2O$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. Crystals, prismatic along [001], to 6 cm; massive.

Physical Properties: *Cleavage*: Perfect on {001}, good on {110}. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 4-4.5 D(meas.) = 2.45 D(calc.) = 2.426

Optical Properties: Transparent to translucent. *Color*: Pink or pale to dark blue, commonly zoned; colorless in thin flakes. *Streak*: White. *Luster*: Vitreous to pearly, may become slightly waxy after long exposure to air.
Optical Class: Uniaxial (-). *Pleochroism:* Weak; *O* = very pale blue; *E* = very pale pinkish brown. ω = 1.521(1) ε = 1.517(1)

Cell Data: *Space Group*: *P4/mbm*. *a* = 13.178(3) *c* = 16.695(4) Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
8.353 (100), 4.171 (100), 2.903 (90), 2.384 (60), 4.053 (50), 16.705 (40), 4.816(40)

Chemistry:

	(1)	(2)
SiO_2	44.9	44.7
TiO_2	trace	trace
Al_2O_3	0.5	0.6
MgO	0.09	0.13
CaO	19.92	19.97
Na_2O	10.23	10.64
K_2O	3.28	3.31
F	0.70	0.73
H_2O^+	3.51	
H_2O^-	0.70	0.63
CO_2		15.2
LOI	19.92	
$-O = F_2$	0.29	0.30
Total	99.95	99.12

(1-2) Mont Saint-Hilaire, Canada; CO_2 by acid evolution-gravimetry, H_2O by direct determination of H; the average corresponds to $K_{0.74}\ Na_{3.56}\ (Ca_{3.74}Mg_{0.03})_{\sum=3.77}\ (Si_{7.89}\ Al_{0.11})_{\sum=8:00}\ O_{18}(CO_3)_{3.65}\ F_{0.41}\cdot 2.05H_2O$.

Occurrence: In cores of thermally metamorphosed wall-rock xenoliths of shale and interbedded limestone, now hornfels and siliceous marble, in nepheline syenite in an intrusive alkalic gabbro-syenite complex.

Association: Quartz, narsarsukite, calcite, fluorite, ancylite, molybdenite, leucosphenite, lorenzenite, galena, albite, pectolite, arfvedsonite, apophyllite, leifite (hornfels); pectolite, microcline, arfvedsonite, apophyllite (marble).

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: For Carleton University, Ottawa, Canada, where it was first studied.

Type Material: Canadian Museum of Nature, Ottawa, Canada, T711.

References: (1) Chao, G.Y. (1971) Carletonite, $KNa_4Ca_4Si_8O_{18}(CO_3)_4(F,OH)\cdot H_2O$; a new mineral from Mount St. Hilaire, Quebec. Amer. Mineral., 56, 1855-1866. (2) Chao, G.Y. (1972) The crystal structure of carletonite, $KNa_4Ca_4Si_8O_{18}(CO_3)_4(F,OH)\cdot H_2O$; a double-sheet silicate. Amer. Mineral., 57, 765-778.

Carlfriesite $CaTe_2^{4+}Te^{6+}O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As euhedral prismatic crystals, to 5 mm, with an "axe head" appearance due to {010} and other forms being curved, in radial sprays; typically in botryoidal crusts.

Physical Properties: *Cleavage:* On {010}, fair. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 6.3(0.25) D(calc.) = [5.70]

Optical Properties: Transparent. *Color:* Bright primrose-yellow; very pale buttery yellow in thin section. *Streak:* Very pale yellow.
Optical Class: Biaxial (–). *Pleochroism:* Weak; in yellows. *Orientation:* $Y = b$; $X \wedge c = 28°$.
Absorption: $X = Y < Z$. $\alpha = 1.982$ $\beta = 2.095$ $\gamma = 2.19$ 2V(meas.) = 80° 2V(calc.) = 79°

Cell Data: *Space Group:* $C2/c$. $a = 12.576(2)$ $b = 5.662(3)$ $c = 9.994(2)$ $\beta = 115.56(3)°$ $Z = 4$

X-ray Powder Pattern: Moctezuma mine, Mexico.
3.167 (10), 3.082 (9b), 5.063 (6), 2.832 (6), 3.369 (4), 4.825 (3), 2.698 (3)

Chemistry:

	(1)	(2)	(3)
TeO_3			31.88
TeO_2	87.0	89.5	57.94
CaO	10.2	10.5	10.18
H_2O	6.5		
Total	103.7	[100.0]	100.00

(1) Moctezuma mine, Mexico; by electron microprobe, average of three analyses, H_2O by the Penfield method. (2) Analysis (1) recalculated to 100.0% after deduction of H_2O. (2) $CaTe_2^{4+}Te^{6+}O_8$ as determined by crystal-structure analysis.

Occurrence: In cavities in an oxidized hydrothermal Au–Te deposit in intensely silicified brecciated rhyolite vitrophyre.

Association: Cerussite, chlorargyrite, argentian gold, cesbronite, calcite, dickite, barite, bornite, galena, hessite.

Distribution: From the Oriental (Bambollita) mine, northeast of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: Honors Carl Fries, Jr. (1910–1965), U.S. Geological Survey and the Geological Institute of the National University, Mexico City, Mexico, authority on the geology of large areas of Mexico.

Type Material: The Natural History Museum, London, England, 1976,406; University of Pierre and Marie Curie, Paris, France; Harvard University, Cambridge, Massachusetts, 119080; National Museum of Natural History, Washington, D.C., USA, 128393, 135058.

References: (1) Williams, S.A. and R.V. Gaines (1975) Carlfriesite, $H_4Ca(TeO_3)_3$, a new mineral from Moctezuma, Sonora, Mexico. Mineral. Mag., 40, 127–130. (2) (1976) Amer. Mineral., 61, 1053 (abs. ref. 1). (3) Effenberger, H., J. Zemann, and H. Mayer (1978) Carlfriesite: crystal structure, revision of chemical formula, and synthesis. Amer. Mineral., 63, 847–852.

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Carlgieseckeite-(Nd) $NaNdCa_3(PO_4)_3F$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$. As tabular hexagonal crystals to 1.3 mm, displaying {001} and {*hk*0} striated along [001]; also epitactically overgrow on prismatic crystals of Sr-bearing fluorapatite. *Twinning:* Microtwinning on {001} observed under the microscope in polarized light.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 5 D(meas.) = n.d. D(calc.) = 3.91

Optical Properties: Transparent. *Color*: Almost colorless with a greenish hue in daylight, pink in yellow electric light; colorless in transmitted light. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (-). ω = 1.655(3) ε = 1.632(2) [can be anomalously biaxial] α = 1.632(2) β = 1.654(3) γ = 1.656(3) 2V(meas.) = 15(5)° 2V(calc.) = 33°

Cell Data: *Space Group*: $P\bar{3}$. a = 9.4553(1) c = 6.9825(1) Z = 2

X-ray Powder Pattern: Kuannersuit Plateau, Ilímaussaq alkaline complex, South Greenland. 2.815 (100), 2.727 (42), 3.923 (27), 3.463 (23), 7.02 (22), 3.095 (19), 5.33 (18)

Chemistry:

	(1)		(1)
Na_2O	5.68	Sm_2O_3	2.89
CaO	18.53	Gd_2O_3	0.52
SrO	7.55	SiO_2	0.56
BaO	0.14	P_2O_5	32.72
La_2O_3	1.32	F	2.80
Ce_2O_3	10.60	Cl	0.06
Pr_2O_3	2.62	$-O=(F,Cl)_2$	1.19
Nd_2O_3	15.08	Total	99.88

(1) Ilímaussaq alkaline complex, South Greenland; average of 10 electron microprobe analyses; corresponding to $Na_{1.17}Ca_{2.11}Sr_{0.46}Ba_{0.01}La_{0.05}Ce_{0.41}Pr_{0.10}Nd_{0.57}Sm_{0.11}Gd_{0.02}Si_{0.06}P_{2.94}O_{12.05}F_{0.94}Cl_{0.01}$.

Mineral Group: Apatite group, belovite subgroup.

Occurrence: In small cavities in veins of saccharoidal albite cross-cutting augite syenite.

Association: Analcime, fluorapatite, albite.

Distribution: From the Kuannersuit (Kvanefjeld) Plateau, Ilímaussaq alkaline complex, South Greenland.

Name: Honors Carl Ludwig Giesecke (1761-1833) for pioneering research in the mineralogy of Greenland; the suffix (-*Nd*) reflects the dominance of Nd over other REE in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 3996/1).

References: (1) Pekov, I.V., N.V. Zubkova, T.A. Husdal, N.N. Kononkova, A.A. Agakhanov, A.E. Zadov, and D.Yu. Puscharovsky (2012) Carlgieseckeite-(Nd), $NaNdCa_3(PO_4)_3F$, a new belovite-group mineral species from the Ilímaussaq alkaline complex, South Greenland. Can. Mineral., 50(2), 571-580. (2) (2014) Amer. Mineral., 99, 2152 (abs. ref. 1).

Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\bar{1}$ or 1. As radiating tufts and bundles of crystals, to 2 mm; crystals elongated || [101] and flattened on {001}. Forms observed are {100} and {001}, also (110). *Twinning:* Always, by rotation about [101].

Physical Properties: Hardness = n.d. D(meas.) = 2.86 D(calc.) = 2.89

Optical Properties: Transparent to translucent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X \simeq b$; $Z \wedge c = 10(5)°$. $\alpha = 1.411(2)$ $\beta = 1.416(2)$ $\gamma = 1.422(2)$ 2V(meas.) = 77(2)° 2V(calc.) = 78°

Cell Data: *Space Group:* $C\bar{1}$ or $C1$. $a = 9.48(5)$ $b = 6.98(3)$ $c = 9.30(5)$ $\alpha = 91.14(10)°$ $\beta = 104.85(10)°$ $\gamma = 90.0(10)°$ Z = 4

X-ray Powder Pattern: Hagendorf, Germany.
3.48 (100), 4.56 (70), 3.69 (60), 2.852 (40), 1.460 (40), 2.277 (30), 2.242 (30)

Chemistry:

	(1)	(2)
Ca	29.86	31.05
Al	10.27	10.45
F	52.1	51.52
H_2O	7.0	6.98
Total	99.23	100.00

(1) Hagendorf, Germany; by electron microprobe, average of two analyses, H_2O by DTA–TGA; corresponds to $Ca_{1.90}Al_{0.97}F_7 \cdot 0.96H_2O$. (2) $Ca_2AlF_7 \cdot H_2O$.

Occurrence: Formed by hydrothermal alteration of triphyllite in a pegmatite.

Association: Rockbridgeite, pyrite, strengite, apatite.

Distribution: Originally noted on a museum specimen, labelled only "Hagendorf", the matrix of which resembles that of pegmatites in the Hagendorf area, Bavaria, Germany. Since found in the Hagendorf-Süd pegmatite.

Name: For Dr. Carl Hintze (1851–1916), Professor of Mineralogy, Univerity of Breslau, Breslau, Germany, noted for his compilation of the famous *Handbuch der Mineralogie.*

Type Material: Royal Ontario Museum, Toronto, Canada, M35498; National Museum of Natural History, Washington, D.C., USA, B20119.

References: (1) Dunn, P.J., D.R. Peacor, and B.D. Sturman (1979) Carlhintzeite, a new calcium aluminum fluoride hydrate from the Hagendorf pegmatites, Bavaria, Germany. Can. Mineral., 17, 103–105. (2) (1980) Amer. Mineral., 65, 205–206 (abs. ref. 1). (3) Mücke, A. (1981) The parageneses of the phosphate minerals of the Hagendorf pegmatite - a general view. Chem. Erde, 40, 217–234.

Carlinite Tl_2S

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Small, to 0.5 mm, mostly anhedral grains. A few grains show poorly defined rhombohedral and tabular forms.

Physical Properties: *Cleavage:* {0001}, perfect, and an imperfect prismatic cleavage. *Fracture:* Hackly. Hardness = ∼1 VHN = 23.5 (50 g load). D(meas.) = 8.1 D(calc.) = 8.55

Optical Properties: Opaque. *Color:* Dark gray, oxidized surfaces become dull and darker; in reflected light, white with faint bluish cast. *Streak:* Dark gray to black. *Luster:* Bright metallic. *Pleochroism:* Brownish gray to bluish gray. *Anisotropism:* Moderate to distinct. *Bireflectance:* Weak.

R_1–R_2: (470) 39.6–41.3, (546) 38.8–40.1, (589) 39.2–40.6, (650) 40.5–42.0

Cell Data: *Space Group:* $R\overline{3}$. $a = 12.12(1)$ $c = 18.175(5)$ Z = 27

X-ray Powder Pattern: Carlin mine, Nevada, USA (shows extreme preferred orientation). 3.030 (100), 2.290 (3), 2.020 (3), 1.749 (3), 2.712 (1), 1.681 (1), 1.513 (1)

Chemistry:

	(1)	(2)
Tl	92.93	92.73
S	7.17	7.27
Total	100.09	100.00

(1) Carlin mine, Nevada, USA; average of three samples. (2) Tl_2S.

Occurrence: As small grains in brecciated fragments of carbonaceous limestone, a result of epithermal mineralization.

Association: Gold, arsenic, antimony, mercury, avicennite, organic carbon, quartz.

Distribution: In the USA, from the east pit of the Carlin mine [TL], 50 km northwest of Elko, and in the Deep Post orebody, Goldstrike mine, Lynn district, Eureka Co., Nevada.

Name: For the Carlin gold deposit, Nevada, USA, in which it was discovered.

Type Material: Department of Geology, Stanford University, Palo Alto, California, Epithermal Minerals Collection; National Museum of Natural History, Washington, D.C., USA, 132497.

References: (1) Radtke, A.S. and F.W. Dickson (1975) Carlinite, Tl_2S, a new mineral from Nevada. Amer. Mineral., 60, 559–565. (2) Radtke, A.S., F.W. Dickson, and J.F. Slack (1978) Occurrence and formation of avicennite, Tl_2O_3, as a secondary mineral at the Carlin gold deposit, Nevada. J. Res. U.S. Geol. Surv., 6, 241–246.

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Carlosbarbosaite $(UO_2)_2Nb_2O_6(OH)_2\cdot 2H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As bent fibrous crystals to 0.12 mm, elongated along [001] and flattened on (100), and displaying {001}, {100} and {010}.

Physical Properties: *Cleavage*: Presumed to be {100} and {010}. *Fracture*: Uneven. *Tenacity*: Flexible. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.713 and 4.172 (for the samples noted below under 'Chemistry')

Optical Properties: Transparent to translucent. *Color*: Cream to pale yellow. *Streak*: Yellowish white. *Luster*: Vitreous.
Optical Class: Biaxial (+). $\alpha = 1.760$ $\beta = 1.775$ $\gamma = 1.795$ 2V(meas.) = 70(1)°
2V(calc.) = 83° *Pleochroism*: Weak, shades of yellowish green. *Orientation*: $X = a$, $Y = b$, $Z = c$.

Cell Data: *Space Group*: *Cmcm*. $a = 14.150(6)$ $b = 10.395(4)$ $c = 7.529(3)$ Z = 4

X-ray Powder Pattern: Jaguaraçu pegmatite, Minas Gerais, Brazil.
7.081 (100), 4.201 (90), 8.405 (80), 3.053 (80), 2.931 (70), 3.333 (60), 2.803 (60)

Chemistry:

	(1)	(2)
UO_3	54.52	41.83
CaO	2.07	2.10
Ce_2O_3	0.33	0.31
Nd_2O_3	0.49	1.12
Nb_2O_5	14.11	14.64
Ta_2O_5	15.25	16.34
TiO_2	2.20	0.95
SiO_2	2.14	3.55
Fe_2O_3	1.08	0.89
Al_2O_3	0.73	0.71
H_2O	[11.49]	[14.99]
Total	104.41	97.43

(1) Jaguaraçu pegmatite, Minas Gerais, Brazil; average of 7 electron microprobe analyses, H_2O calculated, OH and H_2O confirmed by IR spectroscopy; corresponds to $(\square_{0.68}Ca_{0.28}Nd_{0.02}Ce_{0.02})_{\sum=1.00}[U_{1.44}\square_{0.56}O_{2.88}(H_2O)_{1.12}](Nb_{0.80}Ta_{0.52}Si_{0.27}Ti_{0.21}Al_{0.11}Fe_{0.10})_{\sum=2.01}O_{4.72}(OH)_{3.20}(H_2O)_{2.08}$.
(2) Same as above; corresponding to $(\square_{0.67}Ca_{0.27}Nd_{0.05}Ce_{0.01})_{\sum=1.00}[U_{1.04}\square_{0.96}O_{2.08}(H_2O)_{1.92}](Nb_{0.79}Ta_{0.53}Si_{0.42}Ti_{0.08}Al_{0.10}Fe_{0.08})_{\sum=2.00}O_{4.00}(OH)_{3.96}(H_2O)_{2.04}$.

Polymorphism & Series: Forms a series between end members $(UO_2)_2Nb_2O_6(OH)_2(H_2O)_2$ and $(H_2O)_4Nb_2[O_2(OH)_4](OH)_2(H_2O)_2$.

Occurrence: A late-stage cavity filling in albite in a complex pegmatite.

Association: Albite, muscovite, zircon, kaolinite, columbite-(Fe).

Distribution: From the Jaguaraçu pegmatite, Minas Gerais, Brazil.

Name: Honors Carlos do Prado Barbosa (1917-2003), a chemical engineer, who as a dealer in mineral specimens, promoted the discovery and scientific study of rare mineral species.

Type Material: Museu de Geociências, Instituto de Geociências, Universidade de São Paulo, São Paulo, Brazil (DR707) and in the Systematic Reference Series, National Mineral Collection, Geological Survey, Ottawa, Ontario, Canada.

References: (1) Atencio, D., A.C. Roberts, M.A. Cooper, L.A.D. Menezes Filho, J.M.V. Coutinho, J.A.R. Stirling, K.E. Venance, N.A. Ball, E. Moffatt, M.L.S.C. Chaves, P.R.G. Brandão, and A.W. Romano (2012) Carlosbarbosaite, ideally $(UO_2)_2Nb_2O_6(OH)_2\cdot 2H_2O$, a new hydrated uranyl niobate mineral with tunnels from Jaguaraçu, Minas Gerais, Brazil: description and crystal structure. Mineral. Mag. 76, 75-90. (2) (2012) Amer. Mineral., 97, 1526 (abs. ref. 1).

Carlosruizite

$K_6(Na,K)_{10}Mg_{10}(Se^{6+}O_4, SO_4, CrO_4)_{12}(IO_3)_{12}\cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As thin pseudorhombohedral platy {0001} crystals with hexagonal outline, modified by $\{10\overline{1}2\}$, to < 200 μm.

Physical Properties: *Cleavage:* On $\{11\overline{2}0\}$, likely, visible on SEM images. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = n.d. D(calc.) = 3.400 Slowly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to pale yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.655(3)$ $\epsilon = 1.642(1)$

Cell Data: *Space Group:* $P\overline{3}c1$. $a = 9.5901(8)$ $c = 27.56(2)$ Z = 1

X-ray Powder Pattern: Zapiga, Chile.
3.561 (100), 3.058 (39), 2.717 (39), 3.082 (32), 13.75 (30), 7.10 (20), 3.974 (16)

Chemistry:

	(1)
SO_3	7.9
SeO_3	19.0
CrO_3	2.5
I_2O_5	45.6
MgO	9.2
Na_2O	4.7
K_2O	6.7
H_2O	n.d.
Total	95.6

(1) Zapiga, Chile; by electron microprobe, average of ten analyses, amounts thought low due to decay in electron beam, H_2O confirmed by crystal-structure analysis; corresponds to $K_{6.2}Na_{6.7}Mg_{10.0}[(Se^{6+}O_4)_{6.6}(SO_4)_{4.3}(CrO_4)_{1.1}]_{\Sigma=12.0}(IO_3)_{12.0}\cdot 12H_2O$.

Polymorphism & Series: Forms a series with fuenzalidaite.

Occurrence: A rare constituent of nitrate ores.

Association: Iquiqueite, nitratine, halite, darapskite, and residues containing dietzeite, brüggenite, tarapacaite, lopezite, ulexite, probertite, and gypsum after leaching in water.

Distribution: Probably from near Zapiga, Tarapacá, Chile.

Name: Honors Carlos Ruiz F. (1916–), first Director of the Chilean Geological Survey.

Type Material: n.d.

References: (1) Konnert, J.A., H.T. Evans, Jr., J.J. McGee, and G.E. Ericksen (1994) Mineralogical studies of the nitrate deposits of Chile: VII. Two new saline minerals with the composition $K_6(Na,K)_4Na_6Mg_{10}(XO_4)_{12}(IO_3)_{12}\cdot 12H_2O$: fuenzalidaite (X = S) and carlosruizite (X = Se). Amer. Mineral., 79, 1003–1008.

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Carlosturanite $(Mg, Fe^{2+}, Ti)_{21}(Si, Al)_{12}O_{28}(OH)_{34}$

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Crystal Data: Monoclinic. *Point Group:* m. Fibers, to 0.2 μm width, elongated along [010], to several cm. Commonly gathered in folded bundles; intergrown in parallel with brucite and chrysotile.

Physical Properties: *Cleavage:* On {001}, very good; parting on {010}. *Tenacity:* Flexible. Hardness = n.d. D(meas.) = 2.63(2) D(calc.) = 2.606

Optical Properties: Transparent. *Color:* Light brown. *Streak:* Whitish. *Luster:* Vitreous, pearly.
Optical Class: Biaxial. *Pleochroism:* Orange-brown ∥ [010]; pale orange-brown ⊥ [010].
n = 1.605(5) 2V(meas.) = n.d.

Cell Data: *Space Group:* Cm. $a = 36.70$ $b = 9.41$ $c = 7.291$ $\beta = 101.1°$ Z = 2

X-ray Powder Pattern: Near Sampeyre, Italy.
7.17 (100), 3.397 (55), 3.595 (45), 2.562 (40), 2.280 (35), 18.02 (25), 3.637 (20)

Chemistry:

	(1)
SiO_2	35.53
TiO_2	2.24
Al_2O_3	1.07
Cr_2O_3	0.24
FeO	4.03
MnO	0.72
MgO	39.28
H_2O	16.85
Total	99.96

(1) Near Sampeyre, Italy; by electron microprobe, average of 15 analyses, H_2O by TGA; corresponds to $(Mg_{18.88}Fe_{1.08}Ti_{0.54}Mn_{0.20}Cr_{0.06})_{\Sigma=20.76}(Si_{11.46}Al_{0.40})_{\Sigma=11.86}H_{36.26}O_{63.00}$.

Occurrence: In a network of veins crosscutting a metamorphic antigorite serpentinite, in an ophiolite.

Association: Diopside, chrysotile, brucite, magnetite, clinohumite, perovskite, uvarovite (near Sampeyre, Italy).

Distribution: In Italy, in Piedmont, at a number of localities around Sampeyre and Casteldelfino, Varaita Valley; around Crissolo, Po Valley; at Monte Nebin, Maira Valley; and around Viù, Viù Valley. From Taberg, Sweden.

Name: For Professor Carlo Sturani (1938–1976), University of Torino, Torino, Italy.

Type Material: Regional Science Museum, Torino, Italy; Natural History Museum, Vienna, Austria, L9493; National Museum of Natural History, Washington, D.C., USA, 162683.

References: (1) Compagnoni, R., G. Ferraris, and M. Mellini (1985) Carlosturanite, a new asbestiform rock-forming silicate from Val Varaita, Italy. Amer. Mineral., 70, 767–772. (2) Mellini, M., G. Ferraris, and R. Compagnoni (1985) Carlosturanite: HRTEM evidence of a polysomatic series including serpentine. Amer. Mineral., 70, 773–781. (3) Belluso, E. and G. Ferraris (1991) New data on balangeroite and carlosturanite from alpine serpentinites. Eur. J. Mineral., 3, 559–566.

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Carlsbergite CrN

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As oriented platelets, to 30 μm, and feathery to irregular grain-boundary precipitates.

Physical Properties: Hardness = High. VHN = Probably > 1000 D(meas.) = n.d. D(calc.) = [6.09]

Optical Properties: [Opaque.] *Color:* Light gray in reflected light, with a rose-violet tint. *Optical Class:* Isotropic.
R: (481) 49.5, (546) 41.5, (590) 41.0, (644) 40.5

Cell Data: *Space Group:* $Fm3m$. a = 4.16(3) Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 11-65).
2.068 (100), 2.394 (80), 1.463 (80), 1.249 (60), 0.9260 (60), 0.8460 (60), 0.9496 (50)

Chemistry:

	(1)	(2)	(3)
Fe	0.1 – 1.8	1.9	
Mn		0.04	
Cr	76.0 – 78.0	76.3	78.78
Co		0.03	
Ni		0.3	
N	20.0 – 25.0	[21.4]	21.22
Total		[100.0]	100.00

(1) Agpalilik (Cape York) meteorite; by electron microprobe, ranges of several analyses. (2) Descubridora meteorite; by electron microprobe, N by difference, corresponding to $(Cr_{0.96}Fe_{0.02})_{\Sigma=0.98}N$. (3) CrN.

Occurrence: As minute platelets and grain boundary precipitates in kamacite and troilite, and as similar grains ringing daubreelite in iron meteorites.

Association: Kamacite, taenite, daubreelite, troilite, sphalerite.

Distribution: First noted in the Agpalilik (Cape York) iron meteorite; since identified in more than 70 meteorites, mostly of Ga–Ge group IIIA, and also in groups I and IIA.

Name: For the Carlsberg Foundation, Copenhagen, Denmark, which supported recovery and cutting of the Agpalilik meteorite.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1967,410; American Museum of Natural History, New York, New York, USA.

References: (1) Buchwald, V.F. and E.R.D. Scott (1971) First nitride (CrN) in iron meteorites. Nature, Phys. Sci., 233, 113–114. (2) (1972) Amer. Mineral., 57, 1311 (abs. ref. 1). (3) Axon, H.J., J. Kinder, C.W. Haworth, and J.W. Horsfield (1981) Carlsbergite, CrN, in troilite, FeS, of the Sikhote Alin meteoritic iron. Mineral. Mag., 44, 107–109.

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Carmichaelite $(Ti, Cr)_2O_3(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals rare, pseudohexagonal; pyramidal, also thick tabular on pseudo-{0001}; commonly granular, massive, in beds several m thick. *Twinning:* Polysynthetic twin lamellae can be developed by pressure.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 1.602 D(calc.) = 1.598 Soluble in H_2O; deliquescent in high humidity, then dissolving; taste bitter.

Optical Properties: Transparent to translucent. *Color:* Colorless to milk-white, reddish from included hematite scales; rarely yellow or blue; colorless in transmitted light. *Luster:* Greasy, shining.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$.
$\alpha = 1.465$–1.466 $\beta = 1.474$–1.475 $\gamma = 1.494$–1.496 $2V(meas.) = 70°03'$ $2V(calc.) = 66°$

Cell Data: *Space Group: Pnna.* $a = 16.119(3)$ $b = 22.472(4)$ $c = 9.551(2)$ $Z = 12$

X-ray Powder Pattern: Locality unknown. (ICDD 24-869).
3.322 (100), 2.932 (95), 3.604 (70), 3.038 (70), 3.555 (55), 2.346 (50), 3.753 (45)

Chemistry:

	(1)	(2)	(3)
K	13.51	14.07	14.07
Mg	8.80	8.80	8.75
Cl	38.16	38.32	38.28
Br		0.12	
H_2O	[39.53]	38.38	38.90
insol.		0.04	
Total	[100.00]	99.73	100.00

(1) Königslutter, Lower Saxony, Germany; H_2O by difference. (2) Eddy Co., New Mexico, USA. (3) $KMgCl_3 \cdot 6H_2O$.

Occurrence: Thought to form in saline marine deposits by reaction of pre-existing saline minerals with fluids high in potash.

Association: Kieserite, sylvite, halite, polyhalite, bischofite.

Distribution: Found in many saline marine deposits. At Leopoldshall and Westeregeln, near Stassfurt, Magdeburg district, Germany. From Kalusz, Ukraine. At Maman, Azerbaijan. In Spain, in Barcelona and Lerida Provinces. At Mt. Dallol, Danakil, Ethiopia. From Orzinki, Saratov, Russia. In England, at Aislaby, near Whitby, Yorkshire. In the USA, in New Mexico, in the Carlsbad potash district, Eddy Co., and adjacent parts of Texas; from the Paradox basin, Grand Co., and other places in Utah.

Name: For Rudolph von Carnall (1804–1874), Prussian mining engineer.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 92–94. (2) Schlemper, E.O., P.K. Sen Gupta, and T. Zoltai (1985) Refinement of the structure of carnallite, $Mg(H_2O)_6KCl_3$. Amer. Mineral., 70, 1309–1313.

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Carminite $PbFe_2^{3+}(AsO_4)_2(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 2 cm, typically lathlike, flattened on {010}, elongated along [001], showing {010}, {110}, {011}, and other forms; as needlelike crystals, in spherical or tufted aggregates; fibrous, drusy, massive.

Physical Properties: *Cleavage:* On {110}, distinct. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 5.03–5.18; 5.22 D(calc.) = 5.405

Optical Properties: Translucent. *Color:* Carmine, tile-red, reddish brown; red in transmitted light. *Streak:* Reddish yellow. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* X = pale yellowish red; $Y = Z$ = dark carmine. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, strong. *Absorption:* $Y = Z > X$. $\alpha = 2.05–2.07$ $\beta = 2.05–2.07$ $\gamma = 2.06–2.08$ 2V(meas.) = Medium.

Cell Data: *Space Group: Cccm.* $a = 16.591(2)$ $b = 7.580(1)$ $c = 12.285(1)$ Z = 8

X-ray Powder Pattern: Mapimí, Mexico.
3.20 (10), 2.580 (9), 2.929 (8), 1.799 (8), 3.50 (7), 2.705 (7), 2.154 (7)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
As_2O_5	33.98	35.77	36.44	MgO	0.06		
Al_2O_3	0.96	0.17		CaO	0.44		
Fe_2O_3	23.43	23.54	25.33	H_2O^+	2.9		
FeO	0.21			H_2O^-	0.10		
CoO		0.12		H_2O		[2.85]	2.85
CuO		0.18		insol.	0.58		
PbO	37.30	36.98	35.38	Total	99.96	[99.61]	100.00

(1) Ojuela mine, Mapimí, Mexico; estimated impurity cerussite 5%. (2) Pira Inferida mine, Sardinia, Italy; by electron microprobe, total Fe as Fe_2O_3, H_2O from theoretical composition; corresponds to $(Pb_{1.06}Co_{0.01}Cu_{0.01})_{\Sigma=1.08}(Fe_{1.90}Al_{0.02})_{\Sigma=1.92}(AsO_4)_{2.00}(OH)_{2.03}$. (3) $PbFe_2(AsO_4)_2(OH)_2$.

Polymorphism & Series: Dimorphous with mawbyite.

Occurrence: An uncommon alteration product of arsenopyrite in some oxidized lead-bearing mineral deposits.

Association: Beudantite, scorodite, dussertite, arseniosiderite, bayldonite, mimetite, cerussite, anglesite, plumbojarosite, wulfenite.

Distribution: In Germany, from the Louise iron mine, near Horhausen, and in the Schöne Aussicht mine, near Dernbach, Westerwald; at the Merkur mine, Ems, Rhineland-Palatinate. In England, from Caldbeck Fells, and in the Wanthwaite mine, St. John's in the Vale, Cumbria; at the Hingston Downs Consols mine, Calstock; from Penberthy Croft, Wheal Gorland, and other mines in Cornwall. At the Cap Garonne mine, near le Pradet, Var, France. In the USA, at Eureka, Ruby Hill district, Eureka Co., and in the Killie mine, Spruce Mountain district, Elko Co., Nevada; from the Centennial Eureka mine, Tintic district, Juab Co., and at the Gold Hill mine, Tooele Co., Utah. In Mexico, from the Ojuela mine, Mapimí, Durango, in large crystals; at Santa Ana, La Mur, and at the San Félix mine, Caborca, Sonora. From Broken Hill, New South Wales, at Wyloo, and in the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia. As large crystals at Tsumeb, Namibia. Other minor localities are known.

Name: For the characteristic *carmine* color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 912–913. (2) Rosenzweig, A. and J.J. Finney (1959) The unit cell of carminite. Amer. Mineral., 44, 663–665. (3) Olmi, F. and C. Sabelli (1995) Carminite from three localities of Sardinia (Italy). Crystal structure refinements. Neues Jahrb. Mineral., Monatsh., 553–562. (4) Kharisun, M.R. Taylor, D.J.M. Bevan, and A. Pring (1996) The crystal structure of carminite: refinement and bond valence calculations. Mineral. Mag., 60, 805–811.

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Carnallite $KMgCl_3 \cdot 6H_2O$

Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals rare, pseudohexagonal; pyramidal, also thick tabular on pseudo-{0001}; commonly granular, massive, in beds several m thick. *Twinning:* Polysynthetic twin lamellae can be developed by pressure.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 1.602 D(calc.) = 1.598 Soluble in H_2O; deliquescent in high humidity, then dissolving; taste bitter.

Optical Properties: Transparent to translucent. *Color:* Colorless to milk-white, reddish from included hematite scales; rarely yellow or blue; colorless in transmitted light. *Luster:* Greasy, shining.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$.
$\alpha = 1.465$–1.466 $\beta = 1.474$–1.475 $\gamma = 1.494$–1.496 2V(meas.) = 70°03′ 2V(calc.) = 66°

Cell Data: *Space Group: Pnna.* $a = 16.119(3)$ $b = 22.472(4)$ $c = 9.551(2)$ $Z = 12$

X-ray Powder Pattern: Locality unknown. (ICDD 24-869).
3.322 (100), 2.932 (95), 3.604 (70), 3.038 (70), 3.555 (55), 2.346 (50), 3.753 (45)

Chemistry:

	(1)	(2)	(3)
K	13.51	14.07	14.07
Mg	8.80	8.80	8.75
Cl	38.16	38.32	38.28
Br		0.12	
H_2O	[39.53]	38.38	38.90
insol.		0.04	
Total	[100.00]	99.73	100.00

(1) Königslutter, Lower Saxony, Germany; H_2O by difference. (2) Eddy Co., New Mexico, USA. (3) $KMgCl_3 \cdot 6H_2O$.

Occurrence: Thought to form in saline marine deposits by reaction of pre-existing saline minerals with fluids high in potash.

Association: Kieserite, sylvite, halite, polyhalite, bischofite.

Distribution: Found in many saline marine deposits. At Leopoldshall and Westeregeln, near Stassfurt, Magdeburg district, Germany. From Kalusz, Ukraine. At Maman, Azerbaijan. In Spain, in Barcelona and Lerida Provinces. At Mt. Dallol, Danakil, Ethiopia. From Orzinki, Saratov, Russia. In England, at Aislaby, Yorkshire. In the USA, in the Permian salt basin of southeastern New Mexico, in the Carlsbad potash district, Eddy Co., and adjacent parts of Texas; from the Paradox basin, Grand Co., and other places in Utah.

Name: For Rudolph von Carnall (1804–1874), Prussian mining engineer.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 92–94. (2) Schlemper, E.O., P.K. Sen Gupta, and T. Zoltai (1985) Refinement of the structure of carnallite, $Mg(H_2O)_6KCl_3$. Amer. Mineral., 70, 1309–1313.

Carnotite $K_2(UO_2)_2(V_2O_8)\cdot 1{-}3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely in crystals, with a diamond-shaped outline, to 2 mm, flattened on {001}; typically in fine aggregates or powdery; disseminated, compact massive. *Twinning:* On {001} as both twin and composition plane.

Physical Properties: *Cleavage:* Perfect on {001}, micaceous. Hardness = Soft. D(meas.) = 4.70 D(calc.) = 4.91 Radioactive.

Optical Properties: Semitransparent. *Color:* Bright yellow to lemon-yellow, may be greenish yellow. *Streak:* Strontian-yellow. *Luster:* Dull, earthy; silky when crystalline. *Optical Class:* Biaxial (–). *Pleochroism:* X = nearly colorless to pale grayish yellow; $Y = Z$ = canary-yellow to lemon-yellow. *Orientation:* $X = c$; $Y = b$; $Z \wedge a \simeq 14°$. *Dispersion:* $r < v$. $\alpha = 1.750$ $\beta = 1.925$ $\gamma = 1.950$ 2V(meas.) = 40°–50°

Cell Data: *Space Group:* $P2_1/a$ (anhydrous synthetic). $a = 10.47(2)$ $b = 8.41(1)$ $c = 6.91(1)$ $\beta = 103°50(5)'$ Z = 2

X-ray Powder Pattern: Olary, Australia.
6.56 (10), 3.12 (7), 3.53 (5), 4.25 (3), 3.25 (3), 2.156 (3), 2.571 (2)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	62.26	63.41	CaO	0.66	
SO_2	0.26		Na_2O	0.16	
V_2O_5	20.57	20.16	K_2O	10.00	10.44
Fe_2O_3	0.55		H_2O	4.90	5.99
CuO	0.07		insol.	0.04	
MgO	0.30		Total	99.77	100.00

(1) Temple Mountain, Utah, USA. (2) $K_2(UO_2)_2(V_2O_8)\cdot 3H_2O$.

Occurrence: An important ore mineral of uranium, typically in paleochannels in sandstone Colorado Plateau-type U–V deposits, found near fossil carbonaceous matter, and in calcretes and near playas; an alteration product of uraninite, montroseite, or davidite.

Association: Tyuyamunite, metatyuyamunite, volborthite, tangeite, metatorbernite, rossite, hewettite, other U–V oxides, gypsum, barite.

Distribution: Known from hundreds of localities. In the USA, in Colorado, from the Rajah mine, Roc Creek, and many other localities in the Uravan district, along Paradox Valley, Bull Canyon and La Sal Creek, also Gypsum Valley, Montrose Co., the Gateway district, Mesa Co., and the Slick Rock district, San Miguel Co.; in Utah, from the San Rafael Swell, Emery Co., around Thompsons and Richardson, Grand Co.; from mines in the Grants district, McKinley Co., New Mexico; crystallized from the Anderson mine, Yavapai Co., and an ore mineral in Monument Valley, Apache and Navajo Cos., Arizona. In Australia, at El Sherana, Northern Territories; in a large deposit at Yeelirrie, and other smaller deposits in Western Australia; from the Radium Hill mine, near Olary, South Australia. Around Tyuya-Muyun and Uigursai, Fergana Valley, Alai Range, Kyrgyzstan.

Name: To honor Marie-Adolphe Carnot (1839–1920), French mining engineer and chemist.

Type Material: University of Colorado, Boulder, Colorado, 2218; Harvard University, Cambridge, Massachusetts, USA, 106253.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1043–1045. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 243–247. (3) Appleman, D.E. and H.T. Evans, Jr. (1965) The crystal structures of synthetic anhydrous carnotite, $K_2(UO_2)_2V_2O_8$, and its cesium analogue, $Cs_2(UO_2)_2V_2O_8$. Amer. Mineral., 50, 825–842.

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Carobbiite **KF**

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As minute cubic crystals, intermixed with other minerals.

Physical Properties: *Cleavage:* {001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.53] Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Isotropic. $n = 1.362$

Cell Data: *Space Group:* $Fm3m$ (synthetic). a = 5.40 Z = 4

X-ray Powder Pattern: Synthetic.
2.675 (100), 1.8913 (45), 3.088 (21), 1.5443 (10), 1.1959 (7), 1.6125 (6), 1.3370 (4)

Chemistry: Vesuvius, Italy; spectrographic analysis showed K and a little Na; microchemical analysis showed F and a little Cl.

Occurrence: In stalactites in cavities in lava.

Association: Halite, mercallite, hieratite.

Distribution: On Vesuvius, Campania, Italy.

Name: For Professor Guido Carobbi (1900–1983), Italian geologist, Institute of Mineralogy and Geochemistry, University of Florence, Florence, Italy, who collected the first specimens.

Type Material: University of Florence, Florence, Italy, 1972/l.

References: (1) Strunz, H. (1956) Carobbiit, ein neues Mineral. Rend. Soc. Ital. Mineral. Petrol., 12, 212–213 (in German). (2) (1957) Amer. Mineral., 42, 117 (abs. ref. 1). (3) Carobbi, G. (1936) Fluoruro di allumino, magnesio e calcio, bisolfato sodico, mercallite ed hieratite fra i prodotti dell' attivita fumarolica vesuviana del 1934. Atti Accac Sci. Lett. Arti, Modena, 5(1), 33–42. (4) (1937) Mineral. Abs., 6, 444 (abs. ref. 3). (5) McMurdie, H. (1986) Powder Diff., 1, 72.

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Karpatite $C_{24}H_{12}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are acicular, thin tabular parallel to [001], showing {001}, {100}, {$\overline{2}$01}, many other forms, to 1 cm; typically in bladed groups and fibrous radiating aggregates.

Physical Properties: *Cleavage:* On {001}, {100}, {$\overline{2}$01}, perfect. *Fracture:* Splintery. *Tenacity:* Flexible, nearly plastic. Hardness = ∼1 D(meas.) = 1.35–1.40 D(calc.) = 1.29–1.42 Flammable; fluoresces sky-blue under LW and SW UV.

Optical Properties: Subtranslucent. *Color:* Yellow, yellowish brown on exposure.
Luster: Vitreous.
Optical Class: Biaxial (–) or (+). *Orientation:* $X = b$; $Z \wedge c = 21°$. *Dispersion:* $r \gg v$, extreme.
$\alpha = 1.780(2)$ $\beta = 1.977$–1.982 $\gamma = 2.05$–2.15 2V(meas.) = 96°–115°

Cell Data: *Space Group:* $P2_1/c$ or $P2/c$ (synthetic). $a = 10.035$ $b = 4.695$ $c = 16.014$ $\beta = 112°$ Z = 2

X-ray Powder Pattern: Olenevo, Ukraine.
9.40 (10), 3.52 (9), 7.52 (8), 3.97 (7), 3.05 (6), 7.25 (5), 3.43 (4)

Chemistry:

	(1)	(2)
C	96.04	95.97
H	4.04	4.03
O		
Total	100.08	100.00

(1) Olenevo, Ukraine. (2) $C_{24}H_{12}$ (coronene).

Occurrence: In cavities at the contact of diorite porphyry with argillites (Olenevo, Ukraine); a low-temperature hydrothermal mineral (California, USA).

Association: Idrialite, amorphous organic material, calcite, barite, quartz, cinnabar, metacinnabar (Olenevo, Ukraine); cinnabar, quartz (California, USA).

Distribution: From near Olenevo, Transcarpathian region, western Ukraine. At Tamvotney, Kamchatka Peninsula, Russia. From the Picacho mercury mine, south of New Idria, San Benito Co., California, USA.

Name: From the Russian *Karpaty*, for the place of discovery in the Transcarpathian district, Ukraine.

Type Material: n.d.

References: (1) Piotrovsky, G.L. (1955) Karpatite – a new organic mineral from Transcarpathia. Lvovskoe geol. Obshch., Mineral. Sbornik, 9, 120–127 (in Russian). (2) (1957) Amer. Mineral., 42, 120 (abs. ref. 1). (3) Frank-Kamenetskii, V.A., S.K. Filatov, and Y.A. Giller (1967) The crystal structure and chemical formula of carpathite. Mineral. Sbornik L'vov Gos. Univ., 21, 275–278 (in Russian). (4) (1969) Amer. Mineral., 54, 329 (abs. ref. 3). (5) Murdoch, J. (1967) Pendletonite [= karpatite], a new hydrocarbon mineral from California. Amer. Mineral., 52, 611–616. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 110.

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Carpholite $Mn^{2+}Al_2Si_2O_6(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals acicular, prismatic; fibrous, as radiated tufts, to 2 cm. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Very brittle. Hardness = 5.5–6 D(meas.) = 2.935–3.031 D(calc.) = [3.07]

Optical Properties: Semitransparent. *Color:* Yellow. *Luster:* Silky, glistening. *Optical Class:* Biaxial (–). *Pleochroism:* Distinct; $X = Y$ = pale yellow; Z = colorless. $\alpha = 1.624$ $\beta = 1.629$ $\gamma = 1.638$ 2V(meas.) = n.d. 2V(calc.) = 67°

Cell Data: *Space Group: Ccca.* $a = 13.714(2)$ $b = 20.079(2)$ $c = 5.105(1)$ Z = 8

X-ray Powder Pattern: Fukuzumi mine, Japan.
5.73 (100), 5.08 (70), 2.620 (50), 3.46 (30), 3.04 (30), 3.39 (20), 2.761 (20)

Chemistry:

	(1)	(2)	(3)
SiO_2	36.61	38.38	36.52
TiO_2	trace	trace	
Al_2O_3	29.36	29.45	30.98
Fe_2O_3	1.53	1.47	
V_2O_5		0.06	
FeO	3.05	0.22	
MnO	18.08	17.77	21.55
ZnO		0.12	
MgO		1.92	
CaO	trace		
Na_2O		0.19	
K_2O		0.08	
H_2O^+	11.03		
H_2O^-	0.32		
H_2O		10.19	10.95
Total	99.98	99.85	100.00

(1) Fukuzumi mine, Japan. (2) Near Meuville, Belgium; Loss on ignition taken as H_2O. (3) $MnAl_2Si_2O_6(OH)_4$.

Polymorphism & Series: Forms a series with ferrocarpholite.

Occurrence: In low-grade metamorphosed shales.

Association: Sudoite, manganoan garnet, chlorotoid, fluorite.

Distribution: At Horní Slavkov (Schlaggenwald), Czech Republic. From near Meuville, Ardennes Mountains, Belgium. At Wippra, Harz Mountains, Germany. In England, from the Carrock mine, Caldbeck Fells, Cumbria; at Kit Hill Consols, Stokeclimsland, in the Hingston Down Consols mine, near Calstock, and in the Stenna Gwynn mine, St. Stephen-in-Brannel, Cornwall. In the Fukuzumi mine, Kyoto Prefecture, Japan.

Name: From the Greek for *straw*, in allusion to its color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 549. (2) Yoshimura, T. and Y. Aoki (1966) Carpholite from the Fukuzumi mine, Hyogo Prefecture. J. Mineral. Soc. Japan, 8, 43–48. (3) (1967) Mineral. Abs., 18, 200 (abs. ref. 2). (4) A.-M. Fransolet (1972) Données nouvelles sur la carpholite de Meuville (vallée de la Lienne, Belgique). Bull. Soc. fr. Minéral., 95, 84–97 (in French with English abs.). (5) Lindemann, V.W., R. Wögerbauer, and P. Berger (1979) Die Kristallstruktur von Karpholith. Neues Jahrb. Mineral., Monatsh., 282–287 (in German with English abs.). (6) Ghose, S., P.K. Sen Gupta, R.C. Boggs, and E.O. Schlemper (1989) Crystal chemistry of a nonstoichiometric carpholite, $K_x(Mn_{2-x}Li_x)Al_4Si_4O_{12}(OH)_4F_4$: a chain silicate related to pyroxenes. Amer. Mineral., 74, 1084–1090.

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Carraraite $Ca_3Ge(SO_4)(CO_3)(OH)_6 \cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Hexagonal crystals, tabular on {0001}, to prismatic, elongated along $[10\bar{1}0]$, to 0.6 mm.

Physical Properties: Hardness = [2.5] (by analogy to the ettringite group).
D(meas.) = n.d. D(calc.) = 1.979

Optical Properties: Transparent to translucent. *Color:* Milky white. *Luster:* Vitreous.
Optical Class: Uniaxial (–) $\omega = 1.509(1)$ $\epsilon = 1.479(1)$

Cell Data: *Space Group:* $P6_3/m$. a = 11.056(3) $c = 10.629(6)$ Z = 2

X-ray Powder Pattern: Gioia quarry, Italy.
9.57 (vs), 5.53 (s), 3.83 (s), 3.56 (ms), 2.74 (ms), 3.44 (m), 2.53 (m)

Chemistry:

	(1)	(2)
SO_3	16.19	12.00
CO_2		6.60
GeO_2	18.15	15.68
CaO	35.70	25.22
H_2O		40.50
Total		100.00

(1) Gioia quarry, Italy; by electron microprobe, corresponds to $Ca_3Ge(SO_4)_{1.08}(CO_3)_{0.92}(OH)_6 \cdot 12H_2O$. (2) $Ca_3Ge(SO_4)(CO_3)(OH)_6 \cdot 12H_2O$ as confirmed by crystal-structure analysis.

Mineral Group: Ettringite group.

Occurrence: A rare secondary mineral formed by late-stage hydrothermal alteration of earlier sulfides and sulfosalts.

Association: Nordstrandite, dawsonite.

Distribution: From the Gioia quarry, Colonnata Valley, northeast of Carrara, Tuscany, Italy.

Name: For its occurrence in the Carrara district, Italy.

Type Material: Natural History Museum, University of Pisa, Pisa, Italy.

References: (1) Merlino, S. and P. Orlandi (2001) Carraraite and zaccagnaite, two new minerals from the Carrara marble quarries: their chemical compositions, physical properties, and structural features. Amer. Mineral., 86, 1293–1301.

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Carrboydite $(Ni, Al)_9(SO_4)_2(OH)_{18}\cdot 10H_2O(?)$

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Crystal Data: Hexagonal. *Point Group:* n.d. As spherical felted aggregates of platy crystals, to 1 mm, and as amorphous-appearing coatings; massive in thin veins and fracture fillings.

Physical Properties: Hardness = n.d. D(meas.) = 2.50(5), on porous impure material. D(calc.) = 2.692

Optical Properties: Translucent. *Luster:* Dull to waxy. *Color:* Yellowish green, greenish yellow, blue-green, pale green, greenish blue; pale blue-green in transmitted light. *Optical Class:* Uniaxial (–), may be biaxial (–). *Orientation:* Length-slow. $\omega = \sim 1.56$ $\epsilon = \sim 1.54$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 9.14$ $c = 10.34$ Z = [1]

X-ray Powder Pattern: Carr Boyd Rocks mine, Australia.
10.5 (vs), 5.25 (s), 2.55 (ms), 3.48 (m), 1.51 (m), 2.62 (w), 2.36 (wb)

Chemistry:

	(1)
SO_3	14.5
CO_2	1.65
SiO_2	2.6
Al_2O_3	17.9
NiO	38.2
CuO	2.5
H_2O	20.55
Total	97.9

(1) Carr Boyd Rocks mine, Australia; by electron microprobe, C and H by microanalysis, here recalculated to oxides; after deduction of CO_2, SiO_2, and CuO, corresponds to $(Ni_{5.7}Al_{3.9})_{\Sigma=9.6}(SO_4)_{2.0}(OH)_{19.1}\cdot 3.0H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of nickel sulfide deposits.

Association: Malachite, azurite, paratacamite, brochantite, glaukosphaerite, takovite, nickeloan magnesite, chalconatronite, georgeite, halloysite, chabazite, gypsum, epsomite (Carr Boyd Rocks mine, Western Australia).

Distribution: In Australia, from the Carr Boyd Rocks nickel mine, Yerilla district, 80 km north-northeast of Kalgoorlie, and at the 132 North nickel mine, 4 km southwest of Widgiemooltha, Western Australia.

Name: For the Carr Boyd Rocks mine, Australia, the first known locality.

Type Material: Western Australian Museum, Perth, Australia, M.74.1991; National Museum of Natural History, Washington, D.C., USA, 135930.

References: (1) Nickel, E.H. and R.M. Clarke (1976) Carrboydite, a hydrated sulfate of nickel and aluminum: a new mineral from Western Australia. Amer. Mineral., 61, 366–372.

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Carrollite $Cu(Co,Ni)_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Octahedral crystals, to 10 cm; commonly massive, disseminated granular to compact. *Twinning:* On {111}; may show polysynthetic twin lamellae.

Physical Properties: *Cleavage:* {001}, imperfect. *Fracture:* Uneven to subconchoidal. Hardness = 4.5–5.5 VHN = 507–586 (100 g load). D(meas.) = 4.5–4.8 D(calc.) = 4.83

Optical Properties: Opaque. *Color:* Pale gray to steel-gray, tarnishing easily to copper-red or violet-gray. *Luster:* Metallic.

R: (400) 41.4, (420) 41.5, (440) 41.6, (460) 41.8, (480) 42.0, (500) 42.3, (520) 42.6, (540) 42.9, (560) 43.1, (580) 43.3, (600) 43.5, (620) 43.9, (640) 44.3, (660) 44.7, (680) 45.0, (700) 45.3

Cell Data: *Space Group:* $Fd3m$. a = 9.458 Z = 8

X-ray Powder Pattern: N'Kana, Zambia.
2.86 (100), 1.674 (80), 1.825 (60), 2.37 (50), 0.994 (50), 3.35 (40), 1.234 (30)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	20.2	13.90	18.98	9.98
Co	38.6	35.15	35.79	36.08
Ni	0.3	7.01	3.66	7.65
Fe	0.6	0.93	2.25	
S	41.2	40.74	40.64	41.89
insol.		0.27		0.50
Total	100.9	99.25	100.00	98.35

(1) Zaire; by electron microprobe, corresponds to $Cu_{0.99}Co_{2.04}Ni_{0.02}Fe_{0.03}S_{4.00}$. (2) Gladhammar, Sweden; corresponds to $Cu_{0.69}Co_{1.88}Ni_{0.38}Fe_{0.12}S_{4.00}$. (3) Siegen, Germany; recalculated to 100% after deduction of quartz 1.25%; corresponds to $Cu_{0.94}Co_{1.92}Ni_{0.20}Fe_{0.05}S_{4.00}$. (4) Mineral Hill mine, Maryland, USA; corresponds to $Cu_{0.48}Co_{1.88}Ni_{0.40}Fe_{0.12}S_{4.00}$.

Mineral Group: Linnaeite group.

Occurrence: In hydrothermal vein deposits.

Association: Tetrahedrite, linnaeite, siegenite, polydymite, chalcopyrite, bornite, digenite, djurleite, chacocite, pyrrhotite, pyrite, sphalerite, millerite, gersdorffite, ullmannite, cobaltoan calcite.

Distribution: In the USA, from Carroll Co., Maryland, in the Patapsco mine, Finksburg [TL], and the Mineral Hill mine, Sykesville. At Boleo, Baja California, Mexico. In the Carrizal Alto copper district, Atacama, Chile. From near Chernomorets, Burgas, Bulgaria. At Vysna Boca, Nizke Tatry Mountains, Slovakia. In the Kohlenbach mine, near Eiserfeld, and throughout the Siegerland district, North Rhine-Westphalia, Germany. From Gladhammar, Kalmar, Sweden. At Tsumeb, Namibia. Large crystals from Kambove, and in the Kamoto and Musonoi mines, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). From the Rokana mine, Kitwe, Zambia. At the Madziwa (Dry Nickel) mine, Bindura, and Shamva, Zimbabwe. In the Sazare mine, Ehime Prefecture, and the Shirataki mine, Kochi Prefecture, Japan. At the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea. From Kambalda, 56 km south of Kalgoorlie, Western Australia. A substantial number of other minor occurrences are known.

Name: For its occurrence in Carroll Co., Maryland, USA.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 262–264. (2) Riley, J. (1980) Ferroan carrollites, cobaltian violarites, and other members of the linnaeite group: $(Co, Ni, Fe, Cu)_3S_4$. Mineral. Mag., 43, 733–739. (3) Wagner, T. and N.J. Cook (1999) Carrollite and related minerals of the linnaeite group: solid solutions and nmomenclature in light of new data from the Siegerland district, Germany. Can. Mineral., 37, 545–558. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 77. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 74.

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Caryinite $(Na, Pb)(Ca, Na)(Ca, Mn^{2+})(Mn^{2+}, Mg)_2(AsO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As cleavable masses; fine-grained massive, in veins to 10 cm.

Physical Properties: *Cleavage:* On {110} and {010}, distinct. Hardness = 4
D(meas.) = 4.29 D(calc.) = [4.45]

Optical Properties: Subtranslucent. *Color:* Nut-brown to yellowish brown; in transmitted light, pale yellow-brown. *Luster:* Greasy.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, slight.
$\alpha = 1.776(5)$ $\beta = 1.780(5)$ $\gamma = 1.805(5)$ 2V(meas.) = 41(3)°

Cell Data: *Space Group:* $I2/a$. $a = 6.855(2)$ $b = 13.147(3)$ $c = 11.479(4)$
$\beta = 98.97(2)°$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
2.868 (10), 2.849 (10), 2.686 (5), 3.03 (3), 3.29 (2), 3.14 (2), 2.903 (2)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	0.19	0.8	0.95	MgO	3.09	3.1	3.24
As_2O_5	49.78	47.8	48.84	CaO	12.12	10.8	10.82
V_2O_5			0.24	BaO	1.03	0.8	0.17
SiO_2	0.21			Na_2O	5.16	4.18	4.82
FeO	0.54	0.5	0.10	K_2O	0.37		
MnO	18.66	19.1	17.90	Cl	trace		
PbO	9.21	11.5	12.73	H_2O	0.53		
				Total	100.89	98.6	99.81

(1) Långban, Sweden; SiO_2 determined separately and thought to be in berzeliite. (2) Do.; by electron microprobe, total Fe as FeO, Mn as MnO, Na determined by flame photometry. (3) Do.; by electron microprobe, average of two analyses, total Fe as FeO, Mn as MnO; cations apportioned by structure refinement, corresponding to $(Na_{0.61}Pb_{0.39})_{\Sigma=1.00}(Ca_{0.56}Na_{0.43}Ba_{0.01})_{\Sigma=1.00}(Ca_{0.74}Mn^{2+}_{0.26})_{\Sigma=1.00}(Mn^{2+}_{1.45}Mg_{0.54}Fe^{3+}_{0.01})_{\Sigma=2.00}[(AsO_4)_{2.89}(PO_4)_{0.09}(VO_4)_{0.02}]_{\Sigma=3.00}$.

Mineral Group: Alluaudite group.

Occurrence: In veinlets in skarn in a metamorphosed Fe–Mn orebody.

Association: Berzeliite, adelite, hedyphane, hausmannite, rhodonite, diopside, calcite.

Distribution: At Långban, Värmland, Sweden.

Name: From the Greek for *nut-brown*, for its common color.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 221444.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 683–684. (2) Boström, K. (1957) The chemical composition and symmetry of caryinite. Arkiv. Mineral. Geol., 2(20), 333–336. (3) Moore, P.B. (1968) Contributions to Swedish mineralogy. I. Studies on the basic arsenates of manganese: retzian, hemafibrite, synadelphite, arsenoclasite, arseniopleite, and akrochordite. Arkiv. Mineral. Geol., 4(5), 425–444. (4) Dunn, P.J. and D.R. Peacor (1987) New data on the relation between caryinite and arseniopleite. Mineral. Mag., 51, 281–284. (5) Ercit, T.S. (1993) Caryinite revisited. Mineral. Mag., 57, 721–727.

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Caryopilite $(Mn^{2+},Mg)_3Si_2O_5(OH)_4$

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Crystal Data: Monoclinic (?). *Point Group:* n.d. As tabular pseudohexagonal crystals, commonly in rosettes, to 4 mm. Stalactitic, reniform with concentrically radiating fibrous internal structure, or massive.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 3–3.5 D(meas.) = 2.83–2.94 D(calc.) = 2.788

Optical Properties: Semitransparent. *Color:* Reddish brown, tan; light brown to yellow in thin section.
Optical Class: Biaxial (–). *Orientation:* $X = c$. α = 1.602–1.624 β = 1.632–1.650 γ = 1.632–1.650 2V(meas.) = $\sim 0^\circ$

Cell Data: *Space Group:* n.d. $a = 5.668$ $b = 9.811$ $c = 7.527$ $\beta = 104.52^\circ$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
2.49 (100), 7.24 (90), 3.64 (80), 2.78 (70), 2.08 (50), 1.954 (30), 1.617 (20)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	32.1	36.35	MgO	1.9	8.01
Al_2O_3		0.21	CaO		0.03
As_2O_3	6.5		F		< 0.05
FeO	1.7	1.09	Cl		0.14
MnO	48.8	42.39	H_2O	[8.1]	[9.22]
ZnO	0.9	< 0.03	$-O = (F,Cl)_2$		[0.08]
			Total	[100.0]	[97.44]

(1) Sterling Hill, New Jersey, USA; by electron microprobe, H_2O by difference. (2) Bald Knob, North Carolina, USA; by electron microprobe, H_2O calculated from stoichiometry.

Occurrence: A product of the metamorphism of manganese-bearing minerals.

Association: Gonyerite (Långban, Sweden); calcite, rhodonite, lead, sarkinite, brandtite (Pajsberg, Sweden); manganoan calcite, tirodite, rhodonite, jacobsite (Bald Knob, North Carolina, USA).

Distribution: From the Harstigen mine, near Persberg, and at Långban, Värmland, Sweden. In the Molinello and Gambatesa manganese mines, near Chiavari, Val Graveglia, Liguria, Italy. At the Falotta mine, Oberhalbstein, Graubünden, Switzerland. In the Ködnitz Valley, Tirol, Austria. In the USA, at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; at Bald Knob, near Sparta, Alleghany Co., North Carolina; in the Hurricane mine, on the Olympic Penninsula, Washington. From the Ichinomata mine, Kumamoto Prefecture, Japan. At Watson's Beach, southeastern Otago, New Zealand. In the N'Chwaning and Wessels mines, near Kuruman, Cape Province, South Africa.

Name: From the Greek for *walnut* and *felt*, in allusion to its color and habit.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 704. (2) Kato, T. (1963) New data on the so-called bementite. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 49, 93–103 (in Japanese). (3) (1964) Amer. Mineral., 49, 446–447 (abs. ref. 2). (4) Peacor, D.R. and E.J. Essene (1980) Caryopilite–a member of the friedelite rather than the serpentine group. Amer. Mineral., 65, 335–339. (5) Dunn, P.J., D.R. Peacor, J.A. Nelen, and J.A. Norberg (1981) Crystal-chemical data for schallerite, caryopilite and friedelite from Franklin and Sterling Hill, New Jersey. Amer. Mineral., 66, 1054–1062. (6) Bayliss, P. (1981) Unit cell data of serpentine group minerals. Mineral. Mag., 44, 153–156. (7) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 602–603. (8) Guggenheim, S., S.W. Bailey, R.A. Eggleton, and P. Wilkes (1982) Structural aspects of greenalite and related minerals. Can. Mineral., 20, 1–18.

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Cascandite $Ca(Sc, Fe^{2+})Si_3O_8(OH)$

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Crystal Data: Triclinic. *Point Group:* 1. As plates, to 0.2 mm, elongated along [100] and flattened ∥ {001}; forms observed are {001}, {100}, {120}, and $\{5\bar{3}0\}$.

Physical Properties: *Cleavage:* Good on {100} and {001}. Hardness = n.d.
D(meas.) = n.d. D(calc.) = [3.03]

Optical Properties: Transparent. *Color:* Pale pink. *Luster:* Vitreous.
Optical Class: Biaxial. $\alpha = 1.663$ on (001). β = n.d. $\gamma = 1.684$ on (001). 2V(meas.) = n.d.

Cell Data: *Space Group:* $P1$. $a = 9.791(8)$ $b = 10.420(9)$ $c = 7.076(6)$ $\alpha = 98.91(8)°$ $\beta = 102.63(8)°$ $\gamma = 84.17(8)°$ Z = 2

X-ray Powder Pattern: Baveno, Italy.
2.821 (s), 3.62 (m), 3.10 (m), 2.968 (m), 1.429 (m), 7.22 (w), 6.75 (w)

Chemistry:

	(1)
SiO_2	51.83
TiO_2	0.08
Al_2O_3	0.11
Sc_2O_3	14.74
FeO	4.50
MnO	2.32
MgO	0.20
CaO	16.83
Na_2O	0.06
H_2O	[2.59]
Total	[93.26]

(1) Baveno, Italy; by electron microprobe, H_2O calculated from stoichiometry.

Occurrence: In miarolitic cavities in granite.

Association: Quartz, orthoclase, albite, jervisite.

Distribution: From the Diverio quarry, Mt. Mottarone, near Baveno, Piedmont, Italy.

Name: For CAlcium and SCANDium in the composition.

Type Material: Municipal Museum of Natural History, Milan, Italy, 23270.

References: (1) Mellini, M., S. Merlino, P. Orlandi, and R. Rinaldi (1982) Cascandite and jervisite, two new scandium silicates from Baveno, Italy. Amer. Mineral., 67, 599–603. (2) Mellini, M. and S. Merlino (1982) The crystal structure of cascandite, $CaScSi_3O_8(OH)$. Amer. Mineral., 67, 604–609.

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Cassagnaite $Ca_4Fe^{3+}_4(OH)_4V^{3+}_2O_2(OH)_2(SiO_4)_2(Si_3O_{10})$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As prismatic to tabular {001} crystals, usually elongated along [100], to 0.1 mm, exhibiting forms {011}, {001} and {100}; as entangled aggregates.

Physical Properties: *Cleavage*: {001} (or parting). *Tenacity*: Brittle.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.22

Optical Properties: Transparent. *Color*: Golden brown. *Streak*: Nearly white. *Luster*: Vitreous.
Pleochroism: Very weak; *N* = golden yellow-brown, *n* = pale golden yellow-brown.
Optical Class: Biaxial. *N* (parallel to *a*) = 1.810(5) *n* = 1.800(5)

Cell Data: *Space Group*: *Cmcm*. *a* = 6.066(1) *b* = 8.908(1) *c* = 18.995(2) *Z* = 2

X-ray Powder Pattern: Cassagna mine, Italy.
9.52 (100), 2.66 (70), 2.54 (65), 4.85 (50), 4.98 (45), 4.03 (40), 2.32 (40)

Chemistry:

	(1)	(2)	(3)
CaO	17.85–18.93	18.42	18.42
MnO	14.61–15.20	14.98	5.20
Mn_2O_3			10.88
Fe_2O_3	12.37–13.02	12.61	12.61
Al_2O_3	6.71–8.49	7.55	7.55
MgO	2.07–2.61	2.36	2.36
V_2O_3	5.04–5.84	5.42	5.42
SiO_2	29.25–33.75	31.69	31.69
H_2O_{calc}			5.87
Total			100.00

(1) Cassagna mine, Italy; range of 7 electron microprobe analyses, OH^- confirmed by micro-Raman analysis. (2) Cassagna mine, Italy; mean of 7 electron microprobe analyses. (3) Cassagna mine, Italy; H_2O by difference, (Ca + Mn^{2+}) recalculated to equal 4 wt%; corresponding to $Ca_{3.3}Mn^{2+}_{0.7}Fe^{3+}_{1.6}Mn^{3+}_{1.4}Al_{1.5}V^{3+}_{0.7}Mg_{0.6}Si_{5.2}O_{26}H_{6.5}$.

Occurrence: Filling fractures in braunite and quartz layered mineralization developed under prehnite-pumpellyite facies metamorphism.

Association: Braunite, quartz, piemontite.

Distribution: At the Cassagna mine, Graveglia manganese district, Northern Apennines, Liguria, Italy.

Name: For the locality that produced the first specimens, the Cassagna mine, Italy.

Type Material: Dipartimento per lo Studio del Territorio e delle sue Risorse (Dip.Te.Ris), University of Genoa, Italy.

References: (1) Basso, R., C. Carbone, and A. Palenzona (2008) Cassagnaite, a new, V-bearing silicate mineral from the Cassagna mine, northern Apennines, Italy. Eur. J. Mineral., 20, 95–100.
(2) (2008) Amer. Mineral., 93, 1686-7 (abs. ref. 1).

Cassedanneite $Pb_5(VO_4)_2(CrO_4)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As minute pseudohexagonal crystals, flattened on {010}, in rounded aggregates. *Twinning:* Sectorlike twinning observed.

Physical Properties: Hardness = ~3.5 D(meas.) = 6.37 D(calc.) = 6.52

Optical Properties: Semitransparent. *Color:* Red-orange. *Streak:* Yellow-orange.
Luster: Resinous.
Optical Class: Biaxial. $\alpha = 2.395$ $\beta =$ n.d. $\gamma = 2.26$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $A2/m$, $A2$, or Am. $a = 7.693(8)$ $b = 5.763(6)$ $c = 9.795(8)$
$\beta = 115.93(5)^\circ$ Z = 1

X-ray Powder Pattern: Beresovsk, Russia.
3.15 (10), 4.83 (6), 3.22 (6), 2.873 (5), 2.825 (3), 2.123 (3), 1.908 (3)

Chemistry:

	(1)	(2)
P_2O_5	1.56	
V_2O_5	9.90	12.00
CrO_3	12.39	13.19
CuO	0.61	
ZnO	0.65	
PbO	73.24	73.62
H_2O	[1.65]	1.19
Total	[100.00]	100.00

(1) Beresovsk, Russia; by electron microprobe, H_2O by difference; corresponds to $(Pb_{4.92}Zn_{0.12}Cu_{0.11})_{\Sigma=5.15}[(VO_4)_{1.63}(PO_4)_{0.33}]_{\Sigma=1.96}(CrO_4)_{1.86} \cdot 1.37H_2O$. (2) $Pb_5(VO_4)_2(CrO_4)_2 \cdot H_2O$.

Occurrence: On museum samples from the oxidized zone of gold-bearing quartz veins (Beresovsk, Russia).

Association: Crocoite, embreyite, vauquelinite.

Distribution: From Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia.

Name: To honor Prof. Jacques P. Cassedanne (1923–), mineralogist, Institute of Geoscience, University of Rio de Janeiro, Rio de Janeiro, Brazil.

Type Material: National School of Mines, Paris, France, 16569.

References: (1) Cesbron, F., R. Giraud, F. Pillard, and J.-F. Poullen (1988) La cassedannéite, nouveau chromo-vanadate de plomb de Beresovsk (Oural). Compt. Rendus Acad. Sci. Paris, 306, 125–127 (in French with English abs.). (2) (1988) Amer. Mineral., 73, 1493 (abs. ref. 1).

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Cassidyite $Ca_2(Ni,Mg)(PO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Fibrous, as spherules and thin crusts.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.1–3.2

Optical Properties: Semitransparent. *Color:* Pale green to bright green; colorless in transmitted light.
Optical Class: Biaxial. *Orientation:* Length-slow. α = 1.64–1.65 β = n.d. γ = 1.67–1.68
2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.71$ $b = 6.73$ $c = 5.41$ $\alpha = 96°49.5'$ $\beta = 107°21.5'$ $\gamma = 104°34.9'$ Z = [1]

X-ray Powder Pattern: Wolf Creek meteorite.
2.70 (100), 3.03 (95), 2.67 (79), 3.23 (65), 3.13 (48), 1.660 (46), 3.49 (38)

Chemistry:

	(1)	(2)
P_2O_5	39.2	40.83
FeO	0.0	
CoO	0.4	
NiO	6.4 – 16.2	10.74
MgO	2.2 – 5.7	5.80
CaO	32.3	32.26
H_2O		10.37
Total		100.00

(1) Wolf Creek meteorite; partial analyses by electron microprobe. (2) $Ca_2(Ni,Mg)(PO_4)_2 \cdot 2H_2O$ with Ni:Mg = 1:1.

Mineral Group: Fairfieldite group.

Occurrence: An alteration product of a highly weathered iron-nickel meteorite, formed by alteration of schreibersite.

Association: Reevesite, goethite, nickelian maghemite, jarosite, nickel-rich serpentine, apatite, lipscombite.

Distribution: In the Wolf Creek meteorite.

Name: In honor of Dr. William A. Cassidy, who mapped the Wolf Creek, Australia, crater in 1953.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119553, 119554A.

References: (1) White, J.S., Jr., E.P. Henderson, and B. Mason (1967) Secondary minerals produced by weathering of the Wolf Creek meteorite. Amer. Mineral., 52, 1190–1197.

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Cassiterite SnO_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals short to long prismatic ‖ [001], with {110} and {100} well developed, terminated by steep pyramidal forms, to 10 cm; less commonly pyramidal. In radially fibrous botryoidal crusts and concretionary masses; coarse to fine granular, massive. *Twinning:* Very common on {011}, as contact and penetration twins, geniculated; lamellar.

Physical Properties: *Cleavage:* {100} imperfect, {110} indistinct; partings on {111} or {011}. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–7 VHN = 1239–1467 (200 g load). D(meas.) = 6.98–7.01 D(calc.) = 6.993

Optical Properties: Transparent when light colored, dark material nearly opaque; commonly zoned. *Color:* Black, brownish black, reddish brown, red, yellow, gray, white; rarely colorless; in transmitted light, colorless to brown, orange, yellow, green; in reflected light, light gray with white to brownish internal reflections. *Streak:* White, pale brown, pale gray. *Luster:* Adamantine to adamantine metallic, splendent; may be greasy on fractures.
Optical Class: Uniaxial (+); anomalously biaxial. *Pleochroism:* Strong to very weak; yellow, red, brown. *Absorption:* $E > O$. ω = 1.990–2.010 ϵ = 2.093–2.100 2V(meas.) = 0°–38° *Anisotropism:* Strong.
R_1–R_2: (400) 11.7–13.2, (420) 11.6–13.0, (440) 11.5–12.8, (460) 11.4–12.6, (480) 11.3–12.5, (500) 11.2–12.4, (520) 11.0–12.2, (540) 11.0–12.1, (560) 10.9–12.0, (580) 10.9–12.0, (600) 10.8–12.0, (620) 10.8–12.0, (640) 10.7–12.0, (660) 10.7–12.0, (680) 10.6–12.0, (700) 10.6–12.0

Cell Data: *Space Group:* $P4_2/mnm$ (synthetic). a = 4.7382(4) c = 3.1871(1) Z = 2

X-ray Powder Pattern: Synthetic.
3.347 (100), 2.6427 (75), 1.7641 (57), 2.3690 (21), 1.6750 (14), 1.4155 (14), 1.4392 (12)

Chemistry:

	(1)		(1)
SiO_2	0.18	rem.	0.22
SnO_2	99.26	Total	99.66

(1) St. Michael's Mount, Cornwall, England; by electron microprobe, remnant is FeO 0.11%, In_2O_3 0.04%, Nb_2O_5 0.03%, WO_3, TiO_2, IrO_2, Ta_2O_5 each 0.01%.

Mineral Group: Rutile group.

Occurrence: In medium- to high-temperature hydrothermal veins and greisen, in granite, granite pegmatite, rhyolite; rarely in contact metamorphic deposits; in large alluvial placers.

Association: Quartz, muscovite, wolframite, tourmaline, topaz, fluorite, scheelite, lepidolite, arsenopyrite, bismuth, molybdenite.

Distribution: The principal ore of tin; deposits are widespread. Some important localities are: in Germany, in Saxony, at Marienberg, Altenberg, Johanngeorgenstadt, and many other places. At Cínovec (Zinnwald) and Horní Slavkov (Schlaggenwald), Czech Republic. From La Villeder, Morbihan, France. At Panasqueira and Cabreiros, Portugal. In England, at many mines in Cornwall, from St. Just and Carn Brae to Liskeard. From the Jos district, Nigeria. Fine crystals from Otjimbojo, Namibia. Economically important placers on the islands of Banka and Billiton, Indonesia; also in Perak and Selangor States, Malaysia. In Australia, from the New England Ranges, as at Emmaville and Elsmore, New South Wales, and from Greenbushes and Pilbara, Western Australia. At Mt. Bischoff and Mt. Zeehan, Tasmania. In China, from the Xue Bao Diang Mountains, Sichuan Province. Large crystals from Fazenda do Funil, Ferros, Minas Gerais, Brazil. Fine crystals from Bolivia, at Araca, Oruro, Potosí, Huanini, and Llallagua.

Name: From the Greek for *tin*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 574–581. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 5–10. (3) Moore, F. and R.A. Howie (1979) Geochemistry of some Cornubian cassiterites. Mineralium Deposita, 14, 103–107. (4) McCarthy, G.J. and J.M. Welton (1989) X-ray diffraction data for SnO_2. Powder Diffraction, 4(3), 156–159.

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Caswellsilverite $NaCrS_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As anhedral grains, to 1 mm. *Twinning:* The lamellar twinning observed may be the result of pressure-induced deformation.

Physical Properties: Hardness = Very soft. VHN = 17–45 (15 g load) (synthetic). D(meas.) = 3.21 (synthetic). D(calc.) = [3.23]

Optical Properties: Opaque. *Color:* Yellow-gray to pale gray in reflected light. *Luster:* Metallic. *Pleochroism:* Distinct, pale yellow to gray in air, pale yellow with a greenish tint to gray in oil.
R_1–R_2: (400) 19.3–26.7, (420) 20.1–26.2, (440) 21.9–26.3, (460) 21.5–27.4, (480) 21.7–30.0, (500) 22.0–31.6, (520) 22.0–32.3, (540) 21.8–32.8, (560) 21.7–33.0, (580) 21.3–32.5, (600) 20.8–32.2, (620) 20.5–31.4, (640) 20.5–30.7, (660) 20.1–29.4, (680) 18.1–26.7, (700) 18.0–28.8

Cell Data: *Space Group:* $R\overline{3}m$. $a = 3.55$ $c = 19.5$ $Z = 3$

X-ray Powder Pattern: Norton County meteorite.
2.60 (100), 2.07 (80), 1.910 (80), 1.779 (80), 6.49 (70), 1.465 (60), 1.134 (60)

Chemistry:

	(1)	(2)	(3)
Na	15.7	15.5	16.53
Cr	37.4	37.6	37.38
Fe		0.86	
Zn		0.0	
Ca		0.13	
Mg		0.10	
Mn	0.08	0.10	
Ti	0.18	0.0	
S	46.3	46.0	46.09
Total	99.66	100.29	100.00

(1) Norton County meteorite; by electron microprobe. (2) Qingzhen meteorite; by electron microprobe, average of three analyses. (3) $NaCrS_2$.

Occurrence: As inclusions in enstatite crystals and in the brecciated matrix of a meteorite (Norton County meteorite); between coarse pyroxene grains in chondrules in a meteorite (Qingzhen meteorite).

Association: Enstatite, cronusite, daubréelite, titanoan troilite, ferromagnesian alabandite, oldhamite, kamacite, perryite, schollhornite (Norton County meteorite); troilite, kamacite, oldhamite (Qingzhen meteorite).

Distribution: Found in the Norton County enstatite achondrite [TL] and the Qingzhen enstatite chondrite meteorites.

Name: To honor Dr. Caswell Silver (1916–), American geologist associated with the University of New Mexico, Institute of Meteoritics, Albuquerque, New Mexico, USA.

Type Material: n.d.

References: (1) Okada, A. and K. Keil (1982) Caswellsilverite, $NaCrS_2$: a new mineral in the Norton County enstatite achondrite. Amer. Mineral., 67, 132–136. (2) Grossman, J.N., A.E. Rubin, E.R. Rambaldi, R.S. Rajan, and J.T. Wasson (1985) Chondrules in the Qingzhen type-3 enstatite chondrite: possible precursor components and comparison to ordinary chondrite chondrules. Geochim. Cosmochim. Acta, 49, 1781–1795. (3) Rüdorff, W. and K. Stegemann (1943) Kristallstruktur und magnetisches Verhalten der Alkalithiochromite. Z. Anorg. Allg. Chem., 251, 376–395 (in German).

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Catapleiite $Na_2ZrSi_3O_9 \cdot 2H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Crystals pseudohexagonal, thin tabular on {001}, to 15 cm; as rosettes of crystal plates. *Twinning:* Polysynthetically twinned at 30°, 60°, and 90°.

Physical Properties: *Cleavage:* {100}, perfect; {101} and {102}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.65–2.9 D(calc.) = [2.77]

Optical Properties: Transparent, translucent to opaque. *Color:* Colorless, white, light yellow to yellowish brown, pale brown, grayish blue, violet; colorless in thin section. *Streak:* White to pale yellow. *Luster:* Weakly vitreous or dull.
Optical Class: Biaxial (+); may be uniaxial (+). *Dispersion:* $r < v$, moderate.
$\alpha = 1.582 - -1.603$ $\beta = 1.582 - -1.618$ $\gamma = 1.600 - -1.639$ 2V(meas.) = 40° untwinned; 0° twinned.

Cell Data: *Space Group:* $I2/c$. $a = 12.779$ $b = 7.419$ $c = 20.157$ $\beta = 90.41°$ Z = 8

X-ray Powder Pattern: Langesundsfjord, Norway; very close to calcium catapleiite.
3.94 (100), 3.05 (100), 2.96 (100), 2.69 (100), 6.35 (90), 1.969 (60), 5.37 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	41.56	44.90	MnO	0.00	
TiO_2	0.00		CaO	5.21	
ZrO_2	32.53	30.69	Na_2O	9.74	15.44
FeO	1.02		H_2O^+	9.35	8.97
			Total	99.41	100.00

(1) Låven Island, Langesundsfjord, Norway. (2) $Na_2ZrSi_3O_9 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with gaidonnayite; forms a series with calcium catapleiite.

Occurrence: In syenites and nepheline syenites; in pegmatites, typically the result of metasomatic alteration of eudialyte.

Association: Zircon, leucophanite, rinkite, eudialyte, epididymite, låvenite, astrophyllite, sodalite, natrolite, analcime, aegirine.

Distribution: From Låven Island and other localities around the Langesundsfjord, and at Bratthagen, Norway. In the USA, at Magnet Cove, Hot Springs Co., and from Granite Mountain, near Little Rock, Pulaski Co., Arkansas; in the Rocky Boy stock, Bearpaw Mountains, Hill Co., Montana; at Wind Mountain, Otero Co., New Mexico. In Canada, in Quebec, large crystals at Mont Saint-Hilaire, from the Miron quarry, Montreal, and near Saint-Amable; along the Ice River valley, 25 km south of Field, British Columbia. In the Ilímaussaq intrusion, at Narssârssuk, and the Kangderdlugssuaq Fjord, Greenland. From the Norra Kärr complex, near Gränna, Sweden. In Russia, in the Khibiny and Lovozero massifs, Kola Peninsula, and the Inagli massif, 30 km west of Aldan, Yakutia. On the Los Islands, Guinea.

Name: From the Greek *kata*, for *with*, and *pleios*, for *many*, because it is always accompanied by other rare minerals.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 412–413. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 364–371. (3) Chao, G.Y., J.F. Rowland, and T.T. Chen (1973) The crystal structure of catapleiite. Geol. Soc. Amer. Annual Meeting Abs. with Prog. 572 (abs.). (4) Chen, T.T. and G.Y. Chao (1973) Twinning in catapleiite. Geol. Soc. Amer. Annual Meeting Abs. with Program, 573–574 (abs.). (5) Ilyushin, G.D., A.A. Voronkov, V.V. Ilyukhin, N.N. Nevskii, and N.V. Belov (1981) Crystal structure of natural monoclinic catapleiite $Na_2ZrSi_3O_9 \cdot 2H_2O$. Soviet Physics, Doklady Acad. Nauk SSSR, 260, 623–627 (in Russian). (6) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Survey of Canada, Paper 60-4, 19.

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Cattierite CoS_2

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Cubic crystals, to 1 cm; granular intergrowths with other sulfides.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = > 4 VHN = 1018–1114 (10 g load). D(meas.) = 4.82 D(calc.) = 4.80

Optical Properties: Opaque. *Color:* Pinkish to gray, tobacco-brown; in polished section, white. *Luster:* Metallic.

R: (400) 35.8, (420) 35.2, (440) 34.5, (460) 34.3, (480) 34.6, (500) 35.1, (520) 35.8, (540) 36.7, (560) 37.6, (580) 38.4, (600) 39.4, (620) 40.2, (640) 41.1, (660) 41.9, (680) 42.6, (700) 43.3

Cell Data: *Space Group: Pa*3. a = 5.52 Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
2.750 (100), 2.463 (60), 1.663 (55), 1.063 (55), 2.249 (48), 1.950 (34), 1.474 (22)

Chemistry:

	(1)	(2)	(3)
Co	42.20	42.3	47.90
Ni	3.25	0.6	
Cu		0.4	
Fe	2.80	5.4	
S	51.75	51.9	52.10
Total	[100.00]	100.6	100.00

(1) Shinkolobwe, Congo; recalculated to 100% from an original total of 99.86% after deduction of quartz 0.08% and chalcopyrite 0.59%; then corresponds to $(Co_{0.89}Ni_{0.07}Fe_{0.06})_{\Sigma=1.02}S_{2.00}$. (2) Do.; by electron microprobe, corresponds to $(Co_{0.89}Fe_{0.12}Ni_{0.01}Cu_{0.01})_{\Sigma=1.03}S_{2.00}$. (3) CoS_2.

Polymorphism & Series: Forms a series with pyrite and vaesite.

Mineral Group: Pyrite group.

Occurrence: In carbonate rocks (Shinkolobwe, Congo).

Association: Pyrite, chalcopyrite, other linnaeite–polydymite group minerals.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire) [TL]. At Gänsberg, near Wiesloch, and Hohensachsen, Black Forest, Germany. In Sweden, near Filipstad, Värmland. In the USA, from Bald Knob, near Sparta, Alleghany Co., North Carolina, and in the Fletcher mine, Reynolds Co., Missouri.

Name: Honors Félicien Cattier (1869–1946), former Chairman of Union Miniére du Haut Katanga, Belgium.

Type Material: n.d.

References: (1) Kerr, P.F. (1945) Cattierite and vaesite: new Co–Ni minerals from the Belgian Congo. Amer. Mineral., 30, 483–497. (2) Pratt, J.L. and P. Bayliss (1979) Crystal-structure refinement of cattierite. Zeits. Krist., 150, 163–167. (3) Nowack, E., D. Schwarzenbach, and T. Hahn (1991) Charge densities in CoS_2 and NiS_2 (pyrite structure). Acta Cryst., 650–659. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 78.

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Cavansite $Ca(V^{4+}O)Si_4O_{10}\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic crystals, to 1 mm, elongated ‖ [001]; dominant forms {110} and {101}; as spherulitic rosettes, to 5 mm.

Physical Properties: *Cleavage:* Good on {010}. *Tenacity:* Brittle. Hardness = 3–4
D(meas.) = 2.21–2.31 D(calc.) = 2.33

Optical Properties: Transparent. *Color:* Brilliant sky-blue to greenish blue.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Pronounced; $X = Z$ = colorless; Y = blue.
Orientation: $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, extreme. $\alpha = 1.542(2)$ $\beta = 1.544(2)$ $\gamma = 1.551(2)$ $2V(meas.) = 52(2)^\circ$

Cell Data: *Space Group: Pcmn.* $a = 9.792(2)$ $b = 13.644(3)$ $c = 9.629(2)$ $Z = 4$

X-ray Powder Pattern: Owyhee Dam, Oregon, USA.
7.964 (100), 6.854 (50), 6.132 (25), 3.930 (25), 3.420 (25), 2.779 (25), 4.531 (13)

Chemistry:

	(1)	(2)
SiO_2	49.4	53.24
VO_2	17.1	18.38
CaO	11.5	12.42
H_2O	[21.0]	15.96
rem.	0.8	
Total	[99.8]	100.00

(1) Oregon; by XRF, H_2O by estimation; actual H_2O content established by structure analysis.
(2) $Ca(VO)Si_4O_{10}\cdot 4H_2O$.

Polymorphism & Series: Dimorphous with pentagonite.

Occurrence: In a brown tuff partly filling a fault fissure (Lake Owyhee State Park, Oregon, USA); in a vesicular basalt and red tuff breccia, as cavity fillings and in calcite veinlets (Chapman quarry, Oregon, USA); in pores of altered basalt breccia and tuffaceous andesite (Poona district, India).

Association: Pentagonite, calcite, heulandite, stilbite, analcime, apophyllite, thomsonite, copper (Oregon, USA); stilbite, calcite, heulandite, mordenite, chalcocite (India).

Distribution: From near Owyhee Dam, Lake Owyhee State Park, Malheur Co., and the Chapman quarry, Columbia Co., Oregon, USA. Remarkable specimens from quarries around Wagholi, Poona district, Maharashtra, India.

Name: For CAlcium, VANadium, and SIlicon in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120583, 120584, 122769.

References: (1) Staples, L.W., H.T. Evans, Jr., and J.R. Lindsay (1973) Cavansite and pentagonite, new dimorphous calcium vanadium silicate minerals from Oregon. Amer. Mineral., 58, 405–411. (2) Evans, H.T., Jr. (1973) The crystal structures of cavansite and pentagonite. Amer. Mineral., 58, 412–424. (3) Wilke, H.-J., G. Schnorrer-Köhler, and A. Bahle (1989) Cavansit aus Indien. Lapis, 14(1), 39–42 (in German). (4) Kothavala, R. (1991) The Wagholi cavansite locality near Poona, India. Mineral. Record, 22, 415–420.

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Cavoite CaV_3O_7

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, to 2 cm; earthy, massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.195 (synthetic). Radioactive.

Optical Properties: Translucent to transparent. *Color:* Dark greenish amber-yellow, yellow to buff in ocherous aggregates.
Optical Class: Isotropic. $n = > 2$

Cell Data: *Space Group:* $Fm3m$. a = 5.41–5.42 Z = 4

X-ray Powder Pattern: Synthetic; may be confused with thorianite or uraninite.
3.124 (100), 1.913 (51), 1.632 (44), 2.706 (29), 1.241 (15), 0.9146 (13), 1.1044 (12)

Chemistry:

	(1)		(1)
Nb_2O_5	1.8	Y_2O_3	1.2
Ta_2O_5	0.6	La_2O_3	1.5
CeO_2	80.0	Yb_2O_3	1.1
ZrO_2	0.6	F	0.0
ThO_2	5.1	Total	

(1) Sudbury, Canada; partial analysis by semiquantitative emission spectroscopy.

Occurrence: Sparingly, in partially absorbed inclusions of wall-rock in a dikelike zone of carbonate rock cutting nepheline syenite (Sudbury, Canada); a secondary mineral weathered from phonolites and nepheline syenites (Minas Gerais, Brazil); in pegmatite (Kåbuland, Norway).

Association: Nepheline, tremolite, feldspar, apatite, magnetite, ilmenite, calcite (Sudbury, Canada); hydromica, kaolinite, "limonite" (Morro do Ferro, Brazil); fluocerite, bastnäsite, törnebohmite (Kåbuland, Norway); fluocerite, bastnäsite (Karonge, Burundi).

Distribution: From about 11 km northeast of Nemegos, Lackner Township, Sudbury district, Ontario, and in the Lake Zone deposit, Thor Lake, Northwest Territories, Canada. In Paramount Canyon, Taylor Creek district, Catron Co., New Mexico, and on North Sugarloaf Mountain, Bethlehem, Grafton Co., New Hampshire, USA. From Cañon Colorado, Sierra de Bermjillo, Durango, Mexico. On Morro do Ferro, Poços de Caldas plateau, Minas Gerais, Brazil. In Norway, large crystals from near Kåbuland, Iveland; at Tysfjorden, Nordland; and from Høydalen, Telemark. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. From the Khoda-Achkan massif, Alai Range, Kyrgyzstan. In the Karonge rare-earth deposit, Burundi. From near Odegi, Afu Hills, Nigeria. In the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia.

Name: For CERium in its composition, and by analogy to *thorianite* and *uraninite*.

Type Material: Canadian Geological Survey, Ottawa, 16588; Royal Ontario Museum, Toronto, Canada, M34491, M37257.

References: (1) Graham, A.R. (1955) Cerianite: a new rare-earth oxide mineral. Amer. Mineral., 40, 560–564. (2) Frondel, C. and U.B. Marvin (1959) Cerianite, CeO_2, from Poços de Caldas, Brazil. Amer. Mineral., 44, 882–884. (3) Neumann, H. and S. Bergstøl (1963) Cerianite from cleavelandite pegmatite dikes in Iveland. Norsk. Geol. Tidsskr., 43(2), 247–255. (4) van Wambeke, L. (1977) The Karonge rare earth deposits, Republic of Burundi: new mineralogical–geochemical data and origin of the mineralization. Mineralium Deposita, 12, 373–380. (5) (1953) NBS Circ. 539, 1, 56.

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Caysichite-(Y) $\mathbf{Ca_3(Yb,Er)Y_4Si_8O_{20}(CO_3)_6(OH)\cdot 7H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Most commonly as a pulverulent coating or stain. As radiating groups of crystals elongated ‖ [001], terminated by {001}; in thin, brittle incrustations with columnar structure.

Physical Properties: *Cleavage:* {010} (?). Hardness = 4.5 VHN = 551 D(meas.) = 3.03 D(calc.) = 3.029 Faint green cathodoluminescence.

Optical Properties: Semitransparent. *Color:* Colorless, white to pale yellow; rarely greenish. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.586(4)$ $\beta = 1.614(1)$ $\gamma = 1.621(1)$ 2V(meas.) = 53° 2V(calc.) = 54°30′

Cell Data: *Space Group:* $Ccm2_1$. $a = 13.282(3)$ $b = 13.925(3)$ $c = 9.724(4)$ Z = 4

X-ray Powder Pattern: Evans-Lou quarry, Canada.
6.93 (100), 3.321 (90), 4.38 (60), 4.22 (60), 3.481 (60), 4.87 (40), 2.323 (40)

Chemistry:

	(1)
SiO_2	28.84
Al_2O_3	0.58
Y_2O_3	28.18
RE_2O_3	8.08
CaO	10.04
H_2O	8.6
CO_2	15.7
Total	100.02

(1) Evans-Lou quarry, Canada; by electron microprobe, H_2O by gravimetry, CO_2 by titrimetry; $RE_2O_3 = La_2O_3$ 0.08%, CeO_2 0.24%, Pr_2O_3 0.09%, Nd_2O_3 0.30%, Sm_2O_3 0.20%, Eu_2O_3 0.09%, Gd_2O_3 0.51%, Tb_2O_3 0.16%, Dy_2O_3 1.16%, Ho_2O_3 0.66%, Er_2O_3 1.84%, Tm_2O_3 0.21%, Yb_2O_3 2.12%, Lu_2O_3 0.42%; corresponds to $Ca_{2.95}RE_{0.70}Y_{4.11}(Si_{7.90}Al_{0.18})_{\Sigma=8.08}O_{20.36}(CO_3)_{5.87}\cdot 7.86H_2O$.

Occurrence: In perthite surrounding the quartz core of a granite pegmatite, coating fractures and filling cavities in quartz, perthite, or hellandite; apparently of secondary origin.

Association: Quartz, hellandite, fergusonite, kainosite, tengerite, lokkaite, yttrian thorogummite, yttrian spessartine, xenotime, wakefieldite-(Y), synchysite-(Y).

Distribution: In the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada.

Name: For the chemical composition: *Ca, Y, Si, C, H.*

Type Material: Canadian Museum of Nature, Ottawa; Canadian Geological Survey, Ottawa, Canada, 10402; The Natural History Museum, London, England, 1977,278.

References: (1) Hogarth, D.D., G.Y. Chao, A.G. Plant, and H.R. Steacy (1974) Caysichite, a new silico-carbonate of yttrium and calcium. Can. Mineral., 12, 293–298. (2) (1976) Amer. Mineral., 61, 174–175 (abs. ref. 1). (3) Mellini, M. and S. Merlino (1978) Caysichite: a double crank shaft chain structure. Can. Mineral., 16, 81–88.

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Cebaite-(Ce) $Ba_3Ce_2(CO_3)_5F_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular grains, to 0.2 mm, and granular aggregates.

Physical Properties: *Cleavage:* On $\{30\overline{1}\}$ (?), imperfect. *Fracture:* Uneven.
Hardness = 4.5–5 D(meas.) = 4.31–4.66 D(calc.) = 4.81

Optical Properties: Semitransparent. *Color:* Yellow-orange to wax-yellow. *Streak:* Yellow-orange to pale gray. *Luster:* Vitreous to waxy.
Optical Class: Biaxial (–). $\alpha = 1.598$–1.604 $\beta = 1.735$ $\gamma = 1.740$–1.748 2V(meas.) = 5°–10°

Cell Data: *Space Group:* $C2/m$. $a = 21.42(5)$ $b = 5.078(5)$ $c = 13.30(5)$ $\beta = 94.8(2)°$
$Z = 4$

X-ray Powder Pattern: Bayan Obo deposit, China.
3.25 (10), 1.99 (9), 3.98 (8), 2.11 (8), 2.20 (4), 2.52 (3), 2.35 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	0.07			CaO	0.29	0.61	
CO_2	23.43	[21.42]	21.36	SrO	0.62	1.43	
RE_2O_3	29.03	28.34	31.86	BaO	43.28	42.77	44.64
Al_2O_3	0.03			Na_2O	0.28	0.10	
Fe_2O_3	0.42			K_2O	0.37		
ThO_2	0.71	0.92		F	3.81	3.76	3.69
FeO		0.16		$-O = F_2$	1.60	1.58	1.55
MnO		0.16		Total	100.74	[98.09]	100.00

(1) Bayan Obo deposit, China; RE = La 31.69%, Ce 46.94%, Pr 5.15%, Nd 12.63%, Sm 1.36%, Eu 0.24%, Gd 0.43%, Tb 0.28%, Dy 0.18%, Er 0.11%, Tm 0.09%, Yb 0.02%, Y 0.88%; stated to correspond to $(Ba_{2.73}Na_{0.09}K_{0.07}Sr_{0.06}Ca_{0.05})_{\Sigma=3.00}(RE_{1.71}Fe^{3+}_{0.05}Th_{0.03}P_{0.01})_{\Sigma=1.80}$ $C_{5.15}O_{15.95}F_{1.94}$. (2) Khibiny massif, Kola Peninsula, Russia; by electron microprobe, CO_2 calculated for stoichiometry; $RE_2O_3 = La_2O_3$ 5.67%, Ce_2O_3 14.45%, Pr_2O_3 1.63%, Nd_2O_3 5.54%, Sm_2O_3 0.48%, Eu_2O_3 0.07%, Gd_2O_3 0.5%; corresponds to $(Ba_{2.90}Sr_{0.14}Ca_{0.11}Na_{0.03}Mn_{0.02})_{\Sigma=3.20}$ $RE_{1.82}(CO_3)_5F_{2.06}$. (3) $Ba_3Ce_2(CO_3)_5F_2$.

Occurrence: In carbonatite-derived dolomitic marble (Bayan Obo deposit, China); in a differentiated alkalic massif (Khibiny massif, Kola Peninsula, Russia).

Association: Zhonghuacerite-(Ce), aegirine, fluorite, barite, apatite (Bayan Obo deposit, China); mckelveyite-(Ce), ewaldite, cordylite-(Ce), donnayite-(Ce) (Khibiny massif, Kola Peninsula, Russia).

Distribution: From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. At the Khibiny massif, Kola Peninsula, Russia. From the Upohlava conglomerates, Slovakia.

Name: For two of the essential elements, CErium and BArium.

Type Material: n.d.

References: (1) Zhang Peishan and Tao Kejie (1983) New data for cebaite. Scientia Geologica Sinica, 4, 409–413 (in Chinese with English abs.). (2) (1985) Amer. Mineral., 70, 214 (abs. ref. 1). (3) Zhuming Yang (1995) Structure redetermination of natural cebaite-(Ce), $Ba_3Ce_2(CO_3)_5F_2$. Neues Jahrb. Mineral., Monatsh., 56–64. (4) Mercier, N. and M. Leblanc (1993) Crystal growth and structures of rare earth fluorocarbonates: I. Structures of $BaSm(CO_3)_2F$ and $Ba_3La_2(CO_3)_5F_2$: revision of the corresponding huanghoite and cebaite type structures. Eur. J. Solid State Inorg. Chem., 30, 195–205. (5) Zaitsev, A.N., F. Wall, and M.J. Le Bas (1998) REE-Sr-Ba minerals from the Khibina carbonatites, Kola Peninsula, Russia: their mineralogy, pargenesis, and evolution. Mineral. Mag., 62, 225–250.

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Cebollite $Ca_5Al_2Si_3O_{12}(OH)_4$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. As compact masses of minute radiating fibers.

Physical Properties: Hardness = ∼5 D(meas.) = 2.96 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Colorless, white to greenish gray, reddish brown; colorless in thin section. *Luster:* Dull.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, weak. α = 1.592–1.595 β = 1.597–1.60 γ = 1.628–1.630 2V(meas.) = ∼58°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Cebolla Creek, Colorado, USA. (ICDD 16-695).
2.73 (100), 2.88 (90), 2.59 (70), 1.62 (60), 3.01 (50), 2.90 (40), 2.45 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	27.06	33.05	31.07	CaO	29.27	35.75	41.06
Al_2O_3	11.49	14.03	18.48	Na_2O	2.10	2.57	0.28
Fe_2O_3	2.81	3.43		K_2O	trace		
FeO	0.17	0.21	1.36	H_2O	5.13	6.27	[7.75]
MgO	3.84	4.69		insol.	18.05		
				Total	99.92	[100.00]	[100.00]

(1) Cebolla Creek, Colorado, USA. (2) Do.; recalculated to 100%, computed free of insolubles, taken as diopside, garnet, vesuvianite, etc., corresponds to $(Ca_{3.79}Mg_{0.69}Na_{0.24}Fe^{2+}_{0.02})_{\Sigma=4.74}(Al_{1.64}Fe^{3+}_{0.36})_{\Sigma=2.00}Si_{3.26}O_{12.08}(OH)_{4.12}$. (3) Tokatoka, New Zealand; by electron microprobe, H_2O by difference; corresponds to $(Ca_{4.77}Fe^{2+}_{0.12}Na_{0.06})_{\Sigma=4.95}Al_{2.36}Si_{3.37}O_{12.40}(OH)_{5.60}$.

Occurrence: An alteration product of melilite in a carbonatite (Iron Hill, Colorado, USA); along a diabase-chalk contact (Scawt Hill, Ireland); in zeolitized plagioclase-rich gneiss, amphibolite, and basalt xenoliths (Letseng-La-Terai kimberlite, Lesotho); a late-stage primary igneous mineral (Kimberley, South Africa).

Association: Melilite, natrolite, calcite, phlogopite, vesuvianite, garnet, diopside.

Distribution: On Iron Hill and in Cebolla Creek, near Powderhorn, Gunnison Co., Colorado, USA. From Scawt Hill, near Larne, Co. Antrim, Ireland. In the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland. In the Letseng-La-Terai kimberlite, Lesotho. From the De Beers diamond mine, Kimberley, Cape Province, South Africa. In the Tokatoka district, about 150 km north of Auckland, New Zealand.

Name: For Cebolla Creek, Colorado, in the drainage of which the mineral was first collected.

Type Material: The Natural History Museum, London, England, 1923,1022; Harvard University, Cambridge, Massachusetts, 85726; National Museum of Natural History, Washington, D.C., USA, 87530, C3217, R6451.

References: (1) Larsen, E.S. and W.T. Schaller (1914) Cebollite, a new mineral. Wash. Acad. Sci. IV, No. 16, 480–482. (2) Larsen, E.S. and E.A. Goranson (1932) The deuteric and later alterations of the uncompahgrite of Iron Hill, Colorado. Amer. Mineral., 17, 343–356. (3) Kruger, F.J. (1980) The occurrence of cebollite in kimberlite and included zeolitized crustal xenoliths. Mineral. Mag., 43, 583–586. (4) Baker, C.K. and P.M. Black (1980) Assimilation and metamorphism at a basalt-limestone contact, Tokatoka, New Zealand. Mineral. Mag., 43, 797–807.

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Čechite $Pb(Fe^{2+},Mn)(VO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are rough and rounded, to 3 mm, elongated along [001], showing {110} and {010}; as aggregates of anhedral crystals in granular masses.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 VHN = 274–367, 316 average (100 g load). D(meas.) = 5.88 D(calc.) = 5.94 Magnetic.

Optical Properties: Opaque. *Color:* Black; gray-white with a yellowish tint in reflected blue light, yellow-brown to beige in reflected yellow light; white, pale yellow, or rosy internal reflections observed. *Streak:* Black. *Luster:* Submetallic, resinous on fractures.
Optical Class: Biaxial. *Anisotropism:* Perceptible to strong; pale gray to dark gray with brownish tint. *Bireflectance:* Weak to imperceptible.
R_1–R_2: (400) —, (420) 17.0–19.3, (440) 16.3–18.9, (460) 16.0–18.5, (480) 15.6–18.3, (500) 15.4–18.1, (520) 15.1–17.8, (540) 14.8–17.6, (560) 14.6–17.6, (580) 14.4–17.7, (600) 14.4–18.0, (620) 14.5–18.3, (640) 14.8–18.6, (660) 15.1–18.9, (680) 15.2–18.8, (700) 15.3–18.7

Cell Data: *Space Group: Pnam.* $a = 7.605(3)$ $b = 9.435(4)$ $c = 6.099(2)$ $Z = 4$

X-ray Powder Pattern: Vrančice, Czech Republic.
3.228 (100), 2.625 (81), 5.119 (77), 2.908 (77), 2.663 (53), 4.249 (51), 3.345 (42)

Chemistry:

	(1)
As_2O_5	0.29
V_2O_5	22.88
Sb_2O_5	0.16
FeO	15.15
MnO	4.56
ZnO	0.12
PbO	53.97
CaO	0.29
H_2O	2.58
Total	[100.00]

(1) Vrančice, Czech Republic; recalculated to 100% after deduction of hematite 8.88%, quartz 2.02%; corresponding to $(Pb_{0.93}Ca_{0.02})_{\Sigma=0.95}(Fe^{2+}_{0.81}Mn_{0.25}Zn_{0.01})_{\Sigma=1.07}[(V_{0.96}As_{0.01})_{\Sigma=0.97}O_{3.90}](OH)_{1.10}$.

Mineral Group: Descloizite group.

Occurrence: On specimens from old mine dumps from a polymetallic ore deposit.

Association: Hedyphane, calcite, hematite, willemite, quartz.

Distribution: From Vrančice, about 15 km south-southeast of Příbram, Czech Republic.

Name: To honor Dr. František Čech (1929–1995), Head of the Department of Mineralogy (1976–1990), Charles University, Prague, Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 20037.

References: (1) Mrázek, Z. and Z. Táborský (1981) Čechite, $Pb(Fe^{2+},Mn^{2+})(VO_4)(OH)$, a new mineral of the descloizite–pyrobelonite group. Neues Jahrb. Mineral., Monatsh., 520–528. (2) (1982) Amer. Mineral., 67, 1074 (abs. ref. 1). (3) Pertlik, F. (1989) The crystal structure of čechite, $Pb(Fe^{2+},Mn)(VO_4)(OH)$ with Fe> Mn. A mineral of the descloizite group. Neues Jahrb. Mineral., Monatsh., 34–40.

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Celadonite $\mathbf{K(Mg,Fe^{2+})(Fe^{3+},Al)Si_4O_{10}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As minute micaceous scales or earthy aggregates.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Friable to unctuous. Hardness = ∼2 D(meas.) = 2.95–3.05 D(calc.) = 3.00

Optical Properties: Semitransparent. *Color:* Blue-green, olive-green, apple-green. *Luster:* Dull.
Optical Class: Biaxial (–). *Pleochroism:* Yellow-green, blue-green. α = 1.606–1.625. β = n.d. γ = 1.579–1.661 2V(meas.) = 5°–8°

Cell Data: *Space Group:* $C2/m$ or $C2$. $a = 5.23(2)$ $b = 9.06(1)$ $c = 10.13(2)$ $\beta = 100°55(10)'$ Z = 2

X-ray Powder Pattern: Wind River area, Washington, USA.
2.580 (100), 4.53 (85), 3.635 (80), 3.087 (80), 2.678 (75), 2.402 (75), 3.318 (70)

Chemistry:

	(1)
SiO_2	55.61
Al_2O_3	0.79
Fe_2O_3	17.19
FeO	4.02
MnO	0.09
MgO	7.26
CaO	0.21
Na_2O	0.19
K_2O	10.03
H_2O	4.88
Total	100.27

(1) 37 km east of Reno, Storey Co., Nevada, USA; corresponds to $(K_{0.92}Na_{0.03}Ca_{0.02})_{\Sigma=0.97}(Mg_{0.78}Fe^{2+}_{0.24})_{\Sigma=1.02}(Fe^{3+}_{0.93}Al_{0.07})_{\Sigma=1.00}Si_{4.00}O_{10}(OH)_2$.

Polymorphism & Series: 1M polytype.

Mineral Group: Mica group.

Occurrence: Replaces primary ferromagnesian silicate minerals in altered intermediate to mafic volcanic rocks, developed under low-grade zeolite facies metamorphism; as amygdule fillings in basalts or andesites.

Association: Montmorillonite, clinoptilolite, heulandite, laumontite, prehnite, chlorite, quartz, calcite.

Distribution: Many localities; a few for well-characterized material include: on Mt. Baldo, near Verona, Vicenza, and at Val di Fassa, Trentino-Alto Adige, Italy. In the Zillertal, Tirol, Austria. In Scotland, at Scuir Mohr. From Streymoy and Suduroy, Faeroe Islands. In the USA, in the John Day Formation, Grant Co., Oregon; in Mt. Rainier National Park, Pierce Co., Washington; and from Red Rock Canyon, Kern Co., California. On the Pearl Islands, off Nicaragua. In the Hosokura mine, Miyagi Prefecture; at Toyoura, Yamagata Prefecture; Nishikata, Tochigi Prefecture; Kamogawa, Chiba Prefecture; and many other places in Japan.

Name: From the French *celadon*, for *sea green*, its color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 683. (2) Wise, W.S. and H.P. Eugster (1964) Celadonite: synthesis, thermal stability and occurrence. Amer. Mineral., 49, 1031–1083. (3) Buckley, H.A., J.C. Bevan, K.M. Brown, L.R. Johnson, and V.C. Farmer (1978) Glauconite and celadonite: two separate mineral species. Mineral. Mag., 42, 373–382. (4) Cipurskii, S.I. and V.A. Dric (1986) Refining the crystallographic structure of celadonite. Mineral. Zhurnal, 8(3), 32–40 (in Russian with English abs.).

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Celestine $SrSO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Well-formed crystals are common; typically thin to thick tabular on {001} with large {210}; tabular on {001} or {100}, lathlike or with equant cross-sections; also elongated along [010] or [001], to 45 cm; may be equant with equal {001}, {011}, {101} or pyramidal with {122}, {011}, {102}. Also fibrous, lamellar, earthy, massive granular.

Physical Properties: *Cleavage:* On {001}, perfect; on {210}, good; on {010}, poor. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 3.97(1) D(calc.) = 3.98

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale blue, pink, pale green, pale brown, black; colorless or faintly tinted in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* Weak; if blue, indigo-blue, lavender-blue, violet. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, moderate. *Absorption:* $Z > Y > X$. $\alpha = 1.619$–1.622 $\beta = 1.622$–1.624 $\gamma = 1.630$–1.632 2V(meas.) = 50°

Cell Data: *Space Group: Pnma.* $a = 8.359$ $b = 5.352$ $c = 6.866$ Z = 4

X-ray Powder Pattern: Synthetic.
2.972 (100), 3.295 (98), 2.731 (63), 3.177 (59), 2.041 (57), 2.045 (55), 2.674 (49)

Chemistry:

	(1)	(2)
SO_3	43.40	43.59
CaO	0.40	
SrO	56.20	56.41
Total	100.00	100.00

(1) Djebel Kebbouch, Tunisia. (2) $SrSO_4$.

Polymorphism & Series: Forms a series with barite.

Mineral Group: Barite group.

Occurrence: Of primary sedimentary origin, diagenetic, or typically as fissure and cavity fillings (including caves) precipitated by migrating strontium-bearing ground water or basinal brines in carbonate rocks, concretions and nodules; in hydrothermal veins and mafic volcanic rocks.

Association: Gypsum, anhydrite, sulfur (bedded evaporites); strontianite, calcite, dolomite, anhydrite, gypsum, fluorite (cavities in carbonate rocks); analcime, natrolite, hydroxyapophyllite, celadonite (mafic volcanoclastics).

Distribution: The most common strontium mineral; only a few localities for fine and large crystals are listed; in the USA, from near Bellwood, Blair Co., Pennsylvania; in Crystal Cave, Put-in-Bay, South Bass Island, and at Clay Center, Ottawa Co., Ohio; from Cave-in-Rock, Hardin Co., Illinois; at the Scofield quarry, Maybee, Monroe Co., Michigan; from Adamsville, Lampasas Co., Texas. At Dundas, Ontario, Canada. In Mexico, from near Matehuela, San Luis Potosi, and at Musquiz and Ramos Arizpe, Coahuila. From Girgenti, Caltanissetta, and elsewhere in Sicily, Italy. In the Konrad mine, near Salzgitter, Lower Saxony, Germany. At Yate, near Bristol, England. From Bamle, Norway. At Jebel Mokattem, near Cairo, Egypt. From Sakoany, near Mahajanga (Majunga), Madagascar.

Name: From the Latin for *celestial*, in allusion to the typical bluish color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 415–420. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 30–39. (3) Miyake, M., I. Minato, H. Morikawa, and S. Iwai (1978) Crystal structures and sulphate force constants of barite, celestite, and anglesite. Amer. Mineral., 63, 506–510. (4) Jacobsen, S.D., J.R. Smyth, R.J. Swope, and R.T. Downs (1998) Rigid-body character of the SO_4 groups in celestine, anglesite, and barite. Can. Mineral., 36, 1053–1060. (5) (1953) NBS Circ. 539, II, 61.

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Celsian $BaAl_2Si_2O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As short prismatic to acicular crystals with large prism faces, to 2 cm; commonly massive. *Twinning:* Simple twins according to the Manebach, Baveno, or Carlsbad laws.

Physical Properties: *Cleavage:* Perfect on {001}, good on {010}, and poor on {110}. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 3.10–3.39 D(calc.) = 3.26

Optical Properties: Transparent. *Color:* Colorless, white, yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 3°–5°$; $Z \wedge a = 28°–30°$. $\alpha = 1.579–1.587$ $\beta = 1.583–1.593$ $\gamma = 1.588–1.600$ 2V(meas.) = 83°–92°

Cell Data: *Space Group:* $I2/c$. $a = 8.622(4)$ $b = 13.078(6)$ $c = 14.411(8)$ $\beta = 115.09(2)°$ Z = 8

X-ray Powder Pattern: Jakobsberg, Sweden.
3.47 (100), 3.35 (100), 3.02 (95), 2.582 (75), 3.26 (60), 3.80 (55), 6.52 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	32.43	31.07	32.00
Al_2O_3	26.55	28.35	27.16
Fe_2O_3	0.12	0.36	
MgO	0.11		
CaO	0.23		
BaO	39.72	39.92	40.84
Na_2O	0.16		
K_2O	0.22	0.24	
F	0.64		
H_2O	0.64		
Total	100.82	[99.94]	100.00

(1) Jakobsberg, Sweden. (2) Aberfeldy, Scotland; by electron microprobe; original total given as 99.99%. (3) $BaAl_2Si_2O_8$.

Polymorphism & Series: Dimorphous with paracelsian; forms a series with orthoclase.

Mineral Group: Feldspar group.

Occurrence: In amphibolite-grade, regional or contact metamorphic, Mn, Ba-rich rocks, some of which probably were submarine exhalatives.

Association: Manganoan aegirine, manganoan biotite, paracelsian, jacobsite, hausmannite, rhodochrosite, rhodonite, rutile, hyalophane, barite, cymrite, taramellite, quartz, zoisite, spessartine, dolomite, muscovite.

Distribution: At Jakobsberg and Långban, Värmland, Sweden. In the Simplon region, Valais, Switzerland. In the USA, from Franklin, Sussex Co., New Jersey; near Big Creek, Fresno Co., and Trumbull Peak, near Incline, Mariposa Co., California. At the Benallt mine, Rhiw, Lleyn Peninsula, Wales. From near Aberfeldy, Scotland. In Kazakhstan, from the Burultas deposit, west of Lake Balkhash. In Namibia, at Otjosondu. From Piggery Creek, Broken Hill, New South Wales, Australia. In the Kaso mine, Totiki Prefecture, Japan.

Name: To honor the Swedish astronomer and naturalist, Anders Celsius (1701–1744).

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 15. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 166–178. (3) Gay, P. (1965) An X-ray powder method for the estimation of (K,Ba) feldspars. Mineral. Mag., 34, 204–213. (4) Griffen, D.T. and P.H. Ribbe (1976) Refinement of the crystal structure of celsian. Amer. Mineral., 61, 414–418. (5) Fortey, N.J. and B. Beddoe-Stephens (1982) Barium silicates in stratabound Ba–Zn mineralization in the Scottish Dalradian. Mineral. Mag., 46, 63–72.

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. As octahedra, to 2 cm; earthy, massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.195 (synthetic). Radioactive.

Optical Properties: Translucent to transparent. *Color:* Dark greenish amber-yellow, yellow to buff in ocherous aggregates.
Optical Class: Isotropic. $n = > 2$

Cell Data: *Space Group:* $Fm3m$. a = 5.41–5.42 Z = 4

X-ray Powder Pattern: Synthetic; may be confused with thorianite or uraninite.
3.124 (100), 1.913 (51), 1.632 (44), 2.706 (29), 1.241 (15), 0.9146 (13), 1.1044 (12)

Chemistry:

	(1)		(1)
Nb_2O_5	1.8	Y_2O_3	1.2
Ta_2O_5	0.6	La_2O_3	1.5
CeO_2	80.0	Yb_2O_3	1.1
ZrO_2	0.6	F	0.0
ThO_2	5.1	Total	

(1) Sudbury, Canada; partial analysis by semiquantitative emission spectroscopy.

Occurrence: Sparingly, in partially absorbed inclusions of wall-rock in a dikelike zone of carbonate rock cutting nepheline syenite (Sudbury, Canada); a secondary mineral weathered from phonolites and nepheline syenites (Minas Gerais, Brazil); in pegmatite (Kåbuland, Norway).

Association: Nepheline, tremolite, feldspar, apatite, magnetite, ilmenite, calcite (Sudbury, Canada); hydromica, kaolinite, "limonite" (Morro do Ferro, Brazil); fluocerite, bastnäsite, törnebohmite (Kåbuland, Norway); fluocerite, bastnäsite (Karonge, Burundi).

Distribution: From about 11 km northeast of Nemegos, Lackner Township, Sudbury district, Ontario, and in the Lake Zone deposit, Thor Lake, Northwest Territories, Canada. In Paramount Canyon, Taylor Creek district, Catron Co., New Mexico, and on North Sugarloaf Mountain, Bethlehem, Grafton Co., New Hampshire, USA. From Cañon Colorado, Sierra de Bermjillo, Durango, Mexico. On Morro do Ferro, Poços de Caldas plateau, Minas Gerais, Brazil. In Norway, large crystals from near Kåbuland, Iveland; at Tysfjorden, Nordland; and from Høydalen, Telemark. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. From the Khoda-Achkan massif, Alai Range, Kyrgyzstan. In the Karonge rare-earth deposit, Burundi. At Mount Weld, Laverton, Western Australia.

Name: For CERium in its composition, and by analogy to *thorianite* and *uraninite*.

Type Material: Canadian Geological Survey, Ottawa, 16588; Royal Ontario Museum, Toronto, Canada, M34491, M37257.

References: (1) Graham, A.R. (1955) Cerianite: a new rare-earth oxide mineral. Amer. Mineral., 40, 560–564. (2) Frondel, C. and U.B. Marvin (1959) Cerianite, CeO_2, from Poços de Caldas, Brazil. Amer. Mineral., 44, 882–884. (3) Neumann, H. and S. Bergstøl (1963) Cerianite from cleavelandite pegmatite dikes in Iveland. Norsk. Geol. Tidsskr., 43(2), 247–255. (4) van Wambeke, L. (1977) The Karonge rare earth deposits, Republic of Burundi: new mineralogical–geochemical data and origin of the mineralization. Mineralium Deposita, 12, 373–380. (5) (1953) NBS Circ. 539, 1, 56.

Ceriopyrochlore-(Ce) $(Ce, Ca, Y)_2(Nb, Ta)_2O_6(OH, F)$

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Crystal Data: Cubic; may be metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, to 3 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–5.5
D(meas.) = 4.13–4.65 D(calc.) = n.d.

Optical Properties: Transparent to opaque. *Color:* Pale to dark brown, black; yellow-brown to red-brown in transmitted light. *Streak:* Pale brown, yellowish brown. *Luster:* Resinous on fractures.
Optical Class: Isotropic; may be faintly anisotropic in nonmetamict material. $n = 2.02–2.2$

Cell Data: *Space Group: Fd3m.* $a = 10.385–10.416$ $Z = 8$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8	0.00	0.07	MnO	trace	0.1
Nb_2O_5	55.22	64.4	PbO		0.01
Ta_2O_5	5.86	0.41	MgO	0.16	
V_2O_5		0.02	CaO	4.10	12.6
SiO_2	3.10	0.15	SrO		0.2
TiO_2	2.88	2.3	BaO		0.05
ZrO_2	0.00	3.5	Na_2O	2.52	1.9
ThO_2	0.20	0.1	K_2O	0.57	0.04
Al_2O_3		0.12	F	0.00	0.11
Y_2O_3	5.07	0.13	H_2O^+	5.95	0.34
RE_2O_3	13.33	11.93	H_2O^-	0.45	
Fe_2O_3	0.50	2.23	$-O = F_2$		[0.05]
FeO	0.02	0.11	Total	99.93	[100.77]

(1) Wasau, Wisconsin, USA. (2) Schelingen quarry, Germany; original total given as 101.18%; $RE_2O_3 = Ce_2O_3$ 8.4%, La_2O_3 1.6%, Nd_2O_3 1.2%, Pr_2O_3 0.4%, Sm_2O_3 0.2%, Gd_2O_3 0.08%, Dy_2O_3 0.03%, Eu_2O_3 0.016%; corresponds to $[Ca_{0.83}RE_{0.26}Na_{0.21}(Sr, Fe, U, Th, Ba)_{0.02}]_{\Sigma=1.32}[Nb_{1.69}Ti_{0.10}Zr_{0.10}Fe_{0.09}(Si, Ta, Al, V)_{0.02}]_{\Sigma=2.00}O_{6.17}[(OH)_{0.07}F_{0.02}]_{\Sigma=0.09}$.

Mineral Group: Pyrochlore group and subgroup; $\Sigma\ Ce_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: In pegmatites related to alkalic igneous rocks and in nepheline syenites; in weathered residium derived from carbonatites.

Association: Aegirine, quartz, feldspar, ferrian biotite, rutile, fluorite, zirconium minerals (Wasau, Wisconsin, USA); latrappite, apatite, calcite (Oka, Canada).

Distribution: From Wasau, Marathon Co., Wisconsin, USA. At Oka, Quebec, Canada. In the Schelingen quarry, Kaiserstuhl, Baden-Württemberg, Germany. From Alpe Rosso, Val Vigezzo, Piedmont, Italy. At the Kent massif, Kazakhstan. From the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia. In the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire).

Name: For membership in the *pyrochlore* group and significant CERIum content.

Type Material: n.d.

References: (1) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group of minerals. Amer. Mineral., 62, 403–410 [marignacite = ceriopyrochlore-(Ce)].
(2) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 750, 755 [marignacite]. (3) Chistyakova, M.B. and M.E. Kazakova (1975) Find of marignacite [ceriopyrochlore-(Ce)] in crystal-bearing pegmatites (Kent, Central Kazakhstan). Trudy Mineral. Muzeya Akad. Nauk SSSR, 24, 226–228 (in Russian). (4) (1976) Chem. Abs., 85, 160 (abs. ref. 3). (5) Van Wambeke, L. (1980) Latrappite and ceriopyrochlore, new minerals for the Federal Republic of Germany. Neues Jahrb. Mineral., Monatsh., 171–174.

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Cerite-(Ce) $(Ce, La, Ca)_9(Mg, Fe^{3+})(SiO_4)_6(SiO_3OH)(OH)_3$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As crudely formed pseudo-octahedral crystals, to 7 mm; massive.

Physical Properties: *Fracture:* Uneven. Hardness = 5–5.5 D(meas.) = 4.75(11) D(calc.) = 4.86

Optical Properties: Translucent to opaque. *Color:* Clove-brown with a reddish tinge; pale lavender-brown to colorless in thin fragments. *Streak:* Grayish white. *Luster:* Resinous. *Optical Class:* Uniaxial (+); anomalously biaxial. ω = 1.806–1.817 ϵ = 1.808–1.825 2V(meas.) = 0°–25°

Cell Data: *Space Group: R3c.* a = 10.779(6) c = 38.061(7) Z = 6

X-ray Powder Pattern: Mountain Pass, California, USA.
2.95 (100), 1.954 (50), 3.47 (42), 2.69 (42), 2.83 (38), 3.31 (33), 3.11 (30)

Chemistry:

	(1)		(1)
SiO_2	22.24	CaO	4.48
TiO_2	0.08	BaO	0.45
Al_2O_3	1.14	Na_2O	0.24
La_2O_3	30.04	K_2O	0.16
Ce_2O_3	35.05	H_2O^+	2.72
Fe_2O_3	0.92	H_2O^-	0.17
MnO	0.20	SO_3	0.14
MgO	1.90	F	0.07
		Total	[100.00]

(1) Mountain Pass, California, USA; recalculated to 100% after deduction of 17.7% bastnäsite; corresponds to $(Ce_{3.90}La_{3.37}Ca_{1.63})_{\Sigma=8.90}(Mg_{0.61}Fe^{3+}_{0.39}Na_{0.14}K_{0.06}Ba_{0.05})_{\Sigma=1.25}Si_{6.83}O_{25.68}(OH)_{3.89}$.

Occurrence: In rare-earth-bearing hydrothermal quartz-barite-carbonatite veins in shonkinite (Mountain Pass, California, USA).

Association: Bastnäsite, allanite, epidote, monazite, törnebohmite, fluorite, uraninite, barite, quartz, galena.

Distribution: In Sweden, at the Bastnäs mine, Riddarhyttan, Västmanland. In the USA, from the Mountain Pass district, San Bernardino Co., California, and in Colorado, at Jamestown, Boulder Co. In Canada, from Papineau Co., and Mont Saint-Hilaire, Quebec. In the Kyshtymsk district, Ural Mountains, Russia.

Name: For its *cerium* content; the element was discovered in this mineral and named for the planetoid *Ceres*, also then just discovered.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 48851.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 550. (2) Gay, P. (1957) An X-ray investigation of some rare-earth silicates: cerite, lessingite, beckelite, britholite, and stillwellite. Mineral. Mag., 31, 455–468. (3) Gay, P. (1957) The crystallography of cerite. Amer. Mineral., 42, 429–432. (4) Glass, J.J., H.T. Evans, Jr., M.K. Carron, and F.A. Hillebrand (1958) Cerite from Mountain Pass, San Bernardino County, California. Amer. Mineral., 43, 460–475. (5) Moore, P.B. and J. Shen (1983) Cerite, $RE_9(Fe^{3+}, Mg)(SiO_4)_6(SiO_3OH)(OH)_3$: its crystal structure and relation to whitlockite. Amer. Mineral., 68, 996–1003.

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Černýite Cu_2CdSnS_4

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Small anhedral grains, up to 200 μm, in aggregates intergrown with stannite and këesterite.

Physical Properties: Hardness = ∼4 VHN = 189 (Tanco mine, Canada); 210 (Hugo mine, USA) (50 g load). D(meas.) = n.d. D(calc.) = 4.776 (Tanco mine, Canada); 4.618 (Hugo mine, USA).

Optical Properties: Opaque. *Color:* Steel-gray. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Very weak in shades of gray.

R_1–R_2: (470) 24.6 and 25.5, (546) 23.4 and 25.6, (589) 22.3 and 25.0, (650) 22.7 and 24.3. (Tanco mine, Canada and Hugo mine, USA)

Cell Data: *Space Group:* $I\bar{4}2m$. $a = 5.487$ $c = 10.848$ $Z = 2$

X-ray Powder Pattern: Tanco mine, Canada.
3.167 (100), 1.939 (70), 1.662 (50), 1.954 (40),. 1.639 (40), 1.770 (30), 1.257 (30)

Chemistry:

	(1)	(2)	(3)
Cu	28.1	26.5	26.12
Ag		0.02	
Cd	9.3	18.2	23.11
Fe	3.6	1.1	
Zn	4.9	2.0	
Mn	0.06	n.d.	
Sn	26.3	24.9	24.40
S	28.5	26.9	26.37
Total	100.8	99.8	100.00

(1) Hugo mine, USA; by electron microprobe, corresponding to $Cu_{1.99}(Cd_{0.37}Zn_{0.33}Fe_{0.29}Mn_{0.01})_{\Sigma=1.00}Sn_{1.00}S_{4.00}$. (2) Tanco mine, Canada; by electron microprobe, corresponding to $(Cu_{1.99}Ag_{0.01})_{\Sigma=2.00}(Cd_{0.77}Zn_{0.14}Fe_{0.10})_{\Sigma=1.01}Sn_{1.00}S_{4.00}$. (3) Cu_2CdSnS_4.

Mineral Group: Stannite group.

Occurrence: A rare constituent of complex zoned pegmatites, as a component of a very minor sulfide mineral suite.

Association: Pyrrhotite, sphalerite, hawleyite, chalcopyrite, stannite, bismuth, këesterite.

Distribution: In the Hugo [TL] and Peerless mines, near Keystone, Pennington Co., South Dakota, USA. From the Tanco pegmatite at Bernic Lake, southeastern Manitoba, Canada [TL]. In the Barquilla deposit, Salamanca Province, Spain.

Name: To honor Dr. Petr Černý (1934–), Czech-Canadian mineralogist specializing in pegmatites, University of Manitoba, Winnipeg, Canada.

Type Material: University of Manitoba, Winnepeg, 5159, 5160; Canadian Geological Survey, Ottawa, 12119; Royal Ontario Museum, Toronto, Canada, M34728–M34730; Museum of Geology, South Dakota School of Mines, 5098, 5099; National Museum of Natural History, Washington, D.C., USA, 136924.

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Cerotungstite-(Ce) $CeW_2O_6(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* 2 or $2/m$. As bladed crystals, to 100 μm, with {001}, {101}, {100}, {011}, and {110}; as parallel platy and radiating groups. *Twinning:* On {001}.

Physical Properties: *Cleavage:* {100}, perfect. Hardness = ∼1 D(meas.) = n.d. D(calc.) = [6.23]

Optical Properties: Semitransparent. *Color:* Yellow-orange; yellow with a slight greenish tint in thin section.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \simeq (100)$; $Y \simeq \perp (001)$. $\alpha = 1.89(1)$ (α') $\beta = 1.95(1)$ (β') $\gamma = 2.02(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1$ or $P2_1/m$. $a = 5.874(5)$ $b = 8.700(5)$ $c = 7.070(5)$ $\beta = 105°27(5)'$ Z = 2

X-ray Powder Pattern: Uganda.
3.405 (100), 2.273 (52), 6.83 (36), 1.767 (21), 3.337 (18), 2.627 (17), 3.117 (14)

Chemistry:

	(1)	(2)
WO_3	70.68	70.81
Al_2O_3	0.05	
Ce_2O_3		25.06
RE_2O_3	24.12	
Fe_2O_3	0.15	
CaO	0.17	
H_2O^+	4.80	4.13
Total	99.97	100.00

(1) Nyamulilo mine, Uganda; RE = La 5.5%, Ce 41.8%, Pr 6.0%, Nd 24.8%, Sm 6.8%, Eu 1.1%, Gd 3.4%, Tb 0.3%, Dy 1.6%, Ho 0.2%, Er 0.3%, Tm 0.07%, Yb 0.3%, Lu 0.07%, Y 7.7%; corresponds to $(RE_{0.94}Ca_{0.02})_{\Sigma=0.96}(W_{1.94}Fe_{0.01})_{\Sigma=1.95}[O_{5.60}(OH)_{3.40}]_{\Sigma=9.00}$. (2) $CeW_2O_6(OH)_3$.

Occurrence: In oxidized tungsten deposits.

Association: Ferberite.

Distribution: In the Kirwa and Nyamulilo mines, Kigezi district, southwestern Uganda.

Name: For CERium and TUNGSten in the composition.

Type Material: University of Helsinki, Helsinki, Finland.

References: (1) Sahama, T.G., O. von Knorring, and M. Lehtinen (1970) Cerotungstite, a cerian analogue to yttrotungstite, from Uganda. Bull. Geol. Soc. Finland, 42, 223–228. (2) (1972) Amer. Mineral., 57, 1558–1559 (abs. ref. 1). (3) Sahama, T.G. (1981) The secondary tungsten minerals, a review. Mineral. Record, 12, 81–87.

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$Cu_2Al_7(AsO_4)_4(OH)_{13}\cdot 11.5H_2O$ Ceruleite

Crystal Data: Triclinic. *Point Group:* $\bar{1}$ or 1. As rodlike crystals, to 5 μm, in powdery to compact, clayey, massive concretions and in spherical aggregates, to 10 cm.

Physical Properties: Hardness = 5-6 D(meas.) = 2.70–2.80 D(calc.) = [2.77]

Optical Properties: Semitransparent. *Color:* Sky-blue to pale blue.
Optical Class: Biaxial. $n = 1.60$

Cell Data: *Space Group:* $P\bar{1}$ or $P1$. $a = 14.359(3)$ $b = 14.687(3)$ $c = 7.440(1)$
$\alpha = 96.06(3)°$ $\beta = 93.19(4)°$ $\gamma = 91.63(4)°$ $Z = 2$

X-ray Powder Pattern: Bolivia.
5.650 (100), 7.296 (75), 5.926 (70), 4.760 (70), 3.545 (60), 2.650 (60), 4.877 (50)

Chemistry:

	(1)	(2)	(3)
P_2O_5		trace	
As_2O_5	34.56	38.01	35.36
Al_2O_3	31.26	26.85	27.45
Fe_2O_3		0.11	
CuO	11.80	11.79	12.24
H_2O	22.32	23.24	24.95
Total	99.94	100.00	100.00

(1) Emma Louisa mine, Chile. (2) Bolivia; average of seven analyses.
(3) $Cu_2Al_7(AsO_4)_4(OH)_{13}\cdot 11.5H_2O$.

Occurrence: In the oxidized zone of arsenic-rich polymetallic mineral deposits; a post-mine product.

Association: Alumopharmacosiderite, olivenite, schlossmacherite, mansfieldite, quartz (Emma Louisa mine, Chile); mansfieldite, quartz, barite, goethite (Bolivia); liroconite, clinoclase, olivenite (Wheal Gorland, England); posnjakite, scorodite, metazeunerite, cassiterite, tourmaline, quartz (Wheal Maid, England); malachite, azurite, olivenite, mansfieldite, pharmacosiderite (Cap Garonne mine, France).

Distribution: From the Emma Louisa gold mine, Guanaco district, about 100 km east-northeast of Taltal, Antofagasta, Chile. At an unknown locality in southern Bolivia. In England, at Wheal Gorland and Wheal Maid, Gwennap, and in the Penberthy Croft mine, St. Hilary, Cornwall. From the Cap Garonne mine, near Le Pradet, Var, France. At the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia. From Tsumeb, Namibia.

Name: From *cerulean*, for the sky-blue color of the mineral.

Type Material: The Natural History Museum, London, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 927–928. (2) Schmetzer, K., H. Bank, W. Berdesinski, and E. Kroužek (1976) Neue Untersuchungen an Coeruleit. Neues Jahrb. Mineral., Monatsh., 418–425 (in German with English abs.).

Cerussite $PbCO_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 0.6 m, are tabular {010}, equant to elongated on [001] or [100], or pseudohexagonal dipyramidal {111}, exhibiting combinations of {110}, {010}, {111}, {021}, {012}, {011}, {130}, {001}, with many others. Also granular, pulverulent, stalactitic, as randomly intergrown prismatic aggregates, rarely fibrous, massive. *Twinning:* Common, as simple or cyclic contact twins on {110}, producing stellate pseudohexagonal or reticulated composites; as contact twins on {130} producing heart-shaped composites. Both laws may occur in one aggregate.

Physical Properties: *Cleavage:* {110} and {021}, good; {010} and {012}, poor. *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 3–3.5 D(meas.) = 6.55(2) D(calc.) = 6.577 May fluoresce yellow under LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale yellow, smoky to dark gray, black with inclusions; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine, tending toward vitreous, resinous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong.
$\alpha = 1.803$ $\beta = 2.074$ $\gamma = 2.076$ 2V(meas.) = 8°–9°

Cell Data: *Space Group: Pmcn.* $a = 5.179(1)$ $b = 8.492(3)$ $c = 6.141(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.593 (100), 3.498 (43), 2.487 (32), 2.081 (27), 3.074 (24), 1.859 (21), 2.522 (20)

Chemistry:

	(1)	(2)
CO_2	16.64	16.47
PbO	83.27	83.53
insol.	0.24	
Total	100.15	100.00

(1) Tsumeb, Namibia. (2) $PbCO_3$.

Mineral Group: Aragonite group.

Occurrence: Common in the oxidized zone of lead deposits, where it may constitute an important ore.

Association: Anglesite, smithsonite, malachite, azurite, phosgenite, pyromorphite, galena.

Distribution: Some of the many localities for fine crystals include: from the Friedrichssegen mine, near Braubach, Rhineland-Pfalz, Germany. At Příbram, Czech Republic. From Mežica (Mies), Slovenia. At Leadhills, Lanarkshire, Scotland. From the Frankmills mine, Christow, Devon, England. In the Rossignol vein, Chaillac, Indre, France. At Monteponi and Montevecchio, near Iglesias, Sardinia, Italy. From Nerchinsk, Siberia, Russia. At Sidi-Amor-ben-Salem, Tunisia. From Morocco, at Mibladen, with fine twins from the Touissit mine, near Oujda. Superb crystals and twinned groups at Tsumeb and in the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia. At the Nakhlak mine, Anarak district, Iran. In Australia, from Broken Hill, New South Wales; at the Magnet and other mines, near Dundas, Tasmania. In the USA, from the Wheatley mine, Phoenixville, Chester Co., Pennsylvania; in the Bunker Hill mine, Coeur d'Alene district, Shoshone Co., Idaho; from Leadville, Lake Co., Colorado; in Arizona, from the Mammoth-St. Anthony mine, Tiger, Pinal Co., at the Flux mine, Santa Cruz Co., and elsewhere; large twins from the Stevenson-Bennett mine, Organ district, Doña Ana Co., New Mexico.

Name: From the Latin *cerussa*, for *white lead*, synthetic lead carbonate.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 200–207. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 272–276. (3) Chevrier, G., G. Giester, G. Heger, D. Jarosch, M. Wildner, and J. Zemann (1992) Neutron single-crystal refinement of cerussite, $PbCO_3$, and comparison with other aragonite-type carbonates. Zeits. Krist., 199, 67–74.
(4) (1953) NBS Circ. 539, II, 56.

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Cervandonite-(Ce) $(Ce, Nd, La)(Fe^{3+}, Ti, Fe^{2+}, Al)_3(Si, As)_3O_{13}$

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Crystal Data: Monoclinic. *Point Group:* m, 2, or $2/m$. As porous, saddle- or rosettelike, rounded, radial crystal aggregates, to 4 mm.

Physical Properties: *Cleavage:* {001}, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5 VHN = 450 (50 g load). D(meas.) = n.d. D(calc.) = 4.9

Optical Properties: Opaque, translucent in very thin fragments. *Color:* Black; in transmitted light, yellowish, reddish brown to black. *Streak:* Brownish black. *Luster:* Adamantine. *Optical Class:* Biaxial. *Pleochroism:* Yellowish, reddish brown to black. n = 1.99–2.00 2V(meas.) = n.d.

Cell Data: *Space Group:* Cm, $C2$, or $C2/m$. $a = 11.235(4)$ $b = 19.50(2)$ $c = 7.201(3)$ $\beta = 121.22(3)^\circ$ Z = 6

X-ray Powder Pattern: Pizzo Cervandone, Italy.
2.8785 (100), 3.2530 (90), 5.390 (80), 3.0847 (80), 2.7867 (60), 2.6964 (50), 3.5750 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	17.65	15.17	Ce_2O_3	10.00	11.63
TiO_2	11.67	11.42	Nd_2O_3	5.16	6.01
SnO_2	1.24	0.00	Fe_2O_3	15.03	15.53
UO_2	1.35	0.33	As_2O_5	20.41	24.18
ThO_2	2.34	1.92	FeO	4.51	4.67
Al_2O_3	3.60	2.95	PbO	0.17	0.16
Y_2O_3	0.94	0.86	CaO	0.25	0.25
La_2O_3	5.14	5.65	Total	[99.46]	[100.73]

(1) Pizzo Cervandone, Italy; by electron microprobe, Fe^{2+}:Fe^{3+} determined by Mössbauer spectroscopy, original total given as 99.47%; corresponds to $(Ce_{0.39}Nd_{0.20}La_{0.20}Y_{0.05}Th_{0.06}U_{0.03}Ca_{0.03}Pb_{0.01})_{\Sigma=0.97}(Fe^{3+}_{1.21}Ti_{0.94}Al_{0.46}Fe^{2+}_{0.40}Sn_{0.05})_{\Sigma=3.06}(Si_{1.89}As^{5+}_{1.14})_{\Sigma=3.03}O_{13}$. (2) Pizzo Cervandone, Switzerland; by electron microprobe, original total given as 100.72%; corresponds to $(Ce_{0.46}Nd_{0.23}La_{0.23}Y_{0.05}Th_{0.05}Ca_{0.03}U_{0.01}Pb_{0.01})_{\Sigma=1.07}(Fe^{3+}_{1.26}Ti_{0.93}Fe^{2+}_{0.42}Al_{0.38})_{\Sigma=2.99}(Si_{1.64}As^{5+}_{1.36})_{\Sigma=3.00}O_{13}$.

Occurrence: In narrow fissure-veins cutting two-mica gneiss.

Association: Senaite, chernovite, rutile, anatase, muscovite, albite, chlorite, tourmaline, magnetite, hematite, quartz, synchysite.

Distribution: On the east flank of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Italy. On the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais, Switzerland.

Name: After the locality on the border between Italy and Switzerland where the mineral was discovered, Pizzo Cervandone.

Type Material: Natural History Museum, Bern, B3953, B4695, B4880; Natural History Museum, Basel, Switzerland, M30802.

References: (1) Armbruster, T., C. Bühler, S. Graeser, H.A. Stalder, and G. Amthauer (1988) Cervandonite-(Ce), $(Ce, Nd, La)(Fe^{3+}, Fe^{2+}, Ti^{4+}, Al)_3SiAs(Si, As)O_{13}$, a new Alpine fissure mineral. Schweiz. Mineral. Petrog. Mitt., 68, 125–132. (2) (1990) Amer. Mineral., 75, 932 (abs. ref. 1).

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Cervantite $Sb^{3+}Sb^{5+}O_4$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Fine-grained, massive.

Physical Properties: *Cleavage:* {001}, excellent; {100}, distinct. Hardness = 4–5
D(meas.) = > 6.5 D(calc.) = 6.64

Optical Properties: Semitransparent. *Color:* Yellow to nearly white; colorless in transmitted light. *Streak:* Pale yellow to white. *Luster:* Earthy when powdery.
Optical Class: Biaxial. n = 2.0–2.1 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pna2_1$. $a = 5.43$ $b = 4.79$ $c = 11.73$ Z = 4

X-ray Powder Pattern: Brasina, Serbia.
3.06 (10), 2.91 (7), 1.854 (7), 1.635 (7), 2.70 (6), 2.38 (6), 1.774 (6)

Chemistry: The composition has been established by correspondence of other properties with synthetic $Sb^{3+}Sb^{5+}O_4$.

Occurrence: A secondary mineral formed from the oxidation of stibnite.

Association: Stibnite.

Distribution: The existence of the species was re-established on material from the Zajača-Stolice district, Brasina, Serbia. At Baia Sprie (Felsőbánya), Romania. In the Cetine mine, 20 km southwest of Siena, and the Pereta mine, Scansano, Tuscany, Italy. At the Clara Mine, near Oberwolfach, Black Forest, Germany. From Pocca, Bolivia. Material from other localities requires modern confirmation.

Name: For the supposed original occurrence at Cervantes, Spain, type material from which is not available.

References: (1) Gründer, W., H. Pätzold, and H. Strunz (1962) Sb_2O_4 als Mineral (Cervantit) [cervantite confirmed]. Neues Jahrb. Mineral., Monatsh., 93–98 (in German with English abs.).
(2) (1962) Amer. Mineral., 47, 1221 (abs. ref. 1). (3) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 597–598 [probably cervantite in part].
(4) Thornton, G. (1977) A neutron diffraction study of α-Sb_2O_4. Acta Cryst., 33, 1271–1273.
(5) (1960) NBS Circ. 539, 10, 8.

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Cervelleite Ag_4TeS

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Crystal Data: Cubic. *Point Group:* n.d. Rimming acanthite, to 30 μm thick, and as vermiform inclusions in hessite, also intergrown with benleonardite.

Physical Properties: Hardness = n.d. VHN = 26 (10 g load). D(meas.) = n.d. D(calc.) = 8.53(2) Photosensitive.

Optical Properties: Opaque. *Color:* Black; pale blue to pale green in reflected light.
Luster: Metallic.
Optical Class: Isotropic.
R: (400) 39.8, (420) 40.0, (440) 40.1, (460) 40.0, (480) 39.7, (500) 39.3, (520) 38.9, (540) 38.3, (560) 37.8, (580) 37.2, (600) 36.8, (620) 36.3, (640) 35.8, (660) 35.4, (680) 34.9, (700) 34.4

Cell Data: *Space Group:* n.d. a = 14.03(1) Z = 24

X-ray Powder Pattern: Moctezuma mine, Mexico.
5.00 (vvs), 4.24 (vs), 6.29 (s), 3.766 (ms), 4.64 (m), 5.74 (w), 2.596 (w)

Chemistry:

	(1)	(2)
Ag	73.0	72.99
Cu	0.1	
Te	22.2	21.59
S	5.3	5.42
Total	100.6	100.00

(1) Moctezuma mine, Mexico; by electron microprobe, average of eight analyses; corresponds to $Ag_{3.99}Cu_{0.01}Te_{1.02}S_{0.97}$. (2) Ag_4TeS.

Occurrence: In fracture fillings in highly altered and silicified rhyolite vitrophyre in a hydrothermal Au–Te deposit.

Association: Silver, acanthite, hessite, benleonardite, pyrite, sphalerite, dolomite, quartz.

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico [TL]. A number of additional localities are suggested to host this species, but so far in amounts too small for complete confirmation.

Name: To honor Dr. Bernard Cervelle (1940–), French mineralogist, University of Paris, Paris, France, for his work in ore microscopy.

Type Material: The Natural History Museum, London, England, 1985,354, E1161.

References: (1) Criddle, A.J., J.E. Chisholm, and C.J. Stanley (1989) Cervelleite, Ag_4TeS, a new mineral from the Bambolla mine, Mexico, and a description of a photo-chemical reaction involving cervelleite, acanthite and hessite. Eur. J. Mineral., 1, 371–380. (2) (1990) Amer. Mineral., 75, 1431–1437 (abs. ref. 1).

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Cesanite $Na_3Ca_2(SO_4)_3(OH)$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As rare striated subhedral hexagonal prismatic crystals, to 1.5 mm, exhibiting $\{10\bar{1}0\}$, $\{01\bar{1}1\}$, $\{0001\}$; commonly granular. *Twinning:* On $\{10\bar{1}0\}$, uncommon.

Physical Properties: *Cleavage:* On $\{0001\}$. Hardness = 2–3 D(meas.) = 2.786(2) D(calc.) = [2.83] Slightly soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in thin section. *Luster:* Greasy to silky in aggregates.
Optical Class: Uniaxial (–). $\omega = 1.570(2)$ $\epsilon = 1.564(2)$

Cell Data: *Space Group:* $P6_3/m$. $a = 9.446(1)$ $c = 6.895(1)$ Z = 2

X-ray Powder Pattern: Cesano, Italy.
2.727 (100), 3.448 (87), 1.844 (71), 3.896 (66), 2.822 (60), 2.636 (49), 2.269 (47)

Chemistry:

	(1)
SO_3	52.6
CaO	18.9
SrO	0.72
Na_2O	23.3
K_2O	0.21
F	0.25
Cl	0.44
H_2O	2.91
$-O = (F, Cl)_2$	0.21
Total	99.12

(1) Cesano, Italy; by electron microprobe, corresponds to $(Ca_{1.54}Na_{0.44}Sr_{0.03})_{\Sigma=2.01}(Na_{2.98}K_{0.02})_{\Sigma=3.00}[(OH)_{0.44}Cl_{0.06}F_{0.06}]_{\Sigma=0.56}(SO_4)_{2.99} \bullet 0.44H_2O$.

Occurrence: As vein and cavity fillings in brecciated rock in an active geothermal field.

Association: Görgeyite, pyrite, gypsum, anhydrite, aphthitalite, kalistrontite, glauberite.

Distribution: From drill core at the edge of the Baccano caldera, Cesano geothermal field, east of Lake Bracciano, Lazio, Italy.

Name: For the locality near Cesano, Italy.

Type Material: City Museum of Natural History, Milan; Mineralogy Museum, University of Rome, Rome, Italy 24316/1; Natural History Museum, Vienna, Austria, L6891; National Museum of Natural History, Washington, D.C., USA, 150333.

References: (1) Cavarretta, G., A. Mottana, and F. Tecce (1981) Cesanite, $Ca_2Na_3[(OH)(SO_4)_3]$, a sulphate isotypic to apatite, from the Cesano geothermal field (Latium, Italy). Mineral. Mag., 44, 269–273. (2) (1982) Amer. Mineral., 67, 621 (abs. ref. 1). (3) Tazzoli, V. (1983) The crystal structure of cesanite, $Ca_{1+x}Na_{4-x}(SO_4)_3(OH)_x \bullet (1-x)H_2O$, a sulphate isotypic to apatite. Mineral. Mag., 47, 59–63. (4) Deganello, S. (1983) The crystal structure of cesanite at 21 and 236 °C. Neues Jahrb. Mineral., Monatsh., 305–313.

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Cesàrolite $PbMn_3^{4+}O_6(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* n.d. In botryoidal crusts and cokelike masses.

Physical Properties: *Tenacity:* Friable. Hardness = 4.5 D(meas.) = 5.29 D(calc.) = n.d.

Optical Properties: [Opaque.] *Color:* Steel-gray. *Luster:* Dull to submetallic.
Optical Class: Isotropic, grading outwardly to anisotropic spherules.
R: n.d.

Cell Data: *Space Group: R.* $a = 2.8106(1)$ $c = 20.386(1)$ Z = n.d.

X-ray Powder Pattern: Sidi Amor Ben Salem, Tunisia.
2.194 (100), 2.087 (80), 1.760 (50), 1.563 (50), 3.40 (40), 1.406 (30), 3.21 (10)

Chemistry:

	(1)	(2)	(3)
Al	0.79		
Fe	0.49		
Pb	36.29	39.6	41.27
MnO	42.65	43.0	42.39
Na_2O	0.18		
O	13.26		12.75
H_2O	3.30		3.59
rem.	0.36		
insol.	0.75		
Total	98.07		100.00

(1) Sidi Amor Ben Salem, Tunisia; remnant is "other metals". (2) Do.; by electron microprobe, original analysis Mn = 33.3%, here converted to MnO. (3) $PbMn_3O_6(OH)_2$.

Occurrence: In cavities in galena.

Association: Galena, coronadite.

Distribution: From Sidi Amor Ben Salem, Tunisia. In the USA, from Bisbee, Cochise Co., Arizona. Found in the Mori mine, Yamagata Prefecture, Japan. From the Clara Mine, near Oberwolfach, Black Forest, Germany.

Name: To honor Giuseppe Raimondo Pio Cesàro (1849–1939), Professor of Mineralogy and Crystallography at the University of Liège, Liège, Belgium.

Type Material: University of Liège, Liège, Belgium, 1975.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 744. (2) Burkart-Baumann, I., J. Ottemann, and P. Nicolini (1967) Mineralogische Untersuchungen an Jordanit, Semseyit und Cesarolith von drei tunesischen Blei-Zink-Lagerstätten. Chem. Erde, 26, 256–270 (in German with English abs.). (3) Post, J.E. (1994) X-ray and neutron diffraction study of coronadite and cesarolite. IMA, 16th General Meeting, 334 (abs.). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 206.

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Cesbronite $Cu_5(Te^{4+}O_3)_2(OH)_6 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As chisel-shaped dipyramidal crystals, to 0.5 mm, showing dominant and striated {103}, with {180}, {001}, and {010}; as hollow crusts of radiating crystals and fanlike aggregates.

Physical Properties: *Cleavage:* Poor on {010}; good on {021}. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 4.45(2) D(calc.) = 4.455

Optical Properties: Transparent. *Color:* Green; dark green in transmitted light. *Streak:* Pale green.
Optical Class: Biaxial (+). *Pleochroism:* Distinct; X = pale bluish green; Y = dark yellow-green; Z = dark emerald-green. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$; moderate. *Absorption:* $Z \simeq Y \gg X$. $\alpha = 1.880(8)$ $\beta = 1.928(8)$ $\gamma = 2.029(8)$ 2V(meas.) = n.d. 2V(calc.) = 72°

Cell Data: *Space Group: Pbcn.* $a = 8.624(16)$ $b = 11.878(16)$ $c = 5.872(16)$ Z = 2

X-ray Powder Pattern: Oriental mine, Mexico.
5.934 (100), 3.490 (92), 4.889 (71), 2.358 (70), 2.379 (38), 1.592 (34), 2.156 (28)

Chemistry:

	(1)	(2)
TeO_2	38.92	39.55
CuO	49.95	49.29
H_2O	11.00	11.16
Total	99.87	100.00

(1) Oriental mine, Mexico; by electron microprobe, average of four analyses, total Te as TeO_2, H_2O on a separate sample by the Penfield method; corresponds to $Cu_{5.07}(TeO_3)_{1.97}(OH)_{6.20} \cdot 1.83H_2O$. (2) $Cu_5(TeO_3)_2(OH)_6 \cdot 2H_2O$.

Occurrence: A secondary mineral in an oxidized Cu–Te–Pb sulfide deposit (Oriental mine, Mexico).

Association: Argentian gold, teineite, carlfriesite, xocomecatlite (Oriental mine, Mexico); utahite, leisingite, jensenite, hematite (Centennial Eureka mine, Utah, USA).

Distribution: From the Oriental (Bambollita) mine, northeast of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the USA, at Tombstone, Cochise Co., Arizona, and from the Centennial Eureka mine, Tintic district, near Eureka, Juab Co., Utah.

Name: Honors Dr. Fabian Cesbron (1938–), French mineralogist with the Bureau de Recherches Géologiques et Minières, Orléans, France.

Type Material: Natural History Museum, Paris; National School of Mines, Paris, France; The Natural History Museum, London, England, 1976,405; National Museum of Natural History, Washington, D.C., USA, 144518.

References: (1) Williams, S.A. (1974) Cesbronite, a new copper tellurite from Moctezuma, Sonora. Mineral. Mag., 39, 744–746. (2) (1979) Amer. Mineral., 64, 653 (abs. ref. 1).

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Cesplumtantite $(Cs,Na)_2(Pb,Sb^{3+})_3Ta_8O_{24}$

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Crystal Data: Tetragonal. *Point Group:* n.d. As veinlets and elongated aggregates, to 0.3 mm. *Twinning:* Polysynthetic, complex, observed microscopically.

Physical Properties: Hardness = n.d. VHN = 1240 (40 g load). D(meas.) = n.d. D(calc.) = 6.87(5)

Optical Properties: Transparent. *Color:* Colorless; light gray in reflected light. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial. *Anisotropism:* Strong. *Bireflectance:* Weak.
R_1–R_2: (476) 18.2–17.1, (553) 17.3–16.5, (589) 17.1–16.5, (656) 15.6–15.3

Cell Data: *Space Group:* n.d. $a = 13.552(8)$ $c = 6.445(5)$ $Z = 2$

X-ray Powder Pattern: Manono pegmatite, Congo.
3.054 (10), 1.869 (7), 1.593 (7), 6.11 (5), 3.19 (5), 2.037 (5b), 1.181 (5)

Chemistry:

	(1)
Nb_2O_5	3.24
Ta_2O_5	63.85
SnO_2	[1.60]
Sb_2O_3	2.88
SnO	1.49
PbO	20.24
CaO	0.83
Na_2O	0.71
Cs_2O	5.37
Total	[100.21]

(1) Manono pegmatite, Congo; by electron microprobe, average of three analyses; corresponding to $(Cs_{0.94}Na_{0.57}Ca_{0.37})_{\Sigma=1.88}(Pb_{2.24}Sb^{3+}_{0.49}Sn^{2+}_{0.27})_{\Sigma=3.00}(Ta_{7.15}Nb_{0.60}Sn^{4+}_{0.26})_{\Sigma=8.01}O_{24}$.

Occurrence: In veinlets in a museum specimen from a granite pegmatite.

Association: Lithiotantite, cassiterite, calciotantite, microlite, thoreaulite.

Distribution: From the Manono pegmatite, Katanga Province, Congo (Shaba Province, Zaire).

Name: For CESium, lead (PLUMbum), and TANTalum in the composition.

Type Material: Mining Museum, State University, St. Petersburg, Russia, 1547/2.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, A.Y. Bakhchisaraytsev, and N.N. Devnina (1986) Cesplumtantite – a new cesium-lead tantalate from granitic pegmatites. Mineral. Zhurnal, 8(5), 92–98 (in Russian with English abs.). (2) (1989) Amer. Mineral., 74, 501 (abs. ref. 1).

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Cesstibtantite $Cs(Sb^{3+}, Na)Ta_2(O, OH, F)_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As cubo-octahedral crystals; granular, to 3 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼5 VHN = 670–780 (100 g load). D(meas.) = 6.4–6.6 D(calc.) = 6.49 Fluoresces yellow-orange to orange under LW UV; weak yellowish cathodoluminescence.

Optical Properties: Transparent; may be opaque except in thinnest fragments.
Color: Colorless to gray, yellow-orange, black. *Luster:* Adamantine to vitreous.
Optical Class: Isotropic. $n = > 1.8$
R: (480) 13.8, (551) 13.6, (589) 13.6, (656) 13.0

Cell Data: *Space Group:* $Fd3m$. a = 10.496–10.515 Z = 8

X-ray Powder Pattern: Kola Peninsula, Russia.
3.04 (10), 1.860 (10), 1.587 (10), 1.012 (10), 3.17 (9), 1.370 (9), 1.017 (9)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5	2.3	2.8	1.2	CaO	0.1		0.6
Ta_2O_5	72.0	70.8	72.5	Na_2O	1.3	1.7	2.4
Bi_2O_3	0.7	0.3	0.6	K_2O		0.0	0.05
Sb_2O_3	13.6	14.2	9.7	Cs_2O	7.3	7.4	5.4
SnO			0.1	H_2O		[1.5]	[1.2]
PbO	1.6	0.8	5.3	Total	98.9	[99.5]	[99.0]

(1) Kola Peninsula, Russia; by electron microprobe, average of five analyses; $(OH)^{1-}$ confirmed by IR. (2) Do.; by electron microprobe, H_2O calculated from structural considerations; corresponds to $[Cs_{0.31}(OH, F)_{0.69}]_{\Sigma=1.00}(Sb_{0.57}Na_{0.31}Pb_{0.02}Bi_{0.01})_{\Sigma=0.91}(Ta_{1.88}Nb_{0.12})_{\Sigma=2.00}$ $[O_{5.69}(OH, F)_{0.31}]_{\Sigma=6.00}$. (3) Tanco pegmatite, Canada; by electron microprobe, H_2O calculated from structural considerations; corresponds to $[Cs_{0.22}K_{0.01}(OH, F)_{0.55}]_{\Sigma=0.78}(Na_{0.45}Sb_{0.40}$ $Pb_{0.14}Ca_{0.06}Bi_{0.02}Sn_{0.01})_{\Sigma=1.08}(Ta_{1.95}Nb_{0.05})_{\Sigma=2.00}[O_{5.78}(OH, F)_{0.22}]_{\Sigma=6.00}$.

Mineral Group: Pyrochlore group, intermediate between normal and inverse pyrochlores.

Occurrence: A rare accessory in some highly fractionated granite pegmatites.

Association: Simpsonite, stibiotantalite, microlite, wodginite, tantalite, pollucite, sosedkoite (Kola Peninsula, Russia); kimrobinsonite, manganotantalite, antimonian microlite (Mt. Holland, Western Australia).

Distribution: From the Leshaia pegmatite, Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. In the Czech Republic, at the Dobrá Voda pegmatite, Velké Meziříčí. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada. From near Mt. Holland, Western Australia.

Name: For CESium, antimony (STIBium), and TANTalum in the composition [deviant from IMA pyrochlore nomenclature].

Type Material: Mining Museum, St. Petersburg, 1324/1; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5518; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80827, 81058, vis6317.

References: (1) Voloshin, A.V., Y.P. Men'shikov, Y.A. Pakhomovskii, and L.I. Polezhaeva (1981) Cesstibtantite, $(Cs, Na)SbTa_4O_{12}$ – a new mineral from granitic pegmatites. Zap. Vses. Mineral. Obshch., 110, 345–351 (in Russian). (2) (1982) Amer. Mineral., 67, 413–414 (abs. ref. 1). (3) Nickel, E.H. and B.W. Robinson (1985) Kimrobinsonite, a new tantalum mineral from Western Australia, and its association with cesstibtantite. Can. Mineral., 23, 573–576. (4) Ercit, T.S., P. Černý, and F.C. Hawthorne (1993) Cesstibtantite – a geologic introduction to the inverse pyrochlores. Mineral. Petrol., 48, 235–255.

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Cetineite $(K,Na)_{3+x}(Sb_2O_3)_3(SbS_3)(OH)_x \cdot 2.4H_2O$ (x ~0.5)

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Crystal Data: Hexagonal. *Point Group:* 6. As tufts of acicular crystals elongated ‖ [0001], to 0.5 mm in length.

Physical Properties: *Cleavage:* On $\{10\bar{1}0\}$. *Tenacity:* Somewhat sectile. Hardness = n.d. VHN = 127–156 (20 g load). D(meas.) = n.d. D(calc.) = 4.21

Optical Properties: Transparent to translucent. *Color:* Red-orange. *Streak:* Orange. *Luster:* Resinous.
Optical Class: Uniaxial (+). *Pleochroism:* Weak, from orange to slightly orange-brown.
$n = > 1.74$ 2V(meas.) = n.d.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3$. $a = 14.2513(3)$ $c = 5.5900(1)$ Z = 2

X-ray Powder Pattern: Cetine mine, Italy.
2.916 (100), 12.41 (80), 3.000 (74), 2.690 (61), 4.11 (55), 4.67 (54), 3.581 (44)

Chemistry:

	(1)
SiO_2	0.67
Sb_2O_3	81.06
K_2O	6.66
Na_2O	3.87
S	7.15
H_2O	[4.16]
$-O = S$	3.57
Total	[100.00]

(1) Cetine mine, Italy; by electron microprobe, average of two analyses, H_2O by difference; after deduction of SiO_2 corresponds to $(K_{1.78}Na_{1.57})_{\Sigma=3.35}(Sb_2O_3)_{3.03}(SbS_3)_{0.94}(OH)_{0.53} \cdot 2.4H_2O$.

Occurrence: From an antimony deposit in highly silicified evaporites, on ore which has been roasted, then long weathered.

Association: Mopungite, sénarmontite.

Distribution: From the Cetine mine, 20 km southwest of Siena, Tuscany, Italy.

Name: For the Cetine mine, Italy.

Type Material: University of Florence, Florence, Italy, 644/RI; National Museum of Natural History, Washington, D.C., USA, 164388.

References: (1) Sabelli, C. and G. Vezzalini (1987) Cetineite, a new antimony oxide-sulfide mineral from Cetine mine, Tuscany, Italy. Neues Jahrb. Mineral., Monatsh., 419–425. (2) (1989) Amer. Mineral., 74, 1399–1400 (abs. ref. 1). (3) Sabelli, C., I. Nakai, and S. Katsura (1988) Crystal structures of cetineite and its synthetic Na analogue $Na_{3.6}(Sb_2O_3)_3(SbS_3)(OH)_{0.6} \cdot 2.4H_2O$. Amer. Mineral., 73, 398–404.

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Chabazite $CaAl_2Si_4O_{12}\cdot 6H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $P\overline{1}$; $\overline{3}$ $2/m$ pseudohexagonal. In pseudorhombohedral crystals, nearly cubic in aspect, to 4.5 cm; tabular, complex to rounded twinned forms; anhedral, granular, or massive. *Twinning:* About [0001], interpenetrant, simple and repeated, common; contact on $\{10\overline{1}1\}$.

Physical Properties: *Cleavage:* $\{10\overline{1}1\}$, distinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 2.05–2.20 D(calc.) = 2.035

Optical Properties: Transparent to translucent. *Color:* White, yellow, pink, red, colorless; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+) or (–) or uniaxial; commonly shows birefringent panelling in six sections. *Orientation:* $X = c$; rarely $Z = c$. α = 1.478–1.487 β = n.d. γ = 1.480–1.493 2V(meas.) = 0°–32°

Cell Data: *Space Group:* $P\overline{1}$. a = 9.40–9.45 b = 9.40–9.44 c = 9.40–9.44 α = 94.18°−94.33° β = 94.08°−94.36° γ = 94.07°−94.45° Z = [2]

X-ray Powder Pattern: Table Mountain, Colorado, USA; very similar to herschelite. 2.925 (100), 4.32 (75), 9.35 (50), 5.02 (30), 3.87 (30), 2.890 (30), 3.59 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	47.56	47.46	K_2O	0.92	
Al_2O_3	20.40	20.13	H_2O^+	16.28	
MgO	0.20		H_2O^-	3.44	
CaO	10.52	11.07	H_2O		21.34
Na_2O	0.32		Total	99.64	100.00

(1) Ritter Hot Spring, Grant Co., Oregon, USA; corresponds to $(Ca_{0.94}K_{0.10}Na_{0.05}Mg_{0.02})_{\Sigma=1.11}Al_{2.01}Si_{3.97}O_{12}\cdot 5.50H_2O$. (2) $CaAl_2Si_4O_{12}\cdot 6H_2O$.

Mineral Group: Zeolite group.

Occurrence: In volcanic rocks as basalts, andesite; rarer in limestones and schists; hydrothermally deposited in cavities and joints in ore veins. In bedded tuff in lake deposits, altered from volcanic glass.

Association: Zeolites, nepheline, melilite, olivine, pyroxenes, amphiboles, axinite, epidote, calcite, tridymite, dolomite.

Distribution: A common zeolite. Fine crystals from Idar-Oberstein, Rhineland-Palatinate, Germany. At Řepčice (Rübendörfel), near Ústí nad Lábem (Aussig), Czech Republic. At a number of localities in Co. Antrim, Ireland. In Scotland, at Kilmalcolm, Renfrewshire. From Haeddin, on Eysturoy; Dalsnipa, on Sandoy; and Skutin, on Nolsoy, Faeroe Islands. Large crystals at Breidhdalsheidhi, Iceland. In the USA, around Paterson, Passaic Co., and Bergen Hill, Hudson Co., New Jersey; on Table Mountain, Jefferson Co., Colorado; at Goble, Columbia Co., and Springfield, Lane Co., Oregon. In the Bay of Fundy district, Nova Scotia, Canada. On Table Mountain, Rosarito Beach, Baja California, Mexico. In the Khandivali quarry, near Bombay, Maharashtra, India. At Richmond and Collingwood, Victoria, and on Fairy Mount, near Kyogle, New South Wales, Australia.

Name: From the Greek *chabazios*, an ancient name of a stone.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 589–592. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 387–400. (3) Passaglia, E. (1970) The crystal chemistry of chabazites. Amer. Mineral., 55, 1278–1301. (4) Gude, A.J., 3rd and R.A. Sheppard (1966) Silica-rich chabazite from the Barstow Formation, San Bernardino County, Southern California. Amer. Mineral., 51, 909–915. (5) Mazzi, F. and E. Galli (1983) The tetrahedral framework of chabazite. Neues Jahrb. Mineral., Monatsh., 461–480.

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Chabazite $CaAl_2Si_4O_{12}\cdot 6H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $P\overline{1}$; $\overline{3}$ $2/m$ pseudohexagonal. In pseudorhombohedral crystals, nearly cubic in aspect, to 4.5 cm; tabular, complex to rounded twinned forms; anhedral, granular, or massive. *Twinning:* About [0001], interpenetrant, simple and repeated, common; contact on $\{10\overline{1}1\}$.

Physical Properties: *Cleavage:* $\{10\overline{1}1\}$, distinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 2.05–2.20 D(calc.) = 2.035

Optical Properties: Transparent to translucent. *Color:* White, yellow, pink, red, colorless; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+) or (–) or uniaxial; commonly shows birefringent panelling in six sections. *Orientation:* $X = c$; rarely $Z = c$. α = 1.478–1.487 β = n.d. γ = 1.480–1.493 2V(meas.) = 0°–32°

Cell Data: *Space Group:* $P\overline{1}$. a = 9.40–9.45 b = 9.40–9.44 c = 9.40–9.44 α = 94.18°−94.33° β = 94.08°−94.36° γ = 94.07°−94.45° Z = [2]

X-ray Powder Pattern: Table Mountain, Colorado, USA; very similar to herschelite. 2.925 (100), 4.32 (75), 9.35 (50), 5.02 (30), 3.87 (30), 2.890 (30), 3.59 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	47.56	47.46	K_2O	0.92	
Al_2O_3	20.40	20.13	H_2O^+	16.28	
MgO	0.20		H_2O^-	3.44	
CaO	10.52	11.07	H_2O		21.34
Na_2O	0.32		Total	99.64	100.00

(1) Ritter Hot Spring, Grant Co., Oregon, USA; corresponds to $(Ca_{0.94}K_{0.10}Na_{0.05}Mg_{0.02})_{\Sigma=1.11}Al_{2.01}Si_{3.97}O_{12}\cdot 5.50H_2O$. (2) $CaAl_2Si_4O_{12}\cdot 6H_2O$.

Mineral Group: Zeolite group.

Occurrence: In volcanic rocks as basalts, andesite; rarer in limestones and schists; hydrothermally deposited in cavities and joints in ore veins. In bedded tuff in lake deposits, altered from volcanic glass.

Association: Zeolites, nepheline, melilite, olivine, pyroxenes, amphiboles, axinite, epidote, calcite, tridymite, dolomite.

Distribution: A common zeolite. Fine crystals from Idar-Oberstein, Rhineland-Palatinate, Germany. At Řepčice (Rübendörfel), near Ústí nad Lábem (Aussig), Czech Republic. At a number of localities in Co. Antrim, Ireland. In Scotland, at Kilmalcolm, Renfrewshire. From Haeddin, on Eysturoy; Dalsnipa, on Sandoy; and Skutin, on Nolsoy, Faeroe Islands. Large crystals at Breidhdalsheidhi, Iceland. In the USA, around Paterson, Passaic Co., and Bergen Hill, Hudson Co., New Jersey; on Table Mountain, Jefferson Co., Colorado; at Goble, Columbia Co., and Springfield, Lane Co., Oregon. In the Bay of Fundy district, Nova Scotia, Canada. On Table Mountain, Rosarito Beach, Baja California, Mexico. In the Khandivali quarry, near Bombay, Maharashtra, India. At Richmond and Collingwood, Victoria, and on Fairy Mount, near Kyogle, New South Wales, Australia.

Name: From the Greek *chabazios*, an ancient name of a stone.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 589–592. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 387–400. (3) Passaglia, E. (1970) The crystal chemistry of chabazites. Amer. Mineral., 55, 1278–1301. (4) Gude, A.J., 3rd and R.A. Sheppard (1966) Silica-rich chabazite from the Barstow Formation, San Bernardino County, Southern California. Amer. Mineral., 51, 909–915. (5) Mazzi, F. and E. Galli (1983) The tetrahedral framework of chabazite. Neues Jahrb. Mineral., Monatsh., 461–480.

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Chabournéite $(Tl, Pb)_{23}(Sb, As)_{91}S_{147}$

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Crystal Data: Triclinic. *Point Group:* 1. Rarely in crystals larger than 1 mm; typically in intimate intergrowths with pierrotite.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 78–124, 95 average (25 g load). D(meas.) = 5.104 D(calc.) = 5.121

Optical Properties: Opaque. *Color:* Black; white in reflected light, red internal reflections noted along cracks. *Streak:* Red-brown. *Luster:* Submetallic to greasy. *Pleochroism:* Weak. *Anisotropism:* Strong, in bluish and greenish colors.
R_1–R_2: (400) 33.8–39.7, (420) 33.5–39.1, (440) 33.2–38.6, (460) 32.8–37.9, (480) 32.3–37.2, (500) 32.0–36.6, (520) 31.7–36.1, (540) 31.4–35.6, (560) 31.1–34.9, (580) 30.7–34.3, (600) 30.3–33.7, (620) 29.7–33.0, (640) 29.1–32.2, (660) 28.5–31.6, (680) 27.9–30.9, (700) 27.3–30.3

Cell Data: *Space Group:* $P1$. $a = 16.346(5)$ $b = 42.602(10)$ $c = 8.534(3)$ $\alpha = 95.86(3)°$ $\beta = 86.91(3)°$ $\gamma = 96.88(3)°$ Z = 1

X-ray Powder Pattern: Jas Roux, France.
3.573 (10), 2.135 (9), 2.808 (8), 3.928 (7), 3.358 (7), 2.853 (7), 2.709 (7)

Chemistry:

	(1)	(2)
Tl	23.87	17.88
Pb	0.00	10.94
Sb	32.92	31.61
As	17.63	14.83
S	26.05	24.82
Total	100.47	100.08

(1) Jas Roux, France; by electron microprobe, corresponding to $Tl_{21.13}(Sb_{48.93}As_{42.58})_{\Sigma=91.51}S_{147.00}$. (2) Abuta, Japan; by electron microprobe, corresponding to $(Tl_{16.61}Pb_{10.03})_{\Sigma=26.64}(Sb_{49.31}As_{37.59})_{\Sigma=86.90}S_{147.00}$.

Occurrence: In a hydrothermal deposit in dolomitic limestones with other As–Tl minerals (Jas Roux, France).

Association: Pierrotite, parapierrotite, stibnite, pyrite, sphalerite, twinnite, zinkenite, madocite, andorite, smithite, laffittite, routhierite, aktashite, wakabayashilite, realgar, orpiment (Jas Roux, France); getchellite, sphalerite, barite (Abuta, Japan).

Distribution: In France, from the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes [TL]. In the Toya mine, Abuta, Hokkaido, Japan.

Name: For Chabournéou Glacier, near the Jas Roux deposit, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., J. Mantienne, and P. Picot (1981) La chabournéite, un nouveau minéral thallifère. Bull. Minéral., 104, 10–15 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 621 (abs. ref. 1). (3) Nagl, A. (1979) The crystal structure of a thallium sulfosalt, $Tl_8Pb_4Sb_{21}As_{19}S_{68}$. Zeits. Krist., 150, 85–106. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 81.

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Chaidamuite $(Zn, Fe^{2+})Fe^{3+}(SO_4)_2(OH)\cdot 4H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* 1. As thick tabular to pseudocubic crystals, with {001}, {010}, {011}, and $\{\overline{1}01\}$; as grains or granular aggregates, to < 1 mm.

Physical Properties: *Cleavage:* On {001} and {100}, perfect. *Fracture:* Conchoidal. Hardness = 2.5–3 D(meas.) = 2.722(2) D(calc.) = 2.72

Optical Properties: Translucent. *Color:* Brown to yellow-brown. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = pale yellow to colorless; Y = pale yellow; Z = brownish yellow. *Orientation:* $X = b$; $Y \wedge a = 12°$; $Z \wedge c = 28°$. *Dispersion:* $r < v$, strong. $\alpha = 1.632(1)$ $\beta = 1.640(1)$ $\gamma = 1.688(1)$ 2V(meas.) = 44(2)°

Cell Data: *Space Group:* $P1$. $a = 7.309(2)$ $b = 7.202(2)$ $c = 9.691(3)$ $\alpha = 89.64(3)°$ $\beta = 105.89(3)°$ $\gamma = 91.11(2)°$ Z = 2

X-ray Powder Pattern: Xitieshan mine, China.
3.118 (100), 3.090 (95), 9.40 (80), 5.00 (80), 3.64 (70), 5.03 (65), 2.048 (40)

Chemistry:

	(1)	(2)
SO_3	40.63	39.79
SiO_2	0.15	
Al_2O_3	0.12	
Fe_2O_3	20.00	19.84
FeO	2.09	
MnO	0.06	
ZnO	17.00	20.22
Na_2O	0.02	
K_2O	0.01	
H_2O	19.21	20.15
Total	99.29	100.00

(1) Xitieshan mine, China; corresponds to $(Zn_{0.85}Fe^{2+}_{0.12})_{\Sigma=0.97}(Fe^{3+}_{1.01}Al_{0.01})_{\Sigma=1.02}(SO_4)_{2.05}(OH)_{0.90}\cdot 3.87H_2O$. (2) $ZnFe(SO_4)_2(OH)\cdot 4H_2O$.

Occurrence: A secondary mineral in the oxidized portions of a Pb–Zn–Fe sulfide deposit.

Association: Coquimbite, copiapite, butlerite, zincobotryogen.

Distribution: From the Xitieshan Pb–Zn mine, south of Mt. Qilianshan, Chaidamu, Qinghai Province, China.

Name: For the occurrence near Chaidamu, China.

Type Material: Geology Department, Lanzhou University, Lanzhou; Geology and Mineral Resources Museum, Ministry of Geology, Beijing, China.

References: (1) Li Wanmao, Chen Guoying, and Peng Zhizhong (1986) Chaidamuite – a new zinc and ferric sulfate mineral. Acta Mineral. Sinica, 6, 109–113 (in Chinese with English abs.). (2) (1988) Amer. Mineral., 73, 1493 (abs. ref. 1). (3) Li Wanmao and Wang Qiguang (1990) Determination and refinement of the crystal structure of chaidamuite. Science in China, Series B, 33, 623–630.

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Chalcanthite $CuSO_4 \cdot 5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Uncommonly as short prismatic [001] to thick tabular $\{\overline{1}\overline{1}1\}$ crystals, exhibiting {100}, {130}, {120}, {110}, $\{1\overline{1}0\}$, $\{\overline{1}\overline{1}1\}$, with 25 other forms noted, to 2 cm; commonly in stalactitic to reniform crusts, cross-vein fibrous, massive, or granular. *Twinning:* Rarely as cruciform intergrowths with {010} common between individuals.

Physical Properties: *Cleavage:* Perfect on $\{1\overline{1}0\}$; interrupted on {110}. *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 2.286 (synthetic). D(calc.) = 2.282 Soluble in H_2O, metallic taste; dehydrates in dry air.

Optical Properties: Translucent. *Color:* Berlin blue to sky-blue, greenish blue; colorless to pale blue in transmitted light. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (–). *Orientation:* X (169°,76°); Y (76°,78°); Z (–57°,18°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. *Dispersion:* $r < v$. $\alpha = 1.514$ $\beta = 1.537$ $\gamma = 1.543$ 2V(meas.) = 56°02′

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.110$ $b = 10.673$ $c = 5.95$ $\alpha = 97°35'$ $\beta = 107°10'$ $\gamma = 77°33'$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 11-646).
4.73 (100), 3.71 (85), 3.99 (60), 3.30 (60), 5.48 (55), 2.749 (50), 2.824 (40)

Chemistry:

	(1)	(2)
SO_3	32.13	32.07
Fe_2O_3	0.76	
CuO	31.40	31.86
H_2O	35.90	36.07
Total	100.19	100.00

(1) Luishia, Shaba Province, Congo. (2) $CuSO_4 \cdot 5H_2O$.

Mineral Group: Chalcanthite group.

Occurrence: A secondary mineral in the oxidized portions of copper sulfide deposits, commonly of post-mining formation; rarely as a fumarolic deposit.

Association: Melanterite, fibroferrite, rhomboclase, epsomite, goslarite, pickeringite, retgersite, morenosite, brochantite, gypsum.

Distribution: Widespread; commercial deposits may occur in arid regions. From the Island of Cyprus. On Vesuvius, Campania, Italy. From Rammelsberg and Goslar, Harz Mountains, Germany. Abundant at Rio Tinto, Huelva, Spain. In Chile, from Chuquicamata, at Quetena, near Calama, and Copaquire, Antofagasta. In the USA, in Arizona, at the United Verde mine, Yavapai Co., and in the Clifton-Morenci district, Greenlee Co.; from the Blue Bird mine, Fierro-Hanover district, Grant Co., New Mexico; commercial amounts in the Bluestone mine, Yerington district, Lyon Co., Nevada; at Butte, Silver Bow Co., Montana; from Ducktown, Polk Co., Tennessee.

Name: From an older Latin name, *chalcanthum*, for *flowers of copper*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 488–491. (2) Iskhakova, L.D., V.K. Trunov, T.M. Shchegoleva, V.V. Ilyukhin, and A.A. Vedernikov (1983) Crystal structure of chalcanthite $CuSO_4 \cdot 5H_2O$ grown under microgravity. Kristallografiya (Sov. Phys. Crystal.), 28, 383–387.

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Chalcoalumite $CuAl_4(SO_4)(OH)_{12}\cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. As thin tabular enantiomorphous crystals with {100} exhibiting an equilateral triangular outline, to 0.5 mm; as spherical crystal aggregates; most commonly as fibrous to massive botryoidal crusts. *Twinning:* Typically twinned on {100} yielding composites that closely resemble thick untwinned individuals. Twinning on {010} forms diamond-shaped tablets. Twinning on $\{13\overline{6}\}$ produces a swallowtail composite with deep reentrant, or fourlings and eightlings. Diamond-shaped eightlings combining all three twin laws have been noted.

Physical Properties: *Cleavage:* On {100}, perfect. *Tenacity:* Sectile. Hardness = 2.5 D(meas.) = 2.29 D(calc.) = 2.25

Optical Properties: Transparent to translucent. *Color:* Turquoise-green to Nile blue, pale gray to nearly colorless; in transmited light, colorless. *Streak:* White. *Luster:* Vitreous to dull. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; X = pale green; Y = colorless; Z = robin's-egg-blue. *Orientation:* $Y = b$; $Z \wedge c = 22°$. *Dispersion:* $r < v$, strong. $\alpha = 1.523$ $\beta = 1.525$ $\gamma = 1.532$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P2_1$. $a = 17.090$ $b = 8.915$ $c = 10.221$ $\beta = 95°53'$ Z = 4

X-ray Powder Pattern: Bisbee, Arizona, USA.
8.502 (100), 4.250 (91), 4.178 (23), 7.898 (22), 4.786 (22), 5.100 (13), 2.520 (11)

Chemistry:

	(1)	(2)
SO_3	14.67	15.23
Al_2O_3	38.88	38.80
CuO	14.56	15.13
H_2O	30.60	30.84
insol.	0.28	
Total	98.99	100.00

(1) Bisbee, Arizona, USA. (2) $CuAl_4(SO_4)(OH)_{12}\cdot 3H_2O$.

Occurrence: A rare secondary mineral in the oxidized portions of copper deposits.

Association: Cuprite, malachite, azurite, goethite (Bisbee, Arizona, USA); mbobomkulite, hydrombobomkulite (Mbobo Mkulu Cave, South Africa).

Distribution: In the USA, from Bisbee, Cochise Co., and in the Grandview mine, Grand Canyon, Coconino Co., Arizona; at the Titusville mine, head of Kendall Gulch, San Juan Co., Colorado; and in the Lovelock mine, Table Mountain district, Churchill Co., Nevada. On the Spatsum claim, south of Ashcroft Manor, British Columbia, Canada. From the Britannia mine, Snowdonia, Gwynedd, Wales. In England, at South Wheal Crebor, Tavistock, Devon, and in the Penberthy Croft mine, St. Hilary, Cornwall. At Ottré, near Salmchâteau, Belgium. From L'ubietová, near Banská Bystrica (Libethen, near Neusohl), Slovakia. At the Baccu Locci mine, near Villaputzu, Sarrabus district, Sardinia, Italy. From the Sjö mine, near Grythyttan, Örebro, Sweden. In the Mbobo Mkulu Cave, near Ngodwana, Eastern Transvaal, South Africa.

Name: For essential chemical components, from the Greek *chalkos*, for *copper* and Latin *alum*, for *aluminum sulfate*.

Type Material: Harvard University, Cambridge, Massachusetts, 87005–87008; The Natural History Museum, London, England, 1961,27; National Museum of Natural History, Washington, D.C., USA, 95226, R6326.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 580–581. (2) Williams, S.A. and B. Khin (1971) Chalcoalumite from Bisbee, Arizona. Mineral. Record, 2, 126–127.

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Chalcocite Cu_2S

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$ or m. Crystals are short prismatic [001], thick to tabular {001}, to 12 cm across, and prismatic [100], to 25 cm long; {001} is striated ‖ [100]. Massive, compact, fine powdery. *Twinning:* Common on {110} yielding pseudohexagonal stellate forms; also on {032}, {112}. Seen as lamellar twinning in polished section.

Physical Properties: *Cleavage:* Indistinct on {110}. *Fracture:* Conchoidal. *Tenacity:* Brittle, somewhat sectile. Hardness = 2.5–3 VHN = 84–87 (100 g load). D(meas.) = 5.5–5.8 D(calc.) = 5.80

Optical Properties: Opaque. *Color:* Blackish lead-gray. *Streak:* Blackish lead-gray. *Luster:* Metallic. *Anisotropism:* Weak.
R_1–R_2: (400) 37.0–36.8, (420) 37.8–37.4, (440) 37.7–37.6, (460) 37.0–37.2, (480) 36.2–36.2, (500) 35.6–35.4, (520) 34.7–34.4, (540) 33.7–33.5, (560) 32.5–32.5, (580) 32.1–31.8, (600) 31.3–31.2, (620) 30.8–30.7, (640) 30.0–30.0, (660) 29.5–30.0, (680) 29.2–29.7, (700) 29.0–29.6

Cell Data: *Space Group:* $P2_1/c$ or Pc. $a = 11.82$ $b = 27.05$ $c = 13.43$ $\beta = 90°$
$Z = 96$

X-ray Powder Pattern: Bristol, Connecticut, USA (close to djurleite).
1.8800 (100), 2.4030 (70), 1.9746 (70), 1.8811 (70), 2.4074 (50), 3.276 (35), 2.7256 (35)

Chemistry:

	(1)	(2)	(3)
Cu	79.67	79.50	79.86
Fe	0.14	0.17	
S	20.16	20.05	20.14
SiO_2	0.09	0.17	
Total	100.06	99.89	100.00

(1) Butte, Montana, USA; Fe present as pyrite. (2) New London, Maryland, USA; contains Fe as bornite. (3) Cu_2S.

Occurrence: An uncommon primary hydrothermal mineral but important as a secondary mineral. Found in or below the zone of oxidation in hydrothermal veins and in large low-grade porphyry copper orebodies.

Association: Pyrite, chalcopyrite, covellite, bornite, molybdenite, many other sulfides and their alteration products.

Distribution: An important and widely distributed ore mineral of copper. Only a few localities producing exceptional crystals or pure masses can be listed. From the Turinsk copper mine, Bogoslovsk, Ural Mountains, Russia. In England, fine crystals from Cornwall at St. Just, St. Ives, Camborne, and Redruth. In the USA, exceptional crystals from Bristol, Hartford Co., Connecticut; in Arizona, at Bisbee, Cochise Co.; from the Magma mine, Superior, Pinal Co.; in the United Verde Extension mine, Yavapai Co.; from Butte, Silver Bow Co., Montana; crystals at the Flambeau mine, southwest of Ladysmith, Rusk Co., Wisconsin; from Kennicott, Copper River district, Alaska. Large crystals from Nababiep West mine, Cape Province, and Messina, Transvaal, South Africa. At M'Passa, Niari Province, Congo Republic. In the Mashamba West mine, Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). Fine crystals from Telfer, Western Australia.

Name: For its composition, from the Greek for *chalkos*, *copper*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 187–190. (2) Evans, H.T., Jr. (1979) The crystal structures of low chalcocite and djurleite. Zeits. Krist., 150, 299–320. (3) Evans, H.T., Jr. (1979) Djurleite ($Cu_{1.94}S$) and low chalcocite (Cu_2S): new crystal structure studies. Science, 203, 356–358. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 82.

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Chalcocyanite $CuSO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are tabular on {010} and slightly elongated along [001], to several mm; typically in crystalline incrustations.

Physical Properties: Hardness = 3.5 D(meas.) = 3.65(5) D(calc.) = 3.89 Soluble in H_2O; very hygroscopic, altering to chalcanthite.

Optical Properties: Transparent to translucent. *Color:* Pale green, pale brown, pale yellow, sky-blue; colorless in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, extreme.
$\alpha = 1.724(3)$ $\beta = 1.733(3)$ $\gamma = 1.739(3)$ 2V(meas.) = Large.

Cell Data: *Space Group: Pnmb.* $a = 6.709(1)$ $b = 8.409(1)$ $c = 4.833(1)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.549 (100), 2.62 (95b), 4.187 (75), 2.42 (50b), 1.775 (30), 1.433 (20), 1.430 (18)

Chemistry:

	(1)	(2)
SO_3	50.30	50.16
CuO	49.47	49.84
Total	99.77	100.00

(1) Vesuvius, Italy. (2) $CuSO_4$.

Occurrence: As sublimates near volcanic fumaroles.

Association: Dolerophanite, melanothallite, eriochalcite, euchlorine (Vesuvius, Italy); euchlorine, eriochalcite, dolerophanite, melanothallite, piypite, ponomarevite, cotunnite, sofiite, fedotovite, tenorite (Tolbachik volcano, Russia); stoiberite, shcherbinaite, ziesite, bannermanite, chalcanthite (Izalco volcano, El Salvador).

Distribution: From Mount Vesuvius, Campania, Italy. At the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. On Izalco volcano, El Salvador.

Name: From the Greek for *copper* and *azure-blue*, in allusion to the composition and color change caused by hydration.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 429–430. (2) Wildner, M. and G. Giester (1988) Crystal structure refinements of synthetic chalcocyanite ($CuSO_4$) and zincosite ($ZnSO_4$). Mineral. Petrol., 39, 201–209.
(3) (1964) NBS Mono. 25, 3, 29.

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Chalcomenite $CuSe^{4+}O_3 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. As acicular to prismatic [001] crystals, dominated by {110}, {120} and {101}, typically striated or rounded, to 2 cm; also wedgelike and tabular on {010}; as powdery crusts and massive films.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–2.5 D(meas.) = 3.35 D(calc.) = [3.35]

Optical Properties: Transparent. *Color:* Bright blue; pale blue in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale blue; $Y = Z$ = darker blue. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$ or $r > v$, strong. $\alpha = 1.710(3)$ $\beta = 1.732(3)$ $\gamma = 1.732(3)$ 2V(meas.) = 0°–30°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 6.674(2)$ $b = 9.161(1)$ $c = 7.398(3)$ Z = 4

X-ray Powder Pattern: Eagle shaft, Saskatchewan, Canada.
5.39 (10), 4.94 (9), 3.35 (8), 3.77 (7), 3.04 (7), 2.528 (7), 2.883 (6)

Chemistry:

	(1)	(2)
SeO_2	48.12	48.98
CuO	35.40	35.11
H_2O	15.30	15.91
Total	98.82	100.00

(1) Cerro de Cacheuta, Argentina. (2) $CuSeO_3 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with clinochalcomenite.

Occurrence: A rare secondary mineral in oxidized Cu–Se-bearing deposits.

Association: Umangite, clausthalite, molybdomenite, schmiederite (Cerro de Cacheuta, Argentina); penroseite, cobaltomenite, molybdomenite (Hiaco mine, Bolivia); allophane, basaluminite, malachite, clinochalcomenite (El Dragón mine, Bolivia).

Distribution: In Argentina, from Cerro de Cacheuta, Mendoza Province, and at the Cóndor mine, Los Llantenes district, Sierra de Cacheuta, in the Sierra de Umango and Sierra de Famatina, La Rioja Province. In Bolivia, at the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, and in the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí. From the Eagle shaft, Beaverlodge Lake, near Uranium City, Saskatchewan, Canada. In the USA, from the Middlemarch mine, near Pearce, Cochise Co., Arizona; at Majuba Hill, Pershing Co., Nevada; and on the Bozo No. 1 claim, Skull Creek, Moffat Co., Colorado. From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. At the Trogtal quarry, near Lautenthal, Harz Mountains, Germany. Large crystals from the Baccu Locci mine, near Villaputzu, Sarrabus district, Sardinia, Italy. At Ballybunion, Co. Kerry, Ireland. From Wheal Cock and the Botallack mine, St. Just, Cornwall, England. At Liauzun-en-Olloix, Puy-de-Dôme, France. From Skrikerum, near Tryserum, Kalmar, Sweden. From the Musonoi, Kakanda, and Kambove West mines, Katanga Province, Congo (Shaba Province, Zaire).

Name: From the Greek for *copper* and *moon*.

Type Material: Natural History Museum, Paris, France, 81.14; Harvard University, Cambridge, Massachusetts, USA, 101210.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 638–639. (2) Robinson, P.D., P.K. Sen Gupta, G.H. Swihart, and L. Houk (1992) Crystal structure, H positions, and the Se lone pair of synthetic chalcomenite, $Cu(H_2O)_2[SeO_3]$. Amer. Mineral., 77, 834–838. (3) Mandarino, J.A. (1964) X-ray powder data for teineite and chalcomenite. Amer. Mineral., 49, 1481–1485.

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Chalconatronite $Na_2Cu(CO_3)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic (synthetic). *Point Group:* $2/m$. As fine-grained crusts of pseudohexagonal plates or as laths; massive, in blebs and films.

Physical Properties: Hardness = "Soft". D(meas.) = 2.27(3) D(calc.) = 2.31 (synthetic). Partially soluble in H_2O.

Optical Properties: Transparent. *Color:* Pale blue to greenish blue.
Optical Class: Biaxial (+). *Pleochroism:* X = nearly colorless; Y = pale blue; Z = blue.
Orientation: $Z \perp$ flattening; $Y \parallel$ elongation; $Z \wedge c$ very small. $\alpha = 1.483$ $\beta = 1.530$ $\gamma = 1.576$
2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 6.696(2)$ $b = 6.101(2)$ $c = 13.779(3)$
$\beta = 91.83(2)^\circ$ Z = 4

X-ray Powder Pattern: Patina on Egyptian bronze figure.
6.92 (10), 4.17 (8), 3.69 (7), 7.76 (4), 2.85 (4), 2.99 (3), 2.88 (3)

Chemistry:

	(1)	(2)
CO_2	30.5	31.04
SiO_2	0.4	
R_2O_3	0.6	
CuO	29.2	28.05
Na_2O	19.7	21.85
H_2O	19.0	19.06
Total	99.4	100.00

(1) Patina on ancient Egyptian bronze figure; CO_2 determined volumetrically, H_2O by the Penfield method; corresponds to $Na_{1.74}Cu_{1.00}(CO_3)_{1.89} \cdot 2.88H_2O$. (2) $Na_2Cu(CO_3)_2 \cdot 3H_2O$.

Occurrence: A component of patina on bronze artifacts, apparently characteristic of arid weathering environments (Egypt); an uncommon secondary mineral in the oxidation zone of polymetallic deposits.

Association: Cuprite, atacamite (patina on bronze artifact); paratacamite, gypsum, brochantite, malachite, azurite, epsomite, nickeloan magnesite, glaukosphaerite, takovite, georgeite, carrboydite (Carr Boyd Rocks mine, Australia).

Distribution: Initially characterized on several ancient Egyptian artifacts. From the Carr Boyd Rocks nickel mine, Yerilla district, 80 km north-northeast of Kalgoorlie, Western Australia. At the Glückrad mine, near Oberschulenberg, Harz Mountains, Germany. In the USA, from the Deremo-Snyder mine, San Miguel Co., Colorado, and at the White Pine mine, Ontonagon Co., Michigan.

Name: From the Greek *chalcos*, for *copper*, and *natron*, the modern name for naturally occurring sodium carbonate.

Type Material: Canadian Geological Survey, Ottawa, Canada, 17254; Fogg Museum 1943.1121.6; Harvard University, Cambridge, 105297; National Museum of Natural History, Washington, D.C., USA, 112695.

References: (1) Frondel, C. and R.J. Gettens (1955) Chalconatronite, a new mineral from Egypt. Science, 122, 75–76. (2) (1955) Amer. Mineral., 40, 943 (abs. ref. 1). (3) Gettens, R.J. and C. Frondel (1955) Chalconatronite: an alteration product on some ancient Egyptian bronzes. Studies in Conservation, 2(2), 64–75. (4) Mosset, A., J.-J. Bonnet, and J. Galy (1978) Structure cristalline de la chalconatronite synthétique: $Na_2Cu(CO_3)_2.3H_2O$. Zeits. Krist., 148, 165–177 (in French with English abs.).

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Chalcophanite $(Zn, Fe^{2+}, Mn^{2+})Mn_3^{4+}O_7 \cdot 3H_2O$

Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. As tabular platelets, to 8 mm, with {0001} and {10$\bar{1}$0} giving a pseudo-octahedral appearance; commonly in drusy botryoidal or stalactitic aggregates; also colloform, granular, or massive.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Thin plates are flexible. Hardness = 2.5 VHN = 87–166 (50 g load). D(meas.) = 4.00(10) D(calc.) = 3.827

Optical Properties: Opaque, transparent on very thin edges. *Color:* Purplish to iron black; deep red-brown to opaque in transmitted light; white with deep red internal reflections under reflected light. *Streak:* Chocolate-brown. *Luster:* Metallic to submetallic. *Optical Class:* Uniaxial (–). *Pleochroism:* Very strong, in gray and white. $\omega = \gg 2.72$ $\epsilon = \sim 2.72$ *Anisotropism:* Very strong. *Bireflectance:* Well defined; in gray and white. R_1–R_2: (400) 11.4–38.0, (420) 11.0–36.6, (440) 10.6–35.2, (460) 10.3–33.8, (480) 10.0–32.2, (500) 9.8–30.7, (520) 9.8–29.2, (540) 9.7–28.0, (560) 9.5–26.9, (580) 9.3–26.2, (600) 9.3–25.8, (620) 9.2–25.4, (640) 9.2–24.8, (660) 9.0–24.4, (680) 8.9–24.0, (700) 8.9–23.8

Cell Data: *Space Group:* $R\bar{3}$. $a = 7.541(3)$ $c = 20.824(8)$ $Z = 2$

X-ray Powder Pattern: Sterling Hill, New Jersey, USA; nearly indistinguishable from aurorite and jianshuiite.
6.96 (100), 3.50 (60), 4.08 (50), 2.24 (50), 2.57 (40), 1.597 (40), 1.900 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
MnO_2	59.94		65.82	ZnO	21.70	21.6	20.54
Fe_2O_3	0.25	0.1		H_2O	11.58	[13.0]	13.64
MnO	6.58	65.3		Total	100.05	[100.0]	100.00

(1) Sterling Hill, New Jersey, USA; average of two analyses. (2) Do.; by electron microprobe, total Mn as MnO, H_2O by difference. (3) $ZnMn_3O_7 \cdot 3H_2O$.

Occurrence: A common component of the weathered zones above zinc- and manganese-bearing base-metal deposits.

Association: Cryptomelane, manganite, hetaerolite, birnessite, todorokite, woodruffite, kaolinite, quartz.

Distribution: In the USA, at Sterling Hill, Ogdensburg, and Franklin, Sussex Co., New Jersey; from the Price mine, near Newport, Giles Co., Virginia; in the Philipsburg district, Granite Co., Montana; in Colorado, at the Wolftone mine, Leadville, Lake Co.; from the Mohawk mine, San Bernardino Co., California; in the Lone Star mine, Fierro-Hanover district, Grant Co., New Mexico; at Bisbee, Cochise Co., Arizona; and in the Tintic district, Juab Co., Utah. In Mexico, from the Ojuela mine, Mapimí, Durango. In Australia, from Broken Hill, New South Wales; at the Reaphook Hill zinc deposit, near Blinman, Flinders Ranges, and the Iron Monarch mine, 50 km northwest of Whyalla, South Australia. At Bytom, Upper Silesia, Poland. In the N'chwaning mine, near Kuruman, Cape Province, South Africa. Large crystals from Tamera, Tunisia. A number of other minor localities are known.

Name: From the Greek for *copper* and *to appear*, for the mineral's change in color on ignition.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 739–740. (2) Ostwald, J. (1985) Some observations on the chemical composition of chalcophanite. Mineral. Mag., 49, 752–755. (3) Post, J.E. and D.E. Appleman (1988) Chalcophanite, $ZnMn_3O_7 \cdot 3H_2O$: new crystal-structure determinations. Amer. Mineral., 73, 1401–1404. (4) Grice, J.D., B. Gartrell, R.A. Gault, and J. Van Velthuizen (1994) Ernienickelite, $NiMn_3O_7 \cdot 3H_2O$, a new mineral species from the Siberia complex, Western Australia: comments on the chalcophanite group. Can. Mineral., 32, 333–337. (5) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 586–588.

Chalcophyllite $Cu_{18}Al_2(AsO_4)_4(SO_4)_3(OH)_{24}\cdot 36H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. Hexagonal platy crystals, to 1 cm, flattened on [0001], prominent $\{01\bar{1}2\}$, with numerous other forms noted, may be striated triangularly on {0001}; in rosettes, drusy, foliated massive. *Twinning:* On $\{10\bar{1}0\}$ as twin plane, probably universal.

Physical Properties: *Cleavage:* {0001}, perfect, micaceous; $\{10\bar{1}1\}$, in traces. Hardness = 2 D(meas.) = 2.67–2.69 D(calc.) = 2.684

Optical Properties: Transparent to translucent. *Color:* Emerald-green, grass-green, bluish green, blue; green in transmitted light. *Streak:* Pale green to bluish green. *Luster:* Vitreous to subadamantine, pearly on {0001}.
Optical Class: Uniaxial (–). *Pleochroism:* O = bluish green; E = almost colorless. $\omega = 1.618$; 1.680 (dehydrated). $\epsilon = 1.552$; 1.618 (dehydrated).

Cell Data: *Space Group:* $R\bar{3}$. $a = 10.756(2)$ $c = 28.678(4)$ Z = 1.5

X-ray Powder Pattern: El Teniente mine, Chile.
9.47 (100), 2.58 (48), 2.34 (32), 4.71 (31), 2.67 (25), 7.10 (18), 3.59 (12)

Chemistry:	(1)	(2)	(3)
SO_3	7.98	6.67	7.75
P_2O_5	0.64	0.67	
As_2O_5	13.26	13.23	14.84
SiO_2		1.33	
Al_2O_3	3.48	3.49	3.29

	(1)	(2)	(3)
CuO	46.56	46.54	46.21
H_2O^+		14.04	
H_2O^-		14.40	
H_2O	28.21		27.91
Total	100.13	100.37	100.00

(1) Cornwall, England. (2) El Teniente mine, Chile. (3) $Cu_{18}Al_2(AsO_4)_4(SO_4)_3(OH)_{24}\cdot 36H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of some arsenic-bearing hydrothermal polymetallic deposits.

Association: Azurite, malachite, brochantite, chrysocolla, spangolite, connellite, cuprite, cyanotrichite, strashimirite, parnauite, lavendulan, cornubite, langite, clinoclase, pharmacosiderite, mansfieldite.

Distribution: In Germany, from [the Altväter samt Eschig mine, Mordelgrund,] near Sayda, and Schmiedeberg, Saxony; in the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate; at the Clara mine, near Oberwolfach, Black Forest. From Schwaz, Tirol, Austria. At Špania Dolina (Herrengrund), Slovakia. From Moldava, 20 km northwest of Teplice, Czech Republic. At Nizhni Tagil, Ural Mountains, Russia. In England, large crystals from Wheals Gorland, Muttrell, and Unity, also the Ting-Tang mine, Gwennap, and a number of other places in Cornwall; in the Old Potts Gill mine, Caldbeck Fells, Cumbria. At the Cap Garonne mine, near le Pradet, Var, and in the Salsigne mine, 15 km north of Carcassone, Aude, France. In the USA, from the Calumet and Arizona mine, Bisbee, Cochise Co., Arizona; at the Majuba Hill mine, Antelope district, Pershing Co., Nevada; in the Mammoth and Ajax mines, Tintic district, Juab Co., Utah. Fine examples from the El Teniente mine, 67 km west of Rancagua, O'Higgins Province, Chile. In the Maharahara copper mine, near Woodville, Ruahine Mountains, New Zealand. Several other minor localities are known.

Name: From the Greek for *copper* and *a leaf*, for its prominent micaceous appearance.

Type Material: Mining Academy, Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1008–1010. (2) Sabelli, C. (1980) The crystal structure of chalcophyllite. Zeits. Krist., 151, 129–140. (3) Read, A.J. (1986) Chalcophyllite and other rare hydroxy-sulfates from Maharahara, New Zealand. Mineral. Record, 17, 199–204. (4) Corbett, R.K. (1973) X-ray "powder" data for chalcophyllite. Amer. Mineral., 58, 792–793.

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Chalcopyrite $CuFeS_2$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Equant, tetrahedral-shaped crystals, may be modified by scalenohedral faces, to as large as 10 cm. Sphenoidal faces {112} typically large, dull in luster and striated ‖ [$1\bar{1}0$]; {$\bar{1}12$} faces are small and bright. Commonly massive, compact; can be botryoidal. *Twinning:* Twin plane {112}, composition surface commonly {112}; twin plane {012}; also by rotation about [001] with composition plane {110}, producing penetration twins.

Physical Properties: *Cleavage:* Poor on {011} and {111}. Hardness = 3.5–4
VHN = 187–203 (basal section); 181–192 (vertical section) (100 g load). D(meas.) = 4.1–4.3
D(calc.) = 4.283

Optical Properties: Opaque. *Color:* Brass-yellow, may be tarnished and iridescent.
Streak: Greenish black. *Luster:* Metallic. *Anisotropism:* Weak.
R_1–R_2: (400) 16.0–17.3, (420) 20.0–21.3, (440) 24.8–26.1, (460) 30.2–31.4, (480) 34.9–35.9, (500) 38.9–39.9, (520) 41.9–42.7, (540) 44.0–44.9, (560) 45.4–46.4, (580) 46.6–47.6, (600) 47.1–48.3, (620) 47.5–4.86, (640) 47.6–48.7, (660) 47.6–48.7, (680) 47.6–48.6, (700) 47.6–48.6

Cell Data: *Space Group:* $I\bar{4}2d$. $a = 5.281$ $c = 10.401$ Z = 4

X-ray Powder Pattern: Merkur mine, Ems, Hesse, Germany.
3.038 (100), 1.8570 (35), 1.5927 (27), 1.8697 (22), 1.5753 (14), 2.644 (5), 1.2025 (5)

Chemistry:

	(1)	(2)
Cu	35.03	34.63
Fe	31.00	30.43
S	34.96	34.94
Total	100.99	100.00

(1) Western mines, Vancouver Island, British Columbia, Canada; by electron microprobe, leading to $Cu_{1.01}Fe_{1.01}S_{2.00}$. (2) $CuFeS_2$.

Polymorphism & Series: Forms a series with eskebornite.

Mineral Group: Chalcopyrite group.

Occurrence: A primary mineral in hydrothermal veins, stockworks, disseminations, and massive replacements; an exsolution product in mafic igneous rocks; of sedimentary origin controlled by redox conditions.

Association: Sphalerite, galena, tetrahedrite, pyrite, many copper sulfides.

Distribution: A very common copper mineral, so only a few outstanding localities can be mentioned. In the USA an important ore mineral at many of the copper mines of Arizona, as at Bisbee, Cochise Co.; large crystals from the Groundhog mine, Vanadium, Grant Co., New Mexico; in crystals from New York, at the Rossie lead mines, St. Lawrence Co.; at French Creek, Chester Co., Pennsylvania; in Missouri, at Joplin, Jasper Co. From Cananea, Sonora, Mexico. At Huaron, Peru. In Canada, in the Rouyn district, Quebec, at the Noranda mine; from Ontario, in the Kidd Creek mine, near Timmins, and at Sudbury. In Slovakia, at Baňská Štiavnica (Schemnitz). In the Czech Republic, at Horní Slavkov (Schlaggenwald). From Freiberg, Saxony; Dillenburg, Hesse; in the Georg mine, near Horhausen, Westerwald; and a number of mines in North Rhine-Westphalia, Germany. At Vinsknoes, Karmoen, Norway. From the Ani and Arakawa mines, Akita Prefecture, Japan. Large crystals in the Nababiep mine, Cape Province, South Africa.

Name: From the Greek for *brass* and *pyrite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 219–224. (2) Hall, S.R. and J.M. Stewart (1973) The crystal structure refinement of chalcopyrite, $CuFeS_2$. Acta Cryst., 29, 579–585. (3) (1985) NBS Mono. 25, 21, 69. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 84.

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Chalcosiderite $CuFe_6^{3+}(PO_4)_4(OH)_8 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals short prismatic, with a number of forms noted, typically in sheafs, to 3 mm; in crusts.

Physical Properties: *Cleavage:* One, perfect; another, less perfect. Hardness = 4.5 D(meas.) = 3.22 D(calc.) = [3.28]

Optical Properties: Transparent. *Color:* Pale siskin-green to dark green. *Streak:* White to greenish, pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = colorless; Z = pale green. *Orientation:* X (107°,57°); Y (–143°,68°); Z (–32°,40°) using (ϕ,ρ). *Dispersion:* $r > v$, very strong, crossed. $\alpha = 1.775$ $\beta = 1.840$ $\gamma = 1.844$ 2V(meas.) = 22(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.653(4)$ $b = 7.873(4)$ $c = 10.190(4)$ $\alpha = 67.57(2)°$ $\beta = 69.17(2)°$ $\gamma = 64.93(2)°$ Z = 1

X-ray Powder Pattern: Cornwall, England.
3.77 (100), 3.39 (70), 3.02 (60), 3.56 (40), 2.96 (40), 2.14 (40), 2.07 (40)

Chemistry:

	(1)	(2)
P_2O_5	29.93	28.77
As_2O_5	0.61	
Al_2O_3	4.45	
Fe_2O_3	42.81	48.56
CuO	8.15	8.06
H_2O	15.00	14.61
Total	100.95	100.00

(1) West Phoenix mine, Cornwall, England. (2) $CuFe_6(PO_4)_4(OH)_8 \cdot 4H_2O$.

Polymorphism & Series: Forms a series with turquoise.

Mineral Group: Turquoise group.

Occurrence: A rare mineral in the oxidized zone of some hydrothermal mineral deposits.

Association: Dufrénite, goethite (West Phoenix mine, Cornwall, England); dufrénite, cyrilovite, leucophosphite (Gunheath china clay pit, Cornwall, England); sampleite, libethenite, crandallite, cyrilovite, pseudomalachite, saléeite, torbernite, ulrichite (Lake Boga quarry, Australia).

Distribution: In England, from the West Phoenix United mines, Linkinhorne, and the Gunheath china clay pit, St. Austell, Cornwall. In Germany, at Schneckenstein, and in the Tannenberg mine, Mühlleithen, Saxony; from Hagendorf, Bavaria. From the Miguel Vacas mine, Estremoz, Portugal. At Les Montmins, Auvergne, France. In the USA, from the Cole and Shattuck mines, Bisbee, Cochise Co., Arizona; in the Tyrone mine, Santa Rita, Grant Co., New Mexico; at the Mohawk mine, Clark Mountains, San Bernardino Co., California; from the King turquoise mine, Conejos Co., Colorado. In Australia, in the Lake Boga granite quarry, near Swan Hill, Victoria, and the Spring Creek mine, near Wilmington, South Australia.

Name: From the Greek for *copper* and *iron*, for those elements in the mineral's composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 946–951. (2) Giuseppetti, G., F. Mazzi, and C. Tadini (1989) The crystal structure of chalcosiderite, $CuFe_6^{3+}(PO_4)_4(OH)_8 \cdot 4H_2O$. Neues Jahrb. Mineral., Monatsh., 227–239. (3) Graham, R. (1948) X-ray study of chalcosiderite and turquoise. Univ. Toronto Studies, Geol. Series, 52, 39–53.

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Chalcostibite $CuSbS_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Bladed crystals, to 16 cm, flattened ∥ {010}; massive, disseminated and intergrown with other sulfides and sulfosalts. *Twinning:* Twin and composition planes {104}.

Physical Properties: *Cleavage:* Perfect on {010}; less so on {001} and {100}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 3–4 VHN = 226–279 (010). D(meas.) = 4.95 D(calc.) = 5.011

Optical Properties: Opaque. *Color:* Lead-gray to iron-gray, rarely with a blue or green tarnish. *Luster:* Metallic. *Pleochroism:* Feeble in air, somewhat stronger in oil. *Anisotropism:* Observed.
R_1–R_2: (400) 39.2–44.2, (420) 39.3–45.3, (440) 39.4–46.2, (460) 39.4–47.0, (480) 39.5–47.4, (500) 39.5–47.0, (520) 39.1–46.2, (540) 38.2–44.4, (560) 37.0–42.2, (580) 36.1–40.7, (600) 35.3–39.7, (620) 34.7–38.9, (640) 34.4–38.3, (660) 34.2–38.0, (680) 33.8–37.9, (700) 33.4–37.9

Cell Data: *Space Group: Pnam.* $a = 6.02$ $b = 14.49$ $c = 3.79$ Z = 4

X-ray Powder Pattern: Chocoya la Vieja mine, Potosí, Bolivia.
3.13 (10), 3.00 (9), 1.762 (5), 2.31 (4), 1.831 (4), 2.12 (3), 1.895 (3)

Chemistry:

	(1)	(2)
Cu	24.72	25.48
Sb	48.45	48.81
S	26.20	25.71
Total	99.37	100.00

(1) Pulacayo mine, Bolivia. (2) $CuSbS_2$.

Occurrence: Associated with other sulfosalts and sulfides in hydrothermal veins.

Association: Jamesonite, chalcopyrite, pyrite, tetrahedrite, stibnite, andorite, stannite, dadsonite, siderite, barite, quartz.

Distribution: From Wolfsberg, in the Harz Mountains, Germany [TL]. At Capileira, Sierra Nevada, Granada Province, Spain. Fine large crystals from Saint-Pons, Alpes-de-Haute-Provence, France. In Austria, at Saint Gestraudi, near Brixlegg, Tirol. From Baia Mare (Nagybánya) and Baia Sprie (Felsőbánya), Romania. At Tereksai, Kyrgyzstan. As large crystals from Rar el Anz, Wadi of Cherrat, east of Casablanca, Morocco. In Bolivia, at the Pulacayo mine, Huanchaca; Tapi near Tupiza; Torapaka, Cacachaca, Challapata, Colquechaca, Uncia, and Oruro. From Macayan, Philippines. In the Mt. Washington copper mine, Vancouver Island, British Columbia; and the Porter property, Carbon Hill, Wheaton district, Yukon Territory, Canada. From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. Known in small amounts from numerous other localities.

Name: From the Greek *chalkos*, *copper* and *stibium*, *antimony*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 433–435. (2) Cervelle, B.D., F.P. Cesbron, M.-C. Sichère, and J. Dietrich (1979) La chalcostibite et la dadsonite de Saint-Pons, Alpes de Haute Provence, France. Can. Mineral., 17, 601–605 (in French with English abs.??ck). (3) Hoffman, W. (1933) Strukturelle und morphologische Zusammenhänge bei Erzen vom Formeltyp ABC_2. I. Die Struktur von Wolfsbergit [=chalcostibite] $CuSbS_2$ und Emplektit $CuBiS_2$ und deren Beziehungen zu der Struktur von Antimonit Sb_2S_3. Zeits. Krist., 84, 177–203 (in German). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 144 (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 705–707.

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Chalcothallite $Tl_2(Cu,Fe)_6SbS_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As lamellar aggregates, to 2 cm. *Twinning:* A fine grid of lamellae are visible parallel to {110} and $\{1\bar{1}0\}$.

Physical Properties: *Cleavage:* Perfect on {001}, indistinct on {100} and {010}. *Tenacity:* Plastic, tectonically deformed. Hardness = 2–2.5 VHN = 68–76, average 71, on {001} (50 g load). D(meas.) = 6.6 D(calc.) = [6.74]

Optical Properties: Opaque. *Color:* Lead-gray to iron-black, tarnishes iridescent; creamy white to pale gray, with a brownish creamy tint in reflected light. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Notable in air. *Anisotropism:* Distinct in orange to red-browns. R_1–R_2: (400) 27.6–31.0, (420) 27.1–30.5, (440) 26.5–30.1, (460) 26.0–29.6, (480) 25.5–29.2, (500) 25.1–28.8, (520) 24.9–28.4, (540) 24.7–28.1, (560) 24.6–27.7, (580) 24.7–27.3, (600) 24.7–26.9, (620) 24.8–26.6, (640) 24.8–26.2, (660) 24.8–26.0, (680) 24.9–25.7, (700) 24.9–25.5

Cell Data: *Space Group:* $I4/mmm$. $a = 3.827(1)$ $c = 34.280(1)$ $Z = 2$

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
2.447 (10), 1.913 (10), 3.803 (7), 3.015 (7), 3.630(5), 2.704 (5), 2.580 (5)

Chemistry:

	(1)	(2)
Tl	33.72	36.2
K	0.79	
Cu	34.33	32.7
Ag	1.78	
Pb	0.08	
Fe	3.78	3.9
Sb	11.96	11.2
Se	0.02	
S	12.52	13.05
Total	98.98	97.05

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, corresponding to $(Tl_{1.69}K_{0.21})_{\Sigma=1.90}(Cu_{5.53}Fe_{0.69}Ag_{0.17})_{\Sigma=6.39}Sb_{1.01}S_{4.00}$. (2) Do.; by electron microprobe, corresponding to $Tl_{1.74}(Cu_{5.06}Fe_{0.69})_{\Sigma=5.75}Sb_{0.90}S_{4.00}$.

Occurrence: In ussingite veins cutting poikilitic sodalite syenite.

Association: Galena, vrbaite, cuprostibite, thalcusite, silver, gudmundite, chalcocite, sphalerite, molybdenite, avicennite, chkalovite, epistolite, niobophyllite, analcime, natrolite, microcline, lithium-mica, tugtupite.

Distribution: From Mt. Nákâlâq, northwest of Taseq Lake, in the Ilímaussaq intrusion, southern Greenland.

Name: For the composition.

Type Material: National School of Mines, Paris, France.

References: (1) Semenov, E.I., H. Sørensen, M.S. Bezsmertnaya, and L.E. Novorossova (1967) Chalcothallite, a new sulphide of copper and thallium from the Ilímaussaq alkaline intrusion, South Greenland. Medd. Grønland, 181, 13–25. (2) (1968) Amer. Mineral., 53, 1775 (abs. ref. 1). (3) Kovalenker, V.A., I.P. Laputina, Y.I. Semenov, and T.L. Evstigneeva (1978) Potassium-bearing thalcusite from the Ilimaussak pluton and new data on chalcothallite. Doklady Acad. Nauk SSSR, 239, 1203–1206 (in Russian). (4) Makovicky, E., Z. Johan, and S. Karup-Møeller (1980) New data on bukovite, thalcusite, chalcothallite and rohaite. Neues Jahrb. Mineral., Abh., 138, 122–146.

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Chambersite $Mn_3B_7O_{13}Cl$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $mm2$; $\bar{4}3m$ (pseudocubic). Crystals are pseudotetrahedral {111}, modified by {001}, {110}, and {$1\bar{1}1$}, to 2 cm, paramorphous and composed of microscopically twinned aggregates of orthorhombic material inverted from the high-temperature form. *Twinning:* Rare as interpenetrant twins on [111] with twin plane {111} (pseudocubic).

Physical Properties: *Fracture:* Subconchoidal to uneven. Hardness = 7 D(meas.) = 3.49(2) D(calc.) = 3.48

Optical Properties: Transparent to opaque. *Color:* Colorless to deep purple, darkening with exposure to sunlight. *Luster:* [Vitreous.]
Optical Class: Biaxial (+). $\alpha = 1.732(1)$ $\beta = 1.737(1)$ $\gamma = 1.744(1)$ 2V(meas.) = 83(3)°

Cell Data: *Space Group:* $Pca2_1$. $a = 8.68(1)$ $b = 8.68(1)$ $c = 12.26(1)$ Z = 4

X-ray Powder Pattern: Barber's Hill salt dome, Texas, USA.
3.07 (10), 2.74 (6), 2.08 (6), 3.54 (5), 2.17 (5), 1.851 (5), 2.50 (3)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.32		CaO	trace	
TiO_2	trace		Na_2O	0.05	
B_2O_3	49.50	50.35	K_2O	0.03	
Al_2O_3	0.12		Cl	6.34	7.32
FeO	1.28		H_2O	0.87	
MnO	41.87	43.98	$-O = Cl_2$	1.39	1.65
MgO	0.05		Total	99.04	100.00

(1) Barber's Hill salt dome, Texas, USA; $(Mn_{2.90}Fe_{0.09}Mg_{0.01})_{\Sigma=3.00}B_{7.00}O_{13}Cl_{0.88}$.
(2) $Mn_3B_7O_{13}Cl$.

Occurrence: In brine residues from extraction wells in salt domes.

Association: Halite, anhydrite, gypsum.

Distribution: In the USA, from the Barber's Hill salt dome, Mont Belvieu, Chambers Co., Texas and the Venice salt dome, Plaquemines Parish, Louisiana. In the Jixian Mn–B deposits, Hebei Province, China. From Pomyarka, near Truskarets, Carpathian Mountains, Ukraine.

Name: For the location of the first known occurrence, Chambers Co., Texas, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 107884; National Museum of Natural History, Washington, D.C., USA, 115327.

References: (1) Honea, R.M. and F.R. Beck (1962) Chambersite, a new mineral. Amer. Mineral., 47, 665–671.

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Chaméanite $(Cu, Fe)_4As(Se, S)_4$

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Crystal Data: Cubic. *Point Group:* Undetermined, but with a body-centered lattice. Most commonly anhedral granular, to 30 μm, but also intermixed with giraudite in a microscopic myrmekitic texture.

Physical Properties: Hardness = n.d. VHN = 247–292 (25 g load). D(meas.) = n.d. D(calc.) = 6.17

Optical Properties: Opaque. *Color:* Dark gray in reflected light. *Luster:* Metallic.
R: (400) 27.4, (420) 27.1, (440) 26.8, (460) 26.5, (480) 26.1, (500) 26.6, (520) 26.9, (540) 27.1, (560) 27.3, (580) 27.5, (600) 27.7, (620) 27.8, (640) 28.0, (660) 28.2, (680) 28.4, (700) 28.7

Cell Data: *Space Group:* n.d. $a = 11.039(4)$ $Z = 8$

X-ray Powder Pattern: Chaméane mine, France.
3.187 (100), 1.951 (90), 1.665 (80), 1.127 (70), 1.266 (60), 1.062 (50), 1.381 (40)

Chemistry:

	(1)	(2)
Cu	33.93	36.38
Fe	5.63	2.58
As	11.05	11.98
Sb	0.48	0.34
Se	47.06	46.99
S	1.59	1.56
Total	99.74	99.83

(1) Chaméane mine, France; by electron microprobe; corresponds to $(Cu_{3.36}Fe_{0.63})_{\Sigma=3.99}(As_{0.93}Sb_{0.02})_{\Sigma=0.95}(Se_{3.75}S_{0.31})_{\Sigma=4.06}$. (2) Do.; by electron microprobe, corresponds to $(Cu_{3.62}Fe_{0.29})_{\Sigma=3.91}(As_{1.01}Sb_{0.02})_{\Sigma=1.03}(Se_{3.76}S_{0.31})_{\Sigma=4.07}$.

Occurrence: As late-stage deposits in veins cutting granite (Chaméane mine, France); in a telethermal selenium-rich hydrothermal polymetallic deposit, in calcite veins in amphibolites (Tuminico, Argentina).

Association: Giraudite, eskebornite, geffroyite, ankerite (Chaméane mine, France); hakite, bukovite, cadmoselite, umangite (Tuminico, Argentina).

Distribution: From the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France [TL]. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina.

Name: For the occurrence at the Chaméane mine, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, and F. Ruhlmann (1982) Evolution paragénétique de la minéralisation uranifère de Chaméane (Puy-de-Dôme) France: chaméanite, geffroyite et giraudite, trois séléniures nouveaux de Cu, Fe, Ag, and As. Tschermaks Mineral. Petrog. Mitt., 29, 151–167 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 1074–1075 (abs. ref. 1).

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Chamosite $(Fe^{2+}, Mg, Fe^{3+})_5Al(Si_3Al)O_{10}(OH, O)_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In scaly aggregates, foliated or granular; oolitic, made up of very minute radiating crystals; massive. *Twinning:* Twin and composition plane {001}, axis [310].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Somewhat flexible but inelastic. Hardness = 2–3 D(meas.) = 3.0–3.4 D(calc.) = 3.129 Weakly magnetic.

Optical Properties: Translucent to almost opaque. *Color:* Green, greenish grey, black, brown; in thin section, colorless, yellowish, green. *Streak:* Green to gray. *Luster:* Pearly. *Optical Class:* Biaxial (–). *Pleochroism:* Weak to moderate; X = yellow-green to light brownish green; $Y = Z$ = green to dark green. *Orientation:* $Y = b$; $X \wedge a = 88°–90°$; $Z \wedge a = 0°–2°$: or rarely $Y = b$; $X \wedge a \simeq 0°$; $Z \wedge a \simeq 90°$. *Dispersion:* $r < v$, strong. *Absorption:* $Y \simeq Z > X$; rarely $X \simeq Y > Z$. $\alpha = 1.595–1.671$ $\beta = 1.599–1.684$ $\gamma = 1.599–1.685$ 2V(meas.) = 0°–30°

Cell Data: *Space Group:* $C2/m$. $a = 5.373$ $b = 9.306$ $c = 14.222$ $\beta = 97°53'$ Z = 2

X-ray Powder Pattern: Hermanovice, Czech Republic. (ICDD 21-1227).
7.05 (100), 3.52 (100), 2.601 (90), 1.551 (90), 2.392 (80), 14.1 (70), 2.554 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	26.40	26.65	CaO	0.42	
Al_2O_3	18.23	16.14	Na_2O	0.17	
Fe_2O_3	5.70	6.69	K_2O	0.17	
FeO	25.87	34.43	H_2O^+	10.60	11.42
MnO	0.04		H_2O^-	1.05	0.08
MgO	11.35	4.47	Total	[100.00]	99.88

(1) Wickwar, England; recalculated to 100.00%, total Fe as Fe^{2+} in empirical formula; corresponds to $(Fe^{2+}_{2.82}Mg_{1.84}Ca_{0.05}Na_{0.04}K_{0.02})_{\Sigma=4.77}Al_{1.21}(Si_{2.87}Al_{1.13})_{\Sigma=4.00}O_{10}(OH)_8$.
(2) Schmiedefeld, Germany; total Fe as Fe^{2+} in empirical formula; corresponds to $(Fe^{2+}_{3.87}Mg_{0.76})_{\Sigma=4.63}Al_{1.23}(Si_{3.05}Al_{0.95})_{\Sigma=4.00}O_{10}(OH)_8$.

Polymorphism & Series: Dimorphous with orthochamosite; forms a series with clinochlore.

Mineral Group: Chlorite group.

Occurrence: In sedimentary ironstones; authigenically formed under reducing conditions in the presence of decomposed organic material.

Association: Siderite, kaolinite, quartz, magnetite, pyroxenes, plagioclase, olivine, calcite.

Distribution: Many localities, but careful characterization is necessary. From Chamoson, Valais, and in the Maderantal, Uri, Switzerland. At Hermanovice and Kladno, Czech Republic. From Schmiedefeld, near Suhl, and Schleiz, Thuringia, Germany. In England, at Frodingham, Lincolnshire; Wickwar, Gloucestershire; at Penzance, Cornwall, and elsewhere. At Knowehead, Co. Antrim, Ireland. In the Arakawa mine, Akita Prefecture, and at Shogase, Tokushima Prefecture, Japan. From Creede, Mineral Co., Colorado; near Hot Springs, Garland Co., Arkansas; and in the Beacon Hill mine, Champion, Marquette Co., Michigan, USA. At Wabana, Newfoundland, Canada.

Name: For the locality at Chamoson, Switzerland.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 658.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 131–163. (3) Bayliss, P. (1975) Nomenclature of the trioctahedral chlorites. Can. Mineral., 13, 178–180.

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Changbaiite $PbNb_2O_6$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As tabular crystals or spherules, to 5 mm, showing {0001}, {000$\overline{1}$}, {01$\overline{1}$1}, {10$\overline{1}$1}, {10$\overline{1}$2}, {01$\overline{1}$2}, and {11$\overline{2}$0}.

Physical Properties: *Cleavage:* {0001}, perfect; one rhombohedral, distinct. *Fracture:* Hackly; conchoidal for spherules. *Tenacity:* Brittle. Hardness = 5.3 VHN = 472 D(meas.) = 6.48 D(calc.) = 6.51

Optical Properties: Transparent to translucent. *Color:* Colorless, cream-white, pale brown, yellowish brown, pale yellowish green. *Streak:* White. *Luster:* Adamantine to pearly. *Optical Class:* Uniaxial (+); may be anomalously biaxial. *Dispersion:* $r > v$. $\omega = 2.476$ $\epsilon = 2.485$ 2V(meas.) = 0°–38°

Cell Data: *Space Group:* $R3m$. $a = 10.499$ $c = 11.553$ Z = 9

X-ray Powder Pattern: Tonghua, China.
3.100 (10), 3.028 (9), 1.760 (6), 2.160 (5), 1.621 (5), 1.919 (4), 1.745 (3)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	53.43	55.62	54.36
Ta_2O_5	0.37		
TiO_2	0.89	0.95	
Fe_2O_3	0.42		
FeO	0.77	0.94	
PbO	44.12	41.51	45.64
Total	100.00	99.02	100.00

(1) Tonghua, China; corresponds to $(Pb_{0.95}Fe^{2+}_{0.05})_{\Sigma=1.00}(Nb_{1.93}Ti_{0.05}Fe^{3+}_{0.02}Ta_{0.01})_{\Sigma=2.01}O_6$.
(2) Do.; by electron microprobe. (3) $PbNb_2O_6$.

Occurrence: In kaolinite-filled veins and cavities in a potassic granite.

Association: Kaolinite, quartz, potassic feldspar.

Distribution: From Changbai Mountain, Tonghua, southeastern Kirin Province, China.

Name: For Changbai Mountain, China, on which the mineral occurs.

Type Material: "Museum of Geology", location unstated [Beijing, China].

References: (1) Detachment No. 8, Comprehensive Geological Brigade of Tonghua Region and Petrology and Mineralogy Laboratory, Kirin Institute of Geological Science (1978) Changbaiite ($PbNb_2O_6$), a new mineral of lead and niobium from eastern Kirin, China. Acta Geol. Sinica, 1, 54–62 (in Chinese with English abs.). (2) (1979) Amer. Mineral., 64, 242 (abs. ref. 1).

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Changchenite IrBiS

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Crystal Data: Cubic. *Point Group:* 23. In veinlets and massive aggregates, to 2 mm, replacing laurite and iridisite.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.7 VHN = 140–185, 165 average (20 g load). D(meas.) = n.d. D(calc.) = 11.96

Optical Properties: Opaque. *Color:* Steel-black; in reflected light, bright white with a yellowish tint. *Streak:* Black. *Luster:* Metallic.

R: (400) 41.3, (420) 45.2, (440) 45.5, (460) 46.0, (480) 46.4, (500) 46.6, (520) 46.9, (540) 47.1, (560) 47.3, (580) 47.6, (600) 47.7, (620) 47.7, (640) 47.6, (660) 47.4, (680) 47.3, (700) 47.3

Cell Data: *Space Group:* $P2_13$. $a = 6.164(3)$ $Z = 4$

X-ray Powder Pattern: Luanhe River, China.
1.860 (100), 2.75 (70), 2.51 (60), 1.090 (50), 1.027 (50), 1.647 (40), 1.345 (40)

Chemistry:

	(1)	(2)
Ir	41.2	44.37
Pt	2.8	
Cu	0.3	
Te	0.4	
Bi	47.2	48.23
S	7.2	7.40
Total	99.1	100.00

(1) Luanhe River, China; by electron microprobe, average of seven analyses; corresponds to $(Ir_{0.94}Pt_{0.06}Cu_{0.02})_{\Sigma=1.02}Bi_{0.99}(S_{0.98}Te_{0.01})_{\Sigma=0.99}$. (2) IrBiS.

Occurrence: Of hydrothermal origin in chromite bodies in dunites and placers derived therefrom.

Association: Iridium, ferrian platinum, laurite, sperrylite, cooperite, irarsite, shuangfenite, mayingite, chromite, gold.

Distribution: From a branch of the Luanhe River, 14 km west of Chengde City, Hubei Province, China [TL].

Name: From the Chinese word for the Great Wall, situated nearby the occurrence.

Type Material: National Geological Museum, Beijing, China.

References: (1) Yu Zuxiang (1997) Changchenite – a new iridium bismuth-sulfide from the Yanshan Mountains. Acta Geol. Sinica, 71(4), 336–339 (in Chinese with English abs.). (2) (1998) Amer. Mineral., 83, 907 (abs. ref. 1).

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Changoite $Na_2Zn(SO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral crystals, in veinlets, to 1 cm wide.

Physical Properties: Hardness = 2–3 D(meas.) = 2.50 D(calc.) = 2.507 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–) (synthetic). $\alpha = 1.507$ $\beta = 1.512$ $\gamma = 1.516$ 2V(meas.) = Large. 2V(calc.) = 83°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.077(2)$ $b = 8.249(2)$ $c = 5.532(1)$ $\beta = 100.18(2)°$ Z = 2

X-ray Powder Pattern: San Francisco mine, Chile.
3.289 (100), 4.550 (58), 3.262 (35), 4.245 (32), 2.631 (27), 3.325 (25), 3.245 (25)

Chemistry:

	(1)	(2)
SO_3	34.85	42.64
ZnO	20.62	21.67
MgO	0.05	
CaO	0.02	
Na_2O	17.31	16.50
H_2O	18.99	19.19
Total	91.84	100.00

(1) San Francisco mine, Chile; by electron microprobe, average of four analyses, H_2O by CHN analyzer; corresponding to $Na_{2.21}Zn_{1.00}(S_{0.86}O_{3.63})_2 \cdot 4.16H_2O$. (2) $Na_2Zn(SO_4)_2 \cdot 4H_2O$.

Occurrence: A secondary mineral in the oxidized portion of a Cu–Zn sulfide deposit.

Association: Thénardite, zincian paratacamite, gypsum.

Distribution: From the San Francisco mine, two km west of the Sierra Gorda railway station, Sierra Gorda district, southwest of Calama, Antofagasta, Chile.

Name: For the *Changos*, early inhabitants of Chile.

Type Material: University of Hamburg, Hamburg, Germany.

References: (1) Schlüter, J., K.-H. Klaska, and G. Gebhard (1999) Changoite, $Na_2Zn(SO_4)_2 \cdot 4H_2O$, the Zn analogue of blödite, a new mineral from Sierra Gorda, Antofagasta, Chile. Neues Jahrb. Mineral., Monatsh., 97–103. (2) (1999) Amer. Mineral., 84, 1685 (abs. ref. 1).

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Chantalite $CaAl_2SiO_4(OH)_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As anhedral grains up to 0.3 mm.

Physical Properties: Hardness = n.d. D(meas.) = 2.8–2.9 D(calc.) = 2.97

Optical Properties: Semitransparent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.653(1)$ $\epsilon = 1.642(1)$

Cell Data: *Space Group:* $I4_1/a$. $a = 4.952(1)$ $c = 23.275(6)$ Z = 4

X-ray Powder Pattern: Taurus Mountains, Turkey.
2.598 (100), 4.171 (70), 3.349 (60), 1.453 (60), 2.235 (50), 4.828 (45), 2.202 (35)

Chemistry:

	(1)	(2)
SiO_2	23.74	23.64
Al_2O_3	38.44	40.12
FeO	0.02	
MgO	0.06	
CaO	21.57	22.07
Na_2O	0.06	
H_2O	[16.11]	14.17
Total	[100.00]	100.00

(1) Taurus Mountains, Turkey; by electron microprobe, average of four analyses, H_2O by difference. (2) $CaAl_2SiO_4(OH)_4$.

Occurrence: In rodingite dikes in an ophiolite.

Association: Vuagnatite, prehnite, hydrogrossular, chlorite, calcite.

Distribution: From Covur Yokusutepe, Taurus Mountains, Burdur Province, Turkey.

Name: For Chantal Sarp, wife of the mineral's discoverer.

Type Material: Natural History Museum, Geneva, Switzerland, 435/1; The Natural History Museum, London, England, 1984,741; National Museum of Natural History, Washington, D.C., USA, 146559.

References: (1) Sarp, H., J. Deferne, and B.W. Liebich (1977) Chantalite, $CaAl_2SiO_4(OH)_4$, a new natural calcium aluminum silicate. Schweiz. Mineral. Petrog. Mitt., 57, 149–156 (in French with English abs.). (2) (1978) Amer. Mineral., 63, 1282. (abs. ref. 1). (3) Liebich, B.W., H. Sarp, and E. Parthé (1979) The crystal structure of chantalite, $CaAl_2(OH)_4SiO_4$. Zeits. Krist., 150, 53–63.

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Chaoite C

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As thin lamellae, 3–15 μm wide, alternating with graphite.

Physical Properties: Hardness = Slightly harder than graphite [1–2]. VHN = n.d. D(meas.) = n.d. D(calc.) = 3.43

Optical Properties: Opaque. *Color:* Black.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6/mmm$. a = 8.948 c = 14.078 Z = 168

X-ray Powder Pattern: Nördlinger Ries crater, Germany.
4.47 (100), 4.26 (100), 4.12 (80), 3.03 (60), 2.55 (60), 2.28 (60), 3.71 (40)

Chemistry:

	(1)
C	99.5
Si	< 0.5
Cl	< 0.5
Total	100.0

(1) Nördlinger Ries crater, Germany; by electron microprobe, grain containing 35% chaoite.

Polymorphism & Series: Polymorphous with diamond, graphite, and lonsdaleite.

Occurrence: In shock-metamorphosed graphite gneisses and meteorites.

Association: Graphite, zircon, rutile, pseudobrookite, magnetite, nickeliferous pyrrhotite, baddeleyite.

Distribution: From Mottingen, in the Nördlinger Ries crater, Bavaria, Germany. In the Goalpara [??Goalpur??D8??ck??] and Dyalpur achondrite meteorites. [Novo Urei stony meteorite??addbutckname,type??]

Name: For Edward Ching-Te Chao (1919–), Chinese-American petrologist with the U.S. Geological Survey, Washington, D.C, USA.

Type Material: n.d.

References: (1) El Goresy, A. and G. Donnay (1968) A new allotriomorphic form of carbon from the Ries Crater. Science, 161, 363–364. (2) (1969) Amer. Mineral., 54, 326 (abs. ref. 1). (3) El Gorsey, A. (1969) Eine neue Kohlenstoff-Modifikation aus dem Nördlinger Ries. Naturwissenschaften, 56, 493–494 (in German). (4) (1970) Amer. Mineral., 55, 1067 (abs. ref. 3). (5) Smith, P.P.K. and P.R. Buseck (1982) Carbyne forms of carbon: do they exist? Science, 216, 984–986. (6) (1983) Amer. Mineral., 68, 1251 (abs. ref. 5). (7) Sobolev, V.V., V.Y. Slobodskoy, S.N. Selyukov, and A.A. Udoyev (1986) Some conversions of chaoite to other carbon phases. Zap. Vses. Mineral. Obshch., 115, 218–221 (in Russian).

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Chapmanite $Sb^{3+}Fe_2^{3+}(SiO_4)_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* m. Crystals lath-shaped; powdery, compact, massive.

Physical Properties: *Fracture:* Conchoidal to irregular when compact. Hardness = 2.5 when compact. D(meas.) = 3.69–3.75 D(calc.) = [4.29]

Optical Properties: Semitransparent. *Color:* Olive-green to deep yellow. *Streak:* Greenish yellow to deep yellow. *Luster:* Nonmetallic.
Optical Class: Biaxial. $\alpha = 1.85 \perp$ flat face. β = n.d. $\gamma = 1.96 \parallel$ length. 2V(meas.) = n.d.

Cell Data: *Space Group:* Cm. $a = 5.19$ $b = 8.99$ $c = 7.70$ $\beta = 100°40'$ Z = 2

X-ray Powder Pattern: Keeley mine, Canada; could be confused with bismutoferrite.
7.63 (100), 3.58 (100), 3.88 (90), 3.19 (90), 2.90 (70), 2.59 (70), 2.54 (35)

Chemistry:

	(1)	(2)	(3)
SiO_2	27.63	26.34	27.65
Al_2O_3	0.22	0.50	
Fe_2O_3	38.98	38.13	36.74
Sb_2O_3	31.04	30.53	33.54
H_2O^+	1.89	3.62	2.07
H_2O^-	0.31	0.64	
Total	100.07	99.76	100.00

(1) Smilkov, Czech Republic; corresponding to $(Sb^{3+}_{0.93}Fe^{3+}_{0.07})_{\Sigma=1.00}$ $Fe^{2+}_{2.00}(Si_{1.98}Al_{0.02})_{\Sigma=2.00}O_{8.00}(OH)$. (2) Do. (3) $SbFe_2(SiO_4)_2(OH)$.

Occurrence: In veinlets cutting gneisses containing varying amounts of graphite (Smilkov, Czech Republic).

Association: Silver (Keeley mine, Canada).

Distribution: In the Keeley mine, South Lorrain Township, Ontario, Canada. In Mexico, at Velardeña, and in the La Papa mine, Victoria, Hidalgo, Durango. At Smilkov, near Votice, Czech Republic. In Germany, at Bräunsdorf, Freiberg, and Schneeberg, Saxony. From near Tafone, Tuscany, Italy. In the Mine de la Bessade, Massiac, Haute-Loire, France. At the Suzuyama mine, Kagoshima Prefecture, Japan.

Name: To honor Edward John Chapman (1821–1904), Professor of Geology, University of Toronto, Toronto, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M14075; Harvard University, Cambridge, Massachusetts, USA, 91501.

References: (1) Walker, T.L. (1924) Chapmanite, a new mineral from South Lorraine, Ontario. Univ. of Toronto, Geol. Studies, 17, 5–8. (2) Walker, T.L. (1924) Chapmanite, a new hydrous ferrous silicoantimonate, from South Lorraine, Ontario. Contr. to Canadian Mineralogy, 5. (3) (1925) Amer. Mineral., 10, 40 (abs. ref. 2) (4) Milton, C., J.M. Axelrod, and B. Ingram (1958) Bismutoferrite, chapmanite, and "hypochlorite". Amer. Mineral., 43, 656–670. (5) Čech, F. and P. Povondra (1963) Study of chapmanite from Smilkov, near Votice (Bohemia, Czechoslovakia). Acta Univ. Carolinae, Geol., 2, 97–114 (in Czech with English abs.). (6) (1964) Amer. Mineral., 49, 1499 (abs. ref. 5). (7) Zhukhlistov, A.P. and B.B. Zvyagin (1977) Determination of the crystal structures of chapmanite and bismuthoferrite [bismutoferrite] by high-voltage electron diffraction. Kristallografiya (Sov. Phys. Crystal.), 22, 731–738 (in Russian).

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Charlesite $Ca_6(Al,Si)_2(SO_4)_2B(OH)_4(OH,O)_{12}\cdot 26H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$ (probable). Crystals are tabular {0001}, dominated by $\{10\bar{1}4\}$, to 6 mm, may be rounded.

Physical Properties: *Cleavage:* Perfect on $10\bar{1}0$. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 1.77 D(calc.) = 1.79 Pale violet or pale green fluorescence under SW UV, weaker under LW UV.

Optical Properties: Transparent, may appear opaque due to surficial alteration. *Color:* Colorless, white, pale yellow, pale pink. *Streak:* White. *Luster:* Vitreous to dull. *Optical Class:* Uniaxial (–). $\omega = 1.492(3)$ $\epsilon = 1.475(3)$

Cell Data: *Space Group:* $[P31c]$ (by analogy to ettringite). $a = 11.16(1)$ $c = 21.21(3)$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
9.70 (100), 5.58 (80), 3.855 (80), 2.749 (70), 2.538 (70), 2.193 (70), 2.133 (50)

Chemistry:

	(1)
SO_3	12.8
SiO_2	3.1
B_2O_3	3.2
Al_2O_3	5.1
CaO	27.3
H_2O	48.6
Total	100.1

(1) Franklin, New Jersey, USA; corresponds to $Ca_{5.94}(Al_{1.22}Si_{0.63})_{\Sigma=1.85}(SO_4)_{1.95}[B(OH)_4]_{1.12}[(OH)_{10.97}O_{1.03}]_{\Sigma=12.00}\cdot 25.16H_2O$.

Mineral Group: Ettringite group.

Occurrence: Very rare, coating fractures and vugs in a metamorphosed stratiform zinc deposit.

Association: Clinohedrite, ganophyllite, xonotlite, pectolite, prehnite, "Mn-chlorite", roeblingite, willemite, datolite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: Honors Dr. Charles Palache (1869–1954), eminent American crystallographer and mineralogist, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 107733; National Museum of Natural History, Washington, D.C., USA, 148689, C6247, C6401.

References: (1) Dunn, P.J., D.R. Peacor, P.B. Leavens, and J.L. Baum (1983) Charlesite, a new mineral of the ettringite group, from Franklin, New Jersey. Amer. Mineral., 68, 1033–1037.

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Charmarite $Mn_4^{2+}Al_2(CO_3)(OH)_{12}\cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As complexly faceted crystals, several cm in length, with {100}, {221}, {$2\overline{2}1$}, and {001} prominent; 28 forms have been recognized. *Twinning:* Commonly twinned on {100}, producing contact twins or finely polysynthetic lamellae.

Physical Properties: *Cleavage:* {100} and {010}. Hardness = ∼3 D(meas.) = 6.30–6.49 D(calc.) = [6.38]

Optical Properties: Transparent. *Color:* Colorless to yellow; colorless to gray or brown in thin section. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = light brownish; Z = brownish. *Dispersion:* Weak, inclined. $\alpha = 2.250(8)$ $\beta = 2.382(8)$ $\gamma = 2.410(8)$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P2_1/a$. a = 13.37–13.379 b = 7.16–7.174 c = 7.11–7.116 β = 105.96°−106° Z = 4

X-ray Powder Pattern: Mounana mine, Gabon.
3.441 (FFF), 3.428 (FFF), 3.206 (FF), 4.93 (F), 3.081 (F), 4.32 (mF), 3.569 (mF)

Chemistry:

	(1)
V_2O_5	29.1
PbO	71.6
Total	100.7

(1) Mounana mine, Gabon; by electron microprobe, corresponds to $Pb_{2.00}V^{5+}_{2.00}O_7$.

Occurrence: In the oxidized zone of a lead-bearing U–V deposit (Mounana mine, Gabon).

Association: Francevillite, wulfenite (Mounana mine, Gabon).

Distribution: In the Mounana uranium mine, Franceville, Gabon. From the Kusu deposit, 85 km south of Kinshasa, Bas-Congo Province, Congo (Bas-Zaire Province, Zaire). From St. Andreasberg, Harz Mountains, Germany. Found at Vrančice, near Příbram, Czech Republic.

Name: Honors Jean Chervet (1904–1962), French mineralogist.

Type Material: National School of Mines, Paris, France.

References: (1) Bariand, P., F. Chantret, R. Pouget, and A. Rimsky (1963) Une nouvelle espèce minérale: la chervétite, pyrovanadate de plomb $Pb_2V_2O_7$. Bull. Soc. fr. Minéral., 86, 117–120 (in French). (2) (1963) Amer. Mineral., 48, 1416 (abs. ref. 1). (3) Cesbron, F. (1965) Données nouvelles sur la chervétite. Bull. Soc. fr. Minéral., 88, 126–129 (in French). (4) Kawahara, A. (1967) La structure cristalline de la chervétite. Bull. Soc. fr. Minéral., 90, 279–284 (in French with English abs.). (5) Cervelle, B. and F. Cesbron (1973) Propriétés optiques de la chervétite, pyrovanadate de plomb. Bull. Soc. fr. Minéral., 96, 391–392 (in French with English abs.). (6) Shannon, R.B. and C. Calvo (1973) Refinement of the crystal structure of synthetic chervetite, $Pb_2V_2O_7$. Canadian J. Chemistry, 51, 70–76. (7) Mrázek, Z. (1985) Brandtite and chervetite from Vrančice near Příbram (Bohemia). Časopis pro Mineralogii a Geologii, 30(3), 295–302.

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Charoite $\mathbf{K(Ca,Na)_2Si_4O_{10}(OH,F)\cdot H_2O}$

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Crystal Data: Monoclinic. *Point Group:* n.d. Fibrous, massive.

Physical Properties: *Cleavage:* Good in three directions. Hardness = n.d. VHN = 412 (50 g load). D(meas.) = 2.54 D(calc.) = [2.77] Yellow-orange cathodoluminescence.

Optical Properties: Semitransparent. *Color:* Shades of deep lilac to violet; colorless in thin section.
Optical Class: Biaxial (+). *Pleochroism:* X = rose; Z = colorless, in thick fragments.
Orientation: $X = b$; $Z \wedge c = 5°$. $\alpha = 1.550(2)$ $\beta = 1.553(2)$ $\gamma = 1.559(2)$
2V(meas.) = 28°–30°

Cell Data: *Space Group:* n.d. $a = 10.7$ $b = 32.0$ $c = 7.25$ $\beta = 113°$ Z = 18

X-ray Powder Pattern: Murun massif, Russia.
3.348 (100), 3.134 (85), 12.5 (70), 2.79 (50), 2.71 (35), 3.90 (30), 2.97 (30)

Chemistry:

	(1)	(2)
SiO_2	56.88	58.5
Al_2O_3		0.07
Fe_2O_3	0.12	
FeO		0.01
MnO		0.07
CaO	20.95	20.5
SrO	0.90	0.5
BaO	2.52	2.9
Na_2O	3.77	1.8
K_2O	10.36	8.9
F	0.92	0.7
H_2O^+	4.40	4.7
$-O = F_2$	0.39	[0.15]
Total	100.43	98.5

(1) Murun massif, Russia; corresponds to $(K_{0.93}Ba_{0.07}Sr_{0.03})_{\Sigma=1.03}(Ca_{1.57}Na_{0.51})_{\Sigma=2.08}Si_4O_{10}[(OH)_{0.58}F_{0.28}]_{\Sigma=0.86}\cdot 0.72H_2O$. (2) Do.; by electron microprobe, H_2O by TGA; corresponds to $(K_{0.88}Ba_{0.09}Sr_{0.02})_{\Sigma=0.99}(Ca_{1.71}Na_{0.28})_{\Sigma=1.99}Si_{4.55}O_{10}[(OH)_{0.78}F_{0.18}]_{\Sigma=0.96}\cdot 0.82H_2O$.

Occurrence: In potassic feldspar metasomatites at the contact of nepheline and aegirine syenites with limestones.

Association: Canasite, tinaksite.

Distribution: In the Murun massif, between the Chara and Olekma Rivers, southwest of Olekminsk, Yakutia, Russia.

Name: For the Chara River, Russia, near which it was discovered.

Type Material: University of Rome, Rome, Italy, 24352; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Rogova, V.P., Y.G. Rogov, V.A. Drits, and N.N. Kutnetsova (1978) Charoite, a new mineral and a new jewelry stone. Zap. Vses. Mineral. Obshch., 107, 94–100 (in Russian). (2) (1978) Amer. Mineral., 63, 1282 (abs. ref. 1). (3) Kraeff, A., R.P.E. Poorter, and R.D. Schuiling (1980) Additional information on charoite. Neues Jahrb. Mineral., Monatsh., 498–500. (4) Nikishova, L.V., K.A. Lazebnik, and Y.D. Lazebnik (1985) Crystal chemical formula of charoite. Kristallkhim. Strukt. Tipomorfizm Mineral., 100–104. (5) (1988) Amer. Mineral., 73, 198 (abs. ref. 4).

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Chatkalite $Cu_6Fe^{2+}Sn_2S_8$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}m2$. As rounded grains, to 100 μm, which may be included in tetrahedrite.

Physical Properties: Hardness = n.d. VHN = 258–287 (20 g load). D(meas.) = n.d. D(calc.) = 5.00

Optical Properties: Opaque. *Color:* Pale rose in reflected light. *Anisotropism:* Weak, in shades of brown.
R_1–R_2: (400) — , (420) — , (440) 24.4–25.0, (460) 25.0–25.6, (480) 25.6–26.2, (500) 26.2–26.7, (520) 26.7–27.2, (540) 27.2–27.6, (560) 27.6–28.1, (580) 27.9–28.6, (600) 28.3–29.0, (620) 28.5–29.3, (640) 28.6–29.4, (660) 28.6–29.5, (680) 28.4–29.3, (700) 27.9–28.6

Cell Data: *Space Group:* $P\bar{4}m2$. $a = 7.61(1)$ $c = 5.373(5)$ $Z = 1$

X-ray Powder Pattern: Kochbulak deposit, Uzbekistan.
1.904 (100), 3.11 (80), 1.625 (40), 1.568 (40), 2.87 (30), 1.058 (30), 2.70 (20)

Chemistry:

	(1)	(2)
Cu	41.17	40.95
Ag	0.41	
Fe	4.31	6.00
Zn	2.10	
Sn	19.11	25.50
Mo	1.08	
Sb	2.97	
As	0.80	
S	28.77	27.55
Total	[100.72]	100.00

(1) Kochbulak deposit, Uzbekistan; by electron microprobe, total originally given as 100.22%; corresponding to $(Cu_{5.97}Ag_{0.03})_{\Sigma=6.00}(Fe_{0.65}Zn_{0.30}Cu_{0.05})_{\Sigma=1.00}(Sn_{1.34}As_{0.27}As_{0.26}Fe_{0.07}Mo_{0.05})_{\Sigma=1.99}S_{7.95}$. (2) $Cu_6FeSn_2S_8$.

Occurrence: As rounded disseminations in tetrahedrite, from a sulfide-bearing quartz vein (Kochbulak deposit, Uzbekistan).

Association: Cassiterite, hemusite, hessite, tetrahedrite (Kochbulak deposit, Uzbekistan); pyrite, sphalerite, marcasite, galena, chalcopyrite, stannite, tetrahedrite–tennantite, canfieldite, arsenopyrite, digenite, covellite, chalcocite, Au–Ag alloy (Cove deposit, USA).

Distribution: From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan [TL]. In the Cove gold deposit, McCoy district, Lander Co., Nevada, USA. At the Bitin Cu–Au–Ag deposit, Fujian Province, China.

Name: For the occurrence in the Chatkal-Kuramin Mountains, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81595.

References: (1) Kovalenker, V.A., T.L. Evstigneeva, V.S. Malov, and L.N. Vyal'sov (1981) Chatkalite, $Cu_6FeSn_2S_8$, a new mineral. Mineral. Zhurnal, 3, 79–86 (in Russian with English abs.). (2) (1982) Amer. Mineral., 67, 621–622 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 90.

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Chayesite $K(Mg,Fe^{2+})_4Fe^{3+}Si_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As tabular, euhedral to subhedral crystals, to 0.1 mm; dominant forms are {0001}, $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, and $\{10\bar{1}2\}$.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.68

Optical Properties: Transparent. *Color:* Deep blue; in transmitted light, light blue to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* O = sky-blue; E = colorless. $\omega = 1.575(1)$
$\epsilon = 1.578(1)$

Cell Data: *Space Group:* $[P6/mcc]$ (by analogy to the milarite group). $a = 10.153(4)$
$c = 14.388(6)$ $Z = 2$

X-ray Powder Pattern: Moon Canyon, Utah, USA; close similarity to other milarite group minerals may require chemical analysis for identification.
5.076 (vs), 3.751 (vs), 3.238 (vs), 7.194 (s), 2.7840 (s), 4.148 (m), 2.9350 (m)

Chemistry:

	(1)	(2)
SiO_2	69.95	70.29
TiO_2	0.21	0.02
Al_2O_3	0.24	0.00
Fe_2O_3	5.28	
FeO	5.40	12.60
MnO	0.23	0.23
MgO	13.64	11.44
Na_2O	0.45	0.04
K_2O	5.24	4.48
Total	100.64	99.10

(1) Moon Canyon, Utah, USA; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(K_{1.14}Na_{0.15})_{\Sigma=1.29}(Mg_{3.48}Fe^{2+}_{0.77}Fe^{3+}_{0.68}Mn_{0.03}Ti_{0.03}Al_{0.01})_{\Sigma=5.00}(Si_{11.96}Al_{0.04})_{\Sigma=12.00}O_{30}$. (2) Cancarix, Spain; by electron microprobe, total Fe as FeO, Fe^{2+}:Fe^{3+} in empirical formula calculated from stoichiometry; corresponds to $(K_{0.99}Na_{0.01})_{\Sigma=1.00}(Mg_{2.96}Fe^{2+}_{1.20}Fe^{3+}_{0.63}Mn_{0.03})_{\Sigma=4.82}Si_{12.18}O_{30}$.

Mineral Group: Milarite group.

Occurrence: A late-crystallizing mineral, nonuniformly distributed in the groundmass of lamproites.

Association: Potassian richterite, diopside, potassic feldspar.

Distribution: From Moon Canyon, east of Francis, Summit Co., Utah, USA. In Spain, at Cancarix, Albacete Province.

Name: In honor of Dr. Felix Chayes (1916–1993) of the Geophysical Laboratory, Carnegie Institute, Washington, D.C., USA.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany; National Museum of Natural History, Washington, D.C., USA, 165807.

References: (1) Velde, D., O. Medenbach, C. Wagner, and W. Schreyer (1989) Chayesite, $K(Mg,Fe^{2+})_4Fe^{3+}[Si_{12}O_{30}]$: a new rock-forming silicate mineral of the osumilite group from the Moon Canyon (Utah) lamproite. Amer. Mineral., 74, 1368–1373.

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Chegemite $Ca_7(SiO_4)_3(OH)_2$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. Crystals exhibit rhombic cross-sections, typically as granular aggregates, to 5 mm. *Twinning:* Probable on {110}.

Physical Properties: *Cleavage*: Imperfect on {010}. *Fracture*: Conchoidal. *Tenacity*: n.d. Hardness = 5.5-6 VHN = 306–349 (50 g load). D(meas.) = 2.86(1) D(calc.) = 2.892

Optical Properties: Transparent. *Color*: Pink, yellow-pink; white in aggregates; colorless in thin section. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial. α = 1.621(2) β = 1.626(3) γ = 1.630(2) $2V_Z$ (meas.) = –80(8)° $2V_Z$ (calc.) = –83° *Orientation:* $X = a$; $Y = b$; $Z = c$.

Cell Data: *Space Group*: *Pbnm*. a = 5.0696(1) b = 11.3955(1) c = 23.5571(3) Z = 4

X-ray Powder Pattern: Northern Caucasus, Kabardino-Balkaria, Russia.
1.907 (100), 2.993 (80), 2.700 (80), 3.015 (70), 2.720 (70), 2.834 (60), 3.639 (50)

Chemistry:

	(1)
SiO_2	29.76
TiO_2	0.49
Fe_2O_3	0.02
CaO	65.67
F	1.64
H_2O	2.23
-O=F	0.70
Total	99.11

(1) Northern Caucasus, Kabardino-Balkaria, Russia; average of 68 electron microprobe analyses, corresponding to $Ca_7(Si_{0.997}Ti_{0.003}O_4)_3(OH)_{1.48}F_{0.52}$.

Occurrence: A product of sanidinite facies metamorphism of calcareous xenoliths in ignimbrite.

Association: Larnite, spurrite, rondorfite, reinhardbraunsite, wadalite, lakargiite, srebrodolskite.

Distribution: Upper Chegem volcanic structure, Northern Caucasus, Kabardino-Balkaria, Russia.

Name: For the Chegem River, in the headwater area of which the new mineral was discovered.

Type Material: A.E. Fersman Mineralogical Museum in Moscow, Russia (3731/1); Museum of Natural History, Bern, Switzerland (NMBE 39571).

References: (1) Galuskin, E.V., V.M. Gazeev, B. Lazic, T. Armbruster, I.O. Galuskina, A.E. Zadov, N.N. Persev, R. Wrzalik, P. Dzierżanowski, A.G. Gurbanov, and G. Bzowska (2009) Chegemite $Ca_7(SiO_4)_3(OH)_2$ - a new humite-group calcium mineral from the Northern Caucasus, Kabardino-Balkaria, Russia. Eur. J. Mineral., 21, 1045–1059. (2) (2010) Amer. Mineral., 95, 1122-1123 (abs. ref. 1).

Chekhovichite $Bi_2Te_4^{4+}O_{11}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As subhedral platy grains, to 0.1 mm, in crusts and aggregates. *Twinning:* Polysynthetic, parallel elongation.

Physical Properties: *Cleavage:* One, ‖ elongation, perfect; another at 87° to the first, less perfect. Hardness = ∼4 VHN = 205–325, 290 average (100 g load). D(meas.) = 6.88(1.5) D(calc.) = 7.00

Optical Properties: Semitransparent. *Color:* Grayish yellow, pale gray, or grayish green; pale gray to gray with white internal reflections in reflected light. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Orientation:* $X \wedge c = 21°$; $Z \wedge a = 25°$. *Dispersion:* $r < v$, distinct. $\alpha = 2.45(2)$ $\beta = 2.50(2)$ $\gamma = 2.65(2)$ 2V(meas.) = 65(3)° *Anisotropism:* Marked. *Bireflectance:* Observable.
R_1–R_2: (400) 18.9–21.4, (420) 18.8–21.4, (440) 18.7–21.3, (460) 18.6–21.3, (480) 18.3–21.2, (500) 18.1–21.2, (520) 18.1–21.1, (540) 17.9–21.0, (560) 17.7–20.8, (580) 17.6–20.7, (600) 17.4–20.6, (620) 17.3–21.5, (640) 17.3–20.4, (660) 17.2–20.3, (680) 17.2–20.2, (700) 17.1–20.2

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 18.8963(8)$ $b = 7.9593(3)$ $c = 6.9909(3)$ $\beta = 95.176(3)°$ Z = 4

X-ray Powder Pattern: Zod deposit, Armenia.
3.29 (100), 3.14 (100), 3.15 (94), 2.728 (48), 1.998 (45), 2.002 (42), 1.686 (32)

Chemistry:

	(1)	(2)
TeO_2	57.9	57.81
Bi_2O_3	41.5	42.19
Sb_2O_3	trace	
FeO	0.1	
PbO	0.8	
CuO	trace	
Total	100.3	100.00

(1) Zod deposit, Armenia; by electron microprobe, originally an elemental analysis, totaling 100.4%, here converted to oxides; corresponds to $(Bi_{1.96}Pb_{0.04}Fe_{0.02})_{\Sigma=2.02}Te_{3.99}O_{10.99}$.
(2) $Bi_2Te_4O_{11}$.

Occurrence: A rare oxidation product of earlier tellurium-bearing minerals.

Association: Tellurobismuthite, pyrite, chalcopyrite, emmonsite, tripuhyite, "limonite", quartz.

Distribution: From the Zod deposit, 14 km east of Vardenis, Armenia. At the Zhana-Tyube and Northern Aksu deposits, north Kazakhstan.

Name: Honors Professor Sergei Konstantinovich Chekhovich (1917–1997), mineralogist and geologist, Polytechnical Institute of Alma-Ata, Alma-Ata, Kazakhstan.

Type Material: Mining Museum, Leningrad, 1945/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 88052.

References: (1) Spiridonov, E.M., I.V. Petrova, L.A. Demina, V.I. Dolgikh, and G.M. Antonyan (1987) The new mineral chekhovichite ($Bi_2Te_4O_{11}$). Moscow University Geology Bulletin, 42(6), 71–75 (in English). (2) (1989) Amer. Mineral., 74, 1400 (abs. ref. 1). (3) Rossell, H.J., M. Leblanc, G. Férey, D.J.M. Bevan, D.J. Simpson, and M.R. Taylor (1992) On the crystal structure of $Bi_2Te_4O_{11}$. Aust. J. Chem. 45, 1415–1425.
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Chelkarite $CaMgB_2O_4Cl_2 \cdot 7H_2O(?)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As flattened prismatic crystals, to 15 mm.

Physical Properties: *Cleavage:* Perfect ‖ elongation. *Fracture:* Splintery. Hardness = n.d. D(meas.) = 2.21 D(calc.) = [1.96]

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (+). $\alpha = 1.520$ (α') β = n.d. $\gamma = 1.558$ 2V(meas.) = n.d.

Cell Data: *Space Group: Pbca.* $a = 13.69$ $b = 20.84$ $c = 8.26$ Z = [10]

X-ray Powder Pattern: Chelkar salt dome, Kazakhstan.
3.531 (10), 10.42 (9), 2.209 (8), 4.96 (7), 2.029 (7), 6.68 (5), 4.19 (4)

Chemistry:

	(1)	(2)
B_2O_3	20.07	20.06
Fe_2O_3	0.48	
SiO_2	0.49	
MgO	14.92	11.62
CaO	15.85	16.16
Na_2O	0.34	
K_2O	0.44	
Cl	18.38	20.43
H_2O	33.7	36.34
$-O = Cl_2$	4.15	4.61
Total	100.52	100.00

(1) Chelkar salt dome, Kazakhstan. (2) $CaMgB_2O_4Cl_2 \cdot 7H_2O$.

Occurrence: Very rare, in the insoluble residue of brines from a salt dome.

Association: Anhydrite, hilgardite, boracite, halite, carnallite, bischofite.

Distribution: From the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, Kazakhstan.

Name: For the locality where the first samples were collected, the Chelkar salt dome, Kazakhstan.

Type Material: n.d.

References: (1) Avrova, N.P., V.M. Bocharov, I.I. Khalturina, and Z.R. Yunusova (1968) Mineralogy of borates in halogen formations. Geol. Razved. Mestorozhd. Tverd. Polez. Iskop. Kaz. [Geology and Exploration of Solid Mineral Deposits of Kazakhstan], 1969, 169–173 (in Russian). (2) (1971) Amer. Mineral., 56, 1122 (abs. ref. 1). (3) Shipovalov, Y.V. and N.P. Avrova (1971) X-ray study of the new borates aldzhanite and chelkarite. Issled. Oblast. Khim. Fiz. Metod. Anal. Min. Syr'ya, 176–179 (in Russian). (4) (1976) Mineral. Abs., 27, 80 (abs. ref. 3). (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 59.

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Chenevixite $Cu_2Fe_2^{3+}(AsO_4)_2(OH)_4 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals, tabular on {100} with diamond-shaped outline, to 0.5 mm; usually microcrystalline, spheroidal, earthy to compact massive. *Twinning:* Observed during crystal structure refinement, at a very fine scale.

Physical Properties: *Fracture:* Subconchoidal to earthy. *Tenacity:* Brittle.
Hardness = 3.5–4.5 D(meas.) = 4.38 D(calc.) = 4.40

Optical Properties: Semitransparent. *Color:* Greenish yellow to olive-green, dark green.
Streak: Greenish yellow.
Optical Class: Biaxial (+). *Pleochroism:* Very weak. *Orientation:* $X = b$; $Z \simeq c$. $\alpha = 1.92$
$\beta = 1.96$ $\gamma = 2.04$ 2V(meas.) = n.d. 2V(calc.) = 73°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1/a$. $a = 14.985$–15.006 $b = 5.170$–5.189
$c = 5.658$–5.724 $\beta = 102°15'$–$102°55'$ Z = 2

X-ray Powder Pattern: Las Animas, Sonora, Mexico.
3.557 (10), 2.553 (7), 3.817 (5), 2.994 (5), 2.448 (5), 7.322 (4), 2.504 (4)

Chemistry:

	(1)	(2)	(3)
As_2O_5	34.62	37.95	38.13
Al_2O_3	1.17		
Fe_2O_3	26.94	26.6	26.50
CuO	26.88	26.55	26.40
MgO	0.23		
CaO	0.55		
H_2O	9.25	8.5	8.97
rem.	0.71		
Total	100.35	99.6	100.00

(1) American Eagle mine, Utah, USA; remnant is quartz. (2) Las Animas, Sonora, Mexico; average of two analyses, H_2O by the Penfield method. (3) $Cu_2Fe_2^{3+}(AsO_4)_2(OH)_4 \cdot H_2O$.

Mineral Group: Forms a series with luetheite.

Occurrence: An uncommon secondary mineral in the oxidized zone of some hydrothermal polymetallic mineral deposits.

Association: Quartz (Cornwall, England); olivenite, quartz (Tintic district, Utah, USA); olivenite, scorodite (Majuba Hill, Nevada, USA); malachite, bystromite, ordoñezite (Naco, Sonora, Mexico).

Distribution: In England, from Wheal Gorland and Wheal Unity, Gwennap, at the Phoenix United mines, Linkinhorne, and in the Old Gunnislake mine, Calstock, Cornwall; from the Brandy Gill mine, Caldbeck Fells, Cumbria. In the USA, in the American Eagle and Mammoth mines, Tintic district, Juab Co., and the Gold Hill mine, Tooele Co., Utah; at the Majuba Hill mine, Antelope district, Pershing Co., Nevada; from Alum Gulch, near Patagonia, Santa Cruz Co., Arizona. On Benjamín Hill, Las Animas, and on Cerro Morita, about 27 km southwest of Agua Prieta, Sonora, Mexico. In Chile, at Chuquicamata, and the Emma Luisa gold mine, Guanaco district, about 100 km east-northeast of Taltal, Antofagasta; from Collahuasi, Tarapacá. At Musonoi, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). In Australia, from the Consols mine, Broken Hill, New South Wales; at the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia; and from the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia. Reported from additional localities, for some of which modern confirmation would be desirable.

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Name: To honor Richard Chenevix (1774–1830), Irish chemist, who early analyzed a Cornish Cu–Fe arsenate.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 840–841. (2) Williams, S.A. (1977) Luetheite, $Cu_2Al_2(AsO_4)_2(OH)_4 \cdot H_2O$, a new mineral from Arizona, compared with chenevixite. Mineral. Mag., 41, 27–32. (3) Burns, P.C., J.V. Smith, and I.M. Steele (2000) Arizona porphyry copper/hydrothermal deposits. I. The structure of chenevixite and leutheite. Mineral. Mag., 64, 25–30.

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Chengdeite Ir_3Fe

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Subhedral granular aggregates, to 0.5 mm, and as graphic intergrowths with osmiridium.

Physical Properties: *Tenacity:* Malleable. Hardness = 5 VHN = 411–467, 452 average (50 g load). D(meas.) = n.d. D(calc.) = 19.19 Strongly magnetic.

Optical Properties: Opaque. *Color:* Steel-black; bright white with yellowish tint in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R: (400) 61.7, (420) 63.2, (440) 64.5, (460) 65.7, (480) 66.5, (500) 67.4, (520) 68.3, (540) 69.1, (560) 69.9, (580) 70.7, (600) 71.6, (620) 72.4, (640) 72.5, (660) 72.5, (680) 72.7, (700) 72.8

Cell Data: *Space Group:* $Pm3m$. a = 3.792(5) Z = 1

X-ray Powder Pattern: Near Gaotai village, China.
1.142 (100), 2.18 (80), 1.094 (80), 1.34 (70), 1.89 (60), 1.26 (20), 1.200 (15)

Chemistry:

	(1)	(2)
Os	0.06	
Ir	88.5	91.17
Pt	2.2	
Rh	0.19	
Pd	0.00	
Pb	0.00	
Ni	0.03	
Co	0.03	
Cu	0.83	
Fe	7.9	8.83
As	0.02	
Total	99.76	100.00

(1) Near Gaotai village, China; by electron microprobe, average of 13 analyses; corresponds to $(Ir_{2.93}Pt_{0.07}Rh_{0.01})_{\Sigma=3.01}(Fe_{0.90}Cu_{0.08})_{0.98}$. (2) Ir_3Fe.

Occurrence: In chromite ores in ultramafic rocks and in placer concentrates derived therefrom.

Association: Inaglyite, osmiridium, ferrian platinum, laurite, irarsite, isoferroplatinum, erlichmannite, gaotaiite, galena, gold, chromite, magnetite.

Distribution: From a branch of the Luanhe River, near Gaotai village, Chengde Co., about 200 km north-northeast of Beijing, Hebei Province, China [TL].

Name: For Chengde Co., China, in which it was found to occur.

Type Material: Geological Museum of China, Beijing, China.

References: (1) Yu Zuxian (1995) Chengdeite – ordered natural iron-iridium alloy. Acta Geol. Sinica, 69(3), 215–220 (in Chinese with English abs.). (2) (1996) Amer. Mineral., 81, 516–520 (abs. ref. 1).

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Chenite $Pb_4Cu(SO_4)_2(OH)_6$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As complex prismatic crystals elongated along [032], to 1.5 mm. Of the 20 pinacoids identified, {$\overline{1}$32}, {$\overline{22}$1} {100} and {$\overline{1}$10} are dominant, yielding a bricklike shape. *Twinning:* Uncommon by an unresolved twin law.

Physical Properties: *Cleavage:* On {100}, good; traces of a second one on {001}.
Hardness = ∼2.5 D(meas.) = 5.98(2) D(calc.) = 6.044

Optical Properties: Transparent to translucent. *Color:* Sky-blue. *Streak:* Pale blue.
Luster: Vitreous to resinous.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Dispersion:* $r \gg v$, very strong. $\alpha = 1.871(5)$
$\beta = 1.909(5)$ $\gamma = 1.927(5)$ 2V(meas.) = 67(1)° 2V(calc.) = 68°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.791(1)$ $b = 7.940(1)$ $c = 7.976(1)$ $\alpha = 112.02(1)°$
$\beta = 97.73(1)°$ $\gamma = 100.45(1)°$ Z = 1

X-ray Powder Pattern: Susanna mine, Scotland.
3.60 (10), 3.41 (9), 5.55 (7), 2.80 (7), 4.32 (6), 2.07 (6), 3.30 (5)

Chemistry:

	(1)	(2)
SO_3	13.3	13.50
PbO	74.5	75.25
CuO	7.8	6.70
H_2O	[4.4]	4.55
Total	[100.0]	100.00

(1) Susanna mine, Scotland; by electron microprobe, H_2O by difference, presence of $(SO_4)^{2-}$ and $(OH)^{1-}$ and absence of H_2O confirmed by IR, corresponds to $Pb_{3.98}Cu_{1.17}(SO_4)_{1.98}(OH)_{6.08}$.
(2) $Pb_4Cu(SO_4)_2(OH)_6$.

Occurrence: Of rare occurrence in the oxidized portions of some Pb–Cu sulfide deposits.

Association: Caledonite, linarite, leadhillite, susannite, elyite, lanarkite, galena, chalcopyrite.

Distribution: From the Susanna mine, Leadhills, Lanarkshire, Scotland. At the Llechwedd Helyg mine, Tir-y-Mynach, Dyfed, Wales. In the Driggith mine, Caldbeck Fells, Cumbria, England. From the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate, and at Ramsbeck, North Rhine-Westphalia, Germany.

Name: Honors Dr. Tzong T. Chen (1942–), mineralogist at the Canadian Centre for Mineral and Energy Technology (CANMET), Ottawa, Canada.

Type Material: Technical University of Vienna, Vienna, Austria; University of Stuttgart, Stuttgart, Germany, NM14; Royal Ontario Museum, Toronto, Canada; National Museum of Natural History, Washington, D.C., USA, 160384.

References: (1) Paar, W.H., K. Mereiter, R.S.W. Braithwaite, P. Keller, and P.J. Dunn (1986) Chenite, $Pb_4Cu(SO_4)_2(OH)_6$, a new mineral from Leadhills, Scotland. Mineral. Mag., 50, 129–135. (2) (1987) Amer. Mineral., 72, 222 (abs. ref. 1). (3) Hess, H., P. Keller, and H. Riffel (1988) The crystal structure of chenite, $Pb_4Cu(OH)_6(SO_4)_2$. Neues Jahrb. Mineral., Monatsh., 259–264.

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Crystal Data: Monoclinic; commonly metamict. *Point Group:* $2/m$. Subhedral to anhedral, massive, to 5 cm.

Physical Properties: *Cleavage:* {010}, distinct; {100}, difficult; {001}, a parting, poor. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 5.28 D(calc.) = 5.29 Radioactive.

Optical Properties: Semitransparent. *Color:* Pale green to dark green, honey-brown to yellow-brown; pale green or pale brown in transmitted light. *Streak:* White. *Luster:* Resinous or greasy to vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Faint; $X = Y =$ green; $Z =$ yellowish green. *Orientation:* $X = b$; $Z \wedge c = 7°$. $\alpha = 1.779(2)$ $\beta = 1.780(2)$ $\gamma = 1.817(3)$ 2V(meas.) = 17°–20° 2V(calc.) = 17.9°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.747$–6.767 $b = 6.960$–6.975 $c = 6.453$–6.471 $\beta = 103.71°-103.89°$ Z = 4

X-ray Powder Pattern: Kuttankuli, India.
3.074 (100), 2.862 (65), 3.277 (58), 3.481 (30), 4.167 (25), 2.177 (22), 4.664 (20)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
U_3O_8	4.33		Ce_2O_3	12.12	20.65	Dy_2O_3	0.06	
P_2O_5	27.10	20.20	Pr_2O_3	1.20		Ho_2O_3	0.01	
SiO_2	2.08	6.09	Nd_2O_3	5.91		Er_2O_3	0.03	
ThO_2	31.64	28.20	Sm_2O_3	1.81		Tm_2O_3	0.12	
Al_2O_3		0.29	Eu_2O_3	0.25		Fe_2O_3		1.13
Y_2O_3	0.08	0.94	Gd_2O_3	0.45		PbO	1.15	
La_2O_3	5.19	21.63	Tb_2O_3	0.05		CaO	5.99	0.10
						Total	99.57	99.23

(1) Kuttankuli, India; by electron microprobe, corresponding to $[Th_{0.29}Ca_{0.26}Ce_{0.18}Nd_{0.08}La_{0.08}U_{0.04}Sm_{0.02}Pr_{0.02}Pb_{0.01}Gd_{0.01}(Eu, Y, Tm, Tb, Dy, Er, Ho)_{0.01}]_{\Sigma=0.99}(P_{0.92}Si_{0.08})_{\Sigma=1.00}O_4$.
(2) Ratnapura, Sri Lanka; corresponding to $[Ce_{0.32}Th_{0.27}(La, Pr, Nd)_{0.34}Fe_{0.05}Y_{0.02}Al_{0.01}]_{\Sigma=1.01}(P_{0.73}Si_{0.26})_{\Sigma=0.99}O_4$.

Mineral Group: Monazite group.

Occurrence: Disseminated in a kaolinized pegmatite dike and surrounding kaolinized granite gneiss; alluvial (Kuttankuli, India); in a carbonatite (Mt. Weld, Western Australia).

Association: Tourmaline, chrysoberyl, zircon, quartz (Kuttankuli, India).

Distribution: From Kuttankuli (Kuttakuzhi), about 42 km east-southeast of Trivandrum, Kerala State, India. At Ratnapura, Sri Lanka. In the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia. At Binghampton, Broome Co., New York, and in the Uranium King mine, Encampment, Carbon Co., Wyoming, USA.

Name: For *Chera* (Kerala), an ancient Dravidian kingdom predating Travancore (now Kerala State), India, and its dominant *cerium* content.

Type Material: Institute of Geological Sciences, London, MI 28881; The Natural History Museum, London, England, 1947,344.

References: (1) Bowie, S.H.U. and J.E.T. Horne (1953) Cheralite, a new mineral of the monazite group. Mineral. Mag., 30, 93–99. (2) (1954) Amer. Mineral., 39, 403 (abs. ref. 1). (3) Bowles, J.F.W., E.A. Jobbins, and B.R. Young (1980) A re-examination of cheralite. Mineral. Mag., 43, 885–888. (4) Hughes, J.M., E.E. Foord, M.A. Hubbard, and Y. Ni (1995) The crystal structure of cheralite, (Ce, LREE, Ca, Th, U)(P, Si)O_4, a monazite group mineral. Neues Jahrb. Mineral., Monatsh., 344–350. (5) Foord, E.E., J.J. Fitzpatrick, J.G. Crock, and F.E. Lichte (1992) A further re-examination of cheralite, (LREE, Ca, Th, U)(P, Si)O_4. from the type locality: Kuttakuzhi, Trivandrum, Kerala State, India. Trends in Mineral., 1, 103–105.

Cheralite-(Ce) $(Ce, Th, Ca)(P, Si)O_4$

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Crystal Data: Monoclinic; commonly metamict. *Point Group:* $2/m$. Subhedral to anhedral, massive, to 5 cm.

Physical Properties: *Cleavage:* {010}, distinct; {100}, difficult; {001}, a parting, poor. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 5.28 D(calc.) = 5.29 Radioactive.

Optical Properties: Semitransparent. *Color:* Pale green to dark green, honey-brown to yellow-brown; pale green or pale brown in transmitted light. *Streak:* White. *Luster:* Resinous or greasy to vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Faint; $X = Y$ = green; Z = yellowish green. *Orientation:* $X = b$; $Z \wedge c = 7°$. $\alpha = 1.779(2)$ $\beta = 1.780(2)$ $\gamma = 1.817(3)$ 2V(meas.) = 17°–20° 2V(calc.) = 17.9°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.747$–6.767 $b = 6.960$–6.975 $c = 6.453$–6.471 $\beta = 103.71°-103.89°$ Z = 4

X-ray Powder Pattern: Kuttankuli, India.
3.074 (100), 2.862 (65), 3.277 (58), 3.481 (30), 4.167 (25), 2.177 (22), 4.664 (20)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
U_3O_8	4.33		Ce_2O_3	12.12	20.65	Dy_2O_3	0.06	
P_2O_5	27.10	20.20	Pr_2O_3	1.20		Ho_2O_3	0.01	
SiO_2	2.08	6.09	Nd_2O_3	5.91		Er_2O_3	0.03	
ThO_2	31.64	28.20	Sm_2O_3	1.81		Tm_2O_3	0.12	
Al_2O_3		0.29	Eu_2O_3	0.25		Fe_2O_3		1.13
Y_2O_3	0.08	0.94	Gd_2O_3	0.45		PbO	1.15	
La_2O_3	5.19	21.63	Tb_2O_3	0.05		CaO	5.99	0.10
						Total	99.57	99.23

(1) Kuttankuli, India; by electron microprobe, corresponding to $[Th_{0.29}Ca_{0.26}Ce_{0.18}Nd_{0.08}La_{0.08}U_{0.04}Sm_{0.02}Pr_{0.02}Pb_{0.01}Gd_{0.01}(Eu, Y, Tm, Tb, Dy, Er, Ho)_{0.01}]_{\Sigma=0.99}(P_{0.92}Si_{0.08})_{\Sigma=1.00}O_4$.
(2) Ratnapura, Sri Lanka; corresponding to $[Ce_{0.32}Th_{0.27}(La, Pr, Nd)_{0.34}Fe_{0.05}Y_{0.02}Al_{0.01}]_{\Sigma=1.01}(P_{0.73}Si_{0.26})_{\Sigma=0.99}O_4$.

Mineral Group: Monazite group.

Occurrence: Disseminated in a kaolinized pegmatite dike and surrounding kaolinized granite gneiss; alluvial (Kuttankuli, India); in a carbonatite (Mt. Weld, Western Australia).

Association: Tourmaline, chrysoberyl, zircon, quartz (Kuttankuli, India).

Distribution: From Kuttankuli (Kuttakuzhi), about 42 km east-southeast of Trivandrum, Kerala State, India. At Ratnapura, Sri Lanka. In the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia. At Binghampton, Broome Co., New York, and in the Uranium King mine, Encampment, Carbon Co., Wyoming, USA.

Name: For *Chera* (Kerala), an ancient Dravidian kingdom predating Travancore (now Kerala State), India, and its dominant *cerium* content.

Type Material: Institute of Geological Sciences, London, MI 28881; The Natural History Museum, London, England, 1947,344.

References: (1) Bowie, S.H.U. and J.E.T. Horne (1953) Cheralite, a new mineral of the monazite group. Mineral. Mag., 30, 93–99. (2) (1954) Amer. Mineral., 39, 403 (abs. ref. 1). (3) Bowles, J.F.W., E.A. Jobbins, and B.R. Young (1980) A re-examination of cheralite. Mineral. Mag., 43, 885–888. (4) Hughes, J.M., E.E. Foord, M.A. Hubbard, and Y. Ni (1995) The crystal structure of cheralite, (Ce, LREE, Ca, Th, U)(P, Si)O_4, a monazite group mineral. Neues Jahrb. Mineral., Monatsh., 344–350. (5) Foord, E.E., J.J. Fitzpatrick, J.G. Crock, and F.E. Lichte (1992) A further re-examination of cheralite, (LREE, Ca, Th, U)(P, Si)O_4. from the type locality: Kuttakuzhi, Trivandrum, Kerala State, India. Trends in Mineral., 1, 103–105.

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Cheremnykhite $Pb_3Zn_3Te^{6+}O_6(VO_4)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, *or* 222. Crystals are tabular, elongate, to 0.5 mm, showing {100} and {010}.

Physical Properties: *Cleavage:* One, perfect. *Fracture:* Brittle. Hardness = n.d. VHN = 673 (10 g load). D(meas.) = 6.44 D(calc.) = [6.39]

Optical Properties: Transparent. *Color:* Greenish yellow. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.986(5)$ β = n.d. $\gamma = 1.997(5)$ 2V(meas.) = 20°

Cell Data: *Space Group:* $Cmmm$, $Cmm2$, $Cm2m$, or $C222$. $a = 8.58(3)$ $b = 14.86(5)$ $c = 5.18(3)$ Z = 2

X-ray Powder Pattern: Kuranakh deposit, Russia.
3.30 (10), 3.00 (9), 1.607 (6), 1.903 (5), 2.470 (4), 3.66 (3), 2.120 (3)

Chemistry:

	(1)	(2)
TeO_3	13.76	13.81
P_2O_5	0.06	
As_2O_5	2.02	
V_2O_5	9.25	14.31
Sb_2O_5	0.06	
SiO_2	2.16	
ZnO	18.89	19.21
PbO	53.04	52.67
Total	99.24	100.00

(1) Kuranakh deposit, Russia; by electron microprobe, average of 10 analyses, corresponds to $Pb_{3.03}Zn_{2.97}Te_{1.00}O_{5.77}[(V_{0.65}Si_{0.23}As_{0.11})_{\Sigma=0.99}O_4]_2$. (2) $Pb_3Zn_3TeO_6(VO_4)_2$.

Occurrence: A late-stage mineral in the oxidized zone of a tellurium-bearing gold deposit.

Association: Kuksite, Si-rich dugganite, yafsoanite, descloizite, calcite.

Distribution: In the Kuranakh gold deposit, near Aldan, Sakha, Russia.

Name: To honor I.M. Cheremnykh (1928–), geologist, a discoverer of the Kuranakh deposit.

Type Material: Institute of Geosciences, Yakutsk Scientific Center, Academy of Sciences, Yakutsk, Russia, mk-113.

References: (1) Kim, A.A., N.V. Zayakina, and V.F. Makhotko (1990) Kuksite $Pb_3Zn_3TeO_6(PO_4)_2$ and cheremnykhite $Pb_3Zn_3TeO_6(VO_4)_2$ – new tellurates from the Kuranakh gold deposit (central Aldan, southern Yakutia [Sakha]). Zap. Vses. Mineral. Obshch., 119(5), 50–57 (in Russian). (2) (1992) Amer. Mineral., 77, 446 (abs. ref. 1).

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Cherepanovite RhAs

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As grains, up to 0.5 mm, in aggregates.

Physical Properties: *Cleavage:* One distinct. Hardness = n.d. VHN = 726–754 (50 g load). D(meas.) = n.d. D(calc.) = 9.72

Optical Properties: Opaque. *Color:* Pale gray; in reflected light, white with an orange tint. *Streak:* Grayish black. *Luster:* Metallic. *Pleochroism:* Weak, in yellow to pinkish hue and bluish white. *Anisotropism:* Green to gray-brown.
R_1–R_2: (400) — , (420) 39.2–40.5, (440) 39.6–41.0, (460) 40.3–41.9, (480) 41.0–42.9, (500) 41.9–43.8, (520) 42.7–44.7, (540) 43.6–45.5, (560) 44.1–46.1, (580) 44.5–46.6, (600) 44.9–47.1, (620) 45.1–47.3, (640) 45.2–47.4, (660) 45.3–47.6, (680) 45.5–47.6, (700) 45.4–47.6

Cell Data: *Space Group: Pnma.* $a = 5.70(2)$ $b = 3.59(1)$ $c = 6.00(1)$ $Z = 4$

X-ray Powder Pattern: Northern Pekul'nei River, Russia.
3.01 (10), 2.10 (6b), 1.813 (2), 1.771 (2b), 1.501 (2b), 1.354 (2b)

Chemistry:

	(1)	(2)
Rh	55.9	57.87
Ru	1.45	
Pt	0.61	
Ni	0.20	
As	41.6	42.13
Total	99.76	100.00

(1) Northern Pekul'nei River, Russia; by electron microprobe, average of 16 grains; corresponds to $(Rh_{0.98}Ru_{0.03}Pt_{0.01}Ni_{0.01})_{\Sigma=1.03}As_{1.00}$. (2) RhAs.

Occurrence: In a placer with other platinum group element minerals derived from an ultramafic massif in an ophiolite belt (Northern Pekul'nei River, Russia).

Association: Isoferroplatinum, tetraferroplatinum, ferronickelplatinum, rutheniridosmine, laurite, irarsite, cooperite, sperrylite, hollingworthite, chromite, olivine (Northern Pekul'nei River, Russia); isoferroplatinum, rhodian irarsite, hongshiite, sperrylite, tulameenite (Upper Miask River, Russia); laurite, erlichmannite, cuproiridisite, kashinite, rhodian pentlandite, irarsite, chromite, olivine (Ray-Iz complex, Russia).

Distribution: In Russia, from a placer of the Northern Pekul'nei River, Pekul'nei Range, eastern Chukot Peninsula [TL]; in a placer in the Upper Miask River, Ural Mountains; and at the Ray-Iz ophiolite complex, Polar Ural Mountains. In the Onverwacht pipe, in the Merensky Reef, Bushveld complex, Transvaal, South Africa.

Name: In honor of Vladimir Aleksandrovich Cherepanov (1927–1983), Russian geologist and mineralogist, Karpinskii All-Union Research Institute of Geology, St. Petersburg, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 2103/1.

References: (1) Rudashevskii, N.S., A.G. Mochalov, N.V. Trubkin, N.I. Shumskaya, V.I. Shkurskii, and T.L. Evstigneeva (1985) Cherepanovite RhAs – a new mineral. Zap. Vses. Mineral. Obshch., 114, 464–469 (in Russian). (2) (1986) Amer. Mineral., 71, 1544 (abs. ref. 1). (3) (1986) Mineral. Abs., 37, 529 (abs. ref. 1).

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Chernikovite $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As thin platy crystals, elongated along [010]; as oriented inclusions in autunite and meta-autunite.

Physical Properties: *Cleavage:* Perfect on {001}; imperfect on {010}. Hardness = n.d. D(meas.) = 3.259 D(calc.) = 3.258–3.264 Intense yellow-green fluorescence. Radioactive.

Optical Properties: Transparent. *Color:* Pale yellow to lemon-green [*sic*]. *Luster:* Vitreous. *Optical Class:* Uniaxial (–), may be anomalously biaxial. *Pleochroism:* Slight to none. ω = 1.580–1.583 ϵ = 1.569–1.570 2V(meas.) = 5°–10°

Cell Data: *Space Group:* $P4/nmm$. a = 7.016–7.030 c = 9.034–9.055 Z = 1

X-ray Powder Pattern: Karakat deposit, Tajikistan.
4.99 (100), 3.54 (100), 3.26 (100), 5.51 (90), 3.82 (80), 2.16 (70), 2.09 (70)

Chemistry: (1) An analysis of natural material has not been made; the species rests on qualitative spectrographic analyses and identity of other properties with those of synthetic material.

Mineral Group: Meta-autunite group.

Occurrence: In fissures in quartz syenite and around fossil wood (Karakat deposit, Tajikistan); along fractures in tourmaline-bearing granites and granite pegmatites (Perus district, Brazil).

Association: Autunite, meta-autunite, sodium autunite (Karakat deposit, Tajikistan); autunite, meta-autunite, uranophane, uranophane-beta, phosphuranylite, torbernite, metatorbernite, haiweeite, uranian "opal" (Perus district, Brazil).

Distribution: From the Karakat uranium deposit, 60 km northwest of Khodzhent (Leninabad), Karamazar Mountains, Tajikistan. In the Perus district, 25 km north of São Paulo, Brazil. In Germany, in the Rockelmann quarry, near Schwarzenberg, Saxony, and from Ronneburg, Thuringia.

Name: To honor Dr. Andrei Andreevich Chernikov (1927–), Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia, who first described naturally-occurring material.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 88655.

References: (1) Chernikov, A.A. (1958) New data on some uranium and uranium-bearing minerals. Proc. 2nd United Nations int. conf. on the peaceful uses of atomic energy, 2, 298–299 [hydrogen-autunite = chernikovite]. (2) Atencio, D. (1988) Chernikovite, a new mineral name for $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$. Mineral. Record, 19, 249–252. (3) Morosin, B. (1978) Hydrogen uranyl phosphate tetrahydrate, a hydrogen ion solid electrolyte. Acta Cryst., 34, 3732-3734.

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Chernovite-(Y) $YAsO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals prismatic to pseudo-octahedral, to 5 mm, with {010}, {011}, {001}, rare {110}.

Physical Properties: *Cleavage:* On {010}, perfect; may glide on {001} or {110}. *Tenacity:* Brittle. Hardness = 4.5 VHN = 229–429, average 313. D(meas.) = n.d. D(calc.) = 4.866

Optical Properties: Semitransparent. *Color:* Colorless, pale yellow, lemon-yellow, greenish yellow, bright green; may be zoned. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* O = pale rose-yellow; E = colorless. $\omega = 1.783(1)$ $\epsilon = 1.879(2)$

Cell Data: *Space Group:* $I4_1/amd$. $a = 6.99$–7.09 $c = 6.17$–6.32 Z = 4

X-ray Powder Pattern: Synthetic.
3.52 (100), 2.661 (75), 1.817 (65), 2.490 (18), 1.760 (16), 1.468 (16), 1.1272 (16)

Chemistry:

	(2)	(3)
P_2O_5	5.5	17.24
As_2O_5	40.3	27.91
Y_2O_3	36.9	54.85
La_2O_3	15.1	
Total	97.8	100.00

(1) Nyarta-Syu-Yu River, Russia; spectrographic analyses gives Y ≫30%, As ∼30%, La 0.8%, Ce 0.8%, P 0.6%, V 0.3%, Si 2.0%, Ti 0.04%, Mn 0.02%, Pb 0.01%, Cu 0.01%, Cr 0.01%, Sn 0.01%, Be 0.001%; ΣRE = Y 78%, Ce 0.4%, Nd 1.6%, Sm 1.1%, Eu 0.2%, Gd 2.2%, Tb 0.6%, Dy 4.2%, Ho 1.4%, Er 4.7%, Tm 0.6%, Yb 4.1%, Lu 0.9%. (2) Wannigletscher, Binntal, Switzerland; by electron microprobe. (3) $Y(As,P)O_4$ with As:P = 1:1.

Polymorphism & Series: Forms a series with xenotime-(Y).

Occurrence: In piemontite veinlets in liparite porphyry (Nyarta-Syu-Yu River, Russia); in Alpine-type fissures (Binntal, Switzerland).

Association: Piemontite, molybdenian scheelite, albite, calcite, garnet, hastingsite, pyrolusite, hematite (Nyarta-Syu-Yu River, Russia); niobian rutile, magnetite, asbecasite, cafarsite (Binntal, Switzerland).

Distribution: Near the head of the Nyarta-Syu-Yu River, east of Mt. Tel'posiz, Polar Ural Mountains, Russia. On the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais, Switzerland. On the east flank of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont, Italy. At Sailauf, northeast of Aschaffenburg, Bavaria, Germany. In the USA, at the Squaw Creek tin prospect and Paramount Canyon, Taylor Creek district, Sierra Co., New Mexico. Large crystals from Brumado, Bahia, also at the José Pinto pegmatite, at Jaguaraçú, near Coronel Fabriciano, Minas Gerais, Brazil.

Name: Honoring Professor Aleksandr Aleksandrovich Chernov (1877–1963), Russian geologist, Institute of Geology, Syktyvar, Russia, explorer of the Polar Urals.

Type Material: Mining Museum, St. Petersburg, Russia, 1013/1.

References: (1) Goldin, B.A., N.P. Yushkin, and M.V. Fishmin (1967) A new yttrium mineral, chernovite. Zap. Vses. Mineral. Obshch., 96, 699–704 (in Russian). (2) (1968) Amer. Mineral., 53, 1777 (abs. ref. 1). (3) Graeser, S., H. Schwander, and H.A. Stalder (1973) A solid solution series between xenotime ($YtPO_4$) and chernovite ($YtAsO_4$). Mineral. Mag., 39, 145–151. (4) Graeser, S. and A.G. Roggiani (1976) Occurrence and genesis of rare arsenate and phosphate minerals around Pizzo Cervandone, Italy/Switzerland. Rend. Soc. Ital. Mineral. Petrol., 32, 279–288. (5) (1963) NBS Mono. 25, 2, 39.

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Chernykhite $(Ba,Na)(V^{3+},Al)_2(Si,Al)_4O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. In small veinlets and leaflets, to 5 mm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2.5–3.6 on {001}; 2.9–4.5 $\perp$ {001}. D(meas.) = 3.14–3.16 D(calc.) = 3.10

Optical Properties: Translucent. *Color:* Olive-green, dark green. *Streak:* Light green. *Luster:* Pearly on cleavage.
Optical Class: Biaxial (–). α = 1.640–1.643 β = 1.686–1.691 γ = 1.702–1.704
2V(meas.) = 11°–12°

Cell Data: *Space Group:* $C2/c$ or Cc. a = 5.29(1) b = 9.182(2) c = 20.023(6) $\beta = 95°41(5)'$ Z = 4

X-ray Powder Pattern: Kara-Tau Mountains, Kazakhstan.
3.33 (100), 2.607 (70), 1.996 (60), 1.660 (60), 3.01 (50), 1.530 (50), 2.887 (40)

Chemistry:

	(1)	(2)
SiO_2	29.90	30.06
Al_2O_3	25.90	27.24
Fe_2O_3	0.40	0.36
V_2O_4	5.40	5.30
V_2O_3	18.30	18.90
MgO	1.60	trace
BaO	9.35	9.60
Na_2O	1.32	
K_2O	0.70	0.90
H_2O^+	6.00	6.10
H_2O^-	1.10	1.00
Total	99.97	99.46

(1) Kara-Tau Mountains, Kazakhstan; corresponds to $(Ba_{0.28}Na_{0.20}K_{0.07})_{\Sigma=0.55}(V^{3+}_{1.13}Al_{0.65}V^{4+}_{0.30}Mg_{0.18}Fe_{0.02})_{\Sigma=2.28}(Si_{2.30}Al_{1.70})_{\Sigma=4.00}O_{10}(OH)_2$. (2) Do.; corresponds to $(Ba_{0.29}K_{0.09})_{\Sigma=0.38}(V^{3+}_{1.18}Al_{0.76}V^{4+}_{0.29}Fe_{0.02})_{\Sigma=2.25}(Si_{2.30}Al_{1.70})_{\Sigma=4.00}O_{10}(OH)_2$.

Polymorphism & Series: $2M_1$ polytype.

Mineral Group: Mica group.

Occurrence: In small veinlets cutting carbonate rocks interbedded with vanadium-rich lower Paleozoic shales.

Association: n.d.

Distribution: From the Balasauskandyk and Kurumsak vanadium deposits, northwestern Kara-Tau Mountains, southern Kazakhstan.

Name: Honoring Viktor Vasil'evich Chernykh (1889–1941), Professor of Mineralogy, the Mining Institute, St. Petersburg, Russia.

Type Material: Alma-Ata, Kazakhstan; Mining Institute, St. Petersburg, 1056/1; Vernadsky State Geological Museum, Moscow, 49845; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72369, vis5548.

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References: (1) Ankinovich, S.G., E.A. Ankinovich, I.V. Rozhdestvenskaya, and V.A. Frank-Kamenetskii (1972) Chernykhite, a new barium-vanadium mica from northwestern Karatau. Zap. Vses. Mineral. Obshch., 101, 451–458 (in Russian). (2) (1973) Amer. Mineral., 58, 966 (abs. ref. 1). (3) Rozhdestvenskaya, I.V. and V.A. Frank-Kamenetskii (1974) Structure of the dioctahedral mica chernykhite. Kristallokhim. Strukt. Miner., 28–33 (in Russian). (4) (1975) Chem. Abs., 69539 (abs. ref. 3). (5) Rozhdestvenskaya, I.V. (1979) Refinement of the structure of chernykhite. Kristallokhim. Strukt. Miner., 66–69 (in Russian). (6) (1979) Chem. Abs., 115676 (abs. ref. 5).

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As complexly faceted crystals, several cm in length, with {100}, {221}, {$2\bar{2}1$}, and {001} prominent; 28 forms have been recognized. *Twinning:* Commonly twinned on {100}, producing contact twins or finely polysynthetic lamellae.

Physical Properties: *Cleavage:* {100} and {010}. Hardness = ~3 D(meas.) = 6.30–6.49 D(calc.) = [6.38]

Optical Properties: Transparent. *Color:* Colorless to yellow; colorless to gray or brown in thin section. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = light brownish; Z = brownish. *Dispersion:* Weak, inclined. $\alpha = 2.250(8)$ $\beta = 2.382(8)$ $\gamma = 2.410(8)$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P2_1/a$. a = 13.37–13.379 b = 7.16–7.174 c = 7.11–7.116 β = 105.96°–106° Z = 4

X-ray Powder Pattern: Mounana mine, Gabon.
3.441 (FFF), 3.428 (FFF), 3.206 (FF), 4.93 (F), 3.081 (F), 4.32 (mF), 3.569 (mF)

Chemistry:

	(1)
V_2O_5	29.1
PbO	71.6
Total	100.7

(1) Mounana mine, Gabon; by electron microprobe, corresponds to $Pb_{2.00}V_{2.00}^{5+}O_7$.

Occurrence: In the oxidized zone of a vanadium- and lead-bearing uranium deposit (Mounana mine, Gabon).

Association: Francevillite, wulfenite (Mounana mine, Gabon); mottramite, cuprite, heyite, dioptase, malachite, plancheite, vanadinite, wakefieldite-(Ce) (Kusu deposit, Congo).

Distribution: In the Mounana uranium mine, Franceville, Gabon. From the Kusu deposit, 85 km south of Kinshasa, Bas-Zaire Province, Congo (Zaire). From St. Andreasberg, Harz Mountains, Germany. Found at Vrančice, near Příbram, Czech Republic.

Name: Honors Jean Chervet, French mineralogist.

Type Material: National School of Mines, Paris, France.

References: (1) Bariand, P., F. Chantret, R. Pouget, and A. Rimsky (1963) Une nouvelle espèce minérale: la chervétite, pyrovanadate de plomb $Pb_2V_2O_7$. Bull. Soc. fr. Minéral., 86, 117–120 (in French). (2) (1963) Amer. Mineral., 48, 1416 (abs. ref. 1). (3) Cesbron, F. (1965) Données nouvelles sur la chervétite. Bull. Soc. fr. Minéral., 88, 126–129 (in French). (4) Kawahara, A. (1967) La structure cristalline de la chervétite. Bull. Soc. fr. Minéral., 90, 279–284 (in French with English abs.). (5) Cervelle, B. and F. Cesbron (1973) Propriétés optiques de la chervétite, pyrovanadate de plomb. Bull. Soc. fr. Minéral., 96, 391–392 (in French with English abs.). (6) Shannon, R.B. and C. Calvo (1973) Refinement of the crystal structure of synthetic chervetite, $Pb_2V_2O_7$. Canadian J. Chemistry, 51, 70–76. (7) Mrázek, Z. (1985) Brandtite and chervetite from Vrančice near Príbram (Bohemia). Časopis pro Mineralogii a Geologii, 30(3), 295–302. (8) (1992) Mineral. Abs., 43, 224–225 (abs. ref. 7).

Chesnokovite $Na_2[SiO_2(OH)_2]\cdot 8H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As pods to 10 cm; crystals crudely lamellar, to 2 cm, with {010} dominant.

Physical Properties: *Cleavage*: Perfect on {010}, good on {100} and {001}. *Fracture*: Stepped to conchoidal. *Tenacity*: Brittle. Hardness = 2.5 D(meas.) = 1.68(2) D(calc.) = 1.60 (empirical formula) or 1.64 (ideal formula). Highly unstable at normal atmospheric humidity and CO_2 concentration; decomposes to thermonatrite and opal.

Optical Properties: Transparent to translucent. *Color*: Colorless; aggregates white to pale brown or yellowish; colorless in thin section. *Streak*: White. *Luster*: Dull vitreous.
Optical Class: Biaxial (+). α = 1.449(2) β = 1.453(2) γ = 1.458(3) 2V(meas.) = 80(5)° 2V(calc.) = 84° *Orientation: XY* || {010}; *Z* = *b*.

Cell Data: *Space Group*: *Ibca*. *a* = 11.7119(6) *b* = 16.973(1) *c* = 11.5652(6) Z = 8

X-ray Powder Pattern: Mt. Kedykverpakhk, Lovozero alkaline massif, Kola Peninsula, Russia. 2.774 (100), 2.800 (97), 3.847 (89), 4.788 (42), 2.932 (42), 2.832 (35), 5.001 (30)

Chemistry:

	(1)	(2)
Na_2O	21.49	21.81
K_2O	0.38	
Li_2O	0.003	
SiO_2	21.42	21.14
H_2O	54.86	57.05
Total	98.15	100.00

(1) Mt. Kedykverpakhk, Lovozero alkaline massif, Kola Peninsula, Russia; electron microprobe and atomic emission analyses, H_2O by the Alimarin method, H_2O and OH confirmed by IR, corresponding to $(Na_{1.96}K_{0.02})_{\Sigma=1.98}Si_{1.005}O_2(OH)_2\cdot 7.58H_2O$. (2) $Na_2[SiO_2(OH)_2]\cdot 8H_2O$.

Occurrence: A late hydrothermal mineral, intergrown with natrophosphate in a ussingite vein in an alkaline igneous complex.

Association: Natrophosphate, natrolite, sodalite, vuonnemite, steenstrupine-(Ce), phosinaite-(Ce), natisite, gobbinsite, villiaumite, natrosilite, revdite.

Distribution: The Kedykverpakhk–22 vein, Mt. Kedykverpakhk, Karnasurt mine, Lovozero alkaline massif, Kola Peninsula, Russia.

Name: Honors mineralogist Boris Valentinovich Chesnokov (1928–2005) of the Ural Department, Russian Academy of Sciences, Miass.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (catalog no. 3419/1).

References: (1) Pekov, I.V., N.V. Chukanov, A.E. Zadov, N.V. Zubkova, and D.Yu. Pushcharovsky (2007) Chesnokovite, $Na_2[SiO_2(OH)_2]\cdot 8H_2O$, the first natural sodium orthosilicate from the Lovozero alkaline pluton, Kola Peninsula: description and crystal structure of a new mineral species. Zap. Ross. Mineral. Obshch., 136(2), 25–39 (in Russian, English abstract); (2007) Geology of Ore Deposits, 49, 739–751 (in English). (2) (2009) Amer. Mineral., 94, 1077 (abs. ref. 1).

Chessexite $Na_4Ca_2(Mg,Zn)_3Al_8(SiO_4)_2(SO_4)_{10}(OH)_{10}\cdot 40H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As euhedral, thin, square or rectangular plates, to 0.03 mm.

Physical Properties: *Cleavage:* Indistinct ∥ [101]. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.21

Optical Properties: Semitransparent. *Color:* White. *Luster:* Silky. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.456$ $\beta = 1.460$ $\gamma = 1.480$ 2V(meas.) = 47°

Cell Data: *Space Group:* n.d. $a = 13.70$ $b = 27.96$ $c = 9.99$ Z = 2

X-ray Powder Pattern: Maine mine, France.
13.91 (100), 3.422 (100), 4.85 (90), 3.982 (60), 3.451 (40), 3.322 (40), 2.908 (30)

Chemistry:

	(1)
SiO_2	3.64
Al_2O_3	15.30
ZnO	3.73
MgO	3.50
CaO	3.92
Na_2O	4.44
K_2O	0.30
H_2O	31.11
SO_3	31.91
Total	97.85

(1) Maine mine, France; Ca, Mg, Zn, Si, and Al by AA, Na and K by flame photometry, S by chromatography, and H_2O by TGA; corresponds to $(Na_{3.75}K_{0.17}Ca_{0.08})_{\Sigma=4.00}(Ca_{1.75}Mg_{0.25})_{\Sigma=2.00}(Mg_{1.87}Zn_{1.20})_{\Sigma=3.07}(Al_{7.85}Mg_{0.15})_{\Sigma=8.00}Si_{1.58}S_{10.42}O_{53.46}\cdot 45.13H_2O$.

Occurrence: As a coating on fluorite.

Association: Fluorite, gypsum.

Distribution: From the Maine fluorite mine, near Autun, Saône-et-Loire, France.

Name: For Professor Ronald Chessex, petrographer, University of Geneva, Geneva, Switzerland.

Type Material: Natural History Museum, Geneva, Switzerland, 435/70.

References: (1) Sarp, H. and J. Deferne (1982) Le chessexite, un nouveau minéral. Schweiz. Mineral. Petrog. Mitt., 62, 337-341 (in French with English abs.). (2) (1984) Amer. Mineral., 69, 406 (abs. ref. 1).

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Chesterite $(Mg, Fe^{2+})_{17}Si_{20}O_{54}(OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Radiating sprays of prismatic crystals, to 5 cm; as intergrowths ∥ {010} in anthophyllite and cummingtonite.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at ∼45° and 135°; breakage along {100} and {010} may be due to parting. Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.08]

Optical Properties: Transparent. *Color:* Colorless to very light pinkish brown; in thin section, colorless.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, weak.
$\alpha = 1.617(5)$ $\beta = 1.632(5)$ $\gamma = 1.640(5)$ 2V(meas.) = 71(2)°

Cell Data: *Space Group:* $A2_1ma$. $a = 18.6140(3)$ $b = 45.306(1)$ $c = 5.2966(3)$ $Z = 4$

X-ray Powder Pattern: Calculated.
8.609 (100), 3.076 (66), 3.246 (49), 11.327 (41), 2.554 (36), 3.751 (34), 2.779 (31)

Chemistry:

	(1)
SiO_2	57.95
Al_2O_3	0.25
FeO	14.14
MnO	0.99
MgO	24.24
CaO	0.42
Na_2O	0.03
H_2O	[2.60]
Total	[100.62]

(1) Chester, Vermont, USA; by electron microprobe, H_2O assuming (OH) sites filled by $(OH)^{1-}$.

Occurrence: In black wallrock between chlorite and actinolite zones of a metamorphosed ultramafic body.

Association: Jimthompsonite, clinojimthompsonite, anthophyllite, cummingtonite, talc.

Distribution: In the Carleton talc quarry, near Chester, Windsor Co., Vermont, USA.

Name: For the Chester, Vermont, USA, locality.

Type Material: Royal Ontario Museum, Toronto, Canada, M36083; Harvard University, Cambridge, Massachusetts, 134079; National Museum of Natural History, Washington, D.C., USA, 145869.

References: (1) Veblen, D.R. and C.W. Burnham (1978) New biopyriboles from Chester, Vermont: I. Descriptive mineralogy. Amer. Mineral., 63, 1000–1009. (2) Veblen, D.R. and C.W. Burnham (1978) New biopyriboles from Chester, Vermont: II. The crystal chemistry of jimthompsonite, clinojimthompsonite, chesterite, and the amphibole-mica reaction. Amer. Mineral., 63, 1053–1073.

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Chestermanite $Mg_2(Fe^{3+}, Mg, Al, Sb^{5+})O_2BO_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Typically fibrous to asbestiform on [001], curved along {001} and flattened on {010}, to 2 mm. Crystals ubiquitously striated ∥ [011] and diamond-shaped in cross section. Of the nine forms noted, {110}, {210}, and {010} dominate.

Physical Properties: *Fracture:* Uneven to conchoidal, produced more easily ⊥ to length. *Tenacity:* Brittle, tougher than ludwigite. Hardness = 6 D(meas.) = 3.72(2) D(calc.) = 3.650

Optical Properties: Semitransparent. *Color:* Grayish green to black; surface (diffraction grating) iridescence is typical. *Streak:* Pale grayish green. *Luster:* Vitreous to silky. *Optical Class:* Biaxial (+). *Pleochroism:* X = dark greenish blue; Y = green; Z = pale yellowish brown. *Absorption:* $X \gg Y > Z$. $\alpha = 1.753$–1.759 $\beta = 1.763$–1.767 $\gamma = 1.791$–1.797 2V(meas.) = n.d. 2V(calc.) = 63°

Cell Data: *Space Group: Pbam.* $a = 18.525(4)$ $b = 12.272(2)$ $c = 3.0218(4)$ Z = 8

X-ray Powder Pattern: Twin Lakes region, California, USA; shows strong preferred {hk0} orientation.
5.114 (100), 2.559 (91), 2.169 (57), 2.746 (34), 1.9975 (32), 2.475 (19), 1.5300 (19)

Chemistry:

	(1)		(1)
Sb_2O_5	10.3	MgO	48.0
TiO_2	0.8	CaO	0.1
B_2O_3	[18.22]	F	0.1
Al_2O_3	5.3	$-O = F_2$	0.04
Fe_2O_3	16.0	Total	98.88
MnO	0.1		

(1) Twin Lakes region, California, USA; by electron microprobe, average of eight analyses, total Fe as Fe_2O_3, confirmed by Mössbauer spectroscopy, B_2O_3 calculated for stoichiometry; corresponds to $Mg_2(Fe^{3+}_{0.38}Mg_{0.28}Al_{0.20}Sb^{5+}_{0.12}Ti_{0.02})_{\Sigma=1.00}O_2B(O_{2.99}F_{0.01})_{\Sigma=3.00}$. (2) Do.; from crystal-structure analysis, corresponds to $Mg_{2.00}(Fe^{3+}_{0.43}Al_{0.16}Mg_{0.25}Sb_{0.13}Ti_{0.02})_{\Sigma=0.99}O_2BO_3$.

Mineral Group: Ludwigite group.

Occurrence: Rare, in veins and disseminated in a brucite marble lens contained in a multiply metamorphosed roof pendant between two plutons in a granodiorite batholith.

Association: Magnesian–aluminian ludwigite, magnesian calcite, fluoborite, wightmanite, spinel, brucite, safflorite, löllingite.

Distribution: From the north side of Kaiser Crest, about five km north of the easternmost end of Huntington Lake, Twin Lakes region, Fresno Co., California, USA.

Name: Honors Charles Wesley Chesterman (1913–1991), geologist and mineralogist, California Division of Mines and Geology, San Francisco, USA, who discovered the first specimens.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160270, 165968.

References: (1) Erd, R.C. and E.E. Foord (1988) Chestermanite, a new member of the ludwigite–pinakiolite group from Fresno County, California. Can. Mineral., 26, 911–916. (2) (1990) Amer. Mineral., 75, 431 (abs. ref. 1). (3) Alfredsson, V., J.-O. Bovin, R. Norrestam, and O. Terasaki (1991) The structure of the mineral chestermanite, $Mg_{2.25}Al_{0.16}Fe_{0.43}Ti_{0.02}Sb_{0.13}O_2BO_3$. A combined single crystal X-ray and HREM study. Acta Chem. Scand., 45, 797–804. (4) Cooper, M.A. and F.C. Hawthorne (1998) The crystal structure of blatterite, $Sb^{5+}_3(Mn^{3+}, Fe^{3+})_9(Mn^{2+}, Mg)_{35}(BO_3)_{16}O_{32}$, and structural hierarchy in Mn^{3+}−bearing zigzag borates. Can. Mineral., 36, 1171–1193, esp. 1191.

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Chevkinite-(Ce) $(Ce, La, Ca)_4(Fe^{2+}, Mg)_2(Ti, Fe^{3+})_3Si_4O_{22}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Small lamellar, lenticular, and prismatic crystals; massive, in lumps to 10 cm. *Twinning:* Twin plane {001}.

Physical Properties: *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 4.53–4.67 D(calc.) = [4.99]

Optical Properties: Opaque except on thin edges. *Color:* Dark reddish brown to black. *Luster:* Resinous to dull.
Optical Class: Biaxial (–). *Pleochroism:* X = almost colorless; Y = reddish brown; Z = dark brown. *Orientation:* $Z \wedge c = 11°–26°$. *Dispersion:* $r < v$, distinct to strong. *Absorption:* $Z > Y > X$. α = n.d. $\beta = 1.88–2.02$ γ = n.d. 2V(meas.) = Medium.

Cell Data: *Space Group:* $P2_1/a$. $a = 13.370(3)$ $b = 5.660(2)$ $c = 11.280(3)$ $\beta = 100°52(2)'$ Z = [2]

X-ray Powder Pattern: Meade Co., Kansas, USA; some materials are metamict.
3.17 (100), 3.14 (100), 2.71 (100), 2.16 (50), 1.961 (50), 4.58 (40), 3.46 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	19.23	12.04	Nb_2O_5	0.01	
TiO_2	19.61	17.08	FeO	8.85	7.76
ThO_2	0.73	0.82	MnO	1.11	0.50
Al_2O_3	2.17	0.93	MgO	0.05	0.74
Y_2O_3	0.93	1.50	CaO	2.49	3.35
$(La, Dy)_2O_3$	18.77	18.35	$(Na, K)_2O$	0.10	
Ce_2O_3	20.52	25.29	H_2O	0.81	1.50
Fe_2O_3	2.60	9.56	P_2O_5		0.38
Cr_2O_3	0.07		SO_3	0.15	
			Total	98.10	99.80

(1) Ural Mountains, Russia. (2) Mohave Co., Arizona, USA.

Polymorphism & Series: Dimorphous with perrierite.

Occurrence: As an accessory mineral in some granites, and in pegmatites associated with alkalic granite and syenites; in air-fall ash deposits.

Association: Titanite, monazite, apatite, cronstedtite, quartz (Aquarius Mountains, Arizona, USA).

Distribution: From the Ilmen Mountains, Southern Ural Mountains; the Keivy massif, Kola Peninsula; and elsewhere in Russia. At Buer, Björkedalen, Norway. From Glen Bay, Na h-Eagan, and Conachair, in the Isles of St. Kilda, Outer Hebrides, Scotland. In Madagascar, from the Tordendrika-Ifasina region, Androngovato, and Ifasina, Ambatofinandrahana. In the USA, in the Aquarius Mountains, Mohave Co., Arizona; the Jemez Mountains and Pueblo Mesa, Rio Arriba Co., New Mexico; at Onion Creek, Grand Co., Utah; in Yellowstone National Park, Wyoming; from Irish Flats, Meade Co., Kansas. Also in the Spruce Pine district, Mitchell Co., North Carolina; near Martin's Store, Nelson Co., Virginia; and in New Hampshire, from near Stark, Coos Co. A few other localities have been verified.

Name: In honor of General-Major Konstantin Vladimirovich Tschevkin [Chevkin] (1802–1875), Chief of Staff of the Russian Mining Engineers Corps.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 718.
(2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 309–312. (3) Kauffman, A.J., Jr. and H.W. Jaffe (1946) Chevkinite (tscheffkinite) from Arizona. Amer. Mineral., 31, 582–588. (4) Mitchell, R.S. (1966) Virginia metamict minerals: perrierite and chevkinite. Amer. Mineral., 51, 1394–1405. (5) Izett, G.A. and R.E. Wilcox (1968) Perrierite, chevkinite, and allanite in upper Cenozoic ash beds in the western United States. Amer. Mineral., 53, 1558–1567.

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Chiavennite $CaMn^{2+}Be_2Si_5O_{13}(OH)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $mm2$. Crystals are hemimorphic, spearhead-shaped, flattened on {010}, and display the pyramid {161}, to 1 cm. In aggregates and spherulites of such crystals; as grains and crusts.

Physical Properties: *Cleavage:* Good to perfect on {100}, {010}, and {001}. Hardness = ∼3 D(meas.) = 2.56–2.64 D(calc.) = 2.65

Optical Properties: Translucent. *Color:* Pale orange-yellow; in thin section, colorless to yellow or orange-yellow; color sharply zoned near crystal margins. *Streak:* White to pale ocher. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = colorless to pale yellow; Z = yellow-orange. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Absorption:* $Z > X$. α = 1.594–1.596 β = 1.600 γ = 1.613–1.618 2V(meas.) = n.d. 2V(calc.) = 50°

Cell Data: *Space Group:* $P2_1ab$. $a = 8.866(7)$ $b = 31.34(2)$ $c = 4.787(3)$ Z = 4

X-ray Powder Pattern: Tanno, Italy.
15.7 (100bb), 2.903 (100), 3.28 (75), 4.15 (30), 3.93 (30b), 3.82 (30), 1.944 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	52.5	50.0	Na_2O	0.3	0.68
Al_2O_3	3.6	6.76	K_2O		0.04
FeO		2.01	F		0.21
MnO	12.9	10.6	H_2O	11.3	10.4
BeO	9.3	8.72	CO_2		0.83
MgO		0.14	$-O = F_2$		0.09
CaO	10.2	9.69	Total	100.1	99.99

(1) Tanno, Italy; by electron microprobe; Be determined spectrographically, H_2O by TGA; corresponds to $(Ca_{0.97}Na_{0.05})_{\Sigma=1.02}Mn_{0.97}(Be_{1.98}Al_{0.03})_{\Sigma=2.01}(Si_{4.65}Al_{0.35})_{\Sigma=5.00}O_{12.63}(OH)_{2.37} \cdot 2.16H_2O$. (2) Langangen, Norway; by a variety of analytical methods; corresponds to $(Ca_{0.92}Na_{0.12})_{\Sigma=1.04}(Mn_{0.80}Fe_{0.15}Mg_{0.02})_{\Sigma=0.97}(Be_{1.86}Al_{0.14})_{\Sigma=2.00}(Si_{4.43}Al_{0.57})_{\Sigma=5.00}O_{12.45}(OH)_{2.49}F_{0.06} \cdot 1.83H_2O$.

Occurrence: Coating beryl in late-stage pegmatites (Tanno, Italy); in vugs in syenite pegmatites (Norway).

Association: Beryl, bavenite (Tanno, Italy); analcime, aegirine, helvite, eudidymite, natrolite, feldspar (Norway).

Distribution: From Tanno, Chiavenna, Lombardy, Italy. In Norway, in the Heia and Vevja larvikite quarries, near Larvik, Tvedalen district; near Blåfjell, Langangen, and in the Saga larvikite quarry, Porsgrunn, Langesundsfjord; and at Bakkane, Brunlanes. Large crystals on Utö Island, Sweden.

Name: For the Italian locality at Tanno, Chiavenna.

Type Material: University of Rome, Rome, Italy, 24342; University of Oslo, Norway; National Museum of Natural History, Washington, D.C., USA, 159917.

References: (1) Bondi, M., W.L. Griffin, V. Mattioli, and A. Mottana (1983) Chiavennite, $CaMnBe_2Si_5O_{13}(OH)_2 \cdot 2H_2O$, a new mineral from Chiavenna (Italy). Amer. Mineral., 68, 623–627. (2) Raade, G., R. Åmli, M.H. Mladeck, V.K. Din, A.O. Larsen, and A. Åsheim (1983) Chiavennite from syenite pegmatites in the Oslo Region, Norway. Amer. Mineral., 68, 628–633.

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Childrenite $Fe^{2+}Al(PO_4)(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic; probably monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$ $2/m$ $2/m$. As equant to pyramidal crystals, may be short prismatic along [001], thick tabular on {010}, or platy on {100}, commonly doubly terminated, to 2 cm; in radiating groups and fibrous crusts; massive. *Twinning:* May show twinning on {100} and {001}, observed optically, to give pseudo-orthorhombic symmetry; may be due to oxidation.

Physical Properties: *Cleavage:* {100}, poor. *Fracture:* Subconchoidal to uneven. Hardness = 5 D(meas.) = 3.11–3.19 D(calc.) = 3.12–3.15

Optical Properties: Transparent to translucent. *Color:* Yellowish brown to brown, clove-brown. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (–). *Pleochroism:* X = yellow; Y = pink; Z = pale pink to colorless. *Orientation:* $X = b$; $Y = a$; $Z = c$; $Y \wedge c = 4°$–$8°$ in optically twinned individuals. *Dispersion:* $r > v$, strong, for near end-member composition. $\alpha = 1.644$–1.649 $\beta = 1.662$–1.683 $\gamma = 1.671$–1.691 2V(meas.) = 50° in optically twinned crystals.

Cell Data: *Space Group: Bba*2. $a = 10.395(1)$ $b = 13.394(1)$ $c = 6.918(1)$ Z = 8

X-ray Powder Pattern: Stari Trg mine, Serbia.
2.816 (100), 6.71 (64), 2.419 (50), 1.521 (40), 5.197 (36), 3.528 (28), 4.362 (22)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	29.92	30.88	CaO	0.65	
Al_2O_3	21.43	22.18	Na_2O	0.37	
FeO	28.56	31.26	H_2O	15.80	15.68
MnO	3.11		Total	99.84	100.00

(1) Crinnis and Carlyon mine, Cornwall, England. (2) $FeAl(PO_4)(OH)_2 \cdot H_2O$.

Polymorphism & Series: Forms a series with eosphorite.

Occurrence: In some complex granite pegmatites, typically a low-temperature hydrothermal alteration product of primary phosphate minerals.

Association: Siderite, pyrite, apatite, quartz (Tavistock, England); zinnwaldite, tourmaline, apatite, kaolinite (Greifensteine, Germany).

Distribution: In England, from Devon, near Tavistock, at Wheal Crebor, the George and Charlotte mine, Russell United mines, Wheal Betsy, and many other places; from Cornwall, in the Crinnis and Carlyon mine, Wheal Jane, and elsewhere; from the Cobalt mine, Scar Crag, Causey Pike, Keswick, Cumbria. On the Greifensteine, near Ehrenfriedersdorf, Saxony, and Hagendorf, Bavaria. In the Stari Trg mine (Trepča), Kosovo, Serbia. At the Fram pegmatite, Kamativi, and the Kondo pegmatite, Miami, Zimbabwe. In the USA, in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire. From the Rapid Creek–Big Fish River area, Yukon Territory, Canada. Large crystals at the João Modesto dos Santos mine, and from a number of other mines around Linópolis and Mendes Pimental, Minas Gerais, Brazil. At the Siglo XX mine, Llallagua, Potosí, Bolivia. In the Moculta phosphate quarry, northeast of Angaston, South Australia. Other localities are known; the Fe:Mn ratio however should be confirmed.

Name: In honor of John George Children (1777–1852), English chemist and mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 936–939. (2) Hurlbut, C. (1950) Childrenite-eosphorite series. Amer. Mineral., 35, 793–805. (3) Braithwaite, R.S.W. and B.V. Cooper (1982) Childrenite in south-west England. Mineral. Mag., 46, 119–126. (4) Giuseppetti, G. and C. Tadini (1984) The crystal structure of childrenite from Tavistock (SW England), $Ch_{89}Eo_{11}$ term of childrenite–eosphorite series. Neues Jahrb. Mineral., Monatsh., 263–271. (5) Bermanec, V., S. Šćavničar, and V. Zebec (1995) Childrenite and crandallite from the Stari Trg mine (Trepča), Kosovo: new data. Mineral. Petrol., 52, 197–208.

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Chiluite $Bi_6Te_2^{6+}Mo_2^{6+}O_{21}$

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Crystal Data: Hexagonal. *Point Group:* 622, $6/m$, or 6. As hexagonal to irregular grains, to 42 μm, or plumose replacements of other bismuth minerals.

Physical Properties: Hardness = 3.2 VHN = 108 (10 g load). D(meas.) = 3.65 D(calc.) = 3.67

Optical Properties: Semitransparent. *Color:* Yellow; gray in reflected light, with gray-brown internal reflections.
Optical Class: Uniaxial (–). $\omega = 2.4(1)$ $\epsilon = 2.3(1)$ *Anisotropism:* Weak.
R_1–R_2: (410) 19.45–20.75, (430) 19.25–20.45, (450) 18.80–20.00, (470) 18.40–19.50, (490) 18.00–18.90, (510) 17.75–18.60, (530) 17.50–18.40, (550) 17.25–18.25, (570) 17.00–18.05, (590) 16.75–17.80, (610) 16.65–17.60, (630) 16.50–17.40, (650) 16.45–17.30, (670) 16.30–17.20, (690) 16.75–17.00

Cell Data: *Space Group:* $P6_322$, $P6_3m$, or $P6_3$. $a = 8.970$ $c = 13.21$ $Z = 1$

X-ray Powder Pattern: Chilu, China.
3.30 (100), 3.05 (90), 2.51 (50), 2.06 (50), 1.655 (50), 2.88 (40)

Chemistry:

	(1)	(2)
TeO_3	15.83	17.24
MoO_3	15.40	14.13
WO_3	0.21	
Bi_2O_3	68.59	68.63
Sb_2O_3	0.17	
Total	100.20	100.00

(1) Chilu, China; by electron microprobe, average of 24 analyses; O^{2-} confirmed by analysis of synthetic compound, with oxidation states as required for charge balance. (2) $Bi_6Te_2Mo_2O_{21}$.

Occurrence: In quartz veins in a molybdenite deposit.

Association: Bismuthinite, molybdenite, joséite, köchlinite, cassiterite, quartz.

Distribution: From Chilu, Fujian Province, China.

Name: For the occurrence at Chilu, China.

Type Material: n.d.

References: (1) Xiuzhen Yong, Deren Li, Guanxin Wang, Mengxiang Deng, Nansheng Chen, and Shuzhen Wang (1991) A study of chiluite – a new mineral found in Chilu, Fujian, China. Acta Mineralogica Sinica, 9(1), 9–14 (in Chinese with English abs.). (2) (1991) Amer. Mineral., 76, 666 (abs. ref. 1).

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Chiolite $Na_5Al_3F_{14}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals, to 10 cm, dipyramidal {111}, with {001} and {114}; commonly granular, massive. *Twinning:* On {011}.

Physical Properties: *Cleavage:* {001}, perfect; {011}, distinct. Hardness = 3.5–4 D(meas.) = 2.994–3.005 D(calc.) = 2.998

Optical Properties: Transparent to translucent. *Color:* Nearly colorless to snow-white; colorless in transmitted light. *Luster:* Vitreous, pearly on the basal cleavage. *Optical Class:* Uniaxial (–). $\omega = 1.3486$ $\epsilon = 1.3424$

Cell Data: *Space Group:* $P4/mnc$. $a = 7.00$–7.01 $c = 10.39$–10.41 $Z = 2$

X-ray Powder Pattern: Synthetic; composite pattern. (ICDD 2-749).
2.91 (100), 5.18 (80), 2.32 (70), 1.99 (70), 1.79 (70), 1.75 (70), 1.55 (70)

Chemistry:

	(1)	(2)	(3)
Na	24.97	24.79	24.89
Al	17.66	17.54	17.53
F	57.30	57.81	57.58
H_2O^-		0.23	
Total	99.93	100.37	100.00

(1) Miass, Russia. (2) Ivigtut, Greenland. (3) $Na_5Al_3F_{14}$.

Occurrence: In some granite pegmatites.

Association: Topaz, phenakite, fluorite, cryolithionite, thomsenolite (Miass, Russia); cryolite, elpasolite, pachnolite, thomsenolite, ralstonite (Amelia, Virginia, USA).

Distribution: At Miass, Ilmen Mountains, Southern Ural Mountains, Russia. From the Ivigtut cryolite deposit, southwestern Greenland. In the USA, in the Morefield pegmatite mine, Amelia, Amelia Co., Virginia.

Name: From the Greek for *snow* and *stone*, as compared to *cryolite*, *ice-stone*.

Type Material: Vernadsky State Geological Museum, Moscow, Russia, 18270, 18271.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 123–124. (2) Jacobini, C., A. Leble, and J.J. Rosseau (1981) Détermination précise de la structure de la chiolite $Na_5Al_3F_{14}$ et étude par R.P.E. de $Na_5Al_3F_{14}$:Cr^{3+}. J. Solid State Chem., 36, 297–304 (in French with English abs.). (3) Dirken, P.J., J.B.H. Jansen, and R.D. Schuiling (1992) Influence of octahedral polymerization on ^{23}Na and ^{27}Al MAS NMR in alkali fluoroaluminates. Amer. Mineral., 77, 718–724.

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Chkalovite $Na_2BeSi_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As complex equant crystals, to 5 mm; massive.

Physical Properties: *Cleavage:* Fair in one direction; indistinct in two other directions. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 2.662 D(calc.) = 2.70

Optical Properties: Transparent to translucent. *Color:* White; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). $\alpha = 1.544$ $\beta = [1.546]$ $\gamma = 1.549$ 2V(meas.) = 62°–82°

Cell Data: *Space Group:* $Fdd2$. $a = 21.129(5)$ $b = 6.881(2)$ $c = 21.188(5)$ Z = 24

X-ray Powder Pattern: Lovozero massif, Russia.
3.97 (vs), 2.46 (vs), 2.41 (vs), 1.79 (s), 1.48 (s), 1.40 (s), 1.11 (s)

Chemistry:

	(1)	(2)
SiO_2	56.81	58.01
Fe_2O_3	0.30	
FeO	0.12	
BeO	12.67	12.07
CaO	0.37	
Na_2O	28.93	29.92
K_2O	0.13	
H_2O^-	0.23	
SO_3	0.22	
Total	99.78	100.00

(1) Lovozero massif, Russia. (2) $Na_2BeSi_2O_6$.

Occurrence: In veins in pegmatite in a differentiated alkalic massif (Lovozero massif, Russia); in sodalite xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Manganoan pectolite, microcline, sodalite, eudialyte, neptunite, ussingite (Lovozero massif, Russia); villiaumite, ussingite, sodalite, aegirine, lovozerite, vuonnemite, sérandite, lueshite, steenstrupine (Mont Saint-Hilaire, Canada).

Distribution: At two locations on Mt. Punkaruaiv, Lovozero massif, and in the Khibiny massif, Kola Peninsula, Russia. On the Kangerdluarssuk Plateau and on the Taseq slope, in the Ilímaussaq intrusion, southern Greenland. From Mont Saint-Hilaire, Quebec, Canada.

Name: For Valerii Pavlovich Chkalov (1904–1938), first to fly nonstop from Moscow to the USA across the North Pole.

Type Material: Vernadsky State Geological Museum, Moscow, 18767; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 40001.

References: (1) Gerasimovskii, V.I. (1939) Chkalovite. Doklady Acad. Nauk SSSR, 22, 259–263 (in Russian). (2) (1940) Amer. Mineral., 25, 380 (abs. ref. 1) (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 429–432 (in English). (4) Simonov, M.A., Y.K. Egorov, and N.V. Belov (1975) Refined crystal structure of chkalovite, $Na_2Be(Si_2O_6)$. Doklady Acad. Nauk SSSR, 225, 1319–1322 (in Russian). (5) (1977) Mineral. Abs., 28, 140 (abs. ref. 4). (6) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 57.

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Chladniite $Na_2CaMg_7(PO_4)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Granular, to 975 μm, and as rims around other phosphates and silicates.

Physical Properties: *Cleavage:* Rhombohedral, probable. Hardness = 4.5–5
D(meas.) = n.d. D(calc.) = 3.01

Optical Properties: Transparent. *Color:* Colorless, orange-brown with included iron oxides; gray in reflected light, with orange-brown internal reflections. *Luster:* Vitreous to resinous. *Optical Class:* Uniaxial. n = 1.60–1.61 *Anisotropism:* Weak. *Bireflectance:* Weak.

Cell Data: *Space Group:* $R\overline{3}$. a = 14.967(2) c = 42.595(4) Z = 18

X-ray Powder Pattern: Carleton meteorite.
3.694 (s), 2.960 (s), 2.753 (s), 3.558 (m), 2.500 (m), 2.126 (m), 1.851 (m)

Chemistry:

	(1)	(2)	(3)
P_2O_5	49.9	45.8	51.55
SiO_2	0.59		
FeO	2.2	16.0	
MnO	0.30	10.12	
NiO		0.08	
MgO	33.5	17.55	34.16
CaO	6.59	3.60	6.79
Na_2O	6.6	6.66	7.50
Total	99.68	99.81	100.00

(1) Carleton meteorite; by electron microprobe, average of five analyses; corresponding to $Na_{1.77}Ca_{0.96}(Mg_{6.96}Fe_{0.26}Mn_{0.04})_{\Sigma=7.26}[(P_{0.96}Si_{0.08})_{\Sigma=1.04}O_4]_6$. (2) GRA 95209 meteorite; by electron microprobe, average of 8 analyses, total Fe as FeO, total Mn as MnO; corresponds to $Na_{1.99}(Ca_{0.60}Mg_{0.43})_{\Sigma=1.03}(Mg_{3.60}Fe_{2.07}Mn_{1.33})_{\Sigma=7.00}(P_{0.98}O_4)_6$. (3) $Na_2CaMg_7(PO_4)_6$.

Occurrence: As a single grain in a phosphate-rich inclusion in an iron meteorite (Carleton meteorite); in phosphate-rich portions of an acapulcoite-lodranite meteorite.

Association: Chlorapatite, olivine, pyroxene, plagioclase, schreibersite, nickel-iron, troilite, kamacite, hydrated iron oxides [of terrestrial origin] (Carleton meteorite); magnesian graftonite, orthopyroxene, olivine, plagioclase, nickel-iron (GRA 95209 meteorite).

Distribution: In the Carleton type IIICD iron and GRA 95209 primitive achrondite meteorites.

Name: Honors Professor Ernst Florens Friedrich Chladni (1756–1827), German physicist, University of Riga, Riga, Latvia, who first published the hypothesis that meteorites were of extraterrestrial origin.

Type Material: National Museum of Natural History, Washington, D.C., USA, 2707.

References: (1) McCoy, T.J., I.M. Steele, K. Keil, B.F. Leonard, and M. Endre (1994) Chladniite, $Na_2CaMg_7(PO_4)_6$: a new mineral from the Carleton (IIICD) iron meteorite. Amer. Mineral., 79, 375–380. (2) Floss, C. (1999) Fe,Mg,Mn-bearing phosphates in the GRA 95209 meteorite: occurrences and mineral chemistry. Amer. Mineral., 84, 1354–1359.

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Chloraluminite $AlCl_3 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As rhombohedral crystals, showing {0001}, $\{11\overline{2}0\}$, and $\{10\overline{1}1\}$; as crusts, stalactites, compact masses.

Physical Properties: Hardness = Soft. D(meas.) = 1.644 (synthetic). D(calc.) = 1.666 (synthetic). Very soluble in H_2O; deliquescent.

Optical Properties: Transparent. *Color:* Colorless, white, yellow; colorless in transmitted light.
Optical Class: Uniaxial (–). $\omega = 1.560$ $\epsilon = 1.506$

Cell Data: *Space Group:* $R\overline{3}c$. $a = 11.827(6)$ $c = 11.895(3)$ Z = 2

X-ray Powder Pattern: Synthetic.
3.297 (100), 3.246 (55), 2.308 (50), 3.89 (40), 2.764 (40), 3.68 (35), 5.95 (25)

Chemistry: Natural material has not been analyzed.

Occurrence: As crusts around acidic fumaroles (Vesuvius, Italy).

Association: Molysite, chloromagnesite (Vesuvius, Italy); natroalunite, gypsum, anhydrite, pickeringite (Cerro Pintados, Chile).

Distribution: From Vesuvius, Campania, Italy. At Cerro Pintados, 80 km southeast of Iquique, Tarapacá, Chile. On Parícutin volcano, Michoacán, Mexico.

Name: For CHLORine and ALUMINum in its composition.

Type Material: Natural History Museum, Paris, France, 107480.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 50. (2) Mrose, M.E. (1971) New mineral data for hydrated phosphates and sulfates. U.S. Geol. Sur. Prof. Paper 750A, 115. (3) Buchanan, D.R. and P.M. Harris (1968) A neutron and X-ray diffraction investigation of aluminum chloride hexahydrate. Acta Cryst., 24, 954–960. (4) (1957) NBS Circ. 539, 7, 3.

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Chlorapatite $Ca_5(PO_4)_3Cl$

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Crystal Data: Hexagonal or monoclinic. *Point Group:* $6/m$ or $2/m$. As prismatic hexagonal crystals, to 5 cm; granular, massive, may be in zoned intergrowths with fluorapatite.

Physical Properties: *Cleavage:* Poor on {0001} and $\{10\bar{1}0\}$. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = 3.17–3.18 D(calc.) = 3.172 (monoclinic).

Optical Properties: Transparent to translucent. *Color:* Greenish yellow, pinkish white, light greenish gray. *Luster:* Vitreous.
Optical Class: Uniaxial (–), may be biaxial (–). *Pleochroism:* Weak to moderate; in pale colors. *Absorption:* $E > O$. $\omega = 1.650$–1.667 $\epsilon = 1.647$–1.665 $\alpha = 1.665$ $\beta = 1.667$ $\gamma = \sim 1.667$ 2V(meas.) = ∼10°

Cell Data: *Space Group:* $P6_3/m$. $a = 9.5979$ $c = 6.7762$ Z = 2, or *Space Group:* $P2_1/b$. $a = 9.605$ $b = 19.210$ $c = 6.785$ $\beta = 120°$ Z = 6

X-ray Powder Pattern: Bob's Lake, Canada.
2.853 (100), 2.770 (100), 1.960 (50), 1.838 (50), 3.39 (40), 2.306 (40), 1.910 (25)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	41.2	40.62	40.89	Cl	6.2	3.22	6.81
CaO	53.4	54.87	53.84	H_2O	0.09	0.50	
F	0.13	0.84		$-O = (F, Cl)_2$	1.45	1.08	1.54
				Total	99.57	98.97	100.00

(1) Bob's Lake, Canada; $Ca_{4.95}(PO_4)_{3.02}[Cl_{0.91}(OH)_{0.05}F_{0.04}]_{\Sigma=1.00}$. (2) Fairfax, Virginia, USA; H_2O calculated for stoichiometry, corresponding to $Ca_{5.13}(PO_4)_{3.00}[Cl_{0.48}(OH)_{0.29}F_{0.23}]_{\Sigma=1.00}$. (3) $Ca_5(PO_4)_3Cl$.

Polymorphism & Series: End-member chlorapatite is monoclinic.

Mineral Group: Apatite group; Cl > F or OH.

Occurrence: Relatively much rarer than fluorapatite or hydroxylapatite, formed in F-deficient environments. In calcsilicate marble; an accessory mineral in layered mafic intrusions; in veins through diabase; replacing triphylite in granite pegmatite. In meteorites.

Association: Actinolite, diopside, calcite, quartz, talc (Bob's Lake, Canada); amphibole, chlorite, plagioclase, titanite, datolite (Bull Run quarry, Virginia, USA); olivine, orthopyroxene, phlogopite, ferroalluaudite, chromite (Angarf-Sud pegmatite, Morocco).

Distribution: Analyzed material noted from: in the USA, the Fairfax quarry, Centreville, Fairfax Co., and Bull Run quarry, Loudoun Co., Virginia; at the Stillwater complex, Montana; in the White Picacho district, Maricopa and Yavapai Cos., Arizona. From Bob's Lake, Frontenac Co., Quebec, Canada. In the Bushveld complex, Transvaal, South Africa. At the Angarf-Sud pegmatite, Tazenakht Plain, Morocco. From Rajagarh, near Ajmer, Rajasthan, India. At Kurokura, Kangway Prefecture, Japan. From Kragerøand Ødegården, Bamble, and as large crystals from Snarum, Norway.

Name: For dominant *chlorine* and membership in the *apatite* group; see fluorapatite.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 879–889. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 297–334. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 81–84. (4) Hounslow, A.W. and G.Y. Chao (1970) Monoclinic chlorapatite from Ontario. Can. Mineral., 10, 252–259. (5) Mitchell, R.S. and T.V. Dagenhart, Jr. (1981) Chlorapatite from northern Virginia: the first occurrence in the United States. Southeastern Geology, 22, 45–52. (6) Hughes, J.M., M. Cameron, and K.D. Crowley (1989) Structural variation in natural F, OH, and Cl apatites. Amer. Mineral., 74, 870–876. (7) Hughes, J.M., M. Cameron, and K.D. Crowley (1990) Crystal structures of natural ternary apatites: solid solution in the $Ca_5(PO_4)_3X$ (X = F, OH, Cl) system. Amer. Mineral., 75, 295–304.

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Chlorargyrite AgCl

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals cubic, modified by {111} and {011}, to 1 cm; in parallel or subparallel groups; rarely as stalactites or columnar to coralloidal aggregates; fibrous; commonly massive, forming crusts and films. *Twinning:* On {111}.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Sectile and ductile; very plastic. Hardness = 2.5 D(meas.) = 5.556 D(calc.) = 5.57

Optical Properties: Transparent to translucent. *Color:* Colorless, pale yellow, gray; turns violet-brown to purple on exposure to light; colorless to yellow or green in transmitted light. *Streak:* White. *Luster:* Resinous to adamantine, waxy.
Optical Class: Isotropic. $n = 2.071$

Cell Data: *Space Group:* $Fm3m$. $a = 5.554$ Z = 4

X-ray Powder Pattern: Cornwall, England.
2.77 (100), 1.961 (60), 1.240 (40), 3.22 (30), 1.134 (30), 0.926 (30), 1.672 (20)

Chemistry:

	(1)	(2)	(3)
Ag	75.27	67.28	65.16
Cl	24.73	14.36	10.71
Br		15.85	24.13
I		2.35	
Total	100.00	99.84	100.00

(1) Chañarcillo, Chile. (2) Broken Hill, Australia. (3) Ag(Br, Cl) with Br:Cl = 1:1.

Polymorphism & Series: Dimorphous with bromargyrite.

Occurrence: May be a rich ore in the oxidized zone above silver deposits; commonly preserved in arid climates.

Association: Silver, cerussite, iodargyrite, atacamite, malachite, jarosite, Fe–Mn oxides.

Distribution: Only a few localities are given for fine crystals or exceptionally large or pure masses. In Germany, in Saxony, from Marienberg, Freiberg, Johanngeorgenstadt, Schneeberg, and others; at St. Andreasberg, Harz Mountains. From Joachimsthal, Czech Republic. In England, from the Calstock, Cambourne, and St. Just districts, and elsewhere in Cornwall. In Russia, at Schlangenberg, Altai Mountains. In the USA, from the Poorman mine, Silver City, Owyhee Co., Idaho; extraordinary masses in the Lake Valley district, near Hillsboro, Sierra Co., New Mexico; from Tombstone, Cochise Co., and Richmond Basin, near Globe, Gila Co., Arizona; in Nevada, from Bullfrog, Nye Co. and Rochester, Humboldt Co. From Santa Eulalia, Chihuahua; Catorce, San Luis Potosi; and elsewhere in Mexico. In Chile, from Chañarcillo, south of Copiapó, Atacama; at Caracoles, east of Sierra Gorda, Antofagasta; and Huantajaya, Tarapacá. At Broken Hill, New South Wales, Australia, in exceptional masses.

Name: For CHLORine, and the Greek for silver, *argyros*, in its composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 11–15 [cerargyrite]. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 215.

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Chlorartinite $Mg_2(CO_3)Cl(OH)\cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $3m$. As granular aggregates, with grains to 0.01 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.84 Slowly soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White. *Streak:* White.
Optical Class: Uniaxial. $n = 1.510$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R3c$ or $R\overline{3}c$. $a = 23.163(4)$ $c = 7.221(2)$ $Z = 18$

X-ray Powder Pattern: Tolbachik fissure volcano, Russia.
11.66 (100), 3.000 (41), 2.657 (22), 3.264 (21), 3.218 (21), 3.396 (17), 3.356 (17)

Chemistry:

	(1)	(2)
SO_3	0.25	
CO_2	15.35	20.46
MgO	26.26	37.47
CaO	3.70	
Na_2O	1.33	
K_2O	0.52	
Cl	13.65	16.48
H_2O^+	19.52	
H_2O^-	8.39	
H_2O		29.31
insol.	14.40	
$-O = Cl_2$	3.08	3.72
Total	100.29	100.00

(1) Tolbachik volcano, Russia; $(CO_3)^{2-}$ and $(OH)^{1-}$ confirmed by IR; after deduction of halite 3.3% and gypsum 0.4%, corresponds to $(Mg_{1.82}Ca_{0.18})_{\Sigma=2.00}(CO_3)_{0.98}Cl_{1.07}(OH)_{0.98}\cdot 3.05H_2O$.
(2) $Mg_2(CO_3)Cl(OH)\cdot 3H_2O$.

Occurrence: In sublimates around a volcanic fissure.

Association: Halite, gypsum, aragonite, nesquehonite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: For essential *chlorine* and chemical relation to *artinite*.

Type Material: Mining Institute, Saint Petersburg, Russia.

References: (1) Vergasova, L.P., S.K. Filatov, Y.K. Serafimova, and S.V. Sergeyeva (1998) Chlorartinite $Mg_2(CO_3)ClOH\cdot 3H_2O$ – a new mineral from exhalations. Zap. Vses. Mineral. Obshch., 127(2), 55–59 (in Russian). (2) (1999) Amer. Mineral., 84, 1195–1196 (abs. ref. 1).

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Chlorellestadite $Ca_5(SiO_4, SO_4, PO_4)_3(Cl, F)$

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Crystal Data: Hexagonal or monoclinic, pseudohexagonal. *Point Group:* $6/m$ or $2/m$. Massive, granular.

Physical Properties: *Cleavage:* Indistinct on {0001} and $\{10\bar{1}0\}$. Hardness = ~5 D(meas.) = 3.068 D(calc.) = 3.046

Optical Properties: Translucent. *Color:* Pale rose, rose-pink, orange. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.655(2)$ $\epsilon = 1.650(2)$

Cell Data: *Space Group:* $P6_3/m$. a = 9.530(2) $c = 6.914(2)$ Z = 2

X-ray Powder Pattern: Crestmore, California, USA.
2.843 (100), 2.751 (70), 3.458 (50), 2.800 (40), 1.964 (40), 1.855 (40), 2.651 (30)

Chemistry:

	(1)		(1)
SiO_2	17.31	Cl	1.64
Al_2O_3	0.13	H_2O^+	0.53
Fe_2O_3	0.22	H_2O^-	0.10
MnO	0.01	CO_2	0.61
MgO	0.47	P_2O_5	3.06
CaO	55.18	SO_3	20.69
F	0.57	$-O = (F, Cl)_2$	0.61
		Total	99.91

(1) Crestmore, California, USA.

Mineral Group: Ellestadite group.

Occurrence: In veinlets cutting contact metamorphosed limestone.

Association: Diopside, wollastonite, vesuvianite, monticellite, okenite, calcite.

Distribution: From Crestmore, Riverside Co., California, USA.

Name: For Dr. Reuben B. Ellestad (1900–), American analytical chemist, University of Minnesota, Minneapolis, Minnesota, USA, and *chlorine* in the chemical composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 906 [ellestadite]. (2) McConnell, D. (1937) The substitution of SiO_4- and SO_4-groups for PO_4-groups in the apatite structure; ellestadite, the end-member. Amer. Mineral., 22, 977–986. (3) Rouse, R.C. and P.J. Dunn (1982) A contribution to the crystal chemistry of ellestadite and the silicate sulfate apatites. Amer. Mineral., 67, 90–96.

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Chloritoid $(Fe^{2+}, Mg, Mn)_2Al_4Si_2O_{10}(OH)_4$

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Crystal Data: Monoclinic or triclinic, both pseudohexagonal. *Point Group:* $2/m$ or 1. Rarely as rosettes of pseudohexagonal tabular crystals; commonly coarsely foliated with foliae typically curved or bent; massive. *Twinning:* Common on {001}, may be lamellar; twin axes [100], [110], and [130] observed.

Physical Properties: *Cleavage:* Perfect on {001}, distinct on {110}; parting on {010}. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 3.46–3.80 D(calc.) = 3.56

Optical Properties: Translucent. *Color:* Dark gray, greenish gray, greenish black; colorless to green in thin section. *Streak:* White, grayish, or very slightly greenish. *Luster:* Somewhat pearly on cleavage surfaces.
Optical Class: Biaxial (+) or (–). *Pleochroism:* X = olive-green to yellow; Y = grayish blue to blue; Z = colorless to pale greenish yellow. *Orientation:* X or $Y = b$ (monoclinic); $Z \wedge c$ = 2°–30°; $Y \simeq b$ (triclinic). *Dispersion:* $r > v$, strong. α = 1.705–1.730 β = 1.708–1.734 γ = 1.712–1.740 2V(meas.) = ∼45°–70°

Cell Data: *Space Group:* $C2/c$. a = 9.50(3) b = 5.50(2) c = 18.22(5) $\beta = 101°57(5)'$ Z = 4, or *Space Group:* $C\overline{1}$. a = 9.46(1) b = 5.50(1) c = 9.15(1) $\alpha = 97.05(2)°$ $\beta = 101.56(2)°$ $\gamma = 90.10(2)°$ Z = 4

X-ray Powder Pattern: Natick, Rhode Island, USA.
4.498 (100), 4.449 (100), 2.963 (90), 1.5813 (80), 2.367 (70), 2.306 (70), 2.639 (50)

Chemistry:

	(1)		(1)
SiO_2	23.91	CaO	0.04
TiO_2	0.20	Na_2O	0.00
Al_2O_3	40.12	K_2O	trace
Fe_2O_3	1.23	F	0.01
FeO	27.06	H_2O^+	7.03
MnO	0.16	H_2O^-	0.01
MgO	0.51	Total	100.28

(1) Natick, Rhode Island, USA; corresponds to $(Fe^{2+}_{1.89}Mg_{0.06}Mn_{0.01})_{\Sigma=1.96}$ $(Al_{3.95}Fe^{3+}_{0.08}Ti_{0.01})_{\Sigma=4.04}Si_{2.00}O_{9.80}(OH)_{3.20}$.

Polymorphism & Series: Forms a series with carboirite; monoclinic and triclinic polytypes are known.

Mineral Group: Chloritoid group.

Occurrence: In regionally metamorphosed pelitic sediments and schists in the biotite, garnet, and lower grade staurolite zones; in quartz-carbonate veins and other hydrothermal environments.

Association: Muscovite, chlorite, staurolite, garnet, kyanite, quartz, mica, rutile.

Distribution: A widely distributed mineral; only a few studied occurrences are noted. In Russia, from Kosoi Brod, Mramorskii Zavod, south of Yekaterinburg (Sverdlovsk), Ural Mountains. At Salmchâteau, near Ottré, Ardennes Mountains, Belgium. From Nadels and Zermatt, Valais, Switzerland. At Prägraten, Tirol, Austria. In Scotland, along the coast between Stonehaven and Aberdeen; and from Unst, Shetland Islands. Around Tintagel, Cornwall, England. In the USA, at Natick, Kent Co., Rhode Island; Chester, Hampden Co., Massachusetts; in Clove Valley, Duchess Co., New York; from Bull Mountain, Patrick Co., Virginia. In Canada, at Chibougamau and St. Giles, Quebec. From Kalgoorlie, Western Australia.

Name: For its resemblance to members of the *chlorite* group.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 640–642. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 867–912. (3) Halferdahl, L.B. (1961) Chloritoid: its composition, X-ray and optical properties, stability and occurrence. J. Petrol., 2, 49–135. (4) Hanscomb, R.H. (1980) The structure of triclinic chloritoid and chloritoid polymorphism. Amer. Mineral., 65, 534–539.

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Chlormagaluminite $(Mg, Fe^{2+})_4Al_2(OH)_{12}(Cl_2, CO_3)\cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $6mm$, or $\overline{6}m2$. As hexagonal dipyramidal crystals, in aggregates, > 1 mm.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = Very soft. D(meas.) = 1.98–2.09 D(calc.) = 2.06

Optical Properties: Semitransparent. *Color:* Colorless to yellow-brown; colorless in transmitted light. *Luster:* Vitreous to pearly on cleavage surfaces.
Optical Class: Uniaxial (+). $\omega = 1.540(3)$ $\epsilon = 1.560(3)$

Cell Data: *Space Group:* $P6_3/mcm$, $P6_3cm$, or $P\overline{6}c2$. $a = 5.29$ $c = 15.46$ Z = [1]

X-ray Powder Pattern: Kapaevskaya pipe, Russia.
7.67 (10), 1.839 (10), 2.34 (9), 2.17 (9), 1.526 (9), 1.496 (9), 3.86 (8)

Chemistry:

	(1)
TiO_2	0.20
Al_2O_3	21.20
Fe_2O_3	1.15
FeO	4.10
MnO	0.05
MgO	30.84
Na_2O	0.36
Cl	11.31
H_2O^+	27.19
H_2O^-	5.20
CO_2	1.10
$-O = Cl_2$	2.55
Total	100.15

(1) Kapaevskaya pipe, Russia; corresponds to $(Mg_{3.55}Fe^{2+}_{0.27}Na_{0.05})_{\Sigma=3.87}(Al_{1.93}Fe^{3+}_{0.07}Ti_{0.01})_{\Sigma=2.01}(OH)_{12}[Cl_{1.48}(\frac{1}{2}CO_3)_{0.24}]_{\Sigma=1.72}\cdot 2.42H_2O$.

Mineral Group: Manasseite group.

Occurrence: In iron-ore skarns in an explosion pipe.

Association: Magnetite, magnesian chlorite.

Distribution: In the Kapaevskaya pipe, middle Angara River, Irkutsk district,southern Siberia, Russia.

Name: For its principal components, CHLORine, MAGnesium, and ALUMINum.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82771.

References: (1) Kashaev, A.A., G.D. Feoktistov, and S.V. Petrova (1982) Chlormagaluminite, $(Mg, Fe^{2+})_4Al_2(OH)_{12}(Cl, \frac{1}{2}CO_3)_2\cdot 2H_2O$ – a new mineral of the manasseite-sjögrenite group. Zap. Vses. Mineral. Obshch., 11, 121–127 (in Russian). (2) (1983) Amer. Mineral., 68, 849 (abs. ref. 1). (3) Feoktistov, G.D., S.I. Ivanov, A.A. Kashaev, L.N. Klyuchanskii, N.G. Taskina, and Z.F. Ushchapovskaya (1978) The occurrence of chlormanasseite [= chlormagaluminite] in the USSR. Zap. Vses. Mineral. Obshch., 107, 321–325. (in Russian). (4) (1980) Mineral. Abs., 31, 226 (abs. ref. 3).

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Chlormanganokalite K_4MnCl_6

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As rhombohedra, which may be in parallel groupings.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5
D(meas.) = 2.31; 2.315 (synthetic). D(calc.) = 2.303 (synthetic). Readily soluble in H_2O; deliquescent.

Optical Properties: Transparent. *Color:* Pale wine-yellow, lemon-yellow, canary-yellow.
Luster: Vitreous.
Optical Class: Uniaxial (+). $n = 1.59$, low birefringence.

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic). $a = 11.93$ $c = 14.79$ Z = 6

X-ray Powder Pattern: Synthetic. (ICDD 3-856).
2.55 (100), 2.69 (80), 5.90 (50), 3.55 (50), 2.82 (28), 3.45 (24), 2.50 (24)

Chemistry:

	(1)	(2)
KCl	69.42	70.32
$MnCl_2$	26.45	29.68
$MgCl_2$	0.16	
Na_2SO_4	1.19	
H_2O	1.52	
insol.	0.71	
Total	99.45	100.00

(1) Vesuvius, Italy. (2) K_4MnCl_6.

Occurrence: In cavities in ejected scoria.

Association: Halite, sylvite, hematite.

Distribution: On Vesuvius, Campania, Italy.

Name: For CHLORine, MANGANese, and potassium (KALium), in its composition.

Type Material: Natural History Museum, Paris, France, 106.340, 106.341 [decomposed]; The Natural History Museum, London, England, 1907,191–193.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 109. (2) Bellanca, A. (1947) La struttura della cloromanganocalite. Periodico Miner. 16(1–2), 73–88 (in Italian).

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Chlorocalcite $KCaCl_3$

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Crystal Data: Orthorhombic, pseudocubic (probable). *Point Group:* $2/m\ 2/m\ 2/m$. Crystals pseudocubic, with pseudododecahedral and pseudo-octahedral modifications, may be prismatic or tabular. *Twinning:* Polysynthetic, lamellar parallel pseudocube faces.

Physical Properties: *Cleavage:* In three nearly perpendicular directions, one direction better than the other two. Hardness = 2.5–3 D(meas.) = n.d. D(calc.) = 2.16 Deliquescent, bitter taste.

Optical Properties: Semitransparent. *Color:* White, may be violet.
Optical Class: Biaxial (–); weak birefringence. $n = \sim 1.52$ 2V(meas.) = n.d.

Cell Data: *Space Group: Pnma* (synthetic). $a = 7.551$ $b = 10.442$ $c = 7.251$ Z = 5

X-ray Powder Pattern: Synthetic.
2.612 (100), 3.137 (35), 3.697 (30), 3.119 (30), 5.227 (25), 2.107 (25), 3.058 (18)

Chemistry:

	(1)	(2)
Na	0.17	
K	21.44	21.07
Ca	21.40	21.60
Cl	57.56	57.33
Total	100.57	100.00

(1) Vesuvius, Italy. (2) $KCaCl_3$.

Occurrence: As a sublimate in volcanic fumaroles (Vesuvius, Italy).

Association: Sylvite, halite, hematite (Vesuvius, Italy); halite, tachyhydrite (Stassfurt, Germany).

Distribution: On Vesuvius, Campania, Italy. From Stassfurt, 34 km south of Magdeburg, Saxony-Anhalt, Germany.

Name: For CHLORine and CALCium in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 91–92. (2) (1969) NBS Mono. 25, 7, 36.

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Chloromenite $Cu_9O_2(Se^{4+}O_3)_4Cl_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are platy on $\{\overline{1}01\}$, elongated along [111] or $[1\overline{1}1]$, may be equant, with well-developed {001}, $\{\overline{1}01\}$ {101}, {110}, {011}, $\{\overline{3}12\}$, poor $\{\overline{3}01\}$, {310}, to 0.2 mm

Physical Properties: *Cleavage:* Perfect on {101}. *Tenacity:* Plastic. Hardness = n.d. VHN = 60–63, 62 average (5 g load). D(meas.) = n.d. D(calc.) = 4.15(1)

Optical Properties: Transparent. *Color:* Tobacco-green. *Streak:* Yellowish green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = green; Y = pale brownish green; Z = dark brownish green. *Orientation:* $Y = b$; $Z \simeq c$. *Absorption:* $Z > X > Y$. $\alpha = 1.87(1)$ $\beta = 1.92(1)$ $\gamma = 1.94(1)$ 2V(meas.) = 66(2)° 2V(calc.) = 63°

Cell Data: *Space Group:* $I2/m$. $a = 14.170(3)$ $b = 6.262(1)$ $c = 12.999(3)$ $\beta = 113.05(1)°$ Z = 2

X-ray Powder Pattern: Tolbachik volcano, Russia; shows significant preferred orientation. 3.450 (100), 5.56 (83), 11.29 (63), 2.486 (61), 3.239 (39), 2.714 (31), 3.643 (25)

Chemistry:

	(1)	(2)
SeO_2	34.37	33.51
CuO	46.23	54.05
ZnO	5.94	
Cl	16.57	16.06
$-O = Cl_2$	3.74	3.62
Total	[99.37]	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of four analyses, original total given as 99.36%; corresponds to $(Cu_{7.71}Zn_{0.97})_{\Sigma=8.68}O_{1.80}(Se_{1.03}O_3)_4Cl_{6.20}$. (2) $Cu_9O_2(SeO_3)_4Cl_6$.

Occurrence: Formed in a volcanic fumarole.

Association: Melanothallite, sofiite, georgbokiite, ilinskite, chloromenite, burnsite, cotunnite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: From the Greek for *green*, in allusion to its color, and for *moon*, for its *selenium* content.

Type Material: Department of Mineralogy, St. Petersburg State University; Mining Museum, St. Petersburg, Russia.

References: (1) Vergasova, L., S. Krivovichev, T. Semenova, S. Filatov, and V. Ananiev (1999) Chloromenite, $Cu_9O_2(SeO_3)_4Cl_6$, a new mineral from the Tolbachik volcano, Kamchatka, Russia. Eur. J. Mineral., 11, 119–123. (2) (1999) Amer. Mineral., 84, 1464 (abs. ref. 1).
(3) Krivovichev, S.V., S.K. Filatov, T.F. Semenova, and I.V. Rozhdestvenskaya (1998) Crystal chemistry of inorganic compounds based on chains of oxocentered tetrahedra I. Crystal structure of chloromenite, $Cu_9O_2(SeO_3)_4Cl_6$. Zeits. Krist., 213, 645–649.

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Chlorophoenicite $(Mn, Mg)_3Zn_2(AsO_4)(OH, O)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As stout to acicular prismatic crystals, elongated and striated parallel [010], to 1 cm, generally with etched and dull terminations, and prism faces uneven or warped; in divergent sprays, dense masses of acicular crystals, microcrystalline, chalky pulverulent coatings.

Physical Properties: *Cleavage:* Good on {100}. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 3.46–3.53 D(calc.) = 3.47

Optical Properties: Translucent. *Color:* Light grayish green in natural light, pink to light purplish red in artificial light, typically white in aggregates; nearly colorless in transmitted light. *Luster:* Vitreous, silky, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Y = b$. *Dispersion:* $r > v$, strong. $\alpha = 1.682$ $\beta = 1.690$ $\gamma = 1.697$ $2V(meas.) = 83(2)^\circ$

Cell Data: *Space Group:* $C2/m$. $a = 22.98(4)$ $b = 3.32(1)$ $c = 7.32(1)$ $\beta = 106^\circ00(10)'$ $Z = 2$

X-ray Powder Pattern: Franklin, New Jersey, USA; nearly identical to magnesium-chlorophoenicite. (ICDD 25-1159).
2.642 (100), 3.71 (70), 6.87 (50), 3.11 (50), 2.990 (40), 1.758 (30), 1.822 (20)

Chemistry:

	(1)
P_2O_5	0.1
As_2O_5	20.3
FeO	0.0
MnO	33.0
ZnO	30.3
MgO	1.6
CaO	0.1
H_2O	14.9
Total	100.3

(1) Franklin, New Jersey, USA; by electron microprobe, H_2O by DTA–TGA, corresponding to $(Mn_{2.65}Mg_{0.23}Zn_{0.12})_{\Sigma=3.00}Zn_{2.00}(AsO_4)(OH, O)_6$.

Occurrence: Along secondary cracks through franklinite ores in a metamorphosed stratiform zinc orebody.

Association: Leucophoenicite, hodgkinsonite, hetaerolite, tephroite, gageite, chlorophoenicite, sclarite, pyrochroite, willemite, zincite, calcite, barite, franklinite.

Distribution: From Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: From the Greek for *green* and *purple-red*, alluding to the mineral's colors in natural and artificial light.

Type Material: The Natural History Museum, London, England, 1925,501–502; National Museum of Natural History, Washington, D.C., USA, 94964.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 778–780. (2) Moore, P.B. (1968) The crystal structure of chlorophoenicite. Amer. Mineral., 53, 1110–1119. (3) Dunn, P.J. (1981) Magnesium-chlorophoenicite redefined and new data on chlorophoenicite. Can. Mineral., 19, 333–336. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 663–666.

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Chlorothionite $K_2Cu(SO_4)Cl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystalline incrustations.

Physical Properties: Hardness = 2.5 D(meas.) = 2.69 D(calc.) = [2.68] Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Bright to pale blue, may be pale greenish blue. *Optical Class:* Biaxial (+) (synthetic). *Dispersion:* $r > v$. α = n.d. β = n.d. γ = n.d. 2V(meas.) = Moderately large.

Cell Data: *Space Group: Pnma.* $a = 7.732(15)$ $b = 6.078(1)$ $c = 16.292(3)$ Z = 4

X-ray Powder Pattern: Vesuvius, Italy.
3.04 (100), 2.187 (70), 2.847 (35), 5.69 (30), 3.26 (30), 3.15 (20), 2.491 (20)

Chemistry:

	(1)	(2)
SO_3	27.50	25.93
CuO	24.48	25.77
K_2O	31.67	30.51
Cl	20.04	22.97
LOI	1.12	
$-O = Cl_2$	4.52	5.18
Total	100.29	100.00

(1) Vesuvius, Italy; here converted to oxides from an original elemental analysis totalling 100.00%.
(2) $K_2Cu(SO_4)Cl_2$.

Occurrence: As sublimates around volcanic fumaroles.

Association: n.d.

Distribution: From Vesuvius, Campania, Italy.

Name: From the Greek for *chlorine* and *sulfur* in the composition.

Type Material: Mineralogical Museum, University of Bari, Bari, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 547. (2) Giacovazzo, C., E. Scandale, and F. Scordari (1976) The crystal structure of chlorotionite [*sic*], $CuK_2Cl_2SO_4$. Zeits. Krist., 144, 226–237.

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Chloroxiphite $Pb_3CuO_2Cl_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed crystals, often curved, to 4 cm, elongated along [010] and flattened on $\{\bar{1}01\}$, which is striated ‖ [010]; as subparallel groups.

Physical Properties: *Cleavage:* Perfect on $\{\bar{1}01\}$, distinct on {100}. *Tenacity:* Very brittle; friable. Hardness = 2.5 D(meas.) = 6.76–6.93 D(calc.) = 6.84

Optical Properties: Transparent. *Color:* Dull olive-green or pistachio-green. *Streak:* Pale yellowish green. *Luster:* Resinous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Y = yellowish brown; Z = bright emerald-green. *Orientation:* $Z = b$; $X \simeq \perp \{\bar{1}01\}$. *Dispersion:* $r > v$, medium to strong. $\alpha = 2.16$ $\beta = 2.24$ $\gamma = 2.25$ 2V(meas.) = ∼70°

Cell Data: *Space Group:* $P2_1/m$. $a = 10.458(4)$ $b = 5.759(3)$ $c = 6.693(3)$ $\beta = 97.79(4)°$ Z = 2

X-ray Powder Pattern: Higher Pitts Farm, England. (ICDD 8-112).
2.86 (100), 10.3 (80), 3.84 (80), 2.80 (70), 5.90 (60), 2.68 (60), 2.06 (60)

Chemistry:

	(1)	(2)	(3)
CuO	10.90	10.47	9.68
PbO	81.15	79.82	81.45
Cl	7.19	8.97	8.63
H_2O^+	2.56	2.52	2.19
$-O = Cl_2$	1.62	2.03	1.95
Total	100.18	99.75	100.00

(1–2) Higher Pitts Farm, England; H_2O by loss on ignition. (3) $Pb_3CuO_2Cl_2(OH)_2$.

Occurrence: A secondary mineral associated with lead- and copper-bearing pods in Mn–Fe deposits developed along fissures in dolomitic conglomerate and limestone.

Association: Mendipite, diabolite, parkinsonite, wulfenite, cerussite, hydrocerussite.

Distribution: In England, at the Higher Pitts Farm, near Priddy, and in the Merehead quarry, near Shepton Mallet, Mendip Hills, Somerset.

Name: From the Greek for *green* and *blade* or *straight sword*, for the typical crystal habit.

Type Material: The Natural History Museum, London, England, 1923,712–717.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 84–85. (2) Spencer, L.J. and E.D. Mountain (1923) New lead-copper minerals from the Mendip Hills (Somerset). Mineral. Mag., 20, 67–92. (3) Finney, J.J., E.J. Graeber, A. Rosenzweig, and R.D. Hamilton (1977) The structure of chloroxiphite, $Pb_3CuO_2(OH)_2Cl_2$. Mineral. Mag., 41, 357–361. (4) Symes, R.F. and P.G. Embrey (1977) Mendipite and other rare oxychloride minerals from the Mendip Hills, Somerset, England. Mineral. Record, 8, 298–303.

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Choloalite $PbCu(Te^{4+}O_3)_2$

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Crystal Data: Cubic. *Point Group:* 432. As octahedra, the larger crystals corroded, to 2 mm.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3
D(meas.) = 6.4(1) D(calc.) = 6.41

Optical Properties: Semitransparent. *Color:* Forest-green; deep green in transmitted light. *Streak:* Pale green. *Luster:* Adamantine.
Optical Class: Isotropic; may be sectored, with birefringence to 0.011. $n = 2.04$

Cell Data: *Space Group:* $P4_132$. $a = 12.519–12.586$ $Z = 4$

X-ray Powder Pattern: Moctezuma mine, Mexico.
3.036 (100), 3.343 (60), 7.223 (50), 2.454 (50), 3.472 (40), 3.614 (30), 2.952 (30)

Chemistry:

	(1)	(2)	(3)
TeO_2	50.7	51.81	51.32
Sb_2O_5	trace	1.10	
CuO	11.0	11.81	12.79
ZnO		0.37	
PbO	33.0	31.22	35.89
CaO	trace	0.50	
Cl		1.19	
H_2O	3.4		
$-O = Cl_2$		0.27	
Total	98.1	97.73	100.00

(1) Moctezuma mine, Mexico; average of four analyses, H_2O by the Penfield method, apparently adsorbed; corresponds to $Cu_{2.75}Pb_{2.94}(Te_{1.05}O_{3.05})_6 \cdot 3.75H_2O$. (2) Do.; by electron microprobe, corresponds to $Pb_{2.65}(Cu_{2.81}Sb^{5+}_{0.13}Zn_{0.09})_{\Sigma=3.03}(Te_{1.02}O_{3.00})_6Cl_{0.92}$. (3) $PbCu(TeO_3)_2$.

Occurrence: With other tellurites and tellurates in the oxidized portions of base and precious metal deposits.

Association: Emmonsite, rodalquilarite, cerussite, jarosite, "opal" (Tombstone, Arizona, USA).

Distribution: From the Oriental (Bambollita) mine, northeast of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. On the dumps between the Joe and Grand Central shafts, Tombstone, Cochise Co., Arizona, and at the McAlpine mine, Tuolumne Co., California, USA. From an unidentified locality in Saudi Arabia.

Name: From the Nahua language *choloa*, for *evasive*, the mineral having been undetected for many years.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,548.

References: (1) Williams, S.A. (1981) Choloalite, $CuPb(TeO_3)_2 \cdot H_2O$, a new mineral. Mineral. Mag., 44, 55–57. (2) (1981) Amer. Mineral., 66, 1099 (abs. ref. 1). (3) Powell, D.W., R.G. Thomas, P.A. Williams, W.D. Birch, and I.R. Plimer (1994) Choloalite: synthesis and revised chemical formula. Mineral. Mag., 58, 505–508. (4) Lam, A.E., L.A. Groat, J.D. Grice, and T.S. Ercit (1999) The crystal structure of choloalite. Can. Mineral., 721–729.

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Chondrodite $(Mg, Fe^{2+})_5(SiO_4)_2(F, OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals rare, varied in habit, typically flattened ‖ [010], to 10 cm. Commonly as rounded grains, massive. *Twinning:* On {001}, common, simple and lamellar; possibly ‖ {015} and {305}.

Physical Properties: *Cleavage:* {100} indistinct; parting on {001}. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 3.16–3.26 D(calc.) = 3.177

Optical Properties: Transparent to translucent. *Color:* Light yellow, yellow, brown, red; in thin section, pale yellow or brown to colorless. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (+). *Pleochroism:* X = colorless, very pale yellow, brownish yellow; Y = colorless, yellow-green; Z = colorless, pale green. *Orientation:* $Z = b$; $X \wedge c = 22°$–$31°$. *Dispersion:* $r > v$, strong to weak. $\alpha = 1.592$–1.643 $\beta = 1.602$–1.655 $\gamma = 1.621$–1.676 2V(meas.) = 71°–85°

Cell Data: *Space Group:* $P2_1/c$. $a = 7.8404(2)$ $b = 4.7284(3)$ $c = 10.2539(3)$ $\beta = 109°2'$ Z = 2

X-ray Powder Pattern: Tilly Foster mine, New York, USA. (ICDD 12-527). 2.258 (100), 1.740 (70), 3.02 (45), 2.510 (45), 3.56 (35), 2.758 (35), 2.288 (35)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	33.60	32.16	MgO	59.30	53.21
TiO_2	0.06	0.20	CaO	0.00	0.00
Al_2O_3	0.24	0.73	F	6.61	7.11
Fe_2O_3	0.05	0.60	H_2O^+	1.46	1.20
FeO	0.86	6.08	H_2O^-	0.00	0.00
MnO	0.16	1.35	$-O = F_2$	2.78	2.99
			Total	99.56	99.65

(1) Hangelby, Finland; corresponds to $(Mg_{5.13}Fe^{2+}_{0.04}Al_{0.02}Mn_{0.01})_{\Sigma=5.20}Si_{1.95}O_8[F_{1.21}(OH)_{0.56}O_{0.23}]_{\Sigma=2.00}$. (2) Kafveltorp, Sweden; corresponds to $(Mg_{4.74}Fe^{2+}_{0.30}Mn_{0.07}Al_{0.05}Fe^{3+}_{0.03}Ti_{0.01})_{\Sigma=5.20}Si_{1.92}O_8[F_{1.34}(OH)_{0.48}O_{0.18}]_{\Sigma=2.00}$.

Polymorphism & Series: Forms a series with alleghanyite.

Mineral Group: Humite group.

Occurrence: In contact metamorphic zones, in limestones and dolostones, associated with felsic to alkalic plutonic rocks, especially with Fe-B-F metasomatism; in a carbonatite.

Association: Phlogopite, spinel, magnetite, grossular, wollastonite, forsterite, monticellite, cuspidine, diopside, calcite.

Distribution: From Pargas, Hangelby, and Sibbo, Finland. At Kafveltorp, near Kopparberg, Sweden. From Monte Somma and Vesuvius, Campania, Italy. At Le Chipal, Vosges, France. From Bhandara, Maharashtra, India. In the USA, fine crystals from the Tilly Foster mine, Brewster, Putnam Co., and Amity, Orange Co., New York; at Franklin and Sparta, Sussex Co., New Jersey; Johnson Camp, Cochise Co., and the Lakeshore mine, Pinal Co., Arizona; and Crestmore, Riverside Co., California. From Bancroft, Ontario, Canada. In the Loolekop carbonatite, Transvaal, South Africa. A few other localities are known.

Name: From the Greek meaning *grain*, alluding to its occurrence in isolated grains.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 536–538. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 379–417. (3) Gibbs, G.V., P.H. Ribbe, and C.P. Anderson (1970) The crystal structures of the humite minerals. II. Chondrodite. Amer. Mineral., 55, 1182–1194. (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 142–144.

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Chrisstanleyite $Ag_2Pd_3Se_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Anhedral crystals, to several hundred μm, aggregated in grains. *Twinning:* Fine polysynthetic and parquetlike, characteristic.

Physical Properties: *Tenacity:* Slightly brittle. Hardness = ∼5 VHN = 371–421, 395 average (100 g load), D(meas.) = n.d. D(calc.) = 8.30

Optical Properties: Opaque. *Color:* Silvery gray. *Streak:* Black. *Luster:* Metallic. *Optical Class:* Biaxial. *Pleochroism:* Slight; pale buff to slightly gray-green buff. *Anisotropism:* Moderate; rose-brown, gray-green, pale bluish gray, dark steel-blue. *Bireflectance:* Weak to moderate.
R_1–R_2: (400) 35.6–43.3, (420) 36.8–44.2, (440) 37.8–45.3, (460) 39.1–46.7, (480) 40.0–47.5, (500) 41.1–48.0, (520) 42.1–48.5, (540) 42.9–48.7, (560) 43.5–49.1, (580) 44.1–49.3, (600) 44.4–49.5, (620) 44.6–49.6, (640) 44.5–49.3, (660) 44.4–49.2, (680) 44.2–49.1, (700) 44.0–49.0

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 6.350(6)$ $b = 10.387(4)$ $c = 5.683(3)$ $\beta = 114.90(5)^\circ$ Z = 2

X-ray Powder Pattern: Hope's Nose, England.
2.742 (100), 1.956 (100), 2.688 (80), 2.868 (50b), 2.367 (50), 1.829 (30), 2.521 (20)

Chemistry:

	(1)	(2)	(3)
Pd	37.64	35.48	37.52
Pt		0.70	
Hg		0.36	
Ag	25.09	24.07	25.36
Cu	0.18	2.05	
Se	36.39	38.50	37.12
Total	99.30	101.16	100.00

(1) Hope's Nose, England; by electron microprobe, average of 26 analyses; corresponding to $(Ag_{2.01}Cu_{0.02})_{\Sigma=2.03}Pd_{3.02}Se_{3.95}$. (2) Copper Hills prospect, Australia; by electron microprobe, corresponding to $(Ag_{1.86}Cu_{0.27}Hg_{0.02})_{\Sigma=2.15}(Pd_{2.77}Pt_{0.03})_{\Sigma=2.80}Se_{4.06}$. (3) $Ag_2Pd_3Se_4$.

Occurrence: In gold-bearing calcite veins in limestone (Hope's Nose, England); in a carbonate matrix (Tilkerode, Germany); in malachite nodules (Copper Hills prospect, Australia).

Association: Gold, fischesserite, clausthalite, tiemannite, eucairite, verbeekite, umangite, cerussite, bromian chlorargyrite (Hope's Nose, England); clausthalite, tischendorfite, tiemannite, stibiopalladinite, gold (Tilkerode, Germany); oosterboschite, naumannite, berzelianite, umangite, tiemannite, chalcomenite, malachite, quartz (Copper Hills prospect, Australia).

Distribution: From Hope's Nose, Torquay, Devon, England [TL]. At Tilkerode, Harz Mountains, Germany. In the Copper Hills prospect, East Pilbara region, Western Australia.

Name: In honor of Dr. Chris J. Stanley (1954–), The Natural History Museum, London, England, for his contributions to ore mineralogy.

Type Material: Institute for Mineralogy, Salzburg University, Salzburg, Austria, II/A 1070; The Natural History Museum, London, England, 1997,59, E1527, E1534, E1537, E1538.

References: (1) Paar, W.H., A.C. Roberts, A.J. Criddle, and D. Topa (1998) A new mineral, chrisstanleyite, $Ag_2Pd_3Se_4$, from Hope's Nose, Torquay, Devon, England. Mineral. Mag., 62, 257–264. (2) (1998) Amer. Mineral., 83, 1348 (abs. ref. 1). (3) Nickel, E.H. (2002) An unusual occurrence of Pd, Pt, Au, Ag and Hg minerals in the Pilbara region of Western Australia. Can. Mineral., 40, 419–433.

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Christelite $Zn_3Cu_2(SO_4)_2(OH)_6 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As thin bladed crystals, flattened on {001}, to 13 mm.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = n.d. D(meas.) = 3.14 D(calc.) = 3.20

Optical Properties: Transparent. *Color:* Greenish blue. *Streak:* Bright greenish blue. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale blue; $Y = Z$ = blue. $\alpha = 1.598$ $\beta = 1.626$ $\gamma = 1.635$ 2V(meas.) = 59.4° 2V(calc.) = 59°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.4143(8)$ $b = 6.336(1)$ $c = 10.470(3)$ $\alpha = 94.32(3)°$ $\beta = 90.06(2)°$ $\gamma = 90.27(2)°$ Z = 2

X-ray Powder Pattern: San Francisco mine, Chile.
5.230 (100), 10.459 (82), 3.486 (54), 1.743 (12), 2.493 (10), 2.355 (10), 3.157 (8)

Chemistry:

	(1)	(2)
SO_3	23.53	23.22
CuO	18.62	23.08
ZnO	36.25	35.41
H_2O	23.05	18.29
Total	101.45	100.00

(1) San Francisco mine, Chile; by electron microprobe, H by CHN analyzer, H_2O and $(OH)^{1-}$ then proportioned by crystal-structure analysis; corresponds to $Zn_{2.82}Cu_{1.48}(SO_4)_{1.86}(OH)_{4.88} \cdot 5.66H_2O$. (2) $Zn_3Cu_2(SO_4)_2(OH)_6 \cdot 4H_2O$.

Occurrence: A secondary mineral in the oxidized portions of a Cu–Zn sulfide deposit.

Association: Zincian paratacamite, anglesite, hemimorphite, gordaite, quartz.

Distribution: From the San Francisco mine, two km west of the Sierra Gorda railway station, Sierra Gorda district, Antofagasta, Chile.

Name: Honors Christel Gebhard-Giesen (1950–), German mineral collector.

Type Material: University of Hamburg, Hamburg, Germany.

References: (1) Schlüter, J., K.-H. Klaska, G. Adiwidjaja, and G. Gebhard (1996) Christelite, $Zn_3Cu_2(SO_4)_2(OH)_6 \cdot 4H_2O$, a new mineral from the San Francisco mine, Antofagasta, Chile. Neues Jahrb. Mineral., Monatsh., 188–192. (2) (1997) Amer. Mineral., 82, 207–210 (abs. ref. 1). (3) Adiwidjaja, G., K. Friese, K.-H. Klaska, and J. Schlüter (1996) The crystal structure of christelite $Zn_3Cu_2(SO_4)_2(OH)_6 \cdot 4H_2O$. Zeits. Krist., 211, 518–521.

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Christite $TlHgAsS_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As subhedral grains, to 1 mm in length. Some grains are somewhat bladed or flattened, probably on {010}.

Physical Properties: *Cleavage:* Perfect on {010}, excellent on {110} and {001}, good on $\{\bar{1}01\}$. *Fracture:* Uneven. Hardness = 1–2 VHN = 28–35 (10 g load). D(meas.) = 6.15 D(calc.) = 6.37

Optical Properties: Opaque to semitransparent. *Color:* Bright orange to deep red or crimson, darker than realgar; yellowish orange with red tinge, tarnishes brown; in reflected light, grayish white with pale blue tinge, with red or yellow to yellowish brown internal reflections. *Streak:* Bright orange, yellow. *Luster:* Adamantine.
Optical Class: Biaxial. *Pleochroism:* Weak to strong, grayish green, dark violet, bluish violet. *Bireflectance:* Pale gray with blue to yellow tinge.
R_1–R_2: (470) 29.3–30.1, (530) 26.6–26.7, (590) 25.2–26.1, (460) 23.8–24.7

Cell Data: *Space Group:* $P2_1/n$. $a = 6.113$ $b = 16.188$ $c = 6.111$ $\beta = 96.71°$ $Z = 4$

X-ray Powder Pattern: Carlin mine, Nevada, USA.
2.98 (100), 3.62 (80), 4.03 (60), 3.49 (60), 2.692 (60), 3.36 (50), 2.216 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Tl	35.2	35.29	35.48	Cd		0.04	
Hg	35.1	35.46	34.82	Ag		0.08	
Fe		0.10		As	13.1	12.23	13.00
Zn		0.02		Se		0.03	
Cu		0.02		S	16.6	16.57	16.70
				Total	100.0	99.83	100.00

(1) Carlin mine, Nevada, USA; by electron microprobe, average of four analyses; corresponding to $Tl_{1.00}Hg_{1.01}As_{1.01}S_{3.00}$. (2) Lanmuchang deposit, China; by electron microprobe, average of 13 analyses; corresponding to $Tl_{1.00}Hg_{1.02}As_{0.95}S_{3.00}$. (3) $TlHgAsS_3$.

Occurrence: In hydrothermal barite veins and in mineralized carbonaceous silty dolostone (Carlin mine, Nevada, USA); in thallium-rich pods in a stratabound mercury deposit (Lanmuchang deposit, China).

Association: Realgar, orpiment, lorandite, barite, getchellite (Carlin mine, Nevada, USA); lorandite, barite, marcasite, pyrite (Lanmuchang deposit, China).

Distribution: In the USA, in Nevada, at the Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co. [TL], and in the Getchell mine, Potosi district, Humboldt Co. At the Lanmuchang Hg–Tl deposit, Guizhou Province, China. From Alšar (Allchar), near Rošden, Macedonia.

Name: To honor Dr. Charles Louis Christ (1916–1980), American physical chemist, mineralogist, and crystallographer with the U.S. Geological Survey.

Type Material: Geology Department, Stanford University, Palo Alto, California; National Museum of Natural History, Washington, D.C., USA, 144272, 144273.

References: (1) Radtke, A.S., F.W. Dickson, J.F. Slack, and K.L. Brown (1977) Christite, a new thallium mineral from the Carlin gold deposit, Nevada. Amer. Mineral., 62, 421–425. (2) Brown, K.L. and F.W. Dickson (1976) The crystal structure of synthetic christite, $HgTlAsS_3$. Zeits. Krist., 144, 367–376. (3) Li Xi-lin, An Xian-Guo, and Nan Jun-Ta (1989) The second discovery of christite in nature. Kexue Tongbao, 34(11), 942–945 (in English).

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Christofschäferite-(Ce) $(Ce,La,Ca)_4Mn(Ti,Fe^{2+})_3(Fe^{3+},Ti)(Si_2O_7)_2O_8$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As stubby prismatic crystals or isolated grains to 3 mm.

Physical Properties: *Cleavage:* None observed. *Tenacity:* Brittle. *Fracture:* Conchoidal. Hardness = 6 D(meas.) = 4.8(1) D(calc.) = 4.853

Optical Properties: Translucent. *Color:* Black. *Streak:* Brown. *Luster:* Resinous. **Optical Class:** Biaxial (-). α = 1.945(10) β = 2.015(10) γ = 2.050(10) 2V(meas.) = 70(10)° 2V(calc.) = 68° *Pleochroism:* Strong; very dark brown to light brown. *Absorption: Z > Y > X*.

Cell Data: Space Group: $P2_1/m$. a = 13.3722(4) b = 5.7434(1) c = 11.0862(2) β = 100.580(2)° Z = 2

X-ray Powder Pattern: Wingertsbergwand, Eifel Mountains, Rhineland-Palatinate, Germany. 2.730 (100), 3.169 (81), 3.480 (78), 4.64(65), 2.169 (46), 1.737 (46), 3.095 (43), 4.90 (39)

Chemistry:

	(1)
CaO	2.61
La_2O_3	19.60
Ce_2O_3	22.95
Pr_2O_3	0.56
Nd_2O_3	2.28
MgO	0.08
MnO	4.39
FeO	4.18
Fe_2O_3	3.11
Al_2O_3	0.08
TiO_2	19.02
Nb_2O_5	0.96
SiO_2	9.38
Total	99.20

(1) Wingertsbergwand, Eifel Mountains, Rhineland-Palatinate, Germany; average of 5 electron microprobe analyses, Fe^{2+}:Fe^{3+} = 3:2, from structural analysis, corresponds to $(Ce_{1.72}La_{1.48}Nd_{0.17}Pr_{0.04}Ca_{0.57})_{\Sigma=3.98}Mn^{2+}_{0.76}Fe^{2+}_{0.72}Mg_{0.02}Ti_{2.935}Fe^{3+}_{0.48}Al_{0.02}Nb_{0.09}Si_{3.98}O_{22}$.

Mineral Group: Chevkinite group.

Occurrence: A metasomatic reaction product between Mn-rich rock and alkali basalt, found in a volcanic ejectum.

Association: Orthoclase, rhodonite, bustamite, tephroite, zircon, fluorapatite, pyrophanite, jacobsite.

Distribution: From Wingertsbergwand (Wingertsberg Mt.) of the Laacher See volcano near Mendig, Eifel Mountains, Rhineland-Palatinate (Rheinland-Pfalz), Germany.

Name: Honors Christof Schäfer (b. 1961), a German mineral collector, who collected the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; 4227/1.

References: (1) Chukanov, N.V., S.M. Aksenov, R.K. Rastsvetaeva, D.I. Belakovskiy, J. Göttlicher, S.N. Britvin, and S. Möckel (2012) Christofschäferite-(Ce), $(Ce,La,Ca)_4Mn^{2+}(Ti,Fe^{3+})_3(Fe^{3+},Fe^{2+},Ti)(Si_2O_7)_2O_8$, a new chevkinite-group mineral from the Eifel area, Germany. Novye dannye o mineralakh, 47, 33-42 (in English). (2) (2013) Amer. Mineral., 98, 2201 (abs. ref. 1).

Chromatite $CaCrO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Rarely as tetragonal dipyramidal crystals, short to prismatic; typically as grains, to 0.1 mm; as earthy flecks, crusts, nodules, veins, and films.

Physical Properties: *Cleavage:* One prismatic, poor. *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.142 (synthetic). Soluble in H_2O.

Optical Properties: Transparent. *Color:* Bright citron-yellow; yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Dispersion:* Strong. $\omega = 1.81$–1.85 $\epsilon = 1.84$–1.88

Cell Data: *Space Group:* $I4_1/amd$ (synthetic). $a = 7.26(1)$ $c = 6.26(1)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.62 (100), 2.679 (55), 1.8510 (45), 2.880 (16), 2.375 (16), 1.8100 (16), 1.4999 (14)

Chemistry:

	(1)	(2)
CrO_3	62.0	64.07
MgO	0.3	
CaO	32.0	35.93
Na_2O	3.6	
K_2O	0.7	
Total	98.6	100.00

(1) Hatrurim Formation, Israel; by AA, K, Na by flame photometry. (2) $CaCrO_4$.

Occurrence: Formed in an arid climate along fractures in limestones and marls by ascending ground water, the chromium derived from underlying bituminous phosphatic marls.

Association: Gypsum, calcite, aragonite, vaterite, portlandite.

Distribution: From Ma'aleh Adumim, along the Jerusalem-Jericho highway, and in the Hatrurim Formation, Israel.

Name: As a *chromate*.

Type Material: Geological Survey of Israel, Jerusalem, Israel, SG232, SG236, SG261, SG571.

References: (1) Eckhardt, F.-J. and W. Heimbach (1963) Ein natürliches Vorkommen von $CaCrO_4$ (Chromatit). Naturwiss., 50, 612 (in German). (2) (1964) Amer. Mineral., 49, 439 (abs. ref. 1). (3) Heimbach, W. (1965) Zum Vorkommen von Chromatit, $CaCrO_4$, in Jordanien. Geologisches Jahrbuch, 83, 717–724 (in German). (4) Gross, S. (1977) Mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 26–27. (5) Clouse, J.H. (1932) Investigations on the X-ray crystal structures of $CaCrO_4$, $CaCrO_4 \cdot H_2O$, and $CaCrO_4 \cdot 2H_2O$. Zeits. Krist., 83, 161–171. (6) (1957) NBS Circ. 539, 7, 13.

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Chrombismite $Bi_{16}CrO_{27}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals octahedral, modified by the cube or dodecahedron, to 1.6 cm; commonly fine granular, compact, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law.

Physical Properties: *Cleavage:* Parting may develop along {111}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5 VHN = 1278–1456 (100 g load). D(meas.) = 4.5–4.8 D(calc.) = [5.12] Some samples are weakly magnetic.

Optical Properties: Translucent to opaque. *Color:* Black to brownish black; brown to brownish black on thin edges in transmitted light; in reflected light, gray-white with a brownish tint and brownish red internal reflections. *Streak:* Brown. *Luster:* Metallic to submetallic. *Optical Class:* Isotropic. $n = 2.08$–2.16
R: (400) 13.2, (420) 13.1, (440) 13.0, (460) 12.8, (480) 12.6, (500) 12.4, (520) 12.2, (540) 12.0, (560) 11.9, (580) 11.8, (600) 11.7, (620) 11.7, (640) 11.6, (660) 11.6, (680) 11.6, (700) 11.6

Cell Data: *Space Group:* $Fd3m$ (synthetic). $a = 8.344$ $Z = 8$

X-ray Powder Pattern: Zimbabwe.
2.499 (10), 1.592 (9), 1.461 (9), 2.070 (7), 2.93 (6), 1.079 (6), 0.846 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
TiO_2	0.26	0.27		FeO	25.48	19.63	32.10
Al_2O_3	9.89	12.47		MnO		0.44	
Fe_2O_3	5.88	1.29		NiO		0.06	
Cr_2O_3	52.17	56.78	67.90	MgO	5.28	9.29	
V_2O_3	0.28			Total	99.24	100.23	100.00

(1) Bushveld complex, South Africa; by electron microprobe, Fe_2O_3 calculated from stoichiometry; corresponds to $(Fe^{2+}_{0.74}Mg_{0.27})_{\Sigma=1.01}(Cr_{1.42}Al_{0.40}Fe^{3+}_{0.15}Ti_{0.01}V_{0.01})_{\Sigma=1.99}O_4$.
(2) Great Dyke, Zimbabwe; by electron microprobe, Fe_2O_3 calculated from stoichiometry; corresponds to $(Fe^{2+}_{0.54}Mg_{0.45}Mn_{0.01})_{\Sigma=1.00}(Cr_{1.47}Al_{0.48}Fe^{3+}_{0.03}Ti_{0.01})_{\Sigma=1.99}O_4$. (3) $FeCr_2O_4$.

Polymorphism & Series: Forms series with magnesiochromite and hercynite.

Mineral Group: Spinel group.

Occurrence: A cumulus mineral in ultramafic portions of layered mafic igneous rocks; an accessory mineral in alpine-type peridotites; also detrital. Common in all meteorites, except carbonaceous chondrites, and in lunar mare basalts.

Association: Olivine, enstatite, plagioclase, serpentine, magnetite, ilmenite, pyrrhotite, pentlandite, ulvöspinel.

Distribution: Widespread. From Gassin, Var, France. Large crystals from Hangha, Sierra Leone. At Tiebaghi, New Caledonia. As economic deposits in: the Bushveld complex, Transvaal, South Africa. From the Great Dyke, Zimbabwe. From many localities in Turkey. At Saranay and elsewhere in the Ural Mountains, Russia. From the Moa district, northern Cuba, may be crystallized. On Luzon, Philippines. From the Stillwater complex, Montana, USA.

Name: For its CHROMium content.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 709–712. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 78–81. (3) Clark, G.L. and A. Ally (1932) X-ray examination of chrome ores: (I) lattice dimensions; (II) theoretical densities. Amer. Mineral., 17, 66–74. (4) Cameron, E.N. (1978) The Lower Zone of the Eastern Bushveld Complex in the Olifants River Trough. J. Petrol., 19, 437–462. (5) Wilson, A.H. (1982) The geology of the Great 'Dyke', Zimbabwe: the ultramafic rocks. J. Petrol., 23, 240–292. (6) Chen, Y.L., B.F. Xu, J.G. Chen, and Y.Y. Ge (1992) Fe^{2+}–Fe^{3+} ordered distribution in chromite spinels. Phys. Chem. Minerals, 19, 255–259.

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Chromdravite $NaMg_3(Cr^{3+},Fe^{3+})_6(BO_3)_3Si_6O_{18}(OH)_4$

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Crystal Data: Hexagonal. *Point Group:* 3*m*. In pyramidal acicular crystals, to 0.1 mm.

Physical Properties: Hardness = [∼7] (by analogy to the tourmaline group).
D(meas.) = 3.40(1) D(calc.) = [3.39]

Optical Properties: Semitransparent. *Color:* Dark green to nearly black.
Optical Class: Uniaxial (–). *Pleochroism: O* = dark green; *E* = yellow-green.
Absorption: O > *E*. $\omega = 1.778(5)$ $\epsilon = 1.772(5)$

Cell Data: *Space Group: R*3*m*. $a = 16.11$ $c = 7.27$ Z = [3]

X-ray Powder Pattern: Velikaya Guba deposit, Karelia.
2.62 (100), 3.58 (75), 3.04 (75), 6.57 (50), 4.05 (50), 2.079 (50), 4.31 (40)

Chemistry:

	(1)
SiO_2	30.75
TiO_2	0.13
B_2O_3	9.00
Al_2O_3	2.92
Fe_2O_3	7.65
V_2O_3	1.46
Cr_2O_3	31.60
MnO	0.19
MgO	9.05
CaO	0.16
Na_2O	2.66
LOI	4.43
Total	[100.00]

(1) Velikaya Guba deposit, Karelia; recalculated to 100.00% after correction for 6.5% chromian phengite; corresponds to $(Na_{0.97}Ca_{0.03})_{\Sigma=1.00}(Mg_{2.57}V_{0.22}Al_{0.16}Mn_{0.03}Ti_{0.02})_{\Sigma=3.00}(Cr^{3+}_{4.71}Fe^{3+}_{1.08}Al_{0.21})_{\Sigma=6.00}[(B_{0.97}Al_{0.03})_{\Sigma=1.00}O_3]_3(Si_{5.81}Al_{0.19})_{\Sigma=6.00}O_{18}[(OH)_{3.77}O_{0.23}]_{\Sigma=4.00}$.

Mineral Group: Tourmaline group.

Occurrence: In micaceous metasomatic clay-carbonate rocks.

Association: Chromian phengite, taeniolite, vanadian muscovite, quartz, dolomite.

Distribution: From the Velikaya Guba uranium deposit, Zaonezhskii Peninsula, southern Karelia.

Name: For CHROMium in the composition and similarity to *dravite*.

Type Material: Mining Institute, St. Petersburg, Russia, 1239/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82811.

References: (1) Rumantseva, E.V. (1983) Chromdravite, a new mineral. Zap. Vses. Mineral. Obshch., 112, 222–226 (in Russian). (2) (1984) Amer. Mineral., 69, 210 (abs. ref. 1). (3) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 559–602. (4) Dunn, P.J. (1977) Chromium in dravite. Mineral. Mag., 41, 408–410.

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Chromferide $\mathbf{Fe_3Cr_{1-x}}$ (x = 0.6)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As small grains forming aggregates, to several hundred μm.

Physical Properties: Hardness = n.d. VHN = 260 (100 g load). D(meas.) = n.d. D(calc.) = 6.69 Ferromagnetic.

Optical Properties: Opaque. *Color:* Pale gray. *Luster:* Metallic.
R: (400) — , (420) — , (440) 50.4, (460) 51.4, (480) 50.9, (500) 52.6, (520) 53.0, (540) 55.3, (560) 56.5, (580) 56.9, (600) 57.9, (620) 58.3, (640) 59.0, (660) 60.0, (680) 60.7, (700) 60.8

Cell Data: *Space Group:* $Pm3m$. a = 2.859(5) Z = 1

X-ray Powder Pattern: Efim area, Russia.
2.02 (100), 1.16 (100), 1.43 (80), 1.01 (70), 1.28 (50), 2.87 (20), 1.656 (10)

Chemistry:

	(1)	(2)
Fe	88.91	88.96
Cr	11.30	11.04
Total	100.21	100.00

(1) Efim area, Russia; by electron microprobe, corresponding to Fe_3Cr_{1-x}, with x = 0.6.
(2) $Fe_3Cr_{0.4}$.

Occurrence: In quartz veins within brecciated amphibolites and schist.

Association: Iron, copper, bismuth, gold, ferchromide, graphite, cohenite, halite, sylvite, marialite, quartz.

Distribution: From a gold occurrence in the Efim area, Kumak ore field, 110 km east of Orsk, Southern Ural Mountains, Russia [TL].

Name: For the chemical composition, CHROMium and FERrum, *iron*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Novgorodova, M.I., A.I. Gorshkov, N.V. Trubkin, A.I. Tsepin, and M.T. Dmitrieva (1986) New natural intermetallic compounds of iron and chromium – chromferide and ferchromide. Zap. Vses. Mineral. Obshch., 115, 355–360 (in Russian). (2) (1988) Amer. Mineral., 73, 190 (abs. ref. 1).

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Chromite $Fe^{2+}Cr_2O_4$

Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Crystals octahedral, modified by the cube or dodecahedron, to about 1 cm; commonly fine granular, compact, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law.

Physical Properties: *Cleavage:* Parting may develop along {111}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5 VHN = 1278–1456 (100 g load). D(meas.) = 4.5–4.8 D(calc.) = [5.12] Some samples are weakly magnetic.

Optical Properties: Translucent to opaque. *Color:* Black to brownish black; brown to brownish black on thin edges in transmitted light; in reflected light, gray-white with a brownish tint and brownish red internal reflections. *Streak:* Brown. *Luster:* Metallic to submetallic. *Optical Class:* Isotropic. n = 2.08–2.16
R: (400) 13.2, (420) 13.1, (440) 13.0, (460) 12.8, (480) 12.6, (500) 12.4, (520) 12.2, (540) 12.0, (560) 11.9, (580) 11.8, (600) 11.7, (620) 11.7, (640) 11.6, (660) 11.6, (680) 11.6, (700) 11.6

Cell Data: *Space Group:* *Fd3m* (synthetic). a = 8.344 Z = 8

X-ray Powder Pattern: Zimbabwe.
2.499 (10), 1.592 (9), 1.461 (9), 2.070 (7), 2.93 (6), 1.079 (6), 0.846 (6)

Chemistry:

	(1)	(2)	(3)
TiO_2	0.26	0.27	
Al_2O_3	9.89	12.47	
Fe_2O_3	5.88	1.29	
Cr_2O_3	52.17	56.78	67.90
V_2O_3	0.28		

	(1)	(2)	(3)
FeO	25.48	19.63	32.10
MnO		0.44	
NiO		0.06	
MgO	5.28	9.29	
Total	99.24	100.23	100.00

(1) Bushveld complex, South Africa; by electron microprobe, Fe_2O_3 calculated from stoichiometry; corresponds to $(Fe^{2+}_{0.74}Mg_{0.27})_{\Sigma=1.01}(Cr_{1.42}Al_{0.40}Fe^{3+}_{0.15}Ti_{0.01}V_{0.01})_{\Sigma=1.99}O_4$. (2) Great Dyke, Zimbabwe; by electron microprobe, Fe_2O_3 calculated from stoichiometry; corresponds to $(Fe^{2+}_{0.54}Mg_{0.45}Mn_{0.01})_{\Sigma=1.00}(Cr_{1.47}Al_{0.48}Fe^{3+}_{0.03}Ti_{0.01})_{\Sigma=1.99}O_4$. (3) $FeCr_2O_4$.

Polymorphism & Series: Forms series with magnesiochromite and hercynite.

Mineral Group: Spinel group.

Occurrence: A cumulus mineral in ultramafic portions of layered mafic igneous rocks; an accessory mineral in alpine-type peridotites; also detrital. Common in all meteorites, except carbonaceous chondrites, and in lunar mare basalts.

Association: Olivine, enstatite, plagioclase, serpentine, magnetite, ilmenite, pyrrhotite, pentlandite, ulvöspinel.

Distribution: Widespread. From Gassin, Var, France. Large crystals from Hangha, Sierra Leone. At Tiebaghi, New Caledonia. As economic deposits in: the Bushveld complex, Transvaal, South Africa. From the Great Dyke, Zimbabwe. From many localities in Turkey. At Saranay and elsewhere in the Ural Mountains, Russia. From the Moa district, northern Cuba. On Luzon, Philippines. From the Stillwater complex, Montana, USA.

Name: For its CHROMium content.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 709–712. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 78–81. (3) Clark, G.L. and A. Ally (1932) X-ray examination of chrome ores: (I) lattice dimensions; (II) theoretical densities. Amer. Mineral., 17, 66–74. (4) Cameron, E.N. (1978) The Lower Zone of the Eastern Bushveld Complex in the Olifants River Trough. J. Petrol., 19, 437–462. (5) Wilson, A.H. (1982) The geology of the Great 'Dyke', Zimbabwe: the ultramafic rocks. J. Petrol., 23, 240–292. (6) Chen, Y.L., B.F. Xu, J.G. Chen, and Y.Y. Ge (1992) Fe^{2+}–Fe^{3+} ordered distribution in chromite spinels. Phys. Chem. Minerals, 19, 255–259.

Chromium Cr

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$ (synthetic). As spherulitic and rounded grains, to 20 μm.

Physical Properties: *Tenacity:* Brittle (synthetic). Hardness = n.d. VHN = < 1875–2000 D(meas.) = 7.17 D(calc.) = [7.20]

Optical Properties: Opaque. *Color:* White, with a yellow tint in reflected light. *Luster:* Metallic.
R: (480) 65.3, (546) 67.9, (589) 68.8, (656) 70.0

Cell Data: *Space Group:* $Im3m$ (synthetic). $a = 2.8839$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.04 (100), 1.1774 (30), 0.9120 (20), 1.0195 (18), 1.4419 (16), 0.8325 (6)

Chemistry:

	(1)
Cr	98.01
Fe	< 0.01
Cu	0.37
Zn	1.40
Total	99.78

(1) Sichuan Province, China.

Occurrence: In heavy sands derived from the contact metamorphic zone between a siliceous marble and ultramafic rock (Sichuan Province, China); in a kimberlite pipe (Liaoning Province, China); in podiform chromitites (Luobusha ophiolite, China); in ultramafic dike rocks (Gavasai ore field, Russia); in kimberlite (Sakha, Russia); in serpentinite in dunite–peridotite (Far East, Russia).

Association: Pyrrhotite, pentlandite, chalcopyrite, platinum group minerals, danbaite (Sichuan Province, China); cohenite, moissanite, ilmenite, titanite (Gavasai ore field, Russia).

Distribution: In China, from an unspecified locality [Danba] in Sichuan Province [TL]; in "kimberlite pipe 50", Liaoning Province; in sea-floor muds from near the island of Diaoyudao, a few km northeast of Taiwan, at about 1500 m depth; and in the Luobusha ophiolite, 200 km southeast of Lhasa, Tibet. In Russia, from the Gavasai ore field, location not further given; in unspecified kimberlite pipes in Sakha; and at an unspecified locality in the "Soviet Far East".

Name: From the Greek *chroma*, *color*, as all chromium compounds are colored.

Type Material: n.d.

References: (1) Yue Suchin, Wang Wenying, and Sun Sujing (1981) A new mineral – native chromium. Kexue Tongbao, 26, 959–960 (in Chinese). (2) (1982) Amer. Mineral., 67, 854–855 (abs. ref. 1). (3) Yusupov, R.G., D.D. Dzhenchuraev, and F.F. Radzhabov (1982) Native accessory chromium and natural iron-chromium-silicon compounds in intrusive rocks from the Gavasai ore field [USSR]. Izv. Akad. Nauk Kirg. SSR, 5, 24–25 (in Russian). (4) (1983) Chem. Abs., 98, 110815 (abs. ref. 3). (5) Hull, A.W. and W.P. Davy (1931) Chrom, Cr. Strukturbericht 1913–1928, 1, 61 (in German). (6) (1955) NBS Circ. 539, 5, 20.

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Chromschieffelinite $Pb_{10}Te_6O_{20}(OH)_{14}(CrO_4)(H_2O)_5$

Crystal Data: Orthorhombic. *Point Group*: 222. Crystals blocky to tabular on {010} with striations parallel to [001], to 0.2 mm. Forms {010}, {210}, {120}, {150}, {180}, {212}, and {101} observed.

Physical Properties: *Cleavage*: Perfect on {010}. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = 2 D(meas.) = n.d. D(calc.) = 5.892

Optical Properties: Transparent to translucent. *Color*: Pale yellow. *Streak*: Pale yellow. *Luster*: Adamantine.
Optical Class: Biaxial (-). α = 1.930(5) β = 1.960(5) γ = 1.975(5) 2V(meas.) = 68(2)° 2V(calc.) = 69.6° *Orientation*: $X = b$, $Y = c$, $Z = a$. *Dispersion*: Strong, $r < v$.

Cell Data: *Space Group*: $C222_1$. a = 9.6646(3) b = 19.4962(8) c = 10.5101(7) Z = 2

X-ray Powder Pattern: Bird Nest drift, Otto Mountain, near Baker, California, USA.
9.814 (100), 2.9455 (55), 3.262 (53), 3.052 (45), 3.347 (44), 3.575 (41), 2.0396 (33)

Chemistry:

	(1)	(2)
PbO	59.42	61.97
TeO_3	29.08	29.25
CrO_3	1.86	2.78
H_2O	[6.63]	6.00
Total	96.99	100.00

(1) Bird Nest drift, Otto Mountain, near Baker, California, USA; average of 4 electron microprobe analyses, H_2O calculated, low analytical total ascribed to beam damage; corresponding to $Pb_{9.65}Te_6O_{19.96}(OH)_{14.04}(CrO_4)_{0.67}(H_2O)_{6.32}$. (2) $Pb_{10}Te_6O_{20}(OH)_{14}(CrO_4)(H_2O)_{5.}$

Occurrence: A secondary mineral in the oxidized zone of a telluride and galena deposit.

Association: Chalcopyrite, chrysocolla, galena, goethite, hematite, khinite, pyrite, wulfenite.

Distribution: From the Bird Nest drift, southwest flank of Otto Mountain, 0.4 miles northwest of the Aga mine, near Baker, California, USA.

Name: As the chromate analog of *schieffelinite*.

Type Material: Natural History Museum of Los Angeles County, Los Angeles, California, USA (63511).

References: (1) Kampf, A.R., S.J. Mills, R.M. Housley, M.S. Rumsey, and J. Spratt (2012) Lead-tellurium oxysalts from Otto Mountain near Baker, California: VII. Chromschieffelinite, $Pb_{10}Te_6O_{20}(OH)_{14}(CrO_4)(H_2O)_5$, the chromate analog of schieffelinite. Amer. Mineral., 97, 212-219.

Chrysoberyl $BeAl_2O_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are tabular on {001} or short prismatic along [100], to 22 cm; prominently striated on {001} ∥ [100]. *Twinning:* Common on {130}, producing either flattened heart-shaped or pseudohexagonal multiple contact and penetration twins.

Physical Properties: *Cleavage:* Distinct on {110}, imperfect on {010}, poor on {001}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 8.5 D(meas.) = 3.75(1) D(calc.) = 3.69

Optical Properties: Transparent to translucent, may be opaque and chatoyant with oriented inclusions. *Color:* Various shades of green, yellow, brownish to greenish black, may be raspberry-red under incandescent light when chromian; colorless, pale shades of yellow, green, or red in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = red; Y = yellow-orange; Z = emerald-green. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.746$ $\beta = 1.748$ $\gamma = 1.756$ 2V(meas.) = 70°

Cell Data: *Space Group: Pbnm.* $a = 4.428(1)$ $b = 9.415(3)$ $c = 5.481(2)$ Z = 4

X-ray Powder Pattern: Near Golden, Colorado, USA. (ICDD 11-448).
3.24 (100), 2.091 (90), 1.619 (80), 4.01 (50), 2.563 (50), 2.265 (45), 2.081 (45)

Chemistry:

	(1)	(2)
TiO_2	0.55	
Al_2O_3	76.34	80.30
FeO	3.60	
BeO	19.15	19.70
LOI	0.30	
Total	99.94	100.00

(1) Near Golden, Colorado, USA. (2) $BeAl_2O_4$.

Occurrence: Characteristic of some granite pegmatites associated with high-grade mica schists or reaction zones in ultramafic rocks; also detrital in placers.

Association: Quartz, muscovite, albite, beryl, columbite, tourmaline, topaz, kyanite, staurolite (granite pegmatites); phenakite, apatite, tourmaline, fluorite (reaction zone pegmatites).

Distribution: Widespread, however fine crystals are uncommon. Notable localities include: from many places in Brazil, with exceptional crystals from Tancredo, Itaguaçu, and Colatina, Espirito Santo; from Faria Lemos, Santa Luzia de Carangola, and Americana, Teófilo Otoni, Minas Gerais; at Campo Formoso, Teixeira de Freitas, and Cachoeira, Bahia. From Maršíkov, Czech Republic. At the Izumrudnye mines, Tokovaya River, near Yekaterinburg (Sverdlovsk), and Mursinka, Ural Mountains, Russia. From Miakanjovato, near Lake Alaotra, northeast of Ambatosoratra, Madagascar. Near Masvingo (Ft. Victoria), Zimbabwe. Abundant in gem gravel placers in the Ratnapura district, Sri Lanka. In the USA, from near Golden, Jefferson Co., Colorado; in Maine, at Topsham, Sagadahoc Co., from Paris, Norway, and Hartford, Oxford Co., and elsewhere.

Name: From the Greek for *golden*, in allusion to the mineral's color, and *beryl*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 718–722. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 73–77. (3) Farrell, E.F., J.H. Fang, and R.E. Newnham (1963) Refinement of the chrysoberyl structure. Amer. Mineral., 48, 804–810. (4) Hazen, R.M. (1987) High-pressure crystal chemistry of chrysoberyl, Al_2BeO_4: insights on the origin of olivine elastic anisotropy. Phys. Chem. Minerals, 14, 13–20. (5) Pilati, T., F. Demartin, F. Cariati, S. Bruni, and C.M. Gramaccioli (1993) Atomic thermal parameters and thermodynamic functions for chrysoberyl ($BeAl_2O_4$) from vibrational spectra and transfer of empirical force fields. Acta Cryst., 49, 216–222.

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Chrysocolla $(Cu, Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Crystals acicular, to 5 mm, in radiating clusters; fine fibrous, botryoidal, earthy; commonly cryptocrystalline, opaline, or enamel-like.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle to somewhat sectile. Hardness = ∼2–4 D(meas.) = 1.93–2.4 D(calc.) = n.d.

Optical Properties: Translucent to opaque. *Color:* Blue, blue-green, or green; brown to black when impure. *Streak:* White when pure. *Luster:* Vitreous, porcelaneous, earthy. *Optical Class:* Biaxial (–). $\alpha = 1.575$–1.585 $\beta = 1.597$ $\gamma = 1.598$–1.635 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 5.72$–5.92 $b = 17.7$–18.0 $c = 8.00$–8.28 Z = n.d.

X-ray Powder Pattern: Locality unknown. (ICDD 27-188).
1.486 (100), 17.9 (80), 2.90 (80), 2.56 (70), 7.9 (60), 4.07 (60), 1.602 (40)

Chemistry:

	(1)	(2)
SiO_2	35.80	39.48
Al_2O_3	2.00	1.91
Fe_2O_3	trace	0.13
MnO		0.88
CuO	42.00	46.93
MgO	0.08	0.47
CaO	1.04	0.52
Na_2O	0.04	
K_2O	0.05	
H_2O^+	10.00	8.29
H_2O^-	9.46	1.31
Total	100.47	99.92

(1) Mednorudyansk, Russia. (2) Kamoya, Congo.

Occurrence: In the oxidized portions of many copper deposits.

Association: Malachite, tenorite, halloysite, nontronite.

Distribution: A few localities for rich or commercial material include: from Nizhni Tagil, Ural Mountains, Russia. At Lubietová, near Banská Bystrica (Libethen, near Neusohl), Slovakia. In the Timna (King Solomon's) mine, Israel. From the Star of the Congo mine, Lubumbashi, and at Likasi and Kakanda, Katanga Province, Congo (Shaba Province, Zaire). In the USA, in Arizona, constitutes parts of large orebodies, as in the Globe-Miami district, Gila Co., Morenci, Greenlee Co., San Manuel and Ray mines, Pinal Co.; in New Mexico, at Santa Rita, Grant Co.; from Utah, in the Tintic district, Juab Co. At Cananea, Sonora, Mexico. In Chile, in the Chuquicamata and Exotica deposits; around Copiapó and Coquimbo. From the Chillagoe district, Queensland, Australia.

Name: From the Greek for *gold* and *glue*, for a substance used in the soldering of gold, including chrysocolla as well as other blue and green minerals.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 699–700. (2) Chukhrov, F.V., B.B. Zvyagin, A.I. Gorshkov, L.P. Ermilova, and E.S. Rudnitskaya (1968) Chrysocolla. Izv. Akad. Nauk SSSR, Ser. Geol., no. 6, 29–44 (in Russian). (3) (1969) Amer. Mineral., 54, 993 (abs. ref. 2). (4) Van Oosterwyck-Gastuche, M.-C. (1970) La structure de la chrysocolle. Compt. Rendus Acad. Sci. Paris, 271, 1837–1840 (in French).

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Chudobaite $(Mg,Zn)_5(AsO_4)_2(AsO_3OH)_2 \cdot 10H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals equant, to 5 mm, showing prominent {100}, {010}, {001}, with half-a-dozen additional modifying forms.

Physical Properties: *Cleavage:* On {010}, very good; {100}, good. Hardness = 2.5–3 D(meas.) = 2.94 D(calc.) = [2.93]

Optical Properties: Transparent. *Color:* Rose, white, colorless. *Luster:* Good [*sic*]. *Optical Class:* Biaxial (–). *Orientation:* $Z \wedge c = -24°$ on {010}; $Z \wedge c = 11°$ on {100}. $\alpha = 1.583$ $\beta = \sim 1.608$ $\gamma = 1.633$ 2V(meas.) = 79°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.944(1)$ $b = 10.691(1)$ $c = 6.770(1)$ $\alpha = 80.97(1)°$ $\beta = 84.20(1)°$ $\gamma = 81.85(1)°$ Z = 1

X-ray Powder Pattern: Tsumeb, Namibia.
10.16 (10), 2.979 (9), 3.440 (8), 3.273 (8), 2.730 (7), 3.859 (5), 3.746 (5)

Chemistry:

	(1)	(2)
As_2O_5	49.7	50.13
MnO	2.0	
CuO	0.2	
ZnO	11.5	12.43
MgO	12.0	15.82
CaO	1.0	
Na_2O	5.0	
K_2O	2.0	
H_2O	17.0	21.62
Total	100.4	100.00

(1) Tsumeb, Namibia. (2) $(Mg,Zn)_5(AsO_4)_2(AsO_3OH)_2 \cdot 10H_2O$ with Mg:Zn = 3.4:1.6.

Occurrence: In a deep oxidation zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Conichalcite, cuprian adamite, zincian olivenite, ferrilotharmeyerite, chalcocite.

Distribution: From Tsumeb, Namibia.

Name: To honor Dr. Karl Franz Chudoba (1898–1976), Professor of Mineralogy, University of Bonn, Bonn, Germany.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 162628.

References: (1) Strunz, H. (1960) Chudobait, ein neues Mineral von Tsumeb. Neues Jahrb. Mineral., Monatsh., 1–7 (in German with English abs.). (2) (1960) Amer. Mineral., 45, 1130 (abs. ref. 1). (3) Dorner, R. and K. Weber (1976) Die Kristallstruktur von Chudobait, $(Mg,Zn)_5H_2[AsO_4]_4 \cdot 10H_2O$. Naturwiss., 63, 243 (in German). (4) Graeser, S., H. Schwander, R. Bianchi, T. Pilati, and C.M. Gramaccioli (1989) Geigerite, the Mn analogue of chudobaite: its description and crystal structure. Amer. Mineral., 74, 676–684.

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Chukanovite $Fe_2(CO_3)(OH)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Acicular to fibrous, elongated on [001], to 0.5 mm and 2–3 μm thick; often as spherulites (rarely to 1 mm). Typically as botryoidal crusts of spherulitic clusters and parallel- or radial-columnar aggregates, to 1 mm thick.

Physical Properties: *Cleavage*: Perfect, probably on $\{0\bar{2}\ 1\}$. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3.5-4 D(meas.) = n.d. D(calc.) = 3.60

Optical Properties: Transparent. *Color*: Pale-green, colorless; aggregates brownish-green. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (–). α = 1.673(3) β = 1.770(5) γ = 1.780(5) 2V(meas.) = 10(5)°

Cell Data: *Space Group*: $P2_1/a$. a = 12.396(1) b = 9.407(1) c = 3.2152(3) β = 97.78° Z = 1

X-ray Powder Pattern: Dronino iron meteorite, Russia.
2.645 (100), 3.73 (80), 5.15 (60), 6.14 (40), 2.361 (40), 2.171 (40)

Chemistry:

	(1)
MgO	0.1
FeO	68.8
NiO	0.6
CO_2	19.8
H_2O	10.9
Total	100.2

(1) Dronino iron meteorite, Russia; electron microprobe analysis, H_2O by modified Penfield method, CO_2 by selective sorption, corresponding to $(Fe^{2+}_{1.97}Ni_{0.02}Mg_{0.01})_{\Sigma=2.00}(CO_3)_{0.93}(OH)_{2.14}\cdot 0.18\ H_2O$.

Occurrence: In a terrestrially altered meteorite fragment.

Association: Kamacite, taenite, chromite, troilite, goethite, akaganeite, hematite, hibbingite, reevesite, honessite, undetermined Fe-Ni sulfides.

Distribution: In cavities in the Dronino ataxite iron meteorite, collected near Dronino, Kasimov district, Ryazan' Oblast, 350 km southeast of Moscow, Russia.

Name: Honors Nikita V. Chukanov (b. 1953), Russian physicist and mineralogist.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Pekovi, I.V., N. Perchiazzi, S. Merlino, V.N. Kalachev, M. Merlini, and A.E. Zadov (2007) Chukanovite, $Fe_2(CO_3)(OH)_2$, a new mineral from the weathered iron meteorite Dronino. Eur. J. Mineral., 19, 891–898. (2) (2008) Amer. Mineral., 93, 1687 (abs. ref. 1).

Chukhrovite-(Ce) $Ca_3(Ce,Y)Al_2(SO_4)F_{13}\cdot 10H_2O$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Octahedral crystals, to 1.5 mm.

Physical Properties: *Cleavage:* [On {111}, distinct.] [by analogy to chukhrovite-(Y)]. *Fracture:* [Irregular.] *Tenacity:* [Brittle.] Hardness = [∼3] D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* [Colorless.]
Optical Class: Isotropic. $n = 1.443(2)$

Cell Data: *Space Group:* $Fd3$. $a = 16.74(4)$ $Z = 8$

X-ray Powder Pattern: Clara mine, Germany.
9.75 (10), 5.93 (8), 3.22 (7), 2.56 (6), 2.17 (6), 4.20 (5), 2.24 (5)

Chemistry: (1) Clara mine, Germany; by electron microprobe, Ce determined as the dominant rare-earth element, with Y absent. (2) Yaroslavsk deposit, Russia; $RE_2O_3 = Y_2O_3$ 20.7%, La_2O_3 8.9%, Ce_2O_3 27.1%, Pr_2O_3 6.3%, Nd_2O_3 14.8%, Sm_2O_3 7.0%, Gd_2O_3 6.6%, Dy_2O_3 4.0%, Er_2O_3 2.2%, Yb_2O_3 1.4%; identity established by X-ray powder pattern and physical properties.

Occurrence: In a hydrothermal barite–fluorite vein deposit (Clara mine, Germany); from the oxidized zone of a banded sellaite–tourmaline–fluorite deposit (Yaroslavsk deposit, Russia).

Association: Fluorite, jarosite, pyrite, sulfur (Clara mine, Germany); sellaite, gearksutite, yaroslavite (Yaroslavsk deposit, Russia).

Distribution: From the Clara mine, near Oberwolfach, Black Forest, Germany. At the Yaroslavsk tin deposit, 50 km south of Lake Khanka, Primorskiy Kray, Siberia, Russia.

Name: For its relation to *chukhrovite*-(Y) and content of *cerium* as the dominant rare-earth element.

Type Material: n.d.

References: (1) Walenta, K. (1979) Chukhrovit-(Ce) and Rhabdophan-(Ce) aus der Grube Clara bei Oberwolfach im mittlern Schwarzwald. Chem. Erde, 38, 331–339 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 1065 (abs. ref. 2). (3) Novikova, M.I. (1973) Occurrence of chukhrovite in Siberia. Zap. Vses. Mineral. Obshch., 102, 200–202 (in Russian). (4) Mathew, M., S. Takagi, K.R. Waerstad, and A.W. Frazier (1981) The crystal structure of synthetic chukhrovite, $Ca_4AlSi(SO_4)F_{13}\cdot 12H_2O$. Amer. Mineral., 66, 392–397. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 65–66.

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Chukhrovite-(Y) $Ca_3(Y,Ce)Al_2(SO_4)F_{13}\cdot 10H_2O$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Crystals show varying degrees of dominance of {100} and {111}, to 1 cm.

Physical Properties: *Cleavage:* On {111}, distinct. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 2.274–2.398 D(calc.) = [2.16]

Optical Properties: Transparent to opaque. *Color:* Colorless, white, rarely with a lilac tint. *Luster:* Vitreous to pearly, greasy on fracture surfaces.
Optical Class: Isotropic, anomalously birefringent. n = 1.42–1.44

Cell Data: *Space Group:* $Fd3$. a = 16.80(0.5) Z = 8

X-ray Powder Pattern: Kara-Oba deposit, Kazakhstan.
2.193 (10), 1.834 (10), 3.261 (9), 2.572 (9), 2.843 (8), 1.684 (8), 1.512 (8)

Chemistry:

	(1)
SO_3	10.38
Al_2O_3	10.56
RE_2O_3	18.00
MgO	0.40
CaO	21.52
$(Na,K)_2O$	trace
F	28.32
H_2O^+	10.80
H_2O^-	12.00
insol.	trace
$-O = F_2$	11.89
Total	100.09

(1) Kara-Oba deposit, Kazakhstan; $RE_2O_3 = Y_2O_3$ [40.9%], La_2O_3 5%, Ce_2O_3 15%, Pr_2O_3 4%, Nd_2O_3 12%, Sm_2O_3 7.2%, Eu_2O_3 0.2%, Gd_2O_3 6.5%, Tb_2O_3 0.9%, Dy_2O_3 4.1%, Ho_2O_3 0.8%, Er_2O_3 1.7%, Tm_2O_3 0.3%, Yb_2O_3 1.2%, Lu_2O_3 0.2% by X-ray spectroscopy; corresponds to $Ca_{3.03}(Y,Ce)_{0.95}Al_{1.62}(SO_4)_{1.00}[F_{11.46}(OH)_{0.40}]_{\Sigma=11.86}\cdot 9.55H_2O$.

Occurrence: In the oxidation zone of a Mo–W deposit.

Association: Halloysite, gearksutite, fluorite, creedite, anglesite, "limonite".

Distribution: From the Kara-Oba Mo–W deposit, Bet-Pak-Dal Desert, central Kazakhstan.

Name: Honors Fedor Vasil'evich Chukhrov (1908–1988), Russian mineralogist, Director, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia, and *yttrium*, the dominant rare-earth element.

Type Material: Vernadsky State Geological Museum, 46354; Russian Research Institute of Mineral Resources; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 61518, 61519; National Museum of Natural History, Washington, D.C., USA, 144183.

References: (1) Ermilova, L.P., V.A. Moleva, and R.F. Klevtsova (1960) Chukhrovite, a new mineral from central Kazakhstan. Zap. Vses. Mineral. Obshch., 89, 15–25 (in Russian). (2) (1960) Amer. Mineral., 45, 1132 (abs. ref. 1). (3) Mathew, M., S. Takagi, K.R. Waerstad, and A.W. Frazier (1981) The crystal structure of synthetic chukhrovite, $Ca_4AlSi(SO_4)F_{13}\cdot 12H_2O$. Amer. Mineral., 66, 392–397. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 66.

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Churchite-(Y) $YPO_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Crystals rare, to 6 mm, columnar to acicular, in flat radial aggregates; typically as crusts and coatings.

Physical Properties: *Cleavage:* On {001}, perfect; on {010} and {100}, less perfect. *Fracture:* Conchoidal. Hardness = 3 D(meas.) = 3.26 D(calc.) = [3.11]

Optical Properties: Transparent. *Color:* Colorless to snow-white; smoke-gray, with flesh-red tints; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Z \wedge c = 28°–35°$. *Dispersion:* Small to marked. $\alpha = 1.605–1.623$ $\beta = 1.600–1.631$ $\gamma = 1.645–1.657$ 2V(meas.) = Small to medium.

Cell Data: *Space Group:* $A2/a$ or Aa. $a = 5.59$ $b = 15.08$ $c = 6.17$ $\beta = 115.3°$ Z = 4

X-ray Powder Pattern: Cornwall, England.
4.21 (vvs), 7.50 (vs), 3.02 (vs), 2.82 (ms), 4.70 (m), 3.74 (m), 2.62 (m)

Chemistry:

	(1)	(2)	(3)
P_2O_5	31.10	31.15	32.28
$(Y,Er)_2O_3$	41.37	52.90	51.34
$(La,Nd)_2O_3$	7.99		
Ce_2O_3	1.05		
Fe_2O_3	1.43		
CaO	1.55		
H_2O	15.29	15.96	16.38
insol.		0.23	
Total	99.78	100.24	100.00

(1) Cornwall, England; corresponds to $[Y_{0.74}(La,Nd)_{0.11}Er_{0.07}Ce_{0.02}]_{\Sigma=0.94}PO_4 \cdot 2.02H_2O$.
(2) Auerbach, Germany. (3) $YPO_4 \cdot 2H_2O$.

Occurrence: Locally abundant; typically derived from meteoric waters, with yttrium weathered or biochemically leached from trace amounts in surrounding rocks or soil, deposited on colloidal Fe–Mn oxides; less commonly a secondary mineral in hydrothermal mineral deposits.

Association: Florencite, rhabdophane, wavellite, crandallite, turquoise, variscite, cacoxenite, beraunite, dufrénite, goyazite, gorceixite, crandallite, monazite, apatite, todorokite, lithiophorite, hematite, "limonite", clay minerals.

Distribution: In England, from Cornwall, at the Tretoil mine, Lanivet, near Bodmin, and at Wheal Pendarves, Camborne. In Germany, in the Nitzlbuch and Leonie mines, near Auerbach, Bavaria; at Rengersdorf, Saxony; from Reichenbach, near Bensheim, Hesse. At Jáchymov (Joachimsthal), Czech Republic. In the USA, in the Kelly Bank mine, east of Vesuvius, Rockbridge Co., and at the Burley pegmatite, Amherst Co., Virginia; from Girard, Burke Co., Georgia; on Indian Mountain, Cherokee Co., Alabama; found about one km south of Sausalito, Marin Co., California. In the José Pinto pegmatite, at Jaguaraçu, near Coronel Fabriciano, Minas Gerais, Brazil. From the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia. At Chutukou, Yenisei Ridge, Taimyr Peninsula, Russia. Several other poorly-defined occurrences are known; probably more await recognition.

Name: To honor Arthur Herbert Church (1834–1915), English chemist, who originally analyzed and described the mineral.

Type Material: The Natural History Museum, London, England, 40636.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 773; 771–773 [weinschenkite = churchite]. (2) Claringbull, G.F., and M.H. Hey (1953) A re-examination of churchite. Mineral. Mag., 30, 211–217. (3) Milton, D.J. and H. Bastron (1971) Churchite and florencite (Nd) from Sausalito, California. Mineral. Record, 2, 166–168.

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Chursinite $Hg^{1+}Hg^{2+}(AsO_4)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In grains, to 0.2 mm.

Physical Properties: *Cleavage:* One, parallel to elongation. *Tenacity:* Brittle. Hardness = ∼3 VHN = 198–245, 219 average. D(meas.) = n.d. D(calc.) = 9.06 (synthetic).

Optical Properties: Transparent in thin fragments. *Color:* Yellow-brown to orange-brown; in reflected light, gray with bluish tint, tarnishes to a bluish to bluish white film. *Streak:* Grayish yellow. *Luster:* Adamantine, nearly.
Optical Class: Biaxial. *Pleochroism:* Pale brownish yellow to light brown. *Orientation:* Straight. $n = > 2.0$ *Anisotropism:* Dark brown to blue-gray.
R_1–R_2: (460) 18.5–22.8, (546) 16.1–20.4, (590) 15.8–19.7, (656) 14.5–18.5

Cell Data: *Space Group:* $P2_1/c$. $a = 8.71(2)$ $b = 5.08(2)$ $c = 15.66(2)$ $\beta = 128.27(11)^\circ$ $Z = 2$

X-ray Powder Pattern: Khaydarkan deposit, Kyrgyzstan.
3.05 (10), 2.89 (7.5), 2.84 (7), 2.49 (5), 2.16 (5b), 1.911 (5), 1.883 (5)

Chemistry:

	(1)	(2)
As	9.74	13.87
Hg	81.28	74.28
O	9.57	11.85
Total	100.59	100.00

(1) Khaydarkan deposit, Kyrgyzstan; by electron microprobe, average of six analyses; stated to correspond to $Hg_{2.71}As_{0.87}O_{4.00}$. (2) $Hg^{1+}Hg^{2+}(AsO_4)$.

Occurrence: In the oxidized zone of a Sb–As–Hg deposit.

Association: Calomel, eglestonite, terlinguaite, corderoite, montroydite, kuznetsovite, shakhovite, poyarkovite, mercury.

Distribution: From the Khaydarkan deposit, Fergana Valley, Alai Range, Kyrgyzstan.

Name: In honor of the Russian theater and film actress Lyudmila Alekseevna Chursina (1941–).

Type Material: Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, Novosibirsk, XI-41/1; Mining Institute, St. Petersburg, Russia, 1678/1.

References: (1) Vasil'ev, V.I., Y.G. Lavrent'ev, and N.A. Pal'chik (1984) Chursinite, $(Hg_2)_3(AsO_4)_3$, a new natural mercury arsenate. Zap. Vses. Mineral. Obshch., 113, 341–347 (in Russian). (2) (1985) Amer. Mineral., 70, 871 (abs. ref. 1). (3) Kamenar, B. and B. Kaitner (1973) The crystal structure of mercury(I) orthoarsenate. Acta Cryst., 29, 1666–1669.

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Chvaleticeite $(Mn^{2+},Mg)SO_4 \cdot 6H_2O$

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Crystal Data: Monoclinic (by analogy to hexahydrite). *Point Group:* $2/m$. As efflorescences and coatings, granular, to 0.05 mm.

Physical Properties: Hardness = 1.5 D(meas.) = 1.84 D(calc.) = 1.84 Dehydrates readily in air; easily soluble in H_2O.

Optical Properties: Translucent to transparent. *Color:* White, pale pink, yellowish green; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial. $\alpha = 1.457$ (α') $\beta =$ n.d. $\gamma = 1.506$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$ (by analogy to hexahydrite). $a = 10.05(2)$ $b = 7.24(2)$ $c = 24.3(1)$ $\beta = 98.0(2)^\circ$ Z = 8

X-ray Powder Pattern: Chvaletice, Czech Republic.
4.91 (10), 5.45 (8), 4.47 (8), 3.98 (8), 3.25 (8), 3.42 (7), 2.967 (7)

Chemistry:

	(1)
SO_3	31.48
Al_2O_3	trace
Fe_2O_3	0.10
FeO	trace
MnO	15.81
MgO	6.41
CaO	0.04
Na_2O	0.01
K_2O	0.01
H_2O^+	0.37
H_2O^-	45.22
insol.	0.36
Total	99.81

(1) Chvaletice, Czech Republic; Ca, Fe, K, and Na by AA, H_2O by the Penfield method; corresponds to $(Mn_{0.57}Mg_{0.40})_{\Sigma=0.97}SO_4 \cdot 6.39H_2O$.

Mineral Group: Hexahydrite group.

Occurrence: Formed in the oxidation zone of a pyrite–manganese silicate deposit (Chvaletice, Czech Republic).

Association: Melanterite, magnesian–manganoan melanterite, epsomite, magnesian–ferroan mallardite, magnesian jokokuite, magnesian ilesite, rozenite, copiapite, gypsum (Chvaletice, Czech Republic); apjohnite, copiapite, epsomite, gypsum (Jáchymov, Czech Republic).

Distribution: In the Czech Republic, from Chvaletice, and at Jáchymov (Joachimsthal).

Name: For the locality where the first specimens were collected, Chvaletice, Czech Republic.

Type Material: Geological Survey, Prague, Czech Republic.

References: (1) Pašava, J., K. Breiter, M. Huka, and J. Korecký (1986) Chvaleticeite, $(Mn,Mg)SO_4 \cdot 6H_2O$, a new mineral. Neues Jahrb. Mineral., Monatsh., 121–125. (2) (1987) Amer. Mineral., 72, 1023–1024 (abs. ref. 1).

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Chvilevaite $Na(Cu, Fe, Zn)_2S_2$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Tabular, equant, and prismatic grains, up to 0.5 mm, intergrown with other sulfides.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Brittle. Hardness = n.d. VHN = 110–153, 135 average (20 g load). D(meas.) = n.d. D(calc.) = 3.94

Optical Properties: Opaque. *Color:* Bronze, tarnishing to a sooty black coating; in reflected light, orange, changing to rosy purple with time. *Luster:* Metallic. *Pleochroism:* Distinct, from pale orange to dark gray with a lilac tint. *Anisotropism:* Strong, from black to white.
R_1–R_2: (400) — , (420) 17.9–17.9, (440) 17.7–18.0, (460) 17.5–18.4, (480) 17.4–19.0, (500) 17.3–19.7, (520) 17.4–20.7, (540) 17.5–21.6, (560) 17.7–22.5, (580) 17.8–23.3, (600) 18.0–24.0, (620) 18.2–24.8, (640) 18.5–25.6, (660) 18.8–26.2, (680) 19.1–26.8, (700) 19.4–27.4

Cell Data: *Space Group:* $P3m1$. $a = 3.873(1)$ $c = 6.848$ $Z = 1$

X-ray Powder Pattern: Akatui deposit, Russia.
3.02 (100), 2.40 (100), 1.945 (100), 3.40 (90), 1.870 (90), 6.85 (60)

Chemistry:

	(1)
Na	10.93
Cu	38.63
Fe	11.64
Zn	6.72
Ca	0.26
Mn	0.06
As	0.55
S	30.83
Total	99.62

(1) Akatui deposit, Russia; by electron microprobe, corresponding to $(Na_{1.01}Ca_{0.01})_{\Sigma=1.02}(Cu_{1.28}Fe_{0.44}Zn_{0.22}As_{0.01})_{\Sigma=1.95}S_{2.03}$.

Occurrence: Of hydrothermal origin.

Association: Sphalerite, covellite, chalcocite, galena, pyrite, boulangerite, arsenopyrite, carbonates, quartz.

Distribution: From the Akatui Pb–Zn deposit, Akatui, eastern Transbaikal, Russia [TL].

Name: For Tat'yana Nikiforovna Chvileva (1925–), economic mineralogist, Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 88050.

References: (1) Kachalovskaya, V.M., B.S. Osipov, N.G. Nazarenko, V.A. Kukoev, A.O. Mazmanyan, I.N. Egorov, and L.N. Kaplunnik (1988) Chvilevaite – a new alkali sulfide with the composition $Na(Cu, Fe, Zn)_2S_2$. Zap. Vses. Mineral. Obshch., 117, 204–207 (in Russian).
(2) (1989) Amer. Mineral., 74, 946 (abs. ref. 1).

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Cianciulliite $Mn^{2+}(Mg,Mn^{2+})_2Zn_2(OH)_{10}\cdot 2{-}4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, lathlike, tabular on {100}, many faces curved, to 0.6 mm.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Laminae flexible, not elastic. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 2.87 for $2H_2O$; 3.15 for $4H_2O$.

Optical Properties: Opaque in all but one direction, ⊥ {100}, then transparent only in thinnest fragments. *Color:* Dark brown to reddish brown; dark red-brown in transmitted light; gray in reflected light, with red-orange internal reflections. *Luster:* Adamantine to vitreous; dull to pearly on cleavage.
Optical Class: Biaxial. n = 1.76–1.92 *Anisotropism:* Very weak. *Bireflectance:* Very weak. R_1–R_2: (400) 9.52–9.72, (420) 9.13–9.30, (440) 8.85–8.97, (460) 8.65–8.74, (480) 8.44–8.56, (500) 8.34–8.44, (520) 8.23–8.35, (540) 8.09–8.25, (560) 8.06–8.21, (580) 8.01–8.20, (600) 7.98–8.18, (620) 7.96–8.18, (640) 7.98–8.18, (660) 7.98–8.18, (680) 7.93–8.15, (700) 7.90–8.14

Cell Data: *Space Group:* $C2/m$. a = 15.405(3) b = 6.344(1) c = 5.562(2) β = 101.23(2)° Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
7.61 (10), 2.745 (6), 3.96 (5), 2.997 (4), 3.45 (3), 2.673 (3), 5.47 (2)

Chemistry:

	(1)	(2)	(3)
MnO	27.8	29.70	27.56
ZnO	31.1	33.36	30.97
MgO	9.2	9.86	9.15
H_2O	[31.9]	27.08	32.32
Total	[100.0]	[100.00]	[100.00]

(1) Franklin, New Jersey, USA; by electron microprobe, Mn^{2+} from crystal-structure analysis, H_2O by difference. (2) Do.; metal ratios from (1), calculated for $2H_2O$. (3) Do.; metal ratios from (1), calculated for $4H_2O$.

Occurrence: A very rare mineral on a museum specimen, typical of material from secondary veins in a metamorphosed stratiform zinc orebody.

Association: Willemite, zincite, cahnite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: In honor of John Cianciulli, of Sussex, New Jersey, USA, for his assistance to mineralogists studying Franklin-Sterling Hill minerals.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 56469; National Museum of Natural History, Washington, D.C., USA, M03074.

References: (1) Dunn, P.J., J.D. Grice, A. Criddle, and C. Stanley (1991) Cianciulliite, a new magnesium manganese zinc hydroxide from Franklin, New Jersey. Amer. Mineral., 76, 1708–1710. (2) Grice, J.D. and P.J. Dunn (1991) The crystal structure of cianciulliite, $Mn(Mg,Mn)_2Zn_2(OH)_{10}\cdot 2{-}4H_2O$. Amer. Mineral., 76, 1711–1714.

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Cinnabar HgS

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Crystal Data: Hexagonal. *Point Group:* 32. Rhombohedral crystals, to 10 cm; thick tabular {0001}; stout to slender prismatic ‖ [10$\bar{1}$0]. Also as incrustations, granular, and massive. *Twinning:* Twin plane {0001}, twin axis [0001], to form simple contact twins.

Physical Properties: *Cleavage:* {10$\bar{1}$0}, perfect. *Fracture:* Subconchoidal, uneven. *Tenacity:* Slightly sectile. Hardness = 2–2.5 VHN = 82–156 (10 g load). D(meas.) = 8.176 D(calc.) = 8.20

Optical Properties: Transparent in thin pieces. *Color:* Cochineal-red, towards brownish red and lead-gray. *Streak:* Scarlet. *Luster:* Adamantine, inclining to metallic when dark; dull in friable material.
Optical Class: Uniaxial (+). $\omega = 2.905$ (598.5). $\epsilon = 3.256$ (598.5). *Anisotropism:* High.
R_1–R_2: (400) 30.0–33.5, (420) 28.8–32.1, (440) 27.4–30.9, (460) 26.4–29.9, (480) 25.7–29.5, (500) 25.2–29.4, (520) 24.6–29.4, (540) 24.2–29.1, (560) 23.9–28.6, (580) 23.7–27.9, (600) 23.4–27.3, (620) 23.0–26.8, (640) 22.6–26.3, (660) 22.4–26.0, (680) 22.1–25.7, (700) 21.9–25.5

Cell Data: *Space Group:* $P3_121$ or $P3_221$. a = 4.145(2) c = 9.496(2) Z = 3

X-ray Powder Pattern: Almadén, Spain.
2.85 (10), 3.34 (9), 1.672 (6), 2.06 (5), 1.969 (5), 1.725 (5), 1.339 (5)

Chemistry: Essentially pure HgS.

Polymorphism & Series: Trimorphous with metacinnabar and hypercinnabar.

Occurrence: Formed from low-temperature hydrothermal solutions in veins, and in sedimentary, igneous, and metamorphic host rocks.

Association: Mercury, realgar, pyrite, marcasite, stibnite, "opal", "chalcedony", barite, dolomite, calcite.

Distribution: The most common ore of mercury world-wide, so only a few localities for exceptionally abundant or well-crystallized material can be mentioned. In the USA, in California, notably at New Almaden, Santa Clara Co. and New Idria, San Benito Co.; in Texas, at Terlingua, Brewster Co.; in Nevada, at the Cahill mine, Poverty Peak district, Humboldt Co., and near Lovelock, Pershing Co. At Charcas, San Luis Potosí, Mexico. In Spain, from Almadén, Ciudad Real Province, and Mieres, Asturias. At Hydercahn, in the Fergana basin, Kazakhstan. From Tongrin, Wanshanchang, and elsewhere in Guizhou Province, and in exceptional twinned crystals from the Tsar Tien mine, Hunan Province, China. As fine crystals at Mount Avala, near Belgrade, Serbia. From Idrija (Idria), Slovenia.

Name: From the Medieval Latin *cinnabaris*, traceable to the Persian *zinjifrah*, apparently meaning *dragon's blood*, for the red color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 251–255. (2) Auvray, P. and F. Genet (1973) Affinement de la structure cristalline du cinabre α–HgS. Bull. Soc. fr. Minéral., 96, 218–219 (in French). (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 69. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 99.

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Clairite $(NH_4)_2Fe^{3+}_3(SO_4)_4(OH)_3 \cdot 3H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As powdery aggregates of pseudohexagonal plates, to 50 μm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. D(meas.) = 2.31 D(calc.) = 2.32 Slowly soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Yellow.
Optical Class: Biaxial. *Pleochroism:* X = pale yellow; Z' = dark yellow. *Orientation:* $X = c$.
$\alpha = 1.595$ β = n.d. $\gamma = 1.607$ 2V(meas.) = n.d.

Cell Data: *Space Group:* [$P\overline{1}$ or $P1$] (by analogy to metavoltine). $a = 9.368$ $b = 9.150$ $c = 52.610$ $\alpha = 88.15°$ $\beta = 90°$ $\gamma = 118.36°$ Z = 8

X-ray Powder Pattern: Lone Creek Fall Cave, South Africa.
17.5 (100), 8.78 (100), 3.279 (25), 8.23 (20), 3.424 (20), 3.041 (20), 4.743 (15)

Chemistry:

	(1)	(2)
SO_3	43.86	46.21
Al_2O_3	0.10	
Fe_2O_3	31.42	34.57
Mn_2O_3	1.23	
Na_2O	0.35	
K_2O	0.03	
$(NH_4)_2O$	6.97	7.52
H_2O	10.85	11.70
insol.	4.41	
Total	99.22	100.00

(1) Lone Creek Fall Cave, South Africa; Na and K by flame photometry, insoluble is quartz; corresponding to $[(NH_4)_{1.95}Na_{0.08}]_{\Sigma=2.03}(Fe_{2.87}Mn_{0.11}Al_{0.02})_{\Sigma=3.00}(SO_4)_4(OH)_{3.03} \cdot 2.88H_2O$.
(2) $(NH_4)_2Fe_3(SO_4)_4(OH)_3 \cdot 3H_2O$.

Occurrence: A rare secondary mineral formed by alteration of pyrite to ferric sulfate, and reaction, at pH ~2, with ammonia produced as the result of decay of organic matter (*Hyrax* excreta).

Association: Lonecreekite, sabieite, tschermigite.

Distribution: On the ceiling of Lone Creek Fall Cave, near Sabie, Eastern Transvaal, South Africa.

Name: Honors Claire Zingg Martini (1936–), wife of the author of the type description, who assisted her husband in cave exploration and mineral collecting.

Type Material: Museum of the Geological Survey, Pretoria, South Africa.

References: (1) Martini, J.E.J. (1983) Lonecreekite, sabieite, and clairite, new secondary ammonium ferric-iron sulphates from Lone Creek Fall Cave, near Sabie, Eastern Transvaal. Ann. Geol. Surv. S. Africa, 17, 29–34. (2) (1986) Amer. Mineral., 71, 229 (abs. ref. 1).

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Claraite $(Cu, Zn)_3(CO_3)(OH)_4 \cdot 4H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $\overline{1}$ or 1. As crusts and spherules composed of divergent tabular to pseudorhombohedral crystals, to 0.5 mm.

Physical Properties: *Cleavage:* On pseudo-$\{10\overline{1}0\}$, perfect. Hardness = ∼2
D(meas.) = 3.35(5) D(calc.) = 3.34

Optical Properties: Semitransparent. *Color:* Bluish green. *Luster:* Vitreous.
Optical Class: Uniaxial (–), may be weakly biaxial (–). *Pleochroism:* O = pale green to bluish green; E = colorless to pale green. *Dispersion:* $r \gg v$. $\omega = 1.751(2)$ $\epsilon = 1.645(2)$
2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 14.28$ $b = 8.03$ $c = 7.27$ $\alpha = 79.16°$ $\beta = 107.90°$ $\gamma = 99.68°$ Z = 4

X-ray Powder Pattern: Clara mine, Germany.
13.47 (10), 7.84 (9), 3.65 (8), 5.17 (6), 2.96 (6), 3.24 (5), 2.72 (4)

Chemistry:

	(1)
CO_2	11.6
MnO	1.2
CuO	52.2
ZnO	8.0
H_2O	[27.0]
Total	[100.00]

(1) Clara mine, Germany; by electron microprobe, average of two analyses, H_2O by difference; corresponding to $(Cu_{2.56}Zn_{0.38}Mn_{0.06})_{\Sigma=3.00}(CO_3)_{1.03}(OH)_{3.94} \cdot 3.85H_2O$.

Occurrence: A rare secondary mineral in oxidized Cu–Zn deposits.

Association: Malachite, azurite, olivenite, barite, fluorite, quartz (Clara mine, Germany); malachite, devilline, gypsum (Rudabánya, Hungary).

Distribution: From the Clara mine, near Oberwolfach, Black Forest, Germany. At Rudabánya, Hungary.

Name: For the Clara mine, Germany, where the first specimens were collected.

Type Material: University of Stuttgart, Stuttgart, Germany; National Museum of Natural History, Washington, D.C., USA, 148464.

References: (1) Walenta, K. and P.J. Dunn (1982) Clarait, ein neues Karbonatmineral aus der Grube Clara (mittlerer Schwarzwald). Chem. Erde, 41, 97–102 (in German with English abs.). (2) (1983) Amer. Mineral., 68, 471 (abs. ref. 1). (3) Walenta, K. (1999) On the lattice constants of claraite. Der Erzgräber, 13, 20–22 (in German). (4) (2003) Amer. Mineral., 88, 254 (abs. ref. 3).

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Claringbullite $Cu_4Cl(OH)_7$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As micaceous or platy crystals, to 1 cm, flattened on {1000}; in groups of divergent plates.

Physical Properties: *Cleavage:* Perfect on {0001}; distinct on $\{10\bar{1}0\}$ and $\{11\bar{2}0\}$.
Hardness = Soft. D(meas.) = 3.9 D(calc.) = 3.99

Optical Properties: Transparent to translucent. *Color:* Blue; pale blue in transmitted light.
Luster: Pearly.
Optical Class: Uniaxial (–). $\omega = 1.782$ $\epsilon = [1.780]$

Cell Data: *Space Group:* $P6_3/mmc$. a = 6.6733(5) $c = 9.185(1)$ Z = 2

X-ray Powder Pattern: Nchanga mine, Zambia or Kambove, Congo.
5.75 (vvs), 2.700 (vvs), 2.445 (vs), 4.89 (s), 4.58 (s), 2.889 (ms), 1.797 (ms)

Chemistry:

	(1)	(2)	(3)
CuO	78.18	74.42	77.85
Cl	8.55	8.30	8.68
H_2O	[15.14]	[19.03]	15.43
SO_3	0.06	0.12	
$-O = Cl_2$	1.93	1.87	1.96
Total	[100.00]	[100.00]	100.00

(1) Nchanga mine, Zambia; by electron microprobe, H_2O by difference, presence confirmed by elemental analyzer. (2) Kambove, Congo; by electron microprobe, H_2O by difference, presence confirmed by elemental analyzer; the mean of five analyses from both localities above corresponds to $Cu_{8.00}(SO_4)_{0.01}Cl_{1.99}(OH)_{14.00} \cdot 0.68H_2O$. (3) $Cu_4Cl(OH)_7$.

Occurrence: In oxidized copper ore or slag, produced under chlorine-rich conditions.

Association: Cuprite, malachite, quartz, brochantite, nantokite, paratacamite, connellite, spangolite.

Distribution: In the Nchanga mine, Chingola, Zambia. From the M'sesa mine, Kambove, Katanga Province, Congo (Shaba Province, Zaire). In the USA, from the Cole and Southwest mines, Bisbee, Cochise Co., Arizona. In the Malanjkhand copper deposit, north of Durg, Madhya Pradesh, India. At the Great Australia mine, near Cloncurry, Queensland, Australia.

Name: Honors Gordon Frank Claringbull (1911–1990), formerly Keeper of Mineralogy and Director of the British Museum (Natural History), London, England.

Type Material: The Natural History Museum, London, England, 1976,109; University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 145660.

References: (1) Fejer, E.E., A.M. Clark, A.G. Couper, and C.J. Elliott (1977) Claringbullite, a new hydrated copper chloride. Mineral. Mag., 41, 433–436. (2) (1978) Amer. Mineral., 63, 793 (abs. ref. 1). (3) Burns, P.C., M.A. Cooper, and F.C. Hawthorne (1995) Claringbullite: a Cu^{2+} oxysalt with Cu^{2+} in trigonal-prismatic coordination. Can. Mineral., 33, 633–639.

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Clarkeite $(Na, Ca, Pb)(UO_2)O(OH)\cdot 0{-}1H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As dense microcrystalline replacements of uraninite, which may be mineralogically zoned.

Physical Properties: *Fracture:* Conchoidal to splintery. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 6.29–6.39 D(calc.) = 6.74 Radioactive.

Optical Properties: Opaque, transparent in thin grains. *Color:* Dark brown, mahogany-brown, chocolate-brown, or reddish orange; reddish brown to orange-brown or orange in transmitted light. *Streak:* Yellowish brown. *Luster:* Slightly waxy.
Optical Class: Biaxial (–). *Pleochroism:* Weak; in darker oranges. *Dispersion:* $r < v$, weak.
$\alpha = 1.997$ $\beta = 2.098$ $\gamma = 2.108$ 2V(meas.) = 30°–50°

Cell Data: *Space Group:* $R\overline{3}m$. a = 3.954(1) c = 17.660(3) Z = 3

X-ray Powder Pattern: Fanny Gouge mine, North Carolina, USA.
3.195 (100), 5.903 (64), 3.365 (56), 2.707 (34), 1.9772 (33), 2.945 (28), 1.6410 (23)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3	81.72	79.9	83.14	MgO	0.28		
SiO_2	0.50		0.03	CaO	2.84	2.1	0.37
UO_2		0.8		SrO			0.29
ThO_2		2.4	0.49	Na_2O	3.44	2.3	7.01
Al_2O_3	0.92			K_2O	0.48		0.42
Y_2O_3			0.82	H_2O^+	3.36	4.2	
RE_2O_3	2.62			H_2O^-		1.3	
Fe_2O_3	0.18			H_2O			[3.47]
PbO	3.71	7.9	3.96	insol.	0.14	0.2	
				Total	100.19	101.1	[100.00]

(1) Spruce Pine, North Carolina, USA. (2) Ajmer district, India. (3) Fanny Gouge mine, North Carolina, USA; by electron microprobe, H_2O by difference; corresponds to $(Na_{0.73}Pb_{0.06}K_{0.03}Ca_{0.02}Y_{0.02}Sr_{0.01}Th_{0.01})_{\Sigma=0.88}(UO_2)_{0.94}O_{0.92}(OH)_{1.08}\cdot 0.07H_2O$.

Occurrence: Replacing uraninite, as a late-stage hydrothermal alteration product.

Association: Uraninite, uranophane, wölsendorfite, fourmarierite, vandendriesscheite, becquerelite, curite, "gummite", quartz.

Distribution: In the USA, in the Spruce Pine district, from the Deer Park and other mines, Mitchell Co., and the Fanny Gouge mine, Yancey Co., North Carolina. In India, from the Ajmer district, Rajputana.

Name: Honors Frank Wigglesworth Clarke (1847–1931), prominent American geochemist of the U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 96510, R6607.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 624–625. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 95–99. (3) Finch, R.J. and R.C. Ewing (1997) Clarkeite: new chemical and structural data. Amer. Mineral., 82, 607–619.

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Claudetite As_2O_3

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, thin tabular on {010}, with {111} and {$\bar{1}$11}, and cleavages, to 5 cm; also as crusts. *Twinning:* Commonly as penetration or contact twins on {100}.

Physical Properties: *Cleavage:* Perfect micaceous cleavage on {010}. *Fracture:* Splintery. *Tenacity:* Very flexible; deforms plastically. Hardness = 2.5 D(meas.) = 4.14–4.15 D(calc.) = 4.186

Optical Properties: Transparent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous; pearly on cleavage surfaces.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c \simeq 84°$; $Z \wedge c \simeq 6°$. *Dispersion:* $r < v$, strong. $\alpha = 1.871(5)$ $\beta = 1.92(2)$ $\gamma = 2.01(1)$ 2V(meas.) = 58°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 5.25(1)$ $b = 12.99(1)$ $c = 4.53(1)$ $\beta = 93°53(20)'$ Z = 4

X-ray Powder Pattern: San Domingo mines, Portugal.
3.245 (100), 3.454 (50), 2.771 (35), 4.924 (25), 2.264 (25), 3.356 (20), 3.328 (18)

Chemistry:

	(1)	(2)
As	75.99	75.74
O	[23.84]	24.26
insol.	0.17	
Total	[100.00]	100.00

(1) Smolník, Slovakia; average of two analyses, O by difference. (2) As_2O_3.

Polymorphism & Series: Dimorphous with arsenolite.

Occurrence: A secondary oxidation product derived from realgar, arsenopyrite, or other arsenic-bearing minerals. Also produced as a sublimate during mine fires.

Association: Arsenolite, realgar, orpiment, sulfur.

Distribution: From the San Domingo mines, Algarve, Portugal. At Calañas, Andalusia; large cleavages from Rio Tinto, Huelva, Spain. In the Lasalle mine, Decazeville, Aveyron, France. From Smolník (Szomolnok), 16 km northeast of Rožňava, Slovakia, as a sublimation product. At Trebsko, Czech Republic. In Germany, found at St. Andreasberg, Harz Mountains. At Tsumeb, Namibia. In the USA, at the United Verde mine, Jerome, Yavapai Co., Arizona, and in the Tintic Standard mine, near Dividend, East Tintic district, Utah Co., Utah, both from mine fires; and in a sulfur prospect about 10 km north of the 4 S Ranch, Imperial Co., California.

Name: Honors Frederick Claudet, the French chemist who first described naturally occurring material.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 545–547. (2) Pertlik, F. (1978) Verfeinerung der Kristallstruktur des Minerals Claudetit, As_2O_3. ("Claudetit I"). Montash. Chem., 109, 277–282 (in German with English abs.). (3) (1978) Chem. Abs., 88, 201473 (abs. ref. 2). (4) Treacy, D.J. and P.C. Taylor (1981) Nuclear quadripole resonance in two crystalline forms of As_2O_3, arsenolite and claudetite I. Solid State Communications, 40(2), 135–138. (5) (1964) NBS Mono. 25, 3, 9.

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Clausthalite PbSe

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly massive, also fine granular or foliated.

Physical Properties: *Cleavage:* {001}, good. *Fracture:* Granular. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 44–49 (100 g load). D(meas.) = 7.8–8.22 D(calc.) = 8.275

Optical Properties: Opaque. *Color:* Lead-gray, bluish; galena-white with a grayish tinge in reflected light. *Streak:* Grayish black. *Luster:* Metallic.
R: (400) 63.4, (420) 63.0, (440) 61.8, (460) 60.1, (480) 58.4, (500) 56.7, (520) 55.3, (540) 54.0, (560) 52.7, (580) 51.6, (600) 50.7, (620) 49.9, (640) 49.4, (660) 48.8, (680) 48.4, (700) 48.2

Cell Data: *Space Group:* $Fm3m$. a = 6.1243 Z = 4

X-ray Powder Pattern: Synthetic.
3.062 (100), 2.165 (70), 3.536 (30), 1.369 (25), 1.768 (20), 1.846 (18), 1.250 (16)

Chemistry:

	(1)	(2)
Pb	70.85	72.34
Co	1.10	
Se	27.99	27.66
Total	99.94	100.00

(1) Clausthal, Germany. (2) PbSe.

Polymorphism & Series: Forms a series with galena.

Occurrence: Associated in low-sulfur hydrothermal deposits with other selenides, also in mercury deposits. Probably of secondary origin in some deposits.

Association: Tiemannite, klockmannite, berzelianite, umangite, gold, stibiopalladinite, uraninite.

Distribution: Perhaps the most common selenide. In Germany, from the Charlotte mine, Clausthal, 13 km south-southwest of Goslar [TL], Tilkerode, Lerbach, and Zorge, in the Harz Mountains, and at Schneeberg, Saxony. At Skrikerum, Sweden. From Hope's Nose, Torquay, Devon, England. In the Czech Republic, at Bukov, near Tisnova; in the Petrovice uranium deposit, near Ždăr; and the Předbořice uranium deposit, near Krásna Hora. In the USA, in the Blue Range Wilderness Area, Greenlee Co., Arizona; and at the Essex mine, Darwin, Inyo Co., California. In the Goldfields district, Saskatchewan; in the Kidd Creek mine, near Timmins, and the Hemlo gold deposit, Thunder Bay district, Ontario, Canada. In Argentina, from the Sierra de Umango; in the Santa Brigida mine; at Tuminico, Sierra de Cacho; and from Los Llantenes, La Rioja Province, and from Cerro de Cacheuta, Mendoza Province. At the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, Potosí, Bolivia. From El Sharana, Northern Territory, Australia. At Tsumeb, Namibia. Other minor occurrences are known.

Name: For the locality at Clausthal, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 204–205. (2) Ramsdell, ?? (1940) ??title?? Amer. Mineral., 25, 281–??
(3) (1955) NBS Circ. 539, 5, 38. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 100.

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Clearcreekite $Hg_3^{1+}(CO_3)(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular subhedral crystals, showing {001} and {010}, to 0.17 mm.

Physical Properties: *Cleavage:* Good on {001}. *Tenacity:* Brittle. Hardness = "Soft", probable. D(meas.) = n.d. D(calc.) = 6.96

Optical Properties: Transparent. *Color:* Pale greenish yellow. *Streak:* Pale greenish yellow. *Luster:* Vitreous.
Optical Class: Biaxial. n = [2.06–2.12]. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 6.760(4)$ $b = 9.580(4)$ $c = 10.931(4)$ $\beta = 105.53(5)^\circ$ Z = 4

X-ray Powder Pattern: Clear Creek claim, California, USA.
2.831 (100), 2.767 (100), 4.62 (90), 7.09 (70), 5.32 (40), 2.391 (40), 5.40 (30)

Chemistry:

	(1)	(2)
CO_2	n.d.	6.16
Hg_2O	84.65	87.54
H_2O	n.d.	6.30
Total		100.00

(1) Clear Creek claim, California, USA; by electron microprobe, presence of $(CO_3)^{2-}$, $(OH)^{1-}$, and H_2O confirmed by IR, overall composition determined by crystal-structure analysis; corresponds to $Hg_{2.92}(CO_3)_{1.01}(OH)_{0.90}\cdot 2.07H_2O$. (2) $Hg_3(CO_3)(OH)\cdot 2H_2O$.

Polymorphism & Series: Dimorphous with peterbaylissite.

Occurrence: Very rare, probably formed as an alteration product of cinnabar.

Association: Edoylerite, cinnabar.

Distribution: From the Clear Creek claim, near the Clear Creek mercury mine, New Idria district, San Benito Co., California, USA.

Name: For the Clear Creek mine, California, USA.

Type Material: Canadian Geological Survey, Ottawa, Canada, 68074.

References: (1) Roberts, A.C., L.A. Groat, M. Raudsepp, T.S. Ercit, R.C. Erd, E.A. Moffatt, and J.A.R. Sterling (2001) Clearcreekite, a new polymorph of $Hg_3^{1+}(CO_3)(OH)\cdot 2H_2O$, from the Clear Creek claim, San Benito Co., California. Can. Mineral., 39, 779–784.

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Clerite $Mn(Sb, As)_2S_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As irregular equant grains, to 0.2 mm, in aggregates.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. VHN = 224–262, 252 average (15 g load). D(meas.) = n.d. D(calc.) = 4.48

Optical Properties: Opaque. *Color:* Black; pale gray with pink-yellow tint in reflected light. *Luster:* Submetallic. *Anisotropism:* Strong; yellow-brown. *Bireflectance:* Distinct. R_1–R_2: (400) — , (420) 24.8–35.6, (440) 24.5–35.2, (460) 24.1–34.7, (480) 23.9–35.2, (500) 23.8–35.5, (520) 23.7–35.5, (540) 23.8–36.0, (560) 24.1–36.4, (580) 24.6–36.7, (600) 25.2–37.1, (620) 25.4–37.0, (640) 25.6–36.8, (660) 25.7–36.4, (680) 25.8–36.1, (700) 25.8–35.6

Cell Data: *Space Group: Pnam* (by analogy to berthierite). $a = 11.47(2)$ $b = 14.36(3)$ $c = 3.81(1)$ $Z = 4$

X-ray Powder Pattern: Vorontsovskoye deposit, Russia.
2.65 (100), 3.69 (90), 2.90 (80), 3.23 (70), 1.813 (50), 4.46 (40), 2.18 (40)

Chemistry:

	(1)
Mn	13.1
As	4.4
Sb	51.2
S	30.8
Total	99.5

(1) Vorontsovskoye deposit, Russia; by electron microprobe, average of five analyses; corresponding to $Mn_{1.00}(Sb_{1.75}As_{0.25})_{\Sigma=2.00}S_{4.00}$.

Occurrence: In a hydrothermal gold deposit in limestone.

Association: Realgar, pyrite, alabandite, sphalerite, aktashite, routhierite, zinkenite, chalcostibite, orpiment, stibnite, cinnabar, tetrahedrite–tennantite, gold, greigite.

Distribution: From the Vorontsovskoye gold deposit, Serov district, Northern Ural Mountains, Russia [TL].

Name: To honor Onisima Yegorovicha Klera (1845–1920), Russian geologist, President of the Ural Society of Natural Sciences Amateurs, Ykaterinberg (Sverdlovsk), Russia.

Type Material: Ural Geological Museum, Mining Institute, Yekaterinburg (Sverdlovsk), Russia.

References: (1) Murzin, V.V., A.F. Bushmakin, S.G. Sustavov, and D.K. Shcherbachev (1996) Clerite $MnSb_2S_4$ – a new mineral from the Vorontsovskoye gold deposit in the Urals. Zap. Vses. Mineral. Obshch., 125, 95–101 (in Russian with English abs.). (2) (1997) Amer. Mineral., 82, 620–621 (abs. ref. 1). (3) Bente, K. and A. Edenharter (1990) X-ray structure analyis of synthetic $MnSb_2S_4$ and structure refinement of natural $FeSb_2S_4$ (berthierite). Zeits. Krist., sup. 2, 36. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 67.

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Cliffordite $(UO_2)Te_3^{4+}O_7$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As octahedra, to 0.2 mm, in crusts.

Physical Properties: Hardness = 4 D(meas.) = 6.57 (synthetic). D(calc.) = 6.77 Radioactive.

Optical Properties: Semitransparent. *Color:* Bright sulfur-yellow. *Luster:* Adamantine. *Optical Class:* Isotropic. $n = 2.25(2)$ (synthetic).

Cell Data: *Space Group:* $Pa3$. a = 11.37–11.47 Z = 8

X-ray Powder Pattern: San Miguel prospect, Mexico.
3.273 (10), 2.844 (8), 2.007 (8), 2.755 (7), 1.712 (7), 4.63 (6), 4.02 (6)

Chemistry:

	(1)	(2)
U	24.	31.12
Te	54.	50.05
O		18.83
Total		100.00

(1) San Miguel prospect, Mexico; by electron microprobe. (2) $(UO_2)Te_3O_7$.

Occurrence: As rare incrustations along fractures in the oxidized zone of hydrothermal Au–Ag telluride deposits.

Association: Mackayite, barite, quartz, "limonite" (San Miguel prospect, Mexico); tellurium, paratellurite, quartz (Moctezuma mine, Mexico).

Distribution: From the San Miguel prospect, and 10 km southeast at the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: Honors Professor Clifford Frondel (1907–2002), Harvard University, Cambridge, Massachusetts, USA, for his contributions to uranium mineralogy.

Type Material: Natural History Museum, Paris, France, 175.83, 180.61; Harvard University, Cambridge, Massachusetts, 119079; National Museum of Natural History, Washington, D.C., USA, 120246, 164341, 164342.

References: (1) Gaines, R.V. (1969) Cliffordite - a new tellurite mineral from Moctezuma, Sonora, Mexico. Amer. Mineral., 54, 697–701. (2) Brandstaetter, F. (1981) Non-stoichiometric, hydrothermally synthesized cliffordite. Tschermaks Mineral. Petrog. Mitt., 29, 1–8.

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Clinoatacamite $Cu_2Cl(OH)_3$

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Crystal Data: Monoclinic, pseudorhombohedral. *Point Group:* $2/m$. As complex intergrowths of crystals and twinned grains, to 1 mm; as powdery aggregates. *Twinning:* Very common on {100}.

Physical Properties: *Cleavage:* Perfect on {012}. *Fracture:* Even. *Tenacity:* Brittle. Hardness = 3 D(meas.) = n.d. D(calc.) = 3.77

Optical Properties: Transparent to translucent. *Color:* Green to dark greenish black, rarely greenish blue. *Luster:* Adamantine to vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y \wedge a = 10°$. *Dispersion:* $r \gg v$, strong.
α = n.d. β = n.d. γ = n.d. 2V(meas.) = 75(5)° 2V(calc.) = 69(3)°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.157(2)$ $b = 6.814(3)$ $c = 9.105(5)$ $\beta = 99.65(4)°$
Z = 4

X-ray Powder Pattern: Chuquicamata, Chile; nearly identical to paratacamite.
5.47 (100), 2.742 (70), 2.767 (60), 2.266 (60), 2.243 (50), 1.704 (50), 2.887 (40)

Chemistry:

	(1)	(2)
CuO	74.7	74.49
Cl	16.5	16.60
H_2O	[13.5]	12.65
$-O = Cl_2$	3.7	3.74
Total	[101.0]	100.00

(1) Chuquicamata, Chile; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $Cu_{1.96}Cl_{0.97}O_{3.03}H_{3.11}$. (2) $Cu_2Cl(OH)_3$.

Polymorphism & Series: Polymorphous with atacamite, botallackite, and paratacamite.

Occurrence: An oxidation product of other copper minerals.

Association: Atacamite, paratacamite, gypsum, alunite (Chuquicamata, Chile); atacamite, zincian paratacamite, caracolite, schwartzembergite, osarizawaite-beaverite, boleite (Sierra Gorda district, Chile).

Distribution: In Chile, from Chuquicamata, and in the Sierra Gorda district, southwest of Calama, Antofagasta; at Remolinos, Atacama. From Calumet, Keweenaw Co., Michigan, and Mason Pass, near Yerington, Lyon Co., Nevada, USA. At Wallaces Gully, Mount Painter, and Wallaroo, South Australia. From the Castletown mine, Lochgilphead, Scotland.

Name: As the monoclinic polymorph of *atacamite*.

Type Material: Royal Ontario Museum, Toronto, Canada, M32176.

References: (1) Jambor, J.L., J.E. Dutrizac, A.C. Roberts, J.D. Grice, and J.T. Szymański (1996) Clinoatacamite, a new polymorph of $Cu_2(OH)_3Cl$, and its relationship to paratacamite and "anarakite". Can. Mineral., 34, 61–72. (2) Grice, J.D., J.T. Szymański, and J.L. Jambor (1996) The crystal structure of clinoatacamite, a new polymorph of $Cu_2(OH)_3Cl$. Can. Mineral., 34, 73–78. (3) (1996) Amer. Mineral., 81, 1282 (abs. refs. 1 and 2).

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Clinobarylite $BaBe_2Si_2O_7$

Crystal Data: Orthorhombic. *Point Group: mm*2. As radial aggregates of platy to prismatic crystals elongated on [001], to 20 mm. Typically flattened on {100} or less commonly on {010}.

Observed forms are {100}, {010}, {201}, and {$\bar{2}$ 01}, with less common {610}, {101}, and {$\bar{1}$ 01}. Twinning on a microscopic scale noted.

Physical Properties: *Cleavage:* Perfect on {100} and less perfect on {001} and {101}. *Fracture:* n.d. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 3.97(7) D(calc.) = 4.01

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (-). α = 1.695(5) β = 1.702(5) γ = 1.708(8) 2V(calc.) = 85(5)º *Orientation*: $X = b$, $Y = c$.

Cell Data: Space Group: $Pmn2_1$. a = 11.650(10) b = 4.922(4) c = 4.674(4) Z = 2

X-ray Powder Pattern: Mount Yukspor, Khibiny massif, Kola Peninsula, Russia. 2.458 (100), 2.929 (58), 3.388 (56), 2.336 (31), 2.986 (28), 3.042 (26), 2.077 (23)

Chemistry:

	(1)
BaO	47.66
SiO_2	36.38
BeO	14.90
Total	98.94

(1) Mount Yukspor, Khibiny massif, Kola Peninsula, Russia; average of 4 electron microprobe analyses, Be by AA, corresponding to $Ba_{1.03}Be_{1.97}Si_{2.00}O_{7.00}$.

Polymorphism & Series: Dimorphous with barylite.

Occurrence: In pegmatite veins in an alkaline igneous complex.

Association: Natrolite, aegirine, microcline, catapleiite, fluorapatite, titanite, fluorite, galenite, sphalerite, strontianite, annite, astrophyllite, lorenzenite, labuntsovite-Mn, kuzmenkoite-Mn, cerite-(Ce), edingtonite, ilmenite, calcite.

Distribution: Mount Yukspor, southern Khibiny alkaline massif, Kola Peninsula, Russia.

Name: Reflects the relationship to *barylite* and non-orthogonal appearance of its crystals which were originally incorrectly determined to be monoclinc.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia; 2819/1.

References: (1) Chukhanov, N.V., I.V. Pekov, R.K. Rastsvetaeva, G.V. Chilov, and A.E. Zadov (2003) Clinobarylite, $BaBe_2Si_2O_7$, a new mineral from the Khibiny massif, Kola Peninsula. Zap. Vseross. Mineral. Obshch., 132(1), 29-37 (in Russian, English abs.). (2) (2004) Amer. Mineral., 89, 249 (abs. ref. 1). (3) Krivovichev, S.V., V.N. Yakovenchuk, T. Armbruster, Yu. Mikhailova, and Ya.A. Pakhomovsky (2004) Clinobarylite, $BaBe_2Si_2O_7$: structure refinement, and revision of symmetry and physical properties. Neues Jahrb. Mineral. Monatsh., 2004, 373-384. (4) (2005) Amer. Mineral., 90, 522 (abs. ref. 1). (5) Di Domizio, A.J., R.T. Downs, and Hexiong Yang (2012) Redetermination of clinobarylite, $BaBe_2Si_2O_7$. Acta Crystallogr Sect E Struct Rep Online. 2012 October 1, 68(10), i78–i79.

Clinobehoite $Be(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals platy, cuneiform, in radial and spherulitic aggregates, to 1 mm.

Physical Properties: *Cleavage:* Perfect on {100}; imperfect on {010} and {001}. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 1.93(3) D(calc.) = 1.92(2)

Optical Properties: Transparent in thin plates. *Color:* White. *Luster:* Vitreous, pearly. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \simeq c$; $Z \wedge a \simeq 9°$. *Dispersion:* $r < v$, strong. $\alpha = 1.539(1)$ $\beta = 1.544(1)$ $\gamma = 1.548(1)$ 2V(meas.) = 80° 2V(calc.) = 83°

Cell Data: *Space Group:* $P2_1$. $a = 11.020(8)$ $b = 4.746(6)$ $c = 8.646(9)$ $\beta = 98.94(8)°$ Z = 12

X-ray Powder Pattern: Malyshev deposit, Russia.
2.714 (10), 3.61 (9), 5.43 (8), 3.76 (7), 3.16 (7), 2.306 (7), 3.98 (6)

Chemistry:

	(1)	(2)
BeO	55(5)	58.13
H_2O	41.0	41.87
Total		100.00

(1) Malyshev deposit, Russia; Be by laser spectral analysis, H_2O by coulometric analysis.
(2) $Be(OH)_2$.

Polymorphism & Series: Polymorphous with behoite.

Occurrence: In hydrothermally altered zones in desilicated pegmatites.

Association: Bavenite, bityite, phillipsite, analcime, albite.

Distribution: From the Malyshev deposit, Asbest district, near Yekaterinburg (Sverdlovsk), Ural Mountains, Russia.

Name: For its monoclinic symmetry and relation to *behoite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, D.L. Rogatschev, T.N. Nadezhina, D.Y. Pushcharovskii, and A.Y. Bakhchisaraytsev (1989) Clinobehoite – a new natural modification of $Be(OH)_2$ from desilicated pegmatites. Mineral. Zhurnal, 11(5), 88–95 (in Russian with English abs.). (2) (1991) Amer. Mineral., 76, 666–667 (abs. ref. 1). (3) Nadezhina, T.N., D.Y. Pushcharovskii, R.K. Rastsvetaeva, A.V. Voloshin, and I.F. Burshtein (1989) Crystal structure of a new natural $Be(OH)_2$ modification. Doklady Acad. Nauk SSSR, 305, 95–98 (in Russian). (4) (1990) Amer. Mineral., 75, 1213 (abs. ref. 3).

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Clinobisvanite $BiVO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely in platy to pyramidal crystals, to 1 mm; as globular aggregates and coatings. *Twinning:* May exhibit multiple twinning on {101}, composition plane {010}, giving reticulated groups.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = Very soft.
D(meas.) = n.d. D(calc.) = 6.949

Optical Properties: Transparent in thin flakes. *Color:* Yellow, pale orange, yellow-orange, deep reddish orange. *Luster:* Earthy to subvitreous.
Optical Class: Biaxial. $n = [2.63]$

Cell Data: *Space Group:* $I2/a$ (synthetic). $a = 5.195$ $b = 11.701$ $c = 5.092$ $\beta = 90.38°$
$Z = 4$

X-ray Powder Pattern: Synthetic.
3.095 (100), 3.082 (95), 3.120 (30), 4.749 (25), 4.670 (25), 2.924(25), 1.717 (18)

Chemistry:

	(1)	(2)	(3)
V_2O_5	27.63	27.0	28.07
Bi_2O_3	69.88	72.0	71.93
PbO	1.34		
CaO		0.9	
Total	98.85	99.9	100.00

(1) Yinnietharra Station, Western Australia. (2) White Queen mine, California, USA; by electron microprobe, corresponding to $Bi_{1.01}V_{0.97}O_4$. (3) $BiVO_4$.

Polymorphism & Series: Trimorphous with dreyerite and pucherite.

Occurrence: An accessory mineral in pegmatites, as an oxidization product of other bismuth minerals.

Association: Pucherite, bismite, bismutite, bismuth, vanadinite, beyerite, namibite, scheelite.

Distribution: In Western Australia, from five km south of Pyramid Hill, Yinnietharra Station; in the Londonderry quarry, 19 km south of Coolgardie; at Menzies; from Wodgina; on the Champion lease, Westonia; from about three km north-northwest of Corinthia; and east-southeast of Try Again Bore, Yandil Station; from South Australia, at Lively's Find gold mine, Arkaroola. From Mutala, Mozambique. At the Rubicon pegmatite, south of Karibib, and from near Khorixas, Namibia. In the USA, in the Jensen quarry, Riverside Co.; at the Lodi #4 mine, Spring Creek district, Plumas Co., and from the White Queen and Elizabeth "R" mines, Pala, San Diego Co., California; near the Comstock mine, Dos Cabezas Mountains, Cochise Co., Arizona; from the Linka mine, Spencer Hot Springs district, Lander Co., about 30 km northwest of Potts, Nevada. At the La Juana mine, Córdoba Province, Argentina. In China, from near Koktokay [Kyokfogoi], Xinjiang Uygur Autonomous Region. In an undisclosed gold deposit, Ural Mountains, Russia. At Reichenbach, near Bensheim, Hesse, Germany.

Name: For the mineral's *monoclinic* crystal system, and BISmuth and VANadium in its composition.

Type Material: Western Australian Museum, Perth, Australia, MDC5144; National Museum of Natural History, Washington, D.C., USA, 127456.

References: (1) Bridge, P.J. and M.W. Pryce (1974) Clinobisvanite, monoclinic $BiVO_4$, a new mineral from Yinnietharra, Western Australia. Mineral. Mag., 39, 847–849. (2) Foord, E.E. (1995) Clinobisvanite, eulytite, and namibite from the Pala pegmatite district, San Diego Co., California, USA. Mineral. Mag., 60, 387–388. (3) von Knorring, O., T.G. Sahama, M. Lehtinen, P. Rehtijärvi, and J. Siivola (1973) Natural bismuth vanadate from the Mutala pegmatite area, Mozambique. Contr. Mineral. Petrol., 41, 325–331. (4) (1964) NBS Mono. 25, 3, 14.

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Clinochalcomenite $CuSe^{4+}O_3 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic along and striated ‖ [001], to 0.6 mm; {110} and {011} dominant, {210}, {100}, {010}, {001} and {101} observed. Also as crusts and patchy coatings on chalcomenite.

Physical Properties: *Cleavage:* Perfect on {110}. *Tenacity:* Brittle. Hardness = 2
D(meas.) = 3.28 D(calc.) = 3.42

Optical Properties: Transparent. *Color:* Blue-green to pale green, may be black from included umangite; pale blue-green in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = colorless; Z = blue-green. *Orientation:* $Y = b$; $X \wedge a = 3°$; $Z \wedge c = 10°$. *Dispersion:* $r < v$. $\alpha = 1.675$ $\beta = 1.723$ $\gamma = 1.765$
2V(meas.) = 78°

Cell Data: *Space Group:* $P2_1/n$. $a = 8.177$ $b = 8.611$ $c = 6.290$ $\beta = 97°16'$ Z = 4

X-ray Powder Pattern: Gansu Province, China.
5.89 (10), 3.66 (9), 2.926 (8), 4.06 (7), 2.694 (7), 2.482 (7), 1.818 (7)

Chemistry:

	(1)	(2)
SeO_2	53.27	48.98
CuO	37.15	35.11
H_2O		15.91
Total		100.00

(1) Gansu Province, China; by electron microprobe, here converted to oxides, $2H_2O$ by analogy to ahlfeldite and cobaltomenite. (2) $CuSeO_3 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with chalcomenite.

Occurrence: A very rare secondary mineral in the oxidized zone of a uranium deposit in brecciated carbonaceous slate (China); in a hydrothermal selenium vein deposit (El Dragón mine, Bolivia).

Association: Volborthite, chalcomenite, umangite, malachite (China); chalcomenite, cobaltomenite, alunite (El Dragón mine, Bolivia).

Distribution: From an undisclosed locality in Gansu Province, China. At the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí, Bolivia.

Name: As the monoclinic dimorph of *chalcomenite*.

Type Material: n.d.

References: (1) Luo Keding, Wei Jun, Zhang Jingyi, and Gu Qifang (1980) Clinochalcomenite, a new mineral of selenite. Kexue Tongbao, 25, 85–89 (in Chinese), 427–433 (in English).
(2) (1981) Amer. Mineral., 66, 217 (abs. ref. 1). (3) Luo Keding, Chen Zhangru, and Ma Zhesheng (1984) Crystal structure of clinochalcomenite. Kexue Tongbao, 29, 352 (in English).

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Clinochlore $(Mg, Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In thin to thick pseudohexagonal crystals, with tapering pyramidal faces, to 10 cm. Commonly foliated, fibrous, granular, earthy, massive. *Twinning:* Twin plane {001}; twin axis [310], composition plane {001}.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Laminae flexible, inelastic. Hardness = 2–2.5 D(meas.) = 2.60–3.02 D(calc.) = 2.628

Optical Properties: Transparent to translucent. *Color:* Grass-green, olive-green, yellowish, white; pink, rose-red; colorless to pale green or yellow in thin section. *Streak:* Greenish white to white. *Luster:* Pearly, greasy, dull.
Optical Class: Biaxial (+) or (–). *Pleochroism:* Distinct; X = light yellow-green to light blue-green; $Y = Z$ = light greenish yellow to light blue-green. *Orientation:* $Y = b$; $Z \wedge c = 2°$–$9°$. *Dispersion:* $r < v$. *Absorption:* $Y \simeq Z > X$ or $Z \simeq Y > Z$. $\alpha = 1.571$–1.588 $\beta = 1.571$–1.588 $\gamma = 1.576$–1.597 2V(meas.) = 0°–50°

Cell Data: *Space Group:* $C2/m$. $a = 5.350(3)$ $b = 9.267(5)$ $c = 14.27(1)$ $\beta = 96.35(5)°$ Z = 2

X-ray Powder Pattern: Synthetic (IIb structure); berthierine plus clinochlore easily mistaken for chamosite.
3.57 (100), 2.540 (100), 2.008 (100), 1.539 (100), 14.1 (80), 7.14 (80), 4.76 (80)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	33.83	32.12	MgO	34.94	35.36
Al_2O_3	12.95	9.50	CaO		1.24
Fe_2O_3	2.25		H_2O^+	13.11	10.25
Cr_2O_3		7.88	H_2O^-		2.04
FeO	3.02	1.98	Total	100.10	100.37

(1) Zillertal, Austria; corresponds to $(Mg_{4.94}Fe^{2+}_{0.24})_{\Sigma=5.18}(Al_{0.65}Fe^{3+}_{0.16})_{\Sigma=0.81}(Si_{3.21}Al_{0.79})_{\Sigma=4.00}O_{10}(OH)_8$. (2) Deer Park, Wyoming, USA; corresponds to $(Mg_{5.05}Fe^{2+}_{0.16}Ca_{0.13})_{\Sigma=5.34}(Cr_{0.60}Al_{0.15}Fe^{3+}_{0.15})_{\Sigma=0.90}(Si_{3.08}Al_{0.92})_{\Sigma=4.00}O_{10}(OH)_8$.

Polymorphism & Series: Forms a series with chamosite; stacking disorder is common.

Mineral Group: Chlorite group.

Occurrence: A hydrothermal alteration product of amphiboles, pyroxenes, biotite. In chlorite schists, serpentinites, marbles, calc-silicate rocks, amphibolites, less commonly in ultramafic rocks. In ore veins; a detrital component of sediments.

Association: Serpentine, calcite, dolomite, actinolite, biotite, olivine, plagioclase, talc, chromite, uvarovite.

Distribution: Some localities for well-crystallized material are: in the USA, in the Emery mine, Chester, Hampden Co., Massachusetts; at Texas, Lancaster Co., and West Chester, Chester Co., Pennsylvania; in the Tilly Foster mine, Brewster, Putnam Co., New York. In the Zillertal, Tirol, Austria. From the Pfitschtal, Trentino-Alto Adige; Val Malenco, Lombardy; and at Ala, Piedmont, Italy. At Rimpfischwänge, near Zermatt, Valais, Switzerland. From Ojén, Málaga Province, Spain. On Unst, Shetland Islands, Scotland. In the Kop Krom [chrome mine], Kop Mountains, near Aşkale, Turkey. In Russia, in the Ural Mountains, at Akhmatovsk, Berbliouchka, and Hardadinsk; and at Miass, Ilmen Mountains, Southern Ural Mountains.

Name: For its inclined optic axes and the Greek *chloros*, for green, its common color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 644–650, 650–653 [penninite, kämmererite]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 131–163. (3) Bayliss, P. (1975) Nomenclature of the trioctahedral chlorites. Can. Mineral., 13, 178–180. (4) Rule, A.C. and S.W. Bailey (1987) Refinement of the crystal structure of a monoclinic ferroan clinochlore. Clays and Clay Minerals, 35, 129–138.

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Clinochrysotile $Mg_3Si_2O_5(OH)_4$

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Crystal Data: Monoclinic or triclinic. *Point Group:* n.d. Asbestiform, fibrous along [100], curled to cylindrical; also bladed, massive.

Physical Properties: Hardness = 2.5 D(meas.) = 2.53(1) D(calc.) = 2.61

Optical Properties: Semitransparent. *Color:* White, pale green to dark green. *Luster:* Silky in fibrous aggregates.
Optical Class: Biaxial (–). $\alpha = 1.569(2)$ $\beta = [1.569]$ $\gamma = 1.570(2)$ 2V(meas.) = ∼42°

Cell Data: *Space Group:* n.d. $a = 5.3129(9)$ $b = 9.120(3)$ $c = 14.637(2)$ $\beta = 93°9.8(6)'$
Z = 4

X-ray Powder Pattern: Butler Estate chrome mine, California, USA.
7.31 (100), 3.65 (70), 4.57 (50), 1.535 (50), 2.270 (30), 2.205 (30), 2.092 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	42.2	43.37	MnO	0.06	
TiO_2	0.002		NiO	0.04	
Al_2O_3	0.66		MgO	41.7	43.63
Fe_2O_3	1.2		CaO	0.01	
Cr_2O_3	0.02		H_2O^+	13.3	13.00
FeO	0.09		H_2O^-	0.95	
			Total	100.23	100.00

(1) Joe No. 5 pit, California, USA. (2) $Mg_3Si_2O_5(OH)_4$.

Polymorphism & Series: Polymorphous with antigorite, orthochrysotile, lizardite, and parachrysotile; may also be termed chrysotile-$2M_{c1}$.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Intermixed with orthochrysotile in veinlets cutting serpentinite.

Association: Orthochrysotile, lizardite, corundum.

Distribution: Undoubtedly of common occurrence in asbestos deposits, but requires careful characterization for confirmation, which has been accomplished at only a few localities, such as: in the USA, from the Butler Estate chrome mine, Fresno Co., and the Joe No. 5 pit, New Idria, San Benito Co., California; in the Belvidere Mountain quarries, Lowell, Orleans Co., Vermont; and from the Salt River Canyon, near Globe, Gila Co., Arizona. At Thetford Mines, Quebec, Canada. From Quilla, Charsadda Tehsil, Pakistan. In Australia, from Woodsreef, New South Wales.

Name: Chrysotile from the Greek for *golden* and *fiber*; *clino* in reference to the mineral's crystallization in inclined axis crystal systems.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 170–190. (2) Whittaker, E.J.W. (1956) The structure of chrysotile. II. Clino-chrysotile. Acta Cryst., 9, 855–861. (3) Page, N.J. and R.G. Coleman (1967) Serpentine-mineral analyses and physical properties. U.S. Geol. Sur. Prof. Paper 575-B, B103–B107. (4) Wicks, F.J. and E.J.W. Whittaker (1975) A reappraisal of the structures of the serpentine minerals. Can. Mineral., 13, 227–243. (5) Middleton, A.P. and E.J.W. Whittaker (1976) The structure of Povlen-type chrysotile. Can. Mineral., 14, 301–306. (6) Yada, K. (1979) Microstructures of chrysotile and antigorite by high-resolution electron microscopy. Can. Mineral., 17, 679–691. (7) Bayliss, P. (1981) Unit cell data of serpentine group minerals. Mineral. Mag., 44, 153–156. (8) Wicks, F.J. and D.S. O'Hanley (1988) Serpentine minerals: structures and petrology. In: S.W. Bailey, Ed., Hydrous phyllosilicates. Rev. Mineral. 19, MSA, 91–167.

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Clinoclase $Cu_3(AsO_4)(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare in crystals, typically needlelike, to 9 mm, elongated along [010], tabular on {001}, may be pseudorhombohedral, with prominent {100}, {001}, smaller {110}, and additional forms; as rosettes and radial fibrous spherical aggregates, to 5 cm; in crusts and coatings.

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 4.38 D(calc.) = 4.42

Optical Properties: Transparent to translucent. *Color:* Dark greenish blue to greenish black; in transmitted light, blue-green. *Streak:* Bluish green. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (–). *Pleochroism:* X = pale blue-green; Y = pale blue-green; Z = Benzol-green. *Orientation:* $Y = b$; $Z \simeq a$. *Dispersion:* $r < v$, very strong. $\alpha = 1.756$ $\beta = 1.874$ $\gamma = 1.896$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.33$–12.38 $b = 6.42$–6.46 $c = 7.21$–7.26 $\beta = 99°22'$–$99°51'$ $Z = 4$

X-ray Powder Pattern: Cornwall, England and the Tintic district, Utah, USA. 3.55 (10), 3.13 (8), 10.4 (6), 2.30 (5), 2.05 (5), 2.88 (4), 2.53 (4)

Chemistry:

	(1)	(2)
P_2O_5	1.50	
As_2O_5	27.08	30.20
Fe_2O_3	0.49	
CuO	62.80	62.70
H_2O	7.57	7.10
Total	99.44	100.00

(1) Cornwall, England; corresponding to $(Cu_{2.97}Fe^{3+}_{0.02})_{\Sigma=2.99}(As_{0.89}P_{0.08})_{\Sigma=0.97}O_4(OH)_{3.16}$.
(2) $Cu_3(AsO_4)(OH)_3$.

Polymorphism & Series: Dimorphous with gilmarite.

Occurrence: A rare secondary mineral in the oxidized zone of some arsenic-rich hydrothermal base-metal deposits.

Association: Olivenite, cornwallite, cornubite, conichalcite.

Distribution: In England, from Cornwall, at Wheals Gorland and Unity, the Ting Tang and St. Day United mines, and others, Gwennap, in the Providence mine, Lelant, at Wheal Hazard, St. Just; from the Bedford United mines, near Tavistock, Devon. At Sainte-Marie-aux-Mines, Haut-Rhin, and the Cap Garonne mine, near le Pradet, Var, France. From the Altväter samt Eschig mine, near Sayda, Saxony; in the Neues Jahr mine, near Freudenstadt, and the Clara mine, near Oberwolfach, Black Forest, Germany. At the Santa Lucia mine, near Muravera, Sardinia, Italy. From Novoveská Huta, Slovakia. In the Mammoth and other mines, Tintic district, Juab Co., and the Gold Hill mine, Tooele Co., Utah; fine examples from the Majuba Hill mine, Antelope district, Pershing Co., Nevada, USA. From San Francisco de los Andes, San Juan Province, Argentina. At the Lantaro mine, near Copiapó, Atacama, Chile. In the Hillside quarry, near Stavoren, Transvaal, South Africa. From the Kitabira mine, Yamaguchi Prefecture, Japan. At the Dome Rock copper mine, about 40 km northwest of Mingary, and Moonta, South Australia. Many other minor localities are known.

Name: From the Greek for *to incline* and *to break*, remarking the oblique basal cleavage.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 787–789. (2) Palache, C. and L.G. Berry (1946) Clinoclasite. Amer. Mineral., 31, 243–258. (3) Eby, R.K. and F.C. Hawthorne (1990) Clinoclase and the geometry of |5|−coordinate Cu^{2+} in minerals. Acta Cryst., C46, 2291–2294.

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Clinoenstatite $Mg_2Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, to 2 mm; lamellar, fibrous, or massive; as stellate clusters. *Twinning:* Polysynthetic on {100}.

Physical Properties: *Cleavage:* Good on {110}, (110) ∧ (1$\bar{1}$0) ∼91°. *Tenacity:* [Brittle] (by analogy to enstatite). Hardness = [5–6] D(meas.) = n.d. D(calc.) = 3.210

Optical Properties: Semitransparent. *Color:* [White to brown; colorless in thin section.] *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 20°–22°$. $\alpha = 1.651$ $\beta = 1.654$ $\gamma = 1.660$ 2V(meas.) = 53.5°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 9.6065$ $b = 8.8146$ $c = 5.1688$ $\beta = 108.335°$ Z = 4

X-ray Powder Pattern: Synthetic.
2.873 (100), 2.976 (75), 3.17 (30), 2.452 (30), 2.115 (30), 3.28 (25), 2.518 (18)

Chemistry:

	(1)
SiO_2	57.36
TiO_2	0.00
Al_2O_3	0.11
Cr_2O_3	0.28
FeO	6.32
MnO	0.09
MgO	34.97
CaO	0.26
Na_2O	0.00
Total	99.39

(1) Ogasawara Islands, Japan; by electron microprobe, corresponds to $(Mg_{1.81}Fe_{0.18}Ca_{0.01}Cr_{0.01})_{\Sigma=2.01}(Si_{1.99}Al_{0.01})_{\Sigma=2.00}O_6$.

Polymorphism & Series: Dimorphous with enstatite; forms a series with clinoferrosilite.

Mineral Group: Pyroxene group.

Occurrence: As phenocrysts, likely inverted from "protoenstatite," in high-magnesium nonfeldspathic andesites. Exsolved in diopside in ultramafic rocks and in enstatite in high-grade metamorphic hornfelses. An essential constituent of chondrite and achondrite meteorites, likely formed by stress.

Association: Diopside, enstatite, chromite, "hypersthene," glass.

Distribution: From Cape Vogel, Papua New Guinea, and on the inner slope of the Mariana trench. At Chichijima and Mukojima, Ogasawara (Bonin) Islands, Japan. From Népoui, New Caledonia. In the USA, from the Mt. Stuart batholith, central Cascade Mountains, Washington.

Name: For its monoclinic crystal system and chemical identity to *enstatite*.

Type Material: n.d.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 30. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 20–161. (3) Stephenson, D.A., C.B. Sclar, and J.V. Smith (1966) Unit cell volumes of synthetic orthoenstatite and low clinoenstatite. Mineral. Mag., 35, 838–846. (4) Komatsu, M. (1980) Clinoenstatite in volcanic rocks from the Bonin Islands. Contr. Mineral. Petrol., 74, 329–338. (5) Ohashi, Y. (1984) Polysynthetically-twinned structures of enstatite and wollastonite. Phys. Chem. Minerals, 10, 217–229.

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Clinoferrosilite $(Fe^{2+},Mg)_2Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals lacking terminal faces. *Twinning:* On {100}.

Physical Properties: *Cleavage:* [Good on {110}, (110) ∧ $(1\bar{1}0)$ ∼87°] (by analogy to ferrosilite). Hardness = [5–6] D(meas.) = n.d. D(calc.) = 4.068

Optical Properties: Semitransparent. *Color:* Colorless with slight amber tint. *Optical Class:* Biaxial (+). *Orientation:* $Z \wedge c = 31°$. $\alpha = 1.764(2)$ (synthetic $Fe_2Si_2O_6$). $\beta = 1.767(2)$ $\gamma = 1.792(2)$ 2V(meas.) = 25(5)°

Cell Data: *Space Group:* $P2_1/c$ (synthetic $Fe_2Si_2O_6$). $a = 9.7085$ $b = 9.0872$ $c = 5.2284$ $\beta = 108.432°$ Z = 4

X-ray Powder Pattern: Synthetic $Fe_2Si_2O_6$.
3.035 (100), 2.603 (63), 2.909 (55), 2.408 (53), 2.161 (51), 4.605 (49), 3.234 (40)

Chemistry: (1) Material from Lake Naivasha, Kenya, approximates $(Fe_{1.90}Mn_{0.10})_{\Sigma=2.00}Si_2O_6$, with Mg, Al, Ca, Ti, V, Cr, Co, and Ni absent.

Polymorphism & Series: Dimorphous with ferrosilite; forms a series with clinoenstatite.

Mineral Group: Pyroxene group.

Occurrence: As acicular crystals in lithophysae in obsidian (Lake Naivasha, Kenya).

Association: Anorthoclase, magnetite, cristobalite, fayalite, biotite (Lake Naivasha, Kenya).

Distribution: From near Lake Naivasha, Rift Valley, Kenya. In the USA, from the Coso Mountains, Inyo Co., California; and at Obsidian Cliffs, Yellowstone National Park, Wyoming. From Hrafntinnuhryggur, Iceland.

Name: For its monoclinic crystal system and chemical identity with *ferrosilite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 102793.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 20–161. (2) Bowen, N.L. (1935) Ferrosilite as a natural mineral. Amer. J. Sci., 30, 481–494. (3) (1936) Amer. Mineral., 21, 678 (abs. ref. 2). (4) Lindsley, D.H., B.T.C. Davis, and I.D. MacGregor (1964) Ferrosilite ($FeSiO_3$): synthesis at high pressures and temperatures. Science, 144, 73–74. (5) Bown, M.G. (1965) Re-investigation of clinoferrosilite from Lake Naivasha, Kenya. Mineral. Mag., 34, 66–70.

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Clinohedrite $CaZnSiO_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Crystals typically prismatic or tabular, to 4 mm; may be wedge-shaped reflecting the domatic class in which the species crystallizes.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 5.5 D(meas.) = 3.28–3.335 D(calc.) = [3.32] Strongly pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Amethystine, colorless to white. *Luster:* Brilliant, glassy; pearly on {010}.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 28°$. $\alpha = 1.662$ $\beta = 1.667$ $\gamma = 1.669$ 2V(meas.) = Large.

Cell Data: *Space Group:* Cc. $a = 5.090$–5.131 $b = 15.829$–15.928 $c = 5.386$–5.422 $\beta = 103.39°-103.43°$ Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA. (ICDD 17-214).
2.76 (100), 3.23 (70), 2.50 (60), 7.81 (50), 3.97 (50), 2.36 (50), 2.47 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	27.22	26.73	27.87
$(Fe, Al)_2O_3$	0.28	0.37	
MnO	0.50	1.11	
ZnO	37.44	37.13	37.76
MgO	0.07		
CaO	26.25	26.25	26.01
H_2O^+	8.56	8.09	8.36
Total	100.32	99.68	100.00

(1) Franklin, New Jersey, USA; average of two analyses. (2) Do. (3) $CaZnSiO_4 \cdot H_2O$.

Occurrence: In a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Hancockite, nasonite, glaucochroite, roeblingite, calcite, willemite, axinite, larsenite, hodgkinsonite, franklinite (Franklin, New Jersey, USA); stringhamite, kinoite, apophyllite (Christmas mine, Arizona, USA).

Distribution: From Franklin, Sussex Co., New Jersey; in the Christmas mine, Gila Co., Arizona, USA.

Name: From the Greek *klino*, for *incline*, and *hedra*, for *face*, for the inclined facial character of the crystal morphology.

Type Material: Yale University, New Haven, Connecticut, 2.4855; Harvard University, Cambridge, Massachusetts, USA, 131872.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 17–18. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 106–108. (3) Venetopoulos, C.C. and P.J. Rentzeperis (1976) Redetermination of the crystal structure of clinohedrite, $CaZnSiO_4 \cdot H_2O$. Zeits. Krist., 144, 377–392. (4) Simonov, M.A., E.L. Belokoneva, Y.K. Yegorov-Tismenko, and N.V. Belov (1977) Crystal structure of clinohedrite $CaZn[SiO_4] \cdot H_2O$. Doklady Acad. Nauk SSSR, 237, 334–337 (in Russian). (5) (1978) Chem. Abs., 88, 107998 (abs. ref. 4).

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Clinoholmquistite $\mathbf{Li_2[(Mg,Fe^{2+})_3Al_2]Si_8O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As elongated prismatic crystals.

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.00 D(calc.) = [3.07]

Optical Properties: [Transparent to translucent.] *Color:* [Blue.] *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z = c$; $X \wedge a = 15°–16°$. $\alpha = 1.610$ $\beta = 1.627$ $\gamma = 1.633$ 2V(meas.) = 55°–61°

Cell Data: *Space Group:* $P2/m$. $a = 9.80(2)$ $b = 17.83(3)$ $c = 5.30(1)$ $\beta = 109°06'$ Z = 2

X-ray Powder Pattern: Tastyg deposit, Russia.
7.93 (100), 2.985 (100), 2.70 (100), 4.40 (90), 1.371 (90), 1.614 (80), 1.571 (70)

Chemistry:

	(1)		(1)
SiO_2	57.68	CaO	[1.80]
TiO_2	0.00	Li_2O	3.37
Al_2O_3	13.52	Na_2O	1.74
Fe_2O_3	0.44	K_2O	0.28
FeO	5.87	F	1.70
MnO	0.45	H_2O^+	1.67
MgO	9.37	$-O = F_2$	0.71
		Total	[97.18]

(1) Tastyg deposit, Russia; recalculated to remove calcite contamination; corresponds to $(Li_{1.79}Ca_{0.21})_{\Sigma=2.00}(Mg_{1.93}Fe^{2+}_{0.68}Al_{0.21}Li_{0.08}Fe^{3+}_{0.05}Mn_{0.05})_{\Sigma=3.00}Al_{2.00}Si_8O_{22}(OH)_2$.

Polymorphism & Series: Dimorphous with holmquistite; forms a series with magnesio-clinoholmquistite and ferro-clinoholmquistite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: 0.1 $Mg/(Mg + Fe^{2+})$ 0.89; $(Ca + Na)_B < 1.34$; $Li \geq 1.0$.

Occurrence: Partly replaced by holmquistite.

Association: Holmquistite, calcite.

Distribution: From the Tastyg spodumene deposit, Tuva, Siberia, Russia.

Name: In allusion to its similarity to *holmquistite* and its monoclinic structure.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67493.

References: (1) Ginzburg, I.V. (1965) Holmquistite and its structural variety clinoholmquistite. Trudy Mineral. Muzeya Akad. Nauk SSSR, 16, 73–89 (in Russian). (2) (1967) Amer. Mineral., 52, 1585–1586 (abs. ref. 1). (3) Litvin, A.L., I.V. Ginzburg, L.N. Egorova, and A.A. Petrunina (1975) On the crystal structure of clinoholmquistite. Konst. Svoistva Miner., 9, 3–6 (in Russian). (4) (1976) Chem. Abs., 85, 65701 (abs. ref. 3).

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Clinohumite $(Mg,Fe^{2+})_9(SiO_4)_4(F,OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals complex, highly modified, to 2 cm; massive. *Twinning:* Common on {100}, simple, lamellar.

Physical Properties: *Cleavage:* {100}, poor. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.17–3.35 D(calc.) = 3.279

Optical Properties: Transparent to translucent. *Color:* White, yellow to brown with increasing Ti; in thin section, colorless, pale yellow to golden yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* X = golden yellow, yellow-brown, deep reddish yellow; Y = pale yellow, yellow-orange, light yellow; Z = pale yellow, yellow-orange, colorless. *Orientation:* $Z = b$; $X \wedge c = 9°–15°$. *Dispersion:* $r > v$, strong. $\alpha = 1.628–1.638$ $\beta = 1.641–1.654$ $\gamma = 1.662–1.674$ 2V(meas.) = 73°–76°

Cell Data: *Space Group:* $P2_1/c$. $a = 13.68$ $b = 4.75$ $c = 10.27$ $\beta = 100°50'$ Z = 2

X-ray Powder Pattern: Hämeenkylä, Finland. (ICDD 14-692).
1.738 (100), 5.02 (70), 3.70 (70), 2.76 (70), 2.54 (70), 2.51 (70), 2.26 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	36.53	35.90	MgO	54.16	44.16
TiO_2	0.26	5.59	CaO		0.01
Al_2O_3	0.22		F	2.74	0.00
Fe_2O_3	0.56		H_2O^+	1.52	2.64
FeO	5.04	11.21	H_2O^-	0.04	
MnO	0.34	0.50	$-O = F_2$	1.15	
			Total	100.26	100.01

(1) Hämeenkylä, Finland; corresponds to $(Mg_{8.42}Fe^{2+}_{0.50}Mn^{2+}_{0.06}Ti_{0.02})_{\Sigma=9.00}(SiO_4)_4[F_{1.04}(OH)_{0.93}O_{0.03}]_{\Sigma=2.00}$. (2) Franscia, Italy; corresponds to $(Mg_{7.33}Fe^{2+}_{1.04}Ti_{0.47}Mn^{2+}_{0.05})_{\Sigma=8.89}(SiO_4)_4[(OH)_{1.04}O_{0.96}]_{\Sigma=2.00}$.

Mineral Group: Humite group.

Occurrence: In contact metamorphic zones in dolostones and metasomatized limestones adjacent to felsic plutonic rocks; in serpentine and talc schists; in a carbonatite.

Association: Grossular, wollastonite, forsterite, monticellite, cuspidine, fluoborite, ludwigite, dolomite, calcite, talc, biotite, spinel, vesuvianite, sanidine, meionite, nepheline.

Distribution: At Monte Somma and Vesuvius, Campania, and Franscia, Val Malenco, Lombardy, Italy. From Hämeenkylä and Ojamo, Lohja, Finland. At Broadford, Isle of Skye, Scotland. From Llanos de Juanar, Málaga Province, Spain. At the Kangerdlugssuaq Fjord, Greenland. Found near Lake Baikal, eastern Siberia, Russia. Large crystals from Kuche-Lal, Pamir Mountains, Tajikistan. In the USA, at the Tilly Foster iron mine, Brewster, Putnam Co., New York; at Buell Park, near Fort Defiance, Apache Co., Arizona; Crestmore, Riverside Co., and the Twin Lakes region, Fresno Co., California. At Cargill Lake, Ontario, Canada. In the Jacupiranga mine, São Paulo, Brazil.

Name: For its monoclinic crystal system and relation to *humite*.

Type Material: Natural History Museum, Paris, France, 106.395–106.556; National Museum of Natural History, Washington, D.C., USA, 94997.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 538–541. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 379–417. (3) Robinson, K., G.V. Gibbs, and P.H. Ribbe (1973) The crystal structures of the humite minerals. IV. Clinohumite and titanclinohumite. Amer. Mineral., 58, 43–49. (4) Kocman, V. and J. Rucklidge (1973) The crystal structure of a titaniferous clinohumite. Can. Mineral., 12, 39–45.

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Clinojimthompsonite $(Mg, Fe^{2+})_5Si_6O_{16}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As very thin lamellae.

Physical Properties: *Cleavage:* [{110} predicted from the structure.] Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.01]

Optical Properties: Semitransparent. *Color:* Colorless to very light pinkish brown; in thin section, colorless.
Optical Class: [Biaxial.] *Orientation:* Extinction angle direction N $\wedge$ $c \simeq 10°$. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$. a = 9.874(4) b = 27.24(3) c = 5.316(3) β = 109.47(3)° Z = 4

X-ray Powder Pattern: Calculated.
8.809 (100), 13.6 (73), 3.083 (60), 2.639 (56), 2.506 (42), 4.704 (33), 4.036 (31)

Chemistry:

	(1)
SiO_2	58.55
Al_2O_3	0.37
FeO	12.13
MnO	0.73
MgO	24.93
CaO	0.50
Na_2O	0.10
H_2O	[2.93]
Total	[100.24]

(1) Chester, Vermont, USA; by electron microprobe, H_2O assuming (OH) sites filled by $(OH)^{1-}$.

Polymorphism & Series: Dimorphous with jimthompsonite.

Occurrence: In the black wallrock between chlorite and actinolite zones of a metamorphosed ultramafic body.

Association: Chesterite, clinojimthompsonite, anthophyllite, cummingtonite, talc.

Distribution: In the Carleton talc quarry, near Chester, Windsor Co., Vermont, USA.

Name: For its monoclinic crystallography and relation to *jimthompsonite*.

Type Material: Royal Ontario Museum, Toronto, Canada, M36083; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 145689.

References: (1) Veblen, D.R. and C.W. Burnham (1978) New biopyriboles from Chester, Vermont: I. Descriptive mineralogy. Amer. Mineral., 63, 1000–1009. (2) Veblen, D.R. (1978) New biopyriboles from Chester, Vermont: II. The crystal chemistry of jimthompsonite, clinojimthompsonite, and chesterite, and the amphibole-mica reaction. Amer. Mineral., 63, 1053–1073.

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Clinokurchatovite $Ca(Mg, Fe^{2+}, Mn^{2+})B_2O_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As twinned crystals, to 2 mm. *Twinning:* Contact and polysynthetic on {010}.

Physical Properties: Hardness = 4.5 D(meas.) = 3.07–3.08 D(calc.) = [3.10]

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (–). *Orientation:* $Y \wedge a = 64°$; $Y \wedge b = 38°$; $Z \wedge a = 26°$; $Z \wedge b = 52°$.
$\alpha = 1.642$–1.644 $\beta = 1.674$–1.675 $\gamma = 1.699$–1.704 2V(meas.) = 82°–88°

Cell Data: *Space Group:* $P2_1/b$. $a = 12.450$ $b = 5.514$ $c = 11.145$ $\beta = 104.13°$ Z = 8

X-ray Powder Pattern: Sayak-IV deposit, Kazakhstan.
3.045 (10), 2.799 (10), 3.093 (8), 1.937 (8), 2.586 (5), 2.027 (5), 1.236 (5)

Chemistry:

	(1)	(2)
B_2O_3	[37.7]	41.94
FeO	7.1	
MnO	0.9	
MgO	21.9	24.28
CaO	32.4	33.78
Total	[100.0]	100.00

(1) Sayak-IV deposit, Kazakhstan; average of three analyses, B_2O_3 by difference; corresponds to $Ca_{1.00}(Mg_{0.94}Fe_{0.17}Mn_{0.02})_{\Sigma=1.13}B_{1.95}O_5$. (2) $CaMgB_2O_5$.

Polymorphism & Series: Dimorphous with kurchatovite.

Occurrence: A replacement of kurchatovite in boron-bearing rocks.

Association: Kurchatovite, suanite, ludwigite, szaibélyite, sakhaite, clinohumite, svabite, sphalerite (Solongo deposit, Russia).

Distribution: From the Sayak-IV boron deposit, northeast Balkhash region, Kazakhstan. In Russia, at the Solongo boron deposit, Buryatia; from the Titovskoye boron deposit, Tas-Khayakhtakh Mountains, Sakha; in the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains.

Name: As the monoclinic dimorph of *kurchatovite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82777.

References: (1) Malinko, S.V. and N.N. Pertsev (1983) Clinokurchatovite, a new structural modification of kurchatovite. Zap. Vses. Mineral. Obshch., 112, 483–487 (in Russian). (2) (1984) Amer. Mineral., 69, 810 (abs. ref. 1). (3) Simonov, M.A., Y.K. Yegorov-Tismenko, M.A. Yamnova, E.L. Belokoneva, and N.V. Belov (1980) Crystal structure of natural monoclinic kurchatovite $Ca_2(Mg_{0.86}Fe_{0.14})(Mg_{0.92}Fe_{0.08})[B_2O_5]_2$. Doklady Acad. Nauk SSSR, 251, 1125–1128 (in Russian).

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Clinometaborite β-HBO_2

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As prismatic crystals comprised of fibrous individuals and most likely pseudomorphic, in aggregates to 2 mm.

Physical Properties: *Cleavage*: One perfect set. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.049

Optical Properties: Translucent. *Color*: Colorless (chalky white after exposure to open air and it's transformation into orthoboric acid). *Streak*: n.d. *Luster*: Vitreous. *Optical Class: B*iaxial (–). α = 1.434 β = 1.570 γ = 1.588 (for synthetic material)

Cell Data: *Space Group*: $P2_1/a$. a = 7.127(2) b = 8.842(3) c = 6.773(2) β = 93.21(1)° Z = 12

X-ray Powder Pattern: La Fossa crater, Vulcano Island, Aeolian archipelago, Sicily, Italy. 3.078 (100), 4.193 (20), 6.773 (15), 2.550 (10), 3.224 (8), 2.702 (8), 2.518 (7)

Chemistry:
(1) La Fossa crater, Vulcano Island, Aeolian archipelago, Sicily, Italy; electron microprobe analyses did not detect any elements of atomic number greater than 11, BO_2^- confirmed by IR spectroscopy. Species identify based on XRD pattern and crystal structure refinement.

Occurrence: Found as a sublimate in an active fumarole (~250 °C) in a volcanic crater.

Association: Metaborite, sassolite, adranosite.

Distribution: La Fossa crater, Vulcano Island, Aeolian archipelago, Sicily, Italy.

Name: Named for its mono*clinic* symmetry and compositional identity with *metaborite*.

Type Material: Reference Collection, Department of Inorganic Structural and Stereochemistry, University of Milan, Italy (2010–03).

References: (1) Demartin, F., C.M. Gramaccioli, and I. Campostrini (2011) Clinometaborite, natural β-metaboric acid, from La Fossa crater, Vulcano, Aeolian Islands, Italy. Canadian Mineralogist, 49, 1273-1279. (2) (2014) Amer. Mineral., 99, 870 (abs. ref. 1).

Clinomimetite $Pb_5(AsO_4)_3Cl$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As six-sided, barrel-shaped or spindlelike, short to long prismatic crystals, elongated ‖ [001], to 9 mm.

Physical Properties: Hardness = 4 D(meas.) = 7.36(1) D(calc.) = 7.37

Optical Properties: Transparent to translucent. *Color:* Greenish yellow, pale greenish yellow, wax-yellow, white.
Optical Class: Biaxial (–). *Orientation:* $X = c$; Y or $Z \wedge b \simeq 30°$ (probable). $\alpha = [2.129]$ $\beta = [2.144]$ $\gamma = [2.144]$ 2V(meas.) = 8(3)°

Cell Data: *Space Group:* $P2_1/b$. $a = 10.189(3)$ $b = 20.372(8)$ $c = 7.46(1)$ $\beta = 119.88(3)°$ Z = 2

X-ray Powder Pattern: Johanngeorgenstadt, Germany.
3.048 (100), 3.008 (70), 2.947 (70), 2.106 (60), 3.342 (50), 1.961 (50), 1.903 (50)

Chemistry:

	(1)	(2)
SO_3	0.15	
P_2O_5	0.33	
As_2O_5	22.05	23.17
SiO_2	0.14	
PbO	74.61	74.99
CaO	0.00	
Cl	2.58	2.38
$-O = Cl_2$	[0.58]	0.54
Total	[99.28]	100.00

(1) Johanngeorgenstadt, Germany; by electron microprobe, corresponds to $Pb_{5.00}[(As_{0.97}P_{0.02}Si_{0.01}S_{0.01})_{\Sigma=1.01}O_{3.98}]_3Cl_{1.09}$. (2) $Pb_5(AsO_4)_3Cl$.

Polymorphism & Series: Dimorphous with mimetite.

Mineral Group: Apatite group.

Occurrence: A rare secondary mineral in the oxidized zone of some base-metal deposits.

Association: Romanéchite, hematite (Johanngeorgenstadt, Germany).

Distribution: In Germany, from Johanngeorgenstadt, Saxony, and at Horhausen, Harz Mountains. From Eureka, Juab Co., Utah, USA.

Name: For its *monoclinic* structure and relation to *mimetite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, B13647.

References: (1) Dai, Y. (1993) Clinomimetite – the history and substantiation of the natural monoclinic dimorph of mimetite. Mineral. Record, 24, 307–310. (2) (1994) Amer. Mineral., 79, 189 (abs. ref. 1). (3) Dai, Y., J.M. Hughes, and P.B. Moore (1991) The crystal structures of mimetite and clinomimetite, $Pb_5(AsO_4)_3Cl$. Can. Mineral., 29, 369–376.

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Clinophosinaite $Na_3Ca(SiO_3)(PO_4)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Habit not described.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4 D(meas.) = 2.85–2.88 D(calc.) = [2.84]

Optical Properties: Semitransparent. *Color:* Pale lilac. *Luster:* Vitreous. *Optical Class:* Biaxial (+). α = 1.556–1.557 β = 1.559–1.561 γ = 1.563–1.567 2V(meas.) = 75°–80°

Cell Data: *Space Group:* $P2/c$. a = 7.303(2) b = 12.201(5) c = 14.715(4) $\beta = 91°56'$ Z = 8

X-ray Powder Pattern: Mt. Koashva, Russia.
2.724 (100), 2.639 (57), 2.550 (50), 2.031 (50), 1.823 (47), 1.838 (35), 3.97 (12)

Chemistry:

	(1)	(2)	(3)
SiO_2	20.1	20.1	21.45
Ce_2O_3	0.18	0.44	
MnO	0.60	0.54	
CaO	15.65	16.45	20.02
SrO	3.08	1.91	
Na_2O	32.55	32.7	33.19
K_2O	0.09	0.05	
P_2O_5	25.35	25.5	25.34
LOI	1.08	2.55	
Total	98.68	100.24	100.00

(1) Mt. Koashva, Russia; by electron microprobe, contains traces of Ti, Zr, Al, Fe, Mg, Ba, loss on ignition may be H_2O; corresponds to $(Na_{3.04}K_{0.01})_{\Sigma=3.05}(Ca_{0.81}Sr_{0.09}Mn_{0.02})_{\Sigma=0.92}Si_{0.97}P_{1.03}O_{6.95}$. (2) Mt. Yukspor, Russia; by electron microprobe, impurities as in (1), corresponds to $Na_{3.04}(Ca_{0.85}Sr_{0.05}Mn_{0.02})_{\Sigma=0.92}Si_{0.96}P_{1.04}O_{6.97}$. (3) $Na_3CaPSiO_7$.

Occurrence: Apparently as an alteration product of eudialyte in alkalic pegmatites in a differentiated alkalic massif.

Association: Zirsinalite, eudialyte.

Distribution: In Russia, on Mts. Yukspor and Koashva, Khibiny massif, Kola Peninsula.

Name: For its monoclinic crystallography and chemical similarity to *phosinaite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81592.

References: (1) Khomyakov, A.P., D.Y. Pushcharovskii, and J.G. Ronsbo (1981) Clinophosinaite, $Na_3CaPSiO_7$, a new mineral. Zap. Vses. Mineral. Obshch., 110, 351–355 (in Russian). (2) (1982) Amer. Mineral., 67, 414 (abs. ref. 1). (3) Krutik, V.M, D.Y. Pushcharovskii, A.P. Khomyakov, E.A. Pobedimskaya, and N.V. Belov (1980) Anion radical of mixed type (four $[Si_4O_{12}]$ rings and P orthotetrahedra) in the structure of monoclinic phosinaite. Kristallografiya (Sov. Phys. Crystal.), 25, 240–247 (in Russian).

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Clinoptilolite $(Na, K, Ca)_{2-3}Al_3(Al, Si)_2Si_{13}O_{36}\cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Platy crystals, to 1 cm, showing {010}, {001}, {101}, {20$\bar{1}$}; commonly fine-grained, massive.

Physical Properties: *Cleavage:* {010}, perfect. Hardness = 3.5–4 D(meas.) = 2.16(2) D(calc.) = 2.146

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–) or (+). *Orientation:* $Y = b$; $Z \wedge a = 30°–45°$. *Dispersion:* $r < v$, strong. $\alpha = 1.476–1.488$ $\beta = 1.479$ $\gamma = 1.479–1.489$ 2V(meas.) = 32°–48°

Cell Data: *Space Group:* $C2/m$. $a = 17.633(8)$ $b = 17.941(8)$ $c = 7.400(4)$ $\beta = 116.39°$ Z = 2

X-ray Powder Pattern: Agoura, California, USA.
8.92 (100), 2.974 (80), 3.897 (57), 3.964 (55), 2.728 (33), 3.419 (16), 3.119 (15)

Chemistry:

	(1)	(2)
SiO_2	69.93	68.44
Al_2O_3	11.89	11.86
Fe_2O_3	0.02	
MgO	0.47	0.12
CaO	1.07	3.26
Na_2O	2.96	1.51
K_2O	3.47	2.14
H_2O	[10.19]	[12.67]
Total	[100.00]	[100.00]

(1) Agoura, California, USA; H_2O by difference, corresponds to $(Na_{1.22}K_{0.94}Ca_{0.24}Mg_{0.15})_{\Sigma=2.55}Al_{2.99}Si_{15.01}O_{36}\cdot 11.6H_2O$. (2) Richardson Ranch, Oregon, USA; by electron microprobe, after removal of 0.46% FeO as impurity, H_2O by difference; corresponds to $(Ca_{0.78}Na_{0.65}K_{0.60}Mg_{0.04})_{\Sigma=2.07}Al_{3.10}Si_{14.91}O_{36}\cdot 11.5H_2O$.

Mineral Group: Zeolite group.

Occurrence: Formed by devitrification of volcanic glass, and in cavities in rhyolites and andesites.

Association: Zeolites, montmorillonite, hectorite, thenardite, halite, gaylussite, celadonite, quartz, "opal," calcite.

Distribution: Abundant in the western USA, as in Wyoming, at Mt. Hoodoo, Park Co.; in California, from near Agoura, Los Angeles Co., at Owens Lake, Inyo Co., and 10 km west of Hector, San Bernardino Co.; in Arizona, from northwest of Bowie, Cochise Co., and near Wikieup, Mohave Co.; in the Cuchillo deposit, near Winston, Sierra Co., New Mexico. In Oregon, large crystals from Agate Beach, Lincoln Co., Succor Creek, Malheur Co., and at Richardson Ranch, near Bend, Jefferson Co. At Kamloops Lake, near Kamloops, British Columbia, Canada. From near Kapfenberg, Styria, Austria. On the Vogelsberg, Hesse, Germany. From Val di Fassa and Alpe di Siusi, Trentino-Alto Adige, Italy.

Name: For its inclined optics and relation to *ptilolite* [mordenite].

Type Material: The Natural History Museum, London, England, 1939,314.

References: (1) Schaller, W.T. (1932) The mordenite-ptilolite group; clinoptilolite, a new species. Amer. Mineral., 17, 128–134. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 377–385. (3) Wise, W.S., W.J. Nokleberg, and M. Kokinos (1969) Clinoptilolite and ferrierite from Agoura, California. Amer. Mineral., 54, 887–895. (4) Alietti, A. (1972) Polymorphism and crystal chemistry of heulandites and clinoptilolites. Amer. Mineral., 57, 1448–1462. (5) Smyth, J.R., A.T. Spaid, and D.L. Bish (1990) Crystal structures of a natural and Cs-exchanged clinoptilolite. Amer. Mineral., 75, 522–528.

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Clinosafflorite $(Co, Fe, Ni)As_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very fine grained; intimately intergrown with other sulfides.

Physical Properties: Hardness = 4.5–5 VHN = 719–875 (100 g load). D(meas.) = n.d. D(calc.) = 7.46

Optical Properties: Opaque. *Color:* Tin-white. *Luster:* Metallic.
R_1–R_2: (400) 50.7–54.8, (420) 59.8–55.0, (440) 59.0–55.1, (460) 58.0–55.3, (480) 57.1–55.5, (500) 56.3–55.6, (520) 55.4–55.6, (540) 54.5–55.4, (560) 53.8–55.2, (580) 53.0–54.9, (600) 52.4–54.5, (620) 51.9–54.2, (640) 51.4–53.5, (660) 50.9–53.3, (680) 50.6–52.9, (700) 50.4–52.6

Cell Data: *Space Group:* $P2_1/n$. $a = 5.040$ $b = 5.862$ $c = 3.139$ $\beta = 90°13'$ Z = 2

X-ray Powder Pattern: Cobalt, Canada.
2.531 (100), 2.427 (80), 2.422 (80), 2.671 (40), 2.657 (40), 1.865 (30), 1.656 (30)

Chemistry:

	(1)	(2)
Co	27.4	25.7
Ni	0.7	
Fe	0.4	4.1
Cu	0.0	
As	70.1	67.9
S	0.6	2.3
Total	99.2	100.0

(1) Nord mine, Sweden; by electron microprobe, corresponding to $(Co_{0.98}Ni_{0.02}Fe_{0.01})_{\Sigma=1.01}(As_{1.96}S_{0.04})_{\Sigma=2.00}$. (2) Bou Azzer, Morocco; by electron microprobe, corresponding to $(Co_{0.89}Fe_{0.15})_{\Sigma=1.04}(As_{1.85}S_{0.15})_{\Sigma=2.00}$. (3) Cobalt, Canada; by electron microprobe, analyses of three samples, not given, stated to correspond to $(Co_{0.76}Fe_{0.14}Ni_{0.10})_{\Sigma=1.00}As_{2.00}$; $(Co_{0.73}Fe_{0.26}Ni_{0.01})_{\Sigma=1.00}As_{2.00}$; and $(Co_{0.70}Fe_{0.21}Ni_{0.09})_{\Sigma=1.00}As_{2.00}$.

Polymorphism & Series: Dimorphous with safflorite.

Mineral Group: Arsenopyrite group.

Occurrence: In hydrothermal Co–Ni sulfide ores, typically silver-bearing.

Association: Skutterudite, cattierite, cobaltite, siegenite, bismuth, silver, molybdenite, dolomite, barite.

Distribution: From Cobalt, Ontario, Canada [TL]. At the London mine, National district, Humboldt Co., Nevada, USA. In the Aghbar (Arhbar) mine, Bou Azzer district, Morocco. At the Nord mine, Nordmark district, and from near Filipstad, Värmland, Sweden. In Germany, in the Richelsdorf Mountains, Hesse. At the Alva silver mine, Ochil Hills, central Scotland.

Name: In reference to the monoclinic symmetry of this saffloritelike species.

Type Material: Department of Geological Sciences, Queen's University, Kingston, Ontario, Canada.

References: (1) Radcliffe, D. and L.G. Berry (1971) Clinosafflorite: a monoclinic polymorph of safflorite. Can. Mineral., 10, 877–881. (2) (1972) Amer. Mineral., 57, 1552 (abs. ref. 1). (3) Burke, E.A.J. and M.A. Zakrzewski (1983) A cobalt-bearing sulfide–arsenide assemblage from the Nord mine (Finnshytteberg), Sweden: A new occurrence of clinosafflorite. Can. Mineral., 21, 129–136. (4) Darmon, R. and M. Wintenberger (1966) Structure cristalline de $CoAs_2$. Bull. Minéral., 213–215 (in French). (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 102.

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Clinotobermorite $Ca_5Si_6(O,OH)_{18}\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* m or $2/m$. Crystals tabular $\perp$ [001], or acicular $\parallel$ [010], up to 5 mm, and as aggregates. *Twinning:* On {001} or along [100], well-developed polysynthetic on a microscopic scale.

Physical Properties: *Cleavage:* Perfect on {001}, poor on {100}. Hardness = 4.5
D(meas.) = 2.58 D(calc.) = 2.69

Optical Properties: Semitransparent. *Color:* Colorless to white; colorless in thin section.
Luster: Vitreous.
Optical Class: Biaxial. $\alpha = 1.575$ $\beta = 1.580$ $\gamma = 1.585$ 2V(meas.) = n.d. 2V(calc.) = 89.8°

Cell Data: *Space Group:* Cc or $C2/c$. $a = 11.331(9)$ $b = 7.353(7)$ $c = 22.67(2)$
$\beta = 96.59(7)°$ Z = [4]

X-ray Powder Pattern: Fuka, Japan.
11.25 (100), 3.034 (60), 2.794 (60), 3.304 (51), 3.068 (45), 2.811 (41), 3.012 (37)

Chemistry:

	(1)
SiO_2	46.55
TiO_2	0.01
B_2O_3	0.23
Al_2O_3	0.36
Fe_2O_3	0.01
MnO	0.06
MgO	0.11
CaO	39.04
Na_2O	0.02
K_2O	0.10
F	0.18
H_2O	13.75
$-O = F_2$	0.08
Total	100.34

(1) Fuka, Japan; by electron microprobe, wet chemical analysis for B, F, and H_2O; corresponds to $(Ca_{5.29}Mg_{0.02}K_{0.02})_{\Sigma=5.33}(Si_{5.90}Al_{0.05}B_{0.05})_{\Sigma=6.00}[O_{16.54}(OH)_{1.39}F_{0.07}]_{\Sigma=18.00}\cdot 5.1H_2O$.

Polymorphism & Series: Dimorphous with tobermorite.

Occurrence: In gehlenite-spurrite-bearing skarns.

Association: Calcite, tobermorite, plombièrite, apophyllite.

Distribution: At Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For its monoclinic crystal system and chemical identity to *tobermorite*.

Type Material: National Science Museum, Tokyo, Japan.

References: (1) Henmi, C. and I. Kusachi (1989) Monoclinic tobermorite from Fuka, Bitchu-cho, Okayama Prefecture, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 84, 374–379 (in Japanese with English abs.). (2) (1992) Amer. Mineral., 77, 451 (abs. ref. 1). (3) Henmi, C. and I. Kusachi (1992) Clinotobermorite, $Ca_5Si_6(O,OH)_{18}\cdot 5H_2O$, a new mineral from Fuka, Okayama Prefecture, Japan. Mineral. Mag., 56, 353–358. (4) (1993) Amer. Mineral., 78, 672 (abs. ref. 3).

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Clinotyrolite $Ca_2Cu_9(AsO_4,SO_4)_4(OH)_{10}\cdot 10H_2O$

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Crystal Data: Monoclinic. *Point Group:* m or $2/m$. Crystals, flattened parallel to {001}, elongated along [100], in radiated and foliated aggregates, to 3 mm.

Physical Properties: Hardness = n.d. D(meas.) = 3.22 D(calc.) = 3.21

Optical Properties: Semitransparent. *Color:* Emerald-green. *Luster:* Pearly or silky. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = 3°$–$4°$. $\alpha = 1.666$ $\beta = 1.686$ $\gamma = 1.694$ 2V(meas.) = 65°–66°

Cell Data: *Space Group:* Pa or $P2/a$. $a = 10.513$ $b = 5.56$ $c = 27.61$ $\beta = 94.0°$ Z = 2

X-ray Powder Pattern: Dongchuan mine, China.
2.960 (10), 2.673 (10), 4.81 (9), 4.400 (8), 1.748 (8), 3.670 (7), 3.500 (7)

Chemistry:

	(1)
SO_3	1.28
As_2O_5	28.09
CuO	46.04
CaO	7.24
H_2O	17.63
Total	100.28

(1) Dongchuan mine, China; corresponds to $Ca_{2.01}Cu_{9.01}[(AsO_4)_{3.81}(SO_4)_{0.25}]_{\Sigma=4.06}(OH)_{9.87}\cdot 10.32H_2O$.

Occurrence: In the oxidized zone of a copper mine (Dongchuan mine, China).

Association: Tyrolite (Dongchuan mine, China); tennantite, parnauite (Tynagh mine, Ireland); cuprite, posnjakite, gilmarite, langite, connellite, brochantite, malachite, vésigniéite, cornubite, olivenite, trippkeite, domeykite, djurleite (Roua mines, France).

Distribution: From the Dongchuan copper mine, Yunnan Province, China. In the Tynagh mine, near Loughrea, Co. Galway, Ireland. From the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, France. At Richelsdorf, Hesse, Germany. In the Lovelock mine, Table Mountain district, Churchill Co., Nevada, USA.

Name: For its *monoclinic* crystal system and similarity to *tyrolite*.

Type Material: n.d.

References: (1) Ma Zhesheng, Qian Rongyao, and Peng Zhizhong (1980) Clinotyrolite – a new mineral of the hydrous copper arsenate discovered in Dongchuan, Yunnan. Acta Geol. Sinica, 54, 134–143 (in Chinese with English abs.). (2) (1980) Mineral. Abs., 31, 495 (abs. ref. 1).

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Clinoungemachite $K_3Na_8Fe^{3+}(SO_4)_6(NO_3)_2 \cdot 6H_2O(?)$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$ (?). As minute thick tabular pseudorhombohedral crystals, visibly indistinguishable from ungemachite; forms include {001}, {100}, $\{\bar{1}02\}$, {111}, twenty others.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Colorless to pale yellow. *Luster:* Vitreous. *Optical Class:* Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. a = n.d. b = n.d. c = n.d. $\beta = 110°40'$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry: (1) No analysis was made, presumed to be the same as ungemachite.

Occurrence: Very rarely formed by the oxidation of pyrite in an arid climate, in veins and cavities in other massive iron sulfates.

Association: Ungemachite, jarosite, sideronatrite, metasideronatrite, metavoltine, fibroferrite.

Distribution: From Chuquicamata, Antofagasta, Chile.

Name: As the probable monoclinic dimorph of *ungemachite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 597–598.

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Clinozoisite $Ca_2Al_3(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, typically elongated and striated ‖ [010]; commonly coarse to fine granular; also fibrous. *Twinning:* Lamellar on {100}, uncommon.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 3.21–3.38 D(calc.) = 3.364

Optical Properties: Transparent to translucent. *Color:* Colorless, pale yellow, pink, red, gray, green; colorless in thin section.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge a = 0°$–$7°$. *Dispersion:* $r < v$.
$\alpha = 1.670$–1.718 $\beta = 1.670$–1.725 $\gamma = 1.690$–1.734 2V(meas.) = 14°–90°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.879(5)$ $b = 5.583(5)$ $c = 10.155(6)$
$\beta = 115.50(5)°$ Z = 2

X-ray Powder Pattern: Vernirovice, Czech Republic. (ICDD 21-128).
2.89 (100), 2.79 (90), 2.59 (70), 2.68 (60), 2.67 (60), 2.40 (60), 2.29 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.36	38.01	MgO	0.74	0.01
TiO_2	0.09	trace	CaO	22.62	23.86
Al_2O_3	30.67	31.71	H_2O^+	3.50	1.83
Fe_2O_3	0.61	4.68	H_2O^-	0.00	0.01
FeO	1.77	0.23	Total	100.36	100.34
MnO		trace			

(1) Kälviä, Finland; corresponds to $(Ca_{1.86}Fe^{2+}_{0.11}Mg_{0.08})_{\Sigma=2.05}(Al_{2.78}Fe^{3+}_{0.04})_{\Sigma=2.82}Si_{3.10}O_{12.5}$.
(2) Camaderry Mountain, Ireland; corresponds to $(Ca_{1.96}Fe^{2+}_{0.02})_{\Sigma=1.98}(Al_{2.79}Fe^{3+}_{0.27})_{\Sigma=3.06}(Si_{2.92}Al_{0.08})_{\Sigma=3.00}O_{12.5}(OH)_{0.94}$.

Polymorphism & Series: Dimorphous with zoisite.

Mineral Group: Epidote group.

Occurrence: Typically in low- to medium-grade regionally metamorphosed igneous and sedimentary rocks, as well as in contact metamorphosed calcium-rich sediments; an alteration product of plagioclase feldspars (saussuritization).

Association: Amphiboles, plagioclase, quartz.

Distribution: A widespread mineral. Typical occurrences for good crystals include: at the Goslarwand, near Prägraten, Tirol, Austria. From Vernirovice, Czech Republic. At Kälviä, Finland. From Arendal, Norway. At Camaderry Mountain, Co. Wicklow, Ireland. From Amborompotsy, Madagascar. At Sittampundi, Madras, India. In the USA, from the Belvidere Mountain quarries, Lowell, Orleans Co., Vermont; in northern Spade Spring Canyon, Los Angeles Co., California; in the Nightingale district, Pershing Co., Nevada. In Mexico, from the Juarez district, Baja California, and at Alamos, Sonora. In Canada, from Timmins, Ontario.

Name: For its monoclinic crystallography and relation to *zoisite*.

Type Material: n.d.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 18. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 44–134. (3) Dollase, W. A. (1968) Refinement and comparison of the structures of zoisite and clinozoisite. Amer. Mineral., 53, 1882–1898.

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Clintonite $Ca(Mg,Al)_3(Al_3Si)O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In tabular pseudohexagonal crystals, complexly twinned, to 2.5 cm; foliated or lamellar radiated; massive. *Twinning:* On {001}, twin axis [310] or $[3\bar{1}0]$; spiral polysynthetic twinning.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle. Hardness = 3.5 on {001}; $6 \perp \{001\}$. D(meas.) = 3.0–3.1 D(calc.) = 3.096

Optical Properties: Transparent to translucent. *Color:* Colorless, yellow, orange, red-brown, brown, green. *Streak:* White, slightly yellow-gray. *Luster:* Vitreous, pearly, submetallic. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless, pale orange, red-brown; $Y = Z$ = pale brownish yellow, pale green. *Orientation:* $Y \simeq a$ or $Y = b$; $Z = b$ or $\simeq a$; $X \wedge c = 5°$–$10°$. *Dispersion:* $r < v$, weak. *Absorption:* $Y \simeq Z > X$. α = 1.643–1.648 β = 1.655–1.662 γ = 1.655–1.663 2V(meas.) = 2°–40°

Cell Data: *Space Group:* $C2/m$. $a = 5.204$ $b = 9.026$ $c = 9.812$ $\beta = 100°20'$ Z = 2

X-ray Powder Pattern: Zlatoust, Russia.
2.56 (100), 3.21 (70), 2.11 (70), 1.505 (60), 9.68 (50), 2.45 (50), 1.485 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	18.78	16.74	MgO	20.56	20.03
TiO_2	0.54		CaO	12.90	13.09
Al_2O_3	40.00	42.70	F	2.01	
Fe_2O_3		2.85	H_2O^+	[4.20]	4.49
FeO	1.86	0.41	$-O = F_2$	[0.85]	
MnO	0.00		Total	[100.00]	100.31

(1) Amity, New York, USA; by electron microprobe, H_2O by difference; corresponds to $Ca_{0.97}(Mg_{2.15}Al_{0.70}Fe^{2+}_{0.11}Ti_{0.03})_{\Sigma=2.99}(Al_{2.68}Si_{1.32})_{\Sigma=4.00}O_{9.45}[(OH)_{1.55}F_{0.45}]_{\Sigma=2.00}$.
(2) Crestmore, California, USA; corresponds to $Ca_{0.98}(Mg_{2.09}Al_{0.70}Fe^{3+}_{0.15}Fe^{2+}_{0.02})_{\Sigma=2.96}(Al_{2.83}Si_{1.17})_{\Sigma=4.00}O_{9.92}(OH)_{2.10}$.

Polymorphism & Series: 1M polytype; $2M_1$ and 3A polytypes rare.

Mineral Group: Mica group.

Occurrence: In chlorite schists; in metasomatically altered limestones; in siliceous skarns near contact metamorphic zones.

Association: Talc, spinel, grossular, vesuvianite, clinopyroxene, monticellite, chondrodite, phlogopite, chlorite, quartz, calcite, dolomite.

Distribution: In the USA, around Amity, Edenville, and Warwick, Orange Co., New York; from Crestmore, Riverside Co., California; near Ludwig, Lyon Co., Nevada; at Sulzer, Prince of Wales Island, Alaska. On Mt. Monzoni and at Mts. Castone and Adamello, Trentino-Alto Adige, Italy. In the Pargas district, Finland. From the Akhmatovsk mine, near Zlatoust, Ural Mountains, Russia. In the Chichibu mine, Saitama Prefecture, Japan. On the Ertsberg, Irian Jaya.

Name: For De Witt Clinton (1769–1828), American statesman.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 638–640 [seybertite, xanthophyllite]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 99–102. (3) Forman, S.A., H. Kodama, and S. Abbey (1967) A re-examination of xanthophyllite [clintonite] from the type locality. Can. Mineral., 9, 25–30. (4) MacKinney, J.A., C.I. Mora, and S.W. Bailey (1988) Structure and crystal chemistry of clintonite. Amer. Mineral., 73, 365–375.

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. In irregular platelets, to 0.2 mm, and equant grains, intergrown with hydrotalcite–pyroaurite or brucite; also as fibers, to 5 mm. *Twinning:* By reflection across {0001}, common.

Physical Properties: *Cleavage:* {0001}, perfect; another at 45°. Hardness = 1–2
D(meas.) = 2.32–2.42 D(calc.) = 2.26

Optical Properties: Translucent. *Color:* Deep reddish brown, brown, straw-yellow; golden brown in transmitted light. *Luster:* Resinous.
Optical Class: Uniaxial (–); may be anomalously biaxial. *Pleochroism:* Marked; O = golden brown, dark brown; E = colorless. *Absorption:* $O > E$. ω = 1.588–1.606; 1.620–1.634
ϵ = 1.560–1.575; 1.585–1.590 2V(meas.) = 5°–20°

Cell Data: *Space Group:* $R\bar{3}m$. $a = 3.12$ $c = 37.4$ Z = 0.5

X-ray Powder Pattern: Near Coalinga, California, USA.
2.34 (10), 4.20 (8), 6.05 (5), 1.558 (5), 13.4 (4b), 2.67 (3), 1.884 (3)

Chemistry:

	(1)	(2)	(3)
SiO_2	1.7	4.82	
Fe_2O_3	18.3	16.97	20.9
FeO	n.d.	0.05	0.7
MnO			1.0
MgO	46.1	46.43	42.9
CaO	0.5	0.38	
H_2O^+	28.8	27.53	32.0
CO_2	4.8	3.87	1.6
Total	[100.2]	100.05	[99.1]

(1) Near Coalinga, California, USA; original total given as 100.7%, after deduction of SiO_2 as chrysotile and Ca as calcite, corresponds to $Mg_{10.08}Fe^{3+}_{2.08}C_{0.92}H_{27.85}O_{29}$. (2) Do.; corresponds to $Mg_{10.16}Fe^{3+}_{2.06}C_{0.81}H_{28.28}O_{29}$. (3) Muskox intrusion, Canada; after corrections for total loss on ignition 33.4%, partially attributed to introduced density liquids; corresponds to $Mg_{9.4}Mn_{0.2}Fe^{2+}_{0.1}Fe^{3+}_{2.3}(CO_3)_{0.32}(OH)_{25.66}\cdot 2.88H_2O$.

Occurrence: Developed from iron-rich brucite in the surface weathering zone of a serpentinite (near Coalinga, California, USA); formed (after collection) in thin veinlets in serpentinite from a layered ultramafic complex (Muskox intrusive, Canada).

Association: Lizardite, antigorite, chrysotile, hydrotalcite–pyroaurite, artinite, hydromagnesite, brucite, magnetite, chromite, uvarovite, calcite (near Coalinga, California, USA).

Distribution: In the USA, from about 55 km northwest of Coalinga, Fresno Co., California; from the Rockville quarry, Rockville, Montgomery Co., Maryland; in the Cedar Hill quarry, Lancaster Co., Pennsylvania. In the Muskox intrusion, Coppermine River area, Northwest Territories, Canada. At Hagdale, Unst, Shetland Islands, Scotland. From Montjovet, Piedmont, Italy. In Russia, in the Lower Tagil massif, Ural Mountains. Found at Mashiki, Kumamoto Prefecture, Japan. At Woodsreef, Barraba, New South Wales, Australia.

Name: For Coalinga, California, USA, near the original occurrence.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119335.

References: (1) Mumpton, F.A., H.W. Jaffe, and C.S. Thompson (1965) Coalingite, a new mineral from the New Idria serpentinite, Fresno and San Benito Counties, California. Amer. Mineral., 50, 1893–1913. (2) Jambor, J.L. (1969) Coalingite from the Muskox intrusion, Northwest Territories. Amer. Mineral., 54, 437–447. (3) Pastor-Rodriguez, J. and H.F.W. Taylor (1971) Crystal structure of coalingite. Mineral. Mag., 38, 286–294.

Cobaltaustinite $Ca(Co,Cu)(AsO_4)(OH)$

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Crystal Data: [Orthorhombic] (by analogy to the adelite group). *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 25 μm, in botryoidal microcrystalline aggregates and coatings.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ~4.5
D(meas.) = n.d. D(calc.) = 4.24

Optical Properties: Semitransparent. *Color:* Dull green; yellowish green in transmitted light.
Streak: Pale green.
Optical Class: Biaxial (+). α = 1.777(3) (α'). β = n.d. γ = 1.802(3) (γ').
2V(meas.) = Large.

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.498(7)$ $b = 9.006(7)$ $c = 5.920(3)$ Z = 4

X-ray Powder Pattern: Dome Rock mine, Australia.
3.159 (10), 1.609 (10), 2.633 (8), 2.600 (8), 4.13 (7), 2.801 (5b), 2.532 (4)

Chemistry:

	(1)
SO_3	0.3
P_2O_5	0.3
As_2O_5	46.1
CoO	25.8
CuO	2.5
CaO	22.5
H_2O	3.6
Total	101.1

(1) Dome Rock mine, Australia; by electron microprobe, H_2O by CHN analyzer; corresponds to $Ca_{1.02}(Co_{0.87}Cu_{0.08})_{\Sigma=0.95}(As_{1.01}P_{0.01}S_{0.01})_{\Sigma=1.03}O_{4.05}(OH)_{1.01}$.

Polymorphism & Series: Forms a series with conichalcite.

Mineral Group: Adelite group.

Occurrence: A rare secondary mineral in the oxidized zone of a copper deposit, an alteration product of arsenides.

Association: Erythrite, roselite-beta, arthurite, conichalcite, chenevixite, scorodite, heterogenite.

Distribution: From the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia.

Name: For its content of *cobalt* and similarity to *austinite*.

Type Material: Western Australian Museum, Perth, M.73.1991; Museum Victoria, Melbourne, Australia, M32479.

References: (1) Nickel, E.H. and W.D. Birch (1988) Cobaltaustinite - a new arsenate mineral from Dome Rock, South Australia. Australian Mineral., 3, 53–57. (2) (1989) Amer. Mineral., 74, 501 (abs. ref. 1).

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Cobaltite CoAsS

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $mm2$. Commonly as pseudocubic or pseudopyritohedral crystals, or combinations having striated faces as with pyrite, to as large as 8 cm, also as pseudo-octahedra; granular massive. *Twinning:* About [111] as a pseudocubic three-fold axis, with {011} and {111} of the pseudocubic habit as twin planes, rare. Twin lamellae are commonly observed in polished section, which may exhibit a flamelike texture.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5 VHN = 1095–1346 D(meas.) = 6.33 D(calc.) = 6.328

Optical Properties: Opaque. *Color:* Silver-white. *Streak:* Grayish black. *Pleochroism:* Very weak, on grain boundaries.
R: (400) 48.2, (420) 48.0, (440) 47.7, (460) 47.8, (480) 48.2, (500) 48.9, (520) 49.6, (540) 50.4, (560) 51.2, (580) 51.9, (600) 52.6, (620) 53.1, (640) 53.5, (660) 53.7, (680) 53.8, (700) 53.8

Cell Data: *Space Group:* $Pca2_1$. $a = 5.5833(7)$ $b = 5.5892(6)$ $c = 5.5812(8)$ $Z = 4$

X-ray Powder Pattern: Cobalt, Canada.
2.49 (100), 1.680 (100), 2.27 (90), 2.77 (80), 1.490 (80), 1.073 (80), 1.973 (60)

Chemistry:

	(1)	(2)	(3)
Co	28.64	33.2	35.53
Fe	4.11	2.8	
Ni	3.06	0.6	
As	44.77	43.4	45.15
S	19.34	20.6	19.32
Total	99.92	100.6	100.00

(1) Cobalt, Canada; corresponds to $(Co_{0.80}Fe_{0.12}Ni_{0.09})_{\Sigma=1.01}As_{0.99}S_{1.00}$. (2) Tunaberg, Sweden; by electron microprobe, corresponds to $(Co_{0.88}Fe_{0.08}Ni_{0.02})_{\Sigma=0.98}As_{0.90}S_{1.00}$. (3) CoAsS.

Mineral Group: Cobaltite group.

Occurrence: In high-temperature hydrothermal deposits, as disseminations, and as veins in contact metamorphosed rocks.

Association: Magnetite, sphalerite, chalcopyrite, skutterudite, allanite, zoisite, scapolite, titanite, calcite (Tunaberg, Sweden); numerous other Co–Ni sulfides and arsenides.

Distribution: In Sweden, fine crystals from Tunaberg, Södermanland; Riddarhyttan and Håkansboda, Västmanland; and at the Vena mines, near Askersund, Örebro. From Skutterud, Modum, Norway. At Bieber, near Hanau, Hesse, Germany. From Crown's Engine House, Wheal Cock, and the Botallack mine, St. Just, Cornwall, England. Good crystals from Espanola, and at mines in the Cobalt and Sudbury districts, Ontario; from Great Bear Lake, Northest Territories, Canada. In Australia, at Broken Hill and Torrington, New South Wales; Bimbowrie, South Australia; and at Mt. Cobalt and Cloncurry, Queensland. From the Aït Ahmane mine, Bou Azzer, Morocco. Many more minor localities are known.

Name: In allusion to the elemental composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 296–298. (2) Giese, R.F., Jr. and P.F. Kerr (1965) The crystal structures of ordered and disordered cobaltite. Amer. Mineral., 50, 1002–1014. (3) Bayliss, P. (1969) X-ray data, optical anisotropism, and thermal stability of cobaltite, gersdorffite, and ullmannite. Mineral. Mag., 37, 26–33. (4) Bayliss, P. (1982) A further crystal structure refinement of cobaltite. Amer. Mineral., 67, 1048–1057. (?5) Fleet, M.E. and P.C. Burns (1990) Structure and twinning ofcobaltite. Can. Mineral., 28, 719–723. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 104.

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Cobaltkoritnigite $(Co, Zn)(AsO_3OH)\cdot H_2O$

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Crystal Data: Triclinic, pseudomonoclinic (synthetic, and by analogy to koritnigite). *Point Group:* $\overline{1}$. Crystals tabular, to 15 μm.

Physical Properties: *Cleavage:* {010}, perfect; {100}, good. Hardness = [2]
D(meas.) = n.d. D(calc.) = [3.46]

Optical Properties: Transparent. *Color:* Deep violet, deep rose-red, *Streak:* White.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = deep violet; Y = reddish violet; Z = bluish violet. *Orientation:* $X \wedge b < 3°$; $Y \wedge a = 12.5(1.0)°$. $\alpha = 1.646(2)$ $\beta = 1.668(2)$ $\gamma = 1.705(5)$ $2V(meas.) = 78(2)°$

Cell Data: *Space Group:* $[P\overline{1}]$ (by analogy to koritnigite). $a = 7.95$ $b = 15.83$ $c = 6.67$ $\alpha = 90.9°$ $\beta = 96.6°$ $\gamma = 90.0°$ Z = 8

X-ray Powder Pattern: Saxony, Germany; very close to koritnigite.
7.94 (100), 3.14 (70), 3.82 (50), 3.25 (40), 3.23 (40), 2.461 (40), 2.688 (30)

Chemistry:

	(1)	(2)
As_2O_5	54.63	54.14
FeO	0.45	0.48
CoO	20.55	23.46
NiO	0.25	0.37
CuO	0.50	0.41
ZnO	11.73	9.09
H_2O	[12.46]	[12.46]
Total	[100.57]	[100.41]

(1) Saxony, Germany; by electron microprobe, total Fe as FeO, H_2O calculated from stoichiometry; corresponds to $(Co_{0.59}Zn_{0.31}Cu_{0.02}Fe_{0.01}Ni_{0.01})_{\Sigma=0.94}(As_{1.03}O_3OH)\cdot H_2O$. (2) Do.; corresponds to $(Co_{0.68}Zn_{0.24}Cu_{0.02}Fe_{0.01}Ni_{0.01})_{\Sigma=0.96}(As_{1.03}O_3OH)\cdot H_2O$.

Occurrence: A weathering product of glaucodot (Saxony, Germany); altering from cobaltite (Bauhaus district, Germany).

Association: Erythrite–köttigite, sphaerocobaltite, pitticite, glaucodot, löllingite–safflorite, arsenopyrite, quartz (Saxony, Germany); erythrite, cobaltite, calcite, barite, quartz (Bauhaus district, Germany).

Distribution: In Germany, found on an old specimen from the Erzgebirge, Saxony, probably from the Schwarzenberg district, and at Frohnau, near Annaberg; in the Bauhaus district, Richelsdorf Mountains, Hesse; from the Sophia mine, near Wittichen, in the Rötenbach quarry, near Alpirsbach and in the Anton mine, Heubachtal, near Schiltach, Black Forest. From Jáchymov (Joachimsthal), Czech Republic.

Name: For its relation to *koritnigite* and high *cobalt* content.

Type Material: National Museum of Natural History, Washington, D.C., USA, 148979.

References: (1) Schmetzer, K., W. Horn, and O. Medenbach (1981) Über Kobaltkoritnigit, $(Co, Zn)[H_2O|AsO_3OH]$, ein neues Mineral, und Pitticit, $Fe_2O_3\cdot As_2O_5\cdot 9{-}10H_2O$, ein röntgenamorphes Fe-Arsenat-Hydrat. Neues Jahrb. Mineral., Monatsh., 257–266 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 414 (abs. ref. 1). (3) Zettler, F., H. Riffel, H. Hess, and P. Keller (1979) Cobalthydrogenarsenat-Monohydrat. Darstellung und Kristallstruktur. Z. Anorg. All. Chemie, 454, 134–144 (in German with English abs.).

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Cobaltomenite $CoSe^{4+}O_3 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals exhibit {001}, {100}, {010}, and less prominent {101}, to 1 mm; typically as spherical aggregates or crusts.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 3.42 D(calc.) = 3.422 (synthetic).

Optical Properties: Transparent to translucent. *Color:* Rose-red, peach-blossom-pink to brownish pink, pale brown to yellowish brown with increasing nickel content. *Luster:* Vitreous. *Optical Class:* Biaxial (–) (synthetic). *Pleochroism:* X = pale pink; Y = pink; Z = red. *Orientation:* $Z \wedge c = 13°$. *Dispersion:* $r < v$. *Absorption:* $Z > Y > X$. $\alpha = 1.681$ $\beta = 1.728$ $\gamma = 1.769$ 2V(meas.) = 83°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 6.496(1)$ $b = 8.809(2)$ $c = 7.619(2)$ $\beta = 98.87(1)°$ Z = 4

X-ray Powder Pattern: Synthetic; close to ahlfeldite.
5.70 (100), 3.46 (70), 3.017 (55), 3.80 (50), 2.738 (45), 2.378 (40), 1.734 (35)

Chemistry: (1) Composition established by concurrence of properties with those of synthetic material.

Polymorphism & Series: Forms a series with ahlfeldite.

Occurrence: A secondary mineral in the oxidation zone of hydrothermal selenium-sulfide-bearing vein deposits.

Association: Chalcomenite, molybdomenite (Cerro de Cacheuta, Argentina); chalcomenite, clinochalcomenite, lepidocrocite, gypsum (El Dragón mine, Bolivia).

Distribution: From Cerro de Cacheuta, Mendoza Province, Argentina. At the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí, and in the Pacajake mine, Hiaco, 30 km east-northeast of Colquechaca, Potosí, Bolivia. From the Musonoi and Kambove West mines, Shaba Province, Congo (Zaire). In the USA, at the A.E.C. No. 8 mine, Temple Mountain, Emery Co., and at the Parco mine group, Thompson district, Grand Co., Utah.

Name: For the content of *cobalt* and the Greek for *moon*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 639. (2) Aristarain, L.F. and C.S. Hurlbut, Jr. (1969) Ahlfeldite from Pacajake Bolivia; a restudy. Amer. Mineral., 54, 448–456. (3) Sturman, B.D. and J.A. Mandarino (1974) The ahlfeldite-cobaltomenite series. Can. Mineral., 12, 304–307. (4) Wildner, M. (1990) Crystal structure refinements of synthetic cobaltomenite ($CoSeO_3 \cdot 2H_2O$) and ahlfeldite ($NiSeO_3 \cdot 2H_2O$). Neues Jahrb. Mineral., Monatsh., 353–362.

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Cobalt pentlandite $(Co, Ni, Fe)_9S_8$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As exsolved lamellae, granular and as separate crystals, to 4 mm.

Physical Properties: *Cleavage:* {100}. Hardness = n.d. VHN = 278–332 (100 g load). D(meas.) = n.d. D(calc.) = 5.22

Optical Properties: Opaque. *Color:* In polished section, slightly lighter bronze-yellow than pentlandite. *Luster:* Metallic.
R: (400) 36.9, (420) 41.9, (440) 45.9, (460) 49.2, (480) 51.7, (500) 53.8, (520) 55.6, (540) 57.0, (560) 58.2, (580) 59.2, (600) 60.0, (620) 60.5, (640) 61.0, (660) 61.2, (680) 61.4, (700) 61.5

Cell Data: *Space Group: Fm3m.* a = 9.973 Z = 4

X-ray Powder Pattern: Outokumpu mine, Finland.
3.008 (100), 1.763 (100), 1.918 (80), 5.75 (60), 2.878 (60), 1.018 (60), 2.288 (50)

Chemistry:

	(1)	(2)	(3)	(4)
Co	49.33	54.1	34.3	67.40
Ni	9.06	10.4	27.6	
Fe	10.32		6.3	
S	31.29	34.2	32.6	32.60
Total	100.00	98.7	100.8	100.00

(1) Varislahti deposit, Finland; corresponding to $(Co_{6.86}Fe_{1.52}Ni_{1.27})_{\Sigma=9.65}S_{8.00}$. (2) Langis mine, Canada; by electron microprobe, corresponding to $(Co_{6.88}Ni_{1.33})_{\Sigma=8.21}S_{8.00}$. (3) Amianthus mine, South Africa; by electron microprobe, corresponding to $(Co_{4.58}Ni_{3.70}Fe_{0.89})_{\Sigma=9.17}S_{8.00}$. (4) Co_9S_8.

Polymorphism & Series: Forms a series with pentlandite.

Mineral Group: Pentlandite group.

Occurrence: With other sulfides and arsenides in hydrothermal deposits.

Association: Pyrite, marcasite, pyrrhotite, troilite, chalcopyrite, cubanite, bornite, chalcocite, digenite, linnaeite, siegenite, parkerite, bravoite, langisite, magnetite.

Distribution: In Finland, from the Varislahti [TL], Kuusjärvi, and Savonranta pyrrhotite deposits and in the Outokumpu mine, northern Karelia, Finland. At Långban, Värmland, Sweden. From Vîlsan, Romania. In the Erglodd mine, ??, Wales. [??D8,ckMinWales??] From near Eretria, Othris Mountains, and near Perivoli, Pindos Mountains, Greece. In Canada, at the Langis mine, Casey Township, Cobalt-Gowganda area, Ontario, and the Vauze mine, north of Noranda, Quebec. From the Salamanca mine, Mendoza Province, Argentina. In the Amianthus mine, Kaapsche Hoop, Barberton, and the Loolekop carbonatite, Phalaborwa, Transvaal, South Africa. At the Talmessi mine, near Anarak, Iran. From the Mundonguara deposit, Chimoio district, Mozambique. In Japan, at the Shimokaua mine, Hokkaido, and the Kamaishi mine, Iwate Prefecture. On the Mid-Atlantic Ridge at 14°45'N.

Name: For the cobalt content and the relation with pentlandite.

Type Material: n.d.

References: (1) Kouva, O., M. Huhma, and Y. Vuorelainen (1959) A natural cobalt analog of pentlandite. Amer. Mineral., 44, 897–900. (2) Gellers, S. (1962) Refinement of the crystal structure of Co_9S_8. Acta Cryst., 15, 1195–1198. (3) Stumpfl, E.F. and E.M. Clark (1964) A natural occurrence of Co_9S_8, identified by x-ray microanalysis. Neues Jahrb. Mineral., Monatsh., 240–245. (4) Petruk, W., D.C. Harris, and J.M. Stewart (1969) Langisite, a new mineral, and the rare minerals cobalt pentlandite, siegenite, parkerite, and bravoite from the Langis mine, Cobalt-Gowganda area, Ontario, Canada. Can. Mineral., 9, 597–605. (5) Rajamini, V. and C.T. Prewitt (1975) Refinement of the structure of Co_9S_8. Can. Mineral., 13, 75–78. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 103.

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Cobalt-zippeite $Co_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. As minute tabular {010} grains and petallike aggregates. *Twinning:* Simple and polysynthetic twins common in synthetic material.

Physical Properties: *Cleavage:* On {010}, perfect (synthetic). Hardness = ∼2 (synthetic). D(meas.) = > 3.3 D(calc.) = n.d. Radioactive.

Optical Properties: Semitransparent. *Color:* Tan to brownish yellow, yellow-orange. *Optical Class:* Biaxial (–) (synthetic). *Pleochroism:* X = colorless; Y = pale yellow; Z = yellow. *Orientation:* $Z = c$. $\alpha = 1.747$ $\beta = 1.779$ $\gamma = 1.84$ 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Synthetic, nearly identical to nickel-zippeite.
7.21 (100), 3.59 (46), 3.12 (28), 3.47 (22), 1.963 (12), 2.491 (11), 2.653 (10)

Chemistry:

	(1)	(2)
SO_3	10.55	9.67
UO_3	67.2	69.07
FeO	0.57	
MnO	0.27	
MgO	0.56	
NiO	1.87	
CoO	1.98	6.03
H_2O	17.0	15.23
Total	[100.00]	100.00

(1) Happy Jack mine, Utah, USA; recalculated to 100% after deduction of SiO_2 0.80%, ($TiO_2 + Al_2O_3 + Ce_2O_3$) 0.98%, sodium-zippeite 8.0%, johannite 1.6%; corresponds to $(Co_{0.68}Ni_{0.64}Mg_{0.36}Fe_{0.22}Mn_{0.10})_{\Sigma=2.00}(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$. (2) $Co_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$.

Occurrence: Rarely as efflorescences on the mine walls in oxidized portions of a uraninite deposit containing gersdorffite.

Association: Sodium-zippeite, uranopilite, johannite, zeunerite, chalcanthite, antlerite, siderotil, bieberite, erythrite, epsomite, gypsum.

Distribution: From the Happy Jack mine, White Canyon, San Juan Co., Utah, USA.

Name: For its dominant content of *cobalt* and relation to other *zippeite* group species.

Type Material: The Natural History Museum, London, England, 1981,537 and 1981,538.

References: (1) Frondel, C., J. Ito, R.M. Honea, and A.M. Weeks (1976) Mineralogy of the zippeite group. Can. Mineral., 14, 429–436. (2) Haacke, D.F. and P.A. Williams (1979) The aqueous chemistry of uranium minerals. Part I. Divalent cation zippëite. Mineral. Mag., 43, 539–541.

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Cochromite $(Co, Ni, Fe^{2+})(Cr, Al)_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As grains, to about 20 μm.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 1218(100) (50 g load). D(meas.) = n.d. D(calc.) = ∼4.99

Optical Properties: Opaque. *Color:* [Black.] *Streak:* Greenish gray. *Luster:* Metallic. *Optical Class:* Isotropic.
R: (480) 14.3, (546) 13.7, (589) 14.0, (656) 13.9

Cell Data: *Space Group:* [$Fd3m$] (by analogy to spinel). $a = \sim 8.29$ $Z = 8$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SiO_2	0.11	
TiO_2	1.26	0.67
Al_2O_3	9.11	49.61
Fe_2O_3	4.14	
Cr_2O_3	50.38	11.57
FeO	7.45	9.55
MnO	0.84	
CoO	17.45	22.38
NiO	7.67	
ZnO	0.59	
MgO	0.95	6.04
Total	99.95	99.82

(1) Bon Accord, South Africa; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Co_{0.50}Ni_{0.22}Fe^{2+}_{0.22}Mg_{0.05}Mn_{0.03}Zn_{0.02})_{\Sigma=1.04}(Cr_{1.43}Al_{0.38}Fe^{3+}_{0.11}Ti_{0.03})_{\Sigma=1.95}O_4$.
(2) Bo Phloi, Thailand; by electron microprobe, total Fe as FeO; corresponds to $(Co_{0.52}Mg_{0.26}Fe^{2+}_{0.23})_{\Sigma=1.01}(Al_{1.70}Cr_{0.27}Ti_{0.02})_{\Sigma=1.99}O_4$.

Mineral Group: Spinel group.

Occurrence: Replacing chromite in a small tabular nickel deposit at the contact between quartzite and serpentinized ultramafics; it appears to have formed at ∼730 °C and < 2 kbar during thermal metamorphism, possibly of a nickel-rich meteorite (Bon Accord, South Africa); an inclusion in corundum from alkalic basalts (Bo Phloi, Thailand).

Association: Trevorite, nichromite, liebenbergite, bunsenite (Bon Accord, South Africa); corundum, albite (Bo Phloi, Thailand).

Distribution: In the Bon Accord deposit, Barberton, Transvaal, South Africa. From Bo Phloi, 40 km north of Kanchanaburi, Thailand.

Name: For a *chromite* with essential cobalt, Co.

Type Material: n.d.

References: (1) De Waal, S.A. (1978) Nickel minerals from Barberton, South Africa: VIII. The spinels cochromite and nichromite, and their significance to the origin of the Bon Accord nickel deposit. Bull. Bur. Rech. Geol. Minières, Sec. II, Géol. Gîtes Minéraux, 1978, no. 3, 225–230. (2) (1980) Amer. Mineral., 65, 811 (abs. ref. 1). (3) Guo, J., W.L. Griffen, and S.Y. O'Reilly (1994) A cobalt-rich spinel inclusion in a sapphire from Bo Ploi *sic*, Thailand. Mineral. Mag., 58, 247–258.

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Coconinoite $Fe_2^{3+}Al_2(UO_2)_2(PO_4)_4(SO_4)(OH)_2 \cdot 20H_2O$

Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As lathlike to platy grains, to 20 μm, in microcrystalline aggregates, in seams and crusts.

Physical Properties: Hardness = Soft. D(meas.) = 2.70 D(calc.) = 2.68 Radioactive.

Optical Properties: Semitransparent. *Color:* Pale creamy yellow. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = pale yellow. *Orientation:* Y = elongation of laths with positive elongation; $Y \wedge$ 8°–25° to elongation of laths with negative elongation. $\alpha = 1.550(5)$ $\beta = 1.586(5)$ $\gamma = 1.590(5)$ 2V(meas.) = 28°–43°, average 40°.

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 12.50(3)$ $b = 12.97(3)$ $c = 23.00(3)$ $\beta = 106.6°$ Z = 4

X-ray Powder Pattern: Jomac mine, Utah, USA.
11.12 (100), 5.56 (42), 3.30 (22), 5.64 (18), 4.59 (14), 3.71 (12), 4.31 (10)

Chemistry:

	(1)	(2)	(3)
UO_3	34.2	34.9	36.30
SO_3	6.1	5.4	5.08
P_2O_5	17.7	18.3	18.01
CO_2	0.7	< 0.1	
Al_2O_3	6.5	6.6	6.47
Fe_2O_3	10.3	9.7	10.13
CaO	< 0.1	0.1	
Na_2O	0.1	< 0.1	
H_2O^+	23.4	24.0	24.01
insol.	1.0	0.5	
Total	100.0	99.5	100.00

(1) Jomac mine, Utah, USA; by spectrophotometry, Ca and Na by flame photometry, SO_3 by gravimetry, CO_2 and H_2O by CHN analyzer; after deduction of H_2O^- 18.8%, then corresponding to $Fe^{3+}_{2.16}Al_{2.12}(UO_2)_2(PO_4)_{4.16}(SO_4)_{1.28}(OH)_2 \cdot 19.72H_2O$. (2) Blackwater No. 4 mine, Arizona, USA; analytical methods as for (1); after deduction of H_2O^- 18.2%, then corresponding to $Fe^{3+}_{2.0}Al_{2.00}(UO_2)_2(PO_4)_{4.24}(SO_4)_{1.10}(OH)_2 \cdot 19.84H_2O$. (3) $Fe_2Al_2(UO_2)_2(PO_4)_4(SO_4)(OH)_2 \cdot 20H_2O$.

Occurrence: In the oxidized zone of vanadium-poor Colorado Plateau-type U–V deposits (Utah and Arizona, USA).

Association: Gypsum, jarosite, "limonite", quartz, clay minerals, coalized wood (Jomac mine, Utah, USA).

Distribution: In the USA, from the Jomac mine, White Canyon district, San Juan Co., Utah; in the Sun Valley mine and Huskon No. 7 mine, near Cameron, Coconino Co., and the Blackwater No. 4 mine, Apache Co., Arizona; at the Ruggles mine, Grafton, Grafton Co., New Hampshire; from an unspecified locality in Wyoming. From an unspecified locality in the Kyzylkum region, Uzbekistan.

Name: For Coconino Co., Arizona, USA, from which samples were obtained.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119772.

References: (1) Young, E.J., A.D. Weeks, and R. Meyrowitz (1966) Coconinoite, a new uranium mineral from Utah and Arizona. Amer. Mineral., 51, 651–663. (2) (1993) Belova, L.N., A.I. Gorshkov, O.A. Doinikova, A.V. Mokhov, N.V. Trubkin, and A.V. Sivtsov (1993) New data on coconinoite. Doklady Acad. Nauk SSSR, 329, 772–775 (in Russian).

Coeruleolactite $(Ca,Cu)Al_6(PO_4)_4(OH)_8 \cdot 4-5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Microcrystalline to cryptocrystalline, in fibrous veinlets, botryoidal aggregates, and crusts.

Physical Properties: *Fracture:* Uneven to conchoidal. Hardness = 5 D(meas.) = 2.55–2.70 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Milk-white to pale blue. *Streak:* White. *Optical Class:* Uniaxial (+), or nearly so. *Orientation:* Elongation positive. $\omega = 1.580(5)$ $\epsilon = 1.588(5)$

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.529(9)$ $b = 9.951(10)$ $c = 7.782(10)$ $\alpha = 112.51°$ $\beta = 116.54°$ $\gamma = 68.57°$ Z = 1

X-ray Powder Pattern: Rindsberg mine, Germany.
2.96 (10), 3.70 (9), 3.48 (5), 3.34 (5), 6.11 (4d), 1.907 (4), 4.77 (3)

Chemistry:

	(1)	(2)	(3)
P_2O_5	36.33	30.1	36.31
SiO_2	1.82		
Al_2O_3	35.11	40.3	38.27
Fe_2O_3	0.93		
CuO	1.40	0.24	4.25
ZnO	trace		
MgO	0.20	0.40	
CaO	2.41	5.09	
F	trace		
H_2O	21.23	23.4	21.70
insol.			0.54
Total	99.43	99.5	101.07

(1) Rindsberg mine, Germany; CuO, CaO, MgO, SiO_2 considered to be impurities. (2) Do. (3) General Trimble's mine, Pennsylvania, USA.

Mineral Group: Turquoise group.

Occurrence: In brown iron ore (Rindsberg mine, Germany).

Association: Wavellite, variscite, matulaite, gibbsite, cacoxenite, goethite, "limonite" (General Trimble's mine, Pennsylvania, USA); bermanite, purpurite (Kobokobo pegmatite, Congo).

Distribution: May occur at the following localities: the Rindsberg mine, near Katzenelnbogen, Rhineland-Palatinate, Germany. From the Phoenix United mines, Linkinhorne, Cornwall, England. In General Trimble's mine, East Whiteland, Chester Co., Pennsylvania, USA. At the Cruziero mine, Paoiá district, Minas Gerais, Brazil. From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: From the Greek for *blue* and *milk*, for its typical color.

Type Material: Type material cannot be located. All specimens thought to be this species examined by (2) Foord and Taggart proved to be cuprian planerite.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 961. (2) Foord, E.E. and J.E. Taggart, Jr. (1998) A reexamination of the turquoise group: the mineral aheylite, planerite (redefined), turquoise and coeruleolactite. Mineral. Mag., 62, 93–111. (3) Hintze, C. (1933) Handbuch der Mineralogie. Gruyter & Co., Berlin, 1(4.2), 927 (in German).

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Coesite SiO_2

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As irregular to nearly rectangular grains, up to 3 mm.

Physical Properties: *Cleavage:* {010} and {012}, suspected. *Fracture:* Subconchoidal. Hardness = 7.5–8 D(meas.) = n.d. D(calc.) = 2.92

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+) (synthetic). *Orientation:* $X = b$; $Z \wedge c = 4°–6°$. *Dispersion:* $r < v$. $\alpha = 1.5940(5)$ $\beta = 1.5955(5)$ $\gamma = 1.5990(5)$ 2V(meas.) = 64° 2V(calc.) = 66°34′

Cell Data: *Space Group:* $C2/c$. $a = 7.143(2)$ $b = 12.383(3)$ $c = 7.143(2)$ $\beta = 120.00(3)°$ Z = 16

X-ray Powder Pattern: Synthetic. (ICDD 14-654).
3.09 (100), 3.43 (30), 1.71 (12), 1.345 (12), 2.69 (10), 1.70 (10), 1.545 (10)

Chemistry:

	(1)
SiO_2	99.56
TiO_2	0.00
Al_2O_3	0.05
FeO	0.03
MnO	0.00
MgO	0.00
Na_2O	0.04
K_2O	0.00
Total	99.68

(1) Roberts Victor mine, South Africa; by electron microprobe, average of four analyses.

Polymorphism & Series: Quartz, tridymite, cristobalite, and stishovite are polymorphs.

Occurrence: Formed at pressures in excess of 20 kbar, as fine-grained intergrowths with quartz and silica glass in impact metamorphosed rocks and tektites. A primary phase in grospydite (kyanite-garnet-clinopyroxene) xenoliths in kimberlite, and intergrown with quartz as inclusions in garnet and clinopyroxene within eclogites of high-grade metamorphic terranes.

Association: Quartz, stishovite, silica glass, kyanite, omphacite, garnet, sanidine, muscovite, talc, rutile, dolomite.

Distribution: From Meteor Crater, Coconino Co., Arizona, USA. At the Nördlinger Ries crater, Bavaria, Germany. In the Kara structure, Pay-Khoy, Russia. In Italy, in the Dora-Maira massif, Parigi, near Martiniana Po, Piedmont. From Grytting, Selje district, Norway. In the Wabar craters, Rub' al Khali, Saudi Arabia. At Dabie Mountain, west of Qianshan, Anhwei Province, China. In the Roberts Victor diamond mine, near Kimberley, Cape Province, and near Boshoff, Orange Free State, South Africa.

Name: For Loring Coes, Jr. (1915–), American chemist, who synthesized the material prior to the discovery of a natural occurrence.

Type Material: n.d.

References: (1) Frondel, C. (1962) Dana's system of mineralogy, (7th edition), v. III, silica minerals, 310–316. (2) Sclar, C.B., L.C. Carrison, and C.M. Schwartz (1962) Optical crystallography of coesite. Amer. Mineral., 47, 1292–1302. (3) Gibbs, G.V., C.T. Prewitt, and K.J. Baldwin (1977) A study of the structural chemistry of coesite. Zeits. Krist., 145, 108–123. (4) Smyth, J.R. and C.J. Hatton (1977) A coesite-sanidine grospydite from the Roberts Victor kimberlite. Earth and Planetary Science Letters, 34, 284–290.

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Coffinite $U(SiO_4)_{1-x}(OH)_{4x}$

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Crystal Data: Tetragonal; may be metamict. *Point Group:* $4/m\ 2/m\ 2/m$. As crystals, rarely > 20 μm, and in colloform to botryoidal incrustations, radially fibrous. Commonly pulverulent, in aggregates of extremely fine crystallites, or massive.

Physical Properties: *Fracture:* Irregular to subconchoidal, earthy. *Tenacity:* Brittle or friable. Hardness = 5–6 D(meas.) = 5.1 D(calc.) = n.d. Radioactive.

Optical Properties: Opaque, transparent on very thin edges. *Color:* Black from included organic matter; pale brown to dark brown in thin section. *Luster:* Dull to adamantine. *Optical Class:* Isotropic due to fine grain size; uniaxial (+) or (–). *Pleochroism:* Moderate; pale yellow-brown ∥ length, medium brown ⊥ length. $n = 1.73$–1.75

Cell Data: *Space Group:* $I4_1/amd$ (synthetic $USiO_4$). $a = 6.979$ $c = 6.252$ Z = 4

X-ray Powder Pattern: Synthetic $USiO_4$; natural material gives broad peaks or may be metamict.
3.48 (100), 4.64 (95), 2.636 (95), 1.803 (70), 2.789 (45), 1.849 (35), 1.738 (35)

Chemistry:

	(1)	(2)	(3)
SiO_2	5.20	18.20	16.41
UO_2	68.29	81.80	73.75
Al_2O_3	3.87		
Fe_2O_3	1.24		
As_2O_5	4.35		
V_2O_5	2.85		
Pb	0.12		
H_2O	[8.49]		9.84
Total	[94.41]	100.00	100.00

(1) La Sal No. 2 mine, Colorado, USA; H_2O from loss on ignition, contains admixed clay minerals, vanadates, organic matter, etc. (2) $USiO_4$. (3) $USiO_4 \cdot 2H_2O$.

Occurrence: In Colorado Plateau-type black unoxidized U–V deposits, replacing organic material in sandstone; in other sedimentary and hydrothermal vein uranium deposits.

Association: Uraninite, thorite, pyrite, marcasite, roscoelite, clay minerals, amorphous organic matter.

Distribution: Numerous minor occurrences; those mentioned are for well-crystallized or studied material. In the USA, in the La Sal No. 2 mine, Beaver Mesa, Gateway district, Mesa Co., and in the Peanut mine, Montrose Co., Colorado; around the Jackpile and Crownpoint mines, Valencia Co., New Mexico; in the Mi Vida, Homestake, and other mines, San Juan Co., Utah. From Wölsendorf, Bavaria; at Niederramstadt, near Schneeberg, Johanngeorgenstadt, and Niederpfannenstiel, Saxony, Germany. At Hüttenberg, Carinthia, Austria. From Jáchymov (Joachimsthal) and Příbram, Czech Republic. In the Geevor mine, St. Just, the South Terras mine, St. Stephen-in-Brannel, and the Roskrow United mine, Ponsansooth, Cornwall, England.

Name: Honoring Reuben Clare Coffin (1886–1972), Tulsa, Oklahoma, USA, pioneer geologist in the study of uranium deposits of the Colorado Plateau.

Type Material: The Natural History Museum, London, England, 1956,201; National Museum of Natural History, Washington, D.C., USA, 112646.

References: (1) Stieff, L.R., T.W. Stern, and A.M. Sherwood (1956) Coffinite, a uranous silicate with hydroxyl substitution: a new mineral. Amer. Mineral., 41, 675–688. (2) Fuchs,

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L.H. and E. Gebert (1958) X-ray studies of synthetic coffinite, thorite and uranothorites. Amer. Mineral., 43, 243–248. (3) Dubinchuk, V.T., I.S. Naumova, I.Y. Kravtsova, and G.A. Sidorenko (1981) Determination of the crystal structure of naturally occurring coffinite. Mineral. Zhurnal, 3(4), 81–85 (in Russian with English abs.). (4) (1982) Mineral. Abs., 33, 222 (abs. ref. 3). (5) Hansley, P.A. and J.L. Fitzpatrick (1989) Compositional and crystallographic data on REE-bearing coffinite from the Grants uranium region, northwestern New Mexico. Amer. Mineral., 74, 263–270.

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Cohenite $(Fe, Ni, Co)_3C$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As imperfect platy to needlelike crystals; also rimming or in eutectic dendritic intergrowths with iron.

Physical Properties: *Cleavage:* {100}, {010}, and {001}. *Tenacity:* Very brittle. Hardness = 5.5–6 D(meas.) = 7.20–7.65 D(calc.) = 7.68 (synthetic Fe_3C). Strongly magnetic.

Optical Properties: Opaque. *Color:* Tin-white; oxidizes to light bronze then golden yellow. *Luster:* Metallic.
Optical Class: Biaxial.
R_1–R_2: (400) 51.8–54.7, (420) 52.6–55.2, (440) 53.2–55.7, (460) 53.8–56.2, (480) 54.4–56.7, (500) 55.0–57.1, (520) 55.6–57.7, (540) 56.2–58.2, (560) 56.8–58.8, (580) 57.4–59.3, (600) 58.0–60.0, (620) 58.7–60.6, (640) 59.3–61.3, (660) 60.0–62.0, (680) 60.8–62.8, (700) 61.6–63.6

Cell Data: *Space Group: Pbnm.* $a = 4.518$ $b = 5.069$ $c = 6.736$ $Z = 4$

X-ray Powder Pattern: Synthetic Fe_3C. (ICDD 23-1113).
2.01 (100), 2.06 (70), 2.38 (65), 2.10 (60), 2.02 (60), 1.97 (55), 1.85 (40)

Chemistry:

	(1)	(2)	(3)
Fe	89.81	91.23	93.31
Co	0.69	0.34	
Ni	3.08	0.74	
C	6.42	[6.7]	6.69
P		0.01	
Total	100.00	[99.02]	100.00

(1) Magura meteorite. (2) Kitdlît dike, Disko Island, Greenland; by electron microprobe, C by difference. (3) Fe_3C.

Occurrence: In iron meteorites. Also in terrestrial iron, in mafic volcanic rocks chemically reduced from assimilation of graphite.

Association: Iron, schreibersite, troilite, wüstite.

Distribution: Common in iron meteorites. In Greenland, at Niaqornat (Niakornak) and on Disko Island, near Uivfaq and Kitdlît. At Bühl, near Weimar, Hesse, Germany. From Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, and in the Ijim massif, western Sayan Mountains, Tuva, Russia. In the Burobaiskii massif, eastern Kazakhstan.

Name: Honors Emil Wilhelm Cohen (1842–1905), Professor of Mineralogy, University of Greifswald, Greifswald, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 122–123. (2) Ulff-Møller, F. (1985) Solidification history of the Kitdlît Lens: immiscible metal and sulphide liquids from a basaltic dyke on Disko, central West Greenland. J. Petrol., 26, 64–91.

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Colemanite $Ca_2B_6O_{11}\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As equant to short prismatic crystals, with large {110} and multiple terminating forms, to 30 cm; pseudorhombohedral with large {110} and $\{\overline{3}01\}$; pseudo-octahedral with large $\{\overline{2}21\}$ and {011}; nearly 50 forms measured; cleavable massive, granular, most commonly nodular.

Physical Properties: *Cleavage:* On {010}, perfect; on {001}, distinct. *Fracture:* Uneven to subconchoidal. Hardness = 4.5 D(meas.) = 2.423(5) D(calc.) = 2.42 Bright pale yellow fluorescence, may phosphoresce pale green; pyroelectric and piezoelectric at very low temperature.

Optical Properties: Transparent to translucent. *Color:* Colorless, milky white, pale yellow, gray; colorless in transmitted light. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = -6°$; $Z \wedge c = 84°$. *Dispersion:* $r > v$, weak. $\alpha = 1.586$ $\beta = 1.592$ $\gamma = 1.614$ 2V(meas.) = 56°

Cell Data: *Space Group:* $P2_1/a$. $a = 8.712(2)$ $b = 11.247(3)$ $c = 6.091(1)$ $\beta = 110.12(2)°$ Z = 2

X-ray Powder Pattern: Twenty Mule Team Canyon, Death Valley, California, USA.
3.13 (100), 5.64 (50), 3.85 (50), 2.550 (50), 2.010 (50), 4.00 (36), 3.29 (36)

Chemistry:

	(1)	(2)
B_2O_3	50.70	50.81
MgO	0.10	
CaO	27.31	27.28
H_2O	21.87	21.91
Total	99.98	100.00

(1) Death Valley, California, USA. (2) $Ca_2B_6O_{11}\cdot 5H_2O$.

Occurrence: A common constituent in borate deposits formed in arid alkaline lacustrine environments, deficient in sodium and carbonate, typically under warm conditions.

Association: Howlite, ulexite, searlesite, priceite, nobleite, ginorite, gowerite, lüneburgite, kernite, gypsum, calcite, celestine.

Distribution: An important component of sedimentary borate deposits worldwide. In the USA, in California, from Death Valley, near Ryan, Furnace Creek district, in the Thompson mine and the Boraxo mine, fine crystals; at Borate, about 10 km northeast of Yermo, Calico Hills, San Bernardino Co.; from Boron, Kern Co.; at the Anniversary mine, Muddy Mountains district, Clark Co., Nevada. From the Penobsquis and Salt Springs evaporite deposits, near Sussex, New Brunswick, Canada. Large deposits at El Torreon and La Tinaja del Oso, near Magdalena, Sonora, Mexico. In Argentina, on the Salinas Grandes Playa, and at the Loma Blanca deposit, eight km southwest of Coranzulí, Jujuy Province; from the Sijes district, Salta Province. In the Inder borate deposit, Kazakhstan. Near Bela Stena, Jarandol Basin, Serbia, Yugoslavia. From a lake on West Samos Island, Greece. Extensive deposits with about one billion tons reserves in Turkey, as in the Bigadiç borate district, Balıkesir Province, large crystals; from the Kestelek borax deposit, Eskiçehir Province; at the Emet borate deposits, Kütahya Province; large crystals from Mustafakemalpasa, Bursa Province.

Name: Honors William Tell Coleman (1824–1893), pioneer developer of the borax industry in California, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 349–353. (2) Burns, P.C. and F.C. Hawthorne (1993) Hydrogen bonding in colemanite: an X-ray and structure-energy study. Can. Mineral., 31, 297–304. (3) Christ, C.L. (1953) Studies of borate minerals: 1 – X-ray crystallography of colemanite. Amer. Mineral., 38, 411–415.

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Collinsite $Ca_2(Mg,Fe^{2+})(PO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As bladed to prismatic crystals, to 2 cm; fibrous, as globular crystal aggregates; in concentrically layered botryoidal masses.

Physical Properties: *Cleavage:* Fair on {001} and {010}. *Tenacity:* Brittle. Hardness = 3.5–5 D(meas.) = 2.93–2.95 D(calc.) = 2.955

Optical Properties: Translucent. *Color:* Brown, chocolate-black, light brown, yellowish white, white, colorless, pale blue if zincian; in thin section, colorless. *Streak:* White. *Luster:* Subvitreous, silky if fibrous.
Optical Class: Biaxial (+). $\alpha = 1.632(3)$ $\beta = 1.642(3)$ $\gamma = 1.657(3)$ 2V(meas.) = ∼80°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.734(1)$ $b = 6.780(1)$ $c = 5.441(1)$ $\alpha = 97.29°$ $\beta = 108.56°$ $\gamma = 107.28°$ Z = 1

X-ray Powder Pattern: Milgun Station, Australia.
3.04 (10), 2.682 (9), 2.713 (8), 2.735 (6), 3.24 (5), 3.14 (5), 3.02 (5)

Chemistry:

	(1)	(2)
P_2O_5	41.13	41.2
SiO_2		1.31
FeO	7.31	0.07
MgO	9.31	11.3
CaO	32.03	35.2
Na_2O		0.01
K_2O		0.02
F		0.02
H_2O^+	9.69	10.7
H_2O^-		0.15
insol.	0.37	
$-O = F_2$		0.01
Total	99.84	99.97

(1) François Lake, Canada; corresponds to $Ca_{1.92}(Mg_{0.78}Fe_{0.34})_{\Sigma=1.12}(PO_4)_{1.95} \cdot 1.81H_2O$.
(2) Milgun Station, Australia; SiO_2 as quartz impurity.

Mineral Group: Fairfieldite group.

Occurrence: A secondary weathering product typically incrusting other minerals.

Association: Carbonatian fluorapatite, bitumen (Lake François, Canada); parahopeite, scholzite, cryptomelane, Fe–Mn oxides (Reaphook Hill, Australia); bobierrite, kovdorskite, dolomite (Kovdor massif, Russia).

Distribution: From François Lake, south of Babine Lake, Coast district, British Columbia, and as large crystals from the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In the USA, at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; in the Foote mine, near Kings Mountain, Cleveland Co., North Carolina. On Milgun Station, Western Australia, and a zincian variety from Reaphook Hill, near Blinman, Flinders Ranges, South Australia. In the Kovdor massif, Kola Peninsula, Russia.

Name: Honoring William Henry Collins (1878–1937), formerly Director of the Geological Survey of Canada.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 722–723. (2) Bridge, P.J. and M.W. Pryce (1974) Magnesian collinsite from Milgun Station, Western Australia. Mineral. Mag., 39, 577–579. (3) Hill, R.J. and A.R. Milnes (1974) Phosphate minerals from Reaphook Hill, Flinders Ranges, South Australia. Mineral. Mag., 39, 684–695.

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Coloradoite HgTe

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Known only massive, granular.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle, friable. Hardness = 2.5 VHN = 25–28 (100 g load). D(meas.) = 8.10 D(calc.) = 8.092

Optical Properties: Opaque. *Color:* Iron-black inclining to gray; in polished section, white with slight grayish brown tint, tarnishing to dull purple. *Luster:* Bright metallic. *Anisotropism:* Moderate, dark brownish red to blue-gray.
R: (400) 33.8, (420) 35.4, (440) 36.5, (460) 36.9, (480) 36.5, (500) 36.1, (520) 35.9, (540) 36.2, (560) 37.0, (580) 38.2, (600) 38.6, (620) 38.2, (640) 37.4, (660) 36.7, (680) 36.0, (700) 35.5

Cell Data: *Space Group:* $F\bar{4}3m$. a = 6.453 Z = 4

X-ray Powder Pattern: Kalgoorlie, Australia.
3.74 (100), 2.29 (90), 1.949 (70), 1.318 (40), 1.484 (30), 1.244 (30), 1.090 (30)

Chemistry:

	(1)	(2)	(3)
Hg	60.95	61.0	61.12
Te	39.38	38.7	38.88
Total	100.33	99.7	100.00

(1) Kalgoorlie, Australia; corresponding to $Hg_{0.98}Te_{1.00}$. (2) Do.; by electron microprobe, corresponding to $Hg_{1.00}Te_{1.00}$. (4) HgTe.

Occurrence: In hydrothermal tellurium-bearing precious metal veins.

Mineral Group: Sphalerite group.

Association: Altaite, calaverite, krennerite, petzite, gold, pyrite, chalcopyrite, sphalerite, galena, pyrrhotite, tetrahedrite–tennantite.

Distribution: In the USA, in Colorado, at the Good Hope mine, Vulcan, Gunnison Co.; in the La Plata district, La Plata Co.; and at the Keystone, Mountain Lion, Smuggler, and Ellen mines, Boulder Co. [TL]; from the Cresson mine, Cripple Creek district, Teller Co.; in California, at the Norwegian mine, near Tuttletown, and the Jamestown mine, Tuolumne Co.; in Nevada, at the Twin Creeks and Getchell mines, Potosi district, Humboldt Co.; from the Outlaw mine, Round Mountain district, Nye Co.; and at the Gus Schave property, Olinhouse district, Washoe Co.; from the Mayflower mine, Tobacco Root Mountains, Madison Co., Montana. In Canada, at a number of mines in the Kirkland Lake district, in the Hemlo gold deposit, Thunder Bay district, and at Hollinger in the Porcupine district, Ontario; also found at the Ardeen mine and the Robb-Montbray mine, Quebec. From the Jeronimo gold deposit, near Potrerillos, Atacama, Chile. In the Uzel'ginsk deposit and the Yaman-Kasy Cu–Zn–pyrite deposits, Southern Ural Mountains, Russia. From Săcărîmb, Romania. At the Zarshuran gold deposit, 35 km north of Takab, northwestern Iran. From Kalgoorlie, Western Australia. In the Emperor mine, Vatukoula, and in the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands. At the Bulawan deposit, Negros Occidental, Phillipines. From the Guilaizhuang gold deposit, Shandong Province, China. In the Commoner mine, 50 km west-southwest of Kadoma, Zimbabwe. Additional localities are known.

Name: For the Keystone and Mountain Lion mines, Magnolia, Magnolia district, and Smuggler mine, Ballerat district, Boulder Co., type localities in Colorado, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 218–219. (2) Thompson, R.M. (1949) The telluride minerals and their occurrence in Canada. Amer. Mineral., 34, 342–382. (3) de Jong, W.F. (1926) XXIV> Die Struktur des Tiemannit und Koloradoit [=coloradoite]. Zeits. Krist., 63, 466–472 (in German). (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 520–521. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 106.

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Colquiriite $LiCaAlF_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $3m$. As anhedral grains, to about 1 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼4 D(meas.) = 2.94 D(calc.) = 2.983 (synthetic).

Optical Properties: Transparent to translucent. *Color:* White; colorless in thin section. *Optical Class:* Uniaxial (–) to slightly biaxial. $\omega = 1.388(2)$ $\epsilon = 1.385(2)$

Cell Data: *Space Group:* $P\overline{3}1c$ or $P31c$ (synthetic). $a = 5.007(1)$ $c = 9.641(2)$ Z = 2

X-ray Powder Pattern: Colquiri, Bolivia.
3.23 (10), 2.22 (9), 1.736 (8), 3.98 (7), 1.446 (6), 1.978 (5), 1.552 (5)

Chemistry:

	(1)	(2)
Na	0.34	
Li	3.1	3.69
Mg	0.55	
Ca	22.8	21.32
Al	13.4	14.35
F	58.0	60.64
LOI	0.5	
Total	98.69	100.00

(1) Colquiri, Bolivia; by electron microprobe, corresponds to $(Li_{0.86}Na_{0.03})_{\Sigma=0.89}(Ca_{1.06}Mg_{0.05})_{\Sigma=1.11}Al_{1.02}F_{5.89}$. (2) $LiCaAlF_6$.

Occurrence: Associated with hydrothermal tin-bearing veins.

Association: Ralstonite, gearksutite, sphalerite, madocite, pyrite.

Distribution: From the Colquiri tin deposit, Oruro, Bolivia.

Name: For the occurrence in the Colquiri deposit, Bolivia.

Type Material: Institute for Mineralogy and Crystallography, University of Stuttgart, Stuttgart, Germany.

References: (1) Walenta, K., B. Lehmann, and M. Zwiener (1980) Colquiriit, ein neues Fluoridmineral aus der Zinnlagerstätte von Colquiri in Bolivien. Tschermaks Mineral. Petrog. Mitt., 27, 275–281 (in German with English abs.). (2) (1981) Amer. Mineral., 66, 879 and 1099 (abs. ref. 1). (3) Yin, Y. and D.A. Keszler (1992) Crystal chemistry of colquiriite-type fluorides. Chem. Mater., 4, 645–648.

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Colusite $Cu_{26}V_2(As,Sn,Sb)_6S_{32}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Granular, massive; also as complex aggregates of modified tetrahedral crystals, to 5 mm. *Twinning:* Rare on {111}.

Physical Properties: *Tenacity:* Brittle. Hardness = 3–4 VHN = 322–379 (100 g load). D(meas.) = 4.2 D(calc.) = [4.78]

Optical Properties: Opaque. *Color:* Bronze, bronze-brown to bronzy gray; cream colored in reflected light. *Streak:* Black. *Luster:* Metallic.
R: (400) 25.1, (420) 25.5, (440) 25.9, (460) 26.4, (480) 27.0, (500) 27.7, (520) 28.6, (540) 29.6, (560) 30.5, (580) 31.2, (600) 31.7, (620) 32.0, (640) 31.9, (660) 31.6, (680) 31.3, (700) 31.0

Cell Data: *Space Group:* $P\bar{4}3n$. $a = 10.538(6)$ $Z = 1$

X-ray Powder Pattern: Tramway mine, Butte, Montana, USA.
3.07 (100), 1.881 (60), 1.600 (40), 1.222 (30), 1.085 (30), 2.65 (20), 1.324 (20)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Cu	47.99	47.8	50.1	Sn	6.71	8.4	0.26
Zn		0.3		Ge			0.63
V	2.28	2.9	3.3	Te	1.26		
Fe	1.09	0.4		Sb	0.19	2.8	1.4
As	9.54	7.0	13.6	S	30.65	30.5	31.2
				Total	99.71	100.1	100.49

(1) Butte, Montana, USA; corresponds to $Cu_{25.26}V_{1.50}(As_{4.31}Sn_{1.89}Fe_{0.65}Te_{0.33}Sb_{0.05})_{\Sigma=7.23}S_{32.00}$. (2) Do.; by electron microprobe, corresponds to $(Cu_{25.31}Zn_{0.15})_{\Sigma=25.46}V_{1.92}(As_{3.14}Sn_{2.38}Sb_{0.77}Fe_{0.24})_{\Sigma=6.53}S_{32.00}$. (3) Lorano, Italy; by electron microprobe, corresponds to $Cu_{25.93}V_{2.13}(As_{5.97}Sb_{0.38}Te_{0.33}Ge_{0.28}Sn_{0.07})_{\Sigma=7.03}S_{32.00}$.

Mineral Group: Colusite group.

Occurrence: Widespread in small amounts with other sulfides and sulfosalts, typically in hydrothermal vein and disseminated copper deposits.

Association: Pyrite, tetrahedrite–tennantite, enargite, luzonite, stannoidite, goldfieldite, germanite, reniérite, bornite, chalcocite, covellite, chalcopyrite, sphalerite, galena.

Distribution: In the USA, in Montana, from the Leonard mine [TL] and other mines, Butte, Silver Bow Co.; in Arizona, from the Magma mine, Superior, Pinal Co., and the Campbell mine, Bisbee, Cochise Co.; from Red Mountain Pass, San Juan, Ouray Co., and in the Buffalo Boy mine, near Silverton, San Juan Co., Colorado. In the Kidd Creek mine, near Timmins, Ontario, Canada. From Chuquicamata, Antofagasta, Chile. At Cerro de Pasco, Peru. From Lorano, 5 km from Carrara, and in the Costa and Pitone quarries, near Seravezza, 20 km southwest of Carrara, from the La Facciata quarry, Carrara, Tuscany, Italy. At Chizeuil, Saône-et-Loire, France. From Bor, Serbia. In the Medet and Assarel deposits, and at the Chelopech deposit, Sofia, Bulgaria. In the Gay Cu–Zn deposit, Southern Ural Mountains, Russia. From the Grasberg Cu–Au deposit, Irian Jaya. At the Shin-Ohtoyo Cu–Ag deposit, Harukayama district, Hokkaido, Japan. Numerous minor localities are now known.

Name: For the Colusa claim, Butte, Montana, USA, near which it occurs in the Leonard mine.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 386–387. (2) Orlandi, P., S. Merlino, G. Duchi, and G. Vezzalini (1981) Colusite: a new occurrence and crystal chemistry. Can. Mineral., 19, 423–427. (3) Spry, P.G., S. Merlino, S. Wang, X. Zhang, and P.R. Busek (1994) New occurrences and refined crystal chemistry of colusite, with comparisons to arsenosulvanite. Amer. Mineral., 79, 750–762. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 107. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 58.

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Comancheite $Hg_{13}(Cl,Br)_8O_9$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Rarely as sprays of acicular crystals, elongated ‖ [001], up to 80 μm, and as anhedral masses.

Physical Properties: *Cleavage:* Fair on {001} and {110}. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 7.7(4) D(calc.) = 8.0

Optical Properties: Transparent to translucent. *Color:* Red-orange to yellow in crystals; red when massive. *Streak:* Yellow-orange. *Luster:* Vitreous in crystals; resinous when massive. *Optical Class:* Biaxial. *Orientation:* Extinction parallel; length-fast. *Absorption:* Strong. n = 1.78–1.79 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pnnm$ or $Pnn2$. a = 18.41(1) b = 21.64(1) c = 6.677(2) Z = 4

X-ray Powder Pattern: Terlingua, Texas, USA.
2.669 (10), 2.878 (8), 5.68 (7), 5.42 (6), 2.710 (5), 2.457 (5), 1.415 (5)

Chemistry:

	(1)
HgO	89.7
Cl	5.1
Br	8.9
$-O = (Cl,Br)_2$	2.0
Total	101.7

(1) Terlingua, Texas, USA; by electron microprobe, corresponding to $Hg_{13}(Cl_{4.51}Br_{3.50})_{\Sigma=8.01}O_{9.07}$.

Occurrence: A secondary mineral in an oxidized mercury deposit.

Association: Calcite, goethite, hematite, quartz.

Distribution: From the Mariposa mine, Terlingua, Brewster Co., Texas, USA.

Name: For the Comanche Indians, the first miners of the mercury deposits in which this mineral occurs.

Type Material: Canadian Geological Survey, Ottawa, Canada, 14608; National Museum of Natural History, Washington, D.C., USA, 150760.

References: (1) Roberts, A.C., H.G. Ansell, and P.J. Dunn (1981) Comancheite, a new mercury oxychloride-bromide from Terlingua, Texas. Can. Mineral., 19, 393–396. (2) (1982) Amer. Mineral., 67, 622 (abs. ref. 1).

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Combeite $Na_2Ca_2Si_3O_9$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Poorly developed stout hexagonal prisms, to a few tenths mm, lacking terminal faces; most material is strongly altered.

Physical Properties: Hardness = n.d. D(meas.) = 2.844 D(calc.) = 2.79

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Uniaxial (–). $\omega = 1.598(2)$ $\epsilon = 1.598(2)$

Cell Data: *Space Group:* $R\bar{3}m$. a = 10.429(2) c = 13.149(3) Z = 6

X-ray Powder Pattern: Mt. Shaheru, Congo.
2.657 (100), 2.607 (80), 3.304 (70), 3.722 (50), 3.354 (40), 1.861 (40), 4.380 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	49.78	50.20	50.86	Na_2O	16.14	20.53	17.49
TiO_2	0.32	0.23		K_2O	1.18	0.27	
ZrO_2	0.44			F	1.87		
Al_2O_3	2.45	0.05		Cl	0.30	0.02	
Fe_2O_3	1.86			H_2O^+	1.39		
FeO	0.54	0.35		H_2O^-	0.42		
MnO	0.58	0.17		CO_2	0.00		
MgO	0.41	0.17		P_2O_5	0.02	0.00	
CaO	22.68	27.28	31.65	SO_3	0.19		
SrO	0.00			S		0.02	
BaO	0.09			$-O = (F, Cl)_2$	0.86		
				Total	99.80	99.29	100.00

(1) Mt. Shaheru, Congo. (2) Oldoinyo Lengai volcano, Tanzania; by electron microprobe.
(3) $Na_2Ca_2Si_3O_9$.

Occurrence: In nephelinite (Mt. Shaheru, Congo); in nephelinite and ash ejecta (Oldoinyo Lengai volcano, Tanzania).

Association: Götzenite (Mt. Shaheru, Congo); wollastonite, clinopyroxene, nepheline, melilite, titanian garnet, titanian magnetite (Oldoinyo Lengai, Tanzania).

Distribution: On Mt. Shaheru, the extinct southern cone of Mt. Nyiragongo, Kivu Province, Congo (Zaire). From the Oldoinyo Lengai volcano, Tanzania.

Name: To honor Arthur Delmar Combe, Geological Survey of Uganda.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM8037; National Museum of Natural History, Washington, D.C., USA, 142981; The Natural History Museum, London, England, 1957,705.

References: (1) Sahama, T.G. and K. Hytönen (1957) Götzenite and combeite, two new silicates from the Belgian Congo. Mineral. Mag., 31, 503–510. (2) (1958) Amer. Mineral., 43, 791 (abs. ref. 1). (3) Fischer, R.X. and E. Tillmanns (1987) Revised data for combeite, $Na_2Ca_2Si_3O_9$. Acta Cryst., C43, 1852–1854. (4) Dawson, J.B., J.V. Smith, and I.M. Steele (1989) Combeite $(Na_{2.33}Ca_{1.74}others_{0.12})Si_3O_9$ from Oldoinyo Lengai, Tanzania. J. Geol., 97, 365–372.

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Comblainite $Ni_6Co_2^{3+}(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, 32, $\overline{3}$, or 3. As cryptocrystalline crusts.

Physical Properties: Hardness = [∼2] D(meas.) = 3.05(2) D(calc.) = 3.16–3.31

Optical Properties: Semitransparent. *Color:* Turquoise-blue; yellow-green in transmitted light.
Optical Class: Uniaxial (–). $\omega = 1.690(2)$ (ω') $\epsilon = 1.684(2)$ (ϵ')

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, $R32$, $R\overline{3}$, or $R3$. $a = 3.038$ $c = 22.79$ Z = [3/8]

X-ray Powder Pattern: Shinkolobwe, Congo; very close to takovite.
7.64 (100), 2.567 (70), 3.808 (50), 2.278 (50), 1.934 (40), 1.489 (30), 1.519 (20)

Chemistry:

	(1)	(2)
UO_3	4.24	5.20
Co_2O_3	20.80	20.20
NiO	39.30	38.40
MgO	[0.30]	[0.37]
$H_2O^+ + CO_2$	21.29	20.96
H_2O^-	11.59	8.69
H_2O	[1.07]	[1.31]
P_2O_5	[1.05]	[1.29]
Total	[99.64]	[96.42]

(1) Shinkolobwe, Congo; Ni^{2+} and Co^{3+} valences by ESCA spectra; MgO, P_2O_5, and H_2O calculated from UO_3, known to be present as "metasaleeite" $[Mg(UO_2)_2(PO_4)_2\cdot 8H_2O]$; corresponding to $Ni^{2+}_{6.10}Co^{3+}_{2.90}(CO_3)_{1.32}(OH)_{18.27}\cdot 6.7H_2O$. (2) Do.; corresponding to $Ni^{2+}_{6.11}Co^{3+}_{2.89}(CO_3)_{1.02}(OH)_{18.84}\cdot 9.92H_2O$.

Mineral Group: Hydrotalcite group.

Occurrence: An alteration product of nickel and cobalt sulfides in the oxidized zone of a uranium deposit.

Association: Uraninite, "metasaleeite", uranophane, becquerelite, curite, rutherfordine, heterogenite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: For Gordon Comblain (1920–), Royal Museum of Central Africa, Tervuren, Belgium, who discovered the mineral.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM2224; National Museum of Natural History, Washington, D.C., USA, 147188.

References: (1) Piret, P. and M. Deliens (1980) La comblainite, $(Ni_x^{2+}, Co_{1-x}^{3+})(OH)_2(CO_3)_{(1-x)/2}\cdot yH_2O$, nouveau minéral du groupe de la pyroaurite. Bull. Minéral., 103, 113–117 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 1065–1066 (abs. ref. 1).

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Compreignacite $K_2(UO_2)_6O_4(OH)_6 \cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As tabular crystals, to several tenths of one mm, flattened on [001], with large {001} and {010}, modified by {130}, {102}, {110}, {104}, and {118}; as intergrowths of crystals and spherules. *Twinning:* Commonly on {110}, as simple contact or multiple cyclic twins.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 5.03(5) D(calc.) = 5.13(5)

Optical Properties: Transparent to translucent. *Color:* Bright yellow to golden yellow. *Streak:* Pale yellow.
Optical Class: Biaxial (–). *Pleochroism:* Intense; X = colorless; $Y = Z$ = yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = [< 1.790]$ $\beta = 1.798$ $\gamma = 1.802$ 2V(meas.) = 10°–15°

Cell Data: *Space Group:* $Pnmn$ or $Pn2_1n$. $a = 7.16(2)$ $b = 12.16(5)$ $c = 14.88(5)$ Z = 2

X-ray Powder Pattern: Margnac mine, France.
7.40 (FFF), 3.53 (FF), 3.19 (FF), 3.70 (F), 3.58 (F), 3.34 (F), 2.554 (F)

Chemistry:

	(1)	(2)
UO_3	88.8	85.44
K_2O	5.4	4.69
H_2O	[9.9]	9.87
Total	[104.1]	100.00

(1) Margnac mine, France; by electron microprobe, original analysis U 82.0%, K 4.5% after heating material to 450 °C; here converted to oxides, H_2O from theoretical analysis.
(2) $K_2(UO_2)_6O_4(OH)_6 \cdot 8H_2O$.

Occurrence: As a very rare oxidation product of "pitchblende" in uranium deposits.

Association: Uraninite, cuprosklodowskite, uranophane, zeunerite, schoepite, brochantite, connellite, cerian agardite (Margnac mine, France); cuprosklodowskite, uranophane, brochantite, connellite, calcite, chalcopyrite, siderite, uraninite, potassian feldspar (Wheal Edward, Cornwall, England).

Distribution: In France, from the Margnac mine, Compreignac, Haute-Vienne. From Wheal Owles and Wheal Edward, St. Just, Cornwall, England. From Jáchymov (Joachimsthal), Czech Republic. In the Val Masino, Lombardy, Italy. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From White Canyon, near Moab, Grand Co., Utah; in the Marshall Pass district, Saguache Co., Colorado; at the Palermo mine, near North Groton, Grafton Co., New Hampshire, USA.

Name: For Compreignac, the village near the Margnac mine, France.

Type Material: University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 165183.

References: (1) Protas, J. (1964) Une nouvelle espèce minérale: la compreignacite, $K_2O.6UO_3.11H_2O$. Bull. Soc. fr. Minéral., 87, 365–371. (2) (1965) Amer. Mineral., 50, 807–808 (abs. ref. 1). (3) Granger, M.M. and J. Protas (1965) Étude de la structure cristalline de la compreignacite. Bull. Soc. fr. Minéral., 88, 211–213. (4) Pagoaga, M.K., D.E. Appleman, and J.M. Stewart (1987) Crystal structures and crystal chemistry of the uranyl oxide hydrates becquerelite, billietite, and protasite. Amer. Mineral., 72, 1230–1238. (5) Elton, N.J., J.J. Hooper, and G. Ryback (1994) Compreignacite: a second occurrence, from St. Just, Cornwall. Mineral. Mag., 58, 339–341.

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Congolite $(Fe^{2+}, Mg)_3B_7O_{13}Cl$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As grains, to 0.2 mm.

Physical Properties: Hardness = 7 D(meas.) = 3.58 D(calc.) = [3.52]

Optical Properties: Transparent. *Color:* Pink.
Optical Class: Uniaxial (–). $\omega = 1.755(5)$ $\epsilon = 1.731(2)$

Cell Data: *Space Group:* $R3c$. a = 8.6225(15) $c = 21.054(5)$ Z = 6

X-ray Powder Pattern: Brazzaville, Congo.
2.725 (100), 3.05 (80), 2.061 (75), 2.058 (75), 1.838 (70), 1.834 (70), 2.158 (60)

Chemistry:

	(1)
B_2O_3	[56.42]
FeO	25.54
MnO	0.26
MgO	13.52
Cl	7.83
$-O = Cl_2$	1.77
Total	[101.80]

(1) Penobsquis mine, Canada; by electron microprobe, B_2O_3 calculated for stoichiometry; corresponds to $(Fe_{1.55}Mg_{1.45})_{\Sigma=3.00}B_7O_{13}Cl_{0.95}$.

Polymorphism & Series: Dimorphous with ericaite.

Occurrence: Part of insoluble residue from a drill core into sedimentary evaporites (Brazzaville, Congo); in a marine evaporite deposit (Penobsquis mine, Canada).

Association: Anhydrite, halite (Brazzaville, Congo).

Distribution: From Brazzaville, Congo. In the Penobsquis evaporite deposit, near Sussex, New Brunswick, Canada. At Bischofferode, Thuringia, Germany.

Name: For Congo, the country in which the first specimens were collected.

Type Material: n.d.

References: (1) Wendling, E., R. von Hodenberg, and R. Kühn (1972) Congolit, der trigonale Eisenboracit. Kali und Steinsalz, 6, 1–3 (in German). (2) (1972) Amer. Mineral., 57, 1315 (abs. ref. 1). (3) Burns, P.C. and M.A. Carpenter (1996) Phase transitions in the series boracite – trembathite – congolite: phase relations. Can. Mineral., 34, 881–892.

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Conichalcite $CaCu(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Rarely as euhedral crystals, equant to short prismatic along [010], to 3 mm, terminated by many forms, both left- and right-handed; typically in radial fibrous aggregates, as botryoidal to reniform crusts, massive. *Twinning:* Rare on {001}.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5
D(meas.) = 4.33 D(calc.) = 4.29

Optical Properties: Subtranslucent. *Color:* Grass-green to yellowish green, pistachio-green, emerald-green; in transmitted light, pale green to yellowish green, commonly zoned.
Streak: Green. *Luster:* Vitreous to somewhat greasy.
Optical Class: Biaxial (+), may be biaxial (–), commonly zoned. *Pleochroism:* X = colorless to green; Y = pale greenish to yellow-green; Z = pale bluish to blue-green. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong, to $r < v$, moderate. $\alpha = 1.778$–1.800 $\beta = 1.795$–1.831 $\gamma = 1.801$–1.846 2V(meas.) = 0°–90°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.38$–7.40 $b = 9.21$–9.24 $c = 5.82$–5.84 Z = 4

X-ray Powder Pattern: Higgins mine, Bisbee, Arizona, USA.
2.84 (10), 2.59 (10), 3.14 (9), 1.609 (7), 1.720 (6), 4.10 (5), 2.56 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	8.81	1.4		ZnO		0.7	
As_2O_5	30.68	42.6	44.27	CaO	21.36	21.6	21.61
V_2O_5	1.78			H_2O	5.61	[3.6]	3.47
CuO	31.76	30.1	30.65	Total	100.00	[100.0]	100.00

(1) Hinojosa de Córdoba, Spain. (2) Higgins mine, Bisbee, Arizona, USA; by electron microprobe, H_2O by difference. (3) $CaCu(AsO_4)(OH)$.

Polymorphism & Series: Forms three series; with austinite, with cobaltaustinite, and with tangeite.

Mineral Group: Adelite group.

Occurrence: An uncommon secondary mineral in the oxidized zone of copper deposits, typically an alteration product of enargite.

Association: Austinite, olivenite, clinoclase, libethenite, chenevixite, brochantite, malachite, azurite, jarosite, "limonite".

Distribution: Many minor occurrences. Some providing good specimens include: from Hinojosa de Córdoba, Andalusia, Spain. In England, at Wheal Kendall, St. Hilary, and the Hingston Down quarry, Calstock, Cornwall; from Caldbeck Fells, Cumbria. In the USA, at the American Eagle and a number of other mines in the Tintic district, Juab Co., and in the Gold Hill mine, Tooele Co., Utah; from Bisbee, Cochise Co., Arizona; in the Bristol mine, Lincoln Co., and the Empire-Nevada mine, Yerington, Lyon Co., Nevada. From the Ojuela mine, Mapimí, Durango, Mexico. At Collahuasi, Tarapacá, Chile. From the Guchab mine, near Otavi, and at Tsumeb, Namibia.

Name: From the Greek for *lime* and *copper*, as both elements are essential to the composition.

Type Material: Mining Academy, Freiberg, Germany, 21297.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 806–809. (2) Berry, L.G. (1951) Observations on conichalcite, cornwallite euchroite liroconite and olivenite. Amer. Mineral., 36, 484–503. (3) Qurashi, M.M. and W.H. Barnes (1954) The structures of the minerals of the descloizite and adelite groups: I – descloizite and conichalcite (part 1). Amer. Mineral., 39, 416–435. (4) Radcliffe, D. and W.B. Simmons, Jr. (1971) Austinite: chemical and physical properties in relation to conichalcite. Amer. Mineral., 56, 1359–1365.

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Connellite $Cu_{36}(SO_4)_2Cl_6(OH)_{62}\cdot 6{-}12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As acicular prismatic crystals, elongated and striated ‖ [0001], to 2.5 cm; commonly in tight radiating groups; fibrous, felted, or crusty aggregates.

Physical Properties: Hardness = 3 D(meas.) = 3.36–3.41 D(calc.) = 3.46

Optical Properties: Translucent. *Color:* Azure-blue; blue in transmitted light. *Streak:* Pale greenish blue. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.724$–1.738 $\epsilon = 1.746$–1.758

Cell Data: *Space Group:* $P6_3/mmc$. $a = 15.78$–15.82 $c = 9.10$–9.14 Z = 1

X-ray Powder Pattern: Concordia mine, Cape Province, South Africa; close to buttgenbachite.
13.70 (vvs), 8.00 (vvs), 2.75 (vvs), 2.29 (vvs), 3.27 (vs), 1.613 (vs), 2.51 (s)

Chemistry:	(1)	(2)	(4)		(1)	(2)	(4)
SO_3	3.84	3.15	4.04	H_2O	16.81	17.13	19.55
N_2O_5	0.30	0.72		$-O = Cl_2$	1.59	1.53	1.21
CuO	73.41	73.38	72.25	Total	99.82	99.67	100.00
Cl	7.05	6.82	5.37				

(1) Grand Central mine, Tintic, Utah, USA; corresponds to $Cu_{36.00}[(SO_4)_{1.87}(NO_3)_{0.22}]_{\Sigma=2.07}Cl_{7.76}(OH)_{60.28}\cdot 6.26H_2O$. (2) Czar mine, Bisbee, Arizona, USA; corresponds to $Cu_{36.00}[(SO_4)_{1.54}(NO_3)_{0.52}]_{\Sigma=2.06}Cl_{7.51}(OH)_{60.89}\cdot 6.66H_2O$. (3) Toughnut mine, Tombstone, Arizona, USA; crystal structure analysis yields $Cu_{36.0}[(SO_4)_{1.6}(NO_3)_{0.4}]_{\Sigma=2.0}Cl_{7.8}(OH)_{60.6}\cdot 6.7H_2O$. (4) $Cu_{36}(SO_4)_2Cl_6(OH)_{62}\cdot 12H_2O$.

Polymorphism & Series: Forms a series with buttgenbachite.

Occurrence: An uncommon secondary mineral in the oxidized portions of copper deposits.

Association: Cuprite, spangolite, atacamite, botallackite, langite, malachite, azurite.

Distribution: In England, in the Wheals Gorland, Unity, Edward, the Botallack mine, and others in St. Just, and several other mines in Cornwall. At Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland. In the Britannia mine, Snowdonia, Wales. At the Cap Garonne mine, near le Pradet, Var, France. In the Sa Duchessa mine, Oridda district, Sardinia, Italy. From Laurium, Greece, in slag. At Fontana Rossa, Corsica, France. From Weibing, Salzburg, Austria. In the Clara mine, Black Forest, Germany. In the USA, in Arizona, from several mines at Bisbee and in the Toughnut mine, Tombstone, Cochise Co.; in Utah, from the Grand Central mine, Tintic district, Juab Co. and the Gold Hill mine, Tooele Co. At Spring Creek and the Ediacara mine, Flinders Ranges, South Australia, and at Broken Hill, New South Wales, Australia. In the Marharahara mine, near Woodville, New Zealand. Increasingly recognized from other minor localities.

Name: Honors Arthur Connell (1794–1863), Scottish chemist who first examined the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 572–573. (2) Bannister, F.A., M.H. Hey, and G.F. Claringbull (1950) Connellite, buttgenbachite, and tallingite. Mineral. Mag., 29, 280–286. (3) McLean, W.J. and J.W. Anthony (1972) The disordered, "zeolite-like" structure of connellite. Amer. Mineral., 57, 426–438. (4) Pollard, A.M., R.G. Thomas, P.A. Williams, R.E. Bevins, and S. Turgoose (1989) Carbonatian connellite, a new variety, from the Britannia mine, North Wales, and from the Botallack mine, Cornwall. J. Russell Soc., 2(2), 23–27. (5) Hibbs, D.E., P. Leverett, and P.A. Williams (2003) A single crystal X-ray study of a sulphate-bearing buttgenbachite, $Cu_{36}Cl_{7.8}(NO_3)_{1.3}(SO_4)_{0.35}(OH)_{62.2}.5H_2O$, and a re-examination of the crystal chemistry of the buttgenbachite – connellite series. Mineral. Mag., 67, 47–60.

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Cookeite **$LiAl_4(Si_3Al)O_{10}(OH)_8$**

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Pseudohexagonal platy crystals; curved, radial scales, spherulites, barrel-shaped, fibrous. *Twinning:* Around [310], composition plane {001}.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Flexible but inelastic. Hardness = 2.5–3.5 D(meas.) = 2.58–2.69 D(calc.) = 2.968

Optical Properties: Transparent to translucent. *Color:* White, yellowish green, pink, brown; in thin section, colorless to pale green or pink. *Luster:* Pearly or silky.
Optical Class: Biaxial (+); rarely with biaxial sectors around a uniaxial core. *Pleochroism:* $X =$ $Y =$ pale green to pink; $Z =$ colorless to pale yellow. *Orientation:* $Y = b$; $X \wedge a = 0°$–$3°$; $Z \wedge a$ $= 90°$–$87°$. *Dispersion:* $r < v$. *Absorption:* $X = Y > Z$. $\alpha = 1.572$–1.578 $\beta = 1.579$–1.584 $\gamma = 1.589$–1.595 2V(meas.) = 0°–80°

Cell Data: *Space Group:* $C\overline{1}$. $a = 5.14$ $b = 8.90$ $c = 14.15$ $\alpha = 90°33'$ $\beta = 90°12'$ $\gamma = 90°$ Z = 2

X-ray Powder Pattern: Londonderry, Western Australia.
2.315 (10), 4.70 (9), 3.52 (9), 14.1 (8), 7.05 (7), 2.505 (7), 1.489 (7)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	33.40	38.26	CaO	0.45	
Al_2O_3	47.47	44.28	Li_2O	3.12	2.00
Fe_2O_3	0.00	1.31	$(Na,K)_2O$	0.09	
FeO	0.71	0.48	H_2O^+	14.98	13.00
MnO	trace		H_2O^-	0.23	
MgO	0.20		Total	100.65	99.33

(1) Kalbinsky Range, Ural Mountains, Russia; corresponds to $(Li_{1.11}Na_{0.02}K_{0.01})_{\Sigma=1.14}$ $(Al_{3.89}Fe^{2+}_{0.05}Ca_{0.04}Mg_{0.03})_{\Sigma=4.01}(Si_{2.95}Al_{1.05})_{\Sigma=4.00}O_{10}(OH)_8$. (2) Djalair deposit, "Middle Asia," Russia; corresponds to $Li_{0.7}(Al_{3.96}Fe^{3+}_{0.09}Fe^{2+}_{0.04})_{\Sigma=4.09}(Si_{3.38}Al_{0.62})_{\Sigma=4.00}O_{10.35}(OH)_{7.65}$.

Mineral Group: Chlorite group.

Occurrence: A late-stage hydrothermal alteration product of lithium-bearing minerals in pegmatites; a primary hydrothermal vein mineral.

Association: Lepidolite, spodumene, tourmaline, petalite, quartz, albite, microcline.

Distribution: Good examples from: in the USA, at Hebron, Mt. Mica, near Paris, and Buckfield, Oxford Co., Maine; in the Pala and Rincon districts, San Diego Co., California; from the Jeffrey quarry, North Little Rock, Pulaski Co., Arkansas. At Waitabit Creek, northwest of Donald, British Columbia, Canada. From Ogofau, Carmarthenshire, England. At Radkovice and Dobrá Voda, Czech Republic. In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. From Lipovka, Ural Mountains, Russia. In the Muiâne pegmatite, Alto Ligonha district, Mozambique. At Londonderry, Western Australia. Many additional localities are known.

Name: For Josiah B. Cooke, Jr. (1827–1894), American mineralogist and chemist, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Yale University, New Haven, Connecticut, USA, 2.3728 (holotype material probably exhausted in analysis).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 625.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet

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silicates, 131–163. (3) Brown, B.E. and S.W. Bailey (1962) Chlorite polytypism: I. Regular and semi-random one-layer structure. Amer. Mineral., 47, 819–850. (4) Černý, P. (1970) Compositional variations in cookeite. Can. Mineral., 10, 636–647. (5) Vrublevskaja [Vrublevskaya], Z.V., I.S. Delitsin, B.B. Zvyagin, and S.V. Soboleva (1975) Cookeite with a perfect regular structure, formed by bauxite alteration. Amer. Mineral., 60, 1041–1046. (6) Bailey, S.W. and J.S. Lister (1989) Structures, compositions, and X-ray diffraction identification of dioctahedral chlorites. Clays and Clay Minerals, 37, 193–202.

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Coombsite $K(Mn^{2+}, Fe^{2+}, Mg)_{13}(Si, Al)_{18}O_{42}(OH)_{14}$

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Crystal Data: [Hexagonal] (by analogy to zussmanite). *Point Group:* [3 or $\overline{3}$.] Fibrous crystals, to 20 μm, in patchy spherulitic aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 3.0(1) D(calc.) = 3.063

Optical Properties: Semitransparent. *Color:* Pale yellowish brown.
Optical Class: Uniaxial (–). *Absorption:* Weak; $O > E$. $\omega = 1.619(1)$ $\epsilon = 1.600(1)$

Cell Data: *Space Group:* [$R3$ or $R\overline{3}$.] $a = 11.828(2)$ $c = 29.146(9)$ Z = 3

X-ray Powder Pattern: Watson's Beach, New Zealand; closely resembles zussmanite.
9.68 (100), 2.556 (90), 2.793 (70), 2.241 (50), 4.835 (30), 3.241 (25)

Chemistry:

	(1)
SiO_2	45.18
TiO_2	0.01
Al_2O_3	3.59
FeO	3.28
MnO	38.19
MgO	1.08
CaO	0.03
Na_2O	0.08
K_2O	2.19
H_2O	[6.37]
Total	[100.00]

(1) Watson's Beach, New Zealand; by electron microprobe, H_2O by difference; corresponds to $(K_{1.01}Na_{0.06})_{\Sigma=1.07}(Mn_{11.75}Fe_{1.00}Mg_{0.58})_{\Sigma=13.33}(Si_{16.41}Al_{1.54})_{\Sigma=17.95}O_{42}(OH)_{14}$.

Occurrence: In a manganese-rich rock in metagraywacke-argillite in the pumpellyite-prehnite facies.

Association: Rhodonite, quartz, rhodochrosite, kutnohorite, manganoan calcite, spessartine, apatite, parsettensite, caryopilite.

Distribution: At Watson's Beach, southeastern Otago, New Zealand.

Name: For Professor Douglas Saxon Coombs (1924–), mineralogist and petrologist, University of Otago, Dunedin, New Zealand.

Type Material: University of Otago, Dunedin, New Zealand; National Museum of Natural History, Washington, D.C., USA.

References: (1) Sameshima, T. and Y. Kawachi (1991) Coombsite, Mn analogue of zussmanite, and associated Mn-silicates, parsettensite and caryopilite, from southeast Otago, New Zealand. New Zealand J. Geol. Geophys., 34, 329–335. (2) (1992) Amer. Mineral., 77, 671 (abs. ref. 1).

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Cooperite **(Pt, Pd)S**

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As distorted crystal fragments elongated ‖ [101] with {110}, {111}, and {001}; as irregular grains, to 1.5 mm. *Twinning:* Rarely.

Physical Properties: *Cleavage:* {011}. *Fracture:* Conchoidal. Hardness = 4–5 VHN = 743–1018 (100 g load). D(meas.) = 9.5 D(calc.) = 10.2

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, brownish. *Luster:* Metallic. *Pleochroism:* From white to creamy white to bluish white. *Anisotropism:* Strong, greenish gray to whitish yellow to brown-gray and brown. R_1–R_2: (400) 40.9–46.6, (420) 42.0–47.3, (440) 42.6–47.9, (460) 42.7–48.3, (480) 42.2–48.4, (500) 41.5–48.2, (520) 40.4–47.8, (540) 39.4–47.2, (560) 38.5–36.6, (580) 37.8–46.1, (600) 37.2–45.5, (620) 36.6–45.1, (640) 36.0–44.7, (660) 35.6–44.2, (680) 35.1–43.7, (700) 34.6–43.3

Cell Data: *Space Group:* $P4_2/mmc$. $a = 3.4700$ $c = 6.1096$ $Z = 2$

X-ray Powder Pattern: Potgietersrus district, Transvaal, South Africa. 3.013 (10), 1.911 (8), 1.507 (7), 2.450 (6), 1.753 (6), 1.732 (5), 1.231 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pt	85.1	79.7	85.89	Ni	0.7	0.1	
Pd	0.6	5.6		S	13.9	14.3	14.11
				Total	100.3	99.7	100.00

(1) Potgietersrus district, Transvaal, South Africa; by electron microprobe, corresponding to $(Pt_{0.98}Pd_{0.01}Ni_{0.03})_{\Sigma=1.02}S_{0.98}$. (2) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $(Pt_{0.90}Pd_{0.12})_{\Sigma=1.02}S_{0.98}$. (3) PtS.

Polymorphism & Series: Dimorphous with braggite.

Occurrence: A significant platinum ore mineral, found in ultramafics, gabbros, dunites, chromitites, typically layered; in massive chalcopyrite–pyrrhotite orebodies; in alluvial placers.

Association: Braggite, vysotskite, sperrylite, moncheite, platarsite, laurite, malanite, hollingsworthite, platinum, Pt–Fe alloys and many other PGM species, chalcopyrite, bornite, cubanite, pentlandite, pyrrhotite, pyrite, chromite.

Distribution: In South Africa, from the Rustenburg [TL] and Potgietersrus districts, and various other localities along the Merensky Reef of the Bushveld complex, Transvaal. In the Freetown complex, Sierra Leone. From the Stillwater complex, Montana; at the junction of the Trinity and Klamath Rivers, Humboldt Co., and from the Merced River at Snelling and Cressy, Merced Co., California, USA. In Canada, in the Lac des Iles complex, Ontario, and the Tulameen district, British Columbia. In Russia, in the Severnyi mine, Noril'sk region, western Siberia; at the Konder massif, Aldan Shield, Sakha; in the Gusevogorskii magnetite deposits, Ural Mountains; and the Baimka placer, Chukotka, Far Eastern Region. At Round Hill, near Orepuki, New Zealand. A number of additional localities are known, generally in small amounts or in placers of uncertain origin.

Name: Honors Richard A. Cooper (1890–1972), South African metallurgist, Johannesburg, South Africa, who first described the mineral.

Type Material: The Natural History Museum, London, England, 1932,1301; Harvard University, Cambridge, Massachusetts, USA, 101935.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 258–259. (2) Cabri, L.J., J.H.G. Laflamme, J.M. Stewart, K. Turner, and B.J. Skinner (1978) On cooperite, braggite, and vysotskite. Amer. Mineral., 63, 832–839. (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 100–101. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 71. (5) Criddle, A.J. and C.J. Stanley (1985) Characteristic optical data for cooperite, braggite and vysotskite. Can. Mineral., 23, 149–162.

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Coparsite $Cu_4O_2(AsO_4, VO_4)Cl$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As pseudocubic rhombohedral crystals, to 2 mm, with prominent $\{10\bar{1}1\}$; usually in crusts, massive.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 3.5–4.5 D(meas.) = 4.295 D(calc.) = [4.31]

Optical Properties: Transparent. *Color:* Brown to pale yellowish brown, pale yellow, yellowish green to dark green. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–); commonly anomalous biaxial, birefringence weak, showing lamellar structure. n = 1.93–1.96

Cell Data: *Space Group:* $R3m$. a = 7.280 (1) c = 16.821 (1) Z = 3

X-ray Powder Pattern: Glandore mines, Ireland. (ICDD 17-471).
3.03 (100), 5.86 (65), 2.237 (55), 3.61 (35), 2.793 (35), 1.482 (35), 2.508 (30)

Chemistry:

	(1)	(2)	(3)
SO_3	13.76	11.70	11.99
P_2O_5	8.97	10.62	10.63
As_2O_5	0.24	0.29	
Fe_2O_3	40.69	35.79	35.87
CuO	2.45	0.58	
PbO	24.05	32.64	33.42
H_2O	9.77	8.15	8.09
Total	99.93	99.77	100.00

(1) Glandore mines, Ireland. (2) Dernbach, Germany; Pb, Cu, and Fe by AA, P and As by neutron activation, SO_4 by ESCA, H_2O by the phosphoric acid method; corresponding to $Pb_{0.98}Cu_{0.05}Fe_{2.99}(PO_4)_{1.00}(AsO_4)_{0.02}(SO_4)_{0.98}(OH)_{6.04}$. (3) $PbFe_3(PO_4)(SO_4)(OH)_6$.

Mineral Group: Beudantite group.

Occurrence: A rare secondary mineral formed at low temperatures or by weathering in oxidized hydrothermal base-metal deposits.

Association: Pyromorphite, malachite, plumbojarosite, "limonite", quartz.

Distribution: Widespread in small amounts. From the Glandore iron mines, Co. Cork, Ireland. In England, large crystals at the Mexico mine, Caldbeck Fells, Cumbria; in Cornwall, from the Penberthy Croft mine, St. Hilary, at Wheal Unity, Gwennap, and the Gravel Hill mine, Perranzabuloe. In Germany, from Dernbach, near Montabaur, Hesse, and in the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate. At Richelle, near Visé, Belgium. From Maikain, Kazakhstan. In the USA, at the Silver Queen mine, Galena, Lawrence Co., South Dakota; in the Wild Bill, Harrington-Hickory, and other mines, Beaver Co., and the Gold Hill and Honerine mines, Tooele Co., Utah; at the Mex-Tex mine, near Bingham, Hansonburg district, Socorro Co., New Mexico. From Santa Eulalia, Chihuahua, Mexico. At the Osarizawa mine, Akita prefecture, Japan. From Aggeneys, Northern Cape Province, South Africa. At Tsumeb, Namibia. In the Woodcutters Pb–Zn mine, Northern Territory, Australia. A number of other localities are known.

Name: For its first-noted occurrence, in Co. Cork, Ireland.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1002–1003. (2) Giuseppetti, G. and C. Tadini (1987) Corkite, $PbFe_3(SO_4)(PO_4)(OH)_6$, its crystal structure and ordered arrangement of the tetrahedral cations. Neues Jahrb. Mineral., Monatsh., 71–81.

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Copiapite $Fe^{2+}Fe^{3+}_4(SO_4)_6(OH)_2 \cdot 20H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As pseudo-orthorhombic platy crystals, tabular on {010}, may be highly modified, with more than 300 forms measured, to 1 mm; typically in incrustations of scaly or granular pulverulent aggregates. *Twinning:* Contact twins with twin axis [$\overline{1}$01] and composition plane {010}.

Physical Properties: *Cleavage:* On {010}, perfect; on {$\overline{1}$01}, imperfect. Hardness = 2.5–3 D(meas.) = 2.04–2.17 D(calc.) = [2.12] Soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Sulfur-yellow, golden yellow, pale yellow, yellow-orange; may be greenish yellow to olive-green in aggregates. *Luster:* Pearly on {010}.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = pale yellow to colorless; Z = sulfur-yellow. *Orientation:* $X \perp$ {010}; Y = [$\overline{1}$01]; Z = [101]; $Y \wedge c = 38°$. *Dispersion:* $r > v$, strong. *Absorption:* $X = Z > Y$. α = 1.496–1.53 β = 1.531–1.55 γ = 1.579–1.60 2V(meas.) = 52°–73°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.337(6)$ $b = 18.76(1)$ $c = 7.379(6)$ $\alpha = 91.46(7)°$ $\beta = 102.18(6)°$ $\gamma = 98.95(6)°$ Z = 1

X-ray Powder Pattern: Cache Creek, British Columbia, Canada.
18.4 (10), 9.23 (10), 5.57 (7), 6.15 (6), 3.58 (6), 3.49 (6), 4.20 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	38.37	38.43	FeO	4.06	5.75
Al_2O_3	trace		H_2O	30.68	30.27
Fe_2O_3	26.10	25.55	insol.	0.71	
			Total	99.92	100.00

(1) Capo d'Arco, Elba, Italy. (2) $Fe^{2+}Fe^{3+}_4(SO_4)_6(OH)_2 \cdot 20H_2O$.

Mineral Group: Copiapite group.

Occurrence: A secondary mineral formed typically by the weathering and oxidation of pyrite in a wide range of rock types, preserved in arid climates; rarely associated with fumarolic action.

Association: Melanterite, alunogen, fibroferrite, halotrichite, botryogen, butlerite, amarantite.

Distribution: One of the most common ferric sulfates. In small amounts from many localities, with well studied material from: in Chile, at Tierra Amarilla, southeast of Copiapó, Atacama; from Alcaparrosa, near Cerritos Bayos, southwest of Calama, and at Chuquicamata, Antofagasta. In the USA, in California, from Coso Hot Springs, Inyo Co., Sulphur Bank, Lake Co., the Alma mine, Leona Heights, Alameda Co., and elsewhere; from the Comstock Lode, Virginia City, Storey Co., Nevada; in the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah; in Arizona, at Bisbee, Cochise Co., and from the United Verde mine, Jerome, Yavapai Co. At the Rammelsberg mine, near Goslar, Harz Mountains, Germany. In Italy, at Capo Calamita and Capo d'Arco, Elba; in Alum Cave, Vulcano, Lipari Islands. From volcanoes on the Kamchatka Peninsula, Russia.

Name: For the city of Copiapó, Chile, near which specimens were first collected.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 99059.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 623–627. (2) Süsse, P. (1972) Crystal structure and hydrogen bonding of copiapite. Zeits. Krist., 135, 34–55. (3) Fanfani, L., A. Nunzi, P.F. Zanazzi, and A.R. Zanzari (1973) The copiapite problem: the crystal structure of a ferrian copiapite. Amer. Mineral., 58, 314–322. (4) Schmetzer, K. and O. Medenbach (1983) Challantit [= copiapite] aus Cache Creek, British Columbia, Kanada - ein zweiter Fundpunkt. Neues Jahrb. Mineral., Monatsh., 158–162 (in German with English abs.). (5) Bayliss, P. and D. Atencio (1985) X-ray powder-diffraction data and cell parameters for copiapite-group minerals. Can. Mineral., 23, 53–56.

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Copper Cu

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As cubes, dodecahedra, and as tetrahexahedra; rarely as octahedra and complex combinations. Commonly flattened on {111}, elongated along [001]. Also as irregular distortions, in twisted, wirelike shapes; filiform, arborescent, massive; as a coarse powder. Masses weighing hundreds of tons have been found; crystals up to 15 cm. *Twinning:* On {111} to produce simple contact and penetration twins and cyclic groups.

Physical Properties: *Fracture:* Hackly. *Tenacity:* Highly malleable and ductile. Hardness = 2.5–3 VHN = 77–99 (100 g load). D(meas.) = 8.95 D(calc.) = 8.93

Optical Properties: Opaque. *Color:* Pale rose on fresh surface, quickly darkens to copper-red, then metallic, shining; in reflected light, pale rose. *Luster:* Metallic.
R: (400) 45.0, (420) 47.9, (440) 51.3, (460) 54.4, (480) 56.9, (500) 58.9, (520) 60.5, (540) 63.0, (560) 70.5, (580) 86.1, (600) 95.9, (620) 98.4, (640) 98.7, (660) 98.7, (680) 98.7, (700) 98.7

Cell Data: *Space Group:* $Fm3m$. a = 3.615 Z = 4

X-ray Powder Pattern: Synthetic.
2.088 (100), 1.808 (46), 1.278 (20), 1.0900 (17), 0.8293 (9), 0.8083 (8), 1.0436 (5)

Chemistry: Copper, typically with only small amounts of other metals.

Occurrence: Commonly associated with porous zones in mafic extrusive rocks, less commonly in sandstones and shales, where the copper was probably of hydrothermal origin, precipitated as the result of oxidizing conditions; in the oxidized zone of large, disseminated copper deposits as a result of secondary processes. A rare mineral in some meteorites.

Association: Silver, chalcocite, bornite, cuprite, malachite, azurite, tenorite, iron oxides, many other minerals.

Distribution: Occurs in many districts world-wide. In the USA, as remarkably large masses and excellent, large crystals in deposits of the Keweenaw Peninsula, Keweenaw and Houghton Cos., Michigan; in several porphyry copper deposits in Arizona including those at the New Cornelia mine, Ajo, Pima Co.; the Copper Queen and other mines at Bisbee, Cochise Co.; and at Ray, Gila Co.; similarly in the Chino mine at Santa Rita, Grant Co., New Mexico. In Namibia, at the Onganja mine, 60 km northeast of Windhoek, and at Tsumeb. In large crystals from the Turinsk copper mine, Bogoslovsk, Ural Mountains, Russia. In Germany, at Rheinbreitbach, North Rhine-Westphalia, and the Friedrichssegen mine, near Bad Ems, Rhineland-Palatinate. In fine specimens from many mines in Cornwall, England. In Australia, at Broken Hill, New South Wales. In Chile, at Andacolla, near Coquimbo. From Bolivia, at Corocoro.

Name: From the Latin *cuprum*, in turn from the Greek *kyprios*, *Cyprus*, from which island the metal was early produced.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 99–102. (2) Batchelder, D.N. and R.O. Simmons (1965) X-ray lattice constants of crystals by a rotating-camera method: Al, Ar, Au, CaF_2, Cu, Ge, Ne, Si. J. Appl. Phys., 2864–2868. (3) (1953) NBS Circ. 539, 1, 15. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 112.

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Coquandite $Sb_6^{3+}O_8(SO_4)\cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals lamellar, elongated along [001], very thin tabular on {010}, to 0.1 mm, showing {010}, {001}, {$2\overline{1}0$}, and {$1.\overline{12}.0$}. Fibrous, in feathery spheroidal aggregates; in thin crusts, powdery, massive. *Twinning:* On {010} as twin plane, polysynthetic.

Physical Properties: *Tenacity:* Flexible. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.78

Optical Properties: Transparent to translucent. *Color:* Colorless, white. *Streak:* White. *Luster:* Adamantine to pearly.
Optical Class: Biaxial (+); low birefringence. *Orientation:* $Z \simeq c$; OAP ∥ [001]; parallel extinction ∥ {010}; length-slow. $n = 2.08(5)$. $2V(meas.) = \gg 60°$

Cell Data: *Space Group:* $P\overline{1}$. $a = 11.434$–11.449 $b = 29.77$–29.846 $c = 11.314$–11.337 $\alpha = 91.07°-91.16°$ $\beta = 118.88°-119.24°$ $\gamma = 92.49°-92.82°$ Z = 12

X-ray Powder Pattern: Pereta mine, Italy.
3.092 (100), 3.304 (93), 6.81 (67), 14.84 (50), 9.27 (41), 3.200 (39), 8.01 (34)

Chemistry:

	(1)	(2)	(3)	(4)
Sb_2O_3	88.25	88.53	89.96	88.91
CaO	0.04	0.04	0.04	0.04
Na_2O	0.02	0.02	0.05	0.03
H_2O			1.43	1.43
SO_3	8.35	8.33	8.38	8.35
Total			99.86	98.76

(1) Pereta mine, Italy; by electron microprobe, average of 10 analyses on three grains. (2) Cetine mine, Italy; by electron microprobe, average of four analyses on two grains. (3) Lucky Knock mine, Washington, USA; by electron microprobe, average of eight analyses on seven grains, H_2O by elemental analyzer, confirmed by IR. (4) Average of (1–3); corresponding to $Sb_{5.98}Ca_{0.01}Na_{0.01}O_{7.96}(SO_4)_{1.02}\cdot 0.78H_2O$.

Occurrence: Probably produced by action of H_2SO_4 on stibnite, in a stibnite vein in silicified limestone (Pereta mine, Italy).

Association: Klebelsbergite, peretaite, valentinite, sénarmontite, stibiconite, stibnite, sulfur, gypsum, quartz.

Distribution: From the Cetine mine, 20 km southwest of Siena, and the Pereta mine, Scansano, Tuscany, Italy. In the Lucky Knock mine, Tonasket, Okanogan Co., Washington, USA.

Name: For Henri-Jean-Baptiste Coquand (1813–1881), Professor of Geology and Mineralogy, University of Marseilles, Marseilles, France, for his early work on the antimony deposits of Tuscany, Italy.

Type Material: University of Florence, Florence, 1761/RI; University of Pisa, Pisa, Italy, 8800; National Museum of Natural History, Washington, D.C., USA.

References: (1) Sabelli, C., P. Orlandi, and G. Vezzalini (1992) Coquandite, $Sb_6O_8(SO_4)\cdot H_2O$, a new mineral from Pereta, Tuscany, Italy, and two other localities. Mineral. Mag., 56, 599–603. (2) (1993) Amer. Mineral., 78, 845 (abs. ref. 1).

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Coquimbite $Fe_2^{3+}(SO_4)_3 \cdot 9H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As short prismatic to pyramidal crystals, dominated by $\{10\overline{1}0\}$, $\{11\overline{2}0\}$, $\{10\overline{1}1\}$, $\{0001\}$, to 2 cm; massive, granular.

Physical Properties: *Cleavage:* Imperfect on $\{10\overline{1}1\}$; difficult on $\{10\overline{1}0\}$. Hardness = 2.5 D(meas.) = 2.11(1) D(calc.) = [2.12] Soluble in H_2O, astringent taste; effloresces in dry air.

Optical Properties: Transparent. *Color:* Pale violet to amethystine, rarely pale yellow or pale green. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.536$–1.539 $\epsilon = 1.548$–1.572

Cell Data: *Space Group:* $P\overline{3}1c$. $a = 10.922(9)$ $c = 17.084(14)$ $Z = 4$

X-ray Powder Pattern: Smolník, Slovakia. (ICDD 6–40).
8.26 (100), 2.759 (75), 5.45 (65), 3.36 (60), 4.60 (45), 9.44 (40), 3.64 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	42.37	42.74	H_2O	28.48	28.85
Al_2O_3	trace		Total	99.79	100.00
Fe_2O_3	28.94	28.41			

(1) Tierra Amarilla, Chile. (2) $Fe_2(SO_4)_3 \cdot 9H_2O$.

Polymorphism & Series: Dimorphous with paracoquimbite.

Occurrence: Typically a secondary mineral in the oxidized portions of weathering iron sulfide deposits in arid regions; rarely associated with fumarolic activity.

Association: Copiapite, paracoquimbite, voltaite, szomolnokite, römerite.

Distribution: Abundant at numerous localities in Chile: from Tierra Amarilla, southeast of Copiapó, Atacama; at Quetena, west of Calama, from Chuquicamata, and at Alcaparrosa, near Cerritos Bayos, southwest of Calama, Antofagasta. In the USA, in Arizona, at Bisbee, Cochise Co., and from the United Verde mine, Jerome, Yavapai Co.; near Borate, San Bernardino Co., California; fine examples from the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah. Large crystals from Zalamea la Real, Huelva Province, Spain. From Smolník (Szomolnok), 16 km northeast of Rožňava, Slovakia. In Alum Cave, Vulcano, Lipari Islands, Italy. At volcanoes on the Kamchatka Peninsula, Russia.

Name: For the Coquimbo region, Chile.

Type Material: Mining Academy, Freiberg, Germany, 18558.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 532–534. (2) Fang, J.H. and P.D. Robinson (1970) Crystal structures and mineral chemistry of hydrated ferric sulfates. I. The crystal structure of coquimbite. Amer. Mineral., 55, 1534–1540. (3) Fang, J.H. and P.D. Robinson (1974) Polytypism in coquimbite and paracoquimbite. Neues Jahrb. Mineral., Monatsh., 89–91.

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Corderoite $Hg_3S_2(Cl,Br)_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Rare as cubic crystals, to 2 mm; as rims and replacements of cinnabar.

Physical Properties: Hardness = ∼3 VHN = 28–61 (25 g load) (synthetic).
D(meas.) = 6.74 (synthetic). D(calc.) = 6.845

Optical Properties: Transparent. *Color:* Pale orange-pink to salmon-pink; on exposure to light, rapidly darkening to pale gray, then black.
Optical Class: Isotropic. $n = > 2.5$
R: 16.7 (470), 15.5 (546), 15.1 (589), 15.1 (650)

Cell Data: *Space Group:* $I2_13$. $a = 8.940(5)$ Z = 4

X-ray Powder Pattern: Synthetic $Hg_3S_2Cl_2$.
3.62 (100), 2.57 (70), 1.749 (60), 2.81 (50), 2.38 (40), 2.10 (40), 6.23 (30)

Chemistry:

	(1)	(2)	(3)
Hg	82.6	81.4	81.68
S	8.65	8.54	8.70
Cl	9.49	9.11	9.62
Br		1.28	
Total	100.74	100.33	100.00

(1) Arzak deposit, Russia; by electron microprobe, average of four grains; corresponds to $Hg_{3.00}S_{1.96}Cl_{1.95}$. (2) Kadyrel deposit, Russia; by electron microprobe, corresponds to $Hg_{3.00}S_{1.96}(Cl_{1.90}Br_{0.12})_{\Sigma=2.02}$. (2) $Hg_3S_2Cl_2$.

Polymorphism & Series: Dimorphous with lavrentievite.

Occurrence: In lake-bed sediments and underlying silicified rhyolite tuffs, possibly of low-temperature secondary origin (McDermitt mine, Nevada, USA); in an oxidized hydrothermal deposit (Arzak deposit, Russia).

Association: Cinnabar, kleinite, kenhsuite, radtkeite, montmorillonite, quartz, cristobalite, orthoclase, plagioclase (McDermitt mine, Nevada, USA); cinnabar, calomel, eglestonite, arzakite, lavrentievite, kuznetsovite, mercury, quartz, kaolinite (Arzak deposit, Russia).

Distribution: In the USA, in Nevada, from the McDermitt mercury mine, Opalite district, Humboldt Co. [TL]; at the Paradise Peak mine, Fairplay district, Nye Co.; and in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co. From the Arzak and Kadyrel mercury deposits, Tuva, Siberia, Russia. In the Khaydarkan mercury deposit, Fergana Valley, Alai Range, Kyrgyzstan. At Landsberg, near Obermoschel, and from Königsberg, near Wolfstein, Rhineland-Palatinate, Germany.

Name: For its occurrence in the McDermitt (formerly Cordero) mine, USA.

Type Material: Stanford University, Palo Alto, California; National Museum of Natural History, Washington, D.C., USA, 133354.

References: (1) Foord, E.E., P. Berendsen, and L.O. Storey (1974) Corderoite, first natural occurrence of α–$Hg_3S_2Cl_2$, from the Cordero mercury deposit, Humboldt County, Nevada. Amer. Mineral., 59, 652–655. (2) Vasil'ev, V.I. and O.K. Grechishchev (1979) First discovery of corderoite (α–$Hg_3S_2Cl_2$) in mercury ores of the USSR. Doklady Acad. Nauk SSSR, 246, 951–953 (in Russian). (3) Vasil'ev, V.I. and Y.G. Lavrent'ev (1979) New finds and data on the composition of corderoite (α–$Hg_3S_2Cl_2$). Soviet Geol. Geophys., 27(12), 112–115. (4) Aurivillius, K.L. (1967) An X-ray single crystal study of $\alpha - Hg_3S_2Cl_2$. Arkiv för Kemi, 26, 497–505. (5) Carlson, E.H. (1967) The growth of HgS and $Hg_3S_2Cl_2$ single crystals by a vapor phase method. J. Crystal Growth, 1, 271–277. (6) Frueh, A.J. and N. Gray (1968) Confirmation and refinement of the structure of $Hg_3S_2Cl_2$. Acta Cryst., 24, 156–157.

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Cordierite $(Mg, Fe^{2+})_2Al_4Si_5O_{18}$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals short prismatic, striated ‖ [001], to 18 cm; typically granular to compact, massive. *Twinning:* Common on {110}, {130}, simple, lamellar, cyclical.

Physical Properties: *Cleavage:* Fair on {100}, poor on {001} and {010}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 7–7.5 D(meas.) = 2.60–2.66 D(calc.) = 2.505

Optical Properties: Transparent to translucent. *Color:* Blue, smoky blue, bluish violet; greenish, yellowish brown, gray; colorless to very pale blue in thin section. *Luster:* Vitreous. *Optical Class:* Biaxial (+) or (–). *Pleochroism:* X = pale yellow, green; Y = violet, blue-violet; Z = pale blue. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, weak to marked. *Absorption:* $Z > Y > X$. $\alpha = 1.527$–1.560 $\beta = 1.532$–1.574 $\gamma = 1.537$–1.578 2V(meas.) = 35°–106°

Cell Data: *Space Group: Cccm.* $a = 17.079(3)$ $b = 9.730(2)$ $c = 9.356(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
8.45 (100), 8.52 (95), 3.039 (65), 3.035 (65), 3.132 (55), 3.012 (55), 4.09 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	50.2	49.46	MgO	12.8	12.06
TiO_2	< 0.01	0.01	CaO	0.23	0.03
Al_2O_3	33.5	33.58	Na_2O	0.26	0.14
Fe_2O_3	0.14	0.14	K_2O	0.14	0.30
FeO	0.84	2.12	H_2O^+	1.69	1.71
MnO	0.06	0.08	H_2O^-	0.12	0.10
			Total	99.98	99.73

(1) White Well, Western Australia; corresponds to $(Mg_{1.91}Fe^{2+}_{0.08}Na_{0.05}Ca_{0.02}K_{0.02}Mn_{0.01})_{\Sigma=2.09}Al_{3.95}Si_{5.02}O_{18}$. (2) Smith Ridge, Boehls Butte quadrangle, Idaho, USA; corresponds to $(Mg_{1.81}Fe^{2+}_{0.18}K_{0.04}Ca_{0.03}Mn_{0.01})_{\Sigma=2.07}Al_{3.99}Si_{4.98}O_{18}$.

Polymorphism & Series: Dimorphous with indialite; forms a series with sekaninaite.

Occurrence: In thermally metamorphosed argillaceous sediments and high-grade regionally metamorphosed schists, gneisses, and granulites; in mafic igneous rocks and granites; detrital.

Association: Sillimanite, potassic feldspar, muscovite, biotite, corundum, spinel, garnet, andalusite.

Distribution: Widely distributed; some localities for abundant material are: at Bodenmais, Bavaria, Germany. From Orijärvi and Leppävirta, Finland. In Norway, at Kragerö, near Tvedestrand, and Akland, Söndeled, near Risör. In the Mt. Bity district, south of Antsirabe, Madagascar. On the Treasure Casket claims, Fungure Reserve, Zimbabwe. Found around Namib, Namibia. Crystals from the gem gravels of Sri Lanka. Around Tiruchchirappalli and Coimbatore, Tamil Nadu, India. In the Harts Range, Northern Territory, Australia. In the USA, at Richmond, Cheshire Co., New Hampshire; and at Haddam, Middlesex Co., Connecticut. Fine crystals from Thompson, Manitoba, Canada.

Name: Honoring Pierre Louis A. Cordier (1777–1861), French mining engineer and geologist, who first studied the species.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 419–421. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 410–540. (3) (1961) NBS Mono. 25, 1, 28. (4) Pryce, M.W. (1973) Low-iron cordierite in phlogopite schist from White Well, Western Australia. Mineral. Mag., 39, 241–243. (5) Cohen, J.P., F.K. Ross, and G.V. Gibbs (1977) An X-ray and neutron diffraction study of low hydrous cordierite. Amer. Mineral., 62, 67–78. (6) Armbruster, T. (1986) Role of Na in the structure of low-cordierite: a single-crystal X-ray study. Amer. Mineral., 71, 746–757.

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Cordylite-(La) $(Na,Ca)_2Ba_2(La_3Sr)_{\Sigma=4}(CO_3)_8F_2$

Crystal Data: Hexagonal. *Point Group*: 6/*m* 2/*m* 2/*m*. As irregular grains or rounded tabular to short-prismatic, striated hexagonal crystals, to 3 mm. Also as cores within cordylite-(Ce) grains.

Physical Properties: *Cleavage*: Perfect on {0001}. *Fracture*: Conchoidal to uneven. *Tenacity*: Brittle. Hardness = 4 D(meas.) = 4.31(1) D(calc.) = 4.311-4.329

Optical Properties: Translucent. *Color*: Colorless, honey-yellow, or pinkish yellow. *Streak*: White. *Luster*: Greasy to vitreous.
Optical Class: Uniaxial(-). ε = 1.573(1)–1.574(1) ω = 1.749(2)–1.751(2)

Cell Data: *Space Group*: $P6_3/mcc$. a = 5.1182(3) c = 23.1785(16) Z = 1

X-ray Powder Pattern: Biraya Fe-REE deposit, 145 km east of Bodaibo city, Russia.
3.209 (100), 3.532 (95), 2.562 (89), 4.371 (65), 4.148 (54), 2.213 (52), 1.921 (52)

Chemistry:

	(1)	(2)
La_2O_3	18.31	17.01
Ce_2O_3	15.67	15.93
Pr_2O_3	0.48	1.21
Nd_2O_3	2.10	3.09
CaO	3.17	3.22
SrO	6.70	7.16
BaO	23.43	22.21
Na_2O	2.80	2.78
F	2.47	2.10
-O = F	1.01	0.88
CO_2	[25.87]	[25.89]
H_2O	[0.03]	[0.25]
Total	99.99	99.97

(1) Biraya Fe-REE deposit, 145 km east of Bodaibo city, Russia; electron microprobe analysis, H_2O and CO_2 calculated from crystal structure analysis; corresponding to $(Na_{1.24}Ca_{0.78})_{\Sigma=2.02}Ba_{2.10}[(La_{1.54}Ce_{1.31}Nd_{0.17}Pr_{0.04})_{\Sigma=3.06}Sr_{0.89}]_{\Sigma=3.95}(C_{1.01}O_3)_8(F_{1.78}OH_{0.05})_{\Sigma=1.83}$.
(2) same as above; corresponding to $(Na_{1.23}Ca_{0.79})_{\Sigma=2.02}Ba_{1.98}[(La_{1.43}Ce_{1.33}Nd_{0.25}Pr_{0.10})_{\Sigma=3.11}Sr_{0.94}]_{\Sigma=4.05}(C_{1.01}O_3)_8(F_{1.51}OH_{0.38})_{\Sigma=1.89}$.

Occurrence: In carbonatite lenses associated with a fenite dike.

Association: Aragonite-strontianite, calcian strontianite, strontian calcite, ancylite-(Ce), thorite, carbocernaite, barite, biraite-(Ce), niobium-rich chevkinite-(Ce), fergusonite-(Nd), ancylite-(La), daqingshanite-(Ce), daqingshanite-(La), bastnäsite-(Ce), hydroxylbastnäsite-(Ce), monazite-(Ce), talc, humite, galena, pyrite, pyrrhotite.

Distribution: At the Biraya Fe-REE deposit, north of the Irkutsk district, 145 km east of Bodaibo city, Russia.

Name: For its structural and chemical identity with *cordylite* and dominance of *La* among its rare earth elements.

Type Material: Mineral Science Department, Natural History Museum of Los Angeles County, Los Angeles, USA., (63360) and at the A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (4028/1, 4029/1).

References: (1) Mills, S.J., P.M. Kartashov, A.R. Kampf, A.A. Konev, A.A. Koneva, and M. Raudsepp (2012) Cordylite-(La), a new mineral species in fenite from the Biraya Fe-REE deposit, Irkutsk, Russia. Can. Mineral., 50, 1281-1290. (2) (2014) Amer. Mineral., 99, 1512-1513 (abs. ref. 1).

Cordylite-(Ce) $(Na, Ca)Ba(Ce, La)_2(CO_3)_4F$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As prismatic or thin to thick tabular crystals with hexagonal outline and dominant $\{10\bar{1}0\}$, $\{40\bar{4}.15\}$, $\{10\bar{1}1\}$, to 13 mm; may have scepterlike terminations with striations ∥ {0001}; in rosettes, subparallel and spherical aggregates of thin platy crystals.

Physical Properties: *Cleavage:* Good on {0001}. *Fracture:* Conchoidal to irregular. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 4.01–4.44 D(calc.) = 3.97

Optical Properties: Transparent to translucent. *Color:* Colorless, white, wax-yellow, amber-yellow, pale yellow, yellowish green, greenish gray, may be radially zoned, ocher-yellow if altered; colorless to pale yellow in transmitted light. *Streak:* White. *Luster:* Adamantine, vitreous, resinous, oily, pearly on {0001}; waxy if altered.
Optical Class: Uniaxial (–). *Pleochroism:* Weak; O = greenish yellow; E = brownish yellow.
$\omega = 1.764–1.775$ $\epsilon = 1.576–1.598$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.090–5.109$ $c = 23.049–23.289$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
3.193 (10), 3.510 (9), 4.336 (8), 3.843 (8), 2.550 (8), 2.040 (8), 2.122 (7)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
CO_2	[25.36]	[24.50]	Pr_2O_3	1.78	1.46	BaO	22.22	20.91
Ce_2O_3	22.10	23.85	Sm_2O_3		0.21	Na_2O	4.73	3.96
La_2O_3	14.61	14.73	CaO	1.09	0.36	F	3.60	[2.64]
Nd_2O_3	4.58	4.90	SrO	1.44	0.74	$-O = F_2$	1.51	1.11
						Total	[100.00]	[97.15]

(1) Narssârssuk, Greenland; by electron microprobe, CO_2 by difference; corresponds to $(Na_{1.08}Ca_{0.14})_{\Sigma=1.22}(Ba_{1.03}Sr_{0.10})_{\Sigma=1.13}(Ce_{0.96}La_{0.64}Nd_{0.20}Pr_{0.08})_{\Sigma=1.88}(CO_3)_{4.10}F_{1.35}$. (2) Saint-Amable, Canada; by electron microprobe, CO_2 and F calculated from stoichiometry; corresponds to $(Na_{0.92}Ca_{0.04})_{\Sigma=0.96}(Ba_{0.98}Sr_{0.05})_{\Sigma=1.03}(Ce_{1.05}La_{0.65}Nd_{0.21}Pr_{0.06}Sm_{0.01})_{\Sigma=1.98}(CO_3)_4F$.

Occurrence: Rare in an alkali pegmatite (Narssârssuk, Greenland); a late-stage mineral in miarolitic vugs and fractures (Saint-Amable, Canada); in pegmatite dikes associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Aegirine, ancylite-(Ce), synchysite-(Ce), parisite-(Ce), neptunite (Narssârssuk, Greenland); analcime, aegirine, albite, pyrophanite (Mont Saint-Hilaire, Canada); parisite, cebaite-(Ce), barite (Bayan Obo deposit, China); vaterite, alstonite, ancylite-(Ce), kukharenkoite-(Ce), mckelveyite-(Y), fluorapatite, barite (Vuoriyarvi complex, Russia).

Distribution: From Narssârssuk, Greenland. In Canada, large crystals at Mont Saint-Hilaire, and from near Saint-Amable, Quebec. In the Khibiny massif, the Vuoriyarvi carbonatite complex, and the Lesnaya Varaka carbonatite, Kola Peninsula, Russia. From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China.

Name: From the Greek for *club*, in allusion to its typical clublike crytal habit.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 285–287. (2) Chen, T.T. and G.Y. Chao (1975) Cordylite from Mont St. Hilaire, Quebec. Can. Mineral., 13, 93–94. (3) Shen Jinchuan and Mi Jinxiao (1992) A discussion of the composition and structure of cordylite-(Ce). Acta Petrologica et Mineralogica, 11(1), 69–74 (in Chinese with English abs.). (4) (1994) Amer. Mineral., 79, 767 (abs. ref. 3). (5) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 96. (6) Giester, G., Y. Ni, D. Jarosch, J.M. Hughes, J. Rønsbo, Z. Yang, and J. Zemann (1998) Cordylite-(Ce): a crystal chemical investigation of material from four localities, including type material. Amer. Mineral., 83, 178–184.

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Crystal Data: Hexagonal. *Point Group:* $3m$. As pseudocubic rhombohedral crystals, to 2 mm, with prominent $\{10\bar{1}1\}$; usually in crusts, massive.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 3.5–4.5 D(meas.) = 4.295 D(calc.) = [4.31]

Optical Properties: Transparent. *Color:* Brown to light yellowish brown, pale yellow, yellowish green to dark green. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–); commonly anomalous biaxial, birefringence weak, showing lamellar structure. n = 1.93–1.96

Cell Data: *Space Group:* $R3m$. a = 7.280 (1) c = 16.821 (1) Z = 3

X-ray Powder Pattern: Glandore mines, Ireland. (ICDD 17-471).
3.03 (100), 5.86 (65), 2.237 (55), 3.61 (35), 2.793 (35), 1.482 (35), 2.508 (30)

Chemistry:

	(1)	(2)	(3)
SO_3	13.76	11.70	11.99
P_2O_5	8.97	10.62	10.63
As_2O_5	0.24	0.29	
Fe_2O_3	40.69	35.79	35.87
CuO	2.45	0.58	
PbO	24.05	32.64	33.42
H_2O	9.77	8.15	8.09
Total	99.93	99.77	100.00

(1) Glandore mines, Ireland. (2) Dernbach, Germany; Pb, Cu, and Fe by AA, P and As by neutron activation, SO_4 by ESCA, H_2O by the phosphoric acid method; corresponding to $Pb_{0.98}Cu_{0.05}Fe_{2.99}(PO_4)_{1.00}(AsO_4)_{0.02}(SO_4)_{0.98}(OH)_{6.04}$. (3) $PbFe_3(PO_4)(SO_4)(OH)_6$.

Mineral Group: Beudantite group.

Occurrence: A rare secondary mineral formed at low temperatures or by weathering in oxidized hydrothermal base-metal deposits.

Association: Pyromorphite, malachite, plumbojarosite, "limonite", quartz.

Distribution: Widespread in small amounts. From the Glandore iron mines, Co. Cork, Ireland. In England, large crystals at the Mexico mine, Caldbeck Fells, Cumbria; in Cornwall, from the Penberthy Croft mine, St. Hilary, at Wheal Unity, Gwennap, and the Gravel Hill mine, Perranzabuloe. In Germany, from Dernbach, near Montabaur, Hesse, and in the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate. At Richelle, near Visé, Belgium. From Maikain, Kazakhstan. In the USA, at the Silver Queen mine, Galena, Lawrence Co., South Dakota; in the Wild Bill, Harrington-Hickory, and other mines, Beaver Co., and the Gold Hill and Honerine mines, Tooele Co., Utah; at the Mex-Tex mine, near Bingham, Hansonburg district, Socorro Co., New Mexico. From Santa Eulalia, Chihuahua, Mexico. At the Osarizawa mine, Akita prefecture, Japan. From Aggeneys, Northern Cape Province, South Africa. At Tsumeb, Namibia. In the Woodcutters Pb–Zn mine, Northern Territory, Australia. A number of other localities are known.

Name: For its first-noted occurrence, in Co. Cork, Ireland.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1002–1003. (2) Giuseppetti, G. and C. Tadini (1987) Corkite, $PbFe_3(SO_4)(PO_4)(OH)_6$, its crystal structure and ordered arrangement of the tetrahedral cations. Neues Jahrb. Mineral., Monatsh., 71–81.

Cornetite $Cu_3(PO_4)(OH)_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, short prismatic on [001], {210} rounded, also showing large {021}, {221}, with a number of other forms known, to 1 cm; as flat radial aggregates and crusts. *Twinning:* On {*h*0*l*}.

Physical Properties: Hardness = ∼4.5 D(meas.) = 4.10 D(calc.) = 4.14

Optical Properties: Transparent to translucent. *Color:* Deep blue, peacock-blue, pale blue to greenish blue; in transmitted light, greenish blue, may be zoned. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, strong.
$\alpha = 1.744$–1.765 $\beta = 1.81$–1.832 $\gamma = 1.82$–1.848 2V(meas.) = 24°–33° 2V(calc.) = 23°45′

Cell Data: *Space Group: Pbca.* $a = 10.854(1)$ $b = 14.053(3)$ $c = 7.086(2)$ $Z = 8$

X-ray Powder Pattern: Bwana Mkubwa, Zambia.
3.04 (10), 4.29 (9), 3.17 (8), 3.68 (7), 2.06 (7), 5.07 (6), 5.48 (5)

Chemistry:

	(1)	(2)
P_2O_5	19.81	21.08
CuO	70.78	70.89
H_2O	9.41	8.03
Total	[100.00]	100.00

(1) Bwana Mkubwa, Zambia; recalculated after deduction of Fe_2O_3 0.53% and insoluble 4.03%.
(2) $Cu_3(PO_4)(OH)_3$.

Occurrence: A rare secondary mineral in the oxidized zone of some hydrothermal copper deposits.

Association: Copper, brochantite, pseudomalachite, libethenite, malachite, atacamite, chrysocolla, heterogenite.

Distribution: From the Star of the Congo mine, near Lubumbashi, and at the Kalabi and Lukini mines, Katanga Province, Congo (Shaba Province, Zaire). From the Bwana Mkubwa mine, Ndola, and Kansanshi, Zambia. At the Alaska, Mangula, and Molly mines, Lomagundi district, Zimbabwe. In the USA, in the Blue Jay and Empire-Nevada mines, Yerington district, Lyon Co., Nevada; at Tyrone, Santa Rita, Grant Co., New Mexico; on Saginaw Hill, Pima Co., Arizona. From Cerro Verde, Sonora, Mexico. In Chile, at Chuquicamata, Antofagasta; the Manto Ruso mine, about 85 km north of Copiapó, Atacama; and the Brillador mine, La Serena, near Coquimbo. From the Blockade mine, 60 km east of Mount Isa, and at Ravenswood, Queensland, Australia.

Name: To honor Jules Cornet (1865–1929), Belgian geologist.

Type Material: University of Liège, Liège, Belgium, 9.130 and 9.133.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 789–791. (2) Berry, L.G. (1950) On pseudomalachite and cornetite. Amer. Mineral., 35, 365–385. (3) Khin, B. (1979) Cornetite from Saginaw Hill, Arizona. Mineral. Record, 1, 117 and Mineral. Record, 2, 47. (4) Eby, R.K. and F.C. Hawthorne (1989) Cornetite: modulated densely-packed Cu^{2+} oxysalt. Mineral. Petrol., 40, 127–136.

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Cornubite $Cu_5(AsO_4)_2(OH)_4$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals very rare, to 5 mm, tabular ∥ $\{2\overline{1}1\}$, in aggregates. Generally fibrous, botryoidal, globular, porcelaneous massive.

Physical Properties: *Cleavage:* Two observed, both ⊥ $\{2\overline{1}1\}$, intersecting at about 70°. Hardness = ∼4 D(meas.) = 4.64 for fibrous material. D(calc.) = 4.85

Optical Properties: Translucent. *Color:* Apple-green, pale to dark green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r > v$. $\alpha = 1.87$ $\beta =$ n.d. $\gamma = \sim 1.90$
2V(meas.) = Very large.

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.121(1)$ $b = 6.251(1)$ $c = 6.790(1)$ $\alpha = 92.93(1)°$ $\beta = 111.30(1)°$ $\gamma = 107.47(1)°$ Z = 1

X-ray Powder Pattern: Potts Gill mine, England.
4.72 (10), 2.562 (10), 2.489 (10), 2.688 (9), 3.49 (8), 2.868 (7), 2.303 (7)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2		0.34		Fe_2O_3		0.32	
P_2O_5		0.25		CuO	59.86	58.60	59.94
As_2O_5	35.07	32.01	34.63	H_2O	[5.07]	[5.27]	5.43
Al_2O_3		0.15		Total	[100.00]	[96.94]	100.00

(1) Wheal Carpenter, Cornwall, England; by microchemical methods, H_2O by difference; corresponds to $Cu_{4.8}(AsO_4)_{1.95}(OH)_{3.6}$. (2) Reichenbach, Germany; by electron microprobe, total Fe as Fe_2O_3, H_2O calculated from charge balance, original total given as 96.64%; corresponds to $Cu_{5.03}[(As_{0.95}Si_{0.02}P_{0.01}Fe^{3+}_{0.01}Al_{0.01})_{\Sigma=1.00}O_4]_2(OH)_4$. (3) $Cu_5(AsO_4)_2(OH)_4$.

Polymorphism & Series: Dimorphous with cornwallite.

Occurrence: A rare secondary mineral in oxidized copper deposits.

Association: Cornwallite, chalcophyllite, olivenite, liroconite, chenevixite, clinoclase, pseudomalachite, bayldonite, parnauite, tyrolite, azurite, malachite, cuprite, chrysocolla, quartz.

Distribution: In England, from Cornwall, at Wheal Carpenter, Gwinear; Wheals Gorland, Unity, and Muttrell, Gwennap; Wheal Phoenix, Linkinhorne; and a number of other mines; in the Bedford United mines, Tavistock, Devon; from the Potts Gill mine, Caldbeck Fells, Cumbria. At Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland. In Germany, at Neubulach and the Clara mine, near Oberwolfach, Black Forest; and from Reichenbach, near Bensheim, Hesse. From the Cap Garonne mine, near le Pradet, Var, and the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, France. At L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. In the USA, in the Centennial Eureka mine, Tintic district, Juab Co., and Gold Hill, Tooele Co., Utah; at the Majuba Hill mine, Antelope district, Pershing Co., Nevada; from near the Humboldt and Marshall mines, Santa Cruz Co., Arizona; at Sylvanite, Hidalgo Co., and in the Buckhorn mine, Red Cloud district, Lincoln Co., New Mexico. From Mindigi, Katanga Province, Congo (Shaba Province, Zaire).

Name: From *Cornubia*, the Latin name for Cornwall, source of the first specimens.

Type Material: The Natural History Museum, London, England, 1964R,8650.

References: (1) Claringbull, G.F., M.H. Hey, and R.J. Davis (1959) Cornubite, a new mineral dimorphous with cornwallite. Mineral. Mag., 32, 1–5. (2) (1959) Amer. Mineral., 44, 1321 (abs. ref. 1). (3) Laurent, Y. and R. Pierrot (1961) Sur la présence de cornubite au cap Garonne (Var). Bull. Soc. fr. Minéral., 84, 318–319 (in French). (4) Tillmanns, E., W. Hofmeister, and K. Petitjean (1985) Cornubite, $Cu_5(AsO_4)_2(OH)_4$, first occurrence of single crystals, mineralogical description and crystal structure. Bull. Geol. Soc. Finland, 57, 119–127.

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Cornwallite $Cu_5(AsO_4)_2(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As microcrystalline or radial fibrous botryoidal to globular crusts, to 1 mm thick.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 D(meas.) = 4.17 D(calc.) = 4.64

Optical Properties: Semitransparent. *Color:* Verdigris-green to blackish green, pale green; in transmitted light, emerald-green.
Optical Class: Biaxial (+) or (–). *Orientation:* Y = elongation. α = 1.81–1.820 β = 1.815–1.860 γ = 1.85–1.88 2V(meas.) = Small.

Cell Data: *Space Group:* $P2_1/a$. $a = 17.33$ $b = 5.82$ $c = 4.60$ $\beta = 92°13'$ Z = 2

X-ray Powder Pattern: Wheal Carpenter, Cornwall, England.
3.22 (10), 3.10 (9d), 3.53 (9t), 2.414 (9d), 4.60 (8b), 3.02 (8b), 2.478 (8b)

Chemistry:

	(1)	(2)	(3)
P_2O_5	2.71		
As_2O_5	30.47	33.97	34.63
CuO	59.95	60.29	59.94
H_2O	8.23	5.80	5.43
insol.		0.82	
Total	101.36	100.88	100.00

(1) Cornwall, England. (2) Wheal Carpenter, Cornwall, England; by microchemical methods, corresponding to $Cu_{4.85}(AsO_4)_{1.91}(OH)_{4.12}$. (2) $Cu_5(AsO_4)_2(OH)_4$.

Polymorphism & Series: Dimorphous with cornubite.

Occurrence: A rare secondary mineral in oxidized copper deposits.

Association: Olivenite, cornubite, arthurite, clinoclase, chalcophyllite, strashimirite, lavendulan, tyrolite, spangolite, austinite, conichalcite, brochantite, azurite, malachite.

Distribution: In England, in Cornwall, from Wheals Gorland and Unity, Gwennap, at Wheal Carpenter, Gwinear, and other mines; in the Potts Gill mine, Caldbeck Fells, Cumbria. From Sainte-Marie-aux-Mines, Haut-Rhin, Triembach-au-Val, Haut-Rhin, and at the Cap Garonne mine, near le Pradet, Var, France. In the Clara Mine, near Oberwolfach, and at Neubulach, Black Forest; from Reichenbach, near Bensheim, Hesse, Germany. At L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. From Bou Skour and Ounein, Morocco. At Chouichica, Tunisia. In the USA, from the Mammoth and Centennial Eureka mines, Tintic district, Juab Co., and crystallized at the Gold Hill mine, Tooele Co., Utah; at the Majuba Hill mine, Antelope district, Pershing Co., Nevada. From the Guerra al Tirano mine, Guazapares, Chihuahua, Mexico. In Australia, at Broken Hill, New South Wales; in the Ethiudna mine, near Olary, the Arkaroola Station area, and from the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia; and at the Bali Lo copper prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia. A number of other localities are known.

Name: For its occurrence in the County of Cornwall, England.

Type Material: The Natural History Museum, London, England, MI 1985,1754.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 925. (2) Berry, L.G. (1951) Observations on conichalcite, cornwallite, euchroite liroconite and olivenite. Amer. Mineral., 36, 484–503. (3) Claringbull, G.F., M.H. Hey, and R.J. Davis (1959) Cornubite, a new mineral dimorphous with cornwallite. Mineral. Mag., 32, 1–5.

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Coronadite $Pb(Mn^{4+},Mn^{2+})_8O_{16}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As fibrous botryoidal aggregates, banded with other manganese oxides; as microscopic curved lamellae; laminated, granular, massive.

Physical Properties: Hardness = 4.5–5 D(meas.) = 5.246–5.505 D(calc.) = [5.45]

Optical Properties: Opaque. *Color:* Dark gray to black; white in reflected light.
Streak: Brownish black. *Luster:* Dull to submetallic.
Optical Class: Biaxial. *Pleochroism:* Strong; dark brown to gray. *Anisotropism:* Strong.

Cell Data: *Space Group:* $I2/m$. $a = 9.938(1)$ $b = 2.8678(5)$ $c = 9.834(2)$ $\beta = 90.39(2)^\circ$
$Z = 1$

X-ray Powder Pattern: Coronado vein, Arizona, USA; easily mistaken for hollandite.
3.104 (100), 3.466 (60), 1.542 (50), 2.400 (40), 2.205 (40), 2.155 (20), 1.836 (20)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2		0.40	ZnO	0.11	
MnO_2	60.80	58.29	PbO	28.66	26.20
Al_2O_3	0.68	1.51	CaO		0.39
Fe_2O_3	1.10	0.19	Na_2O		0.18
MnO	7.12	9.60	H_2O^+	1.11	1.70
CuO	0.05		rem.	0.48	
			Total	[100.00]	98.46

(1) Coronado vein, Arizona, USA; recalculated to 100% after removal of insolubles and alkalies 7.67%. (2) Bou Tazalt, Morocco. (3) Do.; by electron microprobe, analysis not given, but stated to correspond to $Pb_{1.06}Ba_{0.10}Mn_{7.7}V_{0.20}Al_{0.08}O_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: A primary mineral in hydrothermal veins or from hot springs; of secondary origin in oxidized zones above manganese-bearing rocks; also in bedded sedimentary deposits.

Association: Hollandite, pyrolusite, other manganese oxides.

Distribution: Widespread; a few localities for pure or well-characterized material include: in the USA, in Arizona, from the Coronado vein, Clifton-Morenci district, Greenlee Co.; the Magma mine, Superior, Pinal Co.; from the Artillery Mountains, Mohave Co., and elsewhere. In New Mexico, from the Luis Lopez district, Socorro Co. From the Philipsburg district, Granite Co., Montana. In Mexico, from the Talamantes district, Chihuahua, and in the Ojuela mine, Mapimí, Durango. At many places in the Ouarzazate and Oujda districts, and elsewhere in Morocco. From the Almalyskoye Pb–Zn deposit, Kurgashikan, Uzbekistan. In the Dry Gill mine, Caldbeck Fells, Cumbria, England. In France, from the Richesse mine, near Bourgeten-Huile, Savoy. At Dongari Buzurg, Bhandara, Madhya Pradesh, and Kodur, Andhra Pradesh, India. From Broken Hill, New South Wales, and in the Puttapa zinc mine, near Beltana, South Australia. At Tsumeb, Namibia.

Name: Honors the first Spanish explorer of the American southwest, Francisco Vasquez de Coronado (ca. 1500–1554).

Type Material: National Museum of Natural History, Washington, D.C., USA, R2012, 86040.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 742–743. (2) Frondel, C. and E.W. Heinrich (1942) New data on hetaerolite, hydrohetaerolite, coronadite, and hollandite. Amer. Mineral., 27, 48–56. (3) Hewett, D.F. (1971) Coronadite – modes of occurrence and origin. Econ. Geol., 66, 164–177. (4) Perseil, E.A. and M. Pinet (1976) Contribution à la connaissance des romanéchites et des cryptomélanes - coronadites - hollandites. Traits essentiels et paragenèses. Contr. Mineral. Petrol., 55, 191–204 (in French with English abs.). (5) Post, J.E. and D.L. Bish (1989) Rietveld refinement of the coronadite structure. Amer. Mineral., 74, 913–917.

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Corrensite $(Ca, Na, K)(Mg, Fe, Al)_9(Si, Al)_8O_{20}(OH)_{10} \cdot nH_2O$

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Crystal Data: n.d. *Point Group:* n.d. As aggregates of clay-sized particles.

Physical Properties: *Cleavage:* Perfect basal. *Tenacity:* Unctuous. Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Yellowish green. *Luster:* Dull, earthy. *Optical Class:* Biaxial (–). *Pleochroism:* X = yellowish ocher; $Y = Z$ = brownish green. α = 1.560–1.585 β = n.d. γ = 1.582–1.612 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Wellington Formation, Lyon Co., Kansas, USA; a 30 Å d-spacing changes to: air dried, 28–29; ethylene glycol, 32–33; on heating to ∼500 °C, 23–29.
14.5 (100), 1.54 (90), 2.57 (80), 7.26 (70), 4.60 (60), 3.61 (50), 2.44 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	37.2	34.	MgO	18.9	24.
TiO_2	0.4		CaO	1.0	
Al_2O_3	15.5	13.	Na_2O	0.2	
Fe_2O_3	6.7	7.	K_2O	1.4	
MnO	0.01		H_2O	18.4	22.
			Total	99.7	[100.]

(1) Sparta, Tennessee, USA; total Fe as Fe_2O_3, traces of Zr, V, and Cu determined spectrographically. (2) Do.; recalculated to 100% after removal of impurities.

Polymorphism & Series: A 1:1 mixed-layer interstratification of trioctahedral chlorite with either a trioctahedral vermiculite or a trioctahedral smectite.

Occurrence: From diverse sedimentary environments, which produced clastic, carbonate, volcanoclastic, or evaporite rocks. Also a hydrothermal alteration product, may be formed under retrograde diagenetic conditions; in soils.

Association: Illite, chlorite, laumontite, gypsum, anhydrite, quartz, dolomite.

Distribution: Probably fairly widely distributed; a few localities with material known to meet the definition are: from Zaiserweiher, three km from Maulbronn, Baden-Württemberg, and at the Hünstollen, near Holserode, Lower Saxony, Germany. At Wilkesley, near Audlem, Cheshire, and elsewhere in England. From Hillhouse quarry, Ayrshire, Scotland. In the USA, from Juniper Canyon, Moffat Co., Colorado; in the Wellington Formation, in Lyon Co., Kansas; in the County rock quarry, Sparta, White Co., Tennessee; and from a number of localities in west-central Montana, as between Bowman's Corner and Wolf Creek, Lewis and Clark Co. From Packwood, Western Australia. From the Yamanaka area, Shimane Prefecture, and in the Yoshino mine, Yamagata Prefecture, Japan.

Name: For Professor Carl Wilhelm Correns (1893–1980), Director of the Sedimentary Petrography Institute, Göttingen University, Göttingen, Germany.

Type Material: National Museum of Natural History, Washington, D.C., USA, 107373, 162265.

References: (1) Lippmann, F. (1954) Über einen Keuperton von Zaisersweiher bei Maulbronn. Heidelberg. Beitr. Mineral. Petrog., 4, 130–134 (in German). (2) (1955) Amer. Mineral., 40, 137 (abs. ref. 1). (3) Peterson, M.N.A. (1961) Expandable chloritic clay minerals from Upper Mississippian carbonate rocks of the Cumberland Plateau in Tennessee. Amer. Mineral., 46, 1245–1269. (4) Kopp, O.C. and S.M. Fallis (1974) Corrensite in the Wellington Formation, Lyons, Kansas. Amer. Mineral., 59, 623–624. (5) Yoshimura, T. and S. Okubo (1988) Refractive indices and birefringence of corrensite and the related minerals. Mineral. J. (Japan), 14, 145–149. (6) Reynolds, R.C., Jr. (1988) Mixed layer chlorite minerals. In: S.W. Bailey, Ed., Hydrous phyllosilicates. Rev. Mineral. 19, MSA, 601–629. (7) Shau, Y.-H., D.R. Peacor, and E.J. Essene (1990) Corrensite and mixed-layer chlorite/corrensite in metabasalt from northern Taiwan: TEM/AEM, EMPA, XRD, and optical studies. Contr. Mineral. Petrol., 105, 123–142.

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Corundum Al_2O_3

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. Crystals hexagonal, prismatic or steeply dipyramidal, tabular, rhombohedral, rarely acicular, typically rough, to 1 m; sectorially striated on {0001} ‖ {10$\overline{1}$1}. Also granular, massive. *Twinning:* Common lamellar ‖ {10$\overline{1}$1}, may be an exsolution phenomenon. Contact or penetration twins on {0001} or {10$\overline{1}$1}, rare.

Physical Properties: *Cleavage:* Partings on {0001} and {10$\overline{1}$1}, from exsolved böhmite. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle, tough when compact. Hardness = 9 D(meas.) = 3.98–4.10 D(calc.) = 3.997 May fluoresce or phosphoresce under UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, gray, brown; pink to pigeon-blood-red, orange, yellow, green, blue to cornflower blue, violet; may be color zoned, asteriated; colorless, pale bluish or reddish in transmitted light. *Streak:* White. *Luster:* Adamantine to vitreous; pearly on partings.
Optical Class: Uniaxial (–); commonly anomalously biaxial. *Pleochroism:* Weak; stronger when colored, O = pale to deep blue, E = blue-green to yellow-green, or O = deep purple, E = pale yellow. *Absorption:* $O > E$. $\omega = 1.767–1.772$ $\epsilon = 1.759–1.763$ 2V(meas.) = $\leq 58°$

Cell Data: *Space Group:* $R\overline{3}c$ (synthetic). $a = 4.7540(5)$ $c = 12.9820(6)$ Z = 6

X-ray Powder Pattern: Synthetic. (ICDD 42-1468).
2.085 (100), 2.551 (97), 1.6014 (82), 3.48 (70), 1.3738 (45), 2.379 (42), 1.7398 (42)

Chemistry: Nearly pure Al_2O_3, with traces of Fe, Ti, and Cr.

Mineral Group: Hematite group.

Occurrence: Characteristic of Al-rich, Si-poor geological environments; in syenite and monzonite, and some quartz-free pegmatites; primary or a reaction product in eclogitic xenoliths in kimberlites. In regional or contact, high-grade metamorphic aluminous rocks, and some advanced argillic and potassic hydrothermal alteration assemblages; detrital in placers.

Association: Andesine, oligoclase, nepheline, scapolite (syenites); spinel, rutile, chondrodite, "hornblende", phlogopite, calcite (metamorphosed limestones); kyanite, sillimanite, dumortierite, chlorite (schists); pyrope-rich garnet, spinel, phlogopite, omphacitic clinopyroxene, kyanite, rutile, graphite, diamond (eclogitic xenoliths).

Distribution: Numerous localities. In the USA, from Chester, Hampden Co., Massachusetts; the Cortland district, Westchester Co., New York; at Franklin, Sussex Co., New Jersey; large crystals from Hogback Mountain, Jackson Co., and Buck Creek, Clay Co., North Carolina; and from the Laurel Creek mine, Rabun Co., Georgia. At Bancroft and Haliburton, Ontario, Canada. On Naxos and Samos Islands, Greece. Large crystals from around the Soutpansberg, Transvaal, South Africa. Red gems from: the Mogok district, Myanmar (Burma). In the Ratnapura district, Sri Lanka. Around Mysore, India. In the Jegdalek marble, near Sorobi, Laghman Province, Afghanistan. At Merkestein, near Longido, and the Morogoro district, Tanzania. From Ampanihy, Madagascar. Blue, green, and yellow gems from: Chanthaburi and Trat, Thailand. Around Bottambang and Pailin, Cambodia. From the Zanskar district, Kashmir, India. In the Umba Valley, Tanzania. From around Andranondambo and Antsiermene, Madagascar. At Anakie, Queensland, Australia. From Yogo Gulch, 25 km southwest of Utica, Fergus Co., Montana, USA.

Name: Probably from the Sanskrit *kurivinda*, for *ruby*, through the Tamil *kurundam*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 520–527. (2) Okrusch, M., T.E. Bunch, and H. Bank (1976) Paragenesis and petrogenesis of a corundum-bearing marble at Hunza (Kashmir). Mineralium Deposita, 11, 278–297. (3) White, J.S. (1979) Boehmite exsolution in corundum. Amer. Mineral., 64, 1300–1302. (4) Maslen, E.N., V.A. Streltsov, N.R. Streltsova, N. Ishizawa, and Y. Satow (1993) Synchrotron X-ray study of the electron density in $\alpha-Al_2O_3$. Acta Cryst., 49, 973–980. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 24–26.

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Corvusite $(Na, Ca, K)_x(V^{5+}, V^{4+}, Fe^{2+})_8O_{20}\cdot 4H_2O$ (x = 0.8 to 1.2)

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals are lathlike, elongated ‖ [010] and flattened on {100}, to 0.2 μm; commonly massive, may display shrinkage cracks from loss of H_2O.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3
D(meas.) = 2.82 D(calc.) = 3.02

Optical Properties: Opaque, transparent in very thin lamellae. *Color:* Purplish blue-black to greenish black; olive-green to greenish yellow in thin fragments. *Streak:* Purplish blue-black. *Luster:* "Lusterous". n = [2.05] (rule of Gladstone and Dale).
Optical Class: Biaxial.
R_1–R_2: (400) 10.3–20.7, (420) 9.8–19.8, (440) 9.3–18.9, (460) 9.0–18.0, (480) 8.7–17.3, (500) 8.5–16.6, (520) 8.4–16.0, (540) 8.2–15.6, (560) 8.2–15.1, (580) 8.1–14.7, (600) 8.0–14.3, (620) 8.0–14.0, (640) 8.0–13.7, (660) 8.0–13.5, (680) 8.0–13.4, (700) 8.0–13.3

Cell Data: *Space Group:* $C2/m$. a = 11.706(4) b = 3.644(1) c = 11.11(1) β = 103.46(7)° Z = [1]

X-ray Powder Pattern: Jack claim, Utah, USA; very close to fernandinite.
10.82 (100), 3.464 (18), 3.590 (6), 1.819 (6), 1.934 (4), 2.595 (3), 3.255 (2)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	1.71	0.0	CaO	1.98	1.8
V_2O_5	64.89	85.3	Na_2O	1.44	2.8
V_2O_4	9.67		K_2O	1.06	0.8
SiO_2	0.30	0.0	H_2O^+	11.68	[7.2]
Al_2O_3		0.02	H_2O^-		
Fe_2O_3	5.82	2.0	insol.	1.00	
MgO	0.27	0.06	Total	99.90	[100.0]

(1) Jack claim, Utah, USA; corresponds to $(Na_{0.40}Ca_{0.32}K_{0.20}Fe_{0.20}Mg_{0.06})_{\Sigma=1.18}(V_{7.56}Fe_{0.44})_{\Sigma=8.00}O_{20}\cdot 5.96H_2O$ (2) Do.; by electron microprobe, average of two analyses, all V as V_2O_5, H_2O by difference; assuming Al as an impurity, V^{5+}:V^{4+} from crystal-structure analysis, corresponds to $(Na_{0.73}Ca_{0.26}K_{0.08})_{\Sigma=1.07}(V^{5+}_{7.47}Fe^{2+}_{0.40}V^{4+}_{0.14})_{\Sigma=8.01}O_{20}\cdot 5.85H_2O$.

Occurrence: In roll-front uranium deposits in sandstone.

Association: Carnotite, fervanite, roscoelite, gypsum.

Distribution: In the USA, in Utah, from the Jack claim, La Sal Mountains, Grand Co., 16 km west of Gateway, Colorado, and in the Flat Top mine, Emery Co.; at the Ponto No. 3 claim, Gypsum Valley, San Miguel Co., and the Hummer mine, Paradox Valley, Montrose Co., Colorado. In Arizona, from the Monument No. 2 mine, Monument Valley, and in the Lukachukai Mountains, Apache Co., and in the Monument No. 1 and Mitten No. 2 mines, Monument Valley, Navajo Co.; probably widespread in carnotite deposits of the Colorado Plateau. In the Mounana uranium mine, Franceville, Gabon. From Balasauskandyk, northwestern Kara-Tau Mountains, Kazakhstan.

Name: From the Latin word for *raven*, in allusion to the similarity of the mineral's color to that of a raven.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 96806.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 602–603. (2) Ross, M. (1959) Mineralogical applications of electron diffraction. II. Studies of some vanadium minerals of the Colorado Plateau. Amer. Mineral., 44, 322–341. (3) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 515. (4) Evans, H.T., Jr., J.E. Post, D.R. Ross, and J.A. Nelen (1994) The crystal structure and crystal chemistry of fernandinite and corvusite. Can. Mineral., 32, 339–351.

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Cosalite $Pb_2Bi_2S_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Prismatic crystals elongated ‖ [001], to 8 cm; flexible capillary fibers; commonly massive in aggregates of radiating prismatic, fibrous, or feathery forms.

Physical Properties: *Cleavage:* Very rare. *Fracture:* Uneven. *Tenacity:* Fibers are flexible. Hardness = 2.5–3 VHN = n.d. D(meas.) = 6.86–6.99 D(calc.) = 7.12

Optical Properties: Opaque. *Color:* Lead-gray to steel-gray to silver-white; in polished section, white, with only a trace of cream. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak, but distinct in oil.
R_1–R_2: (400) 48.2–51.4, (420) 47.0–50.3, (440) 45.9–49.5, (460) 44.9–48.7, (480) 43.9–47.9, (500) 43.0–47.1, (520) 42.2–46.4, (540) 41.6–45.9, (560) 41.1–45.5, (580) 40.8–45.3, (600) 40.5–45.2, (620) 40.4–45.2, (640) 40.2–45.2, (660) 40.1–45.2, (680) 40.1–45.2, (700) 40.0–45.1

Cell Data: *Space Group: Pbnm.* $a = 19.09$ $b = 23.87$ $c = 4.055$ $Z = 8$

X-ray Powder Pattern: Hagidaira mine, Gumma Prefecture, Japan.
3.44 (100), 2.81 (30), 3.37 (23), 2.96 (22), 1.911 (17), 2.13 (15), 3.72 (14)

Chemistry:

	(1)	(2)	(3)
Pb	38.68	39.55	41.75
Cu	2.02	2.71	
Fe		0.25	
Bi	42.38	40.21	42.10
S	16.59	17.20	16.15
rem.		0.78	
Total	99.67	100.70	100.00

(1) McElroy Township, Canada; corresponds to $Pb_{1.80}Cu_{0.31}Bi_{1.96}S_{5.00}$. (2) Ocna de Fier, Romania; corresponds to $Pb_{1.78}Cu_{0.40}Fe_{0.04}Bi_{1.79}S_{5.00}$. (3) $Pb_2Bi_2S_5$.

Occurrence: In hydrothermal deposits formed at medium temperatures but also found in contact metasomatic replacements, and epithermal replacements, as well as in pegmatites.

Association: Sphalerite, chalcopyrite, pyrite, skutterudite, cobaltite, bornite, enargite, stromeyerite, bismuth, bismuthinite, calcite, tremolite, diopside, epidote, quartz.

Distribution: From numerous localities world-wide. From the Nuestra Señora mine, Cosalá, Sinaloa, Mexico [TL]. In the USA, at Deer Park, Stevens Co., Washington; in Colorado, in the Red Mountain district, San Juan Co.; in Arizona, at the Magma mine, Superior, Pinal Co., and from Landsman Camp, Gila Co.; at Darwin, Inyo Co., California. In Canada, in Ontario, at Boston Creek, McElroy Township, and at Cobalt; long crystals in the Caribou mine, Wells, British Columbia. From Hůrky, Czech Republic. In Sweden, at the Bjelkes mine, Nordmark, and Boliden, Västerbotten. Large crystals from Kara Oba, Kazakhstan. At the Carrock Fell mine, Caldbeck Fells, Cumbria, England. From Băiţa (Rézbánya) and Ocna de Fier (Morávicza; Vaskő), Romania. In the New England Range, New South Wales, Australia. From Amparindravato, Madagascar.

Name: For the locality at Cosalá, Mexico.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 445–447. (2) Srikrishnan, T. and W. Nowacki (1974) A redetermination of the crystal structure of cosalite, $Pb_2Bi_2S_5$. Zeits. Krist., 140, 114–136. (3) Wulf, R. (1995) Experimental distinction of elements with similar atomic number in (Pb,Bi)-sulfosalts. Mineral. Petrol., 52, 187–196. (4) Hayashi, S. (1961) Cosalite from the Hagidaira mine, Gun'ma Prefecture, Japan. Mineral. J. (Japan), 3, 148–155. (5) Pring, A. and B. Etschmann (2002) HRTEM observations of structural and chemical modulations in cosalite and its relationship to the lillianite homologues. Mineral. Mag., 66, 451–458. (6) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 767–768. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 115.

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Coskrenite-(Ce) $(Ce, Nd, La)_2(SO_4)_2(C_2O_4)\cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are wedge-shaped tabular, to 1 mm, flattened on {100}, with {010} and {001}, typically in aggregates.

Physical Properties: *Cleavage:* On {001}, perfect. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.881 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Very pale pink under incandescent light, pale blue under fluorescent room light; may be cream-white. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z' \wedge c = 21°$ in {001}. *Dispersion:* $r > v$, medium. $\alpha = 1.544(4)$ $\beta = 1.578(4)$ $\gamma = 1.602(4)$ 2V(meas.) = 65(10)° 2V(calc.) = 69(3)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.007(1)$ $b = 8.368(2)$ $c = 9.189(2)$ $\alpha = 99.90(2)°$ $\beta = 105.55(2)°$ $\gamma = 107.71(2)°$ Z = 1

X-ray Powder Pattern: Alum Cave Bluff, Tennessee, USA.
5.48 (100), 8.52 (70), 6.72 (60), 3.84 (60), 4.26 (50), 3.35 (40), 2.744 (40)

Chemistry:

	(1)		(1)
SO_3	22.6	Sm_2O_3	1.0
C_2O_3	[10.2]	Eu_2O_3	0.8
Y_2O_3	0.1	Gd_2O_3	0.3
La_2O_3	4.6	F	0.3
Ce_2O_3	25.9	H_2O	[20.4]
Pr_2O_3	2.1	$-O = F_2$	[0.1]
Nd_2O_3	13.3	Total	[101.5]

(1) Alum Cave Bluff, Tennessee, USA; by electron microprobe, C_2O_3 and H_2O calculated from stoichiometry, original total given as 100.0%; corresponding to $(Ce_{1.06}Nd_{0.56}La_{0.20}Pr_{0.09}Sm_{0.04}Eu_{0.03}Gd_{0.01}Y_{0.01})_{\Sigma=2.00}(SO_4)_2(C_2O_4)\cdot 8H_2O$.

Occurrence: Formed by weathering of pyritiferous phyllite with evaporation of the resulting sulfate-rich solutions in soil, the rare earths probably derived from monazite and xenotime.

Association: Epsomite, apjohnite.

Distribution: From Alum Cave Bluff, Great Smoky Mountains National Park, Tennessee, USA.

Name: Honors Dr. T. Dennis Coskren (1942–), geologist and geochemist, Columbia, Maryland, USA, who studied the minerals of Alum Cave Bluff, Tennessee, USA.

Type Material: University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA.

References: (1) Peacor, D.R., R.C. Rouse, and E.J. Essene (1999) Coskrenite-(Ce), $(Ce, Nd, La)_2(SO_4)_2(C_2O_4)\cdot 8H_2O$, a new rare-earth oxalate mineral from Alum Cave Bluff, Tennessee: characterization and crystal structure. Can. Mineral., 37, 1453–1462. (2) (2000) Amer. Mineral., 85, 1561 (abs. ref. 1).

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Cossaite $(Mg_{0.5},\square)Al_6(SO_4)_6(HSO_4)F_6{\cdot}36H_2O$

Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. As stout prismatic crystals terminated by rhombohedral faces, to 0.1 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.08 D(calc.) = 2.075

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* n.d. *n* = 1.49(1)

Cell Data: *Space Group: R* $\bar{3}$. *a* = 22.010(2) *c* = 9.238(1) *Z* = 3

X-ray Powder Pattern: La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy. 4.15 (100), 3.87 (70), 11.00 (50), 4.58 (25), 2.770 (20), 2.166 (20), 2.345 (17)

Chemistry:

	(1)
MgO	1.4
Al_2O_3	19.5
SO_3	34.7
F	5.7
H_2O	40.85
-O=F	2.4
Total	99.75

(1) La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy; average of 6 electron microprobe analyses, H_2O from structural analysis; corresponding to $Mg_{0.56}Al_{6.19}S_{7.01}H_{73.37}F_{4.85}O_{65.15}$.

Occurrence: A rare phase formed at approximately 350°C by vapor alteration of volcanic breccia in a strongly acidic, fluorine-rich environment.

Association: Thermessaite, vlodavetsite, sassolite, salammoniac.

Distribution: From the rim of the La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy.

Name: Honors Alfonso Cossa (1833–1902), an Italian chemist and mineralogist.

Type Material: Reference Collection of the Dipartimento di Chimica Strutturale e Stereochimica Inorganica , Universita` degli Studi, Milan, Italy; 2009-1.

References: (1) Demartin, F., C.M. Gramaccioli, I. Campostrini, and C. Castellano (2011) Cossaite, $(Mg_{0.5},\square)Al_6(SO_4)_6(HSO_4)F_6{\cdot}36H_2O$, a new mineral from La Fossa crater, Vulcano, Aeolian Islands, Italy. Mineral. Mag., 75(6), 2847-2855. (2) (2013) Amer. Mineral., 98, 1078-1079 (abs. ref. 1).

Costibite CoSbS

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As lamellar inclusions in löllingite, to 1.4 mm, or intergrown with paracostibite.

Physical Properties: Hardness = n.d. VHN = 781 (15 g load). D(meas.) = n.d. D(calc.) = 6.89

Optical Properties: Opaque. *Color:* In polished section, grayish. *Luster:* Metallic. *Pleochroism:* Weak, pale gray with bluish to brownish tints. *Anisotropism:* Weak, reddish brown or orange, to bluish.

R_1–R_2: n.d.

Cell Data: *Space Group:* $Pmn2_1$. $a = 3.603$ $b = 4.868$ $c = 5.838$ Z = 2

X-ray Powder Pattern: Broken Hill, Australia.
2.596 (100), 2.503 (90), 1.908 (80), 2.902 (60), 4.86 (50), 1.803 (50), 3.08 (40)

Chemistry:

	(1)	(2)	(3)
Co	26.7	25.6	27.70
Fe	0.6	0.8	
Ni	0.2	2.4	
Sb	57.0	56.8	57.23
As	0.3	0.3	
S	15.1	14.7	15.07
Total	99.9	100.6	100.00

(1) Consols mine, Australia; by electron microprobe, average of three grains, corresponding to $(Co_{0.96}Fe_{0.02}Ni_{0.01})_{\Sigma=0.99}(Sb_{0.99}As_{0.01})_{\Sigma=1.00}S_{1.00}$. (2) Getön deposit, Sweden; by electron microprobe; corresponding to $(Co_{0.95}Ni_{0.09}Fe_{0.03})_{\Sigma=1.07}(Sb_{1.02}As_{0.01})_{\Sigma=1.03}S_{1.00}$. (3) CoSbS.

Polymorphism & Series: Dimorphous with paracostibite.

Mineral Group: Löllingite group.

Occurrence: Intimately intergrown with other hydrothermal sulfides (Broken Hill, Australia); in Pb–Zn–Cu–Ag ore deposits remobilized by hydrothermal solutions from later granite emplacement (Bergslagen, Sweden).

Association: Löllingite, willyamite, dyscrasite, ullmannite, pyrargyrite (Broken Hill, Australia); nisbite, paracostibite, chalcopyrite, bismuth, pyrrhotite, galena, sphalerite, gersdorffite, ullmannite (Bergslagen, Sweden).

Distribution: In Australia, at the Consols mine, Broken Hill, New South Wales [TL]. From the Gruvåsen and Getön deposits, Bergslagen metallic province, Sweden. At Sulitjelma, northern Norway.

Name: For CObalt and *antimony*, STIBium, in its composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, R849A.

References: (1) Cabri, L.J., D.C. Harris, and J.M. Stewart (1970) Costibite (CoSbS), a new mineral from Broken Hill, N.S.W., Australia. Amer. Mineral., 55, 10–17. (2) Rowland, J.F., E.J. Gabe, and S.R. Hall (1975) The crystal structures of costibite (CoSbS) and paracostibite (CoSbS). Can. Mineral., 13, 188–196. (3) Zakrzewski, M.A., E.A.J. Burke, and H.W. Nugteren (1980) Cobalt minerals in the Hallëfors area, Bergslagen, Sweden: new occurrences of costibite, paracostibite, nisbite and cobaltian ullmannite. Can. Mineral., 18, 165–171.

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Cotunnite $PbCl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic crystals, elongated along [001] and flattened on {010}, to about 2 mm; as scepter-shaped or skeletal crystals; doubly-terminated crystals may exhibit unequally developed equivalent faces; in aggregates of radiating sprays. Also granular, as crusts or pseudomorphs, and massive.

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Subconchoidal. *Tenacity:* Slightly sectile. Hardness = 2.5 D(meas.) = 5.80 (synthetic). D(calc.) = [5.91] Somewhat soluble in H_2O.

Optical Properties: Transparent to opaque. *Color:* Colorless to white, pale green, pale yellow; colorless in thin section. *Luster:* Adamantine, silky to pearly. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 2.199$ $\beta = 2.217$ $\gamma = 2.260$ 2V(meas.) = n.d. 2V(calc.) = $67°12'$

Cell Data: *Space Group:* *Pnam* (synthetic). $a = 7.6222(5)$ $b = 9.0448(7)$ $c = 4.5348(4)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.579 (100), 3.890 (75), 2.776 (55), 2.510 (45), 3.810 (40), 2.096 (40), 4.057 (35)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb		71.96	74.50	Cl	26.9	25.32	25.50
CuO	0.11			H_2O	1.08		
ZnO	0.10			$-O = Cl_2$	4.07		
PbO	77.04			Total	101.16	97.28	100.00

(1) Tolbachik volcano, Russia. (2) Kolar Gold Fields, India; by electron microprobe. (3) $PbCl_2$.

Occurrence: A volcanic sublimate or as an alteration of galena in saline environments. Also as an alteration product on leaden archeological objects or slag immersed in seawater.

Association: Galena, cerussite, anglesite, matlockite (Caracoles, Chile); tenorite, ponomarevite, sofiite, burnsite, ilinskite, georgbokite, chloromenite, halite, sylvite, gold (Tolbachik volcano, Russia).

Distribution: In Italy, on Vesuvius, Campania; in the Niccioleta mine, 40 km southwest of Siena, and along Baratti Beach, Tuscany, in slag. In Germany, from the Christian-Levin mine, near Essen, North Rhine-Westphalia, and at Richelsdorf, Hesse, in slag. At Laurium, Greece, in slag. From Leadhills, Lanarkshire, and Wanlockhead, Dumfriesshire, Scotland. At the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. From the Kolar Gold Fields, Karnataka, India. In Chile, from near Caracoles, Sierra Gorda district, Antofagasta, and at Challacollo, Tarapacá. From the La Pamapa district, Pallasca Province, Peru. In the USA, from the Grand Gulch mine, Grand Wash Cliffs, Bentley district, Mohave Co., Arizona; at Bonanza, Saguache Co., Colorado; from Tintic, Juab Co., Utah; in the Loudville mine, Southampton, Hampshire Co., Massachusetts; at the Minnamax Cu–Ni sulfide deposit, Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota.

Name: Honors Domenico Cotugno (Cotunnius) (1736–1822), Italian physician and Professor of Anatomy, University of Naples, Naples, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 42–44. (2) Sass, R.L., E.B. Brackett, and T.E. Brackett (1963) The crystal structure of lead chloride. J. Phys. Chem, 67, 2863–2864. (3) Nozik, Y.Z., L.E. Fykin, and L.A. Muradyan (1976) Crystal structure of cotunnite $PbCl_2$ determined more precisely by application of the neutron diffraction method. Kristallografiya (Sov. Phys. Crystal.), 21, 76–79 (in Russian). (4) Semenova, T.F., S.F. Filatov, L.P. Vergasova, V.V. Petukhova, and T.A. Dobroskok (1988) Exhalation-derived cotunnite $PbCl_2$. A new find in the USSR. Mineral. Zhurnal, 10, 92–96 (in Russian). (5) Safonov, Y.G., A.D. Genkin, V.N. Vasudev, B. Krishna Rao, and G.V. Anantha Iyer (1984) Genetic features of gold ore deposit at Kolar, Dharwar Craton, India. J. Geol. Soc. India, 25, 145–154. (6) (1975) NBS Mono. 25, 12, 23.

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Coulsonite $Fe^{2+}V_2^{3+}O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As subhedral crystals, less than 1 mm; and as exsolution lamellae along {111} in magnetite.

Physical Properties: *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 5.17–5.20 D(calc.) = 5.15

Optical Properties: Opaque. *Color:* Bluish gray; light gray in reflected light. *Streak:* Dark brown to black. *Luster:* Metallic.
Optical Class: Isotropic; locally slightly anisotropic.
R: 23.5

Cell Data: *Space Group: Fd3m.* a = 8.297(2) Z = 8

X-ray Powder Pattern: Buena Vista Hills, Nevada, USA.
2.50 (100), 1.466 (95), 1.597 (91), 2.07 (78), 2.93 (58), 4.79 (35), 1.693 (28)

Chemistry:

	(1)	(2)	(3)
TiO_2		5.29	
Fe_2O_3	0.52		
V_2O_3	68.41	59.6	67.60
Cr_2O_3		0.12	
FeO	30.75	33.1	32.40
Total	99.68	98.1	100.00

(1) Buena Vista Hills, Nevada, USA; corresponds to $Fe^{2+}_{1.00}(V^{3+}_{1.07}Fe^{3+}_{0.01})_{\Sigma=1.08}O_{4.24}$.
(2) Kalgoorlie, Australia; by electron microprobe, average of three analyses; original analysis Fe 25.7%, Ti 3.17%, Cr 0.08%, V 40.5%, here converted to oxides; corresponding to $Fe^{2+}_{1.03}(V^{3+}_{1.84}Ti_{0.13})_{\Sigma=1.97}O_{4.02}$. (3) $Fe^{2+}V^{3+}_2O_4$.

Mineral Group: Spinel group.

Occurrence: In veinlets of magnetite, with silicate minerals, cutting metamorphosed andesite (Buena Vista Hills, Nevada, USA); exsolved from magnetite in a mantle xenolith in basalt (Panzhihua, China).

Association: Magnetite, scapolite, apatite, titanite, chlorite, "hornblende", muscovite (Buena Vista Hills, Nevada, USA).

Distribution: From the Buena Vista Hills, 32 km southeast of Lovelock, Mineral Basin district, Pershing Co., Nevada, USA. At Kalgoorlie, Western Australia. In India, at Dublahera, Singhbum, Bihar. Found at Panzhihua, Sichuan Province, China.

Name: For Dr. Arthur Lennox Coulson (1898–?), geologist of the Indian Geological Survey.

Type Material: n.d.

References: (1) Radtke, A.S. (1962) Coulsonite, FeV_2O_4, a spinel-type mineral from Lovelock, Nevada. Amer. Mineral., 47, 1284–1291. (2) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 702, 703 [coulsonite = vanadian magnetite]. (3) Spiridonov, E.M. (1979) Titanium coulsonite from the Kalgoorlie deposit, Australia. Doklady Acad. Nauk SSSR, 245, 447–449 (in Russian).

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Cousinite $MgU_2Mo_2O_{13}\cdot 6H_2O(?)$

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Crystal Data: n.d. *Point Group:* n.d. In thin blades, lamellar.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Radioactive.

Optical Properties: Semitransparent. *Color:* Black. *Luster:* Vitreous.
Optical Class: n.d. n = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
MoO_3	28.35	28.55
UO_3		56.73
UO_2	55.25	
PbO	4.60	
MgO	4.10	4.00
H_2O		10.72
insol.	2.43	
LOI	6.64	
Total	101.37	100.00

(1) Shinkolobwe, Congo; after deduction of $PbMoO_4$ (as observed wulfenite), corresponds to $Mg_{1.03}U_{2.08}Mo_{2.00}O_{13.27}\cdot 3.74H_2O$. [possibly a magnesian umohoite or calcurmolite].
(2) $MgU_2Mo_2O_{13}\cdot 6H_2O$.

Occurrence: As an alteration product of molybdenite-bearing uranium ore.

Association: Uraninite, molybdenite, wulfenite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Jules Cousin (1884–1965), President of the Board of Directors of the Union Minière du Haut-Katanga, Congo.

Type Material: Royal Belgium Institute of Natural History, Brussels, Belgium, RC4759 and RC4760.

References: (1) Vaes, J.F. (1958) Cousiniet, een nieuw uraanmineral. Geologie en Mijnbouw, 20(12), 449 (in Dutch). (2) (1959) Amer. Mineral., 44, 910 (abs. ref. 1).

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Covellite CuS

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Forms hexagonal plates as large as 10 cm, flattened on {0001}, which may exhibit hexagonal striae; as rosettes of nearly parallel plates; commonly massive and foliated.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Flexible in thin leaves. Hardness = 1.5–2 VHN = 128–138 (100 g load). D(meas.) = 4.6–4.76 D(calc.) = 4.602

Optical Properties: Opaque. *Color:* Indigo-blue or darker, commonly highly iridescent, brass-yellow to deep red. *Streak:* Lead-gray, shining. *Luster:* Submetallic, inclining to resinous, somewhat pearly on cleavage; subresinous to dull when massive.
Optical Class: Uniaxial (+). *Pleochroism:* Marked, deep blue to pale blue. *Dispersion:* Strong.
$\omega = 1.45$ (589). $\epsilon = 2.62$ (589). *Anisotropism:* Strong.
R_1–R_2: (400) 14.5–32.0, (420) 14.7–31.5, (440) 14.3–30.3, (460) 13.3–29.0, (480) 11.7–27.6, (500) 10.1–26.2, (520) 8.5–24.7, (540) 6.9–23.4, (560) 5.5–22.1, (580) 4.2–21.1, (600) 3.3–21.1, (620) 3.3–21.6, (640) 4.9–22.3, (660) 9.8–22.7, (680) 16.4–22.6, (700) 24.9–22.4

Cell Data: *Space Group:* $P6_3/mmc$. $a = 3.7938(5)$ $c = 16.341(1)$ Z = 6

X-ray Powder Pattern: Synthetic.
2.813 (100), 1.896 (75), 3.048 (65), 2.724 (55), 1.735 (35), 1.556 (35), 3.220 (30)

Chemistry:

	(1)	(2)	(3)
Cu	66.06	65.49	66.48
Fe	0.14	0.25	
S	33.87	33.45	33.52
insol.	0.11		
Total	100.18	99.19	100.00

(1) Butte, Montana, USA. (2) Bor, Serbia. (3) CuS.

Occurrence: Most commonly of secondary origin in the zone of oxidation in sulfide copper deposits. Rarely of primary hydrothermal origin. Widespread in most copper deposits; common as an iridescent tarnish on other sulfides.

Association: Chalcopyrite, chalcocite, djurleite, bornite, enargite, pyrite, other sulfides.

Distribution: Numerous localities, but with only a few producing rich material. In Italy, from Vesuvius, Campania [TL] and as large crystals from the Calabona mine, Alghero, Sardinia. At Bor, Serbia. From Leogang, Salzburg, Austria. At Dillenburg, Hesse, and Sangerhausen, Saxony, Germany. From Kedabek, Caucasus Mountains, Russia. In the Bou-Skour mine, Bou Azzer district, Morocco. In the USA, from Butte, Silver Bow Co., Montana, as fine crystals in the primary ore; at Kennicott, Alaska; from Summitville, Rio Grande Co., Colorado; in the La Sal district, San Juan Co., Utah; a widespread but minor constituent of the ores in most porphyry copper mines in Arizona. In the Sierra de Famatina, La Rioja Province, Argentina.

Name: To honor Niccolò Covelli (1790–1829), discoverer of Vesuvian covellite.

Type Material: Mineral Museum, University of Naples, Naples, Italy, 12338.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 248–251. (2) Evans, H.T., Jr. and J.A. Konnert (1976) Crystal structure refinement of covellite. Amer. Mineral., 61, 996–1000. (3) Ohmasa, M., M. Suzuki, and T. Takéuchi (1977) A refinement of the crystal structure of covellite, CuS. Mineral. J. (Japan), 8, 311–319. (4) Fjellvåg, H., F. Grønvold, and S. Stølen (1988) Low-temperature structural distortion in CuS. Zeits. Krist., 184, 111–121. (5) (1955) NBS Circ. 539, 4, 13–14. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 117.

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Cowlesite $CaAl_2Si_3O_{10}\cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Very thin, lath-shaped crystals showing few forms, with sharp terminations, to 2 mm; radiating sprays of crystals and compact balls.

Physical Properties: *Cleavage:* {010}, perfect. *Tenacity:* Brittle. Hardness = Soft. D(meas.) = 2.14(2) D(calc.) = 2.05

Optical Properties: Transparent. *Color:* Colorless, white, gray, blue-gray. *Luster:* Pearly. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. α = 1.505–1.513 β = 1.509–1.516 γ = 1.509–1.518 2V(meas.) = 44°–53°

Cell Data: *Space Group:* n.d. $a = 11.27(1)$ $b = 15.25(1)$ $c = 12.61(3)$ Z = 6

X-ray Powder Pattern: Goble, Oregon, USA.
15.2 (100), 3.81 (35), 2.964 (35), 2.934 (25), 3.052 (20), 5.08 (17), 7.62 (15)

Chemistry:

	(1)	(2)
SiO_2	42.73	46.37
Al_2O_3	24.32	25.87
Fe_2O_3		0.08
CaO	12.86	15.12
Na_2O	0.70	0.80
K_2O		0.10
H_2O	22.8	21.0
Total	103.41	109.34

(1) Goble, Oregon, USA; by electron microprobe, H_2O by weight loss to 600 °C; corresponds to $(Ca_{0.96}Na_{0.10})_{\Sigma=1.06}Al_{2.00}Si_{2.99}O_{10}\cdot 5.6H_2O$. (2) Superior, Arizona, USA; by electron microprobe; H_2O by weight loss to 600 °C; corresponds to $(Ca_{1.04}Na_{0.10}K_{0.01})_{\Sigma=1.15}Al_{1.96}Si_{2.98}O_{10}\cdot 5.0H_2O$.

Mineral Group: Zeolite group.

Occurrence: In cavities in basalts and scoria, typically the only zeolite within a single vesicle.

Association: Zeolites, apophyllite.

Distribution: In the USA, at Goble, Columbia Co., at Beech Creek, Grant Co., and at Spray, Wheeler Co., Oregon; on Capitol Peak, Thurston Co., Washington; from eight km south of Superior, Pinal Co., Arizona; and at Table Mountain, Jefferson Co., Colorado. In Canada, at Monte Lake, British Columbia. From Dunseverick, Ballyclare, and elsewhere in Co. Antrim, Ireland. At Kingsburgh, Isle of Skye, Scotland. In Mjoädalsá Canyon, near Hvammur, Iceland. From Dalsnipa, on Sandoy and Satan, on Streymoy, Faeroe Islands. At Kuniga, Oki Islands, Japan. From Flinders and Jindivick, Victoria, Australia. A number of other localities are known.

Name: To honor John Cowles (1907–1985), amateur mineralogist of Rainier, Oregon, USA.

Type Material: University of California, Santa Barbara, California, 6720, 6721; National Museum of Natural History, Washington, D.C., USA, 135026.

References: (1) Wise, W.S. and R.W. Tschernich (1975) Cowlesite, a new Ca-zeolite. Amer. Mineral., 60, 951–956. (2) Vezzalini, G., G. Artioli, S. Quartieri, and H. Foy (1992) The crystal chemistry of cowlesite. Mineral. Mag., 56, 575–579.

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Coyoteite $NaFe_3S_5 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. As grains, up to 0.4 mm, showing typically a chevron pattern in polished section, developed by opposing cleavage lamellae.

Physical Properties: *Cleavage:* Perfect on {111}. Hardness = ~1.5 VHN = n.d. D(meas.) = 2.5–2.63 D(calc.) = 2.879 Moderately magnetic.

Optical Properties: Opaque. *Color:* Black; in polished section, pale brownish gray with a pink tint. *Luster:* Metallic. *Pleochroism:* Faint, from gray to pink. *Anisotropism:* Strong, colors from gray to dull golden orange.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 7.409(8)$ $b = 9.881(6)$ $c = 6.441(3)$ $\alpha = 100°25(3)'$ $\beta = 104°37(5)'$ $\gamma = 81°29(5)'$ Z = 2

X-ray Powder Pattern: Coyote Peak, California, USA.
5.12 (100), 7.13 (90), 3.023 (80), 3.080 (70), 9.6 (60), 5.60 (60), 3.910 (50)

Chemistry:

	(1)	(2)
Na	5.99	5.94
Fe	44.0	43.31
S	41.3	41.44
H_2O	[8.71]	9.31
Total	[100.00]	100.00

(1) Coyote Peak, California, USA; by electron microprobe, average of five grains, H_2O by difference, on independent proof of the presence of oxygen; corresponds to $Na_{1.01}Fe_{3.06}S_{5.00} \cdot 1.88H_2O$. (2) $NaFe_3S_5 \cdot 2H_2O$.

Occurrence: With rare iron sulfides in small pegmatitic clots thought to have crystallized late in the consolidation of the Coyote Peak intrusive, an alkalic mafic diatreme.

Association: Pyrrhotite, djerfisherite, rasvumite, bartonite, erdite, phlogopite, schorlomite, acmite, sodalite, cancrinite, pectolite, natrolite, magnetite, calcite.

Distribution: From Coyote Peak, near Orick, Humboldt Co., California, USA [TL].

Name: For Coyote Peak, California, a local prominence on which the mineral was found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150335.

References: (1) Erd, R.C. and G.K. Czamanske (1983) Orickite and coyoteite, two new sulfides from Coyote Peak, Humboldt Co., California. Amer. Mineral., 68, 245–254.

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Crandallite $CaAl_3(PO_4)(PO_3OH)(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As trigonal prismatic crystals, terminated by {0001}, or as pseudocubic rhombohedra, to 1 mm; as rosettes of fibers or spherules and crusts with radial fibrous structure; commonly as colloform to pulverulent crusts, nodular, massive.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Brittle. Hardness = 5
D(meas.) = 2.78–3.04 D(calc.) = 3.00

Optical Properties: Translucent. *Color:* Yellow, white, gray; colorless in thin section.
Streak: White. *Luster:* Vitreous, dull to chalky when massive.
Optical Class: Uniaxial (+). $\omega = 1.613$–1.627 $\epsilon = 1.622$–1.632

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.0062(4)$ $c = 16.192(1)$ Z = 3

X-ray Powder Pattern: Fairfield, Utah, USA. (ICDD 33-257).
2.938 (100), 2.163 (60), 1.8946 (45), 2.983 (40), 1.7520 (35), 3.503 (25), 1.4285 (25)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	3.80			SrO	2.21	10.53	
P_2O_5	27.09	32.64	34.28	H_2O^+	18.86		
Al_2O_3	38.71	35.15	36.94	H_2O^-	1.29		
CaO	7.50	7.19	13.55	H_2O		14.48	15.23
MgO	0.94			Total	100.40	99.99	100.00

(1) Brooklyn mine, Utah, USA; after deduction of insolubles 35.13% as quartz, barite and sulfides. (2) Alto Benedito pegmatite, Brazil; Ca:Sr = 0.56:0.44. (3) $CaAl_3(PO_4)(PO_3OH)(OH)_6$.

Mineral Group: Crandallite group.

Occurrence: In weathered phosphatic aluminous sedimentary rocks and carbonatites. In phosphate-rich nodules; from complex granite pegmatites; in amphibolite-grade metaquartzites. An authigenic mineral in anoxic marine sediments or in clay-rich sediment beneath a tropical swamp.

Association: Fluorapatite, hydroxylherderite, quartz.

Distribution: In the USA, in Utah, from the Brooklyn mine, near Silver City, Tintic district, Juab Co., at the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, and from Amatrice Hill, about 40 km northwest of Fairfield, Utah Co.; in the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., New Hampshire; from near Gore, Frederick Co., Virginia; on Dug Hill, near Avant, Garland Co., Arkansas; in several rock formations in central and northern Florida; from the Everly and Hugo mines, Pennington Co., and in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota. In the Alto Benedito pegmatite, 15 km west of Picuí, Paraíba, Brazil. At Blaton, Belgium. From Ronneburg, Thuringia, Germany. In Wheal Jane, Kea, Cornwall, England. At Fort Lismeenagh, Shenagolden, Co. Limerick, Ireland. From the Kovdor massif, Kola Peninsula, Russia. In Australia, in the Iron Monarch quarry, Iron Knob; the Moculta phosphate quarry, northeast of Angaston; and at the Mt. Weld carbonatite, 35 km south of Laverton, South Australia. In the Buranga pegmatite, near Gatumba, Rwanda.

Name: Honors Milan L. Crandall, Jr., mining engineer, of Provo, Utah, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R5641.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 835–837. (2) Blount, A.M. (1974) The crystal structure of crandallite. Amer. Mineral., 59, 41–47. (3) Cassedanne, J.P. and L. Barreto da Silva Nen (1991) Strontian crandallite from the Alto Benedito pegmatite, Paraiba, Brazil. Mineral. Record, 22, 183–185.

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Crawfordite $Na_3Sr(PO_4)(CO_3)$

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Crystal Data: Monoclinic. *Point Group:* 2. Irregular anhedral grains, to 1 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3 D(meas.) = 3.05 D(calc.) = 3.08 Bright greenish yellow fluorescence under UV.

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X \simeq c$; $Y \simeq a$; $Z \simeq b$. $\alpha = 1.520(2)$ $\beta = 1.564(2)$ $\gamma = 1.565(2)$ 2V(meas.) = 20(1)° 2V(calc.) = 17°

Cell Data: *Space Group:* $P2_1$. $a = 9.187(3)$ $b = 6.707(2)$ $c = 5.279(1)$ $\beta = 89.98(3)°$ Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
2.708 (100), 2.172 (100), 2.648 (90), 1.891 (80), 1.415 (70), 1.129 (60), 1.106 (60)

Chemistry:

	(1)	(2)
P_2O_5	23.64	22.78
CO_2	[14.47]	14.12
CaO	1.45	
SrO	27.42	33.26
Na_2O	31.83	29.84
K_2O	0.22	
Total	[99.03]	100.00

(1) Khibiny massif, Russia; by electron microprobe, average of two analyses, CO_2 from X-ray structural data; corresponding to $Na_{3.03}(Sr_{0.81}Na_{0.10}Ca_{0.08}K_{0.01})_{\Sigma=1.00}(P_{1.01}O_4)(C_{1.00}O_3)$.
(2) $Na_3Sr(PO_4)(CO_3)$.

Occurrence: A hydrothermal mineral in ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Pectolite, astrophyllite, barytolamprophyllite, shcherbakovite, vuonnemite, kazakovite, ershovite, chkalovite, natrite, villiaumite, rasvumite, potassian feldspar, nepheline, sodalite, aegirine.

Distribution: From Mt. Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: To honor Adair Crawford (1748–1795), Scottish physician and Professor of Chemistry, discoverer of strontium salts.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p1346/1.

References: (1) Khomyakov, A.P., L.I. Polezhaeva, and E.V. Sokolova (1994) Crawfordite $Na_3Sr(PO_4)(CO_3)$: a new mineral from the bradleyite group. Zap. Vses. Mineral. Obshch., 123(3), 41–49 (in Russian with English abs.). (2) (1995) Amer. Mineral., 80, 1328 (abs. ref. 1).

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Creaseyite $Pb_2Cu_2Fe_2^{3+}Si_5O_{17}\cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* [$2/m$ $2/m$ $2/m$ or $mm2$.] Fibrous crystals, elongated along [001] and flattened on {010}, to 0.5 mm. As densely packed spherules of crystals; in masses of matted and tangled fibers.

Physical Properties: *Cleavage:* Poor on {010}. Hardness = 2.5 for spherules, greater for crystals. D(meas.) = 4.1(1) D(calc.) = 4.01

Optical Properties: Transparent to translucent. *Color:* Pale green to yellow-green; yellow in thin section. *Streak:* Light green.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow-green; Y = green; Z = yellow-green. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Absorption:* $Z = X > Y$. $\alpha = 1.737(2)$ $\beta = 1.747(2)$ $\gamma = 1.768(2)$ 2V(meas.) = 69° 2V(calc.) = 70°

Cell Data: *Space Group:* *mmmCb* [diffraction symbol]. a = 12.483–12.497 b = 21.375–21.395 c = 7.283 Z = 4

X-ray Powder Pattern: Tiger, Arizona, USA.
10.726 (100), 6.024 (50), 4.067 (50), 3.555 (50b), 3.013 (50), 2.982 (50), 2.696 (50)

Chemistry:

	(1)	(2)
SiO_2	25.5	25.59
Fe_2O_3	12.3	13.61
Al_2O_3	2.1	
CuO	13.5	13.56
ZnO	1.2	
PbO	37.0	38.03
H_2O	8.8	9.21
Total	100.4	100.00

(1) Tiger, Arizona, USA; average of several microchemical analyses, corresponding to $Pb_{1.98}(Cu_{2.02}Zn_{0.18})_{\Sigma=2.20}(Fe^{3+}_{1.85}Al_{0.05})_{\Sigma=1.90}Si_{5.08}O_{17.18}\cdot 5.85H_2O$. (2) $Pb_2Cu_2Fe_2Si_5O_{17}\cdot 6H_2O$.

Occurrence: In the oxidized zone of a base-metal deposit, in andesite breccia loosely cemented with iron oxides and wulfenite (Tiger, Arizona, USA).

Association: Mimetite, dioptase, fluorite, willemite, wulfenite, descloizite, murdochite (Tiger, Arizona, USA); ajoite, fluorite (Potter-Cramer property, Arizona, USA).

Distribution: In the USA, in Arizona, from the Mammoth-St. Anthony mine, Tiger, Pinal Co., at the Potter-Cramer property and Tonopah-Belmont mine, near Wickenburg, Maricopa Co., from near Artillery Peak, Mohave Co., and in the the Copper Point prospect, Amole district, Pima Co.; from near Gold Point, Esmeralda Co., Nevada. In Mexico, at Caborca and Munihuaza, near Alamos, Sonora. In the Cruz del Sur mine, Rio Negro Province, Argentina.

Name: To honor Dr. Saville Cyrus Creasey (1917–), economic geologist, U.S. Geological Survey, expert on Arizona mineral deposits.

Type Material: The Natural History Museum, London, England, 1976,412; University of Arizona, Tucson, Arizona; Harvard University, Cambridge, Massachusetts, 117000; National Museum of Natural History, Washington, D.C., USA, 147661.

References: (1) Williams, S.A. and R.A. Bideaux (1975) Creaseyite, $Cu_2Pb_2(Fe,Al)_2Si_5O_{17}\cdot 6H_2O$. Mineral. Mag., 40, 227–231. (2) (1976) Amer. Mineral., 61, 503 (abs. ref. 1).

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Crednerite $CuMnO_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As striated single plates, to 6 cm, fanlike radiating aggregates, or hemispherical masses of plates; also as coatings, and massive. *Twinning:* Mosaic and polysynthetic intergrowths are probably caused by twinning, producing pseudohexagonal individuals by rotation $\perp$ $(41\overline{1})$.

Physical Properties: *Cleavage:* Perfect parallel to plate surfaces, {001}; also {100}, perfect, $\{\overline{1}11\}$, prominent, {111} and {212}, poor. *Tenacity:* Brittle. Hardness = 4 VHN = 231–297 (100 g load). D(meas.) = 4.98–5.34 D(calc.) = [5.46]

Optical Properties: Opaque. *Color:* Bright gray to iron-black; cream-white in reflected light. *Streak:* Soot-black, with a brownish tint. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Strong. *Bireflectance:* Strong; pale yellow to brownish gray.
R_1–R_2: (400) 28.3–28.6, (420) 27.4–30.1, (440) 26.5–31.6, (460) 25.8–32.9, (480) 25.1–33.7, (500) 24.5–34.0, (520) 24.1–34.3, (540) 23.8–34.2, (560) 23.5–34.1, (580) 23.3–33.7, (600) 23.1–33.1, (620) 22.9–32.6, (640) 22.7–32.0, (660) 22.5–31.2, (680) 22.4–30.5, (700) 22.2–29.9

Cell Data: *Space Group:* $C2/m$. $a = 5.58(1)$ $b = 2.877(5)$ $c = 5.875(1)$ $\beta = 104.0(1)^\circ$ $Z = 2$

X-ray Powder Pattern: Higher Pitts Farm, Somerset, England.
2.71 (10), 2.43 (10), 2.85 (6), 2.24 (5b), 1.613 (4), 1.560 (4), 1.764 (3)

Chemistry:

	(1)	(2)	(3)
MnO	48.0	48.2	47.14
CuO	52.2	52.5	52.86
Total	100.2	100.7	100.00

(1) Friedrichroda, Germany; by electron microprobe. (2) Idikel, Morocco; by electron microprobe. (3) $CuMnO_2$.

Occurrence: A low-temperature secondary mineral, perhaps indicating a reducing chemical environment.

Association: Psilomelane, hausmannite, malachite, volborthite, barite, calcite, "wad" (Friedrichroda, Germany); cerussite, hydrocerussite, malachite, mendipite, "wad" (Mendip Hills, England).

Distribution: From Friedrichroda, Thuringia, Germany. In England, from the Merehead quarry, near Shepton Mallet, and Higher Pitts Farm, near Priddy, Mendip Hills, Somerset. At Långban and Jakobsberg, Värmland, Sweden. From Idikel and Tachgagalt, 17 km south of Ouarzazate, Anti-Atlas Mountains, Morocco. At Tsumeb, and in the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia. In the USA, from Bisbee, Cochise Co., Arizona; at Calistoga, Napa Co., California; and in the Crescent mine, Crescent Lake, Clallam Co., Washington. From 29 km north of Cleve, Eyre Peninsula, South Australia.

Name: Honors Karl F.H. Credner (1809–1876), German mining geologist and mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 722–723. (2) McAndrew, J. (1956) Crystallography and composition of crednerite. Amer. Mineral., 41, 276–287. (3) Gaudefroy, C., J. Dietrich, F. Permingeat, and P. Picot (1966) La crednérite, sa composition chimique et sa signification génétique. Bull. Soc. fr. Minéral., 89, 80–88 (in French).

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Creedite $Ca_3Al_2(SO_4)(F,OH)_{10}\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are prismatic [001], bladelike to acicular, typically with {110}, {111}, {$\overline{1}$11}, {001}, several other minor forms noted, to 8 cm; radiating, drusy to granular aggregates.

Physical Properties: *Cleavage:* {100}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 2.713–2.730 D(calc.) = 2.739

Optical Properties: Transparent to translucent. *Color:* Colorless to white, purple; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 42.5°$. *Dispersion:* $r > v$, strong.
$\alpha = 1.461(1)$ $\beta = 1.478(1)$ $\gamma = 1.485(1)$ 2V(meas.) = 64°22′ 2V(calc.) = 65°

Cell Data: *Space Group:* $C2/c$. $a = 13.936(1)$ $b = 8.606(1)$ $c = 9.985(1)$ $\beta = 94.39(1)°$
Z = 4

X-ray Powder Pattern: Wagon Wheel Gap, Colorado, USA.
3.48 (10), 7.3 (9), 6.9 (9), 3.92 (9), 2.161 (9), 5.79 (8), 3.07 (8)

Chemistry:

	(1)
SO_4	19.10
Al_2O_3	21.42
CaO	35.18
F	30.30
H_2O	10.72
$-O = F_2$	17.28
Total	99.44

(1) Wagon Wheel Gap, Colorado, USA; H_2O by the Penfield method, corresponds to $Ca_{2.99}Al_{2.19}(SO_4)_{1.00}[F_{8.02}(OH)_{2.00}]_{\Sigma=10.02}\cdot 2.06H_2O$.

Occurrence: Uncommon in fluorite-rich hydrothermal mineral deposits.

Association: Fluorite, barite, kaolinite (Wagon Wheel Gap, Colorado, USA).

Distribution: In the USA, from Wagon Wheel Gap, near Creede, Mineral Co., Colorado; in the Liberty and Hall mines and at Granite, near Tonopah, Nye Co., Nevada; in Arizona, at the Grand Reef mine, Graham Co.; from the Thompson and Defiance mines, Darwin district, Inyo Co., California. In Mexico, large crystals from the Potosí and other mines, Santa Eulalia district, Chihuahua. Exceptional crystals from Colquiri, La Paz, Bolivia. In the Dzhaambai deposit, eastern Pamir Mountains, Tajikistan. Fine examples from Aktshatau, 40 km south of Dzhezkazgan, Kazakhstan. Several other minor localities are known.

Name: For the occurrence near Creede, Colorado, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 81273; National Museum of Natural History, Washington, D.C., USA, 93117, C1034.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 129–130. (2) Giuseppetti, G. and C. Tadini (1983) Structural analysis and refinement of Bolivian creedite, $Ca_3Al_2F_8(OH)_2(SO_4)\cdot 2H_2O$. Neues Jahrb. Mineral., Monatsh., 69–78. Navidad mine, Rodeo, Durango, Mexico - 1 cm - Sink; (3) Fleischer, M. (1952) Probable identity of belyankite with creedite. Amer. Mineral., 37, 785–790. (4) Foshag, W.F. (1922) The crystallography and chemical composition of creedite, Proc. U.S. National Museum, 59, 419–424.

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Crerarite $(Pt,Pb)Bi_3(S,Se)_{4-x}$ (x ~0.7)

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Anhedral grains, to 120 μm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ~3.5 (softer than chalcopyrite). D(meas.) = n.d. D(calc.) = 7.75

Optical Properties: Opaque. *Color:* Pale gray in reflected light, with a slight bluish tint in oil. *Luster:* Metallic.

R: (400) 53.7, (420) 53.8, (440) 53.1, (460) 52.4, (480) 51.6, (500) 50.8, (520) 50.5, (540) 49.9, (560) 49.7, (580) 49.4, (600) 49.4, (620) 49.1, (640) 48.9, (660) 48.7, (680) 48.5, (700) 48.5

Cell Data: *Space Group:* $Fm3m$. $a = 5.86(5)$ $Z = 1$

X-ray Powder Pattern: Lac Sheen, Canada.
2.94 (100), 3.37 (50), 1.472 (50), 2.07 (30), 1.766 (15), 1,687 (15), 1.347 (10)

Chemistry:

	(1)
Pt	[10.34]
Pd	0.03
Pb	13.85
Cu	0.09
Ni	< 0.05
Fe	0.08
Te	0.03
Se	0.86
Bi	65.26
S	10.55
Total	[101.09]

(1) Lac Sheen, Canada; by electron microprobe, average of analyses of three grains, original total given as 101.11%; corresponding to $Pt_{0.51}Pb_{0.65}Fe_{0.01}Cu_{0.01}Bi_{3.02}(S_{3.18}Se_{0.11})_{\Sigma=3.29}$.

Occurrence: In an amphibolite boulder, perhaps glacially transported, containing sulfides.

Association: Chalcopyrite, pentlandite, pyrrhotite, sphalerite, galena, michenerite, actinolite, chlorite, quartz.

Distribution: From an erratic boulder found on the north shore of Lac Sheen, near Belleterre, Quebec, Canada [TL].

Name: Honors Professor David Crerar (1945–1994), economic geologist, Princeton University, Princeton, New Jersey, USA.

Type Material: Mineralogical Museum, Bayerische Julius-Maximilians University, Würzburg, Germany, M2897 a/b; Royal Ontario Museum, Toronto, Canada, M46005–46007.

References: (1) Cook, N.J., S.A. Wood, W. Gebert, H.-J. Bernhardt, and O. Medenbach (1994) Crerarite, a new Pt–Bi–Pb–S mineral from the Cu–Ni–PGE deposit at Lac Sheen, Abitibi-Témiscaminque, Québec, Canada. Neues Jahrb. Mineral., Monatsh., 567–575. (2) (1995) Amer. Mineral., 80, 845 (abs. ref. 1).

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Crichtonite $(Sr, La, Ce, Y)(Ti, Fe^{3+}, Mn)_{21}O_{38}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As elongated rhombohedral crystals, to 1.2 cm, with prominent basal face and striae on the primary rhombohedron. *Twinning:* Polysynthetic, probable.

Physical Properties: Hardness = 4.5–5 D(meas.) = 4.46(4) D(calc.) = [4.55]

Optical Properties: Opaque. *Color:* Black. *Luster:* Metallic, dull to bright.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.374(3)$ $c = 20.746(6)$ Z = 3

X-ray Powder Pattern: Bourg d'Oisans, France.
3.39 (s), 2.875 (s), 2.131 (s), 2.838 (ms), 2.243 (ms), 1.796 (ms), 0.90061 (ms)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8		0.40	Nd_2O_3	0.02	0.20
V_2O_5	0.61	0.45	Fe_2O_3	21.14	11.17
TiO_2	60.49	61.38	Cr_2O_3	0.15	
ZrO_2	0.10	0.10	FeO	8.18	12.28
HfO_2	0.23	0.10	MnO	2.78	0.90
ThO_2	0.01		ZnO		1.37
Al_2O_3	0.02	0.10	PbO	0.78	1.73
Sc_2O_3		0.46	CaO	0.06	0.10
Y_2O_3	0.21	2.50	SrO	4.17	3.67
La_2O_3	0.29	0.22	BaO		1.23
Ce_2O_3	0.27	0.35	rem.		0.21
Dy_2O_3		0.34	Total	99.51	99.26

(1) "Dauphiné region", France; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from crystal-structure analysis; corresponds to $[Sr_{0.71}(RE, Pb)_{0.19}]_{\Sigma=0.90}[Ti_{13.43}Fe_{6.71}Mn_{0.69}(V, Cr)_{0.17}]_{\Sigma=21.00}O_{38}$. (2) Selva, Switzerland; by electron microprobe, remnant CoO, NiO, CuO, Fe^{2+}:Fe^{3+} determined separately; corresponding to $[Sr_{0.65}Ba_{0.15}(RE, Ca, U)_{0.15}Pb_{0.14}]_{\Sigma=1.09}[Ti_{14.06}Fe^{2+}_{3.13}Fe^{3+}_{2.56}(Y, Zn, Mn, Sc, V, Al, RE)_{1.30}]_{\Sigma=21.05}O_{38}$.

Mineral Group: Crichtonite group.

Occurrence: In alpine-type fissure veins.

Association: Quartz, chlorite.

Distribution: From St. Christophe, Bourg d'Oisans, Isère, France. At Selva, Tavetsch, Graubünden and Wannigletscher, Binntal, Valais, Switzerland. In Russia, from the Khibiny massif, Kola Peninsula. At Fazenda Guariba, 40 km south of Diamantina, Minas Gerais, Brazil.

Name: For Sir Alexander A. Crichton (1763–1856), Scottish physician and mineral collector, once physician to the Russian Czar Alexander I.

Type Material: The Natural History Museum, London, England, 1926,1191.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 534 [crichtonite = ilmenite, in error]. (2) Hey, M.H., P.G. Embrey, and E.E. Fejér (1969) Crichtonite, a distinct species. Mineral. Mag., 37, 349–356. (3) Grey, I.E., D.J. Lloyd, and J.S. White, Jr. (1976) The structure of crichtonite and its relationship to senaite. Amer. Mineral., 61, 1203–1212. (4) Stalder, H.A. and C. Bühler (1987) Geochemische untersuchungen an Mineralien der Crichtonit-Gruppe aus alpinen Zerrklüften. Schweiz. Mineral. Petrog. Mitt., 67, 93–102 (in German with English abs.).

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Criddleite $TlAg_2Au_3Sb_{10}S_{10}$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$, m, or 2. *Twinning:* Common, according to some simple law. As lathlike or anhedral grains, to 70 μm; may rim or intergrow with aurostibite, gold, and antimony.

Physical Properties: Hardness = 3–3.5 VHN = 94–129 (25 g load). D(meas.) = 6.86(7) (synthetic). D(calc.) = 6.57

Optical Properties: Opaque. *Color:* Gray-blue in reflected light. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak, from gray-blue to slightly greenish gray-blue. *Anisotropism:* Distinct to moderate, from buff to slate gray.

R_1–R_2: (400) 40.6–41.8, (420) 40.1–41.0, (440) 39.4–40.1, (460) 38.6–39.4, (480) 38.1–39.2, (500) 37.6–39.1, (520) 37.3–38.9, (540) 36.7–38.4, (560) 36.1–38.0, (580) 35.6–37.6, (600) 35.0–37.2, (620) 34.4–36.6, (640) 33.7–36.0, (660) 33.1–35.3, (680) 32.6–34.6, (700) 32.5–34.1

Cell Data: *Space Group:* $A2/m$, $A2$, or Am. $a = 19.96$ $b = 8.057$ $c = 7.809$ $\beta = 92.08°$ Z = 2

X-ray Powder Pattern: Synthetic.
2.813 (100), 5.63 (90), 2.860 (70), 1.959 (70), 2.018 (60), 3.91 (50), 3.456 (50)

Chemistry:

	(1)	(2)	(3)
Tl	7.5	5.0	8.02
Ag	8.5	9.0	8.46
Au	22.9	24.7	23.18
Sb	47.7	49.3	47.76
S	13.1	12.7	12.58
Total	99.7	100.71	100.00

(1) Hemlo deposit, Canada; by electron microprobe, average of analyses of five samples; corresponds to $Tl_{0.92}Ag_{1.99}Au_{2.93}Sb_{9.87}S_{10.29}$. (2) Viges deposit, France; by electron microprobe, average of twelve analyses; corresponds to $Tl_{0.61}Ag_{2.10}Au_{3.15}Sb_{10.18}S_{9.96}$. (3) $TlAg_2Au_3Sb_{10}S_{10}$.

Occurrence: A primary hydrothermal mineral in a complex gold deposits.

Association: Aurostibite, gold, antimony, chalcostibite, parapierrotite, stibnite, tetrahedrite, molybdenite, zinkenite, pyrite, quartz (Hemlo deposit, Canada); gold, aurostibite (Viges deposit, France).

Distribution: From the Hemlo gold deposit, Thunder Bay district, Ontario, Canada. In the Viges Au–Sb deposit, Creuse, France.

Name: To honor Dr. Alan John Criddle (1944–2002), English mineralogist of the British Museum (Natural History), London, England.

Type Material: The Natural History Museum, London, England, 1987,351 and E.1230; Canadian Geological Survey, Ottawa, 65186; Royal Ontario Museum, Toronto, Canada.

References: (1) Harris, D.C., A.C. Roberts, J.H.G. Laflamme, and C.J. Stanley (1988) Criddleite, $TlAg_2Au_3Sb_{10}S_{10}$, a new gold-bearing mineral from Hemlo, Ontario, Canada. Mineral. Mag., 52, 691–697. (2) (1990) Amer. Mineral., 75, 706 (abs. ref. 1). (3) Gatellier, J.-P., E. Marcoux, and Y. Moëlo (1990) Nouvelle découverte de criddléite dans le district aurifère de Viges, Massif Central, Creuse, France. Can. Mineral., 28, 739–744 (in Frence with English abs.).

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Cristobalite SiO_2

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* 422. As pseudo-octahedral crystals, to 4 mm, with {110} and {331}, rarely pseudocubic. Commonly dendritic to skeletal; as spherulites to several cm; fibrous or microcrystalline ("opal"), massive. *Twinning:* On {111}, common, interpenetrant, polysynthetic, repeated.

Physical Properties: *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 2.32–2.36 D(calc.) = 2.33

Optical Properties: Transparent. *Color:* Colorless, white, milky white to yellowish; in transmitted light, colorless. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.487$ $\epsilon = 1.484$

Cell Data: *Space Group:* $P4_12_12$. $a = 4.9709(1)$ $c = 6.9278(2)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
4.05 (100), 2.485 (20), 2.841 (13), 3.135 (11), 1.870 (7), 2.465 (5), 2.118 (5)

Chemistry:

	(1)
SiO_2	[99.13]
TiO_2	0.38
Al_2O_3	0.18
FeO	0.09
MnO	< 0.02
MgO	< 0.03
CaO	< 0.02
Na_2O	0.05
K_2O	0.17
P_2O_5	< 0.03
Total	[100.00]

(1) Mare Imbrium, Moon; by electron microprobe, SiO_2 by difference.

Polymorphism & Series: Quartz, tridymite, coesite, and stishovite are polymorphs; inverts from high- or β-cristobalite at 268 °C or below.

Occurrence: In vesicles and lithophysae; a late-crystallizing phase in basaltic to rhyolitic volcanic rocks; from acid-sulfate-type hydrothermal alteration of volcanic rocks; precipitated by hot springs. By contact metamorphism of sandstone; developed during diagenesis, recrystallized from siliceous sedimentary rocks.

Association: Tridymite, quartz, sanidine, anorthoclase, fayalite, magnetite, kaolinite, alunite, "opal."

Distribution: On Cerro San Cristóbal, near Pachuca, Hidalgo, and in the Santín mine, Santa Caterina, Guanajuato, Mexico. In the USA, at Glass Mountain, Little Lake, and Sugarloaf Mountain, near Coso Hot Springs, Inyo Co., California; near Crater Lake, Klamath Co., Oregon; widespread in the San Juan Mountains, San Juan Co., Colorado. At Mayen and Mendig, Eifel district, Germany. From Sárospatak, Hungary. In the Ellora Caves, Maharashtra, India. From the Tokatoka district, about 150 km north of Auckland, New Zealand. In Japan, at Goroyama, Nagano Prefecture; Futo, Shizuoka Prefecture; and many other places.

Name: For the first-noted occurrence at Cerro San Cristóbal, Mexico.

References: (1) Frondel, C. (1962) Dana's system of mineralogy, (7th edition), v. III, silica minerals, 273–286. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 179–230. (3) Mason, B.F. (1972) Lunar tridymite and cristobalite. Amer. Mineral., 57, 1530–1535. (4) Pluth, J.J., J.V. Smith, and J. Faber, Jr. (1985) Crystal structure of low cristobalite at 10, 293, and 473 K: variation of framework geometry with temperature. J. Appl. Physics, 57, 1045–1049. (5) (1960) NBS Circ. 539, 10, 48.

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Crocoite $PbCrO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic to acicular crystals with nearly square outline, elongated and striated [001], to 15 cm.; short prismatic to pseudo-octahedral, may be highly modified, terminations are commonly hollow or incomplete. Typically in radial sprays to randomly intergrown aggregates.

Physical Properties: *Cleavage:* Distinct on {110}; indistinct on {001} and {100}. *Fracture:* Small conchoidal to uneven. *Tenacity:* Sectile. Hardness = 2.5–3 D(meas.) = 6.0–6.1 D(calc.) = [6.10]

Optical Properties: Transparent to translucent. *Color:* Hyacinth-red, red-orange, orange; red-orange in transmitted light. *Streak:* Yellow-orange. *Luster:* Adamantine. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; $X = Y$ = red-orange; Z = blood-red. *Orientation:* $Y = b$; $Z \wedge c = 5.5°$. *Dispersion:* $r > v$, very strong, inclined. $\alpha = 2.29(2)$ $\beta = 2.36(2)$ $\gamma = 2.66(2)$ $2V(meas.) = 54°$

Cell Data: *Space Group:* $P2_1/n$. $a = 7.120$ $b = 7.421$ $c = 6.800$ $\beta = 102°20'$ $Z = 4$

X-ray Powder Pattern: Beresovsk, Russia.
3.277 (10), 3.475 (8), 3.030 (6), 4.374 (5), 2.254 (5), 4.950 (3), 1.846 (3)

Chemistry:

	(1)	(2)
CrO_3	30.35	30.94
SiO_2	1.10	
PbO	68.35	69.06
Total	99.80	100.00

(1) Nontron, France. (2) $PbCrO_4$.

Occurrence: An uncommon secondary mineral in the oxidized portions of lead deposits associated with chromium-bearing rocks; may be of post-mine formation.

Association: Phoenicochroite, vauquelinite, embreyite, pyromorphite, dundasite, vanadinite, descloizite, wulfenite, cerussite, anglesite, quartz, "limonite".

Distribution: From the Tsvetnoi mine, Mt. Uspenskaya, the Preobrazhensky mine, and other mines, Beresovsk district, and on Mt. Tochil'naya, Middle Ural Mountains, near Yekaterinburg (Sverdlovsk), Russia. At Băiţa (Rézbánya), Romania. In Germany, fine examples from Obercallenberg, near Glauchau, Saxony. In the Hopeful vein, Leadhills, Lanarkshire, Scotland. From the Greystone quarry, Lezant, Cornwall, England. At the Cantonniers mine, Nontron, Dordogne, France. From Howard's Luck mine, Umtali, and at a number of other minor occurrences in Zimbabwe. From the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa. In Australia, as exceptional specimens and an ore of lead in the Dundas district, at the Adelaide, West Comet, and other mines, also from the Heazlewood, Whyte River, and Magnet mines, Tasmania; from the Happy Jack mine, Comet Vale, and several other places in Western Australia; at the Wadnaminga gold mines, near Olary, South Australia. From Labo, Luzon, Philippines. At Goyabeira, near Congonhas do Campo, Minas Gerais, Brazil. In the USA, from Darwin, Inyo Co., California; at the Moon Anchor, Potter-Kramer, Pack Rat, and other mines south of Wickenburg, Maricopa Co., Arizona.

Name: From the Greek for *saffron*, an allusion to the distinctive red-orange color.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 646–649. (2) Quareni, S. and R. De Pieri (1965) A three-dimensional refinement of the structure of crocoite, $PbCrO_4$. Acta Cryst., 19, 287–289. (3) Williams, S.A. (1974) The natural occurring chromates of lead. Bull. British Museum (Natural History), Mineralogy, 2(8), 379–419, esp. 403–405.

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Cronstedtite $Fe_2^{2+}Fe^{3+}(SiFe^{3+})O_5(OH)_4$

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Crystal Data: Triclinic, monoclinic, or hexagonal. *Point Group:* See polytypes. As hexagonal prisms, tapering toward one end and vertically striated. In divergent fibrous groups; cylindroidal, reniform, massive. *Twinning:* Twin axis [001]; interpenetrating trigonal pyramids produce six-rayed composite crystals.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Thin laminae are elastic. Hardness = 3.5 D(meas.) = 3.34–3.35 D(calc.) = n.d.

Optical Properties: Nearly opaque. *Color:* Coal-black to brownish black; thin laminae emerald-green by transmitted light, brown to yellow-brown on edges. *Streak:* Dark olive-green. *Luster:* Brilliant.
Optical Class: Biaxial; pseudo-uniaxial (–). *Pleochroism:* In browns and blacks. ω = 1.72–1.80 2V(meas.) = n.d.

Cell Data: *Space Group:* $P1$. $a = 5.472(8)$ $b = 9.467(19)$ $c = 14.241(39)$ $\alpha = 90.015(20)^\circ$ $\beta = 90.042(18)^\circ$ $\gamma = 89.952(15)^\circ$ Z = 4

X-ray Powder Pattern: Wheal Jane, Cornwall, England. (ICDD 17-470).
7.09 (100), 3.54 (85), 2.722 (50), 2.439 (40), 1.586 (40), 2.305 (16), 1.680 (16)

Chemistry:

	(1)	(2)
SiO_2	16.42	15.04
Al_2O_3	0.90	
Fe_2O_3	29.72	39.97
FeO	41.86	35.97
CaO	1.32	
H_2O	10.17	9.02
Total	100.39	100.00

(1) Herja, Romania. (2) $Fe_2^{2+}Fe^{3+}(SiFe^{3+})O_5(OH)_4$.

Polymorphism & Series: Stacking polytypes have space groups:
$P1$, Cc, Cm, $P31m$, $P6_3cm$, $P6_3$, $P3_1$, $P31c$, and $R3$.

Mineral Group: Kaolinite-serpentine group.

Occurrence: A low-temperature hydrothermal product in ore veins.

Association: Siderite, pyrite, sphalerite, clinochlore, quartz.

Distribution: At Příbram, Kutná Hora, Chvaletice, Chynava, and other places in the Czech Republic. Exceptional groups from Herja (Kisbánya), Romania. From Hagental, Harz Mountains, Germany. In the Salsigne gold mine, 15 km north of Carcassone, Aude, France. In England, from Wheal Jane, Kea; at Wheal Maudlin, Lanlivery; and in the Penlee quarry, Newlyn, Cornwall. In the USA, at Long Hill, Fairfield Co., Connecticut; in the Cornucopia mine, Nye Co., Nevada. From Santa Eulalia, Chihuahua, Mexico. At Conghonas do Campo, Minas Gerais, Brazil. From Llallagua, Bolivia. Additional minor occurrences are known.

Name: To honor the Swedish mineralogist and chemist, Axel Fredrik Cronstedt (1722–1765).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 656–657. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 164–169. (3) Frondel, C. (1962) Polytypism in cronstedtite. Amer. Mineral., 47, 781–783. (4) Steadman, R. and P.M. Nuttall (1963) Polymorphism in cronstedtite. Acta Cryst., 16, 1–8. (5) Steadman, R. and P.M. Nuttall (1964) Further polymorphism in cronstedtite. Acta Cryst., 17, 404–406. (6) Geiger, C.A., D.L. Henry, S.W. Bailey, and J.J. Maj (1983) Crystal structure of cronstedtite-$2H_2$. Clays and Clay Minerals, 31, 97–108. (7) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 458–459.

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Cronusite $Ca_{0.2}CrS_2 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. As anhedral grains, to 1 mm, in enstatite.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven. Hardness = 1.5 VHN = 82–109, 98 average (10 g load). D(meas.) = 2.51(3) D(calc.) = 2.55(1)

Optical Properties: Opaque. *Color:* Coal-black; gray in reflected light. *Streak:* Black. *Luster:* Submetallic. *Pleochroism:* In shades of gray. *Anisotropism:* Strong; in shades of gray. *Bireflectance:* Strong.
R_1–R_2: (400) — , (420) — , (440) 14.2–15.4, (460) 14.5–15.8, (480) 14.7–16.4, (500) 15.0–16.8, (520) 15.4–17.2, (540) 15.7–17.6, (560) 15.9–17.9, (580) 16.2–18.2, (600) 16.4–18.4, (620) 16.5–18.5, (640) 16.6–18.6, (660) 16.6–18.6, (680) 16.7–18.6, (700) 16.8–18.7

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. $a = 3.326$ $c = 33.29$ $Z = 3$

X-ray Powder Pattern: Norton County meteorite.
11.1 (100), 5.56 (10), 2.719 (5), 3.700 (4), 2.464 (4), 2.180 (4)

Chemistry:

	(1)
Na	0.0
K	0.6
Ca	4.2
Cr	33.7
S	39.1
O	21.
H	[2.65]
Total	[101.25]

(1) Norton County; by electron microprobe, average of six analyses, H calculated for oxygen content; corresponds to $(Ca_{0.17}K_{0.02})_{\Sigma=0.19}Cr_{1.04}S_{1.96} \cdot 2.14H_2O$.

Occurrence: In an enstatite achondrite meteorite, formed by teresstrial weathering of caswellsilverite.

Association: Enstatite, ferroan alabandite, troilite, daubréelite, iron hydroxides.

Distribution: Found in the Norton County enstatite achondrite meteorite [TL].

Name: For *Cronus*, a Titan in Greek mythology, son of Uranus and Gaea, in allusion to a mixed meteoritic-terrestrial origin of the mineral.

Type Material: n.d.

References: (1) Britvin, S.N., X.Y. Guo, V.D. Kolomensky, M.M. Boldyreva, Y. Kretser, and M.A. Yagovkina (2001) Cronusite $Ca_{0.2}(H_2O)_2CrS_2$ – a new mineral from the Norton County enstatite achrondrite. Zap. Vses. Mineral. Obshch., 130(3), 29–36 (in Russian with English abs.).
(2) (????) Amer. Mineral., ??, ??–?? (abs. ref. 1).

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Crookesite $Cu_7(Tl, Ag)Se_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m$, 4, or $\overline{4}$. As finely divided, disseminated specks, and as small veinlets.

Physical Properties: *Cleavage:* Two at right angles, fairly well developed. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 92–123 (100 g load). D(meas.) = 6.90 D(calc.) = 7.443

Optical Properties: Opaque. *Color:* Lead-gray. *Luster:* Metallic. *Anisotropism:* Weak but distinct, in brownish tones.

R_1–R_2: (400) 33.6–35.9, (420) 33.3–35.8, (440) 32.7–35.8, (460) 32.4–35.7, (480) 32.5–35.6, (500) 32.8–35.3, (520) 33.1–35.1, (540) 33.1–34.8, (560) 33.0–34.7, (580) 32.7–34.6, (600) 32.6–34.7, (620) 32.4–35.0, (640) 32.2–35.2, (660) 31.9–35.2, (680) 31.6–35.3, (700) 31.2–35.3

Cell Data: *Space Group:* $I4/m$, $I4$, or $I\overline{4}$. $a = 10.435$ $c = 3.954$ $Z = 2$

X-ray Powder Pattern: Skrikerum, Sweden.
3.29 (100), 2.59 (100), 3.00 (80), 2.11 (50), 1.833 (40), 1.779 (40), 2.32 (30)

Chemistry:

	(1)	(2)	(3)	(5)
Tl	16.27	18.55	21.03	21.18
Cu	46.55	46.11	46.89	46.09
Ag	5.04	1.44	0.06	
Fe	0.36	0.63		
Se	30.86	33.27	32.43	32.73
Total	99.08	100.00	100.41	100.00

(1) Skrikerum, Sweden; corresponds to $Cu_{7.50}Tl_{0.82}Ag_{0.48}Fe_{0.07}Se_{4.00}$. (2) Do.; corresponds to $Cu_{6.89}Tl_{0.86}Ag_{0.13}Fe_{0.11}Se_{4.00}$. (3) Bukov, Czech Republic; by electron microprobe, leading to $Cu_{7.07}Tl_{0.98}Ag_{0.01}Se_{3.94}$. (4) Tuminico, Argentina; by electron microprobe, analysis not given, corresponds to $Cu_{7.00}Tl_{0.97}Se_{4.04}$. (5) Cu_7TlSe_4.

Occurrence: Of hydrothermal origin, with other selenides.

Association: Umangite, berzelianite, eucairite, klockmannite, clausthalite, sabatierite, selenian linnaeite, calcite, quartz.

Distribution: From Skrikerum, near Tryserum, Kalmar, Sweden [TL]. At Tilkerode, Harz Mountains, Germany. From Bukov, near Tisnova, and in the Petrovice uranium deposit, near Ždár, Czech Republic. In the Pinky Fault uranium deposit, near Lake Athabasca, Saskatchewan, Canada. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina.

Name: In honor of William Crookes (1832–1919), English chemist who discovered thallium.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 183. (2) Earley, J.W. (1950) Description and synthesis of the selenide minerals. Amer. Mineral., 35, 337–364. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 50–51. (4) Johan, Z. (1987) Crookesite, $TlCu_7Se_4$; new data and isotypism with $NH_4Cu_7S_4$. Compt. Rendus Acad. Sci. Paris, 304, 1121–1124 (in French). (5) Berger, R.A. (1987) Crookesite and sabatierite in a new light — a crystallographer's comment. Zeits. Krist., 181, 241–249. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 120.

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Cryolite Na_3AlF_6

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 3 cm, are pseudocubic or short prismatic along [001], striated on {110} ∥ [$1\bar{1}1$], [$1\bar{1}\bar{1}$], and [$1\bar{1}0$]; typically massive or coarsely granular. *Twinning:* Common, according to one or more of 13 distinct twin laws, producing penetration, repeated, or polysynthetic twins.

Physical Properties: *Cleavage:* Partings on {001} and {110}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.97 D(calc.) = 2.973(2) Weakly thermoluminescent; may fluoresce intense yellow under SW UV, with yellow phosphorescence, pale yellow fluorescence under LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale brown, pink, smoky to black; colorless in thin section. *Streak:* White. *Luster:* Vitreous to greasy or waxy, pearly on {001}.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = -44°$. *Dispersion:* $r < v$. $\alpha = 1.338$ $\beta = 1.338$ $\gamma = 1.339$ 2V(meas.) = 43°

Cell Data: *Space Group:* $P2_1/n$. $a = 5.4024(2)$ $b = 5.5959(2)$ $c = 7.7564(3)$ $\beta = 90.278(1)°$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 25-772).
2.748 (100), 1.943 (95), 3.886 (65), 4.54 (55), 4.44 (40), 1.571 (35), 2.337 (30)

Chemistry:

	(1)	(2)
Na	32.41	32.85
Al	13.01	12.85
F	54.28	54.30
Total	99.70	100.00

(1) Ivigtut, Greenland. (2) Na_3AlF_6.

Occurrence: A late-stage mineral in some granite pegmatites; in tin-bearing alkalic granites; a vapor-phase mineral along fractures and in the groundmass of some fluorine-rich, topaz-bearing rhyolites; in pods in a carbonatite vein cutting fenitized biotite gneiss. Also as a rare authigenic component of the marlstones and shales of the Green River Formation.

Association: Pachnolite, thomsenolite, gearksutite, cryolithionite, weberite, jarlite, prosopite, chiolite, microcline, quartz, fluorite, siderite, topaz (Ivigtut, Greenland); sodalite, villiaumite, eudialyte, lovozerite, natrolite, chabazite, aegirine (Mont St. Hilaire, Canada).

Distribution: Formerly in a large deposit at Ivigtut, southwestern Greenland. In the USA, from St. Peters Dome, near Pikes Peak, El Paso Co., in the Goldie carbonatite, Fremont Co., and the Green River Formation, Colorado; in the Round Top intrusion, Sierra Blanca Peaks, Hudspeth Co., Texas; from the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada; in the Morefield pegmatite, Amelia, Amelia Co., Virginia. From the Francon quarry, Montreal Island, Montreal, at Mont Saint-Hilaire, and from near Saint-Amable, Quebec, Canada. From Miass, Ilmen Mountains, Southern Ural Mountains, the Khibiny massif, Kola Peninsula, and elsewhere in Russia. In the Madeira and Agua Boa granites, Pitinga region, Amazonas, Brazil. Several other minor occurrences are known.

Name: From the Greek for *ice* and *stone*, alluding to its appearance.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 110–113. (2) Donnay, J.D.H. (1952) Cryolite twinning. Amer. Mineral., 37,
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230–234. (3) Wrinch, D. (1952) Twinning of cryolite. Amer. Mineral., 37, 234–241. (4) Donnay, J.D.H. and G. Donnay (1952) Remarks on "twinning of cryolite" by D. Wrinch. Amer. Mineral., 37, 242–243. (5) Hawthorne, F.C. and R.B. Ferguson (1975) Refinement of the crystal structure of cryolite. Can. Mineral., 13, 377–382. (6) Heinrich, E.W. (1977) Aluminofluoride minerals of the Goldie carbonatite, Fremont County, Colorado. Mountain Geol., 14, 33–46. (7) Dirken, P.J., J.B.H. Jansen, and R.D. Schuiling (1992) Influence of octahedral polymerization on ^{23}Na and ^{27}Al MAS NMR in alkali fluoroaluminates. Amer. Mineral., 77, 718–724.

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Cryolithionite $Na_3Li_3Al_2F_{12}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As dodecahedra, to 17 cm, which may show {112}; commonly as coarse granular aggregates.

Physical Properties: *Cleavage:* Distinct on {011}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 2.771–2.774 D(calc.) = 2.771

Optical Properties: Transparent; often cloudy from inclusions. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic. n = 1.3393–1.3395

Cell Data: *Space Group: Ia3d.* a = 12.122(2) Z = 8

X-ray Powder Pattern: Synthetic.
4.28 (100), 3.029 (55), 1.966 (55), 2.213 (50), 2.711 (35), 2.376 (35), 1.619 (30)

Chemistry:

	(1)	(2)
Na	18.83	18.55
Li	5.35	5.60
Al	14.46	14.52
F	60.79	61.33
LOI	0.36	
Total	99.79	100.00

(1) Ivigtut, Greenland. (2) $Na_3Li_3Al_2F_{12}$.

Occurrence: In some granite pegmatites.

Association: Cryolite, quartz, fluorite, siderite (Ivigtut, Greenland); cryolite, chiolite, pachnolite, thomsenolite, ralstonite, prosopite (Miass, Russia).

Distribution: In the Ivigtut cryolite deposit, southwestern Greenland. From near Miass, Ilmen Mountains, Southern Ural Mountains, Russia. At the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada, USA.

Name: For its similarity to CRYOlite and high LITHIum content.

Type Material: University of Copenhagen, Copenhagen, Denmark; National Museum of Natural History, Washington, D.C., USA, 106833.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 99–100. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 3–6. (3) Geller, S. (1971) Refinement of the crystal structure of cryolithionite, $\{Na_3\}[Al_2](Li_3)F_{12}$. Amer. Mineral., 56, 18–23. (4) (1971) NBS Mono. 25, 9, 23.

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Cryptohalite $(NH_4)_2SiF_6$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As crusts of interpenetrating tabular crystals, to 1 mm; in aggregates, which may be mammillary, columnar, globular, or arborescent.

Physical Properties: *Cleavage:* Perfect on {111}. Hardness = 2.5 D(meas.) = 2.004 D(calc.) = 2.029 Soluble in H_2O, saline taste.

Optical Properties: Transparent. *Color:* Colorless, white to gray; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.369(1)$

Cell Data: *Space Group:* $Fm3m$. a = 8.392 Z = 4

X-ray Powder Pattern: Synthetic.
4.844 (100), 2.422 (45), 2.098 (35), 4.195 (25), 2.967 (18), 1.615 (18), 2.531 (8)

Chemistry:

	(1)	(2)
Si	15.58	15.77
NH_4	20.43	20.25
F	63.36	63.98
H_2O	0.30	
SO_4	0.06	
insol.	0.15	
Total	99.88	100.00

(1) Barari, India. (2) $(NH_4)_2SiF_6$.

Polymorphism & Series: Dimorphous with bararite, the lower-temperature form.

Occurrence: A volcanic sublimate, or formed from fires in burning coal seams.

Association: Sal ammoniac, bararite, sulfur, selenium.

Distribution: From Vesuvius, Campania, Italy. In the Clara mine, near Wolfach, Black Forest, Germany. At Libusín, Kladno basin, Czech Republic. In the Bararee mine, Barari, Jharia district, West Bengal, India. From Kehley's Run mine, near Shenandoah, Schuylkill Co., and at Glen Lyon, Luzerne Co., Pennsylvania, USA.

Name: From the Greek for *concealed* and *salt*, for being admixed with sal ammoniac.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 104–105. (2) Vainshtein, B.K. and M.M. Stasova (1956) Electron-diffraction investigation of cryptohalite. Kristallografiya (Sov. Phys. Crystal.), 1, 311–320 (in Russian). (3) Lapham, D.M., J.H. Barnes, W.F. Downey, Jr., and R.B. Finkelman (1980) Mineralogy associated with burning anthracite deposits of eastern Pennsylvania. Pennsylvania Geol. Surv. Min. Res. Report, 78, 44–45. (4) (1955) NBS Circ. 539, 5, 5.

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Cryptomelane $\mathbf{K_{1-1.5}(Mn^{4+},Mn^{3+})_8O_{16}}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely in subhedral crystals, to 2 mm; commonly as compact fine-grained masses, banded colloform, botryoidal, or radial fibrous aggregates, all in the same specimen; massive cleavable. *Twinning:* Typically on (010) and $(10\bar{1})$, producing a pseudotetragonal unit cell.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5, compact. D(meas.) = 4.17–4.41 D(calc.) = [4.44]

Optical Properties: Opaque. *Color:* Steel-gray to bluish gray when fresh; tarnishes to dull grayish black; light tan or gray in reflected light. *Streak:* Brownish black. *Luster:* Metallic to dull.
Optical Class: Isotropic, nearly.
R: n.d.

Cell Data: *Space Group:* $I2/m$. $a = 9.956(3)$ $b = 2.8705(9)$ $c = 9.706(4)$ $\beta = 90.95(3)^\circ$
Z = [1]

X-ray Powder Pattern: Philipsburg, Montana, USA.
2.39 (10), 6.90 (9), 4.90 (8), 3.10 (8), 2.15 (6), 1.83 (6), 1.54 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.58	0.18		MgO	0.05	0.07	0.15
TiO_2	0.01	0.00		CaO	0.27	0.00	
MnO_2	83.13	87.09	84.41	SrO	0.00	0.00	1.75
Al_2O_3	0.37	0.39	0.99	BaO	0.13	0.00	1.97
Fe_2O_3	0.46	0.19	3.03	Na_2O	0.44	0.48	1.02
MnO	2.08	2.49		K_2O	3.50	3.10	5.78
CoO	0.00	0.08		H_2O^+	2.58	3.58	
NiO	0.00	0.00		H_2O^-	0.81	0.60	
CuO	0.12	0.00		P_2O_5	0.07	0.00	
ZnO	5.23	1.69		Total	99.83	99.94	[99.10]

(1) Tombstone, Arizona, USA; Mn^{4+} from "available O". (2) Philipsburg, Montana, USA; Mn^{4+} from "available O". (3) Chindwara, India; by electron microprobe, Mn^{4+}:Mn^{3+} from charge balance, original total given as 99.18%; corresponding to $(K_{0.94}Na_{0.25}Sr_{0.13}Ba_{0.10}Mg_{0.03})_{\Sigma=1.45}(Mn^{4+}_{6.33}Mn^{3+}_{1.20}Fe^{3+}_{0.30}Al_{0.15})_{\Sigma=7.98}(O,OH)_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: Widespread in oxidized manganese deposits as open-space fillings or replacing primary manganese-bearing minerals; commonly replaced by other secondary manganese minerals.

Association: Pyrolusite, nsutite, braunite, chalcophanite, manganite, other manganese oxides.

Distribution: Some localities for well-studied and pure material include: in the USA, from the Oregon-Prompter mine, Tombstone, Cochise Co., in the Hardshell and Mowry mines, Santa Cruz Co., and the Artillery Mountains, Mohave Co., Arizona; at Lake Valley, Sierra Co., New Mexico; from the Silver Cliff district, Custer Co., Colorado; at Philipsburg, Granite Co., Montana. From Urucum, Mato Grosso, Brazil. In Oriente Province, Cuba. From Nsuta, Ghana. At Sitapar, Chindwara district, Central Provinces, India. On Groote Eylandt, Northern Territory, Australia.

Name: From the Greek for *hidden* and *black*, alluding to the mineral's obscure identity as one of several black mineral species in "psilomelane", the collective term for hard manganese oxides.

Type Material: n.d.

References: (1) Richmond, W.E. and M. Fleischer (1942) Cryptomelane, a new name for the commonest of the "psilomelane" minerals. Amer. Mineral., 27, 607–610. (2) Larson, L.T. (1964) Geology and mineralogy of certain manganese oxide deposits. Econ. Geol., 59, 54–78. (3) Post, J.E., R.B. Von Dreele, and P.R. Buseck (1982) Symmetry and cation displacements in hollandites: structure refinements of hollandite, cryptomelane, and priderite. Acta Cryst., 38, 1056–1065.

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Cryptophyllite $K_2Ca[Si_4O_{10}]\cdot 5H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As distorted and/or split platelets to 0.2 mm or as rosette-like intergrowths with shlykovite to 1 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.185

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Biaxial (+). α = 1.520(2) β = 1.523(2) γ = 1.527(2) 2V(meas.) > 70° 2V(calc.) = 82° *Orientation*: $X = c$.

Cell Data: *Space Group*: $P2_1/n$. a = 6.4934(14) b = 6.9919(5), c = 32.087(3) β = 94.680(12)° Z = 4

X-ray Powder Pattern: Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia. 16.01 (100), 2.903 (84), 6.24 (48), 2.995 (47), 3.197 (27), 7.98 (24), 3.228 (22)

Chemistry:

	(1)
Na_2O	1.12
K_2O	17.73
CaO	11.59
Al_2O_3	0.08
SiO_2	50.24
H_2O	[19.24]
Total	100.00

(1) Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia; average of 4 electron microprobe analyses, H_2O by difference, OH/H_2O calculated for charge balance; corresponding to $(K_{1.80}Na_{0.17})_{\Sigma=1.97}Ca_{0.99}Al_{0.01}Si_{3.99}O_{9.94}(OH)_{0.06}\cdot 5H_2O$.

Occurrence: A late-stage hydrothermal mineral along fractures in a high-potassium peralkaline pegmatite in urtite rocks near the contact with nepheline-apatite rock.

Association: Shlykovite.

Distribution: At the Central mine, Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: Derived from the Greek words "κρυπτοζ"- *concealed* (*crypto*) and "φυλλον" - *leaf* as an allusion to its occurrence in intimate intergrowths with visually indistinguishable shlykovite and to its layered structure.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3753/2).

References: (1) Pekov, I.V., N.V. Zubkova, Ya.E. Filinchuk, N.V. Chukanov, A.E. Zadov, D.Yu. Pushcharovsky, and E.R. Gobechiya (2010) Shlykovite $KCa[Si_4O_9(OH)]\cdot 3H_2O$ and Cryptophyllite $K_2Ca[Si_4O_{10}]\cdot 5H_2O$ - new mineral species from the Khibiny alkaline pluton (Kola Peninsula, Russia). Zap. Ross. Mineral. Obshch., 139(1), 37-50 (in Russian with English abstract); and Geology of Ore Deposits, 52, 767-777. (2) Zubkova, N.V., Ya.E. Filinchuk, I.V. Pekov, D.Yu. Pushcharovsky, and E.R. Gobechiya (2010) Crystal structures of shlykovite and cryptophyllite: comparative crystal chemistry of phyllosilicate minerals of the mountainite family. Eur. J. Mineral., 22, 547-555. (3) (2012) Amer. Mineral., 97, 1526-1527 (abs. refs. 1 and 2).

Cualstibite $Cu_6Al_3Sb_3^{5+}O_{18}\cdot 16H_2O$

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Crystal Data: Hexagonal. *Point Group:* 3, 32, $3m$, $\overline{6}$, or $\overline{6}2m$. As columnar prismatic crystals, to 0.05 mm, and as radial aggregates, in crusts, and massive.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼2 D(meas.) = 3.18(5) D(calc.) = 3.25

Optical Properties: Transparent to translucent. *Color:* Blue-green. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Uniaxial (–); may be weakly biaxial (–). *Pleochroism:* E = colorless; O = light blue-green. $\omega = 1.672(2)$ $\epsilon = 1.644(2)$

Cell Data: *Space Group:* $P3$, $P312$, $P321$, $P3m1$, $P31m$, $P\overline{6}$, $P\overline{6}m2$, or $P\overline{6}2m$. $a = 9.20$ $c = 9.73$ Z = 1

X-ray Powder Pattern: Clara mine, Germany.
4.89 (10), 2.33 (9), 4.17 (8), 1.793 (8), 2.65 (7), 3.35 (5), 1.388 (5)

Chemistry:

	(1)	(2)
Sb_2O_5	36.8	34.57
Al_2O_3	10.4	10.90
CuO	32.0	34.00
H_2O^+	20.8	20.53
Total	[100.0]	100.00

(1) Clara mine, Germany; H_2O by TGA, after deduction of quartz and barite 9.9%, corresponds to $Cu_{5.62}Al_{2.85}Sb_{3.18}O_{18}\cdot 16.14H_2O$. (2) $Cu_6Al_3Sb_3^{5+}O_{18}\cdot 16H_2O$.

Occurrence: A secondary mineral from oxidation of a hydrothermal polymetallic barite–fluorite deposit.

Association: Cornwallite, arsenogoyazite, goethite, barite, fluorite, quartz.

Distribution: In the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: From the chemical symbols of the mineral's major components, copper (CUprum), ALuminum, and antimony (STIBium).

Type Material: Institute for Mineralogy and Petrography, University of Stuttgart, Stuttgart, Germany.

References: (1) Walenta, K. (1984) Cualstibit, ein neues Sekundärmineral aus der Grube Clara im mittleren Schwarzwald (BRD). Chem. Erde, 43, 255–260 (in German with English abs.).
(2) (1985) Amer. Mineral., 70, 1329 (abs. ref. 1).

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Cubanite $CuFe_2S_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals elongated ‖ [001]; thick tabular {001} and {110}; {001} striated ‖ [010], to 3 cm; also massive. *Twinning:* Common with twin plane {110}, in pairs, also as fourlings and sixlings; then pseudohexagonal.

Physical Properties: *Cleavage:* Parting on {110} and $\{1\bar{3}0\}$. *Fracture:* Conchoidal. Hardness = 3.5 VHN = n.d. D(meas.) = 4.03–4.18 D(calc.) = 4.024 Strongly magnetic.

Optical Properties: Opaque. *Color:* Brass-yellow to bronze-yellow. *Anisotropism:* On polished surface, distinctive.

R_1–R_2: (400) 17.5–23.1, (420) 21.5–27.0, (440) 25.2–30.2, (460) 27.7–33.1, (480) 29.8–35.1, (500) 31.7–36.7, (520) 33.3–38.1, (540) 34.8–39.0, (560) 36.0–39.8, (580) 37.1–40.4, (600) 38.1–41.0, (620) 39.1–41.6, (640) 40.0–42.2, (660) 40.9–42.8, (680) 41.7–43.3, (700) 42.3–43.7

Cell Data: *Space Group: Pcmn.* $a = 6.467(1)$ $b = 11.117(6)$ $c = 6.231(2)$ Z = 4

X-ray Powder Pattern: Sudbury, Canada.
3.22 (10), 1.867 (8), 1.750 (7), 1.165 (5), 3.49 (4), 3.00 (4), 2.79 (4)

Chemistry:

	(1)	(2)	(3)
Cu	24.32	23.52	23.42
Fe	41.15	41.14	41.15
S	34.37	35.30	35.43
Total	99.84	99.96	100.00

(1) Barracanao, Cuba. (2) Prince William Sound, Alaska, USA. (3) $CuFe_2S_3$.

Polymorphism & Series: Dimorphous with isocubanite.

Occurrence: In hydrothermal deposits formed at relatively high temperature, in pyrrhotite–pentlandite ores in which it commonly occurs as intimate oriented intergrowths with chalcopyrite. Cubanite may exsolve from chalcopyrite below about 200 °C–210 °C. A rare constituent of some carbonaceous chondrite meteorites.

Association: Chalcopyrite, pyrite, pyrrhotite, pentlandite, sphalerite.

Distribution: Numerous localities; may be an important ore mineral. From Barracanao, Cuba [TL]. In the USA, at Fierro, Grant Co., New Mexico; at the Christmas mine, Gila Co., Arizona; from Prince William Sound, Alaska. In the Strathcona mine, Sudbury, Ontario; as exceptional crystals from Chibougamau, Quebec, Canada. In Sweden, at Tunaberg, Södermanland; from Kaveltorp, near Ljusnarsberg, Örebro; at Kalkugnstorp, 70 km west of Stockholm. From Virtasalm, Finland. At Traversella, Piedmont, Italy. In Brazil, in the Morro Velho gold mine, Nova Lima, Minas Gerais. At Broken Hill, New South Wales, Australia. From the Noril'sk region, western Siberia, Russia. In the Orgueil and Alais carbonaceous chondrite meteorites.

Name: For its occurrence in Cuba.

Type Material: Mining Academy, Freiberg, Germany, 5467.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 243–246. (2) Cabri, L.J., S.R. Hall, J.T. Szymanski, and J.M. Stewart (1973) On the transformation of cubanite. Can. Mineral., 12, 33–38. (3) Szymański, J.T. (1974) A refinement of the structure of cubanite, $CuFe_2S_3$. Zeits. Krist., 140, 218–239. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 65–66. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 122.

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Cuboargyrite $AgSbS_2$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Myrmekitic and dendritic droplike grains, to 35 μm, within first-generation khatyrkite, and as rounded or irregular grains in cracks and interstices in second-generation khatyrkite.

Physical Properties: Hardness = n.d. VHN = 272–318 (20 g and 50 g loads).
D(meas.) = n.d. D(calc.) = 5.12

Optical Properties: Opaque. *Color:* Steel-yellow. *Luster:* Metallic. *Anisotropism:* Very weak, from pale gray to gray.
R: (400) — , (420) — , (440) 66.8, (460) 66.1, (480) 65.3, (500) 64.5, (520) 63.7, (540) 62.9, (560) 62.1, (580) 61.3, (600) 60.4, (620) 59.7, (640) 58.9, (660) 58.2, (680) 57.7, (700) 57.2

Cell Data: *Space Group:* n.d. $a = 6.95(1)$ $b = 4.16(1)$ $c = 10.04(1)$ Z = 10

X-ray Powder Pattern: Listvenitovyi Stream, Russia.
5.07 (10), 4.12 (8), 3.59 (2), 2.83 (1), 2.607 (1), 2.316 (1), 2.023 (1)

Chemistry:

	(1)
Cu	60.79
Zn	8.42
Al	29.9
Total	99.11

(1) Listvenitovyi Stream, Russia; by electron microprobe, average of nine grains; corresponding to $(Cu_{0.86}Zn_{0.12})_{\Sigma=0.98}Al_{1.00}$.

Occurrence: In black slick washed from greenish gray cover weathering from serpentine.

Association: Khatyrkite, two unnamed zinc aluminides.

Distribution: From near the Listvenitovyi Stream, Khatyrka ultramafic zone of the Koryak–Kamchata fold area, Koryak Mountains, Magadan district, Russia [TL].

Name: For copper, CUPrum, and ALuminum in the composition.

Type Material: Mining Institute, St. Petersburg, Russia, 1688/1.

References: (1) Razin, L.V., N.S. Rudashevskii, and L.N. Vyal'sov (1985) New natural intermetallic compounds of aluminum, copper and zinc – khatyrkite $CuAl_2$, cupalite CuAl and zinc aluminides – from hyperbasites of dunite–harzburgite formation. Zap. Vses. Mineral. Obshch., 114, 90–100 (in Russian). (2) (1986) Amer. Mineral., 71, 1278 (abs. ref. 1).

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Cumengeite $Pb_{21}Cu_{20}Cl_{42}(OH)_{40}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Rarely as isolated single crystals of pseudo-octahedral or pseudocubo-octahedral habit; more commonly as oriented overgrowths on cube faces of crystals of boleite and pseudoboleite, in groupings which mimic twins, to 8 cm.

Physical Properties: *Cleavage:* {101}, good; {110}, distinct; {001}, poor. Hardness = 2.5 D(meas.) = 4.656 D(calc.) = 4.66

Optical Properties: Translucent. *Color:* Indigo blue. *Streak:* Sky-blue. *Luster:* Weakly vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = dark blue with greenish tint; E = blue.
ω = 2.026–2.041 ϵ = 1.926–1.965

Cell Data: *Space Group:* $I4/mmm$. a = 15.065(2) c = 24.436(5) Z = 2

X-ray Powder Pattern: Boleo, Mexico.
2.38 (10), 4.86 (9), 3.73 (6), 7.02 (4), 3.98 (4), 3.08 (4), 2.66 (4)

Chemistry:

	(1)	(2)	(3)
Pb	54.47	54.17	55.85
CuO	20.27	19.93	20.42
Cl	19.03	19.13	19.11
H_2O	5.90	6.19	4.62
insol.	0.19		
Total	99.86	99.42	100.00

(1–2) Boleo, Mexico. (3) $Pb_{21}Cu_{20}Cl_{42}(OH)_{40}$.

Occurrence: A secondary mineral formed through reaction of chloride ions with primary sulfides in the oxidized zone of some Pb–Cu deposits; in smelter slag immersed in and leached by sea water.

Association: Boleite, pseudoboleite, atacamite, anglesite, cerussite, phosgenite, gypsum (Boleo, Mexico).

Distribution: In Mexico, exceptional crystals and groups from the Amelia mine, Boleo, near Santa Rosalía, Baja California. From Laurium, Greece, in slag. Along Baratti Beach, Tuscany, Italy, in slag. In England, in Cornwall, from Tolcarne Beach, Great Western Beach, and Watergate Bay, Newquay; Newporth Beach, Falmouth; in the Porthilly mine, St. Minver; at Daymer Bay, near Polzeath; Trerubies Cove, near Delabole; Gunver Head, near Padstow Consols; and Loe Warren zawn, 0.75 km west of Botallack, St. Just. In Germany, from the Christian-Levin mine, near Essen, North Rhine-Westphalia. In Australia, at the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia, and at Broken Hill, New South Wales.

Name: For Edouard Cumenge (1828–1902), French mining engineer at Boleo, Mexico, who found the first specimens.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 79–80 [cumengite]. (2) Winchell, R.E. and R.C. Rouse (1974) The mineralogy of the boleite group. Mineral. Record, 5, 280–287. (3) Dean, A.C., R.F. Symes, J.H. Thomas, and P.A. Williams (1983) Cumengéite from Cornwall. Mineral. Mag., 47, 235–236. (4) Hawthorne, F.C. and L.A. Groat (1986) The crystal structure and chemical composition of cumengéite. Mineral. Mag., 50, 157–162. (5) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 29.

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Cummingtonite $(Mg,Fe^{2+})_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed, columnar, or fibrous crystals and fibrous aggregates, to 20 cm. *Twinning:* Simple or multiple twinning ∥ {100}.

Physical Properties: *Cleavage:* Good on {110}, intersecting at 54° and 126°. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.1–3.6 D(calc.) = 3.3

Optical Properties: Transparent to translucent. *Color:* Dark green, brown, gray, beige; colorless to pale green in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* With increasing Fe content, weak; $X = Y =$ colorless; $Z =$ pale green. *Orientation:* $Y = b$; $Z \wedge c = -21°$ to $-16°$; $X \wedge a = -9°$ to $-3°$. *Dispersion:* $r < v$, weak. $\alpha = 1.632$–1.663 $\beta = 1.638$–1.677 $\gamma = 1.655$–1.697 2V(meas.) = 70°–90°

Cell Data: *Space Group:* $C2/m$. a = 9.516(5) $b = 18.139(10)$ $c = 5.311$ $\beta = 102.1°$ Z = 2

X-ray Powder Pattern: Labrador City, Canada.
8.30 (100b), 3.06 (90), 3.26 (80), 2.754 (70), 1.403 (60), 9.12 (50), 2.623 (50)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	51.53	53.84	FeO	16.91	25.63	Na_2O	0.65	0.15
TiO_2	0.31	0.01	MnO	0.22	0.19	K_2O	0.00	
Al_2O_3	5.02	1.61	MgO	20.84	17.44	H_2O^+	2.15	
Fe_2O_3	0.82		CaO	1.34	0.41	H_2O^-	0.64	
						Total	100.43	99.28

(1) Geodh Dubh, Scotland; corresponds to $(Mg_{4.44}Fe^{2+}_{2.02}Al_{0.21}Ca_{0.20}Na_{0.18}Fe^{3+}_{0.09}Ti_{0.03}Mn_{0.03})_{\Sigma=7.20}(Si_{7.36}Al_{0.64})_{\Sigma=8.00}O_{22}(OH)_{2.05}$. (2) Orfordville Formation, Mt. Cube quadrangle, Vermont, USA; by electron microprobe, corresponds to $(Mg_{3.77}Fe^{2+}_{3.11}Al_{0.08}Ca_{0.06}Na_{0.04}Mn_{0.02})_{\Sigma=7.08}(Si_{7.80}Al_{0.20})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with magnesio-cummingtonite and grunerite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: 0.3 $Mg/(Mg + Fe^{2+})$ 0.69; $(Ca + Na)_B < 1.34$; Li < 1.0; Mn < 0.5.

Occurrence: Commonly in medium-grade regionally metamorphosed rocks; characteristic of metamorphosed iron formations; a late-stage mineral in some gabbros and norites; rarely in silicic volcanic rocks.

Association: "Hornblende," anthophyllite, actinolite, ferro-actinolite, tremolite, arfvedsonite, magnesio-arfvedsonite, gedrite, glaucophane, quartz, garnet.

Distribution: Well-characterized material from: in the USA, at Cummington, Hampshire Co., Massachusetts; the Homestake mine, Lead, Pennington Co., South Dakota; in the Jackson County Iron Formation, Wisconsin. In the Wabush Iron Formation, Labrador City, Labrador, Newfoundland, Canada. From the Miyamori district, Iwate Prefecture, and the Hitachi mine, Ibaragi Prefecture, Japan. In the Garabal Hill-Glen Fyne complex, Scotland. At Teisko, Finland. From Nordmark, Värmland, Sweden.

Name: For the occurrence at Cummington, Massachusetts, USA.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 386, 390. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 235–248. (3) Ghose, S. (1961) The crystal structure of a cummingtonite. Acta Cryst., 14, 622–627. (4) Klein, C. (1964) Cummingtonite-grunerite series: a chemical, optical and X-ray study. Amer. Mineral., 49, 963–982. (5) Spear, F.S. (1980) The gedrite-anthophyllite solvus and the composition limits of orthoamphibole from the Post Pond Volcanics, Vermont. Amer. Mineral., 65, 1103–1118. (6) Ghose, S. and Y. Hexiong (1989) Mn-Mg distribution in a C2/m manganoan cummingtonite: crystal-chemical considerations. Amer. Mineral., 74, 1091–1096. (7) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 225–258.

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Crystal Data: Orthorhombic. *Point Group:* n.d. Myrmekitic and dendritic drop-like grains up to 35 μm within first-generation khatyrkite, and as rounded or irregular grains to 20 μm in cracks and interstices in second-generation khatyrkite.

Physical Properties: Hardness = n.d. VHN = 272–318 (20 and 50 g loads).
D(meas.) = n.d. D(calc.) = 5.12

Optical Properties: Opaque. *Color:* Steel-yellow. *Luster:* Metallic. *Anisotropism:* Very weak, from light gray to gray.
R: (400) — , (420) — , (440) 66.8, (460) 66.1, (480) 65.3, (500) 64.5, (520) 63.7, (540) 62.9, (560) 62.1, (580) 61.3, (600) 60.4, (620) 59.7, (640) 58.9, (660) 58.2, (680) 57.7, (700) 57.2

Cell Data: *Space Group:* n.d. $a = 6.95(1)$ $b = 4.16(1)$ $c = 10.04(1)$ Z = 10

X-ray Powder Pattern: Listvenitovii stream, USSR.
5.07 (10), 4.12 (8), 3.59 (2), 2.83 (1), 2.607 (1), 2.316 (1), 2.023 (1)

Chemistry:

	(1)
Cu	59.9 – 61.7
Zn	7.66 – 9.35
Al	29.3 – 30.4
Total	

(1) Listvenitovii stream, USSR; by electron microprobe, ranges of analyses on nine grains, corresponding to (Cu, Zn)Al.

Occurrence: In black slick washed from greenish gray cover weathering from serpentine.

Association: Khatyrkite, two unnamed zinc aluminides.

Distribution: Near the Listvenitovii stream, Khatirskii ultramafic zone of the Koryak–Kamchata fold area, Koryak Mountains, USSR.

Name: For the composition.

Type Material: Mining Museum, Leningrad Mining Institute, Leningrad, USSR.

References: (1) Razin, L.V., N.S. Rudashevskii, and L.N. Vyal'sov (1985) New natural intermetallic compounds of aluminum, copper and zinc — khatyrkite $CuAl_2$, cupalite CuAl and zinc aluminides — from hyperbasites of dunite–harzburgite formation. Zap. Vses. Mineral. Obshch., 114, 90–100 (in Russian). (2) (1986) Amer. Mineral., 71, 1278 (abs. ref. 1).

Cuprite $Cu_2^{1+}O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As cubic, octahedral, and dodecahedral crystals, to 14 cm, which may be highly modified; as hairlike capillary forms, with square section, reticulated, tufted and matted; also earthy, compact granular, massive.

Physical Properties: *Cleavage:* {111}, interrupted; {001}, rare. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 3.5–4 VHN = 183–222 (100 g load). D(meas.) = 6.14 D(calc.) = 6.15

Optical Properties: Transparent to translucent. *Color:* Cochineal-red, ruby-red, purplish red, to nearly black; in transmitted light, cochineal-red or red in thick sections; yellow-orange, yellow, lemon-yellow in progressively thinner sections; in reflected light, gray blue, commonly with many red internal reflections. *Streak:* Brownish red, shining. *Luster:* Adamantine to submetallic, earthy.
Optical Class: Isotropic, anomalously anisotropic. *Pleochroism:* Anomalous, common.
$n = 2.849$
R: (400) 32.1, (420) 32.2, (440) 32.3, (460) 31.7, (480) 30.4, (500) 28.8, (520) 27.5, (540) 26.3, (560) 25.5, (580) 24.8, (600) 24.4, (620) 23.9, (640) 23.6, (660) 23.4, (680) 23.2, (700) 23.1

Cell Data: *Space Group:* $Pn3m$ (synthetic). a = 4.2685(1) Z = 2

X-ray Powder Pattern: Synthetic.
2.465 (100), 2.135 (37), 1.510 (27), 1.287 (17), 3.020 (9), 1.233 (4), 0.9795 (4)

Chemistry: No modern analyses are available.

Occurrence: A common mineral in the oxidized portions of many copper deposits.

Association: Copper, tenorite, malachite, azurite, calcite, brochantite, antlerite, atacamite, chrysocolla, iron oxides, clay minerals.

Distribution: A few localities for fine specimens include: at Bogoslovsk, Nizhni Tagil, and Yekaterinburg (Sverdlovsk), Ural Mountains, Russia. At Dzhezkazgan, Kazakhstan. In England, fine crystals from many mines in Cornwall. At Rheinbreitbach, North Rhine-Westphalia, Germany. In Namibia, large crystals from the Onganja mine, 60 km northeast of Windhoek, and at Tsumeb. At Likasi, Ruwe, and the Mashamba West mine, Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). In the USA, in Arizona, large crystals from Bisbee, Cochise Co., at Ray, Pinal Co., Globe, Gila Co., and elsewhere; from Santa Rita, Grant Co., New Mexico. From Boleo, Baja California, Mexico. At Chuquicamata, Antofagasta, Chile. In Australia, from Broken Hill and Cobar, New South Wales; at Burra-Burra and Moonta, South Australia; large crystals in the Red Dome mine, Chilliago, Queensland.

Name: From the Latin *cuprum*, for its copper content.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 491–494. (2) Kirfel, A. and K. Eichhorn (1990) Accurate structure analysis with synchrotron radiation. The electron density in Al_2O_3 and Cu_2O. Acta Cryst., A46, 271–284. (3) (1953) NBS Circ. 539, 2, 23.

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Cuprobismutite $Cu_8AgBi_{13}S_{24}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive and as prismatic crystals and thin blades, to 1 mm, slightly twisted ‖ [010], the elongation axis.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = 6.36 D(calc.) = [6.24]

Optical Properties: Opaque. *Color:* Gray, commonly tarnished to bluish. *Luster:* Metallic. *Anisotropism:* Distinct.
R_1–R_2: (400) 31.8–35.2, (420) 32.4–35.8, (440) 33.1–36.4, (460) 34.4–37.6, (480) 34.9–37.6, (500) 34.9–38.0, (520) 35.4–38.4, (540) 35.9–38.9, (560) 36.2–39.4, (580) 36.6–39.8, (600) 36.8–40.1, (620) 37.0–40.4, (640) 37.2–40.4, (660) 37.2–40.5, (680) 37.2–40.5, (700) 37.2–40.5

Cell Data: *Space Group:* $C2/m$. $a = 17.520(1)$ $b = 3.926(3)$ $c = 15.261(1)$ $\beta = 100.18(1)°$ Z = [2]

X-ray Powder Pattern: Hall's Valley, Colorado, USA.
3.10 (10), 2.73 (6), 3.65 (4b), 4.31 (3), 1.961 (3), 1.719 (3), 6.24 (2)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Cu	15.96	15.1	12.39	Bi	60.80	63.8	66.22
Ag	0.89	1.19	2.63	Sb		0.08	
Pb		0.84		Se		0.50	
Zn	0.10			Te		0.07	
Mn		0.14		S	[19.94]	18.5	18.76
Fe	2.13			Total	[99.82]	100.2	100.00

(1) Hall's Valley, Colorado, USA; analysis by Hillebrand (in 1884), who assumed the sample to contain chalcopyrite 6.97% after deducting gangue 4.43%; sulfur content "calculated for the analysis"; then corresponds to $Cu_{9.69}Ag_{0.32}Zn_{0.06}Bi_{11.23}S_{24.00}$. (2) Ohio district, Utah, USA; by electron microprobe, corresponds to $Cu_{9.77}Ag_{0.45}Pb_{0.17}Mn_{0.10}(Bi_{12.55}Sb_{0.03})_{\Sigma=12.58}(S_{23.72}Se_{0.26}Te_{0.02})_{\Sigma=24.00}$. (3) $Cu_8AgBi_{13}S_{24}$.

Occurrence: Rare, of hydrothermal origin with other sulfides and sulfosalts.

Association: Emplectite, aikinite, wittichenite, benjaminite, berryite, cupropavonite, paděraite, hodrushite, wolframite, bismuthinite.

Distribution: In the USA, in Colorado, from the Missouri mine, Hall's Valley, Park Co. [TL], and at Silver Cliff, Custer Co.; in the Fairfax quarry, Centreville, Fairfax Co., Virginia; and from the Tunnel Extension 2 mine, Marysvale, Ohio district, Piute Co., Utah. From Krupka, Czech Republic. At Băiţa (Rézbánya) and in the Paulus mine, Ocna de Fier (Morávicza; Vaskő), Romania. From Baicolliou, Switzerland.

Name: For copper, CUPRum, and BISMUTh in the composition.

Type Material: Harvard University, Cambridge, Massachusetts, 94989; National Museum of Natural History, Washington, D.C., USA, 92902.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 437. (2) Nuffield, E.W. (1952) Studies of mineral sulfo-salts: XVI Cuprobismuthite [*sic*]. Amer. Mineral., 37, 447–452. (3) Taylor, C.M., A.S. Radtke, and C.L. Christ (1973) New data on cuprobismutite. J. Res. U.S. Geol. Sur., 1, 99–103. (4) Ozawa, T. and W. Nowacki (1975) The crystal structure of, and the bismuth-copper distribution in synthetic cuprobismuthite [*sic*]. Zeits. Krist., 142, 161–176. (5) Cook, N.J. and C.L. Ciobanu (2003) Lamellar minerals of the cuprobismutite series and related paděraite: a new occurrence and implications. Can. Mineral., 41, 441–456. (6) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 143–144. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 126.

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Cuprocopiapite $CuFe_4^{3+}(SO_4)_6(OH)_2 \cdot 20H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. In fine-grained lumpy aggregates of minute crystals.

Physical Properties: *Cleavage:* [010, perfect; $\overline{1}01$ imperfect.] (by analogy with copiapite). Hardness = 2.5 D(meas.) = 2.23 D(calc.) = [2.26] Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Greenish yellow, yellow-orange. *Optical Class:* Biaxial (+). *Pleochroism:* In shades of green. *Orientation:* $X \simeq b$. *Dispersion:* $r > v$, strong. *Absorption:* $X = Y > Z$. $\alpha = 1.558$ $\beta = 1.575$ $\gamma = 1.620$ 2V(meas.) = 63°

Cell Data: *Space Group:* $P\overline{1}$ (ICDD 19–394). $a = 7.34$ $b = 18.19$ $c = 7.28$ $\alpha = 93°51'$ $\beta = 101°30'$ $\gamma = 99°23'$ Z = 1

X-ray Powder Pattern: Quetena, Chile. (ICDD 19-394).
3.56 (100), 8.81 (80), 5.82 (50), 6.32 (40), 3.08 (40), 3.90 (30), 3.76 (30)

Chemistry:

	(1)	(2)
SO_3	41.62	38.20
Al_2O_3	1.47	
Fe_2O_3	27.66	25.40
CuO	5.72	6.32
H_2O	23.51	30.08
insol.	0.21	
Total	100.19	100.00

(1) Chuquicamata, Chile. (2) $CuFe_4(SO_4)_6(OH)_2 \cdot 20H_2O$.

Mineral Group: Copiapite group.

Occurrence: A rare secondary mineral probably formed by reaction between copiapite and copper sulfate-bearing solutions, preserved in arid climates.

Association: Copiapite, parabutlerite, chalcanthite, jarosite.

Distribution: In Chile, from Chuquicamata and at Quetena, west of Calama, Antofagasta.

Name: As the *cuprian* member of the *copiapite* group.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 99048, 99060.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 623–627. (2) Bandy, M.C. (1938) Mineralogy of three sulphate deposits of northern Chile. Amer. Mineral., 23, 669–760, esp. 737–739.

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Cuproiridsite $CuIr_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As inclusions, to 300 μm, in isoferroplatinum and platinum.

Physical Properties: *Tenacity:* Very brittle. Hardness = n.d. VHN = 578 (30 g load). D(meas.) = n.d. D(calc.) = 7.24

Optical Properties: Opaque. *Color:* Iron-black; gray in reflected light. *Luster:* Metallic. R: (400) — , (420) — , (440) — , (460) 35.0, (480) 34.4, (500) 34.0, (520) 34.0, (540) 33.6, (560) 33.4, (580) 33.1, (600) 32.8, (620) 32.6, (640) 32.4, (660) 32.2, (680) 32.1, (700) 32.0

Cell Data: *Space Group: Fd3m.* a = 9.92 Z = 8

X-ray Powder Pattern: Kamchatka, Russia.
3.00 (100), 1.760 (100), 2.489 (90) 1.912 (70), 1.011 (70), 1.290 (60), 1.107 (60)

Chemistry:

	(1)	(2)
Cu	7.41	11.03
Fe	3.17	
Ni	0.27	
Ir	48.9	66.71
Pt	10.5	
Rh	6.05	
S	24.6	22.26
Total	100.9	100.00

(1) Kamchatka, Russia; by electron microprobe, corresponding to $(Cu_{0.61}Fe_{0.30}Ni_{0.02})_{\Sigma=0.93}(Ir_{1.33}Pt_{0.28}Rh_{0.31})_{\Sigma=1.92}S_{4.00}$. (2) $CuIr_2S_4$.

Polymorphism & Series: Forms two series, with cuprorhodsite and with malanite.

Mineral Group: Linnaeite group.

Occurrence: In alluvial deposits.

Association: Isoferroplatinum, cuprorhodsite, malanite, osmium, iridosmine, platinum, laurite, erlichmanite, cherepanovite, kashinite, rhodian pentlandite, irarsite, cooperite, sperrylite, chalcopyrite, bornite.

Distribution: In Russia, from the Kondor [TL] and Chad massifs, Khabarovsk Territory; at Inagli, Aldan Shield; on Mt. Filipp, Kamchatka; and in the Ray-Iz ophiolite complex, Polar Ural Mountains. From Chromwerk, Kraubath massif, Styria, Austria. At Finero, [prov??in D8??], Italy. From Goodnews Bay, Alaska, USA.

Name: For copper, CUPRum, IRIDium, and Sulfur in the chemical composition.

Type Material: Mining Institute, St. Petersburg, Russia, 1686/1.

References: (1) Rudashevskii, N.S., Y.P. Men'shikov, A.G. Mochalov, N.V. Trubkin, N.I. Shumskaya, and V.V. Zhdanov (1985) Cuprorhodsite $CuRh_2S_4$ and cuproiridisite $CuIr_2S_4$ – new natural thiospinels of platinum elements. Zap. Vses. Mineral. Obshch., 114, 187–195 (in Russian). (2) (1986) Amer. Mineral., 71, 1277 (abs. ref. 1).

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Cuprokalininite $CuCr_2S_4$

Crystal Data: Cubic. *Point Group*: 4/*m* $\bar{3}$ 2/*m*. As octahedral or cuboctahedral crystals, to 0.20 mm, some with a pseudododecahedral faces {110}. *Twinning*: Polysynthetic and simple twinning on {111} (Spinel law) common.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Very brittle. Hardness = 4.5-5 VHN = 396 (20-30 g load). D(meas.) = n.d. D(calc.) = 4.16 Slightly electromagnetic.

Optical Properties: Opaque. *Color*: Black with dark-bronze tint, pale cream in reflected light. *Streak*: Black. *Luster*: Submetallic.
Optical Class: Isotropic.
R: (400) 34.30, (420) 34.10, (440) 33.90, (460) 33.70, (480) 33.5, (500) 33.2, (520) 33.00, (540) 32.80, (560) 32.30, (580) 32.20, (600) 31.90, (620) 31.60, (640) 31.20, (660) 30.90, (680) 30.60, (700) 30.40

Cell Data: *Space Group*: *Fd*3*m*. *a* = 9.814(2) Z = 8

X-ray Powder Pattern: Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.
2.94 (100), 1.73 (100), 1.00 (100), 1.88 (90), 3.44 (60), 2.44 (60), 1.13 (60)

Chemistry:

	(1)
Cu	21.03
Fe	0.47
Zn	0.17
Cr	29.01
V	5.85
As	0.21
Sb	0.08
S	43.25
Total	100.07

(1) Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia; average of 202 electron microprobe analyses; corresponding to $(Cu_{0.98}Fe_{0.02}Zn_{0.01})_{\Sigma=1.01}(Cr_{1.65}V_{0.34}As_{0.01})_{\Sigma=2.00}S_{3.99}$.

Mineral Group: Thiospinel group.

Occurrence: As disseminated inclusions in quartz from Cr-V-bearing quartz-diopside granulite facies metamorphic rocks.

Association: Cr-V-tremolite and mica, calcite, Cr-V spinels, V-titanite, pyrite, plagioclase, a mineral of the natalyite-kosmochlor series, goldmanite-uvarovite, dravite-chromdravite, karelianite-eskolaite.

Distribution: In the Sludyanka complex, South Baikal region, Russia.

Name: For its essential copper content and structural identity with *kalininite*, $ZnCr_2S_4$.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3886/1-3).

References: (1) Reznitsky, L.Z., E.V. Sklyarov, Z.F. Ushchapovskaya, L.F. Suvorova, Yu.S. Polekhovsky, P. Dzerzanovsky, and I.G. Barash (2010) Cuprokalininite, $CuCr_2S_4$ - a new sulfospinel from metamorphic rocks of Sludyanka complex, South Baikal region. Zap. Ross. Mineral. Obshch., 139(6), 39-49 (in Russian with English abstract). Geol. Ore Deposits, 53(8), 758-766 (in English). (2) (2012) Amer. Mineral., 97, 1527-1528 (abs. ref. 1).

Cupromakovickyite $Cu_8Pb_4Ag_2Bi_{18}S_{36}$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As lamellar intergrowths or discrete grains in makovickyite, to 0.3 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 4 VHN = 295 (25 g load). D(meas.) = n.d. D(calc.) = 6.78

Optical Properties: Opaque. *Color*: Gray; grayish white in reflected light. *Streak*: Gray. *Luster*: Metallic. *Bireflectance:* Moderate (oil). *Anisotrophism*: Strong (oil); dark bluish gray to yellow brown.
Optical Class: n.d.
R_1-R_2: (470) 42.15-48.45, (546) 41.02-46.93, (589) 40.25-45.83, (650) 39.66-45.01

Cell Data: *Space Group*: *C2/m*. a = 13.405(8) b = 4.016(3) c = 29.949(19) β = 99.989(16)°
Z = 1

X-ray Powder Pattern: Calculated.
3.478 (100), 2.842 (94), 3.646 (57), 3.486 (41), 3.345 (33), 2.964 (33), 2.282 (31)

Chemistry:

	(1)	(2)
Cu	7.66	7.86
Ag	4.01	3.34
Pb	9.45	12.81
Bi	60.02	58.15
Te	0.76	
Se	0.30	
S	17.55	17.84
Total	99.75	100.00

(1) Băița Bihor, Romania; average of 5 electron microprobe analyses, corresponding to $Cu_{7.79}Ag_{2.40}Pb_{2.95}Bi_{18.55}(S_{35.37}Se_{0.25}Te_{0.39})_{\Sigma=36.00}$.
(2) $Cu_8Pb_4Ag_2Bi_{18}S_{36}$.

Occurrence: As exsolution lamellae or discrete grains associated with sulfosalts in contact metamorphic rocks (skarns) around granite and in scheelite-bearing quartz veins in felsic gneisses and amphibolites.

Association: Aikinite-friedrichite, hodrušite, paděraite, kupčikite, emplectite, wittichenite, tetradymite, chalcopyrite, dolomite (Romania); aikinite-krupkaite, hodrušite, cuprobismutite, kupčikite, wittichenite, native bismuth, chalcopyrite, pyrrhotite, quartz (Austria).

Distribution: Băița Bihor, Apuseni Mts, Romania; Felbertal scheelite deposit, Hohe Tauern, Austria.

Name: For its essential copper content and relationship to makovickyite.

Type Material: Division of Mineralogy, University of Salzburg, Austria, 14943 and 14944.

References: (1) Topa, D. and W.H. Paar (2007) Cupromakovickyite, $Cu_8Pb_4Ag_2Bi_{18}S_{36}$, a new mineral species of the pavonite homologous series. Can. Mineral., 46, 503-514. (2) (2008) Amer. Mineral., 93, 1942 (abs. ref. 1).

Cupromolybdite $Cu_3O(MoO_4)_2$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/m 2/*m*. As well-formed, stout prismatic to acicular crystals to 0.2 mm; also in radiating aggregates.

Physical Properties: *Cleavage*: Distinct. *Fracture*: Uneven to splintery. *Tenacity*: Brittle. Hardness = ~ 3 D(meas.) = n.d. D(calc.) = 4.512 VHN = 189 (50 g load).

Optical Properties: Translucent. *Color*: Honey-yellow or dark brown (prismatic crystals) to bright yellow (acicular), gray with a bluish tint in reflected light with orange-red or orange-brown internal reflections. *Streak*: Yellow to light brown. *Luster*: Adamantine. *Anisotropism*: Distinct. *Optical Class*: n.d.
R_1-R_2: (470) 14.95-16.3, (546) 13.4-14.85, (589) 12.73-14.16, (650)12.15-13.5

Cell Data: *Space Group*: *Pnma*. *a* = 7.6638(1) *b* = 6.8670(1) *c* = 14.5554(2) Z = 4

X-ray Powder Pattern: Second Scoria Cone, Tolbachik volcano, Kamchatka Peninsula, Russia. 3.436 (100), 3.301 (99), 3.065 (79), 7.312 (67), 2.506 (66), 2.556 (62), 3.518 (55)

Chemistry:

	(1)	(2)	(3)
MoO_3	54.48	50.3	54.67
SO_3	0.71	2.16	
V_2O_5	0.28	0.91	
SiO_2	0.04	0.10	
CuO	43.03	37.8	45.33
FeO	0.08	0.09	
ZnO	0.53	8.48	.
Total	99.15	99.87	100.00

(1) Second Scoria Cone, Tolbachik volcano, Russia; average of 7 electron microprobe analyses; corresponding to $(Cu_{2.83}Zn_{0.03}Fe_{0.01})_{\Sigma=2.87}(Mo_{1.98}S_{0.05}V_{0.02})_{\Sigma=2.05}O_9$ (prismatic crystals). (2) Second Scoria Cone, Tolbachik volcano, Russia; average of 7 electron microprobe analyses; corresponding to $(Cu_{2.46}Zn_{0.54}Fe_{0.01})_{\Sigma=3.01}(Mo_{1.81}S_{0.14}V_{0.05})_{\Sigma=2.00}O_9$ (acicular variety). (3) $Cu_3O(MoO_4)_2$.

Occurrence: A fumarolic mineral formed during post-volcanic degassing.

Association: Piypite, fedotovite, vergasovite, hematite, magnetite, aphthitalite, langbeinite, palmierite, As-bearing orthoclase, lammerite, klyuchevskite, alumoklyuchevskite, euchlorine, lyonsite, pseudo-lyonsite, averievite, rutile, gold.

Distribution: From the Yadovitaya (poisonous) fumarole, Second Scoria Cone, Tolbachik volcano, Kamchatka Peninsula, Russia.

Name: For its chemical composition. The name also reflects the stoichiometric relationship with cuprotungstite, $Cu_3(OH)_2(WO_4)_2$.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 4072/1).

References: (1) Zelenski, M.E., N.V. Zubkova, I.V. Pekov, Y.S. Polekhovsky, and D.Yu. Pushcharovsky (2012) Cupromolybdite, $Cu_3O(MoO_4)_2$, a new fumarolic mineral from the Tolbachik volcano, Kamchatka Peninsula, Russia. European Journal of Mineralogy, 24(4), 749-757. (2) (2014) Amer. Mineral., 99, 2152-2153 (abs. ref. 1).

Cupropavonite $AgPbCu_2Bi_5S_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rough platy crystals, to 0.5 mm; commonly as fine lamellar intergrowths exsolved from pavonite.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = [7.04]

Optical Properties: Opaque. *Color:* Lead-gray to tin-white; in polished section, white. *Pleochroism:* Weak in air; weak to distinct in oil. *Anisotropism:* Distinct.
R_1–R_2: (400) 45.1–48.2, (420) 45.0–48.8, (440) 45.0–49.4, (460) 44.6–49.8, (480) 44.4–50.2, (500) 43.9–50.0, (520) 43.4–49.1, (540) 43.0–48.2, (560) 42.5–47.5, (580) 42.2–46.9, (600) 42.1–46.4, (620) 42.0–46.4, (640) 41.9–46.2, (660) 41.7–46.1, (680) 41.6–46.0, (700) 41.2–45.6

Cell Data: *Space Group:* $C2/m$. $a = 13.45$ $b = 4.02$ $c = 33.06$ $\beta = 93.50°$ $Z = 4$

X-ray Powder Pattern: Alaska mine, Colorado, USA.
2.892 (vs), 2.257 (vs), 2.193 (vs), 2.118 (vs), 2.019 (vs), 2.007 (vs), 1.8011 (vs)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	5.7	5.9	7.01	5.97
Pb	13.5	13.4	7.65	11.46
Cu	6.2	6.1	7.26	7.03
Bi	56.4	56.8	59.32	57.80
Sb	0.1	0.3		
S	18.0	17.6	18.10	17.74
Total	99.9	100.1	99.34	100.00

(1–2) Alaska mine, Colorado, USA; by electron microprobe, the average corresponding to $Ag_{0.97}Pb_{1.17}Cu_{1.74}Bi_{4.88}S_{10.00}$. (3) Hall's Valley, Colorado, USA; by electron microprobe, corresponding to $Ag_{1.15}Pb_{0.65}Cu_{2.02}Bi_{5.03}S_{10.00}$. (4) $AgPbCu_2Bi_5S_{10}$.

Occurrence: In zoned mesothermal base- and precious-metal veins.

Association: Pavonite, gustavite, cuprobismutite, berryite.

Distribution: In the USA, in Colorado, from the Alaska mine, Poughkeepsie Gulch, near Ouray, San Juan Co. [TL], and at the Missouri mine, Hall's Valley, Park Co.; in the Campbell mine, Bisbee, Cochise Co., Arizona; and from the April Fool mine, Delamar district, Lincoln Co., Nevada. At Stănija and Băiţa (Rézbánya), Romania. In the Waschgang Au–Cu deposit, Goldberg Mountains, Upper Carinthia, Austria. From Saxony, Germany, otherwise undefined.

Name: For its copper, *cuprum*, content, and to stress a similarity with pavonite.

Type Material: University of Pennsylvania, Philadelphia, Pennsylvania, USA, 1124, ("alaskaite").

References: (1) Karup-Møller, S. and E. Makovicky (1979) On pavonite, cupropavonite, benjaminite, and "oversubstituted" gustavite. Bull. Minéral., 102, 351–367. (2) (1980) Amer. Mineral., 65, 206 (abs. ref. 1). (3) Nuffield, E.W. (1980) Cupropavonite from Hall's Valley, Park County, Colorado. Can. Mineral., 18, 181–184. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 128.

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Cuprorhodsite $CuRh_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As small inclusions in isoferroplatinum grains, up to 300 μm.

Physical Properties: *Tenacity:* Very brittle. Hardness = n.d. VHN = 498 (50 g load). D(meas.) = n.d. D(calc.) = [5.88]

Optical Properties: Opaque. *Color:* Iron-black; gray in reflected light. *Luster:* Metallic. R: (400) — , (420) — , (440) — , (460) 35.6, (480) 35.8, (500) 36.4, (520) 36.6, (540) 36.7, (560) 36.8, (580) 36.9, (600) 37.0, (620) 37.0, (640) 37.0, (660) 36.9, (680) 36.8, (700) 36.7

Cell Data: *Space Group: Fd*3*m*. a = 9.88 Z = 8

X-ray Powder Pattern: Far Eastern Region, Russia.
3.00 (100), 1.758 (100), 1.009 (90), 1.904 (80), 2.480 (70), 1.286 (50), 1.102 (50)

Chemistry:

	(1)	(2)
Cu	7.55	15.98
Fe	5.31	
Rh	39.6	51.76
Ir	10.3	
Pt	6.8	
S	29.8	32.26
Total	99.36	100.00

(1) Far Eastern Region, Russia; by electron microprobe, corresponding to $(Cu_{0.51}Fe_{0.41})_{\Sigma=0.92}(Rh_{1.66}Ir_{0.23}Pt_{0.15})_{\Sigma=2.04}S_{4.00}$. (2) $CuRh_2S_4$.

Polymorphism & Series: Forms a series with cuproiridsite.

Mineral Group: Linnaeite group.

Occurrence: In alluvial placers.

Association: Isoferroplatinum, cuproiridsite, malanite, osmium, iridosmine, laurite, erlichmanite, cooperite, sperrylite, chalcopyrite, bornite (Chad massif, Russia).

Distribution: In Russia, from the Gusevogorskii massif, Ural Mountains [TL], and in the Far Eastern Region, from the Chad massif, Khabarovsk Territory, on Mt. Filipp, Kamchatka, and in the Baimka placers, Chukota. At Chromwerk, Kraubath massif, Styria, Austria.

Name: For copper, CUPRum, RHODium, and Sulfur in the chemical composition.

Type Material: Mining Institute, St. Petersburg, Russia, 1685/1.

References: (1) Rudashevskii, N.S., Y.P. Men'shikov, A.G. Mochalov, N.V. Trubkin, N.I. Shumskaya, and V.V. Zhdanov (1985) Cuprorhodsite $CuRh_2S_4$ and cuproiridsite $CuIr_2S_4$ – new natural thiospinels of platinum elements. Zap. Vses. Mineral. Obshch., 114, 187–195 (in Russian). (2) (1986) Amer. Mineral., 71, 1277 (abs. ref. 1).

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Cuprorivaite $CaCuSi_4O_{10}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals tabular on {001}, to 0.1 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = 3.08(6) D(calc.) = 3.09

Optical Properties: Transparent to translucent. *Color:* Azure. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* O = blue; E = nearly colorless, pale rose. $\omega = 1.633(3)$ $\epsilon = 1.590(3)$

Cell Data: *Space Group:* $P4/ncc$. a = 7.30(1) $c = 15.12(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.29 (100), 3.78 (90), 3.00 (90), 3.36 (80), 3.19 (50), 2.270 (50), 7.63 (40)

Chemistry:

	(1)	(2)
SiO_2	64.44	63.92
Al_2O_3	2.12	
Fe_2O_3	0.39	
CuO	12.09	21.16
CaO	12.19	14.92
Na_2O	2.52	
K_2O	1.06	
H_2O^+	2.59	
CO_2	1.18	
SO_3	1.08	
Total	99.66	100.00

(1) Vesuvius, Italy; sample contaminated with 13% quartz. (2) $CaCuSi_4O_{10}$.

Occurrence: Intimately mixed with quartz (Vesuvius, Italy); in a mudstone xenolith ejected from a scoria cone (Sattelberg volcanic cone, Germany).

Association: Quartz.

Distribution: In Italy, on Vesuvius, Campania. From Wheal Edward, Cornwall, England. At Summit Rock, near Diamond Lake, Douglas Co., Oregon, USA. From the Sattelberg volcanic cone, near Brenk, Eifel district, Germany. At Messina, Transvaal, South Africa.

Name: For a high copper content and presumed similarity to *rivaite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 135505.

References: (1) Minguzzi, C. (1938) Cuprorivaite: Un nuovo minerale. Period. Mineral., 9(3), 333–345 (in Italian). (2) (1939) Amer. Mineral., 24, 350 (abs. ref. 1). (3) Pabst, A. (1959) Structures of some tetragonal silicates. Acta Cryst., 12, 733–739. (4) Mazzi, F. and A. Pabst (1962) Reexamination of cuprorivaite. Amer. Mineral., 47, 409–411.

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Cuprosklodowskite $(H_3O)_2Cu(UO_2)_2(SiO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As needles, to 3 cm, commonly somewhat flattened on {010} and elongated along [100]. In radiating groups of crystals, matted fibers, and thin crusts.

Physical Properties: *Cleavage:* {100}. Hardness = n.d. D(meas.) = 3.85(2) D(calc.) = 3.83 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellowish green to grass-green or greenish yellow. *Luster:* Dull to silky in aggregates.
Optical Class: Biaxial (–). *Pleochroism:* X = nearly colorless; $Y = Z$ = yellowish green. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$. α = 1.654–1.655 β = 1.664–1.667 γ = 1.664–1.667 2V(meas.) = Very small to 0°.

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.052(5)$ $b = 9.267(8)$ $c = 6.655(5)$ $\alpha = 109°14(3)'$ $\beta = 89°50(3)'$ $\gamma = 110°1(4)'$ Z = 1

X-ray Powder Pattern: Jáchymov, Czech Republic.
8.18 (100), 4.09 (90), 2.97 (80), 4.82 (70), 3.52 (60), 2.21 (60), 2.72 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	14.4	13.40	13.94
UO_3	64.7	64.96	66.38
CuO	9.0	8.99	9.23
H_2O	12.1	11.72	10.45
Total	100.2	99.07	100.00

(1) Shaba Province, Congo; Fe_2O_3 trace. (2) Jáchymov, Czech Republic; Fe_2O_3, PbO, and CaO in traces. (3) $(H_3O)_2Cu(UO_2)_2(SiO_4)_2 \cdot 2H_2O$.

Occurrence: A secondary mineral formed by alteration of earlier uranium minerals, both *in situ* and after transport of solutions.

Association: Becquerelite, brochantite, uranophane, kasolite, vandenbrandeite, liebigite, uranophane-beta, compreignacite.

Distribution: In Congo (Zaire), from Katanga (Shaba) Province, at Kambove and Kalongwe, with exceptional specimens from Shinkolobwe and the Musonoi mine, Kolwezi. From Jáchymov (Joachimsthal), Czech Republic. At Johanngeorgenstadt, Saxony, Germany. From West Wheal Owles and the Geevor mine, St. Just, Cornwall, England. In the Rabéjac uranium deposit, seven km south-southwest of Lodève, Hérault, France. In the USA, in New Mexico, from the Sanostee area, San Juan Co., in the Woodrow mine, Laguna district, Valencia Co., and in the Grants district, McKinley Co.; in Utah, in the Frey No. 4 mine, Frey Canyon, the Posey mine, Red Canyon, and the Happy Jack mine, White Canyon, San Juan Co.; in California, on the Ram claims, Pinto Mountains, Riverside Co. In Canada, from the Nicholson mine, Lake Athabasca, Saskatchewan. At Kenzan, Okayama Prefecture, Japan.

Name: A name supplied by Buttgenbach while introducing Vaes' paper, in the mistaken belief that it was the copper analog of *sklodowskite*.

Type Material: University of Liège, Liège, Belgium, 16.655.

References: (1) Vaes, J.P. (1933) Sur un minéral de Kalongwe (Katanga). Ann. Soc. Geol. Belg., Bull. 10, 56, 331–332 (in French). (2) (1934) Amer. Mineral., 19, 235 (abs. ref. 1). (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 304–307. (4) Bariand, P., M.T. Le Bihan, and Y. Gillet (1967) Étude cristallographique de la cuprosklodowskite. Bull. Soc. fr. Minéral., 90, 259 (in French). (5) Rosenzweig, A. and R.S. Ryan (1975) Refinement of the crystal structure of cuprosklodowskite, $Cu[(UO_2)_2(SiO_3OH)_2] \cdot 6H_2O$. Amer. Mineral., 60, 448–453. (6) Stohl, F.V. and D.K. Smith (1981) The crystal chemistry of the uranyl silicate minerals. Amer. Mineral., 66, 610–625.

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Cuprospinel $(Cu, Mg)Fe_2^{3+}O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As irregular grains, to ~0.1 mm; these may form lamellar intergrowths with hematite.

Physical Properties: Hardness = n.d. VHN = 920–1081, 985 average (100 g load). D(meas.) = n.d. D(calc.) = [5.25]

Optical Properties: Opaque. *Color:* Black; in reflected light, gray. *Streak:* Black. *Optical Class:* Isotropic.
R: (470) 22.7, (546) 21.7, (589) 21.0, (650) 20.0

Cell Data: *Space Group: Fd3m.* a = 8.369 Z = 8

X-ray Powder Pattern: Baie Verte, Canada.
2.517 (10), 1.479 (6), 2.96 (5), 1.613 (4), 4.79 (3), 2.100 (3), 1.087 (3)

Chemistry:

	(1)
Al_2O_3	2.6
Fe_2O_3	65.7
FeO	1.7
MnO	0.2
CoO	0.6
CuO	27.8
ZnO	0.7
MgO	1.8
Total	101.1

(1) Baie Verte, Canada; by electron microprobe, Fe^{2+}:Fe^{3+} calculated to satisfy the spinel structure; corresponding to $(Cu_{0.80}Mg_{0.10}Fe^{2+}_{0.05}Co_{0.02}Zn_{0.02}Mn_{0.01})_{\Sigma=1.00}(Fe^{3+}_{1.89}Al_{0.11})_{\Sigma=2.00}O_4$.

Mineral Group: Spinel group.

Occurrence: In highly oxidized material, once spontaneously ignited, in an ore dump.

Association: Pyrite, chalcopyrite, sphalerite, pyrrhotite, hematite.

Distribution: On the property of Consolidated Rambler Mines Limited, near Baie Verte, Newfoundland, Canada.

Name: For the mineral's copper, CUPRum, content and having the *spinel* structure.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128673.

References: (1) Nickel, E.H. (1973) The new mineral cuprospinel ($CuFe_2O_4$) and other spinels from an oxidized ore dump at Baie Verte, Newfoundland. Can. Mineral., 11, 1003–1007. (2) (1974) Amer. Mineral., 59, 381 (abs. ref. 1).

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Cuprostibite Cu_2Sb

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As fine-grained aggregates, to 1.5 mm in diameter. *Twinning:* Platy [*sic*].

Physical Properties: *Cleavage:* One direction. *Fracture:* Uneven. Hardness = n.d. VHN = 216–249 (50 g load). D(meas.) = n.d. D(calc.) = 8.42

Optical Properties: Opaque. *Color:* Steel-gray, red-violet tint on fresh fracture; in reflected light, rose-violet. *Luster:* Metallic. *Pleochroism:* Creamy white to dark rose-violet. *Anisotropism:* Strong.
R_1–R_2: (400) 51.1–58.6, (420) 52.5–58.5, (440) 52.2–56.9, (460) 50.0–54.9, (480) 47.4–52.6, (500) 45.5–50.3, (520) 42.2–47.6, (540) 37.8–45.0, (560) 35.4–42.5, (580) 35.7–41.7, (600) 39.6–43.0, (620) 45.4–45.9, (640) 50.7–49.3, (660) 55.9–52.0, (680) 59.7–54.3, (700) 62.6–55.7

Cell Data: *Space Group:* $P4/nmm$. $a = 3.990$ $c = 6.09$ $Z = 2$

X-ray Powder Pattern: Mt. Nákâlâq, Greenland.
2.07 (100), 2.56 (50), 2.82 (40), 1.993 (40), 1.167 (40), 1.424 (30), 3.33 (20)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	53.3	50.4	52.0	51.07
Tl	3.5			
Ag	0.1			
Sb	42.0	48.9	48.4	48.93
S	1.1			
Total	100.0	99.3	100.4	100.00

(1) Mt. Nákâlâq, Greenland; by electron microprobe, average of three analyses; corresponds to $Cu_{2.00}(Sb_{0.82}S_{0.08}Tl_{0.04})_{\Sigma=0.94}$. (2) Långban, Sweden; by electron microprobe, average of three analyses; corresponds to $Cu_{2.00}Sb_{1.01}$. (3) Kangerdluarssuk Plateau, Greenland; by electron microprobe, corresponds to $Cu_{2.00}Sb_{0.97}$. (4) Cu_2Sb.

Occurrence: As fine-grained aggregates in a vein of ussingite cutting sodalite syenite (Ilímaussaq intrusion, Greenland); in sulfide veins in metamorphic siliceous dolostone (Långsjön, Sweden).

Association: Löllingite, antimonian silver, chalcopyrite, chalcothallite (Ilímaussaq intrusion, Greenland); chalcocite, bismuth (Långban, Sweden); sphalerite, galena, dyscrasite, gudmundite, breithauptite, antimony (Långsjön, Sweden).

Distribution: In southern Greenland, from Mt. Nákâlâq [TL], northwest of Taseq Lake, and at other localities in the Ilímaussaq intrusion. From Långsjön, at Långban, and in the Getberg mine, near Långban, Värmland, Sweden. From Franklin, Sussex Co., New Jersey, USA.

Name: For copper, CUPRum, and antimony, STIBium, in the composition.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Sørensen, H., E.I. Semenov, M.S. Bezsmertnaya, and E.B. Khalezova (1969) Cuprostibite, a new natural compound of copper and antimony. Zap. Vses. Mineral. Obshch., 98, 716–724 (in Russian). (2) (1970) Amer. Mineral., 55, 1810 (abs. ref. 1). (3) Burke, E.A.J. (1980) Cuprostibite, cuprian galena, altaite, cuprian massicot, wittichenite, and bismuthinite from Långban, Sweden. Neues Jahrb. Mineral., Monatsh., 241–246. (4) Hålenius, U. and C. Ålinder (1982) Occurrence and formation of cuprostibite in a Zn–Pb–Ag mineralized siliceous dolomite at Långsjön, central Sweden. Neues Jahrb. Mineral., Monatsh., 201–215. (5) Elander, M., G. Hägg, and A. Westgren (1935) The crystal structure of Cu_2Sb and Fe_2As. Ark. Kem. Min. Geol., 12B(1), 1–6. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 131.

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Cuprotungstite $Cu_3(WO_4)_2(OH)_2$

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Crystal Data: Tetragonal. *Point Group:* 422. As dipyramidal crystals, to 30 μm; aggregated into botryoidal globules, incrustations, and veinlets, also compact to friable massive.

Physical Properties: Hardness = n.d. D(meas.) = 5.40–6.98 D(calc.) = 7.06

Optical Properties: Semitransparent. *Color:* Pistachio-green, olive-green, leek-green, emerald-green. *Streak:* Greenish gray to greenish yellow. *Luster:* Vitreous, waxy, earthy. *Optical Class:* Uniaxial (–). $\omega = 2.18(1)$ $\epsilon = 2.10(1)$

Cell Data: *Space Group:* $P4_12_12$. $a = 8.93$ $c = 14.48$ Z = 12

X-ray Powder Pattern: Cave Creek, Arizona, USA.
2.53 (10), 4.03 (8), 3.80 (8), 1.462 (7), 7.76 (5b), 1.729 (5b), 2.45 (4)

Chemistry:

	(1)	(2)	(3)
WO_3	57.80	64.12	64.37
Fe_2O_3	0.80		
CuO	36.0	32.83	33.13
PbO		0.61	
CaO	0.25		
H_2O	4.75	[2.44]	2.50
Total	99.60	[100.00]	100.00

(1) Peralillo, Chile. (2) Cordillera mine, Australia; partial analysis by electron microprobe, H_2O by difference; then corresponds to $(Cu_{2.98}Pb_{0,02})_{\Sigma=2.00}(WO_4)_{2.00}(OH)_{1.96}$. (3) $Cu_3(WO_4)_2(OH)_2$.

Occurrence: A rare secondary mineral typically replacing scheelite.

Association: Scheelite, stolzite, raspite.

Distribution: From La Paz, Baja California, Mexico. In the USA, on the Gold Cliff claims, Cave Creek, Maricopa Co., Arizona; in the Green Monster mine, near White River, Kern Co., California; from the South Peacock mine, Seven Devils district, Adams Co., Idaho. At the Llamuco copper mine, east of Salamanca, Coquimbo, Chile. In England, at Buckbarrow Beck, Corney Fell, Cumbria; in Cornwall, from Wheal Gorland, Gwennap; at the Gunnislake mine, Calstock; in the Gunheath china clay pit, St. Austell. From the Clara mine, near Oberwolfach, Black Forest, Germany. At Natas, Namibia. In the Cordillera mine, near Tuena, New South Wales, Australia. Numerous other localities have been reported but require modern confirmation.

Name: For copper, *cuprum* and *tungsten* in the composition.

Type Material: Natural History Museum, Paris, France, 69.47.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1091–1092. (2) Walenta, K. (1979) New data for cuprotungstite, Mineral. Mag., 43, 448–450. (3) Duggan, M.B. (1988) Cuprotungstite from the Cordillera mine, Crookwell, New South Wales. Australian Mineral., 3, 61–64.

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Curetonite **$Ba(Al,Ti)(PO_4)(OH,O)F$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly euhedral, to 3 mm, may be elongated along [001], showing {100}, {010}, {001}, {011}, and $\{\overline{2}01\}$; may be wedgelike. *Twinning:* Polysynthetic, common on {100}, producing broad lamellae with imperfect composition planes.

Physical Properties: *Cleavage:* On {011}, good; a parting on {010}. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 4.42(5) D(calc.) = 4.31

Optical Properties: Semitransparent. *Color:* Bright yellow-green to nickel-green; colorless in thin section. *Streak:* White.
Optical Class: Biaxial (+). *Pleochroism:* In patchy yellows. *Orientation:* $X = b$; $Z \wedge c = 30°$. *Dispersion:* $r < v$, weak, strongly inclined. *Absorption:* $X \gg Y = Z$. $\alpha = 1.676$ $\beta = 1.680$ $\gamma = 1.693$ 2V(meas.) = 60° 2V(calc.) = 58.4°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.977(2)$ $b = 12.564(4)$ $c = 5.223(1)$ $\beta = 102.15(2)°$ Z = 4

X-ray Powder Pattern: Near Golconda, Nevada, USA.
3.230 (10), 3.286 (8), 2.991 (6), 2.816 (6), 4.290 (5), 2.848 (5), 3.568 (4)

Chemistry:

	(1)	(2)
P_2O_5	23.39	22.83
V_2O_5	1.27	0.65
TiO_2	6.84	4.08
Al_2O_3	12.81	13.20
MgO		0.27
SrO		0.10
BaO	53.09	51.30
F	n.d.	6.46
H_2O	2.46	[2.50]
$-O = F_2$		2.72
Total	99.86	[98.67]

(1) Near Golconda, Nevada, USA; by electron microprobe, Ti and V by wet methods, H_2O by the Penfield method. (2) Do.; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $(Ba_{1.02}Mg_{0.02})_{\Sigma=1.04}(Al_{0.79}Ti_{0.16})_{\Sigma=0.95}[(P_{0.98}V_{0.03})_{\Sigma=1.01}O_4][(OH)_{0.85}O_{0.11}]_{\Sigma=0.96}F_{1.04}$.

Occurrence: A rare mineral, in veins cutting a replacement barite deposit.

Association: Orthoclase, barite, variscite, montgomeryite, englishite, sulvanite, hisingerite, "opal".

Distribution: In the Redhouse Barite mine, near Golconda, Potosi district, Humboldt Co., Nevada, USA.

Name: In honor of Forrest Ellsworth Cureton II (1932–), mineral dealer and collector, Tucson, Arizona, USA, and Michael Edward Cureton (1960–), mineral collector, Stockton, California, USA, who first found the mineral.

Type Material: The Natural History Museum, London, England, 1979,205; Harvard University, Cambridge, Massachusetts, 119100; National Museum of Natural History, Washington, D.C., USA, 145621.

References: (1) Williams, S.A. (1979) Curetonite - a new phosphate from Nevada. Mineral. Record, 10, 219–221. (2) (1980) Amer. Mineral., 65, 206 (abs. ref. 1). (3) Cooper, M. and F.C. Hawthorne (1994) The crystal structure of curetonite, a complex heteropolyhedral sheet mineral. Amer. Mineral., 79, 545–549.

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Curienite $Pb(UO_2)_2(V_2O_8)\cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As a microcrystalline powder.

Physical Properties: Hardness = n.d. D(meas.) = 4.88 D(calc.) = 4.94 Radioactive.

Optical Properties: Semitransparent. *Color:* Canary-yellow.
Optical Class: Biaxial (–) (synthetic). α = n.d. $\beta = > 2$ $\gamma = > 2$ 2V(meas.) = 66°

Cell Data: *Space Group: Pcan* (synthetic). $a = 10.40(4)$ $b = 8.45(3)$ $c = 16.34(4)$
Z = 4

X-ray Powder Pattern: Mounana mine, Gabon.
3.005 (vvs), 8.19 (vvs), 4.10 (vs), 5.13 (s), 4.22 (s), 3.226 (ms), 2.116 (ms)

Chemistry:

	(1)	(2)	(3)
UO_3	53.40	51.50	53.61
V_2O_5	17.32	17.87	17.04
PbO	20.09	20.63	20.91
BaO	0.84		
H_2O	8.30	10.00	8.44
Total	99.95	100.00	100.00

(1) Mounana mine, Gabon; by gravimetric and photometric methods, H_2O by the Penfield method; corresponds to $(Pb_{0.97}Ba_{0.06})_{\Sigma=1.03}(UO_2)_2(V_{2.04}O_8)\cdot 4.94H_2O$. (2) Abertamy mine, Czech Republic; by electron microprobe, H_2O by microchemical methods.
(3) $Pb(UO_2)_2(V_2O_8)\cdot 5H_2O$.

Polymorphism & Series: Forms a series with francevillite.

Occurrence: In the oxidized zone of a Pb-bearing U–V deposit (Mounana mine, Gabon).

Association: Francevillite, duttonite, vanuralite, chervetite, mottramite, carnotite, dewindtite, torbernite, uranopilite, johannite, kasolite (Mounana mine, Gabon); sphalerite, galena, uraninite, quartz (Abertamy mine, Czech Republic); mottramite, metatorbernite, zeunerite (Jáchymov, Czech Republic).

Distribution: From the Mounana uranium mine, Franceville, Gabon. In the Abertamy uranium mine, near Jáchymov, and in the Geister vein, Jáchymov (Joachimsthal), Czech Republic. From Akashat, Iraq.

Name: To honor Professor Hubert Curien (1924–), French mineralogist and crystallographer, Laboratory of Mineralogy and Crystallography, University of Pierre and Marie Curie (Sorbonne), Paris, France.

Type Material: University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France.

References: (1) Cesbron, F. and N. Morin (1968) Une nouvelle espèce minérale: la curiénite. Étude de la série francevillite-curiénite. Bull. Minéral., 91, 453–459 (in French with English abs.). (2) (1969) Amer. Mineral., 54, 1220 (abs. ref. 1). (3) Boréne, J. and F. Cesbron (1971) Structure cristalline de la curiénite $Pb(UO_2)_2(VO_4)_2\cdot 5H_2O$. Bull. Minéral., 94, 8–14 (in French with English abs.). (4) Pauliš, P. (1992) Curienite from Abertamy near Jachymov, Western Bohemia, Czechoslovakia. Časopis pro Mineralogii a Geologii, 37(1), 55–56 (in Czech with English abs.).

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Curite $Pb_3(UO_2)_8O_8(OH)_6 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals long prismatic to acicular and striated ‖ [001], with forms {100}, {110}, {111}; as porous aggregates of fine needles, fine-granular, as opaline crusts, and massive.

Physical Properties: *Cleavage:* {100}. *Tenacity:* Brittle. Hardness = 4–5
D(meas.) = 6.98–7.4 D(calc.) = 7.37

Optical Properties: Semitransparent. *Color:* Deep to pale red-orange, orange, scarlet, may be black with included oxides; yellow to reddish orange in transmitted light. *Streak:* Orange. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; Y = pale red-orange; Z = dark red-orange. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, strong. $\alpha = 2.05$–2.06 $\beta = 2.07$–2.11 $\gamma = 2.12$–2.15 2V(meas.) = Large.

Cell Data: *Space Group: Pnam.* $a = 12.551(9)$ $b = 13.003(20)$ $c = 8.390(13)$ Z = 2

X-ray Powder Pattern: "Katanga" district, Congo.
6.28 (10), 3.97 (9), 3.14 (8), 2.55 (6), 2.10 (5), 1.74 (5), 3.53 (4)

Chemistry:

	(1)	(2)	(3)
UO_3	74.22	76.49	74.63
SiO_2		0.06	
Fe_2O_3	0.17		
PbO	21.32	21.08	21.84
BaO		0.11	
H_2O	3.51	2.43	3.53
Total	[99.22]	100.17	100.00

(1) Congo; average of three analyses, original total given as 99.92%. (2) Do.
(3) $Pb_3(UO_2)_8O_8(OH)_6 \cdot 3H_2O$.

Occurrence: A secondary mineral commonly formed through alteration of uraninite.

Association: Fourmarierite, vandendriesscheite, schoepite, soddyite, kasolite, dewindtite, torbernite, rutherfordine, sklodowskite.

Distribution: At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From La Crouzille, Puy-de-Dôme, France. At Menzenschwand, Black Forest, and Wölsendorf, Bavaria, Germany. In the El Dorado mine, Great Bear Lake, Northwest Territories; from the Elliot Lake district and at Villeneuve, Quebec; and elsewhere in Canada. In Australia, in the Nabarlek, Jabiru, and Koongarra deposits, Northern Territory. From Malakialina, Madagascar.

Name: To honor French physicist Pierre Curie (1856–1906), student of radioactivity.

Type Material: Natural History Museum, Paris, France, 121.248; The Natural History Museum, London, England, 1924,337.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 629–631. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 92–95. (3) Taylor, J.C., W.I. Stuart, and I.A. Mumme (1981) The crystal structure of curite. J. Inorg. Nucl. Chem., 43, 2419–2423.

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Cuspidine $Ca_4Si_2O_7(F,OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals spearhead-shaped, minute. *Twinning:* Simple, lamellar, polysynthetic on {100}.

Physical Properties: *Cleavage:* Very good on {001}; distinct on {110}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.85–2.96 D(calc.) = 2.978

Optical Properties: Transparent to translucent. *Color:* Pale rose-red; in thin section, rose-red to colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 6°$. *Dispersion:* $r > v$, marked, inclined. *Absorption:* Moderate. $\alpha = 1.586–1.592$ $\beta = 1.595$ $\gamma = 1.598–1.606$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/a$. $a = 10.906(5)$ $b = 10.521(6)$ $c = 7.518(3)$ $\beta = 109.30(3)°$ Z = 4

X-ray Powder Pattern: Monte Somma, Italy.
3.062 (100), 2.943 (35), 3.259 (30), 2.900 (30), 2.873 (30), 3.034 (25), 2.018 (18)

Chemistry:

	(1)	(2)	(3)
SiO_2	31.79	32.36	32.79
MnO		0.71	
MgO	0.00		
CaO	59.16	61.37	61.21
Na_2O	trace	0.48	
K_2O	trace	0.27	
F	10.05	9.05	10.37
Cl	trace		
H_2O^+	0.28		
H_2O^-	0.16		
CO_2	0.62		
$-O = (F, Cl)_2$	4.23	3.81	4.37
rem.	1.53		
Total	99.36	100.43	100.00

(1) Monte Somma, Italy; remainder is trivalent oxides. (2) Franklin, New Jersey, USA. (3) $Ca_4Si_2O_7F_2$.

Occurrence: In tuff ejecta (Monte Somma, Italy); in contact metamorphosed limestone (Franklin, New Jersey, USA); in melilite skarn (Dupezeh Mountain, Iraq).

Association: Augite, "hornblende," diopside, grossular, biotite, phlogopite, monticellite, wollastonite, calcite, spinel, magnetite, perovskite.

Distribution: At Monte Somma and Vesuvius, Campania, and in the Alban Hills, as at Ariccia, Lazio, Italy. From Carlingford, Co. Louth, Ireland. At Broadford and Camas Malag, Isle of Skye, and Camas Mór, Isle of Muck, Scotland. From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. In the USA, at Franklin, Sussex Co., New Jersey; in the Alder district, Custer Co., Idaho; at Crestmore, Riverside Co., California; on Cascade Mountain, Adirondack Mountains, Essex Co., New York. On Dupezeh Mountain, near Hero Town, Qala-Diza region, Iraq. In the Hatrurim Formation, Israel. From Fuka, near Bicchu, and in the Sampo and Mihara mines, Kawakami, Okayama Prefecture, Japan.

Name: From the Greek *cuspis*, for a *spear*, the characteristic shape of the twinned crystals.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 533. (2) Tilley, C.E. (1947) Cuspidine from dolomite contact skarns, Broadford, Skye. Mineral. Mag., 28, 90–95. (3) Van Valkenberg, A. and G.F. Rynders (1958) Synthetic cuspidine. Amer. Mineral., 43, 1195–1202. (4) Saburi, S., A. Kawahara, C. Henmi, I. Kusachi, and K. Kihara (1977) The refinement of the crystal structure of cuspidine. Mineral. J. (Japan), 8, 286–298.

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Cuzticite $Fe_2^{3+}Te^{6+}O_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. Minute scales, aggregated in warty to stalactitic crusts.

Physical Properties: Hardness = 3, on compact material. D(meas.) = 3.9 D(calc.) = 4.01

Optical Properties: Semitransparent. *Color:* Yellow to brown; dark yellow in thin section. *Optical Class:* Uniaxial (–). $\omega = 2.06$ $\epsilon = 2.05$

Cell Data: *Space Group:* n.d. $a = 5.045$ $c = 14.63$ Z = 2

X-ray Powder Pattern: Moctezuma mine, Mexico.
3.256 (10), 2.518 (7), 4.871 (4), 2.239 (3), 1.564 (3), 1.457 (3), 1.994 (2)

Chemistry:

	(1)	(2)
TeO_3	45.1	45.10
TeO_2	trace	
Fe_2O_3	41.1	41.02
Mn_2O_3	~0.4	
PbO	0.0	
H_2O	13.6	13.88
Total	100.2	100.00

(1) Moctezuma mine, Mexico; average of three analyses, total Mn as Mn^{3+}, H_2O by the Penfield method on a separate sample. (2) $Fe_2TeO_6 \cdot 3H_2O$.

Occurrence: Very rare in oxidized ore in a matrix of intensely silicified and brecciated rhyolite vitrophyre cemented by drusy quartz and carrying pyrite and tellurides.

Association: Eztlite, emmonsite, schmitterite, kuranakhite, pyrite.

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: From the Nahua language for *something yellow*, in allusion to the color.

Type Material: The Natural History Museum, London, England, 1984,467.

References: (1) Willams, S.A. (1982) Cuzticite and eztlite, two new tellurium minerals from Moctezuma, Mexico. Mineral. Mag., 46, 257–259. (2) (1983) Amer. Mineral., 68, 471 (abs. ref. 1).

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Cyanochroite $K_2Cu(SO_4)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Small euhedral crystals are tabular on {001}; typically forms crystalline crusts intermixed with other soluble compounds.

Physical Properties: *Cleavage:* On $\{\bar{2}01\}$, perfect. Hardness = n.d. D(meas.) = 2.22 D(calc.) = [2.23] Soluble in H_2O.

Optical Properties: Transparent. *Color:* Greenish blue. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 18°33'$. *Dispersion:* $r < v$, strong. $\alpha = 1.484$–1.485 $\beta = 1.486$–1.488 $\gamma = 1.502$ 2V(meas.) = $45°32'$–$46°32'$

Cell Data: *Space Group:* $P2_1/c$. $a = 6.159$ $b = 12.131$ $c = 9.086$ $\beta = 104°27'$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.673 (100), 4.179 (90), 4.057 (79), 2.975 (65), 2.377 (45), 2.816 (42), 2.993 (39)

Chemistry: (1) Analyses of natural material have not been made; identification depends on correspondence of other properties with those of synthetic material.

Mineral Group: Picromerite group.

Occurrence: A rare product of fumarolic action (Vesuvius, Italy).

Association: n.d.

Distribution: From Vesuvius, Campania, Italy. At Laurium, Greece, in slag.

Name: From the Greek for *blue* and *color*, in reference to its appearance in white light.

Type Material: Natural History Museum, Paris, France, 175.358.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 454–455. (2) Carapezza, M. and L. Riva di Sanseverino (1968) Crystallography and genesis of double sulfates and their hydrates. II. Structure, powder pattern and thermo-analysis of cyanochroite, $K_2Cu(SO_4)_2 \cdot 6H_2O$. Mineral. Petrolog. Acta, 14, 23–37. (3) Burns, P.C. and F.C. Hawthorne (1996) Static and dynamic Jahn-Teller effects in Cu^{2+} oxysalt minerals. Can. Mineral., 34, 1089–1105, esp. 1100. (4) (1985) NBS Mono. 25, 21, 99.

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Cyanophillite $Cu_5Al_2Sb_3^{3+}O_{12}(OH)\cdot 12H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As coatings and as spherulitic aggregates of tabular crystals, with dominant {001} and bounded by {hk0}, to 20 μm.

Physical Properties: *Cleavage:* {001}, perfect; another, {100} or {010}, good to very good. Hardness = ∼2 D(meas.) = 3.10(10) D(calc.) = 3.12

Optical Properties: Semitransparent. *Color:* Greenish blue, turquoise-blue; colorless in transmitted light. *Luster:* Pearly to silky.
Optical Class: Biaxial (–). *Orientation:* $X = c$. $\alpha = 1.640(2)$ $\beta = 1.664(2)$ $\gamma = 1.675(2)$
2V(meas.) = n.d. 2V(calc.) = 67°

Cell Data: *Space Group: Pmmb.* $a = 11.82$ $b = 10.80$ $c = 9.64$ Z = 1

X-ray Powder Pattern: Clara mine, Germany.
4.84(10), 9.67 (6), 2.59 (6), 2.44 (5), 4.59 (4), 4.46 (4), 1.917 (4)

Chemistry:

	(1)	(2)
Al_2O_3	8.5	8.77
Sb_2O_3	37.4	37.63
CuO	34.4	34.22
H_2O	19.8	19.38
Total	100.1	100.00

(1) Clara mine, Germany; by AA, Al_2O_3 and Sb_2O_5 average of two analyses, H_2O from weight loss at 200 °C; corresponds to $Cu_{10.11}Al_{3.90}Sb_{6.00}O_{24.96}\cdot 25.74H_2O$.
(2) $Cu_5Al_2Sb_3O_{12}(OH)\cdot 12H_2O$.

Occurrence: A secondary mineral associated with copper mineralization in a hydrothermal polymetallic barite–fluorite deposit.

Association: Chalcophyllite, chrysocolla, brochantite, tripuhyite, quartz, barite.

Distribution: In the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: From the Greek for *blue* and *a leaf*, in allusion to the color and habit.

Type Material: Institute of Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany.

References: (1) Walenta, K. (1981) Cyanophillit, ein neues Mineral aus der Grube Clara bei Oberwolfach im mittleren Schwarzwald. Chem. Erde, 40, 195–200 (in German with English abs.).
(2) (1981) Amer. Mineral., 66, 1274 (abs. ref. 1).

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Cyanotrichite $Cu_4Al_2(SO_4)(OH)_{12}\cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystals are acicular [001], to 3 cm; may be cottonball-like, commonly in radially fibrous and plushlike tufted aggregates forming incrustations.

Physical Properties: Hardness = n.d. D(meas.) = 2.74–2.95 D(calc.) = 2.88

Optical Properties: Transparent to translucent. *Color:* Sky-blue to azure-blue. *Streak:* Pale blue. *Luster:* Silky.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Y = pale blue; Z = bright blue. *Orientation:* $X \perp$ elongation; $Z = c$. α = 1.588–1.591 β = 1.617–1.620 γ = 1.654–1.655 2V(meas.) = 82°

Cell Data: *Space Group:* n.d. $a = 10.16$ $b = 12.61$ $c = 2.90$ Z = 1

X-ray Powder Pattern: Grandview mine, Arizona, USA. (ICDD 11–131).
10.2 (100), 3.88 (90), 5.26 (80), 5.47 (50), 3.04 (40), 3.38 (35), 2.392 (35)

Chemistry:

	(1)	(2)
SO_3	12.19	12.43
Al_2O_3	15.59	15.82
Fe_2O_3	0.43	
CuO	47.50	49.38
CaO	0.11	
H_2O	23.20	22.37
insol.	1.46	
Total	100.48	100.00

(1) Grandview mine, Arizona, USA. (2) $Cu_4Al_2(SO_4)(OH)_{12}\cdot 2H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized portions of copper sulfide deposits.

Association: Brochantite, spangolite, chalcophyllite, olivenite, tyrolite, parnauite, azurite, malachite.

Distribution: From Moldova Nouă (Moldova), Romania. At the Cap Garonne mine, near le Pradet, Var, France. In England, from Wheal Gorland, St. Day, the Phoenix United mine, Linkinhorne, at Lanivet, and elsewhere in Cornwall; in the Old Potts Gill mine, Caldbeck Fells, Cumbria. At the Sa Duchessa mine, Sardinia, Italy. From Laurium, Greece. At the Mednorudyanskoye copper deposit, near Nizhni Tagil, Ural Mountains, Russia. From Akchagyl, Kazakhstan. From the Springbok mine, Namaqualand, South Africa. In the USA, in Arizona, exceptional specimens from the Grandview (Last Chance) mine, Grand Canyon National Park, Coconino Co.; at the Maid of Sunshine mine, Courtland, and Bisbee, Cochise Co.; from Morenci, Greenlee Co.; at Jerome, Yavapai Co. Large sprays from the Mex-Tex mine, near Bingham, Hansonburg district, Socorro Co., New Mexico; in the American Eagle mine, Tintic district, Juab Co., Utah; at Majuba Hill, Pershing Co., and elsewhere in Nevada; fine examples from the Peacock mine, near Leadore, Lemhi Co., Idaho. At Mina la Vieja, near Potrerillos, Atacama, Chile. Other minor localities have been noted.

Name: From the Greek for *blue* and *hair*, in allusion to the typical color and habit.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 578–579.

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Cylindrite $Pb_3Sn_4FeSb_2S_{14}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. In concentric spherical or tubular shells and aggregates, up to 5 cm across and 2–3 cm in length, rarely terminated; also massive.

Physical Properties: *Cleavage:* {100}, excellent. *Tenacity:* Slightly malleable. Hardness = 2.5 VHN = 54–93 (100 g load). D(meas.) = 5.42–5.49 D(calc.) = 5.443

Optical Properties: Opaque. *Color:* In reflected light, galena-white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak in air, stronger in oil. *Anisotropism:* Distinct, gray to pale yellowish or brownish gray.
R_1–R_2: (400) 34.5–40.3, (420) 34.3–40.1, (440) 34.1–40.1, (460) 33.6–39.8, (480) 33.1–39.4, (500) 32.5–38.9, (520) 31.8–38.3, (540) 31.2–37.8, (560) 30.7–37.2, (580) 30.3–36.7, (600) 29.9–36.3, (620) 29.6–35.9, (640) 29.3–35.5, (660) 28.9–35.1, (680) 28.6–34.7, (700) 28.4–34.4

Cell Data: *Space Group:* Two subcells are recognized, both $P\overline{1}$: the first (pseudotetragonal) has $a = 11.733(5)$ $b = 5.790(8)$ $c = 5.810(5)$ $\alpha = 90.00(0.20)°$ $\beta = 92.38(0.20)°$ $\gamma = 93.87(0.20)°$ Z = 2 and the second (pseudohexagonal) has $a = 11.709(5)$ $b = 3.670(8)$ $c = 6.320(5)$ $\alpha = 90.00(0.20)°$ $\beta = 92.58(0.20)°$ $\gamma = 90.85(0.20)°$ Z = 2

X-ray Powder Pattern: Poopó, Bolivia.
3.85 (100), 2.885 (100), 3.9 (90), 3.06 (65), 2.849 (65), 2.044 (65), 2.026 (65)

Chemistry:

	(1)	(2)	(3)	(4)
Pb	34.91	35.5	33.72	33.70
Sn	25.38	26.8	27.37	25.74
Fe	2.79	2.7	2.70	3.03
Ag	0.39	0.5		
Sb	12.64	12.0	11.68	13.20
S	23.86	23.3	24.68	24.33
Total	99.97	100.8	100.15	100.00

(1) Poopó, Bolivia; average of two analyses; corresponds to $Pb_{3.17}Sn_{4.02}Fe_{0.94}Ag_{0.07}Sb_{1.95}S_{14.00}$. (2) Do.; by electron microprobe; corresponds to $Pb_{3.30}Sn_{4.35}Fe_{0.93}Ag_{0.09}Sb_{1.90}S_{14.00}$. (3) Do.; by electron microprobe; corresponds to $Pb_{2.96}Sn_{4.19}Fe_{0.88}Sb_{1.75}S_{14.00}$. (4) $Pb_3Sn_4FeSb_2S_{14}$ [average from structure, not charge balanced; see ref. 3].

Occurrence: In tin-bearing hydrothermal veins.

Association: Franckeite, stannite, incaite, potosiite, teallite, jamesonite, boulangerite, cassiterite, galena, pyrite, sphalerite.

Distribution: In Bolivia, with fine examples from Poopó, in the Santa Cruz [TL] and Trinacria mines; at the Porvenir and Maria Francisca mines, Huanuni; from the Nueva Virginia vein, Colquechaca; and from the Purisima vein, all in Oruro; also from Llallagua, Potosí. In the Smirnovsk deposit, Transbaikalia, Russia.

Name: In allusion to its typical cylindrical habit.

Type Material: Mining Academy, Freiberg, Germany; The Natural History Museum, London, England, 84255.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 482–483. (2) Makovicky, E. (1974) Mineralogical data on cylindrite and incaite, Neues Jahrb. Mineral., Monatsh., 235–256. (3) Makovicky, E. (1976) Crystallography of cylindrite. Part I. Crystal lattices of cylindrite and incaite. Neues Jahrb. Mineral., Abh., 126, 304–326. (4) Wang, S. and P. Busek (1992) Cylindrite: the relation between its cylindrical shape and modulated structure. Amer. Mineral., 77, 758–764. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 739–740. ??ck?? (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 132.

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Cymrite $BaAl_2Si_2(O,OH)_8 \cdot H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* 2. As thin pseudohexagonal platelets and prisms, to 7 mm; also fibrous.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {110}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 3.413(5) D(calc.) = 3.447 Greenish white fluorescence under UV.

Optical Properties: Translucent. *Color:* Colorless when pure; commonly dark green or brown due to inclusions of alteration products. *Luster:* Vitreous to satiny.
Optical Class: Biaxial (–); pseudouniaxial. $\alpha = 1.611$ $\beta = 1.619$ $\gamma = 1.621$
2V(meas.) = 0°–5°

Cell Data: *Space Group:* $P2_1$. $a = 5.324$–5.334 $b = 36.6$ $c = 7.662$–7.705 $\beta = 90°$
Z = [8]

X-ray Powder Pattern: Brooks Range, Alaska, USA.
2.96 (100), 3.96 (90), 2.67 (70), 7.71 (50), 2.24 (40), 2.21 (40), 1.850 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	37.65	30.3	30.54
TiO_2		0.0	
Al_2O_3	14.94	25.9	25.91
Fe_2O_3	9.26		
MnO	0.86		
BaO	31.50	38.7	38.97
K_2O		0.03	
H_2O^+	5.31	[4.58]	4.58
Total	99.52	[99.5]	100.00

(1) Benallt mine, Wales. (2) Pacheco Pass, California, USA; by electron microprobe, theoretical H_2O added. (3) $BaAl_2Si_2O_8 \cdot H_2O$.

Occurrence: In veinlets cutting hydrothermal manganese silicate ore (Benallt mine, Wales); in a copper-bearing deposit in dolostones and siderites (Ruby Creek, Alaska, USA); in jadeite graywacke near the contact of an ultramafic rock and the Franciscan Formation (San Benito Co., California, USA); a product of high-pressure metamorphism of manganese-rich rocks (Andros Island, Greece).

Association: Ganophyllite (Benallt mine, Wales); calcite, albite, lawsonite (San Benito Co., California, USA); hyalotekite, banalsite, hyalophane, hedyphane, manganoan biotite (Långban, Sweden).

Distribution: In the Benallt mine, Rhiw, Lleyn Peninsula, Wales. From Långban, Värmland, Sweden. In the USA, from Ruby Creek, Brooks Range, Alaska, and near Pacheco Pass, San Benito Co., California. On Andros Island, Cyclades Islands, Greece. From the Lianyuan-Shaoyang area, Hunan Province, China. In the Shiramaru mine, Tokyo Prefecture, Japan. At Northwest Nelson, South Island, New Zealand. In the Saureisk deposit, Polar Ural Mountains, and near Lake Baikal, eastern Siberia, Russia. From the Black Rock and Hotazel mines, near Kuruman, Cape Province, South Africa. A number of other occurrences are known.

Name: From *Cymru*, the Welsh name for *Wales*, the locality of discovery.

Type Material: The Natural History Museum, London, England, 1944,36 and 1944,48.

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References: (1) Campbell Smith, W., F.A. Bannister, and M.H. Hey (1949) Cymrite, a new barium mineral from the Benallt manganese mine, Rhiw, Carnarvonshire. Mineral. Mag., 28, 676–681. (2) (1950) Amer. Mineral., 35, 135 (abs. ref. 1). (3) Runnells, D.D. (1964) Cymrite in a copper deposit, Brooks Range, Alaska. Amer. Mineral., 49, 158–165. (4) Essene, E.J. (1967) An occurrence of cymrite in the Franciscan Formation, California. Amer. Mineral., 52, 1885–1890. (5) Drits, V.A., A.A. Kashaev, and G.V. Sokolova (1975) Crystal structure of cymrite. Kristallografiya (Sov. Phys. Crystal.), 20, 280–286 (in Russian).

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Cyrilovite $NaFe_3^{3+}(PO_4)_2(OH)_4 \cdot 2H_2O$

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Crystal Data: Tetragonal. *Point Group:* 422. Thick tabular euhedral crystals, showing {001}, {012}, {113}, to 0.7 mm, in radiating to botryoidal aggregates and crusts.

Physical Properties: *Tenacity:* Conchoidal. Hardness = n.d. D(meas.) = 3.081–3.096 D(calc.) = 3.114

Optical Properties: Translucent. *Color:* Bright yellow, honey-yellow, orange to brownish yellow, brown. *Streak:* Yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Absorption:* O = deep yellow to yellow; E = colorless to yellow.
$\omega = 1.802–1.805$ $\epsilon = 1.769–1.775$

Cell Data: *Space Group:* $P4_12_12$ or $P4_32_12$. $a = 7.313(2)$ $c = 19.315(3)$ Z = 4

X-ray Powder Pattern: Cyrilov pegmatite, Czech Republic.
4.85 (10), 3.186 (8), 2.664 (8), 3.101 (5), 3.60 (4), 2.020 (4), 1.553 (4)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	29.06	31.77	29.29	CaO	0.10	0.80	
Al_2O_3	1.36	0.00		Na_2O	4.70	6.28	6.40
Fe_2O_3	47.87	47.19	49.44	K_2O	0.63	0.00	
FeO	0.00			H_2O	14.45	14.95	14.87
MnO	0.99	0.00		insol.	1.04		
MgO		0.00		Total	100.20	100.99	100.00

(1) Sapucaia mine, Brazil; corresponds to $(Na_{0.74}Mn_{0.07}K_{0.06}Ca_{0.01})_{\Sigma=0.88}(Fe^{3+}_{2.93}Al_{0.13})_{\Sigma=3.06}(PO_4)_2(OH)_{3.84} \cdot 2H_2O$. (2) Near Torre Argentina, Sardinia, Italy; by electron microprobe, H_2O by TGA; corresponds to $(Na_{0.92}Ca_{0.06})_{\Sigma=0.98}Fe^{3+}_{2.98}(PO_4)_{2.03}(OH)_{4.00} \cdot 2.00H_2O$.
(3) $NaFe_3(PO_4)_2(OH)_4 \cdot 2H_2O$.

Occurrence: A rare accessory mineral in some oxidizing phosphate-bearing granite pegmatites and iron deposits.

Association: Dufrénite, frondelite, phosphosiderite, leucophosphite, whitlockite, kingsmountite, triphylite, rockbridgeite, strengite, phosphosiderite, jahnsite, montgomeryite, millisite, wardite, apatite, wavellite.

Distribution: From the Cyrilov pegmatite, Velké Meźiříči, Czech Republic. In the Gunheath china clay pit, St. Austell, Cornwall, England. At Rochefort-en-Terre, Bretagne, France. In Portugal, from the Vermilhas pegmatite, Vouzela; the Mangualde pegmatite, near Mesquitela; and the Bendada pegmatite, near Guarda. At Hagendorf, Bavaria, Germany. Between Torre Argentina and Punta Capuzzo, Bosa region, Sardinia, Italy. In the Kabingo pegmatites, Rwanda. From Kokpatas and Djargantan, central Kyzylkum region, Uzbekistan. At the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, and in the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. In Australia, on Milgun Station, Western Australia; in the Iron Monarch quarry, Iron Knob, at the Moculta phosphate quarry, northeast of Angaston, and in the Fairview quarry, near Robertstown, South Australia; at Wycheproof, and in the Lake Boga granite quarry, near Swan Hill, Victoria. In the USA, from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, and in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota.

Name: For its occurrence in the Cyrilov pegmatite, Czech Republic.

Type Material: National Museum of Natural History, Washington, D.C., USA, 107425.

References: (1) Novotný, M. and J. Staněk (1953) Nový minerál fosforečnan cyrilovit. Acta Acad. Sci. Nat. Moravo-Silesacae, 25(11), 325–336 (in Czech with English abs.). (2) (1955) Mineral. Abs., 12, 512–513 (abs. ref. 1). (3) Lindberg, M.L. (1957) Relationship of the minerals avelinoite, cyrilovite, and wardite. Amer. Mineral., 42, 204–213. (4) (1957) Amer. Mineral., 42, 586 [avelinoite = cyrilovite]. (5) Cozzupoli, D., O. Grubessi, A. Mottana, and P.F. Zanazzi (1987) Cyrilovite from Italy; structure and crystal chemistry. Mineral. Petrol., 37, 1–14.

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Dachiardite $(Ca, Na_2, K_2)_5Al_{10}Si_{38}O_{96}\cdot 25H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed prismatic crystals, commonly fibrous, to 7 mm, and radiating aggregates. *Twinning:* On {110}, rare cyclical eightlings.

Physical Properties: *Cleavage:* Perfect on {001}, {100}. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 2.165–2.206 D(calc.) = 2.138–2.141

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+) or (–). *Orientation:* $X = b$; $Z \wedge c = 35°$. α = 1.484–1.492 β = 1.482–1.496 γ = 1.489–1.500 2V(meas.) = 65°–73°

Cell Data: *Space Group:* $C2/m$. $a = 18.625$ $b = 7.508$ $c = 10.247$ $\beta = 108.056°$ Z = 1

X-ray Powder Pattern: Elba, Italy.
3.452 (100), 3.204 (100), 1.873 (75), 8.90 (50), 6.91 (50), 4.97 (50), 4.88 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	63.20	64.53	Na_2O	1.20	2.16
Al_2O_3	14.31	13.77	K_2O	1.92	1.31
Fe_2O_3		0.01	Cs_2O	0.96	
MgO	0.00	0.00	H_2O^+		11.23
CaO	5.49	5.60	H_2O^-		1.04
SrO	0.13		H_2O	[12.79]	
			Total	[100.00]	99.65

(1) Elba, Italy; by electron microprobe, H_2O by difference; corresponds to $(Ca_{3.52}K_{0.73}Na_{0.70}Cs_{0.24}Sr_{0.04})_{\Sigma=5.23}Al_{10.10}Si_{37.86}O_{96}\cdot nH_2O$. (2) Hatsuneura, Ogasawara Islands, Japan.

Mineral Group: Zeolite group.

Occurrence: Of hydrothermal origin in basalt, quartz veins, and pegmatites; in hydrothermally altered pumiceous tuffaceous sediments.

Association: Mordenite, heulandite, ferrierite.

Distribution: From San Piero in Campo, Elba, and on the Alpe di Siusi, Trentino-Alto Adige, Italy. From near Zvezdel, Rhodope Mountains, Bulgaria. In Japan, at Hatsuneura, Ogasawara Islands; Hokiya-dake, Nagano Prefecture; and in the Onoyama mine, Kagoshima Prefecture. In the USA, from Altoona, Wahkiakum Co., Washington; at Cape Lookout, Tillamook Co., and Agate Beach, Lincoln Co., Oregon; and in the Lower Geyser basin, Yellowstone National Park, Wyoming. A number of other localities are known.

Name: For Antonio D'Achiardi (1839–1902), Italian mineralogist, whose son described the mineral.

Type Material: Natural History Museum, Paris, France, 109.1084; National Museum of Natural History, Washington, D.C., USA, 123998.

References: (1) D'Achiardi, G. (1906) Zeoliti del filone della Speranza presso S. Piero in Campo (Elba). Mem. Soc. Tosc. Sci. Nat., 22, 150–165 (in Italian). (2) Berman, H. (1925) Notes on dachiardite. Amer. Mineral., 10, 421–428. (3) Galli, E. (1965) Lo spettro di polvere della dachiardite. Period. Mineral., 34, 129–135 (in Italian). (4) Bonardi, M. (1979) Composition of type dachiardite from Elba: a re-examination. Mineral. Mag., 43, 548–549. (5) Nishido, H. and R. Otsuka (1981) Chemical composition and physical properties of dachiardite group zeolites. Mineral. J. (Japan), 10, 371–384. (6) Quartieri, S., G. Vezzalini, and A. Alberti (1990) Dachiardite from Hokiya-dake: evidence of a new topology. Eur. J. Mineral., 2, 187–193.

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Dadsonite $Pb_{21}Sb_{23}S_{55}Cl$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2, or Triclinic. *Point Group:* $\overline{1}$ or 1. As fibrous needles, generally multiple crystals, elongated and striated ‖ [010], to 2 mm;; typically in aggregates resembling "steel wool".

Physical Properties: Hardness = 2.5 VHN = 226–279 (15 g load). D(meas.) = 5.68 D(calc.) = 5.51

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, white with a greenish tint, with blood-red internal reflections in oil. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Distinct to strong, in greenish gray.
R_1–R_2: (400) 44.0–46.6, (420) 42.3–45.8, (440) 40.8–45.1, (460) 39.6–44.5, (480) 39.2–44.1, (500) 39.1–44.0, (520) 39.1–44.0, (540) 39.1–43.9, (560) 38.9–43.0, (580) 38.4–42.0, (600) 37.9–41.3, (620) 37.3–40.6, (640) 36.8–39.9, (660) 36.2–39.1, (680) 35.7–38.1, (700) 35.3–37.1

Cell Data: *Space Group:* $P2/m$, Pm, or $P2$, with $a = 19.041$ $b = 8.226$ $c = 17.327$ $\beta = 96°18'$ Z = 1, or *Space Group:* $P\overline{1}$ or $P1$, with $a = 17.33$ $b = 4.11$ $c = 19.05$ $\alpha = 90.0°$ $\beta = 96.3°$ $\gamma = 90.4°$ Z = 2

X-ray Powder Pattern: Saint-Pons, France.
2.795 (100), 2.069 (92), 3.393 (74), 3.371 (72), 3.713 (51), 2.843 (47), 3.792 (45)

Chemistry:

	(1)	(2)	(3)	(4)
Pb	48.9	48.8	48.7	48.61
Fe	0.04			
Sb	29.1	30.4	31.3	31.29
As	1.0			
S	19.9	19.5	19.7	19.70
Cl	0.19	0.23	0.4	0.40
Total	99.13	98.93	100.1	100.00

(1) Madoc, Canada; by electron microprobe, corresponds to $Pb_{20.9}(Sb_{21.2}As_{1.2})_{\Sigma=22.4}S_{55.0}Cl_{0.5}$. (2) Wolfsberg, Germany; by electron microprobe, corresponds to $Pb_{21.0}Sb_{22.6}S_{55.0}Cl_{0.6}$. (3) Saint-Pons, France; by electron microprobe; corresponds to $Pb_{21.0}Sb_{23.0}S_{55.0}Cl_{1.0}$. (4) $Pb_{21}Sb_{23}S_{55}Cl$.

Occurrence: In hydrothermal veins with other sulfides and lead sulfosalt minerals.

Association: Jamesonite (Northwest Territories and Ontario, Canada); robinsonite (Pershing Co., Nevada, USA); bournonite, boulangerite, zinkenite, chalcostibite (Saint-Pons, France).

Distribution: In Canada, in the Brock zone of the Giant property, Yellowknife, Northwest Territories [TL]; and from Madoc, Ontario [TL]. In the USA, at the Red Bird mercury mine, Rye Patch district, Pershing Co., Nevada [TL]. In Germany, in the Harz Mountains, from Wolfsberg [TL], St. Andreasberg, and Harzburg. In France, at Saint-Pons, Alpes-de-Haute-Provence.

Name: To honor the Canadian mineralogist, Alexander Stewart Dadson (1906–1958), active in development of the Yellowknife gold deposits.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M30905; National School of Mines, Paris, France; The Natural History Museum, London, England, 1972,11; National Museum of Natural History, Washington, D.C., USA, 123240.

References: (1) Jambor, J.L. (1969) Dadsonite (minerals Q and QM), a new lead sulphantimonide. Mineral. Mag., 37, 437–441. (2) (1970) Amer. Mineral., 55, 1445 (abs. ref. 1). (3) Cervelle, B.D., F.P. Cesbron, and M.-C. Sichére (1979) La chalcostibite et la dadsonite de Saint-Pons, Alpes de Haute Provence, France. Can. Mineral., 17, 601–605 (in French with English abs.). (4) Jambor, J.L., J.H.G. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100. (5) Makovicky, E. and W.G. Mumme (1984) The crystal structure of izoklakeite, dadsonite and jaskolskiite. Acta Cryst., A40, supplement, C-246.

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Daliranite $PbHgAs_2S_6$

Crystal Data: Monoclinic. *Point Group*: n.d. As matted nests of acicular fibers < 0.2 mm long and < 0.003 mm in diameter, elongated along [010].

Physical Properties: *Cleavage*: none discernable. *Fracture*: n.d.
Tenacity: Brittle, flexible. Hardness = < 2 D(meas.) = n.d. D(calc.) = 5.93

Optical Properties: Transparent. *Color*: Vibrant orange-red; gray in reflected light, orange-red internal reflections. *Streak*: Pale orange-red. *Luster*: Adamantine.
Optical Class: n.d.
R: (470) 32.9, (546) 30.5, (589) 34.0, (650) 39.5

Cell Data: *Space Group*: *P2*, *Pm* or *P2/m*. a = 19.113(5) b = 4.233(2) c = 22.958(8)
β = 114.78(5)° Z = 8

X-ray Powder Pattern: Zarshouran Au-As deposit, northwest Iran.
2.722 (100), 8.67 (80), 4.65 (50), 3.40 (50), 2.894 (50), 2.187 (50), 3.87 (40)

Chemistry:

	(1)	(2)
Pb	23.26	27.63
Hg	24.77	26.75
Tl	0.19	
As	18.75	19.98
S	22.48	25.65
Total	89.44	100.01

(1) Zarshouran Au-As deposit, northwest Iran, average of 8 electron microprobe analyses, corresponding to $Pb_{0.95}Tl_{0.01}Hg_{1.04}As_{2.10}S_{5.91}$. (2) $PbHgAs_2S_6$.

Occurrence: A late-stage hydrothermal mineral formed by reaction with orpiment in a Carlin-type, sediment-hosted disseminated Au-As deposit.

Association: Orpiment, quartz, rarely with galkhaite, hutchinsonite and cinnabar.

Distribution: Zarshouran Au-As deposit, 42 km north of the town of Takab, West Azarbaijan Province, northwest Iran.

Name: Honors Dr. Farahnaz Daliran (b. 1953), mineralogist and economic geologist at the University of Karlsruhe, Germany, for her research on ore deposits in Iran.

Type Material: Mineralogical Museum, Department of Materials Engineering and Physics (Mineralogy), University of Salzburg, Austria (sample nos. 14947/14948); the South Australian Museum, Adelaide, Australia (catalog no. G29976).

References: (1) Paar, W.H., A. Pring, Y. Moëlo, C.J. Stanley, H. Putz, D. Topa, A.C. Roberts, and R.S.W. Braithwaite (2009) Daliranite, $PbHgAs_2S_6$, a new sulfosalt from the Zarshouran Au-As deposit, Takab region, Iran. Mineral. Mag., 73, 871–881. (2) (2010) Amer. Mineral., 95, 1358-1359 (abs. ref. 1).

Dalnegroite $Tl_{5-x}Pb_{2x}(As,Sb)_{21-x}S_{34}$

Crystal Data: Triclinic. *Point Group*: n.d. As imperfect acicular crystals, to 0.03 mm; in sheaflike sub-parallel aggregates.

Physical Properties: *Cleavage*: none discernable. *Fracture*: Uneven.
Tenacity: Brittle. Hardness = 3-3.5 VHN = 87 (25 g load). D(meas.) = n.d. D(calc.) = 4.82

Optical Properties: Opaque. *Color*: Dark gray. *Streak*: Brownish-red.
Luster: Submetallic. *Anistropism:* Strong, bluish to green, red internal reflections.
Bireflectance: Strong. *Pleochroism:* Weak, white to slightly greenish gray.
Optical Class: n.d.
R_1-R_2: (471.1) 45.6-46.1, (548.3) 46.1-46.6, (586.6) 46.1-46.6, (652) 46.4-47.1

Cell Data: *Space Group*: *P1* (probable). a = 16.217(7) b = 42.544(9) c = 8.557(4)
α = 95.72(4)° β = 90.25(4)° γ = 96.78(4)° Z = 4

X-ray Powder Pattern: Lengenbach quarry, Binntal, Switzerland.
3.927 (100), 2.850 (70), 2.929 (60), 2.097 (60), 3.620 (50), 3.124 (50), 3.775 (45)

Chemistry:

	(1)
Pb	10.09
Sb	23.95
Tl	20.36
As	21.38
S	26.16
Total	101.94

(1) Lengenbach quarry, Binntal, Switzerland; average of 11 electron microprobe analyses, corresponding to $Tl_{4.15}Pb_{2.03}(As_{11.86}Sb_{8.20})S_{34}$.

Occurrence: Of hydrothermal origin in dolomitic marble.

Association: Realgar, pyrite, Sb-rich hutchinsonite, jordanite, Sb-rich seligmanite, sinnerite.

Distribution: Lengenbach quarry, Binntal, Switzerland.

Name: Honors Alberto Dal Negro (b. 1941), Professor in Mineralogy and Crystallography at the University of Padova, Italy, since 1976.

Type Material: Museum of Mineralogy, Department of Geosciences, University of Padova, Italy (catalog no. MMP M7620).

References: (1) Nestola, F., A. Guastoni, L. Bindi, and L. Secco (2009) Dalnegroite, $Tl_{5-x}Pb_{2x}(As,Sb)_{21-x}S_{34}$, a new thallium sulfosalt from Lengenbach quarry, Binntal, Switzerland. Mineral. Mag., 73, 1027–1032. (2) (2010) Amer. Mineral., 95, 1359 (abs. ref. 1).

Dalyite $K_2ZrSi_6O_{15}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals short prismatic, to 0.5 mm, dominated by $\{\overline{1}01\}$ and pinacoids ∥ to [001]. *Twinning:* Not uncommon, with {100} as the composition plane.

Physical Properties: *Cleavage:* Distinct on $\{\overline{1}01\}$ and {010}, indistinct on {100}. *Tenacity:* Brittle. Hardness = 7.5 D(meas.) = 2.84(2) D(calc.) = 2.81 Strongly cathodoluminescent in bright azure-blue.

Optical Properties: Transparent. *Color:* Colorless, white, pink, brown. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X \wedge c = 7°$. *Dispersion:* $r > v$, very weak. $\alpha = 1.575(2)$ $\beta = 1.590(2)$ $\gamma = 1.601(2)$ 2V(meas.) = 72(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.371(3)$ $b = 7.730(3)$ $c = 6.912(2)$ $\alpha = 106°14(2)'$ $\beta = 111°27(2)'$ $\gamma = 100°0(2)'$ $Z = 1$

X-ray Powder Pattern: Ascension Island.
4.20 (vs), 3.58 (vs), 3.08 (vs), 5.90 (s), 4.31 (s), 6.54 (m), 3.36 (m)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	61.85	63.07	MgO		0.10
TiO_2		1.23	CaO		0.02
ZrO_2	21.70	19.37	BaO		0.11
Al_2O_3		0.06	Na_2O	1.75	0.04
Fe_2O_3	0.37		K_2O	14.60	15.60
FeO		0.28	H_2O	0.64	
MnO		0.02	P_2O_5		0.04
			Total	100.91	99.94

(1) Ascension Island; corresponds to $(K_{1.79}Na_{0.32})_{\Sigma=2.11}Zr_{1.01}Si_{5.95}O_{15}$. (2) Dalsfjorden, Norway; by electron microprobe, average of ten analyses; corresponds to $(K_{1.90}Fe_{0.02}Mg_{0.02}Na_{0.01})_{\Sigma=1.95}(Zr_{0.90}Ti_{0.09}Al_{0.01})_{\Sigma=1.00}Si_{6.01}O_{15}$.

Occurrence: A rare accessory in ejected blocks of alkalic granite in trachytic and basaltic tuffs (Ascension Island); in syenite (Serra de Agua de Pau, Azores); in lamproite (Cancarix, Spain).

Association: Quartz, aegirine, arfvedsonite, aenigmatite (Ascension Island); sanidine, arfvedsonite, quartz, aegirine, fayalite, astrophyllite, pyrrhotite (Serra de Agua de Pau, Azores); pyrophanite, elpidite, monazite, janhaugite, kupletskite (Gjerdingen, Norway).

Distribution: On Green Mountain and Middleton Peak, Ascension Island, southern Atlantic Ocean. From Serra de Agua de Pau, São Miguel, Azores. Near Cancarix, Albacete Province, Spain. At Dalsfjorden, Sunnfjord, and Gjerdingen, near Oslo, Norway. In the Straumsvola complex, Dronning Maud Land, Antarctica. From the Murun massif, southwest of Olekminsk, and other less-well-defined localities in the Aldan Shield, Yakutia, Russia.

Name: For Reginald Aldworth Daly (1871–1957), Professor of Geology, Harvard University, Cambridge, Massachusetts, USA.

Type Material: The Natural History Museum, London, England, 64685; National Museum of Natural History, Washington, D.C., USA, 113106.

References: (1) Van Tassel, R. and M.H. Hey (1952) Dalyite, a new potassium zirconium silicate from Ascension Island, Atlantic. Mineral. Mag., 29, 850–857. (2) (1952) Amer. Mineral., 37, 1071 (abs. ref. 1). (3) Fleet, S.G. (1965) The crystal structure of dalyite. Zeits. Krist., 121, 349–368. (4) Robins, B., H. Furnes, and P. Ryan (1983) A new occurrence of dalyite. Mineral. Mag., 47, 93–94.

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Damaraite $Pb_4O_3Cl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As tiny flakes and subhedral grains, to 150 μm, in host minerals.

Physical Properties: *Cleavage:* {010}, good. *Fracture:* Irregular to subconchoidal. *Tenacity:* Brittle. Hardness = ∼3 VHN = 145–154, 148 average (50 g load). D(meas.) = n.d. D(calc.) = 7.84

Optical Properties: Transparent. *Color:* Colorless; in reflected light, gray with white to colorless internal reflections. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial; near uniaxial (+). *Pleochroism:* Very weak; gray to slightly bluish gray. *Anisotropism:* Weak. *Bireflectance:* Weak.
R_1–R_2: (400) 19.1–20.8, (420) 18.6–23.1, (440) 17.9–21.1, (460) 17.4–19.4, (480) 16.9–18.5, (500) 16.6–17.9, (520) 16.2–17.4, (540) 16.0–17.0, (560) 15.8–16.7, (580) 15.6–16.5, (600) 15.5–16.3, (620) 15.4–16.2, (640) 15.2–16.0, (660) 15.2–15.9, (680) 15.1–15.8, (700) 15.0–15.6

Cell Data: *Space Group:* $Pmam$, $P2_1am$, or $Pma2$. $a = 15.104(1)$ $b = 6.891(1)$ $c = 5.806(1)$ Z = 3

X-ray Powder Pattern: Kombat mine, Namibia.
2.902 (10), 2.766 (10), 2.877 (9), 3.164 (6), 3.135 (6), 1.747 (6), 3.824 (5)

Chemistry:

	(1)	(2)
Pb	87.04	87.45
O	[5.08]	5.07
Cl	7.29	7.48
Total	[99.41]	100.00

(1) Kombat mine, Namibia; by electron microprobe, average of four analyses; corresponds to $Pb_{4.02}O_{3.03}Cl_{1.97}$. (2) $Pb_4O_3Cl_2$.

Occurrence: From a late-stage vein cutting a banded manganese ore lens in Cu–Pb–Ag ores formed by hydrothermal and metasomatic replacement of dolostones (Kombat mine, Namibia).

Association: Jacobsite, hausmannite, hematophanite, defernite, crednerite, asisite, andradite, vesuvianite, copper, calcite, barite (Kombat mine, Namibia).

Distribution: From the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia. At Laurium, Greece, in slag. Found in the Elura Zn–Pb–Ag deposit, 43 km northeast of Cobar, New South Wales, Australia.

Name: For the Damara dolostone sequence, which hosts the Kombat deposit.

Type Material: The Natural History Museum, London, England, 1988,256–257; Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany.

References: (1) Criddle, A.J., P. Keller, C.J. Stanley, and J. Innes (1990) Damaraite, a new lead oxychloride mineral from the Kombat mine, Namibia (South West Africa). Mineral. Mag., 54, 593–598. (2) (1992) Amer. Mineral., 77, 671 (abs. ref. 1).

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Damiaoite $PtIn_2$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Polycrystalline globules, to 2 mm; exsolved from yixunite.

Physical Properties: *Tenacity:* "weakly malleble." Hardness = 5.3 VHN = 434–529, 485 average (50 g load). D(meas.) = n.d. D(calc.) = 10.95

Optical Properties: Opaque. *Color:* Steel-black; bright white with a yellowish tint in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R: (400) 65.4, (420) 51.4, (440) 49.3, (460) 49.0, (480) 49.9, (500) 52.0, (520) 55.0, (540) 58.5, (560) 62.5, (580) 66.5, (600) 70.2, (620) 74.5, (640) 77.7, (660) 81.5, (680) 84.2, (700) 86.9

Cell Data: *Space Group: Fm3m.* a = 6.363(4) Z = 4

X-ray Powder Pattern: Near Damiao village, China.
2.25 (100), 1.299 (80), 1.006 (70), 1.92 (60), 1.59 (60), 1.125 (60), 3.67 (50)

Chemistry:

	(1)	(2)
Pt	45.6	45.93
In	53.5	54.07
Total	99.1	100.00

(1) Near Damiao village, China; by electron microprobe, average of nine analyses. (2) $PtIn_2$.

Occurrence: In a contact metasomatic Co–Cu–Pt-bearing vein in garnet-amphibole pyroxenite in contact with anorthosite and granite.

Association: Moncheite, sperrylite, cooperite, yixunite, cobaltian malanite, bornite, chalcopyrite, carrolite, magnetite.

Distribution: From near Damiao village and the Yixun River, about 270 km north of Beijing, Hebei Province, China [TL].

Name: For its occurrence near the village of Damiao, China.

Type Material: n.d.

References: (1) Yu Zuxiang (1997) Damiaoite – a new native indium and platinum alloy. Acta Geol. Sinica, 71(4), 328–331 (in Chinese with English abs.). (2) (1998) Amer. Mineral., 83, 653 (abs. ref. 1).

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Danalite $Fe_4^{2+}Be_3(SiO_4)_3S$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As octahedral and dodecahedral crystals, to 10 cm; as irregular segregations.

Physical Properties: *Cleavage:* Poor on {111}, {1$\bar{1}$1}. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.28–3.46 D(calc.) = 3.36

Optical Properties: Semitransparent. *Color:* Yellow, pink, reddish brown, red; in thin section, colorless to pink. *Luster:* Vitreous or greasy.
Optical Class: Isotropic. n = 1.747–1.771

Cell Data: *Space Group:* $P\bar{4}3n$. a = 8.20–8.23 Z = 2

X-ray Powder Pattern: Needlepoint Mountain, Canada.
3.35 (100), 1.932 (70), 1.012 (60), 2.193 (50), 1.118 (50), 1.043 (50), 3.68 (40)

Chemistry:

	(1)	(2)	(3)	(4)
SiO_2	29.48	34.08	30.76	32.26
FeO	37.53	30.66	44.27	51.44
MnO	11.53	13.28	7.37	
ZnO	4.87	2.97	0.89	
BeO	14.17	16.32	[13.42]	13.42
CaO			0.07	
S	5.04	5.61	5.41	5.74
$-O = S$	2.52	2.80	[2.70]	2.86
Total	100.10	100.12	[99.49]	100.00

(1) Redruth, England; corresponds to $(Fe^{2+}_{2.96}Mn^{2+}_{0.92}Zn_{0.34})_{\Sigma=4.22}Be_{3.32}Si_{2.78}O_{12}S$. (2) Imalka, Russia; corresponds to $(Fe^{2+}_{2.28}Mn^{2+}_{1.00}Zn_{0.19})_{\Sigma=3.47}Be_{3.48}Si_{3.02}O_{12}S$. (3) Bartlett, New Hampshire, USA; by electron microprobe, BeO calculated from stoichiometry. (4) $Fe_4Be_3(SiO_4)_3S$.

Polymorphism & Series: Forms two series, with genthelvite, and with helvite.

Occurrence: In granites, granite pegmatites, zones of contact metamorphism, skarns, and gneisses.

Association: Magnetite, garnet, fluorite (skarn); albite, cassiterite, pyrite, muscovite (tin-bearing pegmatites); arsenopyrite, quartz, chlorite (hydrothermal deposits).

Distribution: In the USA, at Rockport and Gloucester, Essex Co., Massachusetts; on Moat Mountain, Conway, Carroll Co., New Hampshire; at Iron Mountain, Sierra Co., New Mexico; and from the Black Hills, south of Jerome, Yavapai Co., Arizona. From Needlepoint Mountain, McDame area, British Columbia, and on Walrus Island, James Bay, Quebec, Canada. In Sweden, from Yxsjö, Örebro. At Redruth, St. Just, Lanlivery, Falmouth, and Lanivet, Cornwall, England. In Russia, from Imalka, Transbaikal, and other less-well-defined localities. From the Kara mine, Tasmania, and on Mt. Francisco, Ribawa area, Western Australia. In the Mihara mine, Hiroshima Prefecture, Japan.

Name: To honor James Dwight Dana (1813–1895), American geologist and mineralogist, Yale University, New Haven, Connecticut, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 85384; National Museum of Natural History, Washington, D.C., USA, 124353; The Natural History Museum, London, England, 1976,422.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 435. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 303–309. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 119–126. (4) Glass, J.J., R.H. Jahns, and R.E. Stevens (1944) Helvite and danalite from New Mexico and the helvite group. Amer. Mineral., 29, 163–191. (5) Thompson, R.M. (1957) Danalite from British Columbia. Can. Mineral., 6, 68–71. (6) Dunn, P.J. (1976) Genthelvite and the helvine group. Mineral. Mag., 40, 627–636. (7) Hassan, I. and H.D. Grundy (1985) The crystal structures of helvite group minerals, $(Mn, Fe, Zn)_8(Be_6Si_6O_{24})S_2$. Amer. Mineral., 70, 186–192.

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Danbaite $CuZn_2$

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Crystal Data: Cubic. *Point Group:* n.d. Botryoidal and spherulitic aggregates, to 0.2 mm, as rims around chromium.

Physical Properties: Hardness = 4.2 VHN = 234–288 (20 g load). D(meas.) = n.d. D(calc.) = 7.36

Optical Properties: Opaque. *Color:* Silver-white to grayish white; white with a milky blue tint in reflected light, slightly yellowish compared to chromium. *Luster:* Strong metallic.
R: (470) [71.0], (546) 68.5, (589) 67.9, (650) [66.7]

Cell Data: *Space Group:* n.d. $a = 7.7615$ $Z = 12$

X-ray Powder Pattern: Danba, China.
2.0803 (10), 2.3552 (5), 2.1574 (4), 1.3732 (4), 1.5901 (3), 1.2256 (3), 1.2154 (3)

Chemistry:

	(1)	(2)	(3)
Cu	33.12	32.52	32.70
Zn	66.70	67.47	67.30
Total	99.82	99.99	100.00

(1) Danba, China; by electron microprobe, corresponding to $Cu_{1.00}Zn_{1.96}$. (2) Do.; corresponding to $Cu_{1.00}Zn_{2.02}$. (3) $CuZn_2$.

Occurrence: In a platinum-bearing Cu–Ni deposit in a highly altered ultramafic intrusion.

Association: Chromium, pyrrhotite, pentlandite, chalcopyrite, violarite, cubanite, bornite, sphalerite, galena, linnaeite, magnetite, testibiopalladite, sudburyite, sperrylite, omeiite, gold.

Distribution: From Danba, Sichuan Province, China [TL].

Name: For the locality at Danba in China.

Type Material: n.d.

References: (1) Yue Shuqin, Wang Wenying, Liu Jinding, Sun Shuqiong, and Che Dianfen (1983) A study on danbaite. Kexue Tongbao, 22, 1383–1386 (in Chinese). (2) (1984) Amer. Mineral., 69, 566 (abs. ref. 1).

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Danburite $CaB_2(SiO_4)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, rhomboidal to square in cross section, to 50 cm; also as disseminated masses.

Physical Properties: *Cleavage:* Indistinct on {001}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 7–7.25 D(meas.) = 2.93–3.02 D(calc.) = 2.99

Optical Properties: Transparent to translucent. *Color:* Colorless, white, wine-yellow, yellowish brown, greenish; colorless in thin section. *Streak:* White. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (–). *Dispersion:* $r < v$, strong. $\alpha = 1.627$–1.633 $\beta = 1.630$–1.636 $\gamma = 1.633$–1.639 2V(meas.) = $\sim 90°$

Cell Data: *Space Group: Pnam.* $a = 8.038(3)$ $b = 8.752(5)$ $c = 7.730(3)$ $Z = 4$

X-ray Powder Pattern: Maglovec Hill, Prešov, Slovakia.
3.57 (100), 2.961 (80), 2.743 (65), 2.655 (55), 2.729 (40), 1.435 (40), 3.65 (35)

Chemistry:

	(1)
SiO_2	49.18
B_2O_3	27.65
Al_2O_3	0.42
FeO	0.26
MnO	0.02
MgO	0.11
CaO	22.10
SrO	0.03
Na_2O	0.07
H_2O	0.24
Total	100.08

(1) Maglovec Hill, Prešov, Slovakia; corresponds to $(Ca_{0.97}Na_{0.01}Mg_{0.01}Fe_{0.01})_{\Sigma=1.00}(B_{1.95}Al_{0.02})_{\Sigma=1.97}Si_{2.01}O_{8.00}$.

Occurrence: In granite and metamorphosed carbonate rocks associated with hydrothermal activity; in evaporites.

Association: Titanite, axinite, tourmaline, mica, quartz, grossular, albite, fluorite, apophyllite, stilbite, datolite, bakerite, dolomite, calcite, anhydrite, gypsum.

Distribution: In the USA, at Danbury, Fairfield Co., Connecticut; and at Russell, St. Lawrence Co., New York. In Mexico, large crystals from Charcas, San Luis Potosí; and in the La Verde mine, near La Huerta, Baja California. From Alto Chapare, Cochabamba, Bolivia. In Switzerland, on the Piz Valatscha, Mt. Scopi, south of Disentis, Graubünden. In Madagascar, very large crystals from Anjanabonoina; at Maharitra, Mt. Bity; at Imalo, near Mania, south of the Betafo district; and at Sahasonjo, northeast of Andina. In Russia, from Alabashka, near Mursinka, Ural Mountains; large crystals from Vostochnaïa, Siberia, and at Dal'negorsk, Primorskiy Kray; numerous other minor occurrences. From the Mogok district, Myanmar (Burma). In Japan, from the Obira mine, Bungo, Oita Prefecture, and at Toroku, Miyazaki Prefecture.

Name: For the locality at Danbury, Connecticut, USA.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 490–492.
(2) Černý, P. (1973) The occurrence of danburite in xenoliths in andesite from Maglovec, near Prešov, Czechoslovakia. Acta Univ. Carol., Geol., Rost vol., 111–118 (in Czech with English abs.).
(3) Phillips, M.W., G.V. Gibbs, and P.H. Ribbe (1974) The crystal structure of danburite: a comparison with anorthite, albite, and reedmergnerite. Amer. Mineral., 59, 79–85.

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Danielsite $(Cu, Ag)_{14}HgS_8$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. As ragged polycrystalline masses of grains, up to 20 μm, in anglesite.

Physical Properties: *Tenacity:* Brittle. Hardness = 2–2.5 VHN = 38 (10 g load). D(meas.) = n.d. D(calc.) = 6.541

Optical Properties: Opaque. *Color:* Gray in polished section. *Anisotropism:* Moderate, in shades of gray. *Bireflectance:* Weak.
R_1–R_2: (470) 32–34, (546) 30–31, (589) 28–30, (650) 27–29

Cell Data: *Space Group:* n.d. $a = 9.644$ $b = 9.180$ $c = 18.156$ $Z = 4$

X-ray Powder Pattern: Coppin Pool, Western Australia.
2.622 (10), 1.959 (6), 1.875 (6), 2.392 (5), 2.831 (3), 4.44 (2), 3.648 (2)

Chemistry:

	(1)
Cu	33.9
Ag	36.5
Hg	12.3
S	16.1
Total	98.8

(1) Coppin Pool, Australia; by electron microprobe, average of four analyses; corresponds to $(Cu_{8.54}Ag_{5.43})_{\Sigma=13.97}Hg_{0.98}S_{8.05}$.

Occurrence: In a gossan pod in a quartz vein, as a weathering product derived from other sulfides.

Association: Anglesite, covellite, stromeyerite, chalcocite, cinnabar, other secondary lead and copper minerals.

Distribution: From near Coppin Pool, about 41 km east-southeast of Mount Tom Price, Western Australia.

Name: For Dr. John L. Daniels (1931–), Geoscan Pty. Ltd., who collected the material in which the species was found.

Type Material: Western Australian Museum, Perth; Museum Victoria, Melbourne, Australia.

References: (1) Nickel, E.H. (1987) Danielsite: a new sulfide mineral from Western Australia. Amer. Mineral., 72, 401–403. (2) Kato, A. and E. H. Nickel (1988) Possible unit cell for danielsite. Amer. Mineral., 73, 187–188.

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Dannemorite $Mn_2(Fe^{2+},Mg)_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, fibrous, to 1 cm; columnar or asbestiform.

Physical Properties: *Cleavage:* Perfect on {110}, with intersections at ∼55° and ∼125°. *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.50 D(calc.) = [3.35]

Optical Properties: Transparent to translucent. *Color:* Yellowish brown, greenish gray, colorless. *Luster:* Silky to vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = red-violet; Y = pale violet; Z = blue. *Orientation:* $Y = b$; $Z \wedge c = 15°$. *Dispersion:* $r < v$. $\alpha = 1.666$ $\beta = 1.682$ $\gamma = 1.698$ 2V(meas.) = 88°

Cell Data: *Space Group:* $C2/m$. a = 9.561 (ICDD 23-302). $b = 18.28$ $c = 5.348$ $\beta = 102.09°$ Z = 2

X-ray Powder Pattern: Väster Silfberg, Sweden. (ICDD 23-302).
8.40 (100), 3.08 (60), 3.28 (20), 2.764 (18), 4.70 (12), 2.637 (10), 2.201 (10)

Chemistry:

	(1)	(2)
SiO_2	50.74	51.6
TiO_2	0.06	0.13
Al_2O_3	0.88	0.65
Fe_2O_3	1.80	
FeO	24.13	23.9
MnO	7.38	8.1
MgO	10.57	11.1
CaO	2.00	0.83
Na_2O	0.22	1.1
K_2O	0.08	0.09
F	0.07	
H_2O^+	1.94	
Total	99.87	97.5

(1) Uttersvik, Sweden; corresponds to $(Fe^{2+}_{3.10}Mg_{2.42}Mn_{0.96}Ca_{0.33}Fe^{3+}_{0.21}Na_{0.07}Ti_{0.01}K_{0.01})_{\Sigma=7.11}(Si_{7.80}Al_{0.16})_{\Sigma=7.96}O_{22}[(OH)_{1.99}F_{0.03}]_{\Sigma=2.02}$. (2) Haute-Maurienne, France; by electron microprobe.

Polymorphism & Series: Forms a series with tirodite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: $Mg/(Mg + Fe^{2+}) < 0.5$; $(Ca + Na)_B < 1.34$; $Li < 1.0$; $Mn \geq 0.5$.

Occurrence: An uncommon mineral in metamorphosed iron-poor manganiferous rocks.

Association: Calcite, quartz, garnet.

Distribution: From Dannemora, Uppland; Uttersvik and Nävekvarn, Södermanland; in the Brunsjö mine, near Grythyttan, Örebro; and at Väster Silfberg, Värmland, Sweden. At Haute-Maurienne, Isère, France. From Guarulhos, São Paulo, Brazil. At Paddy's River mine, Australian Capital Territory, and from Broken Hill, New South Wales, Australia.

Name: For the original locality, Dannemora, Sweden.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 386, 391, 395. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 239. (3) Mottana, A. (1986) Blueschist-facies metamorphism of manganiferous cherts: a review of the alpine occurrences. In: B.W. Evans and E.H. Brown, Eds., Blueschists and eclogites, Geol. Soc. Amer. Memoir 164, 267–299.

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D'ansite $Na_{21}Mg(SO_4)_{10}Cl_3$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As tetrahedral {211} crystals, modified by {$2\bar{1}1$} and {110}. *Twinning:* Polysynthetic twinning observed.

Physical Properties: Hardness = 2.5–3 D(meas.) = 2.63–2.655 D(calc.) = 2.60 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless, yellow, pale brown.
Optical Class: Isotropic. $n = 1.488–1.489$

Cell Data: *Space Group:* $I\bar{4}3m$. $a = 15.95$ $Z = 4$

X-ray Powder Pattern: Synthetic. (ICDD 41-1473).
3.396 (100), 2.815 (100), 3.123 (60), 2.584 (40), 4.257 (30), 3.982 (30), 2.518 (25)

Chemistry:

	(1)	(2)
SO_4	60.24	61.03
HCO_3	0.12	
Ca	0.06	
Mg	1.54	1.54
Na	30.68	30.67
K		
Cl	7.47	6.76
Total	100.11	100.00

(1) Jianghan Plain, China; corresponding to $Na_{21.25}Mg_{1.02}Cl_{3.35}(SO_4)_{10.00}$.
(2) $Na_{21}Mg(SO_4)_{10}Cl_3$.

Occurrence: A component of marine evaporite deposits.

Association: Vanthoffite, thénardite, blödite.

Distribution: In large amounts in the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China. From several locations in the Zechstein Basin, Germany, as in the Unstrut and the northern Harz districts.

Name: Honors Professor Jean D'Ans (1881–1969), German mineralogist, student of salt deposit chemistry, Technical University, Berlin, Germany.

Type Material: n.d.

References: (1) Autenrieth, H. and G. Braune (1958) Ein neues Salzmineral, seine Eigenschaften, sein Auftreten und seine Existenzbedingungen im System der Salze ozeanischer Salzablagerungen. Naturwiss., 45, 362–363 (in German). (2) (1958) Amer. Mineral., 43, 1221 (abs. ref. 1). (3) Shi Nicheng and Ma Zhesheng (1987) Crystal structure of d'ansite. Kexue Tongbao, 32(7), 478–481.

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Daomanite $CuPtAsS_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As tabular crystals, to 0.3 mm across, with prominent {010}, {100}, {001}, {011}, commonly with curved faces. *Twinning:* On {010}, forming "elbow twins", which may be multiple.

Physical Properties: *Cleavage:* Perfect on {010}, distinct on {100}, {001}, less distinct on {110}. *Fracture:* Steplike or uneven. *Tenacity:* Brittle. Hardness = n.d. VHN = 169–175 (10 to 20 g load). D(meas.) = n.d. D(calc.) = 7.57

Optical Properties: Opaque. *Color:* Steel-gray with yellow tint; in polished section, pale greenish yellow. *Luster:* Metallic. *Pleochroism:* Distinct; yellowish with green tint. *Anisotropism:* Strong. *Bireflectance:* Distinct.
R_1–R_2: (400) 37.0–44.0, (420) 37.9–44.6, (440) 39.1–45.0, (460) 40.4–45.3, (480) 41.5–45.5, (500) 42.2–45.6, (520) 42.8–38.6, (540) 42.9–45.3, (560) 42.8–45.2, (580) 42.4–45.0, (600) 41.8–44.8, (620) 41.2–44.7, (640) 40.6–44.5, (660) 40.1–44.4, (680) 39.8–44.0, (700) 39.7–43.7

Cell Data: *Space Group:* $Amam$, $Amam$, or $Ama2_1$. $a = 5.852$ $b = 15.876$ $c = 3.756$
$Z = 4$

X-ray Powder Pattern: Yanshan Mountains, China.
2.93 (10), 3.29 (6), 7.95 (5), 1.63 (5), 1.006 (5), 0.9299 (5), 2.72 (4)

Chemistry:

	(1)	(2)	(4)
Cu	15.68	15.57	15.98
Pt	49.73	50.64	49.06
As	18.30	17.74	18.84
S	16.31	16.43	16.12
Total	100.02	100.38	100.00

(1) China; by electron microprobe, corresponds to $Cu_{0.97}Pt_{1.00}As_{0.96}S_{2.00}$. (2) Do.; by electron microprobe, corresponds to $Cu_{0.96}Pt_{1.01}As_{0.92}S_{2.00}$. (3) Do.; by electron microprobe, average of three analyses, not given, stated to correspond to $Cu_{0.96}(Pt_{0.96}Rh_{0.01})_{\Sigma=0.97}As_{1.08}S_{2.00}$. (4) $CuPtAsS_2$.

Occurrence: A replacement of bornite in contact metasomatic platinum-bearing Co–Cu sulfide mineralization in peridotite-pyroxenite at the contact with anorthosite or granite-gneiss.

Association: Bornite, chalcopyrite, carrolite, pyrite, tetrahedrite, galena, molybdenite; minor sperrylite, cooperite, moncheite, cobaltian malanite, yixunite, damiaoite.

Distribution: In China, from Sandao and Tiema villages [TL] and near Damiao village and the Yixun River, about 270 km north of Beijing, Yanshan Mounains, Hebei Province.

Name: From the last syllables of its two Chinese localities, SanDAO and TieMA villages.

Type Material: n.d.

References: (1) Yu Tsu-Hsiang [Yu Zuxiang], Lin Shu-Jen, Chao Pao, Fang Ching-Sung, and Huang Chi-Shun (1974) A preliminary study of some new minerals of the platinum group and another associated new one in platinum-bearing intrusions in a region of China. Acta Geol. Sinica, 2, 202–218 (in Chinese with English abs.). (2) (1976) Amer. Mineral., 61, 184 (abs. ref. 1). (3) Yu Zuxiang, Ding Kuishou and Zhou Jianxiong (1978) Daomanite, a new platinum mineral. Acta Geol. Sinica, ??4, 320–327 (in Chinese with English abs.). [Yu Zuxiang formerly Yu Tsu-Hsiang]. (4) (1980) Amer. Mineral., 65, 408 (abs. ref. 3). (5) Yu Zuxiang (1986) Some new minerals from platinum-bearing rocks in Yanshan and Tibet regions, China. Bull. Inst. Geol., Chinese Acad. Geol. Sci., 15, 49–57 (in Chinese with English abs.). (6) Yu Zuxiang (2001) New data for daomanite. Acta Geol. Sinica, 75(3), 396–399 (in Chinese with English abs.).

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Daqingshanite-(Ce) $(Sr, Ca, Ba)_3(Ce, La)(PO_4)(CO_3)_{3-x}(OH, F)_x$

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Crystal Data: Hexagonal. *Point Group:* $3m$ (probable). As subhedral to rounded platy crystals, may be crudely rhombohedral, to 3 mm, in aggregates. *Twinning:* Complex polysynthetic twinning observed in some material.

Physical Properties: *Cleavage:* Perfect on $\{10\overline{1}1\}$. *Fracture:* Conchoidal. Hardness = n.d. VHN = 335 (20 g load). D(meas.) = 3.81 D(calc.) = 3.71

Optical Properties: Semitransparent. *Color:* Pale yellow to nearly white; colorless in thin section. *Streak:* White. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (–). $\omega = 1.708$ $\epsilon = 1.609$

Cell Data: *Space Group:* $R3m$, $R\overline{3}m$, or $R32$. $a = 10.058$–10.073 $c = 9.225$–9.234 $Z = 3$

X-ray Powder Pattern: Bayan Obo deposit, China.
3.16 (10), 2.52 (7), 3.95 (6), 2.040 (6), 1.941 (6), 2.110 (5), 1.895 (4)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	11.73	10.50	Fe_2O_3	0.21		K_2O	0.03	
CO_2	16.19	n.d.	MnO	0.02		F	0.80	0.29
ThO_2	0.04	< 0.22	MgO	0.72	< 0.12	Cl		0.10
Al_2O_3	0.18	< 0.12	CaO	6.17	0.94	H_2O^+	0.68	n.d.
La_2O_3	7.88	10.22	SrO	26.10	41.82	$-O = F_2$	0.34	
Ce_2O_3	10.16	12.24	BaO	15.98	4.57	Total	[99.376]	
RE_2O_3	2.696	< 3.36	Na_2O	0.13	< 0.16			

(1) Bayan Obo deposit, China; CO_2 and H_2O by gas chromatography, original total given as 99.20%; $RE_2O_3 = Pr_6O_{11}$ 0.70%, Nd_2O_3 1.59%, Sm_2O_3 0.106%, Eu_2O_3 0.02%, Gd_2O_3 0.12%, Tb_4O_7 0.05%, Dy_2O_3 0.03%, Ho_2O_3 0.03%, Er_2O_3 0.01%, Tm_2O_3 0.01%, Yb_2O_3 0.02%, Lu_2O_3 0.01%; corresponds to $(Sr_{1.52}Ca_{0.67}Ba_{0.63}Mg_{0.11}Na_{0.03})_{\Sigma=2.96}(Ce_{0.37}La_{0.29}RE_{0.10}Al_{0.02}Fe^{3+}_{0.02})_{\Sigma=0.80}(PO_4)_{1.00}(CO_3)_{2.23}[(OH)_{0.46}F_{0.26}]_{\Sigma=0.72}$. (2) Nkombwa Hill, Zambia; by electron microprobe, average of ten partial analyses; $RE_2O_3 = Pr_2O_3$ 0.83%, Nd_2O_3 1.71%, Sm_2O_3 < 0.42%, Gd_2O_3 < 0.40%; corresponds to $(Sr_{2.69}Ba_{0.20}Ca_{0.11})_{\Sigma=3.00}(Ce_{0.50}La_{0.42}RE_{0.10})_{\Sigma=1.02}(PO_4)_{0.99}(CO_3)_{3-x}[(OH), F]_x$.

Occurrence: In rare-earth-bearing carbonatite-derived biotite dolomite at the footwall of an iron orebody (Bayan Obo deposit, China); in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in altered magnesiocarbonatite (Nkombwa Hill, Zambia).

Association: Benstonite, huntite, strontianite, pyrite, phlogopite, monazite (Bayan Obo deposit, China); albite, ancylite, pyrite, anatase, chlorite (Mont Saint-Hilaire, Canada); dolomite, monazite, isokite, apatite, strontianite, quartz (Nkombwa Hill, Zambia).

Distribution: In the western Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. From Mont Saint-Hilaire, Quebec, Canada. At the Nkombwa Hill carbonatite, Zambia.

Name: For Mt. Daqingshan, near the Bayan Obo deposit, China.

Type Material: n.d.

References: (1) Ren Yingchen, Ximen Lulu, and Peng Zhizhong (1983) Daqingshanite – a new mineral recently discovered in China. Geochemistry, 2(2), 180–184 (in English). (2) (1984) Amer. Mineral., 69, 811 (abs. ref. 1). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 304. (4) Appleton, J.D., D.J. Bland, P.H. Nancarrow, M.T. Styles, S.H. Mambwe, and P. Zambezi (1992) The occurrence of daqingshanite-(Ce) in the Nkombwa Hill carbonatite, Zambia. Mineral. Mag., 56, 419–422. (5) Hughes, J.M. and N. Yunxiang (1994) A high-precision crystal structure refinement of daqingshanite-(Ce) from the Nkombwa Hill carbonatite, Zambia. Mineral. Mag., 58, 493–496.

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Darapiozite $KNa_2Li(Mn,Zn)_2ZrSi_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$ (probable). As masses, to 5 cm.

Physical Properties: Hardness = 5 D(meas.) = 2.92 D(calc.) = 2.80

Optical Properties: Semitransparent. *Color:* Colorless, white, rarely brownish or pale to deep blue.
Optical Class: Uniaxial (–). *Pleochroism:* O = violet; E = blue. $\omega = 1.580(2)$ $\epsilon = 1.575(2)$

Cell Data: *Space Group:* $P6/mcc$ (probable). $a = 10.32$ $c = 14.39$ Z = 2

X-ray Powder Pattern: Dara-i-Pioz massif, Tajikistan.
3.26 (100), 2.93 (65), 7.09 (60), 2.56 (55), 4.13 (50), 2.76 (45), 4.43 (40)

Chemistry:

	(1)
SiO_2	63.65
ZrO_2	5.00
RE_2O_3	0.96
Fe_2O_3	1.85
Nb_2O_5	0.90
MnO	8.25
ZnO	7.85
CaO	0.57
Li_2O	1.74
Na_2O	2.96
K_2O	5.14
LOI	0.58
Total	99.45

(1) Dara-i-Pioz massif, Tajikistan; corresponds to $K_{1.23}(Na_{1.08}Li_{0.58}Ca_{0.11})_{\Sigma=1.77}Li_{0.73}(Mn_{1.31}Zn_{1.10})_{\Sigma=2.41}(Zr_{0.46}Fe_{0.26}Nb_{0.07})_{\Sigma=0.79}Si_{12}[O,(OH)]_{30}$.

Mineral Group: Milarite group.

Occurrence: In an alkalic massif.

Association: Aegirine, quartz, sogdianite, eudialyte, manganoan pectolite, polylithionite.

Distribution: In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan.

Name: For the occurrence in the Dara-i-Pioz massif, Tajikistan.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76078.

References: (1) Semenov, E.I., V.D. Dusmatov, A.P. Khomyakov, A.A. Voronkov, and M.E. Kazakova (1975) Darapiosite [darapiozite], a new mineral of the milarite group. Zap. Vses. Mineral. Obshch., 104, 583–585 (in Russian). (2) (1976) Amer. Mineral., 61, 1053–1054 (abs. ref. 1).

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Darapskite $Na_3(NO_3)(SO_4)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular to prismatic crystals, elongated on [001] or [010], flattened on {100}, to 10 cm; less commonly as thick tabular {100} crystals with square to slightly rectangular outlines; rarely stalactitic, as flowstone, or in "flowers"; commonly in granular aggregates mixed with other saline minerals. *Twinning:* With composition plane {100}; may be polysynthetic.

Physical Properties: *Cleavage:* On {010} and {100}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.201(5) D(calc.) = 2.202 Soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 12°–13°$. *Dispersion:* $r > v$, strong. $\alpha = 1.388–1.391$ $\beta = 1.479–1.481$ $\gamma = 1.486$ 2V(meas.) = 27(1)° 2V(calc.) = 26°–33°35′

Cell Data: *Space Group:* $P2_1/m$. $a = 10.564(2)$ $b = 6.913(1)$ $c = 5.1890(9)$ $\beta = 102°47.8(0.8)'$ Z = 2

X-ray Powder Pattern: Oficina Alemania, Chile.
10.29 (100), 3.456 (35), 2.865 (35), 2.594 (30), 4.13 (25), 3.522 (25), 3.266 (18)

Chemistry:

	(1)	(2)
SO_3	32.88	32.67
N_2O_5	22.26	22.04
Na_2O	38.27	37.94
H_2O	7.30	7.35
Total	100.71	100.00

(1) Oficina Lautaro, Chile. (2) $Na_3(NO_3)(SO_4)\cdot H_2O$.

Occurrence: Widespread in commercial nitrate deposits, filling veins and cavities in cemented regolith, in an arid region (Chile); in saline arid soil (Death Valley, California, USA; Antarctica); a component of "flowers" and other cave incrustations, the nitrate probably supplied from urine and guano.

Association: Nitratine, niter, blödite, mirabilite, epsomite, halite, anhydrite.

Distribution: In Chile, in Antofagasta, from Oficina Lautaro, Pampa del Toro, Taltal district, in thick veins from Chuquicamata, and widespread in other nitrate deposits, such as those around Oficinas Alemania, María Elena, Victoria, Santa Lucia, and others; at Zapiga, Tarapacá. In Antarctica, around Mt. Erebus and in the Wright Valley, Victoria Land; in the McMurdo region. In the USA, from the Mineral Mountain mine, south of Stein's Pass, Peloncillo Mountains, Greenlee Co., Arizona; in California, in Death Valley, Inyo Co., as deposits in soil and in caves in the Funeral Mountains; in Flower Cave, southern Big Bend National Park, Texas.

Name: Honors Ludwig Darapsky (1857–1916), German–Chilean chemist and mineralogist, Santiago, Chile.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 309–311. (2) Ericksen, G.E. and M.E. Mrose (1970) Mineralogical studies of the nitrate deposits of Chile. II. Darapskite, $Na_3(NO_3)(SO_4)\cdot H_2O$. Amer. Mineral., 55, 1500–1517. (3) Hill, C.A. and R.C. Ewing (1977) Darapskite, $Na_3(NO_3)(SO_4)\cdot H_2O$, a new occurrence, in Texas. Mineral. Mag., 41, 548–550. (4) Sabelli, C. (1967) La struttura della darapskite. Atti Rend. Accad. Lincei, 42, 874–887 (in Italian with English abs.).

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Dashkovaite $Mg(HCO_3)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous, to 3 mm, in porous aggregates.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Sectile. Hardness = 1 D(meas.) = n.d. D(calc.) = 1.74

Optical Properties: Semitransparent. *Color:* White, colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* X = elongation. $\alpha = 1.465(3)$ $\beta = 1.486(3)$ $\gamma = 1.516(3)$ 2V(meas.) = n.d. 2V(calc.) = 81(5)°

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy to synthetic). $a = 8.64(1)$ $b = 7.15(1)$ $c = 9.38(1)$ $\beta = 98.0(1)°$ Z = 4

X-ray Powder Pattern: Korshunovskoye deposit, Russia.
3.40 (10), 4.90 (9), 4.64 (8), 3.68 (8), 4.30 (7), 5.45 (4), 4.56 (4)

Chemistry:

	(1)	(2)
C	16.2	13.17
Mn	0.2	
Mg	16.4	13.33
H	3.9	3.32
O	[63.3]	70.18
Total	[100.0]	100.00

(1) Korshunovskoye deposit, Russia; by electron microprobe, average of two analyses, C and H by high-temperature sorption in oxygen, O by difference; corresponding to $(Mg_{1.00}Mn_{0.01})_{\Sigma=1.01}(H_{1.00}C_{1.00}O_{3.00})_2 \cdot 1.87H_2O$. (2) $Mg(HCO_3)_2 \cdot 2H_2O$.

Occurrence: Rare, in hydrothermal veinlets in serpentine in dolomite marble.

Association: Shabynite, iowaite, ekaterinite, korshunovskite, halite, hydromagnesite.

Distribution: From the Korshunovskoye iron–boron skarn deposit, Irkutsk district, Siberia, Russia.

Name: To honor Ekaterina Romanova Dashkova (1744–1810), Director of the St. Petersburg Academy of Sciences and President of the Russian Academy of Sciences.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81597.

References: (1) Chukanov, N.V., D.I. Belakovskiy, S.V. Malinko, and N.I. Organova (2000) Dashkovaite $Mg(HCO_3)_2 \cdot 2H_2O$ – a new formate mineral. Zap. Vses. Mineral. Obshch., 129(6), 49–53 (in Russian with English abs.). (2) (2001) Amer. Mineral., 86, 1534 (abs. ref. 1).

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Datolite $CaBSiO_4(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals typically short prismatic, with prominent {110}, {011}, or tabular on {010}, to 12 cm. Botryoidal or globular, having columnar structure; granular to compact; cryptocrystalline.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.96–3.00 D(calc.) = [3.00] Commonly fluoresces blue under SW UV.

Optical Properties: Transparent to translucent, rarely opaque. *Color:* Colorless or white, commonly with a greenish tinge; may be grayish, yellow, green, red, pink; in thin section, colorless. *Luster:* Vitreous, rarely subresinous on fracture surface.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = -1°$ to $-4°$. *Dispersion:* $r > v$, weak. $\alpha = 1.622–1.626$ $\beta = 1.649–1.654$ $\gamma = 1.666–1.670$ 2V(meas.) = 72°–75°

Cell Data: *Space Group:* $P2_1/c$. $a = 4.832(4)$ $b = 7.608(4)$ $c = 9.636(8)$ $\beta = 90.40(7)°$ $Z = 4$

X-ray Powder Pattern: St. Andreasberg, Germany. (ICDD 11-70).
3.11 (100), 2.855 (65), 2.189 (60), 3.76 (45), 1.875 (40), 1.644 (40), 2.986 (35)

Chemistry:

	(1)
SiO_2	38.00
B_2O_3	19.38
Al_2O_3	0.65
Fe_2O_3	0.28
MnO	0.39
MgO	0.09
CaO	35.39
H_2O^+	5.71
H_2O^-	0.26
Total	100.15

(1) Silver Harbour, Lake Superior, Ontario, Canada; corresponds to $(Ca_{1.02}Mg_{0.02}Mn_{0.01})_{\Sigma=1.05}B_{0.90}(Si_{1.03}Al_{0.02})_{\Sigma=1.05}O_{4.05}(OH)_{0.95}$.

Mineral Group: Gadolinite group.

Occurrence: A secondary mineral in mafic igneous rocks; in geodes in tuffs; in skarns in limestones; in serpentinites and "hornblende" schists; from some ore veins.

Association: Calcite, prehnite, zeolites, danburite, axinite, garnet.

Distribution: Widespread; some localities for fine specimens are: in Norway, from Arendal, and north of Hardangerfjiord. At St. Andreasberg, Harz Mountains, Germany. In Italy, from Serra dei Zanchetti, near Bologna, Emilia-Romagna, and from Alpe di Siusi, Trentino-Alto Adige. From the Kratzenberg, Habachtal, Austria. In Japan, from the Iwato copper mine, Miyazaki Prefecture. As exceptional crystals from Dal'negorsk, Primorskiy Kray, Russia. In the USA, large crystals from the Lane quarry, Westfield, Hampden Co., Massachusetts; in the Roncari quarry, East Granby, Hartford Co., Connecticut; from Bergen Hill, Hudson Co., Great Notch, Essex Co., and at Paterson and Prospect Park, Passaic Co., New Jersey; in the Goose Creek quarry, near Leesburg, Loudoun Co., Virginia. Very large crystals from Charcas, San Luis Potosí, Mexico.

Name: From the Greek *to divide*, in reference to the granular structure of a massive variety.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 502–505.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 171–175. (3) Foit, F.F., Jr., M.W. Phillips, and G.V. Gibbs (1973) A refinement of the crystal structure of datolite, $CaBSiO_4(OH)$. Amer. Mineral., 58, 909–914.

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Daubréeite $BiO(OH, Cl)$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Compact massive, columnar.

Physical Properties: *Cleavage:* [{001}, perfect] (by analogy to bismoclite). *Tenacity:* [Very plastic.] Hardness = [2–2.5] D(meas.) = 6.4–6.5 D(calc.) = [7.70]

Optical Properties: Opaque. *Color:* Pale yellow.
Optical Class: Uniaxial (–). $\omega = 1.91(1)$ $\epsilon =$ n.d.

Cell Data: *Space Group:* $P4/nmm$. a = 3.85(1) $c = 7.40(2)$ Z = 2

X-ray Powder Pattern: Tazna, Bolivia.
2.66 (s), 1.672 (s), 2.72 (ms), 1.562 (ms), 7.35 (m), 1.259 (m), 3.70 (w)

Chemistry:

	(1)	(2)
Fe_2O_3	0.72	
Bi_2O_3	89.60	92.74
Cl	7.50	7.06
H_2O	3.84	1.79
$-O = Cl_2$	1.69	1.59
Total	99.97	100.00

(1) Tazna, Bolivia. (2) $BiO(OH, Cl)$ with OH:Cl = 1:1.

Occurrence: A secondary mineral formed by alteration of bismuth or bismuthinite, intermixed with "clay" (Tazna, Bolivia).

Association: Kaolinite (?).

Distribution: From the Constancia mine, Tazna, Bolivia.

Name: For Gabriel Auguste Daubrée (1814–1896), French mineralogist and geologist.

Type Material: National Museum of Natural History, Paris, France, 94.247.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 60–62. (2) Bannister, F.A. (1935) The crystal-structure of the bismuth oxyhalides. Mineral. Mag., 24, 49–58.

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Daubréelite $Fe^{2+}Cr_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, scaly to platy, as exsolution lamellae parallel to {0001} of troilite, and as discrete grains to 500 μm across in kamacite.

Physical Properties: *Cleavage:* Distinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 VHN = 260–303 (100 g load). D(meas.) = 3.81 D(calc.) = 3.842

Optical Properties: Opaque. *Color:* Black. *Streak:* Brown. *Luster:* Metallic, brilliant. R: (400) 33.3, (420) 33.2, (440) 33.1, (460) 33.0, (480) 33.1, (500) 33.1, (520) 33.1, (540) 33.0, (560) 33.0, (580) 32.9, (600) 32.8, (620) 32.7, (640) 32.4, (660) 32.3, (680) 32.1, (700) 31.9

Cell Data: *Space Group: Fd3m.* a = 9.966 Z = 8

X-ray Powder Pattern: Synthetic.
3.01 (10), 1.77 (10), 3.53 (8), 2.50 (8), 1.92 (8), 1.30 (8), 1.25 (8)

Chemistry:

	(1)	(2)	(3)
Fe	20.10	16.7	19.38
Mn		2.8	
Mg		0.06	
Cr	35.91	34.9	36.10
Ti		0.10	
S	42.69	44.3	44.52
Total	98.70	98.86	100.00

(1) Coahuila meteorite; average of three analyses, corresponding to $Fe_{1.08}Cr_{2.08}S_{4.00}$.
(2) Blithfield meteorite; by electron microprobe, average of 15 analyses; corresponding to $(Fe_{0.87}Mn_{0.15}Mg_{0.01})_{\Sigma=1.03}(Cr_{1.94}Ti_{0.01})_{\Sigma=1.95}S_{4.00}$. (3) $FeCr_2S_4$.

Mineral Group: Linnaeite group.

Occurrence: In small amounts in many meteorites.

Association: Troilite, kamacite, orthoenstatite, plagioclase, alabandite, graphite, schreibersite.

Distribution: In iron meteorites, such as the Coahuila [TL], North Chile, and Scottsville hexahedrites, and the Cosby's Creek, Toluca, Cranbourne, and Mundrabilla octahedrites. In stony meteorites, including the Bustee, Mayo Belwa, Norton County, and Cumberland Falls achondrites, the Hvittis and Blythfield enstatite chondrites, and Odessa olivine-bronzite chondrite. Now found in many additional meteorites.

Name: For Professor Gabriel Auguste Daubrée (1814–1896), of Paris, France, French meteorite researcher.

Type Material: n.d. [??first from the Bolson de Mapimi iron meteorite - where is it?? = Coahuila now, ck??]

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 265. (2) Buchwald, V.F. (1977) The mineralogy of iron meteorites. Phil. Trans. Royal Soc. London, A. 286, 453–491. (3) Rubin, A.E. (1984) The Blithfield meteorite and the origin of sulfide-rich, metal-poor clasts and inclusions in brecciated enstatite chrondites. Earth and Planetary Science Letters, 67, 273–283. (4) Lundqvist, D. (1943) The crystal structure of daubréelite. Arkiv Kemi Min. Geol., 17B(12), 1–4. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 135.

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Davanite $K_2TiSi_6O_{15}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As pseudohexagonal grains up to 5 mm. *Twinning:* Twins parallel or complex, with the composition plane parallel to the twin axis.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5 D(meas.) = 2.76 D(calc.) = 2.754

Optical Properties: Semitransparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). $\alpha = 1.623(2)$ $\beta =$ n.d. $\gamma = 1.668(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 7.26$–7.272 $b = 7.480$–7.51 $c = 6.910$–6.92 $\alpha = 105.55°$–$105.6°$ $\beta = 112.82°$–$112.9°$ $\gamma = 99.4°$–$99.42°$ Z = [1]

X-ray Powder Pattern: Murun massif, Russia.
3.51 (100), 3.002 (100), 2.615 (90), 2.789 (70), 5.88 (50), 4.09 (50), 3.34 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	67.47	66.70	67.44
TiO_2	15.07	14.48	14.94
ZrO_2		0.09	
FeO	trace	0.15	
MgO	trace		
Na_2O	trace	0.02	
K_2O	17.40	17.67	17.62
Total	99.94	99.11	100.00

(1) Murun massif, Russia; by electron microprobe, average of four analyses; corresponds to $K_{1.98}Ti_{1.01}Si_{6.01}O_{15.03}$. (2) Smoky Butte, Montana, USA; by electron microprobe. (3) $K_2TiSi_6O_{15}$.

Occurrence: In contact metamorphic rocks in an alkalic massif (Murun massif, Russia); of magmatic origin, lining vugs in lamproites (Smoky Butte, Montana, USA).

Association: Aegirine, pectolite, titanite, quartz, potassic feldspar, calcite (Murun massif, Russia); phlogopite, diopside, leucite, analcime, olivine, pseudobrookite, potassian richterite, Ca-Sr carbonates, priderite, barite (Smoky Butte, Montana, USA).

Distribution: From near the Davan Stream, in the Murun massif, southwest of Olekminsk, Yakutia, Russia. At Smoky Butte, Garfield Co., Montana, USA.

Name: For the Davan Stream, in the Murun massif, Russia.

Type Material: Geological Museum, Yakutsk Scientific Center, Academy of Sciences, Yakutsk, mk-124; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82768.

References: (1) Lazebnik, K.A., Y.D. Lazebnik, and V.J. Mokhotko (1984) Davanite, $K_2TiSi_6O_{15}$, a new alkali titanosilicate. Zap. Vses. Mineral. Obshch., 113, 95–97 (in Russian). (2) (1985) Amer. Mineral., 70, 214–215 (abs. ref. 1). (3) Wagner, C. and D. Velde (1986) Davanite, $K_2TiSi_6O_{15}$, in the Smoky Butte (Montana) lamproites. Amer. Mineral., 71, 1473–1475. (4) Raade, G. (1987) Davanite, $K_2TiSi_6O_{15}$, in the Smoky Butte (Montana) lamproites: discussion of X-ray powder data. Amer. Mineral., 72, 1014–1015.

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Davidite-(Ce) $(Ce, La)(Y, U, Fe^{2+})(Ti, Fe^{3+})_{20}(O, OH)_{38}$

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Crystal Data: Hexagonal; metamict. *Point Group:* [3 or $\overline{3}$] [by analogy to davidite-(La)]. In elongated masses, to 20 cm, with rough semi-linear outlines.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* [Brittle.] Hardness = 6 D(meas.) = 4.29 D(calc.) = n.d. Radioactive.

Optical Properties: Opaque, translucent in very thin fragments. *Color:* Black, brownish on oxidized surfaces; clove-brown in transmitted light; gray in reflected light. *Streak:* Black to very dark gray. *Luster:* Vitreous.
Optical Class: Isotropic. n = n.d.
R: n.d.

Cell Data: *Space Group:* [$R\overline{3}$.] a = n.d. c = n.d. Z = n.d.

X-ray Powder Pattern: Tuftane, Norway; after heating at 1030 °C for one hour.
2.88 (vs), 2.47 (s), 2.23 (s), 2.13 (s), 1.59 (s), 1.43 (s), 3.39 (m)

Chemistry:

	(1)
U_3O_8	1.1
SiO_2	0.34
TiO_2	52.1
RE_2O_3	17.3
Fe_2O_3	9.5
FeO	17.1
MnO	1.0
H_2O	1.63
Total	100.07

(1) Tuftane, Norway; separate spectrographic analysis of RE_2O_3 gave: Y_2O_3 23%, La_2O_3 22%, CeO_2 32%, Pr_6O_{11} 2.4%, Nd_2O_3 2.8%, $Sm_2O_3 < 0.2\%$, Eu_2O_3 0.4%, $Gd_2O_3 < 0.1\%$, $Tb_4O_7 < 0.2\%$, Dy_2O_3 1.6%, Ho_2O_3 0.55%, Er_2O_3 2.5%, Tm_2O_3 1.2%, Yb_2O_3 9.5%, Lu_2O_3 1.7%, and ThO_2 1.5%.

Mineral Group: Crichtonite group.

Occurrence: In a pegmatite dike, rich in rare-earth minerals, in granite.

Association: Ilmenite, rutile, gadolinite, euxenite, thortveitite, xenotime, allanite, zircon.

Distribution: From Tuftane, Iveland, Norway.

Name: For its relation to *davidite* and dominant *cerium* content.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway.

References: (1) Neumann, H. and T.L. Sverdrup (1960) Davidite from Tuftan, Iveland. Norsk geol. tidsskr., 40(3-4), 277–288. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 255–258.

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Davidite-(La) $(La, Ce)(Y, U)(Ti, Fe^{3+})_{20}(O, OH)_{38}$

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Crystal Data: Hexagonal; commonly metamict. *Point Group:* 3 or $\overline{3}$. As complex but rough crystals, to 30 cm, flattened {0001}, cuboidal, or pyramidal; as irregular masses and grains. *Twinning:* Common about $[11\overline{2}0]$.

Physical Properties: *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = ∼6 D(meas.) = 4.33–4.48 D(calc.) = 4.49 May be radioactive.

Optical Properties: Opaque, translucent in very thin fragments. *Color:* Black to grayish black, brownish black, dark brown, or reddish when altered; brown or reddish brown in transmitted light. *Streak:* Grayish black to dark brown. *Luster:* Vitreous to submetallic, shining.
Optical Class: Isotropic when metamict. n = ∼2.3
R: (400) 19.4, (420) 19.0, (440) 18.6, (460) 18.1, (480) 17.8, (500) 17.5, (520) 17.3, (540) 17.2, (560) 17.0, (580) 17.0, (600) 16.9, (620) 16.8, (640) 16.8, (660) 16.8, (680) 16.7, (700) 16.6

Cell Data: *Space Group:* $R\overline{3}$. a = 10.32–10.41 c = 20.85–21.00 Z = 3

X-ray Powder Pattern: Quijotoa Mountains, Arizona, USA; reconstituted by heating.
2.895 (100), 3.42 (70), 2.850 (60), 3.065 (50), 2.248 (50), 3.00 (40), 2.480 (40)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_5		0.19	Sc_2O_3		0.18	MnO	0.04	0.10
Ta_2O_5		0.04	Y_2O_3	1.86	1.57	ZnO		0.04
V_2O_5	2.88	0.42	La_2O_3	3.35	4.66	PbO	0.69	0.14
TiO_2	51.74	54.88	CeO_2	3.06		MgO	0.10	0.54
ZrO_2	0.07	0.37	Ce_2O_3		2.85	CaO	0.23	0.63
HfO_2	0.51		Nd_2O_3	0.35	0.23	SrO	0.02	0.16
ThO_2	0.05	0.73	RE_2O_3	[0.88]	[0.36]	K_2O		0.03
UO_2	6.42	4.94	Fe_2O_3	25.30	26.16	Total	[98.98]	[100.51]
Al_2O_3	0.22	0.41	Cr_2O_3	1.21	0.88			

(1) Olary, South Australia; by electron microprobe, total Fe as Fe_2O_3, corresponds to $(La, Ce, RE)_{0.90}(U_{0.44}Y_{0.31}Ca_{0.08}Pb_{0.06})_{\Sigma=0.89}(Ti_{12.07}Fe_{5.9}V_{0.59}Cr_{0.3}Al_{0.08}Mg_{0.05})_{\Sigma=18.99}(O, OH)_{38}$. (2) Quijotoa Mountains, Arizona, USA; by electron microprobe, total Fe as Fe_2O_3, corresponds to $(La, Ce, RE)_{0.91}[U_{0.33}Y_{0.25}Ca_{0.20}(Sr, Th, Pb)_{0.09}]_{\Sigma=0.87}[Ti_{12.53}Fe_{5.97}Mg_{0.24}Cr_{0.21}Al_{0.14}(Mn, V, Zr, Nb, Sc)_{0.23}]_{\Sigma=19.32}(O, OH)_{38}$.

Mineral Group: Crichtonite group.

Occurrence: A primary mineral in high-temperature hydrothermal veins; in norite and anorthosite; in alkalic rocks and also granite pegmatites and carbonatites.

Association: Rutile, titanite, magnetite, ilmenite, apatite, tourmaline, epidote, albite, calcite.

Distribution: In Australia, in the Olary district, at Radium Hill, Crocker's Well, and Billeroo Station, South Australia, and from Thackeringa, Broken Hill, New South Wales. In the Vishnevy Mountains, Southern Ural Mountains, Russia. At Bek-tau Alta, Kazakhstan, From Iveland, Norway. At Björko, Västervik district, Sweden. At Villanueva del Fresno, Spain. In Mozambique, very large crystals from Mavusi, Tete district; at Matema and Campangula. In the Kirumba massif, Kivu Province, Congo (Zaire). In the USA, from the Quijotoa Mountains, Pima Co., Arizona. At the Faraday mine, Bancroft, Ontario, and elsewhere in Canada. A few other localities are known.

Name: For Professor Tannatt William Edgeworth David (1858–1934), Australian geologist, University of Sydney, Sydney, Australia.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 542. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 337–341. (3) Pabst, A. (1961) X-ray crystallography of davidite. Amer. Mineral., 46, 700–718. (4) Gatehouse, B.M., I.E. Grey, I.H. Campbell, and P.R. Kelly (1978) The crystal structure of loveringite–a new member of the crichtonite group. Amer. Mineral., 63, 28–36. (5) Gatehouse, B.M., I.E. Grey, and P.R. Kelly (1979) The crystal structure of davidite. Amer. Mineral., 64, 1010–1017.

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Davinciite $Na_{12}K_3Ca_6Fe^{2+}{}_3Zr_3(Si_{26}O_{73}OH)Cl_2$

Crystal Data: Hexagonal. *Point Group:* 3*m*. As equant grains to 2 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.82(2) D(calc.) = 2.848

Optical Properties: Transparent. *Color:* Dark lilac. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). ω = 1.603(2) ε = 1.605(2)

Cell Data: *Space Group: R3m.* a = 14.2956(2) c = 30.0228(5) Z = 3

X-ray Powder Pattern: Mount Rasvumchorr, Khibiny massif, Kola Peninsula, Russia. 2.981 (100), 2.860 (96), 4.309 (66), 3.207 (63), 6.415 (54), 3.162 (43), 2.595 (37)

Chemistry:

	(1)		(1)
Na_2O	12.69	SiO_2	51.20
K_2O	3.53	TiO_2	0.39
CaO	11.02	ZrO_2	11.33
SrO	0.98	HfO_2	0.21
BaO	0.15	Nb_2O_5	0.09
FeO	5.33	Cl	1.89
MnO	0.37	H_2O	0.93
Al_2O_3	0.07	$-O = Cl_2$	0.43
		Total	99.75

(1) Mount Rasvumchorr, Khibiny massif, Kola Peninsula, Russia; average of 5 electron microprobe analyses, H_2O from structure analysis; corresponding to $(Na_{11.75}Sr_{0.29}Ba_{0.03})_{\Sigma=12.07}(K_{2.28}Na_{0.72})_{\Sigma=3.00}Ca_{5.99}(Fe_{2.26}Mn_{0.16})_{\Sigma=2.42}(Zr_{2.80}Ti_{0.15}Hf_{0.03}Nb_{0.02})_{\Sigma=3.00}(Si_{1.96}Al_{0.04})_{\Sigma=2.00}[Si_3O_9]_2[Si_9O_{27}]_2[(OH)_{1.42}O_{0.58}]_{\Sigma=2.00}[Cl_{0.62}(H_2O)_{0.38}]_{\Sigma=2.00}\cdot 0.48H_2O$.

Mineral Group: Eudialyte group.

Occurrence: As relict inclusions in rastsvetaevite in a hyperalkaline nepheline-sodalite pegmatite.

Association: Rastsvetaevite.

Distribution: Mount Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: Honors Leonardo da Vinci (1452-1519), Italian scientist, painter, sculptor, and architect.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia.

References: (1) Khomyakov, A.P., G.N. Nechelyustov, R.K. Rastsvetaeva, and K.A. Rozenberg (2012) Davinciite, $Na_{12}K_3Ca_6Fe^{2+}{}_3Zr_3(Si_{26}O_{73}OH)Cl_2$, a new K, Na-ordered mineral of the eudialyte group from the Khibiny alkaline massif, Kola Peninsula, Russia. Zap. Ross. Mineral. Obshch., 141(2), 10-21 (in Russian, English abstract). (2) Rastsvetaeva, R.K., K.A. Rozenberg, and A.P. Khomyakov (2009) Crystal structure of high-silica K,Na-ordered acentric eudialyte analogue. Doklady Akademii Nauk, 424(1), 53-56 (in Russian). English translation: Doklady Chemistry (2009), 424, 11-14. (3) (2013) Amer. Mineral., 98, 812 (abs. refs. 1& 2).

Davreuxite $\mathbf{Mn^{2+}Al_6Si_4O_{17}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Asbestiform; as small bundles of extremely fine fibers, to several cm; these may be folded or imbricated.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* Cross fractures on {010}. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 3.30–3.38 D(calc.) = 3.34

Optical Properties: Transparent to translucent. *Color:* Creamy white to very pale rose; colorless to faint yellow in thin section.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \simeq \perp \{100\}$. $\alpha = 1.660(5)$ $\beta = 1.684(2)$ $\gamma = 1.690(2)$ 2V(meas.) = 48°–70°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.518(6)$ $b = 5.753(2)$ $c = 12.04(1)$ $\beta = 108.00(5)°$ Z = 2

X-ray Powder Pattern: Ottré, Belgium.
3.511 (100), 2.870 (60), 3.103 (45), 4.290 (40), 5.719 (35), 2.840 (35), 8.51 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	37.82	37.45	37.84
TiO_2		trace	
Al_2O_3	46.88	48.09	48.15
Fe_2O_3	1.10		
Cr_2O_3		trace	
FeO		1.29	
MnO	9.08	9.14	11.17
CuO	0.79		
ZnO	0.49		
MgO	0.44	0.45	
H_2O	[2.83]	[2.82]	2.84
P_2O_5	0.35		
Total	[99.78]	[99.24]	100.00

(1) Ottré, Belgium; by electron microprobe, total Fe as Fe_2O_3, H_2O calculated from stoichiometry. (2) Recht, Belgium; by electron microprobe, H_2O calculated from stoichiometry. (3) $MnAl_6Si_4O_{17}(OH)_2$.

Occurrence: In quartz veins cutting Mn, Al-rich metapelites, derived from shales subjected to low-grade metamorphism.

Association: Quartz, pyrophyllite, ottrélite, andalusite, sudoite, kaolinite, rutile, dickite (Ottré, Belgium); chloritoid, hematite, chlorite (Sart-Close, Belgium).

Distribution: In Belgium, in the Stavelot massif, at Ottré, at Sart-Close, near Salmchâteau, at Regne, and at Recht.

Name: For Charles Joseph Davreux (1800–1863), Belgian pharmacist and natural scientist, Professor of Mineralogy at the University of Liège, Belgium.

Type Material: Royal Institute of Natural Sciences of Belgium, Brussels, Belgium.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 706.
(2) Fransolet, A.-M. and P. Bourguignon (1976) Précisions minéralogiques sur la davreuxite. Compt. Rendus Acad. Sci. Paris, 283, 295–296 (in French). (3) (1978) Amer. Mineral., 63, 795 (abs. ref. 2). (4) Fransolet, A.-M., K. Abraham, and K. Sahl (1984) Davreuxite: a reinvestigation. Amer. Mineral., 69, 777–782. (5) Sahl, K., P.G. Jones, and G.M. Sheldrick (1984) The crystal structure of davreuxite, $MnAl_6Si_4O_{17}(OH)_2$. Amer. Mineral., 69, 783–787.

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Davyne $\mathbf{(Na, Ca, K)_8Al_6Si_6O_{24}(Cl, SO_4, CO_3)_{2-3}}$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As prismatic hexagonal crystals, striated lengthwise, up to 4 cm.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}0\}$, perfect to indistinct on $\{0001\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.42–2.53 D(calc.) = [2.50]

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in thin section. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.515–1.519$ $\epsilon = 1.519–1.522$

Cell Data: *Space Group:* $P6_3/m$. $a = 12.705(4)$ $c = 5.368(3)$ $Z = 1$

X-ray Powder Pattern: Vesuvius, Italy; can be distinguished from quadridavyne only by single-crystal diffraction.
4.80 (100), 3.67 (100), 3.28 (100), 2.670 (60), 2.121 (60), 2.756 (50), 2.652 (50)

Chemistry:

	(1)	(2)
SiO_2	32.21	32.23
Al_2O_3	29.22	28.98
CaO	12.60	10.36
Na_2O	10.14	11.01
K_2O	6.79	7.11
Cl	6.71	6.25
CO_2		1.26
SO_3	4.43	4.11
$-O = Cl_2$	1.51	1.56
Total	100.59	99.75

(1) Monte Somma, Italy; corresponds to $(Na_{3.54}Ca_{2.43}K_{1.56})_{\Sigma=7.53}(Al_{6.20}Si_{5.80})_{\Sigma=12.00}O_{24}[Cl_{2.05}(SO_4)_{0.60}]_{\Sigma=2.65}$. (2) Do.; corresponds to $(Na_{3.86}Ca_{2.01}K_{1.64})_{\Sigma=7.51}(Al_{6.18}Si_{5.82})_{\Sigma=12.00}O_{24}[Cl_{2.13}(SO_4)_{0.56}(CO_3)_{0.31}]_{\Sigma=3.00}$.

Mineral Group: Cancrinite group.

Occurrence: In volcanic ejecta and in leucite-rich lavas.

Association: Nepheline, leucite.

Distribution: From Monte Somma and Vesuvius, Campania, and Pitigliano, Tuscany, Italy. On the Island of Zabargad (Zabirget or St. Johns), in the Red Sea, Egypt. From Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: For the great English chemist, Sir Humphrey Davy (1778–1829).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 428–429. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 310–320. (3) Bariand, P., F. Cesbron, and R. Giraud (1968) Une nouvelle espèce minérale: l'afghanite de Sar-e-Sang, Badakhshan, Afghanistan. Comparison avec les minéraux du groupe de la cancrinite. Bull. Soc. fr. Minéral., 91, 34–42 (in French with English abs.). (4) Bonaccorsi, E., S. Merlino, and M. Pasero (1990) Davyne: its structural relationships with cancrinite and vishnevite. Neues Jahrb. Mineral., Monatsh., 97–112.

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Dawsonite $NaAl(CO_3)(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As acicular to bladed crystals, elongated along [001], to 3.5 cm; typically in rosettes and radial fibrous to tufted aggregates.

Physical Properties: *Cleavage:* {110}, perfect. Hardness = 3 D(meas.) = 2.436 D(calc.) = 2.431

Optical Properties: Transparent. *Color:* Colorless to white, rarely pink; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, silky in fibrous aggregates. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, weak. $\alpha = 1.466$ $\beta = 1.542$ $\gamma = 1.596$ 2V(meas.) = 77°

Cell Data: *Space Group:* $Imam$. $a = 6.759(1)$ $b = 10.425(1)$ $c = 5.585(1)$ Z = 4

X-ray Powder Pattern: Mont Saint-Bruno, Canada.
5.67 (10), 2.784 (9), 2.601 (7), 1.988 (7), 1.728 (7), 3.38 (6), 2.151 (6)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	31.41	30.56	Na_2O	21.10	21.52
SiO_2	0.29		K_2O	0.02	
TiO_2	0.01		H_2O	11.85	12.51
Al_2O_3	35.60	35.41	Total	[100.38]	100.00
Fe_2O_3	0.10				

(1) Glen Davis, New South Wales, Australia; original total given as 100.25%.
(2) $NaAl(CO_3)(OH)_2$.

Occurrence: Coating vug walls and fractures in hydrothermally altered feldspathic dikes and hornfels associated with nepheline syenite (Mont Saint-Bruno, Canada); authigenic in alkaline shales and coal-bearing rocks (Green River Formation, USA; Sydney Basin, Australia); in saline soils on nepheline syenite tuffs (Olduvai Gorge, Tanzania).

Association: Fluorite, calcite, dolomite, aragonite, pyrite, quartz (Quebec, Canada); analcime, dolomite, quartz, calcite, pyrite, albite, cryolite, halite, fluorite (Green River Formation, USA).

Distribution: In Canada, in Quebec, from Mont Royal, on the campus of McGill University, and in the Francon quarry, Montreal Island, Montreal; on Mont Saint-Bruno and as large crystals at Mont Saint-Hilaire; from near Saint-Amable; at Bancroft, Ontario. Abundant in the Green River Formation, Colorado and Wyoming, USA. At Pian Castagnaio and Santa Fiora, near Mt. Amiata, Siena, Tuscany; on Monte Tondo, Terlano, Bolzano, Italy. In the Simplon Tunnel, Valais, Switzerland. At Komana, Drin Valley, Albania. From Lahóca Hill, Recsk, Mátra Mountains, Hungary. In the Khibiny massif, Kola Peninsula, Russia. From near Lake Natron, in the Olduvai Gorge area, Tanzania. From east of Tenès, Algeria. In the Sydney Coal Basin, as at Glen Davis and Muswellbrook, New South Wales, Australia. Additional localities are known.

Name: Honors John William Dawson (1820–1899), Canadian geologist and Principal of McGill University, Montreal, Canada.

Type Material: McGill University, Montreal, Canada, RMF2381A.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 276–277. (2) Corazza, E., C. Sabelli, and S. Vannucci (1977) Dawsonite: new mineralogical data and structure refinement. Neues Jahrb. Mineral., Monatsh., 381–397. (3) Goldbery, R. and F.C. Loughnan (1970) Dawsonite and nordstrandite in the Permian Berry Formation of the Sydney Basin, New South Wales. Amer. Mineral., 55, 477–490. (4) Smith, J.W. and C. Milton (1966) Dawsonite in the Green River Formation of Colorado. Econ. Geol., 61, 1029–1042. (5) Mandarino, J.A. and D.C. Harris (1965) New Canadian mineral occurrences: I. eucryptite, pollucite, rozenite, epsomite, dawsonite, fairchildite and bütschliite. Can. Mineral., 8, 377–381.

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Deanesmithite $Hg_2^{1+}Hg_3^{2+}Cr^{6+}O_5S_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As bladed to tabular {100} crystals, dominated by {100}, with minor {320}, {001}, {$\overline{5}$10}, {01$\overline{1}$}, and a dozen other forms, to 0.5 mm; striations on {100} ‖ [001]; typically in radiating clusters and fan-shaped aggregates. *Twinning:* Indicated in reflected light.

Physical Properties: *Cleavage:* Good on {$\overline{1}$10}; fair on {001}. *Fracture:* Irregular to subconchoidal. *Tenacity:* Brittle to friable. Hardness = < 5 D(meas.) = n.d. D(calc.) = 8.06

Optical Properties: Transparent. *Color:* Red-orange; dark bluish gray to pale gray with bright yellow-orange internal reflections in reflected light. *Streak:* Less intense red-orange. *Luster:* Adamantine.
Optical Class: Biaxial. *Pleochroism:* Weak; yellow-orange to dark reddish orange.
Bireflectance: Weak.
R_1–R_2: (400) 24.8–23.1, (420) 25.2–23.1, (440) 24.8–23.15, (460) 23.8–23.3, (480) 22.9–23.6, (500) 22.1–23.8, (520) 21.3–23.5, (540) 20.5–22.9, (560) 20.1–22.05, (580) 20.0–21.7, (600) 20.0–21.55, (620) 19.9–21.3, (640) 19.7–21.0, (660) 19.6–20.8, (680) 19.4–20.45, (700) 19.25–20.3

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.1287(8)$ $b = 9.4916(7)$ $c = 6.8940(4)$
$\alpha = 100.356(6)°$ $\beta = 110.163(7)°$ $\gamma = 82.981(8)°$ Z = 2

X-ray Powder Pattern: Clear Creek claim, California, USA.
3.008 (100), 5.72 (90), 3.373 (60), 2.425 (60), 2.864 (50b), 2.774 (50), 2.536 (50)

Chemistry:

	(1)	(2)
CrO_3	8.6	8.34
HgO	[54.4]	54.19
Hg_2O	[34.9]	34.79
S	5.3	5.35
−O = S	2.6	2.67
Total	[100.6]	100.00

(1) Clear Creek claim, California, USA; by electron microprobe, average of six analyses; after recalculation with Hg_2O and HgO in the ratio 2:3, confirmed by crystal-structure analysis, corresponds to $Hg^{1+}_{1.98}Hg^{2+}_{2.97}Cr^{6+}_{1.02}O_{5.05}S_{1.95}$. (2) $Hg_2^{1+}Hg_3^{2+}CrO_5S_2$.

Occurrence: Very rare in a mercury deposit in silicate–carbonate rock hydrothermally altered from serpentinite.

Association: Cinnabar, edoylerite.

Distribution: From the Clear Creek claim, near the Clear Creek mercury mine, New Idria district, San Benito Co., California, USA.

Name: Honors Professor Deane Kingsley Smith, Jr. (1930–2001), Pennsylvania State University, University Park, Pennsylvania, USA, for his contributions to structural and experimental mineralogy.

Type Material: Canadian Geological Survey, Ottawa, Canada, 65026, 66152.

References: (1) Roberts, A.C., J.T. Szymański, R.C. Erd, A.J. Criddle, and M. Bonardi (1993) Deanesmithite, $Hg_2^{1+}Hg_3^{2+}Cr^{6+}O_5S_2$, a new mineral species from the Clear Creek Claim, San Benito County, California. Can. Mineral., 31, 787–793. (2) Szymański, J.T. and L.A. Groat (1997) The crystal structure of deanesmithite, $Hg_2^{1+}Hg_3^{2+}Cr^{6+}O_5S_2$. Can. Mineral., 35, 765–772.

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Decrespignyite-(Y) $Y_4Cu(CO_3)_4Cl(OH)_5 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. Rarely as thin pseudohexagonal crystals, to 50 μm, commonly curved; in stellate rosettes and as massive crusts and coatings.

Physical Properties: Hardness = ∼4 D(meas.) = 3.64(2) D(calc.) = [3.92]

Optical Properties: Transparent. *Color:* Deep Royal blue to turquoise-blue; very pale blue in transmitted light. *Streak:* Pale blue. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). *Pleochroism:* Medium strong; X = very pale blue; $Y = Z$ = greenish blue. *Absorption:* $Z \simeq Y \gg X$. $\alpha = 1.604(4)$ $\beta = \simeq 1.638$ $\gamma = 1.638(3)$ 2V(meas.) = Very small.

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. $a = 8.899(6)$ $b = 22.77(2)$ $c = 8.589(6)$ $\beta = 120.06(5)°$ Z = 4

X-ray Powder Pattern: Paratoo mine, Australia.
6.241 (100), 7.086 (50), 3.530 (40), 22.8 (30), 7.463 (30), 4.216 (30), 3.336 (30)

Chemistry:

	(1)		(1)
CO_2	19.8	Ho_2O_3	2.6
Y_2O_3	42.2	Er_2O_3	2.5
La_2O_3	0.3	CuO	10.9
Pr_2O_3	0.1	CaO	0.5
Nd_2O_3	1.3	Cl	3.0
Sm_2O_3	1.0	H_2O	10.8
Gd_2O_3	4.8	$-O = Cl_2$	0.7
Tb_2O_3	0.4	Total	103.2
Dy_2O_3	3.7		

(1) Paratoo mine, Australia; by electron microprobe, average of seven analyses, CO_2 and H_2O by CHN analyzer, presence of CO_3^{2-} and H_2O confirmed by IR; corresponds to $(Y_{3.32}Gd_{0.24}Dy_{0.18}Ho_{0.11}Er_{0.12}Ca_{0.08}Nd_{0.07}Sm_{0.05}Tb_{0.02}La_{0.02})_{\Sigma=4.22}Cu_{1.22}(CO_3)_{4.00}Cl_{0.75}(OH)_{6.27} \cdot 2.20H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a copper deposit, the source of rare-earths enigmatic, perhaps from surrounding sediments.

Association: Caysichite-(Y), donnayite-(Y), kamphaugite-(Y), malachite, nontronite, calcite, gypsum, "limonite".

Distribution: From the Paratoo copper mine, 30 km southwest of Yunta, Olary district, South Australia.

Name: Honors Robert James Champion de Crespigny (1950–), Chairman of Normandy Mining Limited and Chairman of the South Australian Museum, for his contributions to Australian education.

Type Material: South Australian Museum, Adelaide, Australia, G25453–G25455.

References: (1) Wallwork, K., U. Kolitsch, A. Pring, and L. Nasdala (2002) Decrespignyite-(Y), a new copper yttrium rare earth carbonate chloride hydrate from Paratoo, South Australia. Mineral. Mag., 66, 181–188. (2) (2002) Amer. Mineral., 87, 1731 (abs. ref. 1).

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Deerite $(Fe^{2+}, Mn^{2+})_6(Fe^{3+}, Al)_3Si_6O_{20}(OH)_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals acicular, lozenge-shaped in cross section, to 1 mm. *Twinning:* Submicroscopic with twin axis [001], pervasive.

Physical Properties: *Cleavage:* Good on {110}. Hardness = n.d. D(meas.) = 3.837 D(calc.) = [3.86]

Optical Properties: Nearly opaque, transparent on thin edges. *Color:* Black. *Optical Class:* Biaxial. *Pleochroism:* Slight; X = dark brown; $Y = Z$ = dark brown-black. *Orientation:* $Z = c$. $\alpha = 1.840(1)$ β = n.d. $\gamma = 1.870(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/a$. $a = 10.786(8)$ $b = 18.88(2)$ $c = 9.564(9)$ $\beta = 107.45(5)^\circ$ Z = 4

X-ray Powder Pattern: Laytonville district, California, USA. (ICDD 19-421). 9.03 (100), 3.01 (70), 2.64 (55), 2.54 (25), 3.22 (20), 2.37 (20), 9.45 (16)

Chemistry:

	(1)	(2)	(3)	(4)
SiO_2	33.44	33.40	33.27	33.50
Al_2O_3	0.92	0.16	0.41	
Fe_2O_3	22.09	20.89	21.41	22.26
FeO	36.77	34.79	35.64	40.06
MnO	2.86	5.72	0.74	
MgO	0.15	0.25	0.64	
H_2O	4.25	[4.25]	[4.25]	4.19
Total	100.48	[99.46]	[96.36]	100.00

(1) Laytonville district, California, USA. (2) Do.; by electron microprobe. (3) Ambin massif, Italy; by electron microprobe; H_2O and Fe^{2+}:Fe^{3+} in (2–3) assumed same as (1). (4) $Fe^{2+}_6Fe^{3+}_3Si_6O_{20}(OH)_5$.

Occurrence: In meta-ironstones and Cu-Fe sulfide deposits, in blueschist facies metasediments formed at high pressure and low temperature.

Association: Howieite, zussmanite, stilpnomelane, spessartine, riebeckite, quartz, aegirine, grunerite, aragonite, manganoan siderite, ferroan kutnohorite (Laytonville district, California, USA).

Distribution: In the USA, in California, in the Laytonville quarry, at Covelo, and at Burn's Flats, Mendocino Co.; at Ward Creek, Cazadero, Sonoma Co.; and at Panoche Pass, San Benito Co.; in Oregon, at Wild Horse Lookout, Curry Co., and in the Powers quarry, Coos Co. From Salbertrand, Viafiorcia, and Beth-Ghinivert, Piedmont, Italy. At Termignon, Haute-Savoie, France. From Sifnos, Greece. At Süpüren-Karaalan, Eskişehir Province, Turkey. From the Diahöt Valley, and at Ouegoa Koumec, New Caledonia. A few other occurrences are known.

Name: To honor Professor William Alexander Deer (1910–), mineralogist-petrologist, Cambridge University, Cambridge, England.

Type Material: National Museum of Natural History, Washington, D.C., USA, 109455; The Natural History Museum, London, England, 1964,543.

References: (1) Agrell, S.O., M.G. Bown, and D. McKie (1965) Deerite, howieite and zussmanite, three new minerals from the Franciscan of the Laytonville district, Mendocino County, California. MSA meeting, Bozeman, Montana, July 26–31, 1964. Amer. Mineral., 50, 278 (abs.). (2) Agrell, S.O. and M. Gay (1970) De la deerite dans les Alpes franco-italiennes. Bull. Soc. fr. Minéral., 93, 263–264 (in French). (3) Fleet, M.E. (1977) The crystal structure of deerite. Amer. Mineral., 62, 990–998. (4) Muir Wood, R. (1979) The iron-rich blueschist facies minerals: I. Deerite. Mineral. Mag., 43, 251–259.

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Defernite $\mathbf{Ca_6(CO_3)_{2-x}(SiO_4)_x(OH)_7(Cl,OH)_{1-2x}}$ (x 0.5)

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As anhedral platy crystals, to 2 cm, flattened on {010}; in fan-shaped forms.

Physical Properties: *Cleavage:* Perfect on {010}; distinct on {100}. *Fracture:* Conchoidal to splintery. Hardness = n.d. D(meas.) = 2.34–2.5 D(calc.) = 2.31–2.42

Optical Properties: Transparent. *Color:* Colorless to deep red or rose-brown. *Streak:* Pink. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = ocher-brown; Y = brownish orange to ocher-brown; Z = colorless to yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, weak. $\alpha = 1.544(2)$ $\beta = 1.580(2)$ $\gamma = 1.584(2)$ 2V(meas.) = 38(2)°

Cell Data: *Space Group: Pnam.* $a = 17.82$–17.86 $b = 22.62$–22.78 $c = 3.63$–3.66 Z = 8

X-ray Powder Pattern: Güneyce-İkizdere, Turkey.
11.37 (100), 2.899 (50), 3.045 (40), 8.29 (35), 2.418 (35), 1.962 (35), 5.68 (30)

Chemistry:

	(1)	(2)
SiO_2	1.2	3.6
FeO		0.1
MnO		1.2
MgO		0.1
CaO	62.9	65.0
Cl	3.3	3.5
H_2O^+	[19.94]	11.47
CO_2	13.4	16.3
$-O = Cl_2$	0.74	0.8
Total	[100.00]	100.5

(1) Güneyce-İkizdere, Turkey; by electron microprobe, average of 18 analyses on three samples, H_2O by difference; corresponds to $Ca_{6.00}(CO_3)_{1.62}(SiO_4)_{0.1}(OH)_{7.82}Cl_{0.50} \bullet 2.00H_2O$ (with zeolitic H_2O). (2) Kombat mine, Namibia; preferred values obtained from analysis by AA, electron microprobe, Heraeus CHN analyzer, and the Penfield method; corresponds to $(Ca_{5.90}Mn_{0.09}Mg_{0.01})_{\Sigma=6.00}(CO_3)_{1.88}(SiO_4)_{0.30}(OH)_{6.48}Cl_{0.50}$.

Occurrence: In skarn at a granite-limestone contact (Güneyce-İkizdere, Turkey); throughout a body of unbanded, granular massive hausmannite (Kombat mine, Namibia).

Association: Vesuvianite, wollastonite, andradite, diopside, calcite, rustumite, spurrite, hillebrandite (Güneyce-İkizdere, Turkey); hausmannite, hillebrandite, brucite, crednerite, barite, calcite, vesuvianite, jacobsite, hematite, copper (Kombat mine, Namibia).

Distribution: From the Güneyce-İkizdere area, Trabzon Province, Turkey. In the Kombat mine, 49 km south of Tsumeb, Namibia.

Name: For Jacques Deferne, Curator of Mineralogy, Museum of Natural History, Geneva, Switzerland.

Type Material: Museum of Natural History, Geneva, Switzerland, 435/30; National Museum of Natural History, Washington, D.C., USA, 163241.

References: (1) Sarp, H., M.F. Taner, J. Deferne, H. Bizouard, and B.W. Liebich (1980) La defernite, $Ca_6(CO_3)_2(OH,Cl)_8 \bullet nH_2O$, un nouveau carbonate de calcium chloro-hydroxylé. Bull. Minéral., 103, 185–189 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 1066 (abs. ref. 1). (3) Liebich, B.W. and H.S. Sarp (1985) La structure cristalline de la defernite. Schweiz. Mineral. Petrog. Mitt., 65, 153–158 (in French with English abs.). (4) Peacor, D.R., H. Sarp, P.J. Dunn, J. Innes, and J.A. Nelen (1988) Defernite from the Kombat mine, Namibia: a second occurrence, structure refinement, and crystal chemistry. Amer. Mineral., 73, 888–893.

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Delafossite $Cu^{1+}Fe^{3+}O_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals tabular on {0001}, to 8 mm; also equant, bounded by {0001} and $\{10\overline{1}1\}$; as botryoidal crusts, spherulitic, powdery, massive. *Twinning:* On {0001}, as contact twins.

Physical Properties: *Cleavage:* $\{10\overline{1}1\}$, imperfect. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 5.41 D(calc.) = 5.52 Weakly magnetic.

Optical Properties: Opaque. *Color:* Black; pale brownish rose in reflected light.
Streak: Black. *Luster:* Metallic.
Optical Class: Uniaxial. *Pleochroism:* Distinct; O = pale golden brown; E = rose-brown.
Anisotropism: Strong.
R_1–R_2: (400) 18.4–22.2, (420) 18.6–22.3, (440) 18.8–22.4, (460) 19.0–22.6, (480) 19.0–22.9, (500) 18.9–23.2, (520) 19.0–23.4, (540) 19.0–23.4, (560) 19.1–23.2, (580) 19.2–23.0, (600) 19.3–23.0, (620) 19.6–23.2, (640) 20.0–23.5, (660) 20.6–23.8, (680) 21.1–24.2, (700) 21.8–24.8

Cell Data: *Space Group:* $R\overline{3}m$. $a = 3.02$–3.04 $c = 17.10$–17.12 $Z = 3$

X-ray Powder Pattern: Locality unknown. (ICDD 12-752).
2.508 (100), 1.512 (40), 2.86 (35), 1.658 (35), 2.238 (25), 1.434 (20), 2.58 (18)

Chemistry:

	(1)	(2)	(3)
Cu	42.14	41.32	41.97
Fe	33.56	37.26	36.89
O	[19.74]	[21.21]	21.14
rem.	3.52	0.21	
Total	[98.96]	[100.00]	100.00

(1) Yekaterinburg, Russia; remnant is Al_2O_3. (2) Bisbee, Arizona, USA; average of two analyses, remnant is hematite. (3) $CuFeO_2$.

Occurrence: Principally as a secondary mineral near the base of the oxidized zone of copper deposits; less commonly a primary mineral.

Association: Cuprite, copper, tenorite, malachite, hematite, kaolinite.

Distribution: In the Mednorudyanskoye copper deposit, Nizhni Tagil, near Yekaterinburg (Sverdlovsk), Ural Mountains, and elsewhere in Russia. From the Cartagenera mine, near Pedroso, Sevilla, Spain. In the Tolvaddon mine, Marazion, Cornwall, England. In Germany, from Pfaffenreuth and Waldsassen, Bavaria; in the Clara mine, near Oberwolfach, Black Forest. At Tary-Ekan, Karamazan, Tajikistan. From Mina Remolinos Nuevo, Atacama, Chile. At the Ojuela mine, Mapimí, Durango, Mexico. In the USA, good crystals from Bisbee, Cochise Co., and in the United Verde mine, Jerome, Yavapai Co., Arizona; from the Alpha mine, Kimberly, White Pine Co., and Eureka, Eureka Co., Nevada; from the Pope-Shenon copper mine near Salmon, Lemhi Co., Idaho; in the Kirwin mineralized area, Park Co., Wyoming. From Akjoujt, Mauritania. In the Malanjkhand copper deposit, north of Durg, Madhya Pradesh, India. A few other less-well-defined localities are known.

Name: For the French mineralogist and crystallographer, Gabriel Delafosse (1796–1878).

Type Material: National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 674–675. (2) Pabst, A. (1946) Notes on the structure of delafossite. Amer. Mineral., 31, 539–546. (3) Wiedersich, H., J.W. Savage, A.H. Muir, Jr., and D.G. Swarthout (1968). On the composition of delafossite. Mineral. Mag., 36, 643–650. (4) Hey, M.H. (1968) On the composition of natural delafossite. Mineral. Mag., 36, 651–653. (5) Pabst, A. (1975) Der Strukturtyp *F*51 und verwandte Strukturen. Neues Jahrb. Mineral., Abh., 123, 116–127 (in German with English abs.).

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Delhayelite $(K,Na)_{10}Ca_5Al_6Si_{32}O_{80}(Cl_2,F_2,SO_4)_3 \cdot 18H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals platy.

Physical Properties: *Cleavage:* Distinct on {010}. Hardness = n.d. D(meas.) = 2.60(3) D(calc.) = [2.50]

Optical Properties: Semitransparent. *Color:* Colorless; in thin section, abnormally bluish gray in sections cut normal to [010].
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.532(2)$ $\beta = 1.532(2)$ $\gamma = 1.532(2)$ $2V(meas.) = 83(3)^\circ$

Cell Data: *Space Group:* $Pmmn$ or $Pmn2_1$. $a = 24.86(1)$ $b = 7.07(2)$ $c = 13.06(2)$ $Z = 1$

X-ray Powder Pattern: Mt. Shaheru, Congo.
3.078 (100), 12.3 (35), 6.158 (25), 3.482 (10), 2.961 (5), 2.788 (5), 1.760 (5)

Chemistry:

	(1)		(1)
SiO_2	52.60	K_2O	9.27
TiO_2	0.09	F	0.33
Al_2O_3	9.22	Cl	3.91
Fe_2O_3	2.72	H_2O^+	5.93
MnO	0.07	H_2O^-	3.35
MgO	1.03	SO_3	1.31
CaO	7.99	$-O = (F,Cl)_2$	1.01
Na_2O	3.20	Total	100.01

(1) Mt. Shaheru, Congo; total Fe as Fe_2O_3; corrected for nepheline 2%.

Occurrence: In a kalsilite-bearing melilite-nepheline lava (Mt. Shaheru, Congo).

Association: Kalsilite, nepheline, götzenite, combeite, kirschsteinite (Mt. Shaheru, Congo); fenaksite, eudialyte, lomonosovite (Khibiny massif, Russia).

Distribution: On Mt. Shaheru, the extinct southern cone of Mt. Nyiragongo, Kivu Province, Congo (Zaire). On Mts. Rasvumchorr and Yukspor, Khibiny massif, Kola Penninsula, Russia.

Name: Honoring Fernard Delhaye (1880–1946), Belgian geologist, a pioneer in the geological exploration of the northern Kivu region of Congo (Zaire).

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM8037.

References: (1) Sahama, T.G. and K. Hytönen (1959) Delhayelite, a new silicate from the Belgian Congo. Mineral. Mag., 32, 6–9. (2) (1959) Amer. Mineral., 44, 1321–1322 (abs. ref. 1). (3) Cannillo, E., G. Rossi, and L. Ungaretti (1969) The crystal structure of delhayelite. Rend. Soc. Ital. Mineral. Petrol., 26, 63–75 (in English).

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Deliensite $Fe^{2+}(UO_2)_2(SO_4)_2(OH)_2 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As crystals, elongated along [001], tabular on {100}, to 0.35 mm; typically in spherical aggregates and in crusts. *Twinning:* Observed on {010}, yielding a parting.

Physical Properties: *Cleavage:* On {100}, perfect; on {010}, a parting. *Tenacity:* "Weak". Hardness = 2 D(meas.) = 3.268(7) D(calc.) = 3.31 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Pale yellow to pale gray. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, weak.
$\alpha = [1.432]$ $\beta = 1.470(2)$ $\gamma = 1.492(2)$ 2V(meas.) = 73(2)°

Cell Data: *Space Group:* $Pnnm$ or $Pnn2$. $a = 15.908(5)$ $b = 16.274(3)$ $c = 6.903(1)$
Z = 4

X-ray Powder Pattern: Mas-d'Alary deposit, France.
5.90 (100), 7.95 (81), 3.94 (71), 2.597 (70), 3.45 (67), 3.166 (50), 2.895 (41)

Chemistry:

	(1)	(2)
SO_3	17.37	18.28
UO_3	67.63	65.29
FeO	7.42	8.20
H_2O	8.63	8.23
Total	101.05	100.00

(1) Mas-d'Alary deposit, France; by electron microprobe, average of five analyses, H_2O by TGA; corresponds to $Fe_{0.91}(UO_2)_{2.08}(SO_4)_{1.95}(OH)_{2.08} \cdot 3.18H_2O$. (2) $Fe(UO_2)_2(SO_4)_2(OH)_2 \cdot 3H_2O$.

Occurrence: A rare mineral in the oxidized portions of a uranium deposit.

Association: Uraninite, gypsum, pyrite.

Distribution: From the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, France.

Name: Honors Dr. Michel Deliens (1939–), Belgian mineralogist of the Royal Belgian Institute of Natural Sciences, Brussels, Belgium, for his contributions to uranium mineralogy.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC4718.

References: (1) Vochten, R., N. Blaton, and O. Peeters (1997) Deliensite, $Fe(UO_2)_2(SO_4)_2(OH)_2 \cdot 3H_2O$, a new ferrous uranyl sulfate hydroxyl hydrate from Mas d'Alary, Lodève, Hérault, France. Can. Mineral., 35, 1021–1025. (2) (1998) Amer. Mineral., 83, 653 (abs. ref. 1).

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Delindeite $(Na,K)_3(Ba,Ca)_4(Ti,Fe,Al)_6Si_8O_{26}(OH)_{14}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As lath-shaped crystals or flakes, forming compact spherulitic aggregates, to 1 mm. *Twinning:* Submicroscopic on {100}, common.

Physical Properties: *Cleavage:* {001}, good. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.3(1) D(calc.) = 3.70(1)

Optical Properties: Translucent. *Color:* Pale pinkish gray. *Luster:* Resinous, pearly. *Optical Class:* Biaxial (+). $\alpha = 1.790(5)$ $\beta = 1.825(5)$ $\gamma = [1.982]$ 2V(meas.) = Moderate. 2V(calc.) = 54°

Cell Data: *Space Group:* $C2/m$ or subgroup. $a = 21.617(13)$ $b = 6.816(5)$ $c = 5.383(3)$ $\beta = 94.03(5)°$ Z = 1

X-ray Powder Pattern: Diamond Jo quarry, Arkansas, USA.
10.80 (100), 2.888 (31), 3.083 (28), 3.54 (24), 2.806 (20), 2.262 (18), 2.753 (16)

Chemistry:

	(1)
SiO_2	27.10
TiO_2	23.02
Al_2O_3	1.10
Fe_2O_3	2.54
MgO	0.00
CaO	0.61
BaO	33.05
Na_2O	3.79
K_2O	1.47
H_2O	[7.32]
Total	[100.00]

(1) Diamond Jo quarry, Arkansas, USA; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponds to $(Na_{2.16}K_{0.55})_{\Sigma=2.71}(Ba_{3.80}Ca_{0.19})_{\Sigma=3.99}(Ti_{5.08}Fe_{0.56}Al_{0.34})_{\Sigma=5.98}(Si_{7.96}Al_{0.04})_{\Sigma=8.00}[O_{32.83}(H_2O)_{7.17}]_{\Sigma=40.00}$.

Occurrence: In vugs and miarolitic cavities, as a weathering product of titaniferous nepheline syenite.

Association: Pectolite, barite, labuntsovite, lourenswalsite, pyroxene, titanite, sphalerite, potassic feldspar.

Distribution: Found in the Diamond Jo quarry, Magnet Cove, Hot Spring Co., Arkansas, USA.

Name: In honor of amateur mineralogist Henry deLinde of Mabelvale, Arkansas, USA, owner of the Diamond Jo quarry.

Type Material: n.d.

References: (1) Appleman, D.E., H.T. Evans, Jr., G.L. Nord, E.J. Dwornik, and C. Milton (1987) Delindeite and lourenswalsite, two new titanosilicates from the Magnet Cove region, Arkansas. Mineral. Mag., 51, 417–425. (2) (1988) Amer. Mineral., 73, 1493–1494 (abs. ref. 1).

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Dellaite $Ca_6Si_3O_{11}(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are bladed, in thin veinlets and patches, to 2 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.975

Optical Properties: Semitransparent (?). *Color:* [White (?).]
Optical Class: Biaxial (–) (synthetic). $\alpha = 1.650$ $\beta = 1.661$ $\gamma = 1.664$ 2V(meas.) = $< 30°$

Cell Data: *Space Group:* $P\overline{1}$ (synthetic). $a = 6.815$ $b = 6.934$ $c = 12.882$ $\alpha = 90.67°$ $\beta = 97.70°$ $\gamma = 98.14°$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 29-376).
2.821 (100), 2.551 (80), 2.806 (70), 3.059 (50), 2.856 (50), 2.982 (45), 2.730 (45)

Chemistry: No chemical analysis appears to have been published.

Occurrence: In late-stage, fracture-controlled replacement veins cutting thermally metamorphosed limestones.

Association: Calcite, spurrite, kilchoanite, foshagite, tilleyite.

Distribution: From near Kilchoan, Ardnamurchan, Argyllshire, Scotland.

Name: To honor Della Martin Roy (1926–), Pennsylvania State University, University Park, Pennsylvania, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119426.

References: (1) Agrell, S.O. (1965) Polythermal metamorphism of limestones at Kilchoan, Ardnamurchan. Mineral. Mag., 34, 1–15. (2) (1965) Amer. Mineral., 50, 2104–2105 (abs. ref. 1).

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Deloneite-(Ce) $NaCa_2SrCe(PO_4)_3F$

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Crystal Data: Hexagonal. *Point Group:* 3. Granular, to 1.5 mm.

Physical Properties: *Cleavage:* On $\{10\overline{1}0\}$ and $\{0001\}$. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.92(5) D(calc.) = 3.95

Optical Properties: Transparent. *Color:* Bright yellow. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.682(2)$ $\epsilon = 1.660(2)$

Cell Data: *Space Group:* $P3$. $a = 9.51(1)$ $c = 7.01(1)$ Z = 2

X-ray Powder Pattern: Mt. Koashva, Kola Peninsula, Russia.
2.84 (100b), 3.12 (40), 2.753 (40), 3.51 (30), 1.967 (30), 1.870 (30), 2.288 (20)

Chemistry:

	(1)		(1)
P_2O_5	30.71	CaO	14.77
SiO_2	0.74	SrO	18.19
ThO_2	0.02	BaO	0.10
Y_2O_3	0.02	Na_2O	4.45
La_2O_3	8.12	K_2O	0.07
Ce_2O_3	13.15	F	2.03
Pr_2O_3	1.13	H_2O	[0.38]
Nd_2O_3	3.81	$-O = F_2$	0.85
Sm_2O_3	0.34	Total	97.18

(1) Mt. Koashva, Kola Peninsula, Russia; by electron microprobe, corresponds to $(Na_{0.96}K_{0.01})_{\Sigma=0.97}Ca_{1.77}Sr_{1.18}(Ce_{0.54}La_{0.34}Nd_{0.15}Pr_{0.04}Sm_{0.02})_{\Sigma=1.09}[(P_{0.97}Si_{0.03})_{\Sigma=1.00}O_4]_3[F_{0.72}(OH)_{0.28}]_{\Sigma=1.00}$.

Occurrence: In the natrolite core of a pegmatite in a differentiated alkalic massif.

Association: Fluorcaphite, belovite-(Ce), lomonosovite, sitinakite, fluorite.

Distribution: From Mt. Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: To honor Boris Nikolaevich Delone (1890–1980), crystallographer and mathematician, Mathematics Institute, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Khomyakov, A.P., D.V. Lisitsin, I.M. Kulikova, and R.K. Rastsvetaeva (1996) Deloneite-(Ce) $NaCa_2SrCe(PO_4)_3F$ – a new mineral with a belovite-like structure. Zap. Vses. Mineral. Obshch., 125(5), 83–94 (in Russian with English abs.). (2) Rastsvetaeva, R.K. and A.P. Khomyakov (1996) Crystal structure of deloneite-(Ce), the highly ordered Ca analog of belovite. Doklady Acad. Nauk SSSR, 349, 354–357 (in Russian). (3) (1997) Amer. Mineral., 82, 820 (abs. ref. 1–2). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 72.

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Deloryite $Cu_4(UO_2)(MoO_4)_2(OH)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, tabular on {010}, elongated along [001], with arcuate terminations, to 3 mm; typically in rosettes of subparallel individuals.

Physical Properties: *Cleavage:* Perfect on {010} and {100}; good on {001}. *Fracture:* Conchoidal. Hardness = 4 D(meas.) = 4.9(1) D(calc.) = 4.78 Radioactive.

Optical Properties: Transparent to nearly opaque. *Color:* Dark green to black; yellow-green in transmitted light. *Streak:* Green. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 21.9°$; $Y \wedge a = 36.2°$. *Dispersion:* $r > v$, strong. $\alpha = 1.90(3)$ $\beta = 1.93(3)$ $\gamma = 1.96(3)$ 2V(meas.) = 90° 2V(calc.) = 91.3(1)°

Cell Data: *Space Group:* $C2/m$. $a = 19.94(1)$ $b = 6.116(2)$ $c = 5.520(3)$ $\beta = 104.18(5)°$ Z = 2

X-ray Powder Pattern: Cap Garonne mine, France.
4.100 (100), 3.734 (90), 4.815 (80), 2.482 (60), 4.425 (40), 4.276 (40), 3.254 (40)

Chemistry:

	(1)	(2)
MoO_3	29.16	30.43
SO_3	0.27	
UO_3	31.78	30.23
Al_2O_3	0.10	
CuO	33.36	33.63
H_2O	5.8	5.71
Total	100.47	100.00

(1) Cap Garonne mine, France; by electron microprobe, average of three analyses, H_2O by TGA, $(MoO_4)^{2-}$ and $(OH)^{1-}$ shown present by IR; corresponds to $Cu_{3.96}(UO_2)_{1.05}Al_{0.02}(MoO_4)_{1.91}(SO_4)_{0.03}(OH)_{6.08}O_{0.06}$. (2) $Cu_4(UO_2)(MoO_4)_2(OH)_6$.

Occurrence: Very rare in the oxidized portion of a uranium deposit in sandstone.

Association: Metazeunerite, atacamite, paratacamite, malachite, barite.

Distribution: From the Cap Garonne mine, near le Pradet, Var, France.

Name: Honors Jean Claude Delory (1953–), French mineral collector and land surveyor, Toulon, France, who collected the first specimens.

Type Material: Natural History Museum, Geneva, Switzerland, 435/82.

References: (1) Sarp H. and P.J. Chiappero (1992) Deloryite, $Cu_4(UO_2)(MoO_4)_2(OH)_6$, a new mineral from the Cap Garonne mine near Le Pradet, Var, France. Neues Jahrb. Mineral., Monatsh., 58–64. (2) (1992) Amer. Mineral., 77, 1305 (abs. ref. 1). (3) Pushcharovskiy, D.Y., R.K. Rastsvetaeva, and H. Sarp (1996) Crystal structure of deloryite, $Cu_4(UO_2)[Mo_2O_8](OH)_6$. J. Alloys and Compounds, 239, 23–26.

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Delrioite $CaSrV_2^{5+}O_6(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* m or $2/m$. As radial aggregates of tiny acicular crystals, intimately intergrown in parallel orientation with metadelrioite. *Twinning:* On {100}, not uncommon.

Physical Properties: Hardness = ∼2 D(meas.) = 3.1(1) D(calc.) = 3.16 Readily soluble in H_2O; reversibly dehydrated.

Optical Properties: Translucent. *Color:* Pale yellow-green to darker green on exposed surfaces, probably the result of photoreduction of some of the vanadium. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–); properties composite with metadelrioite. *Pleochroism:* X = colorless; Y = pale yellow; Z = deeper yellow. *Orientation:* Z = elongation; extinction parallel. $\alpha = 1.783(3)$ $\beta = 1.834(3)$ $\gamma = 1.866(3)$ 2V(meas.) = Medium to large.

Cell Data: *Space Group:* Ia or $I2/a$. $a = 17.170(3)$ $b = 7.081(1)$ $c = 14.644(4)$ $\beta = 102°29(1)'$ Z = 8

X-ray Powder Pattern: Jo Dandy mine, Colorado, USA.
6.52 (vs), 3.54 (s), 4.39 (ms), 3.26 (ms), 2.794 (ms), 2.174 (m), 4.19 (w)

Chemistry:

	(1)	(2)
V_2O_5	46.6	43.97
CaO	13.5	13.56
SrO	24.8	25.05
H_2O^+	5.7	17.42
H_2O^-	9.4	
Total	[100.0]	100.00

(1) Jo Dandy mine, Colorado, USA; an estimated 5:1 mixture with metadelrioite, $CaSrV_2O_6(OH)_2$, recalculated to 100% after deduction of quartz 1.30%.
(2) $CaSrV_2O_6(OH)_2 \cdot 3H_2O$.

Occurrence: An efflorescence on sandstone of the Salt Wash member of the Jurassic Morrison Formation associated with a U–V deposit.

Association: Metadelrioite, rossite, metarossite, quartz.

Distribution: From a dump at the Hummer portal of the Jo Dandy mine, Bull Canyon district, Paradox Valley, Montrose Co., Colorado, USA.

Name: For Mexican mineralogist Andrés Manuel del Rio (1764–1849), who first discovered vanadium in North America.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128296.

References: (1) Thompson, M.E. and A.M. Sherwood (1959) Delrioite, a new calcium strontium vanadate from Colorado. Amer. Mineral., 44, 261–264. (2) Smith, M.L. (1970) Delrioite and metadelrioite from Montrose County, Colorado. Amer. Mineral., 55, 185–200.

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Delvauxite $\mathbf{CaFe_4^{3+}(PO_4,SO_4)_2(OH)_8 \cdot 4-6H_2O(?)}$

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Crystal Data: Amorphous. *Point Group:* n.d. In nodules, surficially botryoidal to reniform, or crusts.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼3.5 D(meas.) = 2.377–2.530 D(calc.) = n.d.

Optical Properties: Opaque to translucent. *Color:* Yellowish brown, brownish black, dark to medium reddish brown, reddish. *Streak:* Pale brown. *Luster:* Waxy to opaline. *Optical Class:* Isotropic. n = 1.57–1.73

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Amorphous to X-rays.

Chemistry:

	(1)	(2)
SO_3	2.03	0.33
CO_2	0.27	0.24
SiO_2	1.64	2.34
P_2O_5	21.35	20.65
Al_2O_3	0.46	2.00
Fe_2O_3	42.91	43.56
MgO	0.08	0.03
CaO	7.36	7.97
H_2O	23.31	22.43
Total	99.41	99.55

(1) Berneau, Belgium; corresponds to $(Ca,Mg)_{1.00}(Fe^{3+},Al)_{4.10}(PO_4,SO_4,CO_3)_{2.74}(OH)_8 \cdot 5.71H_2O$. (2) Leoben, Austria; corresponds to $(Ca,Mg)_{1.00}(Fe^{3+},Al)_{4.10}(PO_4,SO_4,CO_3)_{2.18}(OH)_8 \cdot 4.72H_2O$.

Occurrence: In gossan (Nenačovice, Czech Republic).

Association: Diadochite, vivianite, pitticite, melanterite, "limonite".

Distribution: From Berneau, Richelle, and Argenteau, all near Visé, Belgium. At Tollinggraben, Leoben, Styria, Austria. From Nenačovice and Trubín, Czech Republic. At Železník (Vashegy), Slovakia. From Fouchères, Aube, France. In several mines of the Kurumsak and Balasauskandyk districts, northwestern Kara-Tau Mountains, Kazakhstan. From the St. John's quarry, near Kapunda, Mount Lofty Ranges, South Australia. Possibly from a number of other places, but modern confirmation is required.

Name: In honor of J.S.P.J. Delvaux de Feuffe (1782–1863), Belgian chemist, who first analyzed the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 935–936 [delvauxite]; 915 [borickite (bořickýite), part = delvauxite]; 915–916 [foucherite, part = delvauxite]. (2) Čech, F. and P. Povondra (1979) A re-examination of bořickýite [= delvauxite]. Tschermaks Mineral. Petrog. Mitt., 26, 79–86.

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Demesmaekerite $Pb_2Cu_5(UO_2)_2(Se^{4+}O_3)_6(OH)_6 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are elongated along [001] and flattened on {100} or {010}, with dominant {100} and {010}, secondary faces typically striated ‖ [101], to 1 cm; in radial aggregates.

Physical Properties: Hardness = 3–4 D(meas.) = 5.28(4) D(calc.) = 5.42 Radioactive.

Optical Properties: Translucent to opaque. *Color:* Bottle-green to pale olive-green, becoming brownish green with dehydration.
Optical Class: Biaxial (+). *Pleochroism:* X' = yellow-green; Y' = brown. $\alpha = 1.835(5)$ (α') β = n.d. $\gamma = 1.910(5)$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 11.955(5)$ $b = 10.039(4)$ $c = 5.639(2)$ $\alpha = 89.78(4)°$ $\beta = 100.36(4)°$ $\gamma = 91.34(4)°$ Z = 1

X-ray Powder Pattern: Musonoi mine, Congo.
2.97 (FFF), 5.42 (FF), 5.89 (F), 3.34 (F), 5.14 (mF), 4.72 (mF), 4.67 (mF)

Chemistry:

	(1)	(2)
SeO_2	30.9	30.65
UO_3	27.6	26.34
PbO	19.4	20.55
CuO	18.2	18.31
H_2O	4.2	4.15
Total	100.3	100.00

(1) Musonoi mine, Congo; H_2O by the Penfield method; corresponds to $Pb_{1.87}Cu_{4.93}(UO_2)_{2.08}(SeO_3)_6(OH)_{6.04} \cdot 2H_2O$. (2) $Pb_2Cu_5(UO_2)_2(SeO_3)_6(OH)_6 \cdot 2H_2O$.

Occurrence: Rare in the lower oxidized portions of a selenium-bearing Cu–Co deposit.

Association: Cuprosklodowskite, kasolite, guilleminite, derriksite, chalcomenite, malachite, selenian digenite.

Distribution: From the Musonoi Co–Cu mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Gaston Demesmaeker (1911–), Belgian mining geologist, Director, Geological Department, Union Minière du Haut Katanga.

Type Material: University of Pierre and Marie Curie, Paris, 9.097; Natural History Museum, Paris, 181.36; National School of Mines, Paris, France; The Natural History Museum, London, England, 1969,46.

References: (1) Cesbron, F., B. Bachet, and R. Oosterbosch (1965) La demesmaekerite, sélénite hydraté d'uranium, cuivre, et plomb. Bull. Minéral., 88, 422–425 (in French). (2) (1966) Amer. Mineral., 51, 1815–1816 (abs. ref. 1). (3) Ginderow, D. and F. Cesbron (1983) Structure de la demesmaekerite, $Pb_2Cu_5(SeO_3)_6(UO_2)_2(OH)_6 \cdot 2H_2O$. Acta Cryst., 39, 824–827 (in French). (4) Burns, P.C. and F.C. Hawthorne (1996) Static and dynamic Jahn-Teller effects in Cu^{2+} oxysalt minerals. Can. Mineral., 34, 1089–1105.

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Demicheleite-(I) BiSI

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. Crystals, acicular to stout prismatic, to 0.25 mm; with forms {110} and {111} by analogy to demicheleite-(Br).

Physical Properties: *Cleavage*: None observed. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.411

Optical Properties: Translucent. *Color*: Dark red to black. *Streak*: Brown. *Luster*: Submetallic. *Optical Class*: n.d.

Cell Data: *Space Group*: *Pnam*. *a* = 8.4501(7) *b* = 10.1470(9) *c* = 4.1389(4) Z = 4

X-ray Powder Pattern: La Fossa crater, Vulcano Island, Sicily, Italy. 6.490 (100), 4.346 (94), 3.896 (90), 2.709 (60), 2.161 (38), 3.243 (22), 2.999 (22)

Chemistry:

	(1)	(2)
Bi	58.32	56.80
S	9.43	8.71
I	23.69	34.49
Br	5.66	
Cl	1.01	
Total	98.11	100.00

(1) La Fossa crater, Vulcano Island, Sicily, Italy; electron microprobe analysis, corresponding to $Bi_{0.97}S_{1.03}(I_{0.65}Br_{0.25}Cl_{0.10})_{\Sigma=1.00}$. (2) BiSI.

Occurrence: A product of fumarolic alteration of pyroclastic breccia.

Association: Demicheleite-(Br), bismoclite, bismuthinite, aiolosite, godovikovite, panichiite, brontesite, adranosite.

Distribution: La Fossa crater, Vulcano Island, Aeolian archipelago, Sicily, Italy.

Name: Honors Vincenzo de Michele (b. 1936), former curator of the Natural History Museum, Milan, Italy, and for its chemical composition.

Type Material: Department of Structural Chemistry and Inorganic Stereochemistry, University of Milan, Italy (reference collection 2009-02).

References: (1) Demartin, F., C.M. Gramaccioli, and I. Campostrini (2010) Demicheleite-(I), BiSI, a new mineral from La Fossa Crater, Vulcano, Aeolian Islands, Italy. Mineral. Mag., 74, 141–145. (2) (2010) Amer. Mineral., 95, 1596 (abs. ref. 1).

Denisovite $(K,Na)Ca_2Si_3O_8(F,OH)$

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Crystal Data: Monoclinic. *Point Group:* n.d. As acicular crystals, in parallel columnar aggregates, to 15 cm.

Physical Properties: *Cleavage:* Cleavage or parting observed ⊥ elongation of crystals. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 2.76 D(calc.) = 2.81

Optical Properties: Semitransparent. *Color:* Light gray to greenish gray; colorless to faint yellow in thin section. *Luster:* Pearly to silky.
Optical Class: Biaxial (+). α = 1.565–1.569 β = 1.566–1.570 γ = 1.574–1.578
2V(meas.) = 20°–30°

Cell Data: *Space Group:* n.d. $a = 30.92(7)$ $b = 7.20(3)$ $c = 18.27(5)$ $\beta = 95°$ Z = 20

X-ray Powder Pattern: Khibiny massif, Russia.
3.32 (100), 2.75 (100), 3.24 (90), 3.03 (90), 3.65 (80), 3.08 (80), 2.79 (80)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	49.83	50.30	BaO		0.23
TiO_2	0.13	0.12	Li_2O	0.01	
Al_2O_3	0.65	0.83	Na_2O	2.66	2.26
Fe_2O_3	0.55		K_2O	8.94	9.30
Nb_2O_5	0.14		Rb_2O	0.09	
FeO	0.06	0.31	F	3.95	3.00
MnO	0.83	0.53	H_2O^+	1.16	n.d.
MgO	0.35	0.08	H_2O^-	0.16	n.d.
CaO	31.16	31.50	P_2O_5	0.04	
SrO	0.35	0.65	$-O = F_2$	1.62	1.23
			Total	99.44	[97.88]

(1) Khibiny massif, Russia; after deduction of small amounts of contaminant minerals, corresponds to $(K_{0.68}Na_{0.32})_{\Sigma=1.00}(Ca_{1.95}Mn_{0.04}Sr_{0.01})_{\Sigma=2.00}Si_{3.00}O_8[F_{0.54}(OH)_{0.46}]_{\Sigma=1.00}$.
(2) Murun massif, Russia; by electron microprobe, average of 11 grains, original total given as 98.88%; corresponds to $(K_{0.69}Na_{0.26}Mn_{0.05}Fe_{0.02}Mg_{0.01})_{\Sigma=1.03}(Ca_{1.97}Sr_{0.02}Mn_{0.01})_{\Sigma=2.00}(Si_{2.94}Al_{0.05})_{\Sigma=2.99}O_8F_{0.56}$.

Occurrence: In nepheline syenite in a differentiated alkalic massif (Khibiny massif, Russia).

Association: Nepheline, potassic feldspar, aegirine, fluorite, apatite, biotite, yuksporite (Khibiny massif, Russia): aegirine, kalsilite, feldspar (Murun massif, Russia).

Distribution: On Mts. Eveslogchorr and Yukspor, Khibiny massif, Kola Peninsula, and in the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: Honors Aleksander Petrovich Denisov (1918–1972), Russian specialist in X-ray investigations of minerals, of the Kola Scientific Center, Ruisia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5774/1–2; Mining Institute, St. Petersburg, 1295/1–2; Il'menskii Preserve Museum, Miass, 5392; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82762, vis4773; The Natural History Museum, London, England, 1994,7.

References: (1) Men'shikov, Y.P. (1984) Denisovite, $Ca_4(K_{1.4}Na_{0.6})_2Si_6O_{16}(F,OH)_2$, a new mineral from the Khibina massif. Zap. Vses. Mineral. Obshch., 113, 718–723 (in Russian). (2) (1985) Amer. Mineral., 70, 1329 (abs. ref. 1). (3) Konev, A.A., Y.I. Vorob'ev, L.F. Paradina, and A.N. Sapozhnikov (1987) Denisovite from the Murun pluton, its second find in the world. Doklady Acad. Nauk SSSR, 293, 196–198 (in Russian).

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Denningite $(Ca, Mn^{2+})(Mn^{2+}, Zn)(Te_2^{4+}O_5)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Rare as octagonal thin platy crystals, flattened on {001}, with {001}, {110}, and {100}, to 4 mm; most commonly in cleavable masses.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Conchoidal. Hardness = 4
D(meas.) = 5.05(5) D(calc.) = 5.07

Optical Properties: Translucent to transparent. *Color:* Pale green to pale gray, may be colorless; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (+), may be biaxial. $\omega = 1.89(1)$ $\epsilon = 2.00(1)$ 2V(meas.) = 0°–15°

Cell Data: *Space Group:* $P4_2/nbc$. $a = 8.82(5)$ $c = 13.04(5)$ Z = 4

X-ray Powder Pattern: Moctezuma mine, Mexico.
4.42 (vs), 3.38 (s+), 3.12 (s), 2.62 (s), 2.03 (s), 1.53 (ms), 6.26 (m)

Chemistry:

	(1)
TeO_2	82.34
MnO	10.28
ZnO	2.63
CaO	4.23
H_2O	0.03
excess O	0.09
insol.	0.03
rem.	0.27
Total	99.90

(1) Moctezuma mine, Mexico; Mg determined spectrographically, after deduction of minor components corresponds to $(Ca_{0.60}Mn_{0.40})_{\Sigma=1.00}(Mn_{0.72}Zn_{0.24}Mg_{0.04})_{\Sigma=1.00}(Te_2O_5)_{2.01}$.

Occurrence: In a hydrothermal Au–Te deposit.

Association: Tellurium, tellurite, paratellurite, spiroffite, zemannite.

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: To honor Reynolds McConnell Denning (1916–1967), Professor of Mineralogy, University of Michigan, Ann Arbor, Michigan, USA.

Type Material: Natural History Museum, Paris, 175.81; National School of Mines, Paris, France; Royal Ontario Museum, Toronto, Canada, M25000–M25005.

References: (1) Mandarino, J.A., S.J. Williams, and R.S. Mitchell (1961) Denningite, a new tellurite mineral from Moctezuma, Sonora, Mexico. Can. Mineral., 7, 340–341 (abs.). (2) (1962) Amer. Mineral., 47, 1484 (abs. ref. 1). (3) Mandarino, J.A., S.J. Williams, and R.S. Mitchell (1961) Denningite, a new tellurite mineral from Moctezuma, Sonora, Mexico. Can. Mineral., 7, 443–452. (4) (1963) Amer. Mineral., 48, 1419 (abs. ref. 3). (5) Walitzi, E.M. (1965) Die Kristallstruktur von Denningit, $(Mn, Ca, Zn)Te_2O_5$. Ein Beispiel für die Koordination um vierwertiges Tellur. Tschermaks Mineral. Petrog. Mitt., 10, 241–255 (in German with English abs.).

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Derbylite $(Ti, Fe^{3+}, Fe^{2+})_7Sb^{3+}O_{13}(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 2 mm, elongate along [001], showing many forms, mostly $\{hk0\}$; in small grains. *Twinning:* On {011} or $\{\overline{1}53\}$, commonly as cruciform twins and trillings.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 5 VHN = 1033–1121 (100 g load). D(meas.) = 4.53–4.62 D(calc.) = [4.50]

Optical Properties: Opaque, translucent in small grains. *Color:* Pitch-black; dark brown when translucent; in reflected light, gray with bluish green internal reflections. *Luster:* Resinous to metallic.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 2.45$ $\beta = 2.45$ $\gamma = 2.51$
2V(meas.) = $\sim 0°$
R_1–R_2: (400) 22.1–23.6, (420) 21.3–22.8, (440) 20.5–22.0, (460) 19.8–21.2, (480) 19.2–20.4, (500) 18.8–19.9, (520) 18.4–19.6, (540) 18.1–19.3, (560) 17.8–19.0, (580) 17.6–18.7, (600) 17.4–18.5, (620) 17.3–18.4, (640) 17.1–18.2, (660) 16.9–18.0, (680) 16.8–17.8, (700) 16.7–17.7

Cell Data: *Space Group:* $P2_1/m$. $a = 7.156$–7.160 $b = 14.347$–14.354 $c = 4.970$–4.980 $\beta = 104.61°$–$104.69°$ Z = 2

X-ray Powder Pattern: Buca della Vena mine, Italy.
2.853 (100), 2.674 (73), 3.186 (43), 3.118 (33), 2.479 (23), 2.393 (23), 3.997 (18)

Chemistry:

	(1)	(2)
TiO_2	36.6	40.20
Al_2O_3	3.8	
Fe_2O_3	36.0	31.83
Cr_2O_3	0.3	
Sb_2O_3	21.5	19.80
FeO		4.44
H_2O	[1.3]	[1.24]
Total	[99.5]	[97.51]

(1) Tripuhy, Brazil; by electron microprobe, H_2O calculated for one (OH). (2) Buca della Vena mine, Italy; by electron microprobe, Ti by AA, Fe^{2+}:Fe^{3+} separately determined, H_2O calculated for one (OH); corresponds to $(Ti_{3.66}Fe^{3+}_{2.90}Fe^{2+}_{0.45})_{\Sigma=7.01}Sb^{3+}_{0.99}O_{13.11}(OH)$.

Occurrence: In cinnabar-bearing placer gravels (Tripuhy, Brazil); in microcrystalline barite and in cavities within metasomatically mineralized dolostones (Buca della Vena mine, Italy).

Association: Roméite, tripuhyite, monazite, xenotime, zircon, rutile, hematite, muscovite (Tripuhy, Brazil); pyrite, sphalerite, bournonite, schafarzikite, versiliaite, apuanite, dolomite, barite (Buca della Vena mine, Italy).

Distribution: From around Tripuhy, near Ouro Preto, Minas Gerais, Brazil. In the Buca della Vena iron mine, north of Stazzema, Apuan Alps, Tuscany, Italy.

Name: For the American geologist Orville Adelbert Derby (1851–1915), at one time Director of the Brazilian Geological Survey.

Type Material: The Natural History Museum, London, England, 80143.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1025–1026. (2) Moore, P.B. and T. Araki (1976) Derbylite, $Fe^{3+}_4Ti^{4+}_3Sb^{3+}O_{13}(OH)$, a novel close-packed oxide structure. Neues Jahrb. Mineral., Abh., 126, 292–303. (3) Mellini, M., P. Orlandi, and N. Perchiazzi (1983) Derbylite from Buca della Vena mine, Apuan Alps, Italy. Can. Mineral., 21, 513–516. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 138.

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Derriksite $Cu_4(UO_2)(Se^{4+}O_3)_2(OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As well-formed wedgelike crystals, elongated along [001], flattened on {100}, to 0.7 mm, exhibiting {010}, {100}, {110}, and {121}; typically forms incrustations.

Physical Properties: *Cleavage:* On {010}, very good. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.61 Radioactive.

Optical Properties: Semitransparent. *Color:* Dark green to bottle-green. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.77$ $\beta = [1.85]$ (β') $\gamma = [1.89]$ (γ') 2V(meas.) = 68(19)°

Cell Data: *Space Group:* $Pn2_1m$. $a = 5.570(2)$ $b = 19.088(8)$ $c = 5.965(2)$ Z = 2

X-ray Powder Pattern: Musonoi mine, Congo.
4.78 (FFF), 4.072 (FF), 3.748 (FF), 4.352 (F), 3.218 (F), 5.35 (mF), 4.197 (mF)

Chemistry:

	(1)	(2)
SeO_2	24.87	25.21
UO_3	32.67	32.50
CuO	35.67	36.15
H_2O	8.10	6.14
Total	101.31	100.00

(1) Musonoi mine, Congo; by electron microprobe, H_2O partially adsorbed.
(2) $Cu_4(UO_2)(SeO_3)_2(OH)_6$ confirmed by crystal-structure analysis.

Occurrence: Very rare in the oxidized portions of a selenium-bearing Cu–Co deposit.

Association: Selenian digenite, chalcomenite, demesmaekerite, malachite.

Distribution: From the Musonoi Cu–Co mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Jean Marie François Joseph Derriks (1912–1993), Belgian geologist who studied the Shinkolobwe uranium deposit.

Type Material: University of Pierre and Marie Curie, Paris, 204, 12.251; Natural History Museum, Paris, 181.35; National School of Mines, Paris, France, 9.104.

References: (1) Cesbron, F., P. Pierrot, and T. Verbeek (1971) La derriksite, $Cu_4(UO_2)(SeO_3)_2(OH)_6 \cdot H_2O$, une nouvelle espèce minérale. Bull. Minéral., 94, 534–537 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1912–1913 (abs. ref. 1). (3) Ginderow, D. and F. Cesbron (1983) Structure de la derriksite, $Cu_4(UO_2)(SeO_3)_2(OH)_6$. Acta Cryst., 39, 1605–1607 (in French with English abs.).

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Dervillite Ag_2AsS_2

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Minute crystals, to 0.3 mm.

Physical Properties: Hardness = n.d. VHN = 19.5 (100 g load). D(meas.) = n.d. D(calc.) = 5.62

Optical Properties: Opaque. *Color:* White in reflected light. *Anisotropism:* Moderate. R_1–R_2: (400) 29.7, (420) 25.6, (440) 24.9, (460) 24.2, (480) 23.7, (500) 23.5, (520) 23.1, (540) 22.2, (560) 22.2, (580) 21.9, (600) 21.5, (620) 21.2, (640) 20.9, (660) 20.6, (680) 20.4, (700) 20.4 (averages)

Cell Data: *Space Group:* $P2/a$. $a = 6.833$ $b = 12.932$ $c = 9.638$ $\beta = 99°33'$ Z = [8]

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France.
3.075 (10), 3.019 (8), 2.843 (5), 3.251 (3), 2.659 (3), 3.170 (2), 2.742 (2)

Chemistry:

	(1)	(2)
Ag	61.39	60.81
As	19.03	21.11
S	18.06	18.08
Total	98.48	100.00

(1) Sainte-Marie-aux-Mines, France; by electron microprobe; Pb, Sb and Bi not detected; corresponds to $Ag_{2.02}As_{0.91}S_{2.00}$. (2) Ag_2AsS_2.

Occurrence: In a Co–Ni–Fe–As deposit.

Association: Arsenic, rammelsbergite, safflorite, proustite, calcite, quartz.

Distribution: Found on a museum specimen from the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, France [TL].

Name: For Dr. Henri Derville, French paleontologist, Strasbourg University, Strasbourg, France, who noted the original specimen.

Type Material: Museum of Natural History, 1531; National School of Mines, Paris, France.

References: (1) Bari, H. (1982) Dervillite Ag_2AsS_2, monoclinic, new definition of the species described by Weil, 1941. Pierres et Terre, 23–24, 62–67 (in French). (2) (1983) Amer. Mineral., 68, 1041 (abs. ref. 1). (3) Bari, H., F. Cesbron, Y. Moëlo, F. Permingeat, P. Picot, R. Perriot, H.-J. Schubnel, and R. Weil (1983) La dervillite, Ag_2AsS_2, nouvelle définition de l'espèce. Bull. Minéral., 106, 519–524 (in French with English abs.).

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Desautelsite $Mg_6Mn_2^{3+}(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$ or $3m$. As hexagonal scales and plates, flattened on {0001}, with {0001} and {$10\overline{1}0$}, to 0.2 mm; rarely as isolated crystals, more commonly in druses of microcrystals; as massive coatings. *Twinning:* By rotation about [0001], common.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = ∼2 D(meas.) = 2.13(2) D(calc.) = 2.10

Optical Properties: Semitransparent. *Color:* Bright orange. *Streak:* Pale orange. *Optical Class:* Uniaxial (–). *Pleochroism:* Strong; O = deep orange; E = pale orange. $\omega = 1.569(3)$ $\epsilon = 1.547(3)$

Cell Data: *Space Group:* $R\overline{3}m$ or $R3m$. $a = 3.114(1)$ $c = 23.39(2)$ Z = 3/8

X-ray Powder Pattern: Cedar Hill quarry, Pennsylvania, USA; indistinguishable from pyroaurite.
7.76 (100), 3.88 (60), 2.332 (60), 1.981 (60), 2.622 (50), 1.527 (30), 1.768 (20)

Chemistry:

	(1)	(2)	(3)
Al_2O_3		0.71	
Fe_2O_3	trace	0.05	
Mn_2O_3	23.04	23.60	23.92
MgO	35.88	36.39	36.65
CaO		0.21	
$H_2O + CO_2$	[41.08]	38.15	39.43
Total	[100.00]	99.11	100.00

(1) Cedar Hill quarry, Pennsylvania, USA; by electron microprobe, CO_2 confirmed by effervescence in HCl; total Mn as Mn_2O_3, $H_2O + CO_2$ by difference. (2) Shiraki, Japan; by AA. (3) $Mg_6Mn_2^{3+}(CO_3)(OH)_{16}\cdot 4H_2O$.

Mineral Group: Hydrotalcite group.

Occurrence: Abundantly, in fractures in serpentinite breccia, with other secondary magnesium minerals, the last mineral to form (California, USA); in ultramafics in faults in sediments (Shiraki, Japan).

Association: Brucite, artinite (California, USA); aragonite, hydrotalcite, rhodochrosite, manganese oxides (Shiraki, Japan).

Distribution: In the USA, from the Cedar Hill quarry, Lancaster Co., Pennsylvania, and at the Coalinga asbestos mine and the Herman Akers prospect, New Idria district, San Benito Co., California. In Japan, from Shiraki, Mie Prefecture, and Konomori, Kochi Prefecture.

Name: To honor Paul Ernest Desautels (1920–1991), Curator of Mineralogy, National Museum of Natural History (Smithsonian Institution), Washington, D.C., USA.

Type Material: Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 120219.

References: (1) Dunn, P.J., D.R. Peacor, and T.D. Palmer (1979) Desautelsite, a new mineral of the pyroaurite [hydrotalcite] group. Amer. Mineral., 64, 127–130. (2) Inaba, S., T. Minakawa, and S. Noto (1983) Desautelsite from (the quarry at) Shiraki, Mie Prefecture, Japan. Chigaku Kenkyu, 34, 89–95 (in Japanese). (3) (1985) Chem. Abs., 103, 164 (abs. ref. 2).

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Descloizite $PbZn(VO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, equant or pyramidal {111}, prismatic [001] or [100], or tabular {100}, with {101}, {201}, many others, rarely skeletal, to 5 cm, commonly in drusy crusts, stalactitic or botryoidal, coarsely fibrous, granular to compact, massive.

Physical Properties: *Fracture:* Small conchoidal to uneven. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = ∼6.2 D(calc.) = 6.202

Optical Properties: Transparent to nearly opaque. *Color:* Brownish red, red-orange, reddish brown to blackish brown, nearly black. *Streak:* Orange to brownish red. *Luster:* Greasy. *Optical Class:* Biaxial (–), rarely biaxial (+). *Pleochroism:* Weak to strong; $X = Y =$ canary-yellow to greenish yellow; $Z =$ brownish yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong; rarely $r < v$. $\alpha = 2.185(10)$ $\beta = 2.265(10)$ $\gamma = 2.35(10)$ 2V(meas.) = ∼90°

Cell Data: *Space Group: Pnma.* $a = 7.593$ $b = 6.057$ $c = 9.416$ Z = 4

X-ray Powder Pattern: Venus mine, [El Guaico district, Córdoba Province,] Argentina; close to mottramite.
3.23 (vvs), 5.12 (vs), 2.90 (vs), 2.69 (vsb), 2.62 (vsb), 1.652 (vs), 4.25 (s)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.02		ZnO	19.21	10.08
As_2O_5	0.00		PbO	55.47	55.30
V_2O_5	22.76	22.53	$H_2O^{+350°}$	2.17	
FeO	trace		$H_2O^{-350°}$	0.02	
MnO	trace		H_2O		2.23
CuO	0.56	9.86	Total	100.21	100.00

(1) Abenab, Namibia. (2) $Pb(Zn, Cu)(VO_4)(OH)$ with Zn:Cu = 1:1.

Polymorphism & Series: Forms a series with mottramite.

Mineral Group: Descloizite group.

Occurrence: A secondary mineral in the oxidized zone of vanadium-bearing base metal deposits; rarely an ore of vanadium.

Association: Mottramite, vanadinite, pyromorphite, mimetite, wulfenite, cerussite.

Distribution: Many localities. From "Sierra de Córdoba," Córdoba Province, Argentina. At Los Lamentos and Santa Eulalia, Chihuahua, Mexico. In the USA, in the Mammoth-St. Anthony mine, Tiger, Pinal Co., and from Bisbee, Cochise Co., Arizona; in the Caballo Mountains district, Sierra Co., and several mines around Georgetown, Grant Co., New Mexico; from the Chalk Mountain mine, Churchill Co., Nevada. Large crystals from an economic deposit at Berg Aukas, near Grootfontein; at Abenab; from Tsumeb; and elsewhere in the Otavi district, Namibia. At Kabwe (Broken Hill), Zambia. From M'fouti and Ruwe, Congo Republic. In the Gowde mine, Great Salt Desert, Iran. At Obir, Carinthia, Austria. From Mežica (Mies), Slovenia. In the Prequica mine, Cobral d'Adrea, Portugal.

Name: To honor Alfred Lewis Oliver Legrand Des Cloizeaux (1817–1897), Professor of Mineralogy, University of Paris, Paris, France, who first described the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 811–815. (2) Hawthorne, F.C. and R. Faggiani (1979) Refinement of the structure of descloizite. Acta Cryst., 35, 717–720. (3) Kingsbury, A.W.G. and J. Hartley (1956) New occurrences of vanadium minerals (mottramite, descloizite, and vanadinite) in the Caldbeck area of Cumberland. Mineral. Mag., 31, 289–295.

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Despujolsite $Ca_3Mn^{4+}(SO_4)_2(OH)_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. As hexagonal prisms, to 0.5 mm, displaying dominant $\{10\bar{1}0\}$, modified by $\{10\bar{1}2\}$ and $\{0001\}$.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5
D(meas.) = 2.46(2) D(calc.) = 2.54

Optical Properties: Transparent to translucent. *Color:* Lemon-yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). *Pleochroism:* Weak; O = pale yellow; E = yellow. $\omega = 1.656(2)$ $\epsilon = 1.682(2)$

Cell Data: *Space Group:* $P\bar{6}2c$. $a = 8.56(2)$ $c = 10.76(4)$ $Z = 2$

X-ray Powder Pattern: Tachgagalt, Morocco.
3.34 (FFF), 4.26 (FF), 2.129 (FF), 7.40 (F), 2.570 (F), 2.025 (F), 3.49 (mF)

Chemistry: (1) Tachgagalt, Morocco; electron microprobe analysis confirmed dominant components Ca, Mn and S and the ratio of Ca:Mn = 3.10:1; chemical formula supported by crystal-structure analysis and analogy to schaurteite.

Occurrence: In a hydrothermal manganese deposit.

Association: Gaudefroyite.

Distribution: From Tachgagalt, 17 km south of Ouarzazate, Anti-Atlas Mountains, Morocco.

Name: Honors Pierre Despujols (1888–?), founder of the Moroccan Geologic Survey.

Type Material: National School of Mines, Paris, France.

References: (1) Gaudefroy, C., M.-M. Granger, F. Permingeat, and J. Protas (1968) La despujolsite, une nouvelle espèce minérale. Bull. Minéral., 91, 43–50 (in French with English abs.). (2) (1969) Amer. Mineral., 54, 326 (abs. ref. 1).

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Dessauite $(Sr,Pb)(Y,U)(Ti,Fe^{3+})_{20}O_{38}$

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Crystal Data: Tetragonal. *Point Group:* 4*mm*. Crystals tabular on {001}, exhibiting square or octagonal outline with vicinal forms, rarely showing pyramidal hemihedralism, to 4 cm; in subparallel aggregates; massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 5.42 D(calc.) = 5.48

Optical Properties: Transparent to translucent. *Color:* Deep blue; pale blue in transmitted light. *Streak:* Pale blue. *Luster:* Adamantine, pearly on cleavages.
Optical Class: Uniaxial (–). *Absorption:* $O > E$, in thick fragments. $\omega = 1.98(1)$ $\epsilon = 1.85(1)$

Cell Data: *Space Group:* *P*4*mm*. $a = 5.880(1)$ $c = 5.500(2)$ $Z = 1$

X-ray Powder Pattern: Tiger, Arizona, USA.
5.51 (10), 2.283 (10), 3.305 (9), 2.580 (9), 1.755 (9), 1.537 (9), 2.929 (8)

Chemistry:

	(1)	(2)	(3)
CuO	12.90	12.68	12.90
PbO	72.09	72.01	72.36
Cl	10.89	11.42	11.49
H_2O	6.14	6.03	5.84
insol.		0.19	
$-O = Cl_2$	2.46	2.57	2.59
Total	99.56	99.76	100.00

(1) Mendip Hills, England; corresponding to $Pb_{2.10}Cu_{1.06}Cl_{2.00}(OH)_{4.44}$. (2) Tiger, Arizona, USA; corresponding to $Pb_{1.98}Cu_{0.98}Cl_{1.98}(OH)_{4.01}$. (3) $Pb_2CuCl_2(OH)_4$.

Occurrence: In oxidized manganese ores (Mendip Hills, England); a secondary mineral in deeply oxidized Pb–Cu ores (Tiger, Arizona, USA); in slag exposed to seawater.

Association: Chloroxiphite, hydrocerussite, mendipite, cerussite (Mendip Hills, England); boleite, wherryite, hydrocerussite, leadhillite, phosgenite, caledonite, atacamite, paratacamite, cerussite (Tiger, Arizona, USA).

Distribution: In England, at the Higher Pitts Farm, Mendip Hills, and the Merehead quarry, near Shepton Mallet, Somerset; at Padstow Consols, Padstow, Cornwall. In Germany, from the Christian-Levin mine, near Essen, North Rhine-Westphalia, and from Richelsdorf, Hesse, in slag. Along Baratti Beach, Tuscany, Italy, in slag. At Laurium, Greece, in slag. In the USA, exceptional crystals from the Mammoth-St. Anthony mine, Tiger, Pinal Co., and from the Rowley mine, Maricopa Co., Arizona. In Iran, in the Tchah Khuni and other mines in the Anarak district; the Seh-Changi mine, near Neyband, Khorassan; and at Abdol Abad, Tabas. From Moolyella, and at the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia. In the Santa Ana mine, near Caracoles, Sierra Gorda district, Antofagasta, Chile. Found at an undefined locality in the Kopet-Dag Range, Cheleken Peninsula, Russia.

Name: From the Greek for *separate from*, and the related mineral *boleite*.

Type Material: The Natural History Museum, London, England, 1923,521; National Museum of Natural History, Washington, D.C., USA, 94813.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 82–83. (2) Winchell, R.E. and H.E. Wenden (1968) Synthesis and study of diaboleite. Mineral. Mag., 36, 932–939. (3) Rouse, R.C. (1971) The crystal chemistry of diaboleite. Zeits. Krist., 134, 69–80. (4) Bideaux, R.A. (1980) Tiger, Arizona. Mineral. Record, 11, 155–181. (5) Cooper, M.A. and F.C. Hawthorne (1995) Diaboleite, $Pb_2Cu(OH)_4Cl_4$, a defect perovskite structure with stereoactive lone-pair behavior of Pb^{2+}. Can. Mineral., 33, 1125–1129.

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Devilline **$CaCu_4(SO_4)_2(OH)_6 \cdot 3H_2O$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As pseudohexagonal crystals, platy on {001}, striated ‖ [010], typically in rosettes, to 1 cm; in crusts. *Twinning:* On {010}.

Physical Properties: *Cleavage:* On {001}, perfect; on {110}, {101}, {$10\overline{1}$}, distinct. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 3.13, on impure material. D(calc.) = 3.084 Soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Blue-green, dark emerald-green, verdigris-green; green in transmitted light. *Streak:* Pale green. *Luster:* Vitreous, may be pearly on {001}.
Optical Class: Biaxial (–). *Pleochroism:* X = pale green; Y = bluish green; Z = dark green. *Orientation:* $Z = b$; $X \simeq c$. *Dispersion:* $r < v$, marked. $\alpha = 1.585(3)$ $\beta = 1.649(3)$ $\gamma = 1.660(3)$ 2V(meas.) = 39°

Cell Data: *Space Group:* $P2_1/c$. $a = 20.870(2)$ $b = 6.135(2)$ $c = 22.191(3)$ $\beta = 102°44(1)'$ Z = 8

X-ray Powder Pattern: Špania Dolina, Slovakia (similar to serpierite).
10.22 (100), 5.099 (93), 3.392 (67), 2.098 (37), 3.209 (35), 3.745 (34), 3.185 (33)

Chemistry:

	(1)	(2)
SO_3	24.41	24.92
SiO_2	2.11	
CuO	48.39	49.52
CaO	8.32	8.73
H_2O	16.22	16.83
Total	99.45	100.00

(1) Špania Dolina, Slovakia; after deduction of SiO_2 as quartz, corresponds to $Ca_{0.98}Cu_{4.02}(SO_4)_{2.02}(OH)_{5.96} \cdot 2.97H_2O$. (2) $CaCu_4(SO_4)_2(OH)_6 \cdot 3H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized portions of copper sulfide deposits; may be of post-mining origin in dumps and on timbers.

Association: Langite, antlerite, brochantite, posnjakite, linarite, malachite, azurite, gypsum.

Distribution: In England, from Cornwall, at several mines around St. Just, St. Hilary, and Gwinear; at Wheal Friendship, Mary Tavy, Devon; from Caldbeck Fells, Cumbria. Fine examples at Špania Dolina (Herrengrund) and Piesky, Slovakia. In Germany, from Bad Ems, Rhineland-Palatinate, and at Sailauf, northeast of Aschaffenburg, Bavaria. In Italy, in the Monte Rosso gypsum cave; from the Baccu Locci mine, near Villaputzu, Sarrabus district, Sardinia. At Tsumeb, Namibia. From the Kabasaka and Nyukaku mines, Hyogo Prefecture, Japan. At the Tui mine, Mt. Te Aroha, New Zealand. In the USA, from the Ecton mine, Montgomery Co., Pennsylvania; at Sterling Hill, Ogdensburg, New Jersey; from Majuba Hill, Pershing Co., and at several other minor localities in Nevada; in the Trixie mine, Tintic district, Juab Co., Utah; in Arizona, from the Grandview mine, Grand Canyon, Coconino Co., in the Mammoth mine, Tiger, Pinal Co., at Ajo, Pima Co., and elsewhere.

Name: Honors Henri Etienne Sainte-Claire Deville (1818–1881), French chemist.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 590–592. (2) Mrázek, Z., T. Řidkošil, and J. Ederová (1983) New data for devillite [devilline]. Neues Jahrb. Mineral., Monatsh., 79–88. (3) Sabelli, C. and P.F. Zanazzi (1972) The crystal structure of devillite [devilline]. Acta Cryst., 28, 1182–1189. (4) Krause, W. and H. Täuber (1992) Zum Kenntnisstand der Minerale Serpierit, Orthoserpierit und Devillin. Aufschluss, 43(1), 1–25 (in German).

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Devitoite $Ba_6(PO_4)_2(CO_3)Fe^{2+}_7Fe^{3+}_2(Si_4O_{12})_2O_2(OH)_4$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Crystals, bladed, flattened on {001}, elongate and striated parallel to [100] with no terminations, to 5 mm; typically in subparallel intergrowths.

Physical Properties: *Cleavage*: Perfect on {001}, good on {010}. *Fracture*: Irregular. *Tenacity*: Flexible. Hardness = ~ 4 D(meas.) = n.d. D(calc.) = 4.044

Optical Properties: Transparent to translucent. *Color*: Brown. *Streak*: Cream to pale brown. *Luster*: Silky.
Optical Class: Biaxial (+). α = 1.730(3) β = 1.735(6) γ = 1.755(3) 2V(meas.) = n.d. 2V(calc.) = 53.6° *Pleochroism*: Brown. *Absorption*: Y >>> X > Z. *Orientation*: X ≈ *b*; Y ≈ *c*; *Z* ≈ *a*.

Cell Data: *Space Group*: $P\bar{1}$. *a* = 5.3437(7) *b* = 11.6726(15) *c* = 14.680(2) α = 91.337(4)° β = 96.757(4)° γ = 103.233(4)° *Z* = 1

X-ray Powder Pattern: Esquire #8 claim, eastern Fresno County, California, USA.
2.911 (100), 2.665 (100), 3.629 (73), 1.5597 (73b), 3.457 (70), 2.089 (66), 3.859 (62)

Chemistry:

	(1)	(2)
SiO_2	19.60	20.97
TiO_2	0.75	0.80
Al_2O_3	1.40	1.50
Fe_2O_3		6.08
FeO	25.70	22.02
MgO	0.70	0.75
CaO	0.47	0.50
BaO	36.30	38.83
P_2O_5	4.52	4.84
H_2O		1.67
CO_2		2.04
Total	89.44	100.00

(1) Esquire #8 claim, eastern Fresno County, California, USA; electron microprobe analysis, CO_3 and OH confirmed by IR and calculated from structure refinement, corresponding to $(Ba_{5.45}Ca_{0.19})_{\Sigma=5.64}(PO_4)_{1.47}O_{0.30}(CO_3)(Fe^{2+}_{6.60}Mg_{0.40})_{\Sigma=7}(Fe^{3+}_{1.64}Ti^{4+}_{0.22}Al^{3+}_{0.14})_{\Sigma=2}(Si_{7.51}Al_{0.49})_{\Sigma=8}O_{26}(OH)_4$. (2) $Ba_6(PO_4)_2(CO_3)Fe^{2+}_7Fe^{3+}_2(Si_4O_{12})_2O_2(OH)_4$.

Occurrence: An alteration product of gillepsite along fractures and parting planes in a sanbornite-bearing rock.

Association: Gillespite, titantaramellite, celsian, sanbornite, anandite, quartz, the Fe^{2+} analogue of ericssonite (California); gillespite, titantaramellite, fencooperite (Arizona).

Distribution: Esquire #8 and #7 claims along Big Creek in SE¼ SW¼, Section 22, T11S, R25E, Mount Diablo Meridian, eastern Fresno County, California; Trumbull Peak, Maricopa Co., Arizona, USA.

Name: Honors Alfred (Fred) Devito (1937–2004) a prominent mineral collector (micromounts), field collector and contributor to the California mineralogical community.

Type Material: Natural History Museum of Los Angeles County, Los Angeles, California, USA (catalog nos. 61591, 61592, 61593, 61594).

References: (1) Kampf, A.R., G.R. Rossman, I.M. Steele, J.J. Pluth, G.E. Dunning, and R.E. Walstrom (2010) Devitoite, a new heterophyllosilicate mineral with astrophyllite-like layers from eastern Fresno County, California. Can. Mineral., 48, 29–40. (2) (2010) Amer. Mineral., 95, 1596-1597 (abs. ref. 1).

Dewindtite $H_2Pb_3(UO_2)_6O_4(PO_4)_4 \cdot 12H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are rectangular tablets, flattened along and striated ‖ [001], to 3 mm; more usually pulverulent, fine-grained to compact massive.

Physical Properties: *Cleavage:* {100}, perfect. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 5.03 D(calc.) = 5.12 Radioactive. Fluoresces green under UV.

Optical Properties: Semitransparent. *Color:* Canary-yellow, may exhibit a greenish tint. *Streak:* Pale yellow.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; $Y = Z$ = golden yellow. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$. $\alpha = 1.760$–1.762 $\beta = 1.767$–1.768 $\gamma = 1.768$–1.770 2V(meas.) = Moderate to large.

Cell Data: *Space Group: Bmmb.* $a = 16.031(6)$ $b = 17.264(6)$ $c = 13.605(2)$ Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo; nearly identical to phosphuranylite.
8.01 (10), 5.89 (10), 2.88 (9), 4.00 (7), 3.14 (7), 3.40 (5), 3.07 (5)

Chemistry:

	(1)	(2)	(3)
UO_3	55.77	54.80	59.10
P_2O_5	10.62	10.14	9.78
PbO	26.20	24.85	23.06
H_2O	6.71	7.93	8.06
insol.	0.40		
Total	99.70	97.72	100.00

(1) Shinkolobwe, Congo; loss on ignition taken as H_2O. (2) Do.; corresponding to $Pb_{3.31}(UO_2)_{5.69}(PO_4)_{4.24}O_4 \cdot 13.07H_2O$. (3) $H_2Pb_3(UO_2)_6O_4(PO_4)_4 \cdot 12H_2O$.

Occurrence: A rare secondary mineral formed by alteration of uraninite or earlier-formed secondary uranium minerals.

Association: Torbernite, parsonsite, dumontite, uraninite (Shinkolobwe, Congo); bergenite, torbernite, autunite, "uranocircite", barian uranophane (The Streuberg, Germany); uranosphaerite, wölsendorfite, uraninite (Kerségalec-en-Lignol, France).

Distribution: From Shinkolobwe and Swambo, Katanga Province, Congo (Shaba Province, Zaire). At Wölsendorf, Bavaria, and on the Streuberg, near Bergen, and at Schneeberg, Saxony, Germany. From La Faye, near Grury, Saône-et-Loire, and at Kerségalec-en-Lignol, Morbihan, France. From Jáchymov (Joachimsthal), Czech Republic. At Urgeiriça, Portugal. In the Takwa and Lac Indicateur areas, Quebec, Canada. From the Ranger mine, Jabiru, Northern Territory, Australia.

Name: Honoring Dr. Jean Dewindt, Belgian geologist.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM6433; Natural History Museum, Paris, France, 122.106.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 875; 928 [renardite = dewindtite]. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 230–232. (3) Piret, P., J. Piret-Meunier, and M. Deliens (1990) Composition chimique et structure cristalline de la dewindtite $Pb_3[H(UO_2)_3O_2(PO_4)_2]_2.12H_2O$. Eur. J. Mineral., 2, 399–405 (in French with English abs.). (4) Hogarth, D.D. and E.W. Nuffield (1954) Studies of radioactive compounds: VII – phosphuranylite and dewindtite. Amer. Mineral., 39, 444–447.

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Crystal Data: Tetragonal. *Point Group:* 4*mm*. Crystals tabular on {001}, exhibiting square or octagonal outline with vicinal forms, rarely showing pyramidal hemihedralism, to 2 cm; in subparallel aggregates; massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 5.42 D(calc.) = 5.48

Optical Properties: Transparent to translucent. *Color:* Deep blue; pale blue in transmitted light. *Streak:* Pale blue. *Luster:* Adamantine, pearly on cleavages.
Optical Class: Uniaxial (–). *Absorption:* $O > E$, in thick fragments. $\omega = 1.98(1)$ $\epsilon = 1.85(1)$

Cell Data: *Space Group:* *P*4*mm*. $a = 5.880(1)$ $c = 5.500(2)$ $Z = 1$

X-ray Powder Pattern: Tiger, Arizona, USA.
5.51 (10), 2.283 (10), 3.305 (9), 2.580 (9), 1.755 (9), 1.537 (9), 2.929 (8)

Chemistry:

	(1)	(2)	(3)
CuO	12.90	12.68	12.90
PbO	72.09	72.01	72.36
Cl	10.89	11.42	11.49
H_2O	6.14	6.03	5.84
insol.		0.19	
$-O = Cl_2$	2.46	2.57	2.59
Total	99.56	99.76	100.00

(1) Mendip Hills, England; corresponding to $Pb_{2.10}Cu_{1.06}Cl_{2.00}(OH)_{4.44}$. (2) Tiger, Arizona, USA; corresponding to $Pb_{1.98}Cu_{0.98}Cl_{1.98}(OH)_{4.01}$. (3) $Pb_2CuCl_2(OH)_4$.

Occurrence: In oxidized manganese ores (Mendip Hills, England); a secondary mineral in deeply oxidized Pb–Cu ores (Tiger, Arizona, USA); in slag exposed to seawater.

Association: Chloroxiphite, hydrocerussite, mendipite, cerussite (Mendip Hills, England); boleite, wherryite, hydrocerussite, leadhillite, phosgenite, caledonite, atacamite, paratacamite, cerussite (Tiger, Arizona, USA).

Distribution: In England, at the Higher Pitts Farm, Mendip Hills, and the Merehead quarry, near Shepton Mallet, Somerset; at Padstow Consols, Padstow, Cornwall. In Germany, from the Christian-Levin mine, near Essen, North Rhine-Westphalia, and from Richelsdorf, Hesse, in slag. Along Baratti Beach, Tuscany, Italy, in slag. At Laurium, Greece, in slag. In the USA, exceptional crystals from the Mammoth-St. Anthony mine, Tiger, Pinal Co., and from the Rowley mine, Maricopa Co., Arizona. In Iran, in the Tchah Khuni and other mines in the Anarak district; the Seh-Changi mine, near Neyband, Khorassan; and at Abdol Abad, Tabas. From Moolyella, and at the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia. In the Santa Ana mine, Caracoles, Sierra Gorda district, Chile. Found at an undefined locality in the Kopet-Dag Range, Cheleken Peninsula, Russia.

Name: From the Greek for *separate from*, and the related mineral *boleite*.

Type Material: The Natural History Museum, London, England, 1923,521; National Museum of Natural History, Washington, D.C., USA, 94813.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 82–83. (2) Winchell, R.E. and H.E. Wenden (1968) Synthesis and study of diaboleite. Mineral. Mag., 36, 932–939. (3) Rouse, R.C. (1971) The crystal chemistry of diaboleite. Zeits. Krist., 134, 69–80. (4) Bideaux, R.A. (1980) Tiger, Arizona. Mineral. Record, 11, 155–181. (5) Cooper, M.A. and F.C. Hawthorne (1995) Diaboleite, $Pb_2Cu(OH)_4Cl_4$, a defect perovskite structure with stereoactive lone-pair behavior of Pb^{2+}. Can. Mineral., 33, 1125–1129.

Diadochite $Fe_2^{3+}(PO_4)(SO_4)(OH)\cdot 5H_2O$

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Crystal Data: Triclinic; may be amorphous. *Point Group:* 1 or $\overline{1}$. Rarely microcrystalline, as six-sided platy crystals, in nodular, reniform, botryoidal, stalactitic, colloform aggregates; commonly amorphous, glassy, earthy.

Physical Properties: *Fracture:* Earthy to uneven, conchoidal. *Tenacity:* Pulverulent to brittle. Hardness = 3–4 or less. D(meas.) = 2.0–2.4 D(calc.) = [2.32]

Optical Properties: Semitransparent. *Color:* Yellow, brownish yellow, brown; reddish brown, greenish yellow, pale green, pale yellow; in transmitted light, pale yellow to yellowish brown. *Optical Class:* Biaxial (+), isotropic when glassy. *Dispersion:* $r > v$, strong. n = 1.60–1.61 [isotropic] $\alpha = 1.615$ β = 1.618–1.638 γ = 1.665–1.670 2V(meas.) = Small.

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. a = 9.585(1) b = 10.235(1) c = 7.335(1) $\alpha = 81°46(1)'$ $\beta = 107°57(1)'$ $\gamma = 121°10(1)'$ Z = 2

X-ray Powder Pattern: Haut-le-Wastia, Belgium; commonly X-ray amorphous.
8.74 (100), 4.377 (100), 8.28 (90), 3.929 (85), 4.082 (65), 2.942 (65) 2.918 (40)

Chemistry:

	(1)	(2)	(3)
SO_3	15.14	17.21	19.53
P_2O_5	14.82	16.83	17.32
Fe_2O_3	39.69	37.80	38.97
FeO		0.07	
$H_2O(+)$		16.76	
$H_2O(-)$		10.04	
H_2O	30.35		24.18
rem.		0.86	
Total	100.00	99.57	100.00

(1) Arnsbach, Germany. (2) Haut-le-Wastia, Belgium; H_2O by the Penfield method.
(3) $Fe_2(PO_4)(SO_4)(OH)\cdot 5H_2O$.

Occurrence: A secondary mineral in gossans and some coal deposits, formed by sulfate-rich solutions acting on earlier phosphates, may be post-mine; in cave deposits, the phosphate derived from guano; widespread in secondary phosphate assemblages in granite pegmatites.

Association: Delvauxite, vashegyite, pitticite, melanterite, vivianite, wavellite, leucophosphite, phosphosiderite, ferrostrunzite, beraunite, mitridatite, rockbridgeite, jahnsite, roscherite, "limonite".

Distribution: From Arnsbach, near Gräfenthal, and in the Garnsdorf mine and the Feengrotten (Cave), Saalfeld, Thuringia, Germany. At Visé, Védrin, and Haut-le-Wastia, Belgium. From Hředl, Nučic, Litošice, Vysocany, and Chvaletice, Czech Republic. At Peychagnard, Isère, France. In Slovakia, from Železník (Vashegy). At Leoben, Austria. In the USA, from near Bethel Church, Pike Co., Indiana; at a coal mine in Jackson Township, Coshocton Co., and in Monday Creek Township, Perry Co., Ohio; from the Coon Creek mine, near Shady, Polk Co., Arkansas; in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; from Gringo Gulch, Santa Cruz Co., Arizona. At Rapid Creek, Yukon Territory, Canada. A few additional localities are reported.

Name: From the Greek for *a successor*, as it typically is formed from earlier phosphates.

Type Material: Mining Academy, Freiberg, Germany, 20765.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1011–1013. (2) Van Tassel, R. (1985) Mineraux phosphates secondaires (vashegyite, destinezite [= diadochite], wavellite, crandallite, phosphate de fer) a Haut-le-Wastia, province de Namur (Belgique). Bull. Soc. Belge Géol., 94, 19–27 (in French with English abs.).

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Diamond C

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$, possibly $\overline{4}3m$. Most commonly octahedral, crystals to 10 cm or more, also dodecahedral, tetrahedral, and cubic. Curved and striated faces common; spherical, with internal radial structure. *Twinning:* Contact twins with {111} as twin plane; typically flattened on {111}; as penetration twins, may be repeated.

Physical Properties: *Cleavage:* {111}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 10 VHN = n.d. D(meas.) = 3.511 D(calc.) = 3.515 Fluorescent and phosphorescent; triboelectric; the highest thermal conductivity of any known substance.

Optical Properties: Transparent to translucent. *Color:* Colorless, pale yellow to deep yellow, brown, white, blue-white; less commonly in oranges, pinks, greens, blues, reds, gray to black. *Luster:* Adamantine to greasy.
Optical Class: Isotropic. *Dispersion:* Strong. n = 2.4354 (486), 2.4175 (589), 2.4076 (687). *Anisotropism:* Birefringent where strained.
R: n.d.

Cell Data: *Space Group:* $Fd3m$. a = 3.5595 Z = 8

X-ray Powder Pattern: Synthetic.
2.06 (100), 1.261 (25), 1.0754 (16), 0.8182 (16), 0.8916 (8)

Chemistry: Nearly pure carbon.

Polymorphism & Series: Chaoite, graphite, and lonsdaleite are polymorphs.

Occurrence: Primarily formed in pipes, less commonly in dikes, of deep-seated, igneous origin, composed of kimberlite or lamproite, and in alluvial deposits formed by their weathering. In carbonaceous achondrite and iron meteorites; may be formed by impact.

Association: Forsterite, phlogopite, pyrope, diopside, ilmenite (kimberlite pipes); ilmenite, garnet, rutile, brookite, anatase, hematite, magnetite, tourmaline, gold, zircon, topaz (placers).

Distribution: Numerous occurrences world-wide, but only a few are of economic importance. Formerly important deposits were in India, in the Golconda region, and near Nágpur and Bundelkhand. From the area around Diamantina, Minas Gerais, and other states in Brazil. In South Africa, formerly obtained from the Orange and Vaal Rivers; still from along the coast north into Namibia, with offshore reserves estimated at 3 Bct. Important current alluvial production from Lunda Norte Province, Angola; southeastern Sierra Leone; also from Bakwanga and Tchikapa, Kasai Province, Congo (Zaire). From South Africa, in several pipes around Kimberley, at the Finsch mine, near Postmasburg, Cape Province; from the Premier mine, near Pretoria, and the Venetia mine, Transvaal; about 150 diamondiferous pipes have been mined. From the Jwaneng and Orapa pipes, Botswana. In Russia, in Sakha, from the Mir (Peace), Udatchnaya (Success), Zarnitsa (Thunderflash), Aikhal (Glory), and Jubileynaya (Jubilee) pipes. In China, from pipes at the Wafangdian and Binhai mine, Liaoning Province; at Changma, near Mengyin, Shandong Province. Prolific production from the Argyle pipe, Kimberley, Western Australia. At the Ekati and Diavik mines, Lac de Gras region, Northwest Territories, Canada.

Name: A corruption of the Greek for *invincible*.

Type Material: Natural History Museum, Paris, France, Haüy 6599.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 146–151. (2) (1953) NBS Circ. 539, 2, 5.

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Diaoyudaoite $NaAl_{11}O_{17}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals thin tabular, to 0.5 mm.

Physical Properties: *Cleavage:* One direction, good. *Fracture:* Conchoidal, "rare". Hardness = 7.6 VHN = 1393 (15 g load). D(meas.) = 3.30 D(calc.) = 3.21

Optical Properties: Transparent. *Color:* Colorless to pale green. *Optical Class:* Uniaxial (–). *Absorption:* Weak. $\omega = 1.6876(2)$ $\epsilon = 1.6630(2)$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.602(1)$ $c = 22.626(5)$ $Z = 2$

X-ray Powder Pattern: Diaoyudao Island, China.
11.2 (10), 2.680 (7), 5.65 (6), 1.400 (6), 2.505 (5), 2.028 (4), 1.413 (4)

Chemistry:

	(1)	(2)
SiO_2	0.23	
Al_2O_3	93.00	94.76
Cr_2O_3	1.95	
MgO	0.10	
CaO	0.10	
Na_2O	4.54	5.24
K_2O	0.12	
Total	100.04	100.00

(1) Diaoyudao Island, China; by electron microprobe, average of 13 analyses; corresponds to $(Na_{0.87}K_{0.02}Mg_{0.02}Ca_{0.01})_{\Sigma=0.92}(Al_{10.84}Cr_{0.15}Si_{0.02})_{\Sigma=11.01}O_{17}$. (2) $NaAl_{11}O_{17}$.

Occurrence: In the heavy-mineral (S.G. > 2.8) fraction of the surface layer of sea-floor muds at about 1500 m water depth.

Association: Chromium inclusions; other heavy minerals include "hornblende", epidote, dolomite, muscovite, chlorite, biotite.

Distribution: In the Okinawa Trough, near Diaoyudao Island, a few km northeast of Taiwan.

Name: For Diaoyudao Island, near which it occurs.

Type Material: Museum of Geology, Beijing, China.

References: (1) Shen Shunxi, Chen Lirong, Li Anchun, Dong Tailu, Huang Qiuhuo, and Xu Wenqiang (1986) Diaoyudaoite – a new mineral. Acta Mineralogica Sinica, 6, 224–227 (in Chinese with English abs.). (2) (1990) Amer. Mineral., 75, 240 (abs. ref. 1).

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Diaphorite $Pb_2Ag_3Sb_3S_8$

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Crystal Data: Monoclinic. *Point Group:* $P2/m$. Prismatic by elongation ‖ [001]; typically striated ‖ [001]; highly complex crystals, to nearly 1 cm; commonly as exsolutions and inclusions in galena. *Twinning:* On {120} and {241}.

Physical Properties: *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = n.d. D(meas.) = 6.04 D(calc.) = 6.019

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, white to grayish white. *Luster:* Metallic. *Anisotropism:* Strong.
R_1–R_2: (400) 38.2–40.1, (420) 37.8–39.8, (440) 37.5–39.5, (460) 37.3–39.3, (480) 37.0–39.0, (500) 36.7–38.8, (520) 36.4–38.6, (540) 36.0–38.3, (560) 35.6–38.0, (580) 35.3–37.8, (600) 35.0–37.4, (620) 34.8–37.2, (640) 34.5–37.0, (660) 34.2–36.6, (680) 33.8–36.1, (700) 33.4–35.8

Cell Data: *Space Group:* $P2_1/a$. $a = 15.849(4)$ $b = 17.914(4)$ $c = 5.901(1)$ $\beta = 116°25.5(2)'$ Z = 4

X-ray Powder Pattern: Machacamarca, Bolivia.
3.29 (10), 2.81 (8), 2.03 (5), 1.704 (4), 2.93 (3), 1.759 (3), 1.653 (2)

Chemistry:

	(1)	(2)	(3)
Pb	28.67	28.6	30.48
Ag	23.44	24.4	23.78
Fe	0.67		
Cu	0.73		
Sb	26.43	28.6	26.87
S	20.18	18.0	18.87
Total	100.12	99.6	100.00

(1) Příbram, Czech Republic; corresponds to $Pb_{1.80}Ag_{2.76}Fe_{0.15}Cu_{0.15}Sb_{2.76}S_{8.00}$. (2) Santa Maria de Catorze, Mexico; by electron microprobe, corresponding to $Pb_{1.97}Ag_{3.22}Sb_{3.35}S_{8.00}$. (3) $Pb_2Ag_3Sb_3S_8$.

Occurrence: In hydrothermal veins with other sulfides formed at medium temperatures.

Association: Galena, sphalerite, miargyrite, pyrargyrite, pyrite, siderite, quartz.

Distribution: In the Czech Republic, from Příbram [TL] and Kutná Hora. In Germany, in Saxony, at Bräunsdorf, near Freiberg [TL], in the Neues Hoffnung Gottes mine; at Freiberg; and in the Alte Hoffnung Gottes mine, Voigtsberg. [??ck if Saxony??] From Baia Sprie (Felsőbánya) and Baia Mare (Nagybánya), Romania. From Fournial, Cantal, and Pontgibaud, Puy-de-Dôme, France. In the Mangazeika and Bulatsk Pb–Zn deposits, northeastern Sakha, Russia. In the USA, from the Lake Chelan district, Chelan Co., Washington; the Wood River deposits, Mineral Hill district, Blaine Co., Idaho; and near Morey, Nye Co., Nevada. At Santa Maria de Catorze, San Luis Potosí, Mexico. From Zancudo, Colombia. At Machacamarca and Cerro Rico, Potosí, Bolivia. From the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. Known from a number of other localities.

Name: From the Greek for *difference*, as being distinct from freieslebenite.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 414–415. (2) Hellner, E. (1958) Über komplex zusammengesetzte Spiessglanze III. Zur Struktur des Diaphorits, $Ag_3Pb_2Sb_3S_8$. Zeits. Krist., 110, 169–174 (in German with English abs.). (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 136. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 140.

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Diaspore AlO(OH)

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, platy on {010} and elongated to acicular along [001], to 40 cm; stalactitic, foliated, scaly; disseminated, massive. *Twinning:* On {021}, to form heart-shaped twins or pseudohexagonal aggregates; on {061}, uncommon.

Physical Properties: *Cleavage:* {010} perfect, {110} distinct, {100} in traces. *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 6.5–7 D(meas.) = 3.2–3.5 D(calc.) = 3.380

Optical Properties: Transparent to translucent. *Color:* White, pale gray, colorless, greenish gray, brown, pale yellow, pink, lilac; color may vary with viewing direction in the same specimen, may show a color change from brownish green in daylight to raspberry pink in artificial light; colorless in thin section. *Luster:* Adamantine, vitreous, pearly on cleavage faces. *Optical Class:* Biaxial (+). *Pleochroism:* In thick plates, may be reddish brown to reddish violet; grayish green to green. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, weak. *Absorption:* $Z > Y > X$, seen on strongly colored specimens. $\alpha = 1.682$–1.706 $\beta = 1.705$–1.725 $\gamma = 1.730$–1.752 2V(meas.) = 84°–86°

Cell Data: *Space Group: Pbnm.* $a = 4.4007(6)$ $b = 9.4253(13)$ $c = 2.8452(3)$ Z = 4

X-ray Powder Pattern: Springfield, Massachusetts, USA.
3.99 (100), 2.317 (56), 2.131 (52), 2.077 (49), 1.633 (43), 2.558 (30), 1.480 (20)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.42		Fe_2O_3	0.18	
Al_2O_3	84.44	84.98	H_2O	14.99	15.02
			Total	100.03	100.00

(1) Kossoi Brod, Russia. (2) AlO(OH).

Polymorphism & Series: Dimorphous with böhmite.

Occurrence: Typically a final product of diagenesis in bauxite deposits formed by the tropical weathering of alumino-silicate rocks; from hydrothermal alteration of aluminous minerals; a hydrothermal mineral in some alkalic pegmatites.

Association: Corundum, magnetite, margarite, chloritoid, spinel, chlorite, gibbsite, böhmite, sillimanite, lepidocrocite, hematite, kaolinite, halloysite.

Distribution: Many localities; some prominent ones include: near Kossoi Brod village, about 37 km south of Yekaterinburg (Sverdlovsk), and Kyshtym, Ural Mountains, Russia. From Banská Belá (Dilln), near Banská Štiavnica (Schemnitz), Slovakia. At Jordansmühl, Silesia, Poland. From Campolungo, Tessin, Switzerland. At Gumuch-dagh, near Ephesus, and in large crystals from between Aydin and Mugla, Turkey. From Sivec, near Prilep, Macedonia. On the islands of Naxos and Samos, Greece. From Lohatlha, 30 km north of Postmasburg, Cape Province, South Africa. In the USA, at Chester, Hampden Co., Massachusetts; on Corundum Hill, Newlin, Chester Co., Pennsylvania; at Culsagee, Macon Co., North Carolina; at Swiss, Gasconade Co., Missouri. From the Rosita Hills, Custer Co., Colorado; and at the Champion mine, White Mountains, Mono Co., California.

Name: From the Greek for *to scatter*, in allusion to its decrepitation under the blowpipe.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 675–679. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 102–110. (3) Schmetzer, K. and W. Bartelke (1979) Schleifwürdiger Diaspor aus der Türkei. Zeits. Deutsch Gem. Gess., 28, 69 (in German). (4) Hill, R.J. (1979) Crystal structure refinement and electron density distribution in diaspore. Phys. Chem. Minerals, 5, 179–200. (5) (1954) NBS Circ. 539, 3, 41.

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Dickinsonite $KNa_4Ca(Mn^{2+},Fe^{2+})_{14}Al(PO_4)_{12}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are minute, tabular {100}, commonly pseudorhombohedral, {011}, {$11\bar{1}$}, and many {$h0l$} forms; striated on {100} giving a triangular pattern; curved, lamellar, radiated, stellated; foliated, micaceous, to several cm; disseminated scaly massive.

Physical Properties: *Cleavage:* On {100}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 3.34–3.41 D(calc.) = 3.426

Optical Properties: Transparent to translucent. *Color:* Oil-green to olive-green, pale to dark grass-green, yellowish green to brownish green; green in transmitted light. *Streak:* White, nearly. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* X = pale olive-green; Y = paler olive-green; Z = very pale yellowish green. *Orientation:* $X = b$; $Y \wedge c \simeq 15°$. *Dispersion:* $r > v$, moderate to strong. $\alpha = 1.648–1.658$ $\beta = 1.655–1.662$ $\gamma = 1.662–1.671$ $2V(meas.) = \leq 90°$

Cell Data: *Space Group:* $A2/a$. $a = 24.940(6)$ $b = 10.131(4)$ $c = 16.722(2)$ $\beta = 105.60(2)°$ $Z = 4$

X-ray Powder Pattern: Branchville, Connecticut, USA; close to arrojadite. (ICDD 24-66). 3.04 (100), 2.717 (80), 3.22 (60), 2.85 (45), 5.93 (40), 2.770 (40), 2.554 (35)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	39.57	39.5	39.67	Li_2O	0.17	[0.17]	
Al_2O_3		2.0	2.37	Na_2O	7.46	7.8	5.77
FeO	13.25	13.3	23.42	K_2O	1.52	1.1	2.19
MnO	31.58	32.0	23.13	H_2O	1.65	[1.65]	0.84
MgO		0.0		insol.	2.58		
CaO	2.15	2.3	2.61	Total	99.93	[99.82]	100.00

(1) Branchville, Connecticut, USA. (2) Do.; by electron microprobe, total Fe as FeO, total Mn as MnO, Li_2O and H_2O from (1); corresponds to $K_{0.49}Li_{0.24}Na_{5.33}Ca_{0.87}(Mn^{2+}_{9.55}Fe^{2+}_{3.92})_{\Sigma=13.47}Al_{0.83}(PO_4)_{11.78}(OH)_{3.88}$. (3) $KNa_4Ca(Mn,Fe)_{14}Al(PO_4)_{12}(OH)_2$ with Mn:Fe = 1:1.

Polymorphism & Series: Forms a series with arrojadite.

Occurrence: A high-temperature (≈ 800 °C) primary mineral in granite pegmatites.

Association: Eosphorite, triploidite, lithiophilite, rhodochrosite, reddingite, fairfieldite (Branchville, Connecticut, USA).

Distribution: In the USA, from Branchville, Fairfield Co., and in the Strickland quarry, Portland, Middlesex Co., Connecticut; in Maine, from Auburn and Poland, Androscoggin Co., and at Hebron, Greenwood, and Newry, Oxford Co.; from the White Picacho district, Maricopa and Yavapai Cos., Arizona; in the Nickel Plate mine, near Keystone, Pennington Co., South Dakota. At the Buranga pegmatite, near Gatumba, Rwanda.

Name: In honor of the Reverend John William Dickinson (1835–1899), Redding, Connecticut, USA, an early collector of Branchville minerals.

Type Material: Yale University, New Haven, Connecticut, Brush 3090; Harvard University, Cambridge, Massachusetts, 110679, 103812; National Museum of Natural History, Washington, D.C., USA, 80561.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 717–719. (2) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (3) Moore, P.B., T. Araki, S. Merlino, M. Mellini, and P.F. Zanazzi (1981) The arrojadite-dickinsonite series, $KNa_4Ca(Fe,Mn)^{2+}_{14}Al(OH)_2(PO_4)_{12}$: crystal structure and crystal chemistry. Amer. Mineral., 66, 1034–1049.

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Dickite $Al_2Si_2O_5(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* m. As pseudohexagonal crystals, to 2 mm, which may be elongated along [100]. As aggregates of platelets resembling books; commonly as compact masses of microscopic crystals.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible but inelastic. Hardness = 2–2.5 D(meas.) = 2.60 D(calc.) = [2.62]

Optical Properties: Transparent. *Color:* White, but will assume coloration from included impurities. *Luster:* Satiny.
Optical Class: Biaxial (+). *Orientation:* $X \wedge c = 8°–14°$; $Y \wedge a = 14°–20°$. *Dispersion:* $r > v$.
$\alpha = 1.560–1.564$ $\beta = 1.561–1.566$ $\gamma = 1.566–1.570$ 2V(meas.) = 50°–80°

Cell Data: *Space Group:* Cc. $a = 5.150(1)$ $b = 8.940(1)$ $c = 14.424(2)$ $\beta = 96°44(1)'$
Z = 4

X-ray Powder Pattern: Schuylkill, Pennsylvania, USA. (ICDD 10-446).
7.15 (100), 3.580 (100), 2.326 (90), 4.124 (70), 3.799 (60), 2.510 (50), 1.975 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	46.86	46.14	MgO	0.09	
TiO_2	0.51		CaO	0.22	
Al_2O_3	37.12	39.61	Na_2O	0.07	
Fe_2O_3	1.43		K_2O	0.60	
FeO	0.06		H_2O	13.06	13.91
			Total	100.02	99.66

(1) Anglesey, Wales. (2) Pine Knot colliery, Pennsylvania, USA; corresponds to $Al_{2.02}Si_{1.99}O_5(OH)_{4.00}$.

Polymorphism & Series: Halloysite, kaolinite, and nacrite are polymorphs.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Commonly of hydrothermal origin along veins derived in part from the alteration of aluminosilicate minerals; also as an authigenic sedimentary mineral.

Association: Quartz, "chalcedony."

Distribution: Widespread; some localities for studied materials follow: at Amlwch and the Pant-y-Gaseg quarry, Trwynbychan, Anglesey, Wales. From Mád, Hungary. In the Iza Cave, Mt. Rodna, Romania. From Mas D'Alary, Lodève, Hérault, France. At Postmasburg and Barkly East, Cape Province, and in the Middelburg district, Transvaal, South Africa. In the USA, on Red Mountain, near Ouray, San Juan Co., Colorado; in the Mineral Mountain area, near St. George, Washington Co., Utah; the Pine Knot colliery, Schuylkill, Schuylkill Co., Pennsylvania; and on Bruin Creek, Elliott Co., Kentucky. At San Juanito and Cusihuiriáchic, Chihuahua, Mexico.

Name: For Allan Brugh Dick (1833–1926), Scottish metallurgical chemist, who first described the species.

Type Material: n.d.

References: (1) Ross, C.S. and P.F. Kerr (1930) Dickite, a kaolin mineral. Amer. Mineral., 15, 34–39. (2) Newnham, R.E. (1961) A refinement of the dickite structure and some remarks on polymorphism in kaolin minerals. Mineral. Mag., 32, 683–704. (3) Grim, R.E. (1953) Clay Mineralogy. McGraw Hill, 370. (4) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 194–212. (5) Sen Gupta, P.K., E.O. Schlemper, W.D. Johns, and F. Ross (1984) Hydrogen positions in dickite. Clays and Clay Minerals, 32, 483–485.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are minute, tabular {100}, commonly pseudorhombohedral, {011}, {11$\bar{1}$}, and many {$h0l$} forms; striated on {100} giving a triangular pattern; curved, lamellar, radiated, stellated; foliated, micaceous, to several cm; disseminated scaly massive.

Physical Properties: *Cleavage:* On {100}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 3.34–3.41 D(calc.) = 3.426

Optical Properties: Transparent to translucent. *Color:* Oil-green to olive-green, light to dark grass-green, yellowish green to brownish green; green in transmitted light. *Streak:* White, nearly. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* X = pale olive-green; Y = paler olive-green; Z = very pale yellowish green. *Orientation:* $X = b$; $Y \wedge c \simeq 15°$. *Dispersion:* $r > v$, moderate to strong. $\alpha = 1.648$–1.658 $\beta = 1.655$–1.662 $\gamma = 1.662$–1.671 2V(meas.) = $\leq 90°$

Cell Data: *Space Group:* $A2/a$. $a = 24.940(6)$ $b = 10.131(4)$ $c = 16.722(2)$ $\beta = 105.60(2)°$ Z = 4

X-ray Powder Pattern: Branchville, Connecticut, USA; close to arrojadite. (ICDD 24-66). 3.04 (100), 2.717 (80), 3.22 (60), 2.85 (45), 5.93 (40), 2.770 (40), 2.554 (35)

Chemistry:

	(1)	(2)	(3)
P_2O_5	39.57	39.5	39.67
Al_2O_3		2.0	2.37
FeO	13.25	13.3	23.42
MnO	31.58	32.0	23.13
MgO		0.0	
CaO	2.15	2.3	2.61

	(1)	(2)	(3)
Li_2O	0.17	[0.17]	
Na_2O	7.46	7.8	5.77
K_2O	1.52	1.1	2.19
H_2O	1.65	[1.65]	0.84
insol.	2.58		
Total	99.93	[99.82]	100.00

(1) Branchville, Connecticut, USA. (2) Do.; by electron microprobe, total Fe as FeO, total Mn as MnO, Li_2O and H_2O from (1); corresponds to $K_{0.49}Li_{0.24}Na_{5.33}Ca_{0.87}(Mn^{2+}_{9.55}Fe^{2+}_{3.92})_{\Sigma=13.47}Al_{0.83}(PO_4)_{11.78}(OH)_{3.88}$. (3) $KNa_4Ca(Mn,Fe)_{14}Al(PO_4)_{12}(OH)_2$ with Mn:Fe = 1:1.

Polymorphism & Series: Forms a series with arrojadite.

Occurrence: A high-temperature ($\approx$ 800 °C) primary mineral in granite pegmatites.

Association: Eosphorite, triploidite, lithiophilite, rhodochrosite, reddingite, fairfieldite (Branchville, Connecticut, USA).

Distribution: In the USA, from Branchville, Fairfield Co., and in the Strickland quarry, Portland, Middlesex Co., Connecticut; in Maine, from Auburn and Poland, Androscoggin Co., and at Hebron, Greenwood, and Newry, Oxford Co.; from the White Picacho district, Maricopa and Yavapai Cos., Arizona; in the Nickel Plate mine, near Keystone, Pennington Co., South Dakota. At the Buranga pegmatite, near Gatumba, Rwanda.

Name: In honor of the Reverend John William Dickinson (1835–1899), Redding, Connecticut, USA, an early collector of Branchville minerals.

Type Material: Yale University, New Haven, Connecticut, Brush 3090; Harvard University, Cambridge, Massachusetts, 110679, 103812; National Museum of Natural History, Washington, D.C., USA, 80561.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 717–719. (2) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (3) Moore, P.B., T. Araki, S. Merlino, M. Mellini, and P.F. Zanazzi (1981) The arrojadite-dickinsonite series, $KNa_4Ca(Fe,Mn)^{2+}_{14}Al(OH)_2(PO_4)_{12}$: crystal structure and crystal chemistry. Amer. Mineral., 66, 1034–1049.

Dickthomssenite $Mg(V_2O_6)\cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are needlelike to prismatic platy, with basal terminations, to 1.5 mm.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Hackly. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = > 1.96 to < 2.09 D(calc.) = 2.037(1)

Optical Properties: Translucent. *Color:* Pale golden brown. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 17°$. *Dispersion:* $r < v$. $\alpha = 1.612$ $\beta = 1.674$ $\gamma = 1.710$ 2V(meas.) = 74° 2V(calc.) = 72.7°

Cell Data: *Space Group:* $C2/c$. $a = 38.954(2)$ $b = 7.201(4)$ $c = 16.3645(9)$ $\beta = 97.602(1)°$ Z = 16

X-ray Powder Pattern: Firefly-Pigmay mine, Utah, USA.
9.704 (100), 5.843 (100), 3.139 (90), 8.117 (60), 2.920 (60), 4.061 (50), 2.707 (50)

Chemistry:

	(1)	(2)
V_2O_5	73.92	52.22
FeO	0.46	
MgO	15.38	11.57
H_2O		36.21
Total		100.00

(1) Firefly-Pigmay mine, Utah, USA; by electron microprobe, total Fe as FeO, highly volatilized in the electron beam due to rapid dehydration; atomic ratios correspond to $(Mg_{0.95}Fe_{0.02})_{\Sigma=0.97}(V_{2.01}O_6)\cdot nH_2O$. (2) $Mg(V_2O_6)\cdot 7H_2O$ as established by crystal-structure analysis.

Occurrence: In the oxidized zone of a sandstone U–V deposit.

Association: Pascoite, sherwoodite, selenium.

Distribution: From the Firefly-Pigmay U–V mine, 16 km east of La Sal, San Juan Co., Utah, USA.

Name: To honor Richard Wyatt?? Thomssen (1933–), American economic geologist and collector of microscopic mineral specimens, Dayton, Nevada, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, ??.

References: (1) Hughes, J.M., F.E. Cureton, J. Marty, R.A. Gault, M.E. Gunter, C.F. Campana, J. Rakovan, A. Sommer, and M.E. Brueseke (2001) Dickthomssenite, $Mg(V_2O_6)\cdot 7H_2O$, a new mineral species from the Firefly-Pigmay mine, Utah: descriptive mineralogy and arrangement of atoms. Can. Mineral., 39, 1691–1700. (2) (2002) Amer. Mineral., 87, 1731–1732 (abs. ref. 1).

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Diegogattaite $Na_2CaCu_2Si_8O_{20}·H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As a massive 3 mm aggregate of platy crystals, individually to 0.5 mm.

Physical Properties: *Cleavage*: Good on {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 5-6 D(meas.) = n.d. D(calc.) = 3.10

Optical Properties: Transparent. *Color*: Pale turquoise to teal blue. *Streak*: Very pale blue. *Luster*: Vitreous.
Optical Class: Biaxial (–). α = 1.598(2) β = 1.627(2) γ = 1.632(2) 2V(meas.) = 44.0(6)° 2V(calc.) = 44.5° *Dispersion*: Strong, $r < v$. *Pleochroism*: X = colorless, $Y = Z$ = blue-green. *Absorption:* $Y \approx Z >> X$. *Orientation*: $X = b$, $Y \approx \perp$ (001), $Z \approx a$.

Cell Data: *Space Group*: *C*2/*m*. a = 12.2439(6) b = 15.7514(4) c = 10.6008(3) β = 125.623(2)° Z = 4

X-ray Powder Pattern: Wessels Mine, Northern Cape Province, Republic of South Africa. 3.261 (100), 2.898 (89), 3.951 (77), 4.25 (75), 2.332 (66), 2.079 (64), 1.5024 (59)

Chemistry:

	(1)
Na_2O	8.07
CaO	7.3
CuO	20.5
FeO	0.36
SiO_2	62.4
H_2O	[2.34]
Total	100.97

(1) Wessels Mine, Northern Cape Province, Republic of South Africa; average of 5 electron microprobe analyses, H_2O calculated from stoichiometry; corresponding to $Na_{2.00}Ca_{1.00}Cu_{1.98}Fe_{0.04}Si_{7.99}O_{20}•H_2O$.

Occurrence: In a hydrothermally altered manganese deposit.

Association: Wesselite, aegirine, Cu-rich pectolite, sugilite, quartz, and undifferentiated Fe-Mn oxides, as well as scottyite, lavinskyite, richterite.

Distribution: From the central-eastern ore-body, Wessels Mine, Kalahari manganese fields, Northern Cape Province, Republic of South Africa.

Name: Honors Professor Diego Gatta (b. 1974), Department of Earth Sciences, University of Milan, Italy, for his contributions in the areas of crystal structures and crystal chemistry of zeolites and related silicates with cage structures.

Type Material: Museum of Natural History, London, England, (BM 2012,2).

References: (1) Rumsey, M.S., M.D. Welch, A.R. Kampf, and J. Spratt (2013) Diegogattaite, $Na_2CaCu_2Si_8O_{20}·H_2O$: a new nanoporous copper sheet silicate from Wessels Mine, Kalahari Manganese Fields, Republic of South Africa. Mineral. Mag., 77(8), 3155-3162. (2) (2014) Amer. Mineral., 99, 1807-1808 (abs. ref. 1).

Dienerite Ni_3As

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Crystal Data: Cubic. *Point Group:* n.d. A single cubic crystal, about 0.5 cm on the edge.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* White with a tinge of gray. *Luster:* Bright metallic. R: n.d.

Cell Data: *Space Group:* n.d. a = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Ni	67.11	70.15
Co	1.29	
Cu	0.99	
Fe	0.61	
Ag	0.02	
As	30.64	29.85
Total	100.66	100.00

(1) Radstadt, Austria. (2) Ni_3As.

Occurrence: Known only from one loose single crystal.

Association: n.d.

Distribution: From near Radstadt, Salzburg, Austria. In the Minnamax Cu–Ni sulfide deposit, Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota, USA.

Name: Honors Professor Karl Diener (1862–1928), Austrian paleontologist, the discoverer.

Type Material: Lost.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 175. (2) Hackl, O. (1921) Ein neues Nickel–Arsen Mineral. Verh. Geol. Reichs-Anst. Wien, 107–108 (in German). (3) (1927) Amer. Mineral., 12, 96 (abs. ref. 2). (4) Bayliss, P. (2001) Dienerite - a mystification. Mineral. Mag., 65, 685–687.

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Dietrichite $(Zn, Fe^{2+}, Mn^{2+})Al_2(SO_4)_4 \cdot 22H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous, in tufted aggregates; as incrustations and efflorescences.

Physical Properties: Hardness = 2 D(meas.) = n.d. D(calc.) = [1.85] Soluble in H_2O.

Optical Properties: Transparent. *Color:* Dirty white to brownish yellow; colorless in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c \simeq 29°$. $\alpha = 1.475(3)$ $\beta = 1.480(3)$ $\gamma = 1.488(3)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/c$. $a = 6.240$ $b = 24.434$ $c = 21.379$ $\beta = 100.1°$ Z = 4

X-ray Powder Pattern: Baia Sprie, Romania. (ICDD 25-1173).
4.33 (100), 4.84 (40), 4.99 (30), 4.15 (30), 4.20 (20), 6.09 (15), 4.64 (15)

Chemistry:

	(1)
SO_3	35.94
Al_2O_3	10.92
FeO	3.11
MnO	1.74
ZnO	3.70
MgO	0.33
H_2O	44.38
Total	100.12

(1) Baia Sprie, Romania; corresponds to $(Zn_{0.40}Fe_{0.38}Mn_{0.22})_{\Sigma=1.00}Al_{1.91}(SO_4)_{4.00} \cdot 21.95H_2O$.

Mineral Group: Halotrichite group.

Occurrence: As post-mining efflorescences in abandoned mine workings.

Distribution: From Baia Sprie (Felsőbánya), Romania.

Name: To honor Dr. Gustav Heinrich Dietrich, Příbram, Czech Republic, who analyzed the first specimens.

Type Material: Royal Ontario Museum, Toronto, Canada, M7078.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 528–529.

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Dietzeite $Ca_2(IO_3)_2(CrO_4)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular {100} crystals, elongated along [001], to 1 mm; typically in columnar aggregates or fibrous crusts.

Physical Properties: *Cleavage:* On {100}, interrupted. *Fracture:* Conchoidal. Hardness = 3.5 D(meas.) = 3.62–3.70 D(calc.) = 3.822 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Deep golden yellow. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 6°$. *Dispersion:* $r < v$, very strong, markedly inclined. $\alpha = 1.825$ $\beta = 1.842$ $\gamma = 1.857$ 2V(meas.) = 86°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.118(1)$ $b = 7.238(1)$ $c = 13.965(2)$ $\beta = 106.62(1)°$ Z = 4

X-ray Powder Pattern: Oficina Lautaro, Chile. (ICDD 25-132).
3.48 (100), 3.13 (100), 3.61 (90), 2.98 (60), 2.88 (60), 1.870 (60), 1.741 (50)

Chemistry:

	(1)	(2)
I_2O_5	58.10	59.19
CrO_3	19.90	17.73
CaO	21.50	19.89
H_2O		3.19
Total	99.50	100.00

(1) Atacama Desert, Chile. (2) $Ca_2(IO_3)_2(CrO_4)\cdot H_2O$; crystal-structure analysis confirms one H_2O molecule as an essential chemical component.

Occurrence: In nitrate deposits in an arid region.

Association: Lopezite, tarapacáite, ulexite (Oficina Maria Elena, Chile).

Distribution: In Chile, from the Atacama Desert, as in the Taltal district, from near the Oficina Louisa and Oficina Chacabuco; at Pampa Pique III, about one km north of Oficina Lautaro, and near Oficina Maria Elena, near Tocopilla, Antofagasta; from near Zapiga, Tarapacá.

Name: Honors August Dietze (?–1893?), German chemist who first described this mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 318–319. (2) Burns, P.C. and F.C. Hawthorne (1993) The crystal structure of dietzeite, $Ca_2H_2O(IO_3)_2(CrO_4)$, a heteropolyhedral framework mineral. Can. Mineral., 31, 313–319.

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Digenite Cu_9S_5

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}\,2/m$ most likely. Rarely in pseudocubic crystals, to 3 cm; more commonly as intergrowths with other copper sulfides.

Physical Properties: *Cleavage:* {111} (synthetic). *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 86–106 (100 g load). D(meas.) = 5.546 D(calc.) = 5.706

Optical Properties: Opaque. *Color:* Blue to black; distinctly blue in polished section. *Anisotropism:* Mostly isotropic.
R: (400) 29.6, (420) 28.8, (440) 28.0, (460) 27.0, (480) 25.9, (500) 24.8, (520) 23.5, (540) 22.2, (560) 21.0, (580) 19.9, (600) 18.9, (620) 18.0, (640) 17.2, (660) 16.3, (680) 15.5, (700) 14.8

Cell Data: *Space Group: Fm3m* $a = 5.57$ Z = 4, below 73 °C becoming *Space Group:* $R\overline{3}m$ (pseudocubic). $a = 3.92$ $c = 48.00$ Z = 15

X-ray Powder Pattern: Leonard mine, Butte, Montana, USA. Anilite transforms to digenite during grinding.
1.973 (100), 3.21 (40), 2.79 (40), 1.686 (30), 1.139 (20), 3.05 (10), 2.17 (10)

Chemistry:

	(1)	(2)	(3)
Cu	78.11	77.9	78.10
Fe		0.1	
S	21.85	22.4	21.90
Total	99.96	100.4	100.00

(1) Jerome, Arizona, USA. (2) Seathwaite Tarn, England; by electron microprobe. (3) Cu_9S_5.

Occurrence: In hydrothermal copper deposits of primary and secondary origin. Formed under a wide range of conditions; reported from mafic intrusives, as a volcanic exhalation product, and in pegmatites.

Association: Chalcocite, djurleite, bornite, chalcopyrite, other copper minerals, pyrite.

Distribution: From Sangerhausen, Thuringia, Germany [TL]. In the Botallack mine, St. Just, Cornwall, and from Seathwaite Tarn, near Coniston, Cumbria, England. At Listulli, Norway. From Kiruna, Sweden. In the USA, crystallized at Butte, Silver Bow Co., Montana; in Arizona, from the United Verde mine, Jerome, Yavapai Co., the Magma mine, Superior, Pinal Co., and at Bisbee, Cochise Co. Abundant at Kennicott, Alaska. From Cananea, Sonora, Mexico. In Namibia, at Tsumeb. At Dongxiang, Jiangxi Province, China. Probably not yet recognized at many other localities.

Name: From the Greek for *two kinds* or *sexes*, in reference to the presumed presence of both cuprous and cupric ions.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 180–182. (2) Buerger, N.W. (1942) X-ray evidence of the existence of the mineral digenite, Cu_9S_5. Amer. Mineral., 27, 712–716. (3) Donnay, G., J.D.H. Donnay, and G. Kullerud (1958) Crystal and twin structure of digenite, Cu_9S_5. Amer. Mineral., 43, 230–242. (4) Morimoto, N. and G. Kullerud (1963) Polymorphism in digenite. Amer. Mineral., 48, 110–123. (5) Morimoto, N. and A. Gyobu (1971) The composition and stability of digenite. Amer. Mineral., 56, 1889–1909. (6) Will, G., E. Hinze, and A.R.M. Abdelrahman (2002) Crystal structure analysis and refinement of digenite, $Cu_{1.8}S$, in the temperature range 20 to 500 °C under controlled sulfur partial pressure. Eur. J. Mineral., 14, 591–598. (7) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 40. (8) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 141.

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Dimorphite As_4S_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Dipyramidal by development of {111}; {101} and {110} are also well developed. Commonly in groups of tiny individuals.

Physical Properties: *Tenacity:* Brittle. Hardness = 1.5 VHN = n.d. D(meas.) = 3.58 D(calc.) = 3.60 Burns without residue.

Optical Properties: Transparent. *Color:* Yellow-orange. *Luster:* Adamantine.
R_1–R_2: n.d.

Cell Data: *Space Group: Pnma.* $a = 11.24$ $b = 9.90$ $c = 6.56$ Z = 4

X-ray Powder Pattern: Solfatara, Italy.
4.89 (100), 2.14 (50), 1.620 (50), 3.91 (40), 5.64 (30), 3.07 (25), 2.94 (25)

Chemistry:

	(1)	(2)
As	75.45	75.70
S	24.55	24.30
Total	100.00	100.00

(1) Solfatara, Italy. (2) As_4S_3.

Occurrence: Deposited at a fumerolic vent at temperatures of about 70 °C–80 °C (Solfatara, Italy); formed in an ore deposit under secondary conditions (Chile).

Association: Realgar, sal ammoniac, sulfur, various sulfates (Solfatara, Italy); orpiment (Chile).

Distribution: In Italy, in Campania, from Solfatara di Pozzuoli, Campi Flegri, near Naples [TL], and on Vesuvius. In the Alacrán Ag–As–Sb mine, Pampa Larga district, Copiapó, Chile.

Name: From the Greek for *two* and *form*, in reference to the two forms in which the species was thought to occur.

Type Material: Natural History Museum, Paris, 50.588, 99.492; The Natural History Museum, London, England, 1937,1432.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 197–198. (2) Clark, A.H. (1972) Mineralogy of the Alacrán deposit, Pampa Larga, Chile. Neues Jahrb. Mineral., Monatsh., 423–429. (3) Frankel, L.S. and T. Zoltai (1973) Crystallography of dimorphites. Zeits. Krist., 138, 161–166.

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Dinite $C_{20}H_{36}$

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Crystal Data: Orthorhombic. *Point Group:* 222. Massive.

Physical Properties: *Tenacity:* Very brittle. Hardness = n.d. D(meas.) = 1.01(1) D(calc.) = 1.02 Fuses at 34(1) °C.

Optical Properties: Transparent. *Color:* Pale yellow. *Luster:* "Icy". *Optical Class:* Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_12_12_1$. $a = 12.356(4)$ $b = 12.762(4)$ $c = 11.427(3)$ Z = [1]

X-ray Powder Pattern: Castelnuovo di Garfagnana, Italy. 5.53 (vs), 5.06 (vs), 7.00 (s), 8.92 (ms), 8.32 (ms), 4.02 (ms), 3.870 (m)

Chemistry:

	(1)	(2)
C	86.77	86.88
H	13.44	13.12
Total	100.21	100.00

(1) Castelnuovo di Garfagnana, Italy. (2) $C_{20}H_{36}$.

Occurrence: In bituminous fossil wood in unconsolidated river sediment.

Distribution: From Castelnuovo di Garfagnana, Serchio Valley, Tuscany, Italy.

Name: Honors Professor Olinto Dini (1802–1866), Italian physicist, University of Pisa, Pisa, Italy, who discovered the first specimens.

Type Material: University of Pisa, Pisa, Italy, 8875.

References: (1) Franzini, L., M. Pasero, and N. Perchiazzi (1991) Re-discovery and re-definition of dinite, $C_{20}H_{36}$, a forgotten organic mineral from Garfagnana, northern Tuscany, Italy. Eur. J. Mineral., 3, 855–861. (2) (1992) Amer. Mineral., 77, 674 (abs. ref. 1).

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Diomignite $Li_2B_4O_7$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4mm$. As pseudocubic crystals, to 30 μm, bounded by {111} and {100}; also anhedral.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.437

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (–). $n = \sim 1.6$ $\omega = 1.612(2)$ (synthetic) $\epsilon = 1.554(2)$

Cell Data: *Space Group:* $I4_1cd$. $a = 9.470(4)$ $c = 10.279(5)$ $Z = 8$

X-ray Powder Pattern: Tanco pegmatite, Canada.
4.07 (100), 2.662 (60), 3.495 (50), 2.587 (40), 2.045 (40), 3.908 (20), 2.240 (20)

Chemistry: Analyses by electron microprobe indicate all elements are atomic weight < 11; identification is by inference of other properties to synthetic $Li_2B_4O_7$.

Occurrence: Abundant in fluid inclusions in spodumene crystallized from a late-stage hydrothermal fluid in a granite pegmatite.

Association: Albite, cookeite, quartz, pollucite–analcime, microlite, all as daughter species in fluid inclusions.

Distribution: From the Tanco pegmatite, Bernic Lake, Manitoba, Canada.

Name: From the Greek meaning *divine mix*, in allusion to its likely pronounced fluxing effects.

Type Material: American Museum of Natural History, New York, New York, 98089; National Museum of Natural History, Washington, D.C., USA, 164236.

References: (1) London, D., M.E. Zolensky, and E. Roedder (1987) Diomignite: natural $Li_2B_4O_7$ from the Tanco pegmatite, Bernic Lake, Manitoba. Can. Mineral., 25, 173–180.
(2) (1988) Amer. Mineral., 73, 928 (abs. ref. 1). (3) Krogh-Moe, J. (1962) The crystal structure of lithium diborate, $Li_2O.2B_2O_3$. Acta Cryst., 15, 190–193.

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Diopside $CaMgSi_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals with nearly square cross sections, to 50 cm; granular, columnar, lamellar massive. *Twinning:* Simple or multiple twins on {100} or {010}, common.

Physical Properties: *Cleavage:* Distinct on {110}, (110) $\wedge$ $(1\bar{1}0)$ ~87°; partings on {100} and probably {010}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6.5 D(meas.) = 3.22–3.38 D(calc.) = 3.278

Optical Properties: Transparent to opaque. *Color:* Colorless, white, yellow, pale to dark green, black; colorless in thin section. *Streak:* White, gray, gray-green. *Luster:* Vitreous or dull.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = -38°$ on (010); $X \wedge a = -22°$. *Dispersion:* $r > v$, weak to moderate. $\alpha = 1.664$ $\beta = 1.672$ $\gamma = 1.694$ 2V(meas.) = 59°

Cell Data: *Space Group:* $C2/c$. $a = 9.746$ $b = 8.899$ $c = 5.251$ $\beta = 105.63°$ Z = 4

X-ray Powder Pattern: Schwartzenstein, Austria. (ICDD 11-654).
2.991 (100), 2.528 (40), 2.893 (30), 2.518 (30), 3.23 (25), 2.952 (25), 1.625 (25)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	54.66	54.09	FeO	0.07	1.47	K_2O		0.15
TiO_2		0.28	MnO	0.02	0.09	H_2O^+	0.22	0.22
Al_2O_3	0.07	1.57	MgO	18.78	16.96	H_2O^-		0.08
Fe_2O_3	0.68	0.74	CaO	25.85	21.10	rem.		0.49
Cr_2O_3		2.03	Na_2O		1.37	Total	100.35	100.64

(1) Juva, Finland; corresponds to $Ca_{1.00}(Mg_{1.01}Fe^{3+}_{0.02})_{\Sigma=1.03}Si_{1.98}O_6$. (2) Dutoitspan mine, Kimberley, Cape Province, South Africa; corresponds to $(Ca_{0.82}Na_{0.05}Fe^{2+}_{0.04}Mg_{0.04}K_{0.01})_{\Sigma=0.96}(Mg_{0.88}Cr_{0.06}Al_{0.03}Fe^{3+}_{0.02}Ti_{0.01})_{\Sigma=1.00}(Si_{1.96}Al_{0.04})_{\Sigma=2.00}O_6$.

Polymorphism & Series: Forms two series, with hedenbergite, and with johannsenite.

Mineral Group: Pyroxene group.

Occurrence: Typical of metamorphosed siliceous Ca, Mg-rich rocks of the pyroxene-hornfels or epidote-amphibolite facies; common in skarns, Ca, Mg-rich gneisses and schists, and some kimberlites and peridotites. Less common in alkalic olivine basalts and andesites.

Association: Calcite, forsterite, chondrodite, monticellite, clinohumite, scapolite, wollastonite, grossular, vesuvianite, tremolite, quartz.

Distribution: Selected localities for fine crystals follow: at Schwarzenstein, Zillertal, and near Prägraten, Tirol, Austria. From Ala, Piedmont, and St. Marcel, Val d'Aosta, Italy. At Otokumpu, Finland. In Russia, at the Akhmatovsk deposit, near Zlatoust, Ural Mountains; large crystals in the Inagli massif, 30 km west of Aldan, Yakutia; and along the Slyudyanka River, near Lake Baikal, Siberia. In Canada, many localities; in Ontario, at Bird's Creek, Eganville, Dog's Lake, Littlefield, and Burgess; in Quebec, at Wakefield, Brompton Lake, near Magog, and in the Jeffrey mine, Asbestos. In the USA, at DeKalb, St. Lawrence Co., Natural Bridge, Jefferson Co., Sing Sing, near Ossining, Westchester Co., New York; and at Ducktown, Polk Co., Tennessee. At Ampandrandava and Andranodambo, Taolañaro (Fort Dauphin), Madagascar. Large gemmy crystals from the Kunlun Mountains, Sinkiang Uighur Autonomous Region, China. From Tange-Achin, Kandahar Province, Afghanistan. Found near Jaipur, Rajasthan, India. At Khapalu and Chamachu, Pakistan.

Name: From the Greek for *double* and *appearance*, apparently for two possible orientations of the prism zone.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 351–359.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 198–293.

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Dioptase $CuSiO_2(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Commonly in prismatic to rhombohedral crystals, terminated by $\{02\overline{2}1\}$, to 5 cm. As indistinct crystalline aggregates and massive.

Physical Properties: *Cleavage:* Perfect on $\{10\overline{1}1\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.28–3.35 D(calc.) = [3.30] Pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Emerald-green, blue-green. *Streak:* Green. *Luster:* Vitreous.
Optical Class: Uniaxial (+), with three or six sectors in basal section. $\omega = 1.652–1.658$ $\epsilon = 1.704–1.710$

Cell Data: *Space Group:* $R\overline{3}$. $a = 14.566$ $c = 7.778$ Z = 18

X-ray Powder Pattern: Tsumeb, Namibia. (ICDD 33-487).
2.600 (100), 2.443 (60), 7.29 (50), 4.07 (30), 4.90 (25), 2.714 (20), 2.117 (20)

Chemistry:

	(1)	(2)
SiO_2	38.93	38.11
CuO	49.51	50.46
H_2O	11.27	11.43
Total	99.71	100.00

(1) Unknown locality. (2) $CuSiO_2(OH)_2$.

Occurrence: In the oxidized zone of some copper deposits.

Association: Chrysocolla, malachite, mimetite, wulfenite, cerussite, hemimorphite, fluorite, quartz.

Distribution: From Altyn-Tyube, 50 km east of Karaganda, Kirghiz Steppe, Kazakhstan. At Băiţa (Rézbánya), Romania. In the USA, in Arizona, at the Mammoth-St. Anthony mine, Tiger, at Ray, and in the Table Mountain mine, Galiuro Mountains, Pinal Co., and from the Harquehala mine, Harquehala Mountains, Yuma Co.; in California, from the Blue Bell claims, near Baker, San Bernardino Co. At Chiviquin, Córdoba Province, Argentina. In Chile, from the Mina La Verde, Copiapó. Fine crystals from around Renéville, Mindouli, and Pimbi, Congo Republic. At Tantara and the Mashamba West mine, Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). As splendid large crystals from Tsumeb, Guchab, and the Omaue deposit, Kaokoveld, Namibia. From Mavoyo, Angola. In Zimbabwe, at several mines in the Lomagundi district, the Inez mine, Hartley district, and the Midway mine, Fort Victoria. Many other minor localities are known.

Name: From the Greek for *through* and *to see*, as the cleavage directions may be seen on looking through the crystal.

Type Material: Natural History Museum, Paris, France, Haüy 4969.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 463–464.
(2) Ribbe, P.H., G.V. Gibbs, and M.M. Hamil (1977) A refinement of the structure of dioptase, $Cu_6[Si_6O_{18}]\cdot 6H_2O$. Amer. Mineral., 62, 807–811.

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Dissakisite-(Ce) $Ca(Ce,La)MgAl_2(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely crystallized; as anhedral grains, up to 0.6 mm.

Physical Properties: Hardness = n.d. D(meas.) = 3.75(15) D(calc.) = 3.97–4.02

Optical Properties: Transparent. *Color:* Pale yellow-brown in thin section.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = pale brown; $Y = Z$ = light yellow-brown.
Orientation: $Y = b$; $Z \wedge a = 23.7°$. *Dispersion:* $r < v$, medium. *Absorption:* $Y = Z > X$.
$\alpha = 1.735(3)$ $\beta = 1.741(3)$ $\gamma = 1.758(3)$ 2V(meas.) = 64.2(3)° 2V(calc.) = 62°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.905(1)$ $b = 5.684(1)$ $c = 10.113(1)$
$\beta = 114.62(2)°$ Z = 2

X-ray Powder Pattern: Balchen Mountain, Antarctica.
2.698 (100), 2.910 (90), 2.622 (60), 3.50 (50), 2.842 (50), 9.1 (40), 2.177 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	32.09	31.85	MnO	0.00	0.27
TiO_2	0.89	0.02	MgO	6.84	7.42
ThO_2	0.08		CaO	10.75	9.57
Al_2O_3	17.67	10.09	CdO	0.10	
Y_2O_3	0.04		F	0.21	0.87
RE_2O_3	12.87	15.50	H_2O	[1.54]	1.79
Ce_2O_3	16.94	11.66	P_2O_5	0.02	
Fe_2O_3		5.83	$-O = F_2$	0.09	0.37
FeO	1.80	5.34	Total	[101.75]	99.84

(1) Balchen Mountain, Antarctica; by electron microprobe, H_2O calculated, $RE_2O_3 = La_2O_3$ 9.80%, Nd_2O_3 2.08%, Pr_2O_3 0.86%, Sm_2O_3 0.13%, $Eu_2O_3 < 0.10\%$, $Gd_2O_3 < 0.10\%$, $Dy_2O_3 < 0.05\%$, $Er_2O_3 < 0.05\%$; corresponds to $Ca_{1.08}(Ce_{0.57}RE_{0.45})_{\Sigma=1.02}(Mg_{0.93}Fe_{0.14})_{\Sigma=1.07}(Al_{1.91}Ti_{0.06})_{\Sigma=1.97}Si_3O_{12.25}[(OH)_{0.69}F_{0.06}]_{\Sigma=0.75}$. (2) Östanmossa mine, Sweden; corresponds to $Ca_{1.00}(Ce_{0.42}RE_{0.55})_{\Sigma=0.97}(Al_{1.16}Mg_{1.08}Fe^{3+}_{0.43}Fe^{2+}_{0.43}Mn_{0.02})_{\Sigma=3.12}Si_{1.03}O_{12}[(OH)_{1.16}F_{0.27}]_{\Sigma=1.43}$.

Mineral Group: Epidote group.

Occurrence: Formed in marble, under amphibolite-facies metamorphism, at about 600 °C and 7 kbar (Balchen Mountain, Antarctica).

Association: Calcite, dolomite, forsterite, clinohumite, phlogopite, chlorite, ilmenite-geikelite, spinel, zircon, pyrrhotite (Balchen Mountain, Antarctica).

Distribution: On Balchen Mountain, Sør Rondane Mountains, east Antarctica. From the Östanmossa mine, Norberg, Sweden. At the Fedorovskoye deposit, Yakutia, Russia. From Outokumpu, Finland. Well crystallized from Luzenac, Ariège, France. In the Donghai district, Kiangsu Province, China.

Name: From the Greek for *twice over*, for a magnesium analog of allanite being described twice.

Type Material: National Museum of Natural History, Washington, D.C., USA, 168421.

References: (1) Grew, E.S., E.J. Essene, D.R. Peacor, S.-C. Su, and M. Asami (1991) Dissakisite-(Ce), a new member of the epidote group and the Mg analogue of allanite-(Ce), from Antarctica. Amer. Mineral., 76, 1990–1997. (2) Rouse, R.C. and D.R. Peacor (1993) The crystal structure of dissakisite-(Ce), the Mg analogue of allanite-(Ce). Can. Mineral., 31, 153–157.

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Disulfodadsonite $Pb_{11}Sb_{13}S_{30}(S_2)_{0.5}$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As acicular crystals elongated on [100], to 4 mm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.898 [ideal formula]

Optical Properties: Opaque. *Color*: Black; white with red internal reflections on grain edges in reflected light. *Streak*: Black. *Luster*: Metallic. *Anisotropism*: Weak, brown to dark blue.

Cell Data: *Space Group*: $P\bar{1}$. a = 4.1192(3) b = 17.4167(14) c = 19.1664(16) α = 96.127(6)° β = 90.015(7)° γ = 91.229(7)° Z = 2

X-ray Powder Pattern: Ceragiola area, near Seravezza, Apuan Alps, Italy.
3.381 (vs), 3.649 (s), 3.416(s), 3.820 (ms), 2.857 (ms), 2.814 (ms), 1.897 (ms)

Chemistry:

	(1)	(2)
Pb	46.42	46.94
Sb	32.29	32.59
As	0.41	
S	20.19	20.47
Cl	0.03	.
Total	99.34	100.00

(1) Ceragiola area, near Seravezza, Apuan Alps, Italy; electron microprobe analysis; corresponding to $Pb_{10.87}(Sb_{12.86}As_{0.26})_{\Sigma=13.13}S_{30.56}Cl_{0.04}$. (2) $Pb_{11}Sb_{13}S_{31}$.

Occurrence: In pockets with high sulfur fugacity during hydrothermal alteration of marble.

Association: Boulangerite, calcite, sphalerite.

Distribution: From a marble quarry in the Ceragiola area, near Seravezza, Apuan Alps, Italy.

Name: For the relationship to *dadsonite* and the presence of the *disulfide* ion in the crystal structure.

Type Material: Museum of Natural History, University of Pisa, Italy (# 19442).

References: (1) Orlandi, P., C. Biagioni, Y. Moëlo, and E. Bonaccorsi (2013) Lead-antimony sulfosalts from Tuscany (Italy). XIV. Disulfodadsonite, $Pb_{11}Sb_{13}S_{30}(S_2)_{0.5}$, a new mineral from the Ceragiola marble quarry, Apuan Alps: Occurrence and crystal structure. European Journal of Mineralogy, 25, 1005-1016. (2) (2014) Amer. Mineral., 99, 1808 (abs. ref. 1).

Dittmarite $(NH_4)Mg(PO_4)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As small crystals.

Physical Properties: Hardness = "Low" D(meas.) = 2.15 D(calc.) = 2.19

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (–). $\alpha = 1.549$ $\beta = 1.569$ $\gamma = 1.571$ 2V(meas.) = 40°

Cell Data: *Space Group:* $Pmn2_1$. $a = 5.606$ $b = 8.758$ $c = 4.788$ Z = 2

X-ray Powder Pattern: Skipton lava tube caves, Australia. (ICDD 20-663).
8.77 (100), 2.80 (50), 2.92 (40), 4.72 (30), 4.20 (25), 2.50 (20), 2.28 (10)

Chemistry:

	(1)	(2)
P_2O_5	46.51	45.69
FeO	0.38	
MnO	0.08	
MgO	25.67	25.95
$(NH_4)_2O$	3.94	16.76
H_2O	23.42	11.60
Total	100.00	100.00

(1) Skipton lava tube caves, Australia. (2) $(NH_4)Mg(PO_4)\cdot H_2O$.

Occurrence: In dryer parts of bat guano in caves.

Association: Struvite, newberyite, hannayite, schertelite (Skipton lava tube caves, Australia); swaknoite, mundrabillaite, arcanite (Arnhem Cave, Namibia).

Distribution: From the Skipton lava tube caves, 40 km southwest of Ballarat, Victoria, Australia. In the Arnhem Cave, 150 km east of Windhoek, Namibia. From Gcwihaba Cave, 280 km west of Maun, northwestern Botswana.

Name: Honoring William Dittmar (1833–1892), Professor of Chemistry, University of Glasgow, Glasgow, Scotland.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 699. (2) Mrose, M.E. (1971) New mineral data for hydrated phosphates and sulfates. U.S. Geol. Surv. Prof. Paper 750-A, A115. (3) Frazier, A.W., J.P. Smith, and J.R. Lehr (1966) Precipitated impurities in fertilizers prepared from wet-process phosphoric acid. J. Agricultural Food Chemistry, 14(5), 522–529.

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Dixenite $Cu^{1+}Mn^{2+}_{14}Fe^{3+}(As^{3+}O_3)_5(As^{5+}O_4)(SiO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* 3. In aggregates of thin flakes; massive.

Physical Properties: *Cleavage:* Perfect, basal micaceous. Hardness = 3–4 D(meas.) = 4.36 D(calc.) = 4.375

Optical Properties: Translucent. *Color:* Deep red-brown to nearly black; intense red in thin sheets. *Luster:* Metallic to resinous.
Optical Class: Uniaxial (+). $n = 1.96(2)$

Cell Data: *Space Group: R*3. $a = 8.233(4)$ $c = 37.499(1)$ Z = 3

X-ray Powder Pattern: Långban, Sweden. (ICDD 19-426).
2.92 (100), 4.10 (90), 2.37 (80), 2.40 (55), 3.90 (50), 2.83 (50), 3.31 (45)

Chemistry:

	(1)
SiO_2	5.31
Fe_2O_3	3.75
Mn_2O_3	8.05
As_2O_3	32.16
MnO	43.35
CuO	3.49
MgO	0.32
CaO	0.39
Na_2O	0.13
K_2O	0.14
H_2O	2.80
P_2O_5	0.02
Total	99.91

(1) Långban, Sweden; cationic charges from structural study; corresponds to $Cu^{1+}_{0.85}(Mn^{2+}_{13.58}Mn^{3+}_{0.22}Mg_{0.15})_{\Sigma=13.95}Fe^{3+}_{0.91}As^{3+}_{4.99}As^{5+}_{1.30}Si_{1.71}O_{27}(OH)_6$.

Occurrence: In a metamorphosed Fe–Mn orebody in serpentine.

Association: Hematite, adelite, lead, domeykite, magnussonite.

Distribution: At Långban, Värmland, Sweden.

Name: From the Greek *di*, for *two*, and *xenos*, for *stranger*, in reference to the then unique association of silica and arsenious oxide in the mineral.

Type Material: n.d.

References: (1) Flink, G. (1920) Trigonit och dixenit, två nya mineral från Långbanshytte gruvor. Geol. Fören. Förhandl. Stockholm, 42, 436–439 (in Swedish). (2) (1921) Amer. Mineral., 6, 93 (abs. ref. 1). (3) Wickman, F.E. (1951) From the notes of the late K. Johansson. VII. A revised chemical analysis of dixenite from Långban. Geol. Fören. Förhandl. Stockholm, 73, 637–638. (4) Moore, P.B. and T. Araki (1981) Dixenite, $Cu^{1+}Mn^{2+}_{14}Fe^{3+}(OH)_6(As^{3+}O_3)_5(Si^{4+}O_4)_2(As^{5+}O_4)$: metallic $[As^{3+}_4Cu^{1+}]$ clusters in an oxide matrix. Amer. Mineral., 66, 1263–1273.

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Djerfisherite $K_6(Fe,Cu,Ni)_{25}S_{26}Cl$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As rounded grains, to 0.4 mm in diameter.

Physical Properties: Hardness = < 3.5 VHN = 172 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Greenish yellow, close to khaki, to olive-drab.
Luster: Submetallic.
R: (400) 17.5, (420) 18.3, (440) 19.1, (460) 20.0, (480) 20.8, (500) 21.6, (520) 22.3, (540) 22.9, (560) 23.5, (580) 24.0, (600) 24.5, (620) 24.9, (640) 25.2, (660) 25.5, (680) 25.8, (700) 25.9

Cell Data: *Space Group:* $Pm3m$. $a = 10.465(1)$ $Z = 2$

X-ray Powder Pattern: Kota Kota meteorite.
1.828 (100), 2.985 (70), 2.372 (60), 10.34 (50), 5.97 (50), 3.118 (50), 3.269 (40)

Chemistry:

	(1)	(2)
K	8.7	9.00
Na	0.3	0.76
Fe	50.7	45.4
Cu	4.2	8.37
Ni	0.8	1.41
Mg		< 0.05
S	33.8	33.8
Cl	1.0	1.26
Total	99.5	100.00

(1) St. Marks meteorite; by electron microprobe, average of 12 grains; corresponds to $(K_{5.49}Na_{0.32})_{\Sigma=5.81}(Fe_{22.39}Cu_{1.63}Ni_{0.34})_{\Sigma=24.36}S_{26.00}Cl_{0.70}$. (2) Coyote Peak, California, USA; by electron microprobe, corresponds to $(K_{5.68}Na_{0.82})_{\Sigma=6.50}(Fe_{20.05}Cu_{3.25}Ni_{0.59})_{\Sigma=23.89}S_{26.00}Cl_{0.88}$.

Occurrence: In meteorites, in hydrothermal Cu–Ni sulfide ores, in skarns, in pegmatites, in kimberlites, and alkalic mafics.

Association: "Nickel-iron" (kamacite), troilite, schreibersite, clinoenstatite, tridymite, cristobalite, daubréelite, graphite, roedderite, alabandite (Kota Kota meteorite); talnakhite, pentlandite, chalcopyrite, magnetite, valleriite, sphalerite, platinum minerals (Talnakh area, Russia).

Distribution: Found in the Kota Kota [TL] and St. Marks [TL] enstatite chondrites, the Pena Blañca Spring [ck Springs??] achondrite, also the Toluca and Cape York octahedrite iron meteorites. In the USA, at Coyote Peak, near Orick, Humboldt Co., California. In Russia, in the Talnakh area, Noril'sk region, western Siberia; Udachnaya and other kimberlite pipes, Sakhan; the Inagli complex, Aldan Shield; the Lovozero, Khibiny, and Kovdor massifs, and the Salmagorskii ring igneous complex, Kola Peninsula. On Dupezeh Mountain, near Hero Town, Qala-Dizeh region, northeastern Iraq. From the Ilímaussaq intrusion, southern Greenland. At Kushiro, Hiroshima Prefecture, Japan.

Name: To honor Professor Daniel Jerome Fisher (1896–1988), American mineralogist, University of Chicago, Chicago, USA.

Type Material: n.d. [??where are Kota Kota and St. Marks meteorites??]

References: (1) Fuchs, L.H. (1966) Djerfisherite, alkali copper–iron sulfide: a new mineral from enstatite chondrites. Science, 153, 166–167. (2) (1966) Amer. Mineral., 51, 1815 (abs. ref. 1). (3) Dmitrieva, M.T., V.V. Ilyukhin, and G.B. Bokii (1979) Close packing and cation arrangement in the jerfisherite [*sic*] structure. Kristallografiya (Sov. Phys. Crystal.), 24, 1193–1197 (in Russian). (4) Clarke, D.B., R.H. Mitchell, C.A.T. Chapman, and R.M. MacKay (1994) Occurrence and origin of djerfisherite from the Elwin Bay kimberlite, Somerset Island, Northwest territories. Can. Mineral., 32, 815–823.

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Djurleite $Cu_{31}S_{16}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are short, prismatic and thick tabular, as large as 1.5 cm; massive compact. *Twinning:* Common by rotation of 60° around [100].

Physical Properties: Hardness = 2.5–3 VHN = 65–85 (100 g load). D(meas.) = n.d. D(calc.) = 5.749

Optical Properties: Opaque. *Color:* Black; gray in reflected light. *Luster:* Metallic. *Anisotropism:* Weak.
R_1–R_2: (400) 36.1–37.3, (420) 36.2–37.1, (440) 36.0–36.8, (460) 35.7–36.4, (480) 35.1–35.7, (500) 34.2–34.8, (520) 33.1–33.9, (540) 32.1–33.0, (560) 31.0–32.1, (580) 30.0–31.3, (600) 29.0–30.6, (620) 28.1–29.9, (640) 27.4–29.3, (660) 26.6–28.8, (680) 25.9–28.4, (700) 25.3–28.0

Cell Data: *Space Group:* $P2_1/n$. $a = 26.897(6)$ $b = 15.745(3)$ $c = 13.565(2)$ $\beta = 90.13(3)°$ Z = 8

X-ray Powder Pattern: Butte, Montana, USA (close to chalcocite).
1.871 (100), 2.387 (90), 1.964 (90), 1.957 (90), 3.386 (50), 3.282 (30), 3.192 (30)

Chemistry:

	(1)	(2)
Cu	78.6	79.34
Ag	0.1	
Fe	0.1	
S	20.2	20.66
Total	99.0	100.00

(1) Seathwaite Tarn, England; by electron microprobe. (2) $Cu_{31}S_{16}$.

Occurrence: With other secondary copper sulfides in enriched zones.

Association: Digenite, bornite, chalcocite, chalcopyrite, anilite, pyrite.

Distribution: In Mexico, in Chihuahua, from Barranca de Cobre [TL] and at the Salvadora mine, Milpillas. In the USA, in many of the porphyry copper deposits of the Western Cordillera including Butte, Silver Bow Co., Montana; from Bisbee, Cochise Co., Globe-Miami, Gila Co., and the Magma mine, Superior, Pinal Co., Arizona; in large isolated crystals from the Gem mine, San Benito Co., California. In Peru, from Morococha. At Tsumeb, Namibia. In the Philippine Islands, at Bagacay, Samar Island. In Japan, from the Ani, Osarizawa, and other mines, Akita Prefecture, and elsewhere. At the Mt. Gunson mine, South Australia. In England, from Seathwaite Tarn, near Coniston, Cumbria; at Wheal Owles and the Dean quarry, Cornwall; in the Merehead and Cannington Park quarries, Somerset; and at Gipsy Lane, Leicester. From Bandaksli, Norway. A relatively common mineral, now identified at a number of other localities.

Name: For Dr. Seved Djurle (1918–), Swedish chemist, who first synthesized the compound later found in nature.

Type Material: Royal Ontario Museum, Toronto, Canada, M25369; National Museum of Natural History, Washington, D.C., USA, 92349.

References: (1) Roseboom, E.H., Jr. (1962) Djurleite, $Cu_{1.96}S$, a new mineral. Amer. Mineral., 47, 1181–1184. (2) Morimoto, N. (1962) Djurleite, a new copper sulfide mineral. Mineral. J. (Japan), 3, 338–344. (3) (1963) Amer. Mineral., 48, 215 (abs. ref. 2). (4) Evans, H.T., Jr (1979) The crystal structures of low chalcocite and djurleite. Zeits. Krist., 150, 299–320. (5) Pósfai, M. and P.R. Busek (1994) Djurelite, digenite, and chalcocite: intergrowths and transformations. Amer. Mineral., 79, 308–315. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 143.

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Dmisteinbergite $CaAl_2Si_2O_8$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals tabular, crudely hexagonal, to 0.7 mm.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = 6 D(meas.) = n.d. D(calc.) = 2.747

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Uniaxial (+). $\omega = 1.575$ $\epsilon = 1.580$

Cell Data: *Space Group:* $P6/mmm$. a = 5.122(5) $c = 14.781(5)$ Z = 2

X-ray Powder Pattern: Chelyabinsk coal basin, Russia.
3.73 (100), 2.57 (80), 2.85 (70), 1.847 (70), 4.48 (60), 3.83 (60)

Chemistry:

	(1)
SiO_2	43.89
Al_2O_3	35.39
MgO	0.01
CaO	19.29
Na_2O	0.32
K_2O	0.03
Total	98.93

(1) Chelyabinsk coal basin, Russia; by electron microprobe, average of four analyses; corresponds to $(Ca_{0.96}Na_{0.03})_{\Sigma=0.99}Al_{1.95}Si_{2.05}O_8$.

Polymorphism & Series: Trimorphous with anorthite and svyatoslavite.

Mineral Group: Feldspar group.

Occurrence: On fracture surfaces in blocks from burned coal dumps.

Association: Cordierite, mullite, anorthite, wollastonite, tridymite, fayalite, fassaite, norbergite-chondrodite, graphite, iron sulfides.

Distribution: From Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia.

Name: For Dmitrii Sergeevich Steinberg (1910–), noted petrologist, Institute of Geology and Geochemistry, Yekaterinberg, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Chesnokov, B.V., E.V. Lotova, E.N. Nigmatulina, V.S. Pavlyuchenko, and A.F. Bushmakin (1990) Dmisteinbergite $CaAl_2Si_2O_8$ (hexagonal) – a new mineral. Zap. Vses. Mineral. Obshch., 119(5), 43–45 (in Russian). (2) (1992) Amer. Mineral., 77, 446–447 (abs. ref. 1). (3) Takéuchi, Y. and G. Donnay (1959) The crystal structure of hexagonal $CaAl_2Si_2O_8$. Acta Cryst., 12, 465–470.

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Dolerophanite $Cu_2O(SO_4)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals elongated along [010], flattened on $\{\overline{1}01\}$ and striated ‖ [010], with complex development of over 20 forms, to 1 mm.

Physical Properties: *Cleavage:* Perfect on $\{\overline{1}01\}$. Hardness = 3 D(meas.) = 4.17 D(calc.) = [4.16] Soluble in H_2O, leaving a residue.

Optical Properties: Translucent to opaque. *Color:* Chestnut-brown to dark brown and nearly black; yellow-brown in transmitted light. *Streak:* Yellowish brown.
Optical Class: Biaxial (+). *Pleochroism:* X = deep brown; Y = brownish yellow; Z = lemon-yellow. *Orientation:* $Y = b$; $Z \wedge c = -10°$. *Dispersion:* $r > v$, very strong, crossed. $\alpha = 1.715$ $\beta = 1.820$ $\gamma = 1.880$ 2V(meas.) = 85°

Cell Data: *Space Group:* $C2/m$ (synthetic). $a = 9.370(1)$ $b = 6.319(1)$ $c = 7.639(1)$ $\beta = 122.34(1)°$ Z = 4

X-ray Powder Pattern: Vesuvius, Italy.
3.623 (100), 6.443 (50), 2.615 (42), 2.256 (30), 2.776 (21), 2.546 (18), 2.028 (13)

Chemistry:

	(1)	(2)
SO_3	33.94	33.48
CuO	66.06	66.52
Total	[100.00]	100.00

(1) Vesuvius, Italy; recalculated to 100% from an original total of 98.69%; corresponds to $Cu_{1.98}O_{0.98}(SO_4)_{1.01}$. (2) $Cu_2O(SO_4)$.

Occurrence: A rare volcanic sublimate.

Association: Chalcocyanite, euchlorine, eriochalcite (Vesuvius, Italy); chalcocyanite, euchlorine, eriochalcite, vergasovaite, fedotovite, melanothallite, piypite, ponomarevite, cotunnite, sofiite, halite, sylvite, tenorite, cuprian anglesite, gold (Tolbachik volcano, Russia).

Distribution: On Vesuvius, Campania, Italy. At the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: From the Greek for *fallacious* and *to appear*, in allusion to a physical appearance nonsuggestive of the composition.

Type Material: Natural History Museum, Paris, France, 71.124.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 551–553. (2) Mrose, M.E. (1961) Vernadskite discredited; pseudomorphs of antlerite after dolerophanite. Amer. Mineral., 46, 146–154. (3) Effenberger, H. (1985) $Cu_2O(SO_4)$, dolerophanite: refinement of the crystal structure, with a comparison of $[OCu(II)_4]$ tetrahedra in inorganic compounds. Monatsh. Chem., 116, 927–931.

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Dollaseite-(Ce) **$CaCeMg_2Al(SiO_4)(Si_2O_7)(OH,F)_2$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As subhedral crystals, to 0.3 mm; as fibrous and felted radiating aggregates of thin laths; as irregularly rounded grains, massive. *Twinning:* Simple twins common, "similar to a type exhibited by allanite."

Physical Properties: Hardness = n.d. D(meas.) = 3.9 D(calc.) = [3.86]

Optical Properties: Translucent. *Color:* Brown; very light brown with a pinkish tinge in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). $\alpha = 1.715$ $\beta = 1.718$ $\gamma = 1.733$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$. a = 8.934(18) b = 5.721(7) c = 10.176(22) $\beta = 114.31(12)^\circ$ Z = 2

X-ray Powder Pattern: Östanmossa mine, Sweden.
2.915 (100), 2.709 (70), 2.852 (30), 9.29 (20), 3.52 (20), 2.150 (20), 3.26 (15)

Chemistry:

	(1)
SiO_2	32.4
Al_2O_3	8.9
La_2O_3	6.0
Ce_2O_3	13.2
Pr_2O_3	2.6
Nd_2O_3	6.0
Sm_2O_3	2.4
Gd_2O_3	2.1
FeO	3.3
MgO	13.1
CaO	9.2
F	3.0
H_2O	2.02
$-O = F_2$	1.3
Total	102.9

(1) Östanmossa mine, Sweden; by electron microprobe, H_2O from Geijer (1927); corresponds to $(Ca_{0.91}Ce_{0.45}La_{0.20}Nd_{0.20}Pr_{0.09}Sm_{0.08}Gd_{0.06})_{\Sigma=1.99}(Mg_{1.81}Fe_{0.25})_{\Sigma=2.06}Al_{0.97}Si_3O_{10.99}[(OH)_{1.25}F_{0.88}]_{\Sigma=1.13}$.

Mineral Group: Epidote group.

Occurrence: In tactite replacement deposits developed during metamorphism of dolomitic limestone.

Association: Tremolite, norbergite, magnetite, dolomite, calcite.

Distribution: In the Östanmossa mine, Norberg, Västmanland, Sweden.

Name: Honors Professor Wayne A. Dollase, University of California, Los Angeles, California, USA, for his crystal chemical research on minerals of the epidote group, and its *cerium* content.

Type Material: National Museum of Natural History, Washington, D.C., USA, R6505.

References: (1) Peacor, D.R. and P.J. Dunn (1988) Dollaseite-(Ce) (magnesium orthite redefined): structure refinement and implications for F + M^{2+} substitutions in epidote-group minerals. Amer. Mineral., 73, 838–842. (2) Geijer, P. (1927) Some mineral associations from the Norberg district. Sveriges Geologiska Undersökning, 20, 1–32.

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Dolomite $CaMg(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Crystals typically combinations of $\{10\overline{1}1\}$ and $\{11\overline{2}0\}$, tabular on $\{0001\}$, many minor forms, may exhibit curved faces, to 20 cm; saddle-shaped aggregates, columnar, stalactitic, granular, massive. *Twinning:* With $\{0001\}$, $\{10\overline{1}0\}$, or $\{11\overline{2}0\}$ as twin plane, common as simple contact twins and in combinations; lamellar on $\{02\overline{2}1\}$.

Physical Properties: *Cleavage:* On $\{10\overline{1}1\}$, perfect; on $\{02\overline{2}1\}$, a parting. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.86 D(calc.) = [2.876] May fluoresce white to pink under UV; triboluminescent.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, yellow, brown, pale pink; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to pearly. *Optical Class:* Uniaxial (–), anomalously biaxial. *Dispersion:* Very strong. $\omega = 1.679$ $\epsilon = 1.500$ 2V(meas.) = Small.

Cell Data: *Space Group:* $R\overline{3}$. $a = 4.812(1)$ $c = 16.020(3)$ Z = 3

X-ray Powder Pattern: Haley, Ontario, Canada.
2.886 (100), 2.192 (30), 1.783 (30), 1.804 (20), 2.015 (15), 1.389 (15), 2.670 (10)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	47.22	47.73	MgO	21.12	21.86
SiO_2	0.12		CaO	31.27	30.41
FeO	0.22		H_2O	0.02	
MnO			Total	99.97	100.00

(1) Haley, Ontario, Canada. (2) $CaMg(CO_3)_2$.

Polymorphism & Series: Forms two series, with ankerite and with kutnohorite.

Mineral Group: Dolomite group.

Occurrence: Formed by diagenesis or hydrothermal metasomatism of limestone; a primary phase in hypersaline sedimentary environments; a major component of some contact metamorphic rocks and marbles; a gangue in hydrothermal veins; in carbonatites and ultramafic rocks.

Association: Fluorite, barite, calcite, siderite, quartz, metal sulfides (hydrothermal); calcite, celestine, gypsum, quartz (sedimentary); talc, serpentine, magnesite, calcite, magnetite, diopside, tremolite, forsterite, wollastonite (metamorphic); calcite, ankerite, siderite, apatite (carbonatites).

Distribution: A major rock-forming mineral, abundant worldwide with numerous commercial uses. Some localities for fine examples include: in Italy, from Traversella and Brosso, Piedmont. Exceptional crystals from Eugui, Navarra Province, Spain. At Trieben and Hall, Tirol, Austria. From Freiberg and Schneeberg, Saxony, Germany. At Lengenbach, Binntal, Switzerland. From Trepča, Serbia, Yugoslavia. At Frizington, Cumbria, England. In the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. Fine crystals from Brumado, Bahia, and in the Morro Velho gold mine, Nova Lima, Minas Gerais, Brazil. At Naica, Chihuahua, Mexico. In the USA, in New York, from Lockport, Niagara Co., eastward to Walworth, Wayne Co.; at Stony Point, Alexander Co., North Carolina; in the Mississippi Valley region, in the Tri-State district, at Joplin, Jasper Co., Missouri; Galena, Cherokee Co., Kansas; and Picher, Ottawa Co., Oklahoma.

Name: Honors Dieudonne (Déodat) Sylvain Guy Tancrède de Gratet de Dolomieu (1750–1801), French geologist and naturalist, who contributed to early descriptions of the species in dolostone.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 208–217. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 189–218. (3) Effenberger, H., K. Mereiter, and J. Zemann (1981) Crystal structure refinements of magnesite, calcite, rhodochrosite, siderite, smithsonite, and dolomite, with discussion of some aspects of the stereochemistry of calcite type carbonates. Zeits. Krist., 156, 233–243. (4) Howie, R.A. and F.M. Broadhurst (1958) X-ray data for dolomite and ankerite, Amer. Mineral., 43, 1210–1214.

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Doloresite $H_8V_6^{4+}O_{16}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very rarely in crystals, to 0.1 mm; commonly massive, as veinlets, in radiating bands having botryoidal surfaces, or bladed; almost always intimately intermixed with other vanadium oxide minerals, especially montroseite–paramontroseite. *Twinning:* Lamellar, on {100}, nearly universal.

Physical Properties: *Cleavage:* "Flaky". *Fracture:* "Fibrous". Hardness = n.d. D(meas.) = 3.27–3.33 D(calc.) = 3.41

Optical Properties: Opaque, transparent only in thin fragments. *Color:* Chocolate-brown when pure, commonly nearly black, typically with a dark bronzy tarnish; in transmitted light, reddish brown to reddish yellow; in reflected light, gray with color variation along the crystals. *Streak:* Greenish black. *Luster:* Submetallic; sometimes satinlike on cleavage surfaces. *Optical Class:* Biaxial; optical data not determinable, presumably due to lamellar submicroscopic twinning. *Orientation:* Extinction parallel. $n = \sim 1.90$ 2V(meas.) = n.d. *Anisotropism:* Strong.

Cell Data: *Space Group:* $C2/m$. $a = 19.64(6)$ $b = 2.99(1)$ $c = 4.83(2)$ $\beta = 103°55(5)'$ $Z = 1$

X-ray Powder Pattern: Monument No. 2 mine, Arizona, USA.
4.70 (100), 3.83 (50), 2.45 (50), 3.16 (42), 1.933 (25), 1.799 (21), 2.98 (15)

Chemistry:

	(1)	(2)		(1)	(2)
V_2O_5	78.00		$UO_2 + UO_3$	3.88	
V_2O_4		87.35	FeO	3.83	
SiO_2	0.30		MgO	3.98	
Al_2O_3	1.33		Pb	0.07	
As_2O_3	0.30		H_2O^+	6.33	12.65
V_2O_3	1.89		H_2O^-	0.37	
			Total	100.28	100.00

(1) La Sal No. 2 mine, Colorado, USA; estimated about 50% montroseite–paramontroseite.
(2) $H_8V_6O_{16}$.

Occurrence: In relatively unoxidized uranium-vanadium ores; from the cores of black, concretionary masses high in uranium and vanadium, surrounded by tyuyamunite-bearing sandstone (La Sal No. 2 mine, Colorado, USA).

Association: Coffinite, uraninite, clausthalite, montroseite, paramontroseite, vanadium oxides.

Distribution: In the USA, in Colorado, from the La Sal No. 2 mine, Lumsden Canyon, Gateway district, and in the Matchless, Arrowhead, Corvusite, Black Mama, and Lumsden No. 2 mines, Mesa Co.; from the Golden Cycle, J.J., and Peanut mines, Montrose Co. From the Mi Vida mine, San Juan Co., Utah; at a prospect in Valencia Co., New Mexico; in the Monument No. 2 mine, Apache Co., Arizona; and from Carlile, Crook Co., Wyoming. At the Puttapa zinc mine, near Beltana, South Australia. In the Urcal deposit, La Rioja Province, Argentina.

Name: For the Dolores River, southwestern Colorado, USA.

Type Material: n.d.

References: (1) Stern, T.W., L.R. Stieff, H.T. Evans, Jr., and A.M. Sherwood (1957) Doloresite, a new vanadium oxide mineral from the Colorado Plateau. Amer. Mineral., 42, 587–593. (2) Evans, H.T., Jr. and M.E. Mrose (1960) A crystal chemical study of the vanadium oxide minerals, häggite and doloresite. Amer. Mineral., 45, 1144–1166. (3) Théobald, F. (1975) Synthèse de la dolorésite. Bull. Soc. fr. Minéral., 98, 193–194 (in French).

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Domeykite Cu_3As

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Reniform, botryoidal; massive.

Physical Properties: *Fracture:* Uneven. Hardness = 3–3.5 VHN = 213–235; 124–140 ("domeykite-beta") (100 g load). D(meas.) = 7.2–7.9 D(calc.) = 7.92

Optical Properties: Opaque. *Color:* Tin-white to steel-gray, tarnishes pale yellow, then pale brown, and finally to iridescence. *Luster:* Metallic.
R: (400) 41.1, (420) 41.4, (440) 41.7, (460) 43.1, (480) 45.2, (500) 47.5, (520) 49.3, (540) 50.7, (560) 52.2, (580) 53.6, (600) 54.5, (620) 54.9, (640) 54.8, (660) 54.6, (680) 54.4, (700) 54.6
R_1–R_2: ("domeykite-beta"): (400) 37.2–38.5, (420) 37.9–39.5, (440) 38.6–40.9, (460) 40.2–43.1, (480) 42.4–45.5, (500) 44.2–47.3, (520) 45.4–48.6, (540) 45.9–49.4, (560) 45.9–49.6, (580) 45.8–49.7, (600) 45.5–49.5, (620) 45.2–49.2, (640) 44.8–48.9, (660) 44.4–48.4, (680) 44.0–48.0, (700) 43.6–47.6

Cell Data: *Space Group:* $I\bar{4}3d$. $a = 9.619(1)$ $Z = 16$

X-ray Powder Pattern: Keweenaw Co., Michigan, USA.
2.05 (100), 1.888 (70), 1.965 (50), 1.308 (50), 3.95 (40), 3.05 (40), 2.15 (40)

Chemistry:

	(1)	(2)	(3)
Cu	70.56	71.16	71.79
As	29.50	28.27	28.21
Sb		0.12	
S		0.06	
Total	100.06	99.61	100.00

(1) Mohawk mine, Michigan, USA. (2) Wasserfall, France; by electron microprobe. (3) Cu_3As.

Occurrence: Of hydrothermal origin.

Association: Copper (typically arsenian), silver, algodonite.

Distribution: In Chile, from the Algodones silver mine, near Coquimbo [TL] and at San Antonio and Chañarcillo, near Copiapó, Atacama. From Corocoro, Bolivia. At Cerro de Paracatas, Tlachapa, Guerrero, Mexico. In the USA, from the Mohawk and Ahmeek mines, Keweenaw Co., and in the Sheldon-Columbia mine, Portage Lake, Houghton Co., Michigan; at the Cashin mine, Montrose Co., Colorado; from Franklin, Sussex Co., New Jersey. In Canada, on Michipicoten Island and at the Silver Islet mine, Thunder Bay, Lake Superior, Ontario; in the East Arm area, Great Slave Lake, Northwest Territories. From Långban and at the Harstigen mine, Värmland, Sweden. From Wasserfall, about 20 km northwest of Belfort, Haute-Saône, and at the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, France. From Zwickau, Saxony, and at Sailauf, northeast of Aschaffenburg, Bavaria, Germany. In the Condurrow mine, near Helstone, Cambourne, and at Wheal Druid, Redruth, Cornwall, England. In the Talmessi mine, 35 km west of Anarak, Iran. Several other occurrences are known.

Name: Honors Professor Ignacio Domeyko [born Ignacy Domejko] (1802–1889), Polish–Chilean mineralogist, University of Chile, Santiago, Chile.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 172. (2) Iglesias, J.E. and W. Nowacki (1977) Refinement of the crystal structure of *a*lpha domeykite, a structure related to the *A*15 type. Zeits. Krist., 145, 334–345. (3) Picot, P. and F. Ruhlmann (1978) Présence d'arséniures de cuivre de haute température dan le granite des Ballons (Vosges méridionales). Bull. Minéral., 101, 563–569 (in French with English abs.). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 30. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 393–398. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 144–145.

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Donbassite $Al_{4.33}(Si_3Al)O_{10}(OH)_8$

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Crystal Data: Monoclinic. *Point Group:* 2. As flaky aggregates.

Physical Properties: *Cleavage:* One perfect. *Tenacity:* Flexible. Hardness = 2.5 D(meas.) = 2.63 D(calc.) = [2.66]

Optical Properties: Semitransparent. *Color:* White. *Luster:* Pearly. *Optical Class:* Biaxial (+). *Orientation:* $Z = c$. *Dispersion:* $r > v$, marked. $\alpha = 1.728$ $\beta = 1.729$ $\gamma = 1.735$ 2V(meas.) = 52°

Cell Data: *Space Group:* $C2$. $a = 5.174$ $b = 8.956$ $c = 14.26$ $\beta = 97.83°$ Z = [2]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
SiO_2	33.64	34.73	34.40
Al_2O_3	45.02	48.08	51.85
Fe_2O_3	1.38	1.04	
MgO	1.75	0.80	
CaO	2.03		
Li_2O	trace	trace	
Na_2O	1.30		
H_2O	15.20	14.58	13.75
Total	100.32	99.23	100.00

(1) Utrennyaia shaft, Donets Basin, Ukraine. (2) Uralskaya vein, Donets Basin, Ukraine. (3) $Al_{4.33}(Si_3Al)O_{10}(OH)_8$.

Polymorphism & Series: 1a-2 polytype.

Mineral Group: Chlorite group.

Occurrence: In the lode walls and crushed zones in ore veins and as coatings on slickensides of coals. In soils and sediments in very aluminum-rich environments.

Association: n.d.

Distribution: From a number of places in the Donets Basin, as at Nagol'no Tarasovka, Ukraine. On Novaya Zemlya, Arctic Ocean. From Kesselberg, Black Forest, Germany. At Saint-Paul-de-Fenouillet, Pyrénées-Orientales, France. From Namivu, Alto Ligonha district, Mozambique. At Szabo Bluff, Scott Glacier, Antarctica.

Name: For occurrences in the DONets BASin, Ukraine.

Type Material: n.d.

References: (1) Lazerenko, E.K. (1940) Donbassites, a new group of minerals from the Donets Basin. Doklady Acad. Nauk SSSR, 28, 509–521 (in Russian). (2) (1941) Amer. Mineral., 26, 349 (abs. ref. 1). (3) Aleksandrova, V.A., V.A. Drits, and G.V. Sokolova (1972) Structural features of dioctahedral one-packet chlorite. Kristallografiya (Sov. Phys. Crystal.), 17, 525–532 (in Russian). (4) Bailey, S.W. and J.S. Lister (1989) Structures, compositions, and X-ray diffraction identification of dioctahedral chlorites. Clays and Clay Minerals, 37, 193–202.

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Donharrisite $Ni_8Hg_3S_9$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As isolated thin micalike flakes, to 1 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼2 VHN = 45 average (5 mg load). D(meas.) = n.d. D(calc.) = 5.18

Optical Properties: Opaque. *Color:* Brown; creamy white with a slight yellowish tint in reflected light. *Streak:* Brownish gray. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Distinct, reddish brown to bluish gray.
Bireflectance: Weak.
R_1–R_2: (400) 34.0–37.0, (420) 34.9–37.9, (440) 36.2–39.3, (460) 37.9–40.9, (480) 39.6–42.6, (500) 41.3–44.2, (520) 42.8–45.7, (540) 44.2–47.0, (560) 45.4–48.3, (580) 46.5–49.4, (600) 47.5–50.4, (620) 48.4–51.2, (640) 49.2–51.8, (660) 49.8–52.2, (680) 50.4–52.6, (700) 51.1–52.8

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 11.66(3)$ $b = 6.91(1)$ $c = 10.92(3)$ $\beta = 97.43(20)°$ $Z = 2$

X-ray Powder Pattern: Near Leogang, Austria (some preferred orientation).
2.547 (100), 5.75 (70), 5.09 (70), 3.33 (60), 2.683 (60), 3.71 (50), 2.609 (30)

Chemistry:

	(1)	(2)
Ni	35.2	34.53
Hg	43.3	44.25
S	20.6	21.22
Total	99.1	100.00

(1) Near Leogang, Austria; by electron microprobe, average of seven analyses; corresponding to $Ni_{8.22}Hg_{2.96}S_{8.82}$. (2) $Ni_8Hg_3S_9$.

Occurrence: On an old museum specimen from a polymetallic Hg–Pb-rich dolostone stratabound ore deposit.

Association: Cinnabar, mercury, polydymite, galena, sphalerite, tennantite, pyrite.

Distribution: From the Erasmus mine (probable), Schwarzleo district, near Leogang, Salzburg, Austria [TL].

Name: To honor Dr. Donald C. Harris (1936–), Geological Survey of Canada, Ottawa, Canada, for his contributions to ore mineralogy.

Type Material: Landesmuseum Joanneum, Graz, Austria, LMJ-210; Institute of Geosciences, University of Salzburg, Salzburg, Austria; The Natural History Museum, London, England; Geological Survey of Canada, Ottawa. 65207; Royal Ontario Museum, Toronto, Canada.

References: (1) Paar, W.H., T.T. Chen, A.C. Roberts, A.J. Criddle, and C.J. Stanley (1989) Donharrisite, nickel-mercury sulfide, a new mineral species from Leogang, Salzburg Province, Austria. Can. Mineral., 27, 257–262. (2) (1990) Amer. Mineral., 75, 706 (abs. ref. 1).

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Donnayite-(Y) $NaCaSr_3Y(CO_3)_6 \cdot 3H_2O$

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Crystal Data: Triclinic, pseudohexagonal, and hexagonal. *Point Group:* 1 or $3m$. As platy, tabular, saucer-shaped, columnar, barrel-shaped, or wedge-shaped pseudohexagonal crystals, to 1 cm; also as hemimorphic pyramidal crystals, terminated by {001}; as parallel crystal aggregates; as syntactic intergrowths with related minerals; as irregular grains. *Twinning:* Common by 120° rotation around [103] and reflection on {010}, {30$\overline{1}$} or {$\overline{33}$1}.

Physical Properties: *Cleavage:* On {001}, fair to imperfect. Hardness = ∼3
D(meas.) = 3.30(1) D(calc.) = 3.266 (triclinic); 3.44(3) (hexagonal).

Optical Properties: Transparent to opaque. *Color:* Colorless, pale yellow to yellow, white, gray, commonly radially zoned. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.551$–1.561 $\beta = 1.646(2)$ $\gamma = 1.652(2)$ 2V(meas.) = 0°–30°

Cell Data: *Space Group:* $P1$ with $a = 8.993(2)$ $b = 8.985(2)$ $c = 6.780(2)$ $\alpha = 116.25(2)°$ $\beta = 102.76(2)°$ $\gamma = 60.00(1)°$ Z = 1, or *Space Group:* $R3m$ with $a = 5.211(1)$ $c = 18.57(7)$ Z = 3

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.839 (10), 4.368 (7), 6.103 (4), 2.598 (4), 3.209 (3), 2.038 (3), 2.018 (3)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
CO_2	[30.98]	[29.94]	Nd_2O_3	1.83	2.70	CaO	5.75	2.62
Y_2O_3	13.1	9.13	Gd_2O_3		1.45	SrO	35.8	23.73
La_2O_3	0.45	5.17	Dy_2O_3		1.55	BaO	0.85	1.46
Ce_2O_3		10.33	Er_2O_3		0.87	Na_2O	3.37	3.87
Pr_2O_3		0.69	Yb_2O_3		0.36	H_2O	[6.34]	[6.13]
						Total	[98.47]	[100.00]

(1) Mont Saint-Hilaire, Canada; by electron microprobe, CO_2 and H_2O calculated for stoichiometry by analogy to weloganite; corresponds to $Na_{0.93}(Ca_{0.87}Nd_{0.09}La_{0.03})_{\Sigma=0.99}(Sr_{2.95}Ba_{0.05})_{\Sigma=3.00}Y_{0.99}(CO_3)_6 \cdot 3H_2O$. (2) Khibiny massif, Kola Peninsula, Russia; by electron microprobe, CO_2 and H_2O calculated for stoichiometry; corresponds to $Sr_{2.02}Na_{1.10}(Y_{0.72}Ce_{0.56}Ca_{0.42}La_{0.28}Nd_{0.14}Ba_{0.08}Dy_{0.07}Gd_{0.07}Pr_{0.04}Er_{0.04}Yb_{0.02})_{\Sigma=2.44}(CO_3)_6 \cdot 3H_2O$.

Polymorphism & Series: Polytypes T and R.

Occurrence: In pegmatite dikes, miarolitic cavities, and interstices in nepheline syenite in an alkaline complex (Mont Saint-Hilaire, Canada).

Association: Ewaldite, mckelveyite-(Y), synchysite, gaidonnayite, arfvedsonite, aegirine, calcite, sphalerite, catapleiite, microcline, analcime, natrolite, "chlorite" (Mont Saint-Hilaire, Canada).

Distribution: In Canada, from Mont Saint-Hilaire, and near Saint-Amable, Quebec. In Russia, from Mt. Kukisvumchorr, Khibiny massif, Kola Peninsula, and at the Vishnevogorsk complex, Vishnevy-Ilmen Mountains, Southern Ural Mountains.

Name: Honors Dr. Joseph Désiré Hubert Donnay (1902–1994), Belgian–American–Canadian crystallographer and his wife Dr. Gabrielle Donnay (1920–1987), American–Canadian mineralogist, Johns Hopkins University, Baltimore, Maryland, USA and McGill University, Montreal, Canada, for their contributions to mineralogy and crystallography.

Type Material: Canadian Museum of Nature, Ottawa, 39394–39396; Royal Ontario Museum, Toronto, Canada, M35222, M35544; National Museum of Natural History, Washington, D.C., USA, 144522, 147191.

References: (1) Chao, G.Y., P.R. Mainwaring, and J. Baker (1978) Donnayite, $NaCaSr_3Y(CO_3)_6 \cdot 3H_2O$, a new mineral from Mont St-Hilaire, Québec. Can. Mineral., 16, 335–340. (2) (1979) Amer. Mineral., 64, 653–654 (abs. ref. 1). (3) Trinh Thi Le Thu, E.A. Pobedimskaya, T.N. Nadezhina, and A.P. Khomyakov (1992) Polymorphism of donnayite $(Na, TR)Sr(CO_3)_2 \cdot H_2O$. Moscow University Geol. Bull., 47, 69–78 (in Russian). (4) Khomyakov, A.P. (1995) Mineralogy of hyperagpaitic alkaline rocks. Clarendon Press, Oxford, 82–83, 86–87.

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Donpeacorite $(Mn^{2+}, Mg)MgSi_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Interlocking grains up to 3 mm.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = 5–6 D(meas.) = 3.36(1) D(calc.) = 3.403(2)

Optical Properties: Semitransparent. *Color:* Pale buff, yellow-orange; faint pink in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = c$. $\alpha = 1.677(2)$ $\beta = 1.684(2)$ $\gamma = 1.692(2)$ 2V(meas.) = 88(5)°

Cell Data: *Space Group: Pbca.* $a = 18.384(11)$ $b = 8.879(7)$ $c = 5.226(3)$ $Z = 8$

X-ray Powder Pattern: Balmat, New York, USA.
3.18 (100), 2.896 (60), 1.495 (11), 1.479 (11), 4.03 (10), 3.09 (10), 2.961 (10)

Chemistry:

	(1)
SiO_2	55.12
Al_2O_3	0.23
FeO	0.14
MnO	18.48
MgO	26.31
CaO	0.69
Na_2O	0.03
Total	[101.00]

(1) Balmat, New York, USA; by electron microprobe, original total given as 100.00%; corresponding to $(Mg_{1.41}Mn_{0.56}Ca_{0.03})_{\Sigma=2.00}(Si_{1.98}Al_{0.01})_{\Sigma=1.99}O_{5.99}$.

Polymorphism & Series: Dimorphous with kanoite.

Mineral Group: Pyroxene group.

Occurrence: In manganese-rich siliceous marbles metamorphosed to the upper amphibolite facies.

Association: Tirodite, tourmaline, ferrian braunite, manganoan dolomite, hedyphane, anhydrite.

Distribution: In the Balmat No. 4 mine, Balmat, St. Lawrence Co., New York, USA.

Name: To honor Dr. Donald R. Peacor (1937–), University of Michigan, Ann Arbor, Michigan, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 124237; National Museum of Natural History, Washington, D.C., USA, 159862.

References: (1) Petersen, E.U., L.M. Anovitz, and E.J. Essene (1984) Donpeacorite, $(Mn, Mg)MgSi_2O_6$, a new orthopyroxene and its proposed phase relations in the system $MnSiO_3$ – $MgSiO_3$ – $FeSiO_3$. Amer. Mineral., 69, 472–480.

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Dorallcharite $(Tl,K)Fe_3^{3+}(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As fine-grained earthy masses of pseudocubic and rhombohedral crystals, to 8 μm.

Physical Properties: *Cleavage:* On {0001}, distinct. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.85

Optical Properties: Semitransparent. *Color:* Golden yellow, brownish yellow; colorless in transmitted light. *Streak:* Yellow.
Optical Class: Uniaxial (–). $\omega = 1.822(3)$ $\epsilon = 1.768(2)$

Cell Data: *Space Group:* $R\overline{3}m$. a = 7.3301(3) $c = 17.6631(7)$ Z = 3

X-ray Powder Pattern: Alšar, Macedonia.
3.112 (100), 5.974 (87), 3.666 (34), 1.991 (29), 1.833 (23), 2.988 (22), 2.577 (21)

Chemistry:

	(1)
SO_3	26.52
As_2O_5	1.19
Fe_2O_3	39.54
K_2O	1.23
Tl_2O	24.28
H_2O	[7.59]
Total	[100.35]

(1) Alšar, Macedonia; by electron microprobe, average of seven analyses with lowest Fe/(Tl + K) ratios, H_2O calculated by analogy to jarosite; after deduction of excess Fe and As, corresponds to $(Tl_{0.81}K_{0.19})_{\Sigma=1.00}Fe_3(SO_4)_2(OH)_6$.

Mineral Group: Alunite group.

Occurrence: In oxidized portions of a Tl-bearing hydrothermal sulfide-sulfosalt deposit.

Association: Amorphous Fe–Mn arsenate-sulfate, gypsum, bassanite, rösslerite, pharmacosiderite, melanterite, barite.

Distribution: From Alšar (Allchar), near Rošden, Macedonia.

Name: From the French *doré*, *golden yellow*, and the famous mining locality, Alšar (Allchar), Macedonia.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1993.7.

References: (1) Balić Žunić, T., Y. Moëlo, Ž. Lončar, and H. Micheelsen (1994) Dorallcharite, $Tl_{0.8}K_{0.2}Fe_3(SO_4)_2(OH)_6$, a new member of the jarosite-alunite family. Eur. J. Mineral., 6, 255–263. (2) (1995) Amer. Mineral., 80, 184–185 (abs. ref. 1).

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Dorfmanite $Na_2(PO_3OH)\cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Powdery aggregates and incrustations, with individual particles up to 15 μm.

Physical Properties: Hardness = 1–1.5 in aggregates. D(meas.) = 1.98–2.00 D(calc.) = 2.06 Very soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White. *Luster:* Vitreous to earthy. *Optical Class:* Biaxial (+). *Orientation:* $Z \parallel$ elongation. *Dispersion:* $r > v$, weak. $\alpha = 1.454$ $\beta = 1.461$ $\gamma = 1.471$ 2V(meas.) = 65°

Cell Data: *Space Group:* n.d. (synthetic). $a = 10.34$ $b = 16.82$ $c = 6.601$ Z = 8

X-ray Powder Pattern: Kola Peninsula, Russia.
3.35 (100), 3.25 (81), 4.64 (75), 2.869 (75), 2.260 (75), 5.28 (56), 2.928 (56)

Chemistry:

	(1)	(2)	(3)
P_2O_5	39.49	40.83	39.88
Na_2O	34.84	33.80	34.82
K_2O	trace	0.00	
F	0.00	0.00	
H_2O	25.44	25.60	25.30
Total	99.77	100.23	100.00

(1) Mt. Koashva, Russia; corresponds to $Na_{2.02}H_{0.98}PO_4 \cdot 2.04H_2O$. (2) Kola Peninsula, Russia; corresponds to $Na_{1.89}H_{1.11}PO_4 \cdot 1.97H_2O$. (3) $Na_2(PO_3OH) \cdot 2H_2O$.

Occurrence: Noted in drill cores into alkalic pegmatites in differentiated alkalic massifs, as an alteration product of lomonosovite and nacaphite (Kola Peninsula, Russia); in sodalite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Lomonosovite, olympite, villiaumite (Kola Peninsula, Russia); sodalite, villiaumite, eudialyte, lovozerite, ussingite (Mont Saint-Hilaire, Canada).

Distribution: In Russia, on the Kola Peninsula, from Mts. Yukspor, Kukisvumchorr, Koashva, and Rasvumchorr in the Khibiny massif, and on Mts. Karnasurt and Alluaiv in the Lovozero massif. At Mont Saint-Hilaire, Quebec, and in the Tanco pegmatite, Bernic Lake, Manitoba, Canada.

Name: To honor Moisei Davidovich Dorfman (1908–), Russian mineralogist, A.E. Fersman Mineralogical Museum, Moscow, Russia, investigator of Khibiny minerals.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Kapustin, Y.L., Z.V. Pudovkina, and T.Y. Bykova (1980) Dorfmanite, a new mineral. Zap. Vses. Mineral. Obshch., 109, 211–216 (in Russian). (2) (1981) Amer. Mineral., 66, 217–218 (abs. ref. 1). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 306. (4) Khomyakov, A.P. (1995) Mineralogy of hyperagpaitic alkaline rocks. Clarendon Press, Oxford, 162–163.

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Dorrite $\mathbf{Ca_2Mg_2Fe_4^{3+}Al_4Si_2O_{20}}$

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Crystal Data: Triclinic, pseudomonoclinic by twinning. *Point Group:* $\overline{1}$ or 1. As anhedral to prismatic grains, to 0.1 mm; some grains exhibit hopper and skeletal crystal habit. *Twinning:* Twinned by two-fold rotation about the pseudomonoclinic [010] axis.

Physical Properties: *Cleavage:* Good on {010} and {001}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = n.d. D(calc.) = 3.959

Optical Properties: Nearly opaque. *Color:* Dark red-brown to dark brown. *Streak:* Gray. *Luster:* Submetallic.
Optical Class: Biaxial. *Pleochroism:* In ultrathinned sections, very strong; X = red-orange-brown; Y = yellowish brown; Z = greenish brown. *Absorption:* Extreme. $\alpha = 1.82(1)$ $\beta = 1.84(1)$ $\gamma = 1.86(1)$ 2V(meas.) = 90°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.505(3)$ $b = 10.897(3)$ $c = 9.019(1)$ $\alpha = 106.26(2)°$ $\beta = 95.16(2)°$ $\gamma = 124.75(2)°$ Z = 2

X-ray Powder Pattern: Durham ranch, Wyoming, USA.
2.971 (100), 2.558 (80), 2.515 (80), 2.125 (60), 1.511 (30), 1.482 (30), 8.1 (20)

Chemistry:

	(1)	(2)
SiO_2	11.16	14.37
TiO_2	0.56	
Al_2O_3	24.85	24.39
Fe_2O_3	41.65	38.19
Cr_2O_3	0.05	
FeO	2.77	
MnO	0.19	
MgO	5.57	9.64
CaO	13.63	13.41
Na_2O	0.02	
K_2O	0.02	
Total	100.47	100.00

(1) Durham ranch, Wyoming, USA; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponding to $(Ca_{1.99}Na_{0.01})_{\Sigma=2.00}(Mg_{1.19}Fe^{2+}_{0.33}Fe^{3+}_{0.29}Ca_{0.10}Ti_{0.06}Mn_{0.02}Cr_{0.01})_{\Sigma=2.00}Fe^{3+}_{4.00}Al_{4.00}(Si_{1.60}Al_{0.20}Fe^{3+}_{0.20})_{\Sigma=2.00}O_{20}$. (2) $Ca_2Mg_2Fe_4Al_4Si_2O_{20}$.

Mineral Group: Aenigmatite group.

Occurrence: A product of oxidizing, high-temperature, low-pressure metamorphism of alkalic rocks, in a pyrometamorphic zone in sediments.

Association: Esseneite, titanian andradite, magnetite-magnesioferrite-spinel, plagioclase, gehlenite-åkermanite, wollastonite, ulvöspinel, nepheline, apatite, ferroan sahamalite.

Distribution: From the Durham ranch, Powder River basin, 13 km northeast of Reno Junction and 25 km south of Gillette, Campbell Co., Wyoming, USA.

Name: To honor Dr. John A. Dorr, Jr., Professor of Geology, University of Michigan, Ann Arbor, Michigan, USA, in recognition of his regional geologic research in Wyoming.

Type Material: University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA, 163357.

References: (1) Cosca, M.A., R.R. Rouse, and E.J. Essene (1988) Dorrite [$Ca_2(Mg_2Fe^{3+}_4)(Al_4Si_2)O_{20}$], a new member of the aenigmatite group from a pyrometamorphic melt-rock. Amer. Mineral., 73, 1440–1448.

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Douglasite $K_2Fe^{2+}Cl_4 \cdot 2H_2O$

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Crystal Data: Monoclinic (synthetic). *Point Group:* $2/m$. As coarse granular masses.

Physical Properties: Hardness = n.d. D(meas.) = 2.16 D(calc.) = [2.04]

Optical Properties: Semitransparent. *Color:* Pale green, yellow-green, brownish red on exposure. *Luster:* Vitreous.
Optical Class: Uniaxial (+), or nearly so. $\omega = 1.488(3)$ $\epsilon = 1.500(3)$ 2V(meas.) = 5(5)°

Cell Data: *Space Group:* n.d. $a = 11.80$ $b = 16.27$ $c = 8.225$ $\beta = 104.89°$ Z = [6]

X-ray Powder Pattern: Westeregeln, Germany. (ICDD 41-1358).
3.081 (100), 3.665 (78), 4.032 (62), 4.157 (59), 2.9678 (53), 5.065 (47), 2.3700 (41)

Chemistry: No analysis is available; identification depends on correspondence of other properties with the synthetic compound.

Occurrence: In a halite–potash deposit.

Association: Carnallite, sylvite, halite.

Distribution: From the Douglashall mine, near Westeregeln, northwest of Stassfurt, 34 km south of Magdeburg, Saxony-Anhalt, Germany.

Name: For the locality, Douglashall, Germany, at which it occurs.

Type Material: The Natural History Museum, London, England, 1965,450.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 100.

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Downeyite SeO_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As acute needlelike crystals, up to 2 cm in length, elongated along [001]; also as radiating sprays. *Twinning:* Contact twinning reported.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.165 Extremely hygroscopic; readily soluble in cold H_2O.

Optical Properties: Transparent. *Color:* Colorless; red from inclusions of amorphous selenium or yellowish from sulfur. *Luster:* Adamantine.
Optical Class: Uniaxial (+); determination of indices hindered by reaction with the immersion media. *Orientation:* Extinction parallel. $n = > 1.80$, moderate birefringence.

Cell Data: *Space Group:* $P4_2/mbc$ (synthetic). $a = 8.3622(7)$ $c = 5.0612(5)$ Z = 8

X-ray Powder Pattern: Synthetic.
3.008 (100), 3.742 (60), 4.180 (55), 3.227 (55), 2.531 (25), 1.933 (18), 1.883 (14)

Chemistry: Electron microprobe analyses found only selenium; identity with synthetic SeO_2 established by correspondence of other properties.

Occurrence: As a rare sublimation product of gases escaping through vents in actively burning culm banks in anthracite coal deposits; forms at about 200 °C near the vents.

Association: Selenium, rosickýite, mascagnite.

Distribution: In the USA, from coal waste piles at Glen Lyon, Luzerne Co., Williamstown, Dauphin Co., Forestville, Schuylkill Co., and Burnside, Northumberland Co., Pennsylvania.

Name: For Wayne F. Downey, Jr., of Harrisburg, Pennsylvania, USA, who first collected the mineral.

Type Material: n.d.

References: (1) Finkelman, R.B. and M.E. Mrose (1977) Downeyite, the first verified natural occurrence of SeO_2. Amer. Mineral., 62, 316–320. (2) Ståhl, K., J.P. Legros, and J. Galy (1992)The crystal structure of SeO_2 at 139 and 286 K. Zeits. Krist., 202, 99–107. (3) (1969) NBS Mono. 25, 7, 60.

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Doyleite $Al(OH)_3$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ (probable) or 1. As rosettes of crystals, to 0.6 mm, tabular on {010}, showing forms {101}, {10$\overline{1}$}, and less commonly {100} and {001}, rectangular or square in outline; also finely granular and as porcelaneous coatings.

Physical Properties: *Cleavage:* {010}, perfect; {100}, fair. *Tenacity:* Flexible. Hardness = 2.5–3 D(meas.) = 2.48(1) D(calc.) = 2.482

Optical Properties: Transparent to opaque. *Color:* Colorless, white, creamy, bluish white. *Streak:* White. *Luster:* Vitreous to pearly if colorless; otherwise dull. *Optical Class:* Biaxial (+). *Orientation:* X (90°,41°); Y (240°,53°); Z (343°,74°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. *Dispersion:* $r > v$, moderately strong. $\alpha = 1.545(1)$ $\beta = 1.553(1)$ $\gamma = 1.566(1)$ 2V(meas.) = 77° 2V(calc.) = 76.8°

Cell Data: *Space Group:* $P\overline{1}$ (probable), or $P1$. $a = 5.002(1)$ $b = 5.175(1)$ $c = 4.980(2)$ $\alpha = 97.50(1)°$ $\beta = 118.60(1)°$ $\gamma = 104.74(1)°$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada; minor preferred orientation. 4.794 (100), 2.360 (40), 1.972 (30), 1.857 (30), 1.842 (30), 4.296 (20), 4.182 (20)

Chemistry:

	(1)	(2)	(3)	(4)
SiO_2		0.03	3.22	
Al_2O_3	65.2	63.7	59.6	65.36
FeO		0.14	0.08	
MgO			0.96	
CaO	0.48		0.23	
Na_2O		0.09	0.35	
H_2O	35.76	35.76	[35.56]	34.64
Total	101.44	99.72	[100.00]	100.00

(1) Mont Saint-Hilaire, Canada; H_2O by TGA, $(OH)^{1-}$ confirmed by IR. (2) Do.; by electron microprobe, H_2O from (1). (3) Francon quarry, Canada; by electron microprobe, average of four analyses, H_2O by difference. (4) $Al(OH)_3$.

Polymorphism & Series: Polymorphous with bayerite, gibbsite, and nordstrandite.

Occurrence: A late-stage hydrothermal mineral lining vugs in veins in nepheline syenite associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in vugs within silicocarbonatite sills intruding limestones (Francon quarry, Canada); in miarolitic cavities in a nepheline syenite sill (near Saint-Amable, Canada).

Association: Calcite, albite, pyrite (Mont Saint-Hilaire, Canada); weloganite, calcite, quartz, albite, pyrite, cryolite, strontianite, dresserite, dawsonite, fluorite, analcime (Francon quarry, Canada); microcline, eudialyte, yofortierite, astrophyllite, serandite, aegirine (near Saint-Amable, Canada).

Distribution: Found at Mont Saint-Hilaire, in the Francon quarry, Montreal Island, Montreal, and near Saint-Amable, Quebec, Canada.

Name: Honors Canadian physician E.J. Doyle, of Ottawa, Canada, who found the mineral at Mont Saint-Hilaire, Canada.

Type Material: Canadian Museum of Nature, Ottawa, 48932; Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M41025; National Museum of Natural History, Washington, D.C., USA, 162728.

References: (1) Chao, G.Y., J. Baker, A.P. Sabina, and A.C. Roberts (1985) Doyleite, a new polymorph of $Al(OH)_3$, and its relationship to bayerite, gibbsite and nordstrandite. Can. Mineral., 23, 21–28. (2) (1986) Amer. Mineral., 71, 845 (abs. ref. 1).

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Dravite $NaMg_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals equant or short to long prismatic, with dominant pyramid faces, to 20 cm. Striated ‖ [0001], cross sections typically triangular with curved convex sides. Commonly radiating, granular, and massive. *Twinning:* Rare, on $\{10\bar{1}1\}$ and $\{40\bar{4}1\}$.

Physical Properties: *Cleavage:* $\{11\bar{2}0\}$, $\{10\bar{1}1\}$, very poor. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 7 D(meas.) = 3.03–3.18 D(calc.) = 3.038 Pyroelectric and piezoelectric; may weakly fluoresce under SW UV.

Optical Properties: Transparent to translucent. *Color:* Brown to black, red, yellow, blue, green, colorless, white; colorless to yellow in thin section. *Streak:* Light brown, white. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–). *Pleochroism:* Very strong; O = pale yellow; E = colorless, yellowish, greenish, brownish. *Absorption:* $O > E$. ω = 1.634–1.661 ϵ = 1.612–1.632

Cell Data: *Space Group: R3m.* a = 15.94–15.98 c = 7.19–7.23 Z = 3

X-ray Powder Pattern: Dobrawa, Slovenia.
2.576 (100), 3.99 (85), 2.961 (85), 4.22 (65), 3.48 (60), 2.040 (45), 1.920 (35)

Chemistry:

	(1)		(1)
SiO_2	36.52	MgO	11.25
TiO_2	0.17	CaO	0.42
B_2O_3	10.32	Na_2O	2.34
Al_2O_3	33.41	K_2O	0.57
FeO	0.30	F	0.12
MnO	0.57	H_2O^+	3.76
		Total	99.75

(1) Dobrawa, Slovenia; corresponds to $(Na_{0.73}K_{0.12}Ca_{0.07})_{\Sigma=0.92}(Mg_{2.70}Al_{0.35}Mn_{0.08}Fe^{2+}_{0.04}Ti_{0.02})_{\Sigma=3.19}Al_{6.00}(B_{0.96}O_3)_3Si_{5.88}O_{18}[(OH)_{3.70}O_{0.20}F_{0.10}]_{\Sigma=4.00}$.

Polymorphism & Series: Forms two series, with schorl, and with elbaite.

Mineral Group: Tourmaline group.

Occurrence: Commonly in metamorphosed limestones or mafic igneous rocks with metasomatically introduced boron; rarely in pegmatites; as authigenic overgrowths in sedimentary rocks.

Association: Quartz, calcite, dolomite, epidote, microcline, albite, muscovite, fluorite, titanite.

Distribution: Found around Dravograd (Unterdrauberg), Slovenia. From Beura, Val d'Ossola, Piedmont, Italy. At Arendal and Snarum, Norway. From Outokumpu, and Kaavi, Kuopio, Finland. In the USA, fine crystals from Gouverneur, Pierrepont, and Macomb, St. Lawrence Co., New York; at Franklin and Hamburg, Sussex Co., New Jersey; and Newry, Oxford Co., Maine. In Canada, in Hull Township, Quebec; at Wilberforce, Ontario; and many other places. From Brumado, Bahia, Brazil. Large crystals from Yinnietharra, 800 km north of Perth, Western Australia. At Osarara, Narok district, Kenya. From Gujarkot, Nepal. Increasingly distinguished from other tourmaline group members.

Name: For the district along the Drava (Drave) River in Austria and Slovenia.

Type Material: National Museum of Natural History, Washington, D.C., USA, R18133, R17274.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 551–558 [tourmaline]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 559–602. (3) (1964) NBS Mono. 25, 3, 47.

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Dresserite $BaAl_2(CO_3)_2(OH)_4 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tapering acicular crystals, bladed on {010} and elongated along [001]; typically in divergent spherical and hemispherical aggregates, to 3 mm.

Physical Properties: Hardness = 2.5–3 D(meas.) = 2.96(2) D(calc.) = 3.06

Optical Properties: Transparent. *Color:* White. *Streak:* White. *Luster:* Vitreous to silky. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.518$ $\beta =$ n.d. $\gamma = 1.601(4)$ 2V(meas.) = 30°–40°

Cell Data: *Space Group:* [*Pbnm*] (by analogy with dundasite). $a = 9.27$ $b = 16.8$ $c = 5.63$ Z = 2

X-ray Powder Pattern: Francon quarry, Canada.
8.09 (10), 6.23 (6), 3.66 (5), 2.73 (4), 4.68 (3), 3.17 (3), 2.667 (3)

Chemistry:

	(1)	(2)
CO_2	22.2	22.15
Al_2O_3	25.6	25.66
SrO	0.8	
BaO	36.6	38.59
H_2O	15.3	13.60
Total	100.5	100.00

(1) Francon quarry, Canada; corresponds to $Ba_{0.99}Al_{2.03}(CO_3)_{2.03}(OH)_{4.01} \cdot 1.90H_2O$.
(2) $BaAl_2(CO_3)_2(OH)_4 \cdot H_2O$.

Occurrence: In vugs in an alkalic sill in limestone.

Association: Weloganite, dawsonite, quartz, plagioclase.

Distribution: From the Francon quarry, Montreal Island, Montreal, Quebec, Canada.

Name: Honors John Alexander Dresser (1866–1954), Canadian geologist who contributed to knowledge of the Monteregian Hills.

Type Material: Canadian Museum of Nature, Ottawa, Canada.

References: (1) Jambor, J.L., D.G. Fong, and A.P. Sabina (1969) Dresserite, the new barium analogue of dundasite. Can. Mineral., 10, 84–89. (2) (1969) Amer. Mineral., 55, 1447 (abs. ref. 1).

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Dreyerite $BiVO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals platy ∥ {001}, to 0.5 mm.

Physical Properties: Hardness = 2–3 D(meas.) = n.d. D(calc.) = 6.25

Optical Properties: Semitransparent. *Color:* Yellow-orange to yellow-brown. *Streak:* Yellow. *Luster:* Adamantine.
Optical Class: Uniaxial (+). *Pleochroism:* O = bright yellow; E = brownish yellow. $\omega = > 2.0$ $\epsilon = > 2.0$

Cell Data: *Space Group:* $I4_1/amd$. $a = 7.303(3)$ $c = 6.584(3)$ $Z = 4$

X-ray Powder Pattern: Hirschhorn, Germany.
3.656 (100), 2.739 (60), 4.85 (40), 1.878 (40), 2.918 (20), 2.280 (20), 2.583 (15)

Chemistry:

	(1)	(2)	(3)
V_2O_5	28.55	28.8	28.07
Bi_2O_3	71.9	69.3	71.93
CaO	0.9	1.0	
Total	101.3	99.1	100.00

(1–2) Hirschhorn, Germany; by electron microprobe; the average corresponding to $(Bi_{0.96}Ca_{0.05})_{\Sigma=1.01}VO_4$. (3) $BiVO_4$.

Polymorphism & Series: Trimorphous with clinobisvanite and pucherite.

Occurrence: In rhyolitic tuffs, intercalated with carbonaceous matter and silicified wood.

Association: Bismite, mixite, carnotite, silver, chlorargyrite, kaolinite, hematite, goethite, barite, quartz.

Distribution: From Hirschhorn, near Kaiserlautern, Rhineland-Palatinate, Germany.

Name: In honor of Gerhard Dreyer, Assistant Professor, Johannes Gutenberg University, Mainz, Germany, who found the mineral.

Type Material: Johannes Gutenberg University, Mainz, Germany; National Museum of Natural History, Washington, D.C., USA, 159922.

References: (1) Dreyer, G. and E. Tillmanns (1981) Dreyerit: ein natürliches, tetragonales Wismutvanadat von Hirschhorn/Pfalz. Neues Jahrb. Mineral., Monatsh., 151–154 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 622 (abs. ref. 1). (3) Hazen, R. and J.W.E. Mariathasan (1982) Bismuth vanadate: a high-pressure, high-temperature crystallographic study of the ferroelastic-paraelastic transition. Science, 216, 991–993.

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Drugmanite $HPb_2(Fe^{3+}, Al)(PO_4)_2(OH)_2$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Pseudorhombohedral crystals, to 0.2 mm, with prominent {001}, also {110}, flattened on [001], elongated along [010], in aggregates.

Physical Properties: Hardness = < 6 D(meas.) = > 4.1 D(calc.) = 5.55

Optical Properties: Transparent. *Color:* Pale yellow to colorless; in transmitted light, colorless with anomalous interference colors. *Streak:* White. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Orientation:* OAP = (010); $X \simeq \perp$ (001). *Dispersion:* $r < v$, strong. $n = [1.87]$ $\alpha = > 1.74$ $\beta = > 1.74$ $\gamma = > 1.74$; γ–$\beta = 0.020(2)$ in (001) section. 2V(meas.) = 33(2)°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.111(5)$ $b = 7.986(5)$ $c = 4.643(3)$ $\beta = 90.41(3)°$ Z = 2

X-ray Powder Pattern: Richelle, Belgium.
3.752 (10), 4.63 (9), 2.912 (9), 3.350 (8), 3.247 (8), 2.714 (7b), 2.391 (6)

Chemistry:

	(1)	(2)
P_2O_5	20.37	20.85
Al_2O_3	1.61	3.74
Fe_2O_3	8.85	5.87
PbO	64.37	65.57
H_2O	[3.87]	3.97
Total	[99.07]	100.00

(1) Richelle, Belgium; by electron microprobe, average of eight analyses; total Fe as Fe_2O_3, H_2O calculated for 10 O^{2-}; corresponds to $HPb_2(Fe_{0.78}Al_{0.22})_{\Sigma=1.00}(PO_4)_2(OH)_2$.
(2) $HPb_2(Fe, Al)(PO_4)_2(OH)_2$ with Fe:Al = 1:1.

Occurrence: Very rare, formed at low temperatures in vugs in mineralized limestones, an oxidation product of disseminated sulfides.

Association: Anglesite, corkite, pyromorphite, phosphosiderite.

Distribution: From Richelle, near Visé, Belgium.

Name: To honor Dr. Julien Drugman (1875–1950), Belgian mineralogist.

Type Material: Belgian Royal Institute of Natural Sciences, Brussels, RC5210; University of Liège, Liège, Belgium, 19347.

References: (1) van Tassel, R., A.-M. Fransolet, and K. Abraham (1979) Drugmanite, $Pb_2(Fe^{3+}, Al)(PO_4)_2(OH) \cdot H_2O$, a new mineral from Richelle, Belgium. Mineral. Mag., 43, 463–467. (2) (1980) Amer. Mineral., 65, 809 (abs. ref. 1). (3) King, G.S.D. and L. Sengier-Roberts (1988) Drugmanite, $Pb_2(Fe_{0.78}Al_{0.22})H(PO_4)_2(OH)_2$: its crystal structure and place in the datolite group. Bull. Minéral., 111, 431–437.

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Drysdallite $Mo(Se,S)_2$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$ most probably. Steep pyramidal crystals, to 0.5 mm, embedded in other minerals; massive.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Pliable, difficult to pulverize. Hardness = Very soft. VHN = 46–58 (7.6 g load). D(meas.) = n.d. D(calc.) = 6.248

Optical Properties: Opaque. *Color:* Grayish black with a brownish tint. *Streak:* Brownish black. *Luster:* Metallic. *Pleochroism:* Strong, white to very pale gray, to pinkish gray. *Anisotropism:* Very strong, with colors from pale bluish gray to purplish brown.
R_1–R_2: (400) 17.0–38.0, (420) 18.2–37.8, (440) 19.4–37.6, (460) 20.4–37.6, (480) 21.4–37.5, (500) 21.8–37.5, (520) 21.8–37.4, (540) 21.6–37.1, (560) 21.4–36.7, (580) 21.1–36.0, (600) 20.8–35.5, (620) 20.6–35.1, (640) 20.5–35.0, (660) 20.4–35.0, (680) 20.4–35.2, (700) 20.4–35.6

Cell Data: *Space Group:* $P6_3/mmc$ (synthetic). $a = 3.287(1)$ $c = 12.925(2)$ $Z = 2$

X-ray Powder Pattern: Kapijimpanga deposit, Zambia.
2.373 (100), 6.46 (75), 2.845 (55), 1.913 (55), 1.643 (40), 1.615 (40), 2.153 (25)

Chemistry:

	(1)	(2)
Mo	35.30	37.79
Se	60.40	62.21
S	3.40	
Total	99.10	100.00

(1) Kapijimpanga deposit, Zambia; by electron microprobe, corresponds to $Mo_{0.85}(Se_{1.76}S_{0.24})_{\Sigma=2.00}$, with spectrographic traces of Si, Mg, Al, Pb, Fe, Bi, Ca, Cu, Ni, and Ti, belonging mostly to impurities. (2) $MoSe_2$.

Occurrence: In the oxidation zone of a uranium deposit in a talc schist.

Association: Uraninite, apatite, masuyite, secondary uranium minerals.

Distribution: From the Kapijimpanga uranium deposit, 16 km southeast of Solwezi, Northwestern Province, Zambia [TL].

Name: To honor Dr. A.R. Drysdall (1933–), Director, Geological Survey of Zambia.

Type Material: Charles University, Prague, Czech Republic, 17348; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 145627.

References: (1) Čech, F., M. Rieder, and S. Vrána (1973) Drysdallite, $MoSe_2$, a new mineral. Neues Jahrb. Mineral., Monatsh., 433–442. (2) (1974) Amer. Mineral., 59, 1139 (abs. ref. 1).

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Dufrénite $Ca_{0.5}Fe^{2+}Fe^{3+}_5(PO_4)_4(OH)_6 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals rare, rounded, tabular, to 1 mm; in sheaflike or subparallel aggregates. Usually radial fibrous, botryoidal masses or crusts.

Physical Properties: *Cleavage:* One, perfect; another, less perfect, both ∥ fiber elongation; a third ⊥ first two, in traces. *Tenacity:* Brittle. Hardness = 3.5–4.5 D(meas.) = 3.1–3.34 D(calc.) = [3.41]

Optical Properties: Translucent to almost opaque. *Color:* Greenish black, dark green, olive-green when fresh, olive-brown to reddish brown when oxidized, typically concentrically banded; in transmitted light, bluish green, reddish brown, yellow. *Luster:* Vitreous to silky. *Optical Class:* Biaxial (+). *Pleochroism:* X = deep blue, bluish green, pale yellow-brown, pale brown; Y = buff, pale yellow-brown to brown, deep blue; Z = deep red-brown, olive-brown, dark brown, greenish blue. *Dispersion:* $r < v$, commonly, or $r > v$; both extreme. *Absorption:* $Z > Y > X$; may be $Z > X > Y$. α = 1.810–1.842 β = 1.813–1.850 γ = 1.855–1.925 2V(meas.) = Small to very small.

Cell Data: *Space Group:* $C2/c$. $a = 25.84(2)$ $b = 5.126(3)$ $c = 13.78(1)$ $\beta = 111.20(6)°$ Z = 2

X-ray Powder Pattern: Cornwall, England; close to natrodufrénite.
3.151 (10), 12.00 (9), 5.002 (9), 3.393 (7), 2.860 (6), 4.410 (5), 2.101 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	0.43	0.53	
P_2O_5	31.10	30.26	32.51
Al_2O_3	0.87		
Fe_2O_3	47.03	55.63	45.73
FeO	6.80		8.23
CuO		0.95	
CaO	1.68	1.50	3.21
MgO	0.17	trace	
H_2O	11.47	10.62	10.32
Total	99.55	99.49	100.00

(1–2) Wheal Phoenix, Cornwall, England. (3) $Ca_{0.5}Fe^{2+}Fe^{3+}_5(PO_4)_4(OH)_6 \cdot 2H_2O$.

Occurrence: A secondary mineral formed principally in iron ore deposits.

Association: Goethite, beraunite, quartz.

Distribution: In Germany, from Hirschberg, Ullersreuth, and Lobenstein, Thuringia; at Hauptmannsgrün, near Reichenbach, Saxony; in the Rotläufchen mine, Waldgirmes, near Giessen, Hesse; at Hagendorf, Bavaria. From the West Phoenix United mines, Linkinhorne, and in the Gunheath china clay pit, St. Austell, Cornwall, England. From the Mangualde pegmatite, near Mesquitela, Portugal. In the USA, at Rock Run, Cherokee Co., Alabama; in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; at the Sequoia Pit, Iron Point district, Humboldt Co., and in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada; in the Santa Rita mine, Grant Co., New Mexico. From Dandarragan, Western Australia. In the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 kilometers west of Córdoba, Córdoba Province, Argentina. There are probably additional localities, but requiring confirmation.

Name: To honor Professor Ours Pierre Armand Petit-Dufrénoy (1792–1857), French mineralogist, National School of Mines, Paris, France.

Type Material: University of Chicago, Chicago, Illinois, 1247; Harvard University, Cambridge, Massachusetts, USA, 97427.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 873–875. (2) Moore, P.B (1970) Crystal chemistry of the basic iron phosphates. Amer. Mineral., 55, 135–169.

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Dufrénoysite $Pb_2As_2S_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular in shape and somewhat elongated [100]; also elongated [010] and striated ‖ [100], to 3 cm. *Twinning:* With {001} as twin plane; polysynthetic lamellae are rarely observed in polished section.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = 135–146 (100 g load). D(meas.) = 5.50–5.57 D(calc.) = 5.61

Optical Properties: Subtranslucent. *Color:* Lead-gray to steel-gray; in polished section, white, may show deep red internal reflections; dark red-brown in transmitted light. *Streak:* Reddish brown to chocolate-brown.
Optical Class: Biaxial. *Luster:* Metallic. *Pleochroism:* Very weak. $n = > 2.72$ (Li).
Anisotropism: Strong, in brown-violet and dark green colors.
R_1–R_2: (400) 39.5–42.1, (420) 39.0–41.7, (440) 38.5–41.1, (460) 38.1–40.6, (480) 37.8–40.2, (500) 37.4–39.7, (520) 37.0–39.0, (540) 36.6–38.4, (560) 36.1–37.6, (580) 35.6–36.9, (600) 34.9–36.2, (620) 34.2–35.4, (640) 33.3–34.6, (660) 32.5–33.7, (680) 31.7–33.0, (700) 31.0–32.4

Cell Data: *Space Group:* $P2_1/m$. $a = 7.90$ $b = 25.74$ $c = 8.37$ $\beta = 90°21'$ Z = 2

X-ray Powder Pattern: Binntal, Switzerland.
3.74 (100), 3.00 (90), 2.70 (80), 3.21 (60), 2.36 (60), 2.23 (60), 3.56 (50)

Chemistry:

	(1)	(2)
Pb	57.42	57.20
As	20.89	20.68
S	22.55	22.12
Total	100.86	100.00

(1) Binntal, Switzerland. (2) $Pb_2As_2S_5$.

Occurrence: An uncommon mineral of medium- to low-temperature hydrothermal origin.

Association: Chalcopyrite, sphalerite, realgar, orpiment, tetrahedrite.

Distribution: In Switzerland, from Binntal, Valais, in the Lengenbach quarry [TL], and at Recki Bach. From the Bleikvassli Zn–Pb–Cu deposit, Nordland, Norway. At Wheal Boys, St. Endellion, Cornwall, England. In the USA, from the Silver Star claims, near Fruitland, Stevens Co., Washington, and at the Zuni mine, San Juan Co., Colorado. From the Hemlo gold deposit, Thunder Bay district, Ontario, Canada.

Name: To honor Professor Ours Pierre Armand Petit-Dufrénoy (1792–1857), French mineralogist, National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 442–445. (2) Ribár, B., C. Nicca, and W. Nowacki (1969) Dreidimensionale Verfeinerung der Kristallstruktur von Dufrenoysit, $Pb_8As_8S_{20}$. Zeits. Krist., 130, 15–40 (in German with English abs.). (3) Pring, A. (2001) The crystal chemistry of the sartorite group minerals from Lengenbach, Binntal, Switzerland – a HRTEM study. Schweiz. Mineral. Petrog. Mitt., 81, 69–87. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 151. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 147.

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Duftite $PbCu(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals may be pseudo-octahedral, or elongated along [001], commonly curved and rough, to 5 mm; usually in crusts and aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 D(meas.) = 6.40 D(calc.) = 6.602

Optical Properties: Subtranslucent. *Color:* Bright olive-green to gray-green; pale apple-green in transmitted light, generally zoned due to compositional variations. *Streak:* Pale green to white. *Luster:* Dull to vitreous on fractures.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, perceptible. α = 2.03–2.04 β = 2.06–2.08 γ = 2.08–2.10 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_12_12_1$ (synthetic). $a = 7.768(1)$ $b = 9.211(1)$ $c = 5.999(1)$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
3.26 (10), 2.85 (8), 2.65 (8), 2.57 (6), 4.21 (5), 2.28 (5), 1.87 (5)

Chemistry:	(1)	(2)	(3)
SiO_2	0.44		
As_2O_5	26.01	26.1	26.93
$(Fe,Al)_2O_3$		0.6	
CuO	19.32	18.6	18.65
ZnO	0.46	0.7	
PbO	50.10	50.6	52.31

	(1)	(2)	(3)
CaO	0.75	0.9	
H_2O^+	2.65		
H_2O^-	0.08		
H_2O		2.3	2.11
Total	99.81	99.8	100.00

(1–2) Tsumeb, Namibia. (3) $PbCu(AsO_4)(OH)$.

Mineral Group: Adelite group.

Occurrence: An uncommon mineral in the oxidized zone of some hydrothermal base-metal deposits.

Association: Olivenite, mottramite, azurite, malachite, wulfenite, calcite (Tsumeb, Namibia); bayldonite, beudantite, mimetite, cerussite (Cap Garonne mine, France).

Distribution: Many minor localities. Abundant at Tsumeb, Namibia, rarely in large crystals. From Fitula and Mufulira, Zambia. At the Touissit mine, near Oujda, Morocco. From the Cap Garonne mine, near le Pradet, Var, France. In the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate, Germany. From Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. In England, at Brandy Gill, Caldbeck Fells, Cumbria, and in the Penberthy Croft mine, St. Hilary, Cornwall. From the Ojuela mine, Mapimí, Durango, Mexico. In the USA, from the Mohawk mine, Clark Mountains, San Bernardino Co., and at the Belmont mine, Cerro Gordo, Inyo Co., California; in the Black Pine mine, Philipsburg, Granite Co., Montana; at Granite Gap, Hidalgo Co., New Mexico. In Australia, large crystals in the Mt. Bonnie mine, Grove Hill, Prices Station, Northern Territory; from Broken Hill, New South Wales; and in the Puttapa zinc mine, near Beltana, and the Mt. Malvern mine, near Clarendon, South Australia.

Name: In honor of G. Duft, General Manager of the mine at Tsumeb, Namibia.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 810–811. (2) Claringbull, G.F. (1951) New occurrences of duftite. Mineral. Mag., 29, 609–614. (3) Guillemin, C. (1956) Contribution a la minéralogie des arséniates, phosphates et vanadates de cuivre. I. Arséniates de cuivre. Bull. Soc. fr. Minéral., 79, 7–95, esp. 70–80 (in French). (4) Jambor, J.L., D.R. Owens, and J.E. Dutrizac (1980) Solid solution in the adelite group of arsenates. Can. Mineral., 18, 191–195. (5) Kharisun, M.R. Taylor, D.J.M. Bevan, and A. Pring (1998) The crystal chemistry of duftite, $PbCuAsO_4(OH)$ and the β-duftite problem. Mineral. Mag., 62, 121–130.

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Dugganite $Pb_3(Zn,Cu)_3Te^{6+}O_6(AsO_4)(OH)_3$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals stubby prismatic, slightly curved, with {0001}, {$11\overline{2}0$}, {$11\overline{2}1$}, to 0.3 mm.

Physical Properties: *Cleavage:* {$11\overline{2}0$}, poor. *Fracture:* Brittle. Hardness = 3
D(meas.) = 6.33(15) D(calc.) = 6.33

Optical Properties: Semitransparent. *Color:* Colorless, water-green, yellow-green, may be zoned or sectored. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (–), anomalously slightly biaxial. $\omega = 1.977(2)$ $\epsilon = 1.967$
2V(meas.) = Small.

Cell Data: *Space Group:* $P6/mmm$. $a = 8.472(5)$ $c = 5.208(5)$ Z = 1

X-ray Powder Pattern: Tombstone, Arizona, USA.
3.284 (10), 2.997 (8), 2.446 (6), 1.896 (6), 1.603 (6), 2.773 (5), 1.177 (5)

Chemistry:

	(1)	(2)
TeO_3	14.0	14.26
As_2O_5	10.4	9.33
CuO	1.2	
ZnO	17.6	19.83
PbO	55.3	54.38
H_2O	1.5	2.20
Total	[100.0]	100.00

(1) Tombstone, Arizona, USA; average of four analyses for Pb, Zn, Cu, three for Te, and two for As, H_2O by the Penfield method; recalculated to 100% after deduction of insoluble 3.63% average.
(2) $Pb_3Zn_3(TeO_6)(AsO_4)(OH)_3$.

Occurrence: An alteration product of khinite and parakhinite, formed under acid oxidizing conditions from gold-telluride ores in massive vein quartz (Tombstone, Arizona, USA).

Association: Khinite, parakhinite, bromargyrite, chlorargyrite, cerussite, emmonsite, other tellurium oxysalts (Tombstone, Arizona, USA).

Distribution: In the USA, from the Emerald and Old Guard mines, and the Joe shaft, Tombstone, Cochise Co., Arizona; at the Centennial Eureka mine, Tintic district, Juab Co., Utah. From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: To honor Marjorie Duggan (1927–), American analytical chemist, who first analyzed Te^{6+} from nature.

Type Material: The Natural History Museum, London, England, 1980,544; Harvard University, Cambridge, Massachusetts, 119093; National Museum of Natural History, Washington, D.C., USA, 162207.

References: (1) Williams, S.A. (1978) Khinite, parakhinite, and dugganite, three new tellurates from Tombstone, Arizona. Amer. Mineral., 63, 1016–1019.

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Dumontite $Pb_2(UO_2)_3O_2(PO_4)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, elongated or platy, striated along [001], flattened ‖ {010}, showing {100}, {001}, {010}, {011}, {013}, to 1.5 mm; may form stellate aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 5.65(4) D(calc.) = 5.666 May fluoresce pale green under UV. Radioactive.

Optical Properties: Translucent. *Color:* Yellow to ocher-yellow. *Streak:* Yellow to ocher-yellow.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = pale yellow; Z = deep yellow.
Orientation: $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, strong. $\alpha = 1.85$–1.88 $\beta = 1.87$–1.89 $\gamma = [\approx 1.90]$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/m$. $a = 8.118(6)$ $b = 16.819(8)$ $c = 6.983(3)$ $\beta = 109.03(5)^\circ$ Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
4.27 (FF), 3.00 (F–FF), 2.95 (F–FF), 3.48 (F), 6.14 (mF), 4.20 (mF), 3.74 (mF)

Chemistry:

	(1)	(2)	(3)
UO_3	56.49	54.1	55.85
TeO_3	1.01		
P_2O_5	8.65	10.5	9.24
PbO	27.19	28.6	29.05
H_2O	5.78	5.9	5.86
Total	99.12	99.1	100.00

(1) Shinkolobwe, Congo. (2) Do.; UO_3 and P_2O_5 average of two analyses, PbO and H_2O average of three analyses. (3) $Pb_2(UO_2)_3O_2(PO_4)_2 \cdot 5H_2O$.

Occurrence: In pockets of torbernite in the oxidized zone of a uranium deposit (Shinkolobwe, Congo).

Association: Torbernite (Shinkolobwe, Congo); uranophane, kasolite, autunite (near Nogales, Arizona, USA); kasolite (Goodsprings, Nevada, USA).

Distribution: From Shinkolobwe, Katanga (Shaba) Province, and at the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire). In the USA, at the White Oak property, near Nogales, Santa Cruz Co., Arizona; in the Green Monster and Desert Valley mines, Goodsprings district, Clark Co., Nevada. From the South Alligator Valley, and in the Ranger mine, Jabiru, Northern Territory, Australia.

Name: Honoring André Hubert Dumont (1809–1857), Belgian geologist.

Type Material: Natural History Museum, Paris, France, 125.11.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 928–929. (2) Thoreau, J., M. Van Meerssche, and J. Protas (1958) Sur la dumontite de Shinkolobwe (Katanga). Bull. Soc. fr. Minéral., 81, 63–65 (in French). (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 236–238. (4) Piret, P. and J. Piret-Meunier (1988) Nouvelle détermination de la structure cristalline de la dumontite $Pb_2[(UO_2)_3O_2(PO_4)_2] \cdot 5H_2O$. Bull. Minéral., 111, 439–442 (in French with English abs.). (5) Guillemin, C. (1958) Minéraux d'uranium du Haut Katanga, 54.

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Dumortierite $Al_7(BO_3)(SiO_4)_3O_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As fibrous or columnar crystals, having generally poor face development, to 6 cm; as coarsely crystalline to intimate parallel aggregates of needles; massive. *Twinning:* Common on {110}, which may produce trillings.

Physical Properties: *Cleavage:* Distinct on {100}, poor on {110}; parting on {001}. Hardness = 7–8.5 D(meas.) = 3.21–3.41 D(calc.) = 3.45

Optical Properties: Transparent to translucent. *Color:* Bright smalt-blue to greenish blue, violet, red-violet, purple, brown. *Luster:* Vitreous to dull.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = deep blue or violet; Y = yellow to red-violet or nearly colorless; Z = colorless or very pale blue. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong. α = 1.659–1.686 β = 1.684–1.722 γ = 1.686–1.723 2V(meas.) = 13°–55°

Cell Data: *Space Group: Pmcn.* a = 11.828(1) b = 20.243(3) c = 4.7001(5) Z = 4

X-ray Powder Pattern: Sri Lanka.
5.85 (s), 2.09 (ms), 5.06 (m), 3.43 (m), 3.22 (m), 2.91 (mb), 4.26 (mw)

Chemistry:

	(1)	(2)
SiO_2	29.99	31.52
TiO_2	1.56	
B_2O_3	[6.09]	6.09
Al_2O_3	61.49	62.39
Fe_2O_3	0.06	
MgO	0.10	
CaO	0.02	
H_2O	[0.60]	
Total	[99.91]	100.00

(1) Dehesa, California, USA; by electron microprobe, B_2O_3 and H_2O inferred from structure determination. (2) $Al_7(BO_3)(SiO_4)_3O_3$.

Occurrence: In aluminum-rich regionally metamorphosed rocks, disseminated and in veinlets cutting schists; also in pegmatitic veins.

Association: Quartz, cordierite, kyanite, andalusite, sillimanite, muscovite, rutile.

Distribution: In France, from near Beaunan and at Chaponost, near Lyon, Rhône. At Wolfshau, near Schmiedeberg, Silesia, Poland. From Kaňk, near Kutná Hora, Czech Republic. In the USA, from the Champion mine, near Oreana, Sacramento district, Humboldt Co., Nevada, once mined commercially; at Clip, near Yuma, and Quartzsite, La Paz Co., Arizona; Petaca, Rio Arriba Co., New Mexico; in California, from near Dehesa, San Diego Co., and from near Ogilby, Imperial Co. In Canada, from Ashby Township, Addington Co., Ontario. From the Erongo Mountains, Namibia. On Madagascar, many places for fine examples, as at Soavina, north of Atofinandrahana; Saharina; Ambatolahinanahary; Ambositra; and Riamfotsy. In India, at Mogra, Bhandara district, Maharashtra. Many other minor localities are known.

Name: For Eugène Dumortier (1802–1873?), French paleontologist, of Lyons, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 558.
(2) Claringbull, G.F. and M.H. Hey (1958) New data for dumortierite. Mineral. Mag., 31, 901–907. (3) Moore, P.B. and T. Araki (1978) Dumortierite, $Si_3B[Al_{6.75}\square_{0.25}O_{17.25}(OH)_{0.75}]$: a detailed structure analysis. Neues Jahrb. Mineral., Abh., 132, 231–241. (4) Alexander, V.D., D.T. Griffen, and T.J. Martin (1986) Crystal chemistry of some Fe- and Ti-poor dumortierites. Amer. Mineral., 71, 786–794.

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Dundasite $PbAl_2(CO_3)_2(OH)_4 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As acicular crystals, elongated along [001], made up of subparallel individuals, to 1 cm; typically in spherical aggregates and tufted matted crusts.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 2 D(meas.) = 3.10–3.55 D(calc.) = 3.716

Optical Properties: Transparent. *Color:* White to very pale blue; colorless in transmitted light. *Luster:* Vitreous to silky.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.603(3)$ $\beta = 1.716(3)$ $\gamma = 1.742(3)$ 2V(meas.) = Very large.

Cell Data: *Space Group: Pbnm.* $a = 9.08(1)$ $b = 16.37(2)$ $c = 5.62(1)$ Z = 4

X-ray Powder Pattern: Dundas, Tasmania, Australia.
7.91 (10), 3.60 (8), 3.08 (6), 4.63 (5), 3.23 (5), 2.667 (5), 2.968 (4)

Chemistry:

	(1)	(2)
CO_2		18.84
$CO_2 + H_2O$	28.08	
Al_2O_3	26.06	21.82
Fe_2O_3	5.50	
PbO	41.86	47.77
H_2O		11.57
Total	101.50	100.00

(1) Dundas, Tasmania, Australia. (2) $PbAl_2(CO_3)_2(OH)_4 \cdot H_2O$.

Occurrence: Uncommon in the oxidized zone of lead-bearing deposits.

Association: Cerussite, plattnerite, azurite, malachite, pyromorphite, mimetite, beudantite, duftite, crocoite, gibbsite, allophane, "limonite".

Distribution: In Australia, from near Dundas, Tasmania, notably at the Adelaide Proprietary mine, and at the Hercules mine, Mt. Read. In the Tui mine, Mt. Te Aroha, New Zealand. In Wales, from the Welsh Foxdale mine and others, near Trefriw, Gwynedd. At the Clements mine, near Maam, Co. Galway, Ireland. In England, from the Mill Close mine, Wensley, Derbyshire; at Wheals Rose and Penrose, Sithney, in the Trevinnick mine, St. Kew, and others in Cornwall; from the Brandehow mine, Derwentwater, and the Wanthwaite mine, St. John's in the Vale, Cumbria. In the Bad Ems district, Rhineland-Palatinate, and at Bad Harzburg and elsewhere, Harz, Germany. At Guttaring, and Pleschutz, near Hirt, Carinthia, Austria. In Italy, on Sardinia, from the Punta Sa Torre mine, the Seddas Moddizis mine, and the San Giovanni mine, near Gonessa, Iglesias. In the Kamariza mine, Laurium, Greece. Long crystals from the Cap Garonne mine, near le Pradet, Var, France. At the Touissit mine, Oujda, Morocco. From Tsumeb, Namibia. In the USA, in New Mexico, from the South Juanita, Tip Top, and Kelly mines, near Magdalena, Socorro Co.; in the Success mine, Schell Creek Range, White Pine Co., Nevada; at the Noble mine, Ogdensburg, Sussex Co., New Jersey.

Name: For the occurrence at Dundas, Tasmania, Australia.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 279–280. (2) Jambor, J.L., D.G. Fong, and A.P. Sabina (1969) Dresserite, the new barium analogue of dundasite. Can. Mineral., 10, 84–89. (3) Cocco, G., L. Fanfani, A. Nunzi, and P.F. Zanazzi (1972) The crystal structure of dundasite. Mineral. Mag., 38, 564–569.

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Durangite $NaAl(AsO_4)F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically in euhedral crystals, to 1 cm, slightly elongated along [001], with dominant {110}, {$\bar{1}$11}, and {010}, {100}, {021}, faces commonly rough; in stacked aggregates.

Physical Properties: *Cleavage:* On {110}, distinct. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 3.90–4.07 D(calc.) = 3.92

Optical Properties: Transparent to opaque. *Color:* Pale to dark red-orange, deep red, orange, orange-brown, pale yellow; in transmitted light, color zoned from varying contents of Fe and Mn. *Streak:* Cream-yellow to pale yellow. *Luster:* Vitreous, usually dull.
Optical Class: Biaxial (–). *Pleochroism:* X = yellow-orange; Y = pale yellow-orange; Z = nearly colorless. *Orientation:* $Z = b$; $X \wedge c = -25°$. *Dispersion:* $r < v$, less commonly $r > v$, weak to moderate. *Absorption:* $X > Y > Z$. $\alpha = 1.597–1.634$ $\beta = 1.636–1.673$ $\gamma = 1.647–1.685$ 2V(meas.) = 45°; 68°–85° 2V(calc.) = 55°–81°

Cell Data: *Space Group:* $C2/c$. $a = 6.574–6.579$ $b = 8.505–8.523$ $c = 7.019–7.046$ $\beta = 115.34°–115.47°$ Z = 4

X-ray Powder Pattern: Barranca tin mine, Durango, Mexico.
2.967 (100), 4.76 (80), 3.236 (80), 2.560 (60), 2.549 (57), 3.34 (50), 1.533 (41)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
As_2O_5	53.11	54.0	55.28	Li_2O	0.65	0.46	
TiO_2		0.15		Na_2O	13.06	13.7	14.91
Al_2O_3	17.19	21.5	24.52	F	7.67	8.16	9.14
Fe_2O_3	9.23	2.83		Cl		< 0.2	
Mn_2O_3	2.08	2.38		H_2O^+		0.30	
ZnO		0.18		H_2O^-		0.05	
PbO		0.1		$-O = F_2$	3.23	3.44	3.85
CaO		0.11		Total	99.76	100.48	100.00

(1) Barranca tin mine, Durango, Mexico. (2) Boiler Peak, New Mexico, USA; by ICPA and emission spectroscopy, F by ion chromatography, H_2O by Karl Fischer method, after deduction of SiO_2 3.21%; then corresponds to $(Na_{0.93}Li_{0.07})_{\Sigma=1.00}(Al_{0.89}Fe_{0.07}Mn_{0.06})_{\Sigma=1.02}(As_{0.99}O_4)[F_{0.90}(OH)_{0.07}]_{\Sigma=0.97}$. (3) $NaAl(AsO_4)F$.

Polymorphism & Series: Forms two series, with maxwellite and with tilasite.

Occurrence: In veins in alkalic rhyolite and tin placers derived therefrom; in pegmatite dikes in granite.

Association: Cassiterite, hematite, topaz, ilmenite, tantalite, wickmanite, beudantite, mimetite, fluorite, tridymite, cristobalite, quartz, amblygonite, "chalcedony", zeolites, clay minerals.

Distribution: From the Barranca tin mine, about 30 km northeast of Coneto de Comonfort, Durango, Mexico. Found near Lake Ramsey, New Ross, Nova Scotia, Canada. In the USA, in tin prospects near Boiler Peak, in the Black Range, Sierra Co., New Mexico; and in the Thomas Range, Juab Co., Utah. From the Cheesewring quarry, Linkinhorne, Cornwall, England.

Name: For the original occurrence in Durango, Mexico.

Type Material: Yale University, New Haven, Connecticut, USA, 3.586, 3.3036, 3.3037.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 829–831. (2) Foord, E.E., M.R. Oakman, and C.H. Maxwell (1985) Durangite from the Black Range, New Mexico, and new data on durangite from Durango and Cornwall. Can. Mineral., 23, 241–246. (3) Kokkoros, P. (1938) Über die Struktur des Durangit $NaAlF[AsO_4]$. Zeits. Krist., 99, 38–49 (in German).

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Duranusite As_4S

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Crystal Data: Orthorhombic. *Point Group:* n.d. As small polycrystalline grains, to 0.2 mm; randomly oriented fibers and wiry aggregates.

Physical Properties: Hardness = n.d. VHN = 58 (25 g load). D(meas.) = n.d. D(calc.) = 4.50

Optical Properties: Opaque. *Color:* Red; in polished section, pale gray. *Luster:* Metallic. R_1–R_2: (400) 39.0–42.0, (420) 36.8–39.4, (440) 34.6–36.8, (460) 33.0–34.8, (480) 32.1–33.6, (500) 31.4–32.7, (520) 30.8–32.2, (540) 30.4–31.8, (560) 30.0–31.5, (580) 29.6–31.0, (600) 29.1–30.6, (620) 28.7–30.3, (640) 28.4–30.0, (660) 28.0–29.7, (680) 27.6–29.3, (700) 27.1–29.0

Cell Data: *Space Group:* n.d. $a = 3.576(2)$ $b = 6.759(2)$ $c = 10.074(5)$ Z = 2

X-ray Powder Pattern: Duranus, France.
2.919 (10), 5.620 (9), 5.037 (9), 1.969 (9), 1.788 (9), 2.682 (8), 3.016 (7)

Chemistry:

	(1)	(2)	(3)
As	90.0	90.8	90.33
S	10.3	10.3	9.67
Total	100.3	101.1	100.00

(1) Duranus, France; by electron microprobe, corresponding to $As_{3.95}S_{1.05}$. (2) Do.; corresponding to $As_{3.96}S_{1.04}$. (3) As_4S.

Occurrence: In calcite veinlets in marls and siliceous limestones (Duranus, France).

Association: Arsenic, realgar, orpiment, stibnite, sphalerite, rhodochrosite, quartz, calcite.

Distribution: From Duranus, Alpes-Maritimes, France [TL]. In the Mt. Washington copper mine, Vancouver Island, British Columbia, Canada. At the Capillitas mine, San Luis, Catamarca Province, Argentina.

Name: For the locality at Duranus, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., C. Laforêt, P. Picot, and J. Ferard (1973) La duranusite, As_4S, un nouveau minéral. Bull. Soc. fr. Minéral., 96, 131–134 (in French). (2) (1975) Amer. Mineral., 60, 945 (abs. ref. 1).

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Dussertite $\mathbf{BaFe_3^{3+}(AsO_4)_2(OH)_5}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As crystals, flattened on {0001}, to 0.01 mm; in rosettes and crusts.

Physical Properties: Hardness = 3.5 D(meas.) = 3.75 D(calc.) = 4.09

Optical Properties: Semitransparent. *Color:* Green to pistachio-green, bluish green; yellowish green in transmitted light.
Optical Class: Uniaxial (–), rarely anomalously biaxial. *Pleochroism:* In shades of greenish yellow. $\omega = 1.870$ $\epsilon = 1.845$–1.85 2V(meas.) = 15°–20°

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.4244(3)$ $c = 17.494(1)$ Z = 3

X-ray Powder Pattern: Djebel Debar, Algeria. (ICDD 35-621).
3.13 (100), 2.329 (40), 3.713 (30), 2.915 (30), 2.012 (30), 6.04 (25), 1.857 (25)

Chemistry:

	(1)	(2)
As_2O_5	31.23	34.42
Fe_2O_3	34.57	35.87
CaO	0.08	
BaO	20.93	22.96
H_2O	9.30	6.75
insol.	4.10	
Total	100.21	100.00

(1) Djebel Debar, Algeria. (2) $BaFe_3(AsO_4)_2(OH)_5$.

Mineral Group: Crandallite group.

Occurrence: In the oxidized zone of some base-metal deposits, typically an alteration product of arsenopyrite.

Association: Beudantite, carminite, scorodite, arseniosiderite, stibiconite, goethite, quartz.

Distribution: From Djebel Debar, northeast of Hammam Meskhoutine, Qacentina (Constantine), Algeria. At the Senator mine, 20 km south-southwest of Kutahya, Turkey. In the Ojuela mine, Mapimí, Durango, Mexico. From Tecoma, Elko Co., Nevada, USA. In Germany, on Mt. Borstein, near Reichenbach, Hesse; in the Black Forest, at the Clara mine, near Oberwolfach, the Anton mine, Heubachtal, near Schiltach, and Freudenstadt, near Wittichen; at Schneeberg, Saxony.

Name: Honors Desiré Dussert (1872–?), French mining engineer who worked in Algeria.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 839–840. (2) Walenta, K. (1966) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 3. Folge. Tschermaks Mineral. Petrog. Mitt., 11, 121–164, esp. 129–132 (in German).

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Duttonite $V^{4+}O(OH)_2$

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Crystal Data: Monoclinic; pseudo-orthorhombic. *Point Group:* $2/m$. In crusts and masses of six-sided, platy, pseudo-orthorhombic crystals, to 1 mm, flattened ∥ {001}, with {100} and {110}.

Physical Properties: *Cleavage:* {001}, good to perfect. Hardness = ∼2.5 D(meas.) = n.d. D(calc.) = 3.24

Optical Properties: Transparent. *Color:* Pale brown, becoming greenish with alteration. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = pale pinkish brown; Y = pale yellow-brown; Z = pale brown. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, moderate. $\alpha = 1.810(3)$ $\beta = 1.900(3)$ $\gamma = > 2.01$ 2V(meas.) = ∼60°

Cell Data: *Space Group:* $I2/c$. $a = 8.80(2)$ $b = 3.95(1)$ $c = 5.96(2)$ $\beta = 90°40(5)'$ Z = 4

X-ray Powder Pattern: Peanut mine, Colorado, USA.
4.40 (100), 3.61 (85), 1.838 (21), 2.480 (15), 2.454 (15), 1.974 (14), 3.29 (13)

Chemistry:

	(1)	(2)
V_2O_4	78.1	82.16
V_2O_3	2.7	
FeO	0.4	
H_2O	18.8	17.84
Total	[100.0]	100.00

(1) Peanut mine, Colorado, USA; by spectrophotometry, H_2O by CHN analyzer; recalculated to 100% after deduction of 4.2% insoluble selenium and quartz. (2) $VO(OH)_2$.

Occurrence: A secondary mineral formed by the low-temperature hydrothermal alteration of vanadium-bearing minerals.

Association: Melanovanadite, lenoblite, selenium, simplotite, montroseite, paramontroseite, uraninite, coffinite (Peanut mine, Colorado, USA); hewettite, fervanite, schoderite, metaschoderite, straczekite (Wilson Springs, Arkansas, USA).

Distribution: In the USA, found at the Peanut mine, Bull Canyon area, Uravan district, Montrose Co., and at the Sundown claim, Gypsum Valley, Slick Rock district, San Miguel Co., Colorado; in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas. From the Urcal deposit, La Rioja, Argentina. At the Mounana uranium mine, Franceville, Gabon.

Name: Honors Captain Clarence Edward Dutton (1841–1912), American geologist with the U.S. Geological Survey, an early worker on the Colorado Plateau.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 134144.

References: (1) Thompson, M.E., C.H. Roach, and R. Meyrowitz (1956) Duttonite, new vanadium mineral from Peanut mine, Montrose County, Colorado. Science, 123, 990. (2) (1956) Amer. Mineral., 41, 958 (abs. ref. 1). (3) Thompson, M.E., C.H. Roach, and R. Meyrowitz (1957) Duttonite, a new quadrivalent vanadium oxide from the Peanut mine, Montrose County, Colorado. Amer. Mineral., 42, 455–460. (4) Evans, H.T., Jr. and M.E. Mrose (1958) The crystal structures of three new vanadium oxide minerals. Acta Cryst., 11, 56–58.

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Dwornikite $(Ni, Fe^{2+})SO_4 \cdot H_2O$

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Crystal Data: Monoclinic (by analogy to kieserite group). *Point Group:* $2/m$. As aggregates of anhedral grains, to 1 μm, intermixed with other species.

Physical Properties: *Fracture:* [Conchoidal to uneven.] (by analogy to szomolnokite). *Tenacity:* [Brittle.] Hardness = [2.5] D(meas.) = n.d. D(calc.) = 3.357 [Slowly soluble in H_2O.]

Optical Properties: Semitransparent. *Color:* White, may have a greenish tint from impurities. *Luster:* [Vitreous.]
Optical Class: Biaxial, with fairly strong birefringence. $n = 1.63$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 6.824(2)$ $b = 7.594(2)$ $c = 7.457(1)$ $\beta = 117.79(1)^\circ$ Z = 4

X-ray Powder Pattern: Minasragra, Peru.
3.342 (100), 4.732 (70), 3.024 (70), 4.754 (50), 3.293 (35), 2.4912 (35), 3.792 (25)

Chemistry:

	(1)
SO_3	42.4
FeO	9.3
NiO	39.0
H_2O	n.d.
Total	

(1) Minasragra, Peru; by X-ray fluorescence, average of four partial analyses; corresponds to $(Ni_{0.80}Fe_{0.20})_{\Sigma=1.00}(SO_4)_2 \cdot H_2O$.

Mineral Group: Kieserite group.

Occurrence: In a vanadium sulfide deposit, probably by oxidation of associated bravoite.

Association: Patronite, sulfur, retgersite, szomolnokite, "bitumen".

Distribution: At Minasragra, 46 km from Cerro de Pasco, Peru.

Name: Honors Edward J. Dwornik (1920–), Lunar geologist and mineralogist, U.S. Geological Survey, Washington, D.C., USA, who studied several vanadium deposits.

Type Material: George Washington University, Washington, D.C., USA.

References: (1) Milton, C., H.T. Evans, Jr., and R.G. Johnson (1982) Dwornikite, $(Ni, Fe)SO_4 \cdot H_2O$, a member of the kieserite group from Minasragra, Peru. Mineral. Mag., 46, 351–355. (2) (1983) Amer. Mineral., 68, 642 (abs. ref. 1). (3) Wildner, M. and G. Giester (1991) The crystal structures of kieserite-type compounds. I. Crystal structures of $Me(II)SO_4 \cdot H_2O$ (Me = Mn,Fe,Co,Ni,Zn). Neues Jahrb. Mineral., Monatsh., 296–306.

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Dymkovite $Ni(UO_2)_2(As^{3+}O_3)_2 \cdot 7H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As prismatic, lath-shaped to acicular crystals, to 0.5 mm, elongated on [010]; also as sprays or divergent groups to 1.5 mm, or as crusts.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~ 3 D(meas.) = n.d. D(calc.) = 3.806 Radioactive.

Optical Properties: Transparent. *Color*: Bright yellow. *Streak*: Pale yellow. *Luster*: Vitreous. *Optical Class*: Biaxial (-). α = 1.625(2) β = 1.735(5) γ = 1.745(3) 2V(meas.) = 20(10)° 2V(calc.) = 32° *Dispersion*: Strong, *r* > *v*. *Pleochroism*: Strong, *X* = very pale yellowish-green, *Y* = *Z* = light greenish yellow. *Absorption*: *Z* > *Y* > *X*.

Cell Data: *Space Group*: *C*2/*m*. *a* = 17.91(2) *b* = 6.985(9) *c* = 6.594(9) β = 99.89(2)° Z = 2

X-ray Powder Pattern: Belorechenskoye deposit, Northern Caucasus, Russia.
8.93 (100), 4.463 (34), 2.846 (27), 3.008 (26), 3.523 (23), 3.276 (21), 4.883 (17)

Chemistry:

	(1)	(2)
MgO	1.11	
FeO	0.24	
NiO	5.40	7.70
ZnO	0.23	
As_2O_3	19.57	20.38
P_2O_5	0.58	
UO_3	59.43	58.93
H_2O	[13.44]	12.99
Total	100.00	100.00

(1) Belorechenskoye deposit, Northern Caucasus, Russia; average of 12 electron microprobe analyses, H_2O by difference, presence of H_2O, PO_4, UO_2, $As^{3+}O_4$ groups confirmed by IR spectroscopy; corresponding to $(Ni_{0.69}Mg_{0.26}Fe_{0.03}Zn_{0.03})_{\Sigma=1.01}U_{1.97}(As^{3+}_{1.88}P_{0.08})_{\Sigma=1.96}O_{9.94} \cdot 7.06H_2O$.
(2) $Ni(UO_2)_2(As^{3+}O_3)_2 \cdot 7H_2O$.

Mineral Group: Autunite group.

Occurrence: A secondary mineral found in small cavities and cracks in slightly oxidized uraninite-bearing dolomite veins.

Association: Rauchite, uraninite, nickeline, gersdorffite, limonite, annabergite.

Distribution: From adit #1, Belorechenskoye deposit, Belaya River basin, 60 km south of Maikop city, Adygea Republic, Northern Caucasus, Russia.

Name: Honors Russian mineralogist, Yuriy Maksimovich Dymkov (b. 1926), a specialist in the mineralogy and geology of uranium deposits.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (4065/1).

References: (1) Pekov, I.V., V.V. Levitskiy, S.V. Krivovichev, A.A. Zolotarev, N.V. Chukanov, I.A. Bryzgalov, and A.E. Zadov (2012) New nickel-uranium-arsenic mineral species from the oxidation zone of the Belorechenskoye deposit, Northern Caucasus, Russia: II. Dymkovite, $Ni(UO_2)_2(As^{3+}O_3)_2 \cdot 7H_2O$, a seelite-related arsenite. European Journal of Mineralogy, 24(5), 923-930. (2) (2015) Amer. Mineral., 100, 336-338 (abs. ref. 1).

Dypingite $Mg_5(CO_3)_4(OH)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic (?). *Point Group:* n.d. As reniform, botryoidal, oolitic, or globular aggregates of radially-divergent acicular to flaky crystals, to 0.5 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.15 Fluoresces pale blue under SW and LW UV; some material also displays green phosphorescence.

Optical Properties: Semitransparent. *Color:* Snow-white to gray; colorless in transmitted light. *Luster:* Pearly.
Optical Class: Biaxial (+) or (–). *Orientation:* Elongated ∥ *Y*. α = 1.508–1.515 β = 1.510–1.521 γ = 1.516–1.522 2V(meas.) = n.d. 2V(calc.) = 44.5°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Dypingdal, Norway.
10.6 (100), 5.86 (90), 6.34 (60), 2.53 (50), 2.17 (50), 3.16 (40), 3.07 (40)

Chemistry:

	(1)	(2)	(3)
CO_2	36.3	28.93	36.25
SiO_2		5.01	
Fe_2O_3	0.2	0.21	
MgO	38.3	38.38	41.49
CaO	< 0.2	0.12	
H_2O^+		20.90	
H_2O^-		6.39	
H_2O	22.7		22.26
insol.	2.0		
Total	99.5	99.94	100.00

(1) Dypingdal, Norway; total Fe by spectrophotometry, here given as Fe_2O_3, Mg by EDTA, Ca by AA, $(OH)^{1-}$, H_2O, and $(CO_3)^{2-}$ confirmed by IR; corresponds to $Mg_{4.60}(CO_3)_{4.00}(OH)_{1.20} \cdot 4.92H_2O$. (2) Yoshikawa, Japan; after deduction of SiO_2 due to chrysotile impurity, corresponds to $Mg_{5.09}(CO_3)_{4.04}(OH)_{2.10} \cdot 7.76H_2O$. (3) $Mg_5(CO_3)_4(OH)_2 \cdot 5H_2O$.

Occurrence: Coats fractures and exposed surfaces in serpentine; may be of recent formation on dump materials.

Association: Hydrotalcite, magnesite (Norway); brucite, brugnatellite, pyroaurite, artinite, hydromagnesite, nesquehonite (Yoshikawa, Japan).

Distribution: From Dypingdal, near Snarum, Modum, Norway. At Hagdale, Unst, Shetland Islands, Scotland. From Kraubath, Styria, Austria. In Japan, at Yoshikawa, Aichi Prefecture; Mashiki, Kumamoto Prefecture; and Naradani, Gifu Prefecture. In the Vestford Hills, east Antarctica. From the Rapid Creek–Big Fish River area, Yukon Territory, Canada. In the USA, at Sterling Hill, Ogdensburg, Sussex Co., New Jersey; from Robinson Gulch, Jefferson Co., Colorado; found at the Akers prospect, about six km south of Idria, San Benito Co., California.

Name: For the first-noted occurrence at Dypingdal, Norway.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway, 21886, 21887.

References: (1) Raade, G. (1970) Dypingite, a new hydrous basic carbonate of magnesium, from Norway. Amer. Mineral., 55, 1457–1465. (2) Dunn, P.J. (1979) Contributions to the mineralogy of Franklin and Sterling Hill, New Jersey. Mineral. Record, 10, 160–165. (3) Suzuki, J. and M. Ito (1973) A new magnesium carbonate hydrate mineral, $Mg_5(CO_3)_4(OH)_2 \cdot 8H_2O$, from Yoshikawa, Aichi Prefecture, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol. 68, 353–361.

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Dyscrasite Ag_3Sb

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Pyramidal crystals, to 5 cm, also cylindrical, prismatic to platy, striated; granular, foliated or massive. *Twinning:* On {110}, giving pseudohexagonal forms and V-shapes.

Physical Properties: *Cleavage:* Distinct on {001} and {011}; imperfect on {110}. *Fracture:* Uneven. *Tenacity:* Sectile, but brittle. Hardness = 3.5–4 VHN = 153–179 (100 g load). D(meas.) = 9.712 D(calc.) = 9.720

Optical Properties: Opaque. *Color:* Silver-white, tarnishing to lead-gray, pale yellow, or black. *Streak:* Silver-white. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Weak. R_1–R_2: (400) 57.0–57.7, (420) 57.7–59.0, (440) 58.3–60.1, (460) 59.1–61.2, (480) 59.6–61.7, (500) 59.9–62.1, (520) 60.0–62.4, (540) 60.1–62.7, (560) 60.0–62.9, (580) 59.8–63.0, (600) 59.6–63.0, (620) 59.5–63.0, (640) 59.4–63.1, (660) 59.3–63.0, (680) 59.3–63.1, (700) 59.6–63.4

Cell Data: *Space Group:* $Pmm2$. $a = 3.008$ $b = 4.828$ $c = 5.214$ $Z = 1$

X-ray Powder Pattern: St. Andreasberg, Germany.
2.29 (100), 2.42 (40), 1.370 (40), 2.61 (30), 1.771 (30), 1.506 (30), 1.278 (30)

Chemistry:

	(1)	(2)	(3)
Ag	75.41	73.1	72.66
Sb	24.37	26.1	27.34
Total	99.78	99.2	100.00

(1) St. Andreasberg, Germany; average of seven analyses. (2) Do.; by electron microprobe. (3) Ag_3Sb.

Occurrence: In hydrothermal veins with other silver minerals as both a primary and secondary mineral.

Association: Silver, pyrargyrite, acanthite, stromeyerite, tetrahedrite, allemontite, galena, calcite, barite.

Distribution: In Germany, in the Black Forest, from Wenzelgang, near Wolfach [TL] and Wittichen; at St. Andreasberg, Harz Mountains. In France, from Wasserfall, about 20 km northwest of Belfort, Haute-Saône; and at Sainte-Marie-aux-Mines, Haut-Rhin. From Hiendelaencina, Guadalajara Province, Spain. At Příbram, Czech Republic. From Långsjön, Sweden. At Kongsberg and Sulitjelma, Norway. Large masses in the Consols mine, Broken Hill, New South Wales, Australia. From Chañarcillo, south of Copiapó, Atacama, Chile. At Colquechaca, Bolivia. From the Highbridge mine, Belmont district, Nye Co., Nevada, USA. In Canada, at Cobalt, Ontario, in a number of mines; and in the Tanco pegmatite, Bernic Lake, Manitoba. From the Ilímaussaq intrusion, southern Greenland. In the Yuzhnyi tin deposit, Tetukhe region, southern Maritime Territory, Russia. From the Aktepe Ag–As deposits, near Tashkent, Uzbekistan. At the Shkol'noe deposit, Kurama Ridge, Tadjikistan. From the Rampura Agucha Zn–Pb–Ag deposit, Rajasthan, India.

Name: From the Greek for *a bad alloy*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 173–175. (2) Scott, J.D. (1976) Refinement of the crystal structure of dyscrasite, and its implications for the structure of allargentum. Can. Mineral., 14, 139–142. (3) Cipriani, C., M. Corazza, and G. Mazzetti (1996) Reinvestigation of natural silver antimonides. Eur. J. Mineral., 8, 1347–1350. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 32. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 149.

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Dzhalindite $In(OH)_3$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Massive.

Physical Properties: Hardness = n.d. D(meas.) = 4.38 (synthetic). D(calc.) = 4.344

Optical Properties: Semitransparent. *Color:* Yellow-brown; light yellow in transmitted light; dark gray in reflected light.
Optical Class: Isotropic. $n = 1.725(2)$

Cell Data: *Space Group:* $Im3$ (synthetic). $a = 7.9743(6)$ $Z = 8$

X-ray Powder Pattern: Dzhalinda deposit, Russia.
3.96 (10), 2.80 (9), 1.778 (9), 1.624 (7), 2.290 (6), 1.324 (6), 4.36 (5)

Chemistry:

	(1)	(2)	(3)
In	63.06	61.59	69.24
Sn		7.36	
Fe	5.06	1.74	
Zn		1.65	
O			14.47
S	0.21		
H_2O			16.29
Total			100.00

(1) Dzhalinda deposit, Russia; by electron microprobe, average of 67 analyses. (2) Mount Pleasant, Canada; by electron microprobe, average of three analyses. (3) $In(OH)_3$.

Occurrence: Probably of secondary origin from its occurrence along fractures through primary hydrothermal minerals associated with brecciated felsic volcanic rocks (Dzhalinda deposit, Russia); in sulfides hosted in greisenized granite (Mangabeira, Brazil).

Association: Indite, cassiterite, quartz (Dzhalinda deposit, Russia); sphalerite, galena, chalcopyrite, stannite, calcite, quartz (Mount Pleasant, Canada); roquesite, sphalerite, chalcopyrite, digenite, arsenopyrite, cassiterite, scorodite (Mangabeira, Brazil).

Distribution: In the Dzhalinda tin deposit, Little Khingan Ridge, Far Eastern Region, Russia. From Mount Pleasant, New Brunswick, Canada. In the USA, at the Flambeau mine, southwest of Ladysmith, Rusk Co., Wisconsin. Found in the Mangabeira tin deposit, Goiás, Brazil.

Name: For the occurrence in the Dzhalinda tin deposit, Russia.

Type Material: Mining Institute, St. Petersburg, 106a/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 65279.

References: (1) Genkin, A.D. and I.V. Murav'eva (1963) Indite and dzhalindite – new indium minerals. Zap. Vses. Mineral. Obshch., 92, 445–457 (in Russian). (2) (1964) Amer. Mineral., 49, 439–440 (abs. ref. 1). (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 588–589. (4) Sutherland, J.K. (1971) A second occurrence of dzhalindite. Can. Mineral., 10, 781–786. (5) Mullica, D.F., G.W. Beall, and W.O. Milligan (1979) The crystal structure of cubic $In(OH)_3$ by X-ray and neutron diffraction methods. J. Inorg. Nucl. Chem., 41, 277–282.

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Dzharkenite $FeSe_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As octahedral crystals, may be modified by the dodecahedron, to 0.5 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d.
VHN = 253–388, 338 average (20 g load). D(meas.) = n.d. D(calc.) = 7.349

Optical Properties: Opaque. *Color:* Black; pale orange in reflected light. *Streak:* Black.
Luster: Metallic to adamantine.
Optical Class: Isotropic.
R: (400) — , (420) — , (440) 44.6, (460) 43.1, (480) 41.7, (500) 40.8, (520) 41.3, (540) 42.6, (560) 43.8, (580) 45.1, (600) 46.4, (620) 47.7, (640) 49.0, (660) 50.2, (680) 51.5, (700) 52.8

Cell Data: *Space Group:* $Pa3$. a = 5.783(4) Z = 4

X-ray Powder Pattern: Seluchekinskoye deposit, Kazakhstan.
2.588 (100), 2.364 (80), 1.546 (60), 2.888 (50), 1.743 (50), 2.045 (40), 1.1131 (40)

Chemistry:

	(1)	(2)
Fe	26.70	26.13
Cu	0.45	
Co	0.01	
Se	73.32	73.87
Total	100.07	100.00

(1) Seluchekinskoye deposit, Kazakhstan; by electron microprobe, average of six analyses; corresponds to $Fe_{1.02}Se_{1.94}$. (2) $FeSe_2$.

Polymorphism & Series: Dimorphous with ferroselite.

Mineral Group: Pyrite group.

Occurrence: In Se–U ores in quartz-sandstone (Seluchekinskoye deposit, Kazakhstan); in a massive sulfide deposit (Zapadno-Ozernoe deposit, Russia).

Association: Ferroselite, goethite (Seluchekinskoye deposit, Kazakhstan); pyrite, galena, tetrahedrite, metacinnabar, tiemannite, sulfur, gold, selenium (Zapadno-Ozernoe deposit, Russia).

Distribution: From the Seluchekinskoye deposit, near the middle Ili River, southeastern Kazakhstan [TL]. At the Zapadno-Ozernoe Cu–Zn deposit, Southern Ural Mountains, Russia.

Name: For the Dzharkenskaya depression, within which the Seluchekinskoye deposit occurs.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84060.

References: (1) Yashunsky, Y.V., E.G. Ryabeva, M.A. Abranov, and S.D. Rasulova (1995) Dzharkenite $FeSe_2$ – a new mineral. Zap. Vses. Mineral. Obshch., 124(1), 85–90 (in Russian with English abs.). (2) (1996) Amer. Mineral., 81, 1013 (abs. ref. 1). (3) Yakovleva, V.A., E.V. Belogub, and K.A. Novoselov (2003) Supergene iron sulpho-selenides from the Zapadno-Ozernoe copper-zinc massive sulphide deposit, South Urals, Russia: a new solid-solution series between pyrite FeS_2 and dzharkenite $FeSe_2$. Mineral. Mag., 67, 355–361. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 77–78.

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D'ansite-(Fe) $Na_{21}Fe^{2+}(SO_4)_{10}Cl_3$

Crystal Data: Isometric. *Point Group*: $\bar{4}$ 3*m*. As equant crystals dominated by {211}, {110} and {310} to 0.2 mm.

Physical Properties: *Cleavage*: None. *Tenacity*: Brittle. *Fracture*: n.d. Hardness = n.d. D(meas.) = 2.62(1) D(calc.) = 2.644

Optical Properties: Transparent. *Color*: Colorless to white. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Isotropic. n = 1.51(1)

Cell Data: *Space Group*: $I\bar{4}$ 3*d*. a = 15.882(3) Z = 4

X-ray Powder Pattern: La Fossa crater, Vulcano, Aeolian Islands, Italy.
2.807 (100), 2.570 (37), 1.714 (29), 3.384 (27), 3.113 (26), 2.161 (15), 2.018 (15)

Chemistry:

	(1)
Na_2O	39.12
FeO	4.18
MgO	0.12
SO_3	49.91
Cl	6.81
–O=Cl	1.54
Total	98.60

(1) La Fossa crater, Vulcano, Italy; average of 8 electron microprobe analyses; corresponding to $Na_{20.42}(Fe^{2+}_{0.94}Mg_{0.05})_{\Sigma=0.99}S_{10.08}O_{39.89}Cl_{3.11}$.

Polymorphism & Series: Forms a series with delrioite; dimorphous with rossite.

Occurrence: As encrustations on pyroclastic breccia in volcanic fumaroles; also reported as a secondary mineral (Solvenia).

Association: Sassolite, adranosite (Italy); metasideronatrite-*2M* (Slovenia).

Distribution: From La Fossa crater, Vulcano, Aeolian Islands, Italy; also from Mežica, Republic of Slovenia.

Name: As the iron (Fe)-dominant analog of d'ansite.

Type Material: Department of Chemistry, University of Milan, Italy (# 2011-02).

References: (1) Demartin, F., I. Campostrini, C. Castellano, C.M. Gramaccioli, and M. Russo (2012) D'ansite-(Mn), $Na_{21}Mn^{2+}(SO_4)_{10}Cl_3$ and d'ansite-(Fe), $Na_{21}Fe^{2+}(SO_4)_{10}Cl_3$, two new minerals from volcanic fumaroles. Mineral. Mag., 76(7), 2773-2783. (2) (2014) Amer. Mineral., 99, 2438-2439 (abs. ref. 1).

D'ansite-(Mn) $Na_{21}Mn^{2+}(SO_4)_{10}Cl_3$

Crystal Data: Isometric. *Point Group*: $\bar{4}$ 3*m*. As well-formed tristetrahedral crystals to 0.2 mm.

Physical Properties: *Cleavage*: None. *Tenacity*: Brittle. *Fracture*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.610

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Isotropic. *n* = 1.50(1)

Cell Data: *Space Group*: $I\bar{4}$ 3*d*. *a* = 15.9291(9) Z = 4

X-ray Powder Pattern: Calculated pattern.
2.816 (100), 3.396 (95), 3.124 (45), 2.584 (38), 3.982 (35), 4.257 (30), 2.519 (25)

Chemistry:

	(1)
Na_2O	39.37
MnO	3.46
MgO	0.13
SO_3	49.99
Cl	6.36
–O=Cl	1.14
Total	97.87

(1) Mt. Vesuvius, Naples, Italy; average of 6 electron microprobe analyses; corresponding to $Na_{20.61}(Mn^{2+}_{0.79}Mg_{0.05})_{\Sigma=0.84}S_{10.13}O_{40.09}Cl_{2.91}$.

Polymorphism & Series: Forms a series with delrioite; dimorphous with rossite.

Occurrence: As encrustations on pyroclastic breccia in volcanic fumaroles.

Association: Halite, aphthitalite.

Distribution: From Mt. Vesuvius, Naples, Italy.

Name: As the manganese (Mn)-dominant analog of d'ansite.

Type Material: Mineral collections of the Vesuvius Observatory, Naples, Italy (OV128).

References: (1) Demartin, F., I. Campostrini, C. Castellano, C.M. Gramaccioli, and M. Russo (2012) D'ansite-(Mn), $Na_{21}Mn^{2+}(SO_4)_{10}Cl_3$ and d'ansite-(Fe), $Na_{21}Fe^{2+}(SO_4)_{10}Cl_3$, two new minerals from volcanic fumaroles. Mineral. Mag., 76(7), 2773-2783. (2) (2014) Amer. Mineral., 99, 2438-2439 (abs. ref. 1).

Eakerite $Ca_2Sn^{4+}Al_2Si_6O_{18}(OH)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, up to 5 mm, prism zone striated ‖ [001]. Forms are {111}, {210}, {410}, {201}, {$\bar{2}$01}, {001}, and {100}. As minute lathlike inclusions along {110} in andradite.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5.5 D(meas.) = 2.93(1) D(calc.) = 2.931

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = 23.5°$ *Dispersion:* $r > v$, marked. $\alpha = 1.584$ $\beta = 1.586$ $\gamma = 1.600$ 2V(meas.) = ∼35°

Cell Data: *Space Group:* $P2_1/a$. $a = 15.829(7)$ $b = 7.721(3)$ $c = 7.438(3)$ $\beta = 101°34(3)'$ Z = 2

X-ray Powder Pattern: Kings Mountain, North Carolina, USA.
4.812 (100), 5.257 (90), 7.31 (80), 3.021 (80), 3.353 (60), 6.905 (50), 5.944 (50)

Chemistry:

	(1)
SiO_2	46.75
SnO_2	18.59
Al_2O_3	14.07
CaO	14.2
H_2O	6.7
Total	100.3

(1) Kings Mountain, North Carolina, USA; by microchemical analysis, corresponds to $Ca_{1.96}Sn^{4+}_{0.95}Al_{2.12}Si_{6.03}H_{5.77}O_{22}$.

Occurrence: Probably of hydrothermal origin, in a seam in spodumene-bearing pegmatite (Foote mine, North Carolina, USA); as exsolved inclusions in stanniferous andradite (Kitel'skoye deposit, Karelia).

Association: Tetrawickmanite, bavenite, quartz, albite (Foote mine, North Carolina, USA); andradite (Kitel'skoye deposit, Karelia).

Distribution: In the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA. From the Kitel'skoye tin skarn deposit, north of Lake Lagoda, Karelia.

Name: In honor of Jack Eaker, mineral collector of Kings Mountain, North Carolina, USA, who discovered the mineral.

Type Material: The Natural History Museum, London, England, 1968,204; National Museum of Natural History, Washington, D.C., USA, 120301, 121143.

References: (1) Leavens, P.B., J.S. White, Jr., and M.H. Hey (1970) Eakerite, a new tin silicate. Mineral. Record, 1, 92–96. (2) (1971) Amer. Mineral., 56, 637–638 (abs. ref. 1). (3) Kossiakoff, A.A. and P.B. Leavens (1976) The crystal structure of eakerite, a calcium-tin silicate. Amer. Mineral., 61, 956–962. (4) Gaydukova, V.S., I.M. Grigor'yev, V.T. Dubinchuk, A.M. Il'yasov, V.I. Kuz'min, and G.A. Sidorenko. (1982) Exsolution of stanniferous garnets. Doklady Acad. Nauk SSSR, 250, 151–153 (in Russian). (5) (1983) Mineral. Abs., 34, 164 (abs. ref. 4).

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Earlandite $Ca_3(C_6H_5O_7)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic (synthetic). *Point Group:* n.d. As warty fine-grained nodules, to ~1.5 mm.

Physical Properties: Hardness = n.d. D(meas.) = 1.80–1.95 D(calc.) = 1.96

Optical Properties: Semitransparent. *Color:* White to pale yellow.
Optical Class: Biaxial (+). $\alpha = 1.515$ $\beta = 1.530$ $\gamma = 1.580$ 2V(meas.) = 60°

Cell Data: *Space Group:* n.d. $a = 30.94$ $b = 5.93$ $c = 10.56$ $\beta = 93°44'$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 28-2003).
15.5 (100), 7.7 (50), 5.2 (35), 3.09 (6), 8.5 (4), 6.4 (4), 4.74 (4)

Chemistry:

	(1)	(2)
CaO	28.63	29.49
H	3.48	3.18
C	24.01	25.26
O	[43.88]	42.07
Total	100.00	100.00

(1) Weddell Sea, Antarctica; identity of natural and synthetic material proved by X-ray diffraction. (2) $Ca_3(C_6H_5O_7)_2 \cdot 4H_2O$.

Occurrence: In unconsolidated ocean floor sediment at 2580 m depth.

Association: Quartz.

Distribution: From the Weddell Sea, near Antarctica.

Name: Honors Arthur Earland (1866–1958), English oceanographer.

Type Material: The Natural History Museum, London, England, 1936,978–1936,979; Harvard University, Cambridge, Massachusetts, 134573; National Museum of Natural History, Washington, D.C., USA, 105859, 162618.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1105–1106. (2) Pogainis, E.M. and E.H. Shaw (1957) The unit cell dimensions of tricalcium citrate tetrahydrate. Proc. South Dakota Acad. Sci., 36, 56–59.

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Earlshannonite $(Mn^{2+},Fe^{2+})Fe_2^{3+}(PO_4)_2(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to 1 mm, prismatic, elongated along [001], showing {110}, {100}, {011}, commonly in parallel growth along [001], and in hemispherical radiating clusters. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Two, poor. *Fracture:* Even. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.90(4) D(calc.) = 2.92

Optical Properties: Transparent. *Color:* Dark reddish brown, yellowish brown, yellow-orange, bright yellow. *Streak:* Pale brown. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Moderate; $X = Y$ = pale yellow-brown; Z = yellow-brown. *Orientation:* $Z = c$. *Absorption:* $Z > X \simeq Y$. $\alpha = 1.696(4)$ $\beta = 1.745(4)$ $\gamma = 1.765(4)$ $2V(meas.) = 64(4)^\circ$

Cell Data: *Space Group:* $P2_1/c$. $a = 9.910(13)$ $b = 9.669(8)$ $c = 5.455(9)$ $\beta = 93.95(9)^\circ$ Z = 2

X-ray Powder Pattern: Foote mine, North Carolina, USA.
9.8 (100), 6.9 (80), 2.789 (70), 4.18 (60), 3.45 (60), 2.856 (60), 4.95 (40)

Chemistry:

	(1)	(2)
P_2O_5	30.0	31.0
Al_2O_3	0.1	0.3
Fe_2O_3	33.8	34.4
FeO	4.6	2.5
MnO	8.2	7.3
ZnO		0.3
MgO	0.8	2.3
CaO	0.6	
H_2O	[21.9]	[21.9]
Total	[100.0]	[100.0]

(1) Foote mine, North Carolina, USA; by electron microprobe, Fe confirmed as dominantly Fe^{3+} by microchemical tests and stoichiometry, H_2O by difference; corresponds to $(Mn^{2+}_{0.55}Fe^{2+}_{0.30}Mg_{0.09}Ca_{0.05})_{\Sigma=0.99}(Fe^{3+}_{2.00}Al_{0.01})_{\Sigma=2.01}(PO_4)_{2.00}(OH)_{2.01} \cdot 4.75H_2O$. (2) Hagendorf, Germany; by electron microprobe, corresponds to $(Mn^{2+}_{0.47}Mg_{0.26}Fe^{2+}_{0.16}Zn_{0.02})_{\Sigma=0.91}(Fe^{3+}_{1.97}Al_{0.03})_{\Sigma=2.00}(PO_4)_{2.00}(OH)_{1.82} \cdot 4.66H_2O$.

Mineral Group: Arthurite group.

Occurrence: A very late-stage secondary mineral in a lithium-rich granite pegmatite (Foote mine, North Carolina, USA).

Association: Jahnsite, laueite, mitridatite, rockbridgeite, manganese oxide, quartz (Foote mine, North Carolina, USA); rockbridgeite–frondelite (Hagendorf, Germany).

Distribution: In the USA, from the Foote mine, Kings Mountain, Cleveland Co., and at the LCA pegmatite, Bessemer City, Gaston Co., North Carolina; in Maine, in the Emmons quarry, Greenwood, and at the Dunton quarry, Newry, Oxford Co. From Hagendorf, Bavaria, Germany. At Dolní Bori, near Velké Meziříčí, Czech Republic.

Name: To honor Earl V. Shannon (1895–1981), American mineralogist and chemist, U.S. National Museum, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150168, R12832.

References: (1) Peacor, D.R., P.J. Dunn, and W.B. Simmons (1984) Earlshannonite, the Mn analogue of whitmoreite, from North Carolina. Can. Mineral., 22, 471–474. (2) (1985) Amer. Mineral., 70, 871–872 (abs. ref. 1).

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Ecandrewsite $(Zn, Fe^{2+}, Mn^{2+})TiO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As tabular crystals and grains, to 250 μm.

Physical Properties: Hardness = n.d. VHN = 500–600 (100 g load). D(meas.) = n.d. D(calc.) = 4.98–4.99

Optical Properties: Opaque to translucent. *Color:* Dark brown to black; deep orange-brown in transmitted light; grayish white with a pinkish tint in reflected light. *Streak:* Dark brown to black. *Luster:* Submetallic.
Optical Class: Uniaxial (+). *Pleochroism:* Weak. *Anisotropism:* Strong; greenish gray to dark brownish gray.
R_1–R_2: (470) 17.2–19.9, (546) 17.2–19.7, (589) 17.0–19.6, (650) 16.8–19.2

Cell Data: *Space Group:* $R\overline{3}$. $a = 5.090(1)$ $c = 14.036(2)$ Z = 6

X-ray Powder Pattern: San Valentin mine, Spain.
2.73 (10), 2.53 (9), 1.71 (7), 2.23 (6), 1.87 (4), 3.69 (2), 1.502 (2)

Chemistry:

	(1)	(2)
TiO_2	50.12	52.45
FeO	11.37	12.05
MnO	7.64	6.15
ZnO	30.42	29.35
Total	99.55	100.00

(1) Melbourne Rockwell mine, Australia; by electron microprobe, total Fe as FeO; corresponds to $(Zn_{0.59}Fe_{0.24}Mn_{0.17})_{\Sigma=1.00}Ti_{0.99}O_3$. (2) San Valentin mine, Spain; by electron microprobe, total Fe as FeO; corresponds to $(Zn_{0.56}Fe_{0.26}Mn_{0.13})_{\Sigma=0.95}Ti_{1.02}O_3$.

Polymorphism & Series: Forms a series with ilmenite.

Mineral Group: Ilmenite group.

Occurrence: In quartz-rich metasediments of the amphibolite-granulite facies (Melbourne Rockwell mine, Australia); in a kyanite-bearing pelitic schist (Death Valley, California, USA).

Association: Almandine-spessartine, ferroan gahnite, rutile (Melbourne Rockwell mine, Australia); zincian ilmenite (San Valentin mine, Spain); almandine, kyanite, zincian ilmenite, monazite, muscovite, quartz, chlorite, zircon, titanite (Death Valley, California, USA).

Distribution: From the Melbourne Rockwell mine, Little Broken Hill, and the North mine, Broken Hill, New South Wales, Australia. In Spain, at the San Valentin mine, La Unión district, Sierra de Cartegena, Murcia Province. In the Black Mountains, Death Valley, Inyo Co., California, USA. From Fuzhou, Fujian Province, China.

Name: Honors Ernest Clayton Andrews (1870–1948), New South Wales government geologist, who mapped the Broken Hill region.

Type Material: Museum Victoria, Melbourne, Australia, M35700; Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands.

References: (1) Birch, W.D., E.A.J. Burke, V.J. Wall, and M.A. Etheridge (1988) Ecandrewsite, the zinc analogue of ilmenite, from Little Broken Hill, New South Wales, Australia, and the San Valentin Mine, Sierra de Cartegena, Spain. Mineral. Mag., 52, 237–240. (2) (1989) Amer. Mineral., 74, 501 (abs. ref. 1). (3) Whitney, D.L., M. Hirschmann, and M.G. Miller (1993) Zincian ilmenite-ecandrewsite from a pelitic schist, Death Valley, California, and the paragenesis of $(Zn, Fe)TiO_3$ solid solution in metamorphic rocks. Can. Mineral., 31, 425–436.

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Ecdemite $Pb_6As_2^{3+}O_7Cl_4$

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Crystal Data: Tetragonal. *Point Group:* n.d. As small tabular crystals, and in foliated masses.

Physical Properties: *Cleavage:* {001}, distinct. Hardness = 2.5–3 D(meas.) = 7.14 D(calc.) = [7.30]

Optical Properties: Translucent. *Color:* Greenish yellow to yellow. *Luster:* Vitreous on cleavages, greasy on fractures.
Optical Class: Uniaxial (–); biaxial in part, probably due to intergrown heliophyllite.
$\omega = 2.32(2)$ (Li) $\epsilon = 2.25(2)$

Cell Data: *Space Group:* n.d. $a = 10.82$ $c = 25.60$ Z = 8

X-ray Powder Pattern: Långban, Sweden.
2.85 (100), 3.66 (80), 2.72 (80), 2.07 (70), 1.591 (70), 1.92 (60), 1.652 (50)

Chemistry:

	(1)	(2)
As_2O_3	10.60	12.01
PbO	83.45	81.32
Cl	8.00	8.61
$-O = Cl_2$	1.81	1.94
Total	100.24	100.00

(1) Långban, Sweden. (2) $Pb_6As_2O_7Cl_4$.

Occurrence: A rare mineral in metamorphosed Fe–Mn orebodies (Sweden).

Association: Heliophyllite, finnemanite, freedite, lead, copper, manganoan calcite, andradite, magnetite (Långban, Sweden).

Distribution: In Sweden, from Långban, in the Harstigen mine, near Persberg, and at Jakobsberg, Värmland. From Laurium, Greece, in slag.

Name: From the Greek for *unusual*, in allusion to the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1036–1037. (2) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Eckermannite $NaNa_2[(Mg,Fe^{2+})_4Al]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As elongated prismatic crystals. Also as fibrous aggregates, to 5 cm. *Twinning:* Simple or multiple twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; parting on {010}. *Fracture:* [Uneven.] *Tenacity:* [Brittle.] Hardness = 5–6 D(meas.) = 3.0–3.3 D(calc.) = [3.14]

Optical Properties: Translucent to opaque. *Color:* Black, dark green, bluish green; pale bluish green in thin section. *Luster:* [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = bluish green, yellow, indigo; Y = light bluish green, yellow-brown, gray-violet; Z = pale green, deep green, pale brownish green, colorless. *Orientation:* $Y = b$; $X \wedge c = 30°–50°$; $Z \wedge a = 45°–70°$. *Dispersion:* $r > v$, strong. *Absorption:* $X > Y > Z$. α = 1.610–1.640 β = 1.625–1.650 γ = 1.630–1.655 2V(meas.) = 15°–80°

Cell Data: *Space Group:* $C2/m$. $a = 9.799$ $b = 17.833$ $c = 5.273$ $\beta = 104.18°$ Z = 2

X-ray Powder Pattern: Synthetic $Na_3Mg_4AlSi_8O_{22}(OH)_2$ (ICDD 20-386).
3.10 (100), 2.708 (80), 3.40 (70), 3.25 (70), 2.500 (60), 2.965 (50), 2.164 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	58.65	57.10	CaO	1.40	0.31
TiO_2		0.35	Li_2O		1.15
Al_2O_3	5.98	6.19	Na_2O	9.30	9.77
Fe_2O_3	2.37	8.01	K_2O	1.10	2.38
FeO	1.34	2.69	F		2.69
MnO		0.34	H_2O^+	2.20	0.50
ZnO		0.59	H_2O^-		0.08
MgO	18.56	9.13	$-O = F_2$		1.13
			Total	100.90	100.15

(1) Tawmaw, Myanmar; corresponds to $(Na_{2.43}Ca_{0.20}K_{0.19})_{\Sigma=2.82}(Mg_{3.73}Al_{0.86}Fe^{3+}_{0.24}Fe^{2+}_{0.15})_{\Sigma=4.98}(Si_{7.91}Al_{0.09})_{\Sigma=8.00}O_{22}(OH)_{1.98}$. (2) Norra Kärr complex, Sweden; corresponds to $(Na_{2.66}K_{0.42}Ca_{0.05})_{\Sigma=3.13}(Mg_{1.91}Fe^{3+}_{0.85}Li_{0.65}Fe^{2+}_{0.32}Zn_{0.06}Mn_{0.04}Ti_{0.04})_{\Sigma=3.87}Al_{1.02}Si_{8.02}O_{22}[F_{1.19}(OH)_{0.47}]_{\Sigma=1.66}$.

Polymorphism & Series: Forms a series with ferro-eckermannite.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) < 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) < 0.5$; $(Na + K)_A \geq 0.5$; $Na_B \geq 1.34$.

Occurrence: In alkalic plutonic igneous rocks; rarely in alkalic volcanics and nepheline-bearing pegmatites.

Association: Nepheline, albite, aegirine, katophorite.

Distribution: From the Norra Kärr complex, near Gränna, Sweden. At Tawmaw, Myitkyina-Mogaung district, Kachin State, northern Myanmar (Burma). In the Noda-Tamagawa mine, Iwate Prefecture, Japan. In the Snowy Range mine, Camp Albion, Boulder Co., Colorado, USA.

Name: To honor Professor Claes Walther Harry von Eckermann (1886–1969), Swedish petrologist, Stockholm, Sweden.

Type Material: The Natural History Museum, London, England, 1949,151.

References: (1) Adamson, O.J. (1942) Eckermannite, a new alkali amphibole. Preliminary note. Geol. Fören. Förhandl. Stockholm, 64, 329–334. (2) (1944) Amer. Mineral., 29, 455 (abs. ref. 1). (3) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 364–374. (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 243–245.

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Eclarite $Pb_9(Cu,Fe)Bi_{12}S_{28}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As fan-shaped aggregates of acicular crystals, to 1.5 cm long, and granular.

Physical Properties: *Cleavage:* Distinct on {010}, poor on {0*kl*}. Hardness = 2.5 VHN = Markedly anisotropic from 87 (transverse) to 191 (longitudinal) (50 g load). D(meas.) = 6.85 D(calc.) = 6.88

Optical Properties: Opaque. *Color:* Tin-white; in reflected light, whitish gray, bluish gray in oil. *Luster:* Metallic. *Pleochroism:* Moderate to distinct. *Anisotropism:* Distinct in air, strong in oil.
R_1–R_2: (480) 45.2–51.2, (546) 42.9–47.2, (589) 42.0–46.1, (644) 40.2–45.0

Cell Data: *Space Group: Pnma.* $a = 54.76(4)$ $b = 4.030(3)$ $c = 22.75(3)$ $Z = 4$

X-ray Powder Pattern: Bärenbad, Austria.
3.414 (100), 2.014 (80), 2.893 (70), 3.010 (60), 2.141 (50), 2.037 (45), 3.488 (40)

Chemistry:

	(1)
Pb	34.3
Cu	0.9
Fe	0.6
Ag	0.3
Bi	45.8
Sb	1.5
S	17.3
Total	100.7

(1) Bärenbad, Austria; by electron microprobe, average of 16 analyses of two crystals; corresponds to $Pb_{8.61}(Cu_{0.73}Fe_{0.57}Ag_{0.16})_{\Sigma=9.50}(Bi_{11.36}Sb_{0.62})_{\Sigma=11.98}S_{28.00}$.

Occurrence: In gold-bearing sulfide ores of copper located in quartz veins cutting amphibolite facies metamorphosed mafic rocks (Bärenbad, Austria).

Association: Pyrite, arsenopyrite, chalcopyrite, pyrrhotite, sphalerite, stannite, bismuth, gold, quartz (Bärenbad, Austria).

Distribution: From Bärenbad, west of Hollersbachtal, Salzburg, Austria. At Gordon Camp and the Abril mine, Middle Pass district, Cochise Co., Arizona, USA.

Name: To honor Professor Eberhard Clar (1904–), Austrian mineralogist, University of Vienna, Vienna, Austria.

Type Material: Institute for Geosciences (Mineralogy), University of Salzburg, Salzburg, Austria; Mineralogical-Crystallographical Institute, University of Göttingen, Göttingen, Germany; The Natural History Museum, London, England, 1982,573; Royal Ontario Museum, Toronto, Canada; National Museum of Natural History, Washington, D.C., USA, 150482.

References: (1) Paar, W.H., T.T. Chen, V. Kupcik, and K. Hanke (1984) Eclarite, $(Cu,Fe)Pb_9Bi_{12}S_{28}$, ein neues Sulfosalt von Bärenbad, Hollersbachtal, Salzburg, Österreich. Tschermaks Mineral. Petrog. Mitt., 32, 103–110 (in German with English abs.). (2) (1985) Amer. Mineral., 70, 215 (abs. ref. 1). (3) Kupčík, V. (1984) Die Kristallstruktur des Minerals Eclarit $(Cu,Fe)Pb_9Bi_{12}S_{28}$. Tschermaks Mineral. Petrog. Mitt., 32, 259–269 (in German with English abs.). (4) Wulf, R. (1995) Experimental distinction of elements with similar atomic number in (Pb,Bi)-sulfosalts. Mineral. Petrol., 52, 187–196.

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Edenharterite $PbTlAs_3S_6$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are lathlike, slightly elongated along [001], to 0.2 mm, in subparallel aggregates.

Physical Properties: *Cleavage:* One, parallel to {001}. *Fracture:* Uneven. Hardness = 2.5–3 VHN = 95–101, 98 average (10 g load). D(meas.) = n.d. D(calc.) = 5.09

Optical Properties: Opaque to translucent. *Color:* Brown-black to black, dark red in thin fragments; in reflected light, grayish white with bluish tint, with bright red internal reflections. *Streak:* Raspberry-red.
Optical Class: Biaxial.
R_1–R_2: (480) 28.5–30.5, (546) 28.5–31.5, (589) 27.0–28.5, (656) 27.0–29.0

Cell Data: *Space Group:* $Fdd2$. $a = 15.4764(8)$ $b = 47.602(3)$ $c = 5.8489(4)$ $Z = 16$

X-ray Powder Pattern: Binntal, Switzerland.
3.801 (100), 2.767 (43), 2.732 (41), 3.389 (23), 2.656 (24), 2.901 (19), 3.755 (15)

Chemistry:

	(1)	(2)	(3)
Pb	25.08	23.44	25.01
Tl	25.51	24.71	24.66
Cu		< 0.04	
Sn	0.06	< 0.04	
As	27.09	27.03	27.12
Sb		1.32	
S	23.50	23.17	23.21
Total	100.91	[100.00]	100.00

(1) Binntal, Switzerland; by electron microprobe, average of three analyses; corresponds to $Pb_{1.00}Tl_{1.03}As_{2.99}S_{5.98}$. (2) Do.; by electron microprobe, original total given as 100.02%; corresponds to $Pb_{0.94}Tl_{1.00}(As_{2.98}Sb_{0.09})_{\Sigma=3.07}S_{6.06}$. (3) $PbTlAs_3S_6$.

Occurrence: In a hydrothermal deposit in dolostone.

Association: Baumhauerite, realgar, orpiment, hutchinsonite, hatchite, wallisite, lorandite, sartorite, jentschite, erniggliite, stalderite, bernardite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: Honors Dr. Andreas Edenharter (1933–), University of Göttingen, Göttingen, Germany, who had previously synthesized the compound.

Type Material: Natural History Museum, Basel, Switzerland, L 18,393.

References: (1) Graeser, S. (1988) Three new mineral species from the Binntal. Uni Nova, 49, 17–19 (in German). (2) Graeser, S. and H. Schwander (1992) Edenharterite ($TlPbAs_3S_6$): a new mineral from Lengenbach, Binntal (Switzerland). Eur. J. Mineral., 4, 1265–1270. (3) (1993) Amer. Mineral., 78, 845–846 (abs. refs. 1 and 2). (4) Berlepsch, P. (1995) Chemical and crystallographical investigations on edenharterite ($TlPbAs_3S_6$). Schweiz. Mineral. Petrogr. Mitt., 75, 277–281. (5) Berlepsch, P. (1996) Crystal structure and crystal chemistry of the homeotypes edenharterite ($TlPbAs_3S_6$) and jentschite ($TlPbAs_2SbS_6$) from Lengenbach, Binntal (Switzerland). Schweiz. Mineral. Petrogr. Mitt., 76, 147–157.

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Edenite $\mathbf{NaCa_2(Mg, Fe^{2+})_5(Si_7Al)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly as well-formed prismatic crystals, to 2.5 cm; fibrous; as reaction rims on pyroxenes. *Twinning:* Simple or multiple twinning $\parallel$ {100}.

Physical Properties: *Cleavage:* Good on {110}, intersecting at 56° and 124°; partings on {100}, {001}. *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.05–3.37 D(calc.) = 3.06

Optical Properties: Semitransparent. *Color:* White, gray, pale green; color zoning is commonly seen in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* [Distinct, in greens, blue-greens, and yellow-browns.] *Orientation:* $Y = b$; $Z \wedge c = 18°$–$34°$. *Dispersion:* $r > v$, weak. *Absorption:* $Z > Y > X$.
$\alpha = 1.622$–1.665 $\beta = 1.632$–1.678 $\gamma = 1.641$–1.684 2V(meas.) = 50°–82°

Cell Data: *Space Group:* $C2/m$. $a = 9.837(4)$ $b = 17.954(6)$ $c = 5.307(2)$ $\beta = 105.18(2)°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA. (ICDD 23-1405).
3.120 (100), 8.43 (80), 3.267 (40), 2.699 (20), 2.800 (18), 3.377 (12), 9.01 (10)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	50.91	50.55	Na_2O	3.40	2.35
TiO_2	0.08	0.51	K_2O	0.11	0.54
Al_2O_3	8.68	6.90	F		1.86
Fe_2O_3	1.61		H_2O^+	1.74	1.27
FeO	3.61	1.30	H_2O^-	0.17	
MnO	0.12	0.07	P_2O_5	0.05	
MgO	19.38	22.06	$-O = F_2$		0.78
CaO	10.25	13.30	Total	100.11	99.93

(1) Kotaki, Japan; corresponds to $(Na_{0.70}K_{0.02})_{\Sigma=0.72}(Ca_{1.54}Fe^{2+}_{0.22}Na_{0.22}Mn_{0.02})_{\Sigma=2.00}(Mg_{4.05}Al_{0.57}Fe^{2+}_{0.20}Fe^{3+}_{0.17}Ti_{0.01})_{\Sigma=5.00}(Si_{7.13}Al_{0.87})_{\Sigma=8.00}O_{22}(OH)_{1.63}$. (2) Franklin Marble, Orange Co., New York, USA; by electron microprobe, F by wet chemical analysis; corresponds to $(Na_{0.63}K_{0.10})_{\Sigma=0.73}(Ca_{1.99}Mn_{0.01})_{\Sigma=2.00}(Mg_{4.58}Al_{0.18}Fe^{2+}_{0.15}Ti_{0.05})_{\Sigma=4.96}(Si_{7.05}Al_{0.95})_{\Sigma=8.00}O_{22}[(OH)_{1.18}F_{0.82}]_{\Sigma=2.00}$.

Polymorphism & Series: Forms a series with ferro-edenite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.5$; $(Na + K)_A \geq 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; 6.75 Si 7.25.

Occurrence: In intermediate plutonic igneous and medium-grade metamorphic rocks, as amphibolites and marbles.

Association: Titanite, mica, chondrodite (Edenville, New York, USA).

Distribution: In the USA, perhaps from Edenville, Orange Co., New York, and Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey. At Tory Hill, near Bancroft, and at Wilberforce, Ontario, Canada. From Kotaki, Niigata Prefecture, Japan.

Name: For the locality at Edenville, New York, USA, although it is not certain to occur there.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 386, 391. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 263–314. (3) Kohn, J.A. and J.E. Comeforo (1955) Synthetic asbestos investigations, II: X-ray and other data on synthetic fluor-richterite, -edenite, and -boron edenite. Amer. Mineral., 40, 410–421. (4) Kearns, L.E., L.E. Kite, P.B. Leavens, and J.A. Nelen (1980) Fluorine distribution in the hydrous silicate minerals of the Franklin Marble, Orange County, New York. Amer. Mineral., 65, 557–562.

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Edgarbaileyite $Hg_6^{1+}Si_2O_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As sheaves of ill-formed platy crystals, with dominant {100}, to 200 μm. Also as cryptocrystalline nodular masses, which may be hollow. *Twinning:* Polysynthetic on {100}.

Physical Properties: *Fracture:* Irregular to subconchoidal. *Tenacity:* Brittle. Hardness = 4 VHN = 153–217, 192 average (100 g load). D(meas.) = 9.4(3) D(calc.) = 9.11 Photosensitive, darkening on exposure to UV, IR, X-rays, and visible light.

Optical Properties: Translucent. *Color:* Lemon-yellow to orange-yellow when fresh; dark olive-green, through lighter yellowish green, to dark green-brown on exposed surface; in reflected light, gray to slightly lighter gray, with pale lemon-yellow internal reflections; lemon-yellow in transmitted light. *Streak:* Pale yellowish green. *Luster:* Vitreous, resinous when nodular. *Optical Class:* Biaxial. *Pleochroism:* Weak. *Absorption:* Strong. α = [2.10] β = n.d. γ = [2.58] 2V(meas.) = n.d.
R: (400) 16.7, (420) 17.1, (440) 17.0, (460) 16.4, (480) 15.8, (500) 15.3, (520) 14.9, (540) 14.6, (560) 14.3, (580) 14.2, (600) 14.0, (620) 14.0, (640) 13.8, (660) 13.8, (680) 13.7, (700) 13.6

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 11.755(3)$ $b = 7.678(2)$ $c = 5.991(2)$ $\beta = 111.73(3)^\circ$ Z = 2

X-ray Powder Pattern: Terlingua, Texas, USA.
3.160 (100), 2.715 (63), 1.872 (36), 2.952 (34), 3.027 (27), 2.321 (24), 6.28 (20)

Chemistry:

	(1)	(2)	(3)
SiO_2	8.6	7.9	8.76
Hg_2O	89.6	91.0	91.24
Total	98.2	[98.9]	100.00

(1) Socrates mine, California, USA; by electron microprobe, average of five analyses.
(2) Terlingua, Texas, USA; by electron microprobe, average of three analyses, originally given as Si 3.7%, Hg 87.5%, here recalculated to oxides. (3) $Hg_6Si_2O_7$.

Occurrence: A secondary mineral, probably resulting from reaction between mercury and quartz under unknown conditions.

Association: Mercury, cinnabar, montroydite, terlinguaite, eglestonite, calcite, quartz, barite.

Distribution: In the Socrates mercury mine, Sonoma Co., and near the Clear Creek mercury mine, New Idria district, San Benito Co., California; at Terlingua, Brewster Co., Texas, USA. From the San Luis mine, Huahuaxtla, Guerrero, Mexico.

Name: For Dr. Edgar Herbert Bailey (1914–1983), distinguished geologist and mercury specialist with the U.S. Geological Survey.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 65531; The Natural History Museum, London, England, 1906,190.

References: (1) Roberts, A.C., M. Bonardi, R.C. Erd, A.J. Criddle, C.J. Stanley, G. Cressey, R.J. Angel, and J.H.G. Laflamme (1990) Edgarbaileyite, the first known silicate of mercury, from California and Texas. Mineral. Record, 21, 215–220. (2) (1990) Amer. Mineral., 75, 1431–1432 (abs. ref. 1). (3) Angel, R.J., G. Cressey, and A. Criddle (1990) Edgarbaileyite, $Hg_6Si_2O_7$: the crystal structure of the first mercury silicate. Amer. Mineral., 75, 1192–1196.

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Edgarite $FeNb_3S_6$

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Crystal Data: Hexagonal. *Point Group:* 622. Platy crystals, to 0.15 mm.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. VHN = 135 (5 g load); 205 (10 g load). D(meas.) = 4.98 (synthetic). D(calc.) = 4.99

Optical Properties: Opaque. *Color:* Dark gray. *Pleochroism:* Distinct; gray to pale gray with a bluish tint. *Anisotropism:* Strong; nearly white to dark brown. *Bireflectance:* Distinct. R_1–R_2: (400) 28.4–40.3, (420) 28.3–40.3, (440) 28.2–40.3, (460) 28.2–40.3, (480) 28.1–40.2, (500) 27.9–40.2, (520) 27.5–39.8, (540) 27.4–39.4, (560) 27.1–38.9, (580) 27.0–38.6, (600) 27.0–38.0, (620) 27.0–37.6, (640) 27.0–37.1, (660) 27.0–36.6, (680) 27.2–36.3, (700) 27.4–35.8

Cell Data: *Space Group:* $P6_322$ (by analogy to synthetic). $a = 5.771(1)$ $c = 12.190(6)$ $Z = 2$

X-ray Powder Pattern: Khibiny massif, Russia.
2.096 (10), 6.11 (8), 2.606 (8), 1.665 (8), 1.126 (7), 3.04 (6), 1.524 (6)

Chemistry:

	(1)	(2)
Nb	52.87	52.89
Fe	10.12	10.60
Mn	0.10	
Ti	0.04	
V	0.36	
S	35.86	36.51
Total	99.35	100.00

(1) Khibiny massif, Russia; by electron microprobe, average of four analyses; corresponding to $(Fe_{0.96}V_{0.04}Mn_{0.01})_{\Sigma=1.01}Nb_{3.03}S_{5.95}$. (2) $FeNb_3S_6$.

Occurrence: In a feldspar-rich fenitized xenolith in a differentiated alkalic massif.

Association: Ti-V-rich pyrrhotite, Ti-V-rich marcasite, alabandite, monazite-(Ce), phlogopite.

Distribution: From the Khibiny massif, Kola Peninsula, Russia [TL].

Name: In honor of Dr. Alan D. Edgar (1935–1998), Professor of Petrology, University of Western Ontario, London, Canada, for his work on alkaline rocks.

Type Material: Royal Ontario Museum, Toronto, Canada, M46177.

References: (1) Barkov, A.Y., R.F. Martin, Y.P. Men'shikov, Y.E. Savchenko, Y. Thibault, and K.V.O. Laajoki (2000) Edgarite, $FeNb_3S_6$, first natural niobium-rich sulfide from the Khibina alkaline complex, Russian Far North: evidence for chalcophile behavior of Nb in a fenite. Contr. Mineral. Petrol., 138, 229–236. (2) (2000) Amer. Mineral., 85, 1843 (abs. ref. 1). (3) Anzenhofer, K., J.M. van den Berge, P. Cossee, and J.N. Helle (1970) The crystal structure and magnetic susceptibilities of $MnNb_3S_6$, $FeNb_3S_6$, $CoNb_3S_6$ and $NiNb_3S_6$. J. Phys. Chem. Solids, 31, 1057–1067.

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Edingtonite $BaAl_2Si_3O_{10}\cdot 4H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* 222, $\bar{4}2m$ pseudotetragonal. Prismatic crystals exhibit pseudotetragonal pyramid or sphenoid forms, to 10 cm; also massive. *Twinning:* On {110} and about [001].

Physical Properties: *Cleavage:* {110}, perfect. Hardness = 4–4.5 D(meas.) = 2.73–2.78 D(calc.) = 2.75–2.80 Pyroelectric and piezoelectric.

Optical Properties: Transparent to translucent. *Color:* White, grayish, pink; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, strong.
$\alpha = 1.535–1.541$ $\beta = 1.542–1.553$ $\gamma = 1.545–1.557$ 2V(meas.) = 54°–62°

Cell Data: *Space Group:* $P2_12_12$; $P\bar{4}2_1m$ pseudotetragonal. $a = 9.550(10)$ $b = 9.665(10)$ $c = 6.523(5)$ Z = 2

X-ray Powder Pattern: Kilpatrick, Scotland. (ICDD 25-61).
3.576 (100), 6.51 (80), 2.741 (75), 5.38 (60), 4.79 (50), 4.69 (50), 2.589 (45)

Chemistry:

	(1)	(2)
SiO_2	35.14	36.3
Al_2O_3	20.12	20.6
BaO	31.18	28.6
K_2O		0.32
H_2O	13.16	12.8
Total	99.60	98.62

(1) Bölet mine, Sweden; corresponds to $Ba_{1.03}Al_{2.01}Si_{2.98}O_{10.00}\cdot 3.72H_2O$. (2) Ice River, Canada; by electron microprobe, H_2O by TGA; corresponds to $(Ba_{0.96}K_{0.04})_{\Sigma=1.00}$ $Al_{2.08}Si_{3.12}O_{10.00}\cdot 4.00H_2O$.

Mineral Group: Zeolite group.

Occurrence: In cavities in mafic igneous rocks and nepheline syenites; in carbonatites; in hydrothermal veins.

Association: Thomsonite, analcime, natrolite, harmotome, brewsterite, prehnite, calcite.

Distribution: At several quarries in the Kilpatrick Hills, Dumbartonshire, Scotland. From Disgwylfa Hill, Shropshire, England. Large crystals from the Bölet mine, Västergötland, Sweden. At Staré Ransko, Czech Republic. In the Podol'skoye and other deposits, Southern Ural Mountains, and in the Khibiny massif, Kola Peninsula, Russia. Along Ash Creek, in Mendocino Co. near the Sonoma Co. line, California, USA. In the Brunswick No. 12 mine, near Bathurst, New Brunswick; along the Ice River valley, 25 km south of Field, British Columbia; and at Mont Saint-Hilaire, Quebec, Canada. In the Jacupiranga mine, São Paulo, Brazil.

Name: For James Edington (1787–1844), mineral collector of Glasgow, Scotland, the discoverer of the mineral.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 599.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 358–376. (3) Van Reeuwijk, L.P. (1972) High-temperature phases of zeolites of the natrolite group. Amer. Mineral., 57, 499–510. (4) Galli, E. (1976) Crystal structure refinement of edingtonite, Acta Cryst., 32, 1623–1627. (5) Mazzi, F., E. Galli, and G. Gottardi (1984) Crystal structure refinement of two tetragonal edingtonites. Neues Jahrb. Mineral., Monatsh., 373–382. (6) (1985) Amer. Mineral., 70, 1333–1334 (abs. ref. 5). (7) Grice, J.D., R.A. Gault, and H.G. Ansell (1984) Edingtonite: the first two Canadian occurrences. Can. Mineral., 22, 253–258. (8) Belitsky, I.A., S.P. Gabuda, W. Joswig, and H. Fuess (1986) Study of the structure and dynamics of water in the zeolite edingtonite at low temperature by neutron diffraction and NMR-spectroscopy. Neues Jahrb. Mineral., Monatsh., 541–551.

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Edoylerite $Hg_3^{2+}Cr^{6+}O_4S_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular to prismatic crystals, elongated along [101], showing {010}, {$\bar{1}$11}, {001}, {101}, to 0.5 mm; typically in stellate aggregates.

Physical Properties: *Cleavage:* On {010}, good; on {101}, fair. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.11 Photosensitive, turning olive-green after several months exposure.

Optical Properties: Transparent to opaque. *Color:* Canary yellow to orangeish yellow; pale gray to bluish gray in reflected light with brilliant pale yellow internal reflections. *Streak:* Yellow. *Luster:* Adamantine.
Optical Class: Biaxial. *Pleochroism:* Weak; $X = Y$ = lemon-yellow; Z = darker lemon-yellow. *Orientation:* $Z = [101]$; positive elongation. *Absorption:* $Z > X = Y$. *Bireflectance:* Weak.
R_1–R_2: (400) 17.5–16.8, (420) 18.0–18.0, (440) 18.2–19.1, (460) 17.9–19.2, (480) 17.3–18.95, (500) 17.0–18.5, (520) 17.1–19.5, (540) 17.0–19.8, (560) 16.8–19.6, (580) 16.6–19.55, (600) 16.3–19.5, (620) 16.2–19.3, (640) 16.1–19.2, (660) 15.95–19.1, (680) 15.8–19.1, (700) 15.7–18.9

Cell Data: *Space Group:* $P2_1/c$. $a = 7.5283(4)$ $b = 14.8325(8)$ $c = 7.4629(4)$ $\beta = 118.746(1)^\circ$ $Z = 4$

X-ray Powder Pattern: Clear Creek claim, California, USA.
3.212 (100), 3.012 (60), 4.88 (50), 5.94 (40), 2.307 (40), 2.185 (40), 2.208 (35)

Chemistry:

	(1)	(2)
CrO_3	11.5	12.79
Hg	51.6	51.31
HgO	27.9	27.70
S	8.2	8.20
Total	99.2	100.00

(1) Clear Creek claim, California, USA; by electron microprobe, average of five analyses, Hg and HgO partitioned according to crystal-structure analysis; then corresponding to $Hg^{2+}_{3.26}Cr^{6+}_{0.97}O_4S_{2.16}$. (2) $Hg_3^{2+}CrO_4S_2$.

Occurrence: A rare alteration product of cinnabar, in a mercury deposit in silicate–carbonate rock hydrothermally altered from serpentinite.

Association: Cinnabar, deanesmithite, ferroan magnesite, quartz.

Distribution: From the Clear Creek claim, near the Clear Creek mercury mine, New Idria district, San Benito Co., California, USA.

Name: To honor Edward H. Oyler (1915–), American mineral collector specializing in mercury minerals.

Type Material: Canadian Geological Survey, Ottawa, Canada, 65026; National Museum of Natural History, Washington, D.C., USA, 165270.

References: (1) Erd, R.C., A.C. Roberts, M. Bonardi, A.J. Criddle, Y. Le Page, and E.J. Gabe (1993) Edoylerite, $Hg_3^{2+}Cr^{6+}O_4S_2$, a new mineral from the Clear Creek claim, San Benito County, California. Mineral. Record, 24, 471–475. (2) Burns, P.C. (1999) The structure of edoylerite determined from a microcrystal. Can. Mineral., 37, 113–118.

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Edwardsite $Cu_3Cd_2(SO_4)_2(OH)_6 \cdot 4H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As tabular to bladed crystals, to 0.06 mm, flattened on {100}, elongated on [010], showing forms {100}, {001}, {010} and perhaps {043}; as druses.

Physical Properties: *Cleavage*: Excellent on {100}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3-3.5 D(meas.) = n.d. D(calc.) = 3.53

Optical Properties: Transparent. *Color*: Pale blue. *Streak*: White.
Luster: Vitreous.
Optical Class: Biaxial (-). α = ~ 1.74 β = 1.762(4) γ = ~ 1.77 2V(calc.) = ~ 62°
Orientation: X = *b*; Y ~ *a*; Z ~ *c*.

Cell Data: *Space Group*: $P2_1/c$. *a* = 10.863(2) *b* = 13.129(3) *c* = 11.169(2)
β = 113.04(3)° Z = 4

X-ray Powder Pattern: Block 14 Opencut, Broken Hill, New South Wales, Australia.
9.991 (90), 5.001 (90), 3.332 (60), 2.769 (55), 4.591 (45), 2.670 (45), 2.824 (40)

Chemistry:

	(1)	(2)
CdO	32.43	32.85
CuO	28.06	30.53
ZnO	2.26	
FeO	0.08	
SO_3	20.35	20.48
H_2O_{calc}	16.14	16.14
Total	99.32	100.00

(1) Block 14 Opencut, Broken Hill, New South Wales, Australia; average of 10 electron microprobe analyses, H_2O calculated from structure analysis, OH and SO_4 confirmed by IR, corresponding to $Cu_{2.77}Cd_{1.98}Zn_{0.22}Fe_{0.01}(SO_4)_{2.00}(OH)_{5.95} \cdot 4.06H_2O$. (2) $Cu_3Cd_2(SO_4)_2(OH)_6 \cdot 4H_2O$.

Occurrence: A secondary mineral in the oxidized portion of a Ag-Pb-Zn metal deposit.

Association: Niedermayrite, christelite.

Distribution: Block 14 Opencut, Broken Hill, New South Wales, Australia.

Name: Honors Dr. Austin Burton Edwards (1909–1960), mineralogist and petrologist in the Mineragraphic Section of the Council for Scientific and Industrial Research CSIRO), Melbourne, Australia, for his contributions to the study of Australian ore deposits such as Broken Hill.

Type Material: South Australian Museum, Adelaide, South Australia (catalog no. G32703).

References: (1) Elliott, P., J. Brugger, and T. Caradoc-Davies (2010) Description and crystal structure of a new mineral, edwardsite, $Cu_3Cd_2(SO_4)_2(OH)_6 \cdot 4H_2O$, from Broken Hill, New South Wales, Australia. Mineral. Mag., 74, 39–54. (2) (2010) Amer. Mineral., 95, 1597-1598 (abs. ref. 1).

Efremovite $(NH_4)_2Mg_2(SO_4)_3$

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Crystal Data: Cubic. *Point Group:* 23. As equant grains, to 0.015 mm; typically as crusts.

Physical Properties: *Fracture:* Uneven. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 2.52
Readily hygroscopic, altering to boussingaultite.

Optical Properties: Transparent to nearly opaque. *Color:* White, gray; colorless to pale brown in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.550(1)$

Cell Data: *Space Group:* $P2_13$. $a = 9.99(1)$ Z = 4

X-ray Powder Pattern: Chelyabinsk coal basin, Russia.
3.15 (10), 4.07 (7), 4.33 (6), 2.668 (4), 5.76 (3.5), 3.00 (3.5), 1.620 (2.5)

Chemistry:

	(1)
SO_3	38.37
FeO	0.72
MnO	0.25
MgO	11.47
CaO	0.35
Na_2O	0.13
K_2O	0.50
$(NH_4)_2O$	8.31
insol.	39.97
Total	100.07

(1) Chelyabinsk coal basin, Russia; K by flame photometry, insoluble is organic matter and quartz; corresponds to $[(NH_4)_{2.00}K_{0.06}Na_{0.02}]_{\Sigma=2.08}(Mg_{1.79}Fe_{0.06}Ca_{0.04}Mn_{0.02})_{\Sigma=1.91}(SO_4)_{3.00}$.

Occurrence: As crusts on burning coal mine dumps, formed by the reaction of combustion gases with carbonate rocks.

Association: Sulfur, kladnoite, mascagnite, boussingaultite.

Distribution: From near Kopeysk, in the Chelyabinsk coal basin, Southern Ural Mountains, Russia. At the Scholler mine, near Kladno, Czech Republic.

Name: Honors Dr. Ivan Antonovich Yefremov (1907–1972), Russian geologist and science fiction writer.

Type Material: Il'menskii Preserve Museum, Miass, 5895; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Shcherbakova, Y.P. and L.F. Bazhenova (1989) Efremovite $(NH_4)_2Mg_2(SO_4)_3$ – ammonium analogue of langbeinite – a new mineral. Zap. Vses. Mineral. Obshch., 118, 84–87 (in Russian). (2) (1991) Amer. Mineral., 76, 299–300 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 78.

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Eggletonite $(Na,K,Ca)_2(Mn,Fe)_8(Si,Al)_{12}O_{29}(OH)_7 \cdot 11H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Crystals display a pseudohexagonal cross section, elongated along [100], with {011} and {001} common. As clusters of divergent sprays of radiating acicular prisms, to 2 cm. *Twinning:* On {001}.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Very brittle. Hardness = 3–4 D(meas.) = 2.76 D(calc.) = 2.76

Optical Properties: Semitransparent. *Color:* Dark to golden brown, red-brown. *Streak:* Light brown. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Very weak; X = pale brown to colorless; $Y = Z$ = pale yellow-brown. *Orientation:* $Z = b$; $X \simeq c'$; $Y \simeq a$. *Dispersion:* $r < v$, weak. *Absorption:* $Z \simeq Y > X$. $\alpha = 1.566(2)$ $\beta = 1.606(2)$ $\gamma = 1.606(2)$ 2V(meas.) = 9(3)°

Cell Data: *Space Group:* $I2/a$ or Ia. $a = 5.554$ $b = 13.72$ $c = 25.00$ $\beta = 93.95°$ Z = 2

X-ray Powder Pattern: Big Rock quarry, Arkansas, USA.
12.4 (100), 3.13 (30), 2.691 (25), 2.600 (20), 2.462 (20), 3.45 (15), 2.854 (15)

Chemistry:

	(1)
SiO_2	41.5
Al_2O_3	7.6
FeO	3.0
MnO	31.4
ZnO	0.2
MgO	0.4
CaO	1.5
Na_2O	1.7
K_2O	1.3
H_2O	[11.4]
Total	[100.0]

(1) Big Rock quarry, Arkansas, USA; by electron microprobe, H_2O by difference; corresponds to $(Na_{0.82}K_{0.40}Ca_{0.39})_{\Sigma=1.61}(Mn_{6.61}Fe_{0.61}Al_{0.56}Mg_{0.16}Zn_{0.08})_{\Sigma=8.02}(Si_{10.33}Al_{1.67})_{\Sigma=12.00}[O_{28.92}(OH)_{3.08}]_{\Sigma=32.00}(OH)_{4.00} \cdot 10.66H_2O$.

Occurrence: In miarolitic pockets in nepheline syenite pegmatite.

Association: Albite, natrolite, apophyllite pyrophanite, kupletskite.

Distribution: In the Big Rock quarry, Granite Mountain, near Little Rock, Pulaski Co., Arkansas, USA.

Name: To honor Dr. Richard A. Eggleton, Australian National University, Canberra, Australia.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137143.

References: (1) Peacor, D.R., P.J. Dunn, and W.B. Simmons (1984) Eggletonite, the Na analogue of ganophyllite. Mineral. Mag., 48, 93–96. (2) (1985) Amer. Mineral., 70, 436 (abs. ref. 1).

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Eglestonite $Hg_6^{1+}HCl_3O_2$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As dodecahedra, octahedra, or cubes, complexly modified by {112}, {116}, {223}, {123}, many others; may be acicular to filiform by elongation on [001]. Commonly as granular aggregates or massive crusts and films.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 8.309–8.45 D(calc.) = 8.652

Optical Properties: Translucent. *Color:* Yellow, yellow-orange, light brownish yellow to dark brown or black with exposure to light; yellowish brown to brown in transmitted light. *Streak:* Yellow or greenish yellow, rapidly becoming black. *Luster:* Brilliant adamantine to resinous.
Optical Class: Isotropic, occasionally weakly anisotropic. $n = 2.49(2)$

Cell Data: *Space Group: Ia3d.* $a = 16.036$ Z = 16

X-ray Powder Pattern: Terlingua, Texas, USA.
3.273 (100), 1.890 (57), 2.536 (47), 4.009 (36), 1.709 (14), 2.315 (11), 1.336 (9)

Chemistry:

	(1)	(2)	(3)
Hg	89.00	89.90	89.62
O	1.79		1.79
Cl	8.22	7.79	7.92
Br		0.13	
H_2O			0.67
Total	99.01		100.00

(1) Terlingua, Texas, USA; average of three analyses. (2) Arzak deposit, Russia; by electron microprobe, average of five analyses. (3) $Hg_6HCl_3O_2$.

Polymorphism & Series: Forms a series with kadyrelite.

Occurrence: An oxidation product of other mercury minerals in mercury deposits.

Association: Calomel, mercury, terlinguaite, montroydite, calcite (Terlingua, Texas, USA); cinnabar, mercury, calomel (San Mateo Co., California, USA); lavrentievite, calomel, mercury, kadyrelite (Kadyrel deposit, Russia).

Distribution: In the USA, at Terlingua, Brewster Co., Texas; around Crawford and Jackfork, Pike Co., Arkansas; in the McDermitt and Cordero mercury mines, Opalite district, and at the Cahill mine, Poverty Peak district, Humboldt Co., Nevada; from the Denio district, Harney Co., Oregon. In California, near the New Idria mine, San Benito Co.; in the Challenge deposit, near Emerald Lake, southwest of Redwood City, San Mateo Co.; in the Kings mine, Parkfield district, Kings Co.; and at the Socrates mine, Sonoma Co. At Huahuaxtla, Guerrero, and Guadalćazar, San Luis Potosi, Mexico. From South Africa, in the Monarch cinnabar mine, Transvaal. At Landsberg, near Obermoschel, Rhineland-Palatinate, Germany. In Russia, from Siberia, in the Arzak and Kadyrel deposits, Tuva, and the Kelyan Sb–Hg deposit, Buryatia; in the Aktash mercury deposit, Kosh-Agach district, Kurai Range, Altai Mountains. From Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan. In the Ruziobnok deposit, central Tajikistan. Several other localities are known.

Name: Honors Thomas Egleston (1832–1900), Professor of Mineralogy and Metallurgy, Columbia University, New York City, New York, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R1325.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 51–52. (2) Mereiter, K. and J. Zemann (1976) Neubearbeitung des Quecksilberminerals Eglestonit: Kristallstruktur, chemische Zusammensetzung und Synthese. Tschermaks Mineral. Petrog. Mitt., 23, 105–115. (3) Vasil'ev, V.I. and Y.G. Lavrent'ev (1986) New data on the composition of eglestonite. Doklady Acad. Nauk SSSR, 287, 960–963 (in Russian). (4) Mereiter, K., J. Zeeman, and A.W. Hewat (1992) Eglestonite, $[Hg_2]_3Cl_3O_2H$: confirmation of the chemical formula by neutron powder diffraction. Amer. Mineral., 77, 839–842.

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Ehrleite $Ca_2ZnBe(PO_4)_2(PO_3OH)\cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Thick tabular crystals, showing {100}, {010}, and {001}, to 2 mm. *Twinning:* Contact twins, by reflection on {001}, universal.

Physical Properties: *Cleavage:* Parting on {001}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = ~3.5 D(meas.) = 2.64(2) D(calc.) = [2.66]

Optical Properties: Transparent. *Color:* Milky white to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c^*$; $Y \wedge b = 18°$; $Z \wedge a = 9°$. $\alpha = 1.556(2)$ $\beta = 1.560(1)$ $\gamma = 1.580(1)$ 2V(meas.) = 62° 2V(calc.) = 49°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.130(4)$ $b = 7.430(4)$ $c = 12.479(9)$ $\alpha = 94.31(5)°$ $\beta = 102.07(4)°$ $\gamma = 82.65(4)°$ Z = 2

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
3.161 (10), 12.41 (7), 2.723 (6), 6.95 (5), 4.31 (4), 6.58 (3), 3.014 (3)

Chemistry:

	(1)	(2)
P_2O_5	40.5	41.54
ZnO	14.8	15.88
BeO	7.9	4.88
CaO	20.9	21.88
H_2O	[15.9]	15.82
Total	[100.0]	100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, Be by ion microprobe, thought to be in excess, H_2O by difference, presence of H confirmed by ion probe; corresponds to $Ca_{1.96}Zn_{0.96}Be_{1.66}O_{0.58}(PO_4)_2(PO_3OH)\cdot 4.08H_2O$. (2) $Ca_2ZnBe(PO_4)_2(PO_3OH)\cdot 4H_2O$ as determined from crystal-structure analysis.

Occurrence: A very rare mineral with other secondary phosphates, in the outer to intermediate zone of a complex granite pegmatite.

Association: Apatite, mitridatite, roscherite, hydroxyl-herderite, goyazite–crandallite, parascholzite, manganese oxides, beryl, quartz.

Distribution: In the USA, found in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota.

Name: In honor of Howard Ehrle, Miles City, Montana, USA, who discovered the mineral.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 49289; South Dakota School of Mines and Technology, Rapid City, South Dakota, 2958; National Museum of Natural History, Washington, D.C., USA, 160381.

References: (1) Robinson, G.W., J.D. Grice, and J. Van Velthuizen (1985) Ehrleite, a new calcium beryllium zinc phosphate hydrate from the Tip Top pegmatite, Custer, South Dakota. Can. Mineral., 23, 507–510. (2) (1986) Amer. Mineral., 71, 1544 (abs. ref. 1). (3) Hawthorne, F.C. and J.D. Grice (1987) The crystal structure of ehrleite, a tetrahedral sheet structure. Can. Mineral., 25, 767–774.

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Eifelite $KNa_3Mg_4Si_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals platy to prismatic, to 1 mm, with dominant $\{10\bar{1}0\}$ and $\{0001\}$, and $\{11\bar{2}0\}$ and $\{10\bar{1}2\}$; in druses.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.67

Optical Properties: Transparent. *Color:* Colorless to faintly yellow or green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.5430–1.5445$ $\epsilon = 1.5443–1.5458$

Cell Data: *Space Group:* $P6/mcc$. $a = 10.155$ $c = 14.223(6)$ $Z = 2$

X-ray Powder Pattern: Bellerberg volcano, Germany; essentially identical with roedderite. 3.26 (10), 3.75 (9), 4.43 (6), 7.07 (5), 5.11 (5), 4.14 (5), 2.91 (5)

Chemistry:

	(1)
SiO_2	71.06
TiO_2	0.06
Al_2O_3	0.79
Cr_2O_3	0.06
FeO	0.48
MnO	0.46
CuO	0.08
ZnO	0.34
MgO	16.25
Na_2O	6.48
K_2O	4.18
Total	100.24

(1) Bellerberg volcano, Germany; by electron microprobe, microchemical analysis showed Li_2O 0.1%; corresponding to $(Na_{2.12}K_{0.90})_{\Sigma=3.02}(Mg_{4.08}Al_{0.14}Fe_{0.07}Mn_{0.07}Zn_{0.04}Cr_{0.01}Ti_{0.01}Cu_{0.01})_{\Sigma=4.43}(Si_{11.98}Al_{0.02})_{\Sigma=12.00}O_{30}$.

Polymorphism & Series: Forms a series with roedderite.

Mineral Group: Milarite group.

Occurrence: In vesicles in contact metamorphosed basement gneiss xenoliths in leucite tephrite.

Association: Tridymite, hematite, pseudobrookite, pyroxene, amphibole, quartz, sanidine.

Distribution: From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany.

Name: For the locality in the Eifel district, Rhineland-Palatinate, Germany.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany; National Museum of Natural History, Washington, D.C., USA, 162496.

References: (1) Abraham, K., W. Gebert, O. Medenbach, W. Schreyer, and G. Hentschel (1980) $KNa_2Mg_{4.5}[Si_{12}O_{30}]$, ein neues Mineral der Milaritgruppe aus der Eifel, mit Natrium in Oktaederposition. Fortschr. Mineral., 58, Beiheft 1, 3–4 (abs., in German). (2) (1981) Amer. Mineral., 66, 218 (abs. ref. 1). (3) Abraham, K., W. Gebert, O. Medenbach, W. Schreyer, and G. Hentschel (1983) Eifelite, $KNa_3Mg_4Si_{12}O_{30}$, a new mineral of the osumilite group with octahedral sodium. Contr. Mineral. Petrol., 82, 252–258.

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Eitelite $Na_2Mg(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As imperfect rhombohedral to pseudo-octahedral crystals, to 17 mm, composed of $\{10\overline{1}1\}$, $\{01\overline{1}2\}$ and $\{0001\}$.

Physical Properties: *Cleavage:* On $\{0001\}$, excellent; and another transverse to $\{0001\}$, conspicuous. Hardness = 3.5 D(meas.) = 2.737 D(calc.) = 2.732

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.605$ $\epsilon = 1.450$

Cell Data: *Space Group:* $R\overline{3}$. $a = 4.942(2)$ $c = 16.406(7)$ Z = 3

X-ray Powder Pattern: Synthetic.
2.602 (100), 2.731 (25), 2.469 (25), 2.251 (20), 1.8975 (20), 2.0710 (18), 3.794 (16)

Chemistry:

	(1)	(2)
CO_2	43.94	46.25
FeO	10.93	
MnO	2.07	
MgO	12.20	21.18
Na_2O	31.42	32.57
Total	100.56	100.00

(1) Khibiny massif, Russia; corresponds to $Na_{2.03}(Mg_{0.61}Fe_{0.30}Mn_{0.06})_{\Sigma=0.97}(CO_3)_{2.00}$.
(2) $Na_2Mg(CO_3)_2$.

Occurrence: An authigenic mineral in dolomitic shale and bituminous marlstone (Utah, USA); from an alkaline igneous pluton (Khibiny massif, Russia).

Association: Reedmergnerite, leucosphenite, searlesite, crocidolite, shortite (Kermit Poulson No. 1 well, Utah, USA); trona, nahcolite, shortite, northupite (Mapco Shrine Hospital #1 well, Utah, USA).

Distribution: In the USA, in Utah, from drill core in the Green River Formation, in Duchesne Co., at the Kermit Poulson No. 1 well and abundant in large crystals in the Mapco Shrine Hospital #1 well; in the South Ouray well, Uintah Co. From the Vuonnemiok River Valley, Khibiny massif, Kola Peninsula, Russia.

Name: Honors Wilhelm Hermann Julius Eitel (1891–1979), Director of the Institute of Silicate Research, University of Toledo, Toledo, Ohio, USA, who synthesized the compound.

Type Material: n.d.

References: (1) Milton, C., J.M. Axelrod, and F.S. Grimaldi (1955) New minerals, reedmergnerite ($Na_2O \bullet B_2O_3 \bullet 6SiO_2$) and eitelite ($Na_2O \bullet MgO \bullet 2CO_2$) associated with leucosphenite, shortite, searlesite, and crocidolite in the Green River Formation, Utah. Amer. Mineral., 40, 326–327 (abs.). (2) Pabst, A. (1973) The crystallography and structure of eitelite, $Na_2Mg(CO_3)_2$. Amer. Mineral., 58, 211–217. (3) Khomyakov, A.P., S.M. Sandomirskaya, and Y.A. Malinovskii (1980) Iron eitelite, $Na_2(Mg,Fe)(CO_3)_2$ – a new mineral variety. Doklady Acad. Nauk SSSR, 255, 190–192. (4) Knobloch, D., F. Pertlik, and J. Zemann (1980) Crystal structure refinements of buetschliite and eitelite: a contribution to the stereochemistry of trigonal carbonate minerals. Neues Jahrb. Mineral., Monatsh., 230–236. (5) (1974) NBS Mono. 25, 56.

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Ekanite $Ca_2ThSi_8O_{20}$

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Crystal Data: Tetragonal; may be metamict. *Point Group:* $4/m\ 2/m\ 2/m$. As poorly-formed pyramidal crystals, to 1 cm, striated ‖ [100], showing {101}, {110}, {001}, and {100}; as clusters of grains; rounded massive.

Physical Properties: *Cleavage:* Distinct on {101}, indistinct on {001}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 2.95–3.28 D(calc.) = 3.36 Emits α, β, and γ radiation.

Optical Properties: Transparent to turbidly translucent. *Color:* Colorless, light to dark green, yellow-green to yellowish brown, straw-yellow, red from inclusions; in thin section, dark brown. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–), may be biaxial (–). $n = 1.595$–1.597 (metamict). $\omega = 1.580(3)$ $\epsilon = 1.568(3)$ 2V(meas.) = 10°–15°

Cell Data: *Space Group:* $I422$. $a = 7.483(3)$ $c = 14.893(6)$ $Z = 2$

X-ray Powder Pattern: Tombstone Mountains, Canada.
4.14 (100), 3.343 (96), 3.265 (65), 6.70 (61), 7.45 (58), 2.642 (54), 1.796 (26)

Chemistry:

	(1)	(2)	(3)
SiO_2	55.6	47.6	56.10
ThO_2	27.6	37.8	30.81
UO_2	2.1	1.1	
Al_2O_3	trace	0.8	
Fe_2O_3	0.5		
FeO		0.4	
MnO	trace	0.2	
PbO	0.8		
MgO	trace		
CaO	13.7	9.6	13.09
Total	100.3	97.5	100.00

(1) Eheliyagoda district, Sri Lanka. (2) Tombstone Mountains, Canada; by electron microprobe, heated specimen; separate wet chemical analysis gives F 3.4% and H_2O 7.8%; corresponds to $(Ca_{1.91}Fe_{0.06}Mn_{0.03})_{\Sigma=2.00}(Th_{0.90}U_{0.05})_{\Sigma=0.95}Si_8O_{20}$. (3) $Ca_2ThSi_8O_{20}$.

Occurrence: Detrital (Sri Lanka); in a glacial erratic syenitic boulder (Tombstone Mountains, Canada); in volcanic ejecta (Case Collina, Italy).

Association: Fluorite, garnet, quartz, microcline, clinopyroxene, apatite, sodic plagioclase, hematite, thorogummite, zircon, titanite (Tombstone Mountains, Canada); quartz, feldspar, pyroxene (Case Collina, Italy).

Distribution: From the Eheliyagoda and Okkampitiya districts, near Ratnapura, Sri Lanka. In the Tombstone Mountains, Yukon Territory, Canada. At Case Collina, Pitigliano, near Grosetto, Tuscany, and on the Vico volcano, near Vetralla, Lazio, Italy. From the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: In honor of the mineral's discoverer, F.L.D. Ekanayake, of Colombo, Sri Lanka.

Type Material: Canadian Geological Survey, Ottawa, Canada, 62722; The Natural History Museum, London, England, 1961,472; National Museum of Natural History, Washington, D.C., USA, 148771.

References: (1) Anderson, B.W., G.F. Claringbull, R.J. Davis, and D.K. Hill (1961) Ekanite, a new metamict mineral from Ceylon. Nature, 190, 997. (2) (1961) Amer. Mineral., 46, 1516 (abs. ref. 1). (3) Gübelin, E.J. (1962) Ekanite. The Gemmologist, 31, 142–152, 165–169. (4) Szymański, J.T., D.R. Owens, A.C. Roberts, H.G. Ansell, and G.Y. Chao (1982) A mineralogical study and crystal-structure determination of nonmetamict ekanite, $ThCa_2Si_8O_{20}$. Can. Mineral., 20, 65–75.

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Ekaterinite $Ca_2B_4O_7(Cl,OH)_2 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6 (?). As foliated hexagonal crystals, to 1 mm; massive in veinlets and crusts.

Physical Properties: *Cleavage:* On {0001}, distinct, foliated. Hardness = 1–1.5 D(meas.) = 2.440(5) D(calc.) = [2.17] Hygroscopic with swelling, soluble in H_2O; luminesces and phosphoresces blue at 77 °K and 300 °K.

Optical Properties: Transparent to translucent. *Color:* White, may have a pale rose tint. *Luster:* Pearly.
Optical Class: Biaxial (–). $\alpha = 1.574(1)$ $\beta =$ n.d. $\gamma = 1.577(1)$ 2V(meas.) = Very small.

Cell Data: *Space Group:* $P6$ (?). $a = 11.86$ $c = 23.88$ Z = [6]

X-ray Powder Pattern: Korshunovskoye deposit, Russia.
2.31 (100), 1.916 (100), 2.047 (99), 2.09 (98), 1.281 (97), 2.51 (93), 1.166 (87)

Chemistry:

	(1)		(1)
B_2O_3	38.47	K_2O	0.16
SiO_2	0.04	F	0.00
Fe_2O_3	0.04	Cl	11.07
MnO	trace	H_2O^+	14.17
MgO	0.11	H_2O^-	7.62
CaO	30.67	$-O = (F,Cl)_2$	2.50
Na_2O	0.08	Total	99.93

(1) Korshunovskoye deposit, Russia; H_2O and borate anion confirmed by IR; corresponds to $Ca_{2.00}B_{4.04}O_7[Cl_{1.14}(OH)_{0.86}]_{\Sigma=2.00} \cdot 2.38H_2O$.

Occurrence: In calcite and calcite–anhydrite veins associated with a mineralized skarn.

Association: Halite, calcite, szaibélyite, korshunovskite, shabynite, iowaite, dashkovaite, siderite, hydromagnesite, quartz.

Distribution: From drill cores in the Korshunovskoye iron–boron skarn deposit, Irkutsk district, Siberia, Russia.

Name: Honors Dr. Yekaterina Vladimirovna Rozhkova (1898–1979), Russian mineralogist, Research Institute of Mineral Resources, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1224/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80173; National Museum of Natural History, Washington, D.C., USA, 160242, 160482.

References: (1) Malinko, S.V., B.P. Fitsev, N.N. Kuznetsova, and L.Y. Cherkasova (1980) Yekaterinite – a new boron mineral. Zap. Vses. Mineral. Obshch., 109, 469–476 (in Russian). (2) (1981) Amer. Mineral., 66, 437 (abs. ref. 1).

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Ekplexite $(Nb,Mo)S_2{\cdot}(Mg_{1-x}Al_x)(OH)_{2+x}$

Crystal Data: Hexagonal. *Point Group*: 3*m*, 32, or $\bar{3}$ 2/*m*. As isolated lenticular nests, to 1 mm; as near-parallel, radiating or chaotic aggregates of mica-like, corrugated flakes, to 0.1 mm; or as flakes epitaxially growing on Ti-bearing pyrrhotite, to 0.7 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Laminated. *Tenacity*: Flexible, inelastic. VHN = 64 (5 g load). Hardness = ~1 D(meas.) = n.d. D(calc.) = 3.63

Optical Properties: Opaque. *Color*: Iron black; light to dark gray in reflected light. *Streak*: Black. *Luster*: Metallic. *Anisotropism:* Strong. *Pleochroism*: Strong, light to dark gray. *Optical Class*: n.d.
R_1-R_2: (470) 8.7-18.9, (546) 8.7-19.4, (589) 8.8-19.0, (650) 8.6-18.2

Cell Data: *Space Group*: $P\bar{3}\,m1$, $P3m1$, or $P321$. [a = 3.262(2) c = 11.44(2) sulfide sub-lattice] [a = 3.066(2) c = 11.52(2) hydroxide sub-lattice] One-layer polytypes. Z = 1

X-ray Powder Pattern: Mt. Kaskasnyunchorr, Khibiny alkaline complex, Kola Peninsula, Russia. 11.40 (100), 5.65 (56), 2.812 (21), 1.622 (11), 2.647 (9), 2.248 (4), 1.573 (4)

Chemistry:

	(1)		(1)
Mg	6.25	Nb	18.17
Al	4.31	Mo	15.89
Ca	0.00	W	8.13
V	0.86	S	27.68
Mn	0.00	O	16.33
Fe	0.44	H	[1.03]
		Total	99.09

(1) Mt. Kaskasnyunchorr, Russia; average of 5 electron microprobe analyses, H calculated so that all O are OH^-, OH^- confirmed by Raman spectroscopy; corresponding to $(Nb_{0.45}Mo_{0.38}W_{0.10}V_{0.04})_{\Sigma=0.97}S_2{\cdot}(Mg_{0.60}Al_{0.37}Fe_{0.02})_{\Sigma=0.99}(OH)_{2.36}$.

Mineral Group: Valleriite group.

Occurrence: Of hydrothermal origin in fenites formed by a peralkaline fluid, as a source of Nb, reacting with a large xenolith of alumina-rich metamorphic rocks (metapelites) in agpaitic nepheline syenite.

Association: Orthoclase, anorthoclase, nepheline, fluorophlogopite, corundum, pyrrhotite, pyrite, rutile, monazite-(Ce), graphite, edgarite, molybdenite, tungstenite, alabandite.

Distribution: From Mt. Kaskasnyunchorr, Khibiny alkaline complex, Kola Peninsula, Russia.

Name: After the Greek word έκπληξη meaning "surprise", for its exotic combination of major chemical constituents.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 93628).

References: (1) Pekov, I.V., V.O. Yapaskurt, Y.S. Polekhovsky, M.F. Vigasina, and O.I. Siidra (2014) Ekplexite $(Nb,Mo)S_2{\cdot}(Mg_{1-x}Al_x)(OH)_{2+x}$, kaskasite $(Mo,Nb)S_2{\cdot}(Mg_{1-x}Al_x)(OH)_{2+x}$ and manganokaskasite $(Mo,Nb)S_2{\cdot}(Mn_{1-x}Al_x)(OH)_{2+x}$, three new valleriite-group mineral species from the Khibiny alkaline complex, Kola peninsula, Russia. Mineral. Mag., 78(3), 663-679. (2) (2015) Amer. Mineral., 100, 658-659 (abs. ref. 1).

Elbaite $\mathbf{Na(Al,Li)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4}$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals prismatic to acicular, with prominent trigonal prism and pyramid, to 1.6 m, commonly hemimorphic, striated ‖ [0001]. Also radial, fibrous, and massive. *Twinning:* Rare, on $\{10\bar{1}1\}$ or $\{40\bar{4}1\}$.

Physical Properties: *Cleavage:* $\{11\bar{2}0\}$, $\{10\bar{1}1\}$, very poor. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 7 D(meas.) = 2.90–3.10 D(calc.) = 3.069 Pyroelectric and piezoelectric.

Optical Properties: Transparent to translucent. *Color:* Green, blue, red, orange, yellow, colorless, zoning common parallel to trigonal outline; colorless in thin section. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–); under strain may show slight biaxiality. *Pleochroism:* O = pink, pale green, pale to deep blue; E = colorless, yellow, olive-green, purplish. *Absorption:* $O > E$.
ω = 1.633–1.651 ϵ = 1.615–1.630

Cell Data: *Space Group:* $R3m$. a = 15.80–15.93 c = 7.09–7.13 Z = 3

X-ray Powder Pattern: Mt. Apatite, Auburn, Androscoggin Co., Maine, USA. (ICDD 26-964).
2.560 (100), 2.931 (90), 3.96 (80), 3.45 (70), 4.20 (60), 2.029 (50), 4.96 (35)

Chemistry:

	(1)		(1)
SiO_2	37.89	CaO	0.07
TiO_2	0.04	Li_2O	1.66
B_2O_3	10.28	Na_2O	2.43
Al_2O_3	43.85	F	0.10
FeO	0.11	H_2O^+	3.47
MnO	0.11	$-O = F_2$	0.04
		Total	99.97

(1) Elba, Italy; corresponds to $(Na_{0.74}Ca_{0.01})_{\Sigma=0.75}(Al_{2.11}Li_{1.05}Fe^{2+}_{0.01}Mn_{0.01})_{\Sigma=3.18}$ $Al_{6.00}(B_{0.93}O_3)_3Si_{5.94}O_{18}[(OH)_{3.63}O_{0.32}F_{0.05}]_{\Sigma=4.00}$.

Polymorphism & Series: Forms a series with dravite.

Mineral Group: Tourmaline group.

Occurrence: In granites, granite pegmatites, and some metamorphic rocks; in high-temperature hydrothermal veins; detrital in sediments.

Association: Quartz, albite, lepidolite, microcline, garnet, muscovite, beryl, apatite, spodumene.

Distribution: Many localities; some for exceptional specimens follow. In Italy, around San Piero in Campo, Elba. In the Yekaterinburg (Sverdlovsk) district, Ural Mountains, Russia. From Korgal and Mawi, Laghman Province, Afghanistan. In Pakistan, from around Gilgit and Stak Nala. At Ampantsikahitra, Anjanabonoina, Antandrokomby, Maharitra on Mt. Bity, and elsewhere on Madagascar. In the Alto Ligonha district, Mozambique. At Karibib and Usakos, Namibia. In the USA, from Mt. Mica, near Paris, Newry, and elsewhere in Oxford Co., Maine; at Haddam, Middlesex Co., Connecticut; and from the Pala and Mesa Grande districts, San Diego Co., California. In Brazil, from a large district around Araçuaí-Itinga-Salinas, and the Itatiaia district, Governador Valadares, Minas Gerais; at São José da Batalha, Paraíba.

Name: From the occurrence on the Island of Elba, Italy.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 551–558 [tourmaline]. (2) Vernadsky [Vernadskii], V.I. (1913) Über die chemische Formel der Turmaline. Zeits. Krist., 53, 273–288 (in German). (3) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 559–602. (4) Donnay, G. and R. Barton, Jr. (1972) Refinement of the crystal structure of elbaite and the mechanism of tourmaline solid solution. Tschermaks Mineral. Petrog. Mitt., 18, 273–286.

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Eldfellite $NaFe(SO_4)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, platy on {001}, to 0.02 mm; as rosettes.

Physical Properties: *Cleavage*: Perfect on {001, inferred from structure analysis. *Fracture*: n.d. *Tenacity*: n.d. Hardness = Soft. D(meas.) = n.d. D(calc.) = 3.062

Optical Properties: Transparent to translucent. *Color*: Yellowish-green to greenish-white. *Streak*: White. *Luster*: Vitreous.
Optical Class: n.d.

Cell Data: *Space Group*: *C2/m*. a = 8.043(4) b = 5.139(2) c = 7.115(4) β = 92.13(2)° Z = 2

X-ray Powder Pattern: Eldfell volcano, Heimaey Island, Iceland.
2.77 (100), 3.72 (80), 2.72 (60), 2.370 (60), 3.64 (50), 3.43 (50), 2.57 (30)

Chemistry:

	(1)	(2)
P_2O_5	1.79	
SO_3	62.37	59.09
TiO_2	0.50	
Fe_2O_3	25.36	29.47
Al_2O_3	0.69	
MnO	0.22	
MgO	1.24	
Na_2O	9.20	11.44
K_2O	0.24	
Total	101.60	100.00

(1) Eldfell volcano, Heimaey Island, Iceland; average of 4 EDS analyses, corresponding to $(Na_{0.77}K_{0.01})_{\Sigma=0.78}(Fe_{0.82}Mg_{0.08}Al_{0.03}Mn_{0.01}Ti_{0.02})_{\Sigma=0.96}(S_{2.01}P_{0.07})_{\Sigma=2.08}O_{8.00}$. (2) $NaFe(SO_4)_2$.

Occurrence: As a near surface fumarolic encrustation.

Association: Tamarugite, ralstonite, anhydrite, gypsum, bassanite, hematite, opal, cryptohalite, chessexite, unnamed $Na_3Fe(SO_4)_3$ phase.

Distribution: Eldfell volcano, Heimaey Island, Iceland.

Name: For the first locality, the Eldfell volcano, Iceland.

Type Material: Icelandic Institute of Natural History, Reykjavík, Iceland, (NI 13556).

References: (1) Balić-Žunić, T., A. Garavelli, P. Acquafredda, E. Leonardsen, and S.P. Jakobsson (2009) Eldfellite, $NaFe(SO_4)_2$, a new fumarolic mineral from Eldfell volcano, Iceland. Mineral. Mag., 73, 51–57. (2) (2010) Amer. Mineral., 95, 204-205 (abs. ref. 1).

Eldragónite $Cu_6BiSe_4(Se_2)$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As irregular grains and polycrystalline aggregates to 100 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal to uneven. *Tenacity*: Brittle. Hardness = 3.5 VHN = 225 (15 g load). D(meas.) = n.d. D(calc.) = 6.76

Optical Properties: Opaque. *Color*: Brownish to light maroon. *Streak*: Brownish black. *Luster*: Metallic.
Optical Class: n.d. *Pleochroism:* Distinct, light grayish brown to cream. *Anisotropism:* Strong, orange to blue-black, with undulose extinction.
R_1-R_2: (470) 32.5-34.5 $(17.7\text{-}19.7)_{oil}$, (546) 32.95-36.3 $(18.0\text{-}21.4)_{oil}$, (589) 33.3-36.8 $(18.3\text{-}21.6)_{oil}$, (650) 34.0-36.9 $(19.1\text{-}21.7)_{oil}$

Cell Data: *Space Group*: *Pmcn*. *a* = 4.0341(4) *b* = 27.056(3) *c* = 9.5559(9) Z = 4

X-ray Powder Pattern: El Dragón mine, Quijarro Province, Department of Potosí, Bolivia.
3.579 (100), 3.075 (84), 3.180 (77), 1.920 (76), 3.065 (75), 6.547 (58), 3.165 (56)

Chemistry:

	(1)	(2)
Cu	35.9	35.84
Fe	1.25	
Ni	0.35	
Bi	20.3	19.64
Se	42.5	44.52
Total	100.3	100.00

(1) El Dragón mine, Quijarro Province, Department of Potosí, Bolivia; average of 24 electron microprobe analyses; corresponding to $(Cu_{5.98}Fe_{0.24}Ni_{0.06})_{\Sigma=6.28}Bi_{1.03}Se_{5.70}$. (2) $Cu_6BiSe_4(Se_2)$.

Occurrence: Forms inclusions in compositionally zoned krut'aite masses, in a low-temperature hydrothermal vein-type deposit.

Association: Krut'aite, clausthalite, klockmannite, umangite, tiemannite, watkinsonite, petrovicite.

Distribution: At the El Dragón mine, Quijarro Province, Department of Potosí, Bolivia.

Name: For the locality that provided the first specimens.

Type Material: Canadian Museum of Nature, Ottawa, Canada (CMNMC 86154) and the Department of Materials Engineering and Physics, University of Salzburg, Austria (M17.001, M17.002, and M17.003).

References: (1) Paar, W.H., M.A. Cooper, Y. Moëlo, C.J. Stanley, H. Putz, D. Topa, A.C. Roberts, J. Stirling, J.G. Raith, and R. Rowe (2012) Eldragónite, $Cu_6BiSe_4(Se_2)$, a new mineral species from the El Dragón mine, Potosí, Bolivia, and its crystal structure. Can. Mineral., 50, 281-294.
(2) (2014) Amer. Mineral., 99, 1513 (abs. ref. 1).

Ellenbergerite $Mg_6TiAl_6Si_8O_{28}(OH)_{10}$

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Crystal Data: Hexagonal. *Point Group:* 6. Rarely as elongated prisms, to 1 cm, with hexagonal cross section. Typically as anhedral inclusions in pyrope crystals.

Physical Properties: *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 3.15–3.22 D(calc.) = 3.10–3.17 Faint blue cathodoluminescence.

Optical Properties: Transparent. *Color:* Purple to lilac; some individuals exhibit smoky or pink cores. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* Vivid; O = colorless; E = colorless to deep lilac.
ω = 1.655–1.679 ϵ = 1.654–1.670

Cell Data: *Space Group:* $P6_3$. $a = 12.255(8)$ $c = 4.932(4)$ $Z = 1$

X-ray Powder Pattern: Parigi, Italy.
3.11 (100), 3.54 (75), 2.653 (70), 3.06 (55), 2.183 (55), 3.61 (50), 2.337 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	39.13	32.61	40.11
TiO_2	3.96	0.58	6.67
ZrO_2	0.00	2.13	
Al_2O_3	24.91	20.64	25.52
FeO	0.19	0.41	
MgO	22.05	25.80	20.18
H_2O			7.52
P_2O_5	0.42	8.26	
Total	90.66	90.43	100.00

(1) Parigi, Italy; by electron microprobe, analysis of a most intensely colored crystal; colorometric analysis yielded H_2O 8.0(4)%. (2) Do.; a less intensely colored crystal. (3) $Mg_6TiAl_6Si_8O_{28}(OH)_{10}$.

Occurrence: As inclusions in pyrope porphyroblasts developed during high-pressure (25–30 kbar), medium-temperature (700 °C–800 °C) metamorphism of continental crustal rocks.

Association: Pyrope, kyanite, talc, clinochlore, rutile, zircon, sodic amphibole.

Distribution: In the Dora-Maira massif, Parigi, near Martiniana Po, Piedmont, Italy.

Name: Honors Professor François Ellenberger, Paris, France, for his geological work in the western Alps.

Type Material: University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France; Institute for Mineralogy, Ruhr University, Bochum, Germany; National Museum of Natural History, Washington, D.C., USA, 163497.

References: (1) Chopin, C., R. Klaska, O. Medenbach, and D. Dron (1986) Ellenbergerite, a new high-pressure Mg-Al-(Ti,Zr)-silicate with a novel structure based on face-sharing octahedra. Contr. Mineral. Petrol., 92, 316–321. (2) (1988) Amer. Mineral., 73, 190–191 (abs. ref. 1).

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Ellingsenite $Na_5Ca_6Si_{18}O_{38}(OH)_{13}.6H_2O$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Rhomb-like crystals, flattened on [001] and elongated along [100] in radiating sheaves, to 3 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Smooth. *Tenacity*: Sectile. Hardness = 4 D(meas.) = 2.32(5) D(calc.) = 2.363

Optical Properties: Transparent. *Color*: Colorless, white in aggregates. *Streak*: White. *Luster*: Vitreous individuals, silky aggregates.
Optical Class: Biaxial (-). α = 1.520(2) β = 1.534(2) γ = 1.536 2V(meas.) = 5° 2V(calc.) = n.d. *Orientation*: $X = c$.

Cell Data: *Space Group*: $P\bar{1}$. a = 9.576(11) b = 5.577(11) c = 16.438(19) α = 85.85(2)° β = 75.23(2)° γ = 60.142(14)° Z = 1

X-ray Powder Pattern: Ariskop quarry, Aris alkaline complex, Namibia.
15.50 (100), 3.023 (33), 3.159 (30), 1.827 (27), 2.791 (24), 4.22 (16), 4.98 (14)

Chemistry:

	(1)
Na_2O	9.26
SiO_2	60.35
K_2O	0.23
CaO	17.35
H_2O	12.5
Total	99.69

(1) Ariskop quarry, Aris alkaline complex, Namibia; average of 4 electron microprobe analyses, H_2O by Penfield method; corresponding to $(Na_{4.95}K_{0.09})_{\Sigma=5.04}(Ca_{5.57}Na_{0.43})_{\Sigma=6.00}Si_{18.10}O_{38}(OH)_{13}\cdot 6H_2O$.

Occurrence: A low-temperature mineral in vesicles in hydrothermally altered phonolite.

Association: Aegirine, albite, manganoneptunite, microcline, natrolite, polylithionite.

Distribution: From the Ariskop quarry, Aris alkaline complex, 25 km south of Windhoek, Namibia.

Name: Honors Dr. Hans Vidar Ellingsen (b. 1930), who has been chairman of the Norwegian Amateur Geological Society and who collected the first specimens.

Type Material: Mineralogical Museum, St. Petersburg State University, Russia (1/19443), and at the Natural History Museum, Oslo University, Norway (42188).

References: (1) Yakovenchuk, V.N., G.Yu. Ivanyuk, Y.A. Pakhomovsky, E.A. Selivanova, and J.A. Mikhailova (2011) Ellingsenite, $Na_5Ca_6Si_{18}O_{38}(OH)_{13}.6H_2O$, a new martinite-related mineral species from phonolite of the Aris alkaline complex, Namibia. Can. Mineral., 49, 1165-1173.
(2) (2012) Amer. Mineral., 97, 1261 (abs. ref. 1).

Ellisite Tl_3AsS_3

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Crystal Data: Hexagonal. *Point Group:* $3m$ (synthetic). As anhedral to irregular grains, to 1.3 mm, some having rhombohedral form; also massive.

Physical Properties: *Cleavage:* Excellent to good, rhombohedral. *Fracture:* Hackly. Hardness = n.d. VHN = 36.4–44.0, 39.3 average (50 g load). D(meas.) = 7.10(5) (synthetic). D(calc.) = 7.18

Optical Properties: Opaque. *Color:* Dark gray; pale gray with purplish tint in polished section, with deep red to deep red-orange internal reflections. *Streak:* Pale brown with a tinge of orange. *Luster:* Metallic. *Pleochroism:* Very weak, in colors from pale purplish gray to pale pinkish gray. *Anisotropism:* From blue-purple to red-purple to brownish orange.
R_1–R_2: (470) 31.7, (546) 29.2, (589) 28.9, (650) 28.3

Cell Data: *Space Group:* $R3m$ (synthetic). $a = 12.324$ $c = 9.647$ $Z = 7$

X-ray Powder Pattern: Carlin mine, Nevada, USA.
2.669 (100), 3.214 (53), 5.333 (37), 2.327 (28), 3.559 (20), 1.780 (15), 2.757 (10)

Chemistry:

	(1)	(2)
Tl	78.2	78.18
As	9.6	9.55
S	12.3	12.27
Total	100.1	100.00

(1) Carlin mine, Nevada, USA; by electron microprobe, average of five grains. (2) Tl_3AsS_3.

Occurrence: In a hydrothermal gold deposit, in mineralized, argillaceous, carbonaceous dolostone beds.

Association: Gold, pyrite, christite, lorandite, getchellite, realgar, arsenic, carlinite, hydrocarbons.

Distribution: In the Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co., Nevada, USA.

Name: Honors Dr. Albert J. Ellis (1929–), New Zealand geochemist, Chemistry Division, Department of Scientific and Industrial Research, New Zealand.

Type Material: Department of Geology, Stanford University, Palo Alto, California, USA, Epithermal Minerals Collection.

References: (1) Dickson, F.W., A.S. Radtke, and J.A. Peterson (1979) Ellisite, Tl_3AsS_3, a new mineral from the Carlin gold deposit, Nevada, and associated sulfide and sulfosalt minerals. Amer. Mineral., 64, 701–707. (2) Gostojić, M. (1980) Die Kristallstruktur von synthetishem Ellisit, Tl_3AsS_3. Zeits. Krist., 151, 249–254 (in German with English abs.).

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Elpasolite K_2NaAlF_6

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, trapezohedral or tetrahexahedral crystals, to 0.5 mm; in granular aggregates, massive.

Physical Properties: *Fracture:* Uneven. Hardness = 2.5 D(meas.) = 2.98(1) D(calc.) = 3.01

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Weakly vitreous to slightly greasy.
Optical Class: Isotropic. $n = 1.376(2)$

Cell Data: *Space Group:* $Fm3m$. a = 8.116(2) Z = 4

X-ray Powder Pattern: Pikes Peak, Colorado, USA.
2.863 (10), 2.024 (10), 2.336 (8), 1.428 (6), 0.795 (6), 0.905 (5), 1.650 (4)

Chemistry:

	(1)	(2)	(3)
Na	9.90	7.96	9.50
K	28.94	30.82	32.29
Mg	0.22	0.03	
Ca	0.72	0.08	
Al	11.32	10.04	11.14
F	[47.90]	49.69	47.07
Total	[99.00]	98.62	100.00

(1) Pikes Peak, Colorado, USA; F calculated for charge balance; corresponds to $K_{1.79}Na_{1.07}Ca_{0.04}Al_{1.02}F_{6.11}$. (2) Cetine mine, Italy, by electron microprobe, corresponds to $K_{2.12}Na_{0.93}Al_{1.00}F_{7.03}$. (3) K_2NaAlF_6.

Occurrence: Replacing fluorine-bearing minerals in a quartz-microcline pegmatite (Pikes Peak, Colorado, USA); on vein quartz in a hydrothermal antimony deposit in silicified limestone (Cetine mine, Italy).

Association: Cryolite, pachnolite, thomsenolite, prosopite, gearksutite (Pikes Peak, Colorado, USA); cryolite, chiolite, pachnolite, thomsenolite, ralstonite (Amelia, Virginia, USA); ralstonite, rosenbergite, gypsum, fluorite, quartz (Cetine mine, Italy).

Distribution: In the USA, from the Cincinnati mine, St. Peters Dome, near Pikes Peak, El Paso Co., Colorado; from the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada; and in the Morefield pegmatite mine, Amelia, Amelia Co., Virginia. From the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. In the Ivigtut cryolite deposit, southwestern Greenland.

Name: For El Paso County, Colorado, USA, where the mineral was found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162621, 83302.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 114. (2) Frondel, C. (1948) New data on elpasolite and hagemanite. Amer. Mineral., 33, 84–87. (3) Sabelli, C. (1987) Structure refinement of elpasolite from Cetine mine, Tuscany, Italy. Neues Jahrb. Mineral., Monatsh., 481–487. (4) Dirken, P.J., J.B.H. Jansen, and R.D. Schuiling (1992) Influence of octahedral polymerization on ^{23}Na and ^{27}Al MAS NMR in alkali fluoroaluminates. Amer. Mineral., 77, 718–724.

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Elpidite $Na_2ZrSi_6O_{15}\cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, elongated ‖ [001], to 30 cm, striated ‖ [010]. In fan-shaped aggregates, columnar, fine fibrous, massive. *Twinning:* Noted.

Physical Properties: *Cleavage:* Perfect on {110}. *Fracture:* Splintery. Hardness = 5 D(meas.) = 2.52–2.62 D(calc.) = 2.59

Optical Properties: Opaque to translucent and transparent. *Color:* White, colorless, yellowish, pale to bright orange, brownish yellow, brownish, beige, green, brick-red from inclusions. *Luster:* Silky, vitreous to waxy or dull.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$.
$\alpha = 1.556$–1.563 $\beta = 1.565$–1.569 $\gamma = 1.574$–1.577 2V(meas.) = 76°–89°

Cell Data: *Space Group: Pbcm.* $a = 7.14(2)$ $b = 14.68(1)$ $c = 14.65(1)$ Z = 4

X-ray Powder Pattern: Narssârssuk, Greenland.
3.26 (100), 3.12 (70), 1.945 (70), 1.759 (70), 1.590 (70), 1.352 (70), 1.492 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	59.44	57.13	60.11
TiO_2	trace	0.05	
ZrO_2	20.48	20.33	20.55
Nb_2O_5		1.43	
FeO	0.14	0.14	
CaO	0.17	0.43	
Na_2O	10.41	9.89	10.33
K_2O	0.13	0.19	
F		0.12	
Cl	0.15	0.18	
H_2O^+	5.72	9.94	9.01
H_2O^-	3.89		
Total	100.53	99.83	100.00

(1) Narssârssuk, Greenland. (2) Lovozero massif, Russia. (3) $Na_2ZrSi_6O_{15}\cdot 3H_2O$

Occurrence: In albitized nepheline syenite and associated pegmatites, aegirine-rich granite, and fenites, in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Albite, quartz, aegirine, epididymite, labuntsovite (Lovozero massif, Russia).

Distribution: At Narssârssuk and in the Ilímaussaq intrusion, southern Greenland. In Russia, from the Lovozero and Khibiny massifs, Kola Peninsula; in the Ulan-Erge massif, southeastern Tuva; and in the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia. In large crystals from Tarbagatai, eastern Kazakhstan. In the Khan-Bogdinskii granite massif, Gobi, Mongolia. At Gjerdingen, near Oslo, Norway. On Rockall Island, North Atlantic. In Canada, at Mont Saint-Hilaire and near Saint-Amable, Quebec, and in the Strange Lake complex, southeast of Lac Brisson, Quebec and Labrador, Newfoundland. From Washington Pass, Okanogan Co., Washington, USA.

Name: From the Greek *hope*, named in anticipation of discovery of other interesting minerals.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 24. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 365–370. (3) Cannillo, E., G. Rossi, and L. Ungaretti (1973) The crystal structure of elpidite. Amer. Mineral., 58, 106–109. (4) Sapozhnikov, A.N. and A.A. Kashaev (1978) Features of the crystal structure of calcium-containing elpidite. Kristallografiya (Sov. Phys. Crystal.), 23, 52–56 (in Russian).

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Elyite $Pb_4CuO_2(SO_4)(OH)_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular prismatic to fibrous crystals, elongated along [001], to 1 mm, platy on {100} with minor modifying forms; typically in radiating sprays, tufts, or matted. *Twinning:* Common by reflection across {100}.

Physical Properties: *Cleavage:* On {100}, good. *Tenacity:* Sectile. Hardness = 2
D(meas.) = ∼6 D(calc.) = 6.232

Optical Properties: Transparent. *Color:* Violet. *Streak:* Pale violet to white.
Luster: Silky.
Optical Class: Biaxial (–). *Pleochroism:* Deep to pale purple. *Orientation:* $Y = b$; $X \wedge c = 45°$.
Dispersion: Noticeable. *Absorption:* $Z > Y > X$. $\alpha = 1.990(1)$ $\beta = 1.993(1)$ $\gamma = 1.994(1)$
2V(meas.) = 66°

Cell Data: *Space Group:* $P2_1/c$. $a = 14.233(2)$ $b = 11.532(1)$ $c = 14.611(2)$
$\beta = 100.45(1)°$ Z = 8

X-ray Powder Pattern: Silver King mine, Nevada, USA.
7.00 (100), 7.19 (99), 2.995 (73), 2.884 (37), 3.136 (32), 3.341 (31), 3.047 (30)

Chemistry:

	(1)	(2)	(3)
SO_3	7.10	7.70	7.24
CuO	7.98	6.71	7.19
PbO	81.65	80.36	80.69
H_2O	6.1	[5.23]	4.88
Total	102.83	[100.00]	100.00

(1) Silver King mine, Nevada, USA; by electron microprobe, H_2O determined by TGA; corresponds to $Pb_{4.00}Cu_{1.10}O_{2.00}(SO_4)_{0.97}(OH)_{4.25} \cdot 1.57H_2O$. (2) Mizuhiki mine, Japan; by electron microprobe, H_2O by difference; corresponds to $Pb_{4.00}Cu_{0.94}O_{2.00}(SO_4)_{1.07}(OH)_{3.74} \cdot 1.32H_2O$.
(3) $Pb_4CuO_2(SO_4)(OH)_4 \cdot H_2O$.

Occurrence: Rare in the oxidized zone of base metal sulfides; may be formed in dumps and common in slags.

Association: Galena, langite, serpierite, cerussite, anglesite, litharge, minium.

Distribution: From the Silver King mine, Ward, White Pine Co., Nevada, USA. In Germany, at the Clara mine, near Oberwolfach, from the Altemann rock, at the Freiamt mine, northeast of Freiburg, and from Badenweiler, Black Forest; in the Churfürst mine, Bönkhausen, Sauerland, North Rhine-Westphalia. At the Mizuhiki mine, Fukushima Prefecture, Japan. From Tsumeb, Namibia. At the Red Gill mine, Caldbeck Fells, Cumbria, England. From Leadhills, Lanarkshire, Scotland. In the Esgair Hir mine, Bwlch-y-Esgair, Ceulanymaesmawr, and at the Frongoch mine, Dyfed, Wales. A number of occurrences noted in slags have been omitted.

Name: Honors John H. Ely, nineteenth century frontiersman and promoter of an early mining company in Nevada, USA.

Type Material: The Natural History Museum, London, England, 1972,193.

References: (1) Williams, S.A. (1972) Elyite, basic lead-copper sulfate, a new mineral from Nevada. Amer. Mineral., 57, 646–367. (2) Miyawaki, R., S. Matsubara, and E. Hashimoto (1997) Elyite from the Mizuhiki mine, Fukushima Prefecture, Japan. Bull. Nat. Sci. Museum, Tokyo, C23, 27–33. (3) (1998) Amer. Mineral., 83, 403 (abs. ref. 2). (4) Kolitsch, U. and G. Giester (2000) Elyite, $Pb_4Cu(SO_4)O_2(OH)_4 \cdot H_2O$: crystal structure and new data. Amer. Mineral., 85, 1816–1821.

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Embreyite $Pb_5(PO_4)_2(CrO_4)_2 \cdot H_2O$

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Crystal Data: Monoclinic, pseudorhombohedral. *Point Group:* $2/m$ (probable). Minute tabular crystals, pseudorhombohedral, with apparent $\{10\bar{1}1\}$ and $\{0001\}$, in drusy botryoidal crusts. *Twinning:* Multiple twinning and 60° sector zoning observed optically.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3.5
D(meas.) = 6.45(12) D(calc.) = 6.41

Optical Properties: Translucent to transparent. *Color:* Dull orange, red-violet, dark red, reddish brown; orange in thin section. *Streak:* Yellow. *Luster:* Vitreous, resinous, dull. *Optical Class:* Biaxial (–). *Pleochroism:* X = honey-yellow; $Y = Z$ = amber. *Orientation:* $Y = b$. *Dispersion:* Low. $\alpha = 2.20(4)$ $\beta = 2.36(4)$ $\gamma = 2.36(4)$ 2V(meas.) = 0°–11°

Cell Data: *Space Group:* $[A2/m]$ (probable; by analogy to cassedanneite). $a = 7.135(3)$ $b = 5.636(3)$ $c = 9.599(3)$ $\beta = 115.15(2)°$ Z = 1

X-ray Powder Pattern: Beresovsk, Russia.
3.167 (100), 4.751 (60), 2.818 (60), 1.917 (45), 3.563 (32), 2.213 (32), 2.187 (31)

Chemistry:

	(1)	(2)
CrO_3	13.46	13.55
P_2O_5	9.13	9.62
Fe_2O_3	0.02	
CuO	1.71	
ZnO	0.04	
PbO	74.73	75.61
H_2O	0.91	1.22
Total	[100.00]	100.00

(1) Beresovsk, Russia; by electron microprobe and AA, average of five analyses, H_2O by TGA; corresponds to $Pb_{4.97}(PO_4)_{1.91}(CrO_4)_{2.00} \cdot 0.75H_2O$. (2) $Pb_5(PO_4)_2(CrO_4)_2 \cdot H_2O$.

Occurrence: On museum samples from the oxidized zone of gold-bearing quartz veins (Beresovsk, Russia).

Association: Crocoite, phoenicochroite, vauquelinite, cassedanneite, cerussite (Beresovsk, Russia); crocoite, vauquelinite, fornacite, pyromorphite, mimetite, cerussite (Callenberg mine, Germany).

Distribution: From the Beresovsk gold deposit, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. At the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa. In the Callenberg mine, near Hohenstein-Ernstthal, Saxony, Germany.

Name: To honor Peter Godwin Embrey (1929–), English mineralogist, British Museum (Natural History), London, England.

Type Material: The Natural History Museum, London, England, 39316.

References: (1) Williams, S.A. (1972) Embreyite, a new mineral from Berezov, Siberia. Mineral. Mag., 38, 790–793. (2) (1973) Amer. Mineral., 58, 806 (abs. ref. 1). (3) Cesbron, F., R. Giraud, F. Pillard, and J.-F. Poullen (1988) La cassedannéite, nouveau chromo-vanadate de plomb de Beresovsk (Oural). Compt. Rendus Acad. Sci. Paris, 306, 125–127 (in French with English abs.).

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Emeleusite $Na_4Li_2Fe_2^{3+}Si_{12}O_{30}$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral crystals, tabular ∥ {010} and elongated along [100], to 2 mm; in pseudohexagonal twins; as equidimensional grains. *Twinning:* Interpenetration triplets with {110} as twin plane.

Physical Properties: Hardness = 5–6 D(meas.) = 2.76(7) D(calc.) = 2.81

Optical Properties: Transparent. *Color:* Colorless to creamy pinkish. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, very strong. $\alpha = 1.596(1)$ $\beta = 1.597(1)$ $\gamma = 1.597(1)$ 2V(meas.) = 0°–30°

Cell Data: *Space Group: Acam.* $a = 10.072(3)$ $b = 17.337(6)$ $c = 14.004(3)$ Z = 8

X-ray Powder Pattern: Island of Igdlutalik, Greenland.
4.352 (100), 3.209 (80), 3.501 (70), 3.090 (70), 4.087 (60), 3.192 (60), 2.875 (60)

Chemistry:

	(1)
SiO_2	70.75
TiO_2	0.55
ZrO_2	0.10
Al_2O_3	1.34
Fe_2O_3	12.13
MnO	0.03
MgO	0.10
CaO	0.00
Li_2O	2.78
Na_2O	11.98
K_2O	0.00
Total	99.76

(1) Island of Igdlutalik, Greenland; by electron microprobe, Li by flame photometry; corresponds to $Na_{3.96}Li_{1.91}(Fe^{3+}_{1.56}Al_{0.27}Ti_{0.07}Mg_{0.03}Zr_{0.01})_{\Sigma=1.94}Si_{12.05}O_{30}$.

Mineral Group: Milarite group.

Occurrence: A minor constituent of a peralkalic trachyte dike, in flow-banded aegirine-albite-rich layers.

Association: Albite, aegirine, quartz, riebeckite, micas, zircon, pectolite, apatite, calcite, titanian narsarsukite, zincian nordite, thorite, opaque oxides.

Distribution: On the Island of Igdlutalik, Julianehåb district, Greenland.

Name: To honor Dr. Charles Henry Emeleus, University of Durham, Durham, England.

Type Material: University of Copenhagen, Copenhagen, Denmark; Department of Geology, Edinburgh University, Edinburgh, Scotland; The Natural History Museum, London, England, 1987,118; National Museum of Natural History, Washington, D.C., USA, 146464.

References: (1) Upton, B.G.J., P.G. Hill, O. Johnsen, and O.V. Petersen (1978) Emeleusite: a new $LiNaFe^{III}$ silicate from south Greenland. Mineral. Mag., 42, 31–34. (2) (1979) Amer. Mineral., 64, 242 (abs. ref. 1). (3) Johnsen, O., K. Nielsen, and I. Sotofte (1978) The crystal structure of emeleusite, a novel example of sechser-doppelkette. Zeits. Krist., 147, 297–306.

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Emmonsite $Fe_2^{3+}Te_3^{4+}O_9 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals thin, scaly to hairlike, to 5 mm, in rosettes and sprays; in fibrous globular aggregates and crusts, microcrystalline massive. *Twinning:* Noted.

Physical Properties: *Cleavage:* Perfect on {010}; good on {100} and {001}. Hardness = ~5 D(meas.) = 4.52–4.55 D(calc.) = 4.719

Optical Properties: Opaque to translucent, transparent in small grains. *Color:* Yellowish green; pale yellow-green in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Orientation:* $Y = b$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > X$. $\alpha = 1.962(2)$ $\beta = 2.09(2)$ $\gamma = 2.10(2)$ 2V(meas.) = ≤20°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.90(1)$ $b = 8.00(1)$ $c = 7.62(1)$ $\alpha = 96°44(10)'$ $\beta = 95°00(10)'$ $\gamma = 84°28(10)'$ Z = 2

X-ray Powder Pattern: Goldfield, Nevada, USA.
3.14 (10), 2.87 (9), 2.52 (9), 3.69 (8), 2.67 (8), 1.80 (8), 5.81 (7)

Chemistry:

	(1)	(2)
TeO_2	71.80	70.98
Al_2O_3	0.58	
Fe_2O_3	22.81	23.68
H_2O	4.82	5.34
Total	100.01	100.00

(1) Cripple Creek, Colorado, USA; corresponds to $(Fe_{1.91}Al_{0.08})_{\Sigma=1.99}Te_{3.01}O_{9.00} \cdot 1.78H_2O$.
(2) $Fe_2Te_3O_9 \cdot 2H_2O$.

Occurrence: An alteration product formed from earlier tellurium minerals in the oxide zone of some hydrothermal precious metal deposits.

Association: Tellurium, tellurite, rodalquilarite, mackayite, sonoraite, cuzticite, eztlite, gold, pyrite.

Distribution: In the USA, from the W.P.H., Moose, and Deadwood mines, Cripple Creek, Teller Co., Colorado; in the Toughnut-Empire mine and between the Joe and Grand Central mines, Tombstone, Cochise Co., Arizona; from the Wilcox district, Catron Co., and the Sylvanite district, Hidalgo Co., New Mexico; at the Mohawk mine, Goldfield, Esmeralda Co., Nevada; from the Clinton mine, Lawrence Co., South Dakota. In the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. At the El Plomo mine, Tegucigalpa, Honduras. In the Wendy open pit, Tambo, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. From the Zod gold deposit, 14 km east of Vardenis, Armenia.

Name: To honor Samuel Franklin Emmons (1841–1911), American economic geologist, U.S. Geological Survey.

Type Material: Yale University, New Haven, Connecticut, 5.6300; Harvard University, Cambridge, Massachusetts, USA, 97503.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 640–641. (2) Gaines, R.V. (1972) New data on emmonsite and a second locality for sonoraite. Mineral. Record, 3, 82–84. (3) Pertlik, F. (1972) Der Strukturtyp von Emmonsit, $\{Fe_2[TeO_3]_3 \cdot H_2O\} \cdot xH_2O$ (x = 0–1). Tschermaks Mineral. Petrog. Mitt., 18, 157–168 (in German with English abs.). (4) Williams, S.A. (1980) The Tombstone district, Cochise Co., Arizona. Mineral. Record, 11, 251–256.

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Emplectite $Cu^{1+}BiS_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are small, prismatic and striated parallel [001], flattened on {010}. *Twinning:* Observed in polished section, of unknown law.

Physical Properties: *Cleavage:* Perfect on {010}, less so on {001}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2 VHN = n.d. D(meas.) = 6.38 D(calc.) = 6.393

Optical Properties: Opaque. *Color:* Grayish to tin-white; pale yellow in polished section. *Luster:* Metallic. *Pleochroism:* Very low.
R_1–R_2: (400) 34.6–35.8, (420) 35.4–36.5, (440) 36.2–37.5, (460) 36.8–39.0, (480) 37.2–40.4, (500) 37.6–41.4, (520) 37.6–42.0, (540) 37.4–42.2, (560) 37.2–42.3, (580) 37.0–42.3, (600) 37.0–42.1, (620) 37.1–41.7, (640) 37.1–41.1, (660) 37.1–40.6, (680) 36.8-40.1, (700) 36.6–39.7

Cell Data: *Space Group: Pnma.* a = 6.1426(3) b = 3.9189(4) c = 14.5282(7) Z = 4

X-ray Powder Pattern: Tannenbaum mine, Germany.
3.05 (10), 3.23 (9), 3.13 (7), 7.38 (5), 2.34 (5), 2.17 (4), 1.863 (2)

Chemistry:

	(1)	(2)	(3)
Cu	18.80	18.8	18.88
Bi	61.95	64.0	62.08
S	19.16	18.4	19.04
Total	99.91	101.2	100.00

(1) Tannenbaum mine, Germany; average of two analyses. (2) Sadisdorf, Germany; by electron microprobe. (3) $CuBiS_2$.

Occurrence: In hydrothermal veins with other sulfides and sulfosalts formed at medium temperatures.

Association: Chalcopyrite, pyrite, sphalerite, molybdenite, quartz, fluorite (Horní Slavkov, Czech Republic); tetrahedrite–tennantite, luzonite–famatinite, pyrite, mawsonite, nekrasovite, chalcopyrite, laitakarite, bismuth, calcite, quartz, barite (Khayragatsch deposit, Uzbekistan).

Distribution: In Germany, in Saxony, sharp crystals from Johanngeorgenstadt [TL]; in the Tannenbaum mine, near Schwarzenberg; from Schneeberg, Annaberg, the Sadisdorf copper mine, near Schmiedeberg, and other localities; from Wittichen, Black Forest. In the Czech Republic, at Krupka, Horní Slavkov (Schlaggenwald), and Cínovec (Zinnwald). In Norway, at the Åmdal copper mines, Telemark. In Scotland, from Corrie Buie, Meal nan Oighreag, Perthshire. In the Khayragatsch gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. From Japan, in the Akenobe mine, Hyogo Prefecture, the Hade mine, Okayama Prefecture, and the Shin-Ohtoyo deposit, Hokkaido. In Mexico, from the El Cobre mine, Concepción del Oro, Zacatecas. At Bisbee, Cochise Co., Arizona, USA. In Chile, from Cerro Blanco, near Copiapó, Atacama, and in the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo. Chile. In the Jules Verne mine, Salta Province, Argentina. Additional minor occurrences are known.

Name: From the Greek for *interwoven* or *entwined*; in reference to its sometimes intimate association with quartz.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 435–437. (2) Portheine, J.C. and W. Nowacki (1975) Refinement of the crystal structure of emplectite, $CuBiS_2$. Zeits. Krist., 141, 387–402. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 145–146.

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Empressite AgTe

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As compact, granular masses; crystals rare, to 400 μm.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3.5 VHN = 108–133; 142 (25 g load). D(meas.) = 7.61(1) D(calc.) = 7.59

Optical Properties: Opaque. *Color:* Pale bronze; grayish white in reflected light. *Streak:* Gray-black to black. *Luster:* Metallic. *Pleochroism:* Very strong, in gray to creamy white. *Anisotropism:* Strong, gray to yellowish white to grayish blue. *Bireflectance:* Strong. R_1–R_2: (400) 36.6–42.8, (420) 37.1–44.2, (440) 37.5–45.8, (460) 37.8–47.8, (480) 38.1–49.6, (500) 38.7–51.0, (520) 39.3–51.9, (540) 39.8–52.6, (560) 40.0–52.8, (580) 40.0–52.8, (600) 40.0–52.9, (620) 39.9–53.1, (640) 39.8–53.5, (660) 39.7–53.8, (680) 39.5–53.9, (700) 39.4–54.0

Cell Data: *Space Group: Pmnb.* $a = 8.882(1)$ $b = 20.100(5)$ $c = 4.614(1)$ $Z = 16$

X-ray Powder Pattern: Empress Josephine mine, Colorado, USA.
2.70 (100), 2.23 (80), 3.81 (60), 3.33 (60), 3.18 (50), 2.14 (50), 2.04 (50)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	45.17	44.9	45.2	45.81
Fe	0.22			
Te	54.75	55.8	54.9	54.19
insol.	0.39			
Total	100.53	100.7	100.1	100.00

(1) Empress Josephine mine, Colorado, USA; average of two analyses, corresponding to $Ag_{0.98}Te_{1.00}$. (2) Do.; by electron microprobe, corresponding to $Ag_{0.95}Te_{1.00}$. (3) Do.; by electron microprobe, corresponding to $Ag_{0.97}Te_{1.00}$. (4) AgTe.

Occurrence: In low-temperature gold-poor hydrothermal vein deposits.

Association: Tellurium, sylvanite, petzite, hessite, rickardite, altaite, galena (Empress Josephine mine, Colorado, USA); pyrite, rodalquilarite (Tombstone, Arizona, USA); gold, tellurium, hessite, petzite, rickardite (Pitman, Canada).

Distribution: In the USA, in Colorado, from the Empress Josephine mine, Kerber Creek district [TL], and the Klondike mine, Finley Gulch, both in Saguache Co.; the May Day mine, La Plata Co.; and the Red Cloud, Rex, and other mines, Boulder Co.; from Tombstone, Cochise Co., Arizona. In Canada, from the Grotto group of pits, near Pitman, British Columbia, and the Quetico intrusions, northwestern Ontario. At Kalgoorlie, Western Australia. From the Emperor mine, Vatukoula, Viti Levu, Fiji Islands. At the Kawazu mine, Shizuoka Prefecture, Japan. In the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. At Sulitjelma, Norway. From the Huangshaping Pb–Zn deposit, Guiyang, Hunan Province, China.

Name: For the Empress Josephine mine, Colorado, USA.

Type Material: University of Colorado, Boulder, Colorado, 1649; Harvard University, Cambridge, Massachusetts, 106761; National Museum of Natural History, Washington, D.C., USA, R7243, 117368.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 260. (2) Honea, R.M. (1964) Empressite and stuetzite redefined. Amer. Mineral., 49, 325–383. (3) Stumpfl, E.F. and J. Rucklidge (1968) New data on natural phases in the system Ag–Te. Amer. Mineral., 53, 1513–1522. (4) Bindi, L., P.G. Spry, and C. Cipriani (2004) Empressite, AgTe, from the Empress-Josephine mine, Colorado, U.S.A.: composition, physical properties, and determinatioon ofthe crystal structure. Amer. Mineral., 89, 1043–1047. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 154.

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Enargite Cu_3AsS_4

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Tabular on {001}; also prismatic by elongation of [001]; crystals up to 15 cm. Prism zone typically deeply striated ‖ [001]. *Twinning:* Twin plane {320} common, rarely as interpenetrating pseudohexagonal trillings.

Physical Properties: *Cleavage:* Perfect on {110}, distinct on {100} and {010}, indistinct on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3 VHN = n.d. D(meas.) = 4.45 D(calc.) = 4.40

Optical Properties: Opaque. *Color:* Grayish black to iron-black; in polished section, gray to pale pink-brown, deep red internal reflections may be observed. *Streak:* Grayish black. *Luster:* Metallic to dull. *Pleochroism:* Weak. *Anisotropism:* Very strong, dark violet-red or olive-green tones.
R_1–R_2: (400) 24.8–26.2, (420) 26.6–26.0, (440) 26.5–25.6, (460) 26.5–25.9, (480) 26.2–25.8, (500) 25.6–25.6, (520) 24.9–25.3, (540) 24.4–25.2, (560) 24.0–25.2, (580) 23.8–25.4, (600) 23.8–25.9, (620) 24.1–26.5, (640) 24.6–26.9, (660) 25.2–26.9, (680) 25.6–26.8, (700) 25.7–26.7

Cell Data: *Space Group:* $Pmn2_1$. $a = 7.407(1)$ $b = 6.436(1)$ $c = 6.154(1)$ $Z = 2$

X-ray Powder Pattern: Butte, Montana, USA (shows preferred orientation on [*hk*0]). 3.219 (100), 3.208 (100), 2.846 (83), 1.8567 (72), 1.8514 (62), 1.7285 (48), 3.076 (41)

Chemistry:

	(1)	(2)	(3)
Cu	47.96	49.8	48.42
Fe	1.22		
Zn	0.57		
Sb		1.0	
As	18.16	18.8	19.02
S	32.21	32.3	32.56
Total	100.12	101.9	100.00

(1) Cerro Blanco, Chile. (2) Bor, Serbia; by electron microprobe. (3) Cu_3AsS_4.

Polymorphism & Series: Dimorphous with luzonite.

Occurrence: In hydrothermal vein deposits formed at medium temperatures. Also as a late-stage mineral in low-temperature deposits.

Association: Pyrite, sphalerite, galena, bornite, tetrahedrite–tennantite, chalcocite, covellite, barite, quartz.

Distribution: A widespread mineral, may be an important ore of copper, but not commonly well-crystallized. Only a few localities can be mentioned. In Peru, from Morococha [TL] and Cerro de Pasco, with exceptional crystals from the Mina Luz Angelica, Quiruvilca. In Argentina, in the Sierra de Famatina, La Rioja Province. In the Philippine Islands, at Mancayan, Luzon. From the Chinkuashi mine, Keelung, Taiwan. At Kaize-mura, Nagano Prefecture, and in the Teine mine, Hokkaido, Japan. In the USA, in splendent crystals from Butte, Silver Bow Co., Montana; in Utah, in the Tintic district, Juab Co.; in Colorado, in fine specimens from a number of mines in the Red Mountain district, San Juan Co. In Austria, at Matzenköpfl, Brixlegg, Tirol. From Bor, Serbia. In Italy, on Sardinia, at Alghero and Calabona. At Tsumeb, Namibia.

Name: From the Greek for *distinct*, in allusion to its cleavage.

Type Material: Mining Academy, Freiberg, Germany, 6929.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 389–391. (2) Adiwidjaja, G. and J. Löhn (1970) Strukturverfeinerung von Enargit, Cu_3AsS_4. Acta Cryst., 26, 1878–1879 (in German with English abs.). (3) Pósfai, M. and M. Sundberg (1998) Stacking disorder and polytypism in enargite and luzonite. Amer. Mineral., 83, 365–372. (4) NBS. Mono. 25, 21, 68. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 155.

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Englishite $K_3Na_2Ca_{10}Al_{15}(PO_4)_{21}(OH)_7 \cdot 26H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As plates, in subparallel aggregates, in crusts to 1 mm thick; as friable masses.

Physical Properties: *Cleavage:* On {001}, perfect, micaceous. *Tenacity:* Flexible. Hardness = ∼3 D(meas.) = 2.65–2.68 D(calc.) = 2.69

Optical Properties: Transparent. *Color:* White to colorless, grayish green; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y \simeq a$; $Z \simeq b$. $\alpha = 1.570(5)$ $\beta = 1.572(5)$ $\gamma = 1.573(5)$ 2V(meas.) = Small.

Cell Data: *Space Group:* $A2/a$ or Aa. $a = 38.43(2)$ $b = 11.86$ $c = 20.67$ $\beta = 111°16'$ Z = 4

X-ray Powder Pattern: Fairfield, Utah, USA.
8.94 (10), 17.66 (9), 2.84 (8), 5.57 (6), 2.96 (6), 2.68 (6), 1.71 (5)

Chemistry:

	(1)	(2)	(3)
P_2O_5	41.6	41.0	41.97
Al_2O_3	21.5	21.8	21.54
FeO	0.0	2.5	
MgO	0.1	0.1	
CaO	15.5	15.8	15.79
Na_2O	1.6	0.9	1.75
K_2O	4.0	3.6	3.98
H_2O	15.1	[14.9]	14.97
Total	99.4	[100.6]	100.00

(1) Little Green Monster mine, Utah, USA; by electron microprobe, H_2O by the Penfield method, average of three analyses; corresponds to $K_{3.01}Na_{1.83}(Ca_{9.79}Mg_{0.09})_{\Sigma=9.88}Al_{14.94}(PO_4)_{20.77}(OH)_{7.11} \cdot 26.14H_2O$. (2) Tip Top mine, South Dakota, USA; by electron microprobe, H_2O from stoichiometry. (3) $K_3Na_2Ca_{10}Al_{15}(PO_4)_{21}(OH)_7 \cdot 26H_2O$.

Occurrence: In variscite nodules (Little Green Monster mine, Utah, USA); in a complex granite pegmatite (Tip Top mine, South Dakota, USA).

Association: Variscite, montgomeryite, wardite, millisite, crandallite (Little Green Monster mine, Utah, USA); montgomeryite, eosphorite–childrenite, tiptopite, roscherite, pahasapaite, parafransoletite, robertsite, mitridatite, whitlockite (Tip Top mine, South Dakota, USA).

Distribution: In the USA, from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah; in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; at the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., the Miekle mine, Lynn district, Elko Co., and the Redhouse barite mine, Potosi disict, Humboldt Co., Nevada.

Name: To honor George Letchworth English (1864–1944), New York City, New York, USA, American mineral dealer and collector.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 95494.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 957–958. (2) Dunn, P.J., R.C. Rouse, and J.A. Nelen (1984) Englishite: new chemical data and a second occurrence from the Tip Top pegmatite, Custer, South Dakota. Can. Mineral., 22, 469–470. (3) Moore, P.B, (1976) Derivative structures based on the alunite octahedral sheet: mitridatite and englishite. Mineral. Mag., 40, 863–866.

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Enstatite $Mg_2Si_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, to 40 cm; commonly lamellar, fibrous, or massive. *Twinning:* Simple and lamellar twinning on {100}.

Physical Properties: *Cleavage:* Good, {210}, (210) ∧ $(2\bar{1}0)$ ∼88°; partings on {100} and {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.2–3.9 D(calc.) = 3.189

Optical Properties: Translucent to opaque. *Color:* White, grayish, yellowish, greenish, olive-green, brown; colorless in thin section. *Streak:* White to grayish. *Luster:* Vitreous to pearly on cleavages.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, weak to moderate. $\alpha = 1.649$–1.667 $\beta = 1.653$–1.671 $\gamma = 1.657$–1.680 2V(meas.) = 55°–90°

Cell Data: *Space Group: Pbca*. $a = 18.23$ $b = 8.84$ $c = 5.19$ Z = 8

X-ray Powder Pattern: Bamble, Norway.
3.175 (100), 2.878 (55), 2.540 (25), 1.488 (25), 2.497 (18), 2.477 (18), 1.473 (18)

Chemistry:

	(1)		(1)
SiO_2	58.48	MnO	0.02
TiO_2	trace	MgO	34.71
Al_2O_3	0.88	CaO	0.50
Fe_2O_3	0.72	Na_2O	0.23
Cr_2O_3	0.25	K_2O	0.08
FeO	3.93	H_2O^-	0.21
		Total	100.01

(1) Maliba Matso, Lesotho; corresponds to $(Mg_{1.77}Fe^{2+}_{0.11}Al_{0.04}Ca_{0.02}Na_{0.02}Fe^{3+}_{0.02})_{\Sigma=1.98}Si_{2.00}O_6$.

Polymorphism & Series: Dimorphous with clinoenstatite; forms a series with ferrosilite.

Mineral Group: Pyroxene group.

Occurrence: In pyroxenites, peridotites, and dunites; in ultramafic inclusions in alkalic olivine basalts and kimberlite; in mafic volcanics, rarely in felsic volcanics. Characteristic of charnockites and the granulite metamorphic facies, in regionally metamorphosed rocks and metagabbros. Common in chondrite, achondrite, and stony-iron meteorites.

Association: Olivine, phlogopite, clinopyroxene, diopside, spinel, pyrope.

Distribution: Prominent localities for well-studied material include: from Ždár (Zdjarberg), Czech Republic. At Ødegården and Kjörrestad, Bamble, Norway. From The Lizard, Cornwall, England. At Dawros, Co. Connaught, Ireland. From Kupferberg, Bavaria, and the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. At Kraubath, Styria, Austria. Fine crystals from Mbeya, Tanzania. At Liahobong, Lesotho. In the USA, at Webster, Jackson Co., and on Corundum Hill, Macon Co., North Carolina; at Wood's chrome mine and Texas, Lancaster Co., and elsewhere in Pennsylvania. Gem material from Embilipituya, Sri Lanka.

Name: From the Greek for *opponent*, in allusion to its refractory nature under the blowpipe.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 346–348. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 20–162. (3) Pollack, S.S. and W.D. Ruble (1964) X-ray identification of ordered and disordered orthoenstatite. Amer. Mineral., 49, 983–992.

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Eosphorite $Mn^{2+}Al(PO_4)(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$; pseudo $2/m$ $2/m$ $2/m$. Typically as crystals, short to long prismatic on [001], to 20 cm; in planar radial or spherical radiating groups, with wedge-shaped terminations; globular, rarely massive. *Twinning:* May show twinning on {100} and {001}, observed optically, to give pseudo-orthorhombic symmetry; perhaps due to oxidation.

Physical Properties: *Cleavage:* {100}, poor. *Fracture:* Subconchoidal to uneven. Hardness = 5 D(meas.) = 3.06–3.08 D(calc.) = 3.04

Optical Properties: Transparent to translucent. *Color:* Pink to rose-red, commonly brown to black when oxidized. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (–). *Pleochroism:* X = yellow; Y = pink; Z = pale pink to colorless. *Orientation:* $X = b$; $Y = a$; $Z = c$; $Y \wedge c = 4°$–$8°$ in optically twinned individuals. *Dispersion:* $r < v$, strong, for near end-member composition. $\alpha = 1.628$–1.644 $\beta = 1.648$–1.673 $\gamma = 1.657$–1.679 2V(meas.) = $45°$–$50°$ in optically twinned crystals.

Cell Data: *Space Group:* $P2_1/m$. $a = 10.455(1)$ $b = 13.501(2)$ $c = 6.928(1)$ $\beta = 90.0°$ Z = 8

X-ray Powder Pattern: Newry, Maine, USA. (ICDD 17-131).
2.826 (100), 2.422 (60b), 5.23 (50), 4.39 (50), 3.55 (50), 3.41 (50), 1.535 (50b)

Chemistry:

	(1)	(2)
P_2O_5	29.89	31.00
Al_2O_3	22.37	22.27
FeO	1.38	
MnO	29.94	30.99
H_2O	15.34	15.74
insol.	0.90	
Total	99.82	100.00

(1) Buckfield, Oxford Co., Maine, USA. (2) $MnAl(PO_4)(OH)_2 \cdot H_2O$.

Polymorphism & Series: Forms a series with childrenite.

Occurrence: Typically a secondary mineral in some phosphate-bearing granite pegmatites.

Association: Rhodochrosite, lithiophilite, triploidite, dickinsonite (Branchville, Connecticut, USA); albite, cookeite, apatite, beryllonite, hydroxyl-herderite, tourmaline (Newry, Maine, USA).

Distribution: In the USA, from Branchville, Fairfield Co., Connecticut; at a number of places around Newry, in the Red Hill and Black Mountain quarries, Rumford, Oxford Co., and elsewhere in Maine; in the Hugo mine, 1.5 km south of Keystone, Pennington Co., South Dakota; from the Foote mine, near Kings Mountain, Cleveland Co., North Carolina; in the White Picacho district, Maricopa and Yavapai Cos., Arizona. At Hagendorf, Bavaria, and on the Greifensteine, near Ehrenfriedersdorf, Saxony, Germany. In the Viitaniemi pegmatite, Eräjärvi, Finland. In Brazil, large crystals from the Lavra da Ilha pegmatite, in the Jequitinhonha River, three km north of Taquaral; in the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares; at the João Modesto dos Santos mine, and from a number of other mines around Linópolis and Mendes Pimental, Minas Gerais, Brazil. From Wycheproof, Victoria, Australia.

Name: From the Greek for *dawn-bearing*, in allusion to the pink color.

Type Material: Yale University, New Haven, Connecticut, USA, 3.3231, 3.5847.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 936–939. (2) Hurlbut, C. (1950) Childrenite-eosphorite series. Amer. Mineral., 35, 793–805. (3) Pajunen, A. and S.I. Lahti (1984) The crystal structure of viitaniemiite. Amer. Mineral., 69, 961–966. (4) Hoyos, M.A., T. Calderon, I. Vergara, and J. Garcia-Solé (1993) New structural and spectroscopic data for eosphorite. Mineral. Mag., 57, 329–336.

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Ephesite $NaLiAl_2(Al_2Si_2)O_{10}(OH)_2$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* 1. As books and flakes, to 13 mm. *Twinning:* Commonly twinned about [310] or [$3\bar{1}0$].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.984 D(calc.) = 2.965

Optical Properties: Translucent. *Color:* Pink. *Luster:* Vitreous, pearly on cleavage. *Optical Class:* Biaxial (–). *Dispersion:* $r < v$. $\alpha = 1.592$ $\beta = 1.624$ $\gamma = 1.625$ 2V(meas.) = 28°

Cell Data: *Space Group:* $C1$. $a = 5.123(2)$ $b = 8.872(3)$ $c = 19.307(3)$ $\alpha = 89.97(2)°$ $\beta = 95.15(2)°$ $\gamma = 89.96(2)°$ Z = 4

X-ray Powder Pattern: Postmasburg district, South Africa.
3.20 (100), 9.59 (65), 1.922 (25), 2.52 (20), 4.81 (16), 1.478 (16), 4.41 (10)

Chemistry:

	(1)	(2)	(3)
SiO_2	30.70	30.86	30.97
TiO_2		0.03	
Al_2O_3	55.67	51.68	52.55
Fe_2O_3		0.47	
FeO		0.03	
MnO		0.12	
MgO		0.09	
CaO	2.55	0.02	
BaO		0.17	
Li_2O		3.52	3.85
Na_2O	5.52	7.44	7.99
K_2O	1.10	0.15	
H_2O^+	4.91	4.92	4.64
H_2O^-		0.06	
Total	100.45	99.57	100.00

(1) Gumuch-dagh, Turkey; Li perhaps analyzed as Na and K. (2) Postmasburg district, South Africa. (3) $NaLiAl_2(Al_2Si_2)O_{10}(OH)_2$.

Polymorphism & Series: $2M_1$, 1M polytypes.

Mineral Group: Mica group.

Occurrence: In an emery deposit (Gumuch-dagh, Turkey); a minor constituent in manganese oxide ore (Postmasburg district, South Africa).

Association: Corundum, magnetite (Gumuch-dagh, Turkey); diaspore, braunite, bixbyite (Postmasburg district, South Africa).

Distribution: Some material from the original locality at Gumuch-dagh, near Ephesus, Turkey was later determined to be a mixture, but has not been reexamined by modern methods. From Lohatla, Postmasburg district, Transvaal, and in the Wessels mine, near Kuruman, Cape Province, South Africa. In the Ilímaussaq intrusion, southern Greenland.

Name: For Ephesus, Turkey, near where it may occur.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 707. (2) Schaller, W.T., M.K. Carron, and M. Fleischer (1967) Ephesite, $Na(Li,Al_2)(Al_2Si_2)O_{10}(OH)_2$, a trioctahedral member of the margarite group, and related brittle micas. Amer. Mineral., 52, 1689–1696. (3) Gallagher, M.J. and J.R. Hawkes (1966) Beryllium minerals from Rhodesia and Uganda. Bull. Geol. Sur. Great Britain, 25, 59–75. (4) Slade, P.G., P.K. Schultz, and C. Dean (1987) Refinement of the ephesite structure in C1 symmetry. Neues Jahrb. Mineral., Monatsh., 275–287.

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Epididymite $NaBeSi_3O_7(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As pseudohexagonal crystals, tabular on {001}, also elongated along [010], to 6 cm. Micaceous, spherulitic, fine to coarse granular, porcelaneous massive. *Twinning:* On {001}, common, simple and polysynthetic; also as trillings.

Physical Properties: *Cleavage:* Perfect on {001}, distinct on {100}. *Fracture:* Uneven to conchoidal when massive. Hardness = 5.5 D(meas.) = 2.55–2.61 D(calc.) = 2.56

Optical Properties: Transparent to translucent. *Color:* Colorless, white, also tinted violet, blue, or yellow when finely crystalline. *Luster:* Pearly on cleavages, vitreous on fractures. *Optical Class:* Biaxial (+) or (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, distinct, crossed. $\alpha = 1.536$–1.544 $\beta = 1.51$–1.544 $\gamma = 1.542$–1.546 2V(meas.) = 16°–32° 2V(calc.) = 26°

Cell Data: *Space Group: Pnma.* $a = 12.74(1)$ $b = 13.63(1)$ $c = 7.33(1)$ Z = 8

X-ray Powder Pattern: Narssârssuk, Greenland.
3.37 (10), 3.08 (10), 2.96 (10), 1.790 (6), 1.634 (6), 2.48 (5), 1.537 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	73.74	71.79	73.49
Al_2O_3		1.94	
Fe_2O_3		0.12	
BeO	10.56	10.45	10.20
MgO		trace	
CaO		0.16	
Na_2O	12.88	11.43	12.64
K_2O		0.30	
H_2O^+	3.73	4.14	3.67
H_2O^-		0.03	
Total	100.91	100.36	100.00

(1) Narssârssuk, Greenland. (2) Mt. Karnasurt, Russia. (3) $NaBeSi_3O_7(OH)$.

Polymorphism & Series: Dimorphous with eudidymite.

Occurrence: A late-stage mineral in nepheline syenite pegmatites.

Association: Albite, aegirine, eudialyte, elpidite, neptunite, tugtupite, leucophanite, natrolite, analcime.

Distribution: At Narssârssuk and in the Ilímaussaq intrusion, southern Greenland. On Arø Island, in the Langesundsfjord, and in the Vevja quarry, Tvedalen, Norway. On the Kola Peninsula, in the Lovozero massif, on Mts. Karnasurt and Alluaiv, and at Kuivchorr, and in the Khibiny massif; from the Murun massif, southwest of Olekminsk, Yakutia, Russia. At Věžná, Czech Republic. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada. In the USA, near Quincy, Norfolk Co., Massachusetts. Large crystals on Mt. Malosa, Zomba district, Malawi.

Name: The prefix *epi* from the Greek for *near*, referring to the dimorphous relation with *eudidymite*.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 24–25. (2) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 433–438 (in English). (3) Petersen, O.V. (1966) Crossed axial plane dispersion in epididymite. Amer. Mineral., 51, 916–919. (4) Mandarino, J.A. and D.C. Harris (1969) Epididymite from Mont St. Hilaire, Quebec. Can. Mineral., 9, 706–709. (5) Robinson, P.D. and J.H. Fang (1970) The crystal structure of epididymite. Amer. Mineral., 55, 1541–1549.

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Epidote-(Sr) $CaSrAl_2Fe^{3+}(Si_2O_7)(SiO_4)(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals prismatic, to 1 cm; as radial aggregates of acicular to columnar crystals. Twinning on (100).

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 6.5 D(meas.) = n.d. D(calc.) = 3.74

Optical Properties: Translucent. *Color*: Brown to pale reddish brown. *Streak*: n.d. *Luster*: n.d. *Optical Class*: Biaxial (-). α = 1.737(2) β = 1.780(2) γ = 1.792(2) 2V(calc) = 62° *Pleochroism*: *X* = pale greenish yellow; *Y* = *Z* = pale reddish brown to brownish pink.

Cell Data: *Space Group*: $P2_1/m$. a = 8.928(5) b = 5.652(1) c = 10.244(5) β = 114.46(4)° Z = 2

X-ray Powder Pattern: Nagakawara deposit, Ananai mine, Kochi Prefecture, Japan. 2.92 (100), 2.58 (49), 3.50 (42), 2.61 (42), 2.72 (41), 2.83 (32), 3.26 (23)

Chemistry:

	(1)
CaO	11.72
SrO	17.63
Mn_2O_3	2.96
Fe_2O_3	13.17
Al_2O_3	18.53
SiO_2	34.32
H_2O	1.71
Total	100.04

(1) Nagakawara deposit, Ananai mine, Kochi Prefecture, Japan; average of 41 electron microprobe analyses, H_2O calculated, corresponding to $(Ca_{1.10}Sr_{0.90})_{\Sigma=2.00}(Al_{1.92}Fe^{3+}_{0.87}Mn^{3+}_{0.20})_{\Sigma=2.99}Si_{3.01}O_{12}(OH)$.

Mineral Group: Epidote group, clinozoizite subgroup.

Occurrence: A late-stage hydrothermal vein mineral in a tinzenite deposit in metachert (Nagakawara deposit) and in piemontite breccias (Hohnomori deposit).

Association: Calcite, tinzenite, piemontite-(Sr).

Distribution: Nagakawara and Hohnomori deposits, Ananai mine, Kochi Prefecture, Japan.

Name: For its chemical composition as a member of the epidote group.

Type Material: Hokkaido University museum, Sapporo, Japan (Mineral-07400).

References: (1) Minakawa, T., H. Fukushima, D. Nishio-Hamane, and H. Miura (2008) Epidote-(Sr), $CaSrAl_2Fe^{3+}(Si_2O_7)(SiO_4)(OH)$, a new mineral from the Ananai mine, Kochi Prefecture, Japan. J. Mineral. Petrol. Sci., 103, 400–406. (2) (2009) Amer. Mineral., 94, 1078 (abs. ref. 1).

Epidote $Ca_2Al_2(Fe^{3+}, Al)(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, to 35 cm, commonly elongated and striated ‖ [010]. Fibrous, coarse to fine granular, massive. *Twinning:* On {100}, contact, lamellar, common.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 3.38–3.49 D(calc.) = 3.391–3.464

Optical Properties: Transparent to nearly opaque. *Color:* Pistachio-green to pale green, yellow, yellowish green, greenish yellow, greenish black; yellow-green in thin section. *Luster:* Vitreous, pearly, somewhat resinous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless, pale yellow, pale green; Y = greenish yellow; Z = yellowish green. *Orientation:* $Y = b$. *Dispersion:* $r > v$. $\alpha = 1.715–1.751$ $\beta = 1.725–1.784$ $\gamma = 1.734–1.797$ 2V(meas.) = 90°–116°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.8877(14)$ $b = 5.6275(8)$ $c = 10.1517(12)$ $\beta = 115.383(14)°$ Z = 2

X-ray Powder Pattern: Bourg d'Oisans, [France].
2.900 (100), 2.679 (100), 2.688 (70), 4.02 (50), 2.599 (50), 2.460 (50), 3.40 (40)

Chemistry:

	(1)		(1)
SiO_2	36.52	MnO	0.00
TiO_2	0.00	MgO	0.00
Al_2O_3	20.97	CaO	23.05
Fe_2O_3	17.22	H_2O^+	1.98
FeO	0.45	Total	100.19

(1) Westfield, Hampden Co., Massachusetts, USA; corresponds to $(Ca_{1.99}Fe^{2+}_{0.03})_{\Sigma=2.02}Al_{1.94}Fe^{3+}_{1.04}(Si_{2.94}Al_{0.06})_{\Sigma=3.00}O_{12}(OH)_{1.06}$.

Polymorphism & Series: Forms a series with clinozoisite.

Mineral Group: Epidote group.

Occurrence: Characteristic of several facies of regionally metamorphosed rocks and some contaminated felsic igneous rocks; in contact zones between igneous and calcareous sedimentary rocks; from alteration of plagioclase (saussuritization).

Association: Zeolites, amphiboles, plagioclase feldspars, quartz, actinolite, calcite (greenschist facies); amphiboles, vesuvianite, scapolite, talc, wollastonite, pyroxenes, garnet (epidote-hornfels facies); pumpellyite, glaucophane, lawsonite, riebeckite, garnet, omphacite (blueschist facies).

Distribution: A few notable occurrences follow for this widespread mineral. From Bourg d'Oisans, Isère, France. At Arendal, Norway. From Traversella, Piedmont, Italy. Exceptional crystals from the Knappenwand, Untersulzbachtal, Salzburg, Austria. In the USA, fine crystals from around Sulzer, Prince of Wales Island, Alaska; on Garnet Hill, Calaveras Co., California; at the Calumet mine, Chaffee Co., Colorado; in the Seven Devils district, Adams Co., Idaho; and from the Julie claim, Pamlico district, Mineral Co., Nevada. In Mexico, at San Quentin, Baja California. From Naukluft Farm, Rehoboth, Namibia. In Pakistan, exceptional crystals from Tormiq.

Name: From the Greek for *increase*, the base of the prism with one longer side.

Type Material: Natural History Museum, Paris, France.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 516–521. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 44–134. (3) Seki, Y. (1959) Relation between chemical composition and lattice constants of epidote. Amer. Mineral., 44, 720–730. (4) Gabe, E.J., J.C. Portheine, and S.H. Whitlow (1973) A reinvestigation of the epidote structure: confirmation of the iron location. Amer. Mineral., 58, 218–223. (5) Kvick, Å, J.J. Pluth, J.W. Richardson, Jr., and J.V. Smith (1988) The ferric iron distribution and hydrogen bonding in epidote: a neutron diffraction study at 15 K. Acta Cryst., 44, 351–355.

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Epistilbite $CaAl_2Si_6O_{16}\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. Crystals prismatic, to 3 cm; in spherulitic or sheaflike aggregates. *Twinning:* Always on {100}, pseudo-orthorhombic; on {110} to form penetration crosses.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 2.22–2.28 D(calc.) = 2.266 Piezoelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pinkish, yellowish; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c \simeq -10°$; $X \wedge a = 11°$.
Dispersion: $r < v$. $\alpha = 1.485$–1.505 $\beta = 1.497$–1.515 $\gamma = 1.497$–1.519 2V(meas.) = $\sim 44°$

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 9.08(1)$ $b = 17.74(1)$ $c = 10.25(1)$ $\beta = 124.54(5)°$ Z = 3

X-ray Powder Pattern: Locality unknown. (ICDD 19-213).
3.45 (100), 8.89 (90), 3.21 (90), 3.87 (70), 4.91 (65), 6.89 (60), 2.917 (60)

Chemistry:

	(1)
SiO_2	57.79
Al_2O_3	17.62
Fe_2O_3	0.02
MgO	0.02
CaO	8.21
Na_2O	1.39
K_2O	0.06
H_2O^+	12.21
H_2O^-	3.10
Total	100.42

(1) Fossarfell, Iceland; corresponds to $(Ca_{0.90}Na_{0.27}K_{0.01})_{\Sigma=1.18}Al_{2.12}Si_{5.89}O_{16}\cdot 5.20H_2O$.

Polymorphism & Series: Dimorphous with goosecreekite.

Mineral Group: Zeolite group.

Occurrence: In cavities in basalts and gneisses.

Association: Zeolites, quartz.

Distribution: While relatively rare, many localities are known. Exceptional crystals from around the Berufjord, Iceland. Found near San Piero in Campo, Elba, Italy. At Giebelsbach, near Fiesch, Valais, Switzerland. In Japan, at Kuroiwa, Niigata Prefecture; Yugawara, Kanagawa Prefecture; and elsewhere. Large crystals from Nasik and Khandivali quarry, Bombay, Maharashtra, India. In the USA, large crystals from Kosmos, near Morton, Lewis Co., Washington; at Goble, Columbia Co., Oregon.

Name: From the Greek, *epi* for *near*, and the quite similar mineral *stilbite*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 577–578. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 377–385. (3) Perrotta, A.J. (1967) The crystal structure of epistilbite. Mineral. Mag., 36, 480–490. (4) Slaughter, M. and W.T. Kane (1969) The crystal structure of a disordered epistilbite. Zeits. Krist., 130, 68–87. (5) Galli, E. and R. Rinaldi (1974) The crystal chemistry of epistilbites. Amer. Mineral., 59, 1055–1061. (6) Akizuki, M. and H. Nishido (1988) Epistilbite: symmetry and twinning. Amer. Mineral., 73, 1434–1439.

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Epistolite $Na_4Nb_2Ti(Si_2O_7)_2O_2(OH)_2(H_2O)_4$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As crystals, rectangular and tabular on (001), to 5 cm. Also as irregular plates and curved lamellar masses.

Physical Properties: *Cleavage:* Perfect on {001}, distinct on {110}. *Tenacity*: Very brittle to friable. Hardness = 1.5-3 D(meas.) = 2.65-2.89 D(calc.) = 2.987

Optical Properties: Opaque to translucent, transparent in thin sheets. *Color*: White, gray, yellow-gray, tan, light brown; in thin section, colorless. *Luster*: Pearly to silky. *Optical Class*: Biaxial (-). *Orientation:* Z ^ c = 70°. *Dispersion*: r > v; inclined. α = 1.610 β = 1.650-1.720 γ = 1.682-1.770 2V(meas.) = 60-80°

Cell Data: *Space Group*: $P\bar{1}$. a = 5.460(1) b = 7.170(1) c = 12.041(2) α = 103.63(3)° β = 96.01(3)° γ = 89.98(3)° Z = 1

X-ray Powder Pattern: Ilímaussaq alkaline complex intrusion, Greenland.
4.322 (10), 2.99 (9), 2.869 (9), 12.00 (8), 5.902 (7), 1.790 (7), 2.155 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	27.59	25.60	29.59	CaO	0.77	0.00	1.89
TiO_2	7.22	14.55	10.24	Na_2O	17.59	4.97	14.45
ZrO_2		0.00		K_2O	trace	0.70	0.27
Al_2O_3		2.05		F	1.98	0.00	1.32
Nb_2O_5	33.56	31.40	31.43	H_2O^+	9.26	7.35	
Ta_2O_5		0.90	0.28	H_2O^-	1.75	8.20	
Fe_2O_3			0.35	$H_2O_{(calc)}$			10.46
FeO	0.20	0.90		P_2O_5		2.10	0.36
MnO	0.30	1.20	0.34	$-O = F_2$	0.83		
MgO	0.13	0.00		Total	99.52	99.92	100.43

(1) Julianehåb district, Greenland; material partly altered. (2) Lovozero massif, Russia. (3) Ilímaussaq alkaline complex, South Greenland; electron microprobe analysis, H_2O calculated from structure analysis; K and P considered contaminants; corresponding to $(Na_{3.79}Ca_{0.27}Mn_{0.04})_{\Sigma=4.06}(Nb_{1.92}Ti_{1.04}Fe^{3+}_{0.04})_{\Sigma=3.00}(Si_2O_7)_2O_2(OH_{1.44}F_{0.56})(H_2O)_4$.

Occurrence: A low temperature mineral in alkalic pegmatites, albitites, sodalite xenoliths, and hydrothermal veins.

Association: Aegirine, albite, murmanite, sphalerite, manganoan pectolite, neptunite, steenstrupine, sodalite, eudialyte, nenadkevichite.

Distribution: At a number of localities in the Ilímaussaq alkaline complex intrusion, southern Greenland. From the Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada.

Name: From the Greek for *letter*, in allusion to the flat rectangular crystal habit and white color.

Type Material: University of Copenhagen, Copenhagen, Denmark, 319, 320.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 39. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 562-564. (3) Khalilov, A.P., Y.S. Makarov, K.S. Mamedov, and L.A. P'yanzina (1965) Crystal structure of minerals of the murmanite-lomonosovite group. Doklady Acad. Nauk SSSR, 162, 179-182 (in Russian). (4) Karup-Møller, S. (1986) Epistolite from the Ilímaussaq alkaline complex in South Greenland. Neues Jahrb. Mineral., Abh., 155, 289-304. (5) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 76. (6) Sokolova, E., and F.C. Hawthorne (2004) The crystal chemistry of epistolite. Can. Mineral., 42, 797-806.

Epsomite $MgSO_4 \cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. Rare as crystals, prismatic along {110}, to 8 cm; typically as fibrous crusts, woolly efflorescences, botryoidal to reniform masses, stalactitic. *Twinning:* Rare on {110}.

Physical Properties: *Cleavage:* {010}, perfect; {101}, distinct. *Fracture:* Conchoidal. Hardness = 2–2.5 D(meas.) = 1.677(2) (synthetic). D(calc.) = 1.677 Dehydrates readily in dry air; soluble in H_2O, with a bitter taste.

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale pink, pale green; colorless in transmitted light. *Luster:* Vitreous, silky in fibrous aggregates. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$; weak. $\alpha = 1.432$ $\beta = 1.455$ $\gamma = 1.461$ 2V(meas.) = 52°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 11.876(2)$ $b = 12.002(2)$ $c = 6.859(1)$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 36-419).
4.216 (100), 4.200 (75), 5.98 (30), 5.34 (30), 2.658 (25), 5.31 (20), 2.880 (20)

Chemistry:

	(1)	(2)
SO_3	32.41	32.48
MgO	16.26	16.36
H_2O	51.32	51.16
rem.	0.11	
Total	100.10	100.00

(1) Ashcroft, Canada. (2) $MgSO_4 \cdot 7H_2O$.

Polymorphism & Series: Forms two series, with goslarite and with morenosite.

Occurrence: As efflorescences on the walls of mines, caves, and outcrops of sulfide-bearing magnesian rocks; a product of evaporation at mineral springs and saline lakes; a hydration product of kieserite and langbeinite; rarely a fumarolic sublimate.

Association: Melanterite, gypsum, halotrichite, pickeringite, alunogen, rozenite (efflorescences); mirabilite (lacustrine evaporites).

Distribution: Widespread and common; a few varied localities include: from Epsom, Surrey, England. At Sedlitz and Saidschitz, Czech Republic. From Špania Dolina (Herrengrund), Slovakia. On Vesuvius, Campania, Italy. At volcanoes on the Kamchatka Peninsula, Russia. In the USA, large masses in Mammoth Cave, Kentucky; at the Mt. Princeton hot spring, Chalk Creek, Chaffee Co., Colorado; at Leona Heights, Alameda Co., California; very large crystals from salt lakes on Kruger Mountain, near Oroville, Okanogan Co., Washington; in Idaho, at the Buckhorn mine, Lemhi Co. and the Claytonia mine, Owyhee Co. From Ashcroft, British Columbia, and in the Dundas quarry, Dundas, Ontario, Canada.

Name: For the occurrence at Epsom, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 509–513. (2) Calleri, M., A. Gavetti, G. Ivaldi, and M. Rubbo (1984) Synthetic epsomite, $MgSO_4.7H_2O$: absolute configuration and surface features of the complementary {111} forms. Acta Cryst., 40, 218–222.

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Erdite $NaFeS_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In fine granular, impure masses of minute fibers; single, fine-bladed crystals, to 1 mm in length.

Physical Properties: *Cleavage:* Good on {110}. Hardness = Very soft. VHN = 22–67, 39 average (15 g load). D(meas.) = 2.2, 2.30 (magnetite-contaminated). D(calc.) = 2.216

Optical Properties: Opaque, transmits light in very fine fibers. *Color:* Copper-red to bronze on fresh surface, may be chatoyant, tarnishes rapidly. *Streak:* Black. *Pleochroism:* Extreme: brilliant reddish orange through greenish grays and pinkish grays to dark gray with a barely perceptible bluish or greenish tint. *Anisotropism:* Strong.
R_1–R_2: (400) 10.2–23.8, (420) 9.8–28.8, (440) 10.1–27.3, (460) 10.9–20.8, (480) 11.3–15.6, (500) 11.3–16.6, (520) 11.0–23.3, (540) 10.6–25.7, (560) 10.3–25.7, (580) 10.0–31.6, (600) 9.8–36.6, (620) 9.7–43.1, (640) 9.8–46.9, (660) 10.0–44.3, (680) 10.6–39.3, (700) 11.0–35.3

Cell Data: *Space Group:* $C2/c$. $a = 10.677$–10.693 $b = 9.083$–9.115 $c = 5.499$–5.507 $\beta = 92°10(2)'$–$92°23(4)'$ $Z = 4$

X-ray Powder Pattern: Coyote Peak, California, USA.
6.935 (100), 5.342 (71), 4.556 (41), 3.467 (28), 2.310 (23), 2.902 (15), 3.317 (12)

Chemistry:

	(1)	(2)	(3)
Na	14.1	11.2	12.84
K		0.12	
Fe	36.0	34.9	31.20
S	40.5	37.6	35.82
O	[9.4]	[16.2]	17.88
H			[2.26]
Total	[100.0]	[100.02]	100.00

(1) Coyote Peak, California, USA; by electron microprobe, oxygen by difference; corresponds to $Na_{0.96}Fe_{1.01}S_{1.96} \cdot 0.82H_2O$, presence of H_20 confirmed by evolution, with $2H_2O$ established by crystal structure analysis. (2) Lovozero massif, Russia; by electron microprobe, average of ten analyses, oxygen by difference; corresponds to $(Na_{0.81}K_{0.01})_{\Sigma=0.82}Fe_{1.04}S_{1.96} \cdot 1.50H_2O$. (3) $NaFeS_2 \cdot 2H_2O$.

Occurrence: Found in abundance, typically associated with other sulfides and fine grained magnetite, in discrete, late segregations within an alkalic mafic diatreme (Coyote Peak, California, USA); in pegmatites in nepheline syenite (Lovozero massif, Russia).

Association: Pyrrhotite, magnetite, rasvumite, djerfisherite, bartonite (Coyote Peak, California, USA); pyrite, murmanite (Lovozero massif, Russia).

Distribution: At Coyote Peak, near Orick, Humboldt Co., California, USA [TL]. From Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia. In Canada, at Mont Saint-Hilaire and near Saint-Amable, Quebec.

Name: For Dr. Richard Clarkson Erd (1924–), American mineralogist with the U.S. Geological Survey, who first synthesized the compound.

Type Material: n.d.

References: (1) Czamanske, G.K., B.F. Leonard, and J.R. Clark (1980) Erdite, a new hydrated sodium iron sulfide mineral. Amer. Mineral., 65, 509–515. (2) Konnert, J.A. and H.T. Evans, Jr. (1980) The crystal structure of erdite, $NaFeS_2 \cdot 2H_2O$. Amer. Mineral., 65, 516–521. (3) Khomyakov, A.P., M.F. Korobitsyn, M.G. Dobrovol'skaya, and A.I. Tsepin (1979) Erdite ($NaFeS_2 \cdot 2H_2O$) — first occurrence in the USSR. Doklady Acad. Nauk SSSR, 249, 968–971 (in Russian). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 157.

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Ericaite $(Fe^{2+}, Mg)_3B_7O_{13}Cl$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $mm2$. As pseudocubic crystals, dominated by {100} and modified by {111}, to 2.2 cm.

Physical Properties: Hardness = [7–7.5] (by analogy to boracite). D(meas.) = 3.17–3.22 D(calc.) = 3.58

Optical Properties: Semitransparent. *Color:* Pale green to raspberry-red, red-violet, brownish violet, brown, black, may be zoned.
Optical Class: Biaxial (–). $\alpha = 1.731$ $\beta = 1.755$ $\gamma = 1.755$ 2V(meas.) = Small.

Cell Data: *Space Group:* $Pca2_1$. $a = 8.58$ $b = 8.65$ $c = 12.17$ Z = 4

X-ray Powder Pattern: Thuringia, Germany. (ICDD 29–697, may be congolite).
3.043 (100), 2.056 (70), 2.720 (60), 2.152 (45), 3.51 (40), 1.834 (40), 1.2411 (30)

Chemistry:

	(1)	(2)	(3)
B_2O_3	50.56		55.46
FeO	35.26	31.64	24.53
MnO	1.79	2.53	
MgO		4.53	13.76
Cl			8.07
$-O = Cl_2$			1.82
Total			100.00

(1) Bischofferode, Germany; partial analysis. (2) Thuringia, Germany; partial analysis, corresponds to $(Fe_{2.25}Mg_{0.57}Mn_{0.14})_{\Sigma=2.96}B_7O_{13}Cl$. (3) $(Fe, Mg)_3B_7O_{13}Cl$ with Fe:Mg = 1:1. (4) Boulby mine, England; by AA, analysis not given, stated to correspond to $(Fe_{2.18}Mg_{0.71}Mn_{0.11})_{\Sigma=3.00}B_7O_{13}Cl$.

Polymorphism & Series: Dimorphous with congolite; forms a series with boracite.

Occurrence: An uncommon constituent of marine evaporite deposits.

Association: Halite, sylvite, anhydrite, kieserite (Germany); danburite, boracite (Alto Chapare, Bolivia).

Distribution: In Germany, from Wathlingen-Hänigsen, Lower Saxony; at Bischofferode and Sondershausen, Thuringia. Large crystals in the Boulby potash mine, northwest of Whitby, Yorkshire, England. From Alto Chapare, Cochabamba, Bolivia. In the Louann Salt Formation, Clarke Co., Alabama, USA.

Name: For the typical purple color, characteristic of the heather genus *Erica*.

Type Material: n.d.

References: (1) Werner, H. (1950) Das Borazitvorkommen im Salzstock von Wathlingen-Hänigsen. Aufschluss, 1, 24–26 (in German). (2) Heide, F. (1955) Über bemerkenswerte Borazitvorkommen in den Kalilagern des Südharzbezirkes. Chem. Erde, 17, 211–216 (in German). (3) Kühn, R. and I. Schaacke (1955) Vorkommen und Analyse der Boracit- und Ericaitkristalle aus dem Salzhorst von Wathlingen-Hänigsen. Kali und Steinsalz, 11, 33–42 (in German). (4) (1956) Amer. Mineral., 41, 372 (abs. refs. 2 and 3). (5) Burns, P.C. (1995) X-ray powder diffraction data for the identification of boracite-group minerals. Powder Diffraction, 10, 250–260. (6) Green, D.I. and M.D. Freier (1996) The Boulby mine, Cleveland, England. Mineral. Record, 27, 163–170.

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Ericssonite $BaMn_2^{2+}Fe^{3+}OSi_2O_7(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thick plates, tabular ∥ {100}, intimately intergrown with orthoericssonite, to 2 cm.

Physical Properties: *Cleavage:* Perfect on {100}, fair on {011}. *Tenacity:* Very brittle. Hardness = 4.5 D(meas.) = 4.21 D(calc.) = 4.38 Weakly magnetic.

Optical Properties: Translucent. *Color:* Deep reddish black; in thin section, brown to yellowish brown. *Streak:* Rich brown.
Optical Class: Biaxial (+); properties indistinguishable from orthoericssonite. *Pleochroism:* X = pale greenish tan; Y = red-brown; Z = deep brown. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, perceptible. *Absorption:* $Z > Y > X$. $\alpha = 1.807(5)$ $\beta = 1.833(5)$ $\gamma = 1.89(1)$ 2V(meas.) = 43°

Cell Data: *Space Group:* $C2/m$. $a = 20.46$ $b = 7.03$ $c = 5.34$ $\beta = 95°30'$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.510 (100), 10.12 (60), 2.780 (60), 1.752 (60), 1.597 (60), 5.08 (50), 3.398 (50)

Chemistry:

	(1)	(2)
SiO_2	20.83	23.83
Fe_2O_3	14.47	15.83
As_2O_5	1.23	
MnO	24.38	28.14
PbO	1.40	
BaO	29.81	30.41
H_2O	1.52	1.79
Total	93.64	100.00

(1) Långban, Sweden; by electron microprobe, intergrown with orthoericssonite, oxidation states and H_2O separately determined. (2) $BaMn_2FeOSi_2O_7(OH)$.

Polymorphism & Series: Dimorphous with orthoericssonite.

Occurrence: A rare mineral, embedded in a fine-grained manganoan aegirine zone in well-banded tephroite-rhodonite-manganoan aegirine skarn, in a metamorphosed Fe–Mn orebody.

Association: Orthoericssonite, tephroite, rhodonite, manganoan aegirine, hedyphane, andradite, hausmannite, långbanite, richterite.

Distribution: From Långban, Värmland, Sweden.

Name: In honor of John E. Ericsson (1803–1889), Swedish-American inventor and designer of the iron-clad ship "Monitor," who was born at Långban, Sweden.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120061; The Natural History Museum, London, England, 1987,118.

References: (1) Moore, P.B. (1971) Ericssonite and orthoericssonite, two new members of the lamprophyllite group from Långban, Sweden. Lithos, 4, 137–145. (2) (1971) Amer. Mineral., 56, 2157 (abs. ref. 1).

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Eringaite $Ca_3Sc_2(SiO_4)_3$

Crystal Data: Cubic. *Point Group*: $4/m\,\bar{3}\,2/m$. As growth zones or irregular grains < 10 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.654

Optical Properties: Transparent. *Color*: Light brown to yellow. *Streak*: Creamy white. *Luster*: Vitreous.
Optical Class: n.d.

Cell Data: *Space Group*: $Ia\bar{3}\,d$. a = 12.255(1) Z = 8

X-ray Powder Pattern: Wiluy River, Sakha-Yakutia Republic, Russia. (calculated pattern) 2.740 (100), 1.638 (82), 3.064 (69), 2.502 (68), 1.670 (30), 1.119 (29), 1.370 (20)

Chemistry:

	(1)
SiO_2	29.39
TiO_2	7.17
ZrO_2	5.28
HfO_2	0.14
Al_2O_3	3.15
Sc_2O_3	10.67
Y_2O_3	0.20
V_2O_3	0.14
Cr_2O_3	1.05
Fe_2O_3	8.48
FeO	0.50
MnO	0.01
CaO	33.19
MgO	0.95
Total	100.31

(1) Wiluy River, Sakha-Yakutia Republic, Russia; average of 8 electron microprobe analyses, corresponding to $(Ca_{2.98}Y_{0.01}Mg_{0.01})_{\Sigma=3.00}(Sc_{0.82}Ti^{4+}_{0.44}Fe^{3+}_{0.30}Zr_{0.21}Mg_{0.10}Al_{0.09}Cr^{3+}_{0.08}Fe^{2+}_{0.05}V^{3+}_{0.01})_{\Sigma=2.01}(Si_{2.48}Al_{0.30}Fe^{3+}_{0.22})_{\Sigma=3.00}O_{12}$.

Mineral Group: Garnet group.

Polymorhpism & Series: Continuous solid solution series with andradite, uvarovite, goldmanite.

Occurrence: An accessory mineral in metasomatic rodingite-like rocks; it forms regular growth zones and irregular spots in complex garnet crystals.

Association: Grossular, vesuvianite, serpentine, melilite-group minerals, kimzeyite.

Distribution: Wiluy River, Sakha-Yakutia Republic, Russia.

Name: For the Eringa River, the tributary of the Wiluy River directly across from where the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3837/1).

References: (1) Gałuskina, I.O., E.V. Gałuskin, B. Lazic, T. Armbruster, P. DzierżAnowski, K. Prusik, and R. Wrzalik (2010) Eringaite, $Ca_3Sc_2(SiO_4)_3$, a new mineral of the garnet group. Mineralogical Magazine, 74, 365-373. (2) (2014) Amer. Mineral., 99, 552 (abs. ref. 1).

Eriochalcite $CuCl_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As lichenlike aggregates of crystals elongated along [001]; as grooved spires, to 5 mm, often bent or curving; as woollike aggregates. *Twinning:* On {021}, as penetration twins.

Physical Properties: *Cleavage:* Perfect on {110}; good on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.4 D(calc.) = 2.516 Easily soluble in H_2O.

Optical Properties: Transparent. *Color:* Bluish green to greenish blue, sometimes with a yellowish tint; greenish blue in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = pale green; Y = pale olive-green; Z = pale blue. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, strong. $\alpha = 1.646$ $\beta = 1.685$ $\gamma = 1.745$ 2V(meas.) = 75°

Cell Data: *Space Group: Pbmn.* $a = 7.38$ $b = 8.04$ $c = 3.72$ Z = 2

X-ray Powder Pattern: Synthetic.
5.476 (100), 2.638 (82), 4.050 (56), 3.093 (40), 2.2088 (29), 1.6048 (23), 2.0240 (22)

Chemistry:

	(1)	(2)
Fe_2O_3	0.20	
Cu	36.89	37.28
MgO	0.04	
CaO	0.15	
Cl	40.68	41.59
H_2O	20.81	21.13
insol.	0.95	
Total	99.72	100.00

(1) Quetena, Chile. (2) $CuCl_2 \cdot 2H_2O$.

Occurrence: As an encrustation around fumaroles (Vesuvius, Italy); a product of weathering in a copper sulfide deposit in an arid climate (Quetena, Chile).

Association: Melanothallite, euchlorine, chalcocyanite, dolerophanite (Vesuvius, Italy); atacamite, bandylite (Quetena, Chile); euchlorine, chalcocyanite, dolerophanite, melanothallite, tenorite, tolbachite (Tolbachik volcano, Russia).

Distribution: On Vesuvius, Campania, Italy. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. At Quetena, west of Calama, Antofagasta, Chile. From near Hawthorne, Mineral Co., Nevada, USA. At the Mt. Gunson copper mine, Stuart Shelf, and Moonta, South Australia.

Name: From the Greek for *wool* and *copper*, for the form of aggregates at Vesuvius, Italy.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 97927.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 44–46. (2) Brownstein, S., N.F. Han, E. Gabe, and Y. LePage (1989) A redetermination of the crystal structure of cupric chloride dihydrate. Zeits. Krist., 189, 13–15. (3) (1981) NBS Mono. 25, 18, 33.

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Erionite $(K_2, Ca, Na_2)_2Al_4Si_{14}O_{36}\cdot 15H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals prismatic, to 15 mm; in radiating groups or overgrowing offretite or levyne; typically fibrous, wool-like.

Physical Properties: *Cleavage:* Poor prismatic. *Fracture:* Splintery. Hardness = 3.5–4
D(meas.) = 2.08 D(calc.) = 2.13

Optical Properties: Transparent to translucent. *Color:* White; colorless in thin section.
Streak: White. *Luster:* Vitreous to silky.
Optical Class: Uniaxial (+). $\omega = 1.458$–1.480 $\epsilon = 1.458$–1.468

Cell Data: *Space Group:* $P6_3/mmc$. $a = 13.21$–13.26 $c = 15.04$–15.12 Z = 2

X-ray Powder Pattern: Tecopa, California, USA; close to offretite.
11.41 (100), 6.61 (73), 4.322 (67), 3.746 (65), 2.860 (60), 2.812 (52), 2.839 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	57.40	60.67	Na_2O	1.45	4.39
Al_2O_3	15.60	12.90	K_2O	3.40	4.09
Fe_2O_3		1.35	H_2O^+		7.69
FeO		0.09	H_2O^-		6.94
MgO	1.11	1.09	H_2O	17.58	
CaO	2.92	0.65	rem.		0.14
			Total	99.46	100.00

(1) Durkee, Oregon, USA; corresponds to $(Ca_{0.75}K_{0.52}Mg_{0.40}Na_{0.34})_{\Sigma=2.01}Al_{4.40}Si_{14.10}O_{36}\cdot 14.00H_2O$. (2) Tecopa, California, USA; remainder is TiO_2 0.09%, MnO 0.03%, P_2O_5 0.02%; corresponds to $(Na_{0.99}K_{0.60}Mg_{0.38}Ca_{0.16})_{\Sigma=2.13}Fe_{0.25}Al_{3.54}Si_{13.71}O_{36}\cdot 11.34H_2O$.

Mineral Group: Zeolite group.

Occurrence: In basalts; in altered rhyolitic tuffs and lake-bed sediments formed by alteration of vitric ash fallen into the lakes.

Association: Zeolites, "opal," quartz, celadonite, montmorillonite, dolomite, calcite.

Distribution: Some localities for relatively pure material are: in the USA, at Tecopa, Inyo Co., California; in Nevada, at Pine Valley, Eureka Co., Eastgate, Churchill Co., Jersey Valley, Pershing Co., and Reese River, Lander Co.; in Oregon, at Cape Lookout, Tillamook Co., Agate Beach, Lincoln Co., and Durkee, Baker Co. From the Parkgate quarry, Templepatrick, Co. Antrim, Ireland. At Hvalstod and in the Berufjord area, Iceland. At Moeraki, Otago, South Island, New Zealand. From Mazé, Niigata Prefecture, Japan. Many other localities are known.

Name: For the Greek word for *wool*, recalling its common appearance.

Type Material: Harvard University, Cambridge, Massachusetts, 86532; National Museum of Natural History, Washington, D.C., USA, R4066, 133333.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 25. (2) Staples, L.W. and J.A. Gard (1959) The fibrous zeolite erionite; its occurrence, unit cell, and structure. Mineral. Mag., 32, 261–281. (3) Sheppard, R.A. and A.J. Gude, 3d (1969) Chemical composition and physical properties of the related zeolites offretite and erionite. Amer. Mineral., 54, 875–886. (4) Gard, J.A. and J.M. Tait (1971) Refinement of the crystal structure of erionite. In: Molecular sieves, Leuven Univ. Press, 94. (5) Wise, W.S. and R.W. Tschernich (1976) The chemical composition and origin of the zeolites offretite, erionite, and levyne. Amer. Mineral., 61, 853–863.

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Erlianite $(Fe^{2+},Mg)_4(Fe^{3+},V^{3+})_2Si_6O_{15}(OH,O)_8$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As fibers, flakes, and lathlike aggregates, to 2 cm.

Physical Properties: *Cleavage:* Perfect on {001} and {100}. Hardness = 3.7
D(meas.) = 3.11 D(calc.) = [3.17]

Optical Properties: Opaque. *Color:* Black; brown in thin section. *Streak:* Brownish black. *Luster:* Silky.
Optical Class: Biaxial (–). *Pleochroism:* Slight; X = light brown; $Y = Z$ = dark brown. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak. *Absorption:* $Z = Y > X$.
$\alpha = 1.667$ $\beta = 1.674$ $\gamma = 1.679$ 2V(meas.) = 56°–59°

Cell Data: *Space Group:* $Pmmn$ or $Pm2_1n$. a = 23.20(1) b = 9.20(1) c = 13.18(1)
Z = 6

X-ray Powder Pattern: Harhada mine, China.
11.5 (100), 2.89 (60), 2.61 (60), 3.05 (50), 2.52 (50), 1.560 (50), 2.42 (30)

Chemistry:

	(1)		(1)
SiO_2	38.80	MgO	1.00
TiO_2	0.38	CaO	0.83
Al_2O_3	0.19	K_2O	0.08
Fe_2O_3	21.26	Na_2O	0.09
V_2O_5	1.15	H_2O^+	7.65
FeO	26.67	H_2O^-	0.90
MnO	0.55	P_2O_5	0.05
		Total	99.60

(1) Harhada mine, China; by colorimetric microanalysis, corresponds to $(Fe^{2+}_{3.33}Fe^{3+}_{0.36}Mg_{0.22}Mn_{0.07})_{\Sigma=3.98}(Fe^{3+}_{1.89}V_{0.11})_{\Sigma=2.00}(Si_{5.79}Fe^{3+}_{0.14}Ti_{0.04}Al_{0.03})_{\Sigma=6.00}O_{15}[O,(OH)]_8$.

Occurrence: As coatings along fault surfaces cutting a low-grade metamorphosed volcanic-sedimentary iron formation; presumably formed in a high-pressure, low-temperature environment.

Association: Minnesotaite, stilpnomelane, quartz, magnetite, siderite, albite, deerite.

Distribution: In the Harhada iron mine, along the Jining-Erlian railway, Inner Mongolia, China.

Name: Presumably for the town of Erlian, China.

Type Material: n.d.

References: (1) Feng, X. and R. Yang (1986) Erlianite, a new vanadium- and iron-bearing silicate mineral. Mineral. Mag., 50, 285–289. (2) (1987) Amer. Mineral., 72, 1023–1024 (abs. ref. 1).

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Erlichmanite OsS_2

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Rare as rounded pyritohedral crystals, to 1 mm; as minute grains in Pt–Fe alloy in a platinum nugget, and as inclusions in chromite.

Physical Properties: Hardness = n.d. VHN = 1730–1950, 1854 average (100 g load). D(meas.) = 8.28 D(calc.) = 9.59

Optical Properties: Opaque. *Color:* Gray. *Luster:* Metallic.
R: (400) 44.4, (420) 44.2, (440) 44.0, (460) 43.8, (480) 43.4, (500) 43.0, (520) 42.7, (540) 42.2, (560) 41.7, (580) 41.3, (600) 40.9, (620) 40.4, (640) 40.0, (660) 39.4, (680) 38.8, (700) 38.2

Cell Data: *Space Group: Pa*3 (synthetic). $a = 5.6196(3)$ $Z = 4$

X-ray Powder Pattern: Synthetic. (ICDD 19-882).
3.24 (100), 2.810 (85), 1.694 (85), 0.780 (65), 1.987 (55), 0.787 (55), 1.081 (30)

Chemistry:

	(1)	(2)	(3)
Os	68.0	64.3	74.78
Ir	2.6	3.5	
Rh	3.8	5.5	
Ru	0.4	0.4	
Pd	0.5	0.6	
S	25.2	25.5	25.22
Total	100.5	99.8	100.00

(1) MacIntosh mine, California, USA; by electron microprobe, corresponding to $(Os_{0.89}Rh_{0.09}Ir_{0.04}Pd_{0.01}Ru_{0.01})_{\Sigma=1.04}S_{1.96}$. (2) Western Ethiopia; by electron microprobe, corresponding to $(Os_{0.84}Ir_{0.05}Rh_{0.13}Ru_{0.01}Pd_{0.01})_{\Sigma=1.04}S_{1.96}$. (3) OsS_2.

Polymorphism & Series: Forms a series with laurite.

Mineral Group: Pyrite group.

Occurrence: Typically in PGM placers, likely derived from chromitites associated with ophiolites and other Alaskan-type ultramafic complexes.

Association: Pt–Fe alloy, platinum, osmium, laurite, hollingworthite, irarsite, many other PGM alloys and sulfides.

Distribution: In the USA, in California, from a placer at the MacIntosh mine, Willow Creek, Trinity River, Humboldt Co. [TL], and in gravels from the American River, Sacramento Co.; in the Salmon River placers, Goodnews Bay, Alaska. From placers on the Tulameen River, British Columbia, Canada. In the Ural Mountain placers, Siberia, and in the Konder massif, Aldan Shield, Sakha, Russia. In a platinum metal nugget from Joubdo stream, Birbir River, Ethiopia. From placers at Guma Water, Sierra Leone. At Tiébaghi, New Caledonia. From Maud Creek, Howard River, New Zealand. In the Merensky Reef, Bushveld complex, Transvaal, South Africa. At Rio Pilpe, Colombia. In placers from the Santiago River, Esmeraldas Province, Ecuador. There are numerous other trace occurrences.

Name: For Jozef Erlichman (1935–), American electron probe analyst, Planetary Branch, NASA-Ames Research Branch, who analyzed a number of new minerals.

Type Material: Stanford University, Palo Alto, California, USA, 51965; National Museum of Natural History, Washington, D.C., USA123914.

References: (1) Snetsinger, K.G. (1971) Erlichmanite (OsS_2), a new mineral. Amer. Mineral., 56, 1501–1506. (2) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 103–104. (3) Bowles, J.F.W., D. Atkin, J.L.M. Lambert, T. Deans, and R. Phillips (1983) The chemistry, reflectance, and cell size of the erlichmanite (OsS_2) – laurite (RuS_2) series. Mineral. Mag., 47, 465–471. (4) Stingl, T., B. Müller, and H.D. Lutz (1992) Crystal structure refinement of osmium(II) disulfide, OsS_2. Zeits. Krist., 202, 161–162.

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Ernienickelite $NiMn_3^{4+}O_7 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ or 3. Platy crystals, hexagonal to nearly circular, to 0.5 mm; in rosettes of randomly-oriented plates, and radial aggregates. *Twinning:* On $\{\overline{1}2\overline{1}0\}$.

Physical Properties: *Cleavage:* {0001}, perfect. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 3.84(4) D(calc.) = 3.83

Optical Properties: Opaque, translucent in the thinnest plates. *Color:* Red-brown, nearly black. *Streak:* Yellow-brown. *Luster:* Metallic, submetallic to vitreous.
Optical Class: Uniaxial (–). $\omega = > 2.00$ $\epsilon = 1.97(2)$ *Anisotropism:* White with light blue tint; gray. *Bireflectance:* Strong.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}$ or $R3$. $a = 7.514(2)$ $c = 20.52(2)$ Z = 6

X-ray Powder Pattern: Near Siberia, Western Australia.
6.84 (10), 2.219 (3), 4.01 (2), 1.884 (2), 1.575 (2), 3.44 (1), 2.748 (1)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
MnO_2		65.15	66.96	CuO		1.99	
CeO_2		0.58		MgO	0.30		
Co_2O_3		0.90		BaO		2.29	
MnO	68.25			K_2O		0.38	
CoO	0.30			H_2O	[13.94]	[18.45]	13.87
NiO	16.68	10.26	19.17	Total	[99.47]	[100.00]	100.00

(1) Near Siberia, Western Australia; by electron microprobe, average of two analyses; H_2O calculated from stoichiometry; corresponds to $(Ni_{0.87}Mn_{0.04}Mg_{0.03}Co_{0.02})_{\Sigma=0.96}Mn_3O_7 \cdot 3H_2O$. (2) Kamennyy Kobchik deposit, Russia; by electron microprobe, average of two analyses, H_2O by difference; after correction for cerianite and hollandite as impurities, corresponds to $(Ni_{0.74}Cu_{0.14}Co_{0.06})_{\Sigma=0.94}Mn_{3.06}O_{7.09} \cdot 5.55H_2O$. (3) $NiMn_3^{4+}O_7 \cdot 3H_2O$.

Occurrence: In an intensely laterized ultramafic intrusion (Siberia, Western Australia); in the weathering zone of ultramafic rocks (Kamennyy Kobchik deposit, Russia).

Association: Chalcedonic quartz, magnesite, serpentine, nimite, nontronite, goethite, nickel-rich clay minerals (Siberia, Western Australia); asbolane, lithiophorite, hollandite, cerianite (Kamennyy Kobchik deposit, Russia).

Distribution: In the SM7 open pit, near Siberia, 60 km north of Kalgoorlie, Western Australia. From the Kamennyy Kobchik deposit, Kempirsay massif, Southern Ural Mountains, Russia.

Name: In honor of Dr. Ernest Henry Nickel (1925–), Canadian-Australian mineralogist with the C.S.I.R.O., Perth, Australia.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81510.

References: (1) Grice, J.D., B. Gartrell, R.A. Gault, and J. Van Velthuizen (1994) Ernienickelite, $NiMn_3O_7 \cdot 3H_2O$, a new mineral species from the Siberia complex, Western Australia: comments on the crystallography of the chalcophanite group. Can. Mineral., 32, 333–337. (2) (1995) Amer. Mineral., 80, 404 (abs. ref. 1). (3) Gorshkov, A.I., G.R. Kapustkin, A.V. Sivtsov, I.M. Lazarenko, and L.S. Subrovinskiy (1992) Ni-chalcophanite: a new variety of the mineral from a weathering crust on ultramafic rocks of the Kempirsay massif (southern Urals). Izvest. Akad. Nauk, Ser. Geol., 1992(11), 108–117 (in Russian). (4) (1994) Amer. Mineral., 79, 388–389 (abs. ref. 3).

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Erniggliite $Tl_2SnAs_2S_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Short prismatic crystals, pseudohexgonal, showing $\{10\overline{1}0\}$, $\{10\overline{1}1\}$, $\{01\overline{1}1\}$, and $\{0001\}$, with rough surfaces, to 0.5 mm.

Physical Properties: *Cleavage:* On $\{0001\}$, perfect micaceous. *Tenacity:* Flexible cleavage lamallae. Hardness = 2–3 VHN = 46–49, 48 average (10 g load). D(meas.) = n.d. D(calc.) = 5.24

Optical Properties: Opaque. *Color:* Steel-gray to gray-black; grayish white in reflected light. *Streak:* Reddish black. *Luster:* "Shiny" on cleavage surfaces.
Optical Class: Biaxial; isotropic on basal sections.
R: (470) 28.6, (543) 27.3, (587) 26.9, (657) 25.1

Cell Data: *Space Group:* $P\overline{3}$. $a = 6.680(3)$ $c = 7.164(9)$ $Z = 1$

X-ray Powder Pattern: Lengenbach quarry, Switzerland.
3.343 (100), 3.029 (63), 3.060 (50), 2.679 (48), 4.510 (40), 1.866 (38), 2.25 (37)

Chemistry:

	(1)	(2)
Tl	47.91	47.00
Sn	13.55	13.65
As	17.01	17.23
S	22.20	22.12
Total	100.67	100.00

(1) Lengenbach quarry, Switzerland; by electron microprobe, average of three analyses; corresponds to $Tl_{2.03}Sn_{0.99}As_{1.97}S_{6.01}$. (2) $Tl_2SnAs_2S_6$.

Occurrence: In a hydrothermal deposit in dolostone.

Association: Hutchinsonite, hatchite, wallisite, lorandite, bernardite, realgar, orpiment, edenharterite, stalderite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: In honor of Professor Emeritus Ernie Niggli (1917-), mineralogist and petrologist, University of Bern, Bern, Switzerland

Type Material: Natural History Museum, Basel, Switzerland, L 18,393.

References: (1) Graeser, S., H. Schwaner, R. Wulf, and A. Edenharter (1992) Erniggliite ($Tl_2SnAs_2S_6$), a new mineral from Lengenbach, Binntal (Switzerland): description and crystal stucture determination based on data from synchrotron radiation. Schweiz. Mineral. Petrogr. Mitt., 72, 293–305. (2) (1993) Amer. Mineral., 78, 845–846 (abs. ref. 1).

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Ernstburkeite $Mg(CH_3SO3)_2 \cdot 12H_2O$

Crystal Data: Hexagonal. *Point Group*: 3. As irregular grains to 5 μm.

Physical Properties: *Cleavage*: None; good parting. *Fracture*: Conchoidal. *Tenacity*: Sectle. Hardness = < 2 D(meas.) = n.d. D(calc.) = 1.364 Easily soluble in water.

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Waxy. *Optical Class*: Uniaxial (+). ω = 1.402(1) ε = 1.408(1)

Cell Data: *Space Group*: *R*3 (synthetic $Mg(CH_3SO_3)_2 \cdot 12H_2O$). *a* = 9.27150(8) *c* = 21.1298(4) Z = 3

X-ray Powder Pattern: Calculated pattern.
4.64 (100), 3.87 (89), 3.87 (69), 4.41 (44), 7.04 (42), 6.39 (39), 3.74 (35)

Chemistry:

	(1)
Mg	5.64
C	5.58
S	4.89
H	7.03
O	66.86
Total	100.00

(1) $Mg(CH_3SO_3)_2 \cdot 12H_2O$; the composition of natural material confirmed by ion chromatography and Raman spectroscopy.

Occurrence: As solid inclusions in an ice core (from a depth of 576.5 m), presumably formed by the fixation of CH_3SO_3H on alkaline particles of marine or continental origin during long-range aerosol transport to the polar region.

Association: Gypsum, ice.

Distribution: Beneath the Dome Fuji station, East Antarctica, near the summit of the eastern Dronning Maud Land plateau.

Name: Honors Ernst A.J. Burke (b. 1943), Vrije Universiteit Amsterdam, Netherlands, for his contributions to the mineralogy of opaque minerals and Raman spectrometry of fluid inclusions.

Type Material: In a cold room (at -50° C), Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan (81,616).

References: (1) Güner, F.E.G., T. Sakurai, and T. Hondoh (2013) Ernstburkeite, $Mg(CH_3SO_3)_2 \cdot 12H_2O$, a new mineral from Antarctica. European Jour. Mineral., 25, 79-84. (2) (2014) Amer. Mineral., 99, 1513-1514 (abs. ref. 1). (3) Genceli, F.E., M. Lutz, T. Sakurai, A.L. Spek, and T. Hondoh (2010) Crystallization and characterization of magnesium methanesulfonate hydrate $Mg(CH_3SO_3)_2 \cdot 12H_2O$. Crystal Growth & Design, 10, 4327-4333.

Ernstite $\mathbf{(Mn^{2+}_{1-x}Fe^{3+}_{x})Al(PO_4)O_x(OH)_{2-x}}$ (x = 0.33)

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As crystals, showing {110}, {211}, and {$\overline{2}$11}, rare {100} and {010}, to 15 mm, in radial aggregates.

Physical Properties: *Cleavage:* On {100}, very good; on {010}, good. Hardness = 3–3.5 D(meas.) = 3.07 D(calc.) = 3.086

Optical Properties: Semitransparent. *Color:* Yellow-brown.
Optical Class: Biaxial (–). *Pleochroism:* X = yellowish brown; Y = red-brown; Z = pale yellow. *Orientation:* $Z = b$; $Y \wedge c = -4°$. *Dispersion:* $r > v$. $\alpha = 1.678(3)$ $\beta = 1.706(3)$ $\gamma = 1.721(3)$ 2V(meas.) = n.d. 2V(calc.) = 74°

Cell Data: *Space Group:* $A2/a$ or Aa. $a = 13.32(1)$ $b = 10.497(5)$ $c = 6.969(4)$ $\beta = 90°22(20)'$ Z = 8

X-ray Powder Pattern: Farm Davib-East, Namibia.
2.829 (10), 2.836 (8), 2.438 (5), 4.364 (4), 3.516 (4), 2.424 (4), 2.001 (4)

Chemistry:

	(1)
P_2O_5	29.86
Al_2O_3	24.33
Fe_2O_3	11.83
FeO	0.44
MnO	17.83
MgO	1.01
CaO	0.84
H_2O^+	13.86
Total	[100.00]

(1) Farm Davib-East, Namibia; recalculated after deduction of SiO_2 0.48% from an original total of 99.96%; corresponds to $(Mn^{2+}_{0.56}Fe^{3+}_{0.33}Mg_{0.06}Ca_{0.03}Fe^{2+}_{0.01})_{\Sigma=0.99}Al_{1.00}(PO_4)[O_{0.33}(OH)_{1.67}]_{\Sigma=2.00}$.

Occurrence: Formed by oxidation of eosphorite in a granite pegmatite (Farm Davib-East, Namibia).

Association: Eosphorite (Farm Davib-East, Namibia).

Distribution: Found on the Farm Davib-East, near Karibib, southern Erongo Mountains, Namibia. At St. John's quarry, near Kapunda, Mount Lofty Ranges, South Australia.

Name: To honor Dr. Theodor K.H. Ernst (1904–1983), Professor of Mineralogy, Erlangen University, Erlangen, Germany.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145620.

References: (1) Seeliger, E. and A. Mücke (1970) Ernstit, ein neues $Mn^{2+}-Fe^{3+}-Al-$Phosphate und seine Beziehungen zum Eosphorit. Neues Jahrb. Mineral., Monatsh., 289-298 (in German with English abs.). (2) (1971) Amer. Mineral., 56, 637 (abs. ref. 1).

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Ershovite $Na_4K_3(Fe,Mn,Ti)_2Si_8O_{20}(OH)_4 \cdot 5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Forms parallel fibrous aggregates, fibers elongated along [001], to 3 cm; in disseminated elongated grains, to 1 cm.

Physical Properties: *Cleavage:* {100} and {010}, perfect. *Fracture:* Fibrous.
Hardness = 2–3 D(meas.) = 2.75(2) D(calc.) = 2.73

Optical Properties: Translucent; transparent in thin section. *Color:* Olive-green with brown and yellow tinges. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; $X = Y$ = light green or yellow; Z = dark olive-green. *Orientation:* $X \wedge c = 86°$; $Y \wedge c = 73°$; $Z \wedge c = 17°$. *Dispersion:* $r > v$.
$\alpha = 1.569(2)$ $\beta = 1.574(2)$ $\gamma = 1.590(2)$ 2V(meas.) = 58(2)° 2V(calc.) = 59°

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.244(2)$ $b = 11.924(3)$ $c = 5.276(3)$
$\alpha = 103.491(2)°$ $\beta = 96.960(3)°$ $\gamma = 91.945(3)°$ Z = 1

X-ray Powder Pattern: Khibiny massif, Russia.
11.58 (10), 2.990 (10), 2.709 (8), 1.652 (8), 2.608 (7), 2.459 (6), 2.160 (6)

Chemistry:

	(1)
SiO_2	47.1
TiO_2	3.0
FeO	6.1
MnO	4.7
MgO	0.5
CaO	0.1
Na_2O	12.4
K_2O	13.6
H_2O	[12.5]
Total	[100.0]

(1) Khibiny massif, Russia; by electron microprobe, H_2O by difference; corresponds to $Na_{4.08}K_{2.95}(Fe_{0.87}Mn_{0.68}Ti_{0.38}Mg_{0.13}Ca_{0.02})_{\Sigma=2.08}Si_8O_{19.98}(OH)_{4.04} \cdot 5.06H_2O$.

Occurrence: In unweathered ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Orthoclase, nepheline, sodalite, aegirine, alkalic amphibole, villiaumite, natrite, rasvumite, vuonnemite, astrophyllite, shcherbakovite, kazakovite, koashvite, thermonatrite, nacaphite.

Distribution: From Mts. Rasvumchorr and Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: For Professor Vadim Victorovich Ershov (1939–1989), of the Moscow Mining Institute, Moscow, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Khomyakov, A.P., Y.P. Men'shikov, R.K. Rastsvetaeva, and G.N. Nechelyustov (1993) Ershovite $Na_4K_3(Fe,Mn,Ti)_2Si_8O_{20}(OH)_4 \cdot 4H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 122(1), 116–120 (in Russian). (2) (1994) Amer. Mineral., 79, 1010 (abs. ref. 1). (3) Rastsvetaeva, R.K., O.Y. Rekhlova, and A.P. Khomyakov (1991) Crystal structure of a new natural Na,K,Fe-silicate. Kristallografiya (Sov. Phys. Crystal.), 36, 892–897 (in Russian).

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Ertixiite $Na_2Si_4O_9$

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Crystal Data: Cubic. *Point Group:* n.d. In granular crystals, to 0.5 mm.

Physical Properties: *Fracture:* Subconchoidal. Hardness = 5.8–6.5 D(meas.) = 2.35 D(calc.) = 2.34

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Isotropic. $n = 1.502(1)$

Cell Data: *Space Group:* n.d. $a = 5.975$ $Z = 1$

X-ray Powder Pattern: Altay mine, China.
1.798 (100), 1.996(80), 3.443 (20), 2.988 (20), 2.674 (20)

Chemistry:

	(1)	(2)
SiO_2	77.86	79.50
Al_2O_3	1.45	
FeO	0.04	
CaO	2.82	
Na_2O	17.98	20.50
Total	100.15	100.00

(1) Altay mine, China; by electron microprobe, average of six analyses. (2) $Na_2Si_4O_9$.

Occurrence: As linings of miarolitic cavities in a Ta-Nb-Be-bearing granite pegmatite.

Association: Topaz, albite, muscovite, quartz, apatite, garnet.

Distribution: From the Altay pegmatite mine, Fuyun Co., 600 km northeast of Urumchi, Sinkiang Uighur Autonomous Region, China.

Name: For the Ertixi River, near the occurrence in China.

Type Material: The Geological Museum, Chengdu Geological College, [Ch'engdu], China.

References: (1) Zhang Rubo, Han Fengming, and Du Chonliang (1985) Ertixiite – a new mineral from the Altay pegmatite mine, Xinjiang, China. Geochemistry (China), 4, 192–195. (2) (1986) Amer. Mineral., 71, 1544 (abs. ref. 1). (3) (1988) Mineral. Mag., 52, 724 (abs. ref. 1).

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Erythrite $Co_3(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely well crystallized, typically flattened on [010], may be elongated prismatic and striated ‖ [001], with many forms, to 10 cm. In radial or stellate aggregates, fibrous, drusy; usually powdery, massive.

Physical Properties: *Cleavage:* Perfect on {010}; poor on {100} and {$\bar{1}$02}. *Tenacity:* Sectile, flexible in thin {010} laminae. Hardness = 1.5–2.5 D(meas.) = 3.06 D(calc.) = 3.135

Optical Properties: Transparent to translucent. *Color:* Crimson to peach-red, pale rose, or pink, may be zoned. *Streak:* Pale red to pink. *Luster:* Subadamantine, pearly on cleavages. *Optical Class:* Biaxial (+), may be biaxial (–). *Pleochroism:* X = pale pinkish to pale rose; Y = pale violet to pale violet-rose; Z = deep red. *Orientation:* $X = b$; $Z \wedge c = 30°$–$36°$. *Dispersion:* $r > v$. $\alpha = 1.622$–1.629 $\beta = 1.660$–1.663 $\gamma = 1.681$–1.701 2V(meas.) = Very large to 90°.

Cell Data: *Space Group:* $C2/m$. $a = 10.251(3)$ $b = 13.447(4)$ $c = 4.764(1)$ $\beta = 104.98(1)°$ Z = 2

X-ray Powder Pattern: Bou Azzer, Morocco. (ICDD 11-626).
6.65 (100), 1.677 (14), 3.22 (12), 3.34 (8), 2.70 (8), 2.32 (8), 7.89 (6)

Chemistry:

	(1)	(2)
As_2O_5	38.30	38.39
FeO	4.01	
CoO	33.42	37.54
H_2O	24.08	24.07
Total	99.81	100.00

(1) Schneeberg, Germany. (2) $Co_3(AsO_4)_2 \cdot 8H_2O$.

Polymorphism & Series: Forms two series, with annabergite, and with hörnesite.

Mineral Group: Vivianite group.

Occurrence: A secondary mineral in the oxide zone of some Co–Ni–As-bearing mineral deposits.

Association: Cobaltite, skutterudite, symplesite, roselite-beta, scorodite, pharmacosiderite, adamite, morenosite, retgersite, malachite.

Distribution: Many localities, but few of importance. In France, at Chalanches, near Allemont, Isère. In Germany, fine examples with large crystals from Schneeberg, Saxony, at Wittichen, Black Forest, from Richelsdorf, Hesse, and elsewhere. At Jáchymov (Joachimsthal), Czech Republic. In the Botallack mine, St. Just, and from a number of other places in Cornwall, England. At the Aghbar (Arhbar), Irhtem (Ightem), and other mines in the Bou Azzer district, Morocco, large crystals. From Cobalt, Ontario, Canada. In the USA, at the Blackbird mine, Lemhi Co., Idaho. From the Sara Alicia mine, near Alamos, Sonora, Mexico. In Australia, from Mt. Cobalt, 110 km south of Cloncurry, Queensland, and at the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia.

Name: From the Greek for *red*, for its characteristic deep crimson color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 746–750. (2) Jambor, J.L. and J.E. Dutrizac (1995) Solid solutions in the annabergite – erythrite – hörnesite synthetic system. Can. Mineral., 33, 1063–1071. (3) Wildner, M., G. Giester, C.L. Lengauer, and C.A. McCammon (1996) Structure and crystal chemistry of vivianite-type compounds: crystal structures of erythrite and annabergite with a Mössbauer study of erythrite. Eur. J. Mineral., 8, 187–192.

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Erythrosiderite $K_2Fe^{3+}Cl_5 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tabular pyramidal crystals, flattened on {100}, showing {100}, {210}, {201}, {101}, {011}, {010}, to 0.03 mm.

Physical Properties: *Cleavage:* Perfect on {210} and {011}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.364 Easily soluble in H_2O; very deliquescent.

Optical Properties: Translucent. *Color:* Ruby-red to red and brownish red; brownish red to yellowish in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, strong.
$\alpha = 1.715$ $\beta = 1.75$ $\gamma = 1.79$–1.80 2V(meas.) = 62°

Cell Data: *Space Group: Pnma.* $a = 13.75$ $b = 9.924$ $c = 6.93$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.782 (100), 5.566 (40), 2.427 (40), 5.68 (35), 2.440 (25), 2.993 (19), 2.841 (16)

Chemistry:

	(1)	(2)
K	24.21	23.74
Fe	16.81	16.96
Cl	53.30	53.83
H_2O	[5.68]	5.47
Total	[100.00]	100.00

(1) Vesuvius, Italy; H_2O by difference. (2) $K_2FeCl_5 \cdot H_2O$.

Occurrence: As sublimates around fumaroles (Vesuvius, Italy); rimming rinneite in bedded salt deposits (Stassfurt, Germany; Kansk-Taseev depression, Russia).

Association: Kremersite, molysite, hematite (Vesuvius, Italy); rinneite (Stassfurt, Germany; Kansk-Taseev depression, Russia).

Distribution: On Vesuvius, Campania, Italy. In Germany, at Stassfurt, 34 km south of Magdeburg, Saxony-Anhalt. From Aislaby, near Whitby, Yorkshire, England. In the Kansk-Taseev depression, Siberia, and at the Kliuchevsky volcano, Kamchatka Peninsula, Russia.

Name: From the Greek for *red* and *iron*, in allusion to its color and composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 101–103. (2) Bellanca, A. (1948) La struttura dell'eritrosiderite. Periodico Mineral, 17, 59–72 (in Italian with English abs.). (3) Kolosov, A.S., A.M. Pustyl'nikov, and T.M. Zharkova (1968) Complex chlorides of iron and manganese in Cambrian salt deposits of the Kansk-Taseev depression. Doklady Acad. Nauk SSSR, 181, 1472–1475 (in Russian). (4) (1977) NBS Mono. 25, 14, 27.

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Eskebornite $CuFeSe_2$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $\bar{4}2m$. Crystals thick tabular, to 1 mm; massive, typically intergrown with other selenides.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 3–3.5 VHN = 155–252, 204 average (15 g load). D(meas.) = 5.35 D(calc.) = 5.44 Distinctly magnetic.

Optical Properties: Opaque. *Color:* Brass-yellow, tarnishes dark brown to black; in reflected light, brown-yellow or cream-yellow, may show an orange tint. *Luster:* Metallic. *Pleochroism:* Weak, creamy yellow to yellowish brown. *Anisotropism:* Marked, yellowish to tan. R_1–R_2: (400) 22.0–24.5, (420) 24.8–27.9, (440) 26.5–30.1, (460) 27.8–31.8, (480) 28.7–33.1, (500) 29.5–34.2, (520) 30.4–35.0, (540) 31.1–35.6, (560) 31.6–36.0, (580) 32.0–36.2, (600) 32.6–36.4, (620) 33.0–36.6, (640) 33.3–37.0, (660) 33.7–37.5, (680) 33.8–38.1, (700) 34.0–38.7

Cell Data: *Space Group:* $P\bar{4}2c$. a = 5.518(4) c = 11.048(6) Z = 4

X-ray Powder Pattern: Petrovice, Czech Republic.
3.186 (10), 1.951 (9), 1.664 (8), 5.52 (7), 1.127 (7), 1.380 (6), 2.470 (5)

Chemistry:

	(1)	(2)	(3)
Cu	23.62	22.97	22.91
Fe	19.75	20.70	20.14
Ag		0.05	
Se	55.96	56.35	56.95
S		0.02	
Total	99.32	100.09	100.00

(1) Martin Lake, Canada; by electron microprobe, average of several analyses; corresponding to $Cu_{1.06}Fe_{1.01}Se_{2.00}$. (2) Petrovice, Czech Republic; by electron microprobe, average of 18 analyses; corresponding to $Cu_{1.01}Fe_{1.04}Se_{2.00}$. (3) $CuFeSe_2$.

Polymorphism & Series: Forms a series with chalcopyrite.

Mineral Group: Chalcopyrite group.

Occurrence: In low-temperature hydrothermal vein deposits.

Association: Chalcopyrite, clausthalite, tiemannite, berzelianite, naumannite, umangite, geffroyite, chaméanite, uraninite, ankerite, dolomite.

Distribution: From the Eskeborn adit, Tilkerode, Harz Mountains, Germany [TL]. At the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France. In the Czech Republic, from Bukov, near Tisnova; in the Petrovice uranium deposit, near Ždár; and the Předbořice uranium deposit, near Krásna Hora; at Slavkovice; and on Koksín Hill, near Mitov. In Argentina, at Cerro de Cacheuta, Mendoza Province; from Sierra de Umango, and at Tuminico, Sierra de Cacho, La Rioja Province. From Martin Lake and the Eagle Group, Lake Athabasca area, Saskatchewan, Canada.

Name: For the Eskeborn adit, Tilkerode, Germany, where first discovered.

Type Material: The Natural History Museum, London, England, 1948,325; Harvard University, Cambridge, Massachusetts, USA, 98902.

References: (1) Ramdohr, P. (1949) Neue Erzmineralien. Fortschr. Mineral., 28, 69–70 (in German). (2) Harris, D.C. and E.A.J. Burke (1971) Eskebornite, two Canadian occurrences. Can. Mineral., 10, 786–796. (3) Kvaček, M. (1973) Selenides from the uranium deposits of western Moravia, Czechoslovakia. Part 1. Berzelianite, umangite, eskebornite. Acta. Univ. Carol., Geol., 1-2, 23–36. (4) Johan, Z. (1988) Crystal symmetry of eskebornite, $CuFeS_2$. Neues Jahrb. Mineral., Monatsh., 337–343. (5) Delgado, etal (1992) ??title?? Mat. Res. Bull., 367 ??str??Strunz?? (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 160.

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Eskimoite $Ag_7Pb_{10}Bi_{15}S_{36}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As lamellar grains, the average size of which is 0.5 mm. *Twinning:* On {010}, twin lamellae ∥ [001] may be present.

Physical Properties: Hardness = n.d. VHN = 162–223, 191 average (50 g load).
D(meas.) = n.d. D(calc.) = 7.12

Optical Properties: Opaque. *Color:* In polished section, galena-white. *Pleochroism:* Absent in air, absent to weak in oil. *Anisotropism:* Distinct to strong, pale gray to steel bluish black.
R_1–R_2: n.d.

Cell Data: *Space Group:* $B2/m$ or Bm. $a = 13.459$ $b = 30.194$ $c = 4.100$ $\beta = 93.35°$
$Z = 1$

X-ray Powder Pattern: Ivigtut, Greenland.
3.36 (100), 2.87 (60), 2.96 (50), 2.05 (50), 1.754 (50), 2.08 (40), 1.667 (40)

Chemistry:

	(1)	(2)	(3)
Ag	9.64	9.68	10.61
Pb	30.42	28.80	29.12
Cu	0.21	0.30	
Bi	44.79	46.70	44.05
S	16.40	16.17	16.22
Total	101.46	101.65	100.00

(1) Ivigtut, Greenland; by electron microprobe, average of 9 grains; corresponds to $Ag_{6.29}Cu_{0.23}Pb_{10.33}Bi_{15.09}S_{36.00}$. (2) Ivigtut, Greenland; by electron microprobe, average of 15 grains; corresponds to $Ag_{6.41}Cu_{0.34}Pb_{9.92}Bi_{15.95}S_{36.00}$. (3) $Ag_7Pb_{10}Bi_{15}S_{36}$.

Occurrence: In a cryolite deposit (Ivigtut, Greenland).

Association: Berryite, aikinite, galena (Ivigtut, Greenland); pyrite, enargite (Flathead mine, Montana, USA).

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland [TL]. In the USA, from about 13 km north of Niarada, in the Flathead mine, Flathead Co., Montana, and at Manhattan, Nye Co., Nevada. In the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. From the La Roche-Balue quarry, west of Nantes, Loire Atlantique, France. At Monteneme W–Sn deposit, Galicia?? [=Gallaecia= La Coruña, Lugo, Orense, Pontevedra Provinces = which??], Spain. From Rauriser Goldberg, Salzburg, Austria.

Name: For the Eskimos, early settlers of Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1973,156.

References: (1) Karup-Møller, S. (1977) Mineralogy of some Ag–(Cu–Pb–Bi) sulfide associations. Bull. Geol. Soc. Denmark, 26, 41–68. (2) Makovicky, E. and S. Karup-Møller (1977) Chemistry and crystallography of the lillianite homologous series II: Definition of new minerals: eskimoite, vikingite, ourayite, and treasurite. Redefinition of schirmerite and new data on the lillianite–gustavite solid solution series. Neues Jahrb. Mineral., Abh., 131, 56–82. (3) (1979) Amer. Mineral., 64, 243–244 (abs. refs. 1 and 2).

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Eskolaite Cr_2O_3

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As hexagonal prisms, to 12 mm, showing $\{11\overline{2}0\}$, $\{0001\}$, $\{10\overline{1}1\}$, and $\{2243\}$; as thick plates.

Physical Properties: Hardness = 8 VHN = 3200 D(meas.) = 5.18 D(calc.) = 5.20

Optical Properties: Opaque, translucent in thin edges. *Color:* Black to dark green; gray in reflected light, with emerald-green internal reflections. *Streak:* Pale green. *Luster:* Vitreous. *Optical Class:* Uniaxial. *Pleochroism:* Noted; emerald-green to olive-green.
Absorption: Strong.
R: (400) 24.5, (420) 23.6, (440) 22.7, (460) 22.1, (480) 22.0, (500) 21.8, (520) 21.5, (540) 21.0, (560) 20.5, (580) 20.1, (600) 19.8, (620) 19.7, (640) 19.6, (660) 19.5, (680) 19.5, (700) 19.5

Cell Data: *Space Group:* $R\overline{3}c$. $a = 4.973(15)$ $c = 13.57(4)$ Z = 6

X-ray Powder Pattern: Outokumpu, Finland.
1.6746 (100), 2.665 (97), 3.630 (96), 2.479 (94), 1.8146 (58), 2.174 (48), 1.4331 (47)

Chemistry:

	(1)
SiO_2	0.20
Al_2O_3	0.19
Fe_2O_3	0.55
Cr_2O_3	94.13
V_2O_3	4.58
MnO	0.03
MgO	0.03
H_2O	0.10
Total	99.81

(1) Outokumpu, Finland; corresponds to $(Cr_{1.90}V_{0.09}Fe_{0.01})_{\Sigma=2.00}O_3$.

Mineral Group: Hematite group.

Occurrence: In chromium-rich tremolite skarns, metaquartzites, and chlorite veins (Outokumpu, Finland); on greywacke pebbles in a glacial boulder clay deposit (Callowhill Upper, Ireland); as pebbles in streams (Merume River, Guyana); a very rare component in chondrite meteorites.

Association: Guyanaite, pyrrhotite, pentlandite, chalcopyrite, pyrite, chromian tremolite, uvarovite, chromium tourmaline, calcite, talc, quartz (Outokumpu, Finland); guyanaite, bracewellite, grimaldiite, mcconnellite, chromian gahnite, pyrophyllite, quartz (Merume River, Guyana).

Distribution: From Outokumpu, Finland. In Russia, at Nizhni Tagil, Ural Mountains, and on the western shore of Lake Baikal, 4.5 km south of Olkhon Gate Strait, Siberia. Found near Dukou, Szechwan Province, China. At Callowhill Upper, near Newtown Mt. Kennedy, Co. Wicklow, Ireland. From the Chapada Diamantina, Bahia, Brazil. Along the Merume River and its tributaries, Mazaruni district, Guyana.

Name: Honors Professor Pentti Eelis Eskola (1883–1964), of the University of Helsinki, Helsinki, Finland.

Type Material: n.d.

References: (1) Kouvo, O. and Y. Vuorelainen (1958) Eskolaite, a new chromium mineral. Amer. Mineral., 43, 1098–1106. (2) Milton, C. and E.C.T. Chao (1958) Eskolaite, Cr_2O_3, in "merumite" from British Guiana. Amer. Mineral., 43, 1203. (3) Tennyson, C. (1961) The morphology of eskolaite, Cr_2O_3. Amer. Mineral., 46, 998–999. (4) Cassedanne, J. and J. Cassedanne (1980) Présence d'eskolaïte dans les alluvions stannifères de la Chapada Diamantina (Bahia-Brésil). Bull. Minéral., 103, 600–602 (in French with English abs.). (5) Finger, L.W. and R.M. Hazen (1980) Crystal structure and isothermal compression of Fe_2O_3, Cr_2O_3, and V_2O_3 to 50 kbars. J. Appl. Phys., 51, 5362–5367.

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Esperanzaite $NaCa_2Al_2(AsO_4)_2F_4(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As radiating crystals, in spherulites, to 1.5 mm, which may form botryoidal aggregates.

Physical Properties: *Cleavage:* One, perfect, ‖ [001]. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.24 D(calc.) = 3.36(3)

Optical Properties: Transparent to translucent. *Color:* Pale blue-green; colorless in transmitted ight. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 35°$; $Z \wedge a = 50.5°$. *Dispersion:* $r < v$, medium. $\alpha = 1.580(1)$ $\beta = 1.588(1)$ $\gamma = 1.593(1)$ 2V(meas.) = 74(1)° 2V(calc.) = 76.3°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.687(5)$ $b = 10.7379(6)$ $c = 5.5523(7)$ $\beta = 105.32(1)°$ Z = 2

X-ray Powder Pattern: La Esperanza mine, Mexico.
2.966 (100), 3.527 (90), 2.700 (90b), 5.364 (80), 4.796 (80), 3.801 (80), 2.246 (60)

Chemistry:

	(1)	(2)
As_2O_5	40.67	40.75
Al_2O_3	19.20	18.08
ZnO	0.87	
CaO	20.75	19.89
Na_2O	3.86	5.49
F	13.9	13.47
H_2O	8.65	7.99
$-O = F_2$	5.83	5.67
Total	102.07	100.00

(1) La Esperanza mine, Mexico; by electron microprobe, average of three analyses on two grains; H_2O by Karl Fischer coulometric titration; $(AsO_4)^{3-}$, $(OH)^{1-}$, H_2O confirmed by IR; calculated from an original analysis As 26.50%, Al 10.16%, Zn 0.70%, Ca 14.83%, Na 2.86%, F 13.9%, H_2O 8.65%, O 24.45% calculated for charge balance, total 102.15%; corresponds to $Na_{0.68}Ca_{2.03}Zn_{0.07}Al_{2.06}(As_{0.97}O_{3.94})_2F_{4.00}(OH)\cdot 2.13H_2O$. (2) $NaCa_2Al_2(AsO_4)_2F_4(OH)\cdot 2H_2O$.

Occurrence: Very rare from a tin-bearing rhyolite.

Association: Hematite, cassiterite, quartz, tridymite, cristobalite, "opal", calcite, zeolites, mimetite, clay minerals.

Distribution: From the La Esperanza mine, 3.7 km southeast of Madero, Zaragosa district, Durango, Mexico.

Name: For the La Esperanza mine, Mexico, from which the mineral was collected.

Type Material: National Museum of Natural History, Washington, D.C., USA, 171530.

References: (1) Foord, E.E., J.M. Hughes, F. Cureton, C.H. Maxwell, A.U. Falster, A.J. Sommer, and P.F. Hlava (1999) Esperanzaite, $NaCa_2Al_2(As^{5+}O_4)_2F_4(OH)\cdot 2H_2O$, a new mineral species from the La Esperanza mine, Mexico: descriptive mineralogy and atomic arrangement. Can. Mineral., 37, 67–72. (2) (2000) Amer. Mineral., 85, 263 (abs. ref. 1).

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Esperite $PbCa_3Zn_4(SiO_4)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Granular aggregates, massive, to 9 cm.

Physical Properties: *Cleavage:* Distinct on {010} and {100}; poor on {101}. *Fracture:* Conchoidal. Hardness = 5–5.5 D(meas.) = 4.28–4.42 D(calc.) = 4.25 Brilliant yellow fluorescence under SW UV; kelly green cathodoluminescence.

Optical Properties: Opaque, transparent in small grains. *Color:* White, darkening on exposure to light. *Luster:* Dull to slightly greasy.
Optical Class: Biaxial (–). α = 1.760–1.762 β = 1.769–1.770 γ = 1.769–1.774
2V(meas.) = 5°–40°

Cell Data: *Space Group:* $P2_1/n$. $a = 17.628(4)$ $b = 8.270(3)$ $c = 30.52(2)$ $\beta = 90°$
Z = 12

X-ray Powder Pattern: Franklin, New Jersey, USA.
3.017 (100), 2.534 (75), 7.62 (45), 1.944 (45), 2.367 (40), 2.884 (33), 3.363 (23)

Chemistry:

	(1)	(2)
SiO_2	24.10	25.3
FeO	0.48	
MnO	0.57	0.6
ZnO	30.61	32.3
PbO	27.63	26.8
MgO	0.23	0.4
CaO	16.36	16.4
H_2O^-	0.12	
Total	100.10	101.8

(1) Franklin, New Jersey, USA; corresponding to $Pb_{1.23}(Ca_{2.89}Mn_{0.08}Mg_{0.06})_{\Sigma=3.03}Zn_{3.73}Si_{3.98}O_{16}$. (2) Do.; by electron microprobe, average of 10 analyses, corresponding to $Pb_{1.15}(Ca_{2.80}Mg_{0.09}Mn_{0.08})_{\Sigma=2.97}Zn_{3.80}Si_{4.04}O_{16}$.

Occurrence: In a metamorphosed stratiform zinc orebody.

Association: Willemite, zincite, hardystonite, glaucochroite, andradite, franklinite, clinohedrite, leucophoenicite, larsenite, copper.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: To honor Professor Esper Signius Larsen, Jr. (1879–1961), American petrologist and mineralogist, Harvard University, Cambridge, Massachusetts, USA.

Type Material: n.d.

References: (1) Moore, P.B. and P.H. Ribbe (1965) A study of "calcium-larsenite" renamed esperite. Amer. Mineral., 50, 1170–1178. (2) Palache, C., L.H. Bauer, and H. Berman (1928) Larsenite, calcium-larsenite and associated minerals at Franklin, N.J. Amer. Mineral., 13, 334–340. (3) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 81–82. (4) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727.

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Esseneite $CaFe^{3+}AlSiO_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, up to 8 mm.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = 6 D(meas.) = n.d. D(calc.) = 3.54

Optical Properties: Transparent in thin crystals. *Color:* Reddish brown, becoming darker with increasing Fe content. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = lemon-yellow; Y = greenish yellow; Z = apple-green. *Orientation:* $Y = b$; $Z \wedge c = 9°$. *Dispersion:* $r < v$, strong. $\alpha = 1.795(5)$ $\beta = 1.815(5)$ $\gamma = 1.825(5)$ 2V(meas.) = 77(5)°

Cell Data: *Space Group:* $C2/c$. a = 9.79(1) $b = 8.822(9)$ $c = 5.37(1)$ $\beta = 105.81(9)°$ Z = 4

X-ray Powder Pattern: Durham ranch, Wyoming, USA.
3.000 (100), 2.526 (70), 2.960 (60), 2.554 (40), 2.576 (30), 1.545 (30), 1.430 (25)

Chemistry:

	(1)
SiO_2	29.51
TiO_2	0.99
Al_2O_3	17.95
Fe_2O_3	23.89
FeO	0.69
MnO	0.11
MgO	2.68
CaO	23.40
Na_2O	0.14
Total	99.36

(1) Durham ranch, Wyoming, USA; by electron microprobe, average of 43 analyses on several grains, Fe^{2+}:Fe^{3+} calculated from normalized formula; corresponds to $(Ca_{1.01}Na_{0.01})_{\Sigma=1.02}(Fe^{3+}_{0.72}Mg_{0.16}Al_{0.04}Ti_{0.03}Fe^{2+}_{0.02})_{\Sigma=0.97}(Si_{1.19}Al_{0.81})_{\Sigma=2.00}O_6$.

Mineral Group: Pyroxene group.

Occurrence: A high-temperature, low-pressure, oxidized and quenched crystallization product derived from fused sediments contiguous to naturally combusted coal seams.

Association: Anorthite, melilite, magnetite-hercynite, glass.

Distribution: At Durham ranch, in the Powder River basin, 13 km northeast of Reno Junction and 25 km south of Gillette, Campbell Co., Wyoming, USA.

Name: For Dr. Eric J. Essene, Professor at the University of Michigan, Ann Arbor, Michigan, USA, and discoverer of the first specimens.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163357.

References: (1) Cosca, M.A. and D.R. Peacor (1987) Chemistry and structure of esseneite ($CaFe^{3+}AlSiO_6$), a new pyroxene produced by pyrometamorphism. Amer. Mineral., 72, 148–156.

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Ettringite $Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals prismatic and striated along [0001], to 20 cm, commonly unterminated, rarely dipyramidal $\{10\bar{1}2\}$; fibrous to cottonlike.

Physical Properties: *Cleavage:* On $\{10\bar{1}0\}$, perfect. Hardness = 2–2.5 D(meas.) = 1.77 D(calc.) = 1.77 Partially soluble in H_2O; partially dehydrates on exposure, becoming opaque.

Optical Properties: Transparent to opaque. *Color:* Colorless, pale yellow, milky white; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (–), changing to uniaxial (+) on dehydration. $\omega = 1.464$ $\epsilon = 1.458$

Cell Data: *Space Group:* $P31c$. $a = 11.23$ $c = 21.44$ $Z = 2$

X-ray Powder Pattern: Synthetic.
9.73 (100), 5.61 (80), 3.88 (50), 2.564 (45), 2.209 (45), 2.773 (40), 4.69 (35)

Chemistry:

	(1)	(2)
SO_3	18.8	19.14
CO_2	0.8	
Al_2O_3	7.0	8.12
CaO	26.6	26.81
H_2O	46.3	45.93
Total	99.5	100.00

(1) Scawt Hill, Ireland. (2) $Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$.

Mineral Group: Ettringite group.

Occurrence: In metamorphosed limestone near igneous contacts or in xenoliths; as weathering crusts on larnite rocks (Hatrurim Formation, Israel).

Association: Portlandite, afwillite, hydrocalumite (Scawt Hill, Ireland); afwillite, hydrocalumite, mayenite, gypsum (Hatrurim Formation, Israel).

Distribution: In Germany, from the Ettringer-Bellerberg volcano, near Mayen, and Schellkopf near Brenk, Eifel district; in the Zeilberg quarry, Maroldsweisach, Bavaria. At Boisséjour, near Clermont-Ferrand, Puy-de-Dôme, France. From Scawt Hill, near Larne, Co. Antrim, Ireland. In the Hatrurim Formation, Israel. As large crystals from the N'Chwaning mine, Kuruman district, Cape Province, South Africa. In the USA, at the Crestmore quarry, Riverside Co., California; in the Lucky Cuss mine, Tombstone, Cochise Co., Arizona.

Name: For the occurrence near Ettringen, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 589–590. (2) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 25–26. (3) Moore, A.E. and H.F.W. Taylor (1970) Crystal structure of ettringite. Acta Cryst., 26, 386–393. (4) (1958) NBS Circ. 539, 8, 3–4.

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Eucairite **CuAgSe**

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. In granular masses and as disseminated blebs, with single-crystal domains to 0.1 mm.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle, somewhat sectile. Hardness = 2.5 VHN = 27–31 (25 g load). D(meas.) = 7.6–7.8 D(calc.) = 7.91

Optical Properties: Opaque. *Color:* Brilliant creamy white, tarnishing to bright orange; in polished section, tin-white with a faint creamy tinge. *Streak:* Shining. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: (400) 33.5–35.0, (420) 33.8–34.0, (440) 34.2–33.6, (460) 35.0–33.7, (480) 36.3–34.1, (500) 37.6–34.5, (520) 38.2–35.1, (540) 38.0–35.8, (560) 37.4–36.6, (580) 36.9–37.1, (600) 36.1–36.8, (620) 35.4–36.1, (640) 34.7–35.3, (660) 34.1–34.6, (680) 33.6–34.1, (700) 33.3–33.6

Cell Data: *Space Group:* $P4/nmm$. $a = 4.105$ $b = 20.35$ $c = 6.31$ $Z = 10$

X-ray Powder Pattern: Skrikerum, Sweden.
2.12 (10), 2.61 (7), 2.88 (5), 2.48 (4), 2.02 (2), 3.14 (1), 1.861 (1)

Chemistry:

	(1)	(2)	(3)
Ag	42.20	44.4	43.04
Cu	25.41	24.5	25.36
Se	32.43	32.1	31.60
Total	100.04	101.0	100.00

(1) Argentina. (2) Hope's Nose, England; by electron microprobe. (3) CuAgSe.

Occurrence: Widely distributed in selenium deposits of hydrothermal origin; locally abundant with other selenides.

Association: Berzelianite, weissite, crookesite, clausthalite, umangite, klockmannite, tiemannite, chalcomenite, malachite, calcite.

Distribution: In Sweden, at the Skrikerum copper mine near Tryserum, Kalmar [TL]. From the Frederik VII's mine, near Julianehåb, southern Greenland. In Germany, in the Harz Mountains, from the Trogtal quarry, near Lautenthal, and at Lerbach. From Kletno, Poland. In the Czech Republic, at Bukov, near Tisnova; in the Petrovice uranium deposit, near Ždăr; the Předbořice uranium deposit, near Krásna Hora; from Lasovice, and at Jáchymov (Joachimsthal). In the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France. From Hope's Nose, Torquay, Devon, England. In Canada, in the Martin Lake mine near Lake Athabasca, Saskatchewan, and in the Kidd Creek mine, near Timmins, Ontario. In the Cougar mine, Slick Rock district, San Miguel Co., Colorado, USA. In Argentina, from Sierra de Umango; in the Santa Brigida mine; and at Tuminico, Sierra de Cacho, La Rioja Province. From Aguas Blancas, near Copiapó, Antofagasta, Chile. At Kalgoorlie, Western Australia. A few additional minor localities are known.

Name: From the Greek for *opportunity*, because it was discovered shortly after discovery of the element selenium.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 183–184. (2) Earley, J.W. (1950) Description and synthesis of the selenide minerals. Amer. Mineral., 35, 337–364. (3) Frueh, A.J., Jr., G.K. Czamanske, and C. Knight (1957) The crystallography of eucairite, CuAgSe. Zeits. Krist., 108, 389–396. (4) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 48–49. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 162.

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Euchlorine $KNaCu_3O(SO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, tabular on {001}, with rectangular outline, to 2 mm; typically as an incrustation.

Physical Properties: *Cleavage:* In two directions. Hardness = n.d. D(meas.) = 3.27 D(calc.) = 3.28 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Emerald-green; emerald-green in transmitted light.
Optical Class: Biaxial (+). *Pleochroism:* X = pale grass-green; Y = grass-green; Z = bright yellow-green. $\alpha = 1.580$ $\beta = 1.605$ $\gamma = 1.644$ 2V(meas.) = Moderately large.

Cell Data: *Space Group:* $C2/a$. $a = 18.41(5)$ $b = 9.43(3)$ $c = 14.21(5)$ $\beta = 113.7(3)°$ Z = 8

X-ray Powder Pattern: Vesuvius, Italy.
8.44 (100), 2.816 (47), 2.544 (45), 2.843 (40), 2.852 (37), 3.475 (30), 3.237 (25)

Chemistry:

	(1)	(2)
SO_3	41.41	43.13
Al_2O_3	0.06	
CuO	43.69	42.85
MgO	0.17	
CaO	0.07	
Na_2O	6.35	5.56
K_2O	8.25	8.46
Total	[100.00]	100.00

(1) Vesuvius, Italy; by electron microprobe, average of seven analyses, recalculated to 100% from an original total of 101.86%, $(SO_4)^{2-}$ shown present by IR; corresponds to $K_{1.01}Na_{1.18}Mg_{0.02}Ca_{0.01}Cu_{3.15}O_{1.27}(SO_4)_3$. (2) $KNaCu_3O(SO_4)_3$.

Occurrence: A rare sublimate around volcanic fumaroles.

Association: Dolerophanite, eriochalcite, chalcocyanite, melanothallite (Vesuvius, Italy); stoiberite, fingerite, ziesite, thénardite, mcbirneyite (Izalco volcano, El Salvador); eriochalcite, melanothallite, fedotovite, vergasovaite, chalcocyanite, dolerophanite, tenorite, cuprian anglesite, gold (Tolbachik volcano, Russia).

Distribution: From Vesuvius, Campania, Italy. On the Izalco volcano, El Salvador. At the Tolbachik fissure volcano, Kamchatka Peninsula, Russia,

Name: From the Greek for *pale green*, in allusion to the typical color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 571. (2) Scordari, F., F. Stasi, and A. DeMarco (1989) Euchlorin: new crystallographic and chemical data. Neues Jahrb. Mineral., Monatsh., 541–550. (3) Scordari, F. and F. Stasi (1990) The crystal structure of euchlorin, $NaKCu_3O(SO_4)_3$. Neues Jahrb. Mineral., Monatsh., 241–253.

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Euchroite $Cu_2(AsO_4)(OH)\cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. Typically euhedral crystals, to 2 cm, equant to short prismatic [010], may be thick tabular {100}, showing large {010}, {100}, {110}, {101}, {0*kl*}, {*h*0*l*}, striated ‖ [010].

Physical Properties: *Cleavage:* {101}, {110}, interrupted. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 3.44 D(calc.) = 3.47

Optical Properties: Transparent to translucent. *Color:* Bright emerald-green or leek-green; bright bluish green in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak. *Orientation:* $X = c$; $Y = a$; $Z = b$.
Dispersion: $r > v$, moderate. $\alpha = 1.695(3)$ $\beta = 1.698(3)$ $\gamma = 1.733(3)$ 2V(meas.) = 29(1)°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 10.056(2)$ $b = 10.506(2)$ $c = 6.103(2)$ Z = 4

X-ray Powder Pattern: Lubietová, Slovakia.
5.34 (10), 2.83 (9), 7.37 (8), 2.64 (8), 2.55 (7), 3.71 (6), 1.510 (5)

Chemistry:

	(1)	(2)
P_2O_5	1.48	
As_2O_5	30.90	34.09
CuO	47.26	47.20
H_2O^+	16.16	18.71
H_2O^-	3.12	
Total	98.92	100.00

(1) Lubietová, Slovakia. (2) $Cu_2(AsO_4)(OH)\cdot 3H_2O$.

Occurrence: A very rare mineral in the oxidized zone of some copper-bearing hydrothermal mineral deposits.

Association: Olivenite (Lubietová, Slovakia); strashimirite, olivenite, azurite, malachite (Zapachitsa deposit, Bulgaria).

Distribution: From L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. At Laurium, Greece, in slag. From the Zapachitsa copper deposit, Ismerez, Stara-Planina, Bulgaria. In the USA, at the Black Pine mine, Philipsburg, Granite Co., and along Cramer Creek, Missoula Co., Montana; in the Monte Cristo mine, Weden Creek, Snohomish Co., Washington; at Sterling Hill, Ogdensburg, Sussex Co., New Jersey.

Name: From the Greek for *beautiful color.*

Type Material: Mining Academy, Freiberg, Germany, 21335.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 934–935. (2) Berry, L.G. (1951) Observations on conichalcite, cornwallite, euchroite liroconite and olivenite. Amer. Mineral., 36, 484–503. (3) Eby, R.K. and F.C. Hawthorne (1989) Euchroite, a heteropolyhedral framework structure. Acta Cryst., C45, 1479–1482.

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Euclase $BeAlSiO_4(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, flattened on {100}, commonly morphologically complex, to 12 cm.

Physical Properties: *Cleavage:* Perfect on {010}, imperfect on {110} and {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7.5 VHN = 1310 D(meas.) = 2.99–3.10 D(calc.) = 3.115

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale green to deep yellowish green, greenish blue, pale blue to deep blue, rarely mottled; colorless to pale blue or pale green in thin section. *Streak:* White. *Luster:* Vitreous, somewhat pearly on cleavages. *Optical Class:* Biaxial (+). *Pleochroism:* May be marked in shades of deep blue. *Orientation:* $Z \wedge c = 41°$. *Dispersion:* $r > v$, distinct. $\alpha = 1.651$–1.653 $\beta = 1.655$–1.657 $\gamma = 1.669$–1.675 2V(meas.) = $\sim 50°$ 2V(calc.) = $46°$

Cell Data: *Space Group:* $P2_1/a$. $a = 4.763(5)$ $b = 14.29(2)$ $c = 4.618(5)$ $\beta = 100°15(5)'$ Z = 4

X-ray Powder Pattern: Villa Rica, Brazil.
7.146 (100), 3.219 (50), 3.836 (35), 2.773 (35), 2.444 (35), 2.543 (25), 1.991 (18)

Chemistry:

	(1)	(2)
SiO_2	42.05	41.60
Al_2O_3	33.97	34.76
Fe_2O_3	0.12	
FeO		0.28
BeO	17.51	16.95
Na_2O		0.13
K_2O		0.04
H_2O	6.35	5.95
Total	[100.00]	99.71

(1) Ottré, Belgium; recalculated to 100.00% after deduction of 3.5% quartz; corresponds to $Be_{1.00}Al_{0.95}Si_{1.00}O_4(OH)_{1.01}$. (2) Santo do Encoberto, Brazil; by electron microprobe; corresponds to $(Be_{0.99}Fe_{0.01}Na_{0.01})_{\Sigma=1.01}Al_{1.00}Si_{1.01}O_4(OH)_{0.96}$.

Occurrence: The product of decomposition of beryl in pegmatites, and in low-temperature alpine veins.

Association: Feldspar, quartz, topaz, beryl, mica, calcite, ankerite, chlorite.

Distribution: Fine crystals occur from: the Sanarka River, Orenburg district, and the Kamenka River, Southern Ural Mountains, Russia. At Epprechtstein, Bavaria, Germany. In the Muiâne pegmatite, Alto Ligonha district, Mozambique. Found near Mikese Station, Morogoro district, Tanzania. From Karoi, Miami district, Zimbabwe. In Brazil, in Minas Gerais, around Villa Rica, Boa Vista, Santa do Encoberto, Dom Bosco, Ouro Prêto; Mãe dos Homens, in Capelinha; and many other localities. Large crystals from the Gachalá mine, Las Cruces, near Chivor, Colombia. A number of other minor localities are known.

Name: From the Greek for *easily* and *fracture* regarding its perfect cleavage.

Type Material: Natural History Museum, Paris, France, Haüy 3303.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 508–509. (2) Biscoe, J. and B.E. Warren (1930) The structure of euclase $HBeAlSiO_5$. Zeits. Krist., 86, 292–297. (3) Mrose, M.E. and O. von Knorring (1959) The mineralogy of väyrynenite, $(Mn, Fe)Be(PO_4)(OH)$. Zeits. Krist., 112, 275–288. (4) Graziani, G. and G. Guidi (1980) Euclase from Santa do Encoberto, Minas Gerais, Brazil. Amer. Mineral., 65, 183–187. (5) Anderson, S. (1980) Euclase. J. Gemmology, 17, 18–29. (6) Hanson, A. (1985) Découverte d'euclase dans un filon de quartz à Ottré, massif de Stavelot, Belgique. Bull. Minéral., 108, 139–143 (in French with English abs.).

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Eucryptite $LiAlSiO_4$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. Rare euhedral crystals, to 3 cm; common forms are $\{10\bar{1}0\}$, $\{11\bar{2}0\}$ and $\{0001\}$. In coarse crystalline aggregates and massive.

Physical Properties: *Cleavage:* $\{0001\}$ and $\{10\bar{1}0\}$. *Fracture:* Conchoidal. Hardness = 6.5 D(meas.) = 2.657–2.666 D(calc.) = 2.654–2.661 Fluoresces pink to red or orange under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless.
Optical Class: Uniaxial (+). $\omega = 1.570$–1.573 $\epsilon = 1.583$–1.587

Cell Data: *Space Group:* $R\bar{3}$. $a = 13.47$–13.54 $c = 9.00$–9.01 $Z = 18$

X-ray Powder Pattern: Bikita, Zimbabwe.
3.362 (100), 3.965 (90), 2.733 (70), 2.545 (60), 2.373 (50), 1.797 (50), 6.736 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	49.32	47.97	47.68
Al_2O_3	40.43	40.28	40.46
Li_2O	9.72	11.45	11.86
Na_2O	0.24	0.26	
K_2O	0.01		
Total	99.72	99.96	100.00

(1) Bikita, Zimbabwe. (2) Kings Mountain, North Carolina, USA. (3) $LiAlSiO_4$.

Occurrence: In lithium-rich pegmatites.

Association: Albite, spodumene, petalite, amblygonite, lepidolite, quartz.

Distribution: In the USA, from Branchville, Fairfield Co., Connecticut; Center Strafford, Strafford Co., New Hampshire; in the Harding pegmatite, Dixon, Taos Co., New Mexico; in the Midnight Owl pegmatite, Maricopa Co., Arizona; and in the Foote mine, Kings Mountain, Cleveland Co., North Carolina. From the Tanco pegmatite, Bernic Lake, Manitoba, and near Nakina, Ontario, Canada. In Zimbabwe, large amounts at Bikita, with many other minor localities. From the Haapaluoma quarry, near Peräseinäjoki, Finland.

Name: From the Greek for *well* and *concealed*, in reference to its occurrence as intimate intergrowths with albite.

Type Material: Yale University, New Haven, Connecticut, USA, 2.4206, 2.4208, 2.4209.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 426.
(2) Hurlbut, C.S., Jr. (1962) Eucryptite from Bikita, Southern Rhodesia. Amer. Mineral., 47, 557–559. (3) Leavens, P.B., C.S. Hurlbut, Jr., and J.A. Nelen (1968) Eucryptite and bikitaite from King's [*sic*] Mountain, North Carolina. Amer. Mineral., 53, 1202–1207. (4) Černý, P. (1972) The Tanco pegmatite at Bernic Lake, Manitoba. VII. Eucryptite. Can. Mineral., 11, 708–713.
(5) Hesse, K.-F. (1985) Crystal structures of natural and synthetic α-eucryptite, $LiAlSiO_4$. Zeits. Krist., 172, 147–151.

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Eudialyte $\mathbf{Na_4(Ca,Ce)_2(Fe^{2+},Mn^{2+})ZrSi_8O_{22}(OH,Cl)_2(?)}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Crystals short rhombohedral with {0001} dominant, to long prismatic, up to 10 cm. More commonly as irregular masses and vein fillings.

Physical Properties: *Cleavage:* Perfect to indistinct on {0001}, imperfect on $\{11\bar{2}0\}$. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.74–3.10 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* Brown, yellow-brown, yellow, pink, rose-red, cherry-red, red; colorless in thin section. *Luster:* Vitreous to dull.
Optical Class: Uniaxial (+) or (–). *Pleochroism:* Weak; *O* = colorless, pink, pale yellow; *E* = pink to colorless. $\omega = 1.588$–1.636 $\epsilon = 1.588$–1.658

Cell Data: *Space Group:* $R\bar{3}m$. a = 13.95–14.29 c = 29.89–30.49 Z = 12

X-ray Powder Pattern: Kipawa Lake, Canada; could be mistaken for alluaivite.
2.82 (100), 2.94 (90), 3.10 (80), 4.25 (50), 4.05 (40), 3.35 (40), 3.19 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	50.35	50.14	CaO	9.74	11.18
TiO_2	0.38	0.46	SrO	0.11	0.47
ZrO_2	11.80	11.83	Na_2O	12.53	14.06
Al_2O_3	0.44	0.07	K_2O	0.43	1.39
RE_2O_3	6.40	0.37	F	0.23	
Fe_2O_3	0.19	0.50	Cl	1.47	1.82
Nb_2O_5	0.69	0.11	H_2O^+	1.64	1.07
FeO	2.41	5.32	H_2O^-		0.12
MnO	1.34	0.60	P_2O_5	0.03	
MgO	0.13	0.24	S		0.04
			$-O = (F,Cl)_2$	0.43	0.41
			Total	99.88	99.38

(1) Kipawa Lake, Canada; corresponds to $Na_{3.85}(Ca_{1.65}RE_{0.19}K_{0.17})_{\Sigma=2.01}(Fe^{2+}_{0.32}Mn^{2+}_{0.18}Nb_{0.06}Mg_{0.03})_{\Sigma=0.59}(Zr_{0.91}Al_{0.08}Ti_{0.04}Fe^{3+}_{0.01})_{\Sigma=1.04}Si_{8.02}O_{22}[(OH)_{1.73}Cl_{0.39}]_{\Sigma=2.12}$. (2) Khibiny massif, Russia; corresponds to $Na_{4.29}(Ca_{1.88}K_{0.28}RE_{0.02})_{\Sigma=2.18}(Fe^{2+}_{0.70}Mn^{2+}_{0.08}Mg_{0.06}Nb_{0.01})_{\Sigma=0.85}(Zr_{0.98}Fe^{3+}_{0.13}Ti_{0.05}Al_{0.01})_{\Sigma=1.17}Si_{7.90}O_{22}[(OH)_{1.12}Cl_{0.43}]_{\Sigma=1.55}$.

Occurrence: In nepheline syenites, alkalic granites, and associated pegmatites; may be a major constituent, of both magmatic and late-stage pneumatolytic origin.

Association: Microcline, nepheline, aegirine, lamprophyllite, lorenzenite, murmanite, arfvedsonite, sodalite, aenigmatite, rinkite, låvenite, titanite, titanian magnetite.

Distribution: Numerous localities, a number affording fine crystals. In Greenland, on the Kangerdluarssuk Plateau, in the Ilímaussaq intrusion, at Narssârssuk, and elsewhere. Around the Langesundsfjord, Norway. In Russia, from the Lovozero and Khibiny massifs, Kola Peninsula; at Barynga Ridge, Taimyr; in the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia. In the USA, from Magnet Cove, Hot Spring Co., Arkansas; at Point of Rocks, Colfax Co., and in a large deposit at Pajarito Mountain, Otero Co., New Mexico. In Canada, from Seal Lake and the Red Wine complex, Labrador, Newfoundland; in the Sheffield Lake complex, Kipawa River, Villedieu Township, and from Mont Saint-Hilaire and near Saint-Amable, Quebec. From Tenerife, Canary Islands.

Name: From the Greek for *easily* and *dissolved*, in allusion to its ready dissolution in acids.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 409–412. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 348–363. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 355–364. (4) Rastsvetaeva, R.K. and B.E. Borutzky (1988) Crystallochemical traits of eudialyte in the light of new structural data. Mineral. Zhurnal, 10(1), 48–57 (in Russian). (5) Pol'shin, E.V., A.N. Platonov, B.E. Borutzky, M.N. Taran, and R.K. Rastsvetaeva (1991) Optical and Mössbauer study of minerals of the eudialyte group. Phys. Chem. Minerals, 18, 117–125.

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Eudidymite $NaBeSi_3O_7(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular on {001}, to 5 cm, commonly twinned, intergrown in fanlike aggregates. Spherulitic, micaceous, coarse and fine granular, massive. *Twinning:* On {001}, simple twins, common, may be polysynthetic.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on $\{\bar{5}51\}$. *Fracture:* Uneven to conchoidal. Hardness = 6 D(meas.) = 2.55 D(calc.) = [2.57]

Optical Properties: Transparent to translucent. *Color:* White or colorless, also grayish blue, blue, violet, yellow; colorless in thin section. *Luster:* Vitreous, pearly on cleavage. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = -58.5°$. *Dispersion:* $r > v$, distinct. $\alpha = 1.545$ $\beta = 1.546$ $\gamma = 1.549$–1.551 2V(meas.) = 25°–30°

Cell Data: *Space Group:* $C2/c$. $a = 12.63(1)$ $b = 7.38(1)$ $c = 14.02(1)$ $\beta = 103°43(5)'$ Z = 8

X-ray Powder Pattern: Langesundsfjord, Norway.
3.163 (10), 3.398 (8), 3.074 (8), 6.35 (6), 2.999 (6), 2.848 (6), 3.687 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	72.94	73.11	73.49
Al_2O_3	0.57		
FeO	0.29		
BeO	11.20	10.12	10.20
CaO	0.44		
Na_2O	10.56	12.24	12.64
H_2O^+	0.35		
H_2O^-	4.07	3.79	3.67
Total	100.42	99.26	100.00

(1) Langesundsfjord, Norway. (2) Mt. Alluaiv, Russia. (3) $NaBeSi_3O_7(OH)$.

Polymorphism & Series: Dimorphous with epididymite.

Occurrence: A late-stage mineral in alkalic nepheline syenite pegmatites.

Association: Albite, neptunite, aegirine, elpidite, natrolite, analcime, fluorite, quartz.

Distribution: On Arø Island, in the Langesundsfjord, Norway. In the Ilímaussaq intrusion, southern Greenland. At Meldon, Okehampton, Devon, England. From Věžná, Czech Republic. On Mt. Alluaiv, Lovozero massif, and Mt. Yukspor, Khibiny massif, Kola Peninsula; in the Burpala massif, 120 km north of Lake Baikal, eastern Siberia; and other less-well-defined localities in Russia. From Seal Lake, Labrador, Newfoundland, and at Mont Saint-Hilaire, Quebec, Canada. Large crystals on Mt. Malosa, Zomba district, Malawi.

Name: From the Greek for *well* and *twinned*, in allusion to its common occurrence in twins.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 313–314. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 135-140. (3) Nickel, E.H. (1963) Eudidymite from Seal Lake, Labrador, Newfoundland. Can. Mineral., 7, 643–649. (4) Fang, J.H., P.D. Robinson, and Y. Ohya (1972) Determination of the crystal structure of eudidymite and its dimorphic relationship to epididymite. Amer. Mineral., 57, 1345–1354.

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Eugenite $Ag_{11}Hg_2$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. Granular, up to 4 mm.

Physical Properties: Hardness = n.d. VHN = 85–106, 92 average (15 g load).
D(meas.) = 10.75(3) D(calc.) = 10.45

Optical Properties: Opaque. *Color:* [Black]; white with faint yellow tinge in reflected light.
Luster: Metallic.
Optical Class: Isotropic.
R: (546) 80.1, (589) 82.7, (656) 85.6

Cell Data: *Space Group:* $I4\overline{3}m$. $a = 10.02(2)$ $Z = 4$

X-ray Powder Pattern: Lubin mine, Poland.
2.37 (10), 2.10 (8), 0.950 (8), 0.925 (8), 1.457 (7), 1.240 (7), 1.193 (6)

Chemistry:

	(1)	(2)
Hg	25.50	25.27
Ag	74.00	74.73
S	0.15	
Total	99.70	100.00

(1) Lubin mine, Poland; by electron microprobe, corresponds to $Ag_{11.00}Hg_{2.10}$. (2) $Ag_{11}Hg_2$.

Occurrence: In low-grade copper sulfide ore in black shale and carbonate rocks (Lubin mine, Poland); in cuprite (Bisbee, Arizona, USA).

Association: Chalcocite, covellite, tennantite, hematite, calcite, ankerite, gypsum (Lubin mine, Poland).

Distribution: In Poland, from the Lubin [TL] and Sieroszowice copper mines, near Legnica, Zechstein copper district, Lower Silesia, Poland. In the USA, in the Southwest mine, Bisbee, Cochise Co., Arizona.

Name: To honor Professor Eugen Friedrich Stumpfl (1935–), Austrian mineralogist, Mining University, Leoben, Austria, for his studies of noble metal compounds.

Type Material: Institute of Geology and Mineral Deposit, Cracow, Poland.

References: (1) Kucha, H. (1986) Eugenite, $Ag_{11}Hg_2$ – a new mineral from Zechstein copper deposits in Poland. Mineral. Polonica, 17(2), 3–10. (2) Piestrzyński, A. and W. Tylka (1992) Silver amalgams from the Sieroszowice copper mine, Lubin-Sieroszowice district, SW Poland. Mineral. Polonica, 23(1), 17–24. (3) (1995) Amer. Mineral., 80, 845–846 (abs. refs. 1–2).

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Eugsterite $Na_4Ca(SO_4)_3 \cdot 2H_2O$

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Crystal Data: Monoclinic (?). *Point Group:* n.d. As clusters of thin fibers, to 40 μm.

Physical Properties: Hardness = "Low". D(meas.) = < 2.5 D(calc.) = n.d. Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial. *Orientation:* $Z = b$; $Y \wedge c = 27°$. $\alpha = \sim 1.492$ β = n.d. $\gamma = \sim 1.496$
2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. a = n.d. b = n.d. c = n.d. $\beta = 116°$ Z = n.d.

X-ray Powder Pattern: Synthetic.
3.428 (100), 5.50 (64), 1.7126 (61), 2.746 (46), 9.20 (39), 4.50 (33), 3.454 (32)

Chemistry: (1) Qualitative electron microprobe analysis confirms Na, Ca, and S as the major chemical components; identification depends on correspondence of other properties with those of synthetic material.

Occurrence: As evaporative crusts in carbonate-poor soil, playa sediment and around an active boron-rich spring.

Association: Thénardite, halite, blödite, gypsum, glauberite, nesquehonite, admontite.

Distribution: From northeast of Karapinar, between Konya and Ereğli, Great Konya Basin, Konya Province, Turkey. Along the shore of Lake Victoria, at Sindo and Luanda, and at Kalacha, Turkana district, Kenya. From Schildmauer, near Admont, Styria, Austria. In the USA, from the Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., California. On the Río Grande and Rincón playas, Jujuy Province, Argentina.

Name: Honors Professor Hans Peter Eugster (1927–1985), Swiss–American mineralogist, Johns Hopkins University, Baltimore, Maryland, USA, who studied the mineralogy of saline lakes.

Type Material: National Museum of Geology and Mineralogy, Leiden, The Netherlands.

References: (1) Vergouwen, L. (1981) Eugsterite, a new salt mineral. Amer. Mineral., 66, 632–636.

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Eulytite $Bi_4(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As tetrahedral crystals, to 2 mm, showing {100}, {110}, {111}, and {211}. *Twinning:* Interpenetrant, may be multiple.

Physical Properties: *Cleavage:* Very imperfect on {110}. *Fracture:* Uneven. *Tenacity:* Rather brittle. Hardness = 4.5 D(meas.) = 6.62–6.76 D(calc.) = [6.76]

Optical Properties: Transparent to opaque. *Color:* Dark brown, yellowish gray, grayish white, straw-yellow, colorless; colorless to pale brown in thin section. *Streak:* White or yellowish gray. *Luster:* Resinous or adamantine.
Optical Class: Isotropic; anomalously biaxial (–). $n = 2.05$

Cell Data: *Space Group:* $I\bar{4}3d$. $a = 10.29$ Z = [4]

X-ray Powder Pattern: Synthetic.
3.20 (100), 2.70 (100), 4.13 (80), 2.070 (70), 1.990 (70), 1.664 (70), 1.584 (70)

Chemistry:

	(1)	(2)
SiO_2	16.52	16.21
Bi_2O_3	82.23	83.79
rem.	1.15	
Total	99.90	100.00

(1) Schneeberg, Germany; remainder is Fe_2O_3 and P_2O_5. (2) $Bi_4(SiO_4)_3$.

Occurrence: In bismuth-rich hydrothermal veins.

Association: Bismuth, quartz.

Distribution: In Germany, from Schneeberg and Johanngeorgenstadt, Saxony; at Hechtsberg, near Hausach, and in the Clara Mine, near Oberwolfach, Black Forest. From Dognecea (Dognaczka), Romania. At Lanlivery, Cornwall, England. From the Southwick cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland. In Canada, from the Evans-Lou quarry, near Wakefield Lake, Quebec.

Name: From the Greek for *good* and *dissolved*, in reference to its low point of fusion.

Type Material: Mining Academy, Freiberg, Germany, 23972.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 436.
(2) Menzer, G. (1931) Die Kristallstruktur von Eulytin. Zeits. Krist., 78, 136–163 (in German).
(3) Durif-Varambon, A. (1959) Étude de la substitution du silicium dans quelques types d'orthosilicates. Bull. Soc. fr. Minéral., 82, 285–314 (in French). (4) Segal, D.J., R.P. Santoro, and R.E. Newnham (1966) Neutron diffraction study of $BiSi_3O_{12}$. Zeits. Krist., 123, 73–76.
(5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 412.

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Eurekadumpite $(Cu,Zn)_{16}(TeO_3)_2(AsO_4)_3Cl(OH)_{18}\cdot 7H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*, *m*, or 2. As micaceous crystals (< 1 μm) with either round or hexagonal outlines, to 0.5 mm, as spherulites and rosettes to 1 mm.

Physical Properties: *Cleavage*: Perfect on {010}. *Fracture*: n.d. *Tenacity*: Flexible. Hardness = 2.5-3 D(meas.) = 3.76(2) D(calc.) = 3.826

Optical Properties: Transparent. *Color*: Deep blue-green or turquoise. *Streak*: Light turquoise. *Luster*: Pearly flakes, silky aggregates.
Optical Class: Biaxial (-). $\alpha = 1.69(1)$ $\beta = \gamma = 1.775(5)$ $2V(meas.) = 10(5)^{o}$ 2V(calc.) = n.d.
Pleochorism: Strong, *Y* = *Z* = deep blue-green, *X* = light turquoise. *Absorption*: *Y* = *Z* > *X*.
Orientation: *X* = *b*.

Cell Data: *Space Group*: *P*2/*m*, *P*2, or *Pm*. $a = 8.28(3)$ $b = 18.97(2)$ $c = 7.38(2)$ $\beta = 121.3(6)°$ $Z = 1$

X-ray Powder Pattern: Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.
18.92 (100), 2.524 (41), 3.777 (24), 1.558 (22), 9.45 (19), 2.692 (15), 4.111 (13)

Chemistry:

	(1)
FeO	0.04
CuO	36.07
ZnO	20.92
TeO_2	14.02
As_2O_5	14.97
Cl	1.45
H_2O	13.1
$-O = Cl_2$	0.33
Total	100.24

(1) Centennial Eureka mine, Tintic district, Utah, USA; average of 14 electron microprobe analyses, H_2O by Alimarin method, IR spectroscopy confirms TeO_3, AsO_4 and OH; corresponding to $(Cu_{10.32}Zn_{5.85}Fe_{0.01})_{\Sigma=16.18}(TeO_3)_2(AsO_4)_{2.97}[Cl_{0.93}(OH)_{0.07}](OH)_{18.45}\cdot 7.29H_2O$.

Occurrence: In the oxidation zone of quartz-sulfide ores containing tellurides (mostly hessite) in small cavities and in fractures in quartz.

Association: Mcalpineite, malachite, Zn-bearing olivenite, goethite, unspecified Mn oxides.

Distribution: From old dumps of the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: Reflects the fact that the first samples were found on the *dumps* of the Centennial *Eureka* mine. The mineral name is also related to the Greek word *eureka* -"*I have found it*" – in a *dump*—an allusion to the important role old mine dumps have played in the discovery of new minerals.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3962/1), at the National Museum of Natural History, Washington, D.C. (174877), and the American Museum of Natural History, New York, New York (112206), USA.

References: (1) Pekov, I.V., N.V. Chukanov, A.E. Zadov, A.C. Roberts, M.C. Jensen, N.V. Zubkova, and A.J. Nikischer (2010) Eurekadumpite $(Cu,Zn)_{16}(TeO_3)_2(AsO_4)_3Cl(OH)_{18}\cdot 7H_2O$ - a new supergene mineral species. Zap. Ross. Mineral. Obshch., 139(4), 26-35 (in Russian with English abstract). Geol. Ore Deposits, 53(7), 575-582 (in English). (2) (2012) Amer. Mineral., 97, 1261-1262 (abs. ref. 1).

Euxenite-(Y) $(Y, Ca, Ce, U, Th)(Nb, Ta, Ti)_2O_6$

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Crystal Data: Orthorhombic; typically metamict. *Point Group:* $2/m\ 2/m\ 2/m$. As stout prismatic crystals, to 10 cm, may be flattened ‖ [100] or [010]; commonly in parallel, subparallel, or radiating aggregates; compact massive. *Twinning:* Common on {201}; rare on {101} or {013}.

Physical Properties: *Fracture:* Conchoidal to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6.5 VHN = 633–692 (50 g load). D(meas.) = 5.3–5.9 D(calc.) = [5.16] Radioactive.

Optical Properties: Opaque, translucent on thin edges. *Color:* Black, brownish black, greenish black; brown to yellow-brown in transmitted light. *Streak:* Yellowish, grayish, or reddish brown. *Luster:* Brilliant submetallic, waxy to resinous on fractures.
Optical Class: Isotropic. $n = 2.06$–2.24
R_1–R_2: (470) 13.7–15.6, (546) 13.0–15.6, (589) 12.5–15.0, (650) 12.4–15.0

Cell Data: *Space Group: Pcmn* (synthetic $YNbTiO_6$). $a = 5.5528(6)$ $b = 14.6432(20)$ $c = 5.1953(7)$ $Z = 4$

X-ray Powder Pattern: Risør, Norway; after heating at 1200 °C.
2.99 (100), 3.66 (40), 2.95 (40), 2.60 (30), 1.830 (30), 1.727 (30), 2.78 (25)

Chemistry:

	(1)		(1)		(1)
UO_3	0.04	SnO_2	0.12	MnO	0.59
Nb_2O_5	41.43	UO_2	0.67	PbO	0.37
Ta_2O_5	3.84	Al_2O_3	0.13	MgO	0.13
SiO_2	0.07	Ce_2O_3	4.34	CaO	4.86
TiO_2	16.39	$(Y,Er)_2O_3$	18.22	H_2O^+	1.90
ThO_2	4.95	Fe_2O_3	1.32	H_2O^-	0.06
ZrO_2	0.04	FeO	0.77	Total	100.24

(1) Lyndoch Township, Ontario, Canada.

Occurrence: From granite pegmatites; as a component of detrital black sands.

Association: Albite, microcline, biotite, muscovite, ilmenite, monazite, xenotime, zircon, beryl, magnetite, garnet, allanite, gadolinite, aeschynite-(Y), thorite, uraninite, betafite, columbite.

Distribution: Numerous localities worldwide. In Norway, from Jölster, Söndfjord; at Alve, on Tromö Island; on Hidra (Hitterö) Island, near Flekkefjord; at many other places between Tvedestrand and Arendal, and in Iveland and Evje Parishes, Sätersdal. In Sweden, in the Ruoutevare Fe–Ti deposit, near Kvikkjokk, Norrbotten; at Ytterby, on Resarö Island, near Vaxholm; and elsewhere. From Huntila, Pitkäranta district, Lake Ladoga, Karelia, Russia. In Madagascar, large crystals from Vohimasina; Ambatofotsikely; Ankazobe, near Ambohitantely; Ambolotara; Ranomafana; and elsewhere. In Brazil, from Santa Clara, Pomba, and Espirito Santo, Minas Gerais. In Canada, from Lyndoch, Sabine, and Mattawan Townships, and elsewhere in Ontario; also in Quebec. In the USA, from the Rutherford pegmatite, Amelia Co., the Nanco pegmatite, Bedford Co., and others in Virginia; from Morton, Delaware Co., Pennsylvania; at Encampment, Carbon Co., Wyoming; from Guffey, Park Co., near Bergen Park, Jefferson Co., and the Colorado feldspar pegmatite, Fremont Co., Colorado.

Name: From the Greek for *hospitable*, in allusion to the wide variety of rare elements in its composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 787–792. (2) Berman, J. (1955) Identification of metamict minerals by X-ray diffraction. Amer. Mineral., 40, 805–827. (3) Ewing, R. (1973) Vickers hardness and reflectance determinations for metamict AB_2O_6−type rare earth Ti-Nb-Ta oxides. Amer. Mineral., 58, 942–944. (4) Ewing, R.C. (1976) A numerical approach toward the classification of complex, orthorhombic, rare-earth, AB_2O_6−type Nb-Ta-Ti oxides. Can. Mineral., 14, 111–119. (5) Weitzel, H. and H. Schröcke (1980) Kristallstrukturverfeinerungen von Euxenit, $Y(Nb_{0.5}Ti_{0.5})_2O_6$, und M-Fergusonit, $YNbO_4$. Zeits. Krist., 152, 69–82 (in German with English abs.).

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Evansite $Al_3(PO_4)(OH)_6 \cdot 6H_2O(?)$

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Crystal Data: Amorphous. *Point Group:* n.d. Commonly as reniform or botryoidal coatings; spherulitic or stalactitic, to 0.6 m, may show a concentric structure.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 3–4 D(meas.) = 2.0(2) D(calc.) = n.d. May fluoresce bright green under SW and LW UV, probably due to minor uranium content.

Optical Properties: Transparent to translucent. *Color:* Colorless to milky white, may be tinted blue, green, or yellow; reddish brown to brown with included iron oxides; colorless to brown in transmitted light. *Streak:* White or slightly tinted. *Luster:* Vitreous to resinous or waxy. *Optical Class:* Isotropic; may show birefringence up to 0.02. n = 1.445–1.485

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Amorphous to X-rays.

Chemistry:

	(1)	(2)	(3)
P_2O_5	19.05	18.11	18.38
Al_2O_3	39.31	40.19	39.62
H_2O	39.95	41.27	42.00
insol.	1.41		
Total	99.72	99.57	100.00

(1) Mt. Železník, Czech Republic. (2) Zeehan district, Tasmania, Australia.
(3) $Al_3(PO_4)(OH)_6 \cdot 6H_2O$.

Occurrence: In a graphite deposit (Gross-Tresny, Czech Republic); in graphitic gneiss (Vatoinandry district, Madagascar); in coal seams (Alabama, USA); a coating in caves, the phosphate derived from guano.

Association: Variscite, allophane, "limonite".

Distribution: In Slovakia, from Železník (Vashegy). At Gross-Tresny; Litošice; and Nižná-Slaná, Czech Republic. In Romania, from Alsô-Sajô; Roşia Montană (Verespatak); and Baia-de-Arieş (Offenbánya). From Epernay, Marne, France. In Spain, at Campo Lameiro; Teis, near Vigo; and several other places in Pontevedra Province; from santa Cruz de Olarde, Barcelona Province. At Richelle, near Visé, Belgium. In England, from Yoredale Rocks, near Macclesfield, Cheshire. In the Vatoinandry district, Madagascar. From the Berlin and other caves, Transvaal, South Africa. In the Zeehan and Dundas districts, Tasmania, Australia. In the USA, at Columbiana and Coalville, Shelby Co., Alabama; in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas; and from Goldburg, Custer Co., Idaho. At Cueva de Cunday, Colombia, in a cave. From the Cueva de Urtany and Cueva de Aguapiras Caves, Venezuela.

Name: In honor of Brooke Evans (1797–1862), English mining geologist, Birmingham, England, who provided the first specimens.

Type Material: Narodni Museum, Prague, Czech Republic, 1935-26572; Harvard University, Cambridge, Massachusetts, USA, 110880.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 923–924. (2) García-Guinea, J., A.M. Chagoyen, and E.H. Nickel (1995) A re-investigation of bolivarite and evansite. Can. Mineral., 33, 59–65. (3) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, esp. 168.

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Eveite $Mn_2^{2+}(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals thick tabular on {100}, with {100}, {010}, {110}, {210}, {011}; usually composite, nearly parallel, warped, barrel-shaped, sheaflike, to 2 mm.

Physical Properties: *Cleavage:* On {101}, fair. Hardness = < 4 D(meas.) = 3.67 D(calc.) = [3.75]

Optical Properties: Semitransparent. *Color:* Bright green, apple-green to pale green, pale yellow. *Streak:* White.
Optical Class: Biaxial (+). *Pleochroism:* $X = Z$ = green; Y = yellow. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, medium. $\alpha = 1.700(5)$ $\beta = 1.715(5)$ $\gamma = 1.732(10)$ 2V(meas.) = 65(5)°

Cell Data: *Space Group:* *Pnnm*. $a = 8.57(1)$ $b = 8.77(1)$ $c = 6.27(1)$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
4.39 (10), 3.058 (9), 5.09 (8), 6.10 (7), 2.528 (6), 2.797 (5), 3.14 (4)

Chemistry:

	(1)	(2)	(3)
As_2O_5	43.1	42.89	43.24
FeO		0.01	
MnO	48.8	50.29	53.37
CuO		0.01	
ZnO		0.01	
MgO		1.14	
CaO	1.3	0.50	
H_2O	n.d.	[3.36]	3.39
Total		[98.21]	100.00

(1) Långban, Sweden; by electron microprobe, total Mn as MnO, total As as As_2O_5. (2) Do.; by electron microprobe, average of two analyses, total Mn as MnO, total As as As_2O_5; corresponds to $(Mn_{1.90}Mg_{0.08}Ca_{0.02})_{\Sigma=2.00}(AsO_4)_{1.00}(OH)$. (3) $Mn_2(AsO_4)(OH)$.

Polymorphism & Series: Dimorphous with sarkinite.

Occurrence: Very rare, in fissures in a metamorphosed Fe–Mn orebody (Långban, Sweden); in a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA).

Association: Akrochordite, manganoan hörnesite, hausmannite, carbonates, Fe–Mn oxides (Långban, Sweden); willemite, sarkinite (Sterling Hill, New Jersey, USA).

Distribution: From Långban, Värmland, Sweden. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: Named for the biblical *Eve*, in contrast to adamite, with which it is isostructural.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 390274; The Natural History Museum, London, England; Harvard University, Cambridge, Massachusetts, 108971; National Museum of Natural History, Washington, D.C., USA, 120062, 162614A.

References: (1) Moore, P.B. (1968) Eveite, $Mn_2(OH)(AsO_4)$, a new mineral from Långban. Arkiv Mineral. Geol., 4(26), 473–476. (2) (1970) Amer. Mineral., 55, 319–320 (abs. ref. 1). (3) Moore, P.B. and J.R. Smyth (1968) Crystal chemistry of the basic manganese arsenates: III. The crystal structure of eveite, $Mn_2(OH)(AsO_4)$. Amer. Mineral., 53, 1841–1845. (4) Hålenius, U. and E. Westlund (1998) Manganese valency and the color of the $Mn_2AsO_4(OH)$ polymorphs eveite and sarkinite. Mineral. Mag., 62, 113–119.

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Evenkite $C_{24}H_{50}$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$ (probable). As pseudohexagonal crystals, tabular on {001}, to 3 cm. *Twinning:* Polysynthetic twinning observed.

Physical Properties: *Cleavage:* On {001}, good, micaceous. *Tenacity:* Waxlike. Hardness = 1 D(meas.) = 0.920 D(calc.) = [0.926]

Optical Properties: Transparent. *Color:* Colorless or pale yellow. *Luster:* Waxy. *Optical Class:* Biaxial (+). $\alpha = \leq 1.504$ $\beta = \leq 1.504$ $\gamma = \simeq 1.553$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P2_1/a$ (probable). $a = 7.52$ $b = 4.98$ $c = 32.50$ $\beta = \sim 90°$ Z = 2 (by analogy to *n*-tetracosane).

X-ray Powder Pattern: Evenkia district, Russia. (ICDD 28-2004). 4.18 (100), 3.74 (90), 2.25 (80), 2.52 (70), 2.12 (60), 1.751 (60), 3.02 (50)

Chemistry:

	(1)	(2)
C	85.43	85.63
H	14.99	14.37
Total	100.42	100.00

(1) Evenkia district, Russia; M.P. 49 °C–51 °C. (2) $C_{24}H_{50}$; M.P. 50.7 °C– 50.8 °C.

Occurrence: In mineralized cavities, now quartz geodes, in welded tuff.

Association: Quartz, chalcedony, pyrite, pyrrhotite, sphalerite, galena, chalcopyrite, calcite.

Distribution: From the Khavokiperskiye Rocks deposit, 40 km below Tura, Lower Tunguska River, Evenkia district, Siberia, Russia.

Name: For the occurrence in the Evenkia district, Siberia, Russia.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, Russia, 924-1/1–924-1/3.

References: (1) Skropyshev, A.V. (1953) A paraffin from a polymetallic vein. Doklady Acad. Nauk SSSR, 88, 717–719 (in Russian). (2) (1955) Amer. Mineral., 40, 368 (abs. ref. 1). (3) (1956) Amer. Mineral., 41, 113 (corr. to ref. 2). (4) Strunz, H. and B. Contag (1965) Evenkit, Flagstaffit, Idrialin und Reficit. Neues Jahrb. Mineral., Monatsh., 19–25 (in German). (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 79.

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Ewaldite **$Ba(Ca,Y,Na,K)(CO_3)_2 \cdot nH_2O$**

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Crystal Data: Hexagonal. *Point Group:* $6mm$. As tabular to prismatic or pyramidal hexagonal crystals, to 5 mm; syntactically intergrown with mckelveyite-(Y).

Physical Properties: Hardness = n.d. D(meas.) = 3.25(5), on impure material. D(calc.) = 3.37

Optical Properties: Semitransparent. *Color:* Bluish green, pale greenish gray. *Optical Class:* Uniaxial (–). *Pleochroism:* O = dark bluish green; E = pale yellowish green. $\omega = 1.646(3)$ $\epsilon = < 1.572$

Cell Data: *Space Group:* $P6_3mc$. $a = 5.284$–5.320 $c = 12.78$–12.84 $Z = 2$

X-ray Powder Pattern: Vuoriyarvi complex, Kola Peninsula, Russia. 3.135 (10), 2.044 (9), 2.024 (9), 2.655 (8), 2.626 (8), 4.340 (7), 1.609 (6)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	[27.9]	[25.46]	BaO	45.0	34.60
UO_3	0.8		Na_2O	5.6	3.53
Fe_2O_3	2.0		K_2O	1.4	
RE_2O_3	7.7	11.57	H_2O		[12.55]
CaO	7.6	5.57	insol.	5.4	
SrO	0.8	6.72	Total	[104.2]	[100.00]

(1) Green River Formation, Wyoming, USA; no anions other than CO_3^{2-} detected, here calculated for charge balance excluding Fe^{3+}; separate spectrographic analysis gave Y_2O_3 62.0%, La_2O_3 0.6%, Sm_2O_3 0.4%, Eu_2O_3 0.9%, Gd_2O_3 8.5%, Dy_2O_3 6.5%, Ho_2O_3 1.6%, Er_2O_3 10.6%, Yb_2O_3 8.5%, Lu_2O_3 0.6%; corresponds to $Ba_{1.00}(Ca_{0.48}RE_{0.20}Na_{0.15}K_{0.11}Sr_{0.03}U_{0.02})_{\Sigma=0.99}(CO_3)_{2.00}$. (2) Khibiny massif, Russia; by electron microprobe, CO_2 and H_2O calculated, H_2O confirmed by crystal-structure analysis, RE_2O_3 composed of Y_2O_3 6.98%, La_2O_3 0.80%, Ce_2O_3 1.38%, Nd_2O_3 0.16%, Gd_2O_3 0.29%, Tb_2O_3 0.09%, Dy_2O_3 0.74%, Ho_2O_3 0.27%, Er_2O_3 0.50%, Yb_2O_3 0.36%.

Occurrence: From drill core into trona beds in dolomitic marlstone (Green River Formation, Wyoming, USA); from carbonatites and hydrothermal veins in alkaline igneous rocks (Kola Peninsula, Russia).

Association: Mckelveyite-(Y), shortite, labuntsovite, leucosphenite, searlesite, hematite (Green River Formation, Wyoming, USA); kukharenkoite-(Ce), belovite, fluorite, nenadkevichite, ancylite-(Ce), synchysite-(Ce), mckelveyite-(Y), burbankite, calcite, barite, orthoclase (Khibiny massif, Russia).

Distribution: From the Green River Formation, Sweetwater Co., Wyoming, USA. Large crystals at Mont Saint-Hilaire, Quebec, Canada. In Russia, from the Vuoriyarvi carbonatite complex and the Khibiny massif, Kola Peninsula.

Name: Honors Professor Paul Peter Ewald (1888–1985), German physicist and crystallographer, founder of Zeits. Krist. and Acta Cryst., Polytechnic Institute of New York, Brooklyn, New York, USA.

Type Material: The Natural History Museum, London, England, 1971,137; National Museum of Natural History, Washington, D.C., USA, 121683.

References: (1) Donnay, G. and J.D.H. Donnay (1971) Ewaldite, a new barium calcium carbonate. I. Occurrence of ewaldite in syntactic intergrowth with mackelveyite [= mckelveyite-(Y)]. Tschermaks Mineral. Petrog. Mitt., 15, 185–200. (2) Donnay, G. and H. Preston (1971) Ewaldite, a new barium calcium carbonate. II. Its crystal structure. Tschermaks Mineral. Petrog. Mitt., 15, 201–212. (3) (1971) Amer. Mineral., 56, 2156 (abs. refs. 1 and 2). (4) Voloshin, A.V., V.V. Subbotin, V.M. Yakovenchuk, Y.A. Pakhomovskii, Y.P. Men'shikov, T.N. Nadezhina, and D.Y. Pushcharovskiy (1992) New data on ewaldite. Zap. Vses. Mineral. Obshch., 121, 56–67 (in Russian with English abs.).

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Eylettersite $(Th,Pb)_{1-x}Al_3(PO_4,SiO_4)_2(OH)_6(?)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. In pulverulent nodules.

Physical Properties: Hardness = n.d. D(meas.) = 3.38–3.44 D(calc.) = 3.44–3.50
Radioactive; fluoresces greenish yellow in SW UV, weak cream-brown in LW UV.

Optical Properties: Semitransparent. *Color:* White to cream-white; colorless in transmitted light.
Optical Class: Uniaxial (–), probable; sensibly isotropic, with very low birefringence.
n = 1.615–1.66

Cell Data: *Space Group:* $R\overline{3}m$. a = 6.98–6.99 c = 16.66–16.70 Z = [3]

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
2.95 (100), 3.51 (60), 5.70 (55), 2.187 (40), 1.899 (30), 1.748 (20), 2.848 (15)

Chemistry:

	(1)	(2)
UO_3	2.09	2.42
SiO_2	1.56	1.03
ThO_2	19.18	20.72
CO_2	0.21	0.10
P_2O_5	18.38	19.98
Al_2O_3	37.13	35.98
PbO	4.80	3.21
CaO	0.11	0.26
SrO	0.11	0.21
BaO	1.51	1.96
H_2O	15.18	14.51
Total	100.26	100.38

(1) Kobokobo pegmatite, Congo; adjusted to original total after deduction of "autunite 1.8%–1.9%, fluorapatite 0.9%, limonite 0.1%"; stated then to correspond to $(Th_{0.36}Pb_{0.11}Ba_{0.05}U_{0.04}Ca_{0.01}Sr_{0.01}H_{0.17})_{\Sigma=0.75}Al_{3.58}[(PO_4)_{1.27}(SiO_4)_{0.13}(CO_3)_{0.02}(H_4O_4)_{0.58}]_{\Sigma=2.00}(OH)_{6.10}$.
(2) Do.; adjusted to original total after deduction of "autunite 1.3%, fluorapatite 0.4%"; stated then to correspond to $(Th_{0.39}Pb_{0.07}Ba_{0.06}U_{0.04}Ca_{0.02}Sr_{0.01}H_{0.17})_{\Sigma=0.76}Al_{3.50}[(PO_4)_{1.39}(SiO_4)_{0.09}(CO_3)_{0.01}(H_4O_4)_{0.51}]_{\Sigma=2.00}(OH)_{6.09}$.

Mineral Group: Crandallite group.

Occurrence: An alteration product of thorian crandallite in a phosphate-rich granite pegmatite.

Association: Autunite, phosphuranylite, fluorapatite, "limonite", feldspar, "cyrtolite".

Distribution: In the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: For the wife of the discoverer, Mme. Van Wambeke.

Type Material: Euratom, Ispra, Italy; National Museum of Natural History, Washington, D.C., USA, 136443.

References: (1) Van Wambeke, L. (1972) Eylettersite, un nouveau phosphate de thorium appartenant à la série de la crandallite. Bull. Soc. fr. Minéral., 95, 98–105 (in French with English abs.). (2) (1974) Amer. Mineral., 59, 208 (abs. ref. 1).

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Ezcurrite $Na_4B_{10}O_{17}\cdot 7H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As bladed to fibrous prismatic crystals, moderately striated and elongated along [001], may be bent, to 7.5 cm; as intergrown cleavable masses.

Physical Properties: *Cleavage:* {110}, excellent; {010}, good; {100}, {$\overline{1}\overline{2}6$}, fair; {$1\overline{1}0$}, {$\overline{1}01$}, poor. *Tenacity:* Brittle. Hardness = 3 (‖ {001}), 3.5 (⊥ {001}). D(meas.) = 2.053 D(calc.) = 2.049 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous to satiny. *Optical Class:* Biaxial (–). *Orientation:* X (177°,86°); Y (–90°,47°); Z (82°,43°) [using (ϕ,ρ)]. *Dispersion:* $r > v$. $\alpha = 1.468(1)$ $\beta = 1.507(1)$ $\gamma = 1.529(1)$ 2V(meas.) = 73.5°

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.598(2)$ $b = 9.570(2)$ $c = 6.576(2)$ $\alpha = 102°45(3)'$ $\beta = 107°30(3)'$ $\gamma = 71°31(3)'$ Z = 1

X-ray Powder Pattern: Tincalayu deposit, Argentina.
6.936 (100), 3.074 (38), 4.494 (29), 3.135 (19), 2.780 (19), 2.039 (10), 3.302 (8)

Chemistry:

	(1)	(2)
B_2O_3	59.4	58.20
Na_2O	19.8	21.08
K_2O	0.18	
H_2O^+	20.4	20.72
Total	99.78	100.00

(1) Tincalayu deposit, Argentina; $(OH)^{1-}$ and H_2O confirmed by DTA; corresponds to $Na_{3.98}B_{10.54}O_{17}\cdot 7H_2O$. (2) $Na_4B_{10}O_{17}\cdot 7H_2O$.

Occurrence: Probably formed from solutions derived from dehydration of borax in a discordant deposit in folded playa siltstones and sandstones.

Association: Borax, kernite, halite.

Distribution: From the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina.

Name: Honors Juan Manuel de Ezcurra (1900–1970), Manager of the Compania Productora de Boratos, S.A., owner of the Tincalayu deposit, Argentina.

Type Material: National Museum of Natural History, Washington, D.C., USA, 123927.

References: (1) Muessig, S. and R.D. Allen (1957) Ezcurrite ($2Na_2O\cdot 5B_2O_3\cdot 7H_2O$), a new sodium borate from Argentina: occurrence, mineralogy, and associated minerals. Econ. Geol., 52, 426–437. (2) Hurlbut, C.S., Jr., and L.F. Aristarain (1967) Ezcurrite, $2Na_2O\cdot 5B_2O_3\cdot 7H_2O$: a restudy. Amer. Mineral., 52, 1048–1059. (3) Cannillo, E., A. Dal Negro, and L. Ungaretti (1973) The crystal structure of ezcurrite. Amer. Mineral., 58, 110–115.

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Eztlite $\mathbf{Pb_2Fe_6^{3+}(Te^{4+}O_3)_3(Te^{6+}O_6)(OH)_{10}\cdot 8H_2O}$

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Crystal Data: Monoclinic (?). *Point Group:* n.d. As paper-thin sparkling crusts.

Physical Properties: *Cleavage:* {001}, probable, good. *Tenacity:* Very brittle. Hardness = 3 D(meas.) = 4.5 D(calc.) = 4.6

Optical Properties: Semitransparent. *Color:* Brilliant red; deep cloudy orange in transmitted light. *Streak:* Orange.
Optical Class: Biaxial. *Orientation:* $Z \wedge c = 3°$. $\alpha = 2.14$ β = n.d. $\gamma = 2.15$
2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 6.58$ $b = 9.68$ $c = 20.52$ $\beta = 90°15'$ Z = 2

X-ray Powder Pattern: Moctezuma mine, Mexico.
3.426 (10), 3.289 (10), 4.037 (9), 3.239 (9), 2.445 (7), 5.130 (6), 2.613 (6)

Chemistry:

	(1)	(2)
TeO_3	8.6	9.68
TeO_2	26.8	26.39
Fe_2O_3	24.3	26.41
PbO	25.5	24.61
H_2O	12.3	12.91
Total	97.5	100.00

(1) Moctezuma mine, Mexico; H_2O by the Penfield method, low analytical total likely caused by insoluble lost following acid digestion. (2) $Pb_2Fe_6(Te^{4+}O_3)_3(Te^{6+}O_6)(OH)_{10}\cdot 8H_2O$.

Occurrence: Very rare in oxidized ore in a matrix of intensely silicified and brecciated rhyolite vitrophyre cemented by drusy quartz and carrying pyrite and tellurides.

Association: Cuzticite, emmonsite, schmitterite, kuranakhite, pyrite.

Distribution: From Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: From the Nahua language for *blood*, in allusion to the color.

Type Material: The Natural History Museum, London, England, 1984,468.

References: (1) Williams, S.A. (1982) Cuzticite and eztlite, two new tellurium minerals from Moctezuma, Mexico. Mineral. Mag., 46, 257–259. (2) (1983) Amer. Mineral., 68, 471 (abs. ref. 1).

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Fabianite $CaB_3O_5(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, to 2.5 cm, showing {100}, {120}, {110}, {320}, {011}, and {021}.

Physical Properties: *Cleavage:* On {110}. Hardness = 6 D(meas.) = 2.77–2.796 D(calc.) = 2.788 Slightly soluble in H_2O; fluoresces brownish yellow under UV.

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge a = 22(2)°$; $Z \wedge c = -45(2)°$.
Dispersion: $r < v$, weak. $\alpha = 1.608–1.612$ $\beta = 1.636–1.637$ $\gamma = 1.650–1.653$
2V(meas.) = 65°

Cell Data: *Space Group:* $P2_1/a$. $a = 6.593(1)$ $b = 10.488(2)$ $c = 6.365(1)$
$\beta = 113.38(2)°$ Z = 4

X-ray Powder Pattern: Rehden, Germany.
3.269 (100), 2.920 (87), 3.032 (83), 2.025 (56), 3.962 (54), 2.074 (54), 2.620 (48)

Chemistry:

	(1)	(2)
SO_3	2.2	
B_2O_3	57.9	61.61
Fe_2O_3	0.6	
CaO	32.1	33.08
H_2O	5.2	5.31
Total	98.0	100.00

(1) Rehden, Germany; includes impurities of $CaSO_4$ and Fe_2O_3. (2) $CaB_3O_5(OH)$.

Occurrence: In a marine evaporite deposit.

Association: Halite, anhydrite, howlite, szaibélyite.

Distribution: From drill core at Rehden, near Diepholz, Lower Saxony, Germany.

Name: Honors Hans-Joachim Fabian, German geologist.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160098.

References: (1) Gaertner, H., K.-L. Roese, and R.K. Kühn (1962) Fabianit = $CaB_3O_5(OH)$, ein neues Mineral. Naturwiss., 49, 230 (in German). (2) Kühn, R.K., K.-L. Roese, and H. Gaertner (1962) Fabianit $CaB_3O_5(OH)$, ein neues Mineral. Kali und Steinsalz, 3, 285–290 (in German). (3) (1963) Amer. Mineral., 48, 212–213 (abs. refs. 1 and 2). (4) Erd, R.C., G.D. Eberlein, and C.L. Christ (1969) Fabianite and its synthetic dimorph, $CaB_3O_5(OH)$: new data. Can. Mineral., 10, 108–112. (5) Konnert, J.A., J.R. Clark, and C.L. Christ (1970) Crystal structure of fabianite, $CaB_3O_5(OH)$, and comparison with the structure of its synthetic dimorph. Zeits. Krist., 132, 241–254.

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Fabriesite $Na_3Al_3Si_3O_{12}\cdot 2H_2O$

Crystal Data: Orthorhombic. *Point Group*: n.d. Pseudomorphous after jadeite, as skeletal crystals, to 20 mm, and rarely as pseudo prismatic crystals.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = ~5-5.5 D(meas.) = n.d. D(calc.) = 2.386

Optical Properties: Transparent. *Color*: White to yellow, colorless in thin section. *Streak*: White. *Luster*: Vitreous to greasy. *Optical Class*: Biaxial (–). α = 1.503 β = 1.506 γ = 1.508 2V(calc.) = 78° [synthetic nepheline hydrate I]

Cell Data: *Space Group*: $Pna2_1$. a = 16.426 b = 15.014 c = 5.223 Z = 4 [synthetic orthorhombic $Na_3Al_3Si_3O_{12}\cdot 2H_2O$]

X-ray Powder Pattern: Calculated pattern. [identifiable only by a combination of scanning electron microscopy, electron microprobe analyses and electron backscatter diffraction] 3.41 (100), 4.41 (77), 2.97 (70), 2.61 (40), 8.21 (36), 7.51 (32), 2.45 (29)

Chemistry:

	(1)
Na_2O	19.67
MgO	0.06
SiO_2	38.93
Al_2O_3	33.00
K_2O	0.08
CaO	0.36
FeO	0.06
MnO	0.01
BaO	0.07
H_2O	[7.76]
Total	100.00

(1) Tawmaw-Hpakant Jade Tract, Myanmar; average of 10 electron microprobe analyses, H_2O by difference; corresponding to $(Na_{2.94}Ca_{0.03}K_{0.01}Mg_{0.01})_{\Sigma=2.99}Al_{3.00}Si_{3.00}O_{12}\cdot 2H_{1.99}O$.

Occurrence: In serpentinized peridotite and related to the hydration of trinepheline during the late stage of metamorphism along veins in a jadeite deposit.

Association: Nepheline, trinepheline, more rarely with albite, banalsite, stronalsite.

Distribution: From the Tawmaw-Hpakant Jade Tract, Hpakant Township, Mohnyin District, Kachin State, Myanmar.

Name: Honors Jacques Fabriés (1932-2000), professor of Mineralogy, National Natural History Museum, Paris, France, where he served as chair of Mineralogy from 1969 until 1998, and was the Museum director (1990-1994).

Type Material: National Museum of Natural History, Paris, France (MNHN 212.001).

References: (1) Ferraris, C., G.C. Parodi, S. Pont, B. Rondeau, and J-P. Lorand (2014) Trinepheline and fabriesite: two new mineral species from the jadeite deposit of Tawmaw (Myanmar). European Journal of Mineralogy, 26(2), 257-265. (2) (2014) Amer. Mineral., 99, 1808-1809 (abs. ref. 1).

Faheyite $(Mn^{2+},Mg)Fe_2^{3+}Be_2(PO_4)_4 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* 622 (probable). As needlelike crystals, showing $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, $\{0001\}$, and several $\{h0\bar{i}l\}$ forms; more generally fibrous, to 1 mm, elongated along [0001], in flat rosettes and botryoidal masses; in mats.

Physical Properties: *Cleavage:* One, ‖ [0001], perfect. Hardness = n.d. D(meas.) = 2.660 D(calc.) = 2.670

Optical Properties: Semitransparent. *Color:* White, bluish white to brownish white. *Optical Class:* Uniaxial (+). $\omega = 1.631$ $\epsilon = 1.652$

Cell Data: *Space Group:* $P6_222$, $P6_422$, $6mm$, 622, $\bar{6}m2$, or $6/mmm$. a = 9.42(2) $c = 15.98(3)$ Z = 3

X-ray Powder Pattern: Sapucaia mine, Brazil.
5.72 (10), 7.28 (9), 3.244 (6), 3.085 (6), 3.029 (6), 3.962 (5), 2.724 (3)

Chemistry:

	(1)
P_2O_5	42.08
Al_2O_3	0.11
Fe_2O_3	23.65
Mn_2O_3	0.00
FeO	0.00
MnO	6.61
BeO	8.02
MgO	1.26
Na_2O	0.93
K_2O	trace
F	trace
H_2O	16.45
Total	[99.11]

(1) Sapucaia mine, Brazil; Na and K by flame photometry, recalculated after deduction of insoluble quartz and muscovite 9.44%; then corresponding to $(Mn_{0.61}Mg_{0.21}Na_{0.20})_{\Sigma=1.02}(Fe_{1.95}Al_{0.01})_{\Sigma=1.96}Be_{2.11}(PO_4)_{3.90} \cdot 6.01H_2O$.

Occurrence: A rare late-stage secondary mineral in a complex granite pegmatite (Sapucaia mine, Brazil).

Association: Quartz, muscovite, variscite, frondelite (Sapucaia mine, Brazil); strengite (Roosevelt mine, South Dakota, USA).

Distribution: From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. In the USA, at the Roosevelt mine, near Custer, Custer Co., South Dakota. From the Noumas mine, Blesberg, Cape Province, South Africa.

Name: Honoring Joseph John Fahey (1901–1980), American analytical chemist, U.S. Geological Survey, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 112653.

References: (1) Lindberg, M.L. and K.J. Murata (1953) Faheyite, a new phosphate mineral from the Sapucaia pegmatite mine, Minas Gerais, Brazil. Amer. Mineral., 38, 263–270.
(2) Lindberg, M.L. (1964) Crystallography of faheyite, Sapucaia pegmatite mine, Minas Gerais, Brazil. Amer. Mineral., 49, 395–398.

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Fahleite $\mathbf{Zn_5CaFe_2^{3+}(AsO_4)_6 \cdot 14H_2O}$

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Crystal Data: Orthorhombic, probable. *Point Group:* n.d. Crystals are curved and twisted, in fibrous bundles, to about 1.5 cm; in minute spherical aggregates.

Physical Properties: *Cleavage:* One, perfect, ⊥ fiber length. *Tenacity:* Sectile, flexible. Hardness = Very soft. D(meas.) = n.d. D(calc.) = [3.08]

Optical Properties: Transparent. *Color:* Straw-yellow to gray, bright green; colorless in transmitted light. *Luster:* Silky or pearly.
Optical Class: Biaxial (+). *Orientation:* Z = length, parallel extinction, positive elongation.
$\alpha = 1.628(1)$ $\beta = 1.631(1)$ $\gamma = 1.656(1)$ 2V(meas.) = n.d. 2V(calc.) = 39°

Cell Data: *Space Group:* n.d. $a = 6.60$ $b = 11.6$ $c = 22.$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia; all lines very broad.
22. (10), 11. (10), 3.2 (8), 2.9 (5), 1.65 (2)

Chemistry:

	(1)	(2)
As_2O_5	43.6	44.08
Fe_2O_3	10.2	10.21
MnO	0.5	
ZnO	26.2	26.01
CaO	4.0	3.58
H_2O	15.5	16.12
Total	100.0	100.00

(1) Tsumeb, Namibia; by electron microprobe, average of five analyses; total Fe as Fe_2O_3, total Mn as MnO, H_2O by difference, confirmed by IR; corresponds to $Zn_{5.02}Ca_{1.11}Mn_{0.11}Fe_{1.99}(AsO_4)_{5.91} \cdot 13.42H_2O$. (2) $Zn_5CaFe_2(AsO_4)_6 \cdot 14H_2O$.

Occurrence: On oxidized tennantite–chalcocite ore from a deep oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Lavendulan, cuprian adamite, conichalcite, tsumcorite, tennantite, chalcocite, quartz, calcite, gypsum.

Distribution: From Tsumeb, Namibia.

Name: In honor of Rolf Fahle (1943–), Munich, Germany, mineral dealer specializing in Tsumeb minerals, who supplied the specimen from which the species was described.

Type Material: Mineralogical Institute, Ruhr University, Bochum, Germany.

References: (1) Medenbach, O., K. Schmetzer, and K. Abraham (1988) Fahleite from Tsumeb/Namibia, a new mineral belonging to the smolianinovite group. Neues Jahrb. Mineral., Monatsh., 167–171. (2) (1989) Amer. Mineral., 74, 501–502 (abs. ref. 1).

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Fairbankite $PbTe^{4+}O_3$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals nearly equant, to 0.5 mm; typically as thin crusts.

Physical Properties: *Tenacity:* Brittle. Hardness = 2 D(meas.) = n.d. D(calc.) = 7.45

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Resinous to adamantine. *Optical Class:* Biaxial (–) or (+). *Dispersion:* Weak. $\alpha = 2.29$ $\beta = 2.31$ $\gamma = 2.33$ 2V(meas.) = 86° 2V(calc.) = 90°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 7.81$ $b = 7.11$ $c = 6.96$ $\alpha = 117°12'$ $\beta = 93°47'$ $\gamma = 93°24'$ Z = 4

X-ray Powder Pattern: Grand Central mine, Arizona, USA.
3.265 (10), 3.148 (6), 3.098 (6), 2.828 (6), 3.020 (5), 2.516 (5), 2.076 (3)

Chemistry:

	(1)	(2)
TeO_2	41.70	41.69
PbO	58.30	58.31
Total	[100.00]	100.00

(1) Grand Central mine, Arizona, USA; recalculated to 100% from an original total of 100.3%, after deduction of $PbCO_3$ 13.0% due to cerussite impurity. (2) $PbTeO_3$.

Polymorphism & Series: Dimorphous with plumbotellurite.

Occurrence: Very rare on the mine dump from a hydrothermal Au–Te-bearing ore deposit.

Association: Oboyerite, cerussite, "opal".

Distribution: From the Grand Central mine, Tombstone, Cochise Co., Arizona, USA.

Name: Honors Nathaniel Kellogg Fairbank (1829–1903), who organized the company that developed the Grand Central lode, Tombstone, Arizona, USA.

Type Material: Natural History Museum, Paris; The Natural History Museum, London, England, 1980,540; National Museum of Natural History, Washington, D.C., USA, 160238.

References: (1) Williams, S.A. (1979) Girdite, oboyerite, fairbankite, and winstanleyite, four new tellurium minerals from Tombstone, Arizona. Mineral. Mag., 43, 453–457. (2) (1980) Amer. Mineral., 65, 809 (abs. ref. 1).

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Fairchildite $K_2Ca(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As microscopic hexagonal plates, flattened on {0001}; typically in dense stony aggregates.

Physical Properties: *Cleavage:* On {0001}, good. Hardness = n.d. D(meas.) = 2.45 D(calc.) = 2.45 Slowly hygroscopic in air, altering to bütschliite, which may then leach to calcite.

Optical Properties: Transparent. *Color:* Colorless; light gray to bluish gray in aggregates. *Optical Class:* Uniaxial (–). $\omega = 1.533$ $\epsilon = 1.498$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.294(1)$ $c = 13.355(2)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.192 (100), 2.646 (70), 2.699 (30), 2.168 (20), 2.225 (16), 6.67 (14), 2.039 (14)

Chemistry: (1) Analyses of nearly pure natural material apparently do not exist; identification depends on coincidence of other properties with those of synthetic material.

Polymorphism & Series: Dimorphous with bütschliite.

Occurrence: Formed from fused wood ash in partially burned trees.

Association: Bütschliite, calcite.

Distribution: In the USA, many occurrences in forests from trees struck by lightning. Some studied are: from the Grand Canyon National Park, Coconino Co., Arizona; in the Kaniksu National Forest, near Coolin, Bonner Co., Idaho. From near Eganville and Deseronto, Ontario, Canada.

Name: Honors John Gifford Fairchild (1882–1965), analytical chemist, U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 105675, 105676, 162622.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 222. (2) Pertlik, F. (1981) Structural investigations of synthetic fairchildite, $K_2Ca(CO_3)_2$. Zeits. Krist., 157, 199–205. (3) NBS Mono. 25, 8, 48.

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Fairfieldite $\mathbf{Ca_2(Mn^{2+},Fe^{2+})(PO_4)_2 \cdot 2H_2O}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Prismatic to equant crystals, to 2.8 cm, showing {001}, {010}, {100}, {1$\overline{1}$0}, {$\overline{1}\overline{1}$1}. Commonly in foliated to lamellar aggregates, may be curved; radiating, fibrous.

Physical Properties: *Cleavage:* {001}, perfect; {010}, good; {1$\overline{1}$0}, distinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 3.08–3.11 D(calc.) = 3.095

Optical Properties: Transparent. *Color:* White, greenish white, pale straw-yellow, salmon-yellow; colorless in transmitted light. *Streak:* White. *Luster:* Pearly to subadamantine, vitreous on the {001} cleavage.
Optical Class: Biaxial (+). *Orientation:* X (120°,60°); Y (–102°,36°); Z (18°,69°) using (ϕ,ρ). *Dispersion:* $r > v$, moderate. α = 1.633–1.640 β = 1.641–1.650 γ = 1.652–1.660 2V(meas.) = 86(1)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.79$ $b = 6.57$ $c = 5.51$ $\alpha = 102°16'$ $\beta = 108°40'$ $\gamma = 90°18'$ Z = 1

X-ray Powder Pattern: Buckfield, Maine, USA.
3.23 (10), 6.40 (9), 3.03 (8), 3.20 (7), 2.86 (7), 2.66 (7), 2.63 (7)

Chemistry:

	(1)	(2)	(3)
P_2O_5	38.39	37.79	39.26
FeO	5.62	1.00	9.94
MnO	15.55	19.68	9.81
CaO	28.85	29.77	31.02
Na_2O	0.73		
K_2O	0.13		
H_2O	9.98	9.94	9.97
insol.	1.31	1.07	
Total	100.56	99.25	100.00

(1) Branchville, Connecticut, USA. (2) Buckfield, Maine, USA. (3) $Ca_2(Mn,Fe)(PO_4)_2 \cdot 2H_2O$ with Mn:Fe = 1:1.

Mineral Group: Fairfieldite group.

Occurrence: An accessory mineral in granite pegmatites.

Association: Apatite, strunzite, diadochite, dickinsonite, stewartite, rockbridgeite, mitridatite, eosphorite, a host of other Fe–Mn phosphates, jahnsite, rhodochrosite, quartz, muscovite.

Distribution: In the USA, from Branchville, Fairfield Co., Connecticut; in Maine, in Oxford Co., as large crystals at the Bennett quarry, Buckfield, in the Nevel quarry and elsewhere around Newry, from the Emmons quarry, Greenwood, and from the Berry quarry, Poland, Androscoggin Co.; fine examples from the Foote mine, Kings Mountain, Cleveland Co., North Carolina; in the Tip Top mine, 8.5 km southwest of Custer, and the Bull Moose mine, five km southeast of Custer, Custer Co., South Dakota; from the White Picacho district, Maricopa and Yavapai Cos., Arizona. At Hagendorf, and Hühnerkobel, near Zwiesel, Bavaria, Germany. From the Mangualde pegmatite, near Mesquitela, Portugal. In the Cerdanya basin, east to southwest of Bellver, Lerida Province, Spain. From the Voron'i massif, Kola Peninsula, Russia.

Name: For Fairfield Co., Connecticut, USA, within which is Branchville, the original locality.

Type Material: Yale University, New Haven, Connecticut, USA, 3.3118, 3.3123.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 720–722. (2) Frondel, C. (1955) Neomesselite and beta-roselite: two new members of the fairfieldite group. Amer. Mineral., 40, 828–833. (3) Fanfani, L., A. Nunzi, and P.F. Zanazzi (1970) The crystal structure of fairfieldite. Acta Cryst., 26, 640–645.

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Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As thin platy grains, to 3 mm, in rims on baratovite or complexly intergrown with baratovite and fluorite.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: Brittle.
Hardness = 4-4.5 VHN = 445 (250 g load). D(meas.) = 2.83(2) D(calc.) = 2.819

Optical Properties: Transparent. *Color*: Colorless. *Streak*: n.d. *Luster*: Vitreous.
Fluoresces bright white in SW UV.
Optical Class: Biaxial (+). α = 1.651(2) β = 1.655(2) γ = 1.657(2) 2V(meas.) = -72(2)°
2V(calc.) = -70.4° *Dispersion*: $r < v$, medium.

Cell Data: *Space Group*: $P\bar{1}$. a = 9.8156(9) b = 9.8249(9) c = 17.3087(16) α = 99.209(2)°
β = 94.670(2)° γ = 119.839(1)° Z = 1

X-ray Powder Pattern: Dara-i-Pioz glacier, Alai ridge, Tien-Shan Mountains, Tajikistan.
3.35 (100), 3.06 (90), 4.25 (60), 2.885 (55), 3.14 (20), 1.868 (17), 2.870 (10), 5.60 (9)

Chemistry:

	(1)
SiO_2	60.65
TiO_2	13.44
Nb_2O_5	0.11
CaO	14.52
K_2O	3.93
Na_2O	1.99
SrO	0.72
Rb_2O	0.13
F	1.30
Li_2O	3.76
$-O=F_2$	0.55
Total	100.24

(1) Dara-i-Pioz glacier, Tien-Shan Mountains, Tajikistan; average of 20 electron microprobe and ICP-OES analyses, corresponding to $(K_{1.97}Ba_{0.04}Rb_{0.03})_{\Sigma=2.05}Li_{6.00}(Na_{0.86}\square_{0.14})_{\Sigma=1.00}$ $(Ca_{6.16}Na_{0.67}Sr_{0.17})_{\Sigma=7.00}(Ti_{4.00}Nb_{0.02})_{\Sigma=4.02}Si_{24.01}O_{66}(F_{1.63}O_{0.37})_{\Sigma=2}$.

Occurrence: In a quartz-pectolite boulder in the moraine of a glacier eroding an alkaline massif.

Association: Baratovite, fluorite, quartz, pectolite, aegirine, luorite, polylithionite, neptunite, hyalotekite, sokolovaite, senkevichite, Ti-rich mica.

Distribution: In moraine of the Dara-i-Pioz glacier, Alai ridge, Tien-Shan Mountains, Tajikistan.

Name: Honors Faiziev Abdulkhak Radzhabovitch (b 1938), professor and member-correspondent of the Academy of Sciences, Republic of Tajikistan.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow.

References: (1) Agakhanov, A.A., L.A. Pautov, Y.A. Uvarova, E.V. Sokolova, F.C. Hawthorne, V.Y. Karpenko and F.G. Gafurov (2007) Faizievite, $K_2Na(Ca_6Na)Ti_4Li_6Si_{24}O_{66}F_2$ – A new mineral species. New Data on Minerals, 42, 5-10. (2) Uvarova, Y.A., E. Sokolova, F.C. Hawthorne, A.A. Agakhanov, and L.A. Pautov (2008) The crystal chemistry of faizievite, $K_2Li_6Na(Ca_6Na)Ti_4[Si_6O_{18}]_2[Si_{12}O_{30}]F_2$, a novel structure based on intercalated blocks of the baratovite and berezanskite structures. Can. Mineral., 46, 163–171. (3) (2008) Amer. Mineral., 93, 1942 (abs. ref. 2).

Falcondoite $(Ni, Mg)_4Si_6O_{15}(OH)_2 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As slightly schistose, friable masses of minute fibrous particles, less than 10 μm in length.

Physical Properties: *Tenacity:* Friable. Hardness = 2–3 D(meas.) = 1.9(1) D(calc.) = 2.54

Optical Properties: Transparent to translucent. *Color:* Whitish green. *Optical Class:* Biaxial. $n = < 1.55$; birefringence ~0.01–0.02. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 13.5$ $b = 26.9$ $c = 5.24$ Z = 4

X-ray Powder Pattern: Near Bonao, Dominican Republic.
12.2 (100), 2.58 (35), 3.33 (30), 2.62 (30), 2.44 (30), 3.19 (25), 2.39 (20)

Chemistry:

	(1)	(2)
SiO_2	45.93	49.2
Al_2O_3	0.39	
Cr_2O_3	0.45	
FeO	1.99	< 0.03
NiO	26.7	23.6
MgO	8.46	9.26
LOI	15.0	[18.0]
Total	98.92	[100.0]

(1) Near Bonao, Dominican Republic; corresponds to $(Ni_{2.66}Mg_{1.55}Fe_{0.22}Al_{0.06}Cr_{0.04})_{\Sigma=4.53}Si_{5.71}O_{16} \cdot 6.22H_2O$. (2) Do.; average of five analyses by electron microprobe and other methods; loss on ignition by difference, taken as H_2O; corresponds to $(Ni_{2.32}Mg_{1.68})_{\Sigma=4.00}Si_6O_{16} \cdot 7.30H_2O$.

Occurrence: In garnierite veins which cut an extensive laterite, associated with a serpentinized harzburgite massif (near Bonao, Dominican Republic).

Association: Sepiolite, talc, quartz (near Bonao, Dominican Republic).

Distribution: From near Bonao, Dominican Republic. In the USA, from near Glamis, Imperial Co., California.

Name: For the familiar name "Falcondo" of the company operating the mine in the Dominican Republic where the mineral was first found.

Type Material: Royal Ontario Museum, Toronto, Canada, M34324.

References: (1) Springer, G. (1976) Falcondoite, nickel analogue of sepiolite. Can. Mineral., 14, 407–409.

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Famatinite Cu_3SbS_4

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Massive, granular; reniform; as crusts of tiny crystals. *Twinning:* Polysynthetic, very commonly seen in polished section.

Physical Properties: *Cleavage:* {101}, good; {100}, distinct. *Fracture:* Uneven, conchoidal. *Tenacity:* Brittle. Hardness = 3.5 VHN = n.d. D(meas.) = 4.635 D(calc.) = 4.66

Optical Properties: Opaque. *Color:* Deep pinkish brown; in polished section, pale brownish pink. *Streak:* Black. *Luster:* Dull metallic. *Pleochroism:* Weak, pale orange, pink-violet. *Anisotropism:* Strong, greenish yellow and purplish red.
R_1–R_2: (400) 24.4–30.0, (420) 24.2–25.5, (440) 24.0–25.0, (460) 23.8–24.1, (480) 23.1–23.4, (500) 22.7–23.1, (520) 22.9–23.6, (540) 23.8–25.0, (560) 24.3–26.0, (580) 24.5–26.5, (600) 24.8–27.0, (620) 25.4–27.5, (640) 26.0–28.1, (660) 26.8–28.6, (680) 27.3–29.0, (700) 27.5–29.4

Cell Data: *Space Group:* $I\bar{4}2m$. $a = 5.38$ $c = 10.76$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.108 (100), 1.9020 (65), 1.6233 (35), 1.0989 (25), 2.692 (20), 1.9041 (16), 1.6209 (16)

Chemistry:

	(1)	(2)	(3)
Cu	43.94	42.98	43.27
Fe	0.48	0.26	
Sb	13.19	24.36	27.63
As	9.08	3.31	
Bi	1.79		
S	30.86	28.97	29.10
rem.	0.17		
Total	99.51	99.88	100.00

(1) Goldfield, Nevada, USA. (2) Sierra Famatina, Argentina. (3) Cu_3SbS_4.

Polymorphism & Series: Forms a series with luzonite.

Mineral Group: Stannite group.

Occurrence: In copper deposits formed at low to medium temperatures.

Association: Pyrite, enargite, tetrahedrite–tennantite, chalcopyrite, covellite, sphalerite, bismuthinite, silver, gold, marcasite, quartz, barite.

Distribution: From the Sierra de Famatina, La Rioja Province, Argentina [TL]. In the USA, at Goldfield, Esmeralda Co., Nevada; and in Arizona, from Tombstone and the Campbell mine, Bisbee, Cochise Co.; from the Magma mine, Superior, Pinal Co. Also at Butte, Silver Bow Co., Montana; Red Mountain, Ouray Co., Colorado; and Darwin, Inyo Co., California. In Mexico, at Cananea, Sonora. From Cerro de Pasco and Morococha, Peru. Well-crystallized in the Chinkuashi mine, Keelung, Taiwan. At Isk Amellal, Morocco. In minor amounts from many other localities.

Name: For the locality, Sierra de Famatina, Argentina.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 387–388. (2) Gaines, R. (1957) Luzonite, famatinite, and some related minerals. Amer. Mineral., 42, 766–777. (3) Sugaki, A., A. Kitakaze, and Y. Shimizu (1982) Phase relations in the Cu_3AsS_4–Cu_3SbS_4 join. Sci. Rep. Tohoku Univ., 3rd series, 15(2), 257–271. (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 578–582.

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Fangite Tl_3AsS_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Irregular to subhedral grains, to 0.9 mm.

Physical Properties: Hardness = 2–2.5 VHN = 60–63, 61 average (100 g load) (synthetic). D(meas.) = n.d. D(calc.) = 6.185

Optical Properties: Translucent. *Color:* Deep red to maroon, tarnishing to darker colors; blue-gray in reflected light, with abundant red internal reflections. *Luster:* Vitreous, tarnishing to metallic.
Optical Class: Biaxial. *Bireflectance:* Very low.
R_1–R_2: (400) 29.1–30.2, (420) 28.5–29.5, (440) 27.6–28.7, (460) 26.8–27.8, (480) 26.0–26.8, (500) 25.2–25.9, (520) 24.5–25.0, (540) 23.8–24.2, (560) 23.3–23.6, (580) 22.8–23.1, (600) 22.3–22.7, (620) 22.0–22.3, (640) 21.7–22.0, (660) 21.5–21.8, (680) 21.3–21.6, (700) 21.1–21.5

Cell Data: *Space Group: Pnma.* $a = 8.894(8)$ $b = 10.855(9)$ $c = 9.079(9)$ $Z = 4$.

X-ray Powder Pattern: Mercur deposit, Utah, USA.
2.813 (vs), 3.99 (s), 2.264 (ms), 4.14 (m), 3.80 (m), 3.47 (m), 3.35 (m)

Chemistry:

	(1)	(2)
Tl	75.7	75.11
As	9.16	9.18
S	15.6	15.71
Total	100.4	100.00

(1) Mercur deposit, Utah, USA; by electron microprobe, average of analyses on two grains;
(2) Tl_3AsS_4.

Occurrence: In a sediment-hosted disseminated gold deposit, in sulfide-rich carbonaceous ore, probably formed by alteration of Tl-As-rich sulfosalts or sulfides.

Association: Pyrite, realgar, orpiment, calcite.

Distribution: From the Mercur gold deposit, southern Oquirrh Mountains, about 56 km southwest of Salt Lake City, Tooele Co., USA [TL].

Name: In honor of Dr. Jen-Ho Fang (1929–), crystal chemist, University of Alabama, Tuscaloosa, Alabama, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 17071.

References: (1) Wilson, J.R., P.K. Sen Gupta, P.D. Robinson, and A.J. Criddle (1993) Fangite, Tl_3AsS_4, a new thallium arsenic sulfosalt from the Mercur Au deposit, Utah, and revised optical data for gilluluyite. Amer. Mineral., 78, 1096–1103.

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Farringtonite $Mg_3(PO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Subhedral to euhedral grains, to 2 mm, and as rims on olivine.

Physical Properties: *Cleavage:* {100} and {010}, fair to good. Hardness = n.d. D(meas.) = ∼2.80 D(calc.) = 2.76

Optical Properties: Transparent to opaque. *Color:* Colorless, white, yellow, dark amber. *Optical Class:* Biaxial (+). *Orientation:* $Z \wedge c = 16°–17°$. $\alpha = 1.540(2)$ $\beta = 1.544(2)$ $\gamma = 1.559(2)$ 2V(meas.) = 47°–55°

Cell Data: *Space Group:* $P2_1/a$. a = 8.79(1) $b = 8.22(2)$ $c = 5.07(1)$ $\beta = 120.5(5)°$ Z = 2

X-ray Powder Pattern: Springwater meteorite.
3.443 (100), 3.85 (67), 2.411 (48), 4.09 (40), 4.34 (38), 3.65 (37), 2.122 (33)

Chemistry:

	(1)	(2)	(3)
P_2O_5	53.2	53.9	54.00
SiO_2	0.09	0.07	
FeO	4.1	2.7	
MnO	0.19	0.13	
MgO	43.1	44.9	46.00
CaO	0.07	0.08	
Total	100.8	101.8	100.00

(1) Springwater meteorite; by electron microprobe, average of six grains, total Fe and Mn as FeO and MnO; corresponding to $(Mg_{2.84}Fe_{0.15}Mn_{0.01})_{\Sigma=3.00}(PO_4)_2$. (2) Krasnojarsk meteorite; by electron microprobe, average of six grains, total Fe and Mn as FeO and MnO; corresponding to $(Mg_{2.92}Fe_{0.10}Mn_{0.01})_{\Sigma=3.03}(PO_4)_2$. (3) $Mg_3(PO_4)_2$.

Occurrence: A rare component in pallasite meteorites, rimming and cementing olivine nodules.

Association: Olivine, stanfieldite, troilite, schreibersite, kamacite.

Distribution: In the Springwater, Krasnojarsk, Zaisho, Imilac, and Port Orford pallasite meteorites.

Name: To honor Dr. Oliver Cummings Farrington (1864–1933), Curator of Geology, Field Museum of Natural History, Chicago, Illinois, USA, an authority on meteorites.

Type Material: The Natural History Museum, London, England, 1960,150 and 1960,151.

References: (1) DuFresne, E.R. and S.K. Roy (1961) A new phosphate mineral from the Springwater pallasite. Geochim. Cosmochim. Acta, 24, 198–205. (2) (1961) Amer. Mineral., 46, 1513 (abs. ref. 1). (3) Fuchs, L.H., E. Olsen, and E. Gebert (1973) New X-ray and compositional data for farringtonite, $Mg_3(PO_4)_2$. Amer. Mineral., 58, 949–951. (4) Nord, A.G. (1986) Determination of cation distributions in mineral structures by use of the Rietveld full-profile refinement technique. Chemica Scripta, 26A, 115–118.

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Fassinaite $Pb_2^{2+}(S_2O_3)(CO_3)$

Crystal Data: Orthorhombic. *Point Group:* 2/*m* 2/*m* 2/*m*. Crystals prismatic {101}, to 0.4 mm, with flat chisel-shaped {*hk*0} terminations. As radiating aggregates of acicular crystals. Easily mistaken for anglesite, except for less-steep terminations on anglesite.

Physical Properties: *Cleavage:* None. *Fracture:* Irregular. *Tenacity:* Brittle.
Hardness = 1.5-2 D(meas.) = n.d. D(calc.) = 6.084

Optical Properties: Transparent. *Color:* Colorless; intense internal reflections. *Streak:* White. *Luster:* Vitreous to adamantine.
Optical Class: n.d. *n* = 2.13 *Birefringence:* Very high.

Cell Data: *Space Group: Pnma*. a = 16.320(2) b = 8.7616(6) c = 4.5809(7) *Z* = 4

X-ray Powder Pattern: Trentini mine, Veneto, Italy.
3.108 (100), 2.986 (82), 3.504 (75), 4.080 (62), 2.736 (60), 4.381 (59), 2.952 (49)

Chemistry:

	(1)	(2)
PbO	77.1(4)	76.11
SO_3	12.0(1)	
S^{2-}	4.83(1)	
SO		16.39
CO_2	7.60(4)	7.50
$-O = S^{2-}$	2.41(2)	
Total	99.2	100.00

(1) Trentini mine, Veneto, Italy; average of 11 electron microprobe analyses, thiosulphate and carbonate groups confirmed by Raman spectra, CO_2 calculated for stoichiometry, S^{6+}:S^{2-} ratio (1:1) on structural considerations; corresponding to $Pb_{2.01}(S_{1.82}O_3)(CO_3)$. (2) $Pb_2^{2+}(S^{6+}S^{2-}O_3)(CO_3)$.

Occurrence: A secondary mineral in the weathering zone of a polymetallic hydrothermal deposit.

Association: Galena, quartz, anglesite (Trentini mine, Italy); galena, cerussite, anglesite, sulfur, phosgenite (Erasmus adit, Austria).

Distribution: From the Trentini mine, Mount Naro, Vicenza Province, Veneto, Italy; from the Erasmus adit, Schwarzleo District, Leogang, Salzburg, Austria, and the Friedrich-Christian mine, Schapbach, Black Forest, Baden-Württemberg, Germany.

Name: Honors Bruno Fassina (b. 1943), an Italian mineral collector who found the first samples at the Trentini mine.

Type Material: Museum of Mineralogy, Department of Geosciences, University of Padova, Italy (MMP M10008); Natural History Museum, Vienna, Austria (N9055 and N 9056).

References: (1) Bindi, L., F. Nestola, U. Kolitsch, A. Guastoni, and F. Zorzi (2011) Fassinaite, $Pb_2^{2+}(S_2O_3)(CO_3)$, the first mineral with coexisting thiosulphate and carbonate groups: description and crystal structure. Mineral. Mag., 75(6), 2721-2732. (2) (2013) Amer. Mineral., 98, 1079-1080 (abs. ref. 1).

Faujasite $(Na_2, Ca)Al_2Si_4O_{12}\cdot 8H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals octahedra or rarely trisoctahedra, to 4 mm. *Twinning:* On {111}, contact and penetration twins.

Physical Properties: *Cleavage:* {111}, perfect. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 1.92–1.93 D(calc.) = 2.09

Optical Properties: Transparent to translucent. *Color:* White, colorless, brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous to adamantine.
Optical Class: Isotropic. $n = 1.466$–1.480

Cell Data: *Space Group: Fd3m.* a = 24.638–24.65 Z = 32

X-ray Powder Pattern: San Bernardino Co., California, USA.
3.757 (100), 14.2 (95), 5.64 (83), 3.292 (64), 4.355 (52), 2.904 (36), 2.373 (36)

Chemistry:

	(1)	(2)
SiO_2	46.12	48.59
Al_2O_3	16.81	15.97
MgO		0.79
CaO	4.79	4.93
Na_2O	5.09	3.02
K_2O		0.16
H_2O	27.02	[26.54]
Total	99.83	[100.00]

(1) Kaiserstuhl, Germany. (2) San Bernardino Co., California, USA; by electron microprobe, average of 15 analyses, H_2O by difference, corresponding to $(Na_{0.52}Ca_{0.47}Mg_{0.10}K_{0.02})_{\Sigma=1.11}$ $Al_{1.78}Si_{4.24}O_{12}\cdot 16H_2O$.

Mineral Group: Zeolite group.

Occurrence: Rare, in vesicles of basalts, phonolites, and tuffs; formed by palagonization or authigenically.

Association: Zeolites, olivine, augite, nepheline.

Distribution: In Germany, from Sasbach, Kaiserstuhl, and elsewhere in Baden-Württemberg; from the Pflasterkaute, near Eisenach, Thuringia; at Annerod, near Giessen, and at a number of localities around the Vogelsberg volcano, Hesse. From Aci Reale and Aci Castello, Sicily, Italy. On the Cima Dome, near Valley Wells, San Bernardino Co., California, and at several localities on Oahu, Hawaii, USA. From Davis Hill and Khartoum, Ontario; at Laurel, Hincks Bridge, and Notre-Dame-de-la-Salette, and at the Daisy Mica mine, Ottawa Co., Quebec, Canada. A few other localities are known.

Name: Honoring Barthélemy Faujas de Saint Fond (1741–1819), French mineralogist and vulcanologist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 598–599. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 392–393. (3) Bergerhoff, G., W.H. Baur, and W. Nowacki (1958) Über die Kristallstruktur des Faujasites. Neues Jahrb. Mineral., Monatsh., 193–200 (in German). (4) Baur, W.H. (1964) On the cation and water positions in faujasite. Amer. Mineral., 49, 697–704. (5) Wise, W.S. (1982) New occurrence of faujasite in southeastern California. Amer. Mineral., 67, 794–798.

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Faustite $(Zn, Cu)Al_6(PO_4)_4(OH)_8 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $[\overline{1}]$ (by analogy to turquoise). Fine-grained massive, as veinlets, to 8 mm thick, and as nuggets and nodules.

Physical Properties: *Fracture:* Small conchoidal to smooth. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 2.92, corrected for admixed montmorillonite. D(calc.) = [2.88]

Optical Properties: Opaque, translucent on thin edges. *Color:* Apple-green; in transmitted light, brown with a greenish cast. *Streak:* White to pale yellow-green. *Luster:* Waxy to dull. *Optical Class:* [Biaxial (+)] (by analogy to turquoise); birefringence medium. $n = 1.613$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $[P\overline{1}]$ (by analogy to turquoise). $a = 7.44$ $b = 9.89$ $c = 7.67$ $\alpha = 107°43'$ $\beta = 115°39'$ $\gamma = 69°39'$ Z = 1

X-ray Powder Pattern: Copper King mine, Nevada, USA; nearly identical to turquoise. 3.68 (10), 2.89 (8), 6.70 (7), 6.14 (7), 2.05 (7), 3.44 (6), 3.28 (6)

Chemistry:

	(1)	(2)
P_2O_5	34.83	34.11
Al_2O_3	35.31	36.74
Fe_2O_3	1.73	
CuO	1.61	4.78
ZnO	7.74	4.89
H_2O^+	18.78	19.48
Total	[100.00]	100.00

(1) Copper King mine, Nevada, USA; after deduction of montmorillonite ∼20%; stated to then correspond to $(Zn_{0.8}Cu_{0.2})_{\Sigma=1.0}Al_6(PO_4)_4(OH)_8 \cdot 4.5H_2O$. (2) $(Zn, Cu)Al_6(PO_4)_4(OH)_8 \cdot 4H_2O$ with Zn:Cu = 1:1.

Mineral Group: Turquoise group.

Occurrence: In argillized shales associated with copper mineralization (Copper King mine, Nevada, USA).

Association: Montmorillonite, apatite, chrysocolla, azurite, malachite, cuprite, kaolinite, quartz, alunite (Copper King mine, Nevada, USA).

Distribution: In the USA, from the Copper King mine, about 16 km northwest of Carlin, Maggie Creek district, Eureka Co., and the Rain mine, Carlin district, Elko Co., Nevada; at the Bingham mine, Salt Lake Co., Utah. In the Iron Monarch quarry, Iron Knob, South Australia. At the Phoenix United mines, Linkinhorne, Cornwall, England. In the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate, and at Rengersdorf, Lausitz, Saxony, Germany.

Name: To honor Dr. George Tobias Faust (1908–1985), mineralogist and geologist, U.S. Geological Survey.

Type Material: Harvard University, Cambridge, Massachusetts, 106377; National Museum of Natural History, Washington, D.C., USA, 106879, 113171.

References: (1) Erd, R.C., M.D. Foster, and P.D. Proctor (1953) Faustite, a new mineral, the zinc analogue of turquois. Amer. Mineral., 38, 964–972.

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Fayalite $Fe_2^{2+}SiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are thick to thin, tabular ∥ {100}, typically with wedge-shaped terminations, producing eight-sided cross sections. Commonly granular, compact, or massive. *Twinning:* On {100}; also on {031}, as trillings.

Physical Properties: *Cleavage:* {010}, {100}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 4.392 D(calc.) = [4.40]

Optical Properties: Transparent. *Color:* Greenish yellow, yellow-brown, brown; pale yellow to amber in thin section. *Streak:* White. *Luster:* Vitreous to resinous on fractures. *Optical Class:* Biaxial (–). *Pleochroism:* Faint; $X = Z$ = pale yellow; Y = yellow-orange, reddish brown. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, weak. $\alpha = 1.827$ $\beta = 1.869$ $\gamma = 1.879$ 2V(meas.) = 48°

Cell Data: *Space Group: Pbnm* (synthetic). $a = 4.8211$ $b = 10.4779$ $c = 6.0889$ Z = 4

X-ray Powder Pattern: Rockport, Massachusetts, USA. (ICDD 20-1139).
2.501 (100), 2.828 (90), 1.777 (90), 3.55 (80), 2.565 (70), 1.523 (70), 1.516 (70)

Chemistry:

	(1)
SiO_2	29.83
FeO	69.48
MnO	0.28
H_2O^+	0.34
H_2O^-	0.04
Total	99.97

(1) Brocken massif, Germany; corresponds to $(Fe^{2+}_{1.97}Mn^{2+}_{0.01})_{\Sigma=1.98}Si_{1.01}O_4$.

Polymorphism & Series: Forms two series, with forsterite, and with tephroite.

Mineral Group: Olivine group.

Occurrence: In ultramafic volcanic and plutonic rocks, less commonly in felsic plutonic rocks; rarely in granite pegmatite; in lithophysae in obsidian. In metamorphosed iron-rich sediments and impure carbonate rocks.

Association: Augite, plagioclase, microcline, quartz, apatite, magnetite, ilmenite, spinel, hedenbergite, arfvedsonite, amphiboles, almandine, tridymite, grunerite.

Distribution: Among the occurrences of relatively pure material are: in the USA, in the St. Peters Dome area, near Pikes Peak, El Paso Co., Colorado; at Obsidian Cliff, Yellowstone National Park, Wyoming; from Coso Hot Springs, Inyo Co., California; at Rockport, Essex Co., Massachusetts; from Monroe, Orange Co., New York; in the Iron Hill mine, Cumberland, Providence Co., Rhode Island. In the Blue Bell mine, Riondel, British Columbia, Canada. From the Brocken massif, Harz Mountains, Germany. At Raftsund, Norway. In the Skaergaard and Ilímaussaq intrusions, Greenland. On Red Rock Ridge, Nevy Fjord, Palmer Peninsula, Antarctica.

Name: After Faial (Fayal) Island in the Azores, thought to occur in a local volcanic rock, but probably obtained from slag carried as ship's ballast.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 456–457, 451–456 [chrysolite]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 3–336. (3) Smyth, J.R. (1975) High temperature crystal chemistry of fayalite. Amer. Mineral., 60, 1092–1097.

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Fedorite $KNa_4Ca_4(Si,Al)_{16}O_{36}(OH)_4 \cdot 6H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As pseudohexagonal tabular crystals resembling muscovite crystals, to 5 cm.

Physical Properties: *Cleavage:* Perfect micaceous on {001}. Hardness = n.d.
D(meas.) = 2.43–2.58 D(calc.) = [2.43]

Optical Properties: Transparent to translucent. *Color:* Colorless, whitish to pale raspberry-red. *Luster:* Vitreous, satiny, pearly.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, distinct.
$\alpha = 1.522$ $\beta = 1.530$ $\gamma = 1.531$ 2V(meas.) = 32°

Cell Data: *Space Group:* $C\overline{1}$. $a = 9.676(2)$ $b = 16.706(1)$ $c = 13.233(2)$ $\alpha = 93.35°$ $\beta = 114.96°$ $\gamma = 90.03°$ Z = 2

X-ray Powder Pattern: Turii Peninsula, Russia.
2.93 (100b), 2.97 (90), 1.826 (90b), 11.7 (80), 6.0 (80), 3.13 (80b), 4.21 (70)

Chemistry:

	(1)
SiO_2	62.99
Al_2O_3	3.30
CaO	15.80
Na_2O	8.00
K_2O	3.80
LOI	5.33
Total	99.22

(1) Turii Peninsula, Russia; corresponding to $K_{1.08}Ca_{4.08}Na_{3.72}(Si_{15.20}Al_{0.80})_{\Sigma=16.00}O_{36.20}(OH)_{3.80} \cdot 6H_2O$.

Occurrence: In fine veinlets in fenitized sandstone (Turii Peninsula, Russia).

Association: Narsarsukite, quartz, apophyllite (Turii Peninsula, Russia).

Distribution: On the Turii Peninsula, Kola Peninsula, and in the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: For Evgraf Stepanovich Fedorov (1853–1919), eminent Russian crystallographer, Mining Institute, St. Petersburg, Russia.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, 1505/2–3; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 1873; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73038–73040, 73371, 73772, vis5121.

References: (1) Kukharenko, A.A., M.P. Orlova, and A.G. Bulakh (1965) The Caledonian ultrabasic alkalic rocks and carbonatites of the Kola Peninsula and northern Karelia. Izd. Nedra, Moscow, 479–481 (in Russian). (2) (1967) Amer. Mineral., 52, 561–562 (abs. ref. 1). (3) Sokolova, G.V., A.A. Kashaev, V.A. Drits, and V.V. Ilyukhin (1983) The crystal structure of fedorite. Kristallografiya (Sov. Phys. Crystal.), 28, 170–172 (in Russian).

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Fedorovskite $Ca_2(Mg, Mn^{2+})_2B_4O_7(OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic crystals, sometimes with rhombic outlines, to 1 cm; commonly in fibrous aggregates. *Twinning:* Polysynthetic, with {100} as composition plane.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = 4.5 D(meas.) = 2.65 D(calc.) = 2.60

Optical Properties: Semitransparent. *Color:* Brown. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless to pale yellow; Z = yellow to bright yellow. *Orientation:* $X = c$; $Z = a$. *Dispersion:* $r < v$, very strong. α = 1.619–1.623 β = 1.627–1.632 γ = 1.629–1.634 2V(meas.) = 48°

Cell Data: *Space Group: Pbam.* $a = 8.96(2)$ $b = 13.15(2)$ $c = 8.15(1)$ Z = [4]

X-ray Powder Pattern: Solongo deposit, Russia.
3.92 (10), 2.59 (10), 3.02 (7), 2.119 (7), 1.693 (7), 1.632 (7), 2.28 (6)

Chemistry:

	(1)	(2)
B_2O_3	35.4	33.42
FeO	1.3	
MnO	11.6	17.02
MgO	11.6	9.67
CaO	25.2	26.92
H_2O	n.d.	12.97
Total		100.00

(1) Solongo deposit, Russia; partial elemental analysis, here converted to oxides; corresponds to $Ca_2(Mg_{1.3}Mn_{0.7})_{\Sigma=2.0}B_4O_7(OH)_6$. (2) $Ca_2(Mg, Mn)_2B_4O_7(OH)_6$ with Mg:Mn = 1:1.

Polymorphism & Series: Forms a series with roweite.

Occurrence: In veinlets in a skarn-type boron deposit.

Association: Sakhaite, frolovite, uralborite, szaibélyite, datolite.

Distribution: From the Solongo boron deposit, Buryatia, Transbaikal region, Russia.

Name: Honors Nikolai Mikhailovich Fedorovskii (1886–1956), eminent crystallographer and founder of the Russian Research Institute of Mineral Resources, Moscow, Russia.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, 1223/1; Il'menskii Preserve Museum, Miass, 4239; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76926, 77482, 77659.

References: (1) Malinko, S.V., D.P. Shashkin, and K.V. Yurkina (1977) Fedorovskite, a new boron mineral, and the isomorphous series roweite-fedorovskite. Zap. Vses. Mineral. Obshch., 105, 71–85. (2) (1977) Amer. Mineral., 62, 173 (abs. ref. 1).

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Fedotovite $K_2Cu_3O(SO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crusts of imperfect pseudohexagonal crystals, flaky to platy on {100}, to 5 mm.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = 2.5 D(meas.) = 3.205(3) D(calc.) = 3.09 Unstable in air.

Optical Properties: Transparent. *Color:* Emerald-green to grass-green. *Streak:* Pale grass-green. *Luster:* Vitreous to silky.
Optical Class: Biaxial (+). *Pleochroism:* X = greenish blue; $Y = Z$ = yellow-green.
Orientation: $Z = b$; $Y \wedge c \simeq 0°$. *Absorption:* $Z > Y$. $\alpha = 1.577$ $\beta = 1.594$ $\gamma = 1.633$
2V(meas.) = n.d. 2V(calc.) = 68°

Cell Data: *Space Group:* $C2/c$. $a = 19.037(6)$ $b = 9.479(2)$ $c = 14.231(5)$
$\beta = 111.04(3)°$ Z = 8

X-ray Powder Pattern: Tolbachik volcano, Russia.
8.83 (100), 2.943 (12), 2.844 (5), 6.59 (4), 6.54 (4), 4.405 (3), 4.207 (3)

Chemistry:

	(1)	(2)
SO_3	42.00	41.92
CuO	38.93	41.65
ZnO	0.37	
PbO	0.70	
Na_2O	1.48	
K_2O	13.97	16.43
H_2O	trace	
insol.	2.80	
Total	100.25	100.00

(1) Tolbachik volcano, Russia; presence of $(SO_4)^{2-}$ and absence of $(OH)^{1-}$ and H_2O confirmed by IR; corresponds to $(K_{1.65}Na_{0.28})_{\Sigma=1.93}(Cu_{2.85}Zn_{0.02}Pb_{0.01})_{\Sigma=2.88}O_{0.80}(SO_4)_{3.05}$.
(2) $K_2Cu_3O(SO_4)_3$.

Occurrence: As sublimates around volcanic fumaroles.

Association: Dolerophanite, chalcocyanite, tolbachite, piypite, melanothallite, tenorite, vergasovaite, euchlorine, alarsite, klyuchevskite, lammerite, nabokoite, atlasovite, langbeinite, hematite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Sergei Aleksandrovich Fedotov (1931–), volcanologist and seismologist, Director of the Institute of Volcanology, Petropavlovsk-Kamchatkskii, Russia.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, Russia, 1890/1.

References: (1) Vergasova, L.P., S.K. Filatov, Y.K. Serafimova, and G.L. Starova (1988) Fedotovite, $K_2Cu_3O(SO_4)_3$ – a new volcanic sublimate mineral. Doklady Acad. Nauk SSSR, 299, 961–964 (in Russian). (2) (1990) Amer. Mineral., 75, 240–241 (abs. ref. 1). (3) Starova, G.L., S.K. Filatov, V.S. Fundamensky, and L.P. Vergasova (1991) The crystal structure of fedotovite, $K_2Cu_3O(SO_4)_3$. Mineral. Mag., 55, 613–616. (4) Popova, V.I. and V.A. Popov (1996) Morphology of the fedotovite crystals from Kamchatka. Doklady Acad. Nauk SSSR, 350, 101–103 (in Russian).

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Feinglosite $\mathbf{Pb_2(Zn,Fe^{2+})(AsO_4,SO_4)_2(OH,H_2O)}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As crystals, to 10 μm, composed of multiple individuals, in radiating botryoidal aggregates.

Physical Properties: *Tenacity:* Sectile. Hardness = 4–5 VHN = 253–285, 263 average (100 g load). D(meas.) = n.d. D(calc.) = [6.56]

Optical Properties: Semitransparent. *Color:* Pale olive-green; in reflected light, very pale brownish gray. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d. *Bireflectance:* Very weak.
R_1–R_2: (400) 12.2–12.3, (420) 11.8–12.0, (440) 11.6–11.8, (460) 11.4–11.6, (480) 11.2–11.4, (500) 11.1–11.2, (520) 10.9–11.1, (540) 10.8–11.0, (560) 10.8–10.9, (580) 10.7–10.8, (600) 10.7–10.8, (620) 10.7–10.8, (640) 10.7–10.8, (660) 10.7–10.8, (620) 10.7–10.8, (700) 10.6–10.7

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 8.973(6)$ $b = 5.955(3)$ $c = 7.766(6)$ $\beta = 112.20(6)^\circ$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.246 (100), 2.988 (60), 2.769 (60), 4.85 (50), 2.107 (50), 3.659 (30), 2.293 (30)

Chemistry:

	(1)
SO_3	5.3
As_2O_5	22.1
FeO	1.8
ZnO	7.3
PbO	61.4
H_2O	[2.1]
Total	[100.0]

(1) Tsumeb, Namibia; by electron microprobe, average of seven analyses, total Fe as FeO, H_2O by difference; with $(OH)^{1-}$ supplied for charge balance, corresponds to $Pb_{2.09}(Zn_{0.68}Fe^{2+}_{0.18})_{\Sigma=0.86}[(AsO_4)_{1.46}(SO_4)_{0.50}]_{\Sigma=1.96}(OH)_{0.52}\bullet 0.62H_2O$.

Mineral Group: Brackebuschite group.

Occurrence: A very rare secondary mineral, in a cavity in chalcocite, from an oxidized zone in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Goethite, anglesite, wulfenite, chalcocite, arsendescloizite, gypsum.

Distribution: From Tsumeb, Namibia.

Name: To honor Dr. Mark N. Feinglos (1948–), American medical researcher and mineral collector specializing in Tsumeb minerals, Durham, North Carolina, USA, who first noted the mineral.

Type Material: The Natural History Museum, London, England, 1984,943; Harvard University, Cambridge, Massachusetts, USA, 95.66.

References: (1) Clark, A.M., A.J. Criddle, A.C. Roberts, M. Bonardi, and E.A. Moffatt (1997) Feinglosite, a new mineral related to brackebuschite, from Tsumeb, Namibia. Mineral. Mag., 61, 285–289. (2) (1998) Amer. Mineral., 83, 653–654 (abs. ref. 1). (3) (1998) Amer. Mineral., 83, 1121 (erratum in ref. 2).

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Feitknechtite β–$Mn^{3+}O(OH)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Hexagonal platelets, to 3 mm, in aggregates with hausmannite; granular, earthy.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.249 (synthetic).

Optical Properties: Opaque. *Color:* Brownish black. *Luster:* Dull.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P\overline{3}m1$ (synthetic). $a = 3.32$ $c = 4.71$ $Z = 1$

X-ray Powder Pattern: Synthetic.
4.62 (10), 2.64 (5), 2.36 (2b), 1.96 (2b), 1.55 (1), 1.50 (1)

Chemistry:

	(1)	(2)
SiO_2	1.10	
TiO_2	0.00	
MnO_2	48.78	49.43
Al_2O_3	0.00	
Fe_2O_3	0.44	
MnO	40.91	40.33
MgO	0.02	
CaO	0.08	
BaO	0.00	
H_2O^+	4.53	10.24
H_2O^-	4.57	
Total	100.43	100.00

(1) Noda-Tamagawa mine, Japan. (2) MnO(OH).

Polymorphism & Series: Trimorphous with manganite and groutite.

Occurrence: In a mixture with hausmannite, formed by supergene oxidation of and replacing earlier pyrochroite.

Association: Pyrochroite, hausmannite.

Distribution: From Franklin, Sussex Co., New Jersey, USA. In Japan, in the Noda-Tamagawa and Tanohata mines, Iwate Prefecture; the Hamayokokawa mine, Nagano Prefecture; the Taguchi mine, Aichi Prefecture; and the Ioi mine, Shiga Prefecture. At Långban and Pajsberg, Värmland, Sweden.

Name: To honor Dr. Walter Feitknecht (1899–?), Swiss Professor of Chemistry, University of Berne, Berne, Switzerland, who synthesized the compound.

Type Material: n.d.

References: (1) Bricker, O. (1965) Some stability relations in the system $Mn-O_2-H_2O$ at 25° and one atmosphere total pressure. Amer. Mineral., 50, 1296–1354. (2) Frondel, C. (1953) New manganese oxides: hydrohausmannite [feitknechtite + hausmannite] and woodruffite. Amer. Mineral., 38, 761–769. (3) Nambu, M., K. Tanida, T. Kitamura, and T. Komura (1969) Feitknechtite and its origin from Noda-Tamagawa mine, Iwate Prefecture, Japan. Ganseki Kobutsu Kosho Gakkaishi, 59(3), 91–107 (in Japanese). (4) (1970) Chem. Abs., 72, 121 (abs. ref. 3). (5) Meldau, R., H. Newesley, and H. Strunz (1974) Zur Kristallchemie von Feitknechtit. Naturwiss., 60(8), 387 (in German).

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Felbertalite $Cu_2Pb_6Bi_8S_{19}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As elongated crystals, to 0.5 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.3–3.4 VHN = 197–216, 206 averge (25 g load). D(meas.) = n.d. D(calc.) = 6.948

Optical Properties: Opaque. *Color:* Black; bright white in reflected light. *Streak:* Grayish black. *Luster:* Metallic.
Optical Class: Biaxial. *Pleochroism:* Slight; very pale gray to creamy white.
Anisotropism: Distinct; brown, pale brown, grayish brown. *Bireflectance:* Perceptible.
R_1–R_2: (400) 42.6–45.8, (420) 42.8–45.8, (440) 43.0–46.2, (460) 42.8–46.2, (480) 42.5–45.9, (500) 42.0–45.4, (520) 41.4–44.9, (540) 40.8–44.3, (560) 40.2–43.8, (580) 39.6–43.3, (600) 39.3–43.1, (620) 39.1–43.0, (640) 39.0–43.0, (660) 38.9–43.2, (680) 38.9–43.1, (700) 39.0–43.2

Cell Data: *Space Group:* $C2/m$. $a = 27.637(4)$ $b = 4.0499(6)$ $c = 20.741(3)$ $\beta = 131.258(2)^\circ$ $Z = 2$

X-ray Powder Pattern: Felbertal mine, Austria.
3.78 (s), 3.51 (s), 3.38 (s), 2.320 (s), 2.096 (s), 2.062 (s), 2.031 (s)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Ag	1.10	2.13		Se	0.00	1.38	
Pb	29.9	27.14	34.05	Sb		0.03	
Cu	3.56	3.94	3.48	Bi	48.3	49.67	45.78
Cd	0.43			S	16.8	16.59	16.69
Te	0.21	0.46		Total	[100.3]	101.34	100.00

(1) Felbertal mine, Austria; by electron microprobe, average of fifteen analyses, original total given as 100.36% or 100.4%; corresponds to $Cu_{2.02}Ag_{0.37}(Pb_{5.20}Cd_{0.14})_{\Sigma=5.34}Bi_{8.33}(S_{18.88}Te_{0.06})_{\Sigma=18.94}$. (2) Funiushan deposit, China; by electron microprobe, corresponds to $Cu_{2.19}Ag_{0.70}Pb_{4.64}(Bi_{8.41}Sb_{0.01})_{\Sigma=8.42}(S_{18.31}Se_{0.62}Te_{0.13})_{\Sigma=19.06}$. (3) $Cu_2Pb_6Bi_8S_{19}$.

Occurrence: In a hydrothermal tungsten deposit in amphibolites and felsic gneisses, in discordant quartz veins (Felbertal mine, Austria); in a copper deposit in skarn, developed at the contact between a granodiorite complex with quartz sandstone and slate hornfels (Funiushan deposit, China).

Association: Cosalite, lillianite, bismuthinite–aikinite species, cannizzarite, junoite, pavonite series species, bismuth, chalcopyrite (Felbertal mine, Austria); aikinite, friedrichite, berryite, wittichenite, pekoite, benjaminite, tetradymite, galena, chalcopyrite, andradite (Funiushan deposit, China).

Distribution: From the Felbertal tungsten mine, Salzburg, Austria [TL]. At the Funiushan copper skarn deposit, 26 km east of Nanjing, Jiangsu Province, China.

Name: For the valley of Felbertal, Austria, in which the mineral was found.

Type Material: University of Copenhagen, Copenhagen, Denmark; Mineralogical Institute, University of Salzburg, Salzburg, Austria, 14493, 14494; The Natural History Museum, London, England, 1999,174.

References: (1) Topa, D., E. Makovicky, A.J. Criddle, W.H. Paar, and T. Balič-Žunić (2001) Felbertalite, $Cu_2Pb_6Bi_8S_{19}$, a new mineral species from Felbertal, Salzburg Province, Austria. Eur. J. Mineral., 13, 961–972. (2) (2002) Amer. Mineral., 87, 765 (abs. ref. 1). (3) Topa, D., E. Makovicky, T. Balič-Žunić, and P. Berlepsch (2000) The crystal structure of $Cu_2Pb_6Bi_8S_{19}$. Eur. J. Mineral., 12, 825–833. (4) Xiang-Ping, G., M. Watanabe, M. Ohkawa, L. Hoshino, and Y. Shibata (2001) Felbertalite and related bismuth sulfosalts from the Funiushan copper skarn deposit, Nanjing, China. Can. Mineral., 39, 1641–1652.

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Felsőbányaite $Al_4(SO_4)(OH)_{10}\cdot 4H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* 2. As minute thin tabular crystals, typically in spherulitic aggregates, to 3 mm.

Physical Properties: *Cleavage:* {001}, perfect; {100} and {010}, observed. Hardness = 1.5 D(meas.) = 2.33–2.35 D(calc.) = [2.20]

Optical Properties: Semitransparent. *Color:* Colorless, pale yellow; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (+). *Orientation:* $X \simeq a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.516(3)$ $\beta = 1.518(3)$ $\gamma = 1.533(5)$ 2V(meas.) = 48(2)°

Cell Data: *Space Group:* $P2_1$. $a = 13.026(1)$ $b = 10.015(1)$ $c = 11.115(1)$ $\beta = 104.34(1)°$ Z = 4

X-ray Powder Pattern: Baia Sprie, Romania.
4.79 (10), 4.64 (10), 2.27 (5), 3.67 (4), 2.71 (4), 2.45 (4), 5.96 (3)

Chemistry:

	(1)	(2)
SO_3	16.47	17.95
Al_2O_3	45.63	45.71
H_2O	37.27	36.34
Total	99.37	100.00

(1) Baia Sprie, Romania; average of two analyses. (2) $Al_4(SO_4)(OH)_{10}\cdot 4H_2O$.

Occurrence: A rare product of oxidation of marcasite ores.

Association: Marcasite, stibnite, barite, quartz.

Distribution: In Romania, from Cavnic (Kapnikbánya), near Baia Sprie.

Name: For Baia Sprie, Romania (formerly Felsőbánya, Hungary).

Type Material: Natural History Museum, Vienna, Austria, A.x.323.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 585. (2) Koch, S. and I. Sarudi (1964) Data on felsöbányaite. Acta Mineral. Petrog. Univ. Szegediensis, 16, 49–53. (3) Farkas, L. and F. Pertlik (1997) Crystal structure determinations of felsöbányaite and basaluminite, $Al_4(SO_4)(OH)_{10}\cdot 4H_2O$. Acta Mineral. Petrog. Univ. Szegediensis, 38, 5–15.

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Fenaksite $\mathbf{(K,Na,Ca)_4(Fe^{2+},Fe^{3+},Mn^{2+})_2Si_8O_{20}(OH,F)}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As grains up to 4 cm.

Physical Properties: *Cleavage:* Two intersecting at an angle of 122°. Hardness = 5–5.5 D(meas.) = 2.744 D(calc.) = 2.74

Optical Properties: Transparent to translucent. *Color:* Light rose. *Luster:* Pearly on cleavages.
Optical Class: Biaxial (+) [*sic*]. *Orientation:* $Z = b$; $Z \wedge$ cleavage 1 = 20°; $Y \wedge$ cleavage 2 = 49°; $X \wedge$ cleavage 2 = 8°. $\alpha = 1.541$ $\beta = 1.560$ $\gamma = 1.567$ 2V(meas.) = 84° 2V(calc.) = [61°]

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.98$ $b = 8.24$ $c = 9.98$ $\alpha = 114.20°$ $\beta = 80.22°$ $\gamma = 115.60°$ Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
3.03 (100), 3.55 (70), 3.44 (70), 2.46 (70), 2.88 (60), 2.71 (60), 1.875 (60)

Chemistry:

	(1)		(1)
SiO_2	60.54	CaO	0.74
TiO_2	0.04	Na_2O	7.51
Al_2O_3	0.66	K_2O	11.71
Fe_2O_3	1.54	F	0.47
FeO	12.49	H_2O^+	0.67
MnO	2.49	H_2O^-	0.78
MgO	0.70	$-O = F_2$	0.20
		Total	100.14

(1) Khibiny massif, Russia.

Occurrence: In pegmatites associated with an ijolite-urtite intrusion in a differentiated alkalic massif.

Association: Albite, nepheline, "aegirine-augite," delhayelite, eudialyte.

Distribution: On Mts. Rasvumchorr and Yukspor, Khibiny massif, Kola Peninsula, Russia.

Name: For *Fe, Na, K, Si* in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 1780; Vernadsky Geological Museum, Moscow, 46626; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 61123, 61124, 62013.

References: (1) Dorfman, M.D., D.D. Rogachev, Z.I. Goroshchenko, and A.V. Mokretsova (1959) Fenaksite–a new mineral. Trudy Mineral. Muzeya Akad. Nauk SSSR, 152–157 (in Russian). (2) (1960) Amer. Mineral., 45, 252–253 (abs. ref. 1). (3) (1960) Mineral. Abs., 14, 414 (abs. ref. 1). (4) Golovachev, V.P., Y.N. Drozdov, E.A. Kuz'min, and N.V. Belov (1970) The crystal structure of phenaxite [fenaksite] $FeNaK(Si_4O_{10}) - KFeNa(Si_4O_{10})$. Doklady Acad. Nauk SSSR, 194, 818–820 (in Russian).

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Ferberite $Fe^{2+}WO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As wedge-shaped crystals, typically flattened {100} and elongated along [010] or, less commonly, along [001], to 15 cm; faces striated ‖ [001] or [010]; in groups of bladed crystals; massive. *Twinning:* Contact twins with composition plane {100} or {023}, or more rarely {001}; also interpenetrant or lamellar.

Physical Properties: *Cleavage:* {010}, perfect; {100} and {102}, partings. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 7.58 D(calc.) = 7.60 Slightly magnetic.

Optical Properties: Nearly to entirely opaque. *Color:* Black; dark brown in transmitted light. *Streak:* Brownish black to black. *Luster:* Submetallic to metallic adamantine.
Optical Class: Biaxial (+). α = n.d. β = ∼2.40 γ = n.d. 2V(meas.) = 66°
Anisotropism: Distinct. *Bireflectance:* Weak.
R_1–R_2: (400) 16.5–19.5, (420) 16.4–19.2, (440) 16.3–18.9, (460) 16.2–18.7, (480) 15.9–18.5, (500) 16.0–18.7, (520) 16.0–18.7, (540) 16.0–18.7, (560) 16.0–18.7, (580) 15.8–18.6, (600) 15.8–18.6, (620) 15.7–18.6, (640) 15.6–18.5, (660) 15.5–18.3, (680) 15.4–18.1, (700) 15.5–18.0

Cell Data: *Space Group:* $P2/c$. $a = 4.72$ $b = 5.70$ $c = 4.96$ $\beta = 90°$ Z = 2

X-ray Powder Pattern: Tirpersdorf, near Oelsnitz, Saxony, Germany.
2.940 (10), 4.69 (8), 3.75 (6), 2.476 (6), 2.470 (6), 3.65 (5), 2.195 (5)

Chemistry:

	(1)	(2)
WO_3	75.21	76.34
FeO	24.37	23.66
MnO	0.19	
Total	99.77	100.00

(1) Kurasawa, Yamanashi Prefecture, Japan. (2) $FeWO_4$.

Polymorphism & Series: Forms a series with hübnerite.

Occurrence: In high-temperature hydrothermal veins, greisens, and granitic pegmatites; also residual in alluvial and eluvial deposits.

Association: Scheelite, topaz, fluorite, marcasite, pyrite, hematite, feldspar.

Distribution: Numerous minor localities; material approaching end-member composition is uncommon. From near Aquilas, Sierra de Almagrera, Almería Province, Spain. At Panasqueira, Portugal. From around Calstock and elsewhere in Cornwall, England. Large crystals at Pechtelsgrün and Zinnwald, Saxony, Germany. From Chanteloube, near Limoges, Haute-Vienne, France. In the USA, an ore mineral, well-crystallized, from a number of mines in the Boulder Co. tungsten district, Colorado; on Corral Creek, near Soldier Mountain, Camas Co., Idaho; in the Elizabethtown district, Colfax Co., New Mexico; at the Monarch tungsten mine, Ubehebe district, Inyo Co., California. From Mundo Nuovo and Junin, Peru. In the Quechisla district and elsewhere in Potosí, Bolivia. Large crystals from Kirwa, Kigezi, Uganda. At Gejui, Hunan Province, China. At the Tae wha mine, Chungju, North Chungchong Province, South Korea.

Name: Honors Moritz Rudolph Ferber (1805–1875), amateur mineralogist, Gera, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1064–1072. (2) Cid-Dresdner, H. and C. Escobar (1968) The crystal structure of ferberite, $FeWO_4$. Zeits. Krist., 127, 61–72. (3) Ülkü, D. (1967) Untersuchungen zur Kristallstruktur und magnetischen Struktur des Ferberits $FeWO_4$. Zeits. Krist., 124, 192–219 (in German with English abs.).

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Ferchromide $\mathbf{Cr_3Fe_{1-x}}$ (x = 0.6)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As small grains forming aggregates, to several hundred μm.

Physical Properties: Hardness = n.d. VHN = 900 (100 g load). D(meas.) = n.d. D(calc.) = 6.18 Ferromagnetic.

Optical Properties: Opaque. *Color:* Pale gray. *Luster:* Metallic.
R: (400) — , (420) — , (440) 55.2, (460) 55.4, (480) 56.2, (500) 56.9, (520) 58.0, (540) 58.8, (560) 59.5, (580) 60.4, (600) 61.0, (620) 61.0, (640) 61.8, (660) 62.3, (680) 62.8, (700) 63.2

Cell Data: *Space Group:* $Pm3m$. a = 2.882(5) Z = 1

X-ray Powder Pattern: Efim area, Russia.
2.04 (100), 1.17 (90), 0.77 (80), 1.02 (70), 1.44 (60), 1.66 (50), 1.29 (50)

Chemistry:

	(1)
Fe	12.60
Cr	87.58
Total	100.18

(1) Efim area, Russia; by electron microprobe, corresponding to $Cr_{3.0}Fe_{1-x}$, with x = 0.6.

Occurrence: In quartz veins within brecciated amphibolites and schist.

Association: Iron, copper, bismuth, gold, chromferide, graphite, cohenite, halite, sylvite, marialite, quartz.

Distribution: From a gold deposit in the Efim area, Kumak district, 110 km east of Orsk, Southern Ural Mountains, Russia [TL].

Name: For the chemical composition, FERrum, *iron*, and CHROMium.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Novgorodova, M.I., A.I. Gorshkov, N.V. Trubkin, A.I. Tsepin, and M.T. Dmitrieva (1986) New natural intermetallic compounds of iron and chromium – chromferide and ferchromide. Zap. Vses. Mineral. Obshch., 115, 355–360 (in Russian). (2) (1988) Amer. Mineral., 73, 191 (abs. ref. 1).

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Fergusonite-(Ce) $(Ce, La, Y)NbO_4$

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Crystal Data: [Tetragonal.] *Point Group:* [$4/m$] [by analogy to fergusonite-(Y)]. As prismatic dipyramidal crystals, to 1 mm, and as irregular poikioblasts, to 1 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = [5.5–6.5] VHN = 720–800 D(meas.) = 5.45–5.48 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark red to black; reddish in transmitted light. *Luster:* Adamantine.
Optical Class: Uniaxial (–). $\omega = 2.30$ $\epsilon = 2.20$

Cell Data: *Space Group:* [$I4_1/a$.] $a = 5.17$ $c = 5.30$ Z = [2]

X-ray Powder Pattern: Novopoltavskii massif, Russia.
3.1 (10), 1.882 (9), 1.631 (5), 1.566 (4), 2.60 (3), 3.5 (2), 2.76 (2)

Chemistry:

	(1)
U_3O_8	1.11
Nb_2O_5	42.01
Ta_2O_5	1.00
TiO_2	0.05
ThO_2	0.88
RE_2O_3	52.26
Fe_2O_3	0.13
CaO	0.81
H_2O	1.79
Total	[100.04]

(1) Novopoltavskii massif, Russia; original total given as 99.94%; RE = La 12%, Ce 34%, Pr 4%, Nd 21%, Sm 3%, Eu 0.5%, Gd 5%, Tb 0.2%, Dy 1.7%, Ho 0.3%, Er 2%, Tm 0.1%, Yb 1.6%, Y 11.6%; corresponds to $[(Ce, La, Y)_{0.96}Ca_{0.04}Th_{0.01}]_{\Sigma=1.01}(Nb_{0.98}Ta_{0.02})_{\Sigma=1.00}O_{4.00} \bullet 0.30H_2O$.

Polymorphism & Series: Dimorphous with fergusonite-beta-(Ce).

Occurrence: In a carbonatite (Novopoltavsk massif, Russia); in magnesium-rich skarn of the outer granite contact zone of a carbonatite-derived dolomitic marble (Bayan Obo, China).

Association: Magnetite, phlogopite, graphite, chlorite, quartz, pyrite, columbite, allanite, bastnäsite, parisite, apatite, uranpyrochlore, aeschynite, fersmite, monazite, calcite, dolomite (Novopoltavsk massif, Russia).

Distribution: In the Chernigovskaya zone, Novopoltavskii massif, Azov Sea area, Ukraine. From the eastern Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. On Granite Mountain, near Little Rock, Pulaski Co., Arkansas, USA.

Name: For its relation to *fergusonite-(Y)*, and its dominant *cerium* content.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79595.

References: (1) Kapustin, Y.L. (1976) New occurrence of accessory cerium fergusonite in carbonatites. Trudy Mineral. Muzeya Akad. Nauk SSSR, 25, 166–172 (in Russian). (2) (1977) Chem. Abs., 87, 152 (abs. ref. 1). (3) Kapustin, Y.L. (1986) Rare-earth mineralization in late carbonatites of the Novopoltavsk Massif. Novye Dannye Mineral., 33, 43–52 (in Russian). (4) (1989) Amer. Mineral., 74, 946 (abs. ref. 3). (5) Peishan Zhang and Pejie Tao (1987) Characteristics of the fergusonite- and aeschynite-group minerals in China. Zhongguo Xitu Xuebao, 5(1), 1–7 (in Chinese). (6) (1987) Chem. Abs., 107, 241 (abs. ref. 5).

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Fergusonite-(Nd) $(Nd, Ce)(Nb, Ti)O_4$

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Crystal Data: [Tetragonal]; typically metamict. *Point Group:* [4/*m*] [by analogy to fergusonite-(Y)]. As granular to equant grains.

Physical Properties: Hardness = [5.5–6.5] D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark brown. *Luster:* Adamantine. *Optical Class:* [Isotropic when metamict.] n = n.d.

Cell Data: *Space Group:* [$I4_1/a$.] a = n.d. c = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry: (1) Bayan Obo, China; analysis not published; RE_2O_3 47.54%, with empirical formula $(Nd_{0.33}Ce_{0.14}Fe_{0.10}Gd_{0.05}Pr_{0.04}Dy_{0.03}Y_{0.03}La_{0.02}Eu_{0.01}Tb_{0.01}Er_{0.01}Th_{0.01}U_{0.01}Mn_{0.01})_{\Sigma=0.80}(Nb_{0.83}Ti_{0.17})_{\Sigma=1.00}O_{3.64}$.

Polymorphism & Series: Dimorphous with fergusonite-beta-(Nd).

Occurrence: In veinlets in a carbonatite-derived dolomitic marble.

Association: Aegirine, fergusonite-beta-(Nd).

Distribution: From the central Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China.

Name: For its relation to *fergusonite-(Y)*, and its dominant *neodymium* content.

Type Material: n.d.

References: (1) Peishan Zhang and Kejie Tao (1987) Characteristics of the fergusonite- and aeschynite-group minerals in China. Zhongguo Xitu Xuebao, 5, 1–7 (in Chinese with English abs.). (2) (1989) Amer. Mineral., 74, 946–947 (abs. ref. 1).

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Fergusonite-(Y) $YNbO_4$

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Crystal Data: Tetragonal; typically metamict. *Point Group:* $4/m$. As prismatic to acicular dipyramidal crystals, to 20 cm; granular, massive.

Physical Properties: *Cleavage:* {111}, poor. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6.5 D(meas.) = 5.6–5.8 D(calc.) = [5.65]

Optical Properties: Opaque, transparent on thin edges. *Color:* Gray, yellow, brown, brownish black when altered; light brown to dark brown in transmitted light. *Streak:* Brown, yellow-brown, greenish gray. *Luster:* Dull; vitreous to submetallic on fractures.
Optical Class: Isotropic; rarely uniaxial. $n = 2.05$–2.19

Cell Data: *Space Group:* $I4_1/a$. $a = 5.15$ $c = 10.89$ Z = 4

X-ray Powder Pattern: Madawaska, Canada; after heating at 1200 °C.
3.12 (100), 2.96 (90), 1.901 (50), 2.74 (40), 1.855 (30), 3.01 (20), 2.64 (20)

Chemistry:

	(1)	(2)		(1)	(2)
WO_3	0.15		Ce_2O_3	7.63	
Nb_2O_5	44.45	54.07	Er_2O_3	9.81	
Ta_2O_5	6.30		FeO	0.74	
UO_2	2.58		CaO	0.61	
SnO_2	0.47		H_2O	1.49	
Y_2O_3	24.87	45.93	Total	99.10	100.00

(1) Near Cape Farewell, Greenland. (2) $YNbO_4$.

Polymorphism & Series: Dimorphous with fergusonite-beta-(Y); forms a series with formanite-(Y).

Occurrence: Typical of rare-earth-bearing granite pegmatites; in placers.

Association: Monazite, gadolinite, thalenite, euxenite, allanite, zircon, biotite, magnetite.

Distribution: Widespread, but in small amounts. On Qeqertaussaq [Kikertaursuk] Island, Julienhåb district, Greenland. In Norway, many localities in the Evje-Iveland district; from Arendal; at Berg, near Råde; from Hundholmen; and from near Risör. In Sweden, at Ytterby, on Resarö Island, near Vaxholm, and Kårarfvet, near Falun. In Finland, from Laurinmäki. From the Blum mine, Ilmen Mountains, Southern Ural Mountains, Russia. In the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. In Madagascar, from Ambatofotsikely, Ranomafana, Fiadanana, and elsewhere. In the USA, from the Baringer Hill pegmatite, 26 km west of Burnet, Llano Co., Texas; in the Champion and Rutherford pegmatite deposits, Amelia Co., and at Little Friar Mountain, Amherst Co., Virginia; at Spruce Pine, Mitchell Co., North Carolina; from Storeville, Anderson Co., South Carolina; at Rockport, Cape Ann, Essex Co., Massachusetts. At Madawaska, Ontario, Canada. From Hakatamura, Iyo Prefecture, and at Naegi, Mino Prefecture, Japan.

Name: Honors Robert Ferguson (1767–1840), landowner, politician, and mineral collector, of Raith, near Kirkaldy, Scotland, and for its predominant *yttrium* content.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 757–763. (2) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 729–730. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 430–438. (4) Berman, J. (1955) Identification of metamict minerals by X-ray diffraction. Amer. Mineral., 40, 805–827. (5) Graham, J. and M.R. Thornber (1974) The crystal chemistry of complex niobium and tantalum oxides I. Structural classification of MO_2 phases. Amer. Mineral., 59, 1026–1039. (6) Komkov, A.I. (1959) The structure of natural fergusonite, and of a polymorphic modification. Kristallografiya (Sov. Phys. Crystal.), 4, 836–841 (in Russian).

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Fermorite $(Ca,Sr)_5(PO_4,AsO_4)_3(F,OH)$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Crudely prismatic, massive, granular.

Physical Properties: *Fracture:* Uneven. Hardness = 5 D(meas.) = 3.518 D(calc.) = [3.41]

Optical Properties: Translucent. *Color:* Pale pinkish white to white. *Streak:* White. *Luster:* Greasy.
Optical Class: Uniaxial (–). $n = \sim 1.66$

Cell Data: *Space Group:* $P2_1/m$, pseudo-$P6_3/m$. $a = 9.55$ $c = 6.98$ Z = 2

X-ray Powder Pattern: Sitapar, India.
2.86 (10), 2.75 (6), 3.49 (5), 1.971 (4), 1.867 (4), 3.95 (3), 3.12 (3)

Chemistry:

	(1)
P_2O_5	20.11
As_2O_5	25.23
CaO	44.34
SrO	9.93
F	0.83
H_2O	trace
insol.	0.08
$-O = F_2$	0.35
Total	100.17

(1) Sitapar, India; F determination probably low; corresponds to $(Ca_{4.46}Sr_{0.54})_{\Sigma=5.00}[(PO_4)_{1.60}(AsO_4)_{1.24}]_{\Sigma=2.84}(F,OH)$. (2) Do.; by electron microprobe, corresponds to $(Ca_{4.20}Sr_{0.80})_{\Sigma=5.00}[(PO_4)_{1.45}(AsO_4)_{1.48}]_{\Sigma=2.93}[(OH)_{0.66}(F_{0.34}]_{\Sigma=1.00}$.

Mineral Group: Apatite group.

Occurrence: A rare mineral in veinlets through a manganese deposit.

Association: Braunite, hollandite, pyrolusite.

Distribution: From Sitapar, Chhindwara district, Madhya Pradesh, India.

Name: Honors Dr. Lewis Leigh Fermor (1880–1954), former Director of the Geological Survey of India.

Type Material: National Museum of Natural History, Washington, D.C., USA, 94809.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 904. (2) Hughes, J.M. and J.W. Drexler (1991) Cation substitution in the apatite tetrahedral site: crystal structures of type hydroxylellestadite and type fermorite. Neues Jahrb. Mineral., Monatsh., 327–336. (3) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 36–37.

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Fernandinite $\mathbf{Ca(V^{5+},V^{4+},Fe^{2+})_8O_{20}\cdot 4H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals are platy, rectangular, to 10 μm; fibrous, cryptocrystalline, porous massive.

Physical Properties: Hardness = Soft. D(meas.) = 2.78(5) D(calc.) = 3.07 Somewhat soluble in cold H_2O, giving a yellow solution.

Optical Properties: Opaque to translucent. *Color:* Dull green; light green, dark olive-green, brownish green in transmitted light. *Luster:* Submetallic.
Optical Class: Biaxial; strong birefringence. $n = 2.05$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$. $a = 11.680(1)$ $b = 3.6537(4)$ $c = 11.023(2)$ $\beta = 105.00(2)^\circ$ Z = [1]

X-ray Powder Pattern: Minasragra, Peru; very close to corvusite.
10.68 (100), 3.483 (26), 1.836 (8), 2.826 (7), 1.949 (6), 3.545 (4), 2.549 (4)

Chemistry:

	(1)	(2)
V_2O_5	83.7	76.6
SiO_2	2.3	1.0
TiO_2	0.17	0.40
Al_2O_3	1.4	0.7
Fe_2O_3	0.5	1.5
CaO	5.6	5.7
Na_2O	0.00	0.04
K_2O	0.2	0.5
H_2O	[6.1]	[13.6]
Total	[100.0]	[100.0]

(1) Minasragra, Peru; by electron microprobe, average of five analyses, all V as V_2O_5, H_2O by difference; assuming Si and Al as impurities, V^{5+}:V^{4+} from crystal-structure analysis, corresponds to $(Ca_{0.86}K_{0.04})_{\Sigma=0.90}(V^{5+}_{6.48}V^{4+}_{1.39}Fe^{2+}_{0.05}Ti_{0.02})_{\Sigma=7.94}O_{20}\cdot 2.5H_2O$. (2) Do.; by electron microprobe, average of 10 analyses, all V as V_2O_5, H_2O by difference; V^{5+}:V^{4+} from crystal-structure analysis, corresponds to $(Ca_{0.92}K_{0.04}Na_{0.01})_{\Sigma=0.97}(V^{5+}_{6.73}V^{4+}_{0.88}Fe^{2+}_{0.34}Ti_{0.05})_{\Sigma=8.00}O_{20}\cdot 4.5H_2O$.

Occurrence: In a rich vanadium deposit in fissures that cut red shales and that were probably filled by a remobilized asphaltite deposit.

Association: Hewettite, quartz.

Distribution: From Minasragra, 46 km from Cerro de Pasco, Peru. In the USA, at the Monument No. 2 mine, Monument Valley, Apache Co., Arizona; from the Cactus Rat mine group, Yellow Cat district, 24 km southeast of Thompson, Grand Co., Utah; in the Spring Creek Mesa area, Uravan district, Montrose Co., Colorado.

Name: For Eulagio E. Fernandini, formerly an owner of the Minasragra, Peru deposit.

Type Material: Harvard University, Cambridge, Massachusetts, 101718; National Museum of Natural History, Washington, D.C., USA, 87661, R5706.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1062. (2) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 516–517. (3) Evans, H.T., Jr., J.E. Post, D.R. Ross, and J.A. Nelen (1994) The crystal structure and crystal chemistry of fernandinite and corvusite. Can. Mineral., 32, 339–351.

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Feroxyhyte δ–$Fe^{3+}O(OH)$

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Crystal Data: Hexagonal. *Point Group:* n.d. Acicular, minute, possibly comprised of rolled thin plates; in aggregates with clay particles.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.20 Transforms in air to goethite.

Optical Properties: [Opaque.] *Color:* Brown, yellow-brown.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* n.d. $a = 2.93$ $c = 4.60$ Z = 1

X-ray Powder Pattern: Locality not stated; may be confused with vernadite.
2.54 (10), 1.47 (8), 2.23 (5), 1.69 (3)

Chemistry: Natural material appears not to have been analyzed; confirmation is from the correspondence of X-ray powder pattern and other physical properties with synthetic material.

Polymorphism & Series: Trimorphous with goethite and lepidocrocite.

Occurrence: In sea-floor Fe–Mn concretions. As cement and coatings on clasts in chemically reduced, poorly drained soils and sediments, formed by the rapid oxidation of ferrous compounds.

Association: Lepidocrocite, goethite.

Distribution: In soils around Kolomyya, Carpathian Mountains, Ukraine. Also near Moscow, Ryazan, and Smolensk, Russia. On the floors of the Pacific Ocean, at depths of 4800 m, and the Baltic, White, and Kara Seas. Found in the Koktenkol deposit, central Kazakhstan. In Holocene sediments near Parainen and Somero, Finland. From Laurium, Greece, in slag.

Name: For the principal components, iron (FERrum), OXYgen, and HYdroxyl, in its composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Chukhrov, F.V., B.B. Zvyagin, A.I. Gorshkov, L.P. Yermilova, V.V. Korovushkin, Y.S. Rudnitskaya, and N.Y. Yakubovskaya (1976) Feroxyhyte, a new modification of FeO(OH). Izv. Akad. Nauk SSSR, Ser. Geol., 5, 5–24 (in Russian). (2) (1977) Amer. Mineral., 62, 1057 (abs. ref. 1). (3) Carlson, L. and U. Schwertmann (1980) Natural occurrence of feroxyhite [*sic*](δ-FeOOH). Clays and Clay Minerals, 28, 272–280. (4) Drits, V.A., B.A. Sakharov, and A. Manceau (1993) Structure of feroxyhite as determined by simulation of X-ray diffraction curves. Clay Minerals, 28, 209–222.

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Ferrarisite $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 9H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals, flattened on {110}, slightly elongated along [$\overline{1}$10], with pseudohexagonal outline, to 300 μm.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = n.d. D(meas.) = 2.63 D(calc.) = 2.594 Dehydrates in dry air.

Optical Properties: Transparent. *Color:* Colorless, white on dehydration. *Optical Class:* Biaxial (+). *Orientation:* X $\wedge$ c = 17°; Z $\perp$ {110}. *Dispersion:* Strong. $\alpha = 1.562(2)$ $\beta = 1.572(2)$ $\gamma = 1.585(2)$ 2V(meas.) = ∼90° 2V(calc.) = 83°

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.294(4)$ $b = 6.722(3)$ $c = 11.198(5)$ $\alpha = 106.16(4)°$ $\beta = 92.94(4)°$ $\gamma = 99.20(4)°$ Z = 1

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France.
10.81 (10), 2.831 (9), 3.170 (8), 4.07 (4), 3.573 (4), 6.34 (3), 5.36 (3)

Chemistry:

	(1)	(2)
As_2O_5	49.3	49.95
MgO	0.52	
CaO	30.6	30.47
H_2O	19.4	19.58
Total	99.8	100.00

(1) Sainte-Marie-aux-Mines, France; by AA, MgO considered as admixed picropharmacolite, H_2O average of two determinations, one by the Penfield method 18.1%, another by TGA 20.7%; corresponds to $Ca_{5.00}(AsO_4)_2(AsO_3OH)_2 \cdot 9.85H_2O$. (2) $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 9H_2O$.

Polymorphism & Series: Dimorphous with guérinite.

Occurrence: A post-mine low-temperature reaction product of carbonate gangue with arsenical solutions derived from arsenic (Sainte-Marie-aux-Mines, France).

Association: Picropharmacolite, pharmacolite, sainfeldite, rauenthalite, phaunouxite, calcite, löllingite (Sainte-Marie-aux-Mines, France).

Distribution: From the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, and at Duranus, Alpes-Maritimes, France. In Germany, in the Anton mine, Heubachtal, near Schiltach, Wittichen, Black Forest, in the Bauhaus district, Richelsdorf Mountains, Hesse, and at Ramsbeck, North Rhein-Westphalia.

Name: To honor Professor Giovanni Ferraris (1937–), Institute of Mineralogy, Crystallography and Geochemistry, University of Turin, Turin, Italy, who worked on crystal structures of several arsenate minerals from Sainte-Marie-aux-Mines, France.

Type Material: National School of Mines, Paris, France; Institute of Mineralogy and Crystallography, University of Stuttgart, Stuttgart, Germany; National Museum of Natural History, Washington, D.C., USA, 146899.

References: (1) Bari, H., F. Permingeat, R. Pierrot, and K. Walenta (1980) La ferrarisite $Ca_5H_2(AsO_4)_4.9H_2O$, une nouvelle espèce minérale dimorphe de la guérinite. Bull. Minéral., 103, 533–540 (in French with English abs.). (2) Catti, M., G. Chiari, and G. Ferraris (1980) The structure of ferrarisite, $Ca_5(HAsO_4)_2(AsO_4)_2.9H_2O$: disorder, hydrogen bonding, and polymorphism with guerinite. Bull. Minéral., 103, 541–546. (3) (1981) Amer. Mineral., 66, 637 (abs. refs. 1 and 2).

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Ferricopiapite $\mathbf{Fe^{3+}_{2/3}Fe^{3+}_4(SO_4)_6(OH)_2 \cdot 20H_2O}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. [As pseudo-orthorhombic plates, tabular on {010}, multiply modified, typically in scaly or granular pulverulent aggregates.] (by analogy to copiapite group members).

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = ∼2 D(meas.) = 2.14 D(calc.) = 2.14 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Yellow, yellow-orange.
Optical Class: Biaxial (+). *Pleochroism:* In shades of yellow. *Orientation:* $X \simeq b$.
Dispersion: $r > v$. $\alpha = 1.496$–1.530 $\beta = 1.531$–1.550 $\gamma = 1.579$–1.592 2V(meas.) = 69°–80°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.394(5)$ $b = 18.36(2)$ $c = 7.324(8)$ $\alpha = 93.8(1)°$ $\beta = 102.2(1)°$ $\gamma = 98.9(1)°$ Z = 1

X-ray Powder Pattern: Challant-St. Anselme mine, Italy.
9.06 (100), 5.58 (80), 3.58 (78), 18.4 (70), 6.04 (70), 3.53 (67), 4.03 (48)

Chemistry:

	(1)	(2)
SO_3	38.82	39.01
Fe_2O_3	30.29	30.26
H_2O	31.07	30.73
Total	100.18	100.00

(1) Challant-St. Anselme mine, Italy. (2) $Fe^{3+}_{2/3}Fe^{3+}_4(SO_4)_6(OH)_2 \cdot 20H_2O$.

Mineral Group: Copiapite group.

Occurrence: A secondary mineral formed typically by the weathering and oxidation of iron sulfide in a wide range of rock types, preserved in arid climates.

Association: Pyrite.

Distribution: Studied material from: in Chile, in Atacama, at Tierra Amarilla, southeast of Copiapó; in Antofagasta, from Alcaparrosa, near Cerritos Bayos and in the Sierra Gorda district, both southwest of Calama. In the Capillitas mine, Catamarca Province, Argentina. Along Cache Creek, British Columbia, Canada. In the USA, in the Campbell mine, Bisbee, Cochise Co., Arizona; at Coso Hot Springs, Inyo Co., California; in the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah. At the Challant-St. Anselme mine, Ayas Valley, Val d'Aosta, Piedmont, Italy.

Name: For the *ferric* iron member of the *copiapite* group.

Type Material: National Museum of Natural History, Washington, D.C., USA, 80516.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 623–627. (2) Bayliss, P. and D. Atencio (1985) X-ray powder-diffraction data and cell parameters for copiapite-group minerals. Can. Mineral., 23, 53–56. (3) Fanfani, L., A. Nunzi, P.F. Zanazzi, and A.R. Zanzari (1973) The copiapite problem: the crystal structure of a ferrian copiapite. Amer. Mineral., 58, 314–322. (4) Ramusino, C.C. and G. Guiseppetti (1973) Ritrovamento di un materiale naturale referibile al composto sintetico: $6Fe_2(SO_4)_3.Fe_2O_3.nH_2O$ nelle miniere d'oro di Challant-St. Anselme (Valle d'Ayas). Natura, 64(3–4), 451–460 (in Italian with English abs.). (5) Berry, L.G. (1947) Composition and optics of copiapite. Univ. Toronto Studies, Geol. Ser., 51, 21–34 [ferricopiapite].

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Ferrierite $(Na,K)_2Mg(Si,Al)_{18}O_{36}\cdot 9H_2O$

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Crystal Data: Orthorhombic; rarely monoclinic. *Point Group:* $2/m\ 2/m\ 2/m$ or $2/m$. Radiating groups of thin lath-shaped crystals, tabular on {100}, elongated along [001], to 2.5 cm.

Physical Properties: *Cleavage:* {100}, perfect. Hardness = 3–3.5 D(meas.) = 2.136 D(calc.) = 2.11

Optical Properties: Transparent to translucent. *Color:* White, colorless, pinkish, orange to red. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. α = 1.473–1.479 β = 1.474–1.483 γ = 1.477–1.486 2V(meas.) = 50°

Cell Data: *Space Group: Immm.* a = 18.90–19.22 b = 14.14–14.16 c = 7.48–7.54 Z = 2, or *Space Group:* $P2_1/n$. a = 18.886(9) b = 14.182(6) c = 7.470(5) Z = 2

X-ray Powder Pattern: Agoura, California, USA.
3.537 (100), 3.778 (65), 9.47 (50), 7.07 (38), 3.977 (35), 3.943 (35), 3.313 (35)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	70.14	71.21	BaO	0.38	
Al_2O_3	11.45	9.84	Na_2O	1.86	1.59
Fe_2O_3	0.13	0.05	K_2O	0.63	2.85
MgO	2.56	1.70	H_2O^+		4.25
CaO	0.15		H_2O^-		8.63
SrO	0.18		H_2O	[12.52]	
			Total	[100.00]	100.12

(1) Kamloops Lake, Canada; by electron microprobe, H_2O by difference; corresponding to $(Na_{0.78}K_{0.18})_{\Sigma=0.96}(Mg_{0.82}Ca_{0.04}Ba_{0.04}Sr_{0.02})_{\Sigma=0.92}(Si_{15.11}Al_{2.90})_{\Sigma=18.01}O_{36}\cdot 9H_2O$.
(2) Itomuka mine, Japan; by electron microprobe, H_2O by Penfield method, corresponding to $(K_{0.78}Na_{0.66})_{\Sigma=1.44}Mg_{0.54}(Si_{15.48}Al_{2.52})_{\Sigma=18.00}O_{36}\cdot 9.41H_2O$.

Mineral Group: Zeolite group.

Occurrence: In seams and vesicles in deeply weathered basalts, flow breccias, and andesites; in tuffaceous sediments.

Association: Zeolites, plagioclase, "hypersthene," augite, montmorillonite, "chalcedony," calcite.

Distribution: In Canada, in British Columbia, at Kamloops Lake, near Kamloops, and at Monte Lake and Pinaus Lake, near Westwold. In the USA, from Altoona, Wahkiakum Co., Washington; near Agoura, Los Angeles Co., and on Silver Mountain, southwest of Markleeville, Alpine Co., California. From Albero Basso and Val Timonchio, Vicenza, and near Monastir, Cagliari, Sardinia, Italy. At Weitendorf, near Wildon, Styria, Austria. From Reichweiler, Rhineland-Palatinate, Germany. On Phillip Island, Victoria, and at Unanderra, New South Wales, Australia. In the Itomuka mine, Hokkaido, and at Tadumi, Fukushima Prefecture, Japan. A number of other occurrences are known.

Name: For Dr. Walter Frederick Ferrier (1865–1950), geologist and mining engineer with the Canadian Geological Survey.

Type Material: McGill University, Montreal, Canada, RMF3099.

References: (1) Graham, R.P.D. (1918) Ferrierite, a new zeolitic mineral from British Columbia, with notes on some other Canadian minerals. Trans. Royal Soc. Canada, 12(3),
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185–201. (2) (1919) Amer. Mineral., 4, 90 (abs. ref. 1). (3) Wise, W.S., W.J. Nokleberg, and M. Kokinos (1969) Clinoptilolite and ferrierite from Agoura, California. Amer. Mineral., 54, 887–895. (4) Yajima, S. and T. Nakamura (1971) New occurrence of ferrierite. Mineral. J. (Japan), 6, 343–364. (5) Wise, W.S. and Tschernich, R.W. (1976) Chemical composition of ferrierite. Amer. Mineral., 61, 60–66. (6) Gramlich-Meier, R., V. Gramlich, and W.H. Meier (1985) The crystal structure of the monoclinic variety of ferrierite. Amer. Mineral., 70, 619–623. (7) Alberti, A. and C. Sabelli (1987) Statistical and true symmetry of ferrierite (1987) Zeits. Krist., 178, 249–256.

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Ferrihydrite $5Fe_2O_3 \cdot 9H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. As poorly crystalline spheres, to 50 μm, in globular aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: [Opaque.] *Color:* Yellow-brown to dark brown.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* n.d. $a = 5.08$ $c = 9.4$ Z = [1]

X-ray Powder Pattern: Synthetic.
2.50 (100), 2.21 (80), 1.96 (80), 1.48 (80), 1.51 (70), 1.72 (50)

Chemistry: Natural material appears not to have been analyzed; confirmation is from the correspondence of X-ray powder pattern and other physical properties with synthetic material. Most ferrihydrites contain appreciable silica, chemically adsorbed.

Occurrence: Widespread in the soluble fraction of soils and weathered rock. In precipitates around cold and hot springs, especially those supporting iron-metabolizing bacteria; in acid mine effluent.

Association: Goethite, lepidocrocite, hematite, manganese oxides.

Distribution: Widespread. Well-characterized from: the Ridder (Leninogorsk) and Belousovsk Pb–Zn mines, Rudnyi Altai, Kazakhstan. At Joensuu, Pohjiskarjala, and elsewhere in Finland. From Killiechronan, southwest of Salen, Isle of Mull, Scotland. In the Clara mine, near Oberwolfach, Black Forest, Germany. In the USA, at Mineral Hill, Delaware Co., Pennsylvania; at Hot Springs, Garland Co., Arkansas; and in the Niagara basin of Lake Ontario.

Name: For FERRIc iron in its composition, and a HYDRated mineral.

Type Material: Vernadsky Geological Musem, Moscow, 51508; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76642.

References: (1) Chukhrov, F.V., B.B. Zvyagin, A.I. Gorshkov, L.P. Ermilova, and V.V. Balashova (1973) Ferrihydrite. Izv. Akad. Nauk SSSR, 23–33 (in Russian). (2) (1975) Amer. Mineral., 60, 485–486 (abs. ref. 1). (3) Eggleton, R.A. and R.W. Fitzpatrick (1988) New data and a revised structural model for ferrihydrite. Clays and Clay Minerals, 36, 111–124. (4) Farmer, V.C. (1992) Possible confusion between so-called ferrihydrites and hisingerites. Clay Minerals, 27, 373–378. (5) Drits, V.A., B.A. Sakharov, A.L. Salyn, and A. Manceau (1993) Structural model for ferrihydrite. Clay Minerals, 28, 185–207.

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Ferrilotharmeyerite $Ca(Fe^{3+}, Zn, Cu)_2(AsO_4)_2(OH, H_2O)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As subhedral crystals, to 0.6 mm, tabular on $\{\overline{1}01\}$, slightly elongated along [010], wedge- or lozenge-shaped, terminated by $\{\overline{1}11\}$, composed of multiple crystallites.

Physical Properties: *Cleavage:* Good on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 4.25(5) D(calc.) = 4.21–4.38

Optical Properties: Transparent to translucent. *Color:* Yellow, brownish yellow, yellowish brown. *Streak:* Very pale yellow. *Luster:* Adamantine to greasy.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = olive-green or orange; Y = pale green or yellow; Z = colorless. *Orientation:* $X = b$; $Y \wedge c = \sim 22°$. *Dispersion:* $r > v$, distinct, inclined. *Absorption:* $X > Y \gg Z$. $\alpha = 1.83(1)$ $\beta = [1.835]$ $\gamma = 1.87(1)$ 2V(meas.) = 40°

Cell Data: *Space Group:* $C2/m$. $a = 8.997$–9.010 $b = 6.236$–6.246 $c = 7.387$–7.391 $\beta = 115.52-115.74°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.398 (100), 3.175 (100), 2.938 (100), 2.544 (100), 4.95 (70), 2.823 (70), 2.702 (70)

Chemistry:

	(1)	(2)
As_2O_5	48.66	48.73
Al_2O_3	0.13	< 0.1
Fe_2O_3	13.96	15.68
CuO	5.75	< 0.1
ZnO	13.94	17.88
PbO	2.13	0.14
CaO	10.86	12.07
H_2O	5.85	[5.80]
Total	101.28	[100.30]

(1) Tsumeb, Namibia; by electron microprobe, H_2O by CHN analyzer; corresponds to $(Ca_{0.92}Pb_{0.05})_{\Sigma=0.97}(Fe_{0.87}Zn_{0.81}Cu_{0.34}Al_{0.01})_{\Sigma=2.03}(AsO_4)_2(OH, H_2O)_2$. (2) Do.; by electron microprobe, average of 20 analyses, total Fe as Fe_2O_3, H_2O calculated from theory; corresponds to $Ca_{1.02}(Fe_{0.93}Zn_{1.04})_{\Sigma=1.97}(AsO_4)_{2.02}[(H_2O)_{1.08}(OH)_{0.90}]_{\Sigma=1.98}$.

Mineral Group: Tsumcorite group.

Occurrence: Very rare, on museum specimens from a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Conichalcite, scorodite, schneiderhöhnite, beudantite, tennantite, calcite.

Distribution: From Tsumeb, Namibia.

Name: As the *ferric* iron analog of *lotharmeyerite*.

Type Material: Canadian Geological Survey, Ottawa, Canada, NMC 64573; Museum Victoria, Melbourne, Australia, M38092.

References: (1) Ansell, H.G., A.C. Roberts, P.J. Dunn, W.D. Birch, and V.E. Ansell (1992) Ferrilotharmeyerite, a new Ca–Zn–Fe^{3+} hydroxyl arsenate from Tsumeb, Namibia. Can. Mineral., 30, 225–227. (2) (1992) Amer. Mineral., 77, 1305–1306 (abs. ref. 1). (3) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Ferrimolybdite $Fe_2^{3+}(MoO_4)_3 \cdot 8H_2O(?)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As crusts of needlelike to fibrous crystals, to 2 mm, in tufted to radial aggregates; powdery, earthy, in films, massive.

Physical Properties: Hardness = 1–2 D(meas.) = 2.99 D(calc.) = 3.085

Optical Properties: Transparent to translucent. *Color:* Canary-yellow, straw-yellow, greenish yellow; colorless to canary-yellow in transmitted light. *Streak:* Pale yellow. *Luster:* Adamantine to silky, earthy.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = clear to nearly colorless; Z = dirty gray to canary-yellow. *Orientation:* $Z \parallel$ elongation. *Dispersion:* $r < v$, marked. α = 1.72–1.81 β = 1.73–1.83 γ = 1.85–2.04 2V(meas.) = ∼0° to 28°.

Cell Data: *Space Group:* $Pmmn$ or $Pm2_1n$. $a = 6.665(2)$ $b = 15.423(5)$ $c = 29.901(8)$ Z = 8

X-ray Powder Pattern: Huanglongpu deposit, China.
8.330 (100), 6.841 (69), 9.98 (65), 7.674 (59), 6.732 (26), 3.827 (17), 3.066 (14)

Chemistry:

	(1)	(2)	(3)
MoO_3	60.80	61.03	58.70
SiO_2		1.82	
Fe_2O_3	21.84	17.75	21.71
H_2O^+		13.74	
H_2O^-		5.88	
H_2O	17.36		19.59
Total	[100.00]	100.22	100.00

(1) Santa Rita Mountains, Pima Co., Arizona, USA; average of two analyses, recalculated to 100% after deduction of insoluble 2.66%; corresponds to $Fe_{1.94}(MoO_4)_{3.00} \cdot 6.84H_2O$.
(2) Huanglongpu deposit, China; corresponds to $Fe_{1.68}Si_{0.23}(Mo_{1.07}O_4)_{3.00} \cdot 8.22H_2O$.
(3) $Fe_2(MoO_4)_3 \cdot 8H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized portions of hydrothermal vein and porphyry-type molybdenum-bearing deposits.

Association: Molybdenite, pyrite, chalcopyrite.

Distribution: Widely distributed, but commonly in small amounts. Studied material from the Alekseevskii mine, Khakassia district, Siberia, Russia. At Vielsalm, Belgium. In the USA, abundant in the Climax mine, Lake Co., Colorado; in Sulfur Gulch, Questa, Taos Co., New Mexico; from Mineral Park, Mohave Co., Arizona; in the Little Cottonwood district, Salt Lake Co., Utah. From the Kingsgate district and elsewhere, New South Wales, Australia. In the Huanglongpu deposit, Jinduicheng, Shaanxi Province, China.

Name: For the essential chemical components, FERRIc iron and MOLYBDate anionic group.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1095–1097. (2) Kerr, P.F., A.W. Thomas, and A.M. Langer (1963) The nature and synthesis of ferrimolybdite. Amer. Mineral., 48, 14–32. (3) Huang, D., X. Jiang, Y. Wang, and F. Nie (1986) Type, origin and rhenium distribution of the Huanglongpu molybdenum (lead) deposit in Shaanxi province. Bull. Inst. Mineral Deposits, Chinese Acad. Geol. Sci., 6(4), 1–93 (in Chinese with English abs.). (4) Horn, E., M. Kurahashi, D. Huang, and C. Wu (1995) Crystal data and X-ray powder-diffraction data for ferrimolybdite, $Fe_2(MoO_4)_3 \cdot 6.8H_2O$. Powder Diffraction, 10, 101–103.

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Ferrinatrite $Na_3Fe^{3+}(SO_4)_3 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Crystals with hexagonal outline, short prismatic along [0001] to fibrous, $\{10\overline{1}0\}$, $\{11\overline{2}0\}$, with several terminating forms, to several mm; in stellate aggregates; cryptocrystalline to cleavable massive.

Physical Properties: *Cleavage:* On $\{10\overline{1}0\}$, perfect; on $\{11\overline{2}0\}$, less perfect.
Fracture: Splintery. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.55–2.61 D(calc.) = 2.55
Alters to sideronatrite in moist air.

Optical Properties: Transparent. *Color:* Colorless, grayish white, pale green, bluish green; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.556–1.558$ $\epsilon = 1.610–1.613$

Cell Data: *Space Group:* $P\overline{3}$. $a = 15.566(5)$ $c = 8.69(1)$ $Z = 6$

X-ray Powder Pattern: Cetine mine, Italy.
7.78 (100), 2.909 (87), 3.430 (66), 2.938 (57), 2.827 (57), 3.297 (53), 4.39 (51)

Chemistry:

	(1)	(2)
SO_3	50.50	51.42
Fe_2O_3	18.02	17.10
Na_2O	19.10	19.91
H_2O	12.45	11.57
Total	100.07	100.00

(1) Sierra Gorda, Chile; total originally given as 100.11%. (2) $Na_3Fe(SO_4)_3 \cdot 3H_2O$.

Occurrence: An oxidation product of iron sulfides, typically in arid regions; rarely fumarolic.

Association: Metavoltine, copiapite, coquimbite, sideronatrite, tamarugite, quenstedtite, römerite (Chile); gypsum, sideronatrite, metavoltine, tamarugite, uklonskovite, jurbanite, rostite (Cetine mine, Italy).

Distribution: From various localities in the Atacama Desert, Chile, as at Mina la Compania, near Sierra Gorda, Atacama; at Alcaparrosa, near Cerritos Bayos, southwest of Calama, from Quetena, west of Calama, and at Chuquicamata, Antofagasta. From Vesuvius, Campania, and at the Cetine mine, near Rosia, Tuscany, Italy. In the Escuhu Formation, Teruel Province, and at the Lanjarón mineral springs, Granada Province, Spain.

Name: For the essential chemical components, FERRIc iron and sodium, NATRium.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 456–458. (2) Sabelli, C. and A. Santucci (1987) Rare sulfate minerals from the Cetine mine, Tuscany, Italy. Neues Jahrb. Mineral., Monatsh., 171–182. (3) Scordari, F. (1977) The crystal structure of ferrinatrite, $Na_3(H_2O)_3[Fe(SO_4)_3]$ and its relationship to Maus's salt, $(H_3O)_2K_2K_{0.5}(H_2O)_{0.56}[Fe_3O(H_2O)_3(SO_4)_6](OH)_2$. Mineral. Mag., 41, 375–383. (4) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French).

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Ferripyrophyllite $Fe_2^{3+}Si_4O_{10}(OH)_2$

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Crystal Data: [Monoclinic] (by analogy to pyrophyllite). *Point Group:* [2/*m*.] Fine-scaly, granular, compact.

Physical Properties: *Tenacity:* Waxy. Hardness = 1.5–2 D(meas.) = 2.97–3.01 D(calc.) = [3.05]

Optical Properties: Semitransparent. *Color:* Brownish yellow. *Optical Class:* Biaxial. *Pleochroism:* $X = Y$ = greenish; Z = bright yellow. α = 1.650–1.660 β = 1.676–1.678 γ = 1.686–1.688 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 5.26$ $b = 9.10$ $c = 19.1$ $\beta = 95°30'$ Z = [4]

X-ray Powder Pattern: The Strassenschacht, Germany.
4.54 (10), 9.6 (8), 1.518 (8), 3.17 (7), 2.62 (4), 2.47 (4), 1.725 (3)

Chemistry: (1) The Strassenschacht, Germany; by electron microprobe, analysis not given, stated to correspond to $Fe^{3+}_{1.96}Mg_{0.11}Ca_{0.05}(Si_{3.80}Al_{0.13}Fe^{3+}_{0.07})_{\Sigma=4.00}O_{10}(OH)_2 \bullet H_2O$. (2) Mt. Tologay, Kazakhstan; by electron microprobe, analysis not given, stated to correspond to $Fe^{3+}_{1.97}Ca_{0.18}(Na,K)_{0.03}Mg_{0.02}(Si_{3.74}Al_{0.23})_{\Sigma=3.97}O_{10}(OH)_2 \bullet 1.5H_2O$.

Polymorphism & Series: [Isostructural with the 2M modification of pyrophyllite.]

Occurrence: Found on museum specimens.

Association: n.d.

Distribution: From the Strassenschacht hematite deposit, south of Eibenstock, Saxony, Germany. At the Tulagai Pb–Cu deposit, near Akchatau, Kazakhstan.

Name: Presumably for its FERRIc iron content and relation to *pyrophyllite*.

Type Material: Moscow University, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79071, vis5430, 5431.

References: (1) Chukhrov, F.V., B.B. Svyagin, V.A. Drits, A.I. Gorshkov, L.P. Ermilova, E.A. Goilo, and E.S. Rudnitskaya (1979) On ferripyrophyllite and related phases. Izv. Akad. Nauk SSSR, Ser. Geol. 2, 5–20 (in Russian). (2) (1979) Chem. Abs., 91, 24056 (abs. ref. 1). (3) Tschuchrow [Chukhrov], F.W., B.B. Swjagin [Svyagin], W.A. Driz [Drits], A.I. Gorschkow [Gorshkov], L.P. Jermilowa [Ermilova], E.A. Goilo, and E.S. Rudnizkaja [Rudnitskaya] (1979) Über Ferripyrophyllit. Chem. Erde, 38, 324–330 (in German). (4) (1980) Mineral. Abs., 31, 355–356 (abs. ref. 3).

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Ferrisicklerite $Li(Fe^{3+}, Mn^{2+})PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rare crystals, to 1 mm, in spherical or radial aggregates; usually massive, may be monocrystalline, in nodules, and as rims around crystals and masses of triphylite-lithiophilite.

Physical Properties: *Cleavage:* {010}, perfect; {100}, good. Hardness = ∼4
D(meas.) = 3.2–3.4 D(calc.) = 3.257

Optical Properties: Subtranslucent to opaque. *Color:* Colorless, yellowish brown to dark chocolate-brown. *Streak:* Pale yellowish brown, brown, reddish brown.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Pleochroism:* Faint; X = golden yellow to yellow-orange; Z = pale yellow to golden yellow. $\alpha = 1.790(5)$ $\beta = 1.805(5)$
$\gamma = 1.820(5)$ 2V(meas.) = ∼85°

Cell Data: *Space Group: Pmnb.* $a = 5.918(3)$ $b = 10.037(6)$ $c = 4.799(3)$ Z = 4

X-ray Powder Pattern: Sidi Bou Othmane, Morocco.
2.959 (100), 5.01 (70), 4.33 (40), 2.49 (35), 3.49 (30), 3.82 (20), 2.444 (15)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	44.80	43.73	47.03	CaO	1.36	0.62	0.10
SiO_2		0.12	0.16	Li_2O	3.72	3.95	[1.20]
Fe_2O_3	27.20	32.22	44.76	Na_2O	0.81	0.40	0.01
Mn_2O_3	0.00			H_2O^+	0.51	1.48	n.d.
FeO	0.59	0.34		H_2O^-	0.51	0.63	
MnO	19.13	15.66	1.97	insol.	1.66		
MgO	0.11	0.96	3.57	Total	100.40	100.11	[98.80]

(1) Varuträsk, Sweden. (2) Sidi Bou Othmane, Morocco; corresponds to $(Li_{0.40}Na_{0.02}Fe_{0.01})_{\Sigma=0.43}(Fe^{3+}_{0.61}Mn^{2+}_{0.34}Mg_{0.04}Ca_{0.01})_{\Sigma=1.00}[(PO_4)_{0.94}(OH)_{0.06}]_{\Sigma=1.00}$. (3) Angarf-Sud pegmatite, Morocco; by electron microprobe, Li_2O calculated for charge balance; corresponds to $Li_{0.12}(Fe^{3+}_{0.84}Mg_{0.13}Mn^{2+}_{0.04})_{\Sigma=1.01}(PO_4)$.

Polymorphism & Series: Forms a series with sicklerite.

Occurrence: Formed by late hydrothermal alteration or weathering of triphylite-lithiophilite in complex zoned granite pegmatites.

Association: Triphylite-lithiophilite, heterosite, alluaudite, phosphosiderite, cyrilovite.

Distribution: In Sweden, from the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten; at the Norrö pegmatite, on Rånö Island, and on Utö Island. At Tammela, Finland. From Hühnerkobel, near Zwiesel, and crystallized from Hagendorf, Bavaria, Germany. From pegmatites around Sidi Bou Othmane, Jebilet, and the Angarf-Sud pegmatite, Tazenakht Plain, Anti-Atlas Mountains, Morocco. At the Souchon pegmatite, Lamativi, and Portree mine, Odzi, Zimbabwe. In the Buranga pegmatite, Gatumba district, Rwanda. From the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. In the USA, from Strafford and Rochester, Strafford Co., and in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from Newry and Paris, Oxford Co., Maine; in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; from the Foote mine, near Kings Mountain, Cleveland Co., North Carolina. Probably present at many other pegmatites.

Name: For its dominant *ferric* iron content and relation to *sicklerite*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 672–673. (2) Fontan, F., P. Huvelin, M. Orliac, and F. Permingeat (1976) La ferrisicklérite des pegmatites de Sidi Bou Othmane (Jebilet, Maroc) et le groupe des minéraux à structure de triphylite. Bull. Soc. fr. Minéral., 99, 274–286 (in French with English abs.).
(3) Alberti, A. (1976) The crystal structure of ferrisicklerite, $Li_{<1}(Fe^{3+}, Mn^{2+})PO_4$. Acta Cryst., 32, 2761–2764.

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Ferristrunzite $Fe^{3+}Fe^{3+}_2(PO_4)_2(OH)_3 \cdot 5H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$ or 1. Crystals are acicular, rounded and elongated ‖ [001], in subparallel, radial, and matted aggregates, to 3 mm. *Twinning:* On {110}.

Physical Properties: *Cleavage:* One, probable, parallel *X*-*Z* OAP. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.38–2.50 D(calc.) = 2.55

Optical Properties: Semitransparent. *Color:* Light brownish yellow to pale orange. *Streak:* Very pale yellow.
Optical Class: Biaxial (+). *Pleochroism:* X = greenish yellow; Z = brownish yellow. *Orientation:* $Z \wedge c \simeq 17°$. *Dispersion:* Strong. *Absorption:* $Z > X$. $\alpha = 1.664(4)$ $\beta = [1.698]$ $\gamma = 1.757(5)$ 2V(meas.) = 77(10)°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.01(2)$ $b = 9.73(2)$ $c = 7.334(8)$ $\alpha = 90.50(12)°$ $\beta = 96.99(10)°$ $\gamma = 116.43(10)°$ Z = 2

X-ray Powder Pattern: Blaton, Belgium.
5.34 (100), 8.87 (80), 3.267 (40), 4.20 (30), 3.442 (30), 3.387 (30), 4.48 (20)

Chemistry:

	(1)	(2)
P_2O_5	28.2	28.47
Fe_2O_3	46.3	48.04
H_2O	26.0	23.49
Total	100.5	100.00

(1) Blaton, Belgium; by electron microprobe, total Fe as Fe_2O_3, confirmed by microchemical tests, H_2O by TGA-EGA; corresponds to $Fe^{3+}_{0.92}Fe^{3+}_{2.00}(PO_4)_2(OH)_{2.52} \cdot 5H_2O$.
(2) $Fe_3(PO_4)_2(OH)_3 \cdot 5H_2O$.

Occurrence: A rare secondary mineral in argillaceous and clastic sediments, probably as an oxidation product of strunzite (Blaton, Belgium).

Association: Beraunite, crandallite, diadochite, allophane–evansite, strengite, phosphosiderite, cacoxenite (Blaton, Belgium).

Distribution: From near Blaton, Belgium. In Germany, at Aprath, near Wuppertal, North Rhine-Westphalia; in the Silbergrube quarry, near Waidhaus, Bavaria; from Ventorp, near Arnsberg, North Rhein-Westphalia.

Name: For *ferric* iron in the composition and its relation to *strunzite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162499.

References: (1) Peacor, D.R., P.J. Dunn, W.B. Simmons, and R.A. Ramik (1987) Ferristrunzite, a new member of the strunzite group, from Blaton, Belgium. Neues Jahrb. Mineral., Monatsh., 433–440. (2) (1989) Amer. Mineral., 74, 502 (abs. ref. 1). (3) Schertl, H.-P. and H. Heckmann (1988) Mineralparagenese eines neuen Ferristrunzit-Vorkommens bei Wuppertal. Emser Hefte, 9(4), 35–40 (in German). (4) Vochten, R. and E. De Grave (1990) Mössbauer- and infrared spectroscopic characterization of ferristrunzite from Blaton, Belgium. Neues Jahrb. Mineral., Monatsh., 176–190. (5) Vochten, R., E. De Grave, K. van Springel, and L. van Haverbeke (1995) Mineralogical and Mössbauerspectroscopic study of some strunzite varieties of the Silbergrube, Waidhaus, Oberpfalz, Germany. Neues Jahrb. Mineral., Monatsh., 11–25.

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Ferrisurite

$\mathbf{(Pb,Ca)_{2-3}(CO_3)_{1.5-2}(OH,F)_{0.5-1}\cdot (Fe^{3+},Al)_2Si_4O_{10}(OH)_2\cdot nH_2O}$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* 2 or $2/m$. As crystals, flattened on {010}, tapering to fibrous, elongated ‖ [100]; in compact radial aggregates, to 2 mm.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Very flexible.
Hardness = 2–2.5 D(meas.) = 4.0(1) D(calc.) = 3.89

Optical Properties: Transparent to translucent. *Color:* Forest-green to light yellow-green. *Streak:* Greenish yellow to olive-green. *Luster:* Silky.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow; Y = brown; Z = light green. *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.757(3)$ $\beta = 1.763(3)$ $\gamma = 1.773(3)$ 2V(meas.) = n.d. 2V(calc.) = 76°

Cell Data: *Space Group:* $P2_1$ or $P2_1/m$. $a = 5.241(1)$ $b = 9.076(5)$ $c = 16.23(1)$ $\beta = 90.03(7)°$ Z = 2

X-ray Powder Pattern: Shirley Ann claim, California, USA.
4.53 (100), 3.240 (90), 2.612 (80), 2.272 (50), 16.1 (40), 3.727 (35), 5.40 (25), 1.715 (25)

Chemistry:

	(1)		(1)
SiO_2	26.6	BaO	0.1
Al_2O_3	3.2	Na_2O	0.3
Fe_2O_3	10.5	F	0.8
FeO	0.8	H_2O	3.5
PbO	42.7	CO_2	8.2
MgO	0.2	$-O=F_2$	0.3
CaO	3.4	Total	100.0

(1) Shirley Ann claim, California, USA; by electron microprobe, FeO by potentiometric titration, Fe^{2+}:Fe^{3+} by wet chemical analysis, CO_2 by coulometric titration, H_2O by Karl Fischer titration; corresponding to $(Pb_{1.73}Ca_{0.55}Na_{0.09}Ba_{0.01})_{\Sigma=2.38}(CO_3)_{1.68}[(OH)_{0.51}F_{0.38}]_{\Sigma=0.89}\cdot(Fe^{3+}_{1.19}Al_{0.57}Fe^{2+}_{0.10}Mg_{0.05})_{\Sigma=1.91}Si_4O_{10}(OH)_2\cdot 0.50H_2O$.

Occurrence: In an oxidized lead deposit in contact metamorphosed impure limestone, as an oxidation product of silicates proximate to galena.

Association: Galena, pyrite, chalcopyrite, covellite, chalcocite, quartz, calcite, hematite, cerussite, mimetite, wulfenite, malachite.

Distribution: At the Shirley Ann claim, Ubehebe district, west of Death Valley, Inyo Co., California, USA.

Name: For a predominance of Fe^{3+} over Al and its relation to *surite*.

Type Material: Natural History Museum of Los Angeles Co., Los Angeles, California; National Museum of Natural History, Washington, D.C., USA, 170288.

References: (1) Kampf, A.R., L.L. Jackson, G.B. Sidder, E.E. Foord, and P.M. Adams (1992) Ferrisurite, the Fe^{3+} analogue of surite, from Inyo County, California. Amer. Mineral., 77, 1107–1111.

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Ferrisymplesite $Fe_3^{3+}(AsO_4)_2(OH)_3 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Finely fibrous.

Physical Properties: Hardness = n.d. D(meas.) = 2.885 (of the mixture). D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Deep amber-brown, yellow-brown, yellow. *Luster:* Resinous.
Optical Class: Biaxial; strongly birefringent. *Pleochroism:* Faint. *Orientation:* Parallel extinction. $n = 1.650$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Neubulach, Germany.
6.77 (10), 4.00 (6), 3.72 (6), 2.96 (5), 2.83 (5), 8.93 (4), 3.38 (4)

Chemistry:

	(1)	(2)
As_2O_5	38.79	39.19
SiO_2	0.88	
Al_2O_3	0.31	
Fe_2O_3	11.67	40.84
CoO	16.86	
NiO	5.73	
MgO	1.05	
CaO	1.46	
H_2O	24.05	19.97
Total	100.80	100.00

(1) Hudson Bay mine, Canada; after deduction of erythrite–annabergite 69%, corresponds to $Fe_{2.98}(AsO_4)_{2.00} \cdot 15.4H_2O$. (2) $Fe_3(AsO_4)_2(OH)_3 \cdot 5H_2O$.

Occurrence: In the oxidized zone of a Co–Ni sulfide deposit (Hudson Bay mine, Canada); in the oxidized zone of a polymetallic hydrothermal ore deposit (Neubulach, Germany).

Association: Erythrite–annabergite (Hudson Bay mine, Canada); copper, malachite (Neubulach, Germany).

Distribution: From the Hudson Bay mine, Timiskaming district, Cobalt, Ontario, Canada. At Neubulach, Black Forest, Germany.

Name: For its *ferric* iron content and supposed relation to *symplesite*.

Type Material: Royal Ontario Museum, Toronto, Canada, M14248; Harvard University, Cambridge, Massachusetts, 101313; National Museum of Natural History, Washington, D.C., USA, 95461.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 753. (2) Walenta, K. (1979) Die Sekundärmineralien der Erzgänge von Neubulach im nördlichen Schwarzwald. Aufschluss, 30, 213–252, esp 232–233 (in German).

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Ferritungstite $\mathbf{(K,Ca,Na)(W^{6+},Fe^{3+})_2(O,OH)_6 \cdot H_2O}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, to 250 μm; as rosettes, in aggregates; as microscopic twinned hexagonal plates forming earthy crusts; fibrous.
Twinning: As penetration twins and platy six-sided cyclic twins according to the spinel law.

Physical Properties: Hardness = n.d. D(meas.) = 5.02–5.2 D(calc.) = [5.16]

Optical Properties: Translucent. *Color:* Pale to bright yellow, orange, brownish yellow, brown. *Luster:* Vitreous.
Optical Class: Isotropic, anomalously anisotropic. n = 2.09–2.15

Cell Data: *Space Group:* $Fd3m$. a = 10.352(1) Z = 8

X-ray Powder Pattern: Nevada Scheelite mine, Nevada, USA.
5.94 (10), 2.966 (10), 3.10 (9), 1.819 (8), 1.550 (7), 2.572 (6), 0.9902 (6)

Chemistry:

	(1)	(2)
WO_3	72.61	77.71
Fe_2O_3	7.33	9.99
FeO	6.51	
CaO	6.03	0.73
Na_2O		0.16
K_2O		2.16
H_2O		[8.45]
LOI	7.52	
Total	[100.00]	[99.20]

(1) Nevada Scheelite mine, Nevada, USA; recalculated to 100% after removal of SiO_2 6.56% as quartz. (2) Kalzas Mountain, Yukon Territory, Canada; by electron microprobe, H_2O calculated from crystal-structure analysis; corresponding to $[(H_2O)_{0.59}Ca_{0.06}Na_{0.02}]_{\Sigma=0.67}(W_{1.46}Fe^{3+}_{0.54})_{\Sigma=2.00}[O_{4.70}(OH)_{1.30}]_{\Sigma=6.00}[(H_2O)_{0.80}K_{0.20}]_{\Sigma=1.00}$.

Occurrence: An alteration coating on, or replacing, primary tungsten minerals, as a product of weathering.

Association: Wolframite, ferberite, scheelite, alumotungstite, russellite, anthoinite, mpororoite, jarosite.

Distribution: In the USA, at the Germania tungsten mine, Deer Trail district, Fruitland, Stevens Co., Washington, and the Nevada Scheelite mine, near Rawhide, Leonard district, Mineral Co., Nevada. From the Flo property, Kalzas Mountain, 67 km southeast of Mayo, Yukon Territory, Canada. In the Borrllealha tungsten mine, Minho, Portugal. In France, at La Bertrande, Haute-Vienne, and Meymac, Corrèze. From the Grancarica scheelite deposit, southwest of Velingrad, Bulgaria. In the Hingston Downs quarry, Calstock, Cornwall, England. At the Namulilo mine, Uganda. From Nyakabingu and Gifurwe, Rwanda. Found in the Nita mine, Yaku Island, Kagoshima Prefecture, Japan. From Aktchatau, Kazakhstan.

Name: For FERRIc iron and TUNGsten in its composition.

Type Material: Harvard University, Cambridge, Massachusetts, 101796; National Museum of Natural History, Washington, D.C., USA, 86985.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1093–1094. (2) Richter, D.H., L.E. Reichen, and D.M. Lemmon (1957) New data on ferritungstite from Nevada. Amer. Mineral., 42, 83–90. (3) Sahama, T.G. (1981) The secondary tungsten minerals, a review. Mineral. Record, 12, 83–85. (4) Ercit, T.S. and G.W. Robinson (1994) A refinement of the structure of ferritungstite from Kalzas Mountain, Yukon, and observations on the tungsten pyrochlores. Can. Mineral., 32, 567–574.

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Ferro-actinolite $\mathbf{Ca_2(Fe^{2+},Mg)_5Si_8O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [As bladed or columnar crystals; also radiating fibrous; granular, massive.] *Twinning:* Simple or lamellar twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; parting on {100}. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.24–3.48 D(calc.) = [3.34]

Optical Properties: Transparent to translucent. *Color:* Dark green; in thin section, yellow-green or blue-green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Moderate to strong, in yellows and greens.
Orientation: $Y = b$; $Z \wedge c = 12.5°$–$17°$. *Dispersion:* $r > v$, weak. *Absorption:* $Z > Y \geq X$.
$\alpha = 1.646$–1.686 $\beta = 1.656$–1.696 $\gamma = 1.666$–1.704 2V(meas.) = 71°–81°

Cell Data: *Space Group:* $C2/m$. $a = 9.891(1)$ $b = 18.200(1)$ $c = 5.305(1)$
$\beta = 104.64(1)°$ Z = 2

X-ray Powder Pattern: Prieska, South Africa. (ICDD 23-118).
8.58 (100), 2.728 (40), 3.157 (35), 2.033 (30), 2.546 (25), 4.57 (20), 2.613 (18)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	51.0	49.89	Na_2O	0.35	0.11
TiO_2	0.04	1.04	K_2O	0.16	0.08
Al_2O_3	2.0	0.75	F	0.14	
Fe_2O_3	2.8		H_2O^+	1.6	
FeO	19.9	30.62	H_2O^-	0.11	
MnO	2.4	0.07	CO_2	0.19	
MgO	8.6	4.59	P	0.09	
CaO	10.7	10.99	$-O = F_2$	0.06	
			Total	100.02	98.14

(1) Cumberland, Rhode Island, USA; corresponds to $(Ca_{1.74}Mn_{0.17}Na_{0.10}K_{0.03})_{\Sigma=2.04}(Fe^{2+}_{2.53}Mg_{1.94}Fe^{3+}_{0.31}Mn_{0.14}Al_{0.08})_{\Sigma=5.00}(Si_{7.72}Al_{0.28})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Jackson County Iron Formation, Wisconsin, USA; by electron microprobe, corresponds to $(Ca_{1.86}Na_{0.03}K_{0.02})_{\Sigma=1.91}(Fe^{2+}_{3.98}Mg_{1.08}Fe^{3+}_{0.06}Ti_{0.01}Mn_{0.01}Al_{0.01})_{\Sigma=5.15}(Si_{7.87}Al_{0.13})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with tremolite and actinolite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) < 0.50$; $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si \geq 7.5$.

Occurrence: In iron-rich greenschist and blueschist facies metamorphic rocks; in metamorphosed iron formations; as part of a vein assemblage cutting Ca-Fe-Si tactites.

Association: Hedenbergite (replacement), andradite, ilvaite (contact metamorphic); cummingtonite, quartz, magnetite, riebeckite, biotite, hematite (iron formations).

Distribution: Probably widespread, but many locality references lack qualifying chemical analyses. In the USA, in the Jackson County Iron Formation, Wisconsin, and at Cumberland, Providence Co., Rhode Island. From Black Perry Mountain, New South Wales, Australia. At Prieska, Cape Province, South Africa.

Name: For *ferrous* iron in its composition and similarity to *actinolite*.

Type Material: n.d.

References: (1) Mitchell, J.T., F.D. Bloss, and G.V. Gibbs (1971) Examination of the actinolite structure and four other C2/m amphiboles in terms of double bonding. Zeits. Krist., 133, 273–300. (2) Kimball, K.L. and F.S. Spear (1984) Metamorphic petrology of the Jackson County Iron Formation, Wisconsin. Can. Mineral., 22, 605–619. (3) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 249–262. (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 229–231.

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Ferroalluaudite $NaCaFe^{2+}(Fe^{3+},Mn^{2+},Fe^{2+})_2(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very fine-grained, massive.

Physical Properties: Hardness = [5] D(meas.) = n.d. D(calc.) = [3.67]

Optical Properties: Semitransparent. *Color:* Blue-green.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = dull green to pale blue; $Y = Z$ = bright green with a bluish tinge. *Dispersion:* $r < v$, strong. $n = 1.775(5)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $[C2/c]$ (by analogy to alluaudite). $a = 11.898(2)$ $b = 12.541(2)$ $c = 6.434(1)$ $\beta = 114°6(1)'$ Z = 4

X-ray Powder Pattern: Helen Beryl mine, Custer, South Dakota, USA. (ICDD 39-377).
2.718 (100), 6.28 (68), 3.075 (31), 3.489 (28), 2.525 (25), 5.454 (24), 8.22 (16)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	[43.1]	43.75	CaO	1.59	4.94
Al_2O_3	0.01	0.13	Li_2O	0.04	0.01
Fe_2O_3	28.15	22.43	Na_2O	6.90	6.52
FeO	9.12	13.93	K_2O	0.00	
MnO	7.25	5.04	H_2O^+	0.64	
ZnO	0.06		insol.	1.19	
MgO	1.98	3.25	Total	[100.0]	[100.00]

(1) Pleasant Valley pegmatite, South Dakota, USA; P_2O_5 by difference; corresponds to $Na_{0.24}(Na_{0.83}Ca_{0.13}Mn^{2+}_{0.04})_{\Sigma=1.00}(Fe^{2+}_{0.54}Mn^{2+}_{0.46})_{\Sigma=1.00}(Fe^{3+}_{1.69}Mg_{0.24}Fe^{2+}_{0.06}Li_{0.01})_{\Sigma=2.00}(PO_4)_3$.
(2) Angarf-Sud pegmatite, Morocco; recalculated after deduction of barbosalite 10%; corresponds to $Na_{0.52}(Na_{0.51}Ca_{0.43}Mn^{2+}_{0.06})_{\Sigma=1.00}(Fe^{2+}_{0.72}Mn^{2+}_{0.28})_{\Sigma=1.00}(Fe^{3+}_{1.37}Mg_{0.39}Fe^{2+}_{0.23}Al_{0.01})_{\Sigma=2.00}(PO_4)_3$.

Polymorphism & Series: Forms a series with alluaudite.

Mineral Group: Alluaudite group.

Occurrence: From zoned granite pegmatites; in phosphatic nodules.

Association: Triphylite, barbosalite, ferrisicklerite, apatite.

Distribution: From the Pleasant Valley pegmatite and the Helen Beryl mine, near Custer, Custer Co., South Dakota, USA. At Rapid Creek, Yukon Territory, Canada. In the Angarf-Sud pegmatite, Tazenakht Plain, Anti-Atlas Mountains, Morocco. From the Norrö pegmatite, on Rånö Island, Sweden. At Kiluli, Rwanda.

Name: For its dominant content of *ferrous* iron and relation to *alluaudite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162558.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 669–670 [varulite, part]. (2) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235.
(3) Fransolet, A.-M., K. Abraham, and J.-M. Speetjens (1985) Evolution génétique et signification des associations de phosphates de la pegmatite d'Angarf-Sud, plaine de Tazenakht, Anti-Atlas, Maroc. Bull. Minéral., 108, 551–574 (in French with English abs.).

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Ferroaxinite $Ca_2Fe^{2+}Al_2BSi_4O_{15}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals typically flattened, axe-head-shaped, to 20 cm; granular, massive.

Physical Properties: *Cleavage:* Good on {100}, poor on {001}, {110}, and {011}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 3.25–3.28 D(calc.) = [3.33]

Optical Properties: Transparent to translucent. *Color:* Clove-brown, brown, plum-blue, pearl-gray; colorless to pale brown or blue in thin section. *Luster:* Vitreous. *Optical Class:* Biaxial (–). α = 1.674–1.682 β = 1.682–1.690 γ = 1.685–1.693 2V(meas.) = 65°–75°

Cell Data: *Space Group:* $P\overline{1}$. a = 7.1437(4) b = 9.1898(6) c = 8.9529(4) α = 91.857(6)° β = 98.188(5)° γ = 77.359(4)° Z = 2

X-ray Powder Pattern: Isère, France.
2.812 (100), 3.16 (90), 3.46 (80), 6.30 (70), 3.68 (60), 3.28 (60), 2.998 (60)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	43.14	41.97	42.16	ZnO	0.04		
TiO_2	0.10			MgO	1.34	0.66	
B_2O_3	6.12	[6.14]	6.11	CaO	19.76	19.18	19.67
Al_2O_3	16.70	17.24	17.88	Na_2O	0.36		
Fe_2O_3	1.28			K_2O	0.23		
FeO	7.12	10.41	12.60	H_2O^+	1.56	[1.57]	1.58
MnO	1.66	2.61		Total	99.41	[99.78]	100.00

(1) Durango, Mexico. (2) Rosebery district, Tasmania, Australia; by electron microprobe, B_2O_3 interpolated from end members, H_2O calculated from stoichiometry. (3) $Ca_2FeAl_2BSi_4O_{15}(OH)$.

Polymorphism & Series: Forms a series with manganaxinite.

Mineral Group: Axinite group; Ca > 1.5 per formula unit, Fe > Mn.

Occurrence: In low- to high-grade regionally metamorphosed rocks, in contact metamorphosed rocks, and in pegmatites.

Association: Prehnite, andradite, hedenbergite, zoisite, actinolite, datolite, tourmaline, vesuvianite, calcite, albite, quartz.

Distribution: Many localities, even for fine crystals. On Roscommon Cliff and in the Botallack mine, St. Just, Cornwall, England. From Bourg d'Oisans, Isère, France. In the Maderantal, Uri, Switzerland. Extraordinary crystals from the Puiva deposit, about 100 km west-northwest of Saranpaul, Subpolar Ural Mountains; at Zlatoust, Ural Mountains; and elsewhere in Russia. At Skardu, Pakistan. In the Obira mine, Bungo, Oita Prefecture; the Toroku mine, Miyazaki Prefecture; and elsewhere in Japan. In the USA, from Coarse Gold, Madera Co., near Yreka, Siskiyou Co., and New Melones Lake, Calaveras Co., California; and from Elkhorn, Jefferson Co., Montana. In Canada, found near Hope, British Columbia, and in the Moneta mine, Timmins, Ontario. From Trinidad, Baja California, Mexico. At Vitoria da Conquista, Bahia, Brazil.

Name: From the Greek for *axe*, referring to the common crystal shape, and for dominant FERROan iron, in a mineral of the *axinite* group.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 527–529. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 603–623. (3) Milton, C., F.A. Hildebrand, and A.M. Sherwood (1953) The identity of tinzenite with manganoan axinite. Amer. Mineral., 38, 1148–1158. (4) Swinnea, J.S., H. Steinfink, L.E. Rendon-DiazMiron, and S. Enciso de la Vega (1981) The crystal structure of a Mexican axinite. Amer. Mineral., 66, 428–431.

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Ferro-barroisite $[NaCa][(Fe^{2+},Mg)_3Al_2](Si_7Al)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic; also as rims and cores of mixed amphibole crystals.

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Deep bluish green to blue in thin section.
Luster: [Vitreous.]
Optical Class: [Biaxial.] *Pleochroism:* Strong in blues and bluish green. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* [$C2/m$.] a = n.d. b = n.d. c = n.d. β = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
SiO_2	49.2	42.14	46.71
TiO_2	0.14	1.15	1.81
Al_2O_3	8.86	3.75	2.05
FeO	21.9	35.14	34.08
MnO	0.27	1.28	0.94
MgO	7.03	0.13	0.93
CaO	5.55	6.86	5.56
Na_2O	4.20	2.71	4.12
K_2O	0.55	0.87	1.21
Total	97.70	94.03	97.41

(1) Klamath Mountains, California, USA; by electron microprobe, Fe^{2+}:Fe^{3+} from stoichiometry and charge balance; corresponding to $(Na_{1.19}Ca_{0.87}K_{0.10})_{\Sigma=2.16}(Fe^{2+}_{1.69}Mg_{1.53}Mn_{0.03})_{\Sigma=3.25}(Fe^{3+}_{1.00}Al_{0.73}Ti_{0.02})_{\Sigma=1.75}(Si_{7.20}Al_{0.80})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Cauro-Bastelica, Corsica; by electron microprobe. (3) Iskou ring complex, Niger; by electron microprobe.

Polymorphism & Series: Forms a series with barroisite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg+Fe^{2+}) < 0.5$; $(Na+K)_A < 0.5$; $0.67 \; Na_B \;\; 1.33$; $(Ca+Na)_B \geq 1.34$; $Si < 7.5$.

Occurrence: A primary mineral in some alkalic granites and syenite ring complexes; from blueschist facies metavolcanic rocks.

Association: Crossite (metavolcanic).

Distribution: On Condrey Mountain, Klamath Mountains, Del Norte Co., California, USA. From Cauro-Bastelica, Corsica. In the Iskou ring complex, Aïr, Niger.

Name: For *ferroan* iron in its composition and similarity to *barroisite*.

Type Material: n.d.

References: (1) Giret, A., B. Bonin, and J.-M. Leger (1980) Amphibole compositional trends in oversaturated alkaline plutonic ring-complexes. Can. Mineral., 18, 481–495. (2) Helper, M.A. (1986) Deformation and high P/T metamorphism in the central portion of the Condrey Mountain window, north-central Klamath Mountains, California and Oregon. In: B.W. Evans and E.H. Brown, Eds., Blueschists and eclogites. Geol. Soc. Amer. Mem. 164, 125–141.

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Ferrobustamite $Ca(Fe^{2+}, Ca, Mn^{2+})Si_2O_6$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystalline, massive. *Twinning:* Simple twins on {100}.

Physical Properties: *Cleavage:* {100}, perfect; {110}, {1$\bar{1}$0}, good. Hardness = 6
D(meas.) = 3.09 D(calc.) = [3.09]

Optical Properties: Semitransparent. *Color:* Colorless, pink to brown.
Optical Class: Biaxial. *Orientation:* $X' \wedge c = 44°$ in section perpendicular to the zone of cleavages. $\alpha = 1.640$ β = n.d. $\gamma = 1.653$ 2V(meas.) = 60(3)°

Cell Data: *Space Group:* $A\bar{1}$. $a = 7.862$ $b = 7.253$ $c = 13.967$ $\alpha = 89°44'$ $\beta = 95°28'$ $\gamma = 103°29'$ Z = 6

X-ray Powder Pattern: Kagata or Ofuku mine, Japan. (ICDD 29-336).
3.270 (100), 3.049 (80), 2.278 (65), 3.470 (60), 3.84 (55), 2.696 (30), 7.67 (25)

Chemistry:

	(1)	(2)	(3)
SiO_2	50.00	53.30	49.8
TiO_2	trace		
Al_2O_3			0.0
Fe_2O_3	0.00		
FeO	9.29	10.44	9.0
MnO	1.22	1.58	1.6
MgO	0.00	0.06	0.1
CaO	38.86	34.63	38.9
H_2O	0.00		
insol.	0.45		
Total	99.82	100.01	99.4

(1) Isle of Skye, Scotland; corresponding to $(Ca_{1.65}Fe_{0.31}Mn_{0.04})_{\Sigma=2.00}Si_2O_6$. (2) Do.; by electron microprobe, corresponding to $(Ca_{1.58}Fe_{0.38}Mn_{0.04})_{\Sigma=2.00}Si_2O_6$. (3) Ofuku mine, Japan; by electron microprobe, corresponds to $(Ca_{1.64}Fe_{0.30}Mn_{0.06})_{\Sigma=2.00}Si_2O_6$.

Occurrence: Surrounding chert nodules in a skarn in dolostone (Isle of Skye, Scotland).

Association: Hedenbergite, grossular-andradite (Isle of Skye, Scotland).

Distribution: At Camas Malag, Isle of Skye, Scotland. From Scawt Hill, near Larne, Co. Antrim, Ireland. In the Kagata, Ofuku, and Ohta mines, Yamaguchi Prefecture; in the Kasugayama and Tsuchiarashi deposits, near Iida, Nagano Prefecture; on Kurodaké Peak, near Toyama, Yoyama Prefecture; in the Tsumo mine, Shimane Prefecture; in the Horado mine, Gifu Prefecture; and at a number of other localities in Japan. From the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For FERROan iron in its composition and its relation to *bustamite*.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 575–585. (2) Tilley, C.E. (1948) On iron-wollastonites in contact-skarns: an example from Skye. Amer. Mineral., 33, 736–738. (3) Rapoport, P.A. and C.W. Burnham (1973) Ferrobustamite: the crystal structures of two Ca,Fe bustamite-type pyroxenoids. Zeits. Krist., 138, 419–438. (4) Shimazaki, H. and T. Yamanaka (1973) Iron-wollastonite from skarns and its stability relation in the $CaSiO_3 - CaFeSi_2O_6$ join. Geochem. J., 7, 67–79. (5) Yamanaka, T., R. Sadanaga, and Y. Takéuchi (1977) Structural variation in the ferrobustamite solid solution. Amer. Mineral., 62, 1216–1224. (6) Shimazaki, H. and M. Bunno (1978) Subsolidus skarn equilibria in the system $CaSiO_3 - CaMgSi_2O_6 - CaFeSi_2O_6 - CaMnSi_2O_6$. Can. Mineral., 16, 539–545.

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Ferrocarpholite $(Fe^{2+},Mg)Al_2Si_2O_6(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, elongated along [001], or as aggregates of parallel fibers, to 5 cm.

Physical Properties: *Cleavage:* Perfect on {010}, indistinct on {110}. Hardness = 5.5 D(meas.) = 3.04 D(calc.) = 3.05

Optical Properties: Transparent to translucent. *Color:* Dark green, bright green, grayish green; colorless in thin section.
Optical Class: Biaxial (–). *Pleochroism:* X = yellowish to greenish; Y = colorless to yellowish; Z = pale bluish to bluish green. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, weak to strong. *Absorption:* $X > Y > Z$. α = 1.614–1.628 β = 1.627–1.644 γ = 1.632–1.647 2V(meas.) = 49°–70°

Cell Data: *Space Group: Ccca.* $a = 13.797(9)$ $b = 20.20(2)$ $c = 5.116(5)$ Z = 8

X-ray Powder Pattern: Haute-Ubaye district, France.
5.04 (100), 5.69 (70), 3.355 (30), 2.603 (25), 3.019 (20), 1.680 (11), 3.44 (10)

Chemistry:

	(1)	(2)
SiO_2	37.59	38.56
TiO_2	0.22	0.30
Al_2O_3	29.39	31.68
Fe_2O_3	2.07	1.65
FeO	17.98	12.21
MnO	0.14	0.32
MgO	2.52	4.65
H_2O	10.08	11.02
Total	[99.99]	[100.39]

(1) West of Tomata, Celebes, Indonesia; after deduction of CaO 0.13%, Na_2O 0.14%, K_2O 0.09%, SO_3 0.12%; corresponds to $(Fe^{2+}_{0.81}Mg_{0.20}Mn_{0.01})_{\Sigma=1.02}(Al_{1.87}Fe^{3+}_{0.08}Ti_{0.01})_{\Sigma=1.96}Si_{2.03}O_{9.87}H_{3.64}$.
(2) Haute-Ubaye district, France; after deduction of Na_2O 0.23% and K_2O 0.45% as mica; corresponds to $(Fe^{2+}_{0.53}Mg_{0.36}Mn_{0.01})_{\Sigma=0.90}(Al_{1.95}Fe^{3+}_{0.06})_{\Sigma=2.01}Si_{2.01}O_6(OH)_4$.

Polymorphism & Series: Forms two series, with carpholite, and with magnesiocarpholite.

Occurrence: In quartz veins in blueschists of low metamorphic grade, formed from felsic tuffs at about 250 °C and 3 kbar.

Association: Quartz, glaucophane, lawsonite, pumpellyite, jadeite, stilpnomelane.

Distribution: At several localities west of Tomata, Celebes, Indonesia. In the Diahot region, New Caledonia. From Italy, at Colle Ciarbonet, Piedmont. From the Vanoise massif, Savoie, and Pic du Pelvat, Haute-Ubaye district, Alpes-de-Haute Provence, France. At Ruwi, Oman.

Name: The FERROus iron analogue of *carpholite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106754.

References: (1) De Roever, W.P. (1951) Ferrocarpholite, the hitherto unknown ferrous iron analogue of carpholite proper. Amer. Mineral., 36, 736–745. (2) De Roever, W.P. and C. Kieft (1971) Additional data on ferrocarpholite from Sulawesi (Celebes), Indonesia. Amer. Mineral., 56, 1976–1982. (3) Steen, D. and J. Bertrand (1977) Sur la préscence de ferrocarpholite associée aux schistes à glaucophane de Haute-Ubaye (Basses-Alpes, France). Schweiz. Mineral. Petrog. Mitt., 57, 157–168 (in French with English abs.). (4) Ferraris, G., G. Ivaldi, and B. Goffé (1992) Structural study of a magnesian ferrocarpholite: are carpholites monoclinic? Neues Jahrb. Mineral., Monatsh., 337–347.

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Ferrochiavennite $Ca_{1-2}FeSi_5Be_2O_{13}(OH)_2 \cdot 2H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As spherules to ~2 mm; crystals, to 0.2 mm, are platy on {001} and spear-shaped along [100].

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~3
D(meas.) = 2.67(2) D(calc.) = 2.709

Optical Properties: Translucent. *Color*: Beige to pale-yellow, pale-green. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (+). α = 1.583(1) β = 1.589(1) γ = 1.602(1) 2V(meas.) = 62(4)° 2V(calc.) = 69° *Orientation*: $X \approx a$, $Y \approx c$, $Z \approx b$.

Cell Data: *Space Group*: $P2_1/c$. a = 8.7499(5) b = 4.9160 (3) c = 31.431(2) β = 90.1574(9)° Z = 4

X-ray Powder Pattern: Blåfjell, Langangen, Telemark, Norway.
15.555 (100), 3.251 (66), 2.884 (64), 3.909 (60), 3.938 (36), 3.820 (30), 4.104 (29)

Chemistry:

	(1)	(2)
SiO_2	46.00	46.61
Al_2O_3	4.64	2.76
FeO	5.29	9.94
MnO	4.04	3.53
MgO	0.13	-
CaO	17.62	12.23
Na_2O	0.73	1.00
K_2O	0.02	0.02
BeO	[10.37]	[9.91]
H_2O	[9.81]	[9.44]
Total	98.65	95.24

(1) Blåfjell, Norway; average of 10 electron microprobe analyses, H_2O and BeO calculated from structure analysis; corresponding to $(Ca_{1.73}Na_{0.13})_{\Sigma=1.86}(Fe_{0.41}Mn_{0.31}Mg_{0.02})_{\Sigma=0.74}(Si_{4.22}Al_{0.50}Be_{2.28})_{\Sigma=7.00}O_{13}(OH)_2 \cdot 2H_2O$. (2) AS Granit larvikite quarry, Norway; average of 7 electron microprobe analyses, H_2O and BeO calculated from structure analysis; corresponding to $(Ca_{1.25}Na_{0.19}Mn_{0.08})_{\Sigma=1.52}(Fe_{0.79}Mn_{0.21})_{\Sigma=1.00}(Si_{4.42}Al_{0.31}Be_{2.27})_{\Sigma=7.00}O_{13}(OH)_2 \cdot 2H_2O$

Occurrence: A late hydrothermal stage mineral in alkaline syenite pegmatite.

Association: Albite, magnetite, fayalite, with minor amounts of zircon, nepheline, analcime, pyrite, hambergite (Blåfjell); tvedalite, apophyllite-(KF), natrolite, gonnardite, chiavennite, epididymite, behoite, calcite, chlorite, aegirine, catapleiite, gaidonnayite, neotocite, fluorite, molybdenite (AS Granit quarry).

Distribution: From Norway at Blåfjell, Langangen, Telemark, and the AS Granit larvikite quarry, Tvedalen, Vestfold.

Name: As the iron (*ferro*) analog of *chiavennite*.

Type Material: Canadian Museum of Nature, Ottawa, Canada (CMNMC 86554), and the Department of Geology, Natural History Museum, University of Oslo, Norway (# 42108).

References: (1) Grice, J.D., R. Kristiansen, H. Friis, R. Rowe, G.G. Poirier, R.S. Selbekk, M.A. Cooper, and A.O. Larsen (2013) Ferrochiavennite, a new beryllium silicate zeolite from syenite pegmatites in the Larvik Plutonic Complex, Oslo region, Southern Norway. Can. Mineral., 51, 285-296. (2) (2014) Amer. Mineral., 99, 2439 (abs. ref. 1).

Ferrocolumbite $(Fe^{2+}, Mn^{2+})(Nb, Ta)_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals short prismatic or equant, also flat tabular, to 0.75 m. In groups of parallel or subparallel crystals, to 18 t; massive. *Twinning:* Common as heart-shaped contact and penetration twins, on {021} and {023}, may produce pseudohexagonal trillings. More rarely on {051} and {15•1•0}.

Physical Properties: *Cleavage:* Distinct on {100}, less distinct on {010}. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 6 VHN = 652–739 (100 g load). D(meas.) = 5.20–6.65 D(calc.) = [5.43] Paramagnetic.

Optical Properties: Opaque, translucent through thin edges. *Color:* Black to brownish black; reddish brown in transmitted light; in reflected light, grayish white with a brownish tint and reddish internal reflections. *Streak:* Black to dark brown. *Luster:* Submetallic to vitreous, commonly tarnished iridescent.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$.
Absorption: Strong; $Z > X$. α = n.d. β = 2.29–2.40 γ = n.d. 2V(meas.) = n.d.
R_1–R_2: (400) 18.4–19.1, (420) 17.7–18.6, (440) 17.3–18.2, (460) 17.1–17.9, (480) 16.9–17.7, (500) 16.9–17.6, (520) 16.8–17.5, (540) 16.8–17.4, (560) 16.7–17.3, (580) 16.7–17.2, (600) 16.7–17.2, (620) 16.6–17.1, (640) 16.5–17.1, (660) 16.4–16.9, (680) 16.3–16.8, (700) 16.1–16.8

Cell Data: *Space Group: Pbcn* (synthetic). $a = 14.266(1)$ $b = 5.7321(4)$ $c = 5.0503(4)$ Z = 4

X-ray Powder Pattern: Tinton (?), South Dakota, USA; similar to wodginite or ixiolite. 2.96 (100), 3.66 (48), 1.721 (22), 1.772 (14), 1.465 (14), 7.13 (12), 2.49 (12)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5	72.37	51.72	78.72	SnO_2	0.67	0.46	
Ta_2O_5	5.26	28.68		FeO	15.04	13.03	21.28
WO_3		0.28		MnO	5.97	5.34	
TiO_2		1.30		CaO	0.58	0.01	
				Total	99.89	100.82	100.00

(1) Ånneröd, Norway. (2) Kings Mountain, North Carolina, USA; by electron microprobe, corresponds to $(Fe_{0.68}Mn_{0.28}Ti_{0.06}Sn_{0.01}W_{0.01})_{\Sigma=1.04}(Nb_{1.50}Ta_{0.50})_{\Sigma=2.00}O_6$. (3) $FeNb_2O_6$.

Polymorphism & Series: Forms two series, with ferrotantalite and with manganocolumbite.

Occurrence: An accessory constituent of granite pegmatites; rarely in carbonatites; a detrital mineral in placer deposits.

Association: Albite, microcline, beryl, lepidolite, muscovite, tourmaline, spodumene, lithiophilite, triphylite, amblygonite, triplite, apatite, samarskite, microlite, cassiterite.

Distribution: In the USA, in Connecticut, at Middletown, Portland, and Haddam, Middlesex Co.; large masses from the Beecher Lode, eight km southeast of Custer, Custer Co., and around Keystone, Pennington Co., South Dakota; in the Spruce Pine district, Mitchell Co., and the Foote mine, Kings Mountain, Cleveland Co., North Carolina. At Ånneröd, Tveit, and elsewhere in Norway. In Russia, from Miass, Ilmen Mountains, Southern Ural Mountains. At Craveggia, Val Vigezzo, Piedmont, Italy. Large crystals from Ambatofotsikely and Antsirabe, Madagascar. At Greens Well, Wodgina, Greenbushes, and elsewhere in Western Australia. In the Ishikawa district, Fukushima Prefecture, Japan.

Name: For iron (FERRum), and COLUMBia, for *America*, source of the first specimens.

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Type Material: Western Australian Museum, Perth, Australia, S1832c; The Natural History Museum, London, England, 60309.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 780–787. (2) Wise, M.A., A.C. Turnock, and P. Černý (1985) Improved unit cell dimensions for ordered columbite-tantalite end members. Neues Jahrb. Mineral., Monatsh., 372–378. (3) Wenger, M., T. Armbruster, and C.A. Geiger (1991) Cation distribution in partially ordered columbite from the Kings Mountain pegmatite, North Carolina. Amer. Mineral., 76, 1897–1904.

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Ferro-edenite $\mathbf{NaCa_2(Fe^{2+},Mg)_5(Si_7Al)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly as well-formed prismatic crystals; fibrous; as reaction rims on pyroxenes. *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Good on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = ∼3.4 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark green, black. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* Distinct; X = yellow; Y = green; Z = dark green. *Orientation:* $Y = b$; $Z \wedge c \simeq 15°$. *Dispersion:* Weak. α = 1.65–1.70 β = 1.66–1.71 γ = 1.67–1.73 2V(meas.) = 20°–90°

Cell Data: *Space Group:* [$C2/m$.] a = n.d. b = n.d. c = n.d. β = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SiO_2	45.74	43.25
TiO_2	1.29	0.27
Al_2O_3	4.98	6.07
Fe_2O_3		1.19
FeO	27.86	31.64
MnO	1.14	1.05
MgO	5.96	1.49
CaO	10.02	10.65
Na_2O	1.99	1.34
K_2O	0.54	0.87
Total	99.52	97.82

(1) La Tabatière, Canada; by electron microprobe, Fe^{2+}:Fe^{3+} from stoichiometry and charge balance; corresponds to $(Na_{0.55}K_{0.11})_{\Sigma=0.66}(Ca_{1.66}Mn_{0.15}Fe^{2+}_{0.14}Na_{0.05})_{\Sigma=2.00}(Fe^{2+}_{3.47}Mg_{1.38}Ti_{0.15})_{\Sigma=5.00}(Si_{7.09}Al_{0.91})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Tibchi ring complex, Nigeria; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from charge balance; corresponds to $(Na_{0.42}K_{0.18})_{\Sigma=0.60}(Ca_{1.85}Fe^{2+}_{0.15})_{\Sigma=2.00}(Fe^{2+}_{4.15}Mg_{0.36}Al_{0.18}Fe^{3+}_{0.14}Mn_{0.14}Ti_{0.03})_{\Sigma=5.00}(Si_{7.01}Al_{0.99})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with edenite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) < 0.5$; $(Na + K)_A \geq 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; 6.75 Si 7.25.

Occurrence: An early or deuteric phase replacing pyroxene in syenitic ring complexes; from medium-grade metamorphic amphibolites and gneisses; from plutonic igneous rocks.

Association: Pyroxene, ferro-actinolite, monazite, magnetite, fluorite (Tibchi ring complex, Nigeria).

Distribution: From the Baie-des-Moutons complex, La Tabatière, Quebec, Canada. At the Tibchi ring complex, Nigeria. Undoubtedly occurs at other localities but qualifying analyses appear lacking.

Name: For its high *ferrous* iron content and relation to *edenite*.

Type Material: n.d.

References: (1) Lalonde, A.E. and R.F. Martin (1983) The Baie-des-Moutons syenitic complex, La Tabatière, Québec, II. The ferromagnesian minerals. Can. Mineral., 21, 81–91. (2) Ike, E.C., P. Bowden, and R.F. Martin (1985) Amphibole in the porphyries of the Tibchi anorogenic ring-complex, Nigeria: product of deuteric adjustments. Can. Mineral., 23, 447–456. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 221.

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Ferro-gedrite $(Fe^{2+},Mg)_2[(Fe^{2+},Mg)_3Al_2](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic to bladed crystals; also fibrous.

Physical Properties: *Cleavage:* Perfect on {210}, intersecting at 54° and 126°. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.566 D(calc.) = 3.562

Optical Properties: Transparent to translucent. *Color:* Gray, brown. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* X = pale green; Y = brownish green; Z = greenish blue. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$. $\alpha = 1.690$–1.695 $\beta = 1.705$–1.710 $\gamma = 1.718$–1.725 2V(meas.) = ∼82°

Cell Data: *Space Group: Pnma.* $a = 18.514$ $b = 17.945$ $c = 5.315$ Z = 4

X-ray Powder Pattern: Mt. Yakushi, Japan.
8.23 (100), 3.043 (75), 3.221 (20), 8.95 (12), 4.632 (10), 2.679 (10), 2.581 (10)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	38.41	36.53	CaO	0.03	0.11
TiO_2	0.48	0.07	Na_2O	1.16	2.06
Al_2O_3	19.72	18.80	K_2O	0.04	0.00
Fe_2O_3	2.21		F	0.13	
FeO	33.54	39.18	H_2O^+	2.06	
MnO	2.30	0.42	$-O = F_2$	0.06	
MgO	0.03	0.30	Total	[100.05]	97.47

(1) Mt. Yakushi, Japan; adjusted for removal of estimated 6% chamosite contamination, original total given as 99.92%; corresponds to $(Fe^{2+}_{4.40}Na_{0.33}Mn_{0.31}Mg_{0.01}K_{0.01})_{\Sigma=5.06}(Al_{1.68}Fe^{3+}_{0.35}Ti_{0.06})_{\Sigma=2.09}(Si_{6.03}Al_{1.97})_{\Sigma=8.00}O_{22}[(OH)_{2.15}F_{0.06}]_{\Sigma=2.21}$. (2) Kawai mine, Japan; by electron microprobe.

Polymorphism & Series: Forms a series with magnesio-gedrite and gedrite.

Mineral Group: Amphibole (Fe–Mn–Mg) group; $Mg/(Mg + Fe^{2+}) < 0.10$; $(Ca + Na)_B < 1.34$; Li < 1.0; Si < 7.0.

Occurrence: In contact metamorphosed pelitic rocks.

Association: Chamosite, chlorite, andalusite, cordierite, garnet, muscovite, biotite, spinel, quartz, labradorite, magnetite, graphite.

Distribution: On Mt. Yakushi, Miyamori district, Kitakami Mountainland, Iwate Prefecture, and in the Kawai mine, Ena, Gifu Prefecture, Japan. From Fiskenæsset, Greenland. At Turbeoshov, Shuyeverskoya, Karelia. From Spitzenberg, Harz Mountains, Germany.

Name: For *ferrous* iron in its composition and similarity to *gedrite*.

Type Material: n.d.

References: (1) Seki, Y. and M. Yamasaki (1957) Aluminian ferroanthophyllite from the Kitakami Mountainland, northeastern Japan. Amer. Mineral., 42, 506–520. (2) Matsubara, S., A. Kato, and M. Nomura (1979) The occurrence of ferrogedrite from the Kawai mine, Ena, Gifu Prefecture, Japan. Bull. National Science Museum, Tokyo, Ser. C, Geol., 6, 107–113. (3) (1982) Mineral. Abs., 33, 298 (abs. ref. 2). (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 223–225.

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Ferro-glaucophane $\mathbf{Na_2[(Fe^{2+}, Mg)_3Al_2]Si_8O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [Elongated prismatic crystals.] *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼58° and ∼122°.] *Fracture:* [Conchoidal to uneven.] *Tenacity:* [Brittle.] Hardness = [6] D(meas.) = 3.18–3.34 D(calc.) = 3.224

Optical Properties: Semitransparent. *Color:* Blue to bluish gray. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* Vivid; stronger with increasing iron content; X = colorless; Y = violet; Z = blue. *Orientation:* $Y = b$; $Z \wedge c = 6°$. *Dispersion:* $r < v$, weak. α = 1.62–1.64 β = 1.64–1.67 γ = 1.64–1.68 2V(meas.) = 42°–45°

Cell Data: *Space Group:* $C2/m$. a = 9.587(4) b = 17.832(7) c = 5.315(2) β = 103.47(3)° Z = 2

X-ray Powder Pattern: Bouehndep, New Caledonia. (ICDD 27-714).
8.31 (100), 3.06 (80), 2.756 (30), 2.701 (25), 4.47 (20), 3.23 (20), 3.35 (15)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	54.63	53.8	MnO	0.08	0.1
TiO_2	0.06		MgO	4.75	3.9
Al_2O_3	11.02	10.1	CaO	0.98	0.9
Fe_2O_3	2.76	4.0	Na_2O	6.25	6.8
FeO	16.02	17.88	K_2O	0.01	
			Total	[96.56]	97.48

(1) Calabria, Italy; by electron microprobe, Fe^{2+}:Fe^{3+} from Mössbauer spectroscopy, original total given as 97.56%; corresponding to $(Na_{1.75}Ca_{0.15})_{\Sigma=1.90}(Fe^{2+}_{1.94}Al_{1.83}Mg_{1.03}Fe^{3+}_{0.31}Ti_{0.01}Mn_{0.01})_{\Sigma=5.13}(Si_{7.94}Al_{0.06})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Bouehndep, New Caledonia; by electron microprobe, FeO determined by wet chemical analysis, corresponding to $(Na_{1.91}Ca_{0.14})_{\Sigma=2.05}(Fe^{2+}_{2.17}Mg_{0.84})_{\Sigma=3.01}(Al_{1.51}Fe^{3+}_{0.44}Mn_{0.01})_{\Sigma=1.96}(Si_{7.79}Al_{0.21})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with glaucophane.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) \geq 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) < 0.3$; $(Na + K)_A < 0.5$; $Na_B \geq 1.34$.

Occurrence: In metamorphic rocks of the high-pressure, low-temperature blueschist facies, commonly derived from either siliceous sedimentary, alkalic basaltic, or felsic volcanic predecessors.

Association: Paragonite, lawsonite, albite, spessartine, almandine, epidote, omphacite.

Distribution: Widespread. Representative occurrences include: from Bouehndep, and near Ouégoa, New Caledonia. At Champ de Praz, Val d'Aosta, Italy. From near Menai Bridge, Anglesey, Wales. In Scotland, from near Heriot. On the Ile de Groix, Bay of Biscay, off Morbihan, France.

Name: For its high *ferrous* iron content and similarity to *glaucophane*.

Type Material: n.d.

References: (1) Hoffmann, C. (1972) Natural and synthetic ferroglaucophane. Contr. Mineral. Petrol., 34, 135–149. (2) Hawthorne, F.C. (1979) The crystal chemistry of the amphiboles. X. Refinement of the crystal structure of ferroglaucophane and an ideal polyhedral model for clinoamphiboles. Can. Mineral., 17, 1–10. (3) Hoffmann, C. and K. Katz (1982) Trend surface analysis of some physical properties of alkali (sodic) amphiboles. Lithos, 15, 17–25. (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 237–241.

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Ferrohexahydrite $Fe^{2+}SO_4 \cdot 6H_2O$

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Crystal Data: Monoclinic (by analogy to other group members). *Point Group:* $2/m$. Stalactites and veinlets, fibrous to capillary crystals, to 6 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.934 (Hygroscopic; soluble in H_2O.)

Optical Properties: Transparent. *Color:* Bluish green, colorless.
Optical Class: Biaxial (–) (by analogy to other group members). $\alpha = 1.468(2)$ β = n.d. $\gamma = 1.498(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$ (ICDD 15-393, by analogy to synthetic $MgSO_4 \cdot 6H_2O$).
$a = 10.08$ $b = 7.28$ $c = 24.59$ $\beta = 98°22'$ Z = 8

X-ray Powder Pattern: Northeastern Tatarstan, Russia.
4.43 (10), 2.97 (7), 2.93 (7), 4.89 (6), 2.03 (6), 1.881 (6), 1.862 (6)

Chemistry: (1) Sofiya mine, Ukraine; described with Fe:Mg from 42.28 to 3.54.
(2) Northeastern Tatarstan, Russia; microchemical analysis confirms ferrous iron and absence of Mg or Zn.

Mineral Group: Hexahydrite group.

Occurrence: In oxidized ore-bearing sandstone (Sofiya mine, Ukraine); a dehydration product of melanterite in drill cores (northeastern Tatarstan, Russia).

Association: Melanterite (northeastern Tatarstan, Russia).

Distribution: From the Sofiya mine, Nikitovka mercury deposit, Gorlovka, Ukraine. At Olkusz, northwest of Krakow, Poland. From an unspecified locality in northeastern Tatarstan, Russia. At Jáchymov (Joachimsthal), Czech Republic. In Italy, on Vesuvius, Campania, and from the Conchea mine, near Rio Marina, Elba. Found along Contrary Creek, Louisa Co., Virginia, USA.

Name: As a ferrous iron sulfate with six essential water molecules per formula unit.

Type Material: n.d.

References: (1) Karnitskii, V.A. and O.I. Nekrasova (1930) Secondary minerals of the Nikotovka mercury deposit. Mineral Resources, 1, 135–138 (in Russian). (2) Vlasov, V.V. and A.V. Kuznetsov (1962) Melanterite and the products of its alteration. Zap. Vses. Mineral. Obshch., 91, 490–492 (in Russian). (3) (1963) Amer. Mineral., 48, 433 (abs. ref. 2). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 84.

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Ferrohornblende $Ca_2[(Fe^{2+},Mg)_4Al](Si_7Al)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 10 cm, and as rims on pyroxenes. *Twinning:* [Simple or lamellar twinning ∥ {100}.]

Physical Properties: *Cleavage:* Perfect on {110}, with intersections at 56° and 124°; may show partings on {100}, {010}. *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.12–3.30 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Green, greenish brown. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* X = light brown, greenish yellow; Y = light green, olive-green; Z = dark green, bluish green. *Orientation:* $Y = b$, $Z \wedge c \simeq 18°$. α = 1.641–1.704 β = 1.657–1.718 γ = 1.662–1.727 2V(meas.) = 57°–79°

Cell Data: *Space Group:* [$C2/m$.] a = n.d. b = n.d. c = n.d. β = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	45.24	42.73	MgO	8.90	0.40
TiO_2	1.26	3.32	CaO	10.21	9.20
Al_2O_3	10.77	7.35	Na_2O	1.34	1.09
Fe_2O_3	0.41	7.05	K_2O	0.42	0.90
FeO	19.33	25.86	H_2O^+	1.50	0.75
MnO	0.75	0.48	H_2O^-	0.00	
			Total	100.13	99.13

(1) Centennial mine, Broken Hill, New South Wales, Australia; corresponds to $(Ca_{1.65}Na_{0.39}K_{0.08})_{\Sigma=2.12}(Fe^{2+}_{2.43}Mg_{2.00}Al_{0.72}Ti_{0.14}Mn_{0.09}Fe^{3+}_{0.05})_{\Sigma=5.43}(Si_{6.81}Al_{1.19})_{\Sigma=8.00}O_{22}[(OH)_{1.50}O_{0.50}]_{\Sigma=2.00}$. (2) Mayurbhanj district, Orissa, India; corresponds to $(Ca_{1.60}Na_{0.34}K_{0.19})_{\Sigma=2.13}(Fe^{2+}_{3.51}Fe^{3+}_{0.86}Ti_{0.40}Al_{0.34}Mg_{0.10}Mn_{0.06})_{\Sigma=5.27}(Si_{6.93}Al_{1.07})_{\Sigma=8.00}O_{22}(OH)_{0.81}$.

Polymorphism & Series: Forms a series with magnesiohornblende.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) < 0.50$; $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; 6.50 Si 7.24.

Occurrence: From granites, granodiorites, and metabasalts; common in amphibolites and schists. As reaction rims on ferroan hedenbergite.

Association: Hedenbergite (granite); biotite, epidote, albite, quartz (amphibolite).

Distribution: Very widespread, but many locality references lack qualifying chemical analyses. A few historic localities for well-crystallized material include: at Monte Somma and Vesuvius, Campania, Italy. From Pargas, Finland. At Kragerö, Arendal, and around the Langesundsfjord, Norway. From Bílina and Schima, Czech Republic. In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; from Edwards, Pierrepont, and Gouverneur, St. Lawrence Co., New York. From Bancroft, Pakenham, and Eganville, Ontario, Canada. From Broken Hill, New South Wales, Australia.

Name: For its *ferrous* iron content and from the German for *horn* and *to deceive*, in allusion to its similarity to valuable minerals in ores.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 385–398 [hornblende, in part]. (2) Leake, B.E. (1968) A catalog of analyzed calciferous and subcalciferous amphiboles together with their nomenclature and associated minerals. Geol. Soc. Amer. Special Paper 98, 210 p. [analysis 754]. (3) Iyengar, S.V.P. and K.K. Basu (1980) Ferro-hornblende, an iron-rich end member from Simlipal Granite, Mayurbhanj District, Orissa. J. Geol. Soc. India, 21, 558–561.

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Ferroindialite $(Fe^{2+},Mg)_2Al_4Si_5O_{18}$

Crystal Data: Hexagonal. *Point Group*: 6/*m* 2/*m* 2/m. As hexagonal prismatic or tabular crystals, to 1.5 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle.
Hardness = 7 D(meas.) = 2.66(1) D(calc.) = 2.667

Optical Properties: Transparent. *Color*: Brownish purple to gray with a violet-blue tint.
Streak: White. *Luster*: Vitreous. *Pleochroism*: Weak, *X* = colorless, *Z* = pale violet.
Dispersion: r < *v*, weak.
Optical Class: Biaxial (–) [anomalous]. α = 1.539(2) β = 1.552(2) γ = 1.554(2)
2V(meas.) = 30(10)°

Cell Data: *Space Group*: *P*6/*mcc*. *a* = 9.8759(3) *c* = 9.3102(3) Z = 2

X-ray Powder Pattern: Bellerberg Mountain, Eifel region, Germany.
8.59 (100), 3.390 (35), 3.055 (31), 4.094 (27), 3.147 (19), 2.657 (12), 1.695 (9)

Chemistry:

	(1)
Na_2O	0.14
K_2O	0.46
MgO	4.95
MnO	1.13
FeO	12.66
Fe_2O_3	2.64
Al_2O_3	30.45
SiO_2	47.22
Total	99.65

(1) Bellerberg Mountain, Eifel region, Germany; average of 5 electron microprobe analyses, Fe^{2+} and Fe^{3+} calculated from structure refinement, absence of OH^- and H_2O confirmed by IR spectroscopy; corresponding to $(K_{0.06}Na_{0.03})(Fe^{2+}_{1.12}Mg_{0.78}Mn_{0.10})_{\Sigma=2.00}(Al_{3.79}Fe^{3+}_{0.21})_{\Sigma=4.00}Si_{4.98}O_{18}$.

Mineral Group: Beryl group.

Occurrence: In a metamorphosed pelitic xenolith in alkaline basalt.

Association: Sillimanite, sanidine, phlogopite, enstatite-ferrosilite, wagnerite, fluorapatite, tridymite, zircon, high-Mg almandine.

Distribution: From the Caspar quarry, Bellerberg Mountain, near Mayen, Eifel region, Rheinland-Pfalz, Germany.

Name: As the iron-dominant (*ferro*) analog of *indialite*.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 4400/1).

References: (1) Chukanov, N.V., S.M. Aksenov, I.V. Pekov, B. Ternes, W. Schüller, D.I. Belakovskiy, K.V. Van, and G. Blass (2014) Ferroindialite $(Fe^{2+},Mg)_2Al_4Si_5O_{18}$ - a new beryl-group mineral from the Eifel volcanic region, Germany. Zap. Ross. Mineral. Obshch., 143(1), 46-56 (in Russian with English abstract). Geology of Ore Deposits, 56(8), 637–643 (in English).
(2) (2015) Amer. Mineral., 100, 334-335 (abs. ref. 1).

Ferro-kaersutite $\mathbf{NaCa_2[(Fe^{2+},Mg)_4Ti](Si_6Al_2)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [Prismatic.] *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, with intersections at 56° and 124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = ∼3.2–3.42 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* [Dark brown to black.] *Luster:* [Vitreous.] *Optical Class:* [Biaxial (–).] *Pleochroism:* X = yellow; Y = impure green; Z = greenish brown. *Orientation:* [$Y = b$.] *Dispersion:* [$r > v$.] $\alpha = 1.677$ β = n.d. $\gamma = 1.709$ 2V(meas.) = 72°

Cell Data: *Space Group:* [$C2/m$.] a = n.d. b = n.d. c = n.d. β = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
SiO_2	36.95
TiO_2	6.25
Al_2O_3	15.02
Fe_2O_3	3.62
FeO	19.40
MgO	4.34
CaO	10.25
Na_2O	1.34
K_2O	1.33
H_2O^+	1.26
H_2O^-	0.19
Total	[99.95]

(1) Koraput, India; original total given as 99.98%; corresponds to $(Na_{0.40}K_{0.26})_{\Sigma=0.66}Ca_{1.84}(Fe^{2+}_{2.51}Mg_{1.00}Ti_{0.73}Al_{0.48}Fe^{3+}_{0.42})_{\Sigma=5.14}(Si_{5.74}Al_{2.26})_{\Sigma=8.00}O_{22}[(OH)_{1.30}O_{0.70}]_{\Sigma=2.00}$.

Polymorphism & Series: Forms a series with kaersutite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) < 0.50$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; Si < 6.5; Ti ≥ 0.5.

Occurrence: From syenites, camptonites, and essexites.

Association: Alkalic feldspar, oligoclase, biotite, ilmenite-magnetite.

Distribution: From Koraput, Orissa, India.

Name: For its high *ferrous* iron composition and similarity to *kaersutite*.

Type Material: n.d.

References: (1) Bose, M.K. (1964) Amphiboles in alkaline rocks of Koraput, Orissa. Mineral. Mag., 33, 912–917.

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Ferrokesterite $Cu_2(Fe,Zn)SnS_4$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $\overline{4}$. Massive, granular, to 0.5 mm.

Physical Properties: *Cleavage:* Distinct on {110}; a parting on {001}. Hardness = ∼4 VHN = 228–255, 238 average (100 g load). D(meas.) = n.d. D(calc.) = 4.490

Optical Properties: Opaque. *Color:* Steel-gray; medium gray in reflected light. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Weak; in shades of gray. *Bireflectance:* Weak. R_1–R_2: 23.9–26.8 (470), 26.0–27.0 (546), 26.4–27.3 (589), 26.0–26.8 (650)

Cell Data: *Space Group:* $I\overline{4}$ (by analogy to kesterite). $a = 5.433(36)$ $c = 10.883(89)$ $Z = 2$

X-ray Powder Pattern: Cligga mine, England.
3.13 (10), 1.919 (6), 1.110 (4), 2.712 (3), 1.242 (3), 1.045 (3), 0.9182 (3)

Chemistry:

	(1)
Cu	29.5
Zn	5.0
Cd	0.1
Fe	8.7
Mn	0.1
Sn	27.4
S	30.1
Total	100.9

(1) Cligga mine, England; by electron microprobe, corresponding to $Cu_{1.99}(Fe_{0.67}Zn_{0.33})_{\Sigma=1.00}Sn_{0.99}S_{4.02}$.

Polymorphism & Series: Dimorphous with stannite.

Occurrence: In greisen-bordered sulfide veins in granite.

Association: Arsenopyrite, cassiterite, chalcopyrite, sphalerite, chalcocite, quartz.

Distribution: From the Cligga mine, Perranzabuloe, Cornwall, England [TL].

Name: For its content of iron, *ferrum*, and relation to kesterite.

Type Material: Canadian Geological Survey, Ottawa, Canada, 14747, 65048; The Natural History Museum, London, England, 1984,844.

References: (1) Kissin, S.A. and D.R. Owens (1989) The relatives of stannite in the light of new data. Can. Mineral., 27, 673–688. (2) (1990) Amer. Mineral., 75, 1432 (abs. ref. 1).

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Ferronickelplatinum Pt_2FeNi

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Crystal Data: Tetragonal. *Point Group:* n.d. Intergrown with other platinum group minerals, as unrounded or slightly rounded, nodular grains up to 4.5 mm, but monominerallic areas do not exceed 0.15 mm.

Physical Properties: *Tenacity:* Ductile. Hardness = n.d. VHN = 381–592, 481 average (50 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Silvery white; in polished section, rosy cream. *Luster:* Metallic. *Anisotropism:* Weak.
R_1–R_2: (400) — , (420) 56.5, (440) 56.4, (460) 56.8, (480) 57.4, (500) 58.2, (520) 58.7, (540) 59.0, (560) 59.3, (580) 59.7, (600) 60.2, (620) 60.5, (640) 60.9, (660) 61.4, (680) 62.0, (700) 62.8

Cell Data: *Space Group:* n.d. $a = 3.871(4)$ $c = 3.635(5)$ $Z = 1$

X-ray Powder Pattern: Northern Pekul'nei River, Russia.
2.192 (10), 1.935 (5), 1.324 (4), 1.699 (3), 1.157 (3b), 1.092 (2b), 3.66 (1b)

Chemistry:

	(1)	(2)
Pt	76.7	77.30
Ir	0.47	
Os		
Ru		
Rh		
Fe	10.7	11.07
Ni	11.0	11.63
Cu	0.34	
Total	99.21	100.00

(1) Northern Pekul'nei River, Russia; by electron microprobe, average of six analyses; corresponds to $(Pt_{2.02}Ir_{0.01})_{\Sigma=2.03}Fe_{0.98}(Ni_{0.96}Cu_{0.03})_{\Sigma=0.99}$. (2) Pt_2FeNi.

Polymorphism & Series: Forms a series with tulameenite.

Occurrence: In the heavy fraction of Quaternary alluvial deposits associated with ultramafics from an ophiolite belt (Northern Pekul'nei River, Russia);

Association: Isoferroplatinum, tetraferroplatinum, rutheniridosmine, laurite, irarsite, cooperite, sperrylite, hollingworthite, cherepanovite, chromite, olivine (Northern Pekul'nei River, Russia).

Distribution: From the placer of the Northern Pekul'nei River, Pekul'nei Range, eastern Chukot Peninsula, Russia [TL]. In the Naran massif, western Mongolia. At Goodnews Bay, Alaska, USA.

Name: For iron, FERRum, NICKEL, and PLATINUM in the composition.

Type Material: Mining Institute, St. Petersburg, Russia, 1306/1.

References: (1) Rudashevskiy, N.S., A.G. Mochalov, Y.P. Men'shikov, and N.I. Shumskaya (1983) Ferronickelplatinum, Pt_2FeNi, a new mineral species. Zap. Vses. Mineral. Obshch., 112, 487–494 (in Russian). (2) (1984) Amer. Mineral., 69, 1190–1191 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 84–85.

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Nigerite-6H $(Fe^{2+}, Zn, Mg)(Sn, Zn)_2(Al, Fe^{3+})_{12}O_{22}(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Hexagonal crystals, to 1 cm, platy on {0001}, with poorly developed $\{10\overline{1}1\}$ and other trigonal faces; may form oriented overgrowths on gahnite.

Physical Properties: *Cleavage:* Distinct to perfect on {0001}. *Tenacity:* Brittle. Hardness = 8–9 D(meas.) = 4.25–4.51 D(calc.) = [4.44–4.55] Weakly magnetic.

Optical Properties: Transparent to translucent. *Color:* Dark brown, red-brown, red; brownish yellow, brown, or yellow in transmitted light. *Streak:* Yellow-brown. *Luster:* Vitreous. *Optical Class:* Uniaxial (+) or (–); birefringence 0.003–0.005. *Pleochroism:* Faint, patchy; O = brownish yellow, yellow-brown; E = pale brownish yellow, yellow. $\omega = 1.79$–1.80 $\epsilon = 1.80$–1.81

Cell Data: *Space Group:* $P\overline{3}m1$ or $P\overline{3}1m$. $a = 5.67$–5.72 $c = 13.79$–13.88 Z = 1

X-ray Powder Pattern: Egbe district, Nigeria.
2.83 (vs), 2.42 (vs), 1.644 (s), 1.541 (s), 4.64 (ms), 1.430 (ms), 1.413 (ms)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.48	0.9	FeO	2.65	10.9
TiO_2	0.17	3.3	MnO	0.09	0.1
SnO_2	25.33	23.2	ZnO	4.51	5.3
Al_2O_3	50.91	55.0	PbO	0.94	< 0.1
Ga_2O_3		0.3	MgO	1.28	0.1
Fe_2O_3	11.90		H_2O	1.57	1.2
			Total	99.83	100.3

(1) Egbe district, Nigeria; corresponds to $(Fe^{2+}_{0.39}Zn_{0.38}Mg_{0.33}Fe^{3+}_{0.09}Pb_{0.04}Mn_{0.01})_{\Sigma=1.24}(Sn_{1.77}Zn_{0.21}Ti_{0.02})_{\Sigma=2.00}(Al_{10.52}Fe^{3+}_{1.48})_{\Sigma=12.00}[O_{22.16}(OH)_{1.84}]_{\Sigma=24.00}$. (2) Caramos mine, Portugal; by wet chemical, X-ray fluorescence, colorimetric, and spectrographic methods, total Fe as FeO, H_2O by LOI at 1000 °C.

Polymorphism & Series: 6H and 24R polytypes are known.

Occurrence: In quartz-sillimanite rocks closely associated with tin-bearing granite pegmatites (Egbe district, Nigeria); in riebeckite gneiss (La Guia, Spain).

Association: Quartz, sillimanite, andalusite, muscovite, garnet, cassiterite, gahnite, chrysoberyl, columbite, apatite (Egbe district, Nigeria); quartz, albite, microcline, riebeckite, ferrian biotite, aegirine, zircon, fluorite (La Guia, Spain).

Distribution: From several occurrences in the Egbe district, Kabba Province, Nigeria. At the Caramos mine, Lixa, and other places between Felgueiras and Amarante, Portugal. From La Guia, Vigo, Pontevedra Province, Spain. In Sweden, at Falun. In the Rosendal pegmatite, Kemiö (Kimito) Island, Finland. From an undefined locality in Siberia, Russia. At Shizhuyuan, Guangxi Province, China. From the upper Candeias area, Rondônia, and elsewhere in the Araguarí-Amaparí region, Amapá Territory, Brazil. In the Omaruru River tin deposits, Namibia.

Name: For Nigeria, the country where it was first found.

Type Material: n.d.

References: (1) Jacobson, R. and J.S. Webb (1947) The occurrence of nigerite, a new tin mineral in quartz-sillimanite-rocks from Nigeria. Mineral. Mag., 28, 118–128. (2) Bannister, F.A., M.H. Hey, and H.P. Stadler (1947) Nigerite, a new tin mineral. Mineral. Mag., 28, 129–136. (3) (1948) Amer. Mineral., 33, 98 (abs. refs. 1 and 2). (4) Van Tassel, R. (1965) Nigerite from Lixa, near Felgueiras, Douro Litoral province, Portugal. Mineral. Mag., 34, 482–486. (5) Grey, I.E. and B.M. Gatehouse (1979) The crystal structure of nigerite-24R. Amer. Mineral., 64, 1255–1264. (6) Arakcheeva, A.V., D.Y. Pushcharovskii, R.K. Rastsvetaeva, A.A. Kashaev, and T.N. Nadezhina (1995) Crystal structure of nigerite-6*H*. Kristallografiya (Sov. Phys. Crystal.), 40, 639–644.

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Nigerite-24R $(Fe^{2+}, Zn)_4Sn_2(Al, Si, Fe)_{15}O_{30}(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As hexagonal platelets, to 2 mm, and as oriented overgrowths on gahnite. *Twinning:* By two-fold rotation about [0001], observed as striations on {0001} and repeated intergrowths at 120°, also by X-ray diffraction effects.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.42

Optical Properties: Transparent to translucent. *Color:* Colorless; very pale green in transmitted light.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 5.730(3)$ $c = 55.60(3)$ Z = 3

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
SiO_2	0.89
SnO_2	21.27
Al_2O_3	52.63
FeO	13.91
MnO	0.33
ZnO	8.12
CaO	1.06
H_2O	[1.79]
Total	[100.00]

(1) Mt. Garnet, Australia; by electron microprobe, here computed from average of two elemental analyses, total Fe as FeO, H_2O by difference; corresponds to $(Fe_{2.66}Zn_{1.42}Mn_{0.06})_{\Sigma=4.14}Sn_{2.01}Ca_{0.28}(Al_{14.69}Si_{0.21}Fe_{0.10})_{\Sigma=15.00}O_{30}(OH)_2$.

Polymorphism & Series: 6H and 24R polytypes are known.

Occurrence: In quartz-sillimanite rocks closely associated with tin-bearing granite pegmatites (Egbe district, Nigeria); in tin-bearing skarns (Mt. Garnet, Australia).

Association: Gahnite (Egbe district, Nigeria); magnetite, fluorite, biotite, gahnite, corundum, cassiterite (Mt. Garnet, Australia).

Distribution: Distinction of the 24R from the 6H polytype requires that the unit cell be determined, which has been accomplished for the following localities: from the Egbe district, Kabba Province, Nigeria. At the Mt. Garnet tin deposits, Queensland, Australia. In the Geco Cu–Zn deposit, Manitouwadge district, 80 km north-northeast of Lake Superior, Ontario, Canada.

Name: As the 24R polytype of *nigerite*-6H.

Type Material: Royal Ontario Museum, Toronto, Canada, M24546; National Museum of Natural History, Washington, D.C., USA, 146963.

; nigerite-6T = ferronigerite-2N1S; nigerite-24R = ferronigerite-6N6S; [full list given under högbohmite];

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Ferropargasite $\mathbf{NaCa_2[(Fe^{2+},Mg)_4Al](Si_6Al_2)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As homoaxial intergrowths with grunerite. *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, with intersections at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = 5–6 D(meas.) = n.d. D(calc.) = 3.44 (synthetic ferro-pargasite).

Optical Properties: Semitransparent. *Color:* Bluish green in thin section.
Luster: [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* Moderate. $\alpha = 1.700$ $\beta = 1.713$ $\gamma = 1.718$
2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$. $a = 9.953(5)$ (synthetic ferro-pargasite). $b = 18.152(3)$ $c = 5.330(2)$ $\beta = 105.3(1)°$ Z = 2

X-ray Powder Pattern: Synthetic ferro-pargasite.
8.50 (100), 3.15 (80), 2.718 (60), 2.607 (40), 2.57 (35), 3.40 (25), 2.36 (25)

Chemistry:

	(1)
SiO_2	38.65
Al_2O_3	16.50
FeO	27.75
MnO	0.39
MgO	2.03
CaO	10.30
Na_2O	1.80
K_2O	0.50
Total	97.92

(1) Flowerdale, Scotland; by electron microprobe, corresponds to $(Na_{0.55}K_{0.10})_{\Sigma=0.65}Ca_{1.73}(Fe^{2+}_{3.65}Mg_{0.48}Mn_{0.05})_{\Sigma=4.18}Al_{1.13}(Si_{6.07}Al_{1.93})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with pargasite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) < 0.3$; Fe^{3+} Al^{vi}; $(Na + K)_A \geq 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si < 6.25$; $Ti < 0.5$.

Occurrence: In an amphibolite facies metamorphosed banded iron formation.

Association: Grunerite, almandine, biotite, ferroan clinochlore, magnetite, quartz.

Distribution: From Flowerdale, near Gairloch, Scotland.

Name: For its high *ferrous* iron content and relation to *pargasite*.

Type Material: n.d.

References: (1) Williams, P.J. (1986) Petrology and origin of iron-rich silicate-magnetite-quartz rocks from Flowerdale near Gairloch, Wester Ross. Scottish J. Geol., 22, 1–12. (2) Gilbert, M.C. (1966) Synthesis and stability relationships of ferropargasite. Amer. J. Sci., 264, 698–742. (3) Charles, R.W. (1980) Amphiboles on the join pargasite-ferropargasite. Amer. Mineral., 65, 996–1001.

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Ferro-richterite $\mathbf{Na[NaCa](Fe^{2+},Mg)_5Si_8O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic; in reticulated masses; as overgrowths on clinopyroxene. *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Fracture:* [Uneven.] *Tenacity:* [Brittle.] Hardness = 5–6 D(meas.) = n.d. D(calc.) = 3.46 (synthetic ferro-richterite).

Optical Properties: Semitransparent. *Color:* Brown to green. *Streak:* [White.] *Luster:* [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = yellow; Y = blue-black; Z = dark blue-green. *Orientation:* $Y = b$. *Dispersion:* $r < v$. $\alpha = 1.688$ $\beta = 1.699$ $\gamma = 1.704$ 2V(meas.) = 35°

Cell Data: *Space Group:* $[C2/m.]$ a = 9.982(7) (synthetic ferro-richterite). $b = 18.223(6)$ $c = 5.298(5)$ $\beta = 103°44(7)'$ Z = 2

X-ray Powder Pattern: Synthetic ferro-richterite.
8.58 (100), 2.739 (70), 3.18 (65), 2.540 (50), 3.43 (35), 2.615 (35), 3.32 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.85	51.15	MnO	1.31	1.84
TiO_2	1.02	1.33	MgO	4.20	8.08
Al_2O_3	2.39	1.35	CaO	6.10	5.04
Fe_2O_3		0.82	Na_2O	4.37	6.62
Cr_2O_3	0.04		K_2O	1.24	1.10
FeO	30.19	20.98	Total	[99.71]	98.31

(1) Baie-des-Moutons, Quebec, Canada; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry, original total given as 99.68%, corresponding to $(Na_{0.59}K_{0.25})_{\Sigma=0.84}(Ca_{1.02}Na_{0.73}Mn_{0.17}Fe^{2+}_{0.08})_{\Sigma=2.00}(Fe^{2+}_{3.85}Mg_{0.98}Ti_{0.12}Al_{0.05})_{\Sigma=5.00}(Si_{7.61}Al_{0.39})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Kangerdlugssuaq Fjord, Greenland; by electron microprobe, Fe^{2+}:Fe3+ calculated; corresponding to $(Na_{0.77}K_{0.21})_{\Sigma=0.98}(Ca_{1.82}Na_{0.18})_{\Sigma=2.00}(Fe^{2+}_{2.67}Mg_{1.83}Mn_{0.24}Ti_{0.15}Fe^{3+}_{0.09}Al_{0.02})_{\Sigma=5.00}(Si_{7.78}Al_{0.22})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with richterite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) < 0.5$; $(Na + K)_A \geq 0.5$; 0.67 Na_B 1.33; $(Ca + Na)_B \geq 1.34$; $Si \geq 7.5$.

Occurrence: A rare accessory mineral in sodium-rich syenites and their volcanic equivalents; replacing ferromagnesian minerals in granite.

Association: Feldspar, pyroxenes, zircon, fayalite, ferro-actinolite.

Distribution: From the Baie-des-Moutons complex, La Tabatière, Quebec, Canada. At the Kangerdlugssuaq Fjord, Greenland. From the Tibchi ring complex, Nigeria.

Name: For the *ferrous* iron in its composition and similarity to *richterite*.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 352–358. (2) Charles, R.W. (1974) The physical properties of the Mg–Fe richterites. Amer. Mineral., 59, 518–528. (3) Lalonde, A.E. and R.F. Martin (1983) The Baie-des-Moutons syenitic complex, La Tabatière, Québec: II. The ferromagnesian minerals. Can. Mineral., 21, 81–91. (4) Brooks, C.K. and R.C.O. Gill (1982) Compositional variation in the pyroxenes and amphiboles of the Kangerdlugssuaq intrusion, East Greenland: further evidence for the crustal contamination of syenite magma. Mineral. Mag., 45, 1–9. (5) Ike, E.C., P. Bowden, and R.F. Martin (1985) Amphibole in the porphyries of the Tibchi anorogenic ring-complex, Nigeria: product of deuteric adjustments. Can. Mineral., 23, 447–456.

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Ferroselite $FeSe_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As slender prismatic crystals, to 1 mm, striated on {110} parallel to [001], with rhombic cross sections; fine-grained massive. *Twinning:* As stellate and cruciform twins; twin lamellae noted in polished section.

Physical Properties: *Tenacity:* Very brittle. Hardness = 6–6.5 VHN = 858–933, 897 average (25 g load). D(meas.) = 7.20 D(calc.) = 7.139 Becomes magnetic on heating.

Optical Properties: Opaque. *Color:* Steel-gray to tin-white with a rose tint, also brass-yellow, tarnishes to a brassy tone; in polished section, white with a gray-brown hue. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Distinct. *Anisotropism:* Strong, from greenish gray to lilac-gray. R_1–R_2: (400) 42.3–44.1, (420) 42.5–44.3, (440) 43.0–44.5, (460) 43.5–45.1, (480) 43.9–45.9, (500) 44.4–47.0, (520) 44.9–48.2, (540) 45.3–49.5, (560) 46.0–50.9, (580) 46.8–52.3, (600) 47.6–53.7, (620) 48.2–54.9, (640) 48.7–55.9, (660) 49.1–56.3, (680) 49.3–56.5, (700) 49.5–56.7

Cell Data: *Space Group: Pnnm.* $a = 4.8007$ $b = 5.776$ $c = 3.5850$ $Z = 2$

X-ray Powder Pattern: Powder River basin, Wyoming, USA (nearly identical to rammelsbergite).
2.568 (100), 2.474 (100), 1.885 (70), 2.871 (50), 1.695 (40), 2.400 (35), 1.541 (35)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Fe	27.87	26.4	26.13	Cu		0.2	
Co		0.1		Se	72.13	74.0	73.87
				Total	[100.00]	100.7	100.00

(1) Ust'-Uyuk V–Se–U deposit, Russia; recalculated to 100% after deduction of 4% insoluble; corresponds to $Fe_{1.09}Se_{2.00}$. (2) Trogtal quarry, Germany; by electron microprobe, corresponds to $(Fe_{1.01}Cu_{0.01})_{\Sigma=1.02}Se_{2.00}$. (3) $FeSe_2$.

Polymorphism & Series: Dimorphous with dzharkenite.

Mineral Group: Marcasite group.

Occurrence: In red-bed deposits of the Colorado Plateau type, peripheral to pyrite and uranium concentrations (Utah, USA); in U–V ores in sandstone, with coalified wood (Colorado, USA); with other sulfides and selenides cementing sandstones and pelites (Tuva, Russia).

Association: Uraninite, pyrite, marcasite, chalcopyrite, sphalerite, selenium, clausthalite, cadmoselite, bornite, cobaltomenite, laumontite, barite.

Distribution: In Russia, from the Ust'-Uyuk V–Se–U deposit, Tuva, Siberia [TL]; and in the Zapadno-Ozernogo Cu–Zn deposit, Southern Ural Mountains. From the Seluchekinskoye deposit, Kazakhstan. In Finland, at Kuusamo. In the Czech Republic, at the Petrovice uranium deposit, near Ždăr, and the Předbořice uranium deposit, near Krásna Hora. In the Trogtal quarry, near Lautenthal, Harz Mountains, Germany. In the USA, at several localities in Utah, on the Colorado Plateau, including the A.E.C. no. 8 mine, Temple Mountain, Emery Co. and the Repete mine, San Juan Co.; in Wyoming, from sandstones of the Powder River basin; from the Kermac Sec. 10 mine, McKinley Co., New Mexico; in the Mitten #2 mine, Navajo Co., Arizona; and from a number of mines in the Uravan district, Montrose Co., Colorado. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina.

Name: For iron, FERrum, and SELenium in the composition.

Type Material: Mining Museum, St. Petersburg Mining Institute, St. Petersburg, 46-2/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69853.

References: (1) Bur'yanova, E.Z. and A.I. Komkov (1955) A new mineral – ferroselite. Doklady Acad. Nauk SSSR, 105, 812–813 (in Russian). (2) (1956) Amer. Mineral., 41, 671 (abs. ref. 1). (3) Granger, H.C. (1966) Ferroselite in a roll-type uranium deposit, Powder River basin, Wyoming. U.S. Geol. Sur. Prof. Paper 550-C, C133–C137. (4) Kjekshus, A. etal (1974) ??title?? Acta Chem. Scand., 28, 996–?? (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 167.

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Ferrosilite $(Fe^{2+},Mg)_2Si_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As coarse anhedral to subhedral grains, up to 5 mm. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Good on {210}, (210) $\wedge$ $(2\bar{1}0)$ ~88°; partings on {100}, {010}. Hardness = 5–6 D(meas.) = 3.96 D(calc.) = [3.87]

Optical Properties: Semitransparent. *Color:* Green, dark brown; greenish or reddish in thin section.
Optical Class: Biaxial (–). *Orientation:* $X = b$. *Dispersion:* $r < v$, strong. α = 1.755–1.768 β = 1.763–1.770 γ = 1.772–1.788 2V(meas.) = 55°–90°

Cell Data: *Space Group: Pbca.* a = 18.431 b = 9.080 c = 5.238 Z = 8

X-ray Powder Pattern: Oribi Gorge, South Africa. (ICDD 19-607).
3.21 (100), 2.892 (75), 2.504 (55), 2.577 (50), 2.126 (50), 2.979 (45), 4.58 (35)

Chemistry:

	(1)
SiO_2	44.43
TiO_2	0.12
Al_2O_3	2.96
Fe_2O_3	0.70
FeO	44.91
MnO	1.20
MgO	3.38
CaO	1.69
Na_2O	0.07
K_2O	0.05
Total	99.51

(1) Bauchi, Nigeria; corresponds to $(Fe^{2+}_{1.60}Mg_{0.21}Ca_{0.08}Mn_{0.04}Fe^{3+}_{0.02}Na_{0.01})_{\Sigma=1.96}(Si_{1.90}Al_{0.10})_{\Sigma=2.00}O_6$.

Polymorphism & Series: Dimorphous with clinoferrosilite; forms a series with enstatite.

Mineral Group: Pyroxene group.

Occurrence: In medium- to high-grade metamorphosed iron formations.

Association: Magnetite, hematite, ferroan diopside, quartz, almandine.

Distribution: From Bauchi, Nigeria. At Tiris, Mauritania. From Oribi Gorge, Marble Delta, Natal, South Africa. In the USA, in Montana, around Copper Mountain and Carmichael Creek, in the Tobacco Root Mountains; in the Ruby Creek area, in the Gravelly Range, Madison Co.; also the Carter Creek area, in the Ruby Mountains, Beaverhead and Madison Cos.; and in Utah, at Hanksville, Wayne Co. On Arcedeckne Island, District of Franklin, Arctic Canada.

Name: For FERROus iron and SILicon in the composition; originally a "normative" mineral in rocks.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 20–161. (2) Turnock, A.C., D.H. Lindsley, and J.E. Grover (1973) Synthesis and unit cell parameters of Ca–Mg–Fe pyroxenes. Amer. Mineral., 58, 50–59. (3) Sueno, S., M. Cameron, and C.T. Prewitt (1976) Orthoferrosilite: high temperature crystal chemistry. Amer. Mineral., 61, 38–53.

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Ferroskutterudite $(Fe, Co)(As, S)_3$

Crystal Data: Isometric. *Point Group*: 4/*m* $\bar{3}$ 2/*m*. As grains, 30-100 μm.

Physical Properties: *Cleavage*: Perfect, probably on {0$\bar{2}$ 1}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = n.d. VHN = 700–1050 (50 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color*: Tin white. *Streak*: n.d. *Luster*: Metallic.
Optical Class: Isotropic. Indistinguishable from skutterudite.
R_{air}: (400) 57.2, (420) 57.6, (440) 58.0, (460) 58.2, (470) 58.2, (480) 58.2, (500) 58.0, (520) 57.6, (540) 57.3, (546) 57.2, (560) 56.9, (580) 56.4, (589) 56.2, (600) 56.0, (620) 55.5, (640) 55.2, (650) 54.9, (660) 54.7, (680) 54.3, (700) 53.8

Cell Data: *Space Group*: *Im*3*m*. *a* = 8.17(1) Z = 8

X-ray Powder Pattern: Noril'sk ore field, Russia.
2.858 (100), 2.182 (90), 1.829 (70), 1.602 (70), 1.402 (60), 1.667 (50)

Chemistry:

	(1)
Ni	0.05
Co	8.38
Fe	12.09
As	78.01
S	1.34
Total	99.87

(1) Noril'sk ore field, Russia; average of 4 electron microprobe analyses, corresponding to $(Fe_{0.600}Co_{0.394}Ni_{0.002})_{\Sigma=0.996}(As_{2.888}S_{0.116})_{\Sigma=3.004}$.

Occurrence: In hydrothermal dolomite-calcite veins and apophyllite-anhydrite-carbonate veins in a magmatic hydrothermal Co-Ni antimonide-arsenide deposit.

Association: Wurtzite, sphalerite, galena, chalcopyrite, pyrrhotite, cubanite, chalcocite.

Distribution: From the Noril'sk ore field, Russia.

Name: For the high iron content and relation to *skutterudite*.

Type Material: A. E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (no. 3440/1).

References: (1) Spiridonov, E.M., Yu.D. Gritsenko, and I.M. Kulikova (2007) Ferroskutterudite (Fe,Co)As_3: A new mineral species from the dolomite-calcite veins of the Noril'sk Ore Field. Doklady Earth Sciences, 417, 1278–1280. (2) (2008) Amer. Mineral., 93, 1687-1688 (abs. ref. 1).

Ferrostrunzite $Fe^{2+}Fe^{3+}_2(PO_4)_2(OH)_2 \cdot 6H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$ or 1. Crystals are prismatic, flattened ∥ {100}, elongated along [001], to 6 mm, commonly fibrous in divergent aggregates. *Twinning:* By reflection across {110}.

Physical Properties: *Cleavage:* One nearly ∥ to elongation; one ≃ ⊥ optic normal; one ⊥ *Bxa*. *Fracture:* Very brittle. Hardness = ∼4 D(meas.) = 2.50 D(calc.) = 2.57

Optical Properties: Semitransparent. *Color:* Pale brown, colorless, white, straw-yellow, bright orange. *Streak:* Pale brown. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Faint; *X* = yellow-green; *Z* = orange. *Orientation:* $Z \wedge c \simeq 3°–8°$. *Dispersion:* Moderate, asymmetric. *Absorption:* Minimum ∥ *Z*. $\alpha = 1.628(2)$ $\beta = [1.682]$ $\gamma = 1.723(4)$ 2V(meas.) = 80(5)°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.17–10.23$ $b = 9.77–9.78$ $c = 7.37–7.40$ $\alpha = 88.63°–89.65°$ $\beta = 97.60°–98.28°$ $\gamma = 117.26°–117.60°$ Z = 2

X-ray Powder Pattern: Mullica Hill, New Jersey, USA; nearly identical to strunzite.
5.29 (100), 8.94 (80), 3.277 (40), 4.47 (30), 3.452 (30), 3.213 (30), 4.33 (20)

Chemistry:

	(1)	(2)	(3)
P_2O_5	28.1	29.91	28.41
$Fe_2O_3 + FeO$		43.17	
Fe_2O_3	30.9		31.97
FeO	13.9		14.38
MnO	trace	0.06	
H_2O	[27.1]	27.5	25.24
Total	[100.0]	100.7	100.00

(1) Mullica Hill, New Jersey, USA; by electron microprobe, H_2O by difference, Fe^{2+}:Fe^{3+} estimated at 1:2 from microchemical tests and the known isostructural strunzite formula; corresponds to $Fe^{2+}_{0.98}Fe^{3+}_{1.96}(PO_4)_2(OH)_{1.84} \cdot 6.68H_2O$. (2) Bethel Church, Indiana, USA; by electron microprobe, H_2O by TGA; assuming Fe^{2+}:Fe^{3+} = 1:2, then corresponds to $Fe^{2+}_{0.95}Fe^{3+}_{1.9}(PO_4)_2(OH)_{1.84} \cdot 6H_2O$. (3) $Fe^{2+}Fe^{3+}_2(PO_4)_2(OH)_2 \cdot 6H_2O$.

Occurrence: Replacing a belemnite (Mullica Hill, New Jersey, USA); a secondary mineral in weathered phosphatic black shale beds (Bethel Church, Indiana, USA).

Association: Rockbridgeite, phosphosiderite (Mullica Hill, New Jersey, USA); vivianite, aluminian strengite, diadochite, leucophosphite, beraunite, fluorapatite (Bethel Church, Indiana, USA); beraunite, cacoxenite (Arnsberg, Germany).

Distribution: In the USA, along Raccoon Creek, near Mullica Hill, Gloucester Co., New Jersey; near Bethel Church, Pike Co., Indiana; in the Dunton quarry, Newry, Oxford Co., Maine; from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire. In the Gravel Hill mine, Perranzabuloe, Cornwall, England. At Arnsberg, North Rhein-Westphalia, and Althütte and Waidhaus, Bavaria, Germany. Along Dry Weather road, Glenhope, New Zealand.

Name: For its dominant content of *ferrous* iron and relation to *strunzite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149594.

References: (1) Peacor, D.R., P.J. Dunn, and W.B. Simmons (1983) Ferrostrunzite, the ferrous iron analogue of strunzite from Mullica Hill, New Jersey. Neues Jahrb. Mineral., Monatsh., 524–528. (2) (1984) Amer. Mineral., 69, 811 (abs. ref. 1). (3) Coveney, R.M., Jr., A.V. Allen, J.C. Blankenship, and W.B. Simmons (1984) Hawleyite and phosphate minerals from Bethel Church, Indiana, including a second occurrence for ferrostrunzite. Mineral. Record, 15, 351–357. (4) van Tassel, R. and E. de Grave (1992) Ferrostrunzite from Arnsberg, Sauerland, Germany. Neues Jahrb. Mineral., Monatsh., 207–212.

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Ferrotaaffeite-2*N′*2*S* $BeFe_3Al_8O_{16}$

Crystal Data: Hexagonal. *Point Group*: 6*mm*. As tabular crystals to 100 μm.

Physical Properties: *Cleavage*: Fair on {001}. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 8.5-9 VHN = 2107 (50 g load). D(meas.) = n.d. D(calc.) = 3.99

Optical Properties: Transparent. *Color*: Dark green to dark gray. *Streak*: White. *Luster*: Vitreous.
Optical Class: Uniaxial (+). ω = 1.402(1) ε = 1.408(1)

Cell Data: *Space Group*: $P6_3mc$. a = 5.6978(8) b = 5.6978(8) c = 18.373(4) Z = 2

X-ray Powder Pattern: Xianghualing ore field, Hunan Province, People's Republic of China. 2.43 (100), 2.60 (90), 1.425 (90), 2.86 (80), 1.473 (80), 2.05 (70), 1.595 (70)

Chemistry:

	(1)
SiO_2	0.03
TiO_2	0.02
SnO_2	0.61
Al_2O_3	66.69
Cr_2O_3	0.02
FeO	16.37
MgO	6.41
ZnO	5.56
MnO	1.97
CaO	0.02
BaO	0.01
BeO	[4.09]
Total	101.80

(1) Xianghualing ore field, Hunan Province, People's Republic of China, average of 23 electron microprobe analyses, BeO calculated from stoichiometry; corresponds to $Be(Fe_{1.39}Mg_{0.97}Zn_{0.42}Mn_{0.17}Sn_{0.03})_{\Sigma=2.98}Al_{7.99}O_{16}$.

Mineral Group: Taaffeite group.

Occurrence: In a contact metamorphic skarn zone.

Association: Fe^{2+}-rich magnesiotaaffeite-2*N′*2*S*, ferronigerite-2*N*1*S*, cassiterite, liberite, pyrite, sphalerite, pyrrhotite, galena, spinel, phlogopite.

Distribution: Xianghualing Sn-polymetallic ore field, Linwu County, Hunan Province, People's Republic of China.

Name: Identifies a member in the *taaffeite* group with a structure based on spinel (*S*) and nolanite (*N*) modules and with $Fe^{2+} > Mg^{2+}$.

Type Material: Museum of the Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, People's Republic of China (KDX017).

References: (1) Yang, Z., K. Ding, J. De Fourestier, Q. Mao, and H. Li (2012) Ferrotaaffeite-2*N′*2*S*, a new mineral species, and the crystal structure of Fe^{2+}-rich magnesiotaaffeite-2*N′*2*S* from the Xianghualing tin-polymetallic ore field, Hunan Province, China. Can. Mineral., 50, 21-29.
(2) (2014) Amer. Mineral., 99, 1514 (abs. ref. 1).

Pehrmanite $(Fe^{2+}, Zn, Mg)_2Al_6BeO_{12}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$. Tabular hexagonal crystals, to 250 μm, subhedral; as oriented overgrowths on nigerite.

Physical Properties: *Tenacity:* Very brittle. Hardness = 8–8.5 VHN = 1700 (100 g load). D(meas.) = n.d. D(calc.) = 4.07

Optical Properties: Semitransparent. *Color:* Light green; gray in reflected light.
Luster: Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* Weak to distinct; O = pale greenish; E = pale grayish brown. *Orientation:* Elongation positive. n = [1.79] *Anisotropism:* Very weak.
R: (470) 8.34, (546) 8.11, (589) 8.01, (650) 7.86

Cell Data: *Space Group:* $R\overline{3}m$. a = 5.70 c = 41.16 Z = [6]

X-ray Powder Pattern: Rosendal pegmatite, Finland.
2.422 (10), 2.856 (8), 1.426 (5), 2.666 (4), 2.063 (4), 3.15 (3), 2.529 (3)

Chemistry:

	(1)
SiO_2	0.00
TiO_2	0.00
Al_2O_3	64.40
FeO	23.30
MnO	0.30
ZnO	5.22
BeO	[4.9]
MgO	1.88
Total	100.00

(1) Rosendal pegmatite, Finland; by electron microprobe, average of two analyses; total Fe as FeO, BeO by difference, B shown present by ion microprobe; corresponds to $(Fe_{1.54}Zn_{0.30}Mg_{0.22}Mn_{0.02})_{\Sigma=2.08}Al_{5.99}Be_{0.93}O_{12}$.

Occurrence: In the wall zone of a granite pegmatite in "hornblende" gabbro.

Association: Quartz, plagioclase, sillimanite, muscovite, spessartine-almandine, chlorite, biotite, epidote, allanite, nigerite, calcite.

Distribution: In the Rosendal pegmatite, Kemiö (Kimito) Island, southwestern Finland.

Name: To honor Gunnar Pehrman (1895-?), Emeritus Professor of Mineralogy and Geology, Åbo University, Turku, Finland, for his work on the Kemiö pegmatites.

Type Material: Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands, HL-6, HL-12.

; perhmanite = ferrotaaffeite-6N'3S; [full list given under högbohmite];

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Ferrotantalite $(Fe^{2+}, Mn^{2+})(Ta, Nb)_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$. Commonly as exsolution intergrowths with ferrotapiolite.

Physical Properties: *Cleavage:* {100}, distinct; {010}, less distinct. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 6.65–7.95 D(calc.) = n.d. Paramagnetic.

Optical Properties: Opaque, translucent in thin edges. *Color:* Iron-black; reddish brown in transmitted light; gray in reflected light with red to reddish brown internal reflections. *Streak:* Black. *Luster:* Submetallic to vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$. *Absorption:* Strong; $Z > X$. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.
R_1–R_2: n.d.

Cell Data: *Space Group:* [*Pbcn*](by analogy to ferrocolumbite). a = n.d. b = n.d. c = n.d. Z = [4]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Nb_2O_5	26.8	
Ta_2O_5	56.5	86.02
TiO_2	0.6	
FeO	12.9	13.98
MnO	3.3	
Total	100.1	100.00

(1) Spittal a.d. Drau, Austria; by electron microprobe, total Fe as FeO; corresponds to $(Fe_{0.78}Mn_{0.20})_{\Sigma=0.98}Ti_{0.03}(Ta_{1.11}Nb_{0.87})_{\Sigma=1.98}O_6$. (2) $FeTa_2O_6$.

Polymorphism & Series: Dimorphous with ferrotapiolite; forms two series, with manganotantalite and with ferrocolumbite.

Occurrence: As an accessory and primary constituent of granite pegmatites.

Association: Ferrotapiolite.

Distribution: Material analyzed by microprobe from: Moss, Norway. At Spittal an der Drau, Austria. From Nyanga, Uganda. At Muhembe, Rwanda. At Upper Bear Gulch, Lawrence Co., South Dakota, USA. In the Yellowknife district, Northwest Territories, Canada.

Name: For its dominant content of FERROus iron, and the Greek mythical *Tantalus*, for the difficulty in bringing the mineral into solution.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 780–787. (2) Turnock, A.C. (1966) Synthetic wodginite, tapiolite and tantalite. Can. Mineral., 8, 461–470. (3) Černý, P., T.S. Ercit, and M.A. Wise (1992) The tantalite–tapiolite gap: natural assemblages versus experimental data. Can. Mineral., 30, 587–596.

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Ferrotapiolite $(Fe^{2+}, Mn^{2+})(Ta, Nb)_2O_6$

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Crystal Data: Tetragonal. *Point Group:* $4/m2/m2/m$. Crystals usually well developed, short prismatic or equant, with several forms. *Twinning:* Common on {013}, then distorted along $[0\bar{3}1]$; rarely on {101}.

Physical Properties: *Fracture:* Uneven to subconchoidal. Hardness = n.d. VHN = 885–974 (100 g load). D(meas.) = 7.90(5) D(calc.) = 8.17–8.21

Optical Properties: Opaque, transparent on thin edges. *Color:* Black, may be brownish black on the surface; yellowish to reddish brown in transmitted light. *Streak:* Brown to brownish black. *Luster:* Subadamantine to submetallic, brilliant.
Optical Class: Uniaxial (+). *Pleochroism:* Strong; O = pale yellowish or reddish brown.
$\omega = 2.27(1)$ $\epsilon = 2.42(1)$
R_1–R_2: (400) 17.9–17.1, (420) 17.4–17.0, (440) 16.9–17.2, (460) 16.5–17.5, (480) 16.2–17.6, (500) 15.9–17.6, (520) 15.6–17.5, (540) 15.5–17.4, (560) 15.3–17.2, (580) 15.2–17.1, (600) 15.1–17.0

Cell Data: *Space Group: P4/mnm.* $a = 4.75$–4.76 $c = 9.21$–9.29 $Z = 2$

X-ray Powder Pattern: Synthetic $FeTa_2O_6$. (ICDD 23–1124).
3.36 (100), 2.576 (90), 1.746 (70), 4.22 (30), 2.375 (30), 1.680 (25), 1.407 (25)

Chemistry:

	(1)
Nb_2O_5	1.32
Ta_2O_5	85.21
TiO_2	0.46
SnO_2	0.02
FeO	9.67
MnO	4.17
Total	100.85

(1) Skogböle, Finland; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(Fe_{0.68}Mn_{0.30})_{\Sigma=0.98}(Ta_{1.94}Nb_{0.05}Ti_{0.02})_{\Sigma=2.01}O_6$.

Polymorphism & Series: Forms a series with manganotapiolite.

Mineral Group: Ferrotapiolite group.

Occurrence: An accessory mineral in zoned granite pegmatites; detrital in placers.

Association: Albite, muscovite, tourmaline, beryl, spodumene, columbite–tantalite, wodginite, cassiterite, triplite, triphylite.

Distribution: Well-characterized material from: in Finland, in the Eräjärvi area, Orivesi; at Sukula and Härkäsaari, Tammela; at Skogböle and the Rosendal pegmatite, Kemiö (Kimito) Island. From Maršíkov, Czech Republic. At Olgiasca, Lombardy, Italy. In France, from Chanteloube, Haute-Vienne. Occurs at Angarf-Nord and elsewhere in the Anti-Atlas Mountains, Morocco. From Greenbushes, Strelley, and Tabba Tabba, Pilbara, Western Australia. In the USA, from Topsham, Sagadahoc Co. and Paris, Oxford Co., Maine; in the Old Mike mine, six km north-northwest of Custer, Custer Co., South Dakota; at Rockford, Coosa Co., Alabama.

Name: For its dominant FERROus iron content and for *Tapio*, ancient Finnish god of the forest, as the mineral was first found in Finland.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 775–778 [tapiolite and "mossite"]. (2) Clark, A.M. and E.E. Fejer (1978) Tapiolite, its chemistry and cell dimensions. Mineral. Mag., 42, 477–480. (3) Lahti, S.I., B. Johanson, and M. Virkkunen (1983) Contributions to the chemistry of tapiolite – manganotapiolite, a new mineral [ferrotapiolite]. Bull. Geol. Soc. Finland, 55, 101–109. (4) Wise, M.A. and P. Černý (1996) The crystal chemistry of the tapiolite series. Can. Mineral., 34, 631–647. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 169.

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Ferrotochilinite $6FeS \cdot 5Fe(OH)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*, 2 or *m*. Crystals flattened on [001] mostly split and curved, prismatic to elongated lamellar, or curved ribbon-like, to 3.2 mm; striations on {001} across elongation; as fan- and rosette-like clusters, or chaotic aggregates to 6.5 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: Flexible, inelastic. Hardness = < 1 VHN = 13 (2 g load). D(meas.) = n.d. D(calc.) = 3.467

Optical Properties: Opaque. *Color*: Dark bronze (fresh), to nearly black; in reflected light, gray with a bluish to pale beige tint. *Streak*: Black. *Luster*: Metallic (fresh), dull, or tarnishes to iridescent purplish or golden-brown.
Optical Class: n.d. *Bireflectance:* Distinct. *Anisotropism:* Distinct, gray-bluish to yellowish beige.
R_1-R_2: (470) 11.4-11.6, (546) 11.2-12.4, (589) 11.1-13.6, (650) 11.0-15.5

Cell Data: *Space Group:* *C*2/*m*, *Cm*, or *C*2. a = 5.463(5) b = 15.865(17) c = 10.825(12) β = 93.7(1)° Z = 2

X-ray Powder Pattern: Oktyabr'skiy mine, Norilsk district, Krasnoyarskiy Kray, Russia.
5.392 (100), 10.83 (13), 2.696 (12), 2.524 (12), 1.837 (11), 2.152 (8), 3.281 (7)

Chemistry:

	(1)
Mg	0.02
Fe	61.92
Ni	0.03
Cu	0.09
S	19.45
O	16.3
H	[1.03]
Total	98.84

(1) Oktyabr'skiy mine, Norilsk district, Krasnoyarskiy Kray, Russia; average of 9 electron microprobe analyses, Fe^{2+}/Fe^{3+} calculated for charge balance, H calculated as if present only as OH, presence of OH and absence of H_2O confirmed by IR spectroscopy; corresponding to $(Fe_{5.98}Cu_{0.015}Ni_{0.005})_{\Sigma=6.00}S_6(Fe^{2+}_{4.89}Mg_{0.01})_{\Sigma=4.90}(OH)_{9.80}Fe^{3+}_{0.09}(OH)_{0.27}$.

Occurrence: Of low-temperature hydrothermal origin coating cavities in pentlandite-mooihoekite-cubanite ore with minor magnetite and chalcopyrite.

Association: Ferrovalleriite, magnetite, an Fe-rich chlorite-type phyllosilicate.

Distribution: From Shaft no 1, Oktyabr'skiy mine, Oktyabr'skoye Cu-Ni-PGM deposit, Talnakh, Norilsk district, Krasnoyarskiy Kray, Siberia, Russia.

Name: As the structural analogue (based on chemical, X-ray, and IR data similarities) of *tochilinite* with essential *ferrous iron*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (4058/1).

References: (1) Pekov, I.V., E.V. Sereda, Yu.S. Polekhovsky, S.N. Britvin, N.V. Chukanov, V.O. Yapaskurt, and I.A. Bryzgalov (2012) Ferrotochilinite, $6FeS \cdot 5Fe(OH)_2$, a new mineral from Oktyabr'skoye ore deposit (Norilsk ore district, Siberia, Russia). Zap. Ross. Mineral. Obshch., 141(4), 1-11 (in Russian, with English abstract). (2) (2014) Amer. Mineral., 99, 242-243 (abs. ref. 1).

Ferrotschermakite $\mathbf{Ca_2[(Fe^{2+},Mg)_3Al_2](Si_6Al_2)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [Prismatic.] *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, with intersections at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.323–3.353 D(calc.) = [3.25]

Optical Properties: Transparent to translucent. *Color:* Green; green to tan in thin section. *Luster:* [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = light tan; Y = green; Z = blue-green. *Orientation:* $Y = b$; $Z \wedge c \simeq 7°$–$14°$. *Absorption:* $Z = Y > X$. α = 1.660–1.694 β = 1.680–1.732 γ = 1.688–1.736 2V(meas.) = 45°–75°

Cell Data: *Space Group:* $C2/m$. $a = 9.864$ $b = 18.130$ $c = 5.331$ $\beta = 104.95°$ Z = 2

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.51	40.43	Na_2O	1.05	0.89
TiO_2	1.42	1.25	K_2O	1.00	1.01
Al_2O_3	13.39	12.62	F	0.13	0.90
Fe_2O_3	5.32	4.24	Cl	0.04	
FeO	17.16	22.15	H_2O^+	1.78	1.76
MnO	0.35	0.28	H_2O^-	0.02	0.05
MgO	6.47	3.80	$-O = (F,Cl)_2$	0.06	0.38
CaO	11.43	11.60	Total	100.01	100.60

(1) Emeryville, New York, USA; corresponds to $(Ca_{1.87}Na_{0.31}K_{0.20})_{\Sigma=2.38}(Fe^{2+}_{2.20}Mg_{1.48}Fe^{3+}_{0.61}Al_{0.60}Ti_{0.16}Mn_{0.04})_{\Sigma=5.09}(Si_{6.20}Al_{1.80})_{\Sigma=8.00}O_{22}[(OH)_{1.81}O_{0.12}F_{0.06}Cl_{0.01}]_{\Sigma=2.00}$. (2) Lake's Grave, Australia; corresponds to $(Ca_{1.92}Na_{0.27}K_{0.20})_{\Sigma=2.39}(Fe^{2+}_{2.86}Mg_{0.87}Fe^{3+}_{0.49}Al_{0.53}Ti_{0.15}Mn_{0.04})_{\Sigma=4.94}(Si_{6.24}Al_{1.76})_{\Sigma=8.00}O_{21.75}[(OH)_{1.81}F_{0.44}]_{\Sigma=2.25}$.

Polymorphism & Series: Forms a series with tschermakite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) < 0.5$; $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si < 6.25$; $Ti < 0.5$.

Occurrence: A product of medium- to high-pressure metamorphism of highly aluminous rocks, producing schists, gneisses, or amphibolites; from differentiated mafic plutonic igneous rocks.

Association: Almandine, chlorite, biotite, muscovite, quartz, anorthite, apatite (metamorphic).

Distribution: From Emeryville, St. Lawrence Co., New York, USA. At Lake's Grave, Broken Hill, New South Wales, Australia.

Name: For *ferrous* iron in its composition and relation to *tschermakite*.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 263–314. (2) Leake, B.E. (1968) A catalog of analyzed calciferous and subcalciferous amphiboles together with their nomenclature and associated minerals. Geol. Soc. Amer. Special Paper 98, 210 p. [analyses 882 and 885]. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 232–234.

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Ferrotychite $\mathbf{Na_6(Fe^{2+}, Mg, Mn^{2+})_2(SO_4)(CO_3)_4}$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As grains, to 1 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4 VHN = 214–247, 228 average. D(meas.) = 2.79 D(calc.) = 2.78 Strongly magnetic; soluble in H_2O giving an alkaline solution.

Optical Properties: Semitransparent. *Color:* Colorless to bright yellow, surficially altered to golden brown. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.550(2)$

Cell Data: *Space Group:* $Fd3$. $a = 13.962(5)$ Z = 8

X-ray Powder Pattern: Khibiny massif, Russia.
2.68 (10), 4.18 (9), 2.47 (8), 1.614 (6), 2.36 (4), 1.958 (4), 1.428 (3)

Chemistry:

	(1)	(2)
SO_3	14.00	13.67
CO_2	[30.75]	30.05
FeO	15.26	24.53
MnO	4.35	
MgO	2.77	
Na_2O	32.30	31.75
Total	[99.43]	100.00

(1) Khibiny massif, Russia; by X-ray spectrographic analysis, SO_4^{2-} and CO_3^{2-} confirmed by IR spectroscopy, CO_2 calculated; corresponds to $Na_{6.01}(Fe_{1.23}Mg_{0.40}Mn_{0.35})_{\Sigma=1.98}(S_{0.98}O_4)(C_{1.01}O_3)_4$. (2) $Na_6Fe_2(SO_4)(CO_3)_4$.

Polymorphism & Series: Forms a series with tychite.

Occurrence: A rare constituent of a vein cutting ijolite-urtite in an alkaline igneous complex, from a drill core.

Association: Shortite, bonshtedtite, analcime.

Distribution: From along Olenii Ruchei (Reindeer's Stream), Khibiny massif, Kola Peninsula, Russia.

Name: For essential FERROus iron and the relation to *tychite*.

Type Material: Mining Institute, St. Petersburg, 1301/1; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5708/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81590.

References: (1) Khomyakov, A.P., Y.A. Malinovskii, and S.M. Sandomirskaya (1981) Ferrotychite $Na_6Fe_2(SO_4)(CO_3)_4$ – a new mineral. Zap. Vses. Mineral. Obshch., 110, 600–603 (in Russian). (2) (1982) Amer. Mineral., 67, 622 (abs. ref. 1). (3) Malinovskii, Y.A., S.V. Baturin, and N.V. Belov (1979) Crystal structure of Fe-tychite [ferrotychite]. Doklady Acad. Nauk SSSR, 249, 1365–1368 (in Russian). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 86.

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Ferrovalleriite $2(Fe,Cu)S \cdot 1.5Fe(OH)_2$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ *m*, 3*m*, or 32. As hexagonal or rounded plates to 5 mm, in rose-like aggregates of thin, distorted or curved flakes or as crusts to 2 cm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: Flexible, inelastic. Hardness = 1 VHN = 35 (10 g load). D(meas.) = n.d. D(calc.) = 3.72

Optical Properties: Opaque. *Color*: Dark bronze (fresh), to nearly black. *Streak*: Black. *Luster*: Metallic (fresh), dull, or tarnishes to iridescent golden-brown. *Pleochroism*: Yellow to gray. *Bireflectance:* Moderate. *Anisotropism:* Strong, bluish gray to yellowish beige. *Optical Class*: n.d.
R_1-R_2: (470) 15.0-16.6, (546) 14.8-20.5, (589) 14.5-24.1, (650) 14.5-24.1

Cell Data: *Space Group: R*$\bar{3}$ *m*, *R*3*m*, or *R*32. a = 3.792(2) c = 34.06(3) Z = 3

X-ray Powder Pattern: Oktyabr'skiy mine, Norilsk district, Krasnoyarskiy Kray, Russia.
5.69 (100), 3.268 (58), 1.871 (45), 3.163 (36), 1.894 (34), 2.143 (19), 11.42 (18), 3.784 (17)

Chemistry:

	(1)
Al	0.10
Mn	0.03
Fe	45.31
Ni	0.07
Cu	18.29
S	20.37
O	15.62
H	[0.98]
Total	100.77

(1) Oktyabr'skiy mine, Norilsk district, Krasnoyarskiy Kray, Russia; average of 6 electron microprobe analyses, Fe^{2+}/Fe^{3+} calculated for charge balance, H calculated as if present only as OH, presence of OH and absence of H_2O confirmed by IR spectroscopy; corresponding to $(Fe_{1.09}Cu_{0.91})_{\Sigma=2.00}S_2 \cdot (Fe^{2+}_{1.34}Fe^{3+}_{0.12}Al_{0.01})_{\Sigma=1.47}(OH)_{3.07}$.

Mineral Group: Valleriite group.

Occurrence: Of low-temperature hydrothermal origin coating cavities in pentlandite-mooihoekite-cubanite ore with minor magnetite and chalcopyrite.

Association: Ferrotochilinite, magnetite, an Fe-rich chlorite-type phyllosilicate, hibbingite, rhodochrosite.

Distribution: From several Cu-Ni-PGM deposits of the Norilsk region, including at the Oktyabr'skiy mine, Talnakh, Krasnoyarskiy Kray, Siberia, Russia.

Name: As the structural analogue (based on chemical, X-ray, and IR data similarities) of *valleriite* with essential *ferrous iron*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Pekov, I.V., E.V. Sereda, V.O. Yapaskurt, Yu.S. Polekhovsky, S.N. Britvin, and N.V. Chukanov (2012) Ferrovalleriite, $2(Fe,Cu)S \cdot 1.5Fe(OH)_2$: validation as a mineral species and new data. Zap. Ross. Mineral. Obshch., 141(6), 29-43 (in Russian, with English abstract).
(2) (2014) Amer. Mineral., 99, 243 (abs. ref. 1).

Ferrowodginite $Fe^{2+}Sn^{4+}Ta_2O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As lathlike to irregular inclusions, to 0.3 mm, in tantalian cassiterite. *Twinning:* Polysynthetic on {100}.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 5.5
D(meas.) = n.d. D(calc.) = 7.02

Optical Properties: Transparent to translucent. *Color:* Dark brown to black. *Streak:* Dark brown. *Luster:* Vitreous.
Optical Class: Biaxial. $\alpha = > 2.0$ $\beta = > 2.0$ $\gamma = > 2.0$ 2V(meas.) = n.d.
Anisotropism: Noted.

Cell Data: *Space Group: C*2/*c*. $a = 9.415(7)$ $b = 11.442(6)$ $c = 5.103(4)$ $\beta = 90.8(1)°$
Z = 4

X-ray Powder Pattern: Near Sukula, Finland.
2.97 (100), 4.16 (50), 2.493 (40), 2.55 (30), 1.455 (30), 3.64 (20), 2.86 (20)

Chemistry:

	(1)	(2)
Nb_2O_5	14.8	
TiO_2	4.3	
SnO_2	10.1	22.68
Fe_2O_3	1.9	
Ta_2O_5	56.3	66.51
FeO	9.3	10.81
MnO	2.8	
Total	[99.5]	100.00

(1) Near Sukula, Finland; by electron microprobe, average of two analyses, original total given as 99.4%; Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Fe^{2+}_{0.76}Mn_{0.23})_{\Sigma=0.99}(Sn_{0.40}Ti_{0.32}Ta_{0.15}Fe^{3+}_{0.14})_{\Sigma=1.01}(Ta_{1.34}Nb_{0.66})_{\Sigma=2.00}O_8$. (2) $FeSnTa_2O_8$.

Mineral Group: Wodginite group: $Fe^{2+} > 0.5$; $Ti_B \leq 0.5$; $Fe^{3+}_B \leq 0.25$.

Occurrence: In museum specimens from a granite pegmatite.

Association: Tantalian cassiterite, tapiolite, bismuth, stannomicrolite.

Distribution: Near Sukula, Tammela, Finland, the exact locality now lost.

Name: For its content of FERROus iron and its relation to *wodginite*.

Type Material: R.B Ferguson Museum of Mineralogy, University of Manitoba, Winnipeg, Canada.

References: (1) Ercit, T.S., P. Černý, and F.C. Hawthorne (1992) The wodginite group. III. Classification and new species. Can. Mineral., 30, 633–638. (2) (1993) Amer. Mineral., 78, 848 (abs. ref. 1).

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Ferrowyllieite $(Na, Ca, Mn^{2+})_2(Fe^{2+}, Mn^{2+})(Fe^{2+}, Fe^{3+}, Mg)Al(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crude euhedral crystals, to 10 cm, in interlocking aggregates; rimming arrojadite.

Physical Properties: *Cleavage:* On {010}, perfect; on $\{\bar{1}01\}$, distinct. *Tenacity:* Very brittle. Hardness = > 4 D(meas.) = 3.601(3) D(calc.) = 3.60

Optical Properties: Transparent to opaque. *Color:* Deep bluish green, oily green, grayish green, greenish black; pale green in transmitted light. *Streak:* Dirty olive-green. *Luster:* Oily to submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Observable in thick plates; X = smoky bluish gray; Y = smoky bluish green; Z = green. *Dispersion:* $r < v$, strong. *Absorption:* $Z > Y \simeq X$.
$\alpha = 1.688(2)$ $\beta = 1.691(2)$ $\gamma = 1.696(2)$ 2V(meas.) = ∼50°

Cell Data: *Space Group:* $P2_1/n$. $a = 11.868(15)$ $b = 12.382(12)$ $c = 6.354(9)$ $\beta = 114.52(8)°$ Z = 4

X-ray Powder Pattern: Victory mine, South Dakota, USA.
2.693 (10), 2.674 (10), 6.15 (6), 3.449 (5), 2.498 (5), 8.12 (4), 3.047 (4)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	43.8	44.6	MgO	1.97	4.8
SiO_2	0.8	0.1	CaO	2.5	0.95
Al_2O_3	7.9	7.1	Li_2O	0.01	0.01
Fe_2O_3	0.33	4.8	Na_2O	8.0	7.1
FeO	29.2	20.2	K_2O	0.05	0.00
MnO	4.3	9.6	H_2O^+	0.70	0.60
ZnO	0.04	0.08	Total	99.6	99.94

(1) Victory mine, South Dakota, USA; H_2O by calorimetry, corresponds to $(Na_{1.25}Mn^{2+}_{0.30}Ca_{0.22}Fe^{2+}_{0.01})_{\Sigma=1.78}Fe^{2+}_{1.00}(Fe^{2+}_{0.96}Li_{0.03}Mg_{0.01})_{\Sigma=1.00}(Al_{0.75}Mg_{0.23}Fe^{3+}_{0.02})_{\Sigma=1.00}(PO_4)_3$. (2) G.E. Smith mine, New Hampshire, USA; corresponds to $(Na_{1.07}Mn^{2+}_{0.43}Ca_{0.08})_{\Sigma=1.58}(Fe^{2+}_{0.84}Mn^{2+}_{0.16})_{\Sigma=1.00}(Fe^{2+}_{0.48}Mg_{0.48}Li_{0.03})_{\Sigma=0.99}(Al_{0.65}Fe^{3+}_{0.28}Mg_{0.07})_{\Sigma=1.00}(PO_4)_3$.

Polymorphism & Series: Forms two series, with wyllieite, and with rosemaryite; $Fe^{2+} > Mn^{2+}$ in M(1); Fe^{2+} dominant in M(2a).

Occurrence: A primary phosphate in zoned granite pegmatites.

Association: Arrojadite, muscovite, schorl, plagioclase, quartz (Victory mine, South Dakota, USA).

Distribution: In the USA, from the Victory mine, four km northeast of Custer, Custer Co., South Dakota, and at the G.E. Smith mine, Newport, Sullivan Co., New Hampshire.

Name: As a mineral with dominant *ferrous* iron, and its relation to *wyllieite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 126318, 137244, 162555, 162556.

References: (1) Moore, P.B. and J. Ito (1973) Wyllieite, $Na_2Fe^{2+}_2Al(PO_4)_3$, a new species. Mineral. Record, 4, 131–136 [redefined to be ferrowyllieite]. (2) Moore, P.B. and J. Molin-Case (1974) Contribution to pegmatite phosphate giant crystal paragenesis: II. The crystal chemistry of wyllieite [= ferrowyllieite], $Na_2Fe^{2+}_2Al[PO_4]_3$, a primary phase. Amer. Mineral., 59, 280–290. (3) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (4) (1980) Amer. Mineral., 65, 810–811 (abs. ref. 3).

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Ferruccite $NaBF_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$. As minute tabular crystals.

Physical Properties: *Cleavage:* {100}, {010}, and {001}. Hardness = ∼3
D(meas.) = 2.496 D(calc.) = 2.5075 (synthetic). Soluble in H_2O, bitter and acid taste.

Optical Properties: Translucent. *Color:* Colorless to white; colorless in transmitted light.
Optical Class: Biaxial (+) (synthetic). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.301$
$\beta = [1.3012]$ $\gamma = 1.3068$ 2V(meas.) = 11°25′

Cell Data: *Space Group: Cmcm*(synthetic). $a = 6.8368(9)$ $b = 6.2619(7)$ $c = 6.7916(4)$
Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 11-671).
3.39 (100), 3.41 (85), 2.31 (40), 2.84 (25), 3.82 (20), 2.14 (20), 2.03 (20)

Chemistry: Analyses of relatively pure material are not available.

Occurrence: As a fumarolic sublimate.

Association: Sassolite, fluorborates, and fluorsilicates.

Distribution: From Vesuvius, Campania, and on Vucano, Aeolian Islands, Italy. At volcanoes on the Kamchatka Peninsula, Russia.

Name: Honors Professor Ferruccio Zambonini (1880–1932), Italian mineralogist, student of fumarolic minerals.

Type Material: University of Florence, Florence, Italy, 1974/l; National School of Mines, Paris, France; The Natural History Museum, London, England, 1933,419.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 97–99. (2) Brunton, G. (1968) Refinement of the structure of $NaBF_4$. Acta Cryst., 24, 1703–1704.

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Fersmanite $\mathbf{(Ca,Na)_4(Ti,Nb)_2Si_2O_{11}(F,OH)_2}$

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Crystal Data: Triclinic, pseudotetragonal. *Point Group:* $\overline{1}$ or 1. Crystals commonly distorted, flattened, pseudotetragonal, to 2 cm. *Twinning:* Possibly on {001}.

Physical Properties: *Fracture:* Uneven. Hardness = 5–5.5 D(meas.) = 3.44–3.46 D(calc.) = [3.43]

Optical Properties: Transparent to translucent. *Color:* Dark brown to golden yellow. *Streak:* White with pale brownish tint. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.873$–1.886 $\beta = 1.930$ $\gamma = 1.914$–1.939 2V(meas.) = 0°–7°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 7.210(1)$ $b = 7.213(2)$ $c = 20.451(3)$ $\alpha = 95.15(3)°$ $\beta = 95.60(2)°$ $\gamma = 89.04(5)°$ Z = [8]

X-ray Powder Pattern: Khibiny massif, Russia.
3.058 (100), 2.815 (60), 1.518 (55), 1.801 (50), 1.687 (45), 1.552 (40), 2.530 (35)

Chemistry:

	(1)
SiO_2	22.46
TiO_2	17.08
Nb_2O_5	21.79
CaO	28.80
Na_2O	6.92
F	4.23
$-O = F_2$	1.78
Total	99.50

(1) Khibiny massif, Russia; by electron microprobe, average of several analyses, H_2O in empirical analysis to sum to 13 cations; corresponds to $(Ca_{2.82}Na_{1.21})_{\Sigma=4.03}(Ti_{1.18}Nb_{0.86})_{\Sigma=2.04}Si_2O_{10.89}[F_{1.15}(OH)_{0.96}]_{\Sigma=2.11}$.

Occurrence: In aegirine-rich nepheline pegmatites in a differentiated alkalic massif (Khibiny massif, Russia).

Association: Feldspar, pectolite, apatite, aegirine, lamprophyllite, rinkite, sulfides.

Distribution: On Mt. Eveslogchorr, Khibiny massif, Kola Peninsula, Russia. From Üdersdorf, Eifel district, Germany.

Name: For Academician Aleksandr Evgen'evich Fersman (1883–1945), eminent Russian mineralogist, geochemist, and gemologist.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 33193, 33194.

References: (1) Labuntsov, A.N. (1929) La fersmanite – un nouveau minéral des Monts Chibines [Khibiny massif]. Doklady Acad. Nauk SSSR, 12, 297–301 (in French). (2) (1931) Amer. Mineral., 16, 92 (abs. ref. 1). (3) Machin, M.P. (1977) Fersmanite, $(Ca,Na)_4(Ti,Nb)_2Si_2O(F,OH)_2$: a restudy. Can. Mineral., 15, 87–91. (4) Saf'yanov, Y.N., R.I. Bochkova, and V.V. Ilyukhin (1984) The crystal structure of fersmanite. Kristallografiya (Sov. Phys. Crystal.), 29, 56–59 (in Russian). (5) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 564–566.

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Fersmite $(Ca, Ce, Na)(Nb, Ta, Ti)_2(O, OH, F)_6$

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Crystal Data: Orthorhombic; commonly metamict. *Point Group:* $2/m2/m2/m$. As rough prismatic crystals, slightly elongated along [001], tabular on {010} or {100} and striated parallel to [001]; also acicular, to 15 mm; in intergrowths with columbite and pyrochlore.

Physical Properties: *Cleavage:* {100}, parting. *Fracture:* Subconchoidal. *Tenacity:* Extremely brittle. Hardness = 4–4.5 VHN = 572–593 D(meas.) = 4.69–4.80 D(calc.) = 4.78 Fluoresces yellow-green to bluish green under SW and LW UV; light blue cathodoluminescence.

Optical Properties: Opaque, translucent through thin edges. *Color:* Black, dark brown, lemon-yellow to yellow-brown; dark honey-yellow in thin section. *Streak:* Grayish brown. *Luster:* Resinous to subvitreous, submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Moderate to weak; $X = Y$ = pale greenish yellow to colorless; Z = dark greenish yellow to olive-yellow. $\alpha = 2.07$ $\beta = [2.08]$ $\gamma = 2.19$ 2V(meas.) = 20°–25°

Cell Data: *Space Group: Pcan* (synthetic $CaNb_2O_6$). $a = 5.752(4)$ $b = 14.926(4)$ $c = 5.204(4)$ Z = 4

X-ray Powder Pattern: Ravalli Co., Montana, USA.
3.049 (100), 3.762 (21), 1.527 (15), 2.493 (14), 1.183 (13), 1.211 (11), 1.967 (10)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_5	70.12	66.0	RE_2O_3	4.79		Na_2O	0.46	
Ta_2O_5	trace	16.9	Fe_2O_3	1.71		F	1.87	
SiO_2	0.72		FeO		0.4	H_2O	0.72	
TiO_2	3.21	0.5	MnO	0.48		$-O = F_2$	[0.79]	
Al_2O_3	1.28		MgO	0.98		Total	[100.04]	100.7
Ce_2O_3		0.5	CaO	14.49	16.4			

(1) Vishnevy Mountains, Russia; $RE_2O_3 = Ce_2O_3$ 80%, Y_2O_3 10%, ThO_2 10%. (2) Orcesco, Italy; by electron microprobe, corresponds to $Ca_{1.01}(Nb_{1.72}Ta_{0.26}Ti_{0.02})_{\Sigma=2.00}O_6$.

Occurrence: A rare accessory mineral in nepheline syenites and carbonatites. In miarolitic cavities in an albitized pegmatite dike.

Association: Columbite, pyrochlore, plagioclase, microcline, biotite, apatite, "hornblende", titanite, muscovite, zircon, xenotime (Vishnevy Mountains, Russia); columbite, monazite, ancylite, barite, quartz, apatite (Ravalli Co., Montana, USA).

Distribution: Near Lake Buldym, Vishnevy-Ilmen Mountains, Southern Ural Mountains, Russia. On Alpe Rosso, near Orcesco, Val Vigezzo, Piedmont, Italy. In the USA, from the Dark Star claim, 8 km south of Alta, Ravalli Co., Montana; in the Gem Park ultramafic complex, about six km east of Hillside, Fremont Co., Colorado; from the Mesa Grande and Ramona districts, San Diego Co., California; at the Foote mine, Kings Mountain, Cleveland Co., North Carolina; Granite Mountain, near Little Rock, Pulaski Co., Arkansas. In Canada, at Mt. Brussilof, British Columbia, and at the Huron claim, Greer Lake district, Manitoba. From the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire). A few other localities are reported.

Name: For Academician Aleksandr Evgen'evich Fersman (1883–1945), eminent Russian mineralogist, geochemist, and gemologist.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 44383, 44384.

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References: (1) Bohnstedt-Kupletskaya, E.M. and T.A. Burova (1946) Fersmite, a new calcium niobate from the pegmatites of the Vishnevy Mountains, Central Urals. Doklady Acad. Nauk SSSR, 52, 69–71 (in Russian). (2) (1947) Amer. Mineral., 32, 373 (abs. ref. 1). (3) Hess, H.D. and H.J. Trumpour (1959) Second occurrence of fersmite. Amer. Mineral., 44, 1–8. (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 482–488. (5) Cummings, J.P. and S.H. Simonsen (1970) The crystal structure of calcium niobate ($CaNb_2O_6$). Amer. Mineral., 55, 90–97. (6) Graeser, S., H. Schwander, and H. Hänni (1979) Vigezzite, $(Ca, Ce)(Nb, Ta, Ti)_2O_6$, a new aeschynite-type mineral from the Alps. Mineral. Mag., 43, 459–462.

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Feruvite $(Ca,Na)(Fe^{2+},Mg)_3(Al,Mg)_6(BO_3)_3Si_6O_{18}(OH)_4$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Subhedral to anhedral grains, to 2 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼7
D(meas.) = 3.207(9) D(calc.) = 3.21

Optical Properties: Semitransparent. *Color:* Dark brown-black. *Streak:* Gray.
Luster: Vitreous to dull.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = light brown; E = very dark brown.
$\omega = 1.687(1)$ $\epsilon = 1.669(1)$

Cell Data: *Space Group:* $R3m$. $a = 16.012(2)$ $c = 7.245(2)$ $Z = 3$

X-ray Powder Pattern: Cuvier Island, New Zealand.
2.586 (100), 2.979 (80), 4.24 (60), 4.00 (60), 3.50 (60), 2.051 (50), 6.43 (40)

Chemistry:

	(1)	(2)
SiO_2	33.33	33.33
TiO_2	2.19	2.19
B_2O_3	11.25	[9.93]
Al_2O_3	23.38	23.38
Fe_2O_3		[2.56]
FeO	13.56	[11.26]
MnO	0.07	0.07
MgO	7.80	7.80
CaO	3.30	3.30
Na_2O	1.16	1.16
K_2O	0.05	0.05
H_2O	[3.48]	[3.43]
Total	[99.57]	[98.46]

(1) Cuvier Island, New Zealand; by electron microprobe, average of five analyses, total Fe as FeO, H_2O calculated from stoichiometry. (2) Do.; B_2O_3, Fe_2O_3, FeO, and H_2O calculated from stoichiometry, original total given as 98.45%; corresponding to $(Ca_{0.62}Na_{0.39}K_{0.01})_{\Sigma=1.02}(Fe^{2+}_{1.53}Mg_{1.21}Ti_{0.29}Mn_{0.01})_{\Sigma=3.04}(Al_{4.72}Mg_{0.82}Fe^{3+}_{0.34}Fe^{2+}_{0.12})_{\Sigma=6.00}(BO_3)_3(Si_{5.83}Al_{0.10})_{\Sigma=5.93}O_{18}(OH)_4$.

Mineral Group: Tourmaline group.

Occurrence: By hydrothermal replacement of silicates in a pegmatitic rock.

Association: Dravite, quartz, microcline, chlorapatite, pyrite.

Distribution: On Cuvier Island, New Zealand.

Name: For iron (FERrum), in the formula and the similarity to *uvite*.

Type Material: Canadian Museum of Nature, Ottawa, Canada.

References: (1) Grice, J.D. and G.W. Robinson (1989) Feruvite, a new member of the tourmaline group, and its crystal structure. Can. Mineral., 27, 199–203. (2) (1990) Amer. Mineral., 75, 706–707 (abs. ref. 1).

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Fervanite $Fe_4^{3+}V_4O_{16}\cdot 5H_2O$

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Crystal Data: Monoclinic (probable). *Point Group:* n.d. Crystals fibrous, elongated along [001] and flattened on {010}, to 0.5 cm, in parallel aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 3.28 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Golden brown, yellow-brown, pale green.
Luster: Brilliant.
Optical Class: Biaxial (–). *Orientation:* Extinction inclined to length of fibers. $\alpha = 2.186(5)$ $\beta = 2.222(5)$ $\gamma = 2.224(5)$ 2V(meas.) = Very small.

Cell Data: *Space Group:* n.d. $a = 9.02(1)$ $b =$ n.d. $c = 6.65(3)$ $\beta = 103°20(20)'$
Z = n.d.

X-ray Powder Pattern: Mounana mine, Gabon.
8.79 (FFF), 6.45 (FF), 3.22 (F), 3.15 (mF), 2.99 (mf), 2.93 (mf), 3.29 (ff)

Chemistry:

	(1)	(2)
V_2O_5	46.10	47.04
Fe_2O_3	41.89	41.31
H_2O^-	12.01	11.65
Total	[100.00]	100.00

(1) Gypsum Valley, Colorado, USA; recalculated to 100% after deduction of gypsum 7.34%, insoluble 9.40%. (2) $Fe_4V_4O_{16}\cdot 5H_2O$.

Occurrence: As an impregnation in sandstone (Colorado Plateau-type U–V deposits).

Association: Hewettite, metahewettite, carnotite, steigerite, tyuyamunite, gypsum, other vanadium oxides (Colorado Plateau deposits); hewettite, duttonite, schoderite, metaschoderite, straczekite (Wilson Springs, Arkansas, USA).

Distribution: In the USA, from an unspecified locality in Gypsum Valley [later noted from the Tiny mine], San Miguel Co., on Polar Mesa, Gateway district, La Sal Mountains, Grand Co., at the Hummer mine, Bull Canyon area, Paradox Valley, and from the Fox mine, Uravan district, Montrose Co., Colorado; in the Monument No. 2 mine, Monument Valley, Apache Co., Arizona; in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada; and in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas. At the Mounana uranium mine, Gabon.

Name: Named for its content of FERric iron and VANadium.

Type Material: Harvard University, Cambridge, Massachusetts, 91457; National Museum of Natural History, Washington, D.C., USA, 96420, 96421, 97874.

References: (1) Hess, F.L. and E.P. Henderson (1931) Fervanite, a hydrous ferric vanadate. Amer. Mineral., 16, 273–277. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1049. (3) Weeks, A.D., and M.E. Thompson (1954) Identification and occurrence of uranium and vanadium minerals from the Colorado Plateaus. U.S. Geol. Survey Bull. 1009-B, 48–49. (4) Ross, M. (1959) Mineralogical applications of electron diffraction. II. Studies of some vanadium minerals of the Colorado Plateau. Amer. Mineral., 44, 322–341. (5) Cesbron, F. (1970) La schubnélite, nouveau vanadate de fer hydraté. Bull. Soc. fr. Minéral., 93, 470–475 (in French with English abs.). (6) Evans, H.T., Jr. and L.W. Finger (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 518–519.

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Fetiasite $(Fe^{2+}, Fe^{3+}, Ti)_3O_2(As_2^{3+}O_5)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tabular on {100}, elongated along [010] or [001], showing {100}, {011}, {001}, to 2 cm; in radial to globular aggregates.

Physical Properties: *Cleavage:* {100}, perfect. *Fracture:* Uneven to conchoidal. Hardness = ∼5 VHN = 438–490 (50 g load). D(meas.) = 4.6(1) on altered material. D(calc.) = 4.74–4.80

Optical Properties: Opaque. *Color:* Brown to black, red-brown when altered; creamy white in reflected light. *Luster:* Metallic to semimetallic.
Optical Class: Biaxial. *Anisotropism:* Noted.
R_1–R_2: (470) 15.4–16.0, (546) 15.3–15.8, (589) 14.8–15.2, (650) 14.2–15.0

Cell Data: *Space Group:* $P2_1/m$. $a = 10.595$–10.616 $b = 3.242$–3.252 $c = 8.931$–8.945 $\beta = 108.89°$–$108.95°$ $Z = 2$

X-ray Powder Pattern: Pizzo Cervandone, Italy.
2.749 (100), 2.811 (94), 2.391 (85), 2.985 (67), 1.779 (48), 1.709 (35), 1.754 (32)

Chemistry:

	(1)	(2)
TiO_2	10.09	11.17
Fe_2O_3	17.13	17.93
As_2O_3	46.95	46.76
FeO	23.12	24.23
MnO	1.25	0.89
Total	98.54	100.98

(1) Pizzo Cervandone, Italy; by electron microprobe, average of seven analyses; Fe^{2+}:Fe^{3+} from crystal-structure analysis, total Mn as MnO, As^{3+} confirmed by IR; corresponding to $(Fe^{2+}_{1.38}Fe^{3+}_{0.92}Ti_{0.54}Mn_{0.08})_{\Sigma=2.92}O_2(As_2O_5)$. (2) Binntal, Switzerland; by electron microprobe, average of ten analyses; corresponding to $(Fe^{2+}_{1.40}Fe^{3+}_{0.93}Ti_{0.58}Mn_{0.05})_{\Sigma=2.96}O_2(As_2O_5)$.

Occurrence: Deposited from arsenic-bearing solutions in Alpine fissures in gneisses of the upper greenschist to lower amphibolite facies.

Association: Asbecasite, cafarsite, cervandonite, anatase, chlorite, feldspar, mica, quartz.

Distribution: On the east flank of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont, Italy. At Gorb, Binntal, Valais, Switzerland.

Name: For *Fe, Ti, As* in its composition.

Type Material: Natural History Museum, Basel; Mineralogical Institute, University of Basel, Switzerland.

References: (1) Graeser, S., H. Schwander, F. Demartin, C.M. Gramaccioli, T. Pilati, and E. Reusser (1994) Fetiasite $(Fe^{2+}, Fe^{3+}, Ti)_3O_2[As_2O_5]$, a new arsenite mineral: its description and structure determination. Amer. Mineral., 79, 996–1002.

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Fettelite $Ag_{24}HgAs_5S_{20}$

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Crystal Data: Hexagonal *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. Hexagonal tablets and flakes, to 0.2 mm, in subparallel aggregates, rosettelike groups, and clusters.

Physical Properties: *Cleavage:* Perfect on {0001}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3.75 VHN = 138–174, 158 average (20 g load). D(meas.) = n.d. D(calc.) = 6.29

Optical Properties: Opaque. *Color:* Dark violet to scarlet, wine-red in thin fragments; in reflected light, gray with a greenish tint, with strong red internal reflections. *Streak:* Dark vermillion. *Luster:* Submetallic to adamantine.
Optical Class: Biaxial. *Anisotropism:* Weak; bright greenish gray to dark bluish gray.
Bireflectance: Weak.
R_1–R_2: (400) — , (420) 30.7–31.3, (440) 30.7–31.3, (460) 30.5–31.1, (480) 30.0–30.8, (500) 29.4–30.3, (520) 28.6–29.8, (540) 27.6–29.2, (560) 27.1–28.6, (580) 26.0–27.6, (600) 25.7–27.1, (620) 25.0–26.3, (640) 24.3–25.4, (660) 23.6–24.5, (680) 23.0–23.8, (700) 22.5–23.3

Cell Data: *Space Group:* $P\overline{3}m1$, $P\overline{3}1m$, $P3m1$, $P31m$, $P321$, or $P312$. $a = 15.00$ $c = 15.46$ $Z = 3$

X-ray Powder Pattern: Niederbeerbach mine, Germany.
3.091 (10), 1.878 (8), 3.175 (6), 2.998 (4), 2.755 (3), 3.243 (2), 2.497 (2)

Chemistry:

	(1)	(2)
Tl	0.13	
Hg	5.21	5.27
Ag	67.55	68.03
Pb	0.07	
Cu	0.07	
Fe	0.04	
As	9.80	9.85
Sb	0.23	
S	16.79	16.85
Total	99.88	100.00

(1) Niederbeerbach mine, Germany; by electron microprobe, average of 28 analyses on five crystals; corresponds to $Ag_{24.00}Hg_{1.00}Cu_{0.04}Fe_{0.03}Tl_{0.02}Pb_{0.01}As_{5.01}S_{20.07}$. (2) $Ag_{24}HgAs_5S_{20}$.

Occurrence: A rare mineral in low-temperature hydrothermal prehnite–calcite–quartz veins.

Association: Proustite, pearceite, xanthoconite, safflorite.

Distribution: From the Niederbeerbach mine, 10 km south of Darmstadt, Odenwald, Hesse, Germany [TL].

Name: To honor M. Fettel, who first noted the mineral.

Type Material: Institute of Mineralogy, University of Heidelberg, Heidelberg, Germany.

References: (1) Wang, N. and A. Paniagua (1996) Fettelite a new Hg-sulfosalt mineral from Odenwald. Neues Jahrb. Mineral., Monatsh., 313–320. (2) (1997) Amer. Mineral., 82, 621 (abs. ref. 1).

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Fianelite $\mathbf{Mn_2^{2+}V^{5+}(V^{5+},As^{5+})O_7 \cdot 2H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals, platy, prominent {010}, with {100}, {001}, {041}(?), intergrown and striated ‖ [100], to 0.2 mm; in rosettes and polycrystalline crusts.

Physical Properties: *Cleavage:* Parallel {001}(?) and {100}(?), good. Hardness = ∼3 VHN = 84–89, average 86.5 (15 g load). D(meas.) = 3.21(1) D(calc.) = 3.217(2)

Optical Properties: Transparent. *Color:* Red-orange. *Streak:* Orange. *Luster:* Vitreous. *Optical Class:* Biaxial. *Pleochroism:* Strong; yellow to red on {010} (?). $n = 1.82(2)$ 2V(meas.) = $< 10°$

Cell Data: *Space Group:* $P2_1/n$. $a = 7.809(2)$ $b = 14.554(4)$ $c = 6.705(4)$ $\beta = 93.27(3)°$ Z = 4

X-ray Powder Pattern: Fianel mine, Switzerland.
3.039 (100), 5.32 (80), 2.721 (60), 1.593 (60), 3.436 (50), 3.259 (50), 2.573 (50)

Chemistry:

	(1)
As_2O_5	13.57
V_2O_5	38.23
SiO_2	0.12
MnO	37.49
H_2O	[9.64]
Total	[99.05]

(1) Fianel mine, Switzerland; by electron microprobe, average of eight analyses on three grains, total Mn as MnO, H_2O calculated from crystal-structure analysis; corresponds to $Mn_{1.98}(V_{1.57}As_{0.44}Si_{0.01})_{\Sigma=2.02}O_7 \cdot 2H_2O$.

Occurrence: In fractures crosscutting veinlets in metamorphosed Fe–Mn ores.

Association: Medaite, palenzonaite, saneroite, pyrobelonite, parsettensite, rhodochrosite, kutnohorite, aegirine, quartz.

Distribution: From the Fianel mine, Val Ferrera, Graubünden, Switzerland.

Name: For its occurrence in the Fianel mine, Switzerland.

Type Material: Natural History Museum, Basel, Switzerland.

References: (1) Brugger, J. and P. Berlepsch (1996) Description and crystal structure of fianelite, $Mn_2V(V,As)O_7 \cdot 2H_2O$, a new mineral from Fianel, Val Ferrera, Graubünden, Switzerland. Amer. Mineral., 81, 1270–1276.

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Fibroferrite $Fe^{3+}(SO_4)(OH)\cdot 5H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Acicular crystals, elongated along {001}, to 5 mm; typically as mammillary aggregates, mats, and incrustations. *Twinning:* Repeated contact twins on {110}, yielding trillings.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = ∼2.5 D(meas.) = 1.84–2.09 D(calc.) = 1.996 Soluble in H_2O.

Optical Properties: Translucent. *Color:* Pale yellow, straw-yellow, yellowish green, greenish gray, nearly white; colorless to pale yellow in transmitted light. *Luster:* Pearly, silky in aggregates.
Optical Class: Biaxial (+), anomalous. *Pleochroism:* Colorless to pale amber-yellow.
Orientation: $Z = c$. α = 1.518–1.533 (variable with H_2O content) β = 1.518–1.535 γ = 1.561–1.575 2V(meas.) = ∼0°

Cell Data: *Space Group:* $R\overline{3}$. $a = 24.176$ $c = 7.656$ Z = 18

X-ray Powder Pattern: Cetine mine, Italy.
12.10 (100), 4.57 (53), 6.98 (42), 4.07 (35), 3.346 (33), 2.784 (30), 2.989 (25)

Chemistry:

	(1)	(2)
SO_3	30.73	30.91
Fe_2O_3	30.80	30.83
H_2O	38.21	38.26
Total	99.74	100.00

(1) Saint-Félix de Paillères, France. (2) $Fe(SO_4)(OH)\cdot 5H_2O$.

Occurrence: An uncommon dehydration product of melanterite in oxidized portions of rocks and sediments containing iron sulfide, most stable in arid regions; rarely a volcanic sublimate.

Association: Melanterite, amarantite, hohmannite, krausite, coquimbite, parabutlerite, butlerite, copiapite, epsomite, gypsum, pyrite.

Distribution: Worldwide localities are too numerous to list. Studied material from: in Chile, at Tierra Amarilla, near Coquimbó, Atacama; from Quetena, west of Calama, and at Chuquicamata, Antofagasta. Thick beds in the Santa Elena mine, Quebrada de La Alcaparrosa, San Juan Province, Argentina. In the USA, in California, from Borate, about 10 km northeast of Yermo, Calico Hills, San Bernardino Co., at Island Mountain, Trinity Co., and in the Redington mine, Knoxville, Napa Co.; from the Shattuck mine, Bisbee, Cochise Co., Arizona; in Nevada, at the Cordero mine, Poalit district, Humboldt Co., in the Commonwealth mine, Galena district, Washoe Co., and elsewhere in Nevada; long crystals in the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah. In Canada, from Quatsino, British Columbia, and in the Sydney coal field, Cape Breton, Nova Scotia. From Saint-Félix de Paillères, Gard, France. In the Cae Coch mine, Trefriw, Gwynedd, Wales. At Skouriotissa, Cyprus. In Italy, on Capo Calamita and La Vigneria, Elba, and in the Cetine mine, near Rosia, Tuscany. At Laurium, Greece. On Valachov Hill, near Skřivaň, Czech Republic. From Špania Dolina (Herrengrund), Slovakia. At volcanoes on the Kamchatka Peninsula, Russia. From Yetar Spring, near Chidlows, Western Australia.

Name: For the *fibrous* habit and essential *ferric* iron.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 614–616. (2) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Minéral., 87, 125–143 (in French). (3) Sabelli, C. and A. Santucci (1987) Rare sulfate minerals from the Cetine mine, Tuscany, Italy. Neues Jahrb. Mineral., Monatsh., 171–182. (4) Scordari, F. (1981) Fibroferrite: a mineral with a $\{Fe(OH)(H_2O)_2SO_4\}$ spiral chain and its relationship to $Fe(OH)SO_4$, butlerite and parabutlerite. Tschermaks Mineral. Petrog. Mitt., 28, 17–29.

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Fichtelite $C_{19}H_{34}$

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Crystal Data: Monoclinic. *Point Group:* 2. As crystals, elongated along [010], and tabular on {001}, to 3 mm.

Physical Properties: *Cleavage:* Good on {001} and {100}. Hardness = "Soft". D(meas.) = n.d. D(calc.) = 0.631 M.P. 44.2 °C–45.0 °C.

Optical Properties: Transparent. *Color:* Colorless, white, pale yellow. *Luster:* Greasy. *Optical Class:* [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1$. $a = 10.706(4)$ $b = 7.458(2)$ $c = 10.824(7)$ $\beta = 105.85(3)°$ Z = 2

X-ray Powder Pattern: Sobeslav, Czech Republic.
5.206 (100), 6.100 (90), 4.292 (90), 5.644 (20), 10.533 (10), 3.029 (10), 3.710 (5)

Chemistry:

	(1)	(2)
C	87.13	86.94
H	12.86	13.06
Total	99.99	100.00

(1) Marktredwitz, Germany. (2) $C_{19}H_{34}$.

Occurrence: In fossilized pine wood from a peat bog; in organic-rich modern marine sediment.

Association: n.d.

Distribution: In Germany, from Gampen, seven km north of Marktredwitz, and at Zeitelmoos, northwest of Wunsiedel, Fichtelgebirge. At Sobeslav, Czech Republic. Additional older localities require confirmation by modern methods.

Name: For the original locality in the Fichtelgebirge, Germany.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1000–1001. (2) Strunz, H. (1962) Fichtelit. Dimethyl-isopropyl-perhydropenanthren. Naturwissen., 49, 9–10 (in German). (3) Mace, H.A. and R.C. Peterson (1995) The crystal structure of fichtelite, a naturally occurring hydrocarbon. Can. Mineral., 33, 7–11.

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Fiedlerite $Pb_3Cl_4F(OH)\cdot H_2O$

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Crystal Data: Monoclinic or triclinic. *Point Group:* $2/m$ or $\overline{1}$. As crystals, lathlike, tabular on {100}, elongated along [010], rich in additional forms, to 2 mm. *Twinning:* On {100}, common.

Physical Properties: *Cleavage:* {100}, good. Hardness = ∼3.5 D(meas.) = 5.88 D(calc.) = [5.15 (2M) or 5.69 (1A)]

Optical Properties: Transparent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = -34°$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.98(1)$ $\beta = 2.04(1)$ $\gamma = 2.10(1)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/a$(2M), with $a = 16.681(4)$ $b = 8.043(3)$ $c = 7.281(2)$ $\beta = 102.56(4)°$ Z = 4, or *Space Group:* $P\overline{1}$(1A), with $a = 8.574(3)$ $b = 8.045(4)$ $c = 7.276(2)$ $\alpha = 89.96(4)°$ $\beta = 102.05(4)°$ $\gamma = 103.45(4)°$ Z = 2

X-ray Powder Pattern: Laurium, Greece.
3.89 (100), 2.55 (100), 2.81 (80), 2.01 (60), 3.54 (50), 3.33 (50), 3.22 (50)

Chemistry:

	(1)	(2)
Pb	76.97	76.05
F	2.01	2.32
Cl	17.87	17.35
H	0.35	0.37
O		3.91
Total	97.20	100.00

(1) Laurium, Greece; by electron microprobe, average of five points, H determined by elemental microanalyzer. (2) $Pb_3Cl_4F(OH)\cdot H_2O$.

Polymorphism & Series: 2M and 1A polytypes are known.

Occurrence: Produced by reaction of halide-bearing seawater and metal-bearing slag.

Association: Penfieldite, laurionite, phosgenite, cotunnite (Laurium, Greece). penfieldite, cotunnite (Baratti Beach, Italy).

Distribution: In slag from: Laurium, Greece. Along Baratti Beach, Tuscany, Italy. In South Africa, at the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal.

Name: Honors Karl Gustav Fiedler (1791–1853), Saxon Commissioner of Mines.

Type Material: Museum of Natural History, University of Pisa, Pisa, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 67–69. (2) Goni, J. and C. Guillemin (1954) Description d'espèces minérales néogènes formées sur des jas d'ancres Romaines immergées. Bull. Soc. fr. Minéral., 77, 474–478. (3) Merlino, S., M. Pasero, and N. Perchiazzi (1994) Fiedlerite: revised chemical formula [$Pb_3Cl_4F(OH)\cdot H_2O$], OD description and crystal structure refinement of the two MDO polytypes. Mineral. Mag., 58, 69–78.

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Filatovite $K[(Al,Zn)_2(As,Si)_2O_8]$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As prismatic crystals, to 0.3 mm, showing {001} and {010}, commonly intergrown.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* n.d. *Tenacity:* Brittle. Hardness = 5-6 D(meas.) = n.d. D(calc.) = 2.92

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White.
Luster: Vitreous.
Optical Class: Biaxial (-) α = 1.532(1) β = 1.535(1) γ = 1.537(1) 2V(meas.) = 60(10)° 2V(calc.) = 78° Orientation: X ~ [100]; $Y \perp$ {001}; $Z \perp$ {010}.

Cell Data: *Space Group: I*2/*c*. a = 8.772(1) b = 13.370(2) c = 14.690(2) β = 115.944(6)° Z = 8

X-ray Powder Pattern: Great Fissure Tolbachik eruption, Kamchatka Peninsula, Russia.
3.364 (100), 4.329 (70), 3.897 (70), 2.981 (60), 3.300 (50), 3.066 (40), 2.646 (40)

Chemistry:

	(1)
Na_2O	0.63
K_2O	12.85
FeO	0.28
CuO	0.83
ZnO	3.85
Al_2O_3	27.33
SiO_2	12.35
As_2O_5	40.60
P_2O_5	1.63
Total	100.35

(1) Great Fissure Tolbachik eruption, Kamchatka Peninsula, Russia; electron microprobe analysis, corresponding to $(K_{0.92}Na_{0.07})_{\Sigma=0.99}[(Al_{1.81}Zn_{0.16}Cu_{0.04}Fe_{0.01})_{\Sigma=2.02}(As_{1.20}Si_{0.70}P_{0.08})_{\Sigma=1.98}O_8]$.

Mineral Group: Feldspar group.

Occurrence: A product of fumarolic activity.

Association: Alumokluchevskite, lammerite, johillerite, sylvite, hematite, tenorite, As-bearing orthoclase.

Distribution: From the second cinder core of the North Breach of the Great Fissure Tolbachik eruption, Kamchatka Peninsula, Russia.

Name: Honors Stanislav K. Filatov (b. 1940), Saint Petersburg State University, for his studies of exhalation minerals.

Type Material: Museum, Department of Mineralogy, Saint Petersburg State University, Saint Petersburg, Russia; 1/19086.

References: (1) Vergasova, L.P., S.V. Krivovichev, S.N. Britvin, P.C. Burns, and V.V. Ananiev (2004) Filatovite, $K[(Al,Zn)_2(As,Si)_2O_8]$, a new mineral species from the Tolbachik volcano, Kamchatka Peninsula, Russia. Eur. J. Mineral., 16, 533-536. (2) Filatov, S.K., S.V. Krivovichev, P.C. Burns, and L.P. Vergasova (2004) Crystal structure of filatovite, $K[(Al,Zn)_2(As,Si)_2O_8]$, the first arsenate of the feldspar group. Eur. J. Mineral., 16, 537-543. (3) (2005) Amer. Mineral., 90, 518 (abs. refs. 1 & 2).

Filipstadite $(Mn^{2+},Mg)_4Sb^{5+}Fe^{3+}O_8$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* n.d. As pseudo-octahedral crystals, to 200 μm, modified by pseudododecahedral and pseudocube faces; as overgrowths on jacobsite or hausmannite. *Twinning:* Poorly developed sector twinning evident in reflected light.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 792–882, 831 average (100 g load). D(meas.) = n.d. D(calc.) = 4.9

Optical Properties: Opaque. *Color:* Black; gray in reflected light, with amber-orange, brown, or red internal reflections. *Streak:* Brown. *Luster:* Metallic.
Optical Class: Biaxial. *Dispersion:* $r < v$, slight. *Anisotropism:* Weak; in shades of dark brownish gray.
R: (400) 12.8, (420) 12.5, (440) 12.4, (460) 12.2, (480) 12.0, (500) 11.9, (520) 11.8, (540) 11.7, (560) 11.6, (580) 11.6, (600) 11.6, (620) 11.6, (640) 11.5, (660) 11.5, (680) 11.4, (700) 11.4

Cell Data: *Space Group:* n.d. $a = 36.7$ $b = 36.7$ $c = 25.9$ Z = [216]

X-ray Powder Pattern: Långban, Sweden.
2.56 (100), 1.527 (70), 1.662 (60), 2.157 (40), 3.05 (30), 1.1251 (30), 4.97 (20)

Chemistry:

	(1)	(2)
SiO_2	0.3	0.2 – 0.4
TiO_2		0.1 – 0.2
Al_2O_3	0.7	0.2 – 0.3
Fe_2O_3	14.9	12.6 – 15.1
Sb_2O_3	34.3	24.6 – 27.4
MnO	36.8	46.8 – 48.6
ZnO		1.9 – 2.1
MgO	12.4	7.8 – 8.0
Total	99.4	

(1) Långban, Sweden; by electron microprobe, average of five analyses, total Fe as Fe^{3+}, total Mn as MnO; corresponding to $(Mn_{2.48}Mg_{1.48})_{\Sigma=3.96}Fe_{0.90}Sb^{5+}_{1.02}Al_{0.06}Si_{0.02}O_8$. (2) Jakobsberg, Sweden; by electron microprobe, ranges of seven analyses on two grains, total Fe as FeO, Mn^{2+}:Mn^{3+} from charge balance; the average corresponding to $Mn^{2+}_{2.56}Mg_{0.94}Sb^{5+}_{0.80}Fe^{3+}_{0.82}Mn^{3+}_{0.70}Zn_{0.12}Al_{0.02}Ti_{0.02}Si_{0.02}O_8$.

Occurrence: In metamorphosed Fe–Mn orebodies.

Association: Jacobsite, ingersonite, calcite, antimony (Långban, Sweden); hausmannite, forsterite, phlogopite, calcite, copper, hedyphane, svabite (Jakobsberg, Sweden).

Distribution: From Långban and Jakobsberg, Värmland, Sweden.

Name: For the town of Filipstad, Sweden, which is near the Långban mine.

Type Material: The Natural History Museum, London, England, 1986,410, E1177; National Museum of Natural History, Washington, D.C., USA, 163012.

References: (1) Dunn, P.J., D.R. Peacor, A.J. Criddle, and C.J. Stanley (1988) Filipstadite, a new Mn−Fe^{3+}−Sb derivative of spinel, from Långban, Sweden. Amer. Mineral., 73, 413–419. (2) Holtstam, D. (1993) A second occurrence of filipstadite in Värmland, Sweden. Geol. Fören. Förhandl. Stockholm, 115, 239–240.

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Fillowite $Na_2Ca(Mn^{2+},Fe^{2+})_7(PO_4)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Rarely as tiny rhombohedral crystals, showing $\{01\overline{1}2\}$, $\{0001\}$; usually in granular aggregates.

Physical Properties: *Cleavage:* $\{0001\}$, nearly perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.43 D(calc.) = 3.55

Optical Properties: Transparent to translucent. *Color:* Wax-yellow, pale yellow, greenish yellow, reddish brown, colorless; colorless to yellow in transmitted light. *Streak:* White. *Luster:* Subresinous to greasy.
Optical Class: Uniaxial (+), anomalously biaxial. *Dispersion:* $r < v$, strong. $\omega = 1.672(3)$ $\epsilon = 1.676(3)$ 2V(meas.) = 30°

Cell Data: *Space Group:* $R\overline{3}$. $a = 15.282(2)$ $c = 43.507(3)$ Z = 18

X-ray Powder Pattern: Branchville, Connecticut, USA.
2.814 (100), 3.017 (70), 3.640 (60), 2.552 (60), 3.789 (40), 1.888 (40), 11.44 (35)

Chemistry:

	(1)	(2)	(3)
P_2O_5	39.10	39.68	40.80
FeO	9.33	9.69	24.10
MnO	39.42	39.58	23.79
CaO	4.08	3.63	5.37
Li_2O	0.06	0.07	
Na_2O	5.74	5.44	5.94
H_2O^+	1.66	1.58	
insol.	0.88	1.02	
Total	100.27	100.69	100.00

(1) Branchville, Connecticut, USA; average of two analyses, insoluble is quartz. (2) Do.; insoluble is quartz. (3) $Na_2Ca(Mn,Fe)_7(PO_4)_6$ with Mn:Fe = 1:1.

Occurrence: A primary accessory mineral in a zoned granite pegmatite (Branchville, Connecticut, USA).

Association: Triploidite, fairfieldite, reddingite (Branchville, Connecticut, USA).

Distribution: In the USA, from Branchville, Fairfield Co., Connecticut; in the White Picacho district, Maricopa and Yavapai Cos., Arizona; at the Animike Red Ace pegmatite, Florence Co., Wisconsin. From Buranga, Kiluli, and Rusororo, Rwanda. At Kabira, Uganda.

Name: In honor of Abijah N. Fillow (1822–1895), Branchville, Connecticut, USA, who early supplied minerals from his quarry at the locality.

Type Material: Yale University, New Haven, Connecticut, 3.3094, 3.3096; Harvard University, Cambridge, Massachusetts, USA, 96840.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 719–720. (2) Fisher, D.J. (1965) Dickinsonites, fillowite and alluaudites. Amer. Mineral., 50, 1647–1669. (3) Araki, T. and P.B. Moore (1981) Fillowite, $Na_2Ca(Mn,Fe)_7^{2+}(PO_4)_6$: its crystal structure. Amer. Mineral., 66, 827–842. (4) Moore, P.B. (1989) Perception of structural complexity: fillowite revisited and α-iron related. Amer. Mineral., 74, 918–926.

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Fingerite $Cu_{11}O_2(VO_4)_6$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As crystals, to 150 μm, may be subhedral or anhedral; equant or platelike. *Twinning:* As contact and multiple twins, by rotation about [010].

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.776

Optical Properties: Opaque. *Color:* Black; medium gray in reflected light. *Streak:* Dark reddish brown. *Luster:* Metallic.
Optical Class: Biaxial.

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.1576(6)$ $b = 8.2691(5)$ $c = 8.0437(7)$
$\alpha = 107.144(5)°$ $\beta = 91.389(7)°$ $\gamma = 106.441(5)°$ Z = 1

X-ray Powder Pattern: Izalco volcano, El Salvador.
6.48 (100), 3.042 (80), 2.822 (70), 2.025 (70), 3.894 (60), 3.617 (60), 3.293 (60d)

Chemistry:

	(1)	(2)	(3)
V_2O_5	39.65	39.67	38.41
CuO	59.3	59.53	61.59
Total	98.95	99.20	100.00

(1) Izalco volcano, El Salvador; by electron microprobe, average of seven analyses. (2) Do.; by electron microprobe, averages of 15 analyses of three crystals; corresponds to $Cu_{10.6}O_{1.3}(VO_4)_{6.2}$. (3) $Cu_{11}O_2(VO_4)_6$.

Occurrence: A rare component of vanadium-bearing sublimates in fumaroles on a basaltic volcanic cone, formed between 100 °C and 200 °C.

Association: Thenardite, euchlorine, stoiberite, shcherbinaite, ziesite, bannermanite, chalcocyanite, chalcanthite.

Distribution: On the Izalco volcano, El Salvador.

Name: In honor of Dr. Larry W. Finger (1940–), American mineralogist, Carnegie Institution, Washington, D.C., USA.

Type Material: Carnegie Institution, Washington, D.C.; National Museum of Natural History, Washington, D.C., USA, 160387.

References: (1) Hughes, J.M. and C.G. Hadidiacos (1985) Fingerite, $Cu_{11}O_2(VO_4)_6$, a new vanadium sublimate from Izalco volcano, El Salvador: descriptive mineralogy. Amer. Mineral., 70, 193–196. (2) Finger, L.W. (1985) Fingerite, $Cu_{11}O_2(VO_4)_6$, a new vanadium sublimate from Izalco volcano, El Salvador: crystal structure. Amer. Mineral., 70, 197–199.

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Finnemanite $Pb_5(As^{3+}O_3)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As small distorted crystals, elongated ‖ [0001], showing $\{10\bar{1}0\}$, $\{10\bar{1}1\}$, and $\{0001\}$, in crystalline crusts.

Physical Properties: *Cleavage:* $\{10\bar{1}1\}$, distinct. Hardness = 2.5 D(meas.) = 7.265 D(calc.) = [7.35]

Optical Properties: Translucent to opaque. *Color:* Gray to black; pale olive-green in transmitted light. *Luster:* Subadamantine.
Optical Class: Uniaxial (–). $\omega = 2.2949$ $\epsilon = 2.2847$

Cell Data: *Space Group:* $P6_3/m$. $a = 10.322(7)$ $c = 7.055(6)$ $Z = 2$

X-ray Powder Pattern: Långban, Sweden.
3.03 (10), 2.88 (9), 3.35 (6), 2.07 (6), 1.957 (5), 1.924 (5), 1.352 (5)

Chemistry:

	(1)	(2)
As_2O_3	20.54	20.61
Sb_2O_3	trace	
FeO	trace	
PbO	76.83	77.49
CaO	0.39	
Na_2O	0.24	
K_2O	0.44	
Cl	2.42	2.46
$-O = Cl_2$	0.55	0.56
Total	100.31	100.00

(1) Långban, Sweden. (2) $Pb_5(AsO_3)_3Cl$.

Occurrence: In crevices in hematite in a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Hematite, rouseite, trigonite (Långban, Sweden).

Distribution: From Långban, Värmland, Sweden. In the Puttapa zinc mine, near Beltana, South Australia.

Name: For K.J. Finneman, of Långban, Sweden, who found the first specimen.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1038–1039. (2) Effenberger, H. and F. Pertlik (1979) Die Kristallstruktur des Finnemanits, $Pb_5Cl(AsO_3)_3$, mit einem Vergleich zum Strukturtyp des Chlorapatits, $Ca_5Cl(PO_4)_3$. Tschermaks Mineral. Petrog. Mitt., 26, 95–107 (in German with English abs.). (3) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 37.

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Fischesserite Ag_3AuSe_2

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Crystal Data: Cubic. *Point Group:* 432. Massive; in xenomorphic grains, to 1 mm.

Physical Properties: Hardness = n.d. VHN = 32.7 (50 g load). D(meas.) = n.d. D(calc.) = 9.05

Optical Properties: Opaque. *Color:* Pale pink in reflected light. *Luster:* Metallic.
R: (400) 33.4, (420) 33.4, (440) 33.4, (460) 33.0, (480) 32.3, (500) 31.2, (520) 30.1, (540) 29.8, (560) 30.2, (580) 31.0, (600) 32.0, (620) 33.1, (640) 34.0, (660) 34.8, (680) 35.4, (700) 36.0

Cell Data: *Space Group:* $I4_132$. $a = 9.967$ $Z = 8$

X-ray Powder Pattern: Předbořice, Czech Republic.
2.662 (100), 2.229 (80), 2.035 (80), 1.820 (80), 1.266 (70), 7.08 (60), 1.954 (60)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	47.5	48.6	52.3	47.70
Cu		0.3	0.9	
Au	27.4	27.2	23.4	29.03
Se	24.4	22.8	22.8	23.27
Total	99.3	98.9	99.4	100.00

(1) Předbořice, Czech Republic; by electron microprobe, corresponding to $Ag_{2.85}Au_{0.90}Se_{2.00}$. (2) Do.; corresponding to $Ag_{3.12}Cu_{0.03}Au_{0.96}Se_{2.00}$. (3) Hope's Nose, England; by electron microprobe, corresponding to $Ag_{3.35}Cu_{0.10}Au_{0.82}Se_{2.00}$. (4) Ag_3AuSe_2.

Occurrence: In carbonate veins in epithermal precious metal deposits (Předbořice, Czech Republic).

Association: Naumannite, clausthalite, permingeatite, gold, calcite, quartz (Předbořice, Czech Republic).

Distribution: From the Předbořice uranium deposit, near Krásna Hora, Czech Republic [TL]. At Hope's Nose, Torquay, Devon, England. From the Kidd Creek mine, near Timmins, Ontario, Canada. In the USA, from the De Lamar mine, Silver City district, Owyhee Co., Idaho; in the Ken Snyder, Bonberger, and Eastern Star mines, Gold Circle district, Elko Co., Nevada. At Flamenco, Atacama, Chile.

Name: For Raymond Fischesser (1911–1991), French mineralogist and crystallographer, Director of the National School of Mines, Paris, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, R. Pierrot, and M. Kvaček (1971) La fischesserite, Ag_3AuSe_2, premier séléniurs d'or, isotype de la petzite. Bull. Soc. fr. Minéral., 94, 381–384 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1554 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 172.

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Fivegite $K_4Ca_2[AlSi_7O_{17}(O_{2-x}OH_x)][(H_2O)_{2-x}OH_x]Cl$ (x = 0-2)

Crystal Data: Orthorhombic. *Point Group*: *mm*2. As pseudomorphs after delhayelite to10 cm.

Physical Properties: *Cleavage*: Perfect on {100}, distinct on {010}. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 4 D(meas.) = 2.42(2) D(calc.) = 2.449 Pink under LW UV; purple under SW UV.

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous to pearly. *Optical Class*: Biaxial (+). α = 1.540(2) β = 1.542(2) γ = 1.544(2) 2V(meas.) = 60(10)° 2V(calc.) = n.d. *Orientation*: $X = a$, $Y = c$, $Z = b$.

Cell Data: *Space Group*: $Pm2_1n$. a = 24.335(2) b = 7.0375(5) c = 6.5400(6) Z = 2

X-ray Powder Pattern: Central mine, Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia. 3.072 (100), 2.893 (53), 2.943 (47), 3.040 (46), 3.517 (38), 1.759 (30), 3.239 (28)

Chemistry:

	(1)
Na_2O	0.44
K_2O	19.56
CaO	14.01
SrO	0.13
MnO	0.03
Fe_2O_3	0.14
Al_2O_3	6.12
SiO_2	50.68
SO_3	0.15
F	0.14
Cl	3.52
H_2O	4.59
$-O = (Cl,F)_2$	0.85
Total	99.66

(1) Central mine, Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia; average of 10 electron microprobe analyses, H_2O by Alimarin method, IR spectroscopy confirms OH; corresponding to $H_{4.22}K_{3.44}Na_{0.39}Ca_{2.07}Sr_{0.01}Fe_{0.01}Al_{1.00}Si_{6.99}O_{21.15}F_{0.06}Cl_{0.82}(SO_4)_{0.02}$.

Occurrence: A late-stage hydrothermal phase in high-potassium peralkaline pegmatite in urtite near the contact with nepheline-apatite rock.

Association: Delhayelite, hydrodelhayelite, pectolite, kalborsite.

Distribution: From the Central mine (southern wall, 640 m level), Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: Honors Russian geologist and mining engineer, Mikhail Pavlovich Fiveg (1899-1986), the pioneer prospector of the Khibiny apatite deposits.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3881/1).

References: (1) Pekov, I.V., N.V. Zubkova, N.V. Chukanov, A.E. Zadov, and D.Yu. Pushcharovsky (2010) Fivegite, $K_4Ca_2[AlSi_7O_{17}(O_{2-x}OH_x)][(H_2O)_{2-x}OH_x]Cl$ - a new mineral from the Khibiny alkaline massif (Kola Peninsula, Russia). Zap. Ross. Mineral. Obshch., 139(4), 47-63 (in Russian with English abstract). Geol. Ore Deposits, 53(7), 591-603 (in English).
(2) (2012) Amer. Mineral., 97, 1262 (abs. ref. 1).

Fizélyite $Pb_{14}Ag_5Sb_{21}S_{48}$(?)

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals to 12 mm, deeply striated and lacking terminal faces. *Twinning:* On {010}, with two sets of polysynthetic twins, ‖ to [001] and to {001}, giving a chess-board pattern.

Physical Properties: *Cleavage:* {010}. *Tenacity:* Very brittle. Hardness = 2 VHN = n.d. D(meas.) = 5.56 D(calc.) = 5.224

Optical Properties: Opaque. *Color:* Dark lead-gray to steel-gray. *Streak:* Dark gray. *Luster:* Metallic. *Anisotropism:* Shown, but without distinct color effects.
R_1–R_2: (400) 41.6–48.3, (420) 40.6–47.4, (440) 39.6–46.5, (460) 39.3–46.1, (480) 39.0–45.8, (500) 38.8–45.6, (520) 38.4–45.2, (540) 38.0–44.9, (560) 37.8–44.5, (580) 37.4–43.8, (600) 36.9–43.2, (620) 36.3–42.4, (640) 35.6–41.4, (660) 34.8–40.3, (680) 34.0–39.0, (700) 33.0–37.8

Cell Data: *Space Group:* $P2_1/n$. $a = 13.21$ $b = 19.27$ $c = 8.68$ $\beta = 90.4°$ Z = 1

X-ray Powder Pattern: Herja, Romania.
3.34 (10), 3.49 (5), 2.96 (5), 2.89 (5), 3.80 (4), 2.80 (3), 2.77 (3)

Chemistry:

	(1)	(2)	(3)
Pb	37.48	38.10	38.49
Ag	7.70	7.37	7.16
Fe	0.62	0.51	
Mn		0.20	
Sb	34.02	33.25	33.93
As	0.32		
S	20.10	20.79	20.42
insol.	0.30		
Total	100.54	100.02	100.00

(1) Herja, Romania; corresponds to $Pb_{13.85}Ag_{5.47}Fe_{0.85}Sb_{21.40}As_{0.33}S_{48.00}$. (1) Băiţa, Romania; by electron microprobe, corresponds to $Pb_{13.61}Ag_{5.06}Fe_{0.68}Mn_{0.27}Sb_{20.22}S_{48.00}$. (3) $Pb_{14}Ag_5Sb_{21}S_{48}$.

Occurrence: In hydrothermal veins.

Association: Semseyite, galena, sphalerite, pyrite, pyrrhotite, quartz, dolomite (Herja, Romania).

Distribution: In Romania, from Herja (Kisbánya), Baia Mare (Nagybánya) district, [TL] and Băiţa (Rézbánya). In the Gabe-Gottes mine, at Třebsko, south-southwest of Příbram, Czech Republic. At St. Andreasberg, Harz Mountains, Germany. In the Les Farges mine, near Ussel, Corrèze, and from Bournac, Montagne Noire, Finistère, France. In the USA, from Morey, Nye Co., and at the Boss mine, Goodsprings district, Clark Co., Nevada. In Canada, from the Van Silver mine, ??, British Columbia. [cf Mineral. Record, 31.3, 219–229, among best in world??] At the Candelaria mine, Santa Isabel district, Bolivia. At the Inakuraishi mine, Hokkaido, Japan.

Name: For Sandor Fizély (1856–1918), Hungarian mining engineer, who discovered the mineral.

Type Material: Hungarian Natural History Museum, Budapest, Hungary, A85134.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 450. (2) Moëlo, Y., E. Makovicky, and S. Karup-Møller (1984) New data on the minerals of the andorite series. Neues Jahrb. Mineral., Monatsh., 175–182. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 156–157.

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Flagstaffite $C_{10}H_{20}O_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Prismatic crystals display {110} and {111}, with minor {101} {131}, and {100}, to 1 mm; typically as drusy incrustations.

Physical Properties: *Cleavage:* {110}, imperfect. Hardness = "Soft". D(meas.) = 1.09 D(calc.) = 1.10 Strongly pyroelectric; M.P. 116 °C.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.505$ $\beta = 1.512$ $\gamma = 1.524$ 2V(meas.) = 77°

Cell Data: *Space Group:* $Fdd2$. $a = 18.60$ $b = 23.00$ $c = 10.86$ Z = 16

X-ray Powder Pattern: Synthetic. (ICDD 28-2014).
4.88 (100B), 8.72 (80), 7.16 (80), 4.36 (60), 5.89 (50), 5.65 (50), 4.73 (50)

Chemistry:

	(1)	(2)
C	66.21	63.12
H	11.55	11.65
O	22.24	25.23
Total	100.00	100.00

(1) San Francisco Peaks, Arizona, USA; corresponding to $C_{10.0}H_{20.7}O_{2.5}$. (2) $C_{10}H_{20}O_2 \cdot H_2O$.

Occurrence: Lining cracks in decomposing buried pine logs.

Association: n.d.

Distribution: At the base of the San Francisco Peaks, north of Flagstaff, Coconino Co., Arizona, USA.

Name: For Flagstaff, Arizona, USA, near the type locality.

Type Material: n.d.

References: (1) Guild, F.N. (1920) Flagstaffite, a new mineral from Arizona. Amer. Mineral., 5, 169–172. (2) Guild, F.N. (1921) The identity of flagstaffite and terpin hydrate. Amer. Mineral., 6, 133–134. (3) Strunz, H. and B. Contag (1965) Evenkit, Flagstaffit, Idrialin und Reficit. Neues Jahrb. Mineral., Monatsh., 19–25 (in German).

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Fleischerite $Pb_3Ge^{4+}(SO_4)_2(OH)_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}m2$. Prismatic to fibrous crystals, to 1.5 cm, typically in rounded aggregates.

Physical Properties: Hardness = "Soft. D(meas.) = 4.2–4.4 D(calc.) = 4.59

Optical Properties: Transparent. *Color:* White to pale rose; colorless in transmitted light. *Luster:* Silky in aggregates.
Optical Class: Uniaxial (+). $\omega = 1.747$ $\epsilon = 1.776$

Cell Data: *Space Group:* $P\overline{6}2c$. a = 8.89 $c = 10.86$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.619 (10), 2.635 (8), 3.437 (6), 2.214 (6), 1.889 (6), 7.681 (5), 2.800 (5)

Chemistry:

	(1)	(2)
SO_3	15.06	15.36
Ga_2O_3	0.86	
Fe_2O_3	0.05	
PbO	63.34	64.23
GeO	8.18	10.04
H_2O^+	11.35	
H_2O^-	0.21	
H_2O		10.37
insol.	0.56	
Total	99.61	100.00

(1) Tsumeb, Namibia; corresponds to $Pb_{2.84}(Ge_{0.93}Ga_{0.09})_{\Sigma=1.02}(SO_4)_{1.88}(OH)_{5.91} \cdot 3.47H_2O$.
(2) $Pb_3Ge(SO_4)_2(OH)_6 \cdot 3H_2O$.

Occurrence: Very rare in an oxidized portion of a dolostone-hosted hydrothermal germanium-bearing polymetallic ore deposit.

Association: Cerussite, anglesite, melanotekite, kegelite, alamosite, mimetite, tennantite, plumbojarosite, itoite.

Distribution: From Tsumeb, Namibia.

Name: Honors Dr. Michael Fleischer (1908–1998), mineralogist and geochemist, U.S. Geological Survey, Washington, D.C., USA.

Type Material: National School of Mines, Paris, France; Technical University, Berlin, Germany, 57/1405; Harvard University, Cambridge, Massachusetts, 111461; National Museum of Natural History, Washington, D.C., USA, 115310, 162620.

References: (1) Frondel, C. and H. Strunz (1960) Fleischerit und Itoit, zwei neue Germanium-Mineralien von Tsumeb. Neues Jahrb. Mineral., Monatsh., 132–142 (in German with English abs.). (2) (1960) Amer. Mineral., 45, 1313 (abs. ref. 1). (3) Otto, H.H. (1975) Die Kristallstruktur von Fleischerit, $Pb_3Ge[(OH)_6|(SO_4)_2] \cdot 3H_2O$, sowie kristallchemische Untersuchungen an isotypen Verbindungen. Neues Jahrb. Mineral., Abh., 123, 160–190 (in German with English abs.).

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Fletcherite $Cu(Ni,Co)_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As anhedral crystals, to 200 μm, typically imbedded in other sulfides.

Physical Properties: Hardness = n.d. VHN = 446–464 (25 g load). D(meas.) = n.d. D(calc.) = 4.76

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, creamy white. *Luster:* Metallic.
R: (420) 36.4, (460) 40.9, (500) 42.5, (546) 43.4, (589) 45.3, (640) 43.8

Cell Data: *Space Group:* $Fd3m$ (by analogy to other thiospinels). $a = 9.520$ $Z = 8$

X-ray Powder Pattern: Fletcher mine, Missouri, USA.
1.68 (vs), 1.83 (s), 2.87 (m), 2.39 (m), 1.37 (m), 1.24 (m), 1.19 (m)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	19.5	14.8	26.7	20.53
Ni	25.9	34.9	24.6	18.97
Co	13.6	9.5	2.7	19.05
Fe	0.9	0.2	3.7	
S	41.6	38.5	42.3	41.45
Total	101.5	97.9	100.0	100.00

(1) Fletcher mine, Missouri, USA; by electron microprobe, corresponds to $Cu_{0.95}Fe_{0.05}(Ni_{1.36}Co_{0.71})_{\Sigma=2.07}S_{4.00}$. (2) Do.; corresponds to $Cu_{0.78}Fe_{0.01}(Ni_{1.98}Co_{0.54})_{\Sigma=1.99}S_{4.00}$.
(3) Kalgoorlie, Australia; by electron microprobe, corresponds to $Cu_{1.27}Fe_{0.20}Ni_{1.27}Co_{0.14}S_{4.00}$.
(4) $Cu(Ni,Co)_2S_4$ with Ni:Co = 1:1.

Mineral Group: Linnaeite group.

Occurrence: Disseminated in copper sulfides, in copper-rich pods replacing dolostone (Fletcher mine, Missouri, USA); in black slates (Kalgoorlie, Australia).

Association: Vaesite, pyrite, covellite, chalcopyrite, bornite, digenite (Fletcher mine, Missouri, USA); pyrrhotite (Kalgoorlie, Australia).

Distribution: In the USA, from the Fletcher mine, Reynolds Co., Missouri [TL], and at the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming. From Băiţa (Rézbánya), Romania. In Australia, at Rum Jungle, Alligator River district, Northern Territory, and from Kalgoorlie, Western Australia.

Name: For the Fletcher mine in Missouri, USA.

Type Material: The Natural History Museum, London, England; Royal Ontario Museum, Toronto, Canada, M35070; National Museum of Natural History, Washington, D.C., USA, 137072.

References: (1) Craig, J.R. and A.B. Carpenter (1977) Fletcherite, $Cu(Ni,Co)_2S_4$, a new thiospinel from the Viburnum Trend (New Lead Belt), Missouri. Econ. Geol., 72, 480–486. (2) (1977) Amer. Mineral., 62, 596 (abs. ref. 1). (3) Ostwald, J. (1985) Fletcherite and its genesis in the Kalgoorlie area, Western Australia. Neues Jahrb. Mineral., Monatsh., 35–44.

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Flinkite $Mn_2^{2+}Mn^{3+}(AsO_4)(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely as individual crystals, to 3 mm, bladed, thin tabular {001}, elongated along [010], showing forms {001}, {010}, {110}, {101}, {111}; typically rounded in the zone [100], with {001} striated ‖ [100]. Commonly as rosettes or featherlike aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.87 D(calc.) = 3.73

Optical Properties: Transparent. *Color:* Greenish brown, dark green, dark yellow-brown; brownish yellowish green in transmitted light. *Luster:* Vitreous, resinous to somewhat greasy. *Optical Class:* Biaxial (+). *Pleochroism:* X = pale brownish green; Y = yellow-green; Z = orange-brown. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, weak. $\alpha = 1.783(3)$ $\beta = 1.801(3)$ $\gamma = 1.834(3)$ 2V(meas.) = Large.

Cell Data: *Space Group: Pnma.* $a = 9.55$ $b = 13.11$ $c = 5.25$ Z = 4

X-ray Powder Pattern: Harstigen mine, Sweden.
4.733 (100), 4.386 (100b), 2.662 (100), 3.179 (80), 3.815 (30), 2.506 (30), 1.538 (20)

Chemistry:

	(1)	(2)	(3)
As_2O_5	29.1	29.3	30.91
Sb_2O_5	2.5		
Fe_2O_3		0.4	
$(Fe, Al)_2O_3$	1.5		
Al_2O_3		0.8	
Mn_2O_3	20.2	22.4	21.23
MnO	35.8	33.9	38.17
ZnO		0.6	
MgO	1.7	3.2	
CaO	0.4	0.3	
H_2O	9.9	[9.1]	9.69
Total	101.1	[100.0]	100.00

(1) Harstigen mine, Sweden; corresponds to $(Mn^{2+}_{1.85}Mg_{0.15}Ca_{0.03})_{\Sigma=2.03}[Mn^{3+}_{0.93}(Fe, Al)_{0.08}]_{\Sigma=1.01}[(As_{0.94}Sb_{0.05})_{\Sigma=0.99}O_4](OH)_{4.01}$. (2) Franklin, New Jersey, USA; by electron microprobe, total Fe as Fe_2O_3, Mn^{2+}:Mn^{3+} from stoichiometry, H_2O by difference. (3) $Mn_2^{2+}Mn^{3+}(AsO_4)(OH)_4$.

Occurrence: Very rare, in veinlets in magnetite ore (Harstigen mine, Sweden); in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Sarkinite, brandtite, caryopilite, nadorite, lead, manganoan calcite, barite (Harstigen mine, Sweden); cahnite, jarosewichite, franklinite, hausmannite, andradite (Franklin, New Jersey, USA).

Distribution: From the Harstigen mine, near Persberg, and at Långban, Värmland, Sweden. At Franklin, Sussex Co., New Jersey, USA.

Name: To honor Gustav Flink (1849–1931), Swedish mineralogist and collector.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 793–794. (2) Culver, K.B. and L.G. Berry (1963) Flinkite and atelestite. Can. Mineral., 7, 547–553. (3) Moore, P.B. (1967) Crystal chemistry of the basic manganese arsenate minerals 1. The crystal structures of flinkite, $Mn_2^{2+}Mn^{3+}(OH)_4(AsO_4)$ and retzian, $Mn_2^{2+}Y^{3+}(OH)_4(AsO_4)$. Amer. Mineral., 52, 1603–1613. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 654, 668.

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Florencite-(Ce) $(Ce, La)Al_3(PO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. As pseudocubic rhombohedra, $\{01\bar{1}1\}$, may be modified by $\{10\bar{1}0\}$, $\{02\bar{2}1\}$, $\{0001\}$, to 2 cm.

Physical Properties: *Cleavage:* Good on $\{0001\}$; interrupted on $\{11\bar{2}0\}$. *Fracture:* Splintery to subconchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.45–3.54
D(calc.) = 3.47–3.69

Optical Properties: Transparent to translucent. *Color:* Pale yellow to butterscotch-yellow, red-orange, pink, pale brown, colorless to gray; colorless to pale yellow in thin section, may be zoned. *Luster:* Greasy to resinous.
Optical Class: Uniaxial (+). $\omega = 1.680$–1.702 $\epsilon = 1.705$–1.715

Cell Data: *Space Group:* $R\bar{3}m$. $a = 6.972(2)$ $c = 16.261(6)$ $Z = 3$

X-ray Powder Pattern: Matta dos Creoulos, Brazil; near florencite-(La) and -(Nd). (ICDD 8-143).
2.93 (100b), 5.63 (90), 2.16 (80), 1.885 (80), 3.48 (70), 2.21 (70), 1.741 (70)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3		1.7		Sm_2O_3	1.48	0.2	
P_2O_5	27.40	26.0	27.67	CaO	0.47	1.6	
Al_2O_3	29.60	29.8	29.81	SrO		9.0	
La_2O_3	8.68	5.3		BaO		0.1	
Ce_2O_3	17.79	8.8	31.99	F		1.6	
Nd_2O_3	3.78	2.6		H_2O	n.d.	12.9	10.53
Pr_6O_{11}		0.7		$-O = F_2$		0.7	
				Total		99.6	100.00

(1) Mackenzie Mountains, Canada; by electron microprobe, average of ten partial analyses; corresponding to $(Ce_{0.56}La_{0.28}Nd_{0.12}Sm_{0.04}Ca_{0.04})_{\Sigma=1.04}Al_{3.00}(PO_4)_{1.99}(OH)_6$. (2) Kangankunde Hill, Malawi. (3) $CeAl_3(PO_4)_2(OH)_6$.

Mineral Group: Crandallite group.

Occurrence: As a weathering product, typically of apatite, in highly argillized igneous rocks, bauxite, saprolite, carbonatites; authigenic in shales and sandstones; formed by the interaction of guano-reacted waters with gabbroic rock.

Association: Kaolinite, muscovite, alunite, siderite, quartz (sedimentary rocks); monazite, bastnäsite, apatite, ankerite, strontianite, barite, sphalerite, quartz (carbonatites).

Distribution: Many localities, but chemical analysis is required to determine which florencite species is present. Characterized material from Brazil, at Tripuhy, near Ouro Preto; from Matta dos Creoulos, and Lavra da Tejucana, near Diamantina, Minas Gerais; large crystals at Brumado, Bahia, Brazil. From the Backbone Ranges, Mackenzie Mountains, Northwest Territories, Canada. At Salmchâteau, Belgium. From the Corris area, Gwynedd, Wales. At the La Vanguardia kaolin deposit, near Combarbalá, Illapel region, Chile. On Middleton's Ridge, Ascension Island. At Klein Spitzkopje, Namibia. On Kangankunde Hill, Malawi. From Mt. Weld, 35 km south of Laverton, Western Australia. Most likely widespread in minor amounts in marine sediments.

Name: Honors Dr. William Florence (1864–1942), Brazilian mineralogist who made an early analysis, and for the dominant rare earth element, *cerium*.

Type Material: National Museum of Natural History, Washington, D.C., USA, R5209.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 838–839. (2) McKie, D. (1962) Goyazite and florencite from two African carbonatites. Mineral. Mag., 33, 281–297. (3) Pouliot, G. and H.J. Hofmann (1981) Florencite: a first occurrence in Canada. Can. Mineral., 19, 535–540. (4) Kato, T. (1990) The crystal structure of florencite. Neues Jahrb. Mineral., Monatsh., 227–231.

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Florencite-(La) $(La, Ce)Al_3(PO_4)_2(OH)_6$

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Crystal Data: Hexagonal, may be metamict. *Point Group:* $\overline{3}\ 2/m$. As pseudocubic rhombohedra, to 30 μm; as colloform crusts.

Physical Properties: *Cleavage:* Good on {0001}. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = 3.52(2) D(calc.) = 3.71

Optical Properties: Transparent to translucent. *Color:* Colorless to pale yellow; white in aggregates. *Luster:* Greasy to resinous.
Optical Class: Uniaxial (+). $\omega = 1.694(2)$ $\epsilon = 1.701(2)$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.987(2)$ $c = 16.248(6)$ $Z = 3$

X-ray Powder Pattern: Shituru deposit, Congo; near florencite-(Ce) and -(Nd).
2.93 (100), 5.67 (90), 2.171 (80), 3.49 (70), 1.884 (70), 1.743 (70), 1.601 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3		0.71	Eu_2O_3		0.18
P_2O_5	29.1	27.74	Gd_2O_3	0.9	0.51
SiO_2	1.4		Yb_2O_3		0.04
Al_2O_3	32.0	32.55	Fe_2O_3		0.18
Y_2O_3		0.11	MgO	0.9	
La_2O_3	19.0	11.86	CaO	0.2	1.33
Ce_2O_3	10.5	0.80	SrO		3.88
Pr_2O_3		4.70	BaO		0.62
Nd_2O_3	0.8	4.15	H_2O	n.d.	10.43
Sm_2O_3		0.18	Total		[99.97]

(1) Shituru deposit, Congo; by electron microprobe, corresponding to $(La_{0.61}Ce_{0.34}Gd_{0.03}Nd_{0.02})_{\Sigma=1.00}Al_3(PO_4)_2(OH)_6$. (2) Bohemia, Czech Republic; by electron microprobe, original total given as 100.00%; corresponding to $(La_{0.36}Sr_{0.18}Pr_{0.14}Nd_{0.12}Ca_{0.12}Ce_{0.02}Ba_{0.02}Gd_{0.01})_{\Sigma=1.00}(Al_{3.16}Fe_{0.01})_{\Sigma=3.17}[(PO_4)_{1.94}(SO_4)_{0.04}]_{\Sigma=1.98}(OH)_{5.99}$.

Mineral Group: Crandallite group.

Occurrence: A secondary mineral in weathered metamorphosed corrensitic siltstone (Shituru deposit, Congo); an authigenic mineral in sandstone.

Association: Synchysite-(Nd), manganoan siderite, sphalerite, kaolinite, "chalcedony".

Distribution: From the Shituru copper deposit, Likasi, Katanga Province, Congo (Shaba Province, Zaire). At the Bangombé natural fission reactor, Gabon. In the Hamr, Stráž, and Holičky deposits, Czech Republic.

Name: For a *florencite* with *lanthanum* as the dominant rare earth element.

Type Material: n.d.

References: (1) Lefebvre, J.-J. and C. Gasparrini (1980) Florencite, an occurrence in the Zairian Copperbelt. Can. Mineral., 18, 301–311. (2) (1984) Amer. Mineral., 69, 566 (abs. ref. 1). (3) Scharm, B., P. Kühn, M. Scharmová, and L. Novák (1985) Florencite-(La) in the uranium deposits in the Cretaceous of northern Bohemia. Časopis pro mineralogii a geologii, 30(2), 163–172.

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Florencite-(Nd) $(Nd, Ce)Al_3(PO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As pulverulent aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.70

Optical Properties: Translucent. *Color:* Moderate brown. *Luster:* Earthy.
Optical Class: [Uniaxial.] ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.992(1)$ $c = 16.454(7)$ Z = 3

X-ray Powder Pattern: Near Sausalito, California, USA; near florencite-(Ce) and -(La).
2.948 (100), 5.693 (93), 3.497 (90), 1.748 (63), 2.189 (50), 1.895 (50), 1.286 (27)

Chemistry: (1) Sausalito, California, USA; semiquantitative spectrographic analysis confirms Nd > Ce+La and Ba 7%.

Mineral Group: Crandallite group.

Occurrence: Lining surfaces of fractures in a weathered chert layer in shale.

Association: Churchite-(Y), todorokite, lithiophorite, hematite.

Distribution: From about one km south of Sausalito, Marin Co., California, USA.

Name: For a *florencite* with *neodymium* as the dominant rare earth element.

Type Material: U.S. Geological Survey, Reston, Virginia, USA.

References: (1) Milton, D.J. and H. Bastron (1971) Churchite and florencite (Nd) from Sausalito, California. Mineral. Record, 2, 166–168. (2) Fitzpatrick, J. (1986) Powder X-ray diffraction data of florencite-(Nd). Powder Diffraction, 1, 330.

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Florencite-(Sm) $(Sm,Nd)Al_3(PO_4)_2(OH)_6$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}\,2/m$. As zones to 0.1 mm thick along rhombohedral growth sectors in crystals of florencite-(Ce).

Physical Properties: *Cleavage*: Perfect on {0001}; parting on $\{11\bar{2}\,0\}$. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 5.5-6 D(meas.) = 3.60(1)
D(calc.) = 3.666 and 3.743 (for the 2 compositions given below in 'Chemistry')

Optical Properties: Transparent. *Color*: Colorless to pale pink or pale yellow. *Streak*: White. *Luster*: Vitreous to greasy.
Optical Class: Uniaxial (+). ω = 1.704(2) ε = 1.713(2)

Cell Data: *Space Group*: $F\bar{3}\,m$. a = 6.972(4) c = 16.182(7) Z = 3

X-ray Powder Pattern: Svodovyi site, Maldynyrd Ridge, Subpolar Urals, Russia.
2.925 (100), 1.881(58), 2.161 (46), 5.65 (43), 3.479 (37), 2.191 (22), 1.738 (20)

Chemistry:

	(1)	(2)		(1)	(2)
La_2O_3	n.d.	0.62	SrO	1.91	0.71
Ce_2O_3	1.92	3.29	CaO	0.77	0.35
Pr_2O_3	0.16	1.05	Al_2O_3	30.20	29.89
Nd_2O_3	9.35	10.31	P_2O_5	27.18	26.14
Sm_2O_3	12.96	12.62	SO_3	2.13	0.85
Eu_2O_3	n.d.	0.41	SiO_2	n.d	0.09
Gd_2O_3	2.55	2.30	H_2O	10.74	10.74
Dy_2O_3	n.d.	0.13	Total	99.87	99.50

(1) Svodovyi site, Maldynyrd Ridge, Russia; average of 5 electron microprobe analyses, H_2O by TGA; corresponding to $(Sm_{0.37}Nd_{0.28}Gd_{0.07}Ce_{0.06}Pr_{0.01}Sr_{0.09}Ca_{0.07})_{\Sigma=0.95}Al_{2.97}(P_{1.92}S_{0.13})_{\Sigma=2.05}O_{14}H_{5.98}$.
(2) Same as above; average of 3 electron microprobe analyses; corresponding to $(Sm_{0.37}Nd_{0.32}Ce_{0.10}Gd_{0.07}Pr_{0.03}La_{0.02}Eu_{0.01}Sr_{0.04}Ca_{0.03})_{\Sigma=0.99}Al_{3.02}(P_{1.90}S_{0.05}Si_{0.01})_{\Sigma=1.96}O_{14}H_{6.15}$.

Mineral Group: Plumbogummite group of the alunite supergroup.

Occurrence: In quartz veins cutting quartz meta-conglomerate beds near contacts with Al-enriched metasomatites.

Association: Florencite-(Ce), xenotime-(Y), quartz, dravite.

Distribution: Svodovyi site, Maldynyrd Ridge, Subpolar Urals, Russia.

Name: As the Sm-dominant example of the *florencite* structure.

Type Material: Natural Science Museum, Ilmen State Reserve, Miass, Russia.

References: (1) Repina, S.A.,V.I. Popova, E.I. Churin, E.V. Belogub, and V.V. Khiller (2010) Florencite-(Sm), $(Sm,Nd)Al_3(PO_4)_2(OH)_6$ - a new mineral species of the alunite-jarosite group from the Subpolar Urals. Zap. Ross. Mineral. Obshch., 139(4), 16-25 (in Russian with English abstract). Geol. Ore Deposits, 53(7), 564-574 (in English). (2) (2012) Amer. Mineral., 97, 1527-1528 (abs. ref. 1).

Florensovite $Cu(Cr,Sb)_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Grains, to 0.8 mm, slaglike; as overgrowths on eskolaite–karelianite.

Physical Properties: *Tenacity:* Brittle. Hardness = 5 VHN = 477–541, 511 average (50 g load). D(meas.) = n.d. D(calc.) = 4.28 Strongly magnetic.

Optical Properties: Opaque. *Color:* Black; pale creamy in reflected light.
Luster: Adamantine to metallic luster.
Optical Class: Isotropic.
R: (400) — , (420) — , (440) 23.2, (460) 24.5, (480) 25.7, (500) 26.4, (520) 26.5, (540) 26.5, (560) 26.8, (580) 27.0, (600) 27.4, (620) 27.5, (640) 27.1, (660) 26.6, (680) 26.3, (700) 26.2

Cell Data: *Space Group:* $Fd3m$ (by analogy to $CuCr_2S_4$). $a = 10.005(6)$ $Z = 8$

X-ray Powder Pattern: Slyudyanka complex, Russia.
3.01 (10), 1.768 (10), 2.50 (8), 1.923 (8), 1.021 (8), 1.302 (6), 3.53 (5)

Chemistry:

	(1)
Cu	18.80
Zn	0.75
Cr	24.24
Sb	19.17
V	0.02
S	38.45
Total	100.43

(1) Slyudyanka complex, Russia; by electron microprobe, corresponding to $(Cu_{0.97}Zn_{0.04})_{\Sigma=1.01}(Cr_{1.53}Sb_{0.52})_{\Sigma=2.05}S_{3.94}$.

Mineral Group: Linnaeite group.

Occurrence: Found in a granulite complex, in Cr- and V-rich metasediments.

Association: Cuprian kalininite, uvarovite–goldmanite, karelianite–eskolaite, pyrite, ilmenite, pyrrhotite, magnesiochromite, chalcopyrite, franklinite, barite, apatite, zircon, tremolite, diopside, calcite, quartz.

Distribution: From the Pereval marble quarry, near Slyudyanka, Sayan Mountains, south of Lake Baikal, Siberia, Russia [TL].

Name: To honor Nikolai Aleksandrovich Florensov (1909–1986), Ukrainian geologist, Director of the Institute of the Earth's Crust, Irkutsk, Russia.

Type Material: Central Siberian Geological Museum, Novosibirsk; Mining Institute, St. Petersburg, Russia, 2077/1–2.

References: (1) Reznitskii, L.Z., E.V. Sklyarov, L.F. Piskunova, and Z.F. Ushchapovskaya (1989) Florensovite $Cu(Cr_{1.5}Sb_{0.5})S_4$ – a new sulfospinel from Pribaikalya. Zap. Vses. Mineral. Obshch., 118(1), 57–65. (2) (1990) Amer. Mineral., 75, 1209–1210 (abs. ref. 1).

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Fluckite **$CaMn^{2+}(AsO_3OH)_2 \cdot 2H_2O$**

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Prismatic crystals, to 1.5 mm, elongated along [100] or [010], flattened on {100} or {110}, terminated by large {$2\overline{3}1$}, {$2\overline{3}3$}, with a number of other forms present. Typically radiating to spherulitic.

Physical Properties: *Cleavage:* On {010}, perfect; on {100}, easy; on {$\overline{1}01$}, imperfect and difficult. Hardness = 3.5–4 VHN = 170 (50 g load). D(meas.) = 3.05(2) D(calc.) = 3.11

Optical Properties: Semitransparent. *Color:* Colorless, very pale pink to dark pink with increasing cobalt content.
Optical Class: Biaxial (+), probable. $\alpha = 1.618$ $\beta = 1.627$ $\gamma = 1.642$ 2V(meas.) = Very large.

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.459(2)$ $b = 7.613(1)$ $c = 6.968(1)$ $\alpha = 82.21(1)°$ $\beta = 98.25(1)°$ $\gamma = 95.86(2)°$ Z = 2

X-ray Powder Pattern: Gabe-Gottes mine, France.
7.512 (100), 3.266 (91), 3.528 (90), 2.975 (81), 2.688 (61), 3.767 (56), 8.323 (44)

Chemistry:

	(1)	(2)
As_2O_5	56.60	55.94
MnO	17.17	17.26
MgO	0.04	
CaO	12.98	13.65
H_2O	13.20	13.15
Total	99.99	100.00

(1) Gabe-Gottes mine, France; by AA, H_2O by the Penfield method; corresponds to $Ca_{0.95}Mn_{0.99}(AsO_3OH)_{2.02} \cdot 2H_2O$. (2) $CaMn(AsO_3OH)_2 \cdot 2H_2O$.

Occurrence: A post-mine low-temperature reaction product of carbonate gangue with arsenical solutions derived from arsenic (Gabe-Gottes mine, France).

Association: Arsenic, tennantite, skutterudite, sainfeldite, pharmacolite, villyaellenite, picropharmacolite, calcite, dolomite, ankerite, quartz (Gabe-Gottes mine, France).

Distribution: From the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut Rhin, France. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: In honor of Pierre Fluck, mineralogist, Louis Pasteur University, Strasbourg, France, who found the first specimen.

Type Material: Mineralogical Museum, Sainte-Marie-aux-Mines; National School of Mines, Paris, France; The Natural History Museum, London, England, 1979,341.

References: (1) Bari, H., F. Cesbron, F. Permingeat, and F. Pillard (1980) La fluckite, arséniate hydraté de calcium et manganèse $CaMnH_2(AsO_4)_2.2H_2O$, une nouvelle espèce minérale. Bull. Minéral., 103, 122–128 (in French with English abs.). (2) Catti, M., G. Chiari, and G. Ferraris (1980) Fluckite, $CaMn(HAsO_4)_2.2H_2O$, a structure related by pseudo-polytypism to krautite $MnHAsO_4.H_2O$. Bull. Minéral., 103, 129–134. (3) (1980) Amer. Mineral., 65, 1066 (abs. refs. 1–2).

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Fluellite $Al_2(PO_4)F_2(OH)\cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Dipyramidal crystals, dominant {111}, with {001}, {011}, to 7 mm, commonly in aggregates; powdery, massive.

Physical Properties: *Cleavage:* On {001} and {111}, both indistinct. Hardness = 3 D(meas.) = 2.14–2.18 D(calc.) = 2.16 May fluoresce creamy white under LW UV.

Optical Properties: Transparent. *Color:* Colorless to white, may be pale yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, perceptible to strong. $\alpha = 1.473$–1.490 $\beta = 1.490$–1.496 $\gamma = 1.509$–1.511 2V(meas.) = Very large.

Cell Data: *Space Group: Fddd.* $a = 8.546(8)$ $b = 11.222(5)$ $c = 21.158(5)$ Z = 8

X-ray Powder Pattern: Stenna Gwynn mine, Cornwall, England. (ICDD 19-38).
6.48 (100), 3.24 (70), 3.09 (60), 2.667 (60), 4.96 (50), 2.868 (50), 2.763 (50)

Chemistry:

	(1)	(2)
PO_4	28.70	28.78
Al	16.94	16.35
F	14.71	11.51
OH	[3.46]	5.15
H_2O	35.62	38.21
rem.	0.55	
Total	[99.98]	100.00

(1) Kazakhstan; average of two analyses, $(OH)^{1-}$ calculated for charge balance.
(2) $Al_2(PO_4)F_2(OH)\cdot 7H_2O$.

Occurrence: A rare secondary mineral, formed by weathering of earlier phosphates in some complex granite pegmatites.

Association: Fluorapatite, wavellite, phosphosiderite, strengite, aldermanite, cacoxenite, variscite, turquoise, fluorite, quartz.

Distribution: In England, in Cornwall, from the Stenna Gwynn mine, St. Stephen-in-Brannel, and at the Goonvean china clay pit, St. Austell. In Germany, in Bavaria, on the Kreuzberg, Pleystein, and as large crystals at Hagendorf. At Lázně Kynzvart, near Mariánské Lázně (Königswart, near Marienbad), Czech Republic. From Argenteau, Visé, Belgium. At the Pereta mine, Scansano, Tuscany, Italy. In the USA, from the Carolina pyrophyllite mine, Staley, Randolph Co., North Carolina; in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., and at the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada; from the Tuscarora mine, near Randolph, Rich Co., Utah. At the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina. In Australia, from Wolfdene, near Beenleigh, Queensland; at Phosphate Hill, near Mansfield, Victoria; in South Australia, in the Moculta phosphate quarry, northeast of Angaston, and from St. John's and Tom's quarries, near Kapunda. At an undefined locality in Kazakhstan. A few other localities are now known.

Name: From the Latin *fluate alumine*, for its *fluorine* and *aluminum* content, phosphorus having been overlooked in early analyses.

Type Material: National Museum of Natural History, Washington, D.C., USA, C1028.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 124–125 [described as $AlF_3\cdot H_2O$]. (2) Guy, B.B. and G.A. Jeffrey (1966) The crystal structure of fluellite, $Al_2PO_4F_2(OH)\cdot 7H_2O$. Amer. Mineral., 51, 1579–1592. (3) Guy, B.B., G.A. Jeffrey, and R. Van Tassel (1967) The crystal structure of fluellite: a correction. Amer. Mineral., 52, 1576–1577.

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Fluoborite $Mg_3(BO_3)(F,OH)_3$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As acicular to prismatic crystals with pyramidal terminations, which may be poorly formed, to 2 cm; in fanlike or stellate aggregates.

Physical Properties: *Cleavage:* On {0001}, good. Hardness = ∼3.5 D(meas.) = 2.98 D(calc.) = [2.92] Strong cream-white fluorescence under SW UV.

Optical Properties: Translucent to transparent. *Color:* Colorless to white; colorless in transmitted light.
Optical Class: Uniaxial (–). ω = 1.510–1.530 (smaller values for F-rich compositions).
ϵ = 1.486–1.507

Cell Data: *Space Group:* $P6_3/m$. $a = 8.8612(12)$ $c = 3.1021(6)$ Z = 3

X-ray Powder Pattern: Crestmore quarry, California, USA.
2.424 (s), 4.462 (ms), 2.143 (ms), 2.129 (ms), 7.72 (m), 2.575 (m), 1.815 (m)

Chemistry:

	(1)		(1)
B_2O_3	18.24	MgO	65.08
SiO_2	0.04	CaO	0.10
TiO_2	0.02	F	23.30
Al_2O_3	0.01	Cl	0.03
Cr_2O_3	0.02	H_2O	3.40
FeO	0.16	$-O = (F,Cl)_2$	9.81
MnO	0.00	Total	100.59

(1) Huerta del Vinagre mine, Spain; by electron microprobe, corresponding to $Mg_{3.02}(BO_3)_{0.98}(F_{2.29}OH_{0.71})_{\Sigma=3.00}$.

Occurrence: A rare hydrothermal mineral in skarns developed in metamorphosed boron-rich magnesian rocks.

Association: Ludwigite, chondrodite, magnetite, calcite (Tallgruvan, Sweden); mooreite, willemite, fluorite, hydrozincite, pyrochroite, zincite, rhodochrosite (Sterling Hill, New Jersey, USA).

Distribution: From Tallgruvan, east of Kallmora, Norberg, Sweden. In the USA, around Edenville and Amity, Orange Co., New York; in New Jersey, from Sterling Hill, Ogdensburg, in the Limecrest quarry, Sparta, and at the Edison quarry, Rudeville, Sussex Co.; from near Blind Mountain, Bristol district, Lincoln Co., Nevada; in the Crestmore quarry, Riverside Co., California. Large crystals from the Cardiff mine and several roadcuts in the vicinity of Wilberforce, Ontario, Canada. At Broadford, Skye, Inverness-shire, Scotland. Abundant at the St. Dizier tin deposit, 20 km northwest of Zeehan, Tasmania, Australia. At the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea. From the Palabora mine, Transvaal, South Africa.

Name: For the essential chemical components, FLUOrine and BORon.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 369–370. (2) Ottolini, L., F. Cámara, and S. Bigi (2000) An investigation of matrix effects in the analysis of fluorine in humite-group minerals by EPMA, SIMS, and SREF. Amer. Mineral., 85, 89–102. (3) Cámara, F. and L. Ottolini (2000) New data on the crystal-chemistry of fluoborite by means of SREF, SIMS, and EMP analysis. Amer. Mineral., 85, 103–107. (4) Segnit, E.R. and C.J. Lancucki (1963) Fluoborite from Crestmore, California. Amer. Mineral., 48, 678–683.

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Fluocerite-(La) $(La, Ce)F_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}2/m$(synthetic LaF_3). As platy to tabular crystals, to 7 cm.

Physical Properties: *Cleavage:* "Dipyramidal", imperfect. *Fracture:* Conchoidal. *Tenacity:* [Brittle] [by analogy to fluocerite-(Ce)]. Hardness = [4–5] VHN = 390 D(meas.) = 5.93 D(calc.) = 5.94 (synthetic LaF_3).

Optical Properties: Semitransparent. *Color:* Pale greenish yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.609$ $\epsilon = 1.603$

Cell Data: *Space Group:* $P\overline{3}c1$(synthetic LaF_3). $a = 7.1871(4)$ $c = 7.3501(5)$ Z = 6

X-ray Powder Pattern: Zhanuzak area, Kazakhstan.
3.19 (10), 1.048 (7), 2.07 (6), 2.01 (6), 1.796 (5.5), 3.60 (4), 1.736 (4)

Chemistry:

	(1)		(1)
ThO_2	1.56	Sm_2O_3	0.17
$(Y, Tb, Dy)_2O_3$	0.08	Gd_2O_3	0.08
La_2O_3	42.34	Fe_2O_3	0.14
Ce_2O_3	33.13	MgO	trace
Pr_2O_3	3.68	CaO	0.54
Nd_2O_3	3.12	F	25.27
		$-O = F_2$	10.64
		Total	99.47

(1) Zhanuzak area, Kazakhstan; spectrographic analysis showed Si 0.2%, Al 0.05%, P 0.05%, Mn 0.005%; corresponds to $(La_{0.50}Ce_{0.39}Pr_{0.04}Nd_{0.04}Ca_{0.02}Th_{0.01})_{\Sigma=1.00}F_{2.55}O_{0.22}$.

Occurrence: In hydrothermal quartz veins in granite.

Association: Quartz.

Distribution: From the Zhanuzak area, Kent massif, Karaganda region, central Kazakhstan.

Name: As the *lanthanum* analog of *fluocerite-(Ce)*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 68285, vus1051, vis1053.

References: (1) Chistyakova, M.B. and M.E. Kazakova (1969) Fluocerite from Kazakhstan. Trudy Mineral. Muzeya Akad. Nauk SSSR, 19, 236–238 (in Russian). (2) (1984) Amer. Mineral., 69, 566 (abs. ref. 1). (3) Zalkin, A. and D. Templeton (1985) Refinement of the trigonal crystal structure of lanthanum trifluoride with neutron diffraction data. Acta Cryst., 41, 91–93. (4) Belzner, A., H. Schulz, and G. Heger (1994) The thermal vibrations and the fluorine ionic conductivity in LaF_3. Zeits. Krist., 209, 239–248.

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Fluorapatite $Ca_5(PO_4)_3F$

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Crystal Data: Hexagonal or monoclinic. *Point Group:* $6/m$ or $2/m$. As prismatic hexagonal crystals, elongated on [0001], dominated by $\{10\bar{1}0\}$ and $\{10\bar{1}1\}$, to 2 m; as complex tabular to discoidal crystals flattened on {0001}, typically with many forms; granular, globular to reniform, nodular, massive. *Twinning:* Rare as contact twins on $\{11\bar{2}1\}$ or $\{10\bar{1}3\}$.

Physical Properties: *Cleavage:* Poor on {0001} and $\{10\bar{1}0\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.1–3.25 D(calc.) = 3.18 May be cathodoluminescent, phosphorescent, or fluorescent in UV.

Optical Properties: Transparent to translucent. *Color:* Sea-green, violet, purple, blue, pink, yellow, brown, white, colorless, may be zoned; colorless or faintly tinted in thin section. *Streak:* White. *Luster:* Vitreous to subresinous.
Optical Class: Uniaxial (–). *Pleochroism:* Weak to strong if colored. *Absorption:* $E > O$.
$\omega = 1.631–1.650$ $\epsilon = 1.627–1.646$

Cell Data: *Space Group:* $P6_3/m$. $a = 9.3973$ $c = 6.8782$ Z = 2, or *Space Group:* $P2_1/b$. $a = 9.4877$ $b = 18.9628$ $c = 6.8224$ $\beta = 119.97°$ Z = 6

X-ray Powder Pattern: Synthetic.
2.800 (100), 2.702 (60), 2.772 (55), 3.442 (40), 2.624 (30), 1.837 (30), 1.937 (25)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	42.01	42.22	CaO	55.52	55.60	$-O = F_2$	1.63	1.59
RE_2O_3	0.28		F	3.89	3.67	Total	100.07	100.00

(1) Gloserheia pegmatite, Froland, Norway; $RE_2O_3 = Y_2O_3$ 0.10%, Nd_2O_3 0.06%, Gd_2O_3 0.06%, Yb_2O_3 0.06%; corresponds to $Ca_{5.00}(PO_4)_{2.99}F_{1.03}$. (2) $Ca_5(PO_4)_3F$.

Mineral Group: Apatite group; F > Cl or OH.

Occurrence: The most common rock-forming phosphate mineral. Accessory in most igneous rocks, important in syenites, alkaline rocks, carbonatites, granite pegmatites. Common in marbles and skarns, Ca-rich regional metamorphic rocks, Alpine-type fissures, and hydrothermal tin veins. An essential component of sedimentary phosphorites, common as a detrital or diagenetic component in oolitic ironstones and phosphatic carbonate rocks and shales. Residual in laterites.

Association: Diopside, forsterite, scapolite, phlogopite, chondrodite, calcite, magnetite.

Distribution: A few of the many localities for fine crystals include: at Ehrenfriedersdorf, Saxony, Germany. From Untersulzbachtal, Salzburg, Austria. At Panasqueira, Portugal. From near Pech, Kunar Province, Afghanistan. At Chumar Bakhoor, Nagar, Gilgit district, Pakistan. In Brazil, at the Morro Velho gold mine, Nova Lima, Minas Gerais. From Llallagua, Potosí, Bolivia. At Cerro de Mercado, Durango, Mexico. From the Pulsifer quarry, Mt. Apatite, Auburn, Androscoggin Co., Maine, USA. In Canada, large crystals from southeastern Ontario, as in Renfrew Co., and in adjoining southwestern Quebec, as in Ottawa Co., etc. An important ore in carbonatites; in Russia, in the Khibiny and Kovdor massifs, Kola Peninsula; from the Slyudyanka region, Lake Baikal, eastern Siberia. At Phalaborwa, Transvaal, South Africa. From the Jacupiranga mine, São Paulo, and at Tapira, Minas Gerais, Brazil. In the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia.

Name: For dominant *fluorine* and membership in the *apatite* group, the group name from the Greek for *to deceive*, for the ease with which specimens were confused with other minerals.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 879–889. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 297–334. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 81–84. (4) Hughes, J.M., M. Cameron, and K.D. Crowley (1989) Structural variation in natural F, OH, and Cl apatites. Amer. Mineral., 74, 870–876. (5) Hughes, J.M., M. Cameron, and K.D. Crowley (1990) Crystal structures of natural ternary apatites: solid solution in the $Ca_5(PO_4)_3X$ (X = F, OH, Cl) system. Amer. Mineral., 75, 295–304. (6) (1964) NBS Mono. 25(3), 22.

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Fluorapophyllite $KCa_4Si_8O_{20}(F,OH)\cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals tabular to prismatic, to 20 cm, commonly pseudocubic with {100}, {001}, and modified by {111}; prism zone deeply striated ‖ [001]; granular. *Twinning:* Rare on {111}.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {110}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 2.33–2.37 D(calc.) = 2.37

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pink, pale, yellow, green; in thin section, colorless. *Luster:* Vitreous, pearly on {001}.
Optical Class: Uniaxial (+). *Dispersion:* High, may be anomalous. $\omega = 1.530–1.536$
$\epsilon = 1.532–1.538$

Cell Data: *Space Group:* $P4/mnc$. a = 8.963(2) $c = 15.804(2)$ Z = 2

X-ray Powder Pattern: St. Andreasberg, Germany. (ICDD 19-82).
7.81 (100), 2.49 (90), 3.57 (60), 3.90 (50), 2.95 (50b), 4.51 (45), 3.17 (40)

Chemistry:

	(1)	(2)
SiO_2	51.98	52.98
Al_2O_3	0.36	
CaO	25.10	24.73
K_2O	4.45	5.19
Na_2O	0.61	
F	2.20	2.09
H_2O	16.25	15.89
$-O = F_2$	0.92	0.88
Total	100.03	100.00

(1) Phoenix mine, Keweenaw Co., Michigan, USA; corresponding to $(K_{0.85}Na_{0.16})_{\Sigma=1.01}Ca_{4.05}(Si_{7.83}Al_{0.07})_{\Sigma=7.90}O_{20}F_{1.05}\cdot 8.1H_2O$. (2) $KCa_4Si_8O_{20}F\cdot 8H_2O$.

Polymorphism & Series: Forms a series with hydroxyapophyllite.

Occurrence: A secondary mineral in amygdules or druses in basalts; in cavities in granite; in tactite and other metamorphic rocks; a late-stage hydrothermal mineral in some mineral deposits.

Association: Zeolites, datolite, pectolite, calcite, quartz.

Distribution: Many localities worldwide, but distinction from hydroxyapophyllite requires chemical analysis. Fine specimens with large crystals from the Teigarhorn, Berufjord, Iceland. On the Alpe di Siusi, Trentino-Alto Adige, Italy. At St. Andreasberg, Harz Mountains, Germany. From Korsnäs, Finland. Exceptional groups from India, in the Poona, Nasik, and Bombay districts, Maharashtra. At Shauguang, Guangdong, China. In the USA, from French Creek, Chester Co., and Cornwall, Lebanon Co., Pennsylvania; at Paterson, Passaic Co., and at Bergen Hill, Hudson Co., New Jersey; from the Fairfax quarry, Centreville, Fairfax Co., Virginia. Very large crystals from near Bento Gonçalves, Rio Grande do Sul, Brazil.

Name: For the preponderance of *fluorine* in the composition, and *apophyllite*, from the Greek for *away from* and *leaf*, in allusion to its manner of exfoliating on heating.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 566–569. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 258–266. (3) Colville, A.A., C.P.A. Anderson, and P.M. Black (1971) Refinement of the crystal structure of apophyllite. I. X-ray diffraction and physical properties. Amer. Mineral., 56, 1222–1233. (4) Bartl, H. and G. Pfeifer (1976) Neutronenbeugungsanalyse des Apophyllit $KCa_4(Si_4O_{10})_2(F/OH)\cdot 8H_2O$. Neues Jahrb. Mineral., Monatsh., 58–65 (in German with English abs.). (5) Dunn, P.J. and W.E. Wilson (1978) Nomenclature revisions in the apophyllite group: hydroxyapophyllite, apophyllite, fluorapophyllite. Mineral. Record, 3, 95–98.

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Fluorcaphite $Ca(Sr,Na,Ca)(Ca,Sr,Ce)_3(PO_4)_3(F,OH)$

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Crystal Data: Hexagonal. *Point Group:* 6. Subhedral slender prisms, to 5 mm, in aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.60 D(calc.) = 3.57

Optical Properties: Transparent. *Color:* Light to bright yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.649$ $\epsilon = 1.637$

Cell Data: *Space Group:* $P6_3$. $a = 9.485(3)$ $c = 7.000(3)$ $Z = 2$

X-ray Powder Pattern: Khibiny massif, Kola Peninsula, Russia.
2.838 (100), 2.740 (53), 2.814 (48), 3.498 (45), 1.865 (31), 3.104 (22), 1.963 (21)

Chemistry:

	(1)		(1)
P_2O_5	36.23	CaO	30.46
SiO_2	0.57	SrO	20.78
La_2O_3	2.61	BaO	0.03
Ce_2O_3	4.78	Na_2O	1.74
Pr_2O_3	0.34	F	2.17
Nd_2O_3	1.48	H_2O	[0.52]
Sm_2O_3	0.14	$-O = F_2$	0.91
		Total	[100.94]

(1) Khibiny massif, Kola Peninsula, Russia; by electron microprobe, average of seven analyses; corresponds to $(Ca_{3.16}Sr_{1.16}Na_{0.32})_{\Sigma=4.64}(Ce_{0.17}La_{0.10}Nd_{0.05}Pr_{0.01})_{\Sigma=0.33}[(PO_4)_{2.96}(SiO_4)_{0.06}]_{\Sigma=3.02}[F_{0.66}(OH)_{0.34}]_{\Sigma=1.00}$, structurally recast as $Ca_{1.0}(Sr_{0.5}Na_{0.3}Ca_{0.2})_{\Sigma=1.0}(Ca_{2.1}Sr_{0.6}Ce_{0.3})_{\Sigma=3.0}[(PO_4)_{2.9}(SiO_4)_{0.1}]_{\Sigma=3.0}[F_{0.7}(OH)_{0.3}]_{\Sigma=1.0}$.

Occurrence: In miarolitic cavities in a hyperagpaitic pegmatite in a differentiated alkalic massif.

Association: Deloneite-(Ce), belovite-(Ce), alkalic amphibole, lamprophyllite, labuntsovite, wadeite, sazykinaite-(Y), remondite-(La), sphalerite, galena, fluorite, graphite.

Distribution: From Mt. Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: For FLUORine, CAlcium, and PHosphorus in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Khomyakov, A.P., I.M. Kulikova, and R.K. Rastsvetaeva (1997) Fluorcaphite $Ca(Sr,Na,Ca)(Ca,Sr,Ce)_3(PO_4)_3F$ – a new mineral with the apatite structural motif. Zap. Vses. Mineral. Obshch., 126(3), 87–97 (in Russian with English abs.). (2) (1998) Amer. Mineral., 83, 907–908 (abs. ref. 1). (3) Rastsvetaeva, R.K. and A.P. Khomyakov (1996) Structural features of a new naturally occurring representative of the fluorapatite-deloneite series. Kristallografiya (Sov. Phys. Crystal.), 41, 831–834 (in Russian). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 88.

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Fluorellestadite $Ca_{10}(SiO_4)_3(SO_4)_3(F,OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As acicular or hexagonal prismatic, poorly-terminated crystals, to 3 mm, and as fine-grained aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 D(meas.) = 3.03(1) D(calc.) = 3.090

Optical Properties: Transparent to translucent. *Color:* Blue to pale bluish green; colorless in thin section. *Streak:* White with weak bluish tint. *Luster:* Vitreous to greasy. *Optical Class:* Uniaxial (–). $\omega = 1.638(2)$ $\epsilon = 1.632(2)$

Cell Data: *Space Group:* $P6_3/m$. $a = 9.485(2)$ $c = 6.916(2)$ $Z = 4$

X-ray Powder Pattern: Kopeysk, Russia.
2.84 (100), 2.74 (90), 1.852 (80), 1.954 (70), 1.729 (70), 2.80 (60), 2.28 (60)

Chemistry:

	(1)
SiO_2	15.30
Al_2O_3	1.84
Fe_2O_3	0.11
MnO	0.18
MgO	1.38
CaO	55.00
Na_2O	0.33
K_2O	0.1
F	3.60
H_2O^+	0.30
CO_2	0.66
P_2O_5	1.31
SO_3	20.75
$-O = F_2$	1.52
Total	[99.34]

(1) Kopeysk, Russia; after correction for impurities, MgO, Al_2O_3, 4% CaO, Fe_2O_3, Na_2O, and H_2O^+, original total given as 99.24%; corresponds to $(Ca_{9.96}Mn_{0.04})_{\Sigma=10.00}[(SO_4)_{2.84}(SiO_4)_{2.80}(PO_4)_{0.20}(CO_3)_{0.16}]_{\Sigma=6.00}F_{2.08}$.

Polymorphism & Series: Forms a series with hydroxylellestadite.

Occurrence: Formed in burned fragments of petrified wood in coal dumps (Kopeysk, Russia).

Association: Lime, periclase, magnesioferrite, hematite, srebrodolskite, anhydrite.

Distribution: From mines around Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia. From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. At Crestmore, Riverside Co., California, and Franklin, Sussex Co., New Jersey, USA.

Name: For *fluorine* in the chemical composition and analogy to *ellestadite*.

Type Material: Mining Institute, St. Petersburg, 711/1; Il'menskii Preserve Museum, Miass, 5900; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Chesnokov, B.V., L.F. Bazhenova, and A.F. Bushmakin (1987) Fluorellestadite $Ca_{10}[(SO_4),(SiO_4)]_6F_2$ – a new mineral. Zap. Vses. Mineral. Obshch., 116, 743–746 (in Russian). (2) (1989) Amer. Mineral., 74, 502–503 (abs. ref. 1). (3) Rouse, R.C. and P.J. Dunn (1982) A contribution to the crystal chemistry of ellestadite and the silicate sulfate apatites. Amer. Mineral., 67, 90–96.

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Fluorite CaF_2

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. Cubes, octahedra, rarely dodecahedra, or combinations, with many other forms; rounded or stepped, to 2 m; nodular, botryoidal, rarely columnar or fibrous; granular, massive. *Twinning:* Common on {111}, interpenetrant, flattened.

Physical Properties: *Cleavage:* {111}, perfect; on {011}, parting, poor. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 4 VHN = 174–181 {100}, 174–203 {111} (100 g load). D(meas.) = 3.175–3.184; to 3.56 if high in rare-earth elements. D(calc.) = 3.180 Fluoresces blue, violet, green, yellow, red under UV; may be phosphorescent, thermoluminescent, or triboluminescent.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, purple, blue, green, yellow, orange; red, pink, brown, bluish black; commonly zoned; in transmitted light, colorless, may be colored in thick sections. *Streak:* White. *Luster:* Vitreous; dull when massive. *Optical Class:* Isotropic; weak anomalous anisotropism. $n = 1.433$–1.448

Cell Data: *Space Group:* $Fm3m$. a = 5.4626 Z = 4

X-ray Powder Pattern: Synthetic.
1.931 (100), 3.153 (94), 1.647 (35), 1.1150 (16), 1.366 (12), 1.253 (10), 0.8637 (9)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.05		F	48.29	48.67
MgO	0.03		LOI	0.22	
Ca	51.24	51.33	Total	99.83	100.00

(1) Corvara, Trentino-Alto Adige, Italy. (2) CaF_2.

Occurrence: An accessory mineral in granite, granite pegmatites, syenites; around fumaroles; in carbonatites and alkaline intrusives. Economic deposits in low- to high-temperature hydrothermal veins and stratabound deposits; a cement in sandstones.

Association: Quartz, dolomite, calcite, barite, celestine, sulfides, cassiterite, topaz, wolframite, scheelite, apatite.

Distribution: Notable occurrences include: in England, from many localities in Cornwall; in Durham, as at Weardale; from Castleton, Derbyshire. In France, at Bex, Var; Le Beix, Puy de Dôme; and on Mont Blanc, near Chamonix, Haute-Savoie. On the Göscheneralp, Uri, Switzerland. From Wölsendorf, Bavaria, and in the Clara Mine, near Oberwolfach, Black Forest, Germany. Around Berbes, Asturias Province, Spain. At the Nikolaev mine, Dal'negorsk, Russia. From Kara Oba, Kazakhstan. At Xianghuapu, Hunan Province, China. In Mexico, from Naica, Chihuahua; Musquiz, Coahuila; and the Ojuela mine, Mapimí, Durango. In the USA, from Macomb, St. Lawrence Co., and Penfield, Monroe Co., New York; at Clay Center, Ottawa Co., Ohio; from Rosiclare and Cave-in-Rock, Hardin Co., Illinois; at the Elmwood mine, Smith Co., Tennessee; in the Sunnyside mine, San Juan Co., Colorado; from the Pine Canyon deposit, Burro Mountains, Grant Co., New Mexico. In Canada, from Madoc, Ontario, and in the Rock Candy mine, near Grand Forks, British Columbia. From Huanzala, Huanuco, Peru. At Okorusu, Namibia. In Pakistan, at Nagar, near Karimabad, Gilgit district.

Name: From the Latin *to flow*, in allusion to its low melting point.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 29–37. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 348–356. (3) Westbrook, J.H. and P.J. Jorgensen (1968) Effects of water desorption on indentation microhardness anisotropy in minerals. Amer. Mineral., 53, 1899–1909. (4) (1953) NBS Circ. 539, 1, 69.

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Fluornatromicrolite $(Na,Ca,Bi)_2Ta_2O_6F$

Crystal Data: Cubic. *Point Group*: 4/*m* $\bar{3}$ 2/*m*. As regular to flattened octahedral crystals, to 6 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 5 D(meas.) = 6.49(6) D(calc.) = 6.568

Optical Properties: Transparent. *Color*: Green. *Streak*: White. *Luster*: Adamantine. *Optical Class*: Isotropic. *n* = 2.11(2)

Cell Data: *Space Group*: *Fd3m.* *a* = 10.4451(2) *Z* = 8

X-ray Powder Pattern: Alto Quixaba pegmatite, Frei Martinho, Paraíba, Brazil. 3.015 (100), 1.846 (59), 1.574 (47), 3.14 (33), 6.023 (31), 2.610 (27), 1.198 (23)

Chemistry:

	(1)
Na_2O	6.39
CaO	6.96
Bi_2O_3	6.71
Ta_2O_5	76.81
F	3.63
$-O = F_2$	1.53
Total	98.97

(1) Alto Quixaba pegmatite, Frei Martinho, Paraíba, Brazil; average of 17 electron microprobe analyses, IR spectroscopy confirms absence of H_2O and OH; corresponding to $(Na_{1.10}Ca_{0.64}Bi_{0.15})_{\Sigma=1.89}Ta_{2.00}O_{5.91}F_{1.02}$.

Mineral Group: Pyrochlore supergroup, microlite group.

Occurrence: In a granitic pegmatite.

Association: Perthitic microcline, albite, amblygonite, muscovite, quartz, elbaite, tantalite-(Fe), tantalite-(Mn), beryl.

Distribution: From the Alto Quixaba pegmatite, Frei Martinho municipality, Paraíba State, northeastern Brazil. Similar material from the Altai Mounains, Russia and the Borborema pegmatitic province, northeastern Brazil.

Name: As a member of the *microlite* group with dominant fluorine (*fluor*) at an anion site and sodium (*natro*) in the *A* structural site.

Type Material: Mineralogical Collection of the Bergakademie, Freiberg (77975), and in the Mineralogical Collection, Martin-Luther University, Institute for Geological Science, Halle (010356), Germany.

References: (1) Witzke, T., M. Steins, T. Doering, W. Schuckmann, R. Wegner, and H. Pöllmann (2011) Fluornatromicrolite, $(Na,Ca,Bi)_2Ta_2O_6F$, a new mineral species from Quixaba, Paraíba, Brazil. Can. Mineral., 49, 1105-1110. (2) (2012) Amer. Mineral., 97, 1263 (abs. ref. 1).

Fluoro-aluminoleakeite $NaNa_2(Mg_2Al_2Li)Si_8O_{22}F_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, prismatic, to 2 mm.

Physical Properties: *Cleavage*: Perfect on {110}, intersecting at 56°. *Fracture*: Splintery. *Tenacity*: Brittle. Hardness = ~ 6 D(meas.) = n.d. D(calc.) = 3.14

Optical Properties: Transparent. *Color*: Light greenish blue. *Streak*: Greenish blue. *Luster*: Vitreous. *Pleochroism:* *X* = pale green; *Y* = dark green; *Z* = pale green. *Orientation:* Y = *b*; X ^ a = 62.9°. *Optical Class*: Biaxial (-). α = 1.632(1) β = 1.638(1) γ = 1.643(1) 2V(meas.) = 98.0(4)° 2V(calc.) = 96.9°

Cell Data: *Space Group*: *C*2/*m*. *a* = 9.7043(5) *b* = 17.7341(8) *c* = 5.2833(3) β = 104.067(4)° Z = 2

X-ray Powder Pattern: Norra Kärr, Gränna, Jönköping, Småland, Sweden. 2.687 (100), 4.435 (80), 3.377 (80), 2.527 (60), 8.342 (50), 3.096 (40), 2.259 (40)

Chemistry:

	(1)
SiO_2	58.61
TiO_2	0.32
Al_2O_3	7.06
Fe_2O_3	6.05
FeO	3.27
MnO	0.73
ZnO	0.43
MgO	8.61
CaO	0.05
Na_2O	9.90
K_2O	2.43
Li_2O	1.62
F	3.37
H_2O	0.05
-O=F	1.42
Total	101.08

(1) Norra Kärr, Gränna, Jönköping, Småland, Sweden; average of 10 electron microprobe analyses, Fe_2O_3 and Li_2O from structure refinement, H_2O from stoichiometry, corresponding to $(Na_{0.65}K_{0.43})_{\Sigma=1.09}(Na_{1.99}Ca_{0.01})_{\Sigma=2.00}(Mg_{1.77}Fe^{2+}_{0.38}Mn_{0.09}Zn_{0.04}Fe^{3+}_{0.63}Al_{1.16}Ti_{0.03}Li_{0.90})_{\Sigma=5.00}Si_{8.00}O_{22}(F_{1.47}OH_{0.53})_{\Sigma=2.00}$.

Mineral Group: Amphibole group.

Occurrence: In nepheline syenite.

Association: Albite, aegirine.

Distribution: Norra Kärr, Gränna, Jönköping, Småland, Sweden.

Name: For its composition and relationship to leakeite.

Type Material: Department of Natural History, Royal Ontario Museum, Toronto, Canada (catalog no. M53897).

References: (1) Oberti, R., F. Cámara, F.C. Hawthorne, and N.A. Ball (2009) Fluoro-aluminoleakeite, $NaNa_2(Mg_2Al_2Li)Si_8O_{22}F_2$, a new mineral of the amphibole group from Norra Kärr, Sweden: description and crystal structure. Mineral. Mag., 73, 817–824. (2) (2010) Amer. Mineral., 95, 1359 (abs. ref. 1).

Fluoro-magnesiohastingsite $(Na,K,Ca)Ca_2(Mg,Fe^{3+},Al,Ti)_5(Si,Al)_8O_{22}F_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals prismatic to 3 mm.

Physical Properties: *Cleavage*: Perfect on {110}. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 6 D(meas.) = n.d. D(calc.) = 3.18

Optical Properties: Transparent. *Color*: Reddish brown to yellowish. *Streak*: Light reddish brown. *Luster*: Vitreous.
Optical Class: Biaxial (+). $\alpha = 1.642$ $\beta = 1.647$ $\gamma = 1.662$ 2V(meas.) = 61° 2V(calc.) = 61°
Orientation: $Y = b$, $Z \wedge c = 26°$. *Pleochroism:* Weak; X = yellow-brown, $Y = Z$ = light brown.
Dispersion: None.

Cell Data: *Space Group*: *C*2/*m*. $a = 9.871(1)$ $b = 8.006(2)$ $c = 5.314(1)$ $\beta = 105.37(1)°$ $Z = 2$

X-ray Powder Pattern: Dealul Uroi, Apuseni Mountains, Hunedoara county, Romania.
3.124 (100), 8.421 (61), 3.271 (61), 2.700 (54), 3.377 (44), 2.932 (35), 2.746 (31)

Chemistry:

	(1)
SiO_2	40.77
TiO_2	1.21
Al_2O_3	13.11
Fe_2O_3	6.44
MgO	18.7
CaO	13.99
Na_2O	1.79
K_2O	1.17
F	4.39
-O = F	1.84
Total	99.73

(1) Dealul Uroi, Apuseni Mountains, Hunedoara county, Romania; average of electron microprobe analyses, absence of OH confirmed by IR spectroscopy; corresponding to $(Na_{0.50}K_{0.22}Ca_{0.17})_{\Sigma=0.89}$ $Ca_{2.00}(Mg_{4.03}Fe^{3+}_{0.70}Al_{0.13}Ti_{0.13})_{\Sigma=4.99}(Si_{5.89}Al_{2.11})_{\Sigma=8.00}O_{22.00}F_{2.00}$.

Mineral Group: Amphibole group, calcium amphibole subgroup.

Occurrence: In small cavities in an altered hematite-rich xenolith in trachyandesite.

Association: Titaniferous hematite, augite, phlogopite, enstatite, feldspar, tridymite, titanite, fluorapatite, ilmenite, pseudobrookite.

Distribution: From an abandoned quarry at Dealul Uroi, 10 km east of Deva, Apuseni Mountains, Hunedoara county, Romania.

Name: Signifies an amphibole in the compositional range of *magnesio-hastingsite* with F > Cl, OH.

Type Material: Department of Mineralogy, Landesmuseum Joanneum, Graz, Styria, Austria (83854-83855).

References: (1) Bojar, H-P. and F. Walter (2006) Fluoro-magnesiohastingsite from Dealul Uroi (Hunedoara county, Romania): Mineral data and crystal structure of a new amphibole end-member. Eur. J. Mineral. 118, 503-508. (2) (2007) Amer. Mineral., 92, 703-704 (abs. ref. 1).

Fluoro-potassichastingsite $KCa_2(Fe^{2+}_4Fe^{3+})Si_6Al_2O_{22}F_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, prismatic; in compact aggregates to 1 cm.

Physical Properties: *Cleavage*: Perfect on {110}, intersecting at 56°. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 6 D(meas.) = n.d. D(calc.) = 3.14

Optical Properties: Transparent. *Color*: Black, green on thin edges. *Streak*: Greenish gray. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.668(2)$ $\beta = 1.688(2)$ $\gamma = 1.698(2)$ 2V(meas.) = 40–70° 2V(calc.) = 70° *Pleochroism*: *X* = bluish green; *Y* = greenish to brownish green; *Z* = blue to light blue. *Dispersion*: *r* < *v*, weak. *Orientation*: *Y* = *b*; *Z* ^ *c* ≈ 23°.

Cell Data: *Space Group*: *C*2/*m*. *a* = 9.9480(3) *b* = 18.1777(6) *c* = 5.3302(2) $\beta = 105.140(1)°$ *Z* = 2

X-ray Powder Pattern: Greenwood (Patterson) iron mine, Orange County, New York, USA. 8.499(100), 3.151(76), 2.830 (53), 3.299(32), 2.722(23), 2.402(17), 3.401(11)

Chemistry:

	(1)		(1)
SiO_2	40.49	CaO	11.13
TiO_2	0.11	Na_2O	1.24
Al_2O_3	10.29	K_2O	2.93
V_2O_3	0.03	Li_2O	1.62
Cr_2O_3	0.01	F	2.23
Fe_2O_3	4.49	Cl	0.61
FeO	19.80	H_2O	0.70
MnO	0.20	-O=(F+Cl)	1.08
MgO	6.68	Total	99.86

(1) Greenwood (Patterson) iron mine, Orange County, New York; average of 12 electron microprobe analyses, Fe_2O_3 and FeO by Mössbauer spectroscopy, H_2O by hydrogen extraction; using H_2O from stoichiometry, corresponding to $(K_{0.59}Na_{0.25})_{\Sigma=0.84}(Ca_{1.87}Na_{0.13})_{\Sigma=2.00}(Fe^{2+}_{2.60}Mg_{1.56}Fe^{3+}_{0.53}Al_{0.26}Mn_{0.03}Ti_{0.01})_{\Sigma=4.99}(Si_{6.36}Al_{1.64})_{\Sigma=8.00}O_{22.68}O_3[F_{1.11}(OH)_{0.73}Cl_{0.16}]_{\Sigma=2.00}$.

Mineral Group: Amphibole group.

Occurrence: A product of potassium-halogen metasomatism of a hastingsite and diopside-bearing rock.

Association: Magnetite, diopside, enstatite, pyrrhotite, chalcopyrite, pyrite, phlogopite.

Distribution: Greenwood (Patterson) iron mine, Harriman State Park, near Tuxedo, Orange County, New York, USA.

Name: For its composition and relationship to hastingsite.

Type Material: New York State Museum, Albany, New York, USA (catalog no. 21205).

References: (1) Lupulescu, M.V., J. Rakovan, D.M. Dyar, G.W. Robinson, and J.M. Hughes (2009) Fluoro-potassichastingsite from the Greenwood mine, Orange County, New York: a new end-member calcic amphibole. Can. Mineral., 47, 909–916. (2) (2010) Amer. Mineral., 95, 205 (abs. ref. 1).

Fluoro-potassic-pargasite $KCa_2(Mg_4Al)(Si_6Al_2)O_{22}F_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals prismatic to 2 cm.

Physical Properties: *Cleavage*: Perfect on {110}. *Fracture*: Splintery. *Tenacity*: Brittle. Hardness = 6.5 D(meas.) = 3.46 D(calc.) = 3.151

Optical Properties: Transparent. *Color*: Brownish black. *Streak*: Pale gray. *Luster*: Vitreous. *Optical Class*: Biaxial (+). α = 1.638(2) β = 1.641(2) γ = 1.653(2) 2V(meas.) = 49.6(4)° 2V(calc.) = 53.4° *Orientation*: $X \wedge a$ = 46.9° (in β obtuse), $Y \parallel b$, $Z \wedge c$ = 31.4° (in β acute). *Pleochroism:* X = colorless to very pale gray, Y = very pale gray, Z = colorless.

Cell Data: *Space Group*: *C*2/*m*. a = 9.911(3) b = 17.972(3) c = 5.322(2) β = 105.55(2)° Z = 2

X-ray Powder Pattern: Tranomaro area, Fort Dauphin region, Madagascar.
3.133 (100), 3.270 (55), 2.809 (47), 8.413 (45), 2.698 (39), 3.374 (31), 2.934 (29)

Chemistry:

	(1)
SiO_2	40.20
TiO_2	0.46
Al_2O_3	17.61
Fe_2O_3	[2.51]
FeO	[1.96]
MgO	16.95
MnO	0.05
CaO	13.18
Na_2O	0.99
K_2O	3.72
F	2.75
-O = F	1.16
H_2O	[0.77]
Total	99.99

(1) Tranomaro area, Fort Dauphin region, Madagascar; average of 10 electron microprobe analyses, FeO:Fe_2O_3 calculated from structure analysis, H_2O calculated from stoichiometry; corresponding to $(K_{0.69}Na_{0.28}Ca_{0.04})_{\Sigma=1.01}Ca_{2.00}(Mg_{3.64}Fe^{2+}_{0.24}Mn_{0.01}Al_{0.79}Fe^{3+}_{0.27}Ti_{0.05})_{\Sigma=5.00}(Si_{5.80}Al_{2.20})_{\Sigma=8.00}O_{22}[F_{1.26}(OH)_{0.74}]_{\Sigma=2.00}$.

Mineral Group: Amphibole group, calcium amphibole subgroup.

Occurrence: Part of a single crystal attributed to a skarn deposit.

Association: Diopside, phlogopite, apatite, calcite, anhydrite, titanite.

Distribution: From a skarn in the Tranomaro area, Fort Dauphin region, Madagascar.

Name: Signifies an amphibole in the compositional range of *pargasite* with F > OH, Cl and K dominant in the A structural site.

Type Material: Mineral Museum, Department of Earth Science, University of Pavia, Italy (2009-02).

References: (1) Oberti, R., M. Boiocchi, F.C. Hawthorne, R. Pagano, and A. Pagano (2010) Fluoro-potassic-pargasite, $KCa_2(Mg_4Al)(Si_6Al_2)O_{22}F_2$, from the Tranomaro area, Madagascar: mineral description and crystal chemistry. Mineralogical Magazine, 74, 961-967. (2) (2014) Amer. Mineral., 99, 244 (abs. ref. 1).

Fluoro-sodic-ferropedrizite $NaLi_2(Fe^{2+}{}_2Al_2Li)Si_8O_{22}F_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, acicular to prismatic on [001], to 3 cm; in parallel to sub-parallel aggregates.

Physical Properties: *Cleavage*: Perfect on {110}, intersecting at 56°. *Fracture*: Splintery. *Tenacity*: Brittle. Hardness = ~ 6 D(meas.) = n.d. D(calc.) = 3.116

Optical Properties: Transparent. *Color*: Pale bluish-gray. *Streak*: Grayish-white. *Luster*: Vitreous. *Pleochroism: X* = pale purplish gray; *Y* = light gray; *Z* = colorless. *Orientation:* Y = *b*; X ^ a = 71.2°; Z ^ c = 83.4°. *Optical Class*: Biaxial (+). α = 1.642(1) β = 1.644(1) γ = 1.652(1) 2V(meas.) = 68.0(3)° 2V(calc.) = 56.4°

Cell Data: *Space Group*: *C*2/*m*. *a* = 9.3720(4) *b* = 17.6312(8) *c* = 5.2732(3) β = 102.247(4)° Z = 2

X-ray Powder Pattern: Sutlug River, Tuva Republic, Russia.
8.146 (100), 2.686 (90), 3.008 (80), 4.430 (70), 2.485 (60), 3.383 (40), 2.876 (30)

Chemistry:

	(1)
SiO_2	59.81
TiO_2	0.09
Al_2O_3	12.66
FeO	10.32
MnO	0.73
ZnO	0.17
MgO	5.56
CaO	0.20
Na_2O	2.81
Li_2O	4.80
F	2.43
H_2O	1.10
-O=F	1.02
Total	99.66

(1) Sutlug River, Tuva Republic, Russia; average of 10 electron microprobe analyses on a single grain, Li_2O from structure refinement, H_2O from stoichiometry, corresponding to $(Na_{0.68})(Li_{1.92}Na_{0.05}Ca_{0.03})_{\Sigma=2.00}(Fe^{2+}{}_{1.16}Mg_{1.10}Mn^{2+}{}_{0.08}Zn_{0.02}Al_{1.97}Ti_{0.01}Li_{0.66})_{\Sigma=5.00}(Si_{7.98}Al_{0.02})_{\Sigma=8.00}O_{22}(F_{1.03}OH_{0.97})_{\Sigma=2.00}$.

Mineral Group: Amphibole group.

Occurrence: At the contact of a lithium pegmatite and formed by reaction of the pegmatitic melt with the country rock.

Association: Calcite, plagioclase.

Distribution: Sutlug River, Tuva Republic, Russia.

Name: For its composition and relationship to pedrizite.

Type Material: Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia (64715).

References: (1) Oberti, R., M. Boiocchi, N.A. Ball, and F.C. Hawthorne (2009) Fluoro-sodic-ferropedrizite, $NaLi_2(Fe^{2+}{}_2Al_2Li)Si_8O_{22}F_2$, a new mineral of the amphibole group from the Sutlug River, Tuva Republic, Russia: description and crystal structure. Mineral. Mag., 73, 487–494.
(2) (2010) Amer. Mineral., 95, 1359-1360 (abs. ref. 1).

Flörkeite $K_3Ca_2Na\,[Al_8Si_8O_{32}]\cdot 12H_2O$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Crystals tabular prismatic, pseudo-monoclinic, elongated along [100] and flattened on {010}, to 0.6 mm; exhibit forms {100}, {001}, {20$\bar{1}$}. *Twinning:* Probable on {110}.

Physical Properties: *Cleavage*: Imperfect on {001}. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.266

Optical Properties: Transparent. *Color*: Pink, yellow-pink, white; colorless in thin section. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Biaxial (-). α = 1.506(2) β = 1.514(2) γ = 1.518(2) 2V(meas.) = 71.0(5)° 2V(calc.) = 70.2° *Orientation*: $X \wedge c$ = 43°; $Y \wedge b$ = 40°; $Z \wedge a$ = 8°. *Dispersion*: (r < v), weak.

Cell Data: *Space Group*: $P\bar{1}$. a = 19.965(1) b = 14.274(1) c = 8.704(1) α = 88.37(1)° β = 125.08(1)° γ = 89.57(1)° Z = 2

X-ray Powder Pattern: Bellerberg volcano, near Ettringen, East Eifel volcanic area, Germany. 3.235 (100), 3.162 (80), 3.135 (80), 2.736 (60), 4.956 (45), 2.712 (40), 2.665 (40)

Chemistry:

	(1)	(2)
SiO_2	35.29	34.60
Al_2O_3	30.20	29.36
MgO	0.04	
CaO	8.43	8.07
Na_2O	2.32	2.23
K_2O	10.29	10.17
H_2O	15.57	15.57
Total	102.14	100.00

(1) Bellerberg volcano, near Ettringen, East Eifel volcanic area, Germany; average of 11 electron microprobe analysis, H_2O from structure refinement, corresponding to $K_{2.96}Ca_{2.04}Na_{1.02}Mg_{0.01}[Al_{8.03}Si_{7.97}O_{31.97}]\cdot 11.72H_2O$. (2) $K_3Ca_2Na\,[Al_8Si_8O_{32}]\cdot 12H_2O$.

Group: Zeolite group.

Occurrence: In late-stage, low-temperature mineral in small cavities of a pyrometamorphically modified limestone xenolith in leucite-tephritic lava.

Association: Tobermorite, thaumasite.

Distribution: Bellerberg volcano, near Ettringen, East Eifel volcanic area, Germany.

Name: Honors the German mineralogist and crystallographer Otto Wilhelm Flörke (b. 1926) for his investigations on silica polymorphs.

Type Material: Natural History Museum, Vienna, Austria, (2009-IV-a).

References: (1) Lengauer, C.L., U. Kolitsch, and E. Tillmanns (2009) Flörkeite, $K_3Ca_2Na[Al_8Si_8O_{32}]\cdot 12H_2O$, a new phillipsite-type zeolite from the Bellerberg, East Eifel volcanic area, Germany. Eur. J. Mineral., 21, 901–913. (2) (2010) Amer. Mineral., 95, 1123 (abs. ref. 1).

Foggite $CaAl(PO_4)(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As thin prismatic crystals, tabular {010}, slightly elongated [001], to 0.4 mm; in fanlike and radial aggregates.

Physical Properties: *Cleavage:* {010}, perfect; {100}, good. Hardness = ∼4
D(meas.) = 2.78(1) D(calc.) = 2.77

Optical Properties: Semitransparent. *Color:* Colorless to snow-white.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.610(2)$ $\beta = 1.610(2)$ $\gamma = 1.611(2)$ 2V(meas.) = 40°–45°

Cell Data: *Space Group:* $A2_122$. $a = 9.270(2)$ $b = 21.324(7)$ $c = 5.190(2)$ Z = 8

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
4.24 (10), 2.693 (8), 3.109 (7), 6.96 (5), 4.20 (5), 2.505 (5), 10.67 (4)

Chemistry:

	(1)	(2)
P_2O_5	32.3	33.15
Al_2O_3	22.9	23.82
CaO	25.1	26.20
H_2O		16.83
Total		100.00

(1) Palermo #1 mine, New Hampshire, USA; by electron microprobe.
(2) $CaAl(PO_4)(OH)_2 \cdot H_2O$.

Occurrence: A secondary mineral, probably formed at < 300 °C, in complex granite pegmatites.

Association: Carbonate-apatite, childrenite, whitlockite, montebrasite, siderite, quartz.

Distribution: From the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, USA. On Milgun Station, Western Australia.

Name: To honor Forrest F. Fogg (1920–), mineral collector of Penacook, New Hampshire, USA, who provided the first material.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128068.

References: (1) Moore, P.B., A.J. Irving, and A.R. Kampf (1975) Foggite, $CaAl(OH)_2(H_2O)[PO_4]$; goedkenite, $(Sr,Ca)_2Al(OH)[PO_4]_2$; and samuelsonite, $(Ca,Ba)Fe_2^{2+}Mn_2^{2+}Ca_8Al_2(OH)_2[PO_4]_{10}$: three new species from the Palermo No. 1 pegmatite, North Groton, New Hampshire. Amer. Mineral., 60, 957–964. (2) Moore, P.B., A.R. Kampf, and T. Araki (1975) Foggite, $Ca(H_2O)_2[CaAl_2(OH)_4(PO_4)_2]$: its atomic arrangement and relationship to calcium Tschermak's pyroxene. Amer. Mineral., 60, 965–971.

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Foitite $\mathbf{Na_x[Fe^{2+}_2(Al,Fe^{3+})]Al_6(BO_3)_3Si_6O_{18}(OH)_4}$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals prismatic, elongated and striated ‖ [0001], with triangular cross section, to 5.5 cm

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ∼7
D(meas.) = 3.17 D(calc.) = 3.14

Optical Properties: Translucent in thin fragments. *Color:* Bluish black. *Streak:* Grayish white. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = pale lavender; E = dark blue.
$\omega = 1.664(1)$ $\epsilon = 1.642(1)$

Cell Data: *Space Group:* $R3m$. $a = 15.967(2)$ $c = 7.126(1)$ $Z = 3$

X-ray Powder Pattern: "Southern California," USA.
2.573 (100), 3.452 (91), 6.338 (84), 2.944 (71), 4.212 (48), 3.989 (38), 2.038 (29)

Chemistry:

	(1)
SiO_2	35.90
B_2O_3	[10.37]
Al_2O_3	34.90
FeO	11.45
MnO	1.71
MgO	0.21
CaO	0.03
Li_2O	[0.31]
Na_2O	0.75
H_2O	[3.56]
Total	[99.19]

(1) "Southern California," USA; by electron microprobe, average of 10 analyses; Ti, Cu, K, F not detected, B_2O_3, Li_2O, and H_2O from stoichiometry to fill their respective sites; corresponds to $Na_{0.25}(Fe_{1.60}Al_{0.89}Mn_{0.24}Li_{0.22}Mg_{0.05})_{\Sigma=3.00}Al_{6.00}(BO_3)_3Si_{6.01}O_{18}(OH)_4$.

Mineral Group: Tourmaline group.

Occurrence: Probably in granite pegmatites.

Association: The original specimens are loose crystals without matrix.

Distribution: Found as museum specimens designated only as from "southern California," USA. [White Queen mine, Pala district, San Diego Co., California, USA.] At the Kazionnitsa mine, Alabashka, Ural Mountains, Russia.

Name: To honor Franklin F. Foit, Jr. (1942–), of Washington State University, Pullman, Washington, USA, for his work on tourmaline group minerals.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81512.

References: (1) MacDonald, D.J., F.C. Hawthorne, and J.D. Grice (1993) Foitite, $\square[Fe^{2+}_2(Al,Fe^{3+})]Al_6Si_6O_{18}(BO_3)_3(OH)_4$, a new alkali-deficient tourmaline: description and crystal structure. Amer. Mineral., 78, 1299–1303.

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Fontanite $Ca(UO_2)_3(CO_3)_4 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As rectangular crystals, bladed on {010} and elongated along [001], to 1.2 mm; in divergent sprays.

Physical Properties: *Cleavage:* Good on {100}, {010}, and {001}. Hardness = 3 D(meas.) = 4.10 D(calc.) = 4.19 Radioactive; pale green fluorescence under LW UV.

Optical Properties: Transparent. *Color:* Bright yellow. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, weak. $\alpha = [1.603]$ $\beta = 1.690(2)$ $\gamma = 1.710(3)$ 2V(meas.) = 49(2)°

Cell Data: *Space Group:* $Pmnm$, $Pmn2_1$, or $P2_1nm$. $a = 15.337(3)$ $b = 17.051(3)$ $c = 6.931(2)$ Z = 4

X-ray Powder Pattern: Rabéjac deposit, France.
8.55 (100), 2.772 (70), 4.11 (60), 3.723 (60), 6.94 (50), 3.460 (50), 3.211 (40)

Chemistry:

	(1)	(2)
CO_2	14.80	15.38
UO_3	76.14	75.00
CaO	4.15	4.90
H_2O	[4.91]	4.72
Total	[100.00]	100.00

(1) Rabéjac deposit, France; by electron microprobe, CO_2 by CHN analyzer, UO_3 and CaO averages of four analyses, H_2O by difference; corresponds to $Ca_{0.85}(UO_2)_{3.08}(CO_3)_{3.89} \cdot 3.15H_2O$.
(2) $Ca(UO_2)_3(CO_3)_4 \cdot 3H_2O$.

Occurrence: A rare secondary mineral in the oxidized portions of a uranium deposit.

Association: Billietite, uranophane.

Distribution: From the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France.

Name: Honors François Fontan (1942–), mineralogist specializing in phosphates, University Paul-Sabatier, Toulouse, France.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC4216.

References: (1) Deliens, M. and P. Piret (1992) La fontanite, carbonate hydraté d'uranyle et de calcium, nouvelle espèce minérale de Rabejac, Hérault, France. Eur. J. Mineral., 4, 1271–1274 (in French with English abs.). (2) (1993) Amer. Mineral., 78, 846–847 (abs. ref. 1).

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Foordite $Sn^{2+}(Nb,Ta)_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive, in an extremely fine-grained intergrowth with other minerals.

Physical Properties: *Cleavage:* {100}, perfect; {011}, poor. Hardness = 6
D(meas.) = 6.734 D(calc.) = 6.664

Optical Properties: Semitransparent. *Color:* Brownish yellow with a greenish tint.
Streak: Yellowish white. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+); birefringence > 0.100. n = [2.294] 2V(meas.) = Moderate.

Cell Data: *Space Group:* $C2/c$. a = 17.090–17.101 b = 4.872–4.879 c = 5.556–5.562
β = 90.85°−90.93° Z = 4

X-ray Powder Pattern: Lutsiro, Rwanda; close to thoreaulite.
2.849 (100), 3.100 (50), 3.071 (50), 1.694 (45), 1.681 (45), 3.592 (40), 1.853 (30)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	40.1	28.7	27.20
Ta_2O_5	28.7	42.7	45.23
SnO_2		0.9	
Sb_2O_3		0.3	
SnO	25.4	27.1	27.57
PbO	6.0	0.5	
Total	100.2	100.2	100.00

(1) Lutsiro, Rwanda; by electron microprobe, total Sn as SnO; corresponding to $(Sn_{0.87}Pb_{0.13})_{\Sigma=1.00}(Nb_{1.40}Ta_{0.60})_{\Sigma=2.00}O_6$. (2) Kubitaka, Congo; by electron microprobe, Sn^{2+}:Sn^{4+} calculated from stoichiometry; corresponding to $(Sn^{2+}_{0.97}Sb_{0.01}Pb_{0.01})_{\Sigma=0.99}(Nb_{1.04}Ta_{0.93}Sn^{4+}_{0.03})_{\Sigma=2.00}O_6$. (3) $Sn(Nb,Ta)_2O_6$ with Nb:Ta = 1:1.

Mineral Group: Forms a series with thoreaulite.

Occurrence: A very rare mineral, in an alluvial pebble originating from a highly differentiated granite pegmatite, formed under reducing conditions deficient in Fe, Mn, Na, Ca, and F (Lutsiro, Rwanda).

Association: Ferrocolumbite, cassiterite, stannoan plumbomicrolite, ixiolite (Lutsiro, Rwanda).

Distribution: From about 15 km north-northwest of Lutsiro, near the Sebeya River, western Rwanda. At Kubitaka, near Punia, Kivu Province, Congo (Zaire).

Name: To honor Dr. Eugene Edward Foord (1946–1998), American mineralogist with the U.S. Geological Survey, Denver, Colorado, USA, student of granite pegmatites.

Type Material: Catholic University of Louvain, Louvain, Belgium, P1284.

References: (1) Černý, P., A.-M. Fransolet, T.S. Ercit, and R. Chapman (1988) Foordite $SnNb_2O_6$, a new mineral species, and the foordite-thoreaulite series. Can. Mineral., 26, 889–898.
(2) Ercit, T.S. and P. Černý (1988) The crystal structure of foordite. Can. Mineral., 26, 899–903.
(3) (1990) Amer. Mineral., 75, 707 (abs. refs. 1 and 2).

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Formanite-(Y) $YTaO_4$

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Crystal Data: Tetragonal or monoclinic; typically metamict. *Point Group:* $4/m$ or $2/m$. As prismatic or pyramidal crystals, in parallel or fan-shaped groups, to 6 mm; in concretions, as grains, and massive.

Physical Properties: *Cleavage:* {111}, interrupted. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6.5 D(meas.) = 6.17–6.24 D(calc.) = [6.46] (for $YTaO_4$). May be radioactive.

Optical Properties: Opaque, thin fragments may be transparent. *Color:* Brownish black or velvety black; gray, yellow, or brown with alteration; colorless to pale olive-brown in thin section. *Streak:* Pale yellow. *Luster:* Metallic, resinous to greasy; weathered surfaces are dull. *Optical Class:* Biaxial (+); metamict material is isotropic. *Pleochroism:* Light to dark brown. *Orientation:* $X = b$; $Y \simeq a$; $Z \wedge c \simeq 6°$. $\alpha = 2.053$ $\beta = 2.075$ $\gamma = 2.104$ 2V(meas.) = 80°

Cell Data: *Space Group:* P(ICDD 26-1478), with $a = 7.732$ $c = 11.49$ Z = 8, or *Space Group:* $P2/a$ with $a = 5.23$ $b = 5.45$ $c = 5.13$ $\beta = 93.3°$ Z = [2]

X-ray Powder Pattern: "Siberia", Russia; after heating for one hour at 900° C.
3.13 (10), 2.933 (9), 1.900 (7), 1.641 (7b), 1.567 (7b), 2.723 (6), 1.216 (6)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5	2.15	9.50		RE_2O_3	0.94	33.20	
Ta_2O_5	55.51	47.46	66.18	FeO	trace	0.39	
UO_3	1.18			MnO	0.87	0.21	
TiO_2	2.20	0.38		MgO		0.12	
ThO_2	1.02	0.56		CaO	2.18	1.01	
UO_2		3.65		H_2O^+		2.68	
Y_2O_3	23.00		33.82	H_2O^-		0.17	
Er_2O_3	8.38			LOI	3.36		
				Total	100.79	[99.33]	100.00

(1) Cooglegong, Western Australia. (2) "Siberia", Russia; RE = La 0.8%, Ce 1.3%, Pr 0.7%, Nd 2.4%, Sm 4.9%, Eu+Gd 8.9%, Tb+Y 63.0%, Dy 7.0%, Ho 1.5%, Er 3.6%, Tu 0.5%, Yb+Lu 5.3%; original total given as 99.17%; corresponds to $[(Y,RE)_{0.86}Ca_{0.06}U_{0.04}Fe_{0.02}Mg_{0.01}Th_{0.01}]_{\Sigma=1.00}(Ta_{0.74}Nb_{0.24}Ti_{0.02})_{\Sigma=1.00}O_{3.99}$. (3) $YTaO_4$.

Polymorphism & Series: Dimorphous with yttrotantalite-(Y); forms a series with fergusonite-(Y).

Occurrence: In granites and albitized, RE-rich pegmatitic veins; a detrital mineral in placers.

Association: Cassiterite, monazite, euxenite, gadolinite (Cooglegong, Western Australia).

Distribution: Found at Cooglegong, Pilbara district, and in the Marble Bar district, Western Australia. In Russia, found at an undisclosed location in Siberia. Occurs at an undisclosed locality in Jiangxi Province, China.

Name: Honors Francis Gloster Forman (1904–1980), government geologist of Western Australia.

Type Material: Western Australian Museum, Perth, Australia, S381.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 757–763. (2) Simpson, E.S. (1951) Minerals of Western Australia. vol. II, 259, 263–264 [yttrotantalite]. (3) Wylie, A.W. (1954) Lanthanon and scandium distribution in Western Australian fergusonite. Amer. Mineral., 39, 667–669. (4) Butler, J.R. and R. Hall (1960) Chemical variations in members of the fergusonite-formanite series. Mineral. Mag., 32, 392–407. (5) Kornetova, V.A. and M.E. Kazakova (1964) Discovery of formanite in the USSR. Doklady Acad. Nauk SSSR, 154, 359–362 (in Russian). (6) Wolten, G.M. (1967) The structure of the M'-phase of $YTaO_4$, a third fergusonite polymorph. Acta Cryst., 23, 939–944. (7) Shih Nicheng and Peng Zhizhong (1981) Mineralogy of formanite. K'o Hsueh T'ung Pao, 26(10), 616–617 (in Chinese).

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Formicaite $Ca(HCO_2)_2$

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Crystal Data: Tetragonal. *Point Group:* 422. As tabular crystals, to 30 μm, also in colloform to compact aggregates.

Physical Properties: *Cleavage:* {100}, perfect. *Tenacity:* Brittle. Hardness = 1 D(meas.) = 1.9(1) D(calc.) = 1.93(2) Fluoresces pale blue under SW UV.

Optical Properties: Semitransparent. *Color:* White to pale blue. *Streak:* White. *Optical Class:* Uniaxial (+). $\omega = 1.553(2)$ $\epsilon = 1.573(2)$

Cell Data: *Space Group:* $P4_12_12$. $a = 6.77$ $c = 9.463$ Z = 4

X-ray Powder Pattern: Russia.
3.40 (100), 5.54 (90), 2.859 (80), 2.196 (70), 3.19 (60), 1.947 (60), 2.046 (50)

Chemistry:

	(1)	(2)
C	20.28	18.46
Mn	0.23	
Ca	29.80	30.80
Na	0.13	
K	0.10	
H	[1.90]	1.55
O	[49.19]	49.19
Total	[101.63]	100.00

(1) Russia; by electron microprobe and gas chromatography of combustion products, average of twelve analyses, H calculated for charge balance, O calculated for the ideal formula; corresponds to $(Ca_{0.88}Na_{0.01}H_{0.23})_{\Sigma=1.12}(HCO_2)_2$. (2) $Ca(HCO_2)_2$.

Occurrence: Rare in hydrothermal veinlets cutting kurchatovite-sakhaite ore (Solongo deposit, Russia); in a veinlet in skarnitized marble (Novofrolovskoye deposit, Russia).

Association: Calcite, lizardite, frolovite, pentahydroborite, hexahydroborite, vimsite (Solongo deposit, Russia); calcite, vesuvianite, pentahydroborite, frolovite, calciborite, uralborite, johnbaumite (Novofrolovskoye deposit, Russia).

Distribution: In Russia, from the Solongo boron deposit, Buryatia, and the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains.

Name: Alludes to the composition, a calcium formate.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Chukanov, N.V., S.V. Malinko, A.Y. Lisitsyn, V.T. Dubinchuk, O.V. Kuz'mina, and A.E. Zadov (1999) Formicaite $Ca(HCO_2)_2$ – a new mineral. Zap. Vses. Mineral. Obshch., 128(2), 43–48 (in Russian). (2) (2000) Amer. Mineral., 85, 1321–1322 (abs. ref. 1). (3) (1999) Mineral. Abs., 50, 520 (abs. ref. 1).

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Fornacite $Pb_2Cu(AsO_4)(CrO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals typically steep pyramidal, rounded, to 6 mm; generally in aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3 D(meas.) = 6.27(2) D(calc.) = 6.30

Optical Properties: Transparent to translucent. *Color:* Deep olive-green, greenish yellow; golden yellow in transmitted light. *Streak:* Saffron-yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Dispersion:* Strong. $\alpha = 2.14(2)$ β = n.d. $\gamma = 2.24(2)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/c$. $a = 8.101(7)$ $b = 5.893(11)$ $c = 17.547(9)$ $\beta = 110°00(2)'$ Z = 4

X-ray Powder Pattern: Renéville, Congo Republic and Sebarz, Iran.
3.31 (10), 2.98 (10), 2.88 (10), 2.80 (10), 4.80 (9), 2.71 (9), 8.22 (5)

Chemistry:

	(1)	(2)	(3)
CrO_3	15.3	11.78	13.34
P_2O_5	0.4	0.66	
As_2O_5	13.4	15.03	15.32
Fe_2O_3	0.2	0.40	
CuO	10.2	10.91	10.61
PbO	57.7	57.16	59.53
H_2O	2.4	3.73	1.20
Total	99.6	99.67	100.00

(1) Djoué, Congo Republic. (2) Renéville, Congo Republic. (2) $Pb_2Cu(AsO_4)(CrO_4)(OH)$.

Occurrence: A rare mineral in the oxidized zones of some hydrothermal base-metal deposits.

Association: Dioptase, wulfenite, hemihedrite, phoenicochroite, duftite, mimetite, shattuckite, chrysocolla, hemimorphite, willemite, fluorite.

Distribution: From Djoué and Renéville, Congo Republic. In South Africa, at the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal. From the Seh Changi mine, near Neybaud, Khorassan, and at Sebarz, Iran. In the USA, in Arizona, from the Mammoth-St. Anthony mine, Tiger, Pinal Co., at the Tonopah-Belmont mine, Osborne district, Maricopa Co., from the Lone Star mine, near Copperopolis, Yavapai Co., at the 79 mine, Gila Co., from the Shattuck mine, Bisbee, Warren district, Cochise Co., from the Eagle Eye mine, New Water Mountains, La Paz Co., and at several other localities; from the Blue Bell mine, near Baker, San Bernardino Co., California; at Socorro Peak, Socorro Co., New Mexico; from the Killie mine, Spruce Mountain district, Elko Co., and in the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada. At the Union mine, Taltal, Antofagasta, Chile. In the Teutonic Bore deposit, 300 km north of Kalgoorlie, and at Whim Creek, east of Roeburne, Western Australia.

Name: In honor of Lucien Louis Forneau (1867–1930), Colonial Governor of the French Congo.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 652. (2) Guillemin, C. and J. Prouvost (1951) Étude de la série: fornacite–vauquelinite. Bull. Minéral., 74, 432–438 (in French). (3) Bariand, P. and P. Herpin (1962) Nouvelles données sur la fornacite (chromo-arséniate de plomb et de cuivre) Bull. Minéral., 85, 309–311 (in French). (4) Cocco, G., L. Fanfani, and P.F. Zanazzi (1967) The crystal structure of fornacite. Zeits. Krist., 124, 385–397. (5) Fanfani, L. and P.F. Zanazzi (1968) The crystal structure of vauquelinite and the relationship to fornacite. Zeits. Krist., 126, 433–443.

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Forsterite Mg_2SiO_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In euhedral or subhedral crystals, typically thick, with striations ‖ elongation, with wedge-shaped terminations, to 17 cm. Commonly granular or compact massive. *Twinning:* On {100}, {011}, {012}.

Physical Properties: *Cleavage:* {010}, {100}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7 D(meas.) = 3.275 D(calc.) = 3.271

Optical Properties: Transparent to translucent. *Color:* Green, yellowish, lemon-yellow, white, grayish, blue-gray; colorless in thin section. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.635$ $\beta = 1.651$ $\gamma = 1.670$ 2V(meas.) = 82°

Cell Data: *Space Group: Pbnm* (synthetic). $a = 4.7540$ $b = 10.1971$ $c = 5.9806$ Z = 4

X-ray Powder Pattern: Ojamo, Finland. (ICDD 7-74).
2.458 (100), 3.883 (70), 2.512 (70), 2.768 (60), 5.10 (50), 2.269 (40), 2.250 (30)

Chemistry:

	(1)
SiO_2	41.72
FeO	1.11
MgO	57.83
Total	100.66

(1) Mogok district, Myanmar; corresponds to $(Mg_{2.02}Fe^{2+}_{0.02})_{\Sigma=2.04}Si_{0.98}O_4$.

Polymorphism & Series: Trimorphous with ringwoodite and wadsleyite; forms two series, with fayalite, and with tephroite.

Mineral Group: Olivine group.

Occurrence: In mafic and ultramafic igneous rocks and thermally metamorphosed impure dolomitic limestones.

Association: Enstatite, plagioclase, phlogopite, magnetite, chromite, antigorite, dolomite, brucite, diopside, corundum, amphiboles, calcite, spinel, augite.

Distribution: Localities for near end member material or good crystals include: at Monte Somma and Vesuvius, Campania, Italy. From Ojamo, Lohja, Finland. At Møre og Ramsdel, Norway. Large crystals from the Kovdor massif, Kola Peninsula, and at Zlatoust and Mt. Itkul, Ural Mountains, Russia. In the Eifel district, Germany, at Forstberg. In the USA, in Arizona, on Peridot Mesa, four km southwest of San Carlos, Gila Co., and at Buell Park, Apache Co. In the Mogok district and at Pyaung Gaung, Myanmar (Burma). Exceptional gemmy crystals from Sapat, 24 km northeast of Naran, Northwest Frontier Province, Pakistan. At Kingiti, Mpapwa, Tanzania. Large gem crystals from the Island of Zabargad (Zabirget or St. Johns), in the Red Sea, Egypt.

Name: After Adolarius Jacob Forster (1739–1806), English mineral collector and dealer.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 450–451, 451–456 [chrysolite]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 3–336. (3) Hazen, R.M. (1976) Effects of temperature and pressure on the crystal structure of forsterite. Amer. Mineral., 61, 1280–1293.

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Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As platy crystals to 20 μm, typically in divergent spherical aggregates to 0.1 mm.

Physical Properties: *Cleavage*: Poor on (010). *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = 3-4 D(meas.) = n.d. D(calc.) = 3.286

Optical Properties: Transparent. *Color*: Pale sky blue to aqua. *Streak*: Very pale blue. *Luster*: Vitreous.
Optical Class: Biaxial (n.d.). n = 1.620(5)

Cell Data: *Space Group*: $P\bar{1}$. a = 6.969(9) b = 7.676(9) c = 8.591(11) α = 82.01(9)º β = 71.68(8)º γ = 102.68(8)º Z = 2

X-ray Powder Pattern: Cap Garonne mine, France.
7.307 (100), 3.141 (24), 2.818 (24), 4.519 (23), 2.343 (22), 4.277 (18), 3.455 (17)

Chemistry:

	(1)	(2)
CuO	37.53	37.79
Al_2O_3	24.37	24.22
Fe_2O_3	0.72	
As_2O_5	23.52	27.29
SO_3	1.81	
SiO_2	0.65	
H_2O	[11.40]	10.70
Total	100.00	100.00

(1) Cap Garonne mine, France; average of 6 electron microprobe analyses, presence of H_2O and OH^- confirmed by Raman spectroscopy, H_2O by difference; corresponding to $Cu_{1.94}(Al_{1.96}Fe^{3+}_{0.04})_{\Sigma=2.00}(As_{0.84}S_{0.09}Si_{0.04})_{\Sigma=0.97}O_{10}H_{5.19}$. (2) $Cu_2Al_2(AsO_4)(OH,O,H_2O)_6$.

Occurrence: A secondary mineral in the oxidation zone of a hydrothermal sulfide deposit presumably formed under acidic conditions.

Association: Bariopharmacoalumite, cyanotrichite, parnauite, chalcophyllite, mansfieldite (Cap Garonne mine); chalcophyllite, mansfieldite, olivenite, goethite (Salsigne mine).

Distribution: From the Annex S chamber and pillar 44b, Cap Garonne mine, Var, Provence-Alpes-Côte d'Azur and at the Salsigne gold mine, Aude, Languedoc-Roussillon, France.

Name: Honors Jean-Paul Forêt (b. 1943), a retired engineer of the French Ministry of Equipment, and a co-founder of the Musée de la Mine de Cap Garonne.

Type Material: Natural History Museum of Los Angeles County, California, USA (# 63573, 63574, 63575, 63576, 63577); the Museum Victoria, Melbourne, Australia (M51746); and Muséum National d'Histoire Naturelle, Paris, France (# 211.58).

References: (1) Mills, S.J., A.R. Kampf, A.M. McDonald, G. Favreau, and P.-J. Chiappero (2012) Forêtite, a new secondary arsenate mineral from the Cap Garonne mine, France. Mineral. Mag., 76(3), 769-775. (2) (2015) Amer. Mineral., 100, 659-660 (abs. ref. 1).

Foshagite $Ca_4Si_3O_9(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. Crystals elongated along [010], to 5 cm; fibrous and in compact masses.

Physical Properties: *Cleavage:* Distinct on {001}. *Tenacity:* Brittle. Hardness = 3 when massive. D(meas.) = 2.73 D(calc.) = 2.74

Optical Properties: Translucent. *Color:* White; colorless in thin section. *Luster:* Silky. *Optical Class:* Biaxial (+). *Orientation:* Positive elongation, parallel extinction. $\alpha = 1.594$ $\beta = 1.594$ $\gamma = 1.598$ 2V(meas.) = $\sim 60°$

Cell Data: *Space Group:* A-centered. $a = 10.32$ $b = 7.36$ $c = 14.07$ $\beta = 106.4°$ Z = 4

X-ray Powder Pattern: Crestmore, California, USA.
2.92 (vvs), 1.74 (vs,b), 6.8 (ms), 4.95 (ms), 3.37 (ms), 2.30 (ms), 2.16 (ms)

Chemistry:

	(1)	(2)
SiO_2	36.60	42.66
$(Al,Fe)_2O_3$	0.50	
MgO	2.61	
CaO	48.91	53.08
H_2O	8.88	4.26
CO_2	2.67	
Total	100.17	100.00

(1) Crestmore, California, USA. (2) $Ca_4Si_3O_9(OH)_2$.

Occurrence: In thin veins in thermally altered limestone (Crestmore, California, USA; Kilchoan, Scotland) or melilite skarn (Dupezeh Mountain, Iraq).

Association: Hillebrandite, calcite, vesuvianite, garnet, thaumasite (Crestmore, California, USA); merwinite, larnite, kilchoanite (Kilchoan, Scotland); perovskite, grossular, schorlomite, monticellite, wollastonite, phlogopite, spinel, cuspidine, baddeleyite, baghdadite, pyrrhotite, djerfisherite, valleriite (Dupezeh Mountain, Iraq).

Distribution: In the USA, at Crestmore, Riverside Co., California. From near Kilchoan, Ardnamurchan, Argyllshire, Scotland. On Dupezeh Mountain, near Hero Town, Qala-Diza region, Iraq. From the Hatrurim Formation, Israel. At Kushiro, Hiroshima Prefecture, and in the Akagané mine, Iwate Prefecture, Japan. In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For William Frederick Foshag (1894–1956), Curator of the Smithsonian mineral collections, Washington, D.C., USA, who studied Crestmore minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95229.

References: (1) Eakle, A.S. (1925) Foshagite, a new silicate from Crestmore, California. Amer. Mineral., 10, 97–99. (2) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 53–56. (3) Gard, J.A. and H.F.W. Taylor (1958) Foshagite: Composition, unit cell and dehydration. Amer. Mineral., 43, 1–15. (4) Gard, J.A. and H.F.W. Taylor (1960) The crystal structure of foshagite. Acta Cryst., 13, 785–793.

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Foshallassite $Ca_3Si_2O_7 \cdot 3H_2O(?)$

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Crystal Data: Monoclinic or orthorhombic. *Point Group:* n.d. Crystals, scaly and thin plates, tabular on {100} and elongated and striated parallel [001]; as radial and spheroidal aggregates.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = 2.5–3 D(meas.) = 2.5 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Biaxial (–). *Dispersion:* $r < v$. $\alpha = 1.535$ $\beta = 1.542$ $\gamma = 1.549$
2V(meas.) = 12°–18°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SiO_2	32.65	35.09
RE_2O_3	1.89	
CaO	45.45	49.13
Na_2O	0.40	
H_2O^-	0.16	
H_2O		15.78
LOI	16.66	
Total	97.21	100.00

(1) Mt. Yukspor, Russia. (2) $Ca_3Si_2O_7 \cdot 3H_2O$.

Occurrence: In veins.

Association: Calcite, mesolite.

Distribution: On Mt. Yukspor, Khibiny massif, Kola Peninsula, Russia.

Name: For its relation to *foshagite* and "centrallassite" [gyrolite].

Type Material: n.d.

References: (1) Chirvinsky, P. (1936) Foshallasite [*sic*] from the Chibina-tundra [Khibiny massif]. Acad. Sci. USSR, Vernadsky [Vernadskii] Jubilee Volume, 757 (in Russian). (2) (1938) Amer. Mineral., 23, 667 (abs. ref. 1). (3) (1938) Mineral. Abs., 7, 10 (abs. ref. 1). (4) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 50.

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Fourmarierite $Pb(UO_2)_4O_3(OH)_4 \cdot 4H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group: mm*2. Crystals, flattened on {001}, elongated along [010], striated on {001} ‖ [010], showing prominent {001}, {101}, {111}, to 2 mm; in crusts, dense aggregates, and compact masses.

Physical Properties: *Cleavage:* {001}, perfect; {100}, imperfect. Hardness = 3–4 D(meas.) = 6.05, 5.74 D(calc.) = 5.98 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Red-orange to golden red, carmine red, reddish brown to brown; yellow to reddish yellow in transmitted light. *Luster:* Adamantine to subadamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale amber-yellow; Z = amber-yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, strong. *Absorption:* Moderate; $Z > Y > X$. $\alpha = 1.85–1.865$ $\beta = 1.885–1.92$ $\gamma = 1.890–1.97$ 2V(meas.) = 50°–55°

Cell Data: *Space Group: Bb*2_1m. $a = 13.986(4)$ $b = 16.400(5)$ $c = 14.293(9)$ Z = 8

X-ray Powder Pattern: Shinkolobwe, Congo.
3.562 (100), 3.169 (100), 7.12 (80), 3.523 (50), 2.512 (50), 1.975 (50), 2.739 (20)

Chemistry:

	(1)	(2)
UO_3	77.92	77.54
PbO	15.86	15.13
H_2O	6.22	7.33
Total	[100.00]	100.00

(1) Shinkolobwe, Congo; recalculated to 100% after deduction of SiO_2 2.07%.
(2) $Pb(UO_2)_4O_3(OH)_4 \cdot 4H_2O$.

Occurrence: A rare secondary mineral formed as an alteration product of uraninite in the oxide zone of uranium deposits; a common component of "gummite" replacing uraninite; may replace fossil wood.

Association: Uraninite, ianthinite, schoepite, becquerelite, billietite, dewindtite, phosphuranylite, vandendriesscheite, rutherfordine, torbernite, kasolite, curite, goethite.

Distribution: Relatively abundant from Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Morogoro, Uluguru Mountains, Tanzania. From Wölsendorf and Hagendorf, Bavaria, Germany. At Tvedestrand and Krøderen, Norway. From Great Bear Lake, Northwest Territories, and in the Lac Indicateur area, Quebec, Canada. In the USA, from the Palermo mine, near North Groton, Grafton Co., New Hampshire; at Newry, Oxford Co., Maine; in Liepers quarry, Swarthmore, Delaware Co., Pennsylvania; from Spruce Pine, Mitchell Co., North Carolina. In the Monument No. 2 mine, Monument Valley, Apache Co., Arizona; at the Lucky Strike No. 2 mine, San Rafael Swell, Emery Co., Utah; and at Mica Lake, Hahns Peak, Routt Co., and elsewhere in Colorado.

Name: Honors Paul Fourmarier (1877–1970), Belgian geologist, Professor of Geology, University of Liège, Liège, Belgium.

Type Material: University of Liège, Liège, Belgium, 16871 and 16872; Natural History Museum, Paris, France, 124-181.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 628–629. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 87–91. (3) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates. Amer. Mineral., 45, 1026–1061. (4) Deliens, M. (1977) Review of the hydrated oxides of U and Pb, with new X-ray powder data. Mineral. Mag., 41, 51–57. (5) Piret, P. (1985) Structure cristalline de la fourmariérite, $Pb(UO_2)_4O_3(OH)_4 \cdot 4H_2O$. Bull. Minéral., 108, 659–665 (in French with English abs.).

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Fraipontite $(Zn, Al)_3(Si, Al)_2O_5(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* n.d. Fibrous to porcelaneous massive.

Physical Properties: Hardness = 3.5–4 D(meas.) = 3.08–3.10 D(calc.) = 3.44–3.54

Optical Properties: Opaque to translucent. *Color:* Yellowish white to bluish. *Streak:* White to pale green. *Luster:* Silky.
Optical Class: Biaxial (–). $n = 1.61–1.62$ 2V(meas.) = 15°–20°

Cell Data: *Space Group:* n.d. $a = 5.372$ $b = 9.246$ $c = 7.273$ $\beta = 103°33'$ Z = 2

X-ray Powder Pattern: Vieille-Montagne, Belgium.
7.03 (100), 3.53 (70), 2.650 (40), 2.490 (30), 2.385 (30), 1.540 (30), 4.60 (20)

Chemistry:

	(1)	(2)	(3)
SiO_2	20.86	24.8	32.78
Al_2O_3	16.62	17.3	21.71
Fe_2O_3	0.52		
CuO	0.50	5.2	16.80
ZnO	47.04	40.95	14.50
MgO	0.07		0.24
CaO	0.35	0.34	0.37
K_2O			0.08
H_2O^+	13.13	[12.8]	[13.52]
H_2O^-	1.13		
Total	100.22	[101.39]	[100.00]

(1) Vieille-Montagne, Belgium; corresponds to $(Zn_{2.29}Al_{0.66}Cu_{0.03}Mg_{0.01})_{\Sigma=2.99}(Si_{1.37}Al_{0.63})_{\Sigma=2.00}O_5(OH)_{4.01}$. (2) Silver Bill mine, Arizona, USA; by electron microprobe, H_2O by loss on ignition; corresponds to $(Zn_{1.84}Al_{0.77}Cu_{0.24})_{\Sigma=2.85}(Si_{1.51}Al_{0.49})_{\Sigma=2.00}O_5(OH)_4$. (3) Mohawk mine, California, USA; H_2O by difference, corresponds to $(Al_{1.18}Cu_{0.69}Zn_{0.58})_{\Sigma=2.45}(Si_{1.79}Al_{0.21})_{\Sigma=2.00}O_5(OH)_4$.

Mineral Group: Kaolinite-serpentine group.

Occurrence: In oxidized zinc-bearing mineral deposits.

Association: Smithsonite (Vieille-Montagne, Belgium); gebhardite, willemite, cerussite (Tsumeb, Namibia); sauconite (Silver Bill mine, Arizona, USA).

Distribution: Original locality not known with certainty, but thought to be one of the mines of Vieille-Montagne (Altenberg), near Moresnet, Belgium. From Tsumeb, Namibia. At Laurium, Greece. From the Copperthwaite vein, Swaledale, North Yorkshire, England. In the USA, in the Silver Bill mine, Gleeson, Cochise Co., Arizona; the Blanchard mine, Socorro Co., New Mexico; and the Mohawk mine, San Bernardino Co., California. From the Ojuela mine, Mapimí, Durango, Mexico.

Name: To honor Julien Jean Joseph Fraipont (1857–1910), and Charles Fraipont, of Liège, Belgium, both geologists and paleontologists.

Type Material: University of Liège, Liège, Belgium, 13727.

References: (1) Cesàro, G. (1927) Sur la fraipontite, silicate basique hydraté de zinc et d'aluminum. Ann. Soc. Geol. Belgique, 50, 106–110 (in French). (2) (1928) Amer. Mineral., 13, 492 (abs. ref. 1). (3) Fransolet, A.-M. and P. Bourguignon (1975) Données nouvelles sur la fraipontite de Moresnet (Belgique). Bull. Soc. fr. Minéral., 98, 235–244 (in French with English abs.). (4) (1977) Amer. Mineral., 62, 175 (abs. ref. 3). (5) Foord, E.E., J.E. Taggart, and N.M. Conklin (1983) Cuprian fraipontite and sauconite from the Defiance-Silver Bill mines, Gleeson, Arizona. Mineral. Record, 14, 131–132. (6) Wise, W.S. (1990) The mineralogy of the Mohawk mine, San Bernardino Co., California. San Bernardino Co. Mus. Assoc. Quarterly, 37(1), 31 pp.

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Francevillite $(Ba,Pb)(UO_2)_2(V_2O_8)\cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Commonly as crystals, dominantly {111}, rare {100}, {010}, a few other forms, to 8 mm, in aggregates and crusts. Also massive, in veinlets and as impregnations.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 3 D(meas.) = 4.55 D(calc.) = [4.56] Radioactive.

Optical Properties: Semitransparent. *Color:* Lemon-yellow, yellow-orange, orange, greenish yellow; green, brown.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.750(5)$ $\beta = 1.910(5)$ $\gamma = 1.945(5)$ 2V(meas.) = n.d. 2V(calc.) = 46(2)°

Cell Data: *Space Group:* $Pcan$. $a = 10.419(1)$ $b = 8.510(1)$ $c = 16.763(2)$ Z = 4

X-ray Powder Pattern: Mounana mine, Gabon.
8.30 (10), 2.98 (8), 4.17 (6), 2.57 (6), 2.10 (5), 3.27 (4), 2.01 (4)

Chemistry:

	(1)
UO_3	56.70
V_2O_5	18.56
PbO	2.05
BaO	13.90
H_2O	8.85
Total	100.06

(1) Mounana mine, Gabon; corresponds to $(Ba_{0.92}Pb_{0.09})_{\Sigma=1.01}(UO_2)_{2.00}(V_2O_8)_{1.03}\cdot 4.96H_2O$.

Polymorphism & Series: Forms a series with curienite.

Occurrence: In the oxidized zone of a Pb-bearing U–V deposit (Mounana mine, Gabon).

Association: Curienite, duttonite, vanuralite, chervetite, mottramite, carnotite, dewindtite, torbernite, uranopilite, johannite, kasolite (Mounana mine, Gabon).

Distribution: Exceptional crystals from the Mounana uranium mine, Franceville, Gabon. At Kambove and in the Musonoi mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). On the southwest edge of the Chimeja Range, about four km north of Lubimbi Spring, Zimbabwe. From Bertholène and Lussagues, Aveyron, and Saint-Pierre, Cantal, France. In Germany, on the Donnersberg, near Imsbach, Rhineland-Palatinate; in the Black Forest, at Nussbach, near Triberg, and from the Clara mine, near Oberwolfach. In the South Terras mine, St. Stephen-in-Brannel, Cornwall, England. At the Tyuya-Muyun Cave, Fergana Valley, Alai Range, Kyrgyzstan. From the Otish Mountains, Quebec, Canada. In the USA, at Jim Thorpe, Carbon Co., Pennsylvania.

Name: For its original occurrence near Franceville, Gabon.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1958,597.

References: (1) Branche, G., M.-E. Ropert, F. Chantret, B. Morignat, and R. Pouget (1957) La francevillite, nouveau minéral uranifère. Compt. Rendus Acad. Sci. Paris, 245, 89–91 (in French). (2) (1958) Amer. Mineral., 43, 180 (abs. ref. 1). (3) Cesbron, F. and N. Morin (1968) Une nouvelle espèce minérale: la curiénite. Étude de la série francevillite-curiénite. Bull. Minéral., 91, 453–459 (in French with English abs.). (4) Mereiter, K. (1986) Crystal structure refinements of two francevillites, $(Ba,Pb)[(UO_2)_2V_2O_8]\cdot 5H_2O$. Neues Jahrb. Mineral., Monatsh., 552–560.

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Franciscanite $\mathbf{Mn_3^{2+}V_{1-x}^{5+}(SiO_4)(O,OH)_3}$ (x = 0.5)

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Crystal Data: Hexagonal. *Point Group:* 3. As irregular grains to 1.0 mm.

Physical Properties: *Fracture:* Uneven. Hardness = ∼4 D(meas.) = 4.1(3) D(calc.) = 3.97 May be weakly magnetic, possibly resulting from tiny opaque inclusions.

Optical Properties: Transparent. *Color:* Cherry-red when fresh, darkening to brownish red with exposure. *Streak:* Brownish red. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* Strong; O = wine-red; E = dark red to nearly black. *Absorption:* Intense; $E > O$. $\omega = 1.856(3)$ $\epsilon = 1.882(3)$

Cell Data: *Space Group:* $P3$. $a = 8.1518(3)$ $c = 4.8091(2)$ Z = 2

X-ray Powder Pattern: Pennsylvania mine, California, USA.
2.331 (100), 3.105 (90), 2.844 (90), 1.785 (70), 1.538 (50), 2.668 (40), 3.97 (30)

Chemistry:

	(1)
SiO_2	18.4
Fe_2O_3	0.0
Al_2O_3	0.0
WO_3	0.0
Sb_2O_5	0.0
As_2O_5	0.0
V_2O_5	13.5
MnO	64.9
MgO	0.0
H_2O	[3.4]
Total	[100.2]

(1) Pennsylvania mine, California, USA; by electron microprobe, H_2O by analogy to welinite; corresponds to $Mn_{2.98}V_{0.49}(SiO_4)(O,OH)_{\sim 3}$.

Occurrence: As sparse, irregular segregations within a sheared sonolite-bearing assemblage in chert.

Association: Sonolite, hausmannite, braunite, gageite.

Distribution: From the Pennsylvania mine, San Antonio Valley, Santa Clara Co., California, USA.

Name: For the Franciscan complex of California, USA, where it was found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163041.

References: (1) Dunn, P.J., D.R. Peacor, R.C. Erd, and R.A. Ramik (1986) Franciscanite and örebroite, two new minerals from California and Sweden, related to redefined welinite. Amer. Mineral., 71, 1522–1526. (2) Pertlik, F. (1986) The crystal structure of franciscanite, $Mn_3(V_x\square_{1-x})(SiO_4)(O,OH)_3$, [x ≅ 0.5]. Neues Jahrb. Mineral., Monatsh., 493–499.

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Francisite $Cu_3BiO_2(Se^{4+}O_3)_2Cl$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As bladed crystals, elongated along [010], with dominant forms {100}, {011}, and {101}, to 0.25 mm; in divergent sprays. *Twinning:* Contact twins on {100}.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3–4 D(meas.) = n.d. D(calc.) = 5.42

Optical Properties: Semitransparent. *Color:* Bright apple-green. *Streak:* Pale apple-green. *Luster:* Adamantine.
Optical Class: [Biaxial.] *Pleochroism:* Distinct, from pale green to bright green ∥ [010].
Orientation: Length-slow. $\alpha = > 1.79$ $\beta = > 1.79$ $\gamma = > 1.79$ 2V(meas.) = n.d.

Cell Data: *Space Group: Pmmn.* $a = 6.354(1)$ $b = 9.630(1)$ $c = 7.220(2)$ $Z = 2$

X-ray Powder Pattern: Iron Monarch quarry, Australia.
3.39 (100), 2.866 (80), 2.652 (70), 5.31 (60), 2.491 (60), 1.588 (60), 1.695 (35)

Chemistry:

	(1)	(2)
SeO_2	27.23	30.78
Bi_2O_3	35.75	32.31
CuO	32.62	33.10
Cl	4.11	4.92
$-O = Cl_2$	0.93	1.11
Total	98.78	100.00

(1) Iron Monarch quarry, Australia; by electron microprobe, average of seven analyses, absence of $(OH)^{1-}$ and H_2O and presence of $(SeO_3)^{2-}$ confirmed by IR; corresponds to $Cu_{3.10}Bi_{1.16}O_{2.12}(Se_{0.93}O_3)_2Cl_{0.88}$. (2) $Cu_3BiO_2(SeO_3)_2Cl$.

Occurrence: A rare secondary mineral in an oxidized barite lens in Precambrian sedimentary iron formation.

Association: Chorargyrite, muscovite, naumannite, bismuth, djurleite, Cu–Bi–Ag selenides, barite.

Distribution: From the Iron Monarch quarry, Iron Knob, South Australia. At the Baccu Locci mine, near Villaputzu, Sarrabus district, Sardinia, Italy.

Name: Honors Glyn Francis (1939–), Quality Control Officer at the Iron Monarch quarry, Australia, who collected the first specimen.

Type Material: South Australian Museum, Adelaide, G16415; The Museum of Victoria, Melbourne, Australia, M39650.

References: (1) Pring, A., B.M. Gatehouse, and W.D. Birch (1990) Francisite, $Cu_3Bi(SeO_3)_2O_2Cl$, a new mineral from Iron Monarch, South Australia: description and crystal structure. Amer. Mineral., 75, 1421–1425.

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Franckeite $\mathbf{(Pb, Sn^{2+})_6Fe^{2+}Sn_2^{4+}Sb_2^{3+}S_{14}}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Thin crystals, tabular on {010}; elongated ‖ [100], to 6 cm, striated on {010}, may be warped or bent; typically in spherical, rosette- or cauliflowerlike aggregates of thin plates; commonly massive, radiated, or foliated. *Twinning:* Complex twinning has been observed.

Physical Properties: *Cleavage:* {010}, perfect. *Tenacity:* Flexible, inelastic; slightly malleable. Hardness = 2.5–3. VHN = n.d. D(meas.) = 5.88–5.92 D(calc.) = 5.88

Optical Properties: Opaque. *Color:* Grayish black. *Streak:* Grayish black. *Luster:* Metallic. *Anisotropism:* Weak.
R_1–R_2: (400) 38.2–39.4, (420) 37.9–39.2, (440) 37.6–39.0, (460) 37.3–38.7, (480) 36.9–38.5, (500) 36.6–38.2, (520) 36.2–37.9, (540) 35.8–37.6, (560) 35.4–37.3, (580) 35.0–36.9, (600) 34.6–36.5, (620) 34.2–36.1, (640) 33.8–35.7, (660) 33.4–35.3, (680) 33.0–34.9, (700) 32.6–34.5

Cell Data: *Space Group:* $P\overline{1}$ with pseudohexagonal $a = 17.2$ $b = 3.65$ $c = 6.30$ $\alpha = 91.3°$ $\beta = 96.2°$ $\gamma = 88.6°$ and pseudotetragonal $a = 17.2$ $b = 5.79$ $c = 5.82$ $\alpha = 91.4°$ $\beta = 95.5°$ $\gamma = 88.2°$

X-ray Powder Pattern: Bolivia.
3.44 (100), 2.91 (100), 2.86 (100), 2.82 (100), 2.05 (75), 4.30 (50), 3.11 (50)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Pb	50.57	46.23	48.40	Sn	12.34	17.05	16.64
Fe	2.48	2.69	2.61	Sb	10.51	11.56	11.38
Zn	1.22	0.57		S	21.04	21.12	20.97
Ag		0.97		rem.	0.71		
				Total	98.87	100.19	100.00

(1) Chocaya, Bolivia. (2) Poopó, Bolivia. (3) $Pb_5FeSn_3Sb_2S_{14}$.

Occurrence: In hydrothermal Ag–Sn deposits (Bolivia); in a limestone contact metamorphic deposit (Kalkar quarry, California, USA).

Association: Cylindrite, teallite, plagionite, zinkenite, cassiterite, wurtzite, pyrrhotite, marcasite, arsenopyrite, galena, pyrite, sphalerite, siderite (Bolivia); cassiterite, galena, stannite, teallite, cylindrite (Russia).

Distribution: In Bolivia, from Chocaya [TL], Poopó, Oruro, Llallagua, Huanuni, Colquechaca, and Cerro Rico, Potosí. At the Pirquitas mine, Jujuy Province, Argentina. In the Thompson mine, Darwin district, Inyo Co., and the Kalkar quarry, Santa Cruz, Santa Cruz Co., California, USA. From near the headwaters of the east branch of the Coal River, Yukon Territory, Canada. At Vens Haut, Cantal, France. In the Sinantscha zinc deposit, Sichota-Alin, and from Smirnowsk, Transbaikalia, Russia. At the Changpo-Tongkeng tin deposit, Dachang district, Guangxi Autonomous Region, China. From the Hoei tin mine, Oita Prefecture, Japan. At the Renison Bell mine, Tasmania, and the Wallah Wallah mine, Rye Park, New South Wales, Australia.

Name: For the mining engineers Carl and Ernest Francke.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 448–450. (2) Coulon, M., F. Heitz, and M.T. Le Bihan (1961) Contribution à l'étude structurale d'un sulfure de plomb, d'antimoine et d'étain: la frankeite [*sic*]. Bull. Soc. fr. Minéral., 84, 350–354 (in French). (3) Moh, G. (1987) Mutual Pb^{2+}/Sn^{2+} substitution in sulfosalts. Mineral. Petrol., 36, 191–204. (4) Williams, T.B. and B.G. Hyde (1988) Electron microscopy of cylindrite and franckeite. Phys. Chem. Minerals, 15, 521–544. (5) Wang, S. and K.H. Kuo (1991) Crystal lattices and crystal chemistry of cylindrite and franckeite. Acta Cryst., A47, 381–392. (6) Wang, S., P. Buseck, and J. Liu (1995) High-angle annular dark-field microscopy of franckeite. Amer. Mineral., 1174–1178. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 175.

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Francoanellite $(K,Na)_3(Al,Fe^{3+})_5(PO_4)_2(PO_3OH)_6 \cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $3m$. Minute thin pseudohexagonal plates, in nodular aggregates, to 0.2 mm; earthy or powdery to claylike pulverulent masses.

Physical Properties: *Tenacity:* Unctuous. Hardness = Very soft. D(meas.) = 2.26(2) D(calc.) = 2.295

Optical Properties: Semitransparent. *Color:* Yellowish white; colorless in transmitted light. *Optical Class:* Uniaxial (+). $\omega = 1.510(2)$ $\epsilon = 1.515(2)$

Cell Data: *Space Group:* $R\overline{3}c$ or $R3c$ (synthetic). $a = 8.692$–8.702 $c = 82.413$–82.443 Z = 6

X-ray Powder Pattern: Castellana Cave, Italy.
13.83 (100), 3.40 (65), 2.799 (62), 7.44 (60), 2.773 (51), 6.86 (50), 5.57 (37)

Chemistry:

	(1)	(2)
P_2O_5	45.23	46.00
Al_2O_3	18.32	20.65
Fe_2O_3	2.84	
CaO	trace	
Na_2O	0.98	
K_2O	9.79	11.45
$(NH_4)_2O$	trace	
H_2O	22.84	21.90
Total	[100.00]	100.00

(1) Castellana Cave, Italy; average of two analyses totaling 99.64% and 99.42%, recalculated to 100%; K, Na, and Fe by flame photometry, H_2O by the Penfield method; corresponds to $H_6(K_{2.6}Na_{0.4})_{\Sigma=3.0}(Al_{4.55}Fe_{0.45})_{\Sigma=5.00}(PO_4)_8 \cdot 13H_2O$. (2) $K_3Al_5(PO_4)_2(PO_3OH)_6 \cdot 12H_2O$.

Occurrence: An alteration product probably formed by reaction between bat guano and clay minerals (Castellana Cave, Italy); in soils developed on granite debris and bat guano mixtures, by reaction of phosphate-rich sea mist with clay minerals (Farallon Islands, USA).

Association: Taranakite (Castellana Cave, Italy); taranakite, hydroxylapatite, brushite (Little Swallow Cave, Italy); alunite, aragonite, berlinite, collophane, crandallite, gypsum, huntite, hydromagnesite, leucophosphite, nesquehonite, niter, nitrocalcite (Paddy's River mine, Australia).

Distribution: In Italy, in Puglia, from the Castellana Cave, about 40 km southeast of Bari, and in the Little Swallow Cave, near Polignaro a mare. In Australia, at the Paddy's River mine, Australian Capital Territory. Above Rabbit Cave, Farallon Islands, about 48 km west of San Francisco Co., California, USA.

Name: Honoring Franco Anelli, formerly Professor of Geography, University of Bari, Bari, Italy, who found the Castellana caves.

Type Material: Mineralogical Museum, University of Bari, Bari, Italy; National School of Mines, Paris, France.

References: (1) Balenzano, F., L. Dell'Anna, and M. Di Pierro (1976) Francoanellite, $H_6K_3Al_5(PO_4)_8 \cdot 13H_2O$, a new mineral from the caves of Castellana, Puglia, southern Italy. Neues Jahrb. Mineral., Monatsh., 49–57. (2) (1976) Amer. Mineral., 61, 1054 (abs. ref. 1). (3) Balenzano, F., L. Dell'Anna, and M. Di Pierro (1979) Francoanellite from the "Grotta della Rondinella" (Little Swallow cave) in Apulia (southern Italy): a new occurrence and new data. Neues Jahrb. Mineral., Monatsh., 363–372. (4) Dick, S. and T. Zeiske (1998) Francoanellite $K_3Al_5(HPO_4)_6(PO_4)_2 \cdot 12H_2O$: structure and synthesis by topochemical dehydration of taranakite. Zeits. Naturforsch, 53b, 711–719 (in German with English abs.). (5) (1999) Amer. Mineral., 84, 688 (abs. ref. 4). (6) Smith, J.P. and W.E. Brown (1959) X-ray studies of aluminum and iron phosphates containing potassium or ammonium. Amer. Mineral., 44, 138–142.

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Françoisite-(Nd) $(Nd, Y, Sm, Ce)(UO_2)_3O(PO_4)_2(OH)\cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are platy {010}, elongated along [001], to 0.3 mm, in aggregates. *Twinning:* By reflection across {100}.

Physical Properties: *Cleavage:* On {010}, good. *Fracture:* Uneven. Hardness = 3
D(meas.) = > 4.06 D(calc.) = 4.63 Radioactive.

Optical Properties: Translucent to opaque. *Color:* Yellow. *Streak:* White.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y \wedge c = 14.5°$; $Z \wedge a = 8.3°$. $\alpha = [1.65]$
$\beta = 1.74(1)$ $\gamma = 1.75(1)$ 2V(meas.) = 35°

Cell Data: *Space Group:* $P2_1/c$. $a = 9.298(2)$ $b = 15.605(4)$ $c = 13.668(2)$
$\beta = 112.77(1)°$ Z = 4

X-ray Powder Pattern: Kamoto-East mine, Congo.
7.79 (100), 5.76 (50), 3.88 (50B), 3.13 (50), 4.44 (40), 4.33 (40), 2.874 (40)

Chemistry:

	(1)	(2)
UO_3	69.29	68.96
P_2O_5	10.45	10.54
Al_2O_3		0.21
Y_2O_3	1.57	n.d.
La_2O_3	0.73	0.99
Ce_2O_3	1.03	3.52
Pr_2O_3	0.95	1.04
Nd_2O_3	4.74	3.61
Sm_2O_3	1.65	0.72
Dy_2O_3	0.81	
PbO		2.55
H_2O	8.78	[7.86]
Total	[100.00]	[100.00]

(1) Kamoto-East mine, Congo; by electron microprobe, H_2O by gas chromatography; average of ten analyses, recalculated to 100% from original total of 97.13%; corresponds to $(Nd_{0.18}Y_{0.09}Sm_{0.06}Ce_{0.04}Pr_{0.04}La_{0.03}Dy_{0.03})_{\Sigma=0.47}(UO_2)_{3.15}O(PO_4)_{1.92}(OH)\cdot 6.34H_2O$. (2) Bangombé, Gabon; by electron microprobe, H_2O by difference; corresponds to $(Nd_{0.28}Ce_{0.28}Pb_{0.15}Pr_{0.08}La_{0.08}Sm_{0.05}Al_{0.05}Dy_{0.03})_{\Sigma=1.00}(UO_2)_{3.11}O(PO_4)_{1.92}(OH)\cdot 6H_2O$.

Occurrence: A rare alteration product of uraninite in a sedimentary Cu–Co deposit (Kamoto-East mine, Congo).

Association: Uraninite, schoepite, uranophane, curite, schuilingite-(Nd), kamotoite-(Y), astrocyanite-(Ce), masuyite (Kamoto-East mine, Congo).

Distribution: From the Kamoto-East Cu–Co mine, five km east of Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). At the Bangombé natural fission reactor, Gabon.

Name: To honor Dr. Armand François (1922–), former Director of Geology for Gécamine (the national mining company), and for its dominant *neodymium* content.

Type Material: Royal Institute of Natural Sciences, Brussels, Belgium, RC3512.

References: (1) Piret, P., M. Deliens, and J. Piret-Meunier (1988) La françoisite-(Nd), nouveau phosphate d'uranyle et de terres rares; propriétés et structure cristalline. Bull. Minéral., 111, 443–449 (in French with English abs.). (2) (1990) Amer. Mineral., 75, 241 (abs. ref. 1). (3) Janeczek, J. and R. Ewing (1996) Phosphatian coffinite with rare earth elements and Ce-rich françoisite-(Nd) from sandstone beneath a natural fission reactor at Bangombé, Gabon. Mineral. Mag., 60, 665–669.

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Franconite $Na_2Nb_4O_{11}\cdot 9H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. In bladed to highly elongated crystals with curved faces; in globules composed of radiating crystals, to 2 mm; aggregated in groups.

Physical Properties: *Cleavage:* Basal, parting. Hardness = n.d. D(meas.) = 2.72(1) D(calc.) = 2.74–2.84 Dehydrates, reversibly; fluoresces pale yellow under LW UV, more intensely under SW UV.

Optical Properties: Transparent to opaque. *Color:* White, colorless, grayish blue. *Streak:* White. *Luster:* Vitreous to adamantine, silky on fractures. *Optical Class:* Biaxial (–). *Orientation:* $X \perp$ plane of blades; $Y \perp$ elongation; $Z \parallel$ elongation. $\alpha = 1.72(1)$ $\beta = [1.78(1)]$ $\gamma = 1.79(1)$ 2V(meas.) = 35(5)°

Cell Data: *Space Group:* n.d. $a = 22.22(1)$ $b = 12.857(5)$ $c = 6.359(4)$ $\beta = 92.24(6)°$ Z = 4

X-ray Powder Pattern: Francon quarry, Canada.
11.0 (10), 5.55 (7), 4.73 (6), 3.18 (6), 4.21 (5), 3.21 (5), 2.626 (5)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	75.4	76.2	70.35
SiO_2	0.5		
TiO_2	0.9	0.3	
Al_2O_3	0.0		
CaO	0.7	0.4	
SrO	0.0		
Na_2O	8.5	9.2	8.20
H_2O	[14.0]	13.8	21.45
Total	[100.0]	99.9	100.00

(1) Francon quarry, Canada; by electron microprobe, H_2O by difference, originally given as 13.0%; using H_2O 21%–22% as confirmed by mass spectrometry, corresponds to $(Na_{1.82}Ca_{0.08})_{\Sigma=1.90}(Nb_{3.76}Si_{0.17}Ti_{0.08})_{\Sigma=4.01}O_{11}\cdot 9H_2O$. (2) Vishnevogorsk complex, Russia; by electron microprobe, average of three analyses, H_2O taken as LOI; corresponds to $(Na_{2.03}Ca_{0.09})_{\Sigma=2.12}(Nb_{3.92}Si_{0.10})_{\Sigma=4.02}O_{11}\cdot 9.6H_2O$. (3) $Na_2Nb_4O_{11}\cdot 9H_2O$.

Occurrence: In vugs of a dawsonite-bearing sill in a limestone deposit (Francon quarry, Canada); in cavities in altered pegmatite dikes, hornfels, sodalite syenite, or miarolitic cavities, associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Hochelagaite, weloganite, calcite, quartz (Francon quarry, Canada); burbankite, muscovite, albite, microcline, chlorite, calcite, strontianite, natrolite (Vishnevogorsk complex, Russia).

Distribution: In the Francon quarry, Montreal Island, Montreal, at Mont Saint-Hilaire, and near Saint-Amable, Quebec, Canada. In the Vishnevogorsk alkalic complex, Vishnevy-Ilmen Mountains, Southern Ural Mountains, Russia.

Name: For the Francon quarry, Montreal, Canada, where it was first found.

Type Material: Geological Survey of Canada, Ottawa, 62094, 63748–63750; Royal Ontario Museum, Toronto, Canada, M39041.

References: (1) Jambor, J.L., A.P. Sabina, A.C. Roberts, M. Bonardi, R.A. Ramik, and B.D. Sturman (1984) Franconite, a new hydrated Na–Nb oxide mineral from Montreal Island, Quebec. Can. Mineral., 22, 239–243. (2) (1985) Amer. Mineral., 70, 436–437 (abs. ref. 1). (3) Jambor, J.L., A.P. Sabina, A.C. Roberts, M. Bonardi, D.R. Owens, and B.D. Sturman (1986) Hochelagaite, a new calcium-niobium oxide mineral from Montreal, Quebec. Can. Mineral., 24, 449–453. (4) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 310. (5) Nikandrov, S.N. (1990) Franconite, first find in the USSR. Doklady Acad. Nauk SSSR, 305, 700–703 (in Russian).

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Frankdicksonite BaF_2

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. Crystals, to 4 mm, are euhedral cubes.

Physical Properties: *Cleavage:* Perfect on {111}. Hardness = ∼2.5 VHN = 88–94, 90 average (100 g load). D(meas.) = 4.89(1) D(calc.) = 4.885 Strong blue cathodoluminescence.

Optical Properties: Transparent. *Color:* [Colorless.] *Luster:* Vitreous. *Optical Class:* Isotropic. $n = 1.475(1)$

Cell Data: *Space Group:* $Fm3m$. $a = 6.1964(2)$ $Z = 4$

X-ray Powder Pattern: Carlin mine, Nevada, USA.
3.581 (100), 2.191 (56), 1.870 (47), 3.099 (21), 1.422 (20), 1.266 (20), 1.047 (14)

Chemistry:

	(1)
Ca	0.00
Sr	0.24
Ba	77.98
F	21.41
Total	99.63

(1) Carlin mine, Nevada, USA; by electron microprobe, average of three analyses; corresponds to $Ba_{1.00}F_{2.00}$.

Occurrence: Of hydrothermal origin, encased in quartz veinlets cutting a gold deposit in silicified carbonaceous arsenic-rich limestone.

Association: Quartz.

Distribution: From the Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co., Nevada, USA.

Name: To honor Dr. Frank Wilson Dickson (1922–), Professor of Geochemistry, Stanford University, Palo Alto, California, USA, for his work on low-temperature ore deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 133958.

References: (1) Radtke, A.S. and G.E. Brown (1974) Frankdicksonite, BaF_2, a new mineral from Nevada. Amer. Mineral., 59, 885–888.

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Frankhawthorneite $Cu_2(Te^{6+}O_4)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As stubby crystals, bladed on {010} and prismatic on [001], to 0.1 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–4
D(meas.) = n.d. D(calc.) = 5.43

Optical Properties: Transparent. *Color:* Medium leaf-green; pale gray in reflected light, with viridian-green internal reflections. *Streak:* Pale leaf-green. *Luster:* Vitreous.
Optical Class: [Biaxial.] n = [2.00] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.
Anisotropism: Weak, somber brown. *Bireflectance:* Weak.
R_1–R_2: (400) 12.6–14.2, (420) 12.3–13.7, (440) 12.0–13.3, (460) 11.7–12.9, (480) 11.4–12.6, (500) 11.2–12.4, (520) 11.0–12.2, (540) 10.9–12.0, (560) 10.7–11.9, (580) 10.6–11.7, (600) 10.5–11.6, (620) 10.4–11.4, (640) 10.3–11.3, (660) 10.2–11.2, (680) 10.1–11.2, (700) 10.1–11.2

Cell Data: *Space Group:* $P2_1/n$. $a = 9.107(4)$ $b = 5.213(1)$ $c = 4.605(2)$ $\beta = 98.74(3)^\circ$
$Z = 2$

X-ray Powder Pattern: Centennial Eureka mine, Utah, USA.
2.598 (100), 2.891 (70), 4.337 (60), 3.838 (50), 4.506 (40), 1.834 (40), 1.713 (40)

Chemistry:

	(1)	(2)
TeO_3	48.77	49.79
CuO	45.20	45.10
H_2O	[5.05]	5.11
Total	[99.02]	100.00

(1) Centennial Eureka mine, Utah, USA; by electron microprobe, average of five analyses, H_2O calculated, presence of $(OH)^{1-}$ confirmed by IR and crystal-structure analysis; corresponds to $Cu_{2.03}(Te_{0.99}O_4)(OH)_2$. (2) $Cu_2(TeO_4)(OH)_2$.

Occurrence: A very rare secondary mineral formed by the oxidization of primary Cu–Te-bearing sulfides.

Association: Mcalpineite, hematite, acanthite, chrysocolla, connellite, enargite, hinsdalite–svanbergite, pyrite, quartz.

Distribution: From the dumps of the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: Honors Frank Christopher Hawthorne (1946–), Professor of Crystallography and Mineralogy, University of Manitoba, Winnipeg, Canada, who has determined the crystal structures of many copper minerals.

Type Material: Canadian Geological Survey, Ottawa, Canada, 67263.

References: (1) Roberts, A.C., J.D. Grice, A.J. Criddle, M.C. Jensen, D.C. Harris, and E.A. Moffatt (1995) Frankhawthorneite, $Cu_2Te^{6+}O_4(OH)_2$, a new mineral species from the Centennial Eureka mine, Tintic District, Juab County, Utah. Can. Mineral., 33, 641–647. (2) Grice, J.D. and A.C. Roberts (1995) Frankhawthorneite, a unique HCP framework structure of a cupric tellurate. Can. Mineral., 33, 649–653. (3) (1996) Amer. Mineral., 81, 516–517 (abs. refs. 1 and 2).

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Franklinfurnaceite $Ca_2(Fe^{3+},Al)Mn^{3+}Mn^{2+}_3Zn_2Si_2O_{10}(OH)_8$

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Crystal Data: Monoclinic. *Point Group:* 2. As very thin, platy crystals, tabular on {001}, to 0.3 mm, with dominant {001} showing serrated edges; as polycrystalline aggregates of subparallel individuals.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Extremely brittle. Hardness = 3 D(meas.) = 3.66 D(calc.) = 3.737

Optical Properties: Translucent. *Color:* Dark brown; in thin section, brown to very dark brown. *Streak:* Brown. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Intense; X = very dark brown; Y = brown; Z = deep brown. *Orientation:* $Z = b$; $Y \wedge c = 29°$. *Dispersion:* $r < v$, moderate. *Absorption:* Strong; $X \gg Z > Y$. $\alpha = 1.792(4)$ $\beta = 1.798(4)$ $\gamma = 1.802(4)$ 2V(meas.) = 79° 2V(calc.) = 78.5°

Cell Data: *Space Group:* $C2$. $a = 5.483(7)$ $b = 9.39(3)$ $c = 14.51(1)$ $\beta = 97.04(8)°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.305 (100), 2.707 (80b), 2.602 (70b), 14.4 (50), 3.35 (50), 3.60 (40), 3.20 (40)

Chemistry:

	(1)	(2)
SiO_2	14.5	15.0
Al_2O_3	0.8	0.4
Fe_2O_3	9.4	9.3
Mn_2O_3	9.5	10.6
MnO	17.0	19.0
ZnO	22.7	24.1
MgO	3.6	0.6
CaO	14.3	12.6
H_2O	[8.2]	8.4
Total	[100.0]	100.0

(1) Franklin, New Jersey, USA; by electron microprobe, Fe_2O_3 shown present by microchemical tests, Mn^{2+}:Mn^{3+} from crystal structure, H_2O by difference; corresponds to $Ca_2(Fe^{3+}_{0.76}Al_{0.24})_{\Sigma=1.00}(Mn^{3+}_{0.97}Mg_{0.03})_{\Sigma=1.00}(Mn^{2+}_{0.54}Mg_{0.28}Zn_{0.18})_{\Sigma=2.00}Zn_2Si_2O_{10}(OH)_8$.
(2) Do; H_2O by TGA, corresponds to $Ca_{1.88}(Fe^{3+}_{0.97}Al_{0.06})_{\Sigma=1.03}Mn^{3+}_{1.12}Mn^{2+}_{2.24}Mg_{0.12}Zn_{2.47}Si_{2.08}O_{10.22}(OH)_{7.78}$.

Occurrence: A late-stage mineral in vugs in a metamorphosed stratiform zinc deposit.

Association: Willemite, clinohedrite, hodgkinsonite, hetaerolite, franklinite, barite, rhodonite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: After Franklin Furnace, the former name for Franklin, New Jersey, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, C6309, R19144.

References: (1) Dunn, P.J., D.R. Peacor, R.A. Ramik, S.-C. Su, and R.C. Rouse (1987) Franklinfurnaceite, a Ca–Fe^{3+}–Mn^{3+}–Mn^{2+} zincosilicate isotypic with chlorite, from Franklin, New Jersey. Amer. Mineral., 72, 812–815. (2) Peacor, D.R., R.C. Rouse, and S.W. Bailey (1988) Crystal structure of franklinfurnaceite: a tri-dioctahedral zincosilicate intermediate between chlorite and mica. Amer. Mineral., 73, 876–887.

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Franklinite $(Zn, Mn^{2+}, Fe^{2+})(Fe^{3+}, Mn^{3+})_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. Typically as octahedra, commonly with rounded edges, to 22 cm; may be modified by {011}, {001}, rare {013}, {051}, others. Also exsolved within other minerals; coarse to fine granular, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law, common.

Physical Properties: *Cleavage:* Parting on {111}, fair. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = ∼6 VHN = 852–882 (100 g load). D(meas.) = 5.05–5.22 D(calc.) = 5.163 Strongly to weakly magnetic.

Optical Properties: Opaque, translucent in fine fragments. *Color:* Iron-black, brown, red, may be tarnished; in reflected light, white to gray, with dark red internal reflections. *Streak:* Reddish brown to black. *Luster:* Metallic to semimetallic; may be dull.
Optical Class: Isotropic. $n = 2.36(2)$ (Li).
R: (400) 19.2, (420) 19.2, (440) 19.2, (460) 19.2, (480) 19.2, (500) 19.1, (520) 19.0, (540) 18.6, (560) 18.2, (580) 17.8, (600) 17.4, (620) 17.1, (640) 16.8, (660) 16.6, (680) 16.4, (700) 16.3

Cell Data: *Space Group: Fd3m.* a = 8.43–8.474 Z = 8

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.55 (100), 1.499 (80), 2.99 (70), 1.632 (70), 1.104 (50), 0.978 (50), 2.12 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.72			MnO	9.96	6.6	0.6
TiO_2			0.7	ZnO	20.77	26.2	30.25
Al_2O_3		0.3	1.25	MgO	0.34	0.3	
Fe_2O_3	66.58	66.7	63.9	CaO	0.43		
FeO			3.6	H_2O	0.71		
				Total	99.51	100.1	100.3

(1) New Jersey, USA; total Fe as Fe^{3+}. (2) Do.; by electron microprobe, average of five analyses, total Fe as Fe_2O_3. (3) Långban, Sweden; by electron microprobe, average of four analyses, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Zn_{0.88}Fe^{2+}_{0.12})_{\Sigma=1.00}(Fe^{3+}_{1.90}Al_{0.06}Mn^{2+}_{0.02}Ti_{0.02})_{\Sigma=2.00}O_4$.

Mineral Group: Spinel group.

Occurrence: In beds and veins formed by high-temperature metamorphism of Fe, Zn, Mn-rich marine carbonate sediments. As a minor mineral in some manganese and iron deposits.

Association: Zincite, willemite, calcite, andradite, manganosite, rhodochrosite, gahnite, magnetite, rhodonite, hausmannite, hetaerolite, jacobsite, braunite, sarkinite, berzeliite, hematite.

Distribution: From Franklin and at Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. Found at Långban, Värmland, Sweden. Occurs at Hraničná, Czech Republic. In Kazakhstan, from Nayzatas, Dzhumart, and in the Ushkatyn deposits, Atasui area. At the Pereval marble quarry, near Slyudyanka, Sayan Mountains, south of Lake Baikal, Siberia, Russia. From the Koduru manganese mine, Srikakulam district, Andhra Pradesh, India. At the Bonnie prospect, near Mukinbudin, Western Australia.

Name: Named for Franklin Furnace (now Franklin), New Jersey, USA; and in honor of the American statesman, philosopher and inventor Benjamin Franklin (1706–1790).

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 698–707. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 193. (3) Burke, E.A.J. and C. Kieft (1972) Franklinite from Langban, Sweden: a new occurrence. Lithos, 5, 69–72. (4) Shirakashi, T. and T. Kubo (1979) Cation distribution in franklinite by nuclear magnetic resonance. Amer. Mineral., 64, 599–603. (5) O'Neill, H.St.C. (1992) Temperature dependence of the cation distribution in zinc ferrite ($ZnFe_2O_4$) from powder XRD structural refinements. Eur. J. Mineral., 4, 571–580. (6) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 566–578.

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Franklinphilite

$(K,Na)_4(Mn^{2+},Mg,Zn)_{48}(Si,Al)_{72}(O,OH)_{216}\cdot 6H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* 1 or $\overline{1}$. Platy crystals, to 0.5 mm, in very fine-grained tangled radial aggregates.

Physical Properties: *Cleavage:* Imperfect on {001}. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 2.6–2.8 D(calc.) = 2.66

Optical Properties: Translucent to nearly opaque; transparent to translucent in thin section. *Color:* Very dark brown to black. *Streak:* Light brown. *Luster:* Vitreous to slightly resinous. *Optical Class:* Biaxial (–). *Pleochroism:* Distinct; X = pale yellow; $Y = Z$ = deep brown. *Orientation:* $X \wedge (001) \simeq 6°$. $\alpha = 1.545(5)$ $\beta = 1.583(3)$ $\gamma = 1.583(3)$ 2V(meas.) = 10(3)° 2V(calc.) = 0°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$; orthohexagonal cell is $a = 5.521(4)$ $b = 9.560(6)$ $c = 36.57(5)$ Z = 3/8

X-ray Powder Pattern: Franklin, New Jersey, USA.
12.3 (100), 2.583 (40), 2.737 (30), 2.362 (30), 1.594 (30), 1.580 (30), 4.79 (20)

Chemistry:

	(1)
SiO_2	44.0
Al_2O_3	3.6
Fe_2O_3	7.8
MnO	22.3
MgO	6.4
ZnO	5.9
Na_2O	0.4
K_2O	1.5
H_2O	[8.1]
Total	[100.0]

(1) Franklin, New Jersey, USA.; by electron microprobe, H_2O by difference, corresponding to $(K_{2.6}Na_{1.1})_{\Sigma=3.7}(Mn_{26.1}Mg_{13.2}Zn_{6.0}Fe^{3+}_{2.7})_{\Sigma=48.0}(Si_{60.8}Al_{5.8}Fe^{3+}_{5.4})_{\Sigma=72.0}[O_{163.2}(OH)_{52.8}]_{\Sigma=216.0}\cdot nH_2O$.

Polymorphism & Series: Forms a series with lennilenapeite.

Occurrence: In a veinlet crosscutting a breccia of calcite, aegirine, and serpentine in a metamorphosed stratiform zinc deposit.

Association: Friedelite, nelenite, rhodonite, tirodite.

Distribution: At Franklin, Sussex Co., New Jersey, USA.

Name: From the locality Franklin, New Jersey, USA, and the Greek for *friend*, for the association of elements characteristic of Franklin.

Type Material: National Museum of Natural History, Washington, D.C., USA, 167390.

References: (1) Dunn, P.J., D.R. Peacor, and S.-C. Su (1992) Franklinphilite, the manganese analog of stilpnomelane, from Franklin, New Jersey. Mineral. Record, 23, 465–468. (2) (1993) Amer. Mineral., 78, 672–673 (abs. ref. 1).

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Fransoletite $Ca_3Be_2(PO_4)_2(PO_3OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are arrow-head-shaped, curved, composed of mosaiced aggregates of minute crystallites, to 3 mm. Elongated along [101], tabular on {010}, forms are {100}, {011}, {010}.

Physical Properties: *Cleavage:* {010}, imperfect. *Fracture:* Irregular. Hardness = ∼3
D(meas.) = 2.56(3) D(calc.) = 2.53

Optical Properties: Transparent to translucent. *Color:* Colorless to slightly whitish.
Streak: White. *Luster:* Subvitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 14°$. $\alpha = 1.560(2)$ $\beta = 1.566(2)$
$\gamma = 1.586(2)$ 2V(meas.) = 25° 2V(calc.) = 25°

Cell Data: *Space Group:* $P2_1/a$. $a = 7.3482(13)$ $b = 15.0522(28)$ $c = 7.0685(13)$
$\beta = 96.519(6)°$ Z = 2

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
3.044 (100), 3.47 (90), 3.32 (70), 2.317 (50), 7.52 (40), 2.597 (40), 6.55 (30)

Chemistry:

	(1)	(2)
P_2O_5	47.3	47.93
MnO	0.3	
BeO	9.3	8.45
CaO	28.8	28.41
H_2O	[14.3]	15.21
Total	[100.0]	100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, Be by AA, H_2O by difference; corresponds to $(Ca_{3.08}Mn_{0.02})_{\Sigma=3.10}Be_{2.23}(PO_4)_2(PO_3OH)_2 \cdot 3.76H_2O$.
(2) $Ca_3Be_2(PO_4)_2(PO_3OH)_2 \cdot 4H_2O$.

Polymorphism & Series: Dimorphous with parafransoletite.

Occurrence: Formed by late-stage hydrothermal alteration of beryl and other phosphates in a zoned granite pegmatite.

Association: Beryl, tiptopite, whitlockite, carbonate-apatite, montgomeryite, hurlbutite, englishite, roscherite, quartz.

Distribution: From the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: To honor Dr. André-Mathieu Fransolet (1947-), Professor of Mineralogy, University of Liège, Liège, Belgium, for his work with primary phosphate minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149607.

References: (1) Peacor, D.R., P.J. Dunn, W.L. Roberts, T.J. Campbell, and D. Newbury (1983) Fransoletite, a new calcium beryllium phosphate from the Tip Top pegmatite, Custer, South Dakota. Bull. Minéral., 106, 499–503. (2) (1985) Amer. Mineral., 70, 215 (abs. ref. 1). (3) Kampf, A.R. (1992) Beryllophosphate chains in the structures of fransoletite, parafransoletite, and ehrleite and some general comments on beryllophosphate linkages. Amer. Mineral., 77, 848–856.

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Franzinite $(Na, Ca)_7(Si, Al)_{12}O_{24}(SO_4, CO_3, OH)_3 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$ $2/m$, $3m$, or 32. As squat prisms, to 1 cm, roughly hexagonal in shape, not of measurable quality.

Physical Properties: *Cleavage:* {0001}, distinct. Hardness = 5 D(meas.) = 2.46–2.52 D(calc.) = 2.52–2.57

Optical Properties: Transparent to opaque. *Color:* White to colorless. *Luster:* Pearly. *Optical Class:* Uniaxial (+). $\omega = 1.504$–1.510 $\epsilon = 1.506$–1.512

Cell Data: *Space Group:* $P\bar{3}m1$, $P3m1$, $P31m$, or $P321$. $a = 12.884(9)$ $c = 26.580(21)$ $Z = 1$

X-ray Powder Pattern: Pitigliano, Italy.
3.72 (100), 3.59 (43), 3.81 (42), 3.56 (39), 2.148 (29), 3.302 (17), 3.054 (16)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	32.44	31.85	K_2O	4.24	7.23
Al_2O_3	25.21	25.13	Cl	0.36	0.13
Fe_2O_3	0.04	0.10	H_2O^+	1.88	1.70
MgO	0.14	0.26	CO_2	1.54	1.98
CaO	12.08	10.44	SO_3	10.65	10.22
Na_2O	11.50	10.99	$-O = Cl_2$	0.08	0.03
			Total	[100.00]	[100.00]

(1) Pitigliano, Italy; by a variety of techniques including AA and XRF, recalculated to 100%; corresponding to $(Na_{4.31}Ca_{2.50}Mg_{0.04}Fe_{0.01})_{\Sigma=6.86}(Si_{6.26}Al_{5.74})_{\Sigma=12.00}O_{24}[(SO_4)_{1.54}(OH)_{0.70}(CO_3)_{0.41}Cl_{0.12}]_{\Sigma=2.77} \cdot 0.86H_2O$. (2) Ariccia, Italy; methods as for (1), corresponding to $(Na_{4.16}Ca_{2.18}Mg_{0.08}Fe_{0.01})_{\Sigma=6.43}(Si_{6.22}Al_{5.78})_{\Sigma=12.00}O_{24}[(SO_4)_{1.50}(OH)_{0.64}(CO_3)_{0.53}Cl_{0.04}]_{\Sigma=2.71} \cdot 0.79H_2O$.

Mineral Group: Cancrinite group.

Occurrence: In ejected metasomatized pumice blocks, thought to be the product of a syntectic process between a trachytic magma and carbonate rocks at the volcanic vent.

Association: Diopside, vesuvianite, afghanite, liottite (Pitigliano, Italy); calcite, leucite (Ariccia, Italy).

Distribution: In Italy, in the Pitigliano quarry, near Grosseto, Tuscany; and at Sacrofano and Ariccia, near Rome, Lazio.

Name: For Marco Franzini, Professor of Mineralogy, University of Pisa, Pisa, Italy.

Type Material: University of Pisa, Pisa, 3208; University of Modena, Modena, Italy.

References: (1) Merlino, S. and P. Orlandi (1977) Franzinite, a new mineral phase from Pitigliano (Italy). Neues Jahrb. Mineral., Monatsh., 163–167. (2) (1977) Amer. Mineral., 62, 1259 (abs. ref. 1). (3) Leoni, L., M. Mellini, S. Merlino, and P. Orlandi (1979) Cancrinite-like minerals: new data and crystal chemical considerations. Rend. Soc. Ital. Mineral. Petrol., 35, 713–719.

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Freboldite CoSe

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Massive; as embedded grains.

Physical Properties: Hardness = < 6, much softer than trogtalite and hastite.
VHN = n.d. D(meas.) = n.d. D(calc.) = 7.70

Optical Properties: Opaque. *Color:* Similar to nickeline, but more intense violet in oil.
Anisotropism: Less anisotropic than nickeline.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. a = 3.61 $c = 5.28$ Z = 2

X-ray Powder Pattern: Steinbruch, Germany.
2.05 (100), 1.066 (100), 0.963 (100), 2.4 (50), 1.71 (50), 1.08 (50), 0.992 (50)

Chemistry: Composition established by analogy to synthetic material.

Mineral Group: Nickeline group.

Occurrence: In dolostone veinlets (Steinbruch, Germany).

Association: Clausthalite, nickeline, guanajuatite, hastite, trogtalite, bornhardtite, chalcopyrite, millerite, sphalerite, hematite.

Distribution: In Germany, in the Harz Mountains, from the Trogtal quarry, Steinbruch [TL], and at Rote Berg, St. Andreasberg; also from Hartenstein, Saxony. In the Pinky Fault uranium deposit, Saskatchewan, Canada. At Temple Mountain, Emery Co., Utah, USA.

Name: In honor of Professor Georg Frebold (1891–?) of Hannover, Germany.

Type Material: n.d.

References: (1) Ramdohr, P. and Schmitt, M. (1955) Vier neue natüraliche kobaltselenide von Steinbruch Trogtal bei Lautenthal im Harz. Neues Jahrb. Mineral., Monatsh., 133–142 (in German). (2) (1956) Amer. Mineral., 41, 164–165 (abs. ref. 1). (3) Strunz, H. (1957) Mineralogische Tabellen (3rd edition), 98 (in German). (4) (1959) Amer. Mineral., 44, 907 (abs. ref. 3). (5) Goldschmidt Skr.Norske Vid.-Akad. Oslo, I: Mat. Naturv. Kl. 1926 (8), 45–?? (str - Strunz??)

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Fredrikssonite $Mg_2(Mn^{3+},Fe^{3+})BO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, prismatic and striated along [001], sharp to rounded, to 2.0 mm, with diamond-shaped cross-sections; in parallel to randomly oriented aggregates.

Physical Properties: *Cleavage:* One, poor, and a second, very poor. *Fracture:* Irregular to uneven. *Tenacity:* Brittle. Hardness = ∼6 D(meas.) = 3.84(5) D(calc.) = 3.80

Optical Properties: Nearly opaque to translucent. *Color:* Medium reddish brown. *Streak:* Pale brown to yellow. *Luster:* Vitreous to dull. *Optical Class:* Biaxial (+). *Pleochroism:* Pronounced; X = golden brown; Z = dark reddish brown to black. *Orientation:* Z = elongation of cleavage fragments = c (by analogy to ludwigite). *Dispersion:* $r > v$, strong. *Absorption:* $Z > X$. $\alpha = 1.82(2)$ $\beta = < 1.86$ $\gamma = \sim 1.99$ $2V(meas.) = > 60°$

Cell Data: *Space Group: Pbam.* $a = 9.198(2)$ $b = 12.528(3)$ $c = 2.965(1)$ $Z = 4$

X-ray Powder Pattern: Långban, Sweden.
2.590 (100), 2.486 (90), 5.16 (80), 2.013 (50), 1.513 (40), 2.201 (30), 1.570 (30)

Chemistry:

	(1)
B_2O_3	[17.9]
Al_2O_3	1.9
Fe_2O_3	5.4
Mn_2O_3	35.5
MnO	0.0
MgO	40.3
Total	[101.0]

(1) Långban, Sweden; by electron microprobe, B_2O_3 calculated from stoichiometry and by analogy to orthopinakiolite; corresponds to $Mg_{1.93}(Mn^{3+}_{0.87}Fe^{3+}_{0.13}Al_{0.07})_{\Sigma=1.07}B_{0.99}O_{5.05}$.

Polymorphism & Series: Polymorphous with orthopinakiolite, pinakiolite, takéuchiite.

Mineral Group: Ludwigite group.

Occurrence: From a metamorphosed Fe–Mn orebody.

Association: Hausmannite, manganoan calcite, brucite, adelite, dolomite–kutnohorite, clinohumite, jacobsite.

Distribution: From Långban, Värmland, Sweden.

Name: Honors Dr. Kurt A. Fredriksson (1926–), Swedish–American geochemist and meteoriticist, Smithsonian Institution, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149811, 150341.

References: (1) Dunn, P.J., D.R. Peacor, W.B. Simmons, and D. Newbury (1983) Fredrikssonite, a new member of the pinakiolite group, from Långban, Sweden. Geol. Fören. Förhandl. Stockholm, 150, 335–340. (2) (1986) Amer. Mineral., 71, 227 (abs. ref. 1). (3) Burns, P.C., M.A. Cooper, and F.C. Hawthorne (1994) Jahn-Teller-distorted $Mn^{3+}O_6$ octahedra in fredrikssonite, the fourth polymorph of $Mg_2Mn^{3+}(BO_3)O_2$. Can. Mineral., 32, 397–403.

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Freedite $Pb_8Cu^{1+}(As^{3+}O_3)_2O_3Cl_5$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. As composite crystals in slightly radial aggregates.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 7.0(5) D(calc.) = 7.43

Optical Properties: Transparent to translucent. *Color:* Bright greenish yellow. *Streak:* Yellow. *Luster:* Greasy to vitreous. *Optical Class:* Biaxial. *Pleochroism:* Weak to none. $\alpha = > 1.90$ $\beta = > 1.90$ $\gamma = > 1.90$ 2V(meas.) = n.d.

Cell Data: *Space Group: C*2/*m*. $a = 13.578(2)$ $b = 20.099(3)$ $c = 7.465(1)$ $\beta = 105.73(1)°$ Z = 4

X-ray Powder Pattern: Långban, Sweden. 2.949 (10), 2.830 (8), 2.734 (8), 3.832 (5), 2.096 (5), 6.51 (4), 3.581 (4)

Chemistry:

	(1)	(2)
As_2O_3	9.2	9.02
FeO	0.4	
PbO	80.2	81.45
CuO	4.9	3.26
Cl	8.0	8.09
$-O = Cl_2$	1.8	1.82
Total	100.9	100.00

(1) Långban, Sweden; by electron microprobe, total Cu as CuO, total Fe as FeO, total As as As_2O_3; neglecting $H_2O + CO_2$ 0.2% by TGA-EGA-mass spectrometer, corresponds to $Pb_{29.4}Cu^{2+}_{5.1}Fe^{2+}_{0.5}As^{3+}_{7.6}Cl_{18.4}O_{37.1}$. (2) $Pb_8Cu(AsO_3)_2O_3Cl_5$.

Occurrence: An uncommon mineral in andradite–magnetite ore from a metamorphosed Fe–Mn orebody.

Association: Ecdemite, lead, copper, finnemanite, calcite, andradite, magnetite.

Distribution: At Långban, Värmland, Sweden.

Name: Honors Dr. Robert L. Freed, American mineralogist, of Trinity University, San Antonio, Texas, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160353 and 160354.

References: (1) Dunn, P.J. and R.C. Rouse (1985) Freedite and thorikosite from Långban, Sweden, and Laurion, Greece: two new species related to the synthetic bismuth oxyhalides. Amer. Mineral., 70, 845–848. (2) Pertlik, F. (1987) The structure of freedite, $Pb_8Cu(AsO_3)_2O_3Cl_5$. Mineral. Petrol., 36, 85–92.

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Freibergite $(Ag, Cu, Fe, Zn)_{12}(Sb, As)_4S_{13}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Tetrahedral crystals, to 3.5 cm; massive and as inclusions in other sulfides.

Physical Properties: Hardness = n.d. VHN = 263–340 (100 g load). D(meas.) = n.d. D(calc.) = [5.41]

Optical Properties: Opaque. *Color:* Gray to black.
R: (400) 34.1, (420) 34.0, (440) 33.9, (460) 33.7, (480) 33.6, (500) 33.5, (520) 33.3, (540) 33.1, (560) 32.7, (580) 32.2, (600) 31.5, (620) 31.0, (640) 30.4, (660) 30.0, (680) 29.5, (700) 29.0

Cell Data: *Space Group:* $I\bar{4}3m$. $a = 10.474$–10.560 $Z = 2$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
Ag	36.0	48.9	Sb	25.1	21.0
Cu	12.4	3.2	As	0.5	0.6
Fe	4.1	0.2	Bi		0.1
Zn	0.6	6.1	S	21.8	19.9
Hg		0.1	Total	100.5	100.1

(1) Mt. Isa, Australia; by electron microprobe, corresponding to $(Ag_{6.37}Cu_{3.72}Fe_{1.41}Zn_{0.18})_{\Sigma=11.68}(Sb_{3.95}As_{0.13})_{\Sigma=4.08}S_{13.00}$. (2) Knappenstube mine, Austria; by electron microprobe, average of analyses on 14 samples; corresponding to $(Ag_{9.50}Zn_{1.95}Cu_{1.06}Fe_{0.08}Hg_{0.01})_{\Sigma=12.60}(Sb_{3.61}As_{0.17}Bi_{0.01})_{\Sigma=3.79}S_{13.00}$.

Polymorphism & Series: Forms a series with tetrahedrite and argentotennantite.

Mineral Group: Tetrahedrite group.

Occurrence: In hydrothermal deposits.

Association: A wide variety of sulfides and sulfosalts, as for tetrahedrite.

Distribution: In Germany, in Saxony, from the Freiberg district [TL], as in the Himmelsfürst mine, Erbisdorf, near Freiberg. From Kutná Hora and the Zlate Hore district, Czech Republic. In Austria, from the Knappenstube mine, Hochtor, Salzburg. From Yukhondzha, Sakha, Russia. At Slädekärr and in the Vena mines, near Askersund, Örebro, Sweden. From the Bleikvassli Zn–Pb–Cu deposit, Nordland, Norway. In Scotland, at Tyndrum, Perthshire. In the Hi-Ho mine, Cobalt-Gowganda region, Ontario; and the Keno Hill-Galena Hill area, Yukon Territory, Canada. Large crystals from the San José mine, Oruro, Bolivia. In Japan, in the Inakuraishi, Koryu, and Sanru mines, Hokkaido. In Australia, at Mt. Isa and the Cannington Ag–Pb–Zn deposit, Queensland; and in the Meerschaum mine, north of Omeo, Victoria. Additional localities are known.

Name: For the long-known occurrence of silver-rich tetrahedrite at Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 374–384 (tetrahedrite–tennantite). (2) Riley, J.F (1974) The tetrahedrite–freibergite series with reference to the Mount Isa Pb–Zn–Ag orebody. Mineralium Deposita, 9, 117–124. (3) Peterson, R.C. and I. Miller (1986) Crystal structure and cation distribution in freibergite and tetrahedrite. Mineral. Mag., 50, 717–721. (4) Paar, W.H., T.T. Chen, and W. Guenther. (1978) Extremely silver-rich freibergite in lead-zinc-copper ores of the "Knappenstube" mine, Hochtor, Salzburg. Carinthia 2, 88, 35–42. (5) (1980) Chem. Abs., 93, 189277 (abs. ref. 5). (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 177.

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Freieslebenite $AgPbSbS_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic and striated parallel to [001], to 3 cm, showing {011}, {021}, and {110}; as exsolutions in galena and inclusions in other silver minerals. *Twinning:* Twin plane {100}; lamellae seen in polished section.

Physical Properties: *Cleavage:* Imperfect on {110}. *Fracture:* Subconchoidal to uneven. Hardness = 2–2.5 VHN = n.d. D(meas.) = 6.20–6.23 D(calc.) = 6.22

Optical Properties: Opaque. *Color:* Pale steel-gray to silver-white or lead-gray. *Streak:* Pale steel-gray to silver-white or lead-gray. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Just noticeable.

R_1–R_2: (400) 38.2–42.5, (420) 38.0–42.1, (440) 37.8–41.7, (460) 37.4–41.3, (480) 37.0–40.9, (500) 36.6–40.5, (520) 36.2–40.1, (540) 35.7–39.7, (560) 35.4–39.3, (580) 35.0–38.9, (600) 34.6–38.5, (620) 34.2–38.1, (640) 33.9–37.7, (660) 33.4–37.2, (680) 33.0–36.7, (700) 32.5–36.1

Cell Data: *Space Group:* $P2_1/a$. $a = 7.518(1)$ $b = 12.809(4)$ $c = 5.940(1)$ $\beta = 92.25(1)^\circ$ $Z = 4$

X-ray Powder Pattern: Hiendelaencina, Spain. [ck??this for precisions of d's??< ICDD??] 2.83 (100), 3.48 (80), 2.98 (70), 1.784 (50), 2.08 (40), 3.25 (30), 2.01 (30)

Chemistry:

	(1)	(2)	(3)
Ag	22.45	23.08	20.24
Pb	31.90	30.77	38.87
Fe		0.63	
Sb	26.83	27.11	22.84
S	17.60	18.41	18.05
Total	98.78	100.00	100.00

(1) Hiendelaencina, Spain; corresponds to $Ag_{1.14}Pb_{0.84}Sb_{1.20}S_{3.00}$. (2) Příbram, Czech Republic; corresponds to $Ag_{1.12}Pb_{0.78}Fe_{0.06}Sb_{1.16}S_{3.00}$. (3) $AgPbSbS_3$.

Occurrence: Of hydrothermal origin.

Association: Acanthite, pyrargyrite, silver, andorite, galena, siderite.

Distribution: In Germany, in Saxony, from the Himmelsfürst mine, Erbisdorf [TL] and Braünsdorf, both near Freiberg, and at Marienberg. From Příbram, Czech Republic. As fine crystals from Hiendelaencina, Guadalajara Province, Spain. In the Les Farges mine, near Ussel, Corrèze; Pontgibaud, Puy-de-Dôme; and Vialas, Lozère, France. From Dossena, Lombardy, Italy. At Hällefors, Bergslagen metallic province, Sweden. In the USA, from the Eagle mine, Gilman district, Eagle Co., Colorado, and the Castle Dome Mountains, Yuma Co., Arizona. In Canada, at Cobalt, Ontario, and at the Weber prospect of Mount Nansen Mines, Yukon Territory. From Oruro, Bolivia.

Name: Honoring Johann Karl Freiesleben (1774–1846), Mining Commissioner of Saxony, Germany, who first described the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 416–418. (2) Hellner, E. (1957) Über komplex zusammengesetzte sulfidische Erze. II. Struktur des Freieslebenits, $PbAgSbS_3$. Zeits. Krist., 109, 4 (in German with English abs.). (3) Ito, T. and W. Nowacki (1974) The crystal structure of freieslebenite, $PbAgSbS_3$. Zeits. Krist., 139, 85–102. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 137. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 178.

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Fresnoite $Ba_2TiOSi_2O_7$

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Crystal Data: Tetragonal. *Point Group:* 4*mm*. As subhedral to euhedral tetragonal crystals, slightly elongated along [001], bounded principally by {110} and {001}, to 2.1 cm.

Physical Properties: *Cleavage:* Fair on {001}. Hardness = 3–4 D(meas.) = 4.43(2) D(calc.) = 4.45 Fluoresces pale yellow under SW UV.

Optical Properties: Transparent to translucent. *Color:* Lemon-yellow to canary-yellow, butterscotch-yellow to salmon-pink; yellow to colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = colorless; E = yellow, with anomalous blue interference colors. $\omega = 1.775(3)$ $\epsilon = 1.765$

Cell Data: *Space Group: P4bm*. $a = 8.518(2)$ $c = 5.211(1)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.077 (100), 3.301 (45), 2.697 (25), 3.816 (20), 2.607 (20), 2.151 (20), 1.874 (20)

Chemistry:

	(1)	(2)	(3)
SiO_2	21.8	23.8	23.72
TiO_2	17.2	15.2	15.76
Al_2O_3	0.12		
FeO	1.0	0.77	
MnO	0.027	0.074	
MgO	< 0.05	0.19	
CaO	0.14	0.55	
SrO	0.28		
BaO	59.4	59.4	60.52
K_2O	0.00	0.00	
H_2O	0.00	0.00	
Total	[100.0]	[100.0]	100.00

(1–2) Rush Creek area, California, USA; by D-C arc spectrography, recalculated to 100%.
(3) $Ba_2TiOSi_2O_7$.

Occurrence: Disseminated in gneissic metamorphic rocks composed mainly of sanbornite and quartz (Rush Creek, California, USA).

Association: Quartz, sanbornite, celsian, taramellite, diopside, pyrrhotite (Rush Creek, California, USA); bario-orthojoaquinite, benitoite, baotite, natrolite (Esquire mine No. 1, California, USA); gillespite, sanbornite, taramellite, pellyite, muirite, barite (Gunn claim, Canada).

Distribution: In the USA, in California, from the Rush Creek area and at the Esquire No. 1 mine, Big Creek, Fresno Co.; at the Gem mine, and in the Clear Creek district, at the Victor mine, and large crystals in the Junilla mine, San Benito Co.; on Trumbull Peak, near Incline, Mariposa Co. From the Gunn claim, Itsy Mountains, near Macmillan Pass, Yukon Territory, Canada. At Graulai and Üdersdorf, Eifel district, Germany.

Name: For the original localities in Fresno Co., California, USA.

Type Material: California Division of Mines & Geology, San Francisco, California, USA.

References: (1) Alfors, J.T., M.C. Stinson, R.A. Matthews, and A. Pabst. (1965) Seven new barium minerals from eastern Fresno County, California. Amer. Mineral., 50, 314–340. (2) Moore, P.B. and S.J. Louisnathan (1969) The crystal structure of fresnoite, $Ba_2(TiO)Si_2O_7$. Zeits. Krist., 130, 438–448. (3) (1971) NBS Mono. 25, 9, 19.

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Freudenbergite $Na_2(Ti, Fe^{3+})_8O_{16}$

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Crystal Data: Monoclinic. *Point Group:* $2/m, m$,or 2. As irregularly shaped grains, to 0.15 mm.

Physical Properties: *Cleavage:* {001}, and another prismatic, good. Hardness = < 5 D(meas.) = 3.956 D(calc.) = 3.97

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black; deep brown to light yellowish brown in transmitted light with yellow-brown internal reflections. *Streak:* Pale yellow-brown.
Optical Class: Biaxial (+), near uniaxial. *Pleochroism:* Deep brown to pale yellow-brown. n = ∼2.37–2.42 (Li). 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m, Cm$,or $C2$. $a = 12.305(5)$ $b = 3.822(2)$ $c = 6.500(3)$ $\beta = 107.30(3)°$ Z = 4

X-ray Powder Pattern: Michelsberg, Germany.
3.63 (100), 1.911 (90), 3.10 (80), 3.02 (80), 2.731 (80), 2.069 (80), 1.596 (80)

Chemistry:

	(1)	(2)
Nb_2O_5	1.24	1.2
SiO_2	< 0.02	
TiO_2	70.37	71.6
ZrO_2		0.1
Al_2O_3	< 0.01	
Fe_2O_3	18.15	19.1
MnO	0.14	0.1
MgO	< 0.03	
Na_2O	8.73	8.1
K_2O	0.04	0.1
Total	98.67	100.3

(1) Michelsberg, Germany; by electron microprobe, total Fe as Fe_2O_3; corresponds to $(Na_{1.98}K_{0.01})_{\Sigma=1.99}(Ti_{6.22}Fe_{1.59}Nb_{0.07}Mn_{0.01})_{\Sigma=7.89}O_{16}$. (2) Do.; by electron microprobe, total Fe as Fe_2O_3.

Occurrence: A late-stage mineral in an apatite-bearing alkali syenite.

Association: Hematite, högbomite, diopside, apatite, ilmenite, titanite, biotite, sanidine.

Distribution: Found at Michelsberg, on the Katzenbuckel, Odenwald, Baden-Württemberg, Germany.

Name: For Professor Wilhelm Freudenberg (1881–?), who studied Katzenbuckel rocks.

Type Material: n.d.

References: (1) Frenzel, G. (1961) Ein neues Mineral: Freudenbergit ($Na_2Fe_2Ti_7O_{18}$). Neues Jahrb. Mineral., Monatsh., 12–22 (in German with English abs.). (2) (1961) Amer. Mineral., 46, 765–766 (abs. ref. 1). (3) McKie, D. and J.V.P. Long (1970) The unit-cell contents of freudenbergite. Zeits. Krist., 132, 157–160. (4) Frenzel, G., J. Ottemann, and B. Nuber (1971) Neue Mikrosonden-Untersuchungen an Freudenbergiten. Neues Jahrb. Mineral., Monatsh., 547–551 (in German with English abs.). (5) Ishiguro, T., K. Tanaka, F. Marumo, M.G.M.U. Ismail, S. Hirano, and S. Somiya (1978) Freudenbergite. Acta Cryst., 34, 255–256.

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Friedelite $\mathbf{Mn_8^{2+}Si_6O_{15}(OH,Cl)_{10}}$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As pseudohexagonal tablets, may be hemimorphic, to 1 cm; more rarely as slender needles or as fibrous or lamellar aggregates; stalactitic, massive, cryptocrystalline. *Twinning:* Universal, repeated about [110] and $[\bar{1}10]$, composition plane {001}, giving pseudorhombohedral symmetry.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 4–5 D(meas.) = 3.04–3.06 D(calc.) = 3.066

Optical Properties: Translucent to transparent. *Color:* Pale pink, brownish red, dark red, brown. *Streak:* Pale rose. *Luster:* Vitreous, pearly on basal plane.
Optical Class: Biaxial; sensibly uniaxial (–). ω = 1.654–1.656 ϵ = 1.620–1.625 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$. a = 23.33(5) b = 13.396(8) c = 7.447(4) $\beta = 105.08(8)^\circ$ Z = [4]

X-ray Powder Pattern: Franklin, New Jersey, USA; nearly identical with mcgillite. 2.56 (100), 7.17 (90), 3.60 (70), 2.88 (60), 1.676 (60), 2.115 (40), 2.408 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	36.35	34.45	34.6
Al_2O_3	0.03		
FeO	5.27	0.68	3.4
MnO	46.67	51.48	48.4
ZnO	0.32	1.43	1.0
MgO	0.05	1.54	1.4
CaO	trace		0.1
Cl	3.08	0.29	2.9
H_2O	8.86	9.74	[8.9]
$-O = Cl_2$	0.69	0.06	0.7
Total	99.94	99.55	[100.0]

(1–2) Franklin, New Jersey, USA. (3) Sterling Hill, New Jersey, USA; by electron microprobe, H_2O by difference; corresponding to $(Mn^{2+}_{7.01}Fe_{0.49}Mg_{0.36}Zn_{0.13}Ca_{0.02})_{\Sigma=8.01}Si_{5.92}O_{15}[(OH)_{10.15}Cl_{0.84}]_{\Sigma=10.99}$.

Occurrence: In metamorphosed Mn-Fe deposits.

Association: Rhodochrosite, alabandite (Adervielle, France); franklinite, willemite, calcite, rhodochrosite, barite, chlorite, sphalerite (Franklin, New Jersey, USA); calcite, kutnohorite, andradite, hausmannite (Kuruman, South Africa).

Distribution: In France, at Adervielle, Louron Valley, Hautes-Pyrénées, and Costabonne, Pyrénées-Orientales. From the Harstigen mine, near Persberg, Värmland, and in the Sjö mine, near Grythyttan, Örebro, Sweden. In the Ködnitz Valley, Tirol, Austria. At Dshumart and Kamya, Atasui region, Kazakhstan. In the USA, at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and the Sunnyside mine, Silverton district, San Juan Co., Colorado. From the Wessels and N'Chwaning mines, near Kuruman, Cape Province, South Africa. At Broken Hill, New South Wales, Australia.

Name: For the noted French chemist and mineralogist, Charles Friedel (1832–1899).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 465, 1035. (2) Frondel, C. and L.H. Bauer (1953) Manganpyrosmalite and its polymorphic relation to friedelite and schallerite. Amer. Mineral., 38, 755–760. (3) Dunn, P.J., D.R. Peacor, J.A. Nelen, and J.A. Norberg (1981) Crystal-chemical data for schallerite, caryopilite and friedelite from Franklin and Sterling Hill, New Jersey. Amer. Mineral., 66, 1054–1062. (4) Ozawa, T., Y. Takéuchi, T. Takahata, G. Donnay, and J.D.H. Donnay (1983) The pyrosmalite group of minerals. II. The layer structure of mcgillite and friedelite. Can. Mineral., 21, 7–17.

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Friedrichbeckeite $K(\square_{0.5}Na_{0.5})_2Mg_2Be_3[Si_{12}O_{30}]$

Crystal Data: Hexagonal. *Point Group*: 6/*m* 2/*m* 2/*m*. Crystals, thin tabular, flattened on {0001}, to 0.6 mm, exhibiting forms {0 0 0 1}, {1 0 $\bar{1}$ 0}, {1 1 $\bar{2}$ 0}.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = 6 D(meas.) = n.d. D(calc.) = 2.686

Optical Properties: Transparent to translucent. *Color*: Colorless to pale yellow. *Streak*: Colorless to pale cream. *Luster*: Vitreous. *Pleochroism:* Distinct; *O* = yellow; *E* = light blue. Anomalous extinction, slight biaxiality and zoning sometimes observed. *Optical Class*: Uniaxial (+). ω = 1.552(2) ε = 1.561(2)

Cell Data: *Space Group*: *P*6/*mcc*. a = 9.970(1) c = 14.130(3) Z = 2

X-ray Powder Pattern: Bellerberg volcano, East Eifel volcanic area, Germany. 3.180 (100), 2.885 (70), 4.993 (30), 4.081 (30), 3.690 (30), 4.321 (25), 3.525 (25)

Chemistry:

	(1)	(2)
Na_2O	2.73	3.19
K_2O	4.16	4.86
BeO	4.67	5.16
CaO	0.04	
MgO	11.24	12.46
MnO	2.05	
FeO	1.76	
Al_2O_3	0.15	
SiO_2	73.51	74.33
TiO_2	0.02	
Total	100.33	100.00

(1) Bellerberg volcano, East Eifel volcanic area, Germany; average of 15 electron microprobe analyses, Be determined by laser-ablation ICP-MS, absence of OH and H_2O confirmed by Micro-Raman spectroscopy, corresponding to $K_{0.87}Na_{0.86}(Mg_{1.57}Mn_{0.28}Fe_{0.24})_{\Sigma=2.09}(Be_{1.83}Mg_{1.17})_{\Sigma=3.00}[Si_{12}O_{30}]$. (2) $K(\square_{0.5}Na_{0.5})_2Mg_2Be_3[Si_{12}O_{30}]$.

Mineral Group: Milarite-osumilite group.

Occurrence: In vesicles in pyrometamorphically metasomatized silicate-rich xenoliths in leucite-tephrite volcanic rock.

Association: Tridymite, augite, magnesiohornblende, enstatite, almandine-spessartine garnet, fluorapatite, biotite, braunite, hematite, roedderite.

Distribution: Bellerberg volcano, southeast of Ettringen, East Eifel volcanic area, Germany.

Name: Honors Austrian mineralogist and petrographer Friedrich Johann Karl Becke (1855–1931), best known for developing the Becke-line method for determining indices of refraction.

Type Material: Natural History Museum, Vienna, Austria (catalog no. 2009-IV-a).

References: (1) Lengauer, C.L., N. Hrauda, U. Kolitsch, R. Krickl, and E. Tillmans (2009) Friedrichbeckeite, $K(\square_{0.5}Na_{0.5})_2(Mg_{0.8}Mn_{0.1}Fe_{0.1})_2(Be_{0.6}Mg_{0.4})_3[Si_{12}O_{30}]$, a new milarite-type mineral from the Bellerberg volcano, Eifel area, Germany. Mineral. Petrol., 96, 221–232. (2) (2009) Amer. Mineral., 94, 1497 (abs. ref. 1).

Friedrichite $Pb_5Cu_5Bi_7S_{18}$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As isolated columnar crystals, to 1.5 mm, or as granular aggregates.

Physical Properties: Hardness = n.d. VHN = 224 (50 g load). D(meas.) = 6.98 D(calc.) = 7.06

Optical Properties: Opaque. *Color:* In polished section, creamy yellowish white in air, more pinkish in oil. *Luster:* Metallic. *Anisotropism:* Strong in oil, distinct in air.
R_1–R_2: (470) 41.0–46.7, (546) 40.1–46.2, (589) 39.9–45.8, (650) 39.9–45.6

Cell Data: *Space Group:* $Pb2_1m$. $a = 33.84(6)$ $b = 11.65(07)$ $c = 4.010(3)$ $Z = 2$

X-ray Powder Pattern: Salzburg, Austria.
3.644 (100), 3.584 (100), 3.161 (100), 2.850 (80), 4.05 (40), 2.577 (40), 1.979 (40)

Chemistry:

	(1)	(2)	(3)
Pb	29.7	28.0	30.53
Cu	9.1	10.2	9.36
Bi	44.2	44.7	43.10
S	17.2	17.2	17.01
Total	100.2	100.1	100.00

(1) Salzburg, Austria; by electron microprobe, average of six analyses; corresponding to $Pb_{4.81}Cu_{4.80}Bi_{7.10}S_{18.00}$. (2) Do.; by electron microprobe, average of 12 analyses; corresponding to $Pb_{4.54}Cu_{5.39}Bi_{7.17}S_{18.00}$. (3) $Pb_5Cu_5Bi_7S_{18}$.

Occurrence: As aggregates of granular crystals, in boulders of vein quartz which occur in the scree of a landslip (Salzburg, Austria); in magnesian and calcic skarn deposits (Apuseni Mountains, Romania).

Association: Chalcopyrite, covellite, cerussite, chlorite, mica, quartz (Salzburg, Austria); cuprobismutite, cupropavonite (Apuseni Mountains, Romania).

Distribution: Near the emerald beryl deposit in the "Sedl" region, east of the Habachtal, Salzburg, Austria [TL]. In Romania, from the Antoniu, Blidar, and Secundar deposits, Apuseni Mountains, Băiţa (Rézbánya), and in the Baia Borşa area, Baia Mare (Nagybánya). From Les Houches, Haute-Savoie, France. At the Paliopyrgos area, northern Greece. In the USA, from the Fremont mine, Apache Hills, east of Hachita, Grant Co., New Mexico; near Panguitch, Garfield Co., Utah; on the northeast flank of the Johnny Lyon Hills, Cochise Co., Arizona; and at the Silver Bismuth claim, near the Outlaw mine, Round Mountain district, Nye Co., Nevada. In the Julcani district, Peru. From the Shin-Ohtoyo deposit, Harukayama district, Hokkaido, Japan. In the Funiushan copper skarn deposit, near Nanjing, Jiangsu Province, China. At Inkur, Transbaikal, Russia.

Name: To honor Professor Dr.-Ing Otmar Michael Friedrich (1902–1991), Austrian geologist of the Mining University, Leoben, Styria, Austria.

Type Material: Institute of Mineralogy, University of Salzburg, Salzburg, Austria; Joanneum Provincial Museum, Graz, Styria, Austria; Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada; The Natural History Museum, London, England, 1982,574; Harvard University, Cambridge, Massachusetts, 117007; National Museum of Natural History, Washington, D.C., USA, 144072, 144185.

References: (1) Chen, T.T., E. Kirchner, and W. Paar (1978) Friedrichite, $Cu_5Pb_5Bi_7S_{18}$, a new member of the aikinite–bismuthinite series. Can. Mineral., 16, 127–130. (2) (1979) Amer. Mineral., 64, 654 (abs. ref. 1). (3) Pring, A. (1989) Structural disorder in aikinite and krupkaite. Amer. Mineral., 74, 250–255. (4) Topa, D., E. Makovicky, and W.H. Paar (2002) Composition ranges and exolution pairs for the members of the bismuthinite–aikinite series from Felbertal, Austria. Can. Mineral., 40, 849–869.

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Fritzscheite $Mn^{2+}(UO_2)_2[(PO_4),(VO_4)]_2 \cdot 10H_2O(?)$

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Crystal Data: [Tetragonal] (by analogy to the autunite group). *Point Group:* n.d. Rectangular platy crystals, may overgrow or border autunite or torbernite.

Physical Properties: *Cleavage:* Basal, perfect; prismatic, distinct. Hardness = 2.25–3 D(meas.) = 3.504 (may be low). D(calc.) = n.d. Radioactive.

Optical Properties: Translucent to opaque. *Color:* Reddish brown to hyacinth-red. *Streak:* Reddish brown to hyacinth-red. *Luster:* Vitreous to pearly. *Optical Class:* [Uniaxial] (by analogy to the autunite group). ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry: (1) Germany; qualitative chemical tests indicate the mineral to be a manganese uranium phosphate-vanadate hydrate.

Mineral Group: Autunite group.

Occurrence: In a hematite deposit (Nove Hamry, Czech Republic).

Association: Autunite, torbernite.

Distribution: In Germany, from the Georg Wagsfort mine, Johanngeorgenstadt, and at Schneeberg, Saxony. From Nove Hamry, near Nejdek (Neuhammer, near Neudeck), Czech Republic.

Name: To honor Professor Carl Julius Fritzsche (1808–1871), German chemist.

Type Material: Natural History Museum, Vienna, Austria, Aa 5699.

References: (1) Breithaupt, A. (1865) Mineralogische Studien. Berg- und Huettenmænnische Zeitung, 2(4), 301–303 (in German). (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 984. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 195–196.

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Frohbergite $FeTe_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As thin (to 50 μm) reaction rims around chalcopyrite, and as inclusions; rarely in discrete grains.

Physical Properties: Hardness = 3–4 VHN = 250–297 D(meas.) = n.d. D(calc.) = 8.057

Optical Properties: Opaque. *Color:* In polished section, white with bluish or pinkish tint. *Luster:* Metallic. *Pleochroism:* Extremely weak. *Anisotropism:* Strong, red-orange to inky blue. R_1–R_2: (400) 56.7–57.1, (420) 54.8–56.2, (440) 52.9–55.3, (460) 51.9–54.5, (480) 51.1–53.8, (500) 50.6–53.1, (520) 50.1–52.6, (540) 50.0–52.4, (560) 50.2–52.5, (580) 50.7–53.0, (600) 51.4–53.8, (620) 52.2–54.5, (640) 53.0–55.4, (660) 53.9–56.3, (680) 55.0–57.4, (700) 56.2–58.5

Cell Data: *Space Group: Pnnm.* $a = 5.29$ $b = 6.27$ $c = 3.86$ Z = 2

X-ray Powder Pattern: Robb-Montbray mine, Canada.
2.81 (100), 2.71 (70), 2.07 (50), 1.846 (40), 3.29 (30), 1.940 (30), 1.577 (30)

Chemistry:

	(1)	(2)	(3)
Fe	18.1	18.3	17.94
Te	82.7	82.5	82.06
Total	100.8	100.8	100.00

(1) Robb-Montbray mine, Canada; by electron microprobe. (2) Noranda, Canada; by electron microprobe. (3) $FeTe_2$.

Polymorphism & Series: Forms a series with mattagamite.

Mineral Group: Marcasite group.

Occurrence: In hydrothermal ore deposits, rimming chalcopyrite grains, and as inclusions in gold, petzite, or chalcopyrite.

Association: Chalcopyrite, altaite, gold, melonite, petzite, montbrayite, sylvanite, tellurobismuthite, pyrite, sphalerite, marcasite, chalcocite, covellite.

Distribution: In Canada, from the Robb-Montbray [TL] and Noranda mines, Quebec; and at Lindquist Lake, British Columbia. From Gold Hill, north of San Simon, Cochise Co., Arizona, USA. At Bodennec, Finistère, France. From Faţa Băii (Facebánya) and Săcărîmb (Nagyág), Romania. At Jabal Sayid, Saudi Arabia. In the Kobetsuzawa gold mine, near Sapporo, Hokkaido, Japan. From the North Kalgurli mine, Kalgoorlie, and at Kambalda, Western Australia.

Name: Honors Dr. Max Hans Frohberg (1901–1970), Canadian mining geologist, Toronto, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M31173.

References: (1) Thompson, R.M. (1947) Frohbergite, $FeTe_2$: a new member of the marcasite group. Univ. Toronto Studies, Geol. Ser., 51, 35–40. (2) Thompson, R.M. (1947) Frohbergite, $FeTe_2$, a new member of the marcasite group (abs.). Amer. Mineral., 32, 210. (3) Pertlik, F. (1986) Strukturvergeinerung der synthetischen Verbindung $FeTe_2$ (Frohbergit). Anzeiger der Österreichischen Akademie der Wissenschaften, math.-naturwiss. Klasse, 123, 123–125 (in German). (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 845–847. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 103–104.

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Frolovite $CaB_2(OH)_8$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As veinlets and dense aggregates of grains, to 0.15 mm.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5 VHN = 151–181, 168 average (25 g load). D(meas.) = 2.14–2.22 D(calc.) = 2.259 Violet cathodoluminescence.

Optical Properties: Opaque, translucent through thin edges. *Color:* White, with a grayish tint; colorless in transmitted light. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+). $\alpha = 1.572$ $\beta = 1.573$ $\gamma = 1.586$ 2V(meas.) = ∼75°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.774(2)$ $b = 5.680(1)$ $c = 8.136(2)$ $\alpha = 113.15(1)°$ $\beta = 101.67(2)°$ $\gamma = 107.87(2)°$ Z = 2

X-ray Powder Pattern: Novofrolovskoye deposit, Russia.
6.08 (10), 3.858 (9), 3.471 (8), 2.357 (8), 2.522 (7), 2.330 (7), 2.65 (6)

Chemistry:

	(1)	(2)	(3)
SO_3	1.78		
SiO_2	0.57		
B_2O_3	34.20	34.57	35.20
Fe_2O_3	0.10		
MgO	0.72		
CaO	28.70	27.67	28.36
H_2O^+		35.57	
H_2O^-		2.06	
H_2O	32.96		36.44
Total	99.03	99.87	100.00

(1) Novofrolovskoye deposit, Russia; estimated gypsum 3% impurity. (2) Fuka, Japan; corresponds to $Ca_{1.00}B_{2.01}(OH)_{8.03}$. (3) $CaB_2(OH)_8$.

Occurrence: A rare alteration product of hydrothermal boron minerals in skarn deposits.

Association: Calciborite, calcite, gypsum, garnet, magnetite (Novofrolovskoye deposit, Russia); olshanskyite, parasibirskite, sibirskite, takedaite, pentahydroborite, nifontovite, calcite (Fuka, Japan).

Distribution: In Russia, from the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains, and in the Solongo boron deposit, Buryatia. At the Sayak-IV boron deposit, northeast Balkhash region, Kazakhstan. From Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For the first-noted occurrence in the NovoFROLOVskoye deposit, Russia.

Type Material: Institute of Mining-Chemical Stock, Moscow, Russia, 1317a.

References: (1) Petrova, E.S. (1957) Frolovite, a new hydrous calcium borate. Zap. Vses. Mineral. Obshch., 86, 622–625 (in Russian). (2) (1958) Amer. Mineral., 43, 385–386 (abs. ref. 1). (3) Kusachi, I., C. Henmi, and S. Kobayashi (1995) Frolovite from Fuka, Okayama Prefecture, Japan. Mineral. J. (Japan), 17, 330–337. (4) Simonov, M.A., E.V. Kazanskaya, Y.K. Yegorov-Tismenko, E.P. Zhelezin, and N.V. Belov (1976) Redetermination of the crystal structure of frolovite $Ca[B(OH)_4]_2$. Doklady Acad. Nauk SSSR, 230, 91–94 (in Russian).

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Frondelite $(Mn^{2+},Fe^{2+})Fe_4^{3+}(PO_4)_3(OH)_5$

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Crystal Data: Orthorhombic. *Point Group:* 222. Rarely as euhedral crystals, showing {100}, {010}, {110}, {101}; typically fibrous, to 8 cm, elongated along [001], radiating, in crusts, botryoidal and drusy masses.

Physical Properties: *Cleavage:* {100}, excellent; {010}, good; {001}, fair. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.453 D(calc.) = [3.35]

Optical Properties: Subtranslucent. *Color:* Dark brown, ocher-yellow, red-brown, orange, greenish brown; commonly zoned lengthwise. *Luster:* Vitreous to dull.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow-brown; $Y = Z$ = orange-brown. *Orientation:* $X = c$. *Dispersion:* $r > v$. *Absorption:* $Z > Y > X$. $\alpha = 1.860$ $\beta = 1.880$ $\gamma = 1.893$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* $B22_12$. $a = 13.810(1)$ $b = 17.968(3)$ $c = 5.182(1)$ Z = 4

X-ray Powder Pattern: Sapucaia mine, Brazil. (ICDD 35-625).
3.191 (100), 3.381 (85), 3.615 (40), 3.445 (25), 3.046 (20), 1.5953 (19), 6.91 (17)

Chemistry:

	(1)	(2)
P_2O_5	31.28	32.82
Al_2O_3	1.31	
Fe_2O_3	48.85	49.23
Mn_2O_3	1.75	
FeO	0.00	5.54
MnO	7.74	5.47
MgO	0.20	
CaO	0.02	
Na_2O	0.98	
K_2O	0.12	
H_2O	7.52	6.94
insol.	0.32	
Total	100.09	100.00

(1) Sapucaia mine, Brazil; corresponds to $(Mn^{2+}_{0.70}Na_{0.20}Mg_{0.03}K_{0.02})_{\Sigma=0.95}(Fe^{3+}_{3.94}Mn^{3+}_{0.16}Al_{0.16})_{\Sigma=4.26}(PO_4)_{2.84}(OH)_{5.38}$. (2) $(Mn^{2+},Fe^{2+})Fe_4^{3+}(PO_4)_3(OH)_5$ with Mn^{2+}:Fe^{2+} = 1:1.

Polymorphism & Series: Forms a series with rockbridgeite.

Occurrence: An alteration product of primary phosphates in complex granite pegmatites.

Association: Triphylite, vivianite, heterosite–purpurite, cyrilovite, phosphosiderite, leucophosphite (Sapucaia mine, Brazil).

Distribution: From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. At the Fletcher mine, near North Groton, Grafton Co., New Hampshire, and in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., USA. From Hagendorf, Bavaria, Germany. At the Buranga pegmatite, near Gatumba, Rwanda. From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: To honor Dr. Clifford Frondel (1907–2002), American mineralogist, Professor of Mineralogy, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 100808; National Museum of Natural History, Washington, D.C., USA, 105946.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 867–869. (2) Lindberg, M.L. (1949) Frondelite and the frondelite-rockbridgeite series. Amer. Mineral., 34, 541–549. (3) Lindberg, M.L. (1960) Crystal habit of frondelite, Sapucaia pegmatite mine, Minas Gerais, Brazil. U.S. Geol. Surv. Prof. Paper 400B, 429–430.

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Froodite $PdBi_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As flat cleavage fragments, to 4 mm, and rounded grains. *Twinning:* May be present.

Physical Properties: *Cleavage:* Perfect on {100}, less perfect on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5 VHN = 84 (25 g load). D(meas.) = 12.5–12.6, 11.5 (synthetic). D(calc.) = [11.42]

Optical Properties: Opaque. *Color:* Gray; creamy white in reflected light. *Streak:* Black. *Luster:* Metallic, splendent, tarnishes quickly. *Anisotropism:* Evident, in pale and dark grays. R_1–R_2: (400) — , (420) 50.7–52.9, (440) 51.9–54.3, (460) 53.1–55.5, (480) 54.3–56.4, (500) 55.2–57.2, (520) 55.7–57.8, (540) 56.1–58.4, (560) 56.5–59.0, (580) 56.9–59.6, (600) 57.4–60.2, (620) 57.7–60.7, (640) 58.0–61.1, (660) 58.5–61.4, (680) 58.8–62.0, (700) 59.3–63.0

Cell Data: *Space Group:* $C2/m$. $a = 12.74$ $b = 4.29$ $c = 5.71$ $\beta = 102°27'$ $Z = [4]$

X-ray Powder Pattern: Frood mine, Canada.
2.77 (100), 1.556 (80), 2.97 (70), 2.48 (70), 2.21 (70), 1.637 (60), 1.419 (60)

Chemistry:

	(1)	(2)	(3)
Pd	20.3	19.3	20.29
Bi	79.7	81.5	79.71
Te		0.39	
Total	100.0	101.19	100.00

(1) Frood mine, Canada; by electron microprobe, corresponding to $Pd_{1.00}Bi_{2.00}$. (2) Oktyabr mine, Russia; by electron microprobe, corresponding to $Pd_{0.95}(Bi_{2.03}Te_{0.02})_{\Sigma=2.05}$. (3) $PdBi_2$.

Occurrence: In mill concentrates of As–Pb–Cu-rich ores (Frood mine, Canada); in Pd–Pt-bearing layered or pipelike ultramafic intrusives.

Association: Chalcopyrite, cubanite, pyrite, pentlandite, altaite, hessite, galena, bismuth, pyrrhotite, tsumoite, parkerite, sudburyite, michenerite, sperrylite, insizwaite, niggliite, cabriite, mooihoekite.

Distribution: In Canada, from Sudbury, in the Frood [TL], Creighton, Coleman, and Strathcona mines, Ontario; and at the Pipe mine, Manitoba. In the USA, from Fox Gulch, Goodnews Bay, Alaska, and in the Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota. In Russia, at the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia; from the Karik'yavr Cu–Ni deposit, Kola Peninsula; and in the Kingash massif, eastern Sayan. From the Koillismaa complex, northeast Finland. In the Merensky Reef, Bushveld complex, Transvaal, South Africa. In Australia, at Mulga Springs, northeast of Broken Hill, New South Wales.

Name: For the Frood mine in Canada, from where it was first noted.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M29438; Harvard University, Cambridge, Massachusetts, USA, 108371.

References: (1) Hawley, J.E. and L.G. Berry (1958) Michenerite and froodite, palladium bismuth minerals. Can. Mineral., 6, 200–209. (2) (1959) Amer. Mineral., 44, 207 (abs. ref. 1). (3) Cabri, L.J., D.C. Harris, and R.I. Gait (1973) Michenerite (PdBiTe) redefined and froodite ($PdBi_2$) confirmed from the Sudbury area. Can. Mineral., 11, 903–912. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 104–105, 155.

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Fuenzalidaite $K_6(Na,K)_{10}Mg_{10}(SO_4)_{12}(IO_3)_{12}\cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. As thin pseudorhombohedral platy {0001} crystals with hexagonal outline, modified by $\{10\bar{1}2\}$, to < 200 μm; as blebs and flattened micaceous aggregates.

Physical Properties: *Cleavage:* On $\{11\bar{2}0\}$, likely, visible on SEM images. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = n.d. D(calc.) = 3.284 Slowly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to bright yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.622(5)$ $\epsilon = 1.615(5)$

Cell Data: *Space Group:* $P\bar{3}c1$. $a = 9.4643(4)$ $c = 27.336(6)$ $Z = 1$

X-ray Powder Pattern: Near Oficina Santa Luisa, Chile.
3.927 (100), 13.67 (50), 3.023 (41), 7.05 (40), 2.681 (33), 3.515 (24), 2.327 (21)

Chemistry:

	(1)
SO_3	20.9
SeO_3	0.1
CrO_3	0.2
I_2O_5	49.3
MgO	10.0
Na_2O	5.2
K_2O	5.9
H_2O	n.d.
Total	91.6

(1) Near Oficina Santa Luisa, Chile; by electron microprobe, amounts thought low due to decay in electron beam, H_2O confirmed by crystal-structure analysis; corresponds to $K_{5.7}Na_{7.6}Mg_{11.3}[(SO_4)_{11.9}(CrO_4)_{0.1}]_{\Sigma=12.0}(IO_3)_{13.4}\cdot 12H_2O$.

Polymorphism & Series: Forms a series with carlosruizite.

Occurrence: A rare constituent of nitrate ores.

Association: Nitratine, halite, probertite, darapskite.

Distribution: From one km south of Oficina Santa Luisa, Antofagasta, Chile.

Name: Honors Humberto Fuenzalida P. (1904–1966), first Director of the Chilean School of Geology, University of Chile, Santiago, Chile.

Type Material: n.d.

References: (1) Konnert, J.A., H.T. Evans, Jr., J.J. McGee, and G.E. Ericksen (1994) Mineralogical studies of the nitrate deposits of Chile: VII. Two new saline minerals with the composition $K_6(Na,K)_4Na_6Mg_{10}(XO_4)_{12}(IO_3)_{12}\cdot 12H_2O$: fuenzalidaite (X = S) and carlosruizite (X = Se). Amer. Mineral., 79, 1003–1008.

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Fukalite $Ca_4Si_2O_6(CO_3)(OH,F)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ or $2/m\ 2/m\ 2/m$. As flaky crystals, to 0.2 mm.

Physical Properties: Hardness = ∼4 D(meas.) = 2.770(5) D(calc.) = 2.77

Optical Properties: Translucent. *Color:* White to pale brown; colorless in transmitted light. *Optical Class:* Biaxial. $\alpha = 1.59(5)$ $\beta = 1.60(6)$ $\gamma = 1.62(9)$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $Bm2_1b$, $B2mb$, or $Bmmb$. $a = 5.48(1)$ $b = 3.78(1)$ $c = 23.42(3)$ Z = 2

X-ray Powder Pattern: Fuka, Japan.
2.854 (100), 3.084 (90), 2.926 (65), 2.338 (30), 1.756 (30b), 5.86 (25), 3.904 (20)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	29.09	28.98	K_2O	0.01	0.02
TiO_2	0.00	0.00	F	0.32	0.43
Al_2O_3	0.55	0.27	H_2O^+	4.45	4.26
Fe_2O_3	0.10	0.14	H_2O^-	0.23	0.39
MnO	0.00	0.00	CO_2	10.32	10.22
MgO	0.14	0.02	P_2O_5	0.01	0.07
CaO	54.40	54.81	$-O = F_2$	0.13	0.18
Na_2O	0.17	0.05	Total	99.66	[99.48]

(1) Fuka, Japan; corresponding to $(Ca_{3.97}Na_{0.02}Mg_{0.01}Fe_{0.01})_{\Sigma=4.01}(Si_{1.98}Al_{0.04})_{\Sigma=2.02}O_{6.03}(CO_3)_{0.96}[(OH)_{2.02}F_{0.07}]_{\Sigma=2.09}$. (2) Mihara, Japan; original total given as 99.38%, corresponding to $(Ca_{4.03}Fe_{0.01}Na_{0.01})_{\Sigma=4.05}(Si_{1.99}Al_{0.02})_{\Sigma=2.01}O_{6.08}(CO_3)_{0.96}[(OH)_{1.95}F_{0.09}]_{\Sigma=2.04}$.

Occurrence: A retrograde mineral and alteration product in skarns formed from metasomatism of limestone.

Association: Cuspidine, xonotlite, calcite, spurrite, hillebrandite, scawtite, foshagite, wollastonite, fluorite, gehlenite, perovskite, grossular, hydrogrossular, vesuvianite, monticellite.

Distribution: In Japan, at Fuka, near Bicchu, and Mihara, Okayama Prefecture, and at Kushiro, Hiroshima Prefecture.

Name: For the locality where it was first discovered, Fuka, Japan.

Type Material: Department of Earth Sciences, Okayama University, Okayama, ONM-02; National Science Museum, Tokyo, Japan; National Museum of Natural History, Washington, D.C., USA, 136583.

References: (1) Henmi, C., I. Kusachi, A. Kawahara, and K. Henmi (1977) Fukalite, a new calcium carbonate silicate hydrate mineral. Mineral. J. (Japan), 8, 374–381. (2) (1978) Amer. Mineral., 63, 793 (abs. ref. 1).

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Fukuchilite $(Cu, Fe)S_2$

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Crystal Data: Cubic. *Point Group:* $[2/m\ \overline{3}]$. In a uniform, nearly eutecticlike intergrowth with pyrite and covellite, with grains < 1 μm.

Physical Properties: Hardness = ∼4. VHN = n.d. D(meas.) = 4.86 D(calc.) = 4.90

Optical Properties: Opaque. *Color:* Dark brownish gray; in polished section, pinkish brown, very similar to bornite. *Luster:* Submetallic.
R: n.d.

Cell Data: *Space Group:* $Pa3$ (by analogy to other pyrite group members). $a = 5.58$ $Z = 4$

X-ray Powder Pattern: Hanawa mine, Japan.
2.789 (vs), 3.21 (s), 1.685 (s), 2.281 (m), 2.497 (w), 1.971 (w), 1.545 (w)

Chemistry:

	(1)	(2)
Cu	37.9 – 40.6	37.90
Fe	10.5 – 12.9	11.10
S	49.2 – 53.3	51.00
Total		100.00

(1) Hanawa mine, Japan; by X-ray fluorescence, range of analyses. (2) $(Cu, Fe)S_2$ with Cu:Fe = 3:1.

Mineral Group: Pyrite group.

Occurrence: In an ore body of gypsum–anhydrite, in interstices of small masses consisting of barite, covellite, and pyrite.

Association: Pyrite, covellite, barite, gypsum.

Distribution: From the Hanawa mine, Akita Prefecture, Japan.

Name: Honors Nobuyo Fukuchi (1877–1934), Japanese mineralogist and geologist, who studied many Japanese Kuroko-type deposits.

Type Material: National Science Museum, Tokyo, Japan, M15937; National Museum of Natural History, Washington, D.C., USA, 135971.

References: (1) Kajiwara, Y. (1969) Fukuchilite, Cu_3FeS_8, a new mineral from the Hanawa mine, Akita Prefecture, Japan. Mineral. J. (Japan), 5, 399–416. (2) (1970) Amer. Mineral., 55, 1811 (abs. ref. 1). (3) Shimazaki, H. and L.A. Clark (1970) Synthetic FeS_2−CuS_2 solid solution and fukuchilite-like minerals. Can. Mineral., 10, 648–664.

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Fülöppite $Pb_3Sb_8S_{15}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals short prismatic [201], to 3 mm, and pyramidal; striated on {100} ∥ [$0\bar{1}0$] and on {$\bar{1}12$} ∥ [110]; curved crystals common.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5
VHN = 140–157 (100 g load). D(meas.) = 5.22 D(calc.) = 5.19

Optical Properties: Opaque. *Color:* Lead-gray; may tarnish steel-blue or bronzy white in polished section. *Streak:* Reddish gray. *Luster:* Metallic. *Anisotropism:* May be weak in bluish gray, moderate in blue-green to red-brown.
R_1–R_2: (400) 37.8–45.9, (420) 37.6–45.7, (440) 37.3–45.2, (460) 37.1–44.6, (480) 37.0–44.0, (500) 36.7–43.4, (520) 36.3–42.6, (540) 36.1–42.0, (560) 35.9–41.3, (580) 35.4–40.5, (600) 34.6–39.3, (620) 33.6–38.1, (640) 32.5–36.9, (660) 31.6–35.9, (680) 30.8–35.1, 700) 30.1–34.4

Cell Data: *Space Group:* $C2/c$. $a = 13.441$ $b = 11.726$ $c = 16.930$ $\beta = 94.71(8)°$
Z = 4

X-ray Powder Pattern: Baia Mare, Romania.
3.89 (100), 3.20 (90), 2.919 (80), 2.822 (80), 3.23 (70), 2.749 (70), 6.25 (50)

Chemistry:

	(1)	(2)	(3)
Pb	28.29	30.6	29.93
Sb	47.50	47.0	46.91
S	24.10	23.1	23.16
rem.	0.19		
Total	100.08	100.7	100.00

(1) Baia Mare, Romania; remainder is SiO_2, corresponds to $Pb_{2.95}Sb_{7.90}S_{15.00}$. (2) Skalnoye deposit, Kazakhstan; [??by electron microprobe??,] corresponds to $Pb_{3.01}Sb_{8.02}S_{15.00}$.
(3) $Pb_3Sb_8S_{15}$.

Occurrence: Of hydrothermal origin.

Association: Zinkenite, semseyite, fizélyite, andorite, freieslebenite, geocronite, boulangerite, jamesonite, cinnabar, sphalerite, marcasite, quartz, dolomite.

Distribution: In Romania, in the Baia Mare (Nagybánya) district, from the Dealul Crucii (Kereszthegy) [TL] and Herja mines. At Wet Swine Gill, Caldbeck Fells, Cumbria, England. In France, from Auliac, Cantal; Bodennec and Bournac, Montagne Noire, [Hérault??not=??so double check both Bodennec and Bournac localities??] Finistère. From the North Altyntopkan Pb–Zn skarn deposit, northwestern Karamazar, Tajikistan. At the Skalnoye Hg–Sb deposit, central Kazakhstan. In the Lake George antimony deposit, 40 km west of Fredricton, New Brunswick, Canada.

Name: For Dr. Béla Fülöpp (1863–1938), mineral collector of Hungary.

Type Material: The Natural History Museum, London, England, 1929,248.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 463–464. (2) Jambor, J.L. (1969) Sulfosalts of the plagionite group. Mineral. Mag., 37, 442–446. (3) Nuffield, E.W. (1975) The crystal structure of fülöppite, $Pb_3Sb_8S_{15}$. Acta Cryst., 31, 151–157. (4) Swinnea, J.S., A.J. Tenorio, and H. Steinfink (1985) $Sb_{10}S_{15}$, a Pb-free analog of fülöppite, $Pb_3Sb_8S_{15}$. Amer. Mineral., 70, 1056–1058. (5) Vershkovskaya, O.V., D.K. Shcherbachev, O.Y. Yushko-Zakharova, L.S. Dubakina, and I.Y. Maksimyuk (1984) First fülöppite find in mercury-antimony ore. Doklady Acad. Nauk SSSR, 264, 1203–1206 (in Russian). (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 180.

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Furongite $Al_2(UO_2)(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As tabular crystals, to 0.5 mm, in rosettes, and dense cryptocrystalline aggregates.

Physical Properties: *Cleavage:* On $\{\overline{1}11\}$ and $\{1\overline{1}1\}$, very perfect. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.82–3.0 D(calc.) = 2.92 Radioactive; strong pale yellowish green fluorescence under UV.

Optical Properties: Translucent. *Color:* Bright to pale yellow, lemon-yellow; pale yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Observed, in yellows. *Orientation:* $Z \wedge \{\overline{1}11\} \simeq 38°$.
$\alpha = 1.538–1.549$ $\beta = 1.558–1.567$ $\gamma = 1.566–1.575$ 2V(meas.) = 65°–80° 2V(calc.) = 64°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 19.227–19.271$ $b = 14.094–14.173$
$c = 12.102–12.136$ $\alpha = 67.21°–67.62°$ $\beta = 115.45°–115.64°$ $\gamma = 94.51°–94.58°$ Z = 4

X-ray Powder Pattern: Hunan Province, China.
10.2 (100), 8.62 (80), 4.310 (50), 3.639 (40), 2.868 (35), 5.553 (30), 5.096 (30)

Chemistry:

	(1)	(2)	(3)
UO_3	41.40	49.61	41.33
P_2O_5	18.54	18.56	20.51
SiO_2	0.80		
Al_2O_3	13.67	9.38	14.73
Fe_2O_3	0.61		
MgO	0.015		
CaO	0.094		
BaO	0.59		
K_2O	0.11		
H_2O^+	14.54		
H_2O^-	9.36		
H_2O		22.45	23.43
Total	99.729	100.00	100.00

(1) Hunan Province, China. (2) Kobokobo pegmatite, Congo; by electron microprobe, H_2O by TGA. (3) $Al_2(UO_2)(PO_4)_2(OH)_2 \cdot 8H_2O$.

Occurrence: In the oxidation zone of a uranium deposit (Hunan Province, China); in a complex granite pegmatite (Kobokobo pegmatite, Congo).

Association: Variscite, evansite, autunite, halloysite, "opal", "limonite" (Hunan Province, China); moreauite (Kobokobo pegmatite, Congo).

Distribution: From an undefined locality in western Hunan Province, China. At the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: From a poetic name for Hunan Province, China.

Type Material: n.d.

References: (1) Hunan 230 Laboratory, Hunan 305 Geological Team and X-Ray Laboratory, Wahan Geological Institute (1976) Furongite – a new uranium mineral found in China. Acta Geologica Sinica, 2, 203–204 (in Chinese). (2) (1978) Amer. Mineral., 63, 425 (abs. ref. 1). (3) Shen Jinchuan and Peng Zhizhong (1981) The crystal structure of furongite. Acta Cryst., A37 supplement, C186. (4) Deliens, M. and P. Piret (1985) Les phosphates d'uranyle et d'aluminum de Kobokobo, VIII. La furongite. Ann. Soc. Géol. Belg., 108, 365–368 (in French with English abs.).

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Furutobeite $(Cu, Ag)_6PbS_4$

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Crystal Data: Monoclinic. *Point Group:* m, 2, or $2/m$. Granular, to 300 μm).

Physical Properties: Hardness = n.d. VHN = 100–108 (25 g load). D(meas.) = n.d. D(calc.) = 6.74

Optical Properties: Opaque. *Color:* Gray, with a creamy yellow tint in reflected light. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Moderate, from pale yellow to dark brown. R_1–R_2: (400) 35.7–34.2, (420) 35.2–34.3, (440) 35.0–34.5, (460) 34.7–34.9, (480) 34.5–35.3, (500) 34.4–35.6, (520) 34.4–35.9, (540) 34.6–36.2, (560) 34.7–36.3, (580) 34.8–36.4, (600) 34.9–36.4, (620) 34.9–36.3, (640) 34.9–36.3, (660) 34.8–36.2, (680) 34.5–36.1, (700) 34.3–36.0

Cell Data: *Space Group:* Cm, $C2$, or $C2/m$. a = 20.025(13) b = 3.963(2) c = 9.705(4) $\beta = 101.57(4)°$ Z = 4

X-ray Powder Pattern: Furutobe mine, Japan.
2.50 (100), 2.95 (90), 2.55 (70), 3.43 (50), 2.61 (50), 2.14 (40), 2.09 (40)

Chemistry:

	(1)	(2)	(3)
Cu	40.4	42.4	41.75
Ag	15.7	13.9	14.17
Pb	26.6	27.6	27.23
S	16.8	16.0	16.85
Total	99.5	99.9	100.00

(1) Furutobe mine, Japan; by electron microprobe, average of seven analyses; corresponds to $(Cu_{4.85}Ag_{1.11})_{\Sigma=5.96}Pb_{0.98}S_{4.00}$. (2) Tsumeb, Namibia; by electron microprobe, corresponds to $(Cu_{5.35}Ag_{1.03})_{\Sigma=6.38}Pb_{1.07}S_{4.00}$. (3) $(Cu, Ag)_6PbS_4$ with Cu:Ag = 5:1.

Occurrence: In veinlets of stromeyerite that cut bornite in the Kuroko zone of a stratabound, Kuroko-type, massive sulfide deposit (Furutobe mine, Japan).

Association: Stromeyerite, bornite, galena, sphalerite, tennantite, digenite, argentian gold.

Distribution: In Japan, in Akita Prefecture, in the Daikokuzawa-Higashi deposit of the Furutobe mine [TL], and the No. 11 deposit of the Shakanai mine, near Ohdate City. At Tsumeb, Namibia. In the Erasmus mine, Leogang, Salzburg, Austria.

Name: For the type locality at the Furutobe mine, Japan.

Type Material: Institute of Mineralogy, Petrology and Economic Geology, Faculty of Science, Tohoku University, Sendai, Japan.

References: (1) Sugaki, A., A. Kitakaze, and Y. Odashima (1981) Furutobeite, a new copper–silver–lead sulfide mineral. Bull. Minéral., 104, 737–741. (2) (1982) Amer. Mineral., 67, 1075 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 181.

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Gabrielsonite $PbFe^{2+}(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As crude rounded crystals, in aggregates, and in massive lumps, to 1 cm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 3.5 D(meas.) = 6.67 D(calc.) = 6.69

Optical Properties: Transparent in small fragments. *Color:* Black; greenish brown in transmitted light. *Streak:* Pale chocolate-brown. *Luster:* Adamantine. *Optical Class:* Biaxial (–); very high birefringence. *Pleochroism:* Strong; $X = Z$ = olive-green; Y = red-brown. *Dispersion:* $r < v$, perceptible. *Absorption:* $Y > X = Z$. $n = > 2.00$ 2V(meas.) = 80°–90°

Cell Data: *Space Group:* $P2_1ma$. $a = 7.86(1)$ $b = 5.98(1)$ $c = 8.62(1)$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.192 (10), 3.074 (10), 2.706 (4), 2.651 (4), 1.622 (4), 1.4380 (4), 1.0878 (4)

Chemistry:

	(1)	(2)
As_2O_5	28.54	27.43
Fe_2O_3	0.00	
FeO	18.47	17.15
PbO	50.09	53.27
H_2O	1.21	2.15
Total	98.31	100.00

(1) Långban, Sweden; corresponds to $(Pb_{0.90}Fe_{0.07})_{\Sigma=0.97}Fe_{0.97}(AsO_4)(OH)_{0.55}O_{0.12}$.
(2) $PbFe(AsO_4)(OH)$.

Mineral Group: Adelite group.

Occurrence: In a metamorphosed Fe–Mn orebody.

Association: Roméite, nadorite, finnemanite, calcite, barite.

Distribution: From Långban, Värmland, Sweden.

Name: To honor Dr. Olof Erik Gabrielson (1912–), mineralogist, Swedish Museum of Natural History, Stockholm, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, NRMS 254857; National Museum of Natural History, Washington, D.C., USA, 120063, 162613.

References: (1) Moore, P.B. (1967) Gabrielsonite, $PbFe(AsO_4)(OH)$, a new member of the descloizite-pyrobelonite group, from Långban. Arkiv. Mineral. Geol., 4, 401–405. (2) (1968) Amer. Mineral., 53, 1063–1064 (abs. ref. 1).

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Gadolinite-(Ce) $(Ce, La, Nd, Y)_2Fe^{2+}Be_2Si_2O_{10}$

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Crystal Data: Metamict; monoclinic after recrystallization. *Point Group:* $2/m$. As irregular highly-fractured masses, to 2 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = [6.5–7] (by analogy to the gadolinite group). D(meas.) = 4.20 D(calc.) = 4.90

Optical Properties: Translucent. *Color:* Black; in thin section, olive-green.
Luster: Vitreous.
Optical Class: Isotropic. $n = 1.78$

Cell Data: *Space Group:* $P2/c$ after recrystallization by heating at 700 °C. $a = 4.82(2)$ $b = 7.58(2)$ $c = 10.01(3)$ $\beta = 90°28(16)'$ Z = [2]

X-ray Powder Pattern: Buer, Norway; hydrothermally recrystallized at 700 °C and 2 kb for 48 hours. (ICDD 29-1409).
2.88 (100), 4.81 (90), 2.60 (80), 2.59 (80), 3.18 (70), 3.00 (70), 3.59 (60)

Chemistry:

	(1)		(1)
SiO_2	23.17	FeO	10.03
TiO_2	0.14	MnO	1.33
B_2O_3	0.55	BeO	8.83
Al_2O_3	0.05	MgO	0.33
Y_2O_3	6.78	CaO	2.67
La_2O_3	14.00	Na_2O	0.10
Ce_2O_3	21.25	K_2O	0.53
RE_2O_3	12.05	Total	[101.81]

(1) Buer, Norway; by a combination of wet chemical analysis, electron microprobe, and emission spectroscopy; $RE_2O_3 = Pr_2O_3$ 2.95%, Nd_2O_3 4.36%, Sm_2O_3 0.39%, Eu_2O_3 0.07%, Gd_2O_3 0.92%, Tb_2O_3 0.29%, Dy_2O_3 1.01%, Ho_2O_3 0.39%, Er_2O_3 0.76%, Tm_2O_3 0.13%, Yb_2O_3 0.65%, Lu_2O_3 0.13%; corresponds to $(Ce_{0.68}La_{0.45}Y_{0.32}RE_{0.71})_{\Sigma=2.16}(Fe^{2+}_{0.74}Mn_{0.10}Mg_{0.04}Ti_{0.01})_{\Sigma=0.89}(Be_{1.86}B_{0.08}Al_{0.01})_{\Sigma=1.95}Si_{2.04}O_{10}$.

Mineral Group: Gadolinite group.

Occurrence: In syenite pegmatite veins along a contact between basalt and monzonite.

Association: Aegirine, pyrochlore, zircon, apatite, titanite, pyrophanite, magnetite, loparite, chevkinite, biotite, microcline, helvite, molybdenite, albite, apophyllite, quartz, calcite.

Distribution: From a dump at Buer, nine km southeast of Skien, Bjørkedalen region, and in the Bakken quarry, Tvedalen, Norway.

Name: For its *cerium* content and relation to *gadolinite*-(Y).

Type Material: n.d.

References: (1) Segalstad, T.V. and A.O. Larsen (1978) Gadolinite-(Ce) from Skien, southwestern Oslo region, Norway. Amer. Mineral., 63, 188–195.

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Gadolinite-(Y) $Y_2Fe^{2+}Be_2Si_2O_{10}$

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Crystal Data: Monoclinic; commonly metamict. *Point Group:* $2/m$. Crystals rough; typically prismatic, terminated by {001}, {111}, {221}, and many other forms, to 25 cm; commonly massive.

Physical Properties: *Fracture:* Conchoidal or splintery. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 4.36–4.77 non-metamict. D(calc.) = 4.41

Optical Properties: Opaque, nearly transparent in thin fragments. *Color:* Black, greenish black, brown; grass-green to olive-green in thin fragments. *Streak:* Greenish gray. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (+); isotropic when metamict. *Orientation:* $Z \wedge c = 10°$.
Dispersion: $r < v$, strong. $\alpha = 1.77–1.78$ $\beta =$ n.d. $\gamma = 1.78–1.82$ 2V(meas.) = 85°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.000(2)$ $b = 7.565(2)$ $c = 4.768(1)$ $\beta = 90.31(2)°$ Z = 2

X-ray Powder Pattern: Synthetic.
2.818 (100), 2.816 (100), 4.735 (80), 2.932 (70), 2.558 (60), 2.539 (55), 3.118 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	24.35	22.13	23.36	Fe_2O_3	2.03	3.47	
ThO_2	0.30	0.89	0.00	FeO	11.39	10.43	12.08
Y_2O_3	45.96	22.24	28.55	BeO	10.17	7.19	[9.71]
$(Dy,La)_2O_3$	3.06	21.23	0.21	CaO	0.30	0.48	0.03
Ce_2O_3	1.65	11.10	2.54	Na_2O	0.17	0.46	
RE_2O_3			[21.56]	H_2O	0.52	0.86	[0.46]
				Total	99.90	100.48	[98.50]

(1) Ytterby, Sweden. (2) Douglas Co., Colorado, USA. (3) Near Yokkaichi, Mie Prefecture, Japan; by electron microprobe, $RE_2O_3 = Pr_2O_3$ [1.2%], Nd_2O_3 4.55%, Sm_2O_3 2.82%, Eu_2O_3 [0.6%], Gd_2O_3 2.93%, Tb_2O_3 [1.1%], Dy_2O_3 4.06%, Ho_2O_3 1.98%, Er_2O_3 1.54%, Tm_2O_3 [0.2%], Yb_2O_3 0.58%, Lu_2O_3 trace, BeO and H_2O from stoichiometry; corresponding to $(Y_{1.30}RE_{0.70})_{\Sigma=2.00}Fe^{2+}_{0.86}Be_{2.00}Si_{2.00}[O_{9.72}(OH)_{0.28}]_{\Sigma=10.00}$.

Mineral Group: Gadolinite group.

Occurrence: In granite and alkalic granite pegmatites.

Association: Allanite, fluorite, fergusonite, yttrialite, chevkinite, zircon.

Distribution: Numerous localities worldwide: in Sweden, from Ytterby, on Resarö Island, near Waxholm, and at Kolsva, Västmanland. On Hitterö Island, Flekkefjord; at Slobrekka and Dauren, Iveland; and elsewhere in Norway. From Piz Blas, Val Nalps, also Piz Rondadura and Pizza Rotondo, Val Bedretto, Ticino, Switzerland. In Austria, at Böckstein, near Badgastein, Salzburg. In the USA, in the Clear Creek pegmatite, Burnet Co., and the Baringer Hill pegmatite, 26 km west of Burnet, and at Rode Ranch, near Bluffton, Llano Co., Texas; in Arizona, near Hackberry, Mohave Co.; on Devil's Head Mountain, Douglas Co., and near Lake George, Park Co., Colorado. In Canada, from Loughborough Township, Frontenac Co., Ontario.

Name: For the Finnish chemist, Johan Gadolin (1760–1852), who discovered yttrium.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 509–512. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 235–239. (3) Ito, J. and S.S. Hafner (1974) Synthesis and study of gadolinites. Amer. Mineral., 59, 700–708. (4) Miyawaki, R., I. Nakai, and K. Nagashima (1984) A refinement of the crystal structure of gadolinite. Amer. Mineral., 69, 948–953.

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Gagarinite-(Y) $NaCaY(F,Cl)_6$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As long- and short-prismatic hexagonal crystals, showing the forms $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, $\{0001\}$, and less well-developed rhombohedral faces, to several cm. Commonly as irregular grains and granular aggregates.

Physical Properties: *Cleavage:* One direction, prismatic, distinct. *Tenacity:* Brittle. Hardness = 4.5 VHN = 367–372 D(meas.) = 4.11–4.29 D(calc.) = [4.27] Decomposed by H_2O, most Na going into solution; weakly magnetic.

Optical Properties: Transparent to translucent. *Color:* Pinkish or rosy, yellow, yellowish white or creamy, colorless; in transmitted light, colorless. *Streak:* White. *Luster:* Vitreous to dull.
Optical Class: Uniaxial (+); may be anomalously biaxial. $\omega = 1.472$–1.475 $\epsilon = 1.490$–1.493 2V(meas.) = $\leq 20°$

Cell Data: *Space Group:* $P6_3/m$. $a = 5.987(2)$ $c = 3.5413(7)$ $Z = 1$

X-ray Powder Pattern: Verkhne-Espe massif, Kazakhstan.
1.717 (10b), 2.086 (9), 3.00 (5), 2.92 (5), 5.24 (3), 1.129 (3), 2.28 (2)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.15		K_2O	0.10	trace
TiO_2	trace		F	33.00	33.00
Al_2O_3	0.60	trace	Cl	3.79	
RE_2O_3	54.80	56.75	H_2O	0.07	
Fe_2O_3	0.15	0.33	insol.		2.34
CaO	14.18	8.79	$-O = (F,Cl)_2$	14.73	13.88
Na_2O	7.50	10.64	Total	99.61	97.97

(1) Verkhne-Espe massif, Kazakhstan; RE = La 1.2%, Ce 5.3%, Pr 1.0%, Nd 6.1%, Sm 4.8%, Gd 6.1%, Tb 2.2%, Dy 18.2%, Ho 3.6%, Er 10.6%, Tm 1.4%, Yb 10.1%, Y 29.4%. (2) Erzin massif, Russia; RE = La 0.8%, Ce 3.5%, Pr 0.8%, Nd 3.8%, Sm 3.8%, Eu 0.3%, Gd 10.5%, Tb 1.3%, Dy 11.3%, Ho 2.5%, Er 7.6%, Tm 0.7%, Yb 3.6%, Lu 1.3%, Y 48.5%. (3) Katugino massif, Kazakhstan; analysis not given, stated to correspond to $Na_{0.6}(Ca_{0.95}Y_{0.72}Dy_{0.10}Gd_{0.09}Er_{0.04}Ho_{0.03}Sm_{0.03}Yb_{0.01}Nd_{0.01}Tb_{0.01}Ce_{0.01})_{\Sigma=2.00}F_{5.41}$.

Occurrence: As disseminations, segregations, and in veins and miarolitic cavities within Na-metasomatized alkalic granites and quartz-syenites.

Association: Riebeckite, pyrochlore, zircon, bastnäsite, tengerite, synchysite, yttrofluorite, elpidite (Verkhne-Espe massif, Kazakhstan); riebeckite, aegirine, zircon, fergusonite, polylithionite, siderite, sphalerite, fluorite (Erzin massif, Russia).

Distribution: From the Bol'shoi and Malyi stocks, Verkhne-Espe alkaline massif, Tarbagatai Range, and the Katugino massif, Irkutsk region, Kazakhstan. In Russia, found in the Erzin alkaline massif, southeastern Tuva, and other undefined localities in eastern Siberia. Occurs in the vicinity of Lake Gjerdingen, Nordmarka, Norway. In the USA, found at Washington Pass, Okanogan Co., Washington.

Name: In honor of the first cosmonaut, Yuri Alekseevich Gagarin (1934–1968).

Type Material: Vernadsky Geological Museum, Moscow, 47307; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 62341–62343.

References: (1) Stepanov, A.V. and E.A. Severov (1961) Gagarinite, a new rare-earth mineral. Doklady Acad. Nauk SSSR, 141, 954–957 (in Russian). (2) (1962) Amer. Mineral., 47, 805 (abs. ref. 1). (3) Akelin, N.A. and M.E. Kazakova (1963) New discovery of gagarinite. Doklady Acad. Nauk SSSR, 149, 672–674 (in Russian). (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 223–225. (5) Hughes, J.M. and J.W. Drexler (1994) Refinement of the structure of gagarinite-(Y), $Na_x(Ca_xREE_{2-x})F_6$. Can. Mineral., 32, 563–565.

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Gageite $(Mn^{2+}, Mg, Zn)_{42}Si_{16}O_{54}(OH)_{40}$

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Crystal Data: Monoclinic, pseudotetragonal, or triclinic. *Point Group:* $2/m$ or $\overline{1}$. Minute laths or saddlelike crystals grouped radially, in bundles, or as matted fibers.

Physical Properties: *Cleavage:* {110}, pronounced. Hardness = 3 D(meas.) = 3.46–3.584 D(calc.) = 3.599

Optical Properties: Transparent to translucent. *Color:* Colorless, pale pink, pale brown. *Luster:* Highly vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z \parallel$ fiber length. *Dispersion:* $r < v$, extreme.
$\alpha = 1.723(3)$ $\beta = 1.734(3)$ $\gamma = 1.736(3)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2/n$. $a = 19.42$ $b = 19.42$ $c = 9.84$ $\beta = 89.5°$ Z = [1], or *Space Group:* $P\overline{1}$. $a = 14.17$ $b = 14.07$ $c = 9.84$ $\alpha = 76.5°$ $\beta = 76.6°$ $\gamma = 86.9°$ Z = [1]

X-ray Powder Pattern: Franklin, New Jersey, USA.
6.87 (100), 2.758 (80), 2.707 (80), 3.44 (60), 3.25 (60), 2.556 (60), 1.6742 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	24.71	23.58	23.90
Al_2O_3		0.15	
FeO		0.03	0.20
MnO	50.19	53.74	51.06
ZnO	8.76	3.96	4.30
MgO	11.91	9.95	11.34
CaO			0.19
H_2O	[4.43]	8.24	[9.01]
Total	[100.00]	99.65	[100.00]

(1) Franklin, New Jersey, USA; H_2O by difference. (2) Do. (3) Do.; by electron microprobe, average of seven analyses, H_2O by difference; corresponds to $(Mn_{28.95}Mg_{11.32}Zn_{2.13}Ca_{0.14}Fe_{0.11})_{\Sigma=42.65}Si_{16}O_{54.53}(OH)_{40.23}$.

Polymorphism & Series: 2M, 1A polytypes.

Occurrence: A late-stage low- to medium-temperature mineral, implanted on other species in fissures and solution cavities, in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Zincite, willemite, pyrochroite, leucophoenicite, calcite, chlorophoenicite (Franklin, New Jersey, USA); leucophoenicite, hausmannite, rhodochrosite, manganoan calcite (near Kuruman, South Africa).

Distribution: In the USA, at Franklin, Sussex Co., New Jersey, and in the Pennsylvania mine, San Antonio Valley, Santa Clara Co., California. In the Wessels and N'Chwaning II mines, near Kuruman, Cape Province, South Africa.

Name: For Robert B. Gage, of Trenton, New Jersey, USA, who analyzed the first specimens.

Type Material: National Museum of Natural History, Washington, D.C., USA, R6444, 86845.

References: (1) Phillips, A.H. (1910) Gageite, a new mineral from Franklin, New Jersey. Amer. J. Sci., 30, 283–284. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 111. (3) Moore, P.B. (1968) Relations of the manganese-calcium silicates, gageite and harstigite. Amer. Mineral., 53, 309–315. (4) Moore, P.B. (1969) A novel octahedral framework structure: gageite. Amer. Mineral., 54, 1005–1017. (5) Dunn, P.J. (1979) The chemical composition of gageite: an empirical formula. Amer. Mineral., 64, 1056–1058. (6) Ferraris, G., M. Mellini, and S. Merlino (1987) Electron-diffraction and electron microscopy study of balangeroite and gageite: crystal structures, polytypism, and fiber texture. Amer. Mineral., 72, 382–391.

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Gahnite $ZnAl_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. Typically octahedra, rarely as dodecahedra, may be modified by {100} or {011}, to 12 cm; also as exsolution lamellae in other minerals; granular, massive. *Twinning:* On {111} as both twin and composition plane, common.

Physical Properties: *Cleavage:* Parting {111}, indistinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7.5–8 D(meas.) = 4.38–4.60 D(calc.) = 4.607

Optical Properties: Translucent to nearly opaque. *Color:* Dark green, bluish green, blue to indigo, yellow to brown; in transmitted light, pale green; in reflected light, bluish green to green internal reflections. *Streak:* Gray. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.79$–1.80

Cell Data: *Space Group:* $Fd3m$(synthetic). a = 8.0872(1) Z = 8

X-ray Powder Pattern: Synthetic.
2.438 (100), 2.861 (84), 1.429 (43), 1.556 (40), 1.650 (24), 0.8251 (13), 1.0525 (12)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.03	0.06		MnO	0.65	0.46	
TiO_2	0.00	0.00		ZnO	34.06	19.88	44.39
Al_2O_3	57.71	60.80	55.61	MgO	0.61	7.33	
FeO	7.85	12.09		Total	100.91	100.62	100.00

(1) Desolation Row pluton, Victoria Range, New Zealand; by electron microprobe, total Fe as FeO; corresponding to $(Zn_{0.75}Fe_{0.19}Mg_{0.03}Mn_{0.02})_{\Sigma=0.99}(Al_{2.01}Si_{0.01})_{\Sigma=2.02}O_4$. (2) Geco mine, Canada; by electron microprobe, average of six points, total Fe as FeO; corresponding to $(Zn_{0.41}Mg_{0.30}Fe_{0.28}Mn_{0.01})_{\Sigma=1.00}Al_{1.99}O_{32}$. (3) $ZnAl_2O_4$.

Polymorphism & Series: Forms two series, with spinel, and with hercynite.

Mineral Group: Spinel group.

Occurrence: An accessory mineral in granites and granite pegmatites; in medium- to high-grade metamorphic rocks and metamorphosed base-metal sulfide deposits; in diasporites, formed by the low-grade metamorphism of bauxites; a detrital mineral in placers.

Association: Rhodonite, franklinite, calcite, andradite, willemite (Franklin, New Jersey, USA); corundum, pyrrhotite, högbomite, nigerite, phlogopite, staurolite, cordierite, pyrite, chalcopyrite (Geco mine, Canada).

Distribution: Many localities, but most with small crystals. Abundant at Falun, Sweden. From the Silberberg mine, near Bodenmais, Bavaria, Germany. At Tiriolo, near Catanzaro, Calabria, Italy. In the USA, large crystals from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; at the Mineral Hill and Patapsco mines, Carroll Co., Maryland; in the Deake and Chalk Mountain mines, Mitchell Co., North Carolina; in the Cotopaxi mine, Fremont Co., Colorado. In Canada, found at the Geco mine, Manitouwadge, Ontario; in Hudson township, Quebec; and elsewhere. In Brazil, from the Alto do Giz pegmatite, near Parelhas, Rio Grande do Norte. At Ambatofotsikely, Madagascar. From Otjiwarango, Namibia. At Jemaa, Nigeria. From Broken Hill, New South Wales; at Wodgina and Greenbushes, Western Australia. In New Zealand, occurs in the Victoria Range, Nelson.

Name: For the Swedish chemist and mineralogist, Johan Gottlieb Gahn (1745–1818), who discovered the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 689–697. (2) Tulloch, A.J. (1981) Gahnite and columbite in an alkali-feldspar granite from New Zealand. Mineral. Mag., 44, 275–278. (3) Spry, P.G. (1982) An unusual gahnite-forming reaction, Geco base-metal deposit, Manitouwadge, Ontario. Can. Mineral., 20, 549–553. (4) O'Neill, H.St.C. and W.A. Dollase (1994) Crystal structures and cation distributions in simple spinels from powder XRD structural refinements: $MgCr_2O_4$, $ZnCr_2O_4$, Fe_3O_4 and the temperature dependence of the cation distribution in $ZnAl_2O_4$. Phys. Chem. Minerals, 20, 541–555. (5) (1953) NBS Circ. 539, 2, 38.

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Gaidonnayite $Na_2ZrSi_3O_9 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals well-formed, slightly bladed, flattened on {010}, and elongated and heavily striated along [100], to 6 mm. *Twinning:* Common about [012] with irregular composition plane.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = 2.67(1) D(calc.) = 2.70 Commonly fluoresces bright green fluorescence under SW and LW UV.

Optical Properties: Transparent to opaque. *Color:* Colorless, white, beige, light brown, pale yellowish green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. α = 1.573–1.575 β = 1.590–1.592 γ = 1.599–1.605 2V(meas.) = 53°–59° 2V(calc.) = 55°–62°

Cell Data: *Space Group:* $P2_1nb$. $a = 11.740(3)$ $b = 12.820(3)$ $c = 6.691(1)$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada; very similar to georgechaoite.
3.124 (100), 5.93 (80), 5.84 (80), 3.094 (80), 5.63 (50), 2.931 (40), 1.637 (40)

Chemistry:

	(1)	(2)
SiO_2	42.51	42.5
TiO_2	0.42	0.5
ZrO_2	30.21	27.7
Nb_2O_5	3.00	1.4
CaO		0.6
Na_2O	13.11	8.7
K_2O	2.20	6.4
H_2O	9.25	[12.2]
Total	100.70	[100.0]

(1) Mont Saint-Hilaire, Canada, by electron microprobe, H_2O by TGA; corresponding to $(Na_{1.72}K_{0.19})_{\Sigma=1.91}Zr_{1.00}Nb_{0.09}Ti_{0.02}Si_{2.88}O_9 \cdot 2.10H_2O$. (2) Narssârssuk, Greenland; by electron microprobe, H_2O by difference; corresponding to $(Na_{1.19}K_{0.58}Ca_{0.05})_{\Sigma=1.82}Zr_{0.95}Nb_{0.04}Ti_{0.03}Si_{3.00}O_9 \cdot nH_2O$.

Polymorphism & Series: Dimorphous with catapleiite.

Occurrence: In miarolitic cavities in nepheline syenite and altered pegmatite dikes in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in augite syenite (Narssârssuk, Greenland).

Association: Siderite, analcime, hilairite, aegirine, calcite, albite, catapleiite, zircon, pyrochlore, ancylite, burbankite (Mont Saint-Hilaire, Canada); vlasovite, gittinsite, apophyllite (Kipawa River, Canada); natrolite, aegirine, albite, siderite (Narssârssuk, Greenland).

Distribution: In Canada, from Mont Saint-Hilaire, near Saint-Amable, and in the Sheffield Lake complex, Kipawa River, Villedieu Township, Quebec. From Granite Mountain, near Little Rock, Pulaski Co., Arkansas, USA. In Greenland, at Narssârssuk. From the Lovozero and Khibiny massifs, Kola Peninsula, Russia. At Poços de Caldas, Minas Gerais, Brazil.

Name: For Professor Gabrielle Donnay (1920–1987), mineralogist of McGill University, Montreal, Quebec, Canada.

Type Material: Canadian Museum of Nature, Ottawa, T73/2-1, T73/2-2; Royal Ontario Museum, Toronto, Canada, 34803.

References: (1) Chao, G.Y. and D.H. Watkinson (1974) Gaidonnayite, $Na_2ZrSi_3O_9 \cdot 2H_2O$, a new mineral from Mont St. Hilaire, Quebec. Can. Mineral., 12, 316–319. (2) Mandarino, J.A. and B.D. Sturman (1978) The identity of α-catapleiite and gaidonnayite. Can. Mineral., 16, 195–198. (3) Chao, G.Y. (1985) The crystal structure of gaidonnayite $Na_2ZrSi_3O_9 \cdot 2H_2O$. Can. Mineral., 23, 11–15.

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Gainesite $Na_2(Be,Li)(Zr,Zn)_2(PO_4)_4 \cdot 1-2H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are steep tetragonal bipyramids, to 2 mm, with prominent {111} and tiny {001}.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4 D(meas.) = 2.94(2) D(calc.) = 2.89

Optical Properties: Transparent. *Color:* Pale bluish lavender; nearly colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.618(2)$ $\epsilon = 1.630(2)$

Cell Data: *Space Group:* $I4_1/amd$. a = 6.567(3) c = 17.119(5) Z = 2

X-ray Powder Pattern: Nevel quarry, Maine, USA; close to mccrillisite.
6.068 (100), 3.265 (90), 3.023 (50), 2.881 (40), 4.240 (30), 2.165 (30), 2.012 (30)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	45.0	45.0	CaO	0.86	0.7
SiO_2	0.59	0.1	SrO	0.15	0.0
ZrO_2	33.0	33.0	Li_2O	1.7	0.8
HfO_2	n.d.	0.7	Na_2O	6.82	7.8
Al_2O_3	1.21	0.5	K_2O	1.45	2.4
FeO	0.54	1.0	Rb_2O	0.11	0.1
MnO	0.83	0.7	Cs_2O	1.93	2.2
ZnO	4.11	< 0.1	F		< 0.1
BeO	2.8	2.3	H_2O	n.d.	4.3
MgO	0.30	0.35	Total	101.4	101.95

(1) Nevel quarry, Maine, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(Na_{0.38}Li_{0.06}Mn^{2+}_{0.04}Fe^{2+}_{0.02})_{\Sigma=0.50}(Na_{0.30}K_{0.10}Cs_{0.05}Ca_{0.05})_{\Sigma=0.50}Li_{0.22}(Be_{0.35}Li_{0.08}Al_{0.07})_{\Sigma=1.00}(Zr_{0.83}Zn_{0.15}Mg_{0.02})_{\Sigma=1.00}[(P_{0.99}Si_{0.01})_{\Sigma=1.00}O_4]_4$. (2) Do.; by electron microprobe, Zn, Be, Li by LA-ICP-MS and ion microprobe, H_2O by ion microprobe, total Fe as FeO, total Mn as MnO; corresponds to $Na_{1.00}(Na_{0.59}K_{0.32}Cs_{0.10}Rb_{0.01})_{\Sigma=1.02}(Be_{0.58}Li_{0.34}Mg_{0.06}Al_{0.06})_{\Sigma=1.04}(Zr_{1.69}Fe_{0.09}Ca_{0.08}Mn_{0.06}Hf_{0.02})_{\Sigma=1.94}[(P_{1.00}Si_{0.01})_{\Sigma=1.01}O_4]_4 \cdot 1.5H_2O$.

Occurrence: A very rare accessory mineral in a granite pegmatite.

Association: Roscherite, eosphorite, albite.

Distribution: From the Nevel quarry, Newry, Oxford Co., Maine, USA.

Name: To honor Dr. Richard Venable Gaines (1917–1999), American mineralogist, economic geologist, and mineral collector, of Earlysville, Virginia, USA, for his interest in beryllium minerals.

Type Material: Harvard University, Cambridge, Massachusetts, 119133; National Museum of Natural History, Washington, D.C., USA, 114848, 137843.

References: (1) Moore, P.B., T. Araki, I.M. Steele, G.H. Swihart, and A.R. Kampf (1983) Gainesite, sodium zirconium beryllophosphate: a new mineral and its crystal structure. Amer. Mineral., 68, 1022–1028. (2) Foord, E.E., M.E. Brownfield, F.E. Lichte, A.M. Davis, and S.J. Sutley (1994) Mccrillisite, $NaCs(Be,Li)Zr_2(PO_4)_4 \cdot 1-2H_2O$, a new mineral species from Mount Mica, Oxford County, Maine, and new data for gainesite. Can. Mineral., 32, 839–842.

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Gaitite $Ca_2Zn(AsO_4)_2•2H_2O$

Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals rare, to 1 mm, showing {100}, {010}, {001}, {011}, strongly zoned with talmessite; as polycrystalline coatings.

Physical Properties: *Cleavage:* {010}, {001}, and {011}, probable, equally good.
Hardness = ~5 D(meas.) = 3.81(5) D(calc.) = 3.82

Optical Properties: Semitransparent. *Color:* White to colorless. *Streak:* White.
Luster: Vitreous.
Optical Class: Biaxial (–) or (+). *Orientation: X* (28°,32°); *Y* (185°,60°); *Z* (–79°,80°) using (φ,ρ). α = 1.713(2) β = 1.730(2) γ = 1.748(2) 2V(meas.) = 88(2)° 2V(calc.) = 89°

Cell Data: *Space Group:* $P\bar{1}$. a = 5.899(1) b = 6.978(1) c = 5.755(1) α = 97.41(3)° β = 109.08(3)° γ = 108.09(3)° Z = 1

X-ray Powder Pattern: Tsumeb, Namibia.
2.781 (100), 3.080 (80), 2.750 (70), 1.721 (60), 3.350 (50), 3.208 (50), 5.05 (40)

Chemistry:

	(1)	(2)
As_2O_5	50.2	50.03
FeO	0.2	
MnO	0.2	
ZnO	15.3	17.72
MgO	1.2	
CaO	24.2	24.41
H_2O	7.8	7.84
Total	99.1	100.00

(1) Tsumeb, Namibia; by electron microprobe, H_2O by DTA-TGA; corresponds to $Ca_{1.98}(Zn_{0.86}Mg_{0.14}Fe_{0.01}Mn_{0.01})_{\Sigma=1.02}(AsO_4)_2•2H_2O$. (2) $Ca_2Zn(AsO_4)_2•2H_2O$.

Polymorphism & Series: Dimorphous with zincroselite; forms a series with talmessite.

Mineral Group: Fairfieldite group.

Occurrence: A very rare mineral from a deep oxidized zone in a dolostone-hosted, hydrothermal, polymetallic ore deposit.

Association: Talmessite, prosperite, adamite, conichalcite, austinite, barite, quartz, chalcocite.

Distribution: From Tsumeb, Namibia.

Name: In honor of Dr. Robert Irwin Gait (1938–), South African-Canadian Curator of Mineralogy, Royal Ontario Museum, Toronto, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M35388; National Museum of Natural History, Washington, D.C., USA, 144799.

References: (1) Sturman, B.D. and P.J. Dunn (1980) Gaitite, $H_2Ca_2Zn(AsO_4)_2(OH)_2$, a new mineral from Tsumeb, Namibia (South West Africa). Can. Mineral., 18, 197-200. (2) (1981) Amer. Mineral., 66, 1274 (abs. ref. 1). (3) Keller, P., H. Hess, and H. Riffel (1981) Die Kristallstruktur von zwei neuen Calcium-Zink-Arsenat-Mineralen von Tsumeb/Namibia. Zeits. Krist., 156, 70-71 (in German). (4) Keller, P., F. Lissner, and T. Schleid (2004) The crystal structures of zincroselite and gaitite: Two natural polymorphs of $Ca_2Zn[AsO_4]_2·2H_2O$ from Tsumeb, Namibia. Eur. J. Mineral., 16, 353-359.

Galaxite $(Mn^{2+}, Fe^{2+}, Mg)(Al, Fe^{3+})_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. As octahedra and rounded grains, to 0.5 mm; as exsolution blebs. *Twinning:* On {111} as both twin and composition plane, the spinel law, probable.

Physical Properties: *Fracture:* Conchoidal. Hardness = 7.5 D(meas.) = 4.234 D(calc.) = [4.22]

Optical Properties: Opaque; may be translucent in thin section. *Color:* Black, red-brown, red to yellow; in transmitted light, golden yellow, brownish orange, mahogany-red, deep red to reddish black. *Streak:* Red-brown. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.923$

Cell Data: *Space Group: Fd3m.* $a = 8.258$ $Z = 8$

X-ray Powder Pattern: Synthetic $MnAl_2O_4$.
2.492 (100), 2.921 (60), 1.4600 (45), 1.5896 (40), 0.8429 (30), 2.065 (25), 1.0749 (25)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.96		0.30	MnO	34.03	39.1	39.9
TiO_2	trace	< 0.05	0.13	CoO		0.25	
Al_2O_3	45.71	56.3	48.0	ZnO	trace	0.43	
Fe_2O_3		4.6	8.9	MgO	1.50	0.83	1.79
V_2O_3		0.14		CaO	trace		
FeO	16.36	0.0		Total	98.56	101.7	99.0

(1) Bald Knob, North Carolina, USA; total Fe as FeO. (2) Do.; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Mn^{2+}_{0.95}Mg_{0.04}Zn_{0.01})_{\Sigma=1.00}(Al_{1.90}Fe^{3+}_{0.10})_{\Sigma=2.00}O_4$. (3) Bonneval-sur-Arc, France; by electron microprobe, total Fe as Fe_2O_3; corresponds to $(Mn^{2+}_{0.92}Mg_{0.08})_{\Sigma=1.00}(Al_{1.70}Fe^{3+}_{0.20}Mn^{3+}_{0.09}Si_{0.01})_{\Sigma=2.00}O_4$.

Mineral Group: Spinel group.

Occurrence: In carbonate-rich, silica-undersaturated parts of metamorphosed manganese deposits.

Association: Alleghanyite, rhodonite, sonolite, spessartine, tephroite, kutnohorite, manganhumite, jacobsite, kellyite, alabandite (Bald Knob, North Carolina, USA); katoptrite, magnetite, manganostibite, magnussonite, tephroite, manganhumite, manganosite (Brattfors mine, Sweden).

Distribution: Occurs near Bald Knob, Alleghany Co., North Carolina, USA. In the Brattfors and Jakobsberg mines, Värmland, Sweden. In France, found near Bonneval-sur-Arc, Haute-Savoie. In Japan, found at the Noda-Tamagawa mine and Hijikuzu, Iwate Prefecture; the Oashi mine, Tochigi Prefecture; the Taguchi mine, Aichi Prefecture; the Ioi mine, Shiga Prefecture; and the Fukumaki mine, Yamaguchi Prefecture.

Name: For Galax, Virginia, USA, close to Bald Knob, North Carolina, and for the plant, *galax*, after which the town is named.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 689–697. (2) Ross, C.S. and P.F. Kerr (1932) The manganese minerals of a vein near Bald Knob, North Carolina. Amer. Mineral., 17, 1–18. (3) Chopin, C. (1978) Les paragèneses réduites ou oxydées de concentrations manganésifères des "schistes lustrés" de Haute-Maurienne (Alpes françaises). Bull. Minéral., 101, 514–531 (in French with English abs.). (4) Essene, E.J. and D.R. Peacor (1983) Crystal chemistry and petrology of coexisting galaxite and jacobsite and other spinel solutions and solvi. Amer. Mineral., 68, 449–455. (5) (1960) NBS Circ 539, 9, 35.

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Galeite $Na_{15}(SO_4)_5F_4Cl$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As tabular to barrel-shaped crystals composed of {0001}, {$11\bar{2}0$}, {$11\bar{2}1$}, to 1 mm; typically as nodular aggregates. May form syntactic overgrowths and intergrowths with schairerite.

Physical Properties: Hardness = n.d. D(meas.) = 2.605 D(calc.) = 2.596

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (+). $\omega = 1.447(2)$ $\epsilon = 1.449(2)$

Cell Data: *Space Group:* $P31m$. $a = 12.197(4)$ $c = 13.955(10)$ Z = 3

X-ray Powder Pattern: Searles Lake, California, USA.
2.79 (10), 3.52 (8), 3.68 (7), 2.55 (7), 2.97 (6), 1.758 (6), 3.04 (4)

Chemistry:

	(1)	(2)
SO_4	51.2	51.28
Na	36.4	36.82
F	8.1	8.11
Cl	3.79	3.79
Total	99.49	100.00

(1) Searles Lake, California, USA; by electron microprobe. (2) $Na_{15}(SO_4)_5F_4Cl$.

Occurrence: In a playa lake deposit.

Association: Schairerite, gaylussite, northupite, pirssonite, tychite, trona, hanksite, calcite.

Distribution: From Searles Lake, San Bernardino Co., California, USA.

Name: Honors Dr. William Alexander Gale (1898–1985), Director of Research of the American Potash and Chemical Corporation.

Type Material: National Museum of Natural History, Washington, D.C., USA, 107385.

References: (1) Pabst, A., D.L. Sawyer, and G. Switzer (1963) Galeite and related phases in the system Na_2SO_4−NaF−NaCl. Amer. Mineral., 48, 485–510. (2) Brown, F.H. and A. Pabst (1971) New data of galeite and schairerite. Amer. Mineral., 56, 174–178. (3) Fanfani, L., A. Nunzi, P.F. Zanazzi, and A.R. Zanzari (1975) The crystal structure of galeite, $Na_{15}(SO_4)_5F_4Cl$. Mineral. Mag., 40, 357–361.

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Galena PbS

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Most commonly cubic, crystals to a meter on an edge are known; more rarely cubo-octahedral or octahedral. May be tabular on {001}; also forms reticulated masses and skeletal crystals. As cleavable masses, coarse to very fine granular; fibrous, plumose. *Twinning:* Twin plane {111}, as both contact and penetration twins; twin plane {114}, lamellar.

Physical Properties: *Cleavage:* Perfect on {001}; parting or cleavage on {111}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 2.5–2.75 VHN = 79–104 (100 g load). D(meas.) = 7.58 D(calc.) = 7.57

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, white. *Streak:* Lead-gray. *Luster:* Metallic.
R: (400) 51.9, (420) 50.5, (440) 49.1, (460) 47.7, (480) 46.6, (500) 45.4, (520) 44.4, (540) 43.7, (560) 43.1, (580) 42.8, (600) 42.7, (620) 42.7, (640) 42.8, (660) 42.9, (680) 42.9, (700) 42.6

Cell Data: *Space Group:* $Fm3m$. a = 5.936 Z = 4

X-ray Powder Pattern: Synthetic.
2.969 (100), 3.429 (84), 2.099 (57), 1.790 (35), 1.327 (17), 1.714 (16), 1.484 (10)

Chemistry:

	(1)	(2)	(3)
Pb	86.50	85.9	86.60
Cu	0.07	trace	
Sb		0.7	
Bi		0.2	
S	13.31	12.6	13.40
Total	99.88	99.4	100.00

(1) Katanga Province, Congo (Shaba Province, Zaire); Cu assumed present in covellite and S equivalent deducted. (2) Barrow mine, Newlands, Cumbria, England; by electron microprobe. (3) PbS.

Polymorphism & Series: Forms a series with clausthalite.

Occurrence: In many different types of environments. In hydrothermal veins, formed under a wide range of temperatures; in contact metamorphic deposits, in pegmatites, rarely; limestones and dolostones are common host rocks.

Association: Sphalerite, marcasite, pyrite, chalcopyrite, tetrahedrite, silver minerals, siderite, calcite, dolomite, barite, quartz, many other hydrothermal minerals.

Distribution: The most important ore mineral of lead; only a few deposits of note can be mentioned. In the USA, in Idaho, in the Coeur d'Alene district, Shoshone Co.; in Colorado, at Leadville, Lake Co., and from Breckenridge, Summit Co. In the Mississippi Valley region, in the Tri-State district, at Joplin, Jasper Co., Missouri; Galena, Cherokee Co., Kansas; and Picher, Ottawa Co., Oklahoma. At the Miliken (Sweetwater) mine, Reynolds Co., Missouri, and other mines north along the Viburnum Trend district, brilliant crystals. From Příbram, Czech Republic. At Freiberg, Saxony; from near Bad Ems, Hesse; and at St. Andreasberg, Neudorf, and Clausthal, in the Harz Mountains, Germany. In France, from Pontgibaud, Puy-de-Dôme. In England, at Alston Moor, Cumbria. In Scotland, at Wanlockhead, Dumfries. In Ireland, from the Mogul mine, Silvermines, Co. Tipperary. At Naica and Santa Eulalia, Chihuahua, Mexico.

Name: A Latin word *galena*, given to lead ore or the dross from melted lead.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 200–204. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 180–185. (3) Ramsdell, L.S. (1925) The crystal structures of some metallic sulfides. Amer. Mineral., 10, 281–??. (4) (1953) NBS Circ. 539, 2, 18. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 635–649. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 185.

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Galenobismutite $PbBi_2S_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals lathlike, elongated [001], flattened {100}, may be needlelike [001], and as very thin plates, to 1 cm. Commonly crystalline, massive, indistinctly columnar to fibrous.

Physical Properties: *Cleavage:* Good on {110}. *Tenacity:* Flexible. Hardness = 2.5–3.5 VHN = 142–194 (100 g load). D(meas.) = 7.04 D(calc.) = 7.195

Optical Properties: Opaque. *Color:* Pale gray to tin-white or lead-gray, may tarnish yellow or iridescent. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Strong.
R_1–R_2: (400) 48.0–51.1, (420) 47.9–51.1, (440) 47.8–51.1, (460) 47.7–51.0, (480) 47.5–50.8, (500) 47.1–50.5, (520) 46.6–49.8, (540) 45.9–48.8, (560) 45.3–48.2, (580) 44.8–47.7, (600) 44.6–47.2, (620) 44.4–46.8, (640) 44.4–46.7, (660) 44.4–46.7, (680) 44.5–46.8, (700) 44.7–47.1

Cell Data: *Space Group: Pnam.* $a = 11.669$ $b = 14.533$ $c = 4.090$ $Z = 4$

X-ray Powder Pattern: Cariboo mine, Canada.
3.45 (10), 1.961 (5), 3.03 (4), 2.46 (4), 2.05 (4), 3.65 (3), 2.76 (3)

Chemistry:

	(1)	(2)
Pb	27.65	27.50
Fe	trace	
Bi	54.69	55.48
S	17.35	17.02
Total	99.69	100.00

(1) Nordmark, Sweden. (2) $PbBi_2S_4$.

Occurrence: Of hydrothermal origin.

Association: Galena, bismuth, cosalite, aikinite, tellurobismuthite, joséite, tetradymite, tetrahedrite, gold, pyrite, quartz.

Distribution: In Sweden, from the Ko mine, Nordmark, Värmland [TL]; at Gladhammar and Falun, Kopparberg. From Oberpinzgau, Salzburg, Austria. At Pechtelsgrön, Saxony, Germany. From the Măgura mine, Baia Borşa district, Romania. In the Gupworthy mine, Brendon Hills, Somerset, and at Wheal Penrose, Sithney, Cornwall, England. At Corrie Buie, Meal nan Oighreag, Perthshire, Scotland. From Kingsgate, New South Wales; and at Mt. Farrell, Tasmania, Australia. At Chenzhou, Hunan Province, China. In the USA, in the Belzazzar mine, Quartzburg district, Boise Co., Idaho; and in the Hatfield mine, Okanogan Co., and the Germania mine, Fruitland, Stevens Co., Washington. From the Cariboo mine, Barkerville, Cariboo district, British Columbia; in the Siscoe mine, Gowganda, Ontario; and at Dublin Gulch, Yukon Territory, Canada. At Cerro Bonete, Bolivia. Known from a number of other minor occurrences.

Name: In allusion to *galena* and *bismuth* in its composition.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 3987.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 471–473. (2) Berry, L.G. (1940) Studies of mineral sulfo-salts: IV — galenobismutite and "lillianite". Amer. Mineral., 25, 726–734. (3) Iitaka, Y. and W. Nowacki (1962) A redetermination of the crystal structure of galenobismutite, $PbBi_2S_4$. Acta Cryst., 15, 691–698. (4) Takéuchi, Y. and J. Takagi (1974) Structure of galenobismutite. Proc. Jap. Acad., 50, 222–225 (in English). (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 161–162.

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Galileiite $Na(Fe^{2+},Mn^{2+})_4(PO_4)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. In anhedral grains, to 30 μm.

Physical Properties: *Tenacity:* Sectile. Hardness = $\leq$4 D(meas.) = n.d. D(calc.) = [4.07]

Optical Properties: Transparent. *Color:* Colorless to very pale amber. *Optical Class:* Uniaxial (+). $\omega = 1.72(3)$ $\epsilon = 1.75(5)$

Cell Data: *Space Group:* $[R\overline{3}]$ (by analogy to chladniite and johnsomervilleite). $a = 14.98$ $c = 41.66$ Z = 36

X-ray Powder Pattern: Grant meteorite.
2.71 (100), 3.01 (90), 4.13 (80), 3.47 (50), 3.21 (50), 2.93 (50), 2.85 (50)

Chemistry:

	(1)	(2)
P_2O_5	40.2	40.08
Cr_2O_3	0.07	
FeO	49.0	54.09
MnO	3.98	
Na_2O	5.87	5.83
K_2O	0.04	
Total	99.16	100.00

(1) Grant meteorite; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $Na_{1.01}(Fe_{3.63}Mn_{0.30})_{\Sigma=3.93}(P_{1.01}O_4)_3$. (2) $NaFe_4(PO_4)_3$.

Occurrence: Very rare, as inclusions within troilite nodules in type IIIAB iron meteorites.

Association: Ca-free sarcopside or graftonite, chromite, troilite.

Distribution: In the Grant, El Ampal, Mount Edith, Chupaderos, and Bella Roca meteorites.

Name: To honor Galileo Galilei (1564–1642), Italian astronomer and poet.

Type Material: Field Museum, Chicago, Illinois, Me1959; National Museum of Natural History, Washington, D.C., USA.

References: (1) Olsen, E.J. and I.M. Steele (1997) Galileiite: a new meteoric phosphate mineral. Meteoritics Planet. Sci., 32, A155–A156. (2) (1998) Amer. Mineral., 83, 185 (abs. ref. 1).

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Galkhaite $(Cs,Tl)(Hg,Cu,Zn)_6(As,Sb)_4S_{12}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As cubic crystals, to 1.2 cm, and granular aggregates.

Physical Properties: *Fracture:* Uneven to fine conchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = 186–202 (100 g load). D(meas.) = 5.4 D(calc.) = 5.44

Optical Properties: Opaque. *Color:* Dark red-orange. *Streak:* Yellow-orange. *Luster:* Vitreous to adamantine.
R: (400) 30.5, (420) 29.7, (440) 29.3, (460) 28.8, (480) 28.0, (500) 26.8, (520) 26.6, (540) 24.6, (560) 23.8, (580) 23.1, (600) 22.6, (620) 22.2, (640) 21.9, (660) 21.6, (680) 21.4, (700) 21.2

Cell Data: *Space Group:* $I\bar{4}3m$. $a = 10.365(3)$ $Z = 12$

X-ray Powder Pattern: Gal-Khaya, Russia.
3.01 (100), 2.78 (80), 4.27 (70), 7.40 (50), 1.841 (50), 2.604 (29), 1.569 (29)

Chemistry:

	(1)	(2)
Hg	51.7	50.7
Cu	3.4	3.2
Zn	1.6	1.8
Cs	3.3	5.1
Tl	0.8	2.4
As	14.5	15.2
Sb	3.0	0.3
S	22.3	22.0
Total	100.6	100.7

(1) Khaydarkan, Kyrgyzstan; by electron microprobe, corresponds to $(Cs_{0.43}Tl_{0.07})_{\Sigma=0.50}(Hg_{4.45}Cu_{0.92}Zn_{0.42})_{\Sigma=5.77}(As_{3.34}Sb_{0.42})_{\Sigma=3.76}S_{12.00}$. (2) Getchell mine, Nevada, USA; by electron microprobe, corresponds to $(Cs_{0.67}Tl_{0.21})_{\Sigma=0.88}(Hg_{4.42}Cu_{0.88}Zn_{0.48})_{\Sigma=5.78}(As_{3.55}Sb_{0.04})_{\Sigma=3.59}S_{12.00}$.

Occurrence: In hydrothermal Hg–Au deposits.

Association: Pyrite, stibnite, cinnabar, metacinnabar, aktashite, enargite, wakabayashilite, orpiment, realgar, getchellite, calcite, fluorite, quartz (Russia); pyrite, realgar, stibnite, orpiment, getchellite, fluorite, quartz (Getchell mine, Nevada, USA).

Distribution: From the Gal-Khaya mercury deposit, Sakha, Russia [TL]. In Kyrgyzstan, at Khaydarkan [TL] and in the Chauvai Sb–Hg deposit, both in the Fergana Valley, Alai Range. In the USA, in Nevada, large crystals from the Getchell mine, Potosi district, Humboldt Co.; at the Carlin mine, 50 km northwest of Elko, and the Goldstrike and Rodeo mines, Lynn district, Eureka Co.; in the Jerritt Canyon mine, Independence Mountains district, Elko Co. From the Hemlo gold deposit, Thunder Bay district, Ontario, Canada.

Name: For the Gal-Khaya deposit, Russia.

Type Material: Mining Institute, St. Petersburg, 1052/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73879, 73880.

References: (1) Gruzdev, V.S., V.I. Stepanov, N.G. Shumkova, N.M. Chernitsova, R.N. Yudin, and I.A. Bryzgalov (1972) Galkhaite $HgAsS_2$ – a new mineral from arsenic–antimony–mercury deposits of the U.S.S.R. Doklady Acad. Nauk SSSR, 205, 1194–1197 (in Russian). (2) (1974) Amer. Mineral., 59, 208–209 (abs. ref. 1). (3) Chen, T.T. and J.T. Szymański (1981) The structure and chemistry of galkhaite, a mercury sulfosalt containing Cs and Tl. Can. Mineral., 19, 571–581. (4) Chen, T.T. and J.T. Szymański (1982) A comparison of galkhaite from Nevada and from the type locality, Khaydarkan, Kirgizia [Kyrgyzstan], U.S.S.R. Can. Mineral., 20, 575–577. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 187.

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Gallite $CuGaS_2$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Massive, as minute embedded grains and as exsolution lamellae, to 2 mm. *Twinning:* Parallel to {112} and {111}.

Physical Properties: Hardness = 3.0–3.5 VHN = n.d. D(meas.) = 4.2 D(calc.) = 4.35

Optical Properties: Opaque. *Color:* Gray. *Streak:* Gray-black. *Anisotropism:* Low.
R: (400) 20.7, (420) 19.9, (440) 19.4, (460) 18.8, (480) 18.5, (500) 18.1, (520) 17.9, (540) 17.7, (560) 17.5, (580) 17.4, (600) 17.2, (620) 17.1, (640) 17.0, (660) 16.9, (680) 16.8, (700) 16.6

Cell Data: *Space Group:* $I\bar{4}2d$. $a = 5.360$ $c = 10.49$ Z = 4

X-ray Powder Pattern: Synthetic.
3.07 (100), 1.876 (90), 1.610 (90), 1.089 (90), 1.894 (60), 1.215 (60), 1.076 (60)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	30.8	31.2	33.5	32.19
Pb	2.3			
Zn	4.4	1.7	1.2	
Fe	4.9	2.3	2.8	
Ga	29.2	32.4	30.2	35.32
Ge		0.3	0.5	
S	28.4	32.8	31.8	32.49
Total	[100.0]	100.7	100.0	100.00

(1) Tsumeb, Namibia; by electron microprobe, recalculated to 100.0% after deduction of impurity phases. (2) Do.; by electron microprobe. (3) Kipshi, Congo. (4) $CuGaS_2$.

Mineral Group: Chalcopyrite group.

Occurrence: In base-metal vein deposits with relatively high gallium content.

Association: Reniérite, germanite, bornite, chalcocite, digenite, pyrite, sphalerite, galena, tetrahedrite.

Distribution: From Tsumeb, Namibia [TL]. In Congo (Zaire), at Kipushi, 28 km southwest of Lubumbashi, Katanga (Shaba) Province. From the Radka deposit, Pazardzhik, and the Chelopech deposit, Sofia, Bulgaria. In Cuba, in northwestern Pinar del Rio Province. From Yauricocha, Peru.

Name: For the mineral's gallium content.

Type Material: Berlin Technical University, Berlin, Germany, 86/67, 87/564, 396.

References: (1) Strunz, H., B.H. Geier, and E. Seeliger (1958) Gallit, $CuGaS_2$, das erste selbständige Galliummineral, und seine Verbreitung in den Erzen der Tsumeb- und Kipushi-Mine. Neues Jahrb. Mineral., Monatsh., 241–264 (in German). (2) (1959) Amer. Mineral., 44, 906 (abs. ref. 1). (3) Springer, G. (1969) Microanalytical investigations into germanite, renierite, briartite, and gallite. Neues Jahrb. Mineral., Monatsh., 435–441. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 188.

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Gallobeudantite $PbGa_3(AsO_4,SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Isolated crystals are rhombohedra, to nearly 1 mm, may be modified by {0001}, discoidal, strongly compositionally zoned; in subparallel aggregates.

Physical Properties: *Fracture:* Even to conchoidal. *Tenacity:* Brittle. Hardness = 4 D(meas.) = n.d. D(calc.) = 4.87 [AsO_4:SO_4 = 1:1].

Optical Properties: Transparent. *Color:* Pale yellow, pale green, cream-white. *Streak:* White to pale yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.763(5)$ $\epsilon = 1.750(5)$

Cell Data: *Space Group: R3m.* $a = 7.225(4)$ $c = 17.03(2)$ Z = 3

X-ray Powder Pattern: Tsumeb, Namibia.
3.038 (100), 5.85 (90), 3.59 (40), 2.271 (40), 2.851 (30), 2.513 (30), 1.948 (30)

Chemistry:

	(1)	(2)
SO_3	9.5	10.63
P_2O_5	0.1	
As_2O_5	18.0	15.25
GeO_2	0.1	
Al_2O_3	4.5	
Fe_2O_3	8.9	
Ga_2O_3	19.3	37.32
ZnO	1.1	
PbO	31.0	29.63
CaO	0.0	
H_2O	[7.3]	7.17
Total	[99.8]	100.00

(1) Tsumeb, Namibia; by electron microprobe, average of six analyses, total Fe as Fe_2O_3, H_2O calculated from stoichiometry; corresponds to $Pb_{1.04}(Ga_{1.49}Fe^{3+}_{0.82}Al_{0.62}Zn_{0.10}Ge_{0.02})_{\Sigma=3.05}[(AsO_4)_{1.14}(SO_4)_{0.86}]_{\Sigma=2.00}(OH)_{5.94}$. (2) $PbGa_3(AsO_4,SO_4)_2(OH)_6$ with AsO_4:SO_4 = 1:1.

Mineral Group: Beudantite group.

Occurrence: A rare secondary mineral in vugs in oxidized ore from a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Stolzite, mercurian silver, otjisumeite, gallian beudantite, gallian hidalgoite, scorodite, hematite, goethite, reniérite, gallite, gallian tennantite, chalcocite.

Distribution: From Tsumeb, Namibia.

Name: For its predominant *gallium* content as a member of the *beudantite* group.

Type Material: Canadian Museum of Nature, Ottawa, 81518; Canadian Geological Survey, Ottawa, Canada.

References: (1) Jambor, J.L., D.R. Owens, J.D. Grice, and M.N. Feinglos (1996) Gallobeudantite, $PbGa_3[(AsO_4),(SO_4)]_2(OH)_6$, a new mineral species from Tsumeb, Namibia, and associated new gallium analogues of the alunite – jarosite family. Can. Mineral., 34, 1305–1315. (2) (1997) Amer. Mineral., 82, 1039 (abs. ref. 1).

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Galuskinite $Ca_7(SiO_4)_3(CO_3)$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As veins of highly fractured grains, to 0.5 mm. Simple and polysynthetic twinning on (001).

Physical Properties: *Cleavage:* {001}, {100}, {010}; imperfect. *Parting:* Perfect on (001). *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ~5 VHN = 440 (20 g. load). D(meas.) = n.d. D(calc.) = 3.096

Optical Properties: Transparent. *Color:* Colorless, white, pale gray. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). α = 1.660(3) β = 1.669(3) γ = 1.676(3) 2V(meas.) = 60(5)° 2V(calc.) = 82.4° *Orientation:* $X \parallel b$, $Z \wedge a \approx 25°$, $Y \wedge c \approx 25°$ or $X \parallel b$, $Z \wedge c \approx 25°$, $Y \wedge a \approx 25°$.

Cell Data: *Space Group:* $P2_1/c$. a = 18.7872(5) b = 6.7244(2) c = 10.4673(2) β = 90.788(10)° Z = 4

X-ray Powder Pattern: Birkhin complex, Baikal area, Eastern Siberia, Russia.
2.7032 (100), 2.6706 (100), 2.7338 (98), 2.7030 (85), 2.6166 (82), 2.7141 (78), 3.0323 (59)

Chemistry:

	(1)	(2)
Na_2O	0.43	
CaO	62.61	63.63
SiO_2	28.85	29.22
P_2O_5	0.20	
SO_3	0.05	
CO_2	7.08	7.14
Total	99.22	100.00

(1) Birkhin complex, Baikal area, Eastern Siberia, Russia; electron microprobe analysis, CO_2 from structure analysis, Raman spectroscopy confirmed the presence of CO_3^{2-}, corresponding to $(Ca_{6.936}Na_{0.086})_{\Sigma=7.022}(Si_{2.983}P_{0.018}S_{0.004})_{\Sigma=3.005}O_{12}(CO_3)$. (2) $Ca_7(SiO_4)_3(CO_3)$.

Occurrence: A retrograde product of skarn alteration found in sanidinite facies contact-metamorphosed silicate carbonate xenoliths intruded by gabbroid rocks (Birkhin complex).

Association: Pavlovskyite, dellaite, larnite, bredigite, gehlenite, cuspidine, hydroxylellestadite.

Distribution: At the Birkhin complex, Baikal area, Olkhon region, Eastern Siberia, Russia.

Name: Honors Russian mineralogists Irina Olegovna Galuskina (b. 1961) and Evgeny Vadimovich Galuskin (b. 1960), Faculty of Earth Sciences, University of Silesia, Poland.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia; 4050/1 and the Natural History Museum, Bern, Switzerland; NMBE-40811.

References: (1) Lazic, B., T. Armbruster, V.B. Savelyeva, A.E. Zadov, N.N. Pertsev, and P. Dzierżanowski (2011) Galuskinite, $Ca_7(SiO_4)_3(CO_3)$, a new skarn mineral from the Birkhin gabbro massif, Eastern Siberia, Russia. Mineral. Mag., 75(5), 2631-2648. (2) (2013) Amer. Mineral., 98, 1631 (abs. ref. 1).

Gamagarite $Ba_2(Fe^{3+},Mn^{3+})(VO_4)_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Needlelike crystals, elongated along [010], to more than 1 cm, and as prisms, flattened on [001]; as anhedral grains.

Physical Properties: *Cleavage:* {001} and {100}, distinct; $\{\bar{1}01\}$ difficult, indices probable. Hardness = 4.5–5 D(meas.) = 4.62–4.68 D(calc.) = [4.72] Moderately magnetic.

Optical Properties: Transparent in thin fragments. *Color:* Dark brown to almost black. *Streak:* Reddish brown. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Pleochroism:* X = red-brown; Y = very deep red-brown; Z = light salmon-buff. *Orientation:* $Y = b$; $X \wedge c = 39°–43°$. *Dispersion:* $r < v$, fairly strong. *Absorption:* Y > X > Z. $\alpha = 2.016(10)$ $\beta = 2.040(10)$ $\gamma = 2.130(10)$ 2V(meas.) = 46°–62°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.121–9.15$ $b = 6.142–6.17$ $c = 7.838–7.88$ $\beta = 112.7°–112.88°$ Z = 2

X-ray Powder Pattern: Gloucester Farm, South Africa.
3.309 (100), 3.051 (80), 2.805 (80), 2.349 (50), 4.969 (10), 4.627 (10), 3.711 (10)

Chemistry:

	(1)	(2)	(3)
As_2O_5			3.47
V_2O_5	31.9	31.9	29.07
Al_2O_3	0.0	0.8	
Fe_2O_3	8.4	8.1	7.80
Mn_2O_3		5.7	6.11
MnO	5.5		
SrO			3.60
BaO	52.4	53.5	48.37
H_2O^+	1.06	[1.91]	[1.58]
Total	99.3	[101.9]	[100.00]

(1) Gloucester Farm, South Africa; recalculated from original analysis. (2) Do.; by electron microprobe, total Fe as Fe_2O_3, total Mn as Mn_2O_3, H_2O calculated for charge balance; corresponds to $Ba_{1.99}(Fe^{3+}_{0.58}Mn^{3+}_{0.41}Al_{0.09})_{\Sigma=1.08}(VO_4)_2(OH)_{1.22}$. (3) Molinello mine, Italy; by electron microprobe, total Fe as Fe_2O_3, total Mn as Mn_2O_3, H_2O calculated from crystal-structure analysis; corresponding to $(Ba_{1.80}Sr_{0.20})_{\Sigma=2.00}(Fe^{3+}_{0.56}Mn^{3+}_{0.44})_{\Sigma=1.00}[(VO_4)_{1.83}(AsO_4)_{0.17}]_{\Sigma=2.00}(OH)_{1.00}$.

Mineral Group: Brackebuschite group.

Occurrence: Very rare, in banded manganese ore replacing shale (Gloucester Farm, South Africa); in veinlets cutting manganese ore (Molinello mine, Italy).

Association: Bixbyite, hematite, ephesite, diaspore, amesite (Gloucester Farm, South Africa); braunite, saneroite, bementite, caryopilite, calcite, quartz (Molinello mine, Italy).

Distribution: Along Gamagara Ridge, on Gloucester Farm, about 27 km north of Postmasburg, Cape Province, South Africa. In the Molinello manganese mine, near Chiavari, Val Graveglia, Liguria, Italy.

Name: For the original occurrence on Gamagara Ridge, South Africa.

Type Material: The Natural History Museum, London, England, 1958,553; National Museum of Natural History, Washington, D.C., USA, 105142.

References: (1) de Villiers, J.E. (1943) Gamagarite, a new vanadium mineral from the Postmasburg manganese deposits. Amer. Mineral., 28, 329–335. (2) Harlow, G.E., P.J. Dunn, and G.R. Rossman (1984) Gamagarite: a re-examination and comparison with brackebuschite-like minerals. Amer. Mineral., 69, 803–806. (3) Basso, R., A. Palenzona, and L. Zefiro (1987) Gamagarite: new occurrence and crystal structure refinement. Neues Jahrb. Mineral., Monatsh., 295–305.

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Gananite BiF_3

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. In irregular aggregates, to 0.15 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d.
VHN = 135–153 D(meas.) = n.d. D(calc.) = 8.928

Optical Properties: Translucent. *Color:* Brown to black, greenish black; gray in reflected light. *Streak:* Dark gray. *Luster:* Resinous to semimetallic.
Optical Class: Isotropic.
R: (407) 11.08, (435) 12.31, (546) 12.73, (591) 12.92, (621) 12.96, (647) 13.27

Cell Data: *Space Group:* $P\overline{4}3m$(synthetic, ICDD 11-10). $a = 5.825(1)$ $Z = 4$

X-ray Powder Pattern: Ganan area, China.
3.37 (100), 2.057 (90), 1.756 (80), 2.91 (70), 2.272 (50), 1.334 (50), 1.188 (50)

Chemistry:

	(1)	(2)
Bi	78.98	78.57
F	20.40	21.43
Total	99.38	100.00

(1) Ganan area, China; by electron microprobe, corresponding to $Bi_{1.00}F_{2.84}$. (2) BiF_3.

Occurrence: In wolframite-bearing quartz veins.

Association: Bismuth, bismuthinite, pyrite, chalcopyrite.

Distribution: In the Ganan area, Laikeng district, southern Jiangxi Province, China.

Name: Presumably for its occurrence in the Ganan area, China.

Type Material: National Museum of Geology, Beijing, China.

References: (1) Longzai Cheng, Zongshao Hu, Shiwei Pan, Rongsheng Huang, and Shuliang Guo (1984) Gananite (α-BiF_3), a new bismofluoride mineral from Jiangxi, China. Yanshi Kuangwu Ji Ceshi, 3, 119–123 (in Chinese with English abs.). (2) (1988) Amer. Mineral., 73, 1494 (abs. ref. 1).

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Ganomalite $Pb_9Ca_5Mn^{2+}Si_9O_{33}$

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Crystal Data: Hexagonal. *Point Group:* 3. As simple hexagonal prisms, tabular on {0001}, typically in subparallel groupings.

Physical Properties: *Cleavage:* $\{10\bar{1}0\}$ and {0001}, distinct. *Fracture:* Uneven. *Tenacity:* Very brittle. Hardness = 3 D(meas.) = 5.7 D(calc.) = [5.69]

Optical Properties: Semitransparent. *Color:* Colorless to gray. *Luster:* Resinous to vitreous.
Optical Class: Uniaxial (+). $\omega = 1.910$ $\epsilon = 1.945$

Cell Data: *Space Group:* $P3$. $a = 9.82$ $c = 10.13$ Z = 1

X-ray Powder Pattern: Jakobsberg, Sweden.
3.06 (10), 3.53 (9), 3.38 (8), 2.71 (8), 4.92 (7), 4.43 (7), 1.985 (7)

Chemistry:

	(1)	(2)	(3)
SiO_2	19.8	19.7	18.64
MnO	2.1	2.3	2.44
PbO	66.5	67.4	69.25
CaO	11.5	10.9	9.67
Total	99.9	100.3	100.00

(1) Franklin, New Jersey, USA; by electron microprobe. (2) Jakobsberg, Sweden; by electron microprobe. (3) $Pb_9Ca_5MnSi_9O_{33}$.

Occurrence: In skarn assemblages (Jakobsberg, Sweden); in manganese ores in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Tephroite, lead, jacobsite, calcite, phlogopite, macedonite (Jakobsberg, Sweden); clinohedrite, willemite, andradite, franklinite (Franklin, New Jersey, USA).

Distribution: At Långban, in the Harstigen mine, near Persberg, and at Jakobsberg, Värmland, Sweden. From Franklin, Sussex Co., New Jersey, USA.

Name: From the Greek for *luster*, in allusion to its appearance.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 422. (2) Dunn, P.J. (1979) Ganomalite from Franklin, New Jersey. Mineral. Record, 10, 47–48. (3) Dunn, P.J., D.R. Peacor, J.W. Valley, and C.A. Randall (1985) Ganomalite from Franklin, New Jersey, and Jakobsberg, Sweden: new chemical and crystallographic data. Mineral. Mag., 49, 579–592. (4) (1987) Amer. Mineral., 72, 1028 (abs. ref. 3). (5) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727. (6) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Ganophyllite $(K, Na)_6(Mn, Al, Mg)_{24}(Si, Al)_{40}O_{96}(OH)_{16}\cdot 21H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Short to long prismatic crystals, to 2.5 cm, forming rosettes; as six-sided flakes.

Physical Properties: *Cleavage:* Perfect micaceous on {001}; distinct on {100}, {010}. Hardness = 4–4.5 D(meas.) = 2.77–2.84 D(calc.) = 2.875

Optical Properties: Transparent to translucent. *Luster:* Vitreous, brilliant. *Color:* Light brown, pale pink.
Optical Class: Biaxial (–). *Pleochroism:* Dark to pale yellow-brown. *Orientation:* $X \simeq c$; $Y \simeq a$; $Z = b$. *Dispersion:* $r < v$. $\alpha = 1.571$ $\beta = 1.610$ $\gamma = 1.611$ 2V(meas.) = Small.

Cell Data: *Space Group:* $A2/a$. $a = 16.60$ $b = 27.13$ $c = 50.18$ $\beta = 93.96°$ Z = 8

X-ray Powder Pattern: Harstigen mine, Sweden.
12.5 (100), 3.14 (25), 2.696 (14), 3.46 (10), 2.980 (10), 2.598 (10), 2.465 (10)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	39.67	40.0	40.4	MgO	0.20	0.5	0.2
Al_2O_3	7.95	7.9	7.9	CaO	1.11	1.0	1.5
Fe_2O_3	0.90			BaO		0.6	0.3
FeO		0.4	0.3	Na_2O	2.18	1.3	1.1
MnO	35.15	34.0	34.1	K_2O	2.70	3.2	2.6
ZnO		0.2	0.6	H_2O^+	9.79	[10.9]	[11.0]
PbO	0.20			Total	99.85	[100.0]	[100.0]

(1) Pajsberg, Sweden. (2) Do.; by electron microprobe, H_2O by difference. (3) Franklin, New Jersey, USA; by electron microprobe, average of 10 analyses, H_2O by difference.

Occurrence: In manganese-rich portions of metamorphosed Zn-Mn mineral deposits.

Association: Calcite, rhodonite, caryopilite, barite, lead, garnet, manganoan biotite, pyrophanite (Harstigen mine, Sweden); rhodonite, willemite, bustamite, axinite, clinohedrite, datolite, roeblingite, charlesite (Franklin, New Jersey, USA); parsettensite, caryopilite (Molinello mine, Italy).

Distribution: In Sweden, from the Harstigen mine, near Persberg, and at Långban, Värmland; and in the Sjö mine, near Grythyttan, Örebro. At the Benallt and Nant mines, Rhiw, Lleyn Peninsula, Wales. From the Molinello and Gambatesa manganese mines, near Chiavari, Val Graveglia, Liguria, Italy. In the USA, in the Maple-Hovey deposits, west of Bridgewater, Aroostook Co., Maine, and at Franklin, Sussex Co., New Jersey. From Mont Saint-Hilaire, Quebec, Canada. In the Ananai mine, Nagaoka, Kochi Prefecture; the Noda-Tamagawa mine, Iwate Prefecture; the Kumahata mine, Shiga Prefecture; and the Osu and Yonoyama mines, Kita, Ehime Prefecture, Japan. From Broken Hill, New South Wales, Australia.

Name: From the Greek for *luster* and *leaf*, for the high luster on cleavages.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 564–565. (2) Smith, M.L. and C. Frondel (1968) The related layered minerals ganophyllite, bannisterite and stilpnomelane. Mineral. Mag., 36, 893–913. (3) Kato, T. (1980) The crystal structure of ganophyllite; monoclinic subcell. Mineral. J. (Japan), 10, 1–13. (4) Dunn, P.J., D.R. Peacor, J.E. Nelen, and R.A. Ramik (1983) Ganophyllite from Franklin, New Jersey; Pajsberg, Sweden; and Wales: new chemical data. Mineral. Mag., 47, 563–566. (5) Eggleton, R.A. and S. Guggenheim (1986) A re-examination of the structure of ganophyllite. Mineral. Mag., 50, 307–315.

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Gaotaiite Ir_3Te_8

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As subhedral grains, in aggregates to 0.2 mm; massive, in veinlets.

Physical Properties: *Tenacity:* Brittle. Hardness = 3 VHN = 94–177, 117 average (20 g load). D(meas.) = n.d. D(calc.) = 10.00

Optical Properties: Opaque. *Color:* Steel-black; in reflected light, bright white with a bluish tint. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic. *Anisotropism:* May be weak; bluish or yellowish.
R: (400) 45.9, (420) 46.8, (440) 46.7, (460) 46.6, (480) 46.5, (500) 46.4, (520) 46.3, (540) 46.3, (560) 46.3, (580) 46.3, (600) 46.2, (620) 46.1, (640) 46.0, (660) 45.5, (680) 45.3, (700) 45.2

Cell Data: *Space Group:* $Pa3$. $a = 6.413(4)$ $Z = 1$

X-ray Powder Pattern: Near Gaotai village, China.
1.93 (100), 1.132 (90), 1.235 (80), 1.040 (80), 0.9780 (80), 2.86 (70), 2.60 (60)

Chemistry:

	(1)	(2)
Ir	35.6	36.10
Pt	0.1	
Cu	0.2	
Te	62.8	63.90
S	0.2	
Total	98.9	100.00

(1) Near Gaotai village, China; by electron microprobe, average of nine analyses; corresponds to $(Ir_{2.96}Cu_{0.05}Pt_{0.01})_{\Sigma=3.02}(Te_{7.88}S_{0.10})_{\Sigma=7.98}$. (2) Ir_3Te_8.

Occurrence: In crushed chromite ores and placer concentrates.

Association: Iridium, osmium, osmiridium, ferrian platinum, isoferroplatinum, iridisite, erlichmanite, laurite, irarsite, shuangfengite, chengdeite, inaglyite, chromite, magnetite, gold.

Distribution: From near Gaotai village, about 200 km north-northeast of Beijing, Hebei Province, China [TL].

Name: For Gaotai village, China, near which the mineral was found.

Type Material: Geological Museum of China, Beijing, China.

References: (1) Yu Zxiang (1995) Gaotaiite – a new iridium telluride. Acta Mineralogica Sinica, 15(1), 1–4 (in Chinese with English abs.). (2) (1996) Amer. Mineral., 81, 249–250 (abs. ref. 1).

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Garavellite $FeSbBiS_4$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Small aggregates of anhedral crystals, to 200 μm.

Physical Properties: Hardness = n.d. VHN = 212–222 (50 g load). D(meas.) = n.d. D(calc.) = 5.64

Optical Properties: Opaque. *Color:* In reflected light, gray with olive-brown tint. *Luster:* Metallic. *Pleochroism:* Distinct. *Anisotropism:* Strong, in yellowish green to bluish gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 11.439$ $b = 14.093$ $c = 3.754$ Z = 4

X-ray Powder Pattern: Valle del Frigido, Italy.
3.62 (vs), 3.20 (vs), 2.63 (vs), 2.51 (vs), 2.98 (s), 2.89 (s), 14.0 (m)

Chemistry:

	(1)	(2)
Fe	9.41	10.85
Cu	0.30	
Sb	29.90	23.65
Bi	33.28	40.59
As	0.16	
S	27.43	24.91
Total	100.48	100.00

(1) Valle del Frigido, Italy; by electron microprobe, corresponds to $Fe_{0.79}Cu_{0.02}Sb_{1.15}Bi_{0.74}As_{0.01}S_{4.00}$. (2) $FeSbBiS_4$.

Occurrence: In a hydrothermal copper deposit with disseminated chalcopyrite in siderite gangue.

Association: Chalcopyrite, tetrahedrite, pyrrhotite, pyrite, marcasite, galena, sphalerite, meneghinite, ullmannite, pentlandite, vaesite, bismuthinite, chalcanthite, siderite, quartz.

Distribution: At Valle del Frigido, one km east of Massa, Tuscany, Italy.

Name: In honor of Professor Carlo L. Garavelli (1929–), Italian mineralogist, University of Bari, Bari, Italy.

Type Material: University of Florence, Florence, 100/l; University of Bari, Bari, Italy; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 145868.

References: (1) Gregorio, F., P. Lattanzi, G. Tanelli, and F. Vurro (1979) Garavellite, $FeSbBiS_4$, a new mineral from the Cu–Fe deposit of Valle del Frigido in the Apuane Alps, northern Tuscany, Italy. Mineral. Mag., 43, 99–102. (2) (1979) Amer. Mineral., 64, 1329–1330 (abs. ref. 1).

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Garrelsite $Ba_3NaSi_2B_7O_{16}(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals steep dipyramidal, prismatic, to 3 mm, bounded by {110}, {1$\bar{1}$0}, {21$\bar{1}$}, and {2$\bar{1}\bar{1}$}; commonly striated.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ~6 D(meas.) = 3.68 D(calc.) = 3.89

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial. *Orientation:* $Y = b$; $Z \wedge [101]$ (the edge of the {$\bar{1}$11} form) = 33°; one optic axis is nearly normal to this edge. $\alpha = 1.620(3)$ $\beta = 1.633(3)$ $\gamma = 1.640(3)$ 2V(meas.) = 53°–57°

Cell Data: *Space Group:* $C2/c$. $a = 14.639(3)$ $b = 8.466(2)$ $c = 14.438(3)$ $\beta = 114.21(2)°$ Z = 4

X-ray Powder Pattern: Uintah Co., Utah, USA.
3.05 (100), 3.64 (80), 2.026 (60), 2.873 (45), 2.757 (45), 6.13 (30), 4.23 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	14.6	13.49	13.49
B_2O_3	24.0		27.35
MgO	1.2		
CaO	7.7		
BaO	46.1	51.41	51.64
Na_2O		3.50	3.48
H_2O	[5.9]		4.04
rem.	0.06		
Total	[99.56]		100.00

(1) Uintah Co., Utah, USA; contains visible impurities, original total given as 100.1%, H_2O by loss on ignition, remainder is trivalent oxides. (2) Do.; by electron microprobe, partial analyses on pure material, Na by AA. (3) $Ba_3NaSi_2B_7O_{16}(OH)_4$.

Occurrence: Of authigenic origin, in dolomitic shale in drill core from the Green River Formation (Uintah Co., Utah, USA).

Association: Nahcolite, shortite, searlesite, wurtzite (Uintah Co., Utah, USA).

Distribution: In the USA, from several drill holes in Uintah Co., Utah; in the Kramer borate deposit, Kern Co., and at Searles Lake, San Bernardino Co., California.

Name: For Professor Robert Minard Garrels (1916–1988), American geochemist and educator.

Type Material: n.d.

References: (1) Milton, C., J.M. Axelrod, and F.S. Grimaldi (1955) New mineral, garrelsite $(Ba_{.65}Ca_{.29}Mg_{.06})_4H_6Si_2B_6O_{20}$, from the Green River Formation, Utah. Bull. Geol. Soc. Amer., 66, 1597 (abs.) (2) Milton, C. and A. Pabst (1974) Garrelsite, $NaBa_3Si_2B_7O_{16}(OH)_4$ from the Green River Formation of Utah. J. Res. U.S. Geol. Sur., 2, 213–218. (3) Ghose, S., C. Wan, and H.H. Ulbrich (1976) Structural chemistry of borosilicates. I. Garrelsite $NaBa_3Si_2B_7O_{16}(OH)_4$: a silicoborate with the pentaborate $[B_5O_{12}]^{9-}$ polyanion. Acta Cryst., 32, 824–832.

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Garronite $Na_2Ca_5Al_{12}Si_{20}O_{64}\cdot 27H_2O$

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Crystal Data: Tetragonal; possibly orthorhombic, pseudotetragonal. *Point Group:* $\bar{4}2m$. As radiating crystal aggregates completely filling amygdules, characteristically radially jointed; rare single crystals, to 4 mm, are dipyramidal. *Twinning:* Observed optically at a very fine scale; may be a domain structure.

Physical Properties: *Cleavage:* Two at 90°, prismatic. Hardness = 4.5–5
D(meas.) = 2.13–2.17 D(calc.) = 2.201

Optical Properties: Transparent. *Color:* [Colorless to white, yellowish, grayish.]
Luster: Vitreous to greasy.
Optical Class: Uniaxial (+) or (–) to biaxial; may be zoned, changing optical properties from the core to the extremities. $\omega = 1.500–1.515$ $\epsilon = 1.502–1.512$

Cell Data: *Space Group:* $I\bar{4}m2$. $a = 9.9266(2)$ $c = 10.3031(3)$ Z = [0.5]

X-ray Powder Pattern: Co. Down, Ireland.
4.12 (100), 3.14 (100), 2.66 (100), 7.15 (80), 4.95 (80), 4.07 (60), 3.22 (60)

Chemistry:

	(1)	(2)
SiO_2	43.21	45.15
Al_2O_3	24.20	23.35
Fe_2O_3	0.02	0.02
CaO	10.64	10.32
BaO	trace	0.09
Na_2O	2.94	2.96
K_2O	0.54	0.16
H_2O	18.62	18.74
Total	100.17	100.79

(1) Glenariff, Ireland; corresponds to $(Na_{2.52}K_{0.30})_{\Sigma=2.82}Ca_{5.08}Al_{12.70}Si_{19.24}O_{64}\cdot 27.64H_2O$.
(2) Skessa, Reydarfjord, Iceland; corresponds to $(Na_{2.52}K_{0.08})_{\Sigma=2.60}(Ca_{4.86}Ba_{0.02})_{\Sigma=4.88}$ $Al_{12.10}Si_{19.84}O_{64}\cdot 27.46H_2O$.

Mineral Group: Zeolite group.

Occurrence: As amygdule fillings in silica-undersaturated olivine basalt flows (Co. Antrim, Ireland); in lavas rich in phenocrysts of bytownite and in non-porphyritic olivine basalt flows (Iceland); in diabase porphyry (Angara River, Russia).

Association: Zeolites.

Distribution: In Ireland, from the Glenariff Valley, Co. Antrim, and at a number of other localities towards Belfast. At The Storr, Isle of Skye, Scotland. In Iceland, at numerous localities between Berufjord and Seydisfjord. In Russia, near Nevon, on the Angara River, 50 km below the Ilim River, Siberia. At Gignat, Puy-de-Dôme, France. In the Höwenegg quarry, Hegau, Baden-Württemberg, Germany. From San Giorgio di Perlena, Vicenza, Italy. On Table Mountain, Jefferson Co., Colorado, and from Goble, Columbia Co., Oregon, USA. At Davis Hill, Ontario, and around Laurel and at Mont Saint-Hilaire, Quebec, Canada. A few other localities are known.

Name: For the Garron Plateau area, Co. Antrim, Ireland.

Type Material: n.d.

References: (1) Walker, G.P.L. (1962) Garronite, a new zeolite, from Ireland and Iceland. Mineral. Mag., 33, 173–186. (2) Barrer, R.M., F.W. Bultitude, and I.S. Kerr (1959) Some properties of, and a structural scheme for, the harmotome zeolites. J. Chem. Soc., 294, 1521–1528. (3) (1963) Amer. Mineral., 48, 711–712 (abs. refs. 1 and 2). (4) Artioli, G. (1992) The crystal structure of garronite. Amer. Mineral., 77, 189–196.

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Gartrellite **$PbCu(Fe^{3+},Cu)(AsO_4)_2(OH,H_2O)_2$**

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Nearly cryptocrystalline, with platy crystallites to 10 μm, tabular on {111}, {010}, {112}, additional minor forms; in aggregates, fine-grained coatings and powdery incrustations. *Twinning:* Common, by reflection on {$1\bar{1}0$}.

Physical Properties: *Cleavage:* Perfect on {111}. *Tenacity:* Friable. Hardness = 4.5
D(meas.) = n.d. D(calc.) = 5.38–5.43

Optical Properties: Transparent. *Color:* Bright yellow, greenish yellow, green, brown; pale yellow in transmitted light. *Streak:* Bright yellow. *Luster:* Chalky.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = Y = pale yellow; Z = yellow. *Orientation:* X (45°,-22°); Y (48°,130°); Z (76°,-127°) [with a (90°,90°) and b (90°,0°) using (ϕ,ρ)].
$\alpha = 1.94(1)$ $\beta = [1.98]$ $\gamma = 2.06(2)$ 2V(meas.) = 78(4)°

Cell Data: *Space Group:* $P\bar{1}$. $a = 5.431$–5.460 $b = 5.628$–5.653 $c = 7.565$–7.589
$\alpha = 67.52°-67.77°$ $\beta = 69.27°-69.57°$ $\gamma = 70.04°-70.31°$ Z = 1

X-ray Powder Pattern: Anticline prospect, Australia.
2.962 (100), 3.203 (97), 4.612 (70), 3.339 (70), 2.915 (70), 2.522 (64), 4.847 (54)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	1.68	0.74	CuO	14.02	13.41
As_2O_5	33.11	32.50	ZnO	0.21	0.31
Al_2O_3	0.11	2.09	PbO	36.53	38.62
Fe_2O_3	10.33	7.74	H_2O	[4.47]	n.d.
			Total	[100.46]	95.41

(1) Anticline prospect, Australia; by electron microscope, average of 15 analyses, original total given as 100.47%, total Fe as Fe_2O_3, confirmed by IR and Mössbauer spectroscopy, H_2O calculated from theory; corresponds to $Pb_{1.04}Cu_{1.00}(Fe_{0.82}Cu_{0.12}Zn_{0.02}Al_{0.01})_{\Sigma=0.97}[(AsO_4)_{1.83}(SO_4)_{0.13}]_{\Sigma=1.96}[(OH)_{1.10}(H_2O)_{1.03}]_{\Sigma=2.13}$. (2) Broken Hill, Australia; by electron microprobe, average of two analyses; corresponds to $Pb_{1.07}Cu_{1.00}(Fe_{0.60}Al_{0.25}Cu_{0.05}Zn_{0.02})_{\Sigma=0.92}[(AsO_4)_{1.75}(SO_4)_{0.06}]_{\Sigma=1.81}[(OH),H_2O]_2$.

Mineral Group: Tsumcorite group.

Occurrence: A rare mineral in an oxidized mineralized shear zone cutting graywackes and shales (Anticline prospect, Australia); on fine-grained quartz-spessartine rocks (Broken Hill, Australia).

Association: Secondary copper minerals, quartz, clay minerals, iron oxides (Anticline prospect, Australia); hidalgoite–beudantite, quartz, spessartine (Broken Hill, Australia); mimetite, duftite, beudantite, bayldonite, quartz (Tsumeb, Namibia).

Distribution: From the Anticline and Bali Lo copper prospects, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia, and in the Kintore open cut, Broken Hill, New South Wales, Australia. At Reichenbach, near Bensheim, Hesse, and in the Clara Mine, near Oberwolfach, Black Forest, Germany. From Tsumeb, Namibia. In the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: Honoring Blair J. Gartrell (1950–1994), Australian mineral collector of Beverley, Australia, who found the mineral.

Type Material: Western Australian Museum, Perth, M.61.1991; Museum Victoria, Melbourne, Australia, M39278.

References: (1) Nickel, E.H., B.W. Robinson, Ô. Fitz Gerald, and W.D. Birch (1989) Gartrellite, a new secondary arsenate mineral from Ashburton Downs, W.A. and Broken Hill, N.S.W. Australian Mineral., 4(3), 83–89. (2) (1990) Amer. Mineral., 75, 932 (abs. ref. 1).
(3) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Garyansellite $(Mg, Fe^{3+})_3(PO_4)_2(OH, O)\cdot 1.5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rare crystals prismatic [100], with prominent {111} and {011}, smaller {101}, to 2 mm; commonly as plates flattened on {010}.

Physical Properties: *Cleavage:* {001}, good. Hardness = 4 D(meas.) = 3.16(4) D(calc.) = 3.154

Optical Properties: Semitransparent. *Color:* Clove-brown. *Streak:* Brown. *Luster:* Vitreous, bronze [*sic*] on cleavages. *Optical Class:* Biaxial (–). *Pleochroism:* $X = Z$ = reddish brown; Y = yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$. *Absorption:* $Z = X > Y$. $\alpha = 1.733(2)$ $\beta = 1.757(2)$ $\gamma = 1.761(2)$ 2V(meas.) = 55(2)° 2V(calc.) = 44°

Cell Data: *Space Group: Pbna.* $a = 9.452(4)$ $b = 9.890(5)$ $c = 8.198(4)$ Z = 4

X-ray Powder Pattern: Rapid Creek, Canada.
3.156 (100), 2.705 (60), 4.93 (50), 3.098 (40), 4.26 (30), 2.535 (30), 2.213 (30)

Chemistry:

	(1)
P_2O_5	38.8
Al_2O_3	0.1
Fe_2O_3	30.5
FeO	0.3
MnO	2.7
MgO	16.0
H_2O	11.0
Total	99.4

(1) Rapid Creek, Canada; by electron microprobe, Fe^{2+} by KCr_2O_7 titration, Fe^{3+} by difference, total Mn as MnO, H_2O by DTA/TGA; corresponds to $(Mg_{1.45}Fe^{3+}_{1.39}Mn_{0.14}Al_{0.01}Fe^{2+}_{0.01})_{\Sigma=3.00}(PO_4)_{1.99}(OH)_{1.43}\cdot 1.52H_2O$.

Polymorphism & Series: Forms a series with kryzhanovskite.

Occurrence: A rare low-temperature mineral in fractures in a sedimentary iron formation.

Association: Kryzhanovskite, ludlamite, arrojadite, vivianite, metavivianite, souzalite, quartz.

Distribution: From the east side of Rapid Creek, about one km north of the junction with Lake Creek, Yukon Territory, Canada.

Name: Honors H. Gary Ansell (1943–), Associate Curator, Canadian National Mineral Collection, Geological Survey of Canada, Ottawa, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M37306.

References: (1) Sturman, B.D. and P.J. Dunn (1984) Garyansellite, a new mineral from Yukon Territory, Canada. Amer. Mineral., 69, 207–209.

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Gasparite-(Ce) $(Ce, La, Nd)AsO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As pseudorhombohedral crystals, to 0.5 mm, showing {100}, {001}, {110}, {101}, in aggregates rimming and replacing synchysite.

Physical Properties: *Fracture:* Conchoidal to uneven. Hardness = 4.5–5 VHN = 327(5) (50 g load). D(meas.) = n.d. D(calc.) = 5.63 Bright green fluorescence under a quartz lamp.

Optical Properties: Semitransparent. *Color:* Light red-brown, flesh-pink. *Streak:* White. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 4°$. $\alpha = 1.810(8)$ $\beta = 1.825(8)$ $\gamma = 1.92(1)$ 2V(meas.) = 40°–45°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.937(3)$ $b = 7.137(4)$ $c = 6.738(6)$ $\beta = 104.69(5)°$ Z = 4

X-ray Powder Pattern: Pizzo Cervandone, Italy.
3.156 (100), 3.355 (77), 2.966 (70), 2.003 (45), 2.709 (44), 3.035 (34), 1.7787 (34)

Chemistry:

	(1)	(2)
SO_3	0.99	
As_2O_5	39.21	41.18
SiO_2	0.64	
ThO_2	1.95	
Al_2O_3	0.06	
La_2O_3	12.07	
Ce_2O_3	28.33	58.82
Pr_2O_3	3.89	
Nd_2O_3	11.02	
CaO	1.36	
Total	99.52	100.00

(1) Pizzo Cervandone, Italy; by electron microprobe, average of nine analyses; corresponding to $(Ce_{0.47}La_{0.20}Nd_{0.18}Ca_{0.07}Pr_{0.06}Th_{0.02})_{\Sigma=1.00}(As_{0.94}Si_{0.03}S_{0.03})_{\Sigma=1.00}O_4$. (2) $CeAsO_4$.

Mineral Group: Monazite group.

Occurrence: In fissures, replacing synchysite, formed by amphibolite-grade metamorphism of metasedimentary rocks (Pizzo Cervandone, Italy).

Association: Synchysite-(Ce), chernovite, cafarsite, rutile, anatase, magnetite, hematite (Pizzo Cervandone, Italy).

Distribution: On the southeastern slope of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont, Italy. At the Squaw Creek tin prospect, Catron Co., and on the Beryllium Virgin claim, Paramount Canyon, Sierra Co., New Mexico, USA.

Name: To honor Giovanni Gaspari, mineral collector of Crodo, Italy, who first found the mineral, and for its dominant *cerium* content.

Type Material: Natural History Museum, Basel, 30653; Mineralogical Institute, Basel University, Basel, Switzerland.

References: (1) Graeser, S. and H. Schwander (1987) Gasparite-(Ce) and monazite-(Nd): two new minerals to the monazite group from the Alps. Schweiz. Mineral. Petrog. Mitt., 67, 103-113. (2) (1988) Amer. Mineral., 73, 1494–1495 (abs. ref. 1).

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. As aggregates of rhombic crystals, to 0.6 mm; in nodular concretions, commonly compact massive.

Physical Properties: *Cleavage:* Good on $\{10\bar{1}1\}$. *Fracture:* Uneven. Hardness = 4.5–5 D(meas.) = 3.71(1) D(calc.) = 3.748

Optical Properties: Translucent. *Color:* Pale green to bright grass-green, olive-green. *Streak:* Yellow-green. *Luster:* Vitreous to dull.
Optical Class: Uniaxial (–). $\omega = 1.83(1)$ $\epsilon = 1.61(1)$

Cell Data: *Space Group:* $[R\bar{3}c]$ (by analogy to the calcite group). a = 4.608–4.621 c = 14.805–14.93 Z = 6

X-ray Powder Pattern: Gaspé Peninsula, Canada.
2.741 (100), 1.692 (45), 3.543 (36), 2.098 (36), 1.932 (25), 2.317 (20), 1.337 (11)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	42.0	[35.9]	43.36	MgO	17.3	2.6	19.85
SiO_2	0.9	0.9		CaO		0.3	
FeO	5.7	0.1		insol.	1.8		
NiO	35.0	55.5	36.79	Total	102.7	[95.3]	100.00

(1) Gaspé Peninsula, Canada; CO_2 by ignition and absorption; after removal of MgO and SiO_2 from serpentine, corresponds to $(Ni_{0.49}Mg_{0.43}Fe_{0.08})_{\Sigma=1.00}CO_3$. (2) Otway prospect, Western Australia; by electron microprobe, here converted to oxides from an original elemental analysis totalling 94.8%, CO_2 calculated for charge balance. (3) $(Ni, Mg)CO_3$ with Ni:Mg = 1:1.

Polymorphism & Series: Forms a series with magnesite.

Mineral Group: Calcite group.

Occurrence: An uncommon secondary mineral in a Ni-sulfide-bearing vein in metamorphosed siliceous dolostone (Gaspé Peninsula, Canada); possibly from alteration of a nickel-rich meteorite (Bon Accord, South Africa).

Association: Millerite, nickeline, annabergite, gersdorffite, polydymite, heazlewoodite, magnesite, spinel, dolomite (Gaspé Peninsula, Canada); pecoraite, magnesite, siderite, chrysotile, antigorite, magnetite, millerite, polydymite (Otway prospect, Western Australia); glaukosphaerite, mcguinnessite, jamborite (Shinshiro, Japan); liebenbergite, trevorite, nickeloan ludwigite, bunsenite, violarite, millerite, nimite (Bon Accord, South Africa).

Distribution: Found in a prospect pit near Mount Albert, Gaspé Peninsula, Quebec, Canada. In Western Australia, from the Otway nickel prospect, near Spinnaway, Nullagine district; in the Otter Shoot gossan, Kambalda, 56 km south of Kalgoorlie; at the Rocky's Reward pit, near Agnew; from the 132 North nickel mine, Widgiemooltha district. Found at Shinshiro, Aichi Prefecture, Japan. In South Africa, on Mabilikwe Hill, Pafuri; from three km west of the Scotia Talc mine, Bon Accord, Barberton district, Transvaal. In the San Benedetto mine, Iglesias district, Sardinia, Italy.

Name: For the original locality on the Gaspé Peninsula, Canada.

Type Material: University of British Columbia, Vancouver, Canada, S-75-4222; National Museum of Natural History, Washington, D.C., USA, 119544.

References: (1) Kohls, D.W. and J.L. Rodda (1966) Gaspeite, (Ni, Mg, Fe)(CO_3), a new carbonate from the Gaspé Peninsula, Quebec. Amer. Mineral., 51, 677–684. (2) Nickel, E.H. (1973) An occurrence of gaspéite and pecoraite in the Nullagine region of Western Australia. Mineral. Mag., 39, 113–115. (3) Pertlik, F. (1986) Structures of hydrothermally synthesized cobalt(II) carbonate and nickel(II) carbonate. Acta Cryst., C40, 4–5.

Gatehouseite $Mn_5^{2+}(PO_4)_2(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* 222. As bladelike crystals, with prominent {001}, {110}, {102}, elongated along [010], to 100 μm, in radiating to divergent groups and overgrowths on arsenoclasite. *Twinning:* On {001}, contact twins.

Physical Properties: *Cleavage:* On {010}, distinct. *Fracture:* Splintery. Hardness = ∼4 D(meas.) = n.d. D(calc.) = 3.74

Optical Properties: Transparent. *Color:* Pale brownish orange to yellow or pale yellow. *Streak:* Pale yellow. *Luster:* Adamantine.
Optical Class: Biaxial. *Pleochroism:* Distinct; brown to nearly colorless. *Orientation:* Parallel extinction; length-slow. $\alpha = 1.74(1)$ β = n.d. $\gamma = 1.76(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_12_12_1$ (probable). $a = 9.097(2)$ $b = 5.693(2)$ $c = 18.002(10)$ Z = 4

X-ray Powder Pattern: Iron Monarch quarry, Australia.
2.90 (100), 2.702 (80), 2.853 (70), 2.802 (50), 2.022 (15), 1.608 (15), 4.483 (10)

Chemistry:

	(1)	(2)	(3)
SO_3		0.10	
P_2O_5	22.18	23.05	26.65
As_2O_5	3.58	3.32	
V_2O_5	0.38		
Al_2O_3	0.10		
FeO	0.19	0.32	
MnO	64.42	63.34	66.59
CuO	0.03	0.04	
ZnO	0.03		
PbO	0.05	0.05	
H_2O	[6.44]	[6.43]	6.76
Total	[97.40]	[96.65]	100.00

(1) Iron Monarch quarry, Australia; by electron microprobe, total Mn as MnO, total Fe as FeO, H_2O calculated for 4(OH); corresponds to $Mn_{5.09}Fe_{0.01}Al_{0.01}[(P_{0.87}As_{0.08}V_{0.01})_{\Sigma=0.96}O_4]_2(OH)_4$. (2) Do.; corresponds to $Mn_{4.74}Al_{0.03}[(P_{0.87}As_{0.08}S_{0.01})_{\Sigma=0.96}O_4]_2(OH)_4$. (3) $Mn_5(PO_4)_2(OH)_4$.

Occurrence: As a secondary mineral in cavities in a sedimentary Fe–Mn deposit, probably formed by reaction of phosphorus-rich fluids with hausmannite at low temperature.

Association: Arsenoclasite, shigaite, hematite, hausmannite, triploidite, barite, manganoan ferroan calcite.

Distribution: From the Iron Monarch quarry, Iron Knob, South Australia.

Name: Honoring Dr. Bryan Michael Kenneth Cummings Gatehouse (1932–), crystal chemist, Monash University, Melbourne, Australia.

Type Material: South Australian Museum, Adelaide, G17655; Museum Victoria, Melbourne, Australia, M41982, M42467.

References: (1) Pring, A. and W.D. Birch (1993) Gatehouseite, a new manganese hydroxy phosphate from Iron Monarch, South Australia. Mineral. Mag., 57, 309–313. (2) (1994) Amer. Mineral., 79, 185 (abs. ref. 1).

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Gatumbaite $CaAl_2(PO_4)_2(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. Anhedral crystals, to 5 mm, bladed; in radial fibrous aggregates, in sheaves and rosettes.

Physical Properties: *Cleavage:* One, ‖ to the [010] fiber axis. *Fracture:* Asbestiform. *Tenacity:* Brittle. Hardness = < 5 D(meas.) = 2.92 D(calc.) = 2.95

Optical Properties: Translucent. *Color:* White. *Luster:* Pearly. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; OAP ⊥ {010}. $\alpha = 1.610(2)$ $\beta = [1.63]$ $\gamma = 1.639(2)$ 2V(meas.) = 65(5)° 2V(calc.) = 67°

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. a = 6.907(2) b = 5.095(2) c = 10.764(3) $\beta = 91°3(1)'$ Z = 2

X-ray Powder Pattern: Buranga pegmatite, Rwanda.
4.210 (100), 2.241 (100), 1.726 (75), 2.772 (70), 2.301 (65), 3.207 (50), 3.159 (50)

Chemistry:

	(1)	(2)	(3)
P_2O_5	41.35	41.95	42.24
TiO_2		0.13	
Al_2O_3	28.09	30.16	30.35
Fe_2O_3	2.20	0.04	
MnO	0.30		
CaO	17.35	16.22	16.69
Na_2O	0.30		
H_2O^+	10.68	[11.50]	10.72
H_2O^-	0.32		
Total	100.59	[100.00]	100.00

(1) Buranga pegmatite, Rwanda; $(OH)^{1-}$ and H_2O confirmed by IR, corresponds to $(Ca_{1.06}Na_{0.04}Mn^{2+}_{0.02})_{\Sigma=1.12}(Al_{1.89}Fe^{3+}_{0.10})_{\Sigma=1.99}(PO_4)_2(OH)_{2.14} \cdot 0.96H_2O$. (2) Mt. Perry, Australia; by electron microprobe, H_2O by difference; corresponds to $Ca_{0.98}Al_{2.00}(PO_4)_{2.00}(OH)_2 \cdot H_2O$. (3) $CaAl_2(PO_4)_2(OH)_2 \cdot H_2O$.

Occurrence: From the phosphate assemblage in a complex granite pegmatite (Buranga pegmatite, Rwanda; Hålsjöberg, Sweden.); in andesites altered hydrothermally through hydrogen metasomatism (Mt. Perry, Australia).

Association: Trolleite, scorzalite, apatite, bjarebyite, burangaite (Buranga pegmatite, Rwanda); trolleite, augelite, andalusite, rutile, topaz, quartz (Mt. Perry, Australia).

Distribution: In the Buranga pegmatite, near Gatumba, Rwanda. On Mt. Perry, 75 km southwest of Bundaberg, Queensland, Australia. At Hålsjöberg, Värmland, Sweden.

Name: For its occurrence near Gatumba, Rwanda.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG10560; National Museum of Natural History, Washington, D.C., USA, 142982.

References: (1) von Knorring, O. and A.-M. Fransolet (1977) Gatumbaite, $CaAl_2(PO_4)_2(OH)_2 \cdot H_2O$: a new species from Buranga pegmatite, Rwanda. Neues Jahrb. Mineral., Monatsh., 12, 561–568. (2) (1978) Amer. Mineral., 63, 793–794 (abs. ref. 1). (3) Duggan, M.B., M.T. Jones, D.N.G. Richards, and J.L. Kamprad (1990) Phosphate minerals in altered andesite from Mount Perry, Queensland, Australia. Can. Mineral., 28, 125–131.

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Gaudefroyite $Ca_4Mn^{3+}_{3-x}(BO_3)_3(CO_3)(O,OH)_3$

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Crystal Data: Hexagonal. *Point Group:* 6 or $6m$. Crystals are stubby dipyramidal $\{11\overline{2}0\}$, or prismatic $\{01\overline{1}0\}$ with prominent pyramidal terminations, to 5 cm; typically as stepwise tapered crystals in divergent aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6 VHN = 840 D(meas.) = 3.35–3.50 D(calc.) = 3.44–3.53

Optical Properties: Opaque, transparent in thin slivers. *Color:* Black; in reflected light, gray with strong yellow-orange to reddish internal reflections. *Luster:* Vitreous to dull. *Optical Class:* Uniaxial (+). *Pleochroism:* Strong; O = pale yellowish brown; E = red-orange. $\omega = 1.81(1)$ $\epsilon = 2.02(1)$ *Anisotropism:* Strong, in pale gray.

R_1–R_2: (400) 11.2–15.4, (420) 10.8–14.8, (440) 10.4–14.2, (460) 10.1–13.8, (480) 9.9–13.4, (500) 9.7–13.1, (520) 9.6–12.8, (540) 9.6–12.6, (560) 9.5–12.3, (580) 9.5–12.2, (600) 9.4–12.1, (620) 9.4–12.0, (640) 9.3–11.9, (660) 9.3–11.8, (680) 9.3–11.7, (700) 9.3–11.7

Cell Data: *Space Group:* $P6_3$ or disordered $P6_3/m$. $a = 10.589(1)$ $c = 5.891(1)$ Z = 2

X-ray Powder Pattern: Tachgagalt, Morocco.
2.95 (FF), 2.62 (FF), 2.46 (FF), 9.1 (F), 4.54 (F), 2.69 (F), 1.80 (F)

Chemistry:

	(1)	(2)		(1)	(2)
B_2O_3	16.93	17.15	CaO	35.06	36.83
CO_2	6.57	7.23	BaO		0.07
SiO_2		0.06	Na_2O		0.02
Al_2O_3		0.73	K_2O		0.01
Fe_2O_3		0.35	H_2O^+	0.63	0.61
Mn_2O_3	40.73	37.11	Total	99.92	100.17

(1) Tachgagalt, Morocco; H_2O by the Penfield method, includes pyrolusite estimated at 5.4%; corresponds to $Ca_{4.00}Mn_{2.83}(BO_3)_{3.09}(CO_3)_{0.95}[O_{2.78}(OH)_{0.22}]_{\Sigma=3.00}$. (2) Wessels mine, South Africa; by electron microprobe, corresponding to $Ca_4Mn_{2.86}(BO_3)_3(CO_3)[O_{2.59}(OH)_{0.41}]_{\Sigma=3.00}$.

Occurrence: An uncommon hydrothermal mineral in manganese deposits.

Association: Marokite, braunite, hausmannite, crednerite, pyrolusite, calcite, quartz, brucite (Tachgagalt, Morocco); barite, calcite, hydrogrossular, manganite, bixbyite, braunite, hausmannite, hematite (Kuruman district, South Africa).

Distribution: From Tachgagalt, 17 km south-southwest of Ouarzazate, Anti-Atlas Mountains, Morocco. At the Wessels and N'Chwaning mines, near Kuruman, Cape Province, South Africa.

Name: Honors Abbé Christophe Gaudefroy (1888–1971), French mineralogist who worked in Morocco.

Type Material: Geological Survey of Morocco, Rabat, Morocco; Natural History Museum, Paris, 165.34; National School of Mines, Paris, France.

References: (1) Jouravsky, G. and F. Permingeat (1964) La gaudefroyite, une nouvelle espèce minérale. Bull. Minéral., 87, 216–229 (in French). (2) (1965) Amer. Mineral., 50, 806–807 (abs. ref. 1). (3) Beukes, G.J., H. de Bruiyn, and W.A. van der Westhuizen (1993) Gaudefroyite from the Kalahari manganese field, South Africa. Neues Jahrb. Mineral., Monatsh., 385–392. (4) Hoffmann, C., T. Ambruster, and M. Kunz (1997) Structural refinement of (001) disordered gaudefroyite $Ca_4Mn^{3+}_3[(BO_3)_3(CO_3)O_3]$: Jahn-Teller-distortion in edge-sharing chains of $Mn^{3+}O_6$ octahedra. Eur. J. Mineral., 9, 7–19.

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Gaylussite $Na_2Ca(CO_3)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As flattened wedge-shaped crystals with dominant {110}, {011}, {001}, smaller {010}, {100}, {$\bar{1}$01}, {$\bar{1}$12}; also as prismatic to dipyramidal crystals elongated along [100], to 6 cm.

Physical Properties: *Cleavage:* On {110}, perfect; on {001}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 2.5–3 D(meas.) = 1.991 D(calc.) = 1.991 Dehydrates with efflorescence in dry air; slowly decomposes in H_2O leaving $CaCO_3$ as calcite or aragonite.

Optical Properties: Transparent to translucent. *Color:* Colorless to pale yellow or pale gray, white; colorless in transmitted light. *Streak:* White to pale gray. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = -15°$. *Dispersion:* $r < v$, strong, crossed. $\alpha = 1.444$ $\beta = 1.516$ $\gamma = 1.523$ 2V(meas.) = 34°

Cell Data: *Space Group:* $C2/c$. $a = 11.589$ $b = 7.780$ $c = 11.207$ $\beta = 102.5°$ Z = 4

X-ray Powder Pattern: John Hay, Jr. Well No. 1, Wyoming, USA.
6.403 (100), 3.18 (80), 2.70 (80), 2.61 (80), 1.91 (80), 2.49 (70), 1.98 (70)

Chemistry:

	(1)	(2)
CO_2	30.02	29.72
SiO_2	0.08	
Fe_2O_3	0.03	
MnO	0.01	
MgO	0.01	
CaO	19.02	18.94
Na_2O	20.40	20.93
H_2O	30.47	30.41
insol.	0.16	
Total	100.20	100.00

(1) Taboos-nor salt lake, Mongolia. (2) $Na_2Ca(CO_3)_2 \cdot 5H_2O$.

Occurrence: Typically in evaporites or shales from alkali lakes; rarely in veinlets cutting alkalic igneous rocks.

Association: Shortite, northupite, pirssonite, trona (Green River Formation, Wyoming, USA); thermonatrite, shortite, villiaumite, ferrian "biotite", pectolite, potassian feldspar, aegirine (Khibiny massif, Russia).

Distribution: From Lagunillas, 80 km southeast of Mérida, Venezuela. In the USA, in California, at Mono Lake, Mono Co., Borax Lake, Lake Co., Deep Spring Lake, Inyo Co., China Lake, Kern Co., and Searles Lake, San Bernardino Co.; in the Green River Formation, Sweetwater Co., Wyoming; at several localities in the Carson Desert, near Ragtown, Nevada. Large crystals from Lake Amboseli, Kenya. At Lake Eyasi, Tanzania. On Zoutpan Farm, 40 km northwest of Pretoria, Transvaal, South Africa. At the Taboos-nor salt lake, eastern Gobi Desert, Mongolia. From the Olenii Ruchei area, Khibiny massif, Kola Peninsula, Russia. Around Mt. Erebus, Victoria Land, Antarctica.

Name: Honors Joseph Louis Gay-Lussac (1778–1850), noted French chemist and physicist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 234–235. (2) Fahey, J.J. (1962) Saline minerals of the Green River Formation. U.S. Geol. Surv. Prof. Paper 405, 24, 49. (3) Menchetti, S. (1968) The crystal structure of gaylussite. Atti Rend. Accad. Lincei, 44, 680–694.

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Gearksutite $CaAl(OH)F_4 \cdot H_2O$

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Crystal Data: Monoclinic, probable. *Point Group:* n.d. As extremely minute fibers, which, under the SEM, are seen to be lath-shaped crystals; these form chalklike nodular masses and powders.

Physical Properties: Hardness = 2, in aggregates. D(meas.) = 2.72–2.768 D(calc.) = n.d. Compact, massive material fluoresces dark violet to bluish gray; powdery material fluoresces yellowish brown.

Optical Properties: Opaque; fine fibers are transparent. *Color:* White, pale rose; in transmitted light, colorless. *Luster:* Dull.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge$ elongation = large. $\alpha = 1.448(3)$ $\beta = 1.454(3)$ $\gamma = 1.456(3)$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Ivigtut, Greenland.
4.54 (10), 3.14 (8), 2.28 (8), 1.924 (8), 3.33 (7d), 2.15 (6), 1.741 (6)

Chemistry:

	(1)	(2)	(3)
Na	0.04	0.20	
K	0.07	0.05	
Ca	22.41	22.15	22.51
Al	15.11	15.09	15.15
O	5.09	5.42	4.49
F	41.00	40.20	42.67
H_2O	15.64	15.52	15.18
insol.		0.96	
Total	99.36	99.59	100.00

(1) Wagon Wheel Gap, Colorado, USA. (2) Hot Springs, Virginia, USA. (3) $CaAl(OH)F_4 \cdot H_2O$.

Occurrence: In granite and granite pegmatites; may be formed by low-temperature hydrothermal alteration of aluminous rocks by fluorine-bearing hot springs.

Association: Cryolite, thomsenolite, sellaite, pachnolite, ralstonite, weberite, fluorite.

Distribution: Occurs in the Ivigtut cryolite deposit, southwestern Greenland. In Norway, found near Lake Gjerdingen, Nordmarka. Found at Miass, Ilmen Mountains, Southern Ural Mountains; in the Karasug barite–fluorite deposit, 15 km north of Karasug, western Tannu-Ola Mountains, Siberia; in the Zharchikhinsk molybdenum deposit, on the west side of Lake Baikal, eastern Siberia; in the Voznesensk fluorite deposit, Primorskiy Territory; and other less-well-defined localities in Russia. From Aktchatau and Baynazar, Kazakhstan. Occurs on Vulcano, Lipari Islands, Italy. At Salzburg, and near Hall, Tirol, Austria. In the USA, found between Hot Springs and Warm Springs, Bath Co., Virginia; at the Chancellor mine, Boulder Co., St. Peters Dome, near Pikes Peak, El Paso Co., and the Wagon Wheel Gap fluorite mine, Mineral Co., Colorado; in the Grand Reef mine, Graham Co., Arizona; at the Hall mine, near Tonopah, San Antone district, Nye Co., Nevada; and in the Quitman Mountains, Hudspeth Co., Texas. From Colquiri, Oruro, Bolivia. Found at the Mt. Cleveland tin mine, 14 km southwest of Waratah, Tasmania, and from Gingin, Western Australia. Several other localities are known.

Name: From the Greek *ge* for *Earth*, in allusion to the earthy appearance of the mineral, and *arksutite* (= chiolite), originally thought to be a mineral that gearksutite closely resembled in composition.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 119–120. (2) Ferguson, R.B. (1949) Observations on some aluminum fluoride minerals. Amer. Mineral., 34, 383–397. (3) Ziborova, T.A., V.I. Fin'ko, I.V. Basalaeva, and N.D. Samotoin (1986) About some crystallochemical peculiarities of gearksutite. Izv. Akad. Nauk SSSR, Ser. Geol., (1986)12, 85–89 (in Russian). (4) (1988) Mineral. Abs., 39, 302 (abs. ref. 3).

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Gebhardite $Pb_8(As_2^{3+}O_5)_2OCl_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals elongated along [010], to 5 mm, with {100} and {001}; parallel, subparallel, curved, in fibrous groups.

Physical Properties: *Cleavage:* {001}, perfect; {010}, good. Hardness = ∼3 VHN = 80–180 D(meas.) = n.d. D(calc.) = 6.0

Optical Properties: Transparent. *Color:* Brown. *Streak:* White. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Pleochroism:* Faint; $X = Y$ = pale brown; Z = brown. *Orientation:* $Z = b$; $X \wedge a = 3°$. *Dispersion:* $r \gg v$, with marked horizontal dispersion. $\alpha = 2.08$ β = n.d. $\gamma = 2.12$ 2V(meas.) = 34(1)°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.724(6)$ $b = 11.20(1)$ $c = 34.19(4)$ $\beta = 85.2(1)°$ Z = [4]

X-ray Powder Pattern: Tsumeb, Namibia.
6.70 (100), 3.72 (80), 3.68 (80), 2.801 (80), 3.55 (70), 3.15 (70), 2.925 (60)

Chemistry:

	(1)
As_2O_3	16.7
PbO	75.1
Cl	8.9
$-O = Cl_2$	2.0
Total	98.7

(1) Tsumeb, Namibia; by electron microprobe, As^{3+} valence determined by microchemical analysis; corresponds to $Pb_{7.99}As^{3+}_{3.99}Cl_{5.96}O_{11}$.

Occurrence: On a specimen of highly oxidized ore from the lower oxidation zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Reinerite, mimetite, smithsonite, willemite, hematite, fraipontite, quartz.

Distribution: From Tsumeb, Namibia.

Name: To honor Dr. Georg Gebhard (1945–), German chemist, mineral collector, and authority on rare minerals, who supplied the specimen.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 147360.

References: (1) Medenbach, O., W. Gebert, and K. Abraham (1983) Gebhardit, $Pb_8OCl_6(As_2O_5)_2$, ein neues Arsenit von Tsumeb, Südwest-Afrika/Namibia. Neues Jahrb. Mineral., Monatsh., 445–450 (in German with English abs.). (2) (1985) Amer. Mineral., 70, 215 (abs. ref. 1). (3) Klaska, R. and W. Gebert (1982) Polytypie und Struktur von Gebhardit – $Pb_8OCl_6(As_2O_5)_2$. Zeits. Krist., 159, 75–76 (in German).

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Gedrite $(Mg,Fe^{2+})_2[(Mg,Fe^{2+})_3Al_2](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As bladed and prismatic crystals; fibrous and semi-sheaflike aggregates.

Physical Properties: *Cleavage:* Perfect on {210}, intersecting at 54° and 126°, imperfect on {010}, {100}. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.15–3.259 D(calc.) = 3.18–3.334

Optical Properties: Transparent to translucent. *Color:* White, gray, brown, green; colorless, gray, or brown in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak to moderate, in browns, yellows, or gray.
Orientation: $X = a$; $Y = b$; $Z = c$. α = 1.625–1.690 β = 1.635–1.705 γ = 1.643–1.718
2V(meas.) = 70°–90°

Cell Data: *Space Group: Pnma.* a = 18.531–18.601 b = 17.741–17.839 c = 5.249–5.284
Z = 4

X-ray Powder Pattern: Grafton, Maine, USA.
3.06 (100), 8.27 (80), 3.23 (70), 8.97 (50), 4.48 (40), 3.65 (40), 3.35 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.71	43.46	MgO	10.66	15.17
TiO_2	0.29	0.58	CaO	0.05	0.78
Al_2O_3	18.73	14.18	Na_2O	1.59	2.02
Fe_2O_3	0.90		K_2O	0.06	0.05
FeO	24.39	20.35	H_2O^+	2.75	
MnO	0.14	0.49	H_2O^-	0.15	
			Total	100.42	[97.08]

(1) Grafton, Maine, USA; corresponds to $(Fe^{2+}_{3.00}Mg_{2.34}Al_{1.23}Na_{0.46}Fe^{3+}_{0.10}Ti_{0.03}Mn_{0.02}Ca_{0.01}K_{0.01})_{\Sigma=7.20}(Si_{5.99}Al_{2.01})_{\Sigma=8.00}O_{22}(OH)_{2.70}$. (2) Tallan Lake sill, Peterborough Co., Ontario, Canada; by electron microprobe, original total given as 97.07%; corresponding to $(Mg_{3.31}Fe^{2+}_{2.12}Al_{0.82}Na_{0.57}Fe^{3+}_{0.37}Mn_{0.06}Ti_{0.06})_{\Sigma=7.31}(Si_{6.37}Al_{1.63})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with magnesio-gedrite and ferro-gedrite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: 0.1 $Mg/(Mg + Fe^{2+})$ 0.89; $(Ca + Na)_B < 1.34$; Li < 1.0; Si < 7.0; $Al^{iv} > 0.99$.

Occurrence: Widespread in medium- to high-grade metamorphic rocks; in metasomatized contact metamorphic rocks.

Association: Garnet, cordierite, "hornblende," anthophyllite, cummingtonite, sapphirine, sillimanite, kyanite, quartz, staurolite, biotite.

Distribution: From Gèdre, Héas Valley, Haut Pyrénées, France. At Strathy, Sutherlandshire, and Glen Urquhart, Inverness-shire, Scotland. From Snarum, Bjordammen, and Bamble, Norway. At Schisshyttan, near Väster Silfberg, Värmland, Sweden. From Shuyeverskoya, Karelia. In the USA, at Haddam, Middlesex Co., Connecticut; Grafton, Oxford Co., Maine; Masons' Mountain, Macon Co., North Carolina; and Powder Mill Point, Berkeley, Alameda Co., California. At Budsbrook, Western Australia. In the Wakamatsu mine, Tottori Prefecture, and at Iratsuyama, Ehime Prefecture, Japan.

Name: For the occurrence near Gèdre, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 384–385. (2) Milton, D.J. and J. Ito (1961) Gedrite from Oxford County, Maine. Amer. Mineral., 46, 734–740. (3) Papike, J.J. and M. Ross (1970) Gedrites: crystal structures and intra-crystalline cation distributions. Amer. Mineral., 55, 1945–1972. (4) Hawthorne, F.C., J.L. Griep, and L. Curtis (1980) A three-amphibole assemblage from the Tallan Lake sill, Peterborough County, Ontario. Can. Mineral., 18, 275–284. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 223–225.

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Geerite Cu_8S_5

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}$ $2/m$, $3m$ or 32. As coatings and thin platelets, to 15 μm.

Physical Properties: Hardness = < 3.5, softer than sphalerite. VHN = 75–96 (25 g load). D(meas.) = n.d. D(calc.) = 5.61

Optical Properties: Opaque. *Color:* Bluish white in reflected light. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Moderate, in yellows.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. a = 3.83 c = 46.84 Z = 1

X-ray Powder Pattern: DeKalb Township, New York, USA.
3.128 (100), 1.918 (50), 1.637 (30), 1.109 (20), 2.712 (10), 1.870 (10), 1.683 (10)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	61.44	76.94	78.1	76.02
Fe			0.4	
Zn			1.0	
S	21.47	26.04	21.1	23.98
Total	82.91	102.98	100.6	100.00

(1) DeKalb Township, New York, USA; by electron microprobe, corresponding to $Cu_{7.22}S_{5.00}$. (2) Do.; by electron microprobe, corresponding to $Cu_{7.46}S_{5.00}$; (1) and (2) represent the range of 27 analyses. (3) Eretria, Greece; by electron microprobe, corresponding to $(Cu_{9.34}Zn_{0.11}Fe_{0.05})_{\Sigma=9.50}S_{5.00}$. (4) Cu_8S_5.

Occurrence: Replacing sphalerite along cleavage traces (DeKalb Township, New York, USA); in a serpentine-hosted magnetite–chromite deposit (Eretria, Greece).

Association: Spionkopite, sphalerite, tetrahedrite, chalcopyrite, malachite, azurite, brochantite, chrysocolla, cervantite, stibiconite, hemimorphite, calcite (DeKalb Township, New York, USA); spionkopite, chalcopyrite, cobalt pentlandite, magnetite, chromite, andradite, chlorite, diopside (Eretria, Greece).

Distribution: In the USA, from DeKalb Township, St. Lawrence Co., New York [TL], and at Cuchillo, Winston district, Sierra Co., New Mexico. From near Eretria, Othris Mountains, Greece. In the Lubin and Rudna copper mines, near Legnica, Zechstein copper district, Lower Silesia, Poland. At the Clara mine, near Oberwolfach, Black Forest, Germany. In southwestern Co. Cork, Ireland. From the Lorena gold deposit, near Cloncurry, Queensland, Australia.

Name: To honor the collector of the original specimens, Adam Geer (1895–1973), of Utica, New York, USA.

Type Material: New York State Museum, Albany, New York; The Natural History Museum, London, England, 1986,482; Queen's University, Kingston, Ontario, Canada; National Museum of Natural History, Washington, D.C., USA, 144186.

References: (1) Goble, R.J. and G. Robinson (1980) Geerite, $Cu_{1.60}S$, a new copper sulfide from Dekalb Township, New York. Can. Mineral., 18, 519–523. (2) (1981) Amer. Mineral., 66, 1274 (abs. ref. 1). (3) Economou, M.I. (1981) A second occurrence of the copper sulfides geerite and spionkopite in Eretria area, central Greece. Neues Jahrb. Mineral., Monatsh., 489–494. (4) Goble, R.J. (1985) The relationship between crystal structure, bonding and cell dimensions in the copper sulfides. Can. Mineral., 23, 61–76.

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Geffroyite $(Cu, Fe, Ag)_9(Se, S)_8$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly in a micro-myrmekitic intergrowth, to 0.7 mm, with clausthalite and eskebornite.

Physical Properties: Hardness = n.d. VHN = 67.5–72.4 (15 g load). D(meas.) = n.d. D(calc.) = 5.39

Optical Properties: Opaque. *Color:* Brown with a creamy tint in reflected light. *Luster:* Metallic.
R: (400) — , (420) 19.0, (440) 21.4, (460) 23.5, (480) 25.5, (500) 27.5, (520) 29.1, (540) 30.1, (560) 31.7, (580) 32.7, (600) 33.6, (620) 34.4, (640) 35.1, (660) 35.8, (680) 36.3, (700) 36.9

Cell Data: *Space Group:* $Fm3m$. a = 10.889 Z = 4

X-ray Powder Pattern: Chaméane mine, France.
1.925 (100), 3.282 (90), 3.145 (90), 2.094 (60), 1.112 (60), 1.660 (50), 2.436 (40)

Chemistry:

	(1)	(2)
Cu	28.57	28.81
Fe	19.01	19.38
Ag	7.05	5.16
Se	34.42	35.76
S	10.06	9.87
Total	99.11	98.98

(1) Chaméane mine, France; by electron microprobe, corresponds to $(Cu_{4.80}Fe_{3.63}Ag_{0.70})_{\Sigma=9.13}(Se_{4.65}S_{3.35})_{\Sigma=8.00}$. (2) Do.; by electron microprobe, corresponds to $(Cu_{4.77}Fe_{3.65}Ag_{0.50})_{\Sigma=8.90}(Se_{4.76}S_{3.24})_{\Sigma=8.00}$.

Mineral Group: Pentlandite group.

Occurrence: As late-stage deposits in veins cutting granite (Chaméane mine, France).

Association: Eskebornite, clausthalite, chaméanite, ankerite (Chaméane mine, France).

Distribution: From the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France [TL]. In the San Miguel prospect, 10 km northwest of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: To honor Jacques Geffroy (1918–1993), metallurgist for the French Atomic Energy Commission.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, and F. Ruhlmann (1982) Evolution paragénétique de la minéralisation uranifère de Chaméane (Puy-de-Dôme) France: chaméanite, geffroyite et giraudite, trois séléniures nouveaux de Cu, Fe, Ag, and As. Tschermaks Mineral. Petrog. Mitt., 29, 151–167 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 1074–1075 (abs. ref. 1).

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Gehlenite $Ca_2Al(AlSi)O_7$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Crystals are commonly short prismatic, resembling octahedrally modified cubes; granular, massive. *Twinning:* On {100}, {001}; lamellar on {001}.

Physical Properties: *Cleavage:* Distinct on {001}, poor on {110}. *Fracture:* Uneven, splintery to conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.038 D(calc.) = 3.03

Optical Properties: Transparent to translucent and opaque. *Color:* Colorless, brown, yellowish, greyish green; colorless to pale yellow in thin section. *Streak:* White to grayish white. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–). *Pleochroism:* May show anomalous Berlin blue interference colors. *Absorption:* Weak; $O > E$. $\omega = 1.669$ (synthetic). $\epsilon = 1.658$

Cell Data: *Space Group:* $P\bar{4}2_1m$ (synthetic). $a = 7.6850(4)$ $c = 5.0636(3)$ Z = 2

X-ray Powder Pattern: Crestmore, California, USA.
2.848 (100), 1.818 (75), 1.921 (64), 3.066 (43), 2.437 (38), 1.768 (36), 2.738 (32)

Chemistry:

	(1)	(2)	(3)
SiO_2	30.09	22.86	21.91
TiO_2	trace		
Al_2O_3	21.67	32.09	37.19
Fe_2O_3	1.36	3.03	
FeO	2.14		
MnO	0.04		
MgO	3.87	0.85	
CaO	38.36	41.25	40.90
Na_2O	0.75		
K_2O	0.16		
H_2O^+	1.64		
Total	100.08	100.08	100.00

(1) Val di Fassa, Italy. (2) Carneal, Ireland; by electron microprobe. (3) $Ca_2Al(AlSi)O_7$.

Polymorphism & Series: Forms a series with åkermanite.

Mineral Group: Melilite group.

Occurrence: In contact metamorphosed impure limestones; in calcium-rich ultramafic volcanic rocks.

Association: Dolomite, calcite, augite, olivine, nepheline, leucite, merwinite, spurrite, diopside, ferroan spinel, phlogopite, pyrope, grossular, antigorite, pyroxenes, apatite, vesuvianite.

Distribution: Occurrences are typically of intermediate series members. Relatively pure examples have been found at: Mt. Monzoni, Val di Fassa, and Canzòcoli, Val di Fiemme, Trentino-Alto Adige, Italy. On Scawt Hill, near Larne, and at Carneal, Co. Antrim, Ireland. At Camas Mòr, Isle of Muck, and Camphouse, Ardnamurchan, Argyllshire, Scotland. From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. In the USA, at Crestmore, Riverside Co., California; from the Tres Hermanas district, Luna Co., New Mexico; and at Iron Hill, Gunnison Co., Colorado. From the Terneras mine, Velardeña, Durango, Mexico.

Name: After the German chemist, Adolf Ferdinand Gehlen (1775–1815).

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 476–477. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 285–334. (3) Sabine, P.A., M.T. Styles, and B.R. Young (1982) Gehlenite, an exomorphic mineral from Carneal, Co. Antrim, Northern Ireland. U.K. Inst. of Geol. Sci., Report 82-1, 61–63. (4) (1982) Mineral. Abs., 33, 297 (abs. ref. 3). (5) Swainson, I.P., M.T. Dove, W.S. Schmahl, and A. Putnis (1992) Neutron powder diffraction study of the åkermanite–gehlenite solid solution series. Phys. Chem. Minerals, 19, 185–195.

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Geigerite $Mn_5^{2+}(AsO_4)_2(AsO_3OH)_2 \cdot 10H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Subhedral crystals, to 0.5 mm, platy on {010}, striated ‖ [001]; in fibrous to fine-grained aggregates.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Extremely brittle. Hardness = ∼3 VHN = 105 (20 g load). D(meas.) = 3.05(10) D(calc.) = 3.00

Optical Properties: Transparent to translucent. *Color:* Pale rose-red to colorless. *Streak:* White. *Luster:* Vitreous to pearly. *Optical Class:* Biaxial (–). *Pleochroism:* Very weak; colorless to rose-red in thick sections. *Orientation:* $X \simeq b$; $Y \simeq a$; $Z \simeq c$; $Z \wedge c = 15°$ on {010}; $Z \wedge c = 6°$ on {100}; X almost $\perp$ {010}. *Absorption:* $Z > Y \simeq X$. $\alpha = 1.601(2)$ $\beta = 1.630(2)$ $\gamma = 1.660(2)$ 2V(meas.) = Large. 2V(calc.) = 89°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.944(1)$ $b = 10.691(1)$ $c = 6.770(1)$ $\alpha = 80.97(1)°$ $\beta = 84.20(1)°$ $\gamma = 81.85(1)°$ Z = 1

X-ray Powder Pattern: Falotta mine, Switzerland.
10.45 (100), 3.051 (24), 3.507 (21), 3.340 (20), 3.011 (17), 2.786 (14), 7.85 (13)

Chemistry:

	(1)	(2)
As_2O_5	50.12	45.40
MnO	39.71	35.03
CaO	0.12	
H_2O	[10.05]	19.57
Total	[100.00]	100.00

(1) Falotta mine, Switzerland; by electron microprobe, average of five analyses; H_2O by difference.
(2) $Mn_5(AsO_4)_2(AsO_3OH)_2 \cdot 10H_2O$.

Occurrence: In cavities in radiolarites, formed by metamorphism of manganese oxide ores.

Association: Brandtite, sarkinite, grischunite, bergslagite, manganberzeliite, tilasite.

Distribution: At the Falotta mine, Oberhalbstein, Graubünden, Switzerland.

Name: In honor of Dr. Thomas Geiger (1886–1976), Wiesendangen, Switzerland, who studied Falotta manganese ores.

Type Material: Natural History Museum, Basel, 30804; Basel University, Basel, Switzerland.

References: (1) Graeser, S., H. Schwander, R. Bianchi, T. Pilati, and C.M. Gramaccioli (1989) Geigerite, the Mn analogue of chudobaite: its description and crystal structure. Amer. Mineral., 74, 676–684.

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Geikielite $MgTiO_3$

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Crystal Data: Hexagonal. *Point Group:* 3. As tabular and prismatic crystals, showing {0001}, {10$\bar{1}$1}, {20$\bar{2}$5}, {02$\bar{2}$1}, to 2.5 cm; more commonly subhedral to anhedral, and as irregular to rounded grains.

Physical Properties: *Cleavage:* {10$\bar{1}$1}. *Fracture:* Conchoidal to subconchoidal. Hardness = 5–6 D(meas.) = 3.79–4.2 D(calc.) = 3.895

Optical Properties: Opaque to translucent. *Color:* Black, less commonly ruby-red; in transmitted light, brownish to purplish red; gray in reflected light, with red internal reflections. *Streak:* Purplish brown. *Luster:* Submetallic.
Optical Class: Uniaxial (–). *Pleochroism:* Moderate to weak; O = pinkish red; E = brownish to purplish red. *Absorption:* Weak; $E > O$. $\omega = 2.31$–2.35 $\epsilon = 1.95$–1.98 *Anisotropism:* Strong.
R_1–R_2: (400) 17.7–13.9, (420) 17.2–13.5, (440) 16.8–13.1, (460) 16.4–12.8, (480) 16.1–12.4, (500) 15.8–12.2, (520) 15.5–12.0, (540) 15.4–11.8, (560) 15.3–11.8, (580) 15.2–11.8, (600) 15.2–11.7, (620) 15.2–11.8, (640) 15.3–11.8, (660) 15.3–11.8, (680) 15.4–11.8, (700) 15.4–11.8

Cell Data: *Space Group: R*3(synthetic). $a = 5.05478(26)$ $c = 13.8992(7)$ Z = 6

X-ray Powder Pattern: Synthetic.
2.722 (100), 2.218 (70), 2.527 (55), 1.708 (55), 3.703 (45), 1.852 (40), 1.4592 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2		0.4	
TiO_2	67.74	58.5	66.46
Fe_2O_3		2.0	
Cr_2O_3		0.04	

	(1)	(2)	(3)
FeO	3.81	18.9	
MnO		1.52	
MgO	28.73	18.3	33.54
CaO		0.01	
Total	100.28	99.7	100.00

(1) Sri Lanka. (2) Bergell zone, Switzerland/Italy; by electron microprobe; Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponding to $Mg_{0.60}Fe^{2+}_{0.35}Mn_{0.03}Fe^{3+}_{0.03}Ti_{0.98}Si_{0.01}O_3$. (3) $MgTiO_3$.

Polymorphism & Series: Forms a series with ilmenite.

Mineral Group: Ilmenite group.

Occurrence: Forms during contact metamorphism of impure magnesian limestones. Also in carbonatites, kimberlites, serpentinized ultramafic rocks, and in gem-bearing placer deposits.

Association: Rutile, spinel, clinohumite, perovskite, diopside, serpentine, forsterite, brucite, hydrotalcite, chlorite, calcite.

Distribution: From the Rakwana and Balangoda districts, Sri Lanka. At Baltistan, Kashmir, Pakistan. In the USA, from the Crestmore quarry, Riverside Co. and in the Santa Lucia Mountains, Monterey Co., California; large crystals in Skeleton Canyon, Cochise Co., Arizona. At the Maxwell quarry, near Wakefield, Quebec, Canada. From the Fiskenæsset complex, western Greenland. In the Bergell contact aureole, Central Alps, Switzerland/Italy. From the Naataniemi serpentinite massif, Kuhmo greenstone belt, Finland. In Russia, on Mount Jemorakly-Tube, North Caucasus Mountains; in the Camel Mountains, Southern Ural Mountains; in the Tazheran alkalic massif, west of Lake Baikal, Siberia. At Kimberley, Cape Province, South Africa. From north of the Mahogany mine, Hartley district, Zimbabwe. Several other localities are known.

Name: In honor of Sir Archibald Geikie (1835–1924), Scottish geologist and Director-General of the Geological Survey of Great Britain.

Type Material: The Natural History Museum, London, England, 69078–69079.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 534–541. (2) Gieré, R. (1987) Titanian clinohumite and geikielite in marbles from the Bergell contact aureole. Contr. Mineral. Petrol., 96, 496–502. (3) Wechsler, B.A. and R.B. Von Dreele (1989) Structure refinements of Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ by time-of-flight neutron powder diffraction. Acta Cryst., 45, 542–549. (4) (1955) NBS Circ. 539, 5, 43.

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Geminite $Cu(AsO_3OH)\cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As euhedral crystals, tabular on {001}, slightly elongated along [100], with {001}, {100}, {010}, and {*hk*0} forms, to 0.3 mm, usually in aggregates. *Twinning:* On {001}, polysynthetic, universal.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 3.70(2) D(calc.) = [3.63]

Optical Properties: Transparent. *Color:* Light green to sea-green. *Streak:* Very pale green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; $X = Y$ = colorless; Z = pale green to pale gray. *Orientation:* $X' \wedge c \simeq 90°$; $Y' \wedge a = 17°$–$18.5°$; $Z' \wedge b = 13°$. *Dispersion:* $r > v$, weak. $\alpha = 1.656(2)$ $\beta = 1.692(2)$ $\gamma = 1.770(5)$ 2V(meas.) = 75(5)° 2V(calc.) = 71°

Cell Data: *Space Group:* $C\overline{1}$. $a = 9.841(2)$ $b = 10.818(2)$ $c = 15.733(3)$ $\alpha = 95.71(2)°$ $\beta = 90.94(2)°$ $\gamma = 103.11(2)°$ Z = 16

X-ray Powder Pattern: Cap Garonne mine, France.
7.83 (100), 3.260 (70), 3.070 (70), 3.925 (60), 2.611 (50), 3.107 (40), 2.825 (40)

Chemistry:

	(1)	(2)
As_2O_5	52.4	51.89
CuO	36.5	35.91
H_2O	11.0	12.20
Total	99.9	100.00

(1) Cap Garonne mine, France; by AA, H_2O by TGA; corresponds to $Cu_{1.04}(As_{1.03}O_3OH)\cdot H_2O$.
(2) $Cu(AsO_3OH)\cdot H_2O$.

Polymorphism & Series: Dimorphous with pushcharovskite.

Occurrence: From an arsenic-bearing oxidized Pb–Cu deposit (Cap Garonne mine, France); on specimens from mine dumps at a gold-bearing arsenic sulfide deposit (Salsigne mine, France).

Association: Tennantite, covellite, chalcanthite, lavendulan, pushcharovskite, antlerite, brochantite, quartz (Cap Garonne mine, France); lindackerite, yvonite, arsenopyrite, bismuth, chalcopyrite, pushcharovskite (Salsigne mine, France).

Distribution: In France, from the Cap Garonne mine, near le Pradet, Var, and in the Salsigne mine, 15 km north of Carcassone, Aude. At Jáchymov (Joachimsthal), Czech Republic. From Hartenstein, Saxony, Germany.

Name: From the Latin *gemini*, for *twins*, as the mineral is extensively twinned.

Type Material: Natural History Museum, Geneva, Switzerland, 435/80.

References: (1) Sarp, H. and P. Perroud (1990) Geminite, $Cu_2As_2O_7\cdot 3H_2O$, un nouveau minéral de la mine de Cap Garonne, Var, France. Schweiz. Mineral. Petrog. Mitt., 70, 309–314 (in French with English abs.). (2) (1992) Amer. Mineral., 77, 671 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1995) The crystal structure of geminite, $Cu^{2+}(AsO_3OH)(H_2O)$, a heteropolyhedral sheet structure. Can. Mineral., 33, 1111–1118. (4) Prencipe, M., D.Y. Pushcharovskiy, H. Sarp, and G. Ferraris (1996) Comparative crystal chemistry of geminite $Cu[AsO_3OH]H_2O$ and minerals related to it. Moscow Univ. Bull. Series 4, Geol. 4, 66–74 (in Russian). (5) (1998) Amer. Mineral., 83, 911 (abs. ref. 4).

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Genkinite $(Pt,Pd)_4Sb_3$

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Crystal Data: Tetragonal. *Point Group:* 422. As irregular grains, to about 165 μm.

Physical Properties: Hardness = n.d. VHN = 603–677 (25 g load). D(meas.) = n.d. D(calc.) = 9.256

Optical Properties: Opaque. *Color:* Pale brown or tan with a yellowish tinge. *Pleochroism:* Weak in oil for some grains. *Bireflectance:* Weak. *Anisotropism:* Moderate to strong; from gray to extinction.
R_1–R_2: (400) 45.6–45.6, (420) 46.5–46.7, (440) 47.6–48.0, (460) 48.7–49.2, (480) 49.9–50.4, (500) 51.1–51.5, (520) 52.3–52.7, (540) 53.5–53.8, (560) 54.5–54.8, (580) 55.5–55.8, (600) 56.5–56.7, (620) 57.4–57.6, (640) 58.2–58.2, (660) 58.9–58.9, (680) 59.5–59.5, (700) 60.0–60.1

Cell Data: *Space Group:* n.d. $a = 7.736(1)$ $c = 24.161(2)$ $Z = 8$

X-ray Powder Pattern: Onverwacht mine, South Africa.
2.265 (100), 3.020 (90), 1.934 (60), 1.910 (50), 0.9043 (50b), 0.9025 (50b), 2.146 (40)

Chemistry:

	(1)	(2)
Pt	44.4	41.86
Pd	9.0	7.01
Rh	6.6	8.23
Ni	2.0	3.41
Cu	0.25	
Sb	35.8	38.96
Bi	1.7	
As	0.89	
Total	100.64	99.47

(1) Onverwacht mine, South Africa; by electron microprobe, corresponds to $(Pt_{2.17}Pd_{0.81}Rh_{0.61}Ni_{0.32}Cu_{0.04})_{\Sigma=3.95}(Sb_{2.81}As_{0.11}Bi_{0.08})_{\Sigma=3.00}$. (2) Shetland Islands, Scotland; by electron microprobe, corresponds to $(Pt_{2.04}Rh_{0.76}Pd_{0.62}Ni_{0.55})_{\Sigma=3.97}Sb_{3.03}$.

Occurrence: In ultramafics or ophiolites mineralized with Pt–Fe–Cu–Ni, and placers derived from them.

Association: Sperrylite, platarsite, ruthenarsenite, stibiopalladinite, mertieite-II, Pt–Fe alloy, chromite (Onverwacht mine, South Africa); osmium, Pt–Pd–Cu alloy, hollingworthite, irarsite, laurite, ruthenian pentlandite, chromite (Shetland Islands, Scotland).

Distribution: In South Africa, in the Merensky Reef, Bushveld complex, Transvaal, at the Onverwacht [TL] and Driekop mines. From the Joubdo stream, Birbir River, Ethiopia. On Unst and Fetlar, Shetland Islands, Scotland. From Fox Gulch, Goodnews Bay, Alaska, USA.

Name: For Dr. Alexandr D. Genkin (1919–), Russian mineralogist specializing in platinum group elements.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, N79000; Canadian Museum of Nature, Ottawa; Royal Ontario Museum, Toronto, Canada, M34861; National Museum of Natural History, Washington, D.C., USA, 136485.

References: (1) Cabri, L.J., J.M. Stewart, J.H.G. Laflamme, and J.T. Szymański (1977) Platinum group minerals from Onverwacht. III. Genkinite, $(Pt,Pd)_4Sb_3$, a new mineral. Can. Mineral., 15, 389–392. (2) (1979) Amer. Mineral., 64, 654 (abs. ref. 1). (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 105–107. (4) Prichard, H.M. and M. Tarkian (1988) Platinum and palladium minerals from two PGE-rich localities in the Shetland ophiolite complex. Can. Mineral., 26, 979–990. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 191.

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Genthelvite $Zn_4Be_3(SiO_4)_3S$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As tetrahedra and tristetrahedra, to 5 cm. Also as irregular segregations, to 25 cm.

Physical Properties: *Cleavage:* Poor on {111}, {1$\bar{1}$1}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 3.44–3.70 D(calc.) = 3.70 May fluoresce intense green under LW and SW UV, then phosphorescent.

Optical Properties: Transparent. *Color:* Red, pink, yellow, pale green, emerald-green; colorless or pink in thin section. *Luster:* Vitreous.
Optical Class: Isotropic. n = 1.738–1.752

Cell Data: *Space Group:* $P\bar{4}3n$. a = 8.10–8.15 Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
3.320 (100), 1.916 (80), 2.168 (70), 2.567 (65), 1.657 (65), 1.483 (50), 1.435 (50)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	30.26	30.70	CuO	0.30		LOI	0.21	
Al_2O_3		0.18	ZnO	46.20	40.56	$-O = S$	2.78	2.74
FeO	6.81	11.73	BeO	12.70	12.39	Total	100.41	100.04
MnO	1.22	1.72	S	5.49	5.50			

(1) St. Peters Dome, Colorado, USA; average of two analyses, corresponds to $(Zn_{3.31}Fe^{2+}_{0.56}Mn_{0.10}Cu_{0.02})_{\Sigma=3.99}Be_{2.91}Si_{2.97}O_{11.72}S_{1.00}$. (2) Jos, Nigeria; corresponds to $(Zn_{2.93}Fe^{2+}_{0.96}Mn_{0.14})_{\Sigma=4.03}Be_{2.92}(Si_{3.02}Al_{0.04})_{\Sigma=3.06}O_{11.99}S_{1.01}$.

Polymorphism & Series: Forms two series, with danalite, and with helvite.

Occurrence: In miarolitic cavities in granite pegmatites; in alkaline granites and syenites, greisens, and skarns.

Association: Phenakite, bertrandite, hambergite, siderite, sphalerite, willemite, gahnite, topaz, zircon, quartz, microcline, zeolites.

Distribution: From West Cheyenne Cañon, near St. Peters Dome, El Paso Co., Colorado, and Cumberland, Providence Co., Rhode Island, USA. Large crystals from Mont Saint-Hilaire, Quebec, Canada. At Lågendalen, Tvedalen, Brevik, and on Låven Island, in the Langesundsfjord area, Norway. At the Treburland mine, Altarnun, Cornwall, England. From Coire an Lochain, Cairngorm Mountains, Banffshire, Scotland. In the Jos-Bukuru complex, Nigeria. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina. In the Ilímaussaq intrusion and the Motzfeldt centre, Greenland. From Russia, in the Lovozero and Khibiny massifs, Kola Peninsula. At Titkäranta, Karelia.

Name: The prefix for Frederick August Ludwig Karl Wilhelm Genth (1820–1893), German-American mineralogist, who described a zinc-rich *helvite* (danalite), later renamed genthelvite.

Type Material: Pennsylvania State University, University Park, Pennsylvania; National Museum of Natural History, Washington, D.C., USA, 127180; The Natural History Museum, London, England, 1976,427.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 1032 [danalite]. (2) Glass, J.J., R.H. Jahns, and R.E. Stevens (1944) Helvite and danalite from New Mexico and the helvite group. Amer. Mineral., 29, 163–191. (3) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 303–309. (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 119–126. (5) Dunn, P.J. (1976) Genthelvite and the helvine group. Mineral. Mag., 40, 627–636. (6) Hassan, I. and H.D. Grundy (1985) The crystal structures of helvite group minerals, $(Mn, Fe, Zn)_8(Be_6Si_6O_{24})S_2$. Amer. Mineral., 70, 186–192. (7) Burt, D.M. (1988) Stability of genthelvite, $Zn_4(BeSiO_4)_3S$: an exercise in chalcophilicity using exchange operators. Amer. Mineral., 73, 1384–1394.

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Geocronite $Pb_{14}(Sb, As)_6S_{23}$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals rare, but may be to 8 cm, from several localities; tabular on {001}. Massive, as rounded and irregular grains; earthy. *Twinning:* Common on {001}; lamellar.

Physical Properties: *Cleavage:* Distinct on {011}. *Fracture:* Uneven. Hardness = 2.5 VHN = 144–160 (100 g load). D(meas.) = 6.46 D(calc.) = 6.44

Optical Properties: Opaque. *Color:* Pale lead-gray to pale gray; in polished section, pure white. *Streak:* Pale lead-gray to grayish blue. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Moderate.
R_1–R_2: (400) 40.5–45.3, (420) 40.4–45.0, (440) 40.0–44.4, (460) 39.7–43.9, (480) 39.5–43.6, (500) 39.3–43.2, (520) 39.1–42.8, (540) 38.8–42.3, (560) 38.6–41.9, (580) 38.3–41.5, (600) 38.0–41.1, (620) 37.7–40.6, (640) 37.2–40.1, (660) 36.5–39.4, (680) 35.9–38.8, (700) 35.1–38.2

Cell Data: *Space Group:* $P2_1/m$. $a = 8.963(2)$ $b = 31.93(2)$ $c = 8.500(2)$ $\beta = 118.02(1)^\circ$ $Z = 2$

X-ray Powder Pattern: Park City, Utah, USA.
3.54 (100), 3.06 (90), 2.89 (90), 3.39 (80), 3.18 (86), 2.98 (70), 3.71 (60)

Chemistry:

	(1)	(2)	(3)
Pb	68.90	67.52	68.60
Sb	9.27	11.48	8.64
As	4.54	3.65	5.32
S	17.13	17.45	17.44
Total	99.84	100.10	100.00

(1) Sala, Sweden; corresponds to $Pb_{14.32}(Sb_{3.28}As_{2.61})_{\Sigma=5.89}S_{23.00}$. (2) Silver King mine, Park City, Utah, USA; corresponds to $Pb_{13.77}(Sb_{3.98}As_{2.06})_{\Sigma=6.04}S_{23.00}$. (3) $Pb_{14}(Sb, As)_6S_{23}$ with Sb:As = 1:1.

Polymorphism & Series: Forms a series with jordanite.

Occurrence: In hydrothermal veins with sulfides and other sulfosalt minerals.

Association: Galena, pyrite, tetrahedrite, barite, fluorite, quartz.

Distribution: Only some of the best authenticated localities are mentioned here. In Sweden, from Sala, Västmanland [TL??only, not Falun=DS8??ck Swedish book??], and Falun, Kopparberg [??TL??MRM??]. In Ireland, in the Kilbricken mine, Co. Clare, and at Silvermines, Co. Tipperary. From the Treore mine, St. Treath [Teath in Criddle??ck], Cornwall, England. At Bournac, Montagne Noire, Finistère, France. From the Bayerland mine, Oberpfalz??, Germany. In Italy, at Pietrasanta, Val de Castello [Pollone mine, Valdicastello Carducci??], Tuscany. From Uzunzhal, Kazakhstan. At Smirnovsk, Transbaikal??, Siberia, Russia. From the Xanda mine, Virgem da Lapa, Minas Gerais, Brazil. In the Noche Buena mine, Mazapil, Zacatecas, Mexico. In the USA, in Utah, in the Silver King mine, Park City district, Summit Co.; and in the Tintic district, Juab Co.; in California, at Darwin, Inyo Co.; at the Inexco #1 mine, Jamestown, Boulder Co., Colorado. From the Hemlo gold deposit, Thunder Bay district, Ontario, Canada.

Name: From the Greek for *Earth* and *Saturn*, the alchemistic name for lead.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 395–396. (2) Douglass, R.M., M.J. Murphy, and A. Pabst (1954) Geocronite. Amer. Mineral., 39, 908–928. (3) Birnie, R. and C.W. Burnham (1976) The crystal structure and extent of solid solution of geocronite. Amer. Mineral., 61, 963–970. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 192.

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Georgbarsanovite $Na_{12}(Mn, Sr, REE)_3Ca_6Fe^{2+}{}_3Zr_3NbSi_{25}O_{76}Cl_2 \cdot H_2O$

Crystal Data: Hexagonal. *Point Group*: 3*m*. As 1-2 cm thick, branching veinlets with either gradational or sharp contacts with eudialyte.

Physical Properties: *Cleavage*: None observed. *Fracture*: Uneven to conchoidal. *Tenacity*: Brittle. Hardness = 5 D(meas.) = 3.05(2) D(calc.) = 3.11

Optical Properties: Transparent to translucent. *Color*: Yellow-green. *Streak*: White. *Luster*: Vitreous.
Optical Class: Uniaxial (–) [some grains show anomalous biaxial character, 2V = 10-15°].
ω = 1.639(2) (bottle green) ε = 1.631(2) (pale yellow)

Cell Data: *Space Group*: *R*3*m*. a = 14.274(2) c = 30.02(1) Z = 3

X-ray Powder Pattern: Kola Peninsula, Russia.
3.202 (100), 2.975 (98), 2.857 (94), 3.155 (71), 4.304 (62), 6.42 (54), 2.591 (54)

Chemistry:

	(1)		(1)
Na_2O	11.03	Y_2O_3	0.43
K_2O	0.35	ZrO_2	12.08
CaO	10.73	HfO_2	0.28
SrO	2.24	TiO_2	0.11
BaO	0.14	Nb_2O_5	3.72
FeO	5.57	SiO_2	46.03
MnO	2.55	Cl	1.20
La_2O_3	0.87	F	0.35
Ce_2O_3	1.58	LOI	0.48
Nd_2O_3	0.65	$-O = (F,Cl)_2$	0.42
		Total	99.97

(1) Kola Peninsula, Russia; electron microprobe analysis, IR spectroscopy confirms the presence of (OH), H_2O and minor CO_2, corresponding to $(Na_{11.73}K_{0.24})_{\Sigma=11.97}(Mn_{1.19}Sr_{0.71}REE_{0.63}Ca_{0.30}Y_{0.13}Ba_{0.03})_{\Sigma=2.99}Ca_6(Fe^{2+}{}_{2.55}Zr_{0.23}Ti_{0.05}Hf_{0.04})_{\Sigma=2.87}Zr_3Nb_{0.92}Si_{25.25}O_{76.48}Cl_{1.11}F_{0.61}\cdot 0.88H_2O$.

Mineral Group: Eudialyte subgroup of the eudialyte group.

Occurrence: A late stage reaction product in nepheline-feldspar pegmatite associated with an alkaline massif.

Association: Eudialyte.

Distribution: In boulders, upper reaches of the Petreliusa River valley, Khibiny alkaline massif, Kola Peninsula, Russia.

Name: Honors prominent Russian mineralogist Georgiy Pavlovich Barsanov (1907-1991).

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (catalog no. 61504).

References: (1) Khomyakov, A.P., G.N. Nechelyustov, I.A. Ekimenkova, R.K. Rastsvetayeva (2005) Georgbarsanovite, $Na_{12}(Mn,Sr,REE)_3Ca_6Fe_3{}^{2+}Zr_3NbSi_{25}O_{76}Cl_2\cdot H_2O$, a mineral species of the eudialyte group: revalidation of barsanovite and the new name of the mineral. Zapiski Rossiyskogo Mineralogicheskogo Obshchestva, 134(6), 47-57 (in Russian, English abstract). (2) (2008) Amer. Mineral., 93, 702-703 (abs. ref. 1).

Georgbokiite $Cu_5O_2(SeO_3)_2Cl_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As complex equant to short prismatic crystals, with large {100}, {010}, {111}, {131}, 15 other forms, to 0.3 mm.

Physical Properties: *Cleavage:* Perfect on {100} and {010}. *Tenacity:* Sectile. Hardness = n.d. VHN = 215 (10 g load). D(meas.) = n.d. D(calc.) = 4.88

Optical Properties: Transparent. *Color:* Chestnut-brown to dark brown. *Streak:* Yellowish brown. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = yellowish brown, Y = straw-yellow; Z = dark brown. *Orientation:* $Y = b$; $X \wedge a = 24°$. *Absorption:* $Z > X > Y$. $\alpha = 2.06(2)$ $\beta = 2.11(2)$ $\gamma = 2.15(2)$ 2V(meas.) = 70° 2V(calc.) = 82°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.030(1)$ $b = 13.744(3)$ $c = 5.562(1)$ $\beta = 95.75(1)°$ Z = 2

X-ray Powder Pattern: Tolbachik volcano, Russia.
2.990 (100), 2.296 (95), 2.963 (94), 6.88 (68), 2.566 (67), 5.511 (50), 2.265 (28)

Chemistry:

	(1)	(2)
SeO_2	33.09	32.90
CuO	58.17	58.96
ZnO	0.22	
Cl	10.96	10.51
$-O = Cl_2$	2.47	2.37
Total	99.97	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of 13 analyses; corresponds to $(Cu_{4.92}Zn_{0.02})_{\Sigma=4.94}O_{1.91}(SeO_3)_{2.01}Cl_{2.08}$. (2) $Cu_5O_2(SeO_3)_2Cl_2$.

Occurrence: A rare fumarolic sublimate.

Association: Burnsite, chloromenite, sofiite, ilinskite, cotunnite, halite, moissanite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: To honor Professor Georgiy Borisovich Bokii (1909–2001), Institute of Geology of Ore Deposits, Moscow, Russia, for his work in mineralogy and crystal chemistry.

Type Material: Mineralogy Museum, St. Petersburg University; Mining Institute, St. Petersburg, Russia.

References: (1) Vergasova, L.P., T.F. Semenova, S.K. Filatov, S.V. Krivovichev, R.R. Shuvalov, and V.V. Ananiev (1999) Georgbokiite $Cu_5O_2(SeO_3)_2Cl_2$ – a new mineral from volcanic sublimates. Doklady Acad. Nauk SSSR, 364, 527–531 (in Russian). (2) Krivovichev, S.V., R.R. Shuvalov, T.F. Semenova, and S.K. Filatov (1999) Crystal chemistry of inorganic compounds based on chains of oxocentered tetrahedra. Part 3. Crystal structure of georgbokiite, $Cu_5O_2(SeO_3)_2Cl_2$. Zeits. Krist., 214, 135–138. (3) (2000) Amer. Mineral., 85, 627 (abs. refs. 1–2).

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Georgechaoite $KNaZrSi_3O_9 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As well-formed single and twinned hemimorphic crystals, to 1 mm; forms include {010}, {011}, {100}, {$\bar{1}$00}, {$\bar{1}$01}, {101}, and {120}. *Twinning:* Common, by interpenetration of individuals related by a half-turn about [023]; the [100] axes of twinned crystals are parallel, with [010] of one 14° from [001] of the other.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5 D(meas.) = 2.70(2) D(calc.) = 2.689

Optical Properties: Semitransparent. *Color:* Colorless to white. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.578(1)$ $\beta = 1.597(1)$ $\gamma = 1.606(1)$ 2V(meas.) = 67° 2V(calc.) = 68°

Cell Data: *Space Group:* $P2_1nb$. $a = 11.836(4)$ $b = 12.940(6)$ $c = 6.735(4)$ Z = 4

X-ray Powder Pattern: Wind Mountain, New Mexico, USA; very similar to gaidonnayite. 3.12 (100), 6.46 (73), 5.95 (70), 5.67 (52), 5.83 (32), 2.829 (22), 2.201 (21)

Chemistry:

	(1)	(2)
SiO_2	43.18	43.16
TiO_2	0.11	
ZrO_2	29.03	29.51
FeO	0.15	
Na_2O	7.54	7.42
K_2O	10.75	11.28
H_2O	[9.21]	8.63
Total	[99.97]	100.00

(1) Wind Mountain, New Mexico, USA; by electron microprobe, average of several analyses, H_2O estimated by analogy to gaidonnayite. (2) $NaKZrSi_3O_9 \cdot 2H_2O$.

Occurrence: In miarolitic cavities in analcime-bearing nepheline syenite (Wind Mountain, New Mexico, USA); in a carbonatite, in dolomitic veinlets cutting metasomatically altered pyroxenites, apparently altering from catapleiite (Vuoriyarvi complex, Russia).

Association: Microcline, nepheline, aegirine, catapleiite, monazite, chlorite (Wind Mountain, New Mexico, USA); dolomite, strontianite, phlogopite, barite, komkovite, pyrite (Vuoriyarvi complex, Russia).

Distribution: On Wind Mountain, Otero Co., New Mexico, USA. In the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. From Poços de Caldas, Minas Gerais, Brazil.

Name: Honors Professor George Y. Chao, of Carleton University, Toronto, Canada, for his studies of zirconium silicates.

Type Material: National Museum of Natural History, Washington, D.C., USA, 161902.

References: (1) Boggs, R.C. and S. Ghose (1985) Georgechaoite $NaKZrSi_3O_9 \cdot 2H_2O$, a new mineral species from Wind Mountain, New Mexico. Can. Mineral., 23, 1–4. (2) Ghose, S. and P. Thakur (1985) The crystal structure of georgechaoite $NaKZrSi_3O_9 \cdot 2H_2O$. Can. Mineral., 23, 5–10. (3) (1986) Amer. Mineral., 71, 227 (abs. refs. 1 and 2).

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Georgeericksenite $Na_6CaMg(IO_3)_6(CrO_4)_2 \cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular to prismatic [001] crystals, slightly flattened on {110}, to 0.2 mm, with dominant forms {110}, {100}, {$\overline{2}$33}; in nodular aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = n.d. D(calc.) = 3.035 Readily soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Bright lemon-yellow to pale yellow. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Slight; X = very pale yellow; Z = distinct yellow-green. *Orientation:* $Z \simeq c$. $\alpha = 1.647(2)$ $\beta = 1.674(2)$ $\gamma = 1.704(2)$ 2V(meas.) = n.d. 2V(calc.) = 88.4°

Cell Data: *Space Group:* $C2/c$. $a = 23.645(2)$ $b = 10.918(1)$ $c = 15.768(1)$ $\beta = 114.42(6)°$ Z = 4

X-ray Powder Pattern: Oficina Chacabuco, Chile.
10.69 (100), 3.121 (80), 3.051 (80), 3.590 (70), 6.36 (50), 5.65 (50), 4.36 (40)

Chemistry: (1) Oficina Chacabuco, Chile; major elemental components and anion groups confirmed by qualitative electron microprobe and IR; by crystal-structure analysis, corresponds to $Na_{6.00}Ca_{1.00}Mg_{1.00}(IO_3)_{6.00}[(Cr_{0.84}S_{0.16})_{\Sigma=1.00}O_4]_2 \cdot 12H_2O$.

Occurrence: On a museum specimen from a nitrate deposit.

Association: Halite, nitratine, niter.

Distribution: From Oficina Chacabuco, Taltal district, Antofagasta, Chile.

Name: Honors George E. Ericksen (1920–1996), research geologist, U.S. Geological Survey, Reston, Virginia, USA, who studied Chilean nitrate deposits.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 82914.

References: (1) Cooper, M.A., F.C. Hawthorne, A.C. Roberts, J.D. Grice, J.A.R. Stirling, and E.A. Moffatt (1998) Georgeericksenite, $Na_6CaMg(IO_3)_6(CrO_4)_2(H_2O)_{12}$, a new mineral from Oficina Chacabuco, Chile: description and crystal structure. Amer. Mineral., 83, 390–399.

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Georgeite $Cu_5(CO_3)_3(OH)_4 \cdot 6H_2O$

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Crystal Data: Amorphous. *Point Group:* n.d. As thick to thin pulverulent to massive coatings.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = "Very soft". D(meas.) = 2.55(10) D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Pale Cerulean blue to Calamine blue; pale blue in transmitted light. *Streak:* Very pale blue. *Luster:* Vitreous to earthy. *Optical Class:* Isotropic. $n = 1.593(2)$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Carr Boyd Rocks mine, Australia; amorphous by X-ray and electron diffraction analysis.

Chemistry:

	(1)	(2)
CO_2	19.3	19.59
CuO	58.3	59.02
ZnO	0.6	
H_2O	22.0	21.39
Total	[100.2]	100.00

(1) Carr Boyd Rocks mine, Australia; IR confirms OH^{1-} and H_2O; recalculated after deduction of chalconatronite 12.35% from an original analysis totalling 100.5%; then corresponds to $(Cu_{5.01}Zn_{0.05})_{\Sigma=5.06}(CO_3)_3(OH)_{4.12} \cdot 6.3H_2O$. (2) $Cu_5(CO_3)_3(OH)_4 \cdot 6H_2O$.

Occurrence: A rare secondary mineral in oxidized portions of a Ni–Cu sulfide deposit.

Association: Malachite, chalconatronite, nickelian magnesite, gypsum.

Distribution: From the Carr Boyd Rocks nickel mine, Yerilla district, 80 km north-northeast of Kalgoorlie, Western Australia.

Name: Honors George Herbert Payne (1912–1989), Chief of the Mineral Division, Government Chemical Laboratories, Perth, Western Australia.

Type Material: Western Australian Museum, Perth, Australia, 5775; National Science Museum, Tokyo, Japan; The Natural History Museum, London, England, 1979,323; National Museum of Natural History, Washington, D.C., USA.

References: (1) Bridge, P.J., J. Just, and M.H. Hey (1979) Georgeite, a new amorphous copper carbonate from the Carr Boyd mine, Western Australia. Mineral. Mag., 43, 97–98. (2) (1979) Amer. Mineral., 64, 1330 (abs. ref. 1). (3) Pollard, A.M., R.G. Thomas, P.A. Williams, J. Just, and P.J. Bridge (1991) The synthesis and composition of georgeite and its reactions to form other secondary copper(II) carbonates. Mineral. Mag., 55, 163–166.

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Georgiadèsite $Pb_8(AsO_4)_2OCl_7(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are pseudohexagonal tablets, showing {100}, {001}, {110}, and several other modifying forms, with multiple individuals typically grown in parallel, to 5 mm.

Physical Properties: Hardness = 3.5 D(meas.) = 6.3(3) D(calc.) = 6.39

Optical Properties: Semitransparent. *Color:* White or brownish yellow; colorless in transmitted light. *Luster:* Resinous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z = c$. *Dispersion:* $r < v$, strong. $\alpha = 2.17$ $\beta = 2.17$ $\gamma = 2.18$ 2V(meas.) = Very large.

Cell Data: *Space Group:* $P2_1/c$. $a = 13.803(10)$ $b = 7.910(2)$ $c = 10.812(4)$ $\beta = 102.68(3)°$ Z = 1

X-ray Powder Pattern: Laurium, Greece.
3.096 (10), 3.955 (5), 3.164 (5), 6.33 (3), 5.30 (3), 4.031 (3), 3.773 (3)

Chemistry:

	(1)	(2)	(3)
As_2O_5	12.49	11.2	10.37
PbO	78.05	81.3	80.55
Cl	12.47	11.3	11.20
H_2O	n.d.	n.d.	0.41
$-O = Cl_2$	2.81	2.6	2.53
Total	100.20	101.2	100.00

(1) Laurium, Greece; recalculated from original analyses, O^{2-} calculated for charge balance; corresponds to $Pb_{7.65}(AsO_4)_{2.35}O_{0.3}Cl_{7.65}$. (2) Do.; by electron microprobe, O^{2-} calculated for charge balance; corresponds to $Pb_{7.85}(AsO_4)_{2.1}O_{1.25}Cl_{6.9}$. (3) $Pb_8(AsO_4)_2OCl_7(OH)$.

Occurrence: Formed by the action of seawater on lead-bearing slag (Laurium, Greece).

Association: Laurionite, fiedlerite, matlockite, phosgenite, nealite (Laurium, Greece).

Distribution: At Laurium, Greece, in slag.

Name: In honor of Mr. Georgiadès, a Director of the mines at Laurium Greece.

Type Material: National School of Mines, Paris, France; American Museum of Natural History, New York City, New York, 28427; National Museum of Natural History, Washington, D.C., USA, 137839, 145938.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 791–792. (2) Rouse, R.C. and P.J. Dunn (1983) New data on georgiadesite. Mineral. Mag., 47, 219–220.

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Gerasimovskite $(Mn^{2+}, Ca)(Nb, Ti)_5O_{12}\cdot 9H_2O(?)$

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Crystal Data: Amorphous. *Point Group:* n.d. In platy masses and scales, to 1.5 cm.

Physical Properties: *Cleavage:* One direction, perfect, micaceous. Hardness = 2
D(meas.) = 2.52–2.58 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Cinnamon-brown to light gray, gray, or silvery gray; in transmitted light, colorless. *Luster:* Pearly.
Optical Class: Biaxial (–). *Orientation:* Extinction parallel; elongation positive. $\alpha = \sim 1.74$ $\beta = \sim 1.81$ $\gamma = \sim 1.81$ 2V(meas.) = 18°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Lovozero massif, Russia; after heating at 900 °C.
1.89 (10), 3.70 (8), 3.18 (6), 2.10 (4), 1.64 (2)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	43.91	43.32	40.60
Ta_2O_5	0.38	0.02	0.0
SiO_2	1.83	3.58	
TiO_2	24.37	21.00	23.39
Al_2O_3		2.54	
Fe_2O_3	trace	2.46	1.08
MnO	7.85	2.09	
MgO		0.65	0.80
CaO	1.37	1.59	0.58
Na_2O		0.15	
K_2O		0.15	
H_2O^+	3.95	10.20	9.87
H_2O^-	16.55	11.20	9.51
P_2O_5		0.90	
Total	[100.21]	99.85	

(1) Mt. Punkaruaiv, Russia; original total given as 100.11%; corresponds to $(Mn_{0.84}Ca_{0.18})_{\Sigma=1.02}(Nb_{2.50}Ti_{2.50})_{\Sigma=5.00}O_{12.27}\cdot 9.09H_2O$. (2) Mt. Karnasurt, Russia. (3) Ilímaussaq intrusion, Greenland; partial analysis.

Polymorphism & Series: Forms a series with manganbelyankinite.

Occurrence: As a secondary mineral formed by the late-stage hydrothermal alteration of Nb–Ti minerals (possibly epistolite) within ussingite-bearing pegmatites, associated with alkaline intrusions.

Association: Ussingite, epistolite, steenstrupine, neptunite (Lovozero massif, Russia); albite, analcime, aegirine, natrolite, tetranatrolite, chkalovite, lithian mica, epistolite, niobophyllite, monazite, rhabdophane, tugtupite, nenadkevichite, beryllite (Ilímaussaq intrusion, Greenland).

Distribution: Found on Mts. Punkaruaiv, Karnasurt, Nepkhe, and Alluaiv, in the Lovozero massif, Kola Peninsula, Russia. In Greenland, occurs at Nákâlâq, in the Ilímaussaq intrusion.

Name: Honors Vasily Ivanovich Gerasimovskii (1911–1979), Russian mineralogist and geochemist, discoverer of many new minerals from the Lovozero massif.

Type Material: Vernadsky Geological Museum, Moscow, 46315; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 62290.

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References: (1) Semenov, E.I. (1957) Oxides and hydroxides of titanium and niobium in the Lovozero alkalic massif. Inst. mineral., geokhim., crystallokhim. redkikh. elementov., Trudy, 1, 41–59 (in Russian). (2) (1958) Amer. Mineral., 43, 1220–1221 (abs. ref. 1). (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 392–393 (in English). (4) Semenov, E.I., M.E. Kazakova, and R.A. Aleksandrova (1968) The Lovozero minerals – nenadkevichite, gerassimovskite [*sic*] and tundrite – from Ilimaussaq, South Greenland. Medd. Grønland, 181(5), 5–10.

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Gerdtremmelite $(Zn, Fe^{2+})(Al, Fe^{3+})_2(AsO_4)(OH)_5$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals are tabular, to 0.5 mm, in spherulitic aggregates.

Physical Properties: Hardness = n.d. D(meas.) = > 3.3 D(calc.) = 3.66

Optical Properties: Transparent. *Color:* Brown, yellowish brown, dark brown.
Streak: White. *Luster:* Adamantine.
Optical Class: Biaxial; high birefringence. $n = 1.735(5)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.169(5)$ $b = 13.038(9)$ $c = 4.931(4)$
$\alpha = 98.78(7)°$ $\beta = 100.80(6)°$ $\gamma = 78.73(6)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
12.77 (100), 3.878 (50), 3.631 (50), 3.140 (50), 4.801 (40), 4.695 (40), 4.220 (40)

Chemistry:

	(1)	(2)	(3)
MoO_3	1.08	1.08	
As_2O_5	32.53	31.54	32.79
Al_2O_3	23.76	26.74	24.73
Fe_2O_3	11.38	10.01	6.83
FeO			3.07
CuO	0.01	0.04	
ZnO	19.51	19.58	19.73
H_2O	11.25	11.25	12.85
Total	99.52	100.24	100.00

(1) Tsumeb, Namibia; by electron microprobe, total Fe as Fe_2O_3, H_2O by TGA on a separate sample; corresponds to $(Zn_{0.83}Fe_{0.49}Al_{1.60})_{\Sigma=2.92}[(As_{0.97}Mo_{0.03})_{\Sigma=1.00}O_4](OH)_{4.30}$. (2) Do.; corresponds to $(Zn_{0.85}Fe_{0.44}Al_{1.86})_{\Sigma=3.15}[(As_{0.97}Mo_{0.03})_{\Sigma=1.00}O_4](OH)_{4.43}$. (3) $(Zn_{0.85}Fe^{2+}_{0.15})_{\Sigma=1.00}(Al_{1.70}Fe^{3+}_{0.30})_{\Sigma=2.00}(AsO_4)(OH)_5$.

Occurrence: A very rare secondary mineral from the deep oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Powellite, betpakdalite, scorodite, wilhelmkleinite, adamite, hematite, kaolinite, quartz.

Distribution: From Tsumeb, Namibia.

Name: To honor Dr. Gerd Tremmel (1940–), of Overath-Steinbrück, Germany, who submitted the mineral for identification.

Type Material: Mineralogical-Petrographical Institute, University of Heidelberg, Heidelberg, Germany; National Museum of Natural History, Washington, D.C., USA, 162488.

References: (1) Schmetzer, K. and O. Medenbach (1985) Gerdtremmelite, $(Zn, Fe)(Al, Fe)_2[(AsO_4)|(OH)_5]$, a new mineral from Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 1–6. (2) (1986) Amer. Mineral., 71, 845 (abs. ref. 1).

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Gerhardtite $Cu_2(NO_3)(OH)_3$

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Crystal Data: Orthorhombic. *Point Group:* 222. As crystals, thick tabular on {001}, commonly heavily striated ∥ {001}, with rhombic outline, to 1.5 cm; mammillary, granular, paintlike, massive.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, good. *Tenacity:* Flexible. Hardness = 2 D(meas.) = 3.40–3.43 D(calc.) = 3.389

Optical Properties: Transparent. *Color:* Dark green, emerald-green, bluish green. *Streak:* Pale green. *Luster:* [Vitreous.]
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = green; Z = blue. *Orientation:* X = a; $Y = b$; $Z = c$. *Dispersion:* $r < v$, very strong. $\alpha = 1.703$ $\beta = 1.713$ $\gamma = 1.722$
2V(meas.) = Large.

Cell Data: *Space Group:* $P2_12_12_1$. $a = 6.087(2)$ $b = 13.813(4)$ $c = 5.597(2)$ Z = 4

X-ray Powder Pattern: Kalabi, Congo.
6.91 (100), 2.624 (80), 2.310 (80d), 1.579 (80d), 2.595 (70), 3.454 (60), 2.797 (60d)

Chemistry:

	(1)	(2)
N_2O_5	22.76	22.49
CuO	66.38	66.26
H_2O	11.26	11.25
Total	100.40	100.00

(1) United Verde mine, Arizona, USA. (2) $Cu_2(NO_3)(OH)_3$.

Polymorphism & Series: Dimorphous with rouaite.

Occurrence: A rare secondary mineral in oxidized portions of copper deposits.

Association: Cuprite, malachite, atacamite, miersite, brochantite, pseudomalachite, buttgenbachite, likasite, connellite, claringbullite.

Distribution: In the USA, in Arizona, from the United Verde mine, Jerome, Yavapai Co.; in the Daisy shaft, Mineral Hill mine, Pima district, Pima Co.; and at Chase Creek Canyon, Greenlee Co. Large crystals from Likasi, and at Kalabi, near Likasi, Katanga Province, Congo [Shaba Province, Zaire]. From Dzhezkazgan, Kazakhstan. At Ramsbeck, Westphalia, Germany. From the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, France. At the Great Australia and Monakoff mines, near Cloncurry, Queensland, Australia.

Name: Honors Charles Frederic Gerhardt (1816–1856), American chemist who first prepared the artificial compound.

Type Material: Yale University, New Haven, Connecticut, USA, 3.3269.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 308–309. (2) Bovio, B. and S. Locchi (1982) Crystal structure of the orthorhombic basic copper nitrate, $Cu_2(OH)_3NO_3$. J. Cryst. Spectr. Res., 12, 507–517.
(3) Oswald, H.R. (1961) Über natürlichen und künstlichen Gerhardtit. Zeits. Krist., 116, 210–219 (in German with English abs.).

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Germanite $Cu_{13}Fe_2Ge_2S_{16}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Cubic crystals, rarely to 3 cm [check 3 cm in Gebhardt??!!formerly "tiny"]; commonly massive, intergrown with reniérite.

Physical Properties: *Tenacity:* Brittle. Hardness = 4 VHN = n.d. D(meas.) = 4.46–4.59 D(calc.) = 4.30

Optical Properties: Opaque. *Color:* Reddish gray, tarnishes to a dull brown; in polished section, pinkish gray. *Streak:* Dark gray to black. *Luster:* Metallic, dull.
R: (400) 21.9, (420) 21.5, (440) 21.1, (460) 20.6, (480) 20.0, (500) 19.6, (520) 19.7, (540) 20.2, (560) 21.0, (580) 21.9, (600) 22.8, (620) 23.8, (640) 24.7, (660) 25.5, (680) 26.2, (700) 26.8

Cell Data: *Space Group:* $F\bar{4}3n$. $a = 10.5862(5)$ $Z = 2$

X-ray Powder Pattern: Tsumeb, Namibia.
3.054 (100), 1.870 (72), 1.5954 (40), 1.0802 (20), 1.2141 (16), 2.645 (12), 1.3229 (10)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Cu	45.5	45.06	51.76	V	0.0	0.12	
Fe	6.8	8.14	7.00	Ge	9.6	9.61	9.10
Zn	1.2	1.51		Ga	0.0	0.65	
Mo	0.5	0.26		As	3.3	2.97	
W	0.0	0.33		S	31.6	31.96	32.14
				Total	98.5	100.21	100.00

(1) Tsumeb, Namibia; by electron microprobe, corresponds to $(Cu_{11.63}Zn_{0.30})_{\Sigma=11.93}Fe^{3+}_{1.98}(Ge_{2.15}As_{0.72}Mo_{0.08})_{\Sigma=2.95}S_{16.00}$. (2) Do.; by electron microprobe, average of 30 analyses; corresponds to $(Cu_{11.38}Zn_{0.37}Fe^{2+}_{0.34})_{\Sigma=12.09}Fe^{3+}_{2.00}(Ge_{2.12}As_{0.64}Ga_{0.06}Mo_{0.04}V_{0.04}W_{0.03})_{\Sigma=2.93}S_{16.00}$. (3) $Cu^{1+}_8Cu^{2+}_5Fe^{3+}_2Ge^{4+}_2S_{16}$; Mo-, V-, and W-rich varities are known.

Mineral Group: Colusite group.

Occurrence: In primary Cu–Pb–Zn ores in a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Reniérite, pyrite, tennantite, enargite, galena, sphalerite, digenite, bornite, chalcopyrite.

Distribution: From Tsumeb, Namibia [TL]. At M'Passa, 150 km west of Brazzaville, Congo Republic. From Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). In the USA, at the Inexco #1 mine, Jamestown, Boulder Co., Colorado; and in the Ruby Creek deposit, Brooks Range, near Bornite, Alaska. In Cuba, from Pinar del Rio Province. In Bulgaria, at the Radka deposit, Pazardzhik. From Dastakert, Armenia. At Bor, Serbia. From the Bancairoun mine, Alpes-Maritimes, France. At Weisloch, ??, Germany. In Russia, from Vaygach, Arkhangel'sk, and in the Noril'sk region, western Siberia; at the Vaigach and Sibai deposits, Ural Mountains. In the Shakanai mine, Akita Prefecture, Japan.

Name: For the *germanium* content of the mineral.

Type Material: The Natural History Museum, London, England, 1922,1180.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 385–386. (2) Sclar, C.B. and B.H. Geier (1954) The paragenetic relationships of germanite and reniérite from Tsumeb, South West Africa. Econ. Geol., 52, 612–631. (3) Springer, G. (1969) Microanalytical investigations into germanite, renierite, briartite, and gallite. Neues Jahrb. Mineral., Monatsh., 435–441. (4) Geier, B.H. and J. Otteman (1970) New secondary tin-germanium and primary tungsten-(molybdenum-, vanadium-) germanium minerals from the Tsumeb ore deposit. Neues Jahrb. Mineral., Abh., 114, 89–107. (5) Tettenhorst, R.T. and C.E. Corbató (1984) Crystal structure of germanite, $Cu_{26}Ge_4Fe_4S_{32}$, determined by x-ray powder diffraction. Amer. Mineral., 69, 943–947. (6) Spiridonov, E.M. (1987) On the composition of germanite. Doklady Acad. Nauk SSSR, 295, 477–481 (in Russian). (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 193.

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Germanocolusite $Cu_{26}V_2(Ge,As)_6S_{32}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As single grains, may be in aggregates, to 100 μm.

Physical Properties: Hardness = n.d. VHN = 280–370, 330 average (40 g load). D(meas.) = n.d. D(calc.) = 4.55

Optical Properties: Opaque. *Color:* Yellow, grayish yellow, greenish yellow, olive-yellow, cream-yellow; less commonly yellowish cream with a rose to brownish tint.
R: (400) 22.4, (420) 22.5, (440) 22.7, (460) 23.2, (480) 24.1, (500) 25.5, (520) 26.4, (540) 27.1, (560) 27.6, (580) 27.8, (600) 27.9, (620) 28.0, (640) 27.9, (660) 27.8, (680) 27.7, (700) 27.4

Cell Data: *Space Group:* $P\bar{4}3m$ (by analogy to colusite). $a = 10.568(3)$ $Z = 1$

X-ray Powder Pattern: Urup, Russia.
3.05 (10), 1.870 (5), 1.017 (5), 2.64 (4), 1.595 (3), 1.320 (3), 1.212 (3)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Cu	49.69	49.22	48.04	Mo	0.67	1.18	0.00
Zn	0.91	0.15	1.28	W	0.03	0.06	0.00
Fe	0.47	1.56	1.54	As	5.09	5.90	3.38
Ag	0.13	0.00	0.09	Sb	0.08	0.12	0.40
V	3.32	3.19	3.17	Bi	0.15	0.00	0.00
Ge	8.62	6.55	9.13	S	32.10	31.97	31.05
Ga	0.00	0.35	0.17	Se	0.00	0.00	1.08
Sn	0.14	0.06	1.33	Total	101.40	100.31	100.66

(1) Urup, Russia; by electron microprobe, corresponds to $(Cu_{24.96}Zn_{0.44}Fe_{0.27}Ag_{0.04})_{\Sigma=25.71}V_{2.08}(Ge_{3.79}As_{2.17}Mo_{0.22}Sn_{0.04}Sb_{0.02}Bi_{0.02})_{\Sigma=6.26}S_{31.95}$. (2) Tsumeb, Namibia; by electron microprobe, corresponds to $(Cu_{24.92}Fe_{0.90}Zn_{0.07})_{\Sigma=25.88}V_{2.01}(Ge_{2.90}As_{2.53}Mo_{0.40}Ga_{0.16}Sb_{0.03}Sn_{0.02})_{\Sigma=6.04}S_{32.06}$. (3) Chelopech deposit, Bulgaria; by electron microprobe, corresponds to $(Cu_{24.50}Fe_{0.89}Zn_{0.64}Ag_{0.03})_{\Sigma=26.06}V_{2.02}(Ge_{4.08}As_{1.46}Sn_{0.36}Sb_{0.11}Ga_{0.08})_{\Sigma=6.09}(S_{31.39}Se_{0.44})_{\Sigma=31.83}$.

Mineral Group: Colusite group.

Occurrence: In germanium-rich polymetallic hydrothermal deposits.

Association: Renierite, germanite, gallite, mawsonite, bornite, enargite, tennantite, chalcopyrite, chalcocite, galena, pyrite.

Distribution: From Urup, Karachaevo-Cherkessk district, Northern Caucasus Mountains, Russia [TL]. In the Maykain gold deposit, Pavlodar district, northeastern Kazakhstan. From the Chelopech deposit, Sofia, Bulgaria. At Tsumeb, Namibia.

Name: For its germanium content and relation to colusite.

Type Material: Mining Institute, St. Petersburg, 2050/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Spiridonov, E.M., V.M. Kachalovskaya, V.V. Kovachev, and L.Y. Krapiva (1992) Germanocolusite $Cu_{26}V_2(Ge,As)_6S_{32}$ — a new mineral. Vestnik Moskovskogo Universiteta, Ser. 4, Geologiya, 1992(6), 50–54 (in Russian). (2) (1994) Amer. Mineral., 79, 387 (abs. ref. 1).

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Gersdorffite NiAsS

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Crystals are octahedral, typically modified by the cube, to 4 cm, or pyritohedral, may be striated as is pyrite; commonly internally zoned.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5 VHN = 657–767 (100 g load). D(meas.) = 5.9 D(calc.) = 5.966

Optical Properties: Opaque. *Color:* Silver-white to steel-gray; may tarnish gray or grayish black; in polished section, white. *Streak:* Grayish black. *Luster:* Metallic.
R: (400) 50.2, (420) 49.7, (440) 49.1, (460) 48.6, (480) 47.7, (500) 47.0, (520) 46.2, (540) 45.7, (560) 45.3, (580) 45.1, (600) 45.0, (620) 45.1, (640) 45.3, (660) 45.5, (680) 45.9, (700) 46.3

Cell Data: *Space Group: Pa*3. $a = 5.60$–5.72, 5.594 (synthetic). Z = 4

X-ray Powder Pattern: Synthetic.
2.545 (100), 2.325 (90), 1.716 (80), 2.848 (60), 2.013 (35), 1.521 (35), 1.096 (20)

Chemistry:

	(1)	(2)	(3)
Ni	34.31	35.7	35.42
Fe		0.2	
Co		0.1	
As	45.33	44.3	45.23
Sb	1.17	1.6	
S	18.50	19.0	19.35
rem.	0.69		
Total	[100.00]	100.9	100.00

(1) Rhodesia; recalculated to 100% after deduction of gangue; corresponds to $Ni_{1.01}(As_{1.05}Sb_{0.02})_{\Sigma=1.07}S_{1.00}$. (2) Cochabamba, Bolivia; by electron microprobe, corresponds to $(Ni_{1.03}Fe_{0.01})_{\Sigma=1.04}(As_{1.00}Sb_{0.02})_{\Sigma=1.02}S_{1.00}$. (3) NiAsS.

Polymorphism & Series: Modifications -Pa3, -$P2_13$, and -$Pca2_1$ are known.

Mineral Group: Cobaltite group.

Occurrence: In hydrothermal vein deposits formed at medium temperatures.

Association: Nickeline, nickel-skutterudite, cobaltite, ullmannite, maucherite, löllingite, platinum-group minerals, millerite, pyrite, marcasite, chalcopyrite.

Distribution: A number of new localities have been recognized in recent years, only a few of which can be listed. In Austria, from Schladming, 64 km southeast of Salzburg, Styria [TL], and at Olsa, Freisach, Carinthia. In Germany, at Müsen, Wissen, and Ramsbeck, North Rhine-Westphalia; from Lobenstein, Thuringia; at Bad Ems and Dillenburg, Hesse; and from the Rammelsberg mine, near Goslar, and at Wolfsberg, Harz Mountains. From Dobšiná (Dobschau), Slovakia. In the Craignure mine, Inverary, Strathclyde region, Scotland. At Silvermines, Co. Tipperary, Ireland. In the USA, large crystals from the Snowbird mine, Mineral Co., Montana. In Canada, in several mines at Sudbury and Cobalt, Ontario. At Cochabamba, Bolivia. In the Aït Ahmane mine, 10 km east of Bou Azzer, Morocco, as fine crystals. From the Mt. Ogilvie and Nichol Nob mines, Flinders Ranges, South Australia.

Name: To honor Johann von Gersdorff (1781–1849), owner of the nickel mine at Schladming, Austria.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 298–300. (2) Yund, R.A. (1962) The system Ni–As–S: phase relations and mineralogical significance. Amer. J. Sci., 260, 761–782. (3) Bayliss, P. (1982) A further crystal structure refinement of gersdorffite. Amer. Mineral., 67, 1058–1064. (4) Bayliss, P. (1986) Subdivision of the pyrite group, and a chemical and X-ray diffraction investigation of ullmannite. Can. Mineral., 24, 27–33. (5) (1961) NBS Mono. 25, 1, 35. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 195.

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Gerstleyite $Na_2(Sb, As)_8S_{13}\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group: m.* As spherules with a fibrous to platy structure, to 2.5 cm; also as fine granular aggregates and groups of small thick plates.

Physical Properties: *Cleavage:* Perfect on {010} and {100}; poor on {001}. Hardness = 2.5 VHN = n.d. D(meas.) = 3.62 D(calc.) = 3.723

Optical Properties: Transparent. *Color:* Cinnabar-red. *Streak:* Bright cinnabar-red; powder darkens on exposure. *Luster:* Weakly adamantine.
Optical Class: [Biaxial.] *Pleochroism:* Weak; X = salmon-red; $Y = Z$ = deep blood-red.
$n = > 2.01$
R_1–R_2: n.d.

Cell Data: *Space Group: Cm.* $a = 9.911(8)$ $b = 23.05(2)$ $c = 7.097(8)$ $\beta = 127.85(7)^\circ$
$Z = 2$

X-ray Powder Pattern: Baker mine, California, USA.
11.85 (100), 3.05 (90), 5.64 (70), 4.03 (70), 2.81 (50), 2.739 (40), 1.934 (40)

Chemistry:

	(1)	(2)	(3)
Na	4.28	4.65	3.29
Li	0.135	0.15	
Sb	47.80	51.91	55.74
As	7.38	8.02	8.57
S	27.01	29.33	29.82
H_2O	5.47	5.94	2.58
gangue	n.d.		
Total	92.07	100.00	100.00

(1) Baker mine, California, USA. (2) Analysis (1) recalculated to 100% after deduction of gangue 8%, corresponds to $(Na_{2.87}Li_{0.31})_{\Sigma=3.18}(Sb_{6.06}As_{1.52})_{\Sigma=7.58}S_{13.00}\cdot 4.68H_2O$.
(3) $Na_2(Sb, As)_8S_{13}\cdot 2H_2O$ with Sb:As = 4:1.

Occurrence: A low-temperature mineral found embedded in massive borates and clay.

Association: Borax, probertite, tincalconite, realgar, stibnite.

Distribution: In the USA, from the Baker mine, Kramer borate deposit, Boron, Kern Co., California [TL].

Name: Honors James Mack Gerstley (1907–), President of the Pacific Coast Borax Company.

Type Material: Harvard University, Cambridge, Massachusetts, 111307; National Museum of Natural History, Washington, D.C., USA, 106916.

References: (1) Frondel, C. and V. Morgan (1956) Inderite and gerstleyite from the Kramer borate district, Kern County, California. Amer. Mineral., 41, 839–843. (2) Nakai, I. and D.E. Appleman (1981) The crystal structure of gerstleyite $Na_2(Sb, As)_8S_{13}\cdot 2H_2O$: the first sulfosalt mineral of sodium. Chem. Lett., 10, 1327–1330. (3) (1981) Chem. Abs., 95, 195617 (abs. ref. 2).

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Gerstmannite $(Mg, Mn^{2+})_2Zn(SiO_4)(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As mats and sprays of bunched prismatic crystals, to 1 cm; as single crystals typically bounded by {100}, {010}, {110}, lacking terminations.

Physical Properties: *Cleavage:* Good on {010}. Hardness = 4.5 D(meas.) = 3.68(2) D(calc.) = 3.66

Optical Properties: Translucent to opaque. *Color:* White to very pale pink. *Streak:* White. *Luster:* Vitreous to subadamantine, silky when matted.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.665(2)$ $\beta = 1.675(2)$ $\gamma = 1.678(2)$ 2V(meas.) = 50°–60°

Cell Data: *Space Group: Bbcm*. $a = 8.185(7)$ $b = 18.65(2)$ $c = 6.256(6)$ Z = 8

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
2.598 (100), 9.326 (85), 3.418 (80), 2.758 (75), 2.332 (75), 2.983 (60), 4.806 (50)

Chemistry:

	(1)	(2)	(3)	(4)
SiO_2	23.9	23.2		22.84
FeO	0.06			
MnO	22.1	21.1		20.22
ZnO	31.7	29.6		30.94
MgO	16.6	19.5		19.15
Na_2O	0.04			
H_2O			4.12	6.85
Total	94.4	93.4		100.00

(1) Sterling Hill, New Jersey, USA; after deducting 3.93% of calcite as $CaCO_3$. (2) Do.; by electron microprobe. (3) Do.; H_2O by Penfield method. (4) $(Mg_{1.25}Mn_{0.75})_{\Sigma=2.00}ZnSiO_4(OH)_2$.

Occurrence: In a hydrothermal vein cutting franklinite-willemite ore in a metamorphosed stratiform zinc orebody.

Association: Calcite, manganpyrosmalite, sphalerite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For Ewald Gerstmann (1918–), mineral collector of Franklin, New Jersey, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 126484; National Museum of Natural History, Washington, D.C., USA, 135926, 137021.

References: (1) Moore, P.B. and T. Araki (1977) Gerstmannite, a new zinc silicate mineral and a novel cubic close-packed oxide structure. Amer. Mineral., 62, 51–59.

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Getchellite $AsSbS_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As subhedral crystals, to 2 cm, commonly bent; massive.

Physical Properties: *Cleavage:* Perfect micaceous on {001}, yielding flexible, inelastic lamellae. *Fracture:* Splintery. *Tenacity:* Flexible to some degree, but inelastic. Hardness = 1.5–2 VHN = n.d. D(meas.) = 3.92 D(calc.) = 3.98 (synthetic).

Optical Properties: Transparent. *Color:* Dark blood-red, tarnishes to green to purple iridescence. *Streak:* Red-orange. *Luster:* Pearly to vitreous on cleavage surfaces, otherwise resinous.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $Y \wedge a = 15(5)°$; $Y \wedge c = 101(5)°$. *Dispersion:* $r > v$, strong, crossed. $\alpha = > 2.72$ (Li). $2V(meas.) = < 46°$ *Anisotropism:* Weak.
R_1–R_2: (400) 34.8–37.9, (420) 34.2–37.4, (440) 33.6–36.9, (460) 32.7–36.0, (480) 31.8–34.8, (500) 30.7–33.5, (520) 29.5–31.9, (540) 28.1–30.6, (560) 27.0–29.4, (580) 26.2–28.6, (600) 25.7–28.0, (620) 25.2–27.4, (640) 24.9–27.0, (660) 24.5–26.8, (680) 24.2–26.5, (700) 23.8–26.1

Cell Data: *Space Group:* $P2_1/a$. $a = 11.949(3)$ $b = 9.028(1)$ $c = 10.130(2)$ $\beta = 116.15(1)°$ Z = 8

X-ray Powder Pattern: Zarehshuran, Iran.
3.66 (100), 2.915 (100), 2.880 (100), 4.96 (80), 4.46 (80), 2.815 (80), 4.08 (60)

Chemistry:

	(1)	(2)	(3)
As	25.09	26.50	25.59
Sb	42.04	41.80	41.57
S	32.82	34.30	32.84
Total	99.95	102.60	100.00

(1) Getchell mine, Nevada, USA; average of several analyses. (2) Zarehshuran, Iran. (3) $AsSbS_3$.

Occurrence: In an epithermal gold deposit formed in a narrow, steeply-dipping fault zone cutting interbedded Paleozoic (?) shales, argillites, and limestones, near a granodiorite intrusive (Getchell mine, Nevada, USA).

Association: Orpiment, realgar, stibnite, cinnabar, galkhaite, laffittite, chabournéite, christite, lorandite, marcasite, quartz, barite, fluorite, calcite.

Distribution: In the USA, in Nevada, from the Getchell mine, about 32 km northeast of Golconda, Potosi district, Humboldt Co. [TL], and in the Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co. At the Zarehshuran gold deposit, 35 km north of Takab, northwestern Iran. From the Gal-Khaya deposit, Sakha, Russia. At Khaydarkan and in the Chauvai Sb–Hg deposit, Fergana Valley, Alai Range, Kyrgyzstan. From the Toya mine, Abuta, Hokkaido, Japan.

Name: For the Getchell mine, Nevada, USA, where it was discovered.

Type Material: National Museum of Natural History, Washington, D.C., USA, 118159, 118160.

References: (1) Weissberg, B.G. (1965) Getchellite, $AsSbS_3$, a new mineral from Humboldt County, Nevada. Amer. Mineral., 50, 1817–1826. (2) Bariand, P., F. Cesbron, H. Agrinier, J. Geffroy, and V. Issakhanian (1968) La getchellite $AsSbS_3$ de Zarehshuran, Afshar, Iran. Bull. Soc. fr. Minéral., 91, 403–406 (in French). (3) Kyono, A. and M. Kimata (2004) Structural reinvestigation of getchellite $As_{0.98}Sb_{1.02}S_{3.00}$. Amer. Mineral., 89, 696–700.

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Geversite $Pt(Sb,Bi)_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As tiny grains.

Physical Properties: Hardness = 4.5–5 VHN = 726–766 (50 g load). D(meas.) = n.d. D(calc.) = 10.97

Optical Properties: Opaque. *Color:* In polished section, pale gray. *Luster:* Metallic.
R: (400) 58.9, (420) 59.1, (440) 59.3, (460) 59.4, (480) 59.4, (500) 59.4, (520) 59.2, (540) 58.9, (560) 58.4, (580) 57.8, (600) 57.4, (620) 57.3, (640) 57.2, (660) 57.2, (680) 57.4, (700) 57.8

Cell Data: *Space Group:* $Pa3$. $a = 6.428$ $Z = 4$

X-ray Powder Pattern: Synthetic. (ICDD 14-141).
1.240 (100), 1.940 (83), 1.140 (83), 1.194 (58), 1.720 (50), 1.310 (50), 1.174 (50)

Chemistry:

	(1)	(2)	(3)
Pt	45.0	41.8	44.48
As		0.7	
Sb	51.5	43.1	55.52
Bi		12.8	
Total	96.5	98.4	100.00

(1) Driekop mine, South Africa; by electron microprobe, corresponds to $Pt_{1.00}Sb_{1.84}$.
(2) Onverwacht mine, South Africa; by electron microprobe, corresponds to $Pt_{1.00}(Sb_{1.66}Bi_{0.29}As_{0.04})_{\Sigma=1.99}$ (3) $PtSb_2$.

Mineral Group: Pyrite group.

Occurrence: In concentrates of platinum minerals derived from Pt–Fe–Ni–Cu deposits in ultramafic rocks (Driekop mine, South Africa).

Association: Platinum, gold, hollingworthite, sperrylite, stibiopalladinite, chalcopyrite, pyrrhotite (Driekop mine, South Africa); vozhminite, heazlewoodite, tučekite, magnetite, copper (Vozhmin massif, Russia).

Distribution: In South Africa, in the Merensky Reef, Bushveld complex, Transvaal, in the Driekop [TL] and Onverwacht mines. In Russia, from the Morozova and Oktyabr mines, Talnakh area, Noril'sk region, western Siberia, and in the Vozhmin massif, Segezha district, central Karelia. At the Kelvon Grove prospect, near Fifield, New South Wales, Australia. From the Baula complex, Orissa, India. At Fox Gulch, Goodnews Bay, Alaska, USA. In the Wellgreen Ni–Cu–PGM deposit, Yukon Territory, Canada.

Name: In honor of Professor Traugott Wilhelm Gevers (1900–1991), University of the Witswatersrand, Johannesburg, South Africa, eminent South African geologist.

Type Material: National School of Mines, Paris, France.

References: (1) Thomassen, L. (1929) Über Kristallstrukturen einiger binärer Verbindungen der Platinmetalle. Zeitschrift Physikal Chem., 2, 349–379 (in German). (2) Stumpfl, E.F. (1961) Some new platinoid-rich minerals, identified with the electron microanalyser. Mineral. Mag., 32, 833–846. (3) (1961) Amer. Mineral., 46, 1518 (abs. ref. 2). (4) Rudashevsky, N.S., S.N. Avdontsev, and M.B. Dneprovskaya (1992) Evolution of PGE mineralization in hortonolitic dunites of the Mooihoek and Onverwacht pipes, Bushveld complex. Mineral. Petrol., 47, 37–54. (5) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 107–108.

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Gianellaite $Hg_4(SO_4)N_2$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. As distorted octahedral crystals, to 1 mm; typically as rosettes of flattened crystals.

Physical Properties: Hardness = ∼3 D(meas.) = 7.19 D(calc.) = 7.13

Optical Properties: Transparent. *Color:* Straw-yellow, yellowish gray to gray; colorless in transmitted light. *Luster:* [Vitreous.]
Optical Class: Isotropic; may exhibit anomalous birefringence. $n = 2.085$

Cell Data: *Space Group:* $F\overline{4}3m$. $a = 9.5215(5)$ $Z = 4$

X-ray Powder Pattern: Mariposa mine, Texas, USA.
2.872 (10), 2.743 (10), 5.511 (8), 2.371 (7), 1.679 (7), 1.432 (7), 2.178 (6)

Chemistry:

	(1)	(2)
SO_4	8.5	10.37
SiO_2	0.2	
N	2.9	3.02
Hg	83.6	86.61
Cl	0.0	
H_2O	0.0	
Total	95.2	100.00

(1) Mariposa mine, Texas, USA; by separate microchemical analyses on several samples, corresponding to $Hg_{4.1}(SO_4)_{0.9}N_{2.0}$. (2) $Hg_4(SO_4)N_2$.

Occurrence: A rare secondary mineral coating fracture surfaces in oxidized portions of a hydrothermal mercury deposit, the nitrogen likely derived from decaying organic matter (Mariposa mine, Texas, USA); in a mercury deposit in silicate–carbonate rock hydrothermally altered from serpentinite (Clear Creek claim, California, USA).

Association: Cinnabar, terlinguaite, montroydite, mercury, calomel, hematite, calcite (Mariposa mine, Texas, USA).

Distribution: In the USA, from the Perry pit, Mariposa mine, Terlingua district, Brewster Co., Texas; on the Clear Creek claim, near the Clear Creek mercury mine, New Idria district, San Benito Co., California.

Name: Honors Professor Vincent Paul Gianella (1886–1983), Head of the Department of Geology, MacKay School of Mines, University of Nevada, Reno, Nevada, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 124993; National Museum of Natural History, Washington, D.C., USA, 142886, 142887.

References: (1) Tunell, G., J.J. Fahey, F.W. Daugherty, and G.V. Gibbs (1977) Gianellaite, a new mercury mineral. Neues Jahrb. Mineral., Monatsh., 119–131. (2) (1977) Amer. Mineral., 62, 1057 (abs. ref. 1).

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Gibbsite $Al(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As pseudohexagonal crystals, tabular on {001}, with {101}, {110}, to 3 cm. Also as lamellar or acicular aggregates, stalactitic, or mammillary; in enamellike coatings, compact earthy. *Twinning:* Common on {001}, less common on {100} and {110}; also very common about [130] with {001} of the individuals in parallel.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Tough. Hardness = 2.5–3.5 D(meas.) = 2.40 D(calc.) = [2.42] Strong argillaceous odor when breathed upon.

Optical Properties: Transparent. *Color:* Colorless, white, gray, pale green, pale red; colorless to brownish in thin section. *Luster:* Vitreous, pearly on cleavage surfaces, dull in aggregates. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y \wedge a = 25.5°$; $Z \wedge c \simeq -21°$. *Dispersion:* $r > v$, strong; sometimes $v > r$. $\alpha = 1.56$–1.58 $\beta = 1.56$–1.58 $\gamma = 1.58$–1.60 2V(meas.) = 0°–40°

Cell Data: *Space Group:* $P2_1/n$. $a = 8.684(1)$ $b = 5.078(1)$ $c = 9.736(2)$ $\beta = 94.54(1)°$ Z = 8

X-ray Powder Pattern: Langesundsfjord, Norway. (ICDD 29-41).
4.853 (100), 4.380 (36), 4.328 (18), 2.389 (16), 2.456 (12), 2.052 (12), 1.8074 (10)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	1.03		MgO	trace	
Al_2O_3	64.92	65.36	CaO	0.17	
Fe_2O_3	trace		H_2O	34.12	34.64
			Total	100.24	100.00

(1) Klein-Tresny, Moravia. (2) $Al(OH)_3$.

Polymorphism & Series: Polymorphous with bayerite, doyleite, and nordstrandite.

Occurrence: A typical product of weathering of aluminous minerals, common in lateritic soils and bauxite. Also formed in low-temperature hydrothermal and metamorphic environments, replacing aluminous minerals.

Association: Diaspore, böhmite, corundum, kaolinite, goethite.

Distribution: Widespread, particularly in bauxite deposits. Some prominent localities are: in the USA, at Richmond, Berkshire Co., Massachusetts; Unionville, Chester Co., Pennsylvania; large crystals from the Champion mine, White Mountains, Mono Co., California; from Toomsboro, Wilkinson Co., Georgia; at Tar Branch, near Winston-Salem, Forsyth Co., North Carolina. Around Saramenha, Ouro Prêto, Minas Gerais, Brazil. From Paramaribo, Surinam. On Eikaholmen and Lille-Arø Islands, Langesundsfjord, and at Tredalen, near Larvik, Norway. Large crystals from Schischimskaya, near Zlatoust, Ural Mountains, Russia. On the Vogelsberg, Hesse, and on the Katzenbuckel, Baden-Württemberg, Germany. In India, many localities, as at Kodikanal, Madras, and Talevadi, near Bombay, Maharashtra. From Dundas, Tasmania, Australia.

Name: Honors Colonel George Gibbs (1776–1833), a prominent mineral collector of New Haven, Connecticut, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 663–667. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 93–101. (3) Saalfeld, H. and M. Wedde (1974) Refinement of the crystal structure of gibbsite, $Al(OH)_3$. Zeits. Krist., 139, 129–135. (4) Catti, M., G. Ferraris, and S. Hull (1991) Powder neutron-diffraction study of brucite and gibbsite and pressure dependence of the structure of $Mg(OD)_2$. Zeits. Krist., supplement 4, 316. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 42–43.

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Giessenite $\mathbf{Pb_{28}Cu_2^{1+}(Bi,Sb)_{19}S_{57}}$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As fine needles, to 1.5 mm. *Twinning:* Intimately on {100}.

Physical Properties: Hardness = ∼2.5 VHN = 65 D(meas.) = n.d. D(calc.) = 7.45

Optical Properties: Opaque. *Color:* Grayish black. *Streak:* Grayish black. *Luster:* Metallic. R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/n$. $a = 34.51(3)$ $b = 38.18(5)$ $c = 4.080(8)$ $\beta = 90.33(5)°$ $Z = 2$

X-ray Powder Pattern: Bjørkåsen, Norway.
2.0271 (100), 3.436 (90), 3.404 (90), 2.1514 (90), 2.9061 (70), 2.8867 (70), 2.8413 (70)

Chemistry:

	(1)	(2)	(3)
Pb	47.5	48.3	48.9
Cu	1.2	0.7	0.88
Ag			0.14
Fe			0.09
Bi	29.8	31.7	31.2
Sb	4.2	3.5	3.1
S	16.5	[16.0]	16.4
Total	99.2	[100.2]	[100.71]

(1) Binntal, Switzerland; by electron microprobe, average of three analyses; corresponds to $Pb_{25.88}Cu_{2.13}(Bi_{16.10}Sb_{3.89})_{\Sigma=19.99}S_{58.08}$. (2) Bjørkåsen, Norway; by electron microprobe, average of three analyses, S assumed; corresponds to $Pb_{26.36}Cu_{1.24}(Bi_{17.15}Sb_{3.25})_{\Sigma=20.40}S_{56.41}$. (3) Do.; by electron microprobe, average of eight analyses, original total given as 100.8%; corresponds to $Pb_{26.50}(Cu_{1.55}Fe_{0.18}Ag_{0.15})_{\Sigma=1.88}(Bi_{16.76}Sb_{2.86})_{\Sigma=19.62}S_{57.42}$.

Polymorphism & Series: Forms a series with izoklakeite.

Occurrence: Of hydrothermal origin, with other sulfides.

Association: Galena, pyrite, pyrrhotite, sphalerite, tennantite, seligmannite, geocronite, quartz, dolomite.

Distribution: In Switzerland, from Turtschi, between Giessen and Binn, about 2 km from the Lengenbach quarry, Binntal, Valais [TL]; and at Lake Zervreila, Vals, Graubünden. From the Bjørkåsen sulfide deposit, Otoften, Norway. At the Vena mines, near Askersund, Örebro, Sweden. In the Otome mine, Yamanashi Prefecture, Japan.

Name: For Giessen, a village nearby the Binntal, Switzerland.

Type Material: Natural History Museum, Basel, Switzerland, SG393.

References: (1) Graeser, S. (1963) Giessenit — ein neues Pb–Bi–Sulfosalz aus dem Dolomit des Binnatals. Schweiz. Mineral. Petrog. Mitt., 43, 471–478 (in German with English abs.). (2) (1965) Amer. Mineral., 50, 264 (abs. ref. 1). (3) Graeser, S. and D.C. Harris (1986) Giessenite from Giessen near Binn, Switzerland: new data. Can. Mineral., 24, 19–20. (4) Makovicky, E. and S. Karup-Møller (1986) New data on giessenite from the Bjørkåsen sulfide deposit at Otoften, northern Norway. Can. Mineral., 24, 21–25. (5) Moëlo, Y., G. Roger, D. Maurel-Palacin, E. Marcoux, and A. Loroussi (1995) Chemistry of some Pb-(Cu,Fe)-(Sb,Bi) sulfosalts from France and Portugal. Implications for the crystal chemistry of lead sulfosalts in the Cu-poor part of the Pb_2S_2–Cu_2–Sb_2S_3–Bi_2S_3 system. Mineral. Petrol., 53, 229–250.

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Gilalite $Cu_5Si_6O_{17}\cdot 7H_2O$

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Crystal Data: Monoclinic, probable. *Point Group:* n.d. As spherules of radial fibers, to 0.3 mm.

Physical Properties: *Tenacity:* Waxy or gummy. Hardness = 2 D(meas.) = 2.72(5) D(calc.) = [2.54]

Optical Properties: Transparent or translucent. *Color:* Chrysocolla-green, inclining to pale blue-green. *Luster:* Nonmetallic.
Optical Class: Biaxial (–). *Pleochroism:* Weak in drab grayish green. *Orientation:* Blades extinguish up to 8° from Z ∥ length. *Absorption:* $Z > X = Y$. $\alpha = 1.560$ $\beta = 1.635$ $\gamma = 1.635$ 2V(meas.) = Very small.

Cell Data: *Space Group:* n.d. $a = 13.38$ $b = 19.16$ $c = 9.026$ $\beta = \sim 90°$ Z = [4]

X-ray Powder Pattern: Christmas, Arizona, USA.
13.4 (100), 7.786 (50), 4.790 (40), 3.897 (40), 10.97 (30), 6.684 (30), 3.315 (30)

Chemistry:

	(1)	(2)
SiO_2	41.5	40.77
MnO	0.5	
CuO	36.2	44.97
MgO	2.3	
CaO	3.8	
H_2O	14.6	14.26
Total	98.9	100.00

(1) Christmas, Arizona, USA; average of two closely agreeing analyses. (2) $Cu_5Si_6O_{17}\cdot 7H_2O$.

Occurrence: A retrograde metamorphic or mesogene mineral formed at the expense of a prograde calc-silicate and sulfide assemblage; in tactites, commonly incrusting fractures; also filling cracks or interstices in diopside grains (Christmas, Arizona, USA).

Association: Kinoite, apachite, stringhamite, junitoite, clinohedrite, xonotlite, diopside, apophyllite, calcite, tobermorite (Christmas, Arizona, USA).

Distribution: From the Christmas copper mine, Gila Co., and the Lonestar [ckname??] deposit, near Safford, Graham Co., Arizona, USA.

Name: For Gila Co., Arizona, USA, where it was found.

Type Material: The Natural History Museum, London, England, 1980,533; University of Arizona, Tucson, Arizona; National Museum of Natural History, Washington, D.C., USA, 150201.

References: (1) Cesbron, F.P. and S.A. Williams (1980) Apachite and gilalite, two new copper silicates from Christmas, Arizona. Mineral. Mag., 43, 639–641. (2) (1980) Amer. Mineral., 65, 1065 (abs. ref. 1).

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Gillespite $BaFe^{2+}Si_4O_{10}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As crystalline masses, to 2 cm, and embedded grains.

Physical Properties: *Cleavage:* Very good on {001}, poor on {100}; very poor on {110}. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 3.390–3.402 D(calc.) = 3.404

Optical Properties: Translucent. *Color:* Deep red, rose-red. *Streak:* Pink.
Luster: Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = colorless; E = red. $\omega = 1.619–1.621$
$\epsilon = 1.618–1.620$

Cell Data: *Space Group:* $P4/ncc$. a = 7.5164(6) $c = 16.0768(10)$ Z = 4

X-ray Powder Pattern: Dry Delta, Alaska, and near Incline, California, USA. (ICDD 3-402).
3.39 (100), 4.41 (70), 3.22 (70), 3.09 (50), 2.65 (5), 2.39 (50), 8.02 (40)

Chemistry:

	(1)	(2)
SiO_2	50.08	51.63
TiO_2	0.00	
Al_2O_3	0.34	
Fe_2O_3	0.56	
Mn_2O_3	0.14	
FeO	14.60	15.43
BaO	31.02	32.94
LOI	0.82	
insol.	2.20	
Total	99.76	100.00

(1) Dry Delta, Alaska, USA; nearly pure material, corrected for assumed oxidation of FeO to Fe_2O_3, loss on ignition taken as H_2O. (2) $BaFeSi_4O_{10}$.

Occurrence: In a glacial moraine (Dry Delta, Alaska, USA); probably from a contact metamorphic zone (Trumbull Peak, California, USA).

Association: Celsian, hedenbergite, quartz (Dry Delta, Alaska, USA); sanbornite, celsian, diopside, tourmaline, quartz, pyrrhotite (Trumbull Peak, California, USA); pellyite, sanbornite, taramellite, fresnoite, muirite, barite (Itsy Mountains, Canada).

Distribution: In the USA, near the head of Dry Delta, Alaska Range, Alaska; from Trumbull Peak, near Incline, Mariposa Co., and on the Esquire No. 7 claim, Big Creek, Fresno Co., California. On the Gunn claim, in the Itsy Mountains, near Macmillan Pass, Yukon Territory, Canada. In the La Madrelena mine, Tres Pozos, Baja California, Mexico.

Name: For Frank Gillespie, of Richardson, Alaska, USA, who discovered the first specimen.

Type Material: Harvard University, Cambridge, Massachusetts, 90622; National Museum of Natural History, Washington, D.C., USA, 94347.

References: (1) Schaller, W.T. (1922) Gillespite, a new mineral. J. Wash. Acad. Sci., 123, 7–8. (2) Schaller, W. (1929) The properties and associated minerals of gillespite. Amer. Mineral., 14, 319–322. (3) Pabst A. (1943) Crystal structure of gillespite, $BaFeSi_4O_{10}$. Amer. Mineral., 28, 372–390. (4) Hazen, R.M. and C.W. Burnham (1974) The crystal structure of gillespite I and II: a structure determination at high pressure. Amer. Mineral., 59, 1166–1176.

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Gillulyite $Tl_2(As,Sb)_8S_{13}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely as prismatic crystals, to 2 mm, showing {110}, {010}, and {011}; in cleavable masses.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2–2.5 VHN = 87–132, 108 average (25 g load). D(meas.) = 4.02 D(calc.) = 4.14

Optical Properties: Opaque, translucent in thin fragments. *Color:* Deep red to maroon, tarnishing to darker red or blue; pale gray in reflected light, with abundant deep red internal reflections. *Streak:* Bright brick-red. *Luster:* Vitreous to metallic if tarnished.
Optical Class: Biaxial. *Anisotropism:* Distinct. *Bireflectance:* Weak to moderate in oil; pale rose to dusky rose.
R_1–R_2: (400) 29.8–32.0, (420) 29.3–31.8, (440) 28.6–31.6, (460) 27.8–31.0, (480) 27.3–30.6, (500) 27.0–30.4, (520) 26.1–29.6, (540) 25.1–28.9, (560) 23.6–27.5, (580) 23.1–26.9, (600) 22.6–26.2, (620) 22.2–25.8, (640) 21.9–25.4, (660) 21.6–25.2, (680) 21.4–24.9, (700) 21.2–24.8

Cell Data: *Space Group:* $P2/n$. $a = 9.584(3)$ $b = 5.679(2)$ $c = 21.501(6)$ $\beta = 10.07(2)^\circ$ $Z = 2$

X-ray Powder Pattern: Mercur deposit, Utah, USA.
3.077 (100), 2.814 (100), 3.63 (90), 2.502 (70), 1.766 (70), 4.14 (60), 3.87 (60)

Chemistry:

	(1)
Tl	28.4
As	39.3
Sb	2.2
S	28.7
Total	98.6

(1) Mercur deposit, Utah, USA; by electron microprobe, average of five analyses; corresponding to $Tl_{2.02}As_{7.62}Sb_{0.26})_{\Sigma=7.88}S_{13.00}$.

Occurrence: In a sediment-hosted disseminated gold deposit, in organic-rich unoxidized carbonates.

Association: Orpiment, realgar, lorandite, raguinite, pyrite, barite, calcite.

Distribution: From the Mercur gold deposit, southern Oquirrh Mountains, about 56 km southwest of Salt Lake City, Tooele Co., USA [TL].

Name: To honor James C. Guilluly (1896–1980), U.S. Geological Survey, who worked in the area of the Mercur deposit.

Type Material: Royal Ontario Museum, Toronto, Canada; Harvard University, Cambridge, Massachusetts, 130781; National Museum of Natural History, Washington, D.C., USA, 170773.

References: (1) Wilson, J.R., P.D. Robinson, P.N. Wilson, L.W. Stanger, and G. L. Salmon (1991) Gillulyite, $Tl_2(As,Sb)_8S_{13}$, a new thallium arsenic sulfosalt from the Mercur gold deposit, Utah. Amer. Mineral., 76, 653–656. (2) Wilson, J.R., P.K. Sen Gupta, P.D. Robinson, and A.J. Criddle (1993) Fangite, Tl_3AsS_4, a new thallium arsenic sulfosalt from the Mercur Au deposit, Utah, and revised optical data for gillulyite. Amer. Mineral., 78, 1096–1103. (3) Foit, F.F., Jr., P.D. Robinson, and J.R. Wilson (1995) The crystal structure of gillulyite, $Tl_2(As,Sb)_8S_{13}$, from the Mercur gold deposit, Tooele County, Utah, U.S.A. Amer. Mineral., 80, 394–399.
(4) Makovicky, E. and T. Balič-Žunić (1999) Gillulyite $Tl_2(As,Sb)_8S_{13}$: reinterpretation of the crystal structure and order-disorder phenomena. Amer. Mineral., 84, 400–406.

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Gilmarite $Cu_3(AsO_4)(OH)_3$

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Crystal Data: Triclinic. *Point Group:* 1. Lozenge-shaped crystals, elongated along [101] or [100], flattened on {010}, also showing {100}, {101}, {001}, to 0.1 mm; typically in rosettes.

Physical Properties: *Cleavage:* Good on {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 4.2(1) D(calc.) = 4.21

Optical Properties: Transparent. *Color:* Blue-green. *Streak:* Blue-green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; $X = Y$ = light green; Z = green. *Orientation:* On {010}, $X \wedge c = 33°$ and $Y \wedge a = 37.1°$; on {001}, $Y \wedge a = 34.3°$ and $Z \wedge b = 30.1°$; on {101}, $Z \wedge b = 44°$ and $Y' \wedge [101] = 36.5°$. *Dispersion:* $r > v$, weak. $\alpha = 1.760(5)$ $\beta = 1.80(1)$ $\gamma = 1.83(1)$ 2V(meas.) = 77(4)° 2V(calc.) = 80(1)°

Cell Data: *Space Group:* $P1$. $a = 5.445(4)$ $b = 5.873(3)$ $c = 5.104(3)$ $\alpha = 114.95(3)°$ $\beta = 93.05(5)°$ $\gamma = 91.92(4)°$ Z = 1

X-ray Powder Pattern: Roua mines, France.
4.613 (100), 3.390 (60), 4.580 (50), 2.713 (40), 2.543 (40), 2.445 (30), 3.654 (20)

Chemistry:

	(1)	(2)
As_2O_5	29.64	30.20
CuO	63.0	62.70
H_2O	[7.36]	7.10
Total	[100.00]	100.00

(1) Roua mines, France; by electron microprobe, average of five analyses, H_2O by difference; corresponds to $Cu_{3.00}(As_{0.98}O_4)(OH)_{3.10}$. (2) $Cu_3(AsO_4)(OH)_3$.

Polymorphism & Series: Dimorphous with clinoclase.

Occurrence: A rare secondary mineral associated with other copper arsenates and copper arsenides in the oxidized zone.

Association: Cuprite, posnjakite, langite, clinotyrolite, connellite, brochantite, malachite, vésigniéite, cornubite, olivenite, trippkeite, domeykite, djurleite.

Distribution: From the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, France.

Name: To honor Gilbert Mari (1944–), mineralogist, University of Nice-Sophia Antipolis, Nice, France, who collected the samples in which the mineral was found.

Type Material: Natural History Musem, Geneva, Switzerland, 477.006.

References: (1) Sarp, H. and R. Černý (1999) Gilmarite, $Cu_3(AsO_4)(OH)_3$, a new mineral: its description and crystal structure. Eur. J. Mineral., 11, 549–555. (2) (2000) Amer. Mineral., 85, 263 (abs. ref. 1).

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Giniite $Fe^{2+}Fe_4^{3+}(PO_4)_4(OH)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As crystals, flattened on {100}, elongated along [010], showing {201}, {210}, {103}, {010}, to 0.5 mm, in aggregates. *Twinning:* Common on $\{\overline{1}12\}$, as geniculated and penetration twins.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3–4 D(meas.) = 3.41 D(calc.) = 3.42

Optical Properties: Transparent. *Color:* Dark greenish black to brownish black. *Streak:* Olive-green. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (–). *Pleochroism:* X = light brown; Y = dark brown; Z = dark blue-green. *Orientation:* $X = b$; $Z = c$; $Y \wedge a \simeq 20°$. $\alpha = 1.775(4)$ $\beta = 1.803(4)$ $\gamma = 1.812(4)$ 2V(meas.) = 55(5)°

Cell Data: *Space Group:* $P2/a$. $a = 14.253(3)$ $b = 5.152(1)$ $c = 10.353(2)$ $\beta = 111.30(1)°$ Z = 2

X-ray Powder Pattern: Sandamap pegmatite, Namibia. 3.36 (10), 3.20 (7), 2.04 (7), 1.604 (7), 2.28 (6), 1.679 (6), 2.80 (5)

Chemistry:

	(1)	(2)
P_2O_5	36.99	38.94
Al_2O_3	1.20	
Fe_2O_3	46.07	43.80
FeO	n.d.	9.85
MnO	0.63	
MgO	0.68	
H_2O	6.45	7.41
Total	[92.02]	100.00

(1) Sandamap pegmatite, Namibia; by electron microprobe, total Fe as Fe_2O_3, H_2O by TGA.
(2) $Fe^{2+}Fe_4^{3+}(PO_4)_4(OH)_2 \cdot 2H_2O$.

Occurrence: A secondary mineral in a complex granite pegmatite.

Association: Triphylite, barbosalite, huréaulite, leucophosphite, phosphosiderite, mélonjosephite, tavorite, whitlockite, monetite.

Distribution: At the Sandamap pegmatite, west of Usakos, Namibia.

Name: To honor Adelheid (Gini) Keller (1940–), wife of Paul Keller.

Type Material: University of Stuttgart, Stuttgart, Germany, NM01.

References: (1) Keller, P. (1980) Giniit, $Fe^{2+}Fe_4^{3+}[(H_2O)_2|(OH)_2|(PO_4)_4]$, ein neues Mineral aus dem Pegmatit von Sandamab [*sic*] bei Usakos, Namibia. Neues Jahrb. Mineral., Monatsh., 49–56 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 1066 (abs. ref. 1). (3) Keller, P. (1980) Giniit, $Fe^{2+}Fe_4^{3+}[(H_2O)_2|(OH)_2|(PO_4)_4]$: neue kristallographische Daten. Neues Jahrb. Mineral., Monatsh., 561–563 (in German with English abs.).

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Ginorite $Ca_2B_{14}O_{20}(OH)_6 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As lozenge-shaped plates flattened on {010}, to 1 mm; nodular, granular, dense massive.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 3.5 D(meas.) = 2.07–2.14 D(calc.) = 2.09

Optical Properties: Transparent. *Color:* White.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 39°$; positive elongation. *Dispersion:* Inclined. $\alpha = 1.517–1.526$ $\beta = [1.524]$ $\gamma = 1.577–1.580$ 2V(meas.) = 42(2)°

Cell Data: *Space Group:* $P2_1/c$. $a = 13.375$ $b = 14.368$ $c = 12.261$ $\beta = 101.2°$ Z = 4

X-ray Powder Pattern: Sasso Pisano, Italy.
7.18 (100), 5.36 (80), 2.09 (80), 3.57 (60), 3.28 (60), 3.90 (50), 3.12 (50)

Chemistry:

	(1)	(2)	(3)
B_2O_3	63.64	64.47	65.54
CaO	16.03	14.39	15.08
SrO		1.09	
Na_2O	0.17		
H_2O	20.16	18.91	19.38
rem.		1.48	
Total	100.00	100.34	100.00

(1) Sasso Pisano, Italy. (2) Death Valley, California, USA; corresponds to $(Ca_{1.94}Sr_{0.08})_{\Sigma=2.02}$ $14.02O_{20}(OH)_{6.10} \cdot 4.90H_2O$. (2) $Ca_2B_{14}O_{20}(OH)_6 \cdot 5H_2O$.

Occurrence: As efflorescences on weathered basalt associated with colemanite-bearing limestone (Death Valley, California, USA); in veins in sandstone (Sasso Pisano, Italy).

Association: Calcite (Sasso Pisano, Italy); mirabilite, gypsum, anhydrite (Windsor, Canada); sassolite, colemanite, mcallisterite (Death Valley, California, USA); kieserite, anhydrite, preobrazhenskite, boracite, aksaite, halurgite, strontioborite, metaborite (Ak-saĭ, Kazakhstan).

Distribution: From Sasso Pisano, eight km south of Lardarello, Tuscany, Italy. In the Clinton quarry, Windsor, Nova Scotia, Canada. At the Mott colemanite prospect and on the Hard Scramble claim, Furnace Creek district, Death Valley, Inyo Co., California, USA. In the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. From the Chalkar salt dome, Ak-saĭ Valley, Uralsk district, Kazakhstan.

Name: Honors Prince Piero Ginori Conti (1865–1939), Florence, Italy, for his contributions to the Tuscan borax industry.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 364–365. (2) Allen, R. and H. Kramer (1957) Ginorite and sassolite from Death Valley, California. Amer. Mineral., 42, 56–61. (3) Konnert, J.A., J.R. Clark, and C.L. Christ (1970) Crystal structure of strontioginorite, $(Sr, Ca)_2B_{14}O_{20}(OH)_6 \cdot 5H_2O$. Amer. Mineral., 55, 1911–1931.

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Giorgiosite $Mg_5(CO_3)_4(OH)_2 \cdot 5–6H_2O(?)$

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Crystal Data: n.d. *Point Group:* n.d. Fibrous, spherulitic, admixed with other species in powdery crusts.

Physical Properties: Hardness = n.d. D(meas.) = 2.155–2.185 (synthetic). D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White. *Luster:* Silky.
Optical Class: Biaxial. *Orientation:* Positive elongation, parallel extinction. n = 1.48–1.51
α = 1.498 (synthetic). β = n.d. γ = 1.513 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Thíra Island, Greece.
3.40 (100), 3.29 (70), 2.92 (60), 4.44 (40), 3.97 (40), 2.46 (40), 5.80 (30)

Chemistry: (1) Identification is by near correspondence between the X-ray patterns of natural and synthetic material.

Occurrence: A rare incrustation on recent lava (Thíra Island, Greece); a weathering product in fractures in sideritic iron formation (Big Fish River-Rapid Creek area, Canada).

Association: Sodium chloride, sodium sulfate, magnesium carbonate (Thíra Island, Greece); aragonite, kulanite (Big Fish River-Rapid Creek area, Canada).

Distribution: From Alphroëssa, Thíra (Santorini) Island, Cyclades, Greece. In the Big Fish River-Rapid Creek area, Yukon Territory, Canada.

Name: For Giorgios, a cone formed during the volcanic eruption of 1866 on Thíra Island.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 274. (2) Raade, G. (1970) Dypingite, a new hydrous basic carbonate of magnesium, from Norway. Amer. Mineral., 55, 1457–1465 [comments on giorgiosite]. (3) Friedel, B. (1975) Synthetischer Giorgiosit. Neues Jahrb. Mineral., Monatsh., 196–208 (in German with English abs.). (4) Canterford, J.H., G. Tsambourakis, and B. Lambert (1984) Some observations on the properties of dypingite, $Mg_5(CO_3)_4(OH)_2 \cdot 5H_2O$ and related minerals. Mineral. Mag., 48, 437–442. (5) Robinson, G.W., J. Van Velthuizen, H.G. Ansell, and B.D. Sturman (1992) Mineralogy of the Rapid Creek and Big Fish River area, Yukon Territory. Mineral. Record, 23(4), 1–47, esp. 37.

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Giraudite $(Cu, Zn, Ag)_{12}(As, Sb)_4(Se, S)_{13}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As anhedral individuals, to 400 μm; more rarely as micro-myrmekitic intergrowths with chaméanite.

Physical Properties: Hardness = n.d. VHN = 233–333 (25 g load). D(meas.) = n.d. D(calc.) = 5.75

Optical Properties: Opaque. *Color:* Pale gray, with a creamy tint in reflected light. *Luster:* Metallic.
R: (400) — , (420) 32.2, (440) 32.1, (460) 31.8, (480) 31.7, (500) 31.6, (520) 31.5, (540) 31.7, (560) 31.8, (580) 31.7, (600) 31.7, (620) 31.8, (640) 31.6, (660) 31.5, (680) 31.3, (700) 30.8

Cell Data: *Space Group:* $I\bar{4}3m$. a = 10.578 Z = 2

X-ray Powder Pattern: Chaméane mine, France.
3.050 (100), 1.868 (90), 1.593 (70), 1.932 (60), 2.497 (50), 2.076 (40), 1.714 (40)

Chemistry:

	(1)	(2)	(3)
Cu	30.06	32.78	32.70
Zn	3.37	3.19	0.22
Ag	3.89	1.73	0.15
Hg	0.57	0.30	8.97
Fe	0.19	0.03	0.22
As	7.61	9.56	14.02
Sb	10.66	7.50	0.19
Se	41.09	40.62	39.08
S	2.73	4.12	3.69
Total	100.17	99.83	99.04

(1) Chaméane mine, France; by electron microprobe, corresponding to $(Cu_{9.24}Ag_{0.76})_{\Sigma=10.00}(Zn_{1.12}Cu_{0.84}Fe_{0.08}Hg_{0.04})_{\Sigma=2.08}(As_{2.16}Sb_{1.88})_{\Sigma=4.04}(Se_{11.08}S_{1.80})_{\Sigma=12.88}$. (2) Do.; by electron microprobe, corresponding to $(Cu_{9.68}Ag_{0.32})_{\Sigma=10.00}(Zn_{1.00}Cu_{0.92}Hg_{0.04})_{\Sigma=1.96}(As_{2.60}Sb_{1.28})_{\Sigma=3.88}(Se_{10.52}S_{2.64})_{\Sigma=13.16}$. (3) Niederschlema-Alberoda deposit, Germany; by electron microprobe, corresponding to $(Cu_{9.96}Ag_{0.04})_{\Sigma=10.00}(Hg_{1.00}Cu_{0.92}Zn_{0.08}Fe_{0.01})_{\Sigma=2.01}(As_{3.95}Sb_{0.06})_{\Sigma=4.00}(Se_{10.84}S_{2.14})_{\Sigma=12.98}$.

Mineral Group: Tetrahedrite group.

Occurrence: A rare late-stage mineral with other selenides and sulfides in uranium deposits.

Association: Geffroyite, chaméanite, ankerite (Chaméane mine, France); berzelianite, clausthalite (Niederschlema-Alberoda deposit, Germany).

Distribution: From the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France [TL]. In the Niederschlema-Alberoda uranium deposit, Saxony, Germany.

Name: To honor Roger Giraud (1936–), French electron microprobe analyst, B.R.G.M.–C.N.R.S., Orléans, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, and F. Ruhlmann (1982) Evolution paragénétique de la minéralisation uranifère de Chaméane (Puy-de-Dôme) France: chaméanite, geffroyite et giraudite, trois séléniures nouveaux de Cu, Fe, Ag, and As. Tschermaks Mineral. Petrog. Mitt., 29, 151–167 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 1074–1075 (abs. ref. 1). (3) Förster, H.-J., D. Rhede, and G. Tischendorf (2002) Continuous solid solution beteen mercurian giraudite and hakite. Can. Mineral., 40, 1161–1170.

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Girdite $H_2Pb_3(Te^{4+}O_3)(Te^{6+}O_6)$

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Crystal Data: Monoclinic. *Point Group:* m (?). As dense spherules, to 6 mm, also as bow-tie aggregates of tapered prismatic crystals. *Twinning:* Complex twins noted.

Physical Properties: *Tenacity:* Brittle in aggregates. Hardness = 2 D(meas.) = 5.5(2) D(calc.) = 5.49

Optical Properties: Transparent to translucent. *Color:* White. *Luster:* Chalky in aggregates.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 34°$. *Dispersion:* $r > v$, strong. $\alpha = 2.44$ $\beta = 2.47$ $\gamma = 2.48$ 2V(meas.) = 70°

Cell Data: *Space Group:* n.d. $a = 6.241$ $b = 5.686$ $c = 8.719$ $\beta = 91°41'$ Z = 1

X-ray Powder Pattern: Grand Central mine, Arizona, USA.
3.054 (10), 2.842 (8), 1.765 (8), 3.118 (7), 2.994 (7), 2.102 (7), 1.682 (7)

Chemistry:

	(1)	(2)
TeO_3	18.3	17.17
TeO_2	16.6	15.60
PbO	61.4	65.47
H_2O	2.0	1.76
insol.	0.7	
Total	99.0	100.00

(1) Grand Central mine, Arizona, USA; H_2O by the Penfield method on a separate sample; corresponds to $H_{2.3}Pb_{2.8}(Te^{4+}O_3)_{1.0}(Te^{6+}O_6)_{1.0}$. (2) $H_2Pb_3(Te^{4+}O_3)(Te^{6+}O_6)$.

Occurrence: Very rare, coating fractures in oxidized tellurite and tellurate ores.

Association: Chlorargyrite, quartz.

Distribution: From the dumps of the Grand Central mine, Tombstone, Cochise Co., Arizona, USA.

Name: Honors Richard Gird (1836–1910), mining engineer and assayer, a discoverer of the Tombstone district, Arizona, USA.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,539.

References: (1) Williams, S.A. (1979) Girdite, oboyerite, fairbankite, and winstanleyite, four new tellurium minerals from Tombstone, Arizona. Mineral. Mag., 43, 453–457. (2) (1980) Amer. Mineral., 65, 809 (abs. ref. 1).

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Girvasite $NaCa_2Mg_3(PO_4)_2[PO_2(OH)_2](CO_3)(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare prismatic crystals, elongated along [100], to 1 mm; in spherulites.

Physical Properties: *Cleavage:* On {001}, perfect. *Tenacity:* Very brittle. Hardness = 3.5 D(meas.) = 2.46(2) D(calc.) = 2.42

Optical Properties: Transparent. *Color:* Colorless, creamy white. *Streak:* White. *Luster:* Vitreous, silky in aggregates.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = 31°$. $\alpha = 1.541(2)$ $\beta = 1.557(2)$ $\gamma = 1.565(2)$ 2V(meas.) = 60(5)° 2V(calc.) = 71°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.522(3)$ $b = 12.25(3)$ $c = 21.56(2)$ $\beta = 89.48(5)°$ Z = 4

X-ray Powder Pattern: Kovdor massif, Russia.
10.72 (100), 3.57 (80), 2.016 (35), 3.08 (32), 2.108 (32), 3.42 (26), 2.817 (26)

Chemistry:

	(1)	(2)
P_2O_5	32.6	33.84
CO_2	[7.4]	7.00
FeO	1.2	
MnO	0.1	
MgO	18.5	19.22
CaO	16.7	17.83
Na_2O	5.0	4.93
H_2O	18.0	17.18
Total	[99.5]	100.00

(1) Kovdor massif, Russia; by electron microprobe, H_2O by coulometry and TGA, CO_2 by difference between total weight loss and H_2O; corresponds to $Na_{1.05}Ca_{1.95}(Mg_{3.00}Fe^{3+}_{0.11}Mn_{0.01})_{\Sigma=3.12}(PO_4)_2[PO_2(OH)_2](CO_3)_{1.10} \cdot 4.53H_2O$.
(2)$NaCa_2Mg_3(PO_4)_2[PO_2(OH)_2](CO_3)(OH)_2 \cdot 4H_2O$.

Occurrence: A low-temperature hydrothermal mineral filling solution cavities in dolomite carbonatite in a differentiated alkaline massif.

Association: Bobierrite, pyrite, dolomite.

Distribution: From the Zheleznyi iron mine, Kovdor massif, Kola Peninsula, Russia.

Name: For Lake Girvas, northwest of the Kovdor massif, Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5948; Mining Institute, St. Petersburg, 2025/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87981.

References: (1) Britvin, S.N., Y.A. Pakhomovskii, A.N. Bogdanova, and Y.V. Sokolova (1990) Girvasite – a new carbonate-phosphate of sodium, calcium and magnesium from carbonatites of the Kovdor massif (Kola Peninsula). Mineral. Zhurnal, 12(3), 79–83 (in Russian with English abs.). (2) (1992) Amer. Mineral., 77, 207 (abs. ref. 1). (3) (1990) Y.V. Sokolova and Y.K. Yegorov-Tismenko (1990) Crystal structure of girvasite. Doklady Acad. Nauk SSSR, 311, 1372–1376 (in Russian).

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Gismondine $Ca_2Al_4Si_4O_{16}\cdot 9H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals dipyramidal, composite, to 2 cm. In stellate or radiating spherulitic aggregates; powdery. *Twinning:* On the normal to {100}, giving pseudotetragonal or pseudo-orthorhombic individuals.

Physical Properties: *Cleavage:* $\{\bar{2}32\}$, distinct. *Fracture:* Subconchoidal. Hardness = 4.5 D(meas.) = 2.20–2.26 D(calc.) = 2.28 Piezoelectric.

Optical Properties: Transparent to translucent. *Color:* White, grayish, bluish white, reddish; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–); sectored. *Orientation:* $Y = b$; $Z \wedge c = 42.5°$. $\alpha = 1.525$–1.540 $\beta = 1.531$–1.544 $\gamma = 1.541$–1.550 2V(meas.) = 82°–86°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.02$ $b = 10.62$ $c = 9.84$ $\beta = 92°25'$ $Z = 2$

X-ray Powder Pattern: Round Top volcano, Hawaii, USA.
2.706 (100), 4.25 (70), 3.19 (70), 4.93 (60), 3.13 (60), 7.26 (55), 2.738 (55)

Chemistry:

	(1)	(2)	(3)
SiO_2	33.89	38.03	33.45
Al_2O_3	28.14	26.61	28.38
Fe_2O_3	0.00	trace	
CaO	13.96	12.81	15.61
SrO	0.025		
BaO	0.27	0.00	
Na_2O		1.32	
K_2O	2.86	0.07	
H_2O	20.76	21.58	22.56
Total	99.91	100.42	100.00

(1) Capo di Bove, Italy; corresponds to $(Ca_{1.78}K_{0.44})_{\Sigma=2.22}Al_{3.95}Si_{4.03}O_{16}\cdot 8.24H_2O$.
(2) Eyrarfjäll, Reydarfjord, Iceland; corresponds to $(Ca_{1.59}Na_{0.30}K_{0.02})_{\Sigma=1.91}$ $Al_{3.63}Si_{4.40}O_{16}\cdot 8.34H_2O$. (3) $Ca_2Al_4Si_4O_{16}\cdot 9H_2O$.

Mineral Group: Zeolite group.

Occurrence: In cavities in nepheline and olivine basalt and leucite tephrite.

Association: Zeolites, calcite, chlorite, quartz.

Distribution: At Capo di Bove and elsewhere around Rome, Lazio, Italy. In Germany, from the Hohenberg, near Bühne, Westphalia; on the Frauenberg, near Fulda, Hesse; at the Schlauroth, Görlitz, Saxony; on the Arensberg, near Zilsdorf; and from the Schellkopf, near Brenk, and elsewhere in the Eifel district. From near Zálezly (Salesel), Czech Republic. Found near the Gorner glacier, near Zermatt, Valais, Switzerland. In Ireland, at many localities in Co. Antrim, as in the Bruslee quarry, Ballyclare. On Iceland, many localities around Reydarfjord, Fáskrúdsfjord, and Fagridalur. At Round Top volcano, Oahu, and Alexander Dam, Kauai, Hawaii, USA. From Concepción del Oro, Zacatecas, Mexico. A number of other localities are known.

Name: For Professor Carlo Giuseppe Gismondi (1762–1824), Italian mineralogist, Rome, Italy, who first examined the mineral.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 586–587. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 401–407. (3) Walker, G.P.L. (1962) Low-potash gismondine from Ireland and Iceland. Mineral. Mag., 33, 187–201. (4) Fischer, K. (1963) The crystal structure determination of the zeolite gismondite. $CaAl_2Si_2O_8\cdot 4H_2O$. Amer. Mineral., 48, 664–672. (5) Iijima, A. and K. Harada (1969) Authigenic zeolites in zeolitic palagonite tuffs on Oahu, Hawaii. Amer. Mineral., 54, 182–197. (6) Nawaz, R. (1980) Morphology, twinning, and optical orientation of gismondine. Mineral. Mag., 43, 841–844. (7) Vezzalini, G. and R. Oberti (1984) The crystal chemistry of gismondines: the non-existence of K-rich gismondines. Bull. Minéral., 107, 805–812.

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Gittinsite $CaZrSi_2O_7$

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Crystal Data: Monoclinic. *Point Group:* 2. As radiating sheaves of crystals and fibrous masses, with individual fibers to about 0.3 mm. In fine intergrowths with vlasovite and apophyllite.

Physical Properties: Hardness = 3.5–4 D(meas.) = n.d. D(calc.) = 3.624

Optical Properties: Translucent. *Color:* Chalky white; colorless in thin section.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = 5°–10°$; Y and $Z \simeq \perp$ to elongation.
$\alpha = 1.720(2)$ $\beta = 1.736(2)$ $\gamma = 1.738(2)$ 2V(meas.) = 20°–40°

Cell Data: *Space Group:* $C2$. $a = 6.852(2)$ $b = 8.659(1)$ $c = 4.686(2)$ $\beta = 101.69(2)°$
Z = 2

X-ray Powder Pattern: Kipawa River, Canada.
3.155 (100), 3.232 (80), 3.026 (80), 2.660 (80), 1.677 (70), 5.32 (60), 2.226 (50)

Chemistry:

	(1)
SiO_2	40.8
ZrO_2	40.3
CaO	18.4
Total	99.5

(1) Kipawa River, Canada; by electron microprobe, corresponding to $Ca_{0.98}Zr_{0.98}Si_{2.03}O_7$.

Occurrence: In eudialyte-rich pegmatitic lenses in a regionally metamorphosed agpaitic syenite complex (Kipawa River, Canada); an alteration product of eudialyte in syenite, quartz syenite, and alkalic granite (Pajarito Mountain, New Mexico, USA).

Association: Apophyllite, vlasovite, eudialyte, fluorite, graphite, calcite, apatite, "opal" (Kipawa River, Canada); eudialyte, zircon, chlorite (Pajarito Mountain, New Mexico, USA).

Distribution: From the [Sheffield Lake complex,] Kipawa River, Villedieu Township, Quebec, and in the Strange Lake complex, southeast of Lac Brisson, Quebec and Labrador, Newfoundland, Canada. On Pajarito Mountain, Mescalero Indian Reservation, Otero Co., New Mexico, USA.

Name: For Professor John Gittins, Canadian petrologist, University of Toronto, Toronto, Ontario, Canada.

Type Material: Canadian Geological Survey, Ottawa, 19558; University of Toronto, Toronto; Royal Ontario Museum, Toronto, Canada, M37321; Harvard University, Cambridge, Massachusetts, 117030, 117031; National Museum of Natural History, Washington, D.C., USA, 147002.

References: (1) Ansell, H.G., A.C. Roberts, A.G. Plant, and B.D. Sturman (1980) Gittinsite, a new calcium zirconium silicate from the Kipawa agpaitic syenite complex, Quebec. Can. Mineral., 18, 201–203. (2) (1981) Amer. Mineral., 66, 1274–1275 (abs. ref. 1). (3) Roelofsen-Ahl, J.N. and R.C. Peterson (1989) Gittinsite: a modification of the thortveitite structure. Can. Mineral., 27, 703–708.

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Giuseppettite $[Na_{42}K_{16}Ca_6]_{\Sigma=64}Si_{48}Al_{48}O_{192}(SO_4)_{10}Cl_2 \cdot 5H_2O$

Crystal Data: Hexagonal. *Point Group*: 3*m*. As anhedral grains, in veinlets a few mm thick. Twinned on (001).

Physical Properties: Hardness = 6-7 D(meas.) = 2.35 D(calc.) = 2.32

Optical Properties: Transparent. *Color:* Pale blue-violet.
Optical Class: Uniaxial (+). ω = 1.491 ε = 1.507

Cell Data: *Space Group: P31c*. a = 12.856(2) c = 42.256(8) Z = 1

X-ray Powder Pattern: Sacrofano, Italy.
3.712 (100), 3.446 (80), 3.126 (70), 2.141 (66), 6.42 (62), 2.640 (62), 4.318 (53)

Chemistry:

	(1)	(2)
SiO_2	33.25	32.87
Al_2O_3	28.56	27.79
Fe_2O_3	0.03	
CaO	4.85	4.55
Na_2O	14.37	14.06
K_2O	8.00	8.12
Cl	0.78	0.63
F	n.d.	0.01
SO_3	9.92	9.94
H_2O	n.d.	1.50
-O = Cl,F	0.18	0.15
Total	99.58	99.32

(1) Sacrofano, Italy; by electron microprobe, SO_3 confirmed by IR; corresponds to $(Na_{5.0}K_{1.8}Ca_{1.0})_{\Sigma=7.8}(Al_{6.05}Si_{5.95})_{\Sigma=12.00}O_{24}(SO_4)_{1.8}Cl_{0.25}$. (2) Sacrofano, Italy; electron microprobe analysis, IR spectra do not confirm presence of SO_3 and does confirm presence of H_2O and SO_4, H_2O estimated from structure analysis; corresponding to $[Na_{42}K_{16}Ca_6]_{\Sigma=64}Si_{48}Al_{48}O_{192}(SO_4)_{10}Cl_2 \cdot 5H_2O$.

Mineral Group: Cancrinite group.

Occurrence: As veinlets in a block of sanidinite volcanic ejecta.

Association: Potassic feldspar, nepheline, häuyne, biotite, kalsilite.

Distribution: At Sacrofano, in the Biachella Valley, Lazio, Italy.

Name: Honors Giuseppe Giuseppetti, Professor of Mineralogy, University of Pavia, Pavia, Italy.

Type Material: University of Pavia, Pavia, and Mineralogical Museum, University of Rome (# 24341), Italy.

References: (1) Mazzi, F. and C. Tadini (1981) Giuseppettite, a new mineral from Sacrofano (Italy), related to the cancrinite group. Neues Jahrb. Mineral., Monatsh., 103-110. (2) (1982) Amer. Mineral., 67, 415 (abs. ref. 1). (3) Bonaccorsi, E. (2004) The crystal structure of giuseppettite, the 16-layer member of the cancrinite-sodalite group. Microporous Mesoporous Mat. 73, 129-136. (4) (2005) Amer. Mineral., 90, 771 (abs. ref. 3). (5) Ballirano, P., A. Mara and P.R. Buseck (1996) Crystal chemistry and IR spectroscopy of Cl- and SO_4-bearing cancrinite-like minerals. Amer. Mineral., 81, 1003-1012.

Gjerdingenite-Ca $K_2Ca(Nb_3Ti)Si_8O_{24}(OH)O_3 \cdot 6H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, to 2 mm, are poorly formed and divergent, with indistinct terminations. They are elongate on [010], and their major forms are probably pinacoids {100} and {001}. As massive granular pseudomorphs of vuonnemite, to 1 cm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 5
D(meas.) = 2.79(1) D(calc.) = 2.775

Optical Properties: Transparent to translucent. *Color*: White, pinkish brown. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (+). α = 1.680(1) β = 1.682(2) γ = 1.762(3) 2V(meas.) = 25(10)° 2V(calc.) = 19° *Orientation*: *Y* = *b*. *Pleochroism:* Weak; *X* = *Z* = colorless, *Y* = pale yellowish. *Dispersion*: None.

Cell Data: *Space Group*: *C*2/*m*. *a* = 14.6365(6) *b* = 14.2059(5) *c* = 7.8919(4)
β = 117.467(5)° *Z* = 2

X-ray Powder Pattern: Mount Karnasurt, Lovozero massif, Kola Peninsula, Russia.
7.100 (100), 6.999 (88), 4.985 (78), 3.167 (46), 3.246 (43), 3.252 (42), 6.476 (38)

Chemistry:

	(1)	(2)		(1)	(2)
Na_2O	1.14		Fe_2O_3	0.19	
K_2O	3.61	7.68	Al_2O_3	0.13	
CaO	3.56	4.57	SiO_2	39.29	39.19
SrO	3.47		TiO_2	9.96	6.51
BaO	1.04		Nb_2O_5	27.34	32.50
MnO	0.84		H_2O	9.23	9.55
ZnO	0.05		Total	100.85	100.00

(1) Mount Karnasurt, Lovozero massif, Kola Peninsula, Russia; average of 8 electron microprobe analyses, H_2O by TGA; corresponding to $(K_{0.93}Na_{0.45}Sr_{0.41}Ca_{0.15}Ba_{0.08})_{\sum=2.02}(Ca_{0.62}Mn_{0.14}Fe_{0.03}Zn_{0.01})_{\sum=0.80}(Nb_{2.51}Ti_{1.52})_{\sum=4.03}(Si_{7.97}Al_{0.03})_{\sum=8}O_{24}[O_{2.86}(OH)_{1.14}]_{\sum=4} \cdot 5.67H_2O$.
(2) $K_2Ca(Nb_3Ti)Si_8O_{24}(OH)O_3 \cdot 6H_2O$.

Mineral Group: Labuntsovite group, kuzmenkoite subgroup.

Occurrence: As alteration of vuonnemite formed in hydrothermal assemblages of peralkaline pegmatites related to agpaitic feldspathoidal syenites.

Association: Microcline, natrolite, aegirine, organovaite-Mn, organovaite-Zn, beryllite, epididymite, altered steenstrupine-(Ce), ranciéite (pseudomorph after sérandite), yakhontovite; or komarovite, organovaite-Mn, strontiopyrochlore.

Distribution: Pegmatite #61 at Mount Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: Signifies the structural analog of *gjerdingenite*-Mn with dominant *Ca* in the *D* structural site.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (92111).

References: (1) Pekov, I.V., N.V. Chukanov, N.A. Yamnova, A.E. Zadov, and P. Tarassoff (2007) Gjerdingenite-Na and Gjerdingenite-Ca, two new mineral species of the labuntsovite group. Can. Mineral., 45, 529-539. (2) Yamnova, N. A., I. V. Pekov, Yu. K. Kabalov, N. V. Chukanov, and J. Shneider (2007) Crystal structures of gjerdingenite-Ca and gjerdingenite-Na, new minerals of the labuntsovite group. Doklady Akademii Nauk, 414(1), 57-62 (in Russan), English translation Doklady Chemistry, 414(1), 109-114. (3) (2007) Amer. Mineral., 92, 1776-1777 (abs. ref. 1).

Gjerdingenite-Na $K_2Na(Nb_3Ti)Si_8O_{24}(OH)_2O_2 \cdot 5H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, to 0.5 mm, are equant, prismatic or tabular, and poorly formed, displaying {100}, {001} and {010}. Crystals curved or divergent; some are hollow. As cavernous, or massive granular pseudomorphs of vuonnemite, to 13 cm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 5
D(meas.) = 2.71(1) D(calc.) = 2.69

Optical Properties: Transparent to translucent. *Color*: Colorless to pale pink, whitish pink and cream-colored. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (+). α = 1.647(2) β = 1.653(2) γ = 1.755(3) 2V(meas.) = 25(10)°
2V(calc.) = 28.5° *Orientation*: *Y* = *b*. *Dispersion*: None.

Cell Data: *Space Group*: *C*2/*m*. *a* = 14.6119(5) *b* = 14.1426(6) *c* = 7.9022(6)
β = 117.432(6)° *Z* = 2

X-ray Powder Pattern: Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada.
3.249 (100), 7.044 (54), 3.252 (51), 4.995 (44), 6.510 (42), 7.102 (29), 3.148 (28)

Chemistry:

	(1)	(2)		(1)	(2)
Na_2O	4.04	2.60	Fe_2O_3	0.61	
K_2O	3.97	7.90	Al_2O_3	0.20	
CaO	1.95		SiO_2	41.02	40.30
BaO	0.92		TiO_2	10.20	6.70
MnO	0.27		Nb_2O_5	27.78	33.43
ZnO	0.17		H_2O	9.85	9.07
			Total	100.98	100.00

(1) Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada; average of 9 electron microprobe analyses, H_2O by TGA; corresponding to $(K_{0.98}Na_{0.62}Ca_{0.37}Ba_{0.07})_{\sum=2.04}(Na_{0.90}Ca_{0.04}Mn_{0.04}Zn_{0.02})_{\sum=1.00}(Nb_{2.43}Ti_{1.49}Fe^{3+}_{0.09})_{\sum=4.01}(Si_{7.95}Al_{0.05})_{\sum=8}O_{24}[(OH)_{2.09}O_{1.91}]_{\sum=4} \cdot 5.32H_2O$.
(2) $K_2Na(Nb_3Ti)Si_8O_{24}(OH)_2O_2 \cdot 5H_2O$.

Mineral Group: Labuntsovite group, kuzmenkoite subgroup.

Occurrence: As alteration of vuonnemite formed in hydrothermal assemblages of peralkaline pegmatites related to agpaitic feldspathoidal syenites.

Association: Microcline, albite, aegirine, analcime, a eudialyte-group mineral, natrolite, epistolite, polylithionite, steacyite, thorite, ekanite, brockite, fluorapatite, yofortierite, calcite, hemimorphite, sauconite (?), earthy Mn oxides.

Distribution: From the East Hill suite, De-Mix quarry (now part of the Poudrette quarry), Mont Saint-Hilaire, Quebec, Canada.

Name: Signifies the structural analog of *gjerdingenite*-Fe with dominant *Na* in the *D* structural site.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (92112) and Canadian Museum of Nature, Ottawa, Canada (CMNMC 85457).

References: (1) Pekov, I.V., N.V. Chukanov, N.A. Yamnova, A.E. Zadov, and P. Tarassoff (2007) Gjerdingenite-Na and Gjerdingenite-Ca, two new mineral species of the labuntsovite group. Can. Mineral., 45, 529-539. (2) Yamnova, N. A., I. V. Pekov, Yu. K. Kabalov, N. V. Chukanov, and J. Shneider (2007) Crystal structures of gjerdingenite-Ca and gjerdingenite-Na, new minerals of the labuntsovite group. Doklady Akademii Nauk, 414(1), 57-62 (in Russan), Englsh translation Doklady Chemistry, 414(1), 109-114. (3) (2007) Amer. Mineral., 92, 1776-1777 (abs. ref. 1).

Gladite $PbCuBi_5S_9$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Prismatic crystals, to 2 cm.

Physical Properties: *Cleavage:* Good on {010}, fair on {100}. Hardness = 2–3
VHN = n.d. D(meas.) = 6.96 D(calc.) = 6.903

Optical Properties: Opaque. *Color:* Lead-gray. *Streak:* Black. *Luster:* Metallic.
R_1–R_2: (400) 44.0–46.0, (420) 44.6–46.1, (440) 44.9–46.2, (460) 45.1–46.3, (480) 45.1–46.4, (500) 45.1–46.6, (520) 45.0–46.8, (540) 44.9–46.9, (560) 44.8–46.9, (580) 44.7–46.8, (600) 44.6–46.7, (620) 44.4–46.4, (640) 44.1–46.0, (660) 43.8–45.4, (680) 43.5–44.9, (700) 43.2–44.4

Cell Data: *Space Group: Pmcn.* $a = 4.0044(4)$ $b = 33.575(3)$ $c = 11.480(1)$ Z = 4

X-ray Powder Pattern: Gladhammar, Sweden. (ICDD 25-1422).
3.56 (100), 1.308 (90b), 1.101 (90), 1.082 (90), 2.81 (70), 1.948 (70), 1.916 (70)

Chemistry:

	(1)	(2)	(3)
Pb	12.40	13.4	12.92
Cu	3.98	3.84	3.96
Fe	0.19	0.05	
Bi	64.96	64.3	65.14
S	18.04	17.88	17.98
insol.	0.12		
Total	99.69	99.5	100.00

(1) Gladhammar, Sweden; corresponding to $Pb_{0.96}Cu_{1.00}Fe_{0.05}Bi_{4.97}S_{9.00}$. (2) Felbertal, Austria; by electron microprobe, corresponding to $Pb_{1.02}Cu_{0.99}Bi_{4.98}S_{9.00}$. (3) $PbCuBi_5S_9$.

Occurrence: Of hydrothermal origin.

Association: Bismuthinite-aikinite, galenobismutite, makovickyite, nuffieldite, berryite, galena, quartz.

Distribution: From Gladhammar, Kalmar, Sweden [TL]. At Bleka, Telemark, Norway. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. At Krupka, Czech Republic. In Romania, from Ocna de Fier (Morávicza; Vaskő); at Baia Borşa, Baia Mare (Nagybánya); and Băiţa (Rézbánya). From Narechenski Basni, southern Rhodope Mountains, Bulgaria. In the Loch Shin monzogranite, near Lairg, Scotland. From the Felbertal tungsten mine, Salzburg, and in the Waschgang Au–Cu deposit, Goldberg Mountains, Upper Carinthia, Austria. In the Beregovo district, near Mukachevo, Ukraine. From the Tanco deposit, Bernic Lake, Manitoba, Canada. In the Comstock mine, Dos Cabezas, Cochise Co., Arizona, USA.

Name: For the original locality, Gladhammar, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 483. (2) Welin, E. (1968) Notes on the mineralogy of Sweden. 5. Bismuth-bearing sulphosalts from Gladhammar, a revision. Arkiv Mineral. Geol., 4(30), 377–386. (3) (1968) Amer. Mineral., 53, 351 (abs. ref. 2). (4) Topa, D., E. Makovicky, and T. Balić-Žunić (2002) The structural role of excess Cu and Pb in gladite and krupkaite based on new refinements of their structure. Can. Mineral., 40, 1147–1159. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 200.

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Gladiusite $(Fe^{2+},Mg)_4Fe_2^{3+}(PO_4)(OH)_{11}\cdot H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Needles, of micron size, aggregated in concretions.

Physical Properties: Hardness = ∼5 D(meas.) = 2.23–2.40 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White to yellow.
Optical Class: n.d. *Orientation:* Elongation positive, extinction parallel. $\alpha = 1.547$ β = n.d. $\gamma = 1.571$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Boevskoye deposit, Russia.
11.0 (10), 2.42 (9), 3.17 (8), 1.957 (8), 1.395 (8), 4.06 (6), 2.68 (6b)

Chemistry:

	(1)	(2)	(3)
P_2O_5	36.99	34.02	41.37
CO_2	1.88	2.14	
SiO_2	0.00	0.95	
Al_2O_3	0.95	0.00	
Fe_2O_3	0.00	0.60	
BeO	28.97	29.46	29.16
MgO	0.00	trace	
CaO	14.11	12.72	16.34
F	0.00	0.12	
H_2O	13.70	13.70	13.13
insol.	2.90	n.d.	
Total	99.50		100.00

(1) Boevskoye deposit, Russia; corresponds to $Ca_{0.86}Be_{3.94}[(PO_4)_{1.79}(CO_3)_{0.15}(AlO_4)_{0.06}]_{\Sigma=2.00}(OH)_{3.63}\cdot 0.80H_2O$. (2) Do.; Fe_2O_3 considered to be "limonite"; corresponds to $Ca_{0.84}Be_{4.28}[(PO_4)_{1.76}(CO_3)_{0.18}(SiO_4)_{0.06}]_{\Sigma=2.00}[(OH)_{4.34}F_{0.02}]_{\Sigma=4.36}\cdot 0.62H_2O$.
(3) $CaBe_4(PO_4)_2(OH)_4\cdot 0.5H_2O$.

Occurrence: As segregations in mica-fluorite greisen in illite rocks (Boevskoye deposit, Russia).

Association: Moraesite, fluorite, rutile, "limonite", quartz, mica-clay minerals (Boevskoye deposit, Russia); mitridatite, moraesite, siderite, tourmaline, albite (Paris, Maine, USA).

Distribution: From the Boevskoye phenakite-beryl deposit, 35 km southwest of Kamensk–Ural'skii, Ural Mountains, Russia. In the Mt. Mica quarry, Paris, Oxford Co., Maine, USA.

Name: From the Latin *glucinium*, *beryllium*, for its content of that element.

Type Material: Il'menskii Preserve Museum, Miass, 11344vr; Mining Institute, St. Petersburg, 118/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 65901, 65902.

References: (1) Grigor'ev, N.A. (1963) Glucine, a new beryllium mineral. Zap. Vses. Mineral. Obshch., 92, 691–696 (in Russian). (2) (1964) Amer. Mineral., 49, 1152 (abs. ref. 1).

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Glauberite $Na_2Ca(SO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 10 cm, tabular on {001}, prismatic along [$\bar{1}$01] with dominant {111} or along [001] with dominant {110}, or dipyramidal with dominant {111}, {110}; {001} and {111} may be striated ‖ mutual intersections, yielding steplike terminations.

Physical Properties: *Cleavage:* {001}, perfect; {110}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 2.75–2.85 D(calc.) = 2.78 Slightly saline taste; powdery surface alteration in humid environments, leaching Na_2SO_4 and leaving gypsum.

Optical Properties: Transparent to translucent. *Color:* Gray or pale yellow, colorless. *Streak:* White. *Luster:* Vitreous to waxy, pearly on {001} cleavage surfaces. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 12°$. *Dispersion:* $r > v$, strong, horizontal. $\alpha = 1.515$ $\beta = 1.535$ $\gamma = 1.536$ 2V(meas.) = 7°

Cell Data: *Space Group:* $C2/c$. $a = 10.129(2)$ $b = 8.306(2)$ $c = 8.533(2)$ $\beta = 112.19(1)°$ Z = 4

X-ray Powder Pattern: Synthetic.
3.126 (100), 3.110 (80), 3.175 (75), 2.808 (65), 2.677 (60), 1.975 (60), 2.861 (50)

Chemistry:

	(1)	(2)
SO_4	57.29	57.56
CaO	21.04	20.16
Na_2O	21.27	22.28
Total	99.60	100.00

(1) Berchtesgaden, Bavaria, Germany. (2) $Na_2Ca(SO_4)_2$.

Occurrence: A common constituent of continental and marine evaporite deposits; as sublimates around fumaroles; in mineral-filled cavities in basaltic lava; in nitrate deposits in arid climates.

Association: Halite, polyhalite, anhydrite, gypsum, thénardite, mirabilite (evaporites); thénardite, sassolite (fumaroles); thénardite, blödite (nitrate deposits).

Distribution: Many localities, most minor. In Spain, from Villarrubia de Santiago, near Ocaña, Toledo Province, and elsewhere. At Douglashall, near Westeregeln, Saxony-Anhalt, Germany. From Hallstatt, Austria. At Varangéville, near Nancy, Meurthe-et-Moselle, France. Found at many places in the Taltal nitrate district, Antofagasta, Chile. In the USA, from Searles Lake, San Bernardino Co., Borax Lake, Lake Co., and the Salton Sea, Imperial Co., California; in the Permian salt deposits of Ector and Upton Cos., Texas and Eddy Co., New Mexico; near Camp Verde, Yavapai Co., Arizona; from the Great Salt Lake, Davis Co., Utah. At Gypsumville, Manitoba, Canada. From Lake Gillies, Lochiel, South Australia. On Vulcano, Lipari Islands, Italy. In the Grillid volcanic cave, Surtsey Island, Iceland.

Name: In allusion to Glauber's Salt (Na_2SO_4), the synthetic equivalent of the dominant chemical component, named for Johann Rudolf Glauber (1604–1668), German alchemist.

Type Material: Natural History Museum, Paris, France, 23.400–23.402.

References: (1) Dana, E.S. (1868) Dana's system of mineralogy, (5th edition), 627–628. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 431–433. (3) Araki, T. and T. Zoltai (1967) Refinement of the crystal structure of a glauberite. Amer. Mineral., 52, 1272–1277. (4) (1968) NBS Mono. 25, 6, 59–60.

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Glaucocerinite $(Zn, Cu)_{10}Al_6(SO_4)_3(OH)_{32}\cdot 18H_2O$

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Crystal Data: Hexagonal (?). *Point Group:* n.d. As banded botryoidal crusts, to 3 mm thick, with divergent fibrous to platy internal structure.

Physical Properties: *Tenacity:* Waxlike. Hardness = 1 D(meas.) = 2.4(2) D(calc.) = 2.33

Optical Properties: Semitransparent. *Color:* Sky-blue to bluish green, grading to pale blue, color-banded. *Luster:* Waxy.
Optical Class: Uniaxial, anomalously biaxial (–). *Orientation:* Positive elongation parallel fibers. $n = 1.542$ $\alpha = 1.540(2)$ $\beta = 1.554(2)$ $\gamma = 1.562(2)$ 2V(meas.) = 60°

Cell Data: *Space Group:* n.d. $a = 3.070(8)$ $c = 32.65(1)$ Z = n.d.

X-ray Powder Pattern: Laurium, Greece.
10.9 (100), 5.45 (90), 3.63 (80), 2.62 (60), 2.46 (60), 2.231 (50), 1.981 (50)

Chemistry:

	(1)
SO_3	11.8
Al_2O_3	15.4
CuO	11.6
ZnO	28.7
Cl	0.0
H_2O	30.9
Total	98.4

(1) Laurium, Greece, low analytical total probably due to experimental error in H_2O determination by CHN analyzer; corresponds to $(Zn_{7.03}Cu_{2.91})_{\Sigma=9.94}Al_{6.02}(SO_4)_{2.94}(OH)_{32.06}\cdot 18.18H_2O$.

Occurrence: A rare secondary mineral on museum specimens from a Cu–Zn sulfide deposit.

Association: Smithsonite, adamite, ktenasite, serpierite, malachite, azurite, gypsum, pyrite, galena, sphalerite, fluorite, calcite, "limonite".

Distribution: From Laurium, Greece.

Name: From the Greek for *bluish green* and *waxlike*.

Type Material: University of Vienna, Vienna, C11.130; Natural History Museum, Vienna, Austria, G1378, G1379.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 574. (2) Raade, G., C.J. Elliott, and V.K. Din (1985) New data on glaucocerinite. Mineral. Mag., 49, 583–590.

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Glaucochroite $CaMn^{2+}SiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals commonly long prismatic, to 1 cm, typically unterminated, alone or in columnar aggregates; forms include {100}, {010}, {110}, {120}, {103}, {021}, {111}, {121}. Coarse-grained cleavable, fine-grained massive. *Twinning:* Penetration and contact twins, rarely triplets at about 60°, with {011} as twin plane.

Physical Properties: *Cleavage:* Very poor on {001}. *Fracture:* Conchoidal. Hardness = ~6 D(meas.) = 3.407 D(calc.) = 3.465

Optical Properties: Semitransparent. *Color:* Bluish green; small crystals white or pinkish; may be brown when massive, perhaps due to manganese oxides. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Dispersion:* $r > v$, marked. $\alpha = 1.682–1.686$ $\beta = 1.716–1.722$ $\gamma = 1.729–[1.735]$ $2V(meas.) = 60°51'$

Cell Data: *Space Group: Pbnm.* $a = 4.92(3)$ $b = 11.19(2)$ $c = 6.51(2)$ $Z = 4$

X-ray Powder Pattern: Franklin, New Jersey, USA. (ICDD 14-376).
1.85 (100), 2.69 (80), 2.63 (80), 3.69 (60), 2.96 (60), 1.13 (50), 1.11 (50)

Chemistry:

	(1)	(2)
SiO_2	31.48	32.2
FeO	trace	
MnO	38.00	37.5
ZnO		0.8
PbO	1.74	
MgO		0.2
CaO	28.95	29.5
Total	100.17	100.2

(1) Franklin, New Jersey, USA; neglecting PbO, corresponds to $Ca_{0.99}Mn_{1.02}Si_{1.00}O_4$. (2) Do.; by electron microprobe, corresponds to $(Ca_{0.98}Zn_{0.02}Mg_{0.01})_{\Sigma=1.01}Mn_{0.99}Si_{1.00}O_4$.

Occurrence: In a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA); in skarn at the contact between diabase and marble (Anakit Creek, Russia); in calc-silicate rocks with manganese ores (Kuruman, South Africa).

Association: Nasonite, willemite, andradite, hardystonite, tephroite, clinohedrite, esperite, leucophoenicite, hodgkinsonite, diopside, cuspidine, calcite, franklinite, zincite (Franklin, New Jersey, USA).

Distribution: At Franklin, Sussex Co., New Jersey, USA. From near Anakit Creek, at the mouth of the Lower Tunguska River, central Siberia, Russia. In the Wessels mine, near Kuruman, Cape Province, South Africa. From the Kombat mine, 49 km south of Tsumeb, Namibia.

Name: From the Greek for *blue green* and *color*, in allusion to its color.

Type Material: Yale University, New Haven, Connecticut, USA, 2.4359, 2.4360.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 29; Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 46. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 79–80. (3) O'Mara, J.H. (1951) Unit cell and space group of glaucochroite. Amer. Mineral., 36, 918. (4) Pertsev, N.N. and I.P. Laputina (1974) Glaucochroite in the Anakit skarns, Lower Tunguska. Doklady Acad. Nauk SSSR, 216, 1379–1382 (in Russian). (5) Lager, G.A. and E.P. Meagher (1978) High-temperature structural study of six olivines. Amer. Mineral., 63, 365–377. (6) Leavens, P.B., P.J. Dunn, and D.M. Burt (1987) Glaucochroite (olivine, $CaMnSiO_4$) from Franklin, New Jersey: its composition, occurrence, and formation. Amer. Mineral., 72, 423–428.

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Glaucodot $(Co, Fe)AsS$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic by elongation ‖ [001]; less commonly ‖ [010], striated ‖ [001], to 7 cm; massive. *Twinning:* On {101}; on {012}, forming cruciform penetration twins; also as trillings.

Physical Properties: *Cleavage:* Perfect on {010}, less so on {101}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 VHN = n.d. D(meas.) = 6.055 D(calc.) = 6.155

Optical Properties: Opaque. *Color:* Grayish tin-white to reddish silver-white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Less distinct than for arsenopyrite. *Anisotropism:* Distinct, less strong than arsenopyrite.
R_1–R_2: (400) 47.9–52.0, (420) 48.3–51.8, (440) 48.7–51.6, (460) 49.1–51.5, (480) 49.4–51.4, (500) 49.6–51.3, (520) 49.9–51.2, (540) 50.2–51.1, (560) 50.5–51.1, (580) 50.6–51.0, (600) 50.7–50.9, (620) 51.0–50.7, (640) 51.1–50.6, (660) 51.1–50.5, (680) 51.1–50.5, (700) 51.6–50.5

Cell Data: *Space Group:* $P2_1/c$. $a = 5.741$ $b = 5.651$ $c = 5.795$ $\beta = 110.61°$ $Z = 4$

X-ray Powder Pattern: Håkansböda, Sweden.
2.72 (100), 1.827 (90), 2.45 (80), 2.42 (70), 1.125 (60), 1.006 (60), 0.981 (50)

Chemistry:

	(1)	(2)
Co	16.68	11.99
Fe	19.60	22.72
Ni	trace	
As	44.01	45.72
S	20.18	19.57
insol.	0.20	
Total	100.67	100.00

(1) Håkansböda, Sweden. (2) $(Co, Fe)AsS$ with Co:Fe = 2:1.

Polymorphism & Series: Dimorphous with alloclasite.

Mineral Group: Arsenopyrite group.

Occurrence: In deep-seated deposits of high-temperature hydrothermal origin.

Association: Cobaltite, pyrite, chalcopyrite.

Distribution: From Huasco, Tarapacá, Chile [TL]. In the USA, at the Standard Consolidated mine, Sumpter, Grant Co., Oregon, and at Franconia, Grafton Co., New Hampshire. From the Cobalt-Gowganda district, Ontario, Canada. In Sweden, at Håkansboda, Västmanland, as large twinned and untwinned crystals; also at Tunaberg, Södermanland. From Skutterud, Norway. At Oraviţa (Oravicza), Banat, Romania. From Gosenbach, North Rhine-Westphalia, Germany. In the Tynebottom mine, Garrigill, near Alston, Cumbria, England. From Tsumeb, Namibia. Numerous minor occurrences are known.

Name: From the Greek for *blue*, in reference to its use in the dark blue glass called smalt.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 322–325. (2) Ferguson, R.B. (1947) The unit cell of glaucodot. Univ. of Toronto Studies, Geol. Ser., 51, 41–47. (3) Kratz, T., H. Fuess, G. Miehe, and J. Töpel-schadt (1986) Strukturverfeinerung und Tramsmissionselektronenmikroskopie von Glaukodot $(Fe, Co)(As, S)$. Fortschr. Mineral., 64(1), 86.

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Glauconite $\mathbf{(K,Na)(Fe^{3+},Al,Mg)_2(Si,Al)_4O_{10}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* m or $2/m$. In grains or pellets composed partly of aggregates of small micaceous crystals.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 2 D(meas.) = 2.4–2.95 D(calc.) = 2.903

Optical Properties: Translucent to nearly opaque. *Color:* Grass-green, yellow-green, blue-green; in thin section, green, yellow, olive-green. *Luster:* Dull, glistening. *Optical Class:* Biaxial (–). *Pleochroism:* X = yellow-green, green; $Y = Z$ = deeper yellow, bluish green. *Orientation:* $Y = b$; $Z \simeq a$; $X \wedge a \simeq 10°$. *Dispersion:* $r > v$. *Absorption:* $Y \simeq Z > X$. α = 1.592–1.610 β = 1.614–1.641 γ = 1.614–1.641 2V(meas.) = 0°–20°

Cell Data: *Space Group:* Cm or $C2/m$. a = 5.25–5.31 b = 9.09–9.19 c = 10.03–10.15 $\beta = \sim 100°$ Z = 2

X-ray Powder Pattern: Anzoategni, Venezuela. (ICDD 9-439).
10.1 (100), 2.587 (100), 4.53 (80), 3.33 (60), 2.396 (60), 1.511 (60), 3.63 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	49.29	46.52	CaO	0.74	0.51
TiO_2	0.12		Na_2O	0.12	0.19
Al_2O_3	3.17	4.61	K_2O	6.02	7.65
Fe_2O_3	21.72	24.76	H_2O^+	7.21	5.83
FeO	3.19	2.02	H_2O^-	4.60	3.20
MgO	3.85	4.65	P_2O_5	0.32	0.08
			Total	100.35	100.02

(1) Whare Flat, Otago, New Zealand; corresponds to $(K_{0.60}Ca_{0.06}Na_{0.02})_{\Sigma=0.68}(Fe^{3+}_{1.27}Mg_{0.44}Fe^{2+}_{0.21}Al_{0.11})_{\Sigma=2.03}(Si_{3.82}Al_{0.18})_{\Sigma=4.00}O_{10}(OH)_2$. (2) Makhtesh Ramon, Israel; corresponds to $(K_{0.76}Ca_{0.04}Na_{0.03})_{\Sigma=0.83}(Fe^{3+}_{1.33}Mg_{0.54}Fe^{2+}_{0.13}Al_{0.06})_{\Sigma=2.06}(Si_{3.64}Al_{0.36})_{\Sigma=4.00}O_{10}(OH)_2$.

Polymorphism & Series: 1M polytype.

Mineral Group: Mica group.

Occurrence: Altered from detrital biotite or other parent materials, by marine diagenesis in shallow water under reducing conditions; especially in loosely consolidated sandstone (greensand), and impure limestone and siltstone.

Association: Quartz, feldspars, glaucophane, dolomite, siderite, calcite, ankerite, pyrite, "limonite".

Distribution: Worldwide in marine sediments. A few localities for studied material are: on the Otago Peninsula, New Zealand. From the Flinders Ranges and Yorke Peninsula, South Australia. Around Sandwich and Folkestone, Kent, and Hollybush Hill, Worcester, England. At Villers-sur-Mer, Calvados, France. From Verona, Vicenza, Italy. At a number of localities in Israel. From the N'Chwaning mine, near Kuruman, Cape Province, South Africa. In the USA, particularly widespread in Alabama; from Burnet Co., Texas; both on and offshore in several of the coastal counties of California; from Baker Co., Oregon; in the Black Hills of South Dakota.

Name: From the Greek *glaucos*, for *bluish green*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 683–684. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 35–41. (3) Bentor, Y.K. and M. Kastner (1965) Notes on the mineralogy and origin of glauconite. J. Sed. Petrol., 35, 155–166. (4) Buckley, H.A., J.C. Bevan, K.M. Brown, L.R. Johnson, and V.C. Farmer (1978) Glauconite and celadonite: two separate mineral species. Mineral. Mag., 42, 373–382.

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Glaucophane $Na_2[(Mg,Fe^{2+})_3Al_2]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals; columnar, fibrous, or granular aggregates; massive. *Twinning:* Simple or multiple twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {010}, {001}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.08–3.22 D(calc.) = 3.132

Optical Properties: Translucent. *Color:* Gray, lavender-blue, commonly zoned; lavender-blue to colorless in thin section. *Streak:* Blue-gray. *Luster:* Vitreous to pearly. *Optical Class:* Biaxial (–). *Pleochroism:* Vivid; X = yellow to colorless; Y = violet to lavender; Z = blue. *Orientation:* $Y = b$; $Z \wedge c = -7°$ to $-6°$, $X \wedge a \simeq 8°$. *Dispersion:* $r < v$, weak. $\alpha = 1.594$–1.630 $\beta = 1.612$–1.648 $\gamma = 1.619$–1.652 2V(meas.) = 0°–50°

Cell Data: *Space Group:* $C2/m$. $a = 9.595$ $b = 17.798$ $c = 5.307$ $\beta = 103.66°$ Z = 2

X-ray Powder Pattern: Sebastopol quadrangle, California, USA. (ICDD 20–453). 8.26 (100), 3.06 (65), 2.693 (60), 4.45 (25), 3.38 (25), 2.937 (25), 2.523 (25)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	58.04	56.28	FeO	6.12	10.34	K_2O	0.02	0.11
TiO_2	0.66	0.17	MnO	0.07	0.25	F	0.02	
Al_2O_3	10.31	12.16	MgO	11.71	8.41	Cl	0.01	
Fe_2O_3	2.89	1.72	CaO	1.37	0.62	H_2O^+	1.98	
Cr_2O_3		0.11	Na_2O	6.97	7.04	H_2O^-	0.00	
						Total	100.17	97.21

(1) Tiburon Peninsula, California, USA; corresponds to $(Na_{1.96}Ca_{0.04})_{\Sigma=2.00}(Mg_{2.39}Al_{1.82}Fe^{2+}_{0.61}Fe^{3+}_{0.18})_{\Sigma=5.00}Si_8O_{22}(OH)_2$. (2) Kodiak Islands, Alaska, USA; by electron microprobe, Fe^{2+}:Fe^{3+} calculated; corresponds to $(Na_{1.90}Ca_{0.09}K_{0.02})_{\Sigma=2.01}(Al_{1.82}Mg_{1.74}Fe^{2+}_{1.20}Fe^{3+}_{0.18}Mn_{0.03}Ti_{0.02}Cr_{0.01})_{\Sigma=5.00}(Si_{7.83}Al_{0.17})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with ferroglaucophane.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) < 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) < 0.3$; $(Na + K)_A < 0.5$; $Na_B \geq 1.34$.

Occurrence: Characteristic of the blueschist facies, in former subduction zones in mountain belts; in the greenschist facies and in eclogites that have undergone retrograde metamorphism.

Association: Crossite, chlorite, epidote, pumpellyite, lawsonite, omphacite, jadeite, actinolite, barroisite, cummingtonite, aragonite.

Distribution: Widespread in some mountain belts. On Syra Island, Cyclades Islands, Greece. At numerous sites in the California Coast Ranges, as on the Tiburon Peninsula and at Vonsen Ranch, Marin Co., at Glaucophane Ridge, Panoche Valley, San Benito Co., and near Valley Ford, Sonoma Co.; in the Kodiak Islands, Alaska, USA. At St. Marcel, Val d'Aosta, and Piollore (Biella), Piedmont, Italy. On Anglesey, Wales. In Japan, at Ubuzan, Aichi Prefecture, and Otakiyama, Tokushima Prefecture.

Name: From the Greek for *bluish green* and *to appear*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 399. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 333–351. (3) Borg, I.Y. (1967) Optical properties and cell parameters in the glaucophane-riebeckite series. Contr. Mineral. Petrol., 15, 67–92. (4) Papike, J.J. and J.R. Clark (1968) The crystal structure and cation distribution of glaucophane. Amer. Mineral., 53, 1156–1173. (5) Hoffmann, C. and K. Katz (1982) Trend surface analysis of some physical properties of alkali (sodic) amphiboles. Lithos, 15, 17–25. (6) Roeske, S.M. (1986) Field relations and metamorphism of the Raspberry Schist, Kodiak Islands, Alaska. In: B.W. Evans and E.H. Brown, Eds., Blueschists and eclogites, Geol. Soc. Amer. Memoir 164, 169–184. (7) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 237–241.

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Glaukosphaerite $(Cu,Ni)_2(CO_3)(OH)_2$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* n.d. As divergent fibrous to concentrically zoned spherules, to 3 mm; in plumose aggregates, rarely as felted masses of parallel fibers.

Physical Properties: *Cleavage:* One ‖ [001]. *Tenacity:* Brittle. Hardness = 3–4
D(meas.) = 3.78–3.96 D(calc.) = 3.78–4.03

Optical Properties: Semitransparent. *Color:* Deep malachite-green to apple-green.
Streak: Pale green. *Luster:* Subvitreous to dull, silky if fibrous.
Optical Class: Biaxial (–). *Pleochroism:* X = deep malachite-green; $Y = Z$ = apple-green.
Orientation: $X \wedge c = 7°$. $\alpha = 1.69$–1.71 $\beta = 1.83$–1.85 $\gamma = 1.83$–1.85 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 9.36(3)$ $b = 11.92(3)$ $c = 3.08(1)$ $\beta = 91.1(0.04)°$
Z = 4

X-ray Powder Pattern: Kambalda, Western Australia.
2.591 (100b), 3.690 (80), 2.952 (70), 2.484 (70b), 2.931 (60), 5.048 (50), 2.517 (50)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	21.70	20.15	CoO	0.07	
SiO_2	< 0.01		MgO	1.23	
Fe_2O_3	0.47	0.40	H_2O^+	9.85	8.25
ZnO	0.02		H_2O^-	< 0.01	0.19
CuO	41.57	44.03	insol.		2.28
NiO	25.22	23.92	Total	100.13	99.22

(1) Kambalda, Western Australia; corresponds to $(Cu_{1.08}Ni_{0.70}Mg_{0.06})_{\Sigma=1.84}(CO_3)_{1.02}(OH)_{1.94}$.
(2) Kasompi, Congo; neglecting impurities, corresponds to $(Cu_{1.23}Ni_{0.71})_{\Sigma=1.94}(CO_3)_{1.02}(OH)_{2.04}$.

Mineral Group: Rosasite group.

Occurrence: A rare secondary mineral in the oxidized portions of Cu–Ni sulfide deposits.

Association: Nickeloan malachite, azurite, paratacamite, brochantite, chalconatronite, takovite, georgeite, carrboydite, gaspéite, népouite, nickeloan chrysotile, nickeloan celadonite, gypsum, epsomite, nickeloan magnesite, goethite, quartz.

Distribution: In Australia, from around Kambalda, at the Hampton East Location 48, three km north of the Durkin shaft, from three km southeast at Widgiemooltha, and 11 km southeast of Widgiemooltha, at the Dordie North nickel prospect, in the 132 North nickel mine, four km southwest of Widgiemooltha, and in the Otter Shoot gossan; in the Discovery gossan, eleven km south of Windarra; from the Carr Boyd Rocks nickel mine, Yerilla district, 80 km north-northeast of Kalgoorlie, in the Scotia nickel mine, Kalgoorlie, and at the Jan nickel deposit, St. Ives, all in Western Australia. From Shinshiro, Aichi Prefecture, Japan. At Kasompi, Katanga Province, Congo (Shaba Province, Zaire). In the Key West mine, east of Moapa, Bunkerville district, Clark Co., Nevada, USA. At the Kamariza mine, Laurium, Greece.

Name: From the Greek for *bluish green* and *spherical*, the typical color and habit.

Type Material: Western Australian Museum, Perth, MDC5309; National School of Mines, Paris, France; The Natural History Museum, London, England, 1975,419; National Museum of Natural History, Washington, D.C., USA, 131889.

References: (1) Pryce, M.W. and J. Just (1974) Glaukosphaerite: A new nickel analogue of rosasite. Mineral. Mag., 39, 737–743. (2) Deliens, M. (1975) La glaucosphaerite de Kasompi (Shaba méridional, Zaïre). Bull. Minéral., 98, 175–178 (in French with English abs.). (3) Nickel, E.H. and L.G. Berry (1981) The new mineral nullaginite and additional data on the related minerals rosasite and glaukosphaerite. Can. Mineral., 19, 315–324.

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Glucine $CaBe_4(PO_4)_2(OH)_4 \cdot 0.5H_2O$

Crystal Data: n.d. *Point Group:* n.d. Needles, of micron size, aggregated in concretions.

Physical Properties: Hardness = ~5 D(meas.) = 2.23–2.40 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White to yellow.
Optical Class: n.d. *Orientation:* Elongation positive, extinction parallel. $\alpha = 1.547$ β = n.d. $\gamma = 1.571$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Boevskoye deposit, Russia.
11.0 (10), 2.42 (9), 3.17 (8), 1.957 (8), 1.395 (8), 4.06 (6), 2.68 (6b)

Chemistry:

	(1)	(2)	(3)
P_2O_5	36.99	34.02	41.37
CO_2	1.88	2.14	
SiO_2	0.00	0.95	
Al_2O_3	0.95	0.00	
Fe_2O_3	0.00	0.60	
BeO	28.97	29.46	29.16
MgO	0.00	trace	
CaO	14.11	12.72	16.34
F	0.00	0.12	
H_2O	13.70	13.70	13.13
insol.	2.90	n.d.	
Total	99.50		100.00

(1) Boevskoye deposit, Russia; corresponds to $Ca_{0.86}Be_{3.94}[(PO_4)_{1.79}(CO_3)_{0.15}(AlO_4)_{0.06}]_{\Sigma=2.00}(OH)_{3.63} \cdot 0.80H_2O$. (2) Do.; Fe_2O_3 considered to be "limonite"; corresponds to $Ca_{0.84}Be_{4.28}[(PO_4)_{1.76}(CO_3)_{0.18}(SiO_4)_{0.06}]_{\Sigma=2.00}[(OH)_{4.34}F_{0.02}]_{\Sigma=4.36} \cdot 0.62H_2O$.
(3) $CaBe_4(PO_4)_2(OH)_4 \cdot 0.5H_2O$.

Occurrence: As segregations in mica-fluorite greisen in illite rocks (Boevskoye deposit, Russia).

Association: Moraesite, fluorite, rutile, "limonite", quartz, mica-clay minerals (Boevskoye deposit, Russia); mitridatite, moraesite, siderite, tourmaline, albite (Paris, Maine, USA).

Distribution: In Russia, from the Boevskoye phenakite-beryl deposit, 35 km southwest of Kamensk-Ural'skii, Ural Mountains. In the Mt. Mica quarry, Paris, Oxford Co., Maine, USA.

Name: From the Latin *glucinium*, *beryllium*, for its content of that element.

Type Material: Il'menskii Preserve Museum, Miass, 11344vr; Mining Institute, St. Petersburg, 118/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 65901, 65902.

References: (1) Grigor'ev, N.A. (1963) Glucine, a new beryllium mineral. Zap. Vses. Mineral. Obshch., 92, 691–696 (in Russian). (2) (1964) Amer. Mineral., 49, 1152 (abs. ref. 1).

Glushinskite $Mg(C_2O_4)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As granular, distorted pyramidal crystals, to 5 μm, with curved and striated faces; in platy aggregates.

Physical Properties: Hardness = 2 D(meas.) = 1.85 D(calc.) = n.d. Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Creamy white, colorless.
Luster: Subadamantine.
Optical Class: Biaxial (–). $\alpha = 1.365$ $\beta = 1.530$ $\gamma = 1.595$ 2V(meas.) = 58(1)°

Cell Data: *Space Group:* $C2/c$ (synthetic β form). $a = 12.675$ $b = 5.406$ $c = 9.984$ $\beta = 129.45°$ Z = 4

X-ray Powder Pattern: Mill of Johnston, Scotland.
4.89 (100), 3.179 (70), 2.039 (60), 2.379 (50), 1.861 (50), 3.340 (40), 2.541 (40)

Chemistry: (1) Mill of Johnston, Scotland; identity of natural material confirmed by agreement with the X-ray pattern and IR spectrum of the synthetic compound.

Polymorphism & Series: Both α and β forms are known.

Occurrence: As veinlets in brown coal seams impregnated with natural acetic acid (Chai-Tumus deposit, Russia); formed by reaction between Mg-rich minerals and oxalic acid secreted by incrusting lichen, *Lecanora atra* (Mill of Johnston, Scotland); in desert plants (Lake Huleh basin, Israel).

Association: Whewellite, weddellite, calcite, dolomite, stepanovite, zhemchuzhnikovite (Chai-Tumus deposit, Russia); whewellite, chrysotile, quartz (Mill of Johnston, Scotland).

Distribution: Likely more common than known localities suggest. From the Chai-Tumus coal deposit, 200 km up from the Lena River estuary, Bulun district, polar Sakha, Russia. In Scotland, near Mill of Johnston, six km west-southwest of Insch, Kincardineshire, and on the Island of Rhum, Inner Hebrides. In the Lake Huleh basin, Jordan Rift Valley, Israel (α form). From Gcwihaba Cave, 280 km west of Maun, northwestern Botswana.

Name: To honor Petr Ivanovich Glushinskii (1908–), coal geologist, Institute of Arctic and Antarctic Geology, St. Petersburg, Russia.

Type Material: Royal Scottish Museum, Edinburgh, Scotland; The Natural History Museum, London, England.

References: (1) Wilson, M.J., D. Jones, and J.D. Russell (1980) Glushinskite; a naturally occurring magnesium oxalate. Mineral. Mag., 43, 837–840. (2) (1981) Amer. Mineral., 66, 439 (abs. ref. 1). (3) Bayliss, P. (1987) Mineral nomenclature: glushinskite. Mineral. Mag., 51, 327–328. (4) Cowgill, U.M. (1989) A naturally occurring alpha magnesium oxalate dihydrate from northern Jordan Valley (Israel). Mineral. Mag., 53, 505–507. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 92.

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Gmelinite $(Na_2, Ca)Al_2Si_4O_{12}\cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As euhedral crystals, pyramidal, tabular, or rhombohedral, striated ‖ (0001) or less commonly, ‖ [0001], to 4 cm. Rarely in radiating aggregates or granular. *Twinning:* Penetration twins on $\{10\bar{1}1\}$, common.

Physical Properties: *Cleavage:* $\{10\bar{1}0\}$, distinct; parting on {0001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 2.02–2.17 D(calc.) = 2.098 Piezoelectric.

Optical Properties: Transparent to translucent, opaque. *Color:* Colorless, white, reddish white, salmon-red, yellowish, greenish white; colorless in thin section. *Luster:* Vitreous. *Optical Class:* Uniaxial (–) or (+); may be anomalously biaxial. ω = 1.476–1.494 ϵ = 1.474–1.480

Cell Data: *Space Group:* $P6_3/mmc$. a = 13.75–13.80 c = 9.97–10.08 Z = 4

X-ray Powder Pattern: Montecchio Maggiore, Italy.
4.106 (100), 11.908 (63), 2.978 (55), 2.690 (44), 3.227 (41), 7.68 (29), 5.026 (28)

Chemistry:

	(1)	(2)
SiO_2	50.00	46.57
Al_2O_3	19.17	21.12
CaO	2.95	7.04
SrO	0.58	0.25
Na_2O	7.20	4.35
K_2O	0.10	0.27
H_2O	20.00	20.40
Total	100.00	100.00

(1) Montecchio Maggiore, Italy; by electron microprobe, corresponds to $(Na_{1.16}Ca_{0.26}Sr_{0.03}K_{0.01})_{\Sigma=1.46}Al_{1.88}Si_{4.16}O_{12}\cdot 5.54H_2O$. (2) South quarry, White Head, Co. Antrim, Ireland; by electron microprobe, corresponds to $(Na_{0.71}Ca_{0.64}Sr_{0.03}K_{0.01})_{\Sigma=1.39}Al_{2.10}Si_{3.92}O_{12}\cdot 5.73H_2O$.

Mineral Group: Zeolite group.

Occurrence: Formed from sodium-rich fluids, in basalts and related igneous rocks, also pegmatites.

Association: Zeolites, calcite, aragonite, quartz.

Distribution: Widespread in small amounts. A few localities for well studied material follow. From Montecchio Maggiore, Vicenza, Italy. At Glenarm and elsewhere in Co. Antrim, Ireland. On the Isle of Skye, Scotland. At Pyrgos, Cyprus. In the USA, from Bergen Hill, Hudson Co., and Great Notch, Paterson, and Prospect Park, Passaic Co., New Jersey; at Springfield, Lane Co., Oregon. On Pinnacle Rock, Five Islands, and Two Islands, Nova Scotia, Canada. In the Ilímaussaq intrusion, southern Greenland. At Sarbay-Sokolov, Kazakhstan. Large crystals from Bekiady, Madagascar. From around Flinders, Victoria, Australia.

Name: For Christian Gottlob Gmelin (1792–1860), German mineralogist and chemist of Tübingen, Germany.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 593–594. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 387–400. (3) Passaglia, E., D. Pongiluppi, and G. Vezzalini (1978) The crystal chemistry of gmelinites. Neues Jahrb. Mineral., Monatsh., 310–322. (4) Galli, E., E. Passaglia, and P.F. Zanazzi (1982) Gmelinite: structural refinements of sodium-rich and calcium-rich natural crystals. Neues Jahrb. Mineral., Monatsh., 145–155. (5) Vezzalini, G., S. Quartieri, and E. Passaglia (1990) Crystal structure of a K-rich natural gmelinite and comparison with the other refined gmelinite samples. Neues Jahrb. Mineral., Monatsh., 504–516.

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Gobbinsite $(Na_2, Ca)_2K_2Al_6Si_{10}O_{32}\cdot 12H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal, or tetragonal. *Point Group:* *mm*2 or 422. Individual crystals very rare, spikelike pyramidal, to 2 mm; more commonly as clusters of lath-shaped or fibrous crystals, elongated along [001]; massive. *Twinning:* On {110}, inferred from X-ray studies.

Physical Properties: *Fracture:* Brittle. Hardness = ∼4 D(meas.) = 2.194 on a mixture with impurities. D(calc.) = 2.147

Optical Properties: Transparent to translucent. *Color:* Chalky white to light brown. *Streak:* White.
Optical Class: Uniaxial (–) or biaxial (–). *Orientation:* $X = c$. $\omega = 1.494(3)$ $\epsilon = 1.489(3)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pmn2_1$. $a = 10.108(1)$ $b = 9.766(1)$ $c = 10.171(1)$ Z = 1, or *Space Group:* $P4_22_12$. $a = 10.115(3)$ $c = 9.766(3)$ Z = 1

X-ray Powder Pattern: Gobbins area, Ireland.
7.11 (100b), 4.116 (100), 3.201 (100), 3.106 (80), 2.699 (80b), 5.056 (50), 2.651 (40)

Chemistry:

	(1)	(2)
SiO_2	49.21	44.82
Al_2O_3	23.64	22.81
Fe_2O_3	0.04	
MgO	1.00	
CaO	1.58	2.51
SrO	0.36	
BaO	0.12	
Na_2O	9.85	6.01
K_2O	0.66	7.73
H_2O	[13.54]	16.12
Total	[100.00]	100.00

(1) Gobbins area, Ireland; by electron microprobe, average of six analyses; H_2O by difference, originally given as 13.55%; corresponds to $(Na_{3.98}Ca_{0.35}Mg_{0.31}Sr_{0.04}Ba_{0.01}Fe_{0.01})_{\Sigma=4.70}K_{0.18}Al_{5.80}Si_{10.25}O_{32}\cdot 9.41H_2O$. (2) Two-Mouth Cave, Ireland; by electron microprobe, corresponds to $(Na_{2.50}Ca_{0.59})_{\Sigma=3.09}K_{2.11}Al_{6.17}Si_{9.93}O_{32}\cdot 12H_2O$.

Mineral Group: Zeolite group.

Occurrence: A secondary mineral in amygdules in basalts (Co. Antrim, Ireland); in cavities in sodalite syenite in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Gmelinite, calcite (Co. Antrim, Ireland); tetranatrolite, sérandite (Mont Saint-Hilaire, Canada).

Distribution: On Island Magee, from Two Mouth Cave, at the coastal escarpment near Hills Port, south of The Gobbins, and at Dunseverick, near Giant's Causeway, Co. Antrim, Ireland. From Mont Saint-Hilaire, Quebec, Canada.

Name: For the type locality at The Gobbins, Ireland.

Type Material: Ulster Museum, Belfast, Ireland, I7881; The Natural History Museum, London, England, 1982,203; National Museum of Natural History, Washington, D.C., USA, 149432.

References: (1) Nawaz, R. and J.F. Malone (1982) Gobbinsite, a new zeolite mineral from Co. Antrim, N. Ireland. Mineral. Mag., 46, 365–369. (2) (1983) Amer. Mineral., 68, 642–643 (abs. ref. 1). (3) Nawaz, R. (1983) New data on gobbinsite and garronite. Mineral. Mag., 47, 567–568. (4) McCusker, L.B., C. Baerlocher, and R. Nawaz (1985) Rietveld refinement of the crystal structure of the new zeolite mineral gobbinsite. Zeits. Krist., 171, 281–289. (5) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 97.

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Godlevskite $(Ni, Fe)_9S_8$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* 222. As aggregates and single grains, to 1 mm; in fine disseminations. *Twinning:* Common and complex, ⊥ (101), may result in geniculated forms.

Physical Properties: Hardness = n.d. VHN = 383–415 (40–50 g load). D(meas.) = n.d. D(calc.) = 5.273

Optical Properties: Opaque. *Color:* In polished section, pale yellow. *Luster:* Metallic. *Pleochroism:* Weak, pale cream to pinkish cream. *Anisotropism:* Strong, from bluish to reddish. R_1–R_2: (400) 25.7–27.1, (420) 30.3–32.1, (440) 35.7–37.9, (460) 40.6–42.6, (480) 44.5–46.5, (500) 47.4–49.1, (520) 49.7–50.9, (540) 51.3–52.2, (560) 52.5–53.0, (580) 53.6–53.8, (600) 54.6–54.4, (620) 55.4–55.0, (640) 56.1–55.6, (660) 57.0–56.2, (680) 57.8–56.8, (700) 58.4–57.4

Cell Data: *Space Group: C*222. $a = 9.3359(7)$ $b = 11.2185(10)$ $c = 9.4300(6)$ $Z = 4$

X-ray Powder Pattern: Zapolyarnyi mine, Russia.
2.85 (100), 1.803 (90), 1.795 (80), 1.654 (80), 3.28 (50), 2.10 (50), 2.33 (40)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	61.5	64.45	68.2	67.31
Fe	3.0	2.08		
Co	0.6	0.19		
S	35.0	32.85	32.7	32.69
Total	100.1	99.57	100.9	100.00

(1) Zapolyarnyi mine, Russia; by electron microprobe, corresponding to $(Ni_{7.68}Fe_{0.39}Co_{0.08})_{\Sigma=8.15}S_{8.00}$. (2) Do.; by electron microprobe, corresponding to $(Ni_{8.58}Fe_{0.29}Co_{0.02})_{\Sigma=8.89}S_{8.00}$. (3) Barberton district, South Africa; by electron microprobe, corresponding to $Ni_{9.12}S_{8.00}$. (4) Ni_9S_8.

Occurrence: In hydrothermal veins, or in peridotite with other nickel sulfides.

Association: Millerite, heazlewoodite, pentlandite, pyrrhotite, pyrite, bornite, chalcopyrite, magnetite.

Distribution: In Russia, from the Talnakh area, Noril'sk region, western Siberia, in the Zapolyarnyi [TL], Mayak, and other mines; at the Bazhenovo ultramafic massif, Middle Ural Mountains. From the Swat Valley, northwestern Pakistan. At the Amianthus mine, Kaapsche Hoop, Barberton, Transvaal, South Africa. From Bou Azzer, Morocco. At Fiskenæsset, Greenland. In Canada, in the Texmont mine, about 50 km south of Timmins, Ontario, and at the Orford nickel mine, Brompton Lake, Quebec. From near Moapa, Clark Co., Nevada, USA. At Mount Clifford, 54 km north-northwest of Leonora, Western Australia. Several other less-well-defined occurrences are known.

Name: In honor of Mikhail Nikolaevich Godlevskii (1902–1984), Russian economic geologist, Central Institute of Geological Exploration for Base and Precious Metals, Moscow, Russia.

Type Material: Institute of Geology; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73000.

References: (1) Kulagov, E.A., T.L. Evstigneeva, and O.E. Yushko-Zakharova (1969) The new nickel sulfide godlevskite. Geol. Rudn. Mestorozhd. 11, 115–121 (in Russian). (2) (1970) Amer. Mineral., 55, 317–318 (abs. ref. 1). (3) Fleet, M.E. (1987) Structure of godlevskite, Ni_9S_8. Acta Cryst., C43, 2255–2257. (4) Fleet, M.E. (1988) Stoichiometry, structure and twinning of godlevskite and synthetic low-temperature Ni-excess nickel sulfide. Can. Mineral., 26, 283–291. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 201.

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Godovikovite $(NH_4)(Al, Fe^{3+})(SO_4)_2$

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Crystal Data: Hexagonal. *Point Group:* 32. Fibrous crystals, to 0.015 mm, in compact to porous aggregates.

Physical Properties: *Fracture:* Uneven. Hardness = 2 D(meas.) = 2.53 D(calc.) = 2.52 Slowly soluble in H_2O.

Optical Properties: Translucent. *Color:* White; colorless in thin section. *Luster:* Dull to chalky in aggregates.
Optical Class: Uniaxial (+). $\omega = 1.572(2)$ $\epsilon = 1.581(2)$

Cell Data: *Space Group:* [$P321$] [by analogy to synthetic $(NH_4)Al(SO_4)_2$]. $a = 4.75(1)$ $c = 8.30(1)$ Z = 1

X-ray Powder Pattern: Kopeysk, Russia.
3.69 (10), 8.30 (9), 2.921 (9), 2.374 (8), 2.764 (7), 1.848 (7), 2.280 (6)

Chemistry:

	(1)
SO_3	57.02
TiO_2	0.66
Al_2O_3	11.98
Fe_2O_3	7.70
MnO	0.04
MgO	1.00
CaO	0.40
Na_2O	< 0.05
K_2O	0.52
$(NH_4)_2O$	8.50
insol.	12.49
Total	100.31

(1) Kopeysk, Russia; K by flame photometry; after removal of insoluble as quartz, corresponds to $[(NH_4)_{0.92}Mg_{0.07}K_{0.03}Ca_{0.02}]_{\Sigma=1.04}(Al_{0.66}Fe_{0.27}Ti_{0.02})_{\Sigma=0.95}(SO_4)_2$.

Occurrence: As reaction crusts around outlets releasing sulfuric acid from burning coal heaps.

Association: Unspecified anhydrous calcium and magnesium sulfates.

Distribution: From near Kopeysk, Chelyabinsk coal basin, Southern Urals, Russia. At the Schoeller mine, Libušin, near Kladno, Czech Republic. From near Ravat, Tien-Shan Mountains, Tajikistan.

Name: Honors Aleksandr Aleksandrovich Godovikov (1927–1995), Russian mineralogist and Director of the Fersman Mineralogical Museum, Moscow, Russia.

Type Material: Il'menskii Preserve Museum, Miass, 5894; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87566.

References: (1) Shcherbakova, Y.P., L.F. Bazhenova, and B.V. Chesnokov (1988) Godovikovite – $NH_4(Al, Fe)(SO_4)_2$, a new ammonium-bearing sulfate. Zap. Vses. Mineral. Obshch., 117, 208–211 (in Russian). (2) (1990) Amer. Mineral., 75, 241–242 (abs. ref. 1).

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Goedkenite $(Sr,Ca)_2Al(PO_4)_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are lozenge- to spearhead-shaped, to 1 mm, flattened on {001}, slightly elongated along [100], showing prominent {001}, {111}, with {011}, {012}, {$\overline{1}$01}; {001} commonly warped, with feathered ends; in bunched aggregates.

Physical Properties: *Cleavage:* On {100}, fair. Hardness = 5 D(meas.) = n.d.
D(calc.) = 3.83

Optical Properties: Semitransparent. *Color:* Colorless to pale yellow.
Luster: Subadamantine.
Optical Class: Biaxial (+). *Orientation:* $X = b$. $\alpha = 1.669(2)$ $\beta = 1.673(2)$ $\gamma = 1.692(3)$
2V(meas.) = 45°–50°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.45(2)$ $b = 5.74(2)$ $c = 7.26(2)$ $\beta = 113.7(1)°$
Z = 2

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
3.061 (10), 2.585 (7), 2.841 (6), 7.76 (5), 4.33 (4), 3.423 (4), 2.813 (4)

Chemistry:

	(1)	(2)
P_2O_5	34.9	38.15
Al_2O_3	13.7	13.70
MgO	0.17	
CaO	11.4	11.76
SrO	32.7	33.97
H_2O	n.d.	2.42
Total		100.00

(1) Palermo #1 mine, New Hampshire, USA; by electron microprobe. (2) $(Sr_{1.22}Ca_{0.78})_{\Sigma=2.00}$ $Al(PO_4)_2(OH)$.

Mineral Group: Brackebuschite group.

Occurrence: A rare late-stage secondary hydrothermal mineral in a complex granite pegmatite.

Association: Palermoite, childrenite, bjarebyite, goyazite, whitlockite, carbonate apatite, siderite, quartz.

Distribution: From the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, USA.

Name: To honor Dr. Virgil Linus Goedken (1940–1992), Department of Chemistry, University of Chicago, Chicago, Illinois, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128070.

References: (1) Moore, P.B., A.J. Irving, and A.R. Kampf (1975) Foggite, $CaAl(OH)_2(H_2O)[PO_4]$; goedkenite, $(Sr,Ca)_2Al(OH)[PO_4]_2$; and samuelsonite, $(Ca,Ba)Fe^{2+}_2Mn^{2+}_2Ca_8Al_2(OH)_2[PO_4]_{10}$: three new species from the Palermo No. 1 pegmatite, North Groton, New Hampshire. Amer. Mineral., 60, 957–964.

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Goethite α–$Fe^{3+}O(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$. As prismatic crystals, striated ‖ [001], to 45 cm, or tabular on {010}. More commonly as aggregates of capillary to acicular crystals, in divergent sprays, or reniform, botryoidal, or stalactitic masses with concentric or radial fibrous internal structure; nearly cryptocrystalline in "limonite".

Physical Properties: *Cleavage:* {010}, perfect; {100}, less perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 VHN = 667 (100 g load). D(meas.) = 4.28(1) D(calc.) = 4.18

Optical Properties: Opaque, transparent on thin edges. *Color:* Blackish brown; yellowish to reddish brown in massive aggregates, may be banded; shades of yellow in thin section; gray with bluish tint in reflected light, with yellow, red, brown internal reflections. *Streak:* Brownish yellow, yellow-orange, ocher-yellow. *Luster:* Imperfect adamantine metallic to dull earthy; silky when fibrous.
Optical Class: Biaxial (–); uniaxial (–) for red light. *Pleochroism:* Strong; X = yellow to colorless; Y = yellow-brown, reddish orange; Z = yellow-orange, deep reddish orange. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, extreme. *Absorption:* $Z > Y > X$. α = 2.260–2.275 β = 2.393–2.409 γ = 2.398–2.515 2V(meas.) = 0°–27° *Anisotropism:* Distinct; in bluish grays. R_1–R_2: (400) 17.5–19.2, (420) 16.7–18.3, (440) 15.9–17.4, (460) 15.2–16.7, (480) 14.6–16.0, (500) 14.1–15.5, (520) 13.7–15.0, (540) 13.3–14.6, (560) 13.0–14.3, (580) 12.8–14.0, (600) 12.5–13.7, (620) 12.4–13.5, (640) 12.2–13.4, (660) 12.0–13.2, (680) 12.0–13.1, (700) 11.9–13.0

Cell Data: *Space Group: Pbnm.* $a = 4.608$ $b = 9.956$ $c = 3.0215$ Z = 4

X-ray Powder Pattern: Hindlow quarry, Derbyshire, England.
4.183 (100), 2.450 (50), 2.693 (35), 1.7192 (20), 2.190 (18), 2.253 (14), 4.98 (12)

Chemistry:

	(1)	(2)
SiO_2	0.36	
Fe_2O_3	89.65	89.86
H_2O	10.19	10.14
Total	100.20	100.00

(1) El Paso Co., Colorado, USA. (2) FeO(OH).

Polymorphism & Series: Trimorphous with feroxyhyte and lepidocrocite.

Occurrence: A common weathering product derived from numerous iron-bearing minerals in oxygenated environments; an important component of ore in weathered iron deposits. Also a primary precipitate in hydrothermal, marine, and bog environments upon oxidation of reduced iron-bearing waters.

Association: Lepidocrocite, hematite, pyrite, siderite, pyrolusite, manganite, many other iron- and manganese-bearing species.

Distribution: Widespread; some localities for good crystals include: from Siegen, North Rhine-Westphalia, and near Giessen, Hesse, Germany. At Příbram, Czech Republic. Exceptional crystals from the Restormel mine, Lanlivery; the Botallack mine, St. Just; and elsewhere in Cornwall, England. From Chaillac, Indre-et-Loire, France. In the USA, from the Pikes Peak district and Florissant, El Paso Co., Colorado; an ore mineral in the Lake Superior district, as at the Jackson mine, Negaunee, and the Superior mine, Marquette, Marquette Co., Michigan.

Name: Honors the German poet, dramatist, and philosopher, Johann Wolfgang von Goethe (1749–1832).

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 680–687. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 118–121. (3) Harrison, R.K., N. Aitkenhead, B.R. Young, and P.F. Dagger (1975) Goethite from Hindlow, Derbyshire. Bull. Geol. Surv. Great Britain, 52, 51–54. (4) Ramdohr, P. (1980) The ore minerals and their intergrowths, (4th edition), 1071–1076.

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Gold Au

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, dodecahedra, and cubes, typically crude or rounded, to about 5 cm; also elongated ‖ [111]. In twinned and parallel crystal groups; reticulated, dendritic, arborescent, platy, filiform, spongy; massive, and in rounded nuggets; scales and flakes. *Twinning:* Common on {111}; repeated to form reticulated and dendritic aggregates.

Physical Properties: *Fracture:* Hackly. *Tenacity:* Very malleable and ductile. Hardness = 2.5–3 VHN = 30–34, 44-58 (argentian) (10 g load). D(meas.) = 19.3 D(calc.) = 19.302

Optical Properties: Opaque in all but thinnest foils. *Color:* Gold-yellow with a reddish tint when pure, silver-white to copper-red when impure; blue and green in transmitted light. *Luster:* Metallic.
R: (400) 36.8, (420) 36.8, (440) 36.4, (460) 36.1, (480) 36.7, (500) 45.3, (520) 62.5, (540) 75.0, (560) 82.2, (580) 86.8, (600) 89.7, (620) 91.9, (640) 93.3, (660) 94.1, (680) 94.8, (700) 95.3

Cell Data: *Space Group: Fm3m.* a = 4.0786 Z = 4

X-ray Powder Pattern: Synthetic.
2.355 (100), 2.039 (52), 1.230 (36), 1.442 (32), 0.9357 (23), 0.8325 (23), 0.9120 (22)

Chemistry:

	(1)		(1)
Au	99.6	Ag	0.1
Cu	0.1	Total	99.8

(1) Porthcurnick Beach, Cornwall, England; by electron microprobe. Commonly contains Ag, Cu, Fe; rarely Pb, Ti, Sb, Hg, V, Bi, Mn, As, Sn, Zn, Pd, Pt, Cd, many other elements.

Polymorphism & Series: Forms a series with silver.

Occurrence: Widespread in very small quantities in rocks of many kinds throughout the world, and in sea water. In veins of epithermal origin, typically in quartz with pyrite and other sulfides, and with tellurides; in pegmatites; in contact metamorphic deposits. Common in placers.

Association: Pyrite, chalcopyrite, arsenopyrite, pyrrhotite, sylvanite, krennerite, calaverite, altaite, tetradymite, scheelite, ankerite, tourmaline, quartz.

Distribution: Many localities for fine specimens. In Russia, in Siberia, along the eastern slope of the Ural Mountains; important localities near Yekaterinburg (Sverdlovsk), as at Beresovsk; in the Miass district; large crystal groups from along the Lena River, Sakha. Sharply crystallized from Romania, at Roşia Montană (Verespatak) and Săcărîmb (Nagyág). In Australia, many occurrences, as at Bendigo, Ballarat, and Matlock, Victoria; along the Palmer River and at Gympie, Queensland; from Kalgoorlie, Western Australia, with gold telluride ores, also very large alluvial nuggets. At the Porgera mine, Mt. Kare, Papua New Guinea. The world's most important gold district is the Witwatersrand, Transvaal, South Africa, which, however, only rarely produces crystalline material. In Canada, especially in Ontario, in the Porcupine and Hemlo districts. In the USA, in California, in the Mother Lode belt of the Sierra Nevada, with fine examples from both lode and placer deposits. In South Dakota, from the Homestake mine at Lead, Lawrence Co.; in Colorado, wire and leaf gold from Breckenridge, Summit Co.; in Lake Co., at Leadville; in Alaska, in lode mines in the Juneau district and placers along the Yukon River. Near Santa Elena, in the Grand Savannah River region, Venezuela, a placer producing exceptional skeletal crystals. A bonanza gold rush occurred at Serra Pelada, Pará, Brazil.

Name: An Old English word for the metal; perhaps related to the Sanskrit *jval*; chemical symbol from the Latin *aurum*, *shining dawn*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 90–95. (2) Jones, R.S. and M. Fleischer (1969) Gold in minerals and the composition of native gold. U.S. Geol. Surv. Circ. 612, 17 pp. (3) Ewald, P.P. and C. Hermann, Eds. (1931) Gold, *Au*. Strukturbereicht, 1, 38–40 (in German). (3) (1953) NBS Circ. 539, 1, 33. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 204.

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Goldfieldite $Cu_{12}(Te, As, Sb)_4S_{13}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Massive; as crusts.

Physical Properties: *Tenacity:* Brittle. Hardness = 3–3.5 VHN = 291–342 (100 g load). D(meas.) = 4.95 D(calc.) = 4.935

Optical Properties: Opaque. *Color:* Dark lead-gray. *Luster:* Metallic.
R: (400) 30.7, (420) 30.7, (440) 30.7, (460) 30.7, (480) 30.7, (500) 30.7, (520) 30.6, (540) 30.6, (560) 30.6, (580) 30.6, (600) 30.6, (620) 30.7, (640) 30.9, (660) 31.0, (680) 31.1, (700) 31.2

Cell Data: *Space Group:* $I\bar{4}3m$. $a = 10.263$–10.38 $Z = 2$

X-ray Powder Pattern: Goldfield, Nevada, USA. (ICDD 29-531).
2.97 (100), 1.819 (60), 3.64 (30), 1.552 (30), 2.58 (20), 2.43 (20), 5.15 (10)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Cu	43.38	44.3	46.5	Te	25.74	14.5	18.0
Ag		0.6		Sb	0.23	7.1	2.3
Fe		0.1		As	5.30	5.3	7.1
Zn		0.2		S	25.56	27.8	25.8
				Total	100.21	99.9	99.7

(1) Yelshishche [Elshitsa] deposit, Bulgaria; by electron microprobe, corresponds to $Cu_{10.92}(Te_{3.23}As_{1.13}Sb_{0.03})_{\Sigma=4.39}S_{12.75}$. (2) Goldfield, Nevada, USA; by electron microprobe, corresponds to $(Cu_{11.12}Ag_{0.09}Zn_{0.05}Fe_{0.03})_{\Sigma=11.29}(Te_{1.81}As_{1.13}Sb_{0.93})_{\Sigma=3.87}S_{13.84}$. (3) Tramway mine, Montana, USA; by electron microprobe, corresponds to $Cu_{11.85}(Te_{2.28}As_{1.53}Sb_{0.93})_{\Sigma=4.74}S_{12.41}$.

Mineral Group: Tetrahedrite group.

Occurrence: In epithermal gold-bearing veins; less commonly in porphyry copper and volcanogenic massive sulfide deposits.

Association: Marcasite, famatinite, tennantite, hessite, petzite, sylvanite, altaite, chalcostibite, emplectite, gold, kuramite, bismuthinite, pyrite, sphalerite.

Distribution: In the USA, in Nevada, from Goldfield, Esmeralda Co., in the Mohawk [TL] and Claremont mines; at the Tramway mine, Butte, Silver Bow Co., Montana; in the Campbell mine, Bisbee, Cochise Co., Arizona; and at the Sweethome mine, Lake City, Hinsdale Co., Colorado. From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In the Bittibulakhsk Cu–As deposit, Lesser Caucasus Mountains, Russia. In the Elshitsa massive sulfide deposit, Srena Gora district, and the Assarel porphyry copper deposit, Bulgaria. At Kremnica (Kremnitz), Slovakia. From the Kawazu mine, Shizuoka Prefecture, and in the Iriki mine, Kagoshima Prefecture, Japan. At Ufuo, Left April River area, Papua New Guinea. From the Marian gold deposit, Luzon, Philippines. In the Peak Hill Au–Cu deposit, New South Wales, Australia.

Name: After the type locality, Goldfield, Nevada, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 384. (2) Dmitriyeva, M.T., Y.A. Yefremov, and V.A. Kovalenker (1987) Crystal structure of As-goldfieldite. Doklady Acad. Nauk SSSR, 297, 687–690 (in Russian). (3) Pohl, D., W. Liessmann, and V.M. Okrugin (1996) Rietveld analysis of selenium-bearing goldfieldites. Neues Jahrb. Mineral., Monatsh., 1-8. (4) Trudu, A.G. and U. Knittel (1998) Crystallography, mineral chemistry and chemical nomenclature of goldfeldite, the tellurian member of the tetrahedrite solid-solution series. Can. Mineral., 36, 1115–1137. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 209.

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Goldichite $KFe^{3+}(SO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As singly- or doubly-terminated lathlike crystals, to 4 mm, flattened on {100} and elongated along [001], with dominant {011}, {100}, and {110}; the latter two may be striated ∥ [001]; in parallel and radiating clusters, aggregated into incrustations.

Physical Properties: *Cleavage:* On {100}, perfect. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 2.43 D(calc.) = 2.461 Slightly soluble in cold H_2O; soluble in hot H_2O with hydrolysis.

Optical Properties: Transparent. *Color:* Pale yellowish green, with a lavender tint under artificial light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Y = colorless to very pale yellow; Z = very pale yellow. *Orientation:* $X = b$; $Y \simeq a$; $Z \wedge c = 9°–11°$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > Y > X$. $\alpha = 1.582–1.584$ $\beta = 1.602(2)$ $\gamma = 1.629–1.639$ 2V(meas.) = n.d. 2V(calc.) = 75°–82°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.387(6)$ $b = 10.486(6)$ $c = 9.086(5)$ $\beta = 101.68(7)°$ Z = 4

X-ray Powder Pattern: Dexter No. 7 mine, Utah, USA.
3.068 (10), 7.35 (9), 10.29 (8), 6.85 (7), 4.00 (6), 3.403 (6), 2.656 (6)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	43.65	44.59	K_2O	12.87	13.11
TiO_2	0.02		Rb_2O	0.03	
Al_2O_3	0.32		H_2O	20.35	20.07
Fe_2O_3	22.16	22.23	insol.	0.23	
Na_2O	0.09		Total	99.72	100.00

(1) Dexter No. 7 mine, Utah, USA; Al_2O_3 from alunogen impurity. (2) $KFe(SO_4)_2 \cdot 4H_2O$.

Occurrence: Cementing fragments in slope debris from an oxidizing pyritiferous Colorado Plateau-type uranium deposit (Dexter No. 7 mine, Utah, USA); coating mine walls in an argillized sulfur deposit formed by underground fumarole activity (Santa Bárbara mine, Argentina).

Association: Alunogen, coquimbite, copiapite, halotrichite (Dexter No. 7 mine, Utah, USA); metavoltine, hexahydrite, ferrinatrite, krausite, halotrichite, voltaite, sulfur, sideronatrite, alunogen, halite (Santa Bárbara mine, Argentina).

Distribution: From the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah, USA. At the Santa Bárbara sulfur mine, El Palmar district, Jujuy Province, Argentina. From the Lanjarón mineral springs, Granada Province, Spain. On the island of Saba, Netherland Antilles.

Name: Honors Dr. Samuel Stephen Goldich (1909–2000), American mineralogist, petrologist, and analytical isotope chemist, Professor of Geology, University of Minnesota, Minneapolis, Minnesota, USA, who analyzed the mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106903.

References: (1) Rosenzweig, A. and E.B. Gross (1955) Goldichite, a new hydrous potassium ferric sulfate from the San Rafael Swell, Utah. Amer. Mineral., 40, 469–480. (2) Zavalía, M.F.M. and M.A. Galliski (1995) Goldichite of fumarolic origin from the Santa Bárbara mine, Jujuy, northwestern Argentina. Can. Mineral., 33, 1059–1062. (3) Graeber, E.J. and A. Rosenzweig (1971) The crystal structures of yavapaiite, $KFe(SO_4)_2$, and goldichite, $KFe(SO_4)_2 \cdot 4H_2O$. Amer. Mineral., 56, 1917–1933.

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Goldmanite $\mathbf{Ca_3(V^{3+}, Al, Fe^{3+})_2(SiO_4)_3}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As dodecahedra, to 0.1 mm; in anhedral grains.

Physical Properties: Hardness = 7 D(meas.) = 3.74–3.77 D(calc.) = 3.765

Optical Properties: Transparent. *Color:* Dark green to brownish green, commonly sector zoned; green to brown in thin section.
Optical Class: Isotropic to weakly anisotropic. $n = 1.821(1)$

Cell Data: *Space Group:* $Ia3d$. $a = 12.06$ Z = 8

X-ray Powder Pattern: Sandy mine, New Mexico, USA.
2.688 (100), 3.005 (65), 1.607 (49), 2.453 (38), 1.951 (22), 1.667 (18), 2.357 (16)

Chemistry:

	(1)	(2)
SiO_2	36.6	35.58
Al_2O_3	4.9	
Fe_2O_3	5.4	0.24
V_2O_3	18.3	28.66
Cr_2O_3		0.88
MnO	0.3	
MgO	0.7	
CaO	33.3	33.06
Total	99.5	98.42

(1) Sandy mine, New Mexico, USA; corresponds to $(Ca_{2.91}Mg_{0.08}Mn_{0.02})_{\Sigma=3.01}(V_{1.20}Al_{0.47}Fe_{0.33})_{\Sigma=2.00}Si_{2.99}O_{12}$. (2) North Sea; by electron microprobe, corresponds to $Ca_{2.98}(V_{1.94}Cr_{0.06}Fe^{3+}_{0.01})_{\Sigma=2.01}Si_{3.00}O_{12}$.

Mineral Group: Garnet group.

Occurrence: In a small metamorphosed U–V deposit in sandstone, embedded in vanadium-rich clays and calcite (Sandy mine, New Mexico, USA); in calcareous metapelites and tungsten-bearing skarns (Coat-an-Noz, France); detrital.

Association: Quartz, calcite, diopside, vesuvianite, wollastonite, epidote, grossular-andradite, biotite, spinel, plagioclase, pyrrhotite, roscoelite, montmorillonite (Sandy mine, New Mexico, USA); plagioclase, titanite, clinopyroxene, actinolite, chlorite, pyrite, arsenopyrite (Coat-an-Noz, France); rhodonite, braunite (Yamoto mine, Japan).

Distribution: In the Sandy mine, near Laguna, Valencia Co., New Mexico, USA. From Coat-an-Noz, Côtes-du-Nord, France. In a deep well in the United Kingdom sector of the North Sea. From Tetetice, Klatovy, Czech Republic. At Ishimskaya Luka, northern Kazakhstan. From the Slyudyanka complex, Sayan Mountains, near Lake Baikal, Siberia, Russia. In the Yamoto mine, Kagoshima Prefecture, Japan.

Name: For Dr. Marcus Isaac Goldman (1881–1965), American sedimentary petrologist, U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 121717, 121953.

References: (1) Moench, R.H. and R. Meyrowitz (1964) Goldmanite, a vanadium garnet from Laguna, New Mexico. Amer. Mineral., 49, 644–655. (2) Novak, G.A. and G.V. Gibbs (1971) The crystal chemistry of the silicate garnets. Amer. Mineral., 56, 791–825. (3) Benkerrou, C. and M. Fonteilles (1989) Vanadian garnets in calcareous metapelites and skarns at Coat-an-Noz, Belle-Isle-en-Terre (Côtes du Nord), France. Amer. Mineral., 74, 852–858. (4) Hallsworth, C.R., A. Livingstone, and A.C. Morton (1992) Detrital goldmanite from the Palaeocene of the North Sea. Mineral. Mag., 56, 117–120.

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Golyshevite $(Na,Ca)_{10}Ca_9(Fe^{3+},Fe^{2+})_2Zr_3NbSi_{25}O_{72}(CO_3)(OH)_3 \cdot H_2O$

Crystal Data: Hexagonal. *Point Group*: 3/*m*. As tabular crystals exhibiting $10\bar{1}\,1\}$, $\{01\bar{1}\,2\}$ and {0001}, to 2 cm.

Physical Properties: *Cleavage*: Imperfect on {0001}. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 5.5 D(meas.) = 2.89(1) D(calc.) = 2.889

Optical Properties: Translucent. *Color*: Brown to reddish brown. *Streak*: White.
Luster: Vitreous.
Optical Class: Uniaxial (-). ω = 1.618(2) ε = 1.628(1) *Pleochroism*: Weak, colorless to yellow.

Cell Data: *Space Group*: *R3m*. *a* = 14.231(3) *c* = 29.984(8) Z = 3

X-ray Powder Pattern: Kovdor massif, Kola Peninsula, Russia.
2.848 (100), 2.971 (78), 4.30 (53), 2.055 (51), 3.200 (46), 2.597 (43), 5.70 (38)

Chemistry:

	(1)		(1)
Na_2O	9.19	SiO_2	48.74
K_2O	0.46	ZrO_2	12.03
CaO	17.24	Nb_2O_5	2.63
MnO	0.69	Cl	0.24
FeO	1.19	H_2O	1.30
Fe_2O_3	4.44	CO_2	1.52
Al_2O_3	0.14	-O = Cl	0.05
La_2O_3	0.15	Total	100.20
Ce_2O_3	0.29		

(1) Kovdor massif, Kola Peninsula, Russia; by electron microprobe analysis, IR and Mössbauer spectroscopy, and TGA; corresponding to $(Na_{9.02}Ca_{0.43}K_{0.30})_{\Sigma=9.75}(Ca_{5.92}Ce_{0.05}La_{0.03})_{\Sigma=6.00}(Fe^{3+}_{1.69}Fe^{2+}_{0.50}Mn_{0.29})_{\Sigma=2.48}Zr_{2.97}(Si_{0.66}Nb_{0.60}Al_{0.08})_{\Sigma=1.34}Si_{24}O_{72}(OH)_{2.37}(CO_3)_{1.05}Cl_{0.21} \cdot 1.01H_2O$.

Mineral Group: Eudialyte group, the CO_3-dominant analog of feklichevite with Si > Nb in the M3 structural site.

Occurrence: In a calcium-rich peralkaline pegmatite.

Association: Cancrinite, aegirine-augite, hedenbergite, orthoclase, pectolite, thomsonite-Ca, tacharanite, calcite.

Distribution: From the northern face of the Mica quarry, pegmatite no. 10, Kovdor massif, Kola Peninsula, Russia.

Name: Honors crystallographer Vladimir Mikhailovich Golyshev (1943-2000), Mordvinian State University, Saransk, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, (3220/1).

References: (1) Chukanov, N.V., M.M. Moiseyev, R.K. Rastsvetayeva, K.A. Rozenberg, and A.E. Zadov (2005) Golyshevite $(Na,Ca)_{10}Ca_9(Fe^{3+},Fe^{2+})_2Zr_3NbSi_{25}O_{72}(CO_3)(OH)_3 \cdot H_2O$, and mogovidite, $Na_9(Ca,Na)_6Ca_6(Fe^{3+},Fe^{2+})_2Zr_3\square Si_{25}O_{72}(CO_3)(OH,H_2O)_4$, new eudialyte-group minerals from calcium-rich agpaitic pegmatites of the Kovdor massif, Kola Peninsula. Zap.Ross. Mineral. Obshch., 134(6), 36-47 (in Russian with English abstract). (2) (2007) Amer. Mineral., 92, 1541 (abs. ref. 1).

Gonnardite $Na_2CaAl_4Si_6O_{20}\cdot 7H_2O$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Fibrous crystals, at the centers of radiating spherulites, to 3 cm; massive.

Physical Properties: Hardness = 5 D(meas.) = 2.25–2.36 D(calc.) = 2.33

Optical Properties: Translucent. *Color:* White, yellowish to salmon-red. *Luster:* Silky. *Optical Class:* Biaxial (+) or (–); commonly zoned. *Orientation:* $X = c$. α = 1.497–1.508 β = 1.498–1.510 γ = 1.499–1.513 2V(meas.) = 50°

Cell Data: *Space Group:* $I\bar{4}2d$. a = 13.21(1) c = 6.622(4) Z = 2

X-ray Powder Pattern: Chaux de Bergonne, France; may be confused with natrolite and tetranatrolite.
2.92 (100), 5.93 (80), 6.70 (60), 4.44 (60), 4.74 (50), 3.23 (50), 3.12 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	43.45	43.20	44.58
Al_2O_3	27.91	27.90	25.22
CaO	6.95	3.61	6.94
Na_2O	8.69	13.16	7.66
H_2O	[13.00]	11.74	15.60
Total	[100.00]	99.61	100.00

(1) Chaux de Bergonne, France; by electron microprobe, H_2O by difference; corresponding to $Na_{2.22}Ca_{0.98}Al_{4.32}Si_{5.71}O_{20}\cdot 5.70H_2O$. (2) Aci Trezza, Sicily, Italy; corresponds to $Na_{3.5}Ca_{0.5}Al_{4.5}Si_{5.9}O_{20.8}\cdot 5.35H_2O$. (3) $Na_2CaAl_4Si_6O_{20}\cdot 7H_2O$.

Mineral Group: Zeolite group.

Occurrence: In cavities in basalt, leucite tephrite, and altered skarn.

Association: Zeolites, calcite.

Distribution: Well characterized material from: in France, at Chaux de Bergonne, Gignat, Puy de Dôme. In Italy, from Capo di Bove, near Rome, Lazio; and at Aci Castello, Aci Trezza, Osilo, and other places on Sardinia. From Arendal, Tvedalen, at Brevik and elsewhere around the Langesundsfjord, Norway. At Klöch, Styria, Austria. From the Schellkopf, near Brenk, Eifel district, and in the Höwenegg quarry, Hegau, Baden-Württemberg, Germany. From Allt Ribhein, Fiskavaig Bay, Isle of Skye, Scotland. In the USA, at Crestmore, Riverside Co., California, and around Honolulu, Oahu, Hawaii. At Mazé, Niigata Prefecture, Japan. A number of other localities are known.

Name: For Ferdinand Gonnard, French mineralogist, Lyons, France, who first noted the mineral.

Type Material: The Natural History Museum, London, England, 1930,166.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 30. (2) Hey, M.H. and F.A. Bannister (1932) Studies on the zeolites. Part II. Thomsonite (including faroelite) and gonnardite. Mineral. Mag., 23, 51–125. (3) Meixner, H., M.H. Hey, and A.A. Moss. (1956) Some new occurrences of gonnardite. Mineral. Mag., 31, 265–271. (4) Mazzi, F., A.O. Larsen, G. Gottardi, and E. Galli (1986) Gonnardite has the tetrahedral framework of natrolite: experimental proof with a sample from Norway. Neues Jahrb. Mineral., Monatsh., 219–228. (5) Nawaz, R. (1988) Gonnardite and disordered natrolite-group minerals: their distinction and relations with mesolite, natrolite and thomsonite. Mineral. Mag., 52, 207–219.

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Gonyerite $(Mn^{2+},Mg)_5Fe^{3+}(Si_3Fe^{3+})O_{10}(OH)_8$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* n.d. In rounded, radial aggregates of lath- and plate-shaped crystals, to several mm; as tiny rosettes of intergrown pseudohexagonal plates.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Cleavage foliae are flexible but inelastic. Hardness = 2.5 D(meas.) = 3.01(4) D(calc.) = 3.03

Optical Properties: Translucent. *Color:* Deep brown with reddish internal reflections, light chocolate-brown; in transmitted light, pale to dark brown.
Optical Class: Biaxial (–). *Pleochroism:* X = dark brown; Z = light brown. $\alpha = 1.646$ $\beta = 1.664$ $\gamma = 1.664$ 2V(meas.) = 0°

Cell Data: *Space Group:* n.d. $a = 5.47$ $b = 9.46$ $c = 28.8$ Z = [4]

X-ray Powder Pattern: Långban, Sweden.
7.23 (10), 3.61 (8), 4.79 (5), 1.574 (5), 14.6 (3), 2.697 (3), 1.634 (3)

Chemistry:

	(1)	(2)
SiO_2	33.06	32.35
Al_2O_3	0.58	0.57
Fe_2O_3	9.42	
FeO		7.30
MnO	33.83	35.50
ZnO	0.42	0.47
PbO	0.56	
MgO	11.55	10.26
CaO	0.07	0.08
F		< 0.05
Cl		0.05
H_2O^+	10.31	[9.89]
H_2O^-	0.02	
$-O = (F,Cl)_2$		[0.05]
Total	99.82	[96.47]

(1) Långban, Sweden; corresponds to $(Mn^{2+}_{3.25}Mg_{1.95}Fe^{3+}_{0.64}Zn_{0.04}Pb_{0.02}Ca_{0.01})_{\Sigma=5.91}$ $(Si_{3.75}Fe^{3+}_{0.17}Al_{0.08})_{\Sigma=4.00}[O_{10.20}(OH)_{7.80}]_{\Sigma=18.00}$. (2) Do.; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $(Mn^{2+}_{3.64}Mg_{1.85}Fe_{0.74}Zn_{0.04}Ca_{0.01})_{\Sigma=6.28}$ $(Si_{3.92}Al_{0.08})_{\Sigma=4.00}O_{10}[(OH)_{7.99}Cl_{0.01}]_{\Sigma=8.00}$.

Mineral Group: Chlorite group.

Occurrence: In hydrothermal veinlets cutting skarn (Långban, Sweden).

Association: Caryopilite, bementite, berzeliite, barite, garnet (Långban, Sweden).

Distribution: From Långban, and at the Harstigen mine, near Persberg, Värmland, Sweden. In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: In honor of Forest A. Gonyer, analytical chemist in the Department of Mineralogy and Petrography, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 112842; National Museum of Natural History, Washington, D.C., USA, 106913; The Natural History Museum, London, England, 1956,190–191.

References: (1) Frondel, C. (1955) Two chlorites: gonyerite and melanolite. Amer. Mineral., 40, 1090–1094. (2) Peacor, D.R. and E.J. Essene (1980) Caryopilite – a member of the friedelite rather than the serpentine group. Amer. Mineral., 65, 335–339.

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Goosecreekite $CaAl_2Si_6O_{16}\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. As equant euhedral crystals, highly curved, to 4 cm; in polycrystalline aggregates.

Physical Properties: *Cleavage:* {010}, perfect. Hardness = ∼4.5 D(meas.) = 2.21 D(calc.) = 2.23

Optical Properties: Transparent. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous to pearly on crystal faces.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 46°$. $\alpha = 1.495(2)$ $\beta = 1.498(2)$ $\gamma = 1.502(2)$ $2V(meas.) = 82(5)°$

Cell Data: *Space Group:* $P2_1$. $a = 7.401(3)$ $b = 17.439(36)$ $c = 7.293(3)$ $\beta = 105.44(4)°$ $Z = 2$

X-ray Powder Pattern: Goose Creek quarry, Virginia, USA.
4.53 (100), 7.19 (50), 5.59 (50), 4.91 (50), 3.350 (40), 3.526 (25), 3.277 (25)

Chemistry:

	(1)
SiO_2	59.3
Al_2O_3	17.2
CaO	9.3
H_2O	15.0
Total	100.8

(1) Goose Creek quarry, Virginia, USA; by electron microprobe, H_2O by DTA-TGA analysis; corresponding to $Ca_{1.01}Al_{2.05}Si_6O_{16.09}\cdot 5.06H_2O$.

Polymorphism & Series: Dimorphous with epistilbite.

Mineral Group: Zeolite group.

Occurrence: A late-stage mineral in vugs and fractures in a Triassic diabase (Goose Creek quarry, Virginia, USA); in cavities in basalt (Nasik, India).

Association: Prehnite, actinolite, chlorite, epidote, babingtonite, quartz, titanite, stilbite, albite, apophyllite (Goose Creek quarry, Virginia, USA); quartz (Nasik, India).

Distribution: In the Goose Creek quarry, Leesburg, Loudoun Co., Virginia, USA. Exceptional crystals from the Pandulena quarry, Nasik, Maharashtra, India. In the Oberbaumühle quarry, Windischeschenbach, Bavaria, Germany.

Name: For the initially described occurrence in the Goose Creek quarry, Virginia, USA.

Type Material: American Museum of Natural History, New York City, New York; Harvard University, Cambridge, Massachusetts, 117087; National Museum of Natural History, Washington, D.C., USA, 145880; Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada; The Natural History Museum, London, England, 1980,579.

References: (1) Dunn, P.J., D.R. Peacor, N. Newberry, and R.A. Ramik (1980) Goosecreekite, a new calcium aluminum silicate hydrate, possibly related to brewsterite and epistilbite. Can. Mineral., 18, 323–327. (2) (1981) Amer. Mineral., 66, 1275 (abs. ref. 1). (3) Rouse, R.C. and D.R. Peacor (1986) Crystal structure of the zeolite mineral goosecreekite $CaAl_2Si_6O_{16}\cdot 5H_2O$. Amer. Mineral., 71, 1494–1501.

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Gorceixite $BaAl_3(PO_4)(PO_3OH)(OH)_6$

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Crystal Data: Monoclinic, pseudorhombohedral. *Point Group: m.* Rare rhombic crystals. May be radial fibrous in spheroidal concretions, to 1 cm; in microcrystalline grains and pebbles.

Physical Properties: *Fracture:* Porcelaneous [*sic*]. Hardness = 6 D(meas.) = 3.036–3.185 D(calc.) = 3.389

Optical Properties: Transparent. *Color:* Colorless, green, brown, may be mottled; colorless in thin section. *Luster:* Vitreous.
Optical Class: Uniaxial (+); anomalous, with low birefringence. *Orientation:* Length positive, parallel extinction. $\omega = 1.610$ $\epsilon = 1.620$

Cell Data: *Space Group: Cm* (probable). $a = 12.195$–12.225 $b = 7.040$–7.056 $c = 7.055$–7.061 $\beta = 125.10°-125.30°$ Z = 2

X-ray Powder Pattern: Big Fish River, Canada.
3.010 (100), 5.769 (93), 3.529 (56), 2.292 (39), 1.9197 (29), 2.232 (23), 1.7626 (20)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	28.11	27.76	BaO	28.9	29.99	S	0.28	
Al_2O_3	30.28	29.92	H_2O	[9.8]	12.33	Total	[100.0]	100.00
SrO	0.28		F	2.3				

(1) Sydney Basin, Australia; by electron microprobe and X-ray fluorescence, H_2O by difference; corresponds to $(Ba_{0.95}Sr_{0.01})_{\Sigma=0.96}Al_{3.02}(PO_4)_{2.01}[(OH),F]_{5.83}$. (2) $BaAl_3(PO_4)(PO_3OH)(OH)_6$.

Mineral Group: Crandallite group.

Occurrence: Probably always a secondary mineral; in novaculites and other sedimentary rocks; in carbonatites; from hydrothermal argillic alteration zones; in topaz greisen; in the fine-grained fraction of soils; commonly as favas in diamantiferous river sands.

Association: Dawsonite, alumohydrocalcite, nordstrandite (Sydney Basin, Australia); lazulite, siderite, "limonite", quartz (Big Fish River, Canada); diamond (river sands, may be coincidental).

Distribution: In Brazil, in Minas Gerais, along the Rio Abaeté, Rio Bagagem, and Rio Douradinho, near Curralinho and Dattas, Diamantina, and in the Araxá carbonatite, containing an estimated 20 million tons; in Goyaz, in the Rio Paranaíba and at Veríssimo; in São Paulo, in the Rio Canoas and at Patrocínio de Sapucahy. At Somabula, Zimbabwe. From the Mrima Hill carbonatite, Kenya. At Issineru, Guiana. In the Bonsa River, near Dompim, Gold Coast. From the Oiyi district, Sierra Leone. In the Buffels River, Spektakel Valley, west of Springbok, Namaqualand, South Africa. From the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In the Zig Zag Mountains, about 10 km northeast of Hot Springs, Garland Co., Arkansas; at the Silver Mine area, Madison Co., Missouri; from Indian Mountain, Cherokee Co., Alabama, USA. In the Hospital quarry, Elgin, Morayshire, Scotland. At the Lengenbach quarry, Binntal, Valais, Switzerland. In Australia, from Glen Alice and elsewhere in the Sydney Basin, New South Wales, and in the Moculta phosphate quarry, northeast of Angaston, South Australia; from the Magnet and Adelaide mines, Dundas, Tasmania. A few other localities are known.

Name: To honor Henrique Gorceix (1842–1919), French mining geologist and mineralogist, Director, School of Mines, Ouro Preto, Brazil.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 833. (2) Radoslovich, E.W. and P.G. Slade (1980) Pseudo-trigonal symmetry and the structure of gorceixite. Neues Jahrb. Mineral., Monatsh., 157–170. (3) Radoslovich, E.W. (1982) Refinement of gorceixite structure in Cm. Neues Jahrb. Mineral., Monatsh., 446–464. (4) Blanchard, F.N. (1989) New X-ray powder data for gorceixite, $BaAl_3(PO_4)_2(OH)_5 \cdot H_2O$, an evaluation of *d*-spacings and intensities, pseudosymmetry and its influence on the figure of merit. Powder Diffraction, 4(4), 227–230.

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Gordaite $NaZn_4(SO_4)(OH)_6Cl \cdot 6H_2O$

Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. As thin tabular flakes with hexagonal outline or as blades, to 2 cm; in rosettelike aggregates.

Physical Properties: *Cleavage:* On {0001}, perfect. *Tenacity:* Flexible. Hardness = ~2.5 D(meas.) = 2.627 D(calc.) = 2.640

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale green if cuprian. *Luster:* Vitreous to pearly.
Optical Class: Uniaxial (–). $\omega = 1.5607(8)$ $\epsilon = 1.5382(4)$

Cell Data: *Space Group:* $P\bar{3}$. $a = 8.3556(3)$ $c = 13.025(1)$ $Z = 2$

X-ray Powder Pattern: San Francisco mine, Chile; strong preferred orientation on {0001}. 12.95 (100), 6.501 (23), 4.339 (15), 3.258 (14), 2.967 (10), 2.523 (6), 2.676 (5)

Chemistry:

	(1)	(2)
SO_3	15.33	12.79
ZnO	52.85	51.99
Na_2O	9.15	4.95
Cl	6.46	5.66
H_2O	12.33	25.89
$-O = Cl_2$	1.46	1.28
Total	94.66	100.00

(1) San Francisco mine, Chile; by electron microprobe, H_2O by CHN analyzer; low analytical total due to loss of H_2O during grinding, Na too high due to peak overlaps with Zn; after adjusting Na_2O to 5.5% from AA, and partitioning H between H_2O and $(OH)^{1-}$ according to crystal-structure analysis, corresponds to $Na_{1.54}Zn_{3.39}(SO_4)_{1.00}(OH)_6Cl_{0.95} \cdot 6H_2O$.
(2) $NaZn_4(SO_4)(OH)_6Cl \cdot 6H_2O$.

Occurrence: In the oxidized portions of a Cu–Zn sulfide deposit (San Francisco mine, Chile); on weathered mine dumps (Helbra, Germany); on the outside oxidized portions of a sea floor chimney formed by the mixing of hydrothermal fluids with sea water (Juan de Fuca Ridge).

Association: Zincian paratacamite, anglesite, hemimorphite, christelite, quartz (San Francisco mine, Chile); connellite, anglesite, chlorian bromargyrite (Helbra, Germany); sphalerite, barite, pyrite, pyrrhotite, sulfur, iron hydroxides (Juan de Fuca Ridge).

Distribution: From the San Francisco mine, two km west of the Sierra Gorda railway station, Sierra Gorda district, Antofagasta, Chile. On the Juan de Fuca Ridge, southwest of Vancouver Island, Canada. From near Helbra, Mansfeld region, Saxony-Anhalt, Germany. At the Kamariza mine, Laurium, Greece.

Name: For the Sierra Gorda, Chile, from which the mineral was first fully characterized.

Type Material: University of Hamburg, Hamburg, Germany.

References: (1) Schlüter, J., K.-H. Klaska, K. Friese, G. Adiwidjaja, and G. Gebhard (1997) Gordaite, $NaZn_4(SO_4)(OH)_6Cl \cdot 6H_2O$, a new mineral from the San Francisco mine, Antofagasta, Chile. Neues Jahrb. Mineral., Monatsh., 155–162. (2) (1998) Amer. Mineral., 83, 185–186 (abs. ref. 1). (3) Adiwidjaja, G., K. Friese, K.-H. Klaska, and J. Schlüter (1997) The crystal structure of gordaite $NaZn_4(SO_4)(OH)_6Cl \cdot 6H_2O$. Zeits. Krist., 212, 704–707. (4) Nasdala, L., T. Witzke, B. Ullrich, and R. Brett (1998) Gordaite $[Zn_4Na(OH)_6(SO_4)Cl \cdot 6H_2O]$: second occurrence in the Juan de Fuca Ridge, and new data. Amer. Mineral., 83, 1111–1116.

Gordonite $MgAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* 1. Rare prismatic to platy crystals, to 2 mm, with dominant basal pedions, many lesser forms, elongated and striated along [001]; typically in bundles and sheaflike aggregates.

Physical Properties: *Cleavage:* {010}, perfect; {100}, fair; {001}, poor.
Fracture: Conchoidal. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.23 D(calc.) = 2.22

Optical Properties: Transparent. *Color:* Smoky white, buff, to colorless, crystals pale pink or pale green on tips; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, pearly on {010}.
Optical Class: Biaxial (+). *Orientation:* $X \simeq \perp \{010\}$. *Dispersion:* $r > v$. $\alpha = 1.534$ $\beta = 1.543$ $\gamma = 1.558$ 2V(meas.) = 73°

Cell Data: *Space Group:* $P1$. $a = 5.246(2)$ $b = 10.532(5)$ $c = 6.975(3)$ $\alpha = 107.51(3)°$ $\beta = 111.03(3)°$ $\gamma = 72.21(3)°$ Z = 1

X-ray Powder Pattern: [Little Green Monster mine, near] Fairfield, Utah, USA.
9.78 (10), 3.17 (8), 2.83 (7), 2.56 (6), 6.32 (5), 4.76 (5), 3.07 (5)

Chemistry:

	(1)	(2)
P_2O_5	32.80	31.80
Al_2O_3	20.68	22.84
MgO	10.01	9.03
H_2O^+	16.80	
H_2O^-	18.20	
H_2O		36.33
Total	98.49	100.00

(1) [Little Green Monster mine, near] Fairfield, Utah, USA. (2) $MgAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$.

Mineral Group: Paravauxite group.

Occurrence: Rare in variscite-rich phosphate nodules in limestones ([Little Green Monster mine, near] Fairfield, Utah, USA); a late-stage hydrothermal mineral in a complex granite pegmatite (Tip Top mine, South Dakota, USA).

Association: Variscite, crandallite, wardite ([Little Green Monster mine, near] Fairfield, Utah, USA); robertsite, collinsite (Tip Top mine, South Dakota, USA); montgomeryite, hydroxylapatite (Milgun Station, Western Australia).

Distribution: In the USA, from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah, and at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota. From Rapid Creek, Yukon Territory, Canada. At the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. In Australia, from 15 km northwest of Milgun Station, Western Australia, and in Oliver's quarry, near Noarlunga, Mount Lofty Ranges, South Australia. On Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia.

Name: To honor Samuel George Gordon (1897–1953), American mineralogist, Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137128.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 975–976. (2) Leavens, P.B. and A.L. Rheingold (1988) Crystal structures of gordonite, $MgAl_2(PO_4)_2(OH)_2(H_2O)_6 \cdot 2H_2O$, and its Mn analog. Neues Jahrb. Mineral., Monatsh., 265–270. (3) Hurlbut, C., Jr. and R. Honea (1962) Sigloite, a new mineral from Llallagua, Bolivia. Amer. Mineral., 47, 1–8 [X-ray data].

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Görgeyite $K_2Ca_5(SO_4)_6 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, tabular on {001}, to 8.5 cm, showing {001}, {100}, {111}, {110}.

Physical Properties: *Cleavage:* On {100}, imperfect. *Fracture:* Splintery to hackly. Hardness = 3.5–4 D(meas.) = 2.90–2.93 D(calc.) = 2.90

Optical Properties: Translucent. *Color:* Colorless, white, pale yellow, greenish yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). α = 1.560 β = 1.569–1.570 γ = 1.584–1.585
2V(meas.) = 79°–80°

Cell Data: *Space Group:* $C2/c$. a = 17.51–17.519 b = 6.822–6.840 c = 18.21–18.252 β = 113.3°−113.33° Z = 4

X-ray Powder Pattern: Ischl salt deposit, Austria.
3.005 (100), 3.164 (70), 2.817 (40), 2.756 (30), 1.841 (25), 1.896 (20), 3.029 (15)

Chemistry:

	(1)	(2)	(3)
SO_3	54.08	54.45	55.03
R_2O_3	0.18		
CaO	30.04	31.02	32.12
SrO		1.20	
Na_2O	1.77	0.15	
K_2O	10.82	10.77	10.79
Cl	0.06		
H_2O^+	2.82		
H_2O^-	0.34		
H_2O		n.d.	2.06
gangue	0.08		
Total	100.19	97.59	100.00

(1) Ischl salt deposit, Austria. (2) Cesano, Italy; by electron microprobe. (3) $K_2Ca_5(SO_4)_6 \cdot H_2O$.

Occurrence: Typically an uncommon secondary mineral in evaporite deposits; in hydrothermal veins.

Association: Glauberite, halite, polyhalite, anhydrite, gypsum (evaporites); cesanite, pyrite (Cesano, Italy).

Distribution: From the Ischl salt deposit, near Salzburg, Austria. In drill core at the edge of the Baccano caldera, Cesano geothermal field, east of Lake Bracciano, Lazio, Italy. From Astakós, Greece. At Praid, Romania. Very large crystals from Inder Lake, Kazakhstan. From Nongle, Sichuan Province, and the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China.

Name: Honors Rolf von Görgey (1886–1915), mineralogist specializing in Austrian salt deposits.

Type Material: Natural History Museum, Vienna, Austria, M474; Harvard University, Cambridge, Massachusetts, USA, 107559.

References: (1) Mayrhofer, H. (1953) Görgeyit, ein neues Mineral aus der Ischler Salzlagerstätte. Neues Jahrb. Mineral., Monatsh., 35–44 (in German). (2) (1954) Amer. Mineral., 39, 403–404 (abs. ref. 1). (3) Braitsch, O. (1965) Zur Gittermetrik des Görgeyit $K_2Ca_5(SO_4)_6 \cdot H_2O$. Neues Jahrb. Mineral., Monatsh., 126–128 (in German). (4) Smith, G.W. and R. Walls (1980) The crystal structure of görgeyite $K_2SO_4 \cdot 5CaSO_4 \cdot H_2O$. Zeits. Krist., 151, 49–60. (5) Mukhtarova, N.N., N.V. Belov, V.R. Kalinin, R.K. Rastsvetaeva, and V.V. Ilyukhin (1980) Crystal structure of gorgeyite $K_2Ca_5(SO_4)_6 \cdot H_2O$. Dokl. Sov. Phys., 25, 323–325 (in Russian).

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Gormanite $Fe_3^{2+}Al_4(PO_4)_4(OH)_6 \cdot 2H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$ or 1. Crystals are elongated along [010], with large {001}, giving a bladelike aspect, with smaller {100}, {102}, {$\overline{1}$02}, {010}, to 1 cm; commonly in radial aggregates. *Twinning:* Polysynthetic around [010], composition plane {001}, universal.

Physical Properties: *Cleavage:* On {001}, poor. Hardness = 4–5 D(meas.) = 3.10–3.13 D(calc.) = 3.10–3.12

Optical Properties: Semitransparent. *Color:* Blue-green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Z$ = colorless; Y = blue. *Orientation:* X (163°,7°); Y (-77.5°,86.5°); Z (12.5°,84°) [using (ϕ,ρ)]. *Dispersion:* $r > v$, very strong. *Absorption:* $Y > X = Z$. $\alpha = 1.619(3)$ $\beta = 1.653(3)$ $\gamma = 1.660(3)$ 2V(meas.) = 53(2)° 2V(calc.) = 56°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 11.79(1)$ $b = 5.11(1)$ $c = 13.61(1)$ $\alpha = 90°50(5)'$ $\beta = 99°00(5)'$ $\gamma = 90°05(5)'$ Z = 2

X-ray Powder Pattern: Yukon Territory, Canada.
3.395 (100), 2.554 (90d), 2.925 (80), 4.761 (60), 3.154 (60d), 3.062 (40), 6.72 (30)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	37.23	38.05	MgO	6.65	8.10
Al_2O_3	25.51	27.33	CaO	0.26	
Fe_2O_3	3.82		H_2O	11.45	12.07
FeO	14.68	14.45	Total	99.91	100.00
MnO	0.31				

(1) Yukon Territory, Canada; Mg, Ca, Al by AA, P by XRF, H_2O by TGA; after removal of quartz 7.0%, corresponds to $(Fe^{2+}_{1.56}Mg_{1.26}Ca_{0.04}Mn_{0.03})_{\Sigma=2.89}(Al_{3.82}Fe^{3+}_{0.36})_{\Sigma=4.18}(PO_4)_4(OH)_{6.32} \cdot 1.69H_2O$. Commonly strongly chemically zoned, although optical property variations are not a guide. (2) $(Fe^{2+},Mg)_3Al_4(PO_4)_4(OH)_6 \cdot 2H_2O$ with Fe^{2+}:Mg = 1:1.

Polymorphism & Series: Forms a series with souzalite.

Occurrence: As low-temperature fracture fillings in phosphate-ironstones (Yukon Territory, Canada); in fractures in tonalite (Bisbee, Arizona, USA).

Association: Souzalite, siderite, ludlamite, oxidized vivianite, arrojadite, kryzhanovskite, quartz (Yukon Territory, Canada); chlorite, calcite, quartz (Bisbee, Arizona, USA).

Distribution: From Rapid Creek, Yukon Territory, Canada. In the USA, in large crystals at Bisbee, Cochise Co., Arizona; in New Hampshire, from the G.E. Smith mine, Newport, Sullivan Co. and the Charles Davis pegmatite, Groton, Grafton Co. At the Tsaobismund pegmatite, 60 km south of Karibib, Namibia.

Name: Honoring Donald Herbert Gorman (1922–), Professor of Mineralogy, Department of Geology, University of Toronto, Toronto, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M35123, M35124, M37368; National Museum of Natural History, Washington, D.C., USA, 137494, 137495, 145741.

References: (1) Sturman, B.D., J.A. Mandarino, M.E. Mrose, and P.J. Dunn (1981) Gormanite, $Fe_3^{2+}Al_4(PO_4)_4(OH)_6 \cdot 2H_2O$, the ferrous analogue of souzalite, and new data for souzalite. Can. Mineral., 19, 381–387. (2) (1982) Amer. Mineral., 67, 622–623 (abs. ref. 1).

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Gortdrumite $Cu_{18}FeHg_6S_{16}(?)$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As anhedral grains, to 200 μm. *Twinning:* Fine lamellar twinning in some grains.

Physical Properties: Hardness = n.d. VHN = 186–230 (10 g load). D(meas.) = n.d. D(calc.) = [6.80]

Optical Properties: Opaque. *Color:* Blackish lead-gray, resembling chalcocite. *Luster:* Metallic. *Anisotropism:* Strong, with colors from grayish white with a bluish tint to blue. R_1–R_2: (400) 28.0–31.4, (420) 28.1–31.4, (440) 28.0–31.3, (460) 27.8–31.2, (480) 27.6–31.1, (500) 27.4–31.1, (520) 27.0–30.8, (540) 26.7–30.5, (560) 26.2–30.0, (580) 25.9–29.5, (600) 25.6–29.0, (620) 25.4–28.6, (640) 25.3–28.4, (660) 25.3–28.2, (680) 25.3–28.1, (700) 25.2–28.0

Cell Data: *Space Group:* n.d. $a = 14.958$ $b = 7.900$ $c = 24.10$ Z = 4

X-ray Powder Pattern: Gortdrum deposit, Ireland.
4.58 (100), 3.38 (70), 2.88 (50), 2.78 (50), 6.03 (40), 3.08 (30), 3.02 (30)

Chemistry:

	(1)	(2)	(3)
Cu	38.68	36.8	
Fe	2.07	2.1	
Hg	41.55	39.6	
S	16.81	21.0	
Total	99.11	99.5	

(1) Gortdrum deposit, Ireland; by electron microprobe, average of four analyses; corresponds to $Cu_{18.58}Fe_{1.13}Hg_{6.32}S_{16.00}$. (2) Do.; by electron microprobe, corresponds to $Cu_{14.15}Fe_{0.92}Hg_{4.82}S_{16.00}$.

Occurrence: Admixed with other sulfide minerals in a vein cutting dolomitized limestone; mineral associations suggest formation at less than 200 °C.

Association: Chalcopyrite, bornite, chalcocite, cinnabar, ferroan dolomite, barite.

Distribution: From the Gortdrum deposit, near Tipperary, Co. Tipperary, Ireland [TL].

Name: For the type locality, the Gortdrum deposit, Ireland.

Type Material: The Natural History Museum, London, England, 1983,62.

References: (1) Steed, G.M. (1983) Gortdrumite, a new sulphide mineral containing copper and mercury, from Ireland. Mineral. Mag., 47, 35–36. (2) (1984) Amer. Mineral., 69, 407 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 210.

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Goslarite $ZnSO_4 \cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. Typically stalactitic or in efflorescent crusts; fibrous, granular or massive.

Physical Properties: *Cleavage:* On {010}, perfect. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 1.98(5) D(calc.) = 1.972 Soluble in H_2O, taste astringent, metallic, nauseous; dehydrates in air; strongly diamagnetic.

Optical Properties: Transparent. *Color:* Colorless, white; pale shades of blue, green, or brown from impurities; colorless in transmitted light. *Luster:* Vitreous, silky if fibrous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, weak.
$\alpha = 1.463$ $\beta = 1.475$ $\gamma = 1.480$ 2V(meas.) = Small to moderate.

Cell Data: *Space Group:* $P2_12_12_1$. $a = 11.779$ $b = 12.050$ $c = 6.822$ Z = 4

X-ray Powder Pattern: Synthetic.
4.21 (100), 5.36 (80), 4.18 (50), 5.29 (35), 2.867 (35), 2.651 (30), 4.46 (25)

Chemistry:

	(1)	(2)
SO_3	27.29	27.84
FeO	1.12	
MnO	1.24	
NiO	0.06	
ZnO	23.12	28.30
MgO	0.81	
H_2O	42.42	43.86
insol.	3.65	
Total	99.71	100.00

(1) Ushaw Moor, Durham, England. (2) $ZnSO_4 \cdot 7H_2O$.

Polymorphism & Series: Forms a series with epsomite.

Occurrence: A secondary mineral in oxidized portions of zinc sulfide deposits, particularly as coatings on walls of mine passages.

Association: Epsomite, melanterite, pickeringite, chalcanthite, gypsum.

Distribution: Widespread as post-mining efflorescences. A few notable localities include: in Germany, from the Rammelsberg mine, near Goslar, Harz Mountains, and at Freiberg and Altenberg, Saxony. From Baňská Štiavnica (Schemnitz), Slovakia. At Falun, Sweden. From Sain-Bel, near Lyon, Rhône, France. At the Almagrera mine, Tharsis, Huelva Province, Spain. In Italy, at Capanne Vecchie, Elba, and Raibl, Venezia Giulia. At Broken Hill, New South Wales, Australia. In the USA, in Arizona, at Bisbee, Cochise Co. and many other districts; from the Central district, Grant Co., New Mexico; at Island Mountain, Trinity Co., California; from Butte, Silver Bow Co., Montana; at Bingham Canyon, Salt Lake Co., Utah; in the Comstock Lode, Storey Co., Nevada; at Friedensville, Lehigh Co., Pennsylvania. From Quebrada de La Alcaparrosa, San Juan Province, Argentina.

Name: For the locality at Goslar, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 513–516. (2) (1959) NBS Circ. 539, 8, 71–73.

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Götzenite **$Na_2Ca_5Ti(Si_2O_7)_2F_4$**

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals prismatic, acicular, to 1 cm, may be skeletal. *Twinning:* Lamellar twinning on {001}, twin axis [010], ubiquitous.

Physical Properties: *Cleavage:* Perfect on {100}, good on {001}. Hardness = n.d. D(meas.) = 3.03–3.14 D(calc.) = [2.84]

Optical Properties: Transparent. *Color:* Colorless, white to honey-yellow. *Luster:* Greasy. *Optical Class:* Biaxial (+). *Orientation:* $Z' \wedge c \simeq 58°$. *Dispersion:* $r > v$, strong. $\alpha = 1.651–1.660$ $\beta = 1.653–1.662$ $\gamma = 1.659–1.670$ 2V(meas.) = 52°–84° 2V(calc.) = 53.5°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.667$ $b = 5.731$ $c = 7.334$ $\alpha = 90°$ $\beta = 101.05°$ $\gamma = 101.31°$ Z = 1

X-ray Powder Pattern: Mt. Shaheru, Congo.
3.100 (100), 2.986 (100), 1.911 (50), 2.648 (40), 2.511 (25), 1.696 (25), 3.994 (15)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	32.50	32.34	34.01	BaO	0.09	0.00	
TiO_2	9.72	8.74	11.31	Na_2O	4.85	6.32	8.77
ZrO_2		0.19		K_2O	0.14	0.09	
Al_2O_3	4.26	0.45		F	8.33	9.15	10.76
RE_2O_3		1.84		Cl	0.15	0.00	
Fe_2O_3	0.35	0.02		H_2O^+	0.26	0.57	
Nb_2O_5		3.36		H_2O^-	0.14	0.04	
FeO	0.45	0.14		CO_2	0.00		
MnO	0.07	0.62		P_2O_5	0.01	0.00	
MgO	0.29	0.04		SO_3	0.19	0.00	
CaO	41.80	38.95	39.68	$-O = (F, Cl)_2$	3.54	3.85	4.53
SrO	0.00	0.87		Total	100.06	99.88	100.00

(1) Mt. Shaheru, Congo. (2) Lovozero massif, Russia. (3) $Na_2Ca_5Ti(Si_2O_7)_2F_4$.

Occurrence: In a nephelinite from the wall of the crater of an extinct volcano (Mt. Shaheru, Congo); in hornfels and marble xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Combeite (Mt. Shaheru, Congo); aegirine, apatite, fersmanite, pectolite (Kola Peninsula, Russia); cancrinite, fluorite, titanite (Azov region, Ukraine).

Distribution: On Mt. Shaheru, the extinct southern cone of Mt. Nyiragongo, Kivu Province, Congo (Zaire). In Russia, from Mt. Yukspor, Khibiny massif, and the Lovozero massif, Kola Peninsula. At Barkevik, Langesundsfjord, Norway. From the Azov region, Ukraine. Near Kirchberg, Saxony; in the Kaiserstuhl, Baden-Württemberg; and around the Laacher See, Eifel district, Germany. At Mont Saint-Hilaire, Quebec, Canada.

Name: For Count Gustav Adolph von Götzen (1886–?), noted German traveller who climbed Mt. Shaheru, Congo (Zaire), in 1894.

Type Material: The Natural History Museum, London, England, 1957,702; Royal Museum of Central Africa, Tervuren, Belgium, RGM8037; National Museum of Natural History, Washington, D.C., USA, 142981.

References: (1) Sahama, T.G. and K. Hytönen (1957) Götzenite and combeite, two new silicates from the Belgian Congo. Mineral. Mag., 31, 503–510. (2) (1958) Amer. Mineral., 43, 790

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(abs. ref. 1). (3) Sahama, G. (1960) Identity of calcium rinkite and götzenite. Amer. Mineral., 45, 221–224. (4) Cannillo, E., F. Mazzi, and G. Rossi (1972) Crystal structure of götzenite. Kristallografiya (Sov. Phys. Crystal.), 16, 1167–1172 (in Russian). (5) Bulakh, A.G. and Y.L. Kapustin (1973) Götzenite from alkaline rocks of the Tur'ev Peninsula (Kola Peninsula). Zap. Vses. Mineral. Obshch., 102, 464–466 (in Russian). (6) (1974) Mineral. Abs., 25, 130 (abs. ref. 5). (7) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 343–347.

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Goudeyite $(Al,Y)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6 (probable). Crystals are hairlike hexagonal prisms, elongated along [0001], to 1 cm, in tufted groups and cross-fiber veinlets.

Physical Properties: Hardness = 3–4 D(meas.) = 3.50(3) D(calc.) = [3.49]

Optical Properties: Semitransparent. *Color:* Yellow-green, blue-green.
Optical Class: Uniaxial (+). *Pleochroism:* O = pale yellow-green; E = green.
Absorption: $O < E$. $\omega = 1.704$–1.705 $\epsilon = 1.765$–1.772

Cell Data: *Space Group:* [$P6_3/m$ or $P6_3$] (by analogy to mixite). $a = 13.472(1)$ $c = 5.902(4)$ Z = [2]

X-ray Powder Pattern: Majuba Hill, Nevada, USA; identical to mixite.
11.63 (100), 2.920 (50), 3.235 (46), 2.546 (46), 4.41 (43), 2.677 (42), 3.367 (20)

Chemistry:

	(1)
P_2O_5	4.55
As_2O_5	27.85
Al_2O_3	4.00
Y_2O_3	3.40
CuO	46.77
CaO	1.37
H_2O	11.00
Total	98.94

(1) Majuba Hill, Nevada, USA; by electron microprobe, average of five analyses, H_2O by weight loss to 600 °C; corresponds to $(Al_{0.77}Y_{0.29})_{\Sigma=1.06}(Cu_{5.80}Ca_{0.24})_{\Sigma=6.04}[(AsO_4)_{2.40}(PO_4)_{0.63}]_{\Sigma=3.03}(OH)_{6.17} \cdot 2.95H_2O$.

Mineral Group: Mixite group.

Occurrence: A rare secondary mineral in a hydrothermal Cu–Sn orebody in rhyolite porphyries and breccias (Majuba Hill, Nevada, USA).

Association: Olivenite, clinoclase, cornwallite, strashimirite, scorodite, pharmacosiderite, arthurite, metazeunerite, chalcanthite, chrysocolla, spangolite, chalcophyllite, malachite, azurite, brochantite (Majuba Hill, Nevada, USA); malachite, montmorillonite (Chessy, France).

Distribution: From the Majuba Hill mine, Antelope district, Pershing Co., Nevada, USA. In the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate, Germany. At Chessy, near Lyon, Rhône, France. Large crystals from Tsumeb, Namibia.

Name: To honor Hatfield Goudey (1906–1985), American economic geologist, mineral collector and dealer in microscopic specimens, San Mateo, California, USA, who contributed to knowledge of the type locality.

Type Material: University of California, Santa Barbara, California, 8091; National Museum of Natural History, Washington, D.C., USA, 144005.

References: (1) Wise, W.S. (1978) Parnauite and goudeyite, two new copper arsenate minerals from the Majuba Hill mine, Pershing County, Nevada. Amer. Mineral., 63, 704–708. (2) Sarp, H., J. Bertrand, and J. Deferne (1981) Présence de goudeyite, $Cu_6Al(AsO_4)_2(OH)_6 \cdot 3H_2O$ [*sic*], dans des échantillons provenant de l'ancienne mine de Chessy (Rhône, France). Schweiz. Mineral. Petrog. Mitt., 61, 173–176 (in French with English abs.).

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Gowerite $CaB_6O_8(OH)_4 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic to acicular crystals, striated and elongated along [001], to 1.5 mm; typically as globular clusters of divergent bladed crystals.

Physical Properties: *Cleavage:* {001}, distinct; {100}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.00(1) D(calc.) = 2.003 Slowly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, white in aggregates; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 27°$. *Dispersion:* $r > v$, slight.
$\alpha = 1.484(2)$ $\beta = 1.501(2)$ $\gamma = 1.550(2)$ 2V(meas.) = n.d. 2V(calc.) = 63°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.882(4)$ $b = 16.360(7)$ $c = 6.558(4)$
$\beta = 121.62(5)°$ Z = 4

X-ray Powder Pattern: Death Valley, California, USA.
8.23 (100), 9.20 (25), 4.094 (20), 3.88 (10b), 3.345 (10), 6.57 (5), 5.37 (5)

Chemistry:

	(1)	(2)
B_2O_3	58.10	58.83
CaO	15.50	15.80
SrO	0.71	
H_2O	25.76	25.37
Total	100.07	100.00

(1) Death Valley, California, USA; average of two analyses, Sr by flame photometry, H_2O by TGA; corresponds to $Ca_{1.00}B_{5.90}O_8(OH)_4 \cdot 3.05H_2O$. (2) $CaB_6O_8(OH)_4 \cdot 3H_2O$.

Occurrence: A rare weathering product of colemanite and priceite.

Association: Meyerhofferite, nobleite, hydroboracite, ulexite, ginorite, gypsum.

Distribution: From the Hard Scramble claim, the Mott colemanite prospect, and two other nearby occurrences south of Furnace Creek Wash, Death Valley, Inyo Co., California, USA.

Name: To honor Harrison Preston Gower (1890–1967), Mining Manager, U.S. Borax and Chemical Company, for his assistance to scientific studies of Death Valley borate deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 136417, 147960.

References: (1) Erd, R.C., J.F. McAllister, and H. Almond (1959) Gowerite, a new hydrous calcium borate, from the Death Valley region, California. Amer. Mineral., 44, 911–919.
(2) Christ, C.L. and J.R. Clark (1960) X-ray crystallography and crystal chemistry of gowerite, $CaO \cdot 3B_2O_3 \cdot 5H_2O$. Amer. Mineral., 45, 230–234. (3) Konnert, J.A., J.R. Clark, and C.L. Christ (1972) Gowerite, $CaB_5O_8(OH) \cdot B(OH)_3 \cdot 3H_2O$: crystal structure and comparison with related borates. Amer. Mineral., 57, 381–396.

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Goyazite **$SrAl_3(PO_4)(PO_3OH)(OH)_6$.**

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Rhombohedral crystals, to 2 cm, pseudocubic or flattened on {0001}, with $\{10\overline{1}2\}$ striated $\perp$ [0001], $\{20\overline{2}1\}$, $\{01\overline{1}1\}$, small {0001}, may be composite; massive, in detrital pebbles and grains.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 4.5–5 D(meas.) = 3.26 D(calc.) = 3.29

Optical Properties: Transparent. *Color:* Colorless, pink, lilac, honey-yellow, orange; colorless in transmitted light. *Luster:* Greasy to resinous, pearly on cleavages.
Optical Class: Uniaxial (+), may be anomalously biaxial, sectored. *Pleochroism:* Weak in thick grains; O = light pink; E = yellowish or greenish. ω = 1.620–1.635 ϵ = 1.630–1.651 2V(meas.) = $\leq 30°$

Cell Data: *Space Group:* $R\overline{3}m$. a = 7.015(3) c = 16.558(6) Z = 3

X-ray Powder Pattern: Rapid Creek, Canada. (ICDD 34-152).
2.965 (100), 5.704 (65), 2.209 (45), 3.511 (40), 2.765 (20), 1.903 (20), 2.991 (13)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	28.92	28.9	30.75	BaO	4.00	5.1	
SiO_2	0.96	0.2		Na_2O	0.40		
Al_2O_3	32.30	33.9	33.14	K_2O	0.34		
Fe_2O_3	0.90			F	1.93	2.8	
MgO		0.3		H_2O	12.00	[13.2]	13.66
CaO		2.0		$-O = F_2$	0.81	[1.2]	
SrO	18.43	14.8	22.45	Total	99.37	[100.0]	100.00

(1) Oxford Co., Maine, USA. (2) Alto Bernardino, Brazil; by electron microprobe, H_2O by difference. (3) $SrAl_3(PO_4)(PO_3OH)(OH)_6$.

Mineral Group: Crandallite group.

Occurrence: In granite pegmatites; from hydrothermal argillic alteration zones; in kaolinitic claystones derived from air-fall volcanic tuffs; in carbonatites; detrital.

Association: Herderite, apatite, quartz (Alto Bernardino, Brazil); monazite, sphalerite, pyrite, barite, quartz (Wigu carbonatite, Tanzania); kaolinite (alteration zones); diamonds (river sands; may be coincidental).

Distribution: In Brazil, from the Serra de Congonhas, near Diamantina, Minas Gerais, and at Alto Bernardino, about 20 km northwest of Picuí, Paraíba. In the USA, from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; in Maine, in Oxford Co., in the Bennett quarry, Buckfield, the Harvard quarry, Greenwood, the Mt. Mica quarry, Paris, at Lord Hill, Stoneham, and elsewhere. In Colorado, along the Dakota hogback, from Turkey Creek, Jefferson Co., to Boxelder Creek, Larimer Co.; at the Apex mine, near St. George, Washington Co., Utah. Large crystals from the Rapid Creek-Big Fish River area, Yukon Territory, Canada. In Germany, large crystals from the Fuchsbau quarry, Fichtelgebirge, Bavaria; at Ehrenfriedersdorf, Saxony. In the Simplon Tunnel, and at Lengenbach, Binntal, Valais, Switzerland. From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire). In the Wigu carbonatite, about 64 km south of Morogoro, Tanzania. From near Myponga Beach, Fleurieu Peninsula, South Australia. Other localities are known but may require confirmation of composition.

Name: For Goiás [Goyaz] State, Brazil.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 834–835. (2) White, J.S. (1981) Barian goyazite from Brazil. Mineral. Record, 12, 379. (3) Kato, T. (1987) Further refinement of the goyazite structure. Mineral. J. (Japan), 13, 390–396.

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Graemite $CuTe^{4+}O_3 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As divergent bladed crystals, with {100}, {010}, {001}, {021}, to 8 mm.

Physical Properties: *Cleavage:* On {010}, good; on {100}, a parting. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 4.13(9) D(calc.) = 4.24

Optical Properties: Translucent. *Color:* Blue-green, jade-green. *Streak:* Pale blue-green. *Luster:* [Vitreous.]
Optical Class: Biaxial (+). *Pleochroism:* Moderate; X = yellowish green; $Y = Z$ = blue-green. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Absorption:* $Y > X = Z$ $\alpha = 1.920(3)$ $\beta = 1.960(3)$ $\gamma = 2.20(0.5)$ 2V(meas.) = n.d. 2V(calc.) = 48.5°

Cell Data: *Space Group:* *Pcmm* (probable). $a = 6.805(6)$ $b = 25.613(15)$ $c = 5.780(6)$ Z = 10

X-ray Powder Pattern: Cole shaft, Arizona, USA.
6.395 (10), 3.434 (8), 12.803 (5), 2.558 (5), 2.873 (4), 2.343 (4), 5.640 (3)

Chemistry:

	(1)	(2)
TeO_2	61.2	62.06
CuO	31.0	30.93
H_2O	8.2	7.01
Total	100.4	100.00

(1) Cole shaft, Arizona, USA; average of three analyses, H_2O by the Penfield method, average of two determinations, $(TeO_3)^{4+}$ confirmed by microchemical tests; corresponds to $Cu_{0.98}(TeO_3)_{0.96} \cdot 1.14H_2O$. (2) $CuTeO_3 \cdot H_2O$.

Occurrence: A rare dehydration product of teineite, as pseudomorphs and incrustations.

Association: Teineite, malachite, cuprite (Cole mine, Arizona, USA); teineite, malachite, brochantite, djurleite, bornite, weissite, gold, goethite (Dome Rock Mountains, Arizona, USA).

Distribution: In the USA, in Arizona, from the Cole shaft and in the Shattuck mine, Bisbee, Warren district, Cochise Co., and in the Dome Rock Mountains, La Paz Co.

Name: Honors Richard Graeme (1941–), American mining engineer and mineral collector, Phelps Dodge Corporation, USA, who found the first specimen.

Type Material: n.d.

References: (1) Williams, S.A. and P. Matter III (1975) Graemite, a new Bisbee mineral. Mineral. Record, 6, 32–34. (2) (1975) Amer. Mineral., 60, 486 (abs. ref. 1).

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Graftonite $(Fe^{2+}, Mn^{2+}, Ca)_3(PO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very rare crude crystals, stout prismatic; usually massive, cleavable, in laminated intergrowths with triphylite, to 0.5 m.

Physical Properties: *Cleavage:* On {010}, good; on {100}, fair. *Fracture:* Uneven to subconchoidal. Hardness = 5 D(meas.) = 3.67–3.79 D(calc.) = [3.71]

Optical Properties: Semitransparent. *Color:* Salmon-pink to reddish brown, dark brown when altered; in transmitted light, nearly colorless. *Streak:* White to pale pink. *Luster:* Vitreous towards resinous.
Optical Class: Biaxial (+). *Pleochroism:* Faint; $X = Y$ = colorless; Z = pink. *Orientation:* $X = b$; $Z \wedge c = -36°$. *Dispersion:* $r > v$ or $r < v$, strong. $\alpha = 1.695–1.709$ $\beta = 1.699–1.714$ $\gamma = 1.719–1.736$ 2V(meas.) = 50°–60°

Cell Data: *Space Group:* $P2_1/c$. $a = 8.87–8.91$ $b = 11.57–11.58$ $c = 6.17–6.24$ $\beta = 98°54'–99°12'$ Z = 4

X-ray Powder Pattern: Greenwood, Maine, USA.
2.867 (10), 3.50 (9), 2.715 (7), 3.01 (4), 4.30 (3), 2.953 (3), 2.410 (2)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	41.20	39.66	Na_2O		0.28
Al_2O_3		0.20	$(Li, Na)_2O$	0.33	
Fe_2O_3		0.00	K_2O		0.00
FeO	30.65	30.70	F		0.20
MnO	17.62	21.81	H_2O	0.75	0.60
MgO	0.40	0.10	$-O = F_2$		0.08
CaO	9.23	6.00	insol.		0.16
Li_2O		0.05	Total	100.18	99.68

(1) Grafton, New Hampshire, USA. (2) Nickel Plate mine, South Dakota, USA; corresponds to $(Fe^{2+}_{1.52}Mn^{2+}_{1.09}Ca_{0.38}Na_{0.03}Al_{0.02}Mg_{0.01}Li_{0.01})_{\Sigma=3.06}(PO_4)_{1.98}$.

Polymorphism & Series: Forms a series with beusite.

Occurrence: A primary mineral or exsolution product in complex granite pegmatites.

Association: Triphylite, lithiophilite, sarcopside, ferrisicklerite, heterosite, arrojadite, fairfieldite, barbosalite, huréaulite, almandine, zircon, albite, muscovite, biotite.

Distribution: In the USA, on Melvin Mountain, about eight km west of Grafton, at the Palermo #1 and Rice mines, near North Groton, Grafton Co., at the Parker Mountain quarry, Center Strafford, Strafford Co., and many other places in New Hampshire; from the Waisenen quarry, Greenwood, Oxford Co., Maine; in the Bull Moose mine, five km southeast of Custer, Custer Co., and at the Nickel Plate mine, 1.5 km south of Keystone, Pennington Co., South Dakota. From near São Luiz do Paraitinga, São Paulo, and the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. At the Ranquel and Cacique Canchuleta mines, San Luis, Argentina. From Sidi Bou Othmane, Morocco. In the Valle della Madonna, Brissago, Tessin, Switzerland. At Olgiasca, Lake Como, Lombardy, Italy. From Hagendorf, Bavaria, Germany. In the Kondakov district, eastern Siberia, Russia. Additional localities continue to be recognized.

Name: For its first-noted occurrence near Grafton, New Hampshire, USA.

Type Material: Yale University, New Haven, Connecticut, 3.2345; National Museum of Natural History, Washington, D.C., USA, C4037, R5183.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 686–688. (2) Lindberg, M.L. (1950) Arrojadite, hühnerkobelite, and graftonite. Amer. Mineral., 35, 59–76. (3) Calvo, C. (1968) The crystal structure of graftonite. Amer. Mineral., 53, 742–750. (4) Nord, A.G. and T. Ericsson (1982) The cation distribution in synthetic $(Fe, Mn)_3(PO_4)_2$ graftonite-type solid solutions. Amer. Mineral., 67, 826–832.

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Grandaite $Sr_2Al(AsO_4)_2(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/m. As platy tablets; typically as thin fan-like masses to ~1 cm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 6-6.5 D(meas.) = n.d. D(calc.) = 4.378

Optical Properties: Translucent. *Color*: Bright orange to salmon to brown.
Streak: Reddish brown. *Luster*: Waxy to vitreous.
Optical Class: Biaxial (+). α = 1.726(1) β = 1.731(1) γ = 1.752(1) 2V(meas.) = 52(2)°
2V(calc.) = 53°

Cell Data: *Space Group*: $P2_1/m$. a = 7.5764(5) b = 5.9507(4) c = 8.8050(6)
β = 112.551(2)° Z = 2

X-ray Powder Pattern: Valletta mine, Piedmont, Italy.
3.194 (100), 2.705 (65), 2.981 (51), 2.087 (51), 2.922 (40), 2.743 (31), 1.685 (24)

Chemistry:

	(1)	(2)
SrO	29.81	41.68
CaO	7.28	
BaO	1.56	
Al_2O_3	7.07	10.23
Fe_2O_3	2.34	
Mn_2O_3	1.88	
MgO	1.04	
PbO	0.43	
As_2O_5	44.95	46.28
V_2O_5	0.50	
P_2O_5	0.09	
H_2O	1.83	1.81
Total	98.78	100.00

(1) Valletta mine, Piedmont, Italy; average of 8 electron microprobe analyses, H_2O calculated from structure refinement, OH^- and $(AsO_4)^{3-}$ confirmed by Raman and IR spectroscopy; corresponding to $(Sr_{1.41}Ca_{0.64}Ba_{0.05}Pb_{0.01})_{\Sigma=2.11}(Al_{0.68}Fe^{3+}_{0.14}Mn^{3+}_{0.12}Mg_{0.13})_{\Sigma=1.07}[(As_{0.96}V_{0.01})_{\Sigma=0.97}O_4]_2(OH)$.
(2) $Sr_2Al(AsO_4)_2(OH)$.

Occurrence: From a small Fe-Mn-As deposit in metamorphosed quartzites (high-P, low-T blueschist facies).

Association: Aegirine, adelite, barite, braunite, hematite, quartz, tilasite.

Distribution: Found on the dumps of the Valletta mine, Valletta Valley, Canosio municipality, Maira Valley, Cuneo province, Piedmont, Italy.

Name: For the informal appellation of the Province where the Valletta mine is located - called ‘‘la *Granda*’’ (the Big One) for its considerable areal extent, one of the biggest in Italy.

Type Material: At the Museo Regionale di Scienze Naturali di Torino, Sezione di Mineralogia, Petrografia e Geologia, Torino, Italy (# M/15999), and the mineralogical collection, Museo Civico Archeologico e di Scienze Naturali “Federico Eusebio”, Alba, Cuneo, Italy (#G. 1723 prog. 505).

References: (1) Cámara, F., M.E. Ciriotti, E. Bittarello, F. Nestola, F. Massimi, F. Radica, E. Costa, P. Benna, and G.C. Piccoli (2014) Arsenic-bearing new mineral species from Valletta mine, Maira Valley, Piedmont, Italy: I. Grandaite, $Sr_2Al(AsO_4)_2(OH)$, description and crystal structure. Mineral. Mag., 78(3), 757-774. (2) (2015) Amer. Mineral., 100, 335 (abs. ref. 1).

Grandidierite $(Mg, Fe^{2+})Al_3(BO_3)(SiO_4)O_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As anhedral elongated individuals, to 8 cm, typically strongly corroded.

Physical Properties: *Cleavage:* {100}, more perfect, and {010}. Hardness = 7.5
D(meas.) = 2.98–2.99 D(calc.) = [3.00]

Optical Properties: Transparent to translucent. *Color:* Bluish green, greenish blue with increasing Fe; in thin section, colorless to blue or green. *Luster:* Vitreous, somewhat pearly on the cleavage.
Optical Class: Biaxial (–). *Pleochroism:* X = deep blue to blue-green; Y = colorless; Z = light greenish blue to deep green. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, very strong. *Absorption:* $Z > X > Y$. α = 1.590–1.602 β = 1.618–1.636 γ = 1.623–1.639
2V(meas.) = 27°–32°

Cell Data: *Space Group: Pbnm.* $a = 10.335(2)$ $b = 10.978(2)$ $c = 5.760(2)$ Z = 4

X-ray Powder Pattern: Sakatelo, Madagascar.
5.17 (vvs), 5.04 (vvs), 5.482 (vs), 2.744 (vs), 2.166 (s), 3.708 (ms), 2.584 (ms)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	20.39	19.9	19.77	MnO	0.04	0.12	
TiO_2	0.13	0.02		MgO	12.04	9.2	6.63
B_2O_3	11.57	n.d.	11.45	CaO	0.00	0.00	
Al_2O_3	52.12	50.35	50.33	Na_2O	0.04	0.01	
Fe_2O_3	0.80			K_2O	0.09	0.04	
FeO	2.87	7.75	11.82	Total	100.09	87.39	100.00

(1) Sakatelo, Madagascar; corresponds to $(Mg_{0.87}Fe^{2+}_{0.12}Fe^{3+}_{0.03})_{\Sigma=1.02}Al_{3.00}(B_{0.97}O_3)(Si_{0.99}O_4)O_2$.
(2) Mt. Amiata, Italy; by electron microprobe, corresponds to $(Mg_{0.69}Fe_{0.32})_{\Sigma=1.01}$ $Al_{2.98}(BO_3)(Si_{1.00}O_4)O_2$. (3) $(Mg, Fe)Al_3(BO_3)(SiO_4)O_2$ with Mg:Fe = 1:1.

Occurrence: A rare accessory mineral in aluminous boron-rich rocks, thermally and high-grade regionally metamorphosed under low pressure; in pegmatites, aplites, gneisses; in xenoliths.

Association: Quartz, potassic feldspar, plagioclase, biotite, garnet, "hypersthene," spinel, corundum, sillimanite, andalusite, cordierite, tourmaline, kornerupine, sapphirine, serendibite, sinhalite.

Distribution: In large crystals from Andrahomana, southwest of Taolañaro (Fort Dauphin); at Marotrana, Amboasara; from Vohiboly, near Behara; Ampamatoa; and elsewhere on Madagascar. In the Kachebere Hills, Mchinji district, Malawi. From Tizi-Ouchen, Béjaia, Algeria. From near Gananoque, Ontario, Canada. At Johnsburg, Warren Co., New York, USA. On Mt. Amiata and Mt. Cimino, Tuscany, Italy. Around Vestpolltind, and on Almjotheia, 12 km north of Moi, Norway. At Maratakka, Surinam. On Cuvier Island, New Zealand. Known from a number of other minor localities.

Name: For Alfred Grandidier (1836–1912), French naturalist and explorer, an authority on Madagascar.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 86382.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 47. (2) McKie, D. (1965) The magnesium aluminum borosilicates: kornerupine and grandidierite. Mineral. Mag., 34, 346–357. (3) Stephenson, D.A. and P.B. Moore (1968) The crystal structure of grandidierite, $(Mg, Fe)Al_3SiBO_9$. Acta Cryst., 24, 1518–1522. (4) Van Bergen, M.J. (1980) Grandidierite from aluminous metasedimentary xenoliths within acid volcanics, a first record in Italy. Mineral. Mag., 43, 651–658.

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Grandreefite $Pb_2(SO_4)F_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladelike to prismatic crystals, to 7 mm, with {120}, {130}, {101}, {293}, {$2\bar{9}3$}. *Twinning:* Coarse polysynthetic twins of undetermined law observed only in transmitted light under crossed polars.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼2.5
D(meas.) = 7.0(1) D(calc.) = 7.15 Decomposed by H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White.
Luster: Subadamantine.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, weak.
$\alpha = 1.872(5)$ $\beta = 1.873(5)$ $\gamma = 1.897(5)$ 2V(meas.) = Very small. 2V(calc.) = 23°

Cell Data: *Space Group:* $A2/a$. $a = 8.667(1)$ $b = 4.4419(6)$ $c = 14.242(2)$
$\beta = 107.418(2)°$ Z = 4

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
3.159 (100), 3.116 (90), 3.084 (80), 1.806 (60), 2.281 (50), 1.824 (50), 1.370 (50b)

Chemistry:

	(1)	(2)
SO_3	13.8	14.60
PbO	82.9	81.39
F	7.1	6.93
$-O = F_2$	3.0	2.92
Total	100.8	100.00

(1) Grand Reef mine, Arizona, USA: by electron microprobe, absence of H_2O confirmed by IR spectroscopy, corresponds to $Pb_{2.07}S_{0.96}O_{3.92}F_{2.08}$. (2) $Pb_2(SO_4)F_2$.

Occurrence: A rare secondary mineral in isolated vugs in the oxidized portions of a breccia-hosted hydrothermal Cu–Pb–Ag deposit.

Association: Pseudograndreefite, laurelite, aravaipaite, galena, fluorite, anglesite.

Distribution: From the Grand Reef mine, about six km northeast of Klondyke, Aravaipa district, Graham Co., Arizona, USA.

Name: For the Grand Reef mine, Arizona, USA.

Type Material: Natural History Museum, Los Angeles, California, USA, 33608; National Museum of Natural History, Washington, D.C., USA, 166055.

References: (1) Kampf, A.R., P.J. Dunn, and E.E. Foord (1989) Grandreefite, pseudograndreefite, laurelite, and aravaipaite: four new minerals from the Grand Reef mine, Graham County, Arizona. Amer. Mineral., 74, 927–933. (2) Kampf, A.R (1991) Grandreefite, $Pb_2F_2SO_4$: crystal structure and relationship to the lanthanide oxide sulfates, $Ln_2O_2SO_4$. Amer. Mineral., 76, 278–282.

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Grantsite $(Na, Ca)_x(V^{5+}, V^{4+})_6O_{16} \cdot 4H_2O$ (x = ~2.3)

Crystal Data: Monoclinic. *Point Group:* $2/m$. As aggregates of microscopic fibrous or bladed crystals elongated on [010]. Also as botryoidal crusts.

Physical Properties: *Tenacity:* Smears easily. Hardness = Soft. D(meas.) = 2.94(1) D(calc.) = 2.95

Optical Properties: Translucent. *Color:* Dark olive-green to greenish black; shades of green and brown in transmitted light. *Streak:* Olive-green to brownish green. *Luster:* Silky or pearly to subadamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = green; Y = greenish brown; Z = brown. *Orientation:* $Z = b$. *Absorption:* $Z > Y > X$. $\alpha = 1.82(1)$ $\beta = > 2.0$ $\gamma = > 2.0$
2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$. $a = 12.429$ $b = 3.604$ $c = 17.542$ $\beta = 95.33°$ Z = [2]

X-ray Powder Pattern: Golden Cycle mine, Colorado, USA.
8.74 (100), 3.606 (28), 12.4 (18), 3.008 (14), 2.869 (12), 2.280 (11), 4.37 (10)

Chemistry:

	(1)	(2)
UO_3	0.3	
V_2O_5	65.2	65.6
V_2O_4	10.8	9.3
Fe_2O_3		0.2
CaO	4.4	2.9
SrO	0.1	< 0.1
Na_2O	8.3	8.2
K_2O		< 0.1
H_2O^+	10.1	11.4
CO_2	0.6	
insol.	0.3	1.9
Total	100.1	99.5

(1) F-33 mine, New Mexico, USA; corresponds to $Na_{1.90}Ca_{0.46}Sr_{0.01}V_{6.02}O_{16} \cdot 3.49H_2O$.
(2) Golden Cycle mine, Colorado, USA; corresponds to $Na_{1.91}Ca_{0.38}V_{6.03}O_{16} \cdot 4.59H_2O$.

Occurrence: In partially oxidized portions of sandstone seams and coalified wood in vanadiferous uranium deposits of the Colorado Plateau type.

Association: Häggite, paramontroseite, corvusite, rauvite, hewettite, carnotite, tyuyamunite.

Distribution: In the USA, from the F-33 mine, Grants district, McKinley Co., New Mexico; the Golden Cycle mine, Atkinson Mesa, Uravan district, and the La Salle mine, Club Mesa, Montrose Co., Colorado; and in the Parco No. 23 mine, about 21 km southeast of Thompson, Grand Co., Utah.

Name: For the town of Grants, New Mexico, USA, near which it was first discovered.

Type Material: National Museum of Natural History, Washington, D.C., USA, 121956.

References: (1) Weeks, A.D., M.L. Lindberg, A.H. Truesdell, and R. Meyrowitz (1964) Grantsite, a new hydrated sodium calcium vanadate from New Mexico, Colorado, and Utah. Amer. Mineral., 49, 1511–1526. (2) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 513–515.

Graphite C

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$ (2H); $\overline{3}\ 2/m$ (3R). As hexagonal platy {0001} crystals having triangular striations on the base, to 20 cm. Massive, foliated; also scaly, columnar, granular, compact, earthy; in globular aggregates having radial structure. *Twinning:* Twin plane probably $\{11\overline{2}1\}$; twinning due to pressure gliding, produces trigonal or hexagonal striae on {0001}; also by 30° (90°) rotation about [0001].

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Flexible but not elastic; sectile. Hardness = 1–2 VHN = 7–11 (10 g load). D(meas.) = 2.09–2.23 D(calc.) = 2.26 Greasy feel.

Optical Properties: Opaque, transparent only in extremely thin flakes. *Color:* Iron-black to steel-gray; deep blue in transmitted light. *Streak:* Black to steel-gray, shining. *Luster:* Metallic; may be dull, earthy.
Optical Class: Uniaxial (–). *Pleochroism:* Strong. ω = 1.93–2.07 (red). ϵ = n.d. (extreme birefringence). *Anisotropism:* Extreme.
R_1–R_2: (400) 6.4–23.6, (420) 6.3–24.2, (440) 6.3–24.5, (460) 6.2–24.7, (480) 6.2–25.1, (500) 6.2–25.4, (520) 6.2–25.9, (540) 6.2–26.3, (560) 6.2–26.7, (580) 6.2–27.1, (600) 6.3–27.5, (620) 6.3–27.9, (640) 6.4–28.2, (660) 6.4–28.7, (680) 6.5–29.0, (700) 6.5–29.5

Cell Data: *Space Group:* $P6_3/mmc$ (2H), with $a = 2.464(2)$ $c = 6.711(4)$ Z = 4, or *Space Group:* $R\overline{3}m$ (synthetic 3R), with $a = 2.456$ $c = 10.044$ Z = 6

X-ray Powder Pattern: Sri Lanka.
3.36 (10), 1.678 (8), 2.03 (5), 1.158 (5), 0.994 (4), 0.829 (4), 1.232 (3)

Chemistry: Carbon.

Polymorphism & Series: Polymorphous with chaoite, diamond, and lonsdaleite.

Occurrence: Formed by metamorphism of sedimentary carbonaceous material, by the reduction of carbon compounds; a primary constituent in igneous rocks.

Association: A wide variety of minerals stable in the metamorphic conditions under which graphite forms. In meteorites, in nodules with troilite, silicates.

Distribution: Numerous localities, but only a few afford well-crystallized examples. In the USA, at Monroe and Ticonderoga, Essex Co., New York; at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey. In Canada, commercially significant occurrences in Quebec, at Buckingham and Grenville, and in adjacent parts of Ontario. In Russia, from Nizhni Tunguski, east of Turukhansk, near the Yenisei River, Siberia; at Shunga, Karelia. Around Ratnapura, Matara, and Kurunegale, Sri Lanka, large deposits of pure material. At Passau, Bavaria, Germany. From Pargas, Finland. In England, at Barrowdale, near Keswick, Cumbria. In Mexico, at Santa Maria, Sonora, formed by metamorphism of coal beds.

Name: From the Greek *to write*, in allusion to its use as a crayon.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 152–154. (2) Trucano, P. and R. Chen (1975) Structure of graphite by neutron difraction. Nature, 258, 136–137. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 23. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 211.

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Gratonite $Pb_9As_4S_{15}$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals, to 5 mm, prismatic by elongation ‖ [0001] with $\{11\bar{2}0\}$ prominent; $\{02\bar{2}1\}$ is well developed and commonly the only terminal form; massive.

Physical Properties: *Tenacity:* Brittle. Hardness = 2.5 VHN = 130–146 (100 g load). D(meas.) = 6.22(2) D(calc.) = 6.17

Optical Properties: Opaque. *Color:* Dark lead-gray; in polished section, white, distinctly yellow against galena. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Very weak.
R_1–R_2: (400) 38.7–39.8, (420) 38.0–39.3, (440) 37.6–38.4, (460) 37.1–37.6, (480) 36.5–36.9, (500) 36.1–36.4, (520) 36.0–36.2, (540) 36.1–36.2, (560) 36.3–36.4, (580) 36.6–36.6, (600) 36.7–36.7, (620) 36.3–36.4, (640) 35.7–35.8, (660) 34.8–35.0, (680) 33.8–34.1, (700) 33.0–33.3

Cell Data: *Space Group:* $R3m$. $a = 17.758(14)$ $c = 7.807(6)$ $Z = 3$

X-ray Powder Pattern: Cerro de Pasco, Peru.
3.43 (100), 3.74 (80), 2.86 (70), 2.71 (70), 2.20 (60), 2.05 (60), 1.746 (40)

Chemistry:

	(1)	(2)	(3)
Pb	71.12	71.0	70.49
Fe	0.39		
As	10.82	11.0	11.33
Sb	0.21		
S	17.38	18.0	18.18
Total	99.92	100.0	100.00

(1) Cerro de Pasco, Peru. (2) Rio Tinto, Spain; by electron microprobe. (3) $Pb_9As_4S_{15}$.

Occurrence: In vugs in hydrothermal copper ores.

Association: Realgar, pyrite, sphalerite, pyrrhotite, arsenopyrite, enargite, tetrahedrite–tennantite, jordanite, canfieldite, hutchinsonite.

Distribution: In the Excelsior mine, Cerro de Pasco, Peru [TL], in large crystals. At the Santa Lucia deposit, Cuba. In abundance, in large crystals in the Blei-Scharley mine, Upper Silesia, Poland. At Zvezdel, Bulgaria. From Wiesloch, near Heidelberg, Black Forest, Germany. In the Lengenbach quarry, Binntal, Valais, Switzerland. On the Isle of Man, from the North Laxey mine. At Rio Tinto, Huelva Province, Spain. From Tsumeb, Namibia. In the Yunosawa mine, Aomori Prefecture, Japan.

Name: In honor of Louis Caryl Graton (1880–1970), Professor of Mining Geology, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 94611.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 397–398. (2) Ribar, B. and W. Nowacki (1969) Neubestimmung der Kristallstruktur von Gratonit, $Pb_9As_4S_{15}$. Zeits. Krist., 128, 321–338 (in German with English abs.). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 212.

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Grattarolaite $Fe_3^{3+}O_3(PO_4)$

Crystal Data: Hexagonal. *Point Group:* 3*m*. In microcrystalline nodules, intimately mixed with rodolicoite, as crystallites to < 1000 Å.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.08

Optical Properties: Opaque. *Color:* Reddish brown. *Streak:* Brown. *Luster:* Greasy. *Optical Class:* Uniaxial. ω = n.d. ε = n.d.

Cell Data: *Space Group:* [*R*3*m*] (by analogy to synthetic material). *a* = 7.994(4) *c* = 6.855(4) Z = 3

X-ray Powder Pattern: Synthetic.
3.09 (100), 1.623 (23), 2.078 (20), 2.446 (16), 1.440 (16), 1.997 (13), 1.545 (12)

Chemistry: (1) Due to the tiny particle sizes (average about 380 Å) only bulk composition of the mixture could be determined; this is compatible with a composition of $Fe_{2.99}P_{1.01}O_{7.00}$; the identity of the mineral rests also on its X-ray powder pattern.

Occurrence: Very rare, in microcrystalline nodules in lignite beds which appear to have burned naturally.

Association: Rodolicoite, heterosite.

Distribution: From the Castelnuovo mine, Santa Barbara lignite district, 30 km southeast of Florence, Florence, Italy.

Name: Honoring Giuseppe Grattarola (1844–1907), Professor of Mineralogy, Florence University, Florence, Italy.

Type Material: Museum of Natural History, Florence University, Florence, Italy, 2087/RI.

References: (1) Cipriani, C., M. Mellini, G. Pratesi, and C. Viti (1997) Rodolicoite and grattarolaite, two new phosphate minerals from Santa Barbara mine, Italy. Eur. J. Mineral., 9, 1101–1106. (2) (1998) Amer. Mineral., 83, 654 (abs. ref. 1). (3) Modaressi, A., A. Courtois, R. Gerardin, B. Malaman, and C. Gleitzer (1983) Fe_3PO_7, un cas de coordinence 5 du fer trivalent, étude structurale et magnétique. J. Solid State Chem., 47, 245–255 (in French with English abs.).

Gravegliaite $Mn^{2+}(SO_3)\cdot 3H_2O$

Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As pseudohexagonal prismatic crystals elongated along [010], to 0.5 mm; typically as radial or sheaflike aggregates.

Physical Properties: *Cleavage:* One || [010]. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.39

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$. *Dispersion:* Strong. $\alpha = 1.590(2)$ $\beta = 1.596(2)$ $\gamma = 1.636(2)$ 2V(meas.) = 41(3)° 2V(calc.) = 43°

Cell Data: *Space Group: Pnma.* $a = 9.763(1)$ $b = 5.635(1)$ $c = 9.558(1)$ $Z = 4$

X-ray Powder Pattern: Gambatesa mine, Italy.
4.33 (VS), 3.43 (VS), 6.83 (S), 2.704 (M), 2.666 (M), 2.414 (M), 1.726 (M)

Chemistry:

	(1)	(2)
SO_2	33.51	33.89
MnO	37.83	37.52
H_2O	[28.66]	28.59
Total	[100.00]	100.00

(1) Gambatesa mine, Italy; by electron microprobe, averages of 13 analyses of 3 crystals, H_2O by difference; corresponds to $Mn_{1.01}(SO_3)_{0.99}\cdot 3.01H_2O$. (2) $Mn(SO_3)\cdot 3H_2O$.

Occurrence: Very rare, along fractures in metamorphosed manganiferous layers in radiolarian cherts in an ophiolite sequence.

Association: Tephroite, bementite, braunite, hausmannite, hematite.

Distribution: From the Gambatesa mine, near Reppia, Val Graveglia, Liguria, Italy.

Name: For Val Graveglia, Italy, within which the Gambatesa mine is located.

Type Material: Department of Earth Sciences, University of Genoa, Genoa, Italy.

References: (1) Basso, R., G. Lucchetti, and A. Palenzona (1991) Gravegliaite, $MnSO_3\cdot 3H_2O$, a new mineral from Val Graveglia (Northern Apennines, Italy). Zeits. Krist., 197, 97–106.
(2) (1992) Amer. Mineral., 77, 672 (abs. ref. 1).

Grayite $ThPO_4 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 622. Quasi-pyramidal grains, to 2 mm; powdery.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3–4 D(meas.) = 3.7–4.3 D(calc.) = [4.63] Radioactive. May fluoresce yellow-green under SW UV.

Optical Properties: Semitransparent. *Color:* Pale yellow, yellow, yellowish gray, reddish brown. *Luster:* Resinous to waxy.
Optical Class: Uniaxial, moderate birefringence. n = 1.66–1.69

Cell Data: *Space Group:* $P6_222$ (ICDD 42-1389). $a = 6.957(24)$ $c = 6.396(18)$ Z = 3

X-ray Powder Pattern: Gunnison, Colorado, USA; after heating to 800 °C, pattern is similar to monazite.
3.03 (vs), 2.82 (s), 2.15 (s), 4.35 (m), 1.856 (m), 6.05 (w), 3.46 (vw)

Chemistry: (1) Fremont Co., Wyoming, USA; semiquantitative spectrographic analysis shows Si and Th > 10%; Ca 7%, P and Al 3%, Fe and Mg 1.5%. The name is applied to a mineral with composition approximating $Th(PO_4)$ and showing a rhabdophane X-ray pattern, which changes to a monazitelike X-ray pattern on heating to 800 °C–900 °C.

Mineral Group: Rhabdophane group.

Occurrence: In a lithium-bearing pegmatite (Mtoko district, Zimbabwe); in an oxidized granitic vein in Precambrian rocks (Gunnison, Colorado, USA); in fracture fillings and disseminated through limestone (Fremont Co., Wyoming, USA).

Association: Thorite (Mtoko district, Zimbabwe); monazite-(Ce), xenotime-(Y), zircon (Havey quarries, Maine, USA).

Distribution: In the Gooddays mine, Mtoko district, and on the Mahaka and Verdale claims, Wedza district, Zimbabwe. From the Mungenyi pegmatite, about 65 km southwest of Mbarara, Ankole district, Uganda. In the USA, from southwest of Gunnison, Gunnison Co., Colorado; in Fremont Co., Wyoming; from the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada; at the Havey quarries, Topsham, Sagadahoc Co., Maine.

Name: In honor of Anton Gray, mining engineer, advisor to the United Kingdom Atomic Energy Authority.

Type Material: n.d.

References: (1) Bowie, S.H.U. (1957) Summary of progress for 1956, Geol. Surv. of Great Britain, 67 [introduces name]. (2) Dooley, J.R., Jr., and J.C. Hathaway (1961) Two occurrences of thorium-bearing minerals with rhabdophane-like structure. U.S. Geol. Survey Prof. Paper 424-C, 339–341. (3) (1962) Amer. Mineral., 47, 419–420 [discussion of grayite].

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Grechishchevite $Hg_3S_2(Br,Cl,I)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m2/m2/m, \overline{4}2m$, or $4mm$. As prismatic crystals, granular, to 0.3 mm; in coatings and powdery masses.

Physical Properties: *Cleavage:* One direction, ‖ prism elongation, distinct.
Tenacity: Brittle. Hardness = ∼2.5 VHN = 88–116, average 106 (25 g load).
D(meas.) = 7.23 (synthetic). D(calc.) = 7.16 (synthetic).

Optical Properties: Transparent. *Color:* Bright to dark orange, darkening to orange-brown, then black; in reflected light, gray-white with strong orange internal reflections. *Streak:* Deep yellow to yellow with slight orange tint. *Luster:* Vitreous to adamantine.
Optical Class: Uniaxial (+). *Pleochroism:* E = straw-yellow; O = yellow. $\omega = > 2.0$ $\epsilon = > 2.0$
Anisotropism: Observed. *Bireflectance:* Distinct; gray-white to gray.
R_1–R_2: (436) 22.8–19.2, (460) 24.5–22.2, (500) 21.4–18.9, (546) 19.8–17.3, (590) 18.8–16.5, (620) 18.9–16.7, (656) 18.1–15.9

Cell Data: *Space Group:* $[P4/mmm, P\overline{4}2m$, or $P4mm]$ (by analogy to synthetic material).
$a = 13.208(6)$ $c = 6.698(9)$ Z = 8

X-ray Powder Pattern: Arzak deposit, Russia.
2.65 (100), 3.95 (60), 3.02 (60), 2.60 (40), 2.341 (40), 2.180 (30b), 1.873 (30)

Chemistry:

	(1)
Hg	73.00
Cl	2.05
Br	9.85
I	5.86
S	7.83
Se	0.02
Total	98.61

(1) Arzak and Kadyrel deposits, Russia; by electron microprobe (average of 11 analyses from Arzak and two from Kadyrel); corresponds to $Hg_{3.05}S_{2.04}(Br_{1.03}Cl_{0.49}I_{0.39})_{\Sigma=1.91}$.

Occurrence: In hydrothermal mercury deposits.

Association: Cinnabar, calomel, kuzminite, corderoite, kadyrelite, lavrentievite, eglestonite.

Distribution: In the Arzak and Kadyrel deposits, Tuva, Siberia, Russia.

Name: To honor Oleg Konstantinovich Grechishchev (1936–), Institute of Geology, Novosibirsk, Russia, a student of the Tuva mercury deposits.

Type Material: Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, Novosibirsk; Mining Museum, State University, St. Petersburg, Russia.

References: (1) Vasil'ev, V.I., L.V. Usova, and N.A. Pal'chik (1989) Grechishchevite – $Hg_3S_2(Br,Cl,I)_2$ – a new supergene mercury sulfohalide. Geol. Geophys., 30(7), 61–69 (in Russian). (2) (1991) Amer. Mineral., 76, 1729–1730 (abs. ref. 1).

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Greenalite $(Fe^{2+}, Fe^{3+})_{2-3}Si_2O_5(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* n.d. Rarely as minute crystals, more commonly as rounded grains, to 1 mm; as porphyroblasts, oolites; cryptocrystalline.

Physical Properties: Hardness = n.d. D(meas.) = 2.85–3.15 D(calc.) = n.d. Moderately magnetic.

Optical Properties: Semitransparent. *Color:* Green, light yellow-green; blue-green in transmitted light.
Optical Class: Isotropic when fine grained. *Pleochroism:* Pale yellow to green. $n = 1.670$

Cell Data: *Space Group:* n.d. $a = 5.54$ $b = 9.55$ $c = 7.44$ $\beta = 104°20'$ Z = 2

X-ray Powder Pattern: Mesabi Range, Minnesota, USA.
2.571 (100), 7.12 (80), 3.559 (80), 1.593 (60), 2.184 (40), 1.553 (40), 2.849 (20)

Chemistry:

	(1)	(2)	(3)
SiO_2	33.58	34.7	36.5
Al_2O_3		0.90	0.25
Fe_2O_3	11.16		
FeO	45.19	47.3	40.2
MnO		0.15	8.71
MgO		4.98	3.75
H_2O	10.07	n.d.	n.d.
Total	[100.00]	88.03	89.41

(1) Mesabi Range, Minnesota, USA; recalculated to 100% after deduction of SiO_2 and other impurities; corresponds to $(Fe^{2+}_{2.34}Fe^{3+}_{0.45})_{\Sigma=2.79}Si_{2.18}O_5(OH)_{3.28}$. (2) Do.; by electron microprobe. (3) Bluebell mine, Riondel, Canada; by electron microprobe.

Polymorphism & Series: Group A (1M, $2M_1$, 3A) and Group C (1A, 2A, 3R) polytypes may be intergrown.

Mineral Group: Kaolinite-serpentine group.

Occurrence: A primary phase in some banded iron formations.

Association: Minnesotaite, stilpnomelane, siderite, chamosite, quartz, pyrite.

Distribution: Some localities for studied material follow. Widespread in the Biwabik Iron Formation, Mesabi Range, St. Louis Co., Minnesota, USA. In Canada, in the Sokoman Iron Formation, Howells River area, Labrador, Newfoundland; in the Gunflint Iron Formation, northeast of Gunflint Lake, Ontario; and in the Bluebell mine, Riondel, British Columbia. In the Matsumo mine, Kochi prefecture, Japan. From the Weld Range, northwest of Cue, Western Australia. In the Salsigne mine, 15 km north of Carcassone, Aude, France. At Glenluce, Wigtownshire, Scotland. From the San Valentin mine, Cartagena district, La Union, Murcia Province, Spain.

Name: In allusion to its *green* color.

Type Material: National Museum of Natural History, Washington, D.C., USA, 91160, 124953.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 47. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 164–169. (3) Jolliffe, F. (1935) A study of greenalite. Amer. Mineral., 20, 405–425. (4) Gruner, J.W. (1936) The structure and chemical composition of greenalite. Amer. Mineral., 21, 449–455. (5) Bayliss, P. (1981) Unit cell data of serpentine group minerals. Mineral. Mag., 44, 153–156. (6) Guggenheim, S., S.W. Bailey, R.A. Eggleton, and P. Wilkes (1982) Structural aspects of greenalite and related minerals. Can. Mineral., 20, 1–18.

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Greenockite CdS

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Crystal Data: Hexagonal. *Point Group:* 6*mm*. Crystals hemimorphic pyramidal, to 3 cm; most commonly as earthy coatings. *Twinning:* Twin plane $\{11\bar{2}2\}$ rare, forming fourlings.

Physical Properties: *Cleavage:* Distinct on $\{11\bar{2}2\}$, imperfect on $\{0001\}$.
Fracture: Conchoidal. *Tenacity:* Brittle. Hardness = 3–3.5 VHN = n.d. D(meas.) = 4.820 D(calc.) = 4.824

Optical Properties: Nearly opaque to translucent. *Color:* Shades of yellow and orange, rarely deep red; in polished section, very pale lemon-yellow to red-brown and blood-red.
Streak: Yellow-orange to brick-red. *Luster:* Adamantine to resinous.
Optical Class: Uniaxial (+) for red to blue-green, uniaxial (–) for blue-green to blue; isotropic at 523 nm. *Pleochroism:* Weak. $\omega = 2.506$ (Na); 2.431 (Li). $\epsilon = 2.529$ (Na); 2.456 (Li).
R: (400) 20.3, (420) 20.5, (440) 20.6, (460) 21.0, (480) 21.3, (500) 21.2, (520) 20.5, (540) 19.7, (560) 19.0, (580) 18.6, (600) 18.2, (620) 17.8, (640) 17.7, (660) 17.3, (680) 17.1, (700) 16.9

Cell Data: *Space Group:* $P6_3mc$. $a = 4.136$ $c = 6.713$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.160 (100), 3.583 (75), 3.367 (60), 2.068 (55), 1.761 (45), 1.898 (40), 2.450 (25)

Chemistry:

	(1)	(2)	(3)
Cd	77.45	70.6	77.81
Zn		5.3	
S	22.48	23.3	22.19
Total	99.93	99.2	100.00

(1) Bishopton, Scotland; average of two analyses. (2) Madjarovo district, Bulgaria; by electron microprobe. (3) CdS.

Polymorphism & Series: Dimorphous with hawleyite.

Occurrence: As earthy coatings, especially on sphalerite, in which it also occurs as a substituent; also rarely as crystals in cavities in mafic igneous rocks; in high-temerature hydrothermal vein deposits.

Association: Sphalerite, smithsonite, prehnite, other zeolites (low temperature); cassiterite, tetrahedrite, herzenbergite, chalcopyrite, other sulfides (high temperature).

Distribution: In Scotland, from Bishopton, near Glasgow, Renfrewshire [TL], large crystals on prehnite; as coatings on sphalerite in the Leadhills-Wanlockhead district, Dumfries. From the Los Blancos mine, Sierra de Cartagena, ??, Spain. At Příbram, Czech Republic. In the Madjarovo district, eastern Rhodope Mountains, Bulgaria. From Pierrefitte, Hautes-Pyrénées, France. In Greece, at Laurium. Pigmenting smithsonite stalactites from Masua, Sardinia, Italy. In Russia, in the Kti-Teberda deposit, northern Caucasus Mountains. In the USA, in New Jersey, at Franklin and Sterling Hill, Ogdensburg, Sussex Co.; from Paterson, Passaic Co.; at the Fanwood quarry, Somerset Co.; from the Summit quarry, Union Co.; in the Arlington quarry, Leesburg, Loudoun Co., Virginia, as crystals; at Friedensville, Lehigh Co., Pennsylvania. In the Joplin district, Jasper Co., Missouri, on sphalerite; as bright yellow coatings on smithsonite in Marion Co., Arkansas. Complex twins from the Asunta Ag–Sn mine, four km northeast of San Vicente, Potosí, and at Llallagua, Bolivia. Numerous other minor occurrences are known.

Name: In honor of Charles Murray Cathcart (1783–1859), Lord Greenock.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 228–230. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 570–572. (3) Ulrich, F. and W. Zachariason (1925) Über die Kristallstruktur des α- und β-CdS, sowie des Wurtzits. Zeits. Krist., 62, 260–273 (in German). (4) (1955) NBS Circ. 549, 4, 15–16. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 213.

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Greenwoodite $Ba_{2-x}(V^{3+}OH)_xV_9(Fe^{3+},Fe^{2+})_2Si_2O_{22}$

Crystal Data: Hexagonal. *Point Group*: 3*m*. As semi-prismatic to tabular grains, to 200 μm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 5
D(meas.) = n.d. D(calc.) = 4.81

Optical Properties: Opaque. *Color*: Black, gray with a weak brownish tint in reflected light.
Streak: n.d. *Luster*: Semi-metallic, dull.
Optical Class: n.d. Distinct bireflectance, pleochroism, and anisotropism.
R_1-R_2: (470) 12.5-15.75 $(2.82\text{-}4.83)_{oil}$, (546) 12.63-15.50 $(2.98\text{-}4.80)_{oil}$, (589) 12.81-15.75 $(3.31\text{-}4.95)_{oil}$, (650) 13.60-16.22 $(3.57\text{-}5.28)_{oil}$

Cell Data: *Space Group*: *P*3*m*1. a = 5.750(1) c = 14.459(1) Z = 1

X-ray Powder Pattern: Calculated pattern.
2.925 (100), 2.875 (38), 2.469 (35), 1.438 (35), 2.354 (28), 2.212 (28), 1.669 (26)

Chemistry:

	(1)
MgO	0.12
Al_2O_3	0.91
SiO_2	8.63
TiO_2	1.05
V_2O_3	58.03
Cr_2O_3	1.42
MnO	0.11
FeO	[3.72]
Fe_2O_3	[9.1]
ZnO	1.52
BaO	15.13
H_2O	[0.62]
Total	100.36

(1) Wigwam deposit, British Columbia, Canada; average of 13 electron microprobe analyses, Fe^{+2}/Fe^{+3} calculated from charge balance, H_2O determined by crystal structure analysis; corresponding to $Ba_{0.60}(V^{3+}OH)_{0.40}(V^{3+}_{8.33}Cr_{0.33}Ti_{0.13}Al_{0.13}Mn^{3+}_{0.02})_{\Sigma=9}$ $(Fe^{3+}_{1.08}Fe^{2+}_{0.60}Zn_{0.22}Al_{0.06}Mg_{0.04})_{\Sigma=2}(Si_{1.72}Fe^{3+}_{0.28})_{\Sigma=2}O_{22}$.

Occurrence: Part of the prograde assemblage in a green schist facies metamorphosed Mississippi-Valley type base-metal deposit.

Association: Quartz, celsian, apatite, sphalerite, pyrrhotite, galena, pyrite, zoltaiite, batisivite.

Distribution: At the Wigwam deposit, Akolkolex River area, southeast of Revelstoke, British Columbia, Canada.

Name: Honors Professor Hugh J. Greenwood (b. 1931), former head of the Geological Sciences Department, University of British Columbia, Vancouver, British Columbia, Canada, for his contributions to petrology.

Type Material: American Museum of Natural History, New York, New York, USA (109839).

References: (1) Bartholomew, P.R., F. Mancini, G.E. Harlow, N. Deifel, C. Cahill, and H.-J. Bernhardt (2012) Greenwoodite, a new nesosilicate from British Columbia with a Ba-VOH coupled substitution and tetrahedral Fe; description and structure. Can. Mineral., 50, 1233-1242.
(2) (2014) Amer. Mineral., 99, 1514-1515 (abs. ref. 1).

Gregoryite $(Na_2, K_2, Ca)CO_3$

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Crystal Data: Hexagonal (synthetic). *Point Group:* $6mm$. As minute imperfect rounded crystals.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.27 Soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Brown, milky white.
Optical Class: [Uniaxial.] ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P6_3mc$ (synthetic). $a = 5.215$ $c = 6.584$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 25–815).
2.66 (100), 2.61 (75), 3.29 (40), 2.137 (40), 1.863 (30), 3.72 (27), 1.707 (8)

Chemistry:

	(1)
SO_3	4.28
P_2O_5	1.92
CO_2	[36.22]
CaO	9.10
SrO	0.66
BaO	0.24
Na_2O	44.87
K_2O	3.95
F	0.4
Cl	0.60
H_2O	n.d.
$-O = (F, Cl)_2$	0.31
Total	[101.93]

(1) Oldoinyo Lengai, Tanzania; by electron microprobe, CO_2 presumably calculated; corresponds to $(Na_{1.56}K_{0.10}Ca_{0.17})_{\Sigma=1.83}CO_3$.

Occurrence: As phenocrysts in lengaite carbonatite lava.

Association: Nyerereite, alabandite, halite, sylvite, fluorite, calcite.

Distribution: From Oldoinyo Lengai volcano, Tanzania.

Name: Honors Professor John Walter Gregory (1864–1932), University of Melbourne, Melbourne, Australia and University of Glasgow, Glasgow, Scotland, who completed early scientific studies of the volcanism and structure of the East African Rift system.

Type Material: n.d.

References: (1) Gittins, J. and D. McKie (1980) Alkalic carbonatite magmas: Oldoinyo Lengai and its wider applicability. Lithos, 13, 213–215. (2) (1981) Amer. Mineral., 66, 879 (abs. ref. 1).

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Greifensteinite $\mathbf{Ca_2Be_4(Fe^{2+},Mn)_5(PO_4)_6(OH)_4 \cdot 6H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}m2$. Prismatic hexagonal crystals, showing dominant $\{10\overline{1}0\}$, $\{10\overline{1}1\}$, $\{0001\}$, to 0.3 mm, commonly anhedral in fine granular crusts.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 3.30 (synthetic). D(calc.) = 3.27 Radioactive; soluble in H_2O.

Optical Properties: Translucent to transparent. *Color:* Yellow. *Streak:* Pale yellow. *Luster:* [Vitreous.]
Optical Class: Uniaxial (–) or weakly biaxial (–). *Pleochroism:* Distinct; O = yellow; E = colorless. $\omega = 1.601(2)$ $\epsilon = 1.480(2)$

Cell Data: *Space Group:* $P\overline{6}2c$. $a = 9.30(2)$ $c = 8.26(2)$ $Z = 2$

X-ray Powder Pattern: Grimsel region, Switzerland.
5.76 (10), 8.09 (8), 3.08 (8), 0.985 (8), 3.65 (7b), 2.86 (7), 2.68 (7)

Chemistry: (1) Identity confirmed by concurrence of optical properties and X-ray diffraction pattern with those of the synthetic compound; microchemical and electron microprobe analyses confirm compositional dominance of K, Na, U, and CO_2 in natural material.

Occurrence: A rare secondary mineral in veins in mineralized granodiorite.

Association: Schröckingerite, baylissite, monohydrocalcite, calcite.

Distribution: From a cable tunnel between Gerstenegg and Sommerloch, Oberhasli, north of Grimsel Pass, Bern, Switzerland.

Name: For the Grimsel region of Switzerland, which produced the first specimens.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany.

References: (1) Walenta, K. (1972) Grimselit, ein neues Kalium–Natrium–Uranylkarbonat aus dem Grimselgebiet (Oberhasli, Kt. Bern, Schweiz). Schweiz. Mineral. Petrog. Mitt., 52(1), 93–108 (in German with English abs.). (2) (1973) Amer. Mineral., 58, 139–140 (abs. ref. 1).

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Greigite $Fe^{2+}Fe_2^{3+}S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As balls of intergrown octahedra with curved faces, to 0.5 mm, rarely as cubes; also as minute grains, and very fine-grained, disseminated.

Physical Properties: Hardness = 4–4.5 VHN = 401–423 (50 g load). D(meas.) = 4.049 D(calc.) = 4.079 Strongly magnetic.

Optical Properties: Opaque. *Color:* Pale pink, tarnishing to a metallic blue; sooty black when very fine grained; in polished section, pale creamy white. *Luster:* Metallic.
R: (400) 30.5, (420) 31.1, (440) 31.7, (460) 32.2, (480) 32.7, (500) 33.2, (520) 33.6, (540) 34.2, (560) 34.7, (580) 35.3, (600) 35.9, (620) 36.4, (640) 37.1, (660) 37.6, (680) 38.1, (700) 38.7

Cell Data: *Space Group:* $Fd3m$. a = 9.876 Z = 8

X-ray Powder Pattern: Kramer-Four Corners area, California, USA.
2.980 (100), 1.746 (77), 2.470 (55), 3.498 (32), 1.008 (31), 1.901 (29), 1.105 (16)

Chemistry:

	(1)	(2)	(3)
Fe	56.5	55.9	56.64
Cu	0.08	0.2	
Ni	0.10		
Zn	0.01		
Mn		0.1	
Cr	0.14		
Sb		1.3	
As	0.38		
S	42.2	42.2	43.36
Total	99.41	99.7	100.00

(1) Zacatecas, Mexico; corresponds to $(Fe_{3.08}As_{0.02}Cr_{0.01}Ni_{0.01})_{\Sigma=3.12}S_{4.00}$. (2) Cornwall, England; by electron microprobe, corresponds to $(Fe_{3.04}Sb_{0.03}Mn_{0.01}C_{0.01})_{\Sigma=3.09}S_{4.00}$.
(3) $Fe^{2+}Fe_2^{3+}S_4$.

Mineral Group: Linnaeite group.

Occurrence: Formed in lacustrine beds consisting of interbedded calcareous clays, silts, and fine- to medium-grained arkosic sands; in varvelike laminae of grayish black sulfide-bearing clays and fine silts; possibly as the result of seasonal variation in the composition and physical condition of lake waters; also in hydrothermal vein deposits; formed in magnetotactic bacteria, and by sulfate-reducing bacteria.

Association: Montmorillonite, chlorite, calcite, colemanite, veatchite (Kramer-Four Corners area, California, USA); sphalerite, pyrite, marcasite, galena, calcite, dolomite (Zacatecas, Mexico).

Distribution: In the USA, in California, from the Kramer-Four Corners area, San Bernardino Co. [TL]; about 13 km west, in the Mudd mine, Kramer borate district, Boron, Kern Co.; and at Coyote Peak, near Orick, Humboldt Co. In Mexico, near Zacatecas. From the bed of the Black Sea, and in the Gal-Khaya deposit, northeast Sakha, Russia. At Montemesola, Taranto, Italy. In the Lojane chromium deposit, 40 km northeast of Skopje, Macedonia. From the Treore mine, St. Teath, Cornwall, England. In the Hanoaka mine, Odate, Akita Prefecture, and the Akagane mine, Iwate Prefecture, Japan. Additional occurrences have been characterized.

Name: Honoring Dr. Joseph Wilson Greig (1895–1977), mineralogist and physical chemist, Pennsylvania State University, State College, Pennsylvania, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 117502, 136415.

References: (1) Skinner, B.J., R.C. Erd, and F.S. Grimaldi (1964) Greigite, the thio-spinel of iron; a new mineral. Amer. Mineral., 49, 543–555. (2) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 214.

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Griceite LiF

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Crystal Data: Cubic. *Point Group:* $4/m\overline{3}2/m$. As tiny cubes and octahedra, tapering prismatic aggregates, to 3 mm; botryoidal, as irregular grains and fine-grained powdery patches.

Physical Properties: *Cleavage:* {100}, good. *Fracture:* Uneven to conchoidal.
Hardness = ∼4.5 D(meas.) = 2.62 D(calc.) = 2.67 May fluoresce pale yellow under SW UV.

Optical Properties: Translucent, quickly becoming opaque on exposure. *Color:* Bright to dull white surfaces, pale yellowish green or light orange cores. *Streak:* White. *Luster:* Vitreous or porcelaneous to waxy or dull.
Optical Class: Isotropic. $n = 1.3986(5)$

Cell Data: *Space Group: Fm3m.* a = 4.0293(2) Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.013 (10), 2.324 (9), 1.424 (5), 1.213 (1), 1.163 (1), 0.924 (1), 0.900 (1)

Chemistry:

	(1)
Li	24.72
Fe	0.03
Mn	0.01
Ca	0.03
Al	0.06
F	72.20
Total	97.05

(1) Mont Saint-Hilaire, Canada; by AA, F by ion selective electrode; corresponds to $Li_{0.97}F_{1.03}$.

Occurrence: In sodalite inclusions in hornfels associated with an intrusive alkalic gabbro-syenite complex.

Association: Sodalite, ussingite, villiaumite, eudialyte, sphalerite, serandite, lovozerite, vuonnemite.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Dr. Joel Denison Grice (1946–), Curator of Minerals at the Canadian Museum of Nature [National Museum of Natural Sciences], Ottawa, Canada.

Type Material: Canadian Museum of Nature, Ottawa, 52310–52313; Royal Ontario Museum, Toronto, Canada, M43055.

References: (1) Van Velthuizen, J. and G.Y. Chao (1989) Griceite, LiF, a new mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 27, 125–127. (2) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 313.

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Grigorievite $Cu_3Fe_2^{3+}Al_2(VO_4)_6$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As prismatic to thick tabular crystals, to 100 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~ 5 VHN = 412-588 (50 g load). D(meas.) = n.d. D(calc.) = 3.67

Optical Properties: Opaque. *Color*: Black, gray with weak deep red internal reflections in reflected light. *Streak*: Reddish brown. *Luster*: Semi-metallic. *Anisotropism:* Weak. *Optical Class*: n.d.
R_1-R_2: (470) 14.4-16.4, (546) 13.2-15.5, (589) 13.0-14.9, (650) 12.7-14.1

Cell Data: *Space Group*: $P\bar{1}$. a = 8.0217(5) b = 9.6858(10) c = 6.5475(9)
α = 103.645(10)° β = 102.369(8)° γ = 106.281(8)° Z = 1

X-ray Powder Pattern: Tolbachik volcano, Kamchatka Peninsula, Russia.
3.141 (100), 3.044 (92), 4.718 (29), 7.36 (27), 3.671 (26), 2.811 (26), 4.417 (24)

Chemistry:

	(1)	(2)
MgO	2.78	
CaO	0.95	
MnO	0.04	
CuO	17.70	22.82
ZnO	0.14	
Al_2O_3	11.76	9.75
Fe_2O_3	10.10	15.27
TiO_2	1.47	
P_2O_5	0.13	
V_2O_5	54.97	52.16
Total	100.04	100.00

(1) Tolbachik volcano, Russia; average of 5 electron microprobe analyses; corresponding to $Ca_{0.17}Mg_{0.69}Mn_{0.01}Cu_{2.23}Zn_{0.02}Al_{2.31}Fe^{3+}_{1.27}Ti_{0.18}P_{0.02}V_{6.05}O_{24}$. (2) $Cu_3Fe_2^{3+}Al_2(VO_4)_6$.

Mineral Group: Howardevansite group.

Occurrence: A sublimate on basaltic scoria deposited from fumarolic gas.

Association: Hematite, bannermanite, ziesite.

Distribution: From the apical part of the Second scoria cone, Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka Peninsula, Russia.

Name: Honors Professor Dmitry Pavlovich Grigoriev (1909-2003), Saint Petersburg Mining Institute, Russia, for his contributions to the mineralogical sciences.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 49123).

References: (1) Pekov I.V., N.V. Zubkova, V.O. Yapaskurt, P.M. Kartashov, Y.S. Polekhovsky, M.N. Murashko, and D.Y. Pushcharovsky (2014) Koksharovite, $CaMg_2Fe_4^{3+}(VO_4)_6$, and grigorievite, $Cu_3Fe_2^{3+}Al_2(VO_4)_6$, two new howardevansite-group minerals from volcanic exhalations. European Journal of Mineralogy, 26(5), 667-677. (2) (2015) Amer. Mineral., 100, 660-661 (abs. ref. 1).

Grimaldiite $Cr^{3+}O(OH)$

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Crystal Data: Hexagonal. *Point Group:* 3*m*. Very rarely as single rhombohedral crystals; commonly as parallel intergrowths with mcconnellite in tabular rhombohedral crystals, to 1 mm; in radially bladed to platy or granular aggregates.

Physical Properties: *Cleavage:* {0001}. Hardness = n.d. D(meas.) = 4.11–4.12 (synthetic). D(calc.) = [4.13]

Optical Properties: Transparent, translucent in intergrowths with mcconnellite. *Color:* Deep red to pinkish brown.
Optical Class: Uniaxial. $n = \sim 2.05$, varies in mixtures. $\omega = 2.155$ (synthetic). $\epsilon = 1.975$

Cell Data: *Space Group: R*3*m*. $a = 2.973(2)$ $c = 13.392(1)$ $Z = 3$

X-ray Powder Pattern: Merume River, Guyana.
4.47 (vvs), 2.401 (vs), 1.857 (vs), 1.486 (ms), 1.537 (mw), 2.528 (w), 1.409 (w)

Chemistry:

	(1)	(2)
SiO_2	0.42	
Al_2O_3	4.3	
Fe_2O_3	0.85	
Cr_2O_3	77.3	89.40
CuO	5.5	
H_2O		10.60
LOI	11.5	
Total	99.87	100.00

(1) Merume River, Guyana; intergrowth of 80%–86% estimated grimaldiite, the balance mcconnellite and H_2O. (2) CrO(OH).

Polymorphism & Series: Trimorphous with bracewellite and guyanaite.

Occurrence: In fine-grained intergrowth with other chromium oxide-hydroxide minerals in alluvial gravels (Merume River, Guyana); in cracks and crevices in penroseite from a hydrothermal mineral deposit (Hiaco, Bolivia).

Association: Bracewellite, eskolaite, guyanaite, mcconnellite (Merume River, Guyana); penroseite, barite (Hiaco, Bolivia).

Distribution: In the basin of the Merume River, Guyana. From the Hiaca mine, 30 km north-northeast of Colquechaca, Potosí, Bolivia.

Name: For Dr. Frank Saverio Grimaldi (1915–), formerly Chief Chemist, U.S. Geological Survey.

Type Material: Harvard University, Cambridge, Massachusetts, USA; The Natural History Museum, London, England, 1979,136.

References: (1) Milton, C., D.E. Appleman, M.H. Appleman, E.C.T. Chao, F. Cuttitta, J.I. Dinnin, E.J. Dwornik, B.L. Ingram, and H.J. Rose, Jr. (1976) Merumite, a complex assemblage of chromium minerals from Guyana. U.S. Geol. Surv. Prof. Paper 887, 1–29. (2) (1977) Amer. Mineral., 62, 593 (abs. ref. 1). (3) Livingstone, A., B. Jackson, and P.J. Davidson (1984) Grimaldiite, CrOOH, a second occurrence from the Hiaca mine, Colquechaca, Bolivia. Mineral. Mag., 48, 560–562. (4) Douglass, R.M. (1957) The crystal structure of $HCrO_2$. Acta Cryst., 10, 423–427.

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Grimselite $K_3Na(UO_2)(CO_3)_3 \cdot H_2O$

Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Prismatic hexagonal crystals, showing dominant $\{10\bar{1}0\}$, $\{10\bar{1}1\}$, $\{0001\}$, to 0.3 mm, commonly anhedral in fine granular crusts.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 3.30 (synthetic). D(calc.) = 3.27 Radioactive; soluble in H_2O.

Optical Properties: Translucent to transparent. *Color:* Yellow. *Streak:* Pale yellow. *Luster:* [Vitreous.]
Optical Class: Uniaxial (–) or weakly biaxial (–). *Pleochroism:* Distinct; O = yellow; E = colorless. $\omega = 1.601(2)$ $\epsilon = 1.480(2)$

Cell Data: *Space Group:* $P\bar{6}2c$. $a = 9.30(2)$ $c = 8.26(2)$ $Z = 2$

X-ray Powder Pattern: Grimsel region, Switzerland.
5.76 (10), 8.09 (8), 3.08 (8), 0.985 (8), 3.65 (7b), 2.86 (7), 2.68 (7)

Chemistry: (1) Identity confirmed by concurrence of optical properties and X-ray diffraction pattern with those of the synthetic compound; microchemical and electron microprobe analyses confirm compositional dominance of K, Na, U, and CO_2 in natural material.

Occurrence: A rare secondary mineral in veins in mineralized granodiorite.

Association: Schröckingerite, baylissite, monohydrocalcite, calcite.

Distribution: From a cable tunnel between Gerstenegg and Sommerloch, Oberhasli, north of Grimsel Pass, Bern, Switzerland.

Name: For the Grimsel region of Switzerland, which produced the first specimens.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany.

References: (1) Walenta, K. (1972) Grimselit, ein neues Kalium–Natrium–Uranylkarbonat aus dem Grimselgebiet (Oberhasli, Kt. Bern, Schweiz). Schweiz. Mineral. Petrog. Mitt., 52(1), 93–108 (in German with English abs.). (2) (1973) Amer. Mineral., 58, 139–140 (abs. ref. 1).

Griphite $\mathbf{Ca(Mn^{2+},Na,Li)_6Fe^{2+}Al_2(PO_4)_6(F,OH)_2}$

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Crystal Data: Cubic; typically metamict in whole or part. *Point Group:* $2/m\ \overline{3}$. Massive, may be reniform, in nodules to 2 m.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 3.40–3.64 D(calc.) = 3.65 May be radioactive.

Optical Properties: Transparent to translucent. *Color:* Very pale yellow, dark brown to brownish black when metamict; yellowish brown to brown in transmitted light. *Luster:* Resinous to vitreous.
Optical Class: Isotropic. $n = 1.630–1.687$

Cell Data: *Space Group: Pa*3. $a = 12.205(2)$ Z = 4

X-ray Powder Pattern: Mas Claret, France.
2.720 (10), 3.04 (5), 2.482 (5), 2.951 (4), 1.625 (4), 3.36 (3), 2.275 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	38.52	41.15	41.93	Na_2O	5.52	3.20	3.40
Al_2O_3	10.13	10.41	9.67	K_2O	0.30		
Fe_2O_3		0.70		F	trace	3.02	3.77
FeO	4.00	7.34	13.12	Cl	0.11		
MnO	29.64	25.20	21.45	H_2O	4.29	1.00	
MgO	0.15	0.25	0.00	insol.	0.16	0.22	
CaO	7.47	7.87	5.86	$-O = (F,Cl)_2$	[0.02]	1.27	1.58
Li_2O	trace	0.78	[1.06]	Total	[100.27]	99.87	[98.68]

(1) Everly pegmatite, South Dakota, USA; average of two complete and three partial analyses; corresponds to $Ca_{1.00}(Mn^{2+}_{3.85}Na_{1.75}Ca_{0.31}K_{0.06}Mg_{0.04})_{\Sigma=6.01}(Fe^{2+}_{0.50}Mn^{2+}_{0.25})_{\Sigma=0.75}(Al_{1.95}Fe^{3+}_{0.05})_{\Sigma=2.00}[(PO_4)_{5.32}(OH)_{0.68}]_{\Sigma=6.00}[(OH)_{1.97}Cl_{0.03}]_{\Sigma=2.00}$. (2) Mas Claret, France; by AA, colorimetry, H_2O by the Penfield method; corresponds to $Ca_{1.00}(Mn^{2+}_{3.56}Na_{1.03}Li_{0.52}Ca_{0.41}Fe^{2+}_{0.32}Fe^{3+}_{0.09}Mg_{0.06})_{\Sigma=5.99}(Fe^{2+}_{0.70}Mn^{2+}_{0.05})_{\Sigma=0.75}Al_{2.00}[(PO_4)_{5.81}(OH)_{0.19}]_{\Sigma=6.00}[F_{1.59}(OH)_{0.37}]_{\Sigma=1.96}$. (3) Buranga pegmatite, Rwanda; by electron microprobe, total Fe as FeO; corresponds to $Ca_{1.00}(Mn^{2+}_{3.07}Na_{1.11}Fe^{2+}_{1.10}Li_{0.72}Ca_{0.06})_{\Sigma=6.06}Fe^{2+}_{0.75}Al_{1.93}(PO_4)_{6.00}F_{2.02}$.

Occurrence: An accessory mineral in complex granite pegmatites.

Association: Crandallite, apatite, montebrasite, triplite, hausmannite, albite, mica, quartz.

Distribution: From the Riverton Lode [Everly mine], near Harney City, three km east of Keystone, and in the Sitting Bull mine, 1.5 km northwest of Keystone, Pennington Co., South Dakota, USA. At Mt. Ida, about 160 km northwest of Alice Springs, Northern Territory, Australia. In the Jaffit pegmatite, Kamativu, Zimbabwe. From the Buranga pegmatite, near Gatumba, Rwanda. In a pegmatite near Rehamna, Morocco. At Mas Claret, in the Albères massif, Pyrénées-Orientales, France. From an undefined locality near the Karachin River, Turkestan.

Name: From the Greek for *enigma*, as the chemical composition was originally puzzling.

Type Material: National Museum of Natural History, Washington, D.C., USA, R5315.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 843–844. (2) Fontan, F., M. Orliac, and F. Permingeat (1978) Nouvelles données sur la griphite, d'après un énchantillon non métamicte des pegmatites du massif des Albères (Pyrénées-Orientales). Bull. Minéral., 101, 536–543 (in French with English abs.). (3) Rinaldi, R. (1978) The crystal structure of griphite, a complex phosphate, not a garnetoid. Bull. Minéral., 101, 543–547. (4) Fransolet, A.-M. and K. Abraham (1983) Une association triplite – montebrasite – griphite dans la pegmatite de Buranga, Rwanda. Ann. Soc. Géol. Belg., 106, 299–309 (in French with English abs.).

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Grischunite $NaCa_2Mn_5^{2+}Fe^{3+}(AsO_4)_6 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As lathlike crystals, flattened on {100}, elongated along [010], with {100}, {010}, {101}, small {111}, to 1 mm; anhedral granular.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = ∼5 VHN = 450–550 (50 g load). D(meas.) = 3.8(2) D(calc.) = [4.144]

Optical Properties: Semitransparent. *Color:* Dark red-brown. *Streak:* Yellow-brown to orange. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow-green; Y = yellow-brown; Z = dark red-brown. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r \ll v$. *Absorption:* $Z \simeq Y \gg X$.
$\alpha = 1.784(3)$ $\beta = 1.785(3)$ $\gamma = 1.790(3)$ 2V(meas.) = 40°–50° 2V(calc.) = 48°

Cell Data: *Space Group: Pcab.* $a = 12.855(2)$ $b = 13.487(2)$ $c = 12.047(1)$ Z = 4

X-ray Powder Pattern: Falotta mine, Switzerland.
2.839 (100), 3.150 (90), 3.015 (80), 3.617 (70), 2.943 (60), 6.037 (30), 4.244 (30)

Chemistry:

	(1)	(2)
As_2O_5	54.55	52.91
TiO_2	0.08	
Fe_2O_3	5.00	6.13
MnO	27.51	27.21
CaO	9.05	8.61
Na_2O	1.74	2.38
H_2O	[2.07]	2.76
Total	[100.00]	100.00

(1) Falotta mine, Switzerland; by electron microprobe, average of three analyses, total Fe as Fe_2O_3, total Mn as MnO, H_2O by difference; corresponds to $(Na_{0.72}Ca_{0.07})_{\Sigma=0.79}Ca_{2.00}Mn_{5.04}^{2+}Fe_{0.81}^{3+}(AsO_4)_{6.12} \cdot 2H_2O$. (2) $NaCa_2Mn_5Fe(AsO_4)_6 \cdot 2H_2O$.

Occurrence: An alteration product of sarkinite in a manganese deposit.

Association: Sarkinite, brandtite, manganoan berzeliite, tilasite, rhodochrosite, braunite.

Distribution: In the Falotta mine, Oberhalbstein, Graubünden, Switzerland.

Name: From the former Romansch name *Grischun* for Graubünden Canton.

Type Material: Natural History Museum, Basel, Switzerland, MB19.295.

References: (1) Graeser, S., H. Schwander, and B. Suhner (1984) Grischunit ($CaMn_2[AsO_4]_2$), eine neue Mineralart aus den Schweizer Alpen. Schweiz. Mineral. Petrog. Mitt., 64, 1–10 (in German with English abs.). (2) (1986) Amer. Mineral., 71, 227–228 (abs. ref. 1). (3) Bianchi, R., T. Pilati, and G. Mannucci (1987) Crystal structure of grischunite. Amer. Mineral., 72, 1225–1229.

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Groatite $NaCaMn^{2+}_2(PO_4)[PO_3(OH)]_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As divergent to stellate sprays of acicular crystals, to 1 mm.

Physical Properties: *Cleavage*: None observed. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3 D(meas.) = n.d. D(calc.) = 3.213

Optical Properties: Translucent. *Color*: Colorless to pale yellow, pale orange. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (+). α = 1.622(1) β = 1.634(1) γ = 1.663(1) 2V (meas.) = 67(1)°
2V (calc.) = 66.5° *Orientation*: X ^ a = 35.4 (in β obtuse); Y ^ c = 10.1° (in β acute); Z || b.

Cell Data: *Space Group*: *C*2/*c*. *a* = 12.5435(9) *b* = 12.4324(9) *c* = 6.7121(4)
β = 115.332(2)° Z = 4

X-ray Powder Pattern: Tanco Mine, Lake Bernic, Manitoba, Canada.
3.187 (100), 2.726 (90), 6.204 (80), 2.788 (80), 5.653 (70), 2.580 (70), 3.608 (30)

Chemistry:

	(1)
P_2O_5	46.66
FeO	0.49
MnO	29.31
CaO	12.51
Na_2O	6.87
H_2O	3.93
Total	99.77

(1) Tanco Mine, Lake Bernic, Manitoba, Canada; average of 4 electron microprobe analyses, H_2O from stoichiometry, corresponding to $Na_{1.02}Ca_{1.02}(Mn_{1.90}Fe^{2+}_{0.03})_{\Sigma=1.93}P_{3.02}O_{10}(OH)_2$.

Group: Alluaudite group.

Occurrence: A late-stage mineral, most likely derived from the dissolution of lithiophosphate and lithiophilite, in a spodumene-rich portion of a zoned petalite-subgroup pegmatite.

Association: Whitlockite, crandallite, an unidentified Na–Al phosphate, quartz.

Distribution: Tanco Mine, Lake Bernic, Manitoba, Canada.

Name: Honors Lee A. Groat (b. 1959), professor of Mineralogy at the University of British Columbia, Vancouver, British Columbia, Canada, for his extensive contributions to pegmatite mineralogy.

Type Material: Royal Ontario Museum, Toronto, Canada (M40501).

References: (1) Cooper, M.A., F.C. Hawthorne, N.A. Ball, R.A. Ramik, and A.C. Roberts (2009) Groatite, $NaCaMn^{2+}_2(PO_4)[PO_3(OH)]_2$, a new mineral species of the alluaudite group from the Tanco pegmatite, Bernic Lake, Manitoba, Canada: description and crystal structure. Can Mineral, 47, 1225–1235. (2) (2010) Amer. Mineral., 95, 1123-1124 (abs. ref. 1).

Grossite $CaAl_4O_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As lathlike or subhedral rounded grains, to 30 μ; in polycrystalline aggregates rimmed by melilite.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.88

Optical Properties: Transparent. *Color:* White to colorless. *Streak:* White.
Luster: Vitreous.
Optical Class: Biaxial (+); low birefringence. *Orientation:* Elongation negative. $n = < 1.730$
$\alpha = 1.6178(3)$ (synthetic). $\beta = 1.6184(3)$ $\gamma = 1.6516(3)$ 2V(meas.) = 12(1)°
2V(calc.) = 15.5°

Cell Data: *Space Group:* $C2/c$. a = 12.94(1) $b = 8.910(8)$ $c = 5.446(4)$ $\beta = 107.0(1)°$
Z = 4

X-ray Powder Pattern: Acfer 182 meteorite.
3.515 (100), 4.460 (43), 2.605 (36), 2.440 (21), 1.764 (20), 3.609 (13), 2.882 (13)

Chemistry:

	(1)	(2)
SiO_2	0.11	
TiO_2	0.15	
Al_2O_3	77.8	78.43
FeO	0.31	
MgO	0.06	
CaO	21.4	21.57
Total	99.83	100.00

(1) Acfer 182 meteorite; by electron microprobe, average of 20 grains; corresponding to $(Ca_{1.00}Fe_{0.01})_{\Sigma=1.01}Al_{3.99}O_7$. (2) $CaAl_4O_7$.

Occurrence: In argillaceous limestones metamorphosed at high temperature and low pressure (Hatrurim Formation, Israel); in Ca–Al-rich inclusions thought formed by condensation from a hot gas or molten droplets (meteorites).

Association: Brownmillerite, mayenite, larnite (Hatrurim Formation, Israel); perovskite, melilite, hibonite, spinel, calcian pyroxene (meteorites).

Distribution: In the Hatrurim Formation, Israel. From the chondritic meteorites Acfer 182, Acfer 059-El Djouf 001, ALH85085, and others.

Name: Honors Dr. Shulamit Gross (1923–), Geological Survey of Israel, Jerusalem, Israel, who noted the species in the Hatrurim Formation, Israel.

Type Material: Institute for Planetology, Münster; Natural History Museum, Humboldt University, Berlin, Germany.

References: (1) Weber, D. and A. Bischoff (1994) Grossite ($CaAl_4O_7$) – a rare phase in terrestrial rocks and meteorites. Eur. J. Mineral., 6, 591–594. (2) (1995) Amer. Mineral., 80, 630 (abs. ref. 1). (3) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 11. (4) Boyko, E.R. and L.G. Wisnyi (1958) The optical properties and structures of $CaO \cdot 2Al_2O_3$ and $SrO \cdot 2Al_2O_3$. Acta Cryst., A11, 444–445.

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Grossular $Ca_3Al_2(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Commonly in dodecahedra or trapezohedra, up to 15 cm, with striated faces. Also granular, compact, and massive.

Physical Properties: *Cleavage:* Parting on {110} rarely observed. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 3.594 D(calc.) = 3.594 May fluoresce weak golden yellow under LW or SW UV.

Optical Properties: Transparent to opaque. *Color:* Yellow-green, pale to dark green; golden yellow, pink, red, orange, brownish red, yellowish brown; colorless, white, gray, black; may be sectored: colorless in thin section. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Isotropic; weak strain birefringence. $n = 1.734$

Cell Data: *Space Group: Ia3d.* $a = 11.851$ Z = 8

X-ray Powder Pattern: Georgetown, Placer Co., California, USA. (ICDD 26-292). 2.647 (100), 1.581 (50), 2.959 (25), 1.921 (25), 1.643 (25), 2.417 (20), 2.321 (18)

Chemistry:

	(1)	(2)
SiO_2	39.30	40.02
TiO_2	0.00	
Al_2O_3	21.93	22.63
Fe_2O_3	0.80	
Cr_2O_3	0.13	
FeO	0.28	
MgO	trace	
CaO	37.10	37.35
H_2O	0.30	
Total	99.84	100.00

(1) Georgetown, Placer Co., California, USA; corresponds to $(Ca_{3.00}Fe^{2+}_{0.02})_{\Sigma=3.02}(Al_{1.92}Fe^{3+}_{0.05})_{\Sigma=1.97}(Si_{2.97}Al_{0.03})_{\Sigma=3.00}O_{12}$. (2) $Ca_3Al_2(SiO_4)_3$.

Polymorphism & Series: Forms three series: with andradite; with hibschite and katoite; and with uvarovite.

Mineral Group: Garnet group.

Occurrence: In contact and regionally metamorphosed calcareous rocks, or rocks which have undergone calcium metasomatism; in some schists and serpentinites.

Association: Calcite, dolomite, epidote, clinozoisite, wollastonite, scapolite, vesuvianite, diopside, tremolite, quartz.

Distribution: Many localities, even for fine crystals and gem material. In Russia, near Chernyshevsk, at the confluence of the Vilyui and Akhtaragda Rivers, Yakutia. In the Ala Valley, Piedmont, Italy. From the Zillertal, Tirol, Austria. At Ocna de Fier, Romania. In the Jeffrey mine, Asbestos, Quebec, Canada. In the USA, at Standish, Cumberland Co., Maine, and at the Belvidere Mountain quarries, Lowell, Orleans Co., Vermont. In California, from Crestmore, Riverside Co., the Old Cosumnes copper mine, El Dorado Co., San Carlos mine, Mazourka Canyon, Inyo Range, Inyo Co., and Santa Rosa, Sonoma Co.; on Vesper Peak, Sultan basin, Snohomish Co., Washington. In Mexico, large crystals from Xalostoc and Morelos, Chihuahua, and from the Sierra de la Cruces, near Lake Jaco, Coahuila. Gems from the Merelani Hills, southeast of Arusha, Tanzania. In the Taita Hills, near Voi, Kenya.

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Name: From *Ribes Grossularium* or gooseberry; the botanical name, in reference to a typical greenish color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 437–447. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 468–698, esp. 603–616. (3) Novak, G.A. and G.V Gibbs (1971) The crystal chemistry of the silicate garnets. Amer. Mineral., 56, 791–825.

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Groutite $Mn^{3+}O(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$. As wedge- or lens-shaped crystals with rounded and curved faces, to 1 cm; also as acicular striated prismatic crystals, in radiating groups. *Twinning:* Twinning by an undescribed law reported.

Physical Properties: *Cleavage:* {010}, perfect; {100}, less perfect. *Tenacity:* Brittle. Hardness = 3.5–4 VHN = 630–711 (100 g load). D(meas.) = 4.144 D(calc.) = 4.172

Optical Properties: Opaque. *Color:* Jet-black. *Streak:* Dark brown. *Luster:* Brilliant submetallic to adamantine.
Optical Class: Biaxial. *Pleochroism:* Very strong; X = very dark brown to black; Y = yellowish brown.
R_1–R_2: (400) 13.7–22.0, (420) 13.4–21.3, (440) 13.3–20.7, (460) 13.1–20.2, (480) 13.0–19.7, (500) 13.0–19.4, (520) 12.9–19.1, (540) 12.9–19.0, (560) 12.8–19.0, (580) 12.7–18.7, (600) 12.7–18.6, (620) 12.7–18.5, (640) 12.6–18.3, (660) 12.5–18.2, (680) 12.4–18.0, (700) 12.4–17.9

Cell Data: *Space Group: Pbnm.* $a = 4.560$ $b = 10.700$ $c = 2.870$ Z = 4

X-ray Powder Pattern: Sagamore mine, Minnesota, USA.
4.17 (10), 2.798 (6), 2.675 (6), 2.369 (6), 2.303 (5), 1.692 (5), 1.603 (4)

Chemistry:

	(1)	(2)
Fe_2O_3	0.02	
MnO	79.97	80.66
O	8.94	9.10
H_2O^+	10.39	10.24
H_2O^-	0.04	
P_2O_5	0.34	
Total	[99.70]	100.00

(1) Mahnomen mine, Minnesota, USA; after correction for quartz 2.39%, original total given as 99.71% (2) MnO(OH).

Polymorphism & Series: Trimorphous with manganite and feitknechtite.

Occurrence: A secondary mineral lining vugs in weathered banded iron formations (Minnesota, USA); manganiferous talc schists (Talcville, New York, USA); a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA); and a variety of hydrothermal orebodies (Arizona, USA).

Association: Manganite, hematite, goethite, lepidocrocite, quartz, calcite.

Distribution: In the USA, in significant amounts at several sites in the Cuyuna Iron Range, including the Sagamore, Mahnomen, Robert, and Mangan No. 2 mines, Crow Wing Co., Minnesota; at Franklin, Sussex Co., New Jersey; from the No. Two and One Half mine, Talcville, New York. In Arizona, in the Campbell mine, Bisbee, Cochise Co.; the Magma mine, Superior, and at Malpais Hill, Pinal Co.; the North Star and King of Arizona mines, Yuma Co.; and near Holbrook, Navajo Co. From the Walton mine, Hants Co., Nova Scotia, Canada. At Bülten-Adenstadt, near Peine, Lower Saxony, Germany. From Bleiberg, Carinthia, Austria. At Akdala, Kazakhstan. In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: Honors Professor Frank Fitch Grout (1880–1958), petrologist, of the University of Minnesota, Minneapolis, Minnesota, USA.

Type Material: The Natural History Museum, London, England, 1948,106; National Museum of Natural History, Washington, D.C., USA, 105004.

References: (1) Gruner, J.W. (1947) Groutite, $HMnO_2$, a new mineral of the diaspore-goethite group. Amer. Mineral., 32, 654–659. (2) Dent Glasser, L.S. and L. Ingram (1968) Refinement of the crystal structure of groutite, α-MnOOH. Acta Cryst., 24, 1233–1236.

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Grumantite $NaHSi_2O_5 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As irregular crystals; compact massive.

Physical Properties: *Cleavage:* Perfect on {110}; another unspecified cleavage was observed. *Fracture:* Steplike. Hardness = 4–5 D(meas.) = 2.21 D(calc.) = 2.26 Weak bluish white fluorescence in UV.

Optical Properties: Transparent to slightly turbid in crystals. *Color:* White in aggregates. *Streak:* White. *Luster:* Vitreous, silky to dull in aggregates.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, weak.
$\alpha = 1.494(2)$ $\beta = 1.507(2)$ $\gamma = 1.523(2)$ 2V(meas.) = 85(2)° 2V(calc.) = 84.9°

Cell Data: *Space Group:* $Fdd2$. $a = 15.979$ $b = 18.25$ $c = 7.169$ Z = 16

X-ray Powder Pattern: Mt. Alluaiv, Russia.
3.505 (100), 3.006 (100), 6.20 (50), 6.05 (50), 4.46 (50), 3.087 (50), 3.346 (25)

Chemistry:

	(1)	(2)
SiO_2	68.17	67.44
Na_2O	17.20	17.39
H_2O	14.65	15.17
Total	100.02	100.00

(1) Mt. Alluaiv, Russia; corresponds to $Na_{0.98}H_{1.02}Si_2O_5 \cdot 0.93H_2O$. (2) $NaHSi_2O_5 \cdot H_2O$.

Occurrence: In veins cutting alkalic feldspathoid-bearing pegmatites in a differentiated alkalic massif.

Association: Ussingite, makatite, kazakovite, tisinalite, nordite, sodalite, nepheline, potassic feldspar, arfvedsonite, aegirine, eudialyte, loparite.

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: From an old Russian name for the Spitsbergen Archipelago.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5924; Mineralogical Museum, St. Petersburg, 17070; Mining Institute, St. Petersburg, 2065/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87576.

References: (1) Khomyakov, A.P., M.F. Korobitsyn, T.A. Kurova, and G.E. Cherepivskaya (1987) Grumantite $NaHSi_2O_5 \cdot H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 116, 244–248 (in Russian). (2) (1988) Amer. Mineral., 73, 440 (abs. ref. 1). (3) Pushcharovsky [Pushcharovskii], D.Y., T.N. Nadezhina, N.A. Yamnova, and R.L. Rastsvetaieva [Rastsvetaeva] (1988) New types of tetrahedral radicals in mineral structures: $Be(OH)_2$ and grumantite. Zeits. Krist., 185, 612.

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Grumiplucite $HgBi_2S_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very slender prismsmatic crystals, to 1.0 mm, elongated along [010]. *Twinning:* On {001}, universal.

Physical Properties: *Cleavage:* Perfect on {001}, near micaceous. Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.02

Optical Properties: n.d. *Color:* Gray-black.; creamy white in reflected light.
Luster: Metallic.
Optical Class: Biaxial. *Anisotropism:* Distinct; bluish gray to yellowish gray.
Bireflectance: Low.
R_1–R_2: (400) 33.9–36.1, (420) 34.4–36.6, (440) 35.1–37.2, (460) 35.6–37.7, (480) 35.9–38.0, (500) 35.9–38.0, (520) 35.5–37.6, (540) 35.4–37.5, (560) 35.3–37.4, (580) 35.2–37.3, (600) 34.7–36.8, (620) 34.2–36.2, (640) 33.9–35.9, (660) 33.8–35.7, (680) 33.8–35.6, (700) 33.9–35.

Cell Data: *Space Group:* $C2/m$. $a = 14.185(5)$ $b = 4.071(7)$ $c = 13.995(5)$ $\beta = 118.22(3)^\circ$ Z = 4

X-ray Powder Pattern: Levigliani mine, Italy.
3.05 (s), 2.914 (ms), 2.865 (ms), 3.86 (m), 3.55 (m), 2.644 (m), 1.913 (m)

Chemistry:

	(1)	(2)
Hg	25.4	26.86
Bi	57.6	55.97
S	17.4	17.17
Total	100.4	100.00

(1) Levigliani mine, Italy; by electron microprobe, average of 12 analyses; corresponds to $Hg_{0.94}Bi_{2.04}S_{4.00}$. (2) $HgBi_2S_4$.

Mineral Group: Benjaminite group.

Occurrence: Very rare, in quartz-carbonate veins in a mercury deposit, probably formed during retrograde metamorphism.

Association: Cinnbar, mercurian sphalerite, mercury, pyrite.

Distribution: From the Levigliani mercury mine, near Levigliani, Tuscany, Italy [TL].

Name: For the GRUppo MIneralogico e Paleontological LUcchese, a group of amateur mineralogists, including Luigi Pierotti, Ugo Quilici, and Moeno Romani, who provided the specimens for study.

Type Material: Museum of Natural History, University of Pisa, Pisa, Italy.

References: (1) Orlandi, P. and A. Dini (1998) Grumiplucite, a new mercury – bismuth sulfosalt species from the Levigliani mine, Apuan Alps, Tuscany, Italy. Can. Mineral., 36, 1321–1326. (2) (????) Amer. Mineral., ??, ?? (abs. ref. 1). (3) Mumme, W.G. and J.A. Watts (1980) $HgBi_2S_4$: crystal structure and relationship with the pavonite homologous series. Acta Cryst., 36, 1300–1304.

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Grunerite $Fe_2^{2+}(Fe^{2+},Mg)_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly as acicular or fibrous radiating crystals; may be asbestiform. *Twinning:* Simple or multiple twinning common ∥ {100}, producing narrow twin lamellae.

Physical Properties: *Cleavage:* Perfect on {110}, with intersections of ∼56° and ∼124°. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.40–3.60 D(calc.) = 3.531

Optical Properties: Translucent. *Color:* Dark green to brown, gray to greenish gray; colorless to pale green or brown in thin section. *Luster:* Vitreous, silky when fibrous.
Optical Class: Biaxial (–). *Pleochroism:* With increasing Fe content, X = pale yellow; Y = pale yellow-brown; Z = pale brown. *Orientation:* $Y = b$; $Z \wedge c = -16°$ to $-12°$; $X \wedge a = -3°$ to 2°. *Dispersion:* $r > v$, weak. $\alpha = 1.663–1.688$ $\beta = 1.677–1.709$ $\gamma = 1.697–1.729$
2V(meas.) = 80°–90°

Cell Data: *Space Group:* $C2/m$. $a = 9.5642(7)$ $b = 18.393(2)$ $c = 5.3388(3)$ $\beta = 101.892(3)°$ Z = 2

X-ray Powder Pattern: Wabush Iron Formation, White Lake, Newfoundland, Canada.
8.33 (100), 3.06 (70), 2.756 (70), 2.189 (50), 4.13 (40), 3.26 (40), 2.628 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	49.33	47.54	MgO	6.65	0.04
TiO_2	0.02		CaO	0.18	0.00
Al_2O_3	0.39	0.20	Na_2O	0.12	0.29
Fe_2O_3		0.71	K_2O	0.20	0.11
FeO	40.94	47.25	F		0.01
MnO	0.54	2.14	H_2O^+	1.54	1.55
			Total	99.91	99.84

(1) Wabush Iron Formation, Newfoundland, Canada; corresponds to $(Fe^{2+}_{5.50}Mg_{1.59}Mn_{0.08}Na_{0.04}K_{0.04}Ca_{0.03})_{\Sigma=7.28}(Si_{7.92}Al_{0.08})_{\Sigma=8.00}O_{22}(OH)_{1.64}$. (2) Rockport, Essex Co., Massachusetts, USA; corresponds to $(Fe^{2+}_{6.63}Mn_{0.30}Fe^{3+}_{0.09}Na_{0.09}K_{0.02}Mg_{0.01}Al_{0.01})_{\Sigma=7.15}(Si_{7.97}Al_{0.03})_{\Sigma=8.00}O_{22}(OH)_{1.74}$.

Polymorphism & Series: Dimorphous with ferro-anthophyllite; forms a series with cummingtonite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: $Mg/(Mg + Fe^{2+}) < 0.3$; $(Ca + Na)_B < 1.34$; $Li < 1.0$; $Mn < 0.5$.

Occurrence: Common in medium- to high-grade metamorphosed iron formations. A product of contact metamorphism, and in some blueschist facies metaquartzites.

Association: Magnetite, hematite, hedenbergite, riebeckite, fayalite, garnet, quartz.

Distribution: Many localities. From Collobrières, Var, France. At Loch Duich, Ross-shire, and Glen Beag, Glenelg, Inverness-shire, Scotland. From the Botallack mine, St. Just, Cornwall, England. In Portugal, at Vila Real. At Strömshult, near Tunaberg, Sweden. Commercial production from the Penge area, Transvaal, South Africa. From around Michigamme, Marquette Co., Michigan, USA. In Canada, in the Labrador City area, Labrador, Newfoundland. At Gualilan, Argentina.

Name: To honor the French chemist, Louis Emmanuel Gruner (1809–1883), who provided the first analysis.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 386, 391. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 235–248. (3) Klein, C. (1964) Cummingtonite-grunerite series: a chemical, optical and X-ray study. Amer. Mineral., 49, 963–982. (4) Finger, L.W. (1969) The crystal structure and cation distribution of a grunerite. MSA Special Paper 2, 95–100. (5) Chakraborty, K.L. (1963) Relationship of anthophyllite, cummingtonite and mangano-cummingtonite in the metamorphosed Wabush Iron-formation, Labrador. Can. Mineral., 7, 738–750. (6) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 225–228.

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Gruzdevite $Cu_6Hg_3Sb_4S_{12}$

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Crystal Data: Hexagonal. *Point Group:* 3 (probable). May be in zoned crystals with aktashite, to 4 mm; typically massive, presumably.

Physical Properties: Hardness = n.d. VHN = 295(5) (30 g load). D(meas.) = n.d. D(calc.) = 5.88

Optical Properties: Opaque. *Color:* Gray-black; white in reflected light. *Luster:* Metallic. *Anisotropism:* Weak.
R: (460) 33.1, (540) 32.8, (580) 32.7, (660) 31.9

Cell Data: *Space Group:* *R*3 (by analogy to aktashite). $a = 13.90(2)$ $c = 9.432$ Z = 3

X-ray Powder Pattern: Chauvai deposit, Kyrgyzstan.
3.16 (10), 1.929 (9), 1.645 (8), 1.113 (6), 1.251 (5), 2.12 (3), 1.363 (3)

Chemistry:

	(1)	(2)
Cu	19.99	20.55
Fe	0.29	
Hg	32.73	32.45
Sb	26.21	26.26
As	0.37	
S	20.44	20.74
Total	100.03	100.00

(1) Chauvai deposit, Kyrgyzstan; by electron microprobe, average of six samples, corresponding to $(Cu_{5.87}Fe_{0.10})_{\Sigma=5.97}Hg_{3.04}(Sb_{4.01}As_{0.09})_{\Sigma=4.10}S_{11.89}$. (2) $Cu_6Hg_3Sb_4S_{12}$.

Polymorphism & Series: Forms a series with aktashite.

Occurrence: In veinlets of probable low-temperature hydrothermal origin (Chauvai deposit, Kyrgyzstan).

Association: Aktashite, stibnite, cinnabar, metacinnabar, wurtzite, fluorite, calcite, barite (Chauvai deposit, Kyrgyzstan).

Distribution: From the Chauvai Sb–Hg deposit, Fergana Valley, Alai Range, southern Kyrgyzstan [TL]. In the San Miguel prospect, 10 km northwest of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. At the Goldstrike mine, Lynn district, Eureka Co., Nevada, USA.

Name: To honor the Russian mineralogist, Vyacheslav Sergeevich Gruzdev (1938–1977), Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Spiridonov, E.P., L.Y. Krapiva, A.K. Gapeev, V.I. Stepanov, E.Y. Prushinskaya, and V.Y. Volgin (1981) Gruzdevite, $Cu_6Hg_3Sb_4S_{12}$, a new mineral from the Chauvai antimony–mercury deposit, Central Asia. Doklady Acad. Nauk SSSR, 261, 971–976 (in Russian). (2) (1982) Amer. Mineral., 67, 855 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 95.

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Guanajuatite Bi_2Se_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Acicular crystals, to 2 cm, striated lengthwise, forming semicompact masses. Also massive, having granular, foliated, or fibrous texture.

Physical Properties: *Cleavage:* Distinct on {010}, indistinct on {001}. *Tenacity:* Somewhat sectile. Hardness = 2.5–3 VHN = 53–82 (10 g load). D(meas.) = 6.25–6.98 D(calc.) = 7.54

Optical Properties: Opaque. *Color:* Bluish gray; in polished section, white with a yellowish hue. *Streak:* Shiny gray. *Luster:* Metallic. *Pleochroism:* Distinct. *Anisotropism:* Strong. R_1–R_2: (400) 41.2–51.8, (420) 41.8–51.8, (440) 42.3–51.9, (460) 42.8–51.9, (480) 43.3–52.0, (500) 43.3–52.0, (520) 43.3–52.0, (540) 43.1–52.0, (560) 42.9–52.0, (580) 42.7–52.2, (600) 42.4–52.2, (620) 42.2–52.1, (640) 41.9–51.9, (660) 41.5–51.6, (680) 41.2–51.2, (700) 40.8–50.7

Cell Data: *Space Group: Pnma.* $a = 11.37$ $b = 11.55$ $c = 4.054$ $Z = 4$

X-ray Powder Pattern: Guanajuato, Mexico.
3.19 (100), 3.65 (90), 1.989 (70), 2.88 (60), 2.58 (50), 2.31 (50), 5.16 (40)

Chemistry:

	(1)	(2)	(3)
Bi	67.38	68.0	63.83
Se	24.13	24.5	36.17
S	6.60	6.6	
Total	98.11	99.1	100.00

(1) Guanajuato, Mexico; corresponds to $Bi_{1.89}(Se_{1.79}S_{1.21})_{\Sigma=3.00}$. (2) Do.; by electron microprobe, corresponds to $Bi_{1.89}(Se_{1.80}S_{1.20})_{\Sigma=3.00}$. (3) Bi_2Se_3.

Polymorphism & Series: Dimorphous with paraguanajuatite.

Occurrence: In hydrothermal deposits of low to medium temperatures.

Association: Bismuthinite, bismuth, clausthalite, nevskite, galena, pyrite, calcite.

Distribution: In Mexico, from the Santa Catarina [TL], La Industrial [TL], and Nuestra Señora de la Luz mines, Sierra de Santa Rosa, near Guanajuato. In the USA, near Salmon, Lemhi Co., Idaho; and at the Thomas and Essex mines, Darwin, Inyo Co., California. From the Roter Bär mine, St. Andreasberg, Harz Mountains, Germany. At Falun, Kopparberg, Sweden.

Name: For the locality in Guanajuato, Mexico.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 278–279. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 85. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 216.

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Guanine $C_5H_3(NH_2)N_4O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically as fine-grained granular crusts, to 2 mm in diameter.

Physical Properties: Hardness = "Soft". D(meas.) = n.d. D(calc.) = n.d. M.P. 360 °C.

Optical Properties: Transparent to translucent. *Color:* White.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 16.510$ $b = 11.277$ $c = 3.645$ $\beta = 98.84°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 28-2012).
3.22 (100b), 6.32 (70b), 3.53 (50), 2.63 (50), 2.00 (50), 1.80 (50), 7.9 (40)

Chemistry: (1) Identification is by coincidence of X-ray diffraction pattern with that of synthetic material.

Occurrence: An uncommon component of phosphatic crusts associated with guano from seabirds or bats.

Association: Aphthitalite, biphosphammite, brushite, gypsum, monetite, syngenite, taylorite, hannayite (Murra-el-elevyn Cave, Australia); biphosphammite, archerite, aphthitalite, halite, syngenite, stercorite, oxammite, weddellite, whitlockite, mundrabillaite, newberyite, calcite (Petrogale Cave, Australia).

Distribution: From North Chincha Island, off the coast of Peru. In Australia, in Murra-el-elevyn Cave, Cocklebiddy, and Petrogale Cave, near Madura, Western Australia.

Name: From the Peruvian *guanu*, for *dung*, in allusion to its mode of formation in nature.

References: (1) Bridge, P.J. (1973) Guano minerals from Murra-el-elevyn Cave, Western Australia. Mineral. Mag., 39, 467–469. (2) Bridge, P.J. (1974) Guanine and uricite, two new organic minerals from Peru and Western Australia. Mineral. Mag., 39, 889–890. (3) Bugg, C.E., U.T. Thewalt, and R.E. Marsh (1968) Base stacking in nucleic acid components: the crystal structures of guanine, guanosine and inosine. Biochem. Biophysical Res. Comm., 33(3), 436–440.

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Guarinoite $(Zn, Co, Ni)_6(SO_4)(OH, Cl)_{10} \cdot 5H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6, $6/m$, or 622. As thin hexagonal crystals, tabular on {0001}, to 0.2 mm; typically in rounded aggregates.

Physical Properties: *Cleavage:* On {0001}, perfect. *Fracture:* Irregular. *Tenacity:* "Fragile". Hardness = "Very soft". D(meas.) = 2.80(1) D(calc.) = 2.77

Optical Properties: Transparent. *Color:* Bright to deep pink. *Streak:* Pale pink. *Luster:* Vitreous to pearly.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = pink; E = pale pink. $\omega = 1.584(2)$ $\epsilon = 1.544(2)$

Cell Data: *Space Group:* $P6_3$, $P6_3/m$ or $P6_322$. $a = 8.344(4)$ $c = 21.59(2)$ $Z = 3$

X-ray Powder Pattern: Cap Garonne mine, France.
10.8 (100), 3.300 (90), 2.725 (60), 2.563 (50), 2.351 (40), 1.575 (30), 5.40 (25)

Chemistry:

	(1)
SO_3	11.85
CoO	22.17
NiO	6.74
CuO	0.05
ZnO	33.31
Cl	0.77
H_2O	24.4
$-O = Cl_2$	0.17
Total	99.12

(1) Cap Garonne mine, France; by electron microprobe, average of five analyses, H_2O by CHN analyzer; corresponds to $(Zn_{2.99}Co_{2.16}Ni_{0.66})_{\Sigma=5.81}(SO_4)_{1.08}[(OH)_{9.30}Cl_{0.16}]_{\Sigma=9.46} \cdot 5.23H_2O$.

Occurrence: A secondary mineral in the oxidized portions of a polymetallic sulfide deposit.

Association: Anglesite, antlerite, cobaltoan-nickeloan ktenasite, cerussite, brochantite, covellite, tennantite, gersdorffite, thérèsemagnanite, rutile, quartz.

Distribution: From the Cap Garonne mine, near le Pradet, Var, France.

Name: Honors André Guarino (1945–), mineral collector and medical technologist, Toulon, France, who first collected the mineral.

Type Material: Mineralogy Department, Natural History Museum, Geneva, Switzerland, 435/85.

References: (1) Sarp, H. (1993) Guarinoite $(Zn, Co, Ni)_6(SO_4)(OH, Cl)_{10} \cdot 5H_2O$ et theresemagnanite $(Co, Zn, Ni)_6(SO_4)(OH, Cl)_{10} \cdot 8H_2O$, deux nouveaux minéraux de la Mine de Cap Garonne, Var, France. Archs. Sci. Genève, 46(1), 37–44 (in French with English abs.).
(2) (1993) Amer. Mineral., 78, 1314–1315 (abs. ref. 1).

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Gudmundite FeSbS

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Prismatic ‖ [001]; prism zone typically tapered, to 2 mm. *Twinning:* On {101}, forming penetration and contact twins, with cruciform and butterfly shapes, very common.

Physical Properties: *Tenacity:* Brittle. Hardness = ∼5–6 VHN = 572–673 (100 g load). D(meas.) = 6.72 D(calc.) = 6.95

Optical Properties: Opaque. *Color:* Silver-white to steel-gray in polished section. *Luster:* Metallic. *Pleochroism:* Distinct, in pure white and pinkish white. *Anisotropism:* Strong, in yellow and red tints.
R_1–R_2: (400) 49.1–54.3, (420) 49.4–55.7, (440) 49.5–56.1, (460) 49.7–56.4, (480) 49.9–56.8, (500) 50.2–57.1, (520) 50.7–57.0, (540) 51.3–56.7, (560) 52.0–56.3, (580) 52,7–55.8, (600) 53.2–55.1, (620) 53.6–54.5, (640) 53.9–53.9, (660) 54.1–53.4, (680) 54.2–52.7, (700) 54.4–52.4

Cell Data: *Space Group:* $P2_1/c$. $a = 10.00$ $b = 5.95$ $c = 6.73$ $\beta = 90°00'$ Z = 8

X-ray Powder Pattern: Gudmundstorp, Sweden.
2.55 (10), 1.917 (7), 4.09 (5), 1.416 (5), 2.81 (4), 1.098 (4), 1.024 (4)

Chemistry:

	(1)	(2)	(3)
Fe	26.79	26.4	26.63
Ni	trace		
Sb	57.31	58.3	58.08
As		0.2	
S	15.47	14.6	15.29
Total	99.57	99.5	100.00

(1) Gudmundstorp, Sweden; corresponds to $Fe_{0.99}Sb_{0.98}S_{1.00}$. (2) Vlastéjovice, Czech Republic; by electron microprobe, corresponds to $Fe_{0.98}Sb_{0.99}As_{0.01}S_{0.94}$. (3) FeSbS.

Mineral Group: Arsenopyrite group.

Occurrence: A late-stage hydrothermal mineral formed in sulfide deposits.

Association: Pyrite, pyrrhotite, chalcopyrite, lead sulfantimonides, antimony, bismuth, kermesite, arsenopyrite, argentian gold.

Distribution: In Sweden, from Gudmundstorp, 3 km north of Sala, Västmanland [TL]; also at Boliden, Holmtjärn, Malånäs, Tunaberg, and in the Vena mines, near Askersund, Örebro. In Finland, from Kalliolampi, near Nurma. At Sulitjelma, Norway. From Waldsassen, Bavaria, Germany. In the Salsigne mine, 15 km north of Carcassone, Aude, France. In the Czech Republic, at Vlastéjovice, Sáxova. From the Pezinok mine, Male Karpaty Mountains, Slovakia. In Ireland, at the Shallee and Gortnadyne mines, Silvermines, Co. Tipperary. From the Ilímaussaq intrusion, southern Greenland. An ore at the Lac Nicolet antimony mine, South Ham, Quebec; in the Hemlo gold deposit, Thunder Bay district; and from near Red Lake, Ontario, Canada. At Broken Hill, New South Wales, Australia. From Askot, Pithoragarh district, and in the Kolar Gold Fields, Karnataka, India. A number of other minor occurrences are known.

Name: For the occurrence at Gudmundstorp, Sweden.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 325–326. (2) Buerger, M.J. (1939) The crystal structure of gudmundite (FeSbS) and its bearing on the existance field of the arsenopyrite structural type. Zeits. Krist., 101, 290–316. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 106–107. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 217.

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Guérinite $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 9H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As wedge-shaped prismatic crystals, to 3 mm; in sprays, as spherulites or rosettes of acicular to platy crystals.

Physical Properties: *Cleavage:* Perfect, ‖ plane of the plates; good, ‖ elongation; poor, ⊥ to elongation. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = 2.68–2.76 D(calc.) = 2.74

Optical Properties: Translucent to opaque. *Color:* Colorless, white. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). *Orientation:* Z = elongation; $X \wedge c = 10°$ ⊥ plane of the plates. *Dispersion:* $r > v$, strong; rarely $r < v$. $\alpha = 1.574(1)$ $\beta = 1.582(1)$ $\gamma = 1.582(1)$
2V(meas.) = 7°–15°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 17.63(1)$ $b = 6.734(3)$ $c = 23.47(2)$ $\beta = 90.6(1)°$ Z = 5

X-ray Powder Pattern: Wittichen, Germany.
14.0 (FFF), 3.89 (FF), 3.01 (FF), 2.90 (FF), 3.49 (F), 11.7 (mF), 4.84 (mF)

Chemistry:

	(1)	(2)
As_2O_5	49.76	49.95
CaO	30.06	30.47
H_2O	19.18	19.58
insol.	0.40	
Total	99.40	100.00

(1) Sainte-Marie-aux-Mines, France. (2) $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 9H_2O$.

Polymorphism & Series: Dimorphous with ferrarisite.

Occurrence: A recent weathering product in oxidizing arsenic-rich mineral deposits.

Association: Realgar, erythrite, quartz, calcite.

Distribution: In Germany, from the Daniel mine, Schneeberg, Saxony; at the Bauhaus district, Richelsdorf, Hesse; from the Anton mine, Heubachtal, near Schiltach, and at Wittichen, Black Forest. At Sainte-Marie-aux-Mines, Haut-Rhin, France. In the USA, at Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and in the Getchell mine, Potosi district, Humboldt Co., Nevada.

Name: Honors Henri Guérin (1906–), who synthesized the compound.

Type Material: n.d.

References: (1) Nefedov, E.I. (1961) Guerinite, a new mineral. Materialy Vses. Nauchno-Issled. Geol. Inst., 45, 113–115 (in Russian). (2) (1962) Amer. Mineral., 47, 416–417 (abs. ref. 1). (3) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésiens naturels. Bull. Minéral., 87, 169–211 (in French). (4) Catti, M. and G. Ferraris (1974) Crystal structure of $Ca_5(HAsO_4)_2(AsO_4)_2 \cdot 9H_2O$ (Guérinite). Acta Cryst., 30, 1789–1794.

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Guettardite $Pb(Sb, As)_2S_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals, to 2 mm, the faces of which are irregularly streaked parallel to the axis of elongation; also as small anhedral grains. *Twinning:* Polysynthetic twinning on {100}, common in polished section.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = n.d. VHN = 180–197 (50 g load). D(meas.) = 5.26 D(calc.) = 5.39

Optical Properties: Opaque. *Color:* Grayish black; in polished section, white with reddish internal reflections. *Luster:* Metallic. *Pleochroism:* Relatively strong.
R_1–R_2: (470) 37.6–42.6, (546) 36.1–41.2, (589) 34.8–39.3, (650) 32.8–36.7

Cell Data: *Space Group:* $P2_1/a$. $a = 20.05(5)$ $b = 7.95(2)$ $c = 8.44(2)$ $\beta = 101°46(10)'$
$Z = 8$

X-ray Powder Pattern: Madoc, Canada.
3.52 (100), 2.795 (90), 4.19 (50), 3.90 (50), 2.670 (50), 2.653 (50), 2.335 (40)

Chemistry:

	(1)	(2)	(3)
Pb	38.8	38.50	38.94
Cu		0.49	
Sb	24.1	23.57	22.88
As	12.2	13.61	14.08
S	24.1	23.46	24.10
Total	99.2	99.63	100.00

(1) Madoc, Canada; by electron microprobe, corresponding to $Pb_{1.01}(Sb_{1.07}As_{0.88})_{\Sigma=1.95}S_{4.05}$.
(2) Pitone quarry, Italy; by electron microprobe; corresponding to $Pb_{1.04}Cu_{0.04}(Sb_{1.00}As_{0.94})_{\Sigma=1.94}S_{3.78}$. (3) $Pb(Sb, As)_2S_4$ with Sb:As = 1:1.

Polymorphism & Series: Dimorphous with twinnite.

Occurrence: Of low-temperature hydrothermal origin, in marbles (Madoc, Canada; Seravezza, Italy).

Association: Pyrite, sphalerite, wurtzite, galena, stibnite, orpiment, realgar, enargite, tetrahedrite, zinkenite, jordanite, bournonite, sterryite, boulangerite, jamesonite, sartorite (Madoc, Canada); zinkenite, boulangerite, semseyite, jordanite, enargite (Silverton, Colorado, USA).

Distribution: From Madoc, Ontario, Canada [TL]. At the Brobdingnag mine, near Silverton, San Juan Co., Colorado, USA. In the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France. At the Pitone, Tognetti, and Ceragiola marble quarries, near Seravezza, Tuscany, Italy. From Novoye, Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan.

Name: Honors Jean Etienne Guettard (1715–1786), French mineralogist and geologist.

Type Material: Canadian Geological Survey, Ottawa, 12167; Royal Ontario Museum, Toronto, Canada.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Ontario. Part 2 – Mineral descriptions. Can. Mineral., 9, 191–213. (2) (1968) Amer. Mineral., 53, 1425 (abs. ref. 1). (3) Bracci, G., D. Dalena, P. Orlandi, G. Duchi, and G. Vezzalini (1980) Guettardite from Tuscany, Italy: a second occurrence. Can. Mineral., 18, 13–15. (4) Mozgova, N.N., N.S. Bortnikov, Y.S. Borodaev, and A.I. Tzépine (1982) Sur la non-stoechiométrie des sulfosels antimonieux arséniques de plomb. Bull. Minéral., 105, 3–10 (in French with English abs.). (5) Jambor, J.L., J.H.G. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100.

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Gugiaite $Ca_2BeSi_2O_7$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As thin square tablets, to 3 mm, with prominent {001}, also {011}, {111}, and {110}.

Physical Properties: *Cleavage:* Perfect on {010}, distinct on {001}, poor on {110}. *Fracture:* Irregular. Hardness = ∼5 D(meas.) = 3.034 D(calc.) = 3.03 Strongly piezoelectric.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.664(1)$ $\epsilon = 1.672(1)$

Cell Data: *Space Group:* $P\bar{4}2m$. $a = 7.48(2)$ $c = 5.044(3)$ Z = [2]

X-ray Powder Pattern: Gugia, China.
2.765 (10), 1.709 (7), 1.485 (7), 5.25 (4), 2.97 (4), 2.359 (4), 2.315 (4)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	45.26	44.90	46.70	Na_2O		0.72	
TiO_2	0.02	trace		K_2O		0.20	
$(Zr,Hf)O_2$	0.45			F		0.25	
Al_2O_3	1.08	2.17		Cl	0.73	0.18	
Fe_2O_3	0.03	0.11		H_2O^+	0.40	0.90	
MnO	0.11	0.07		H_2O^-	0.02	0.36	
BeO	8.89	9.49	9.72	P_2O_5		0.08	
MgO	0.39	0.38		$-O = (F,Cl)_2$	0.17	0.15	
CaO	42.94	40.09	43.58	Total	100.15	[99.75]	100.00

(1) Gugia, China. (2) Do.; original total given as 99.79%. (3) $Ca_2BeSi_2O_7$.

Polymorphism & Series: Dimorphous with jeffreyite.

Mineral Group: Melilite group.

Occurrence: In cavities in skarns and melanite adjacent to an alkalic syenite.

Association: Orthoclase, vesuvianite, aegirine, titanite, apatite, prehnite.

Distribution: Near the village of Gugia, otherwise unlocated in China.

Name: For the locality near Gugia, China.

Type Material: n.d.

References: (1) Chi-Jui Peng, Rung-Lung Tsao, and Zu-Rung Zou (1962) Gugiaite, $Ca_2BeSi_2O_7$, a new beryllium mineral and its relation to the melilite group. Scientia Sinica, 11, 977–988 (in English). (2) (1963) Amer. Mineral., 48, 211–212 (abs. ref. 1). (3) Kimata, M. and H. Ohashi (1982) The crystal structure of synthetic gugiaite, $Ca_2BeSi_2O_7$. Neues Jahrb. Mineral., Abh., 143, 210–222.

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Guidottiite $(Mn_2Fe^{3+})(SiFe^{3+})O_5(OH)_4$

Crystal Data: Hexagonal. *Point Group*: 6. As grains with a very fine (non-separable) fibrous structure perpendicular to cleavage, to 3 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 4.25 D(meas.) = 3.33(1) D(calc.) = 3.236-3.291 (for the observed compositional range)

Optical Properties: Nearly opaque. *Color*: Black. *Streak*: n.d. *Luster*: Vitreous to silky. *Optical Class*: n.d. n = 1.765

Cell Data: *Space Group*: (2H_2 polytype) $P6_3$. a = 5.5472(3) c = 14.293(2) Z = 2

X-ray Powder Pattern: N'chwaning 2 mine, Kalahari manganese field, South Africa.
7.21 (100), 3.543 (50), 2.568 (39), 1.982 (26), 2.381 (25), 2.706 (14), 1.640 (12)

Chemistry:

	(1)
MgO	5.65
MnO	34.21
Fe_2O_3	25.97
SiO_2	21.23
Total (anhydrous)	87.06
H_2O	9.4

(1) N'chwaning 2 mine, Kalahari manganese field, South Africa; average of 90 electron microprobe analyses, H_2O by loss on ignition, presence of Fe^{3+} and Mn^{2+} by analogy to cronstedtite; corresponding to $(Mn_{1.86}Fe^{3+}_{0.61}Mg_{0.54})_{\Sigma=3.01}(Si_{1.36}Fe^{3+}_{0.64})_{\Sigma=2.00}O_5(OH)_4$.

Mineral Group: Serpentine group.

Polymorphism and Series: 2H_1 polytype (i.e., ordered, no layer displacement), with minor amounts of the 2H_2 (with alternating + and –b/3 displacement) randomly interlayered.

Occurrence: In a pocket in a hydrothermally altered, bedded manganese deposit.

Association: Hematite, chlorite, leucophoenicite, caryopilite, barite, rhodochrosite, shigaite, gageite.

Distribution: N'chwaning 2 mine, Kalahari manganese field, Republic of South Africa.

Name: Honors Charles V. Guidotti (1935-2005), University of Maine, USA., for his many contributions to phyllosilicate mineralogy.

Type Material: National Museum of Natural History, Washington, D.C., USA., (174879).

References: (1) Wahle, M.W., T.J. Bujnowski, S. Guggenheim, and T. Kogure (2010) Guidottiite, the Mn-analogue of cronstedtite: A new serpentine-group mineral from South Africa. Clays and Clay Minerals, 58(3), 364-376. (2) (2014) Amer. Mineral., 99, 244-245 (abs. ref. 1).

Guildite $Cu(Fe^{3+}, Al)(SO_4)_2(OH)\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As short prismatic pseudocubic to platy crystals, to 5 mm, showing {001}, {100}, {110}, {540}, {011}, {101}, {$\bar{1}$01}.

Physical Properties: *Cleavage:* Perfect on {001} and {100}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.695–2.72 D(calc.) = 2.717

Optical Properties: Translucent to transparent in thin fragments. *Color:* Honey-yellow, deep chestnut-brown. *Streak:* Pale canary-yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = Y = pale yellow; Z = greenish yellow.
Orientation: $X = a$; $Y = b$; $Z = c$. α = 1.622–1.623 β = 1.628–1.630 γ = 1.681–1.684
2V(meas.) = 62(2)°

Cell Data: *Space Group:* $P2_1/m$. a = 9.786(2) b = 7.134(1) c = 7.263(1)
β = 105.28(1)° Z = 2

X-ray Powder Pattern: United Verde mine, Arizona, USA.
3.144 (100), 9.46 (35), 4.998 (27), 3.606 (20), 2.076 (12), 2.909 (11), 2.355 (10)

Chemistry:

	(1)	(2)	(3)
SO_3	39.68	38.6	39.97
Al_2O_3	2.11	2.0	
Fe_2O_3	19.12	21.8	19.93
FeO	1.49		
CuO	15.78	16.4	19.86
Na_2O	1.23	0.0	
H_2O	22.15	21.7	20.24
Total	101.56	100.5	100.00

(1) United Verde mine, Arizona, USA. (2) Do.; Cu, Fe, and Na by AA, Al by electron microprobe, H_2O by moisture analyzer; total Fe as Fe_2O_3. (3) $CuFe(SO_4)_2(OH)\cdot 4H_2O$.

Occurrence: A rare secondary mineral formed in mine workings by burning pyritic ores.

Association: Coquimbite, ransomite.

Distribution: From the United Verde mine, Jerome, Yavapai Co., Arizona, USA.

Name: Honors Professor Frank Nelson Guild (1870–1939), American mineralogist and economic geologist, University of Arizona, Tucson, Arizona, USA.

Type Material: National School of Mines, Paris, France; University of Arizona, Tucson, Arizona, M47; Harvard University, Cambridge, Massachusetts, 90540; National Museum of Natural History, Washington, D.C., USA, 95950.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 619. (2) Laughon, R.B. (1970) New data on guildite. Amer. Mineral., 55, 502–505. (3) C. Wan, S. Ghose, and G.R. Rossman (1978) Guildite, a layer structure with a ferric hydroxy-sulphate chain and its optical absorption spectra. Amer. Mineral., 63, 478–483.

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Guilleminite $Ba(UO_2)_3O_2(Se^{4+}O_3)_2 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As rectangular crystals, tabular on {010}, to 0.4 mm, bounded by {001}, {010}, {001}, modified by {101}; as coatings and silky masses.

Physical Properties: *Cleavage:* Perfect on {100}; good on {010}. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 4.88(2) D(calc.) = [4.90] Radioactive.

Optical Properties: Transparent to translucent. *Color:* Canary-yellow. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = bright yellow; Y = yellow; Z = colorless. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong. $\alpha = 1.720(2)$ $\beta = 1.798(2)$ $\gamma = 1.805(5)$ 2V(meas.) = 35° 2V(calc.) = 32°

Cell Data: *Space Group:* $P2_1nm$. $a = 7.293(1)$ $b = 16.881(4)$ $c = 7.084(1)$ Z = 2

X-ray Powder Pattern: Musonoi mine, Congo.
8.39 (F), 7.29 (F), 3.55 (mF), 6.68 (m), 3.04 (m), 2.80 (m), 3.17 (mf)

Chemistry:

	(1)	(2)	(3)
SeO_2	16.8	19.5	17.24
UO_3	64.5	65.5	66.65
BaO	10.8	8.0	11.91
H_2O	7.1	n.d.	4.20
Total	99.2		100.00

(1) Musonoi mine, Congo; H_2O by the Penfield method. (2) Do.; by electron microprobe. (3) $Ba(UO_2)_3O_2(SeO_3)_2 \cdot 3H_2O$, determined from crystal-structure analysis.

Occurrence: In the oxidized portions of a Cu–Co sulfide deposit (Musonoi mine, Congo).

Association: Malachite, cuprosklodowskite, kasolite, marthozite, derriksite, uranophane, wulfenite (Musonoi mine, Congo).

Distribution: From the Musonoi Cu–Co mine, near Kolwezi, and at Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Dr. Claude Guillemin (1923–1994), eminent French mineralogist, Bureau de Recherches Géologiques et Minières, Paris, France.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 119360.

References: (1) Pierrot, R., J. Toussaint, and T. Verbeek (1965) La guilleminite, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 88, 132–135 (in French). (2) (1965) Amer. Mineral., 50, 2103 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1995) The crystal structure of guilleminite, a hydrated Ba-U-Se sheet structure. Can. Mineral., 33, 1103–1109.

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Gunningite $(Zn, Mn^{2+})SO_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As delicate, nearly cryptocrystalline, efflorescences.

Physical Properties: Hardness = ∼2.5 D(meas.) = 3.195 (synthetic). D(calc.) = 3.369 Readily soluble in H_2O.

Optical Properties: Translucent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+) (by analogy to other members of the kieserite group). $\alpha = 1.577$ (α') β = n.d. $\gamma = 1.630$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 6.925(2)$ $b = 7.591(2)$ $c = 7.635(3)$ $\beta = 118.19(1)^\circ$ Z = 4

X-ray Powder Pattern: Synthetic.
3.404 (100), 3.056 (47), 2.5185 (46), 4.81 (39), 4.759 (39), 3.307 (28), 3.348 (23)

Chemistry:

	(1)	(2)
SO_3		44.61
FeO	0.6	
MnO	3.1	
ZnO	40.8	45.35
CdO	1.0	
H_2O		10.04
Total		100.00

(1) Calumet mine, Galena Hill, Canada; partial XRF analysis of reprecipitated H_2O−soluble material. Identity in general can be established by spectrographic determination of dominant zinc and agreement of X-ray diffraction pattern with the synthetic compound. (2) $ZnSO_4 \cdot H_2O$.

Mineral Group: Kieserite group.

Occurrence: Of rare occurrence in dry areas of the oxidized portions of sphalerite-bearing deposits; occurs also as a post-mining efflorescence on museum specimens.

Association: Sphalerite, scorodite, gypsum, pharmacosiderite, jarosite, arsenopyrite, "limonite" (Keno Hill–Galena Hill district, Canada); woodruffite, smithsonite (Willett mine, Canada); szomolnokite, starkeyite, anhydrite, gypsum (Goldstrike mine, Nevada, USA); boyleite, coquimbite, zincocopiapite, jarosite, melanterite, römerite, siderotil, voltaite, chalcanthite, hexahydrite, gypsum (Les Vallettes, Switzerland).

Distribution: In Canada, from the Comstock-Keno mine and several other deposits in the Keno Hill–Galena Hill district, about 56 km northeast of Mayo, Yukon Territory; at the Willett mine, near Lardeau, British Columbia; in the Brunswick No. 2 mine, Bathurst, New Brunswick. In the USA, from Goldstrike mine, Lynn district, Eureka Co., Nevada, and at Bisbee, Cochise Co., Arizona. From Les Vallettes, Valais, Switzerland. At the Kamariza mine, Laurium, Greece. From Kropbach, Münstertal, Black Forest, Germany.

Name: Honors Dr. Henry Cecil Gunning (1901–1991), Geological Survey of Canada and Professor of Geology, University of British Columbia, Vancouver, Canada.

Type Material: Geological Survey of Canada, Ottawa, 12139; Royal Ontario Museum, Toronto, Canada.

References: (1) Jambor, J.L. and R.W. Boyle (1962) Gunningite, a new zinc sulphate from the Keno Hill-Galena Hill area, Yukon. Can. Mineral., 7, 209–218. (2) (1962) Amer. Mineral., 47, 1218–1219 (abs. ref. 1). (3) Pistorius, C.W.F.T. (1961) Crystallographic properties of $CuSO_4 \cdot H_2O$ and $ZnSO_4 \cdot H_2O$. Acta Cryst., 14, 534. (4) Wildner, M. and G. Giester (1991) The crystal structures of kieserite-type compounds. I. Crystal structures of $Me(II)SO_4 \cdot H_2O$ (Me = Mn,Fe,Co,Ni,Zn). Neues Jahrb. Mineral., Monatsh., 296–306. (5) (1982) NBS Mono. 25, 19, 86.

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Gunterite $Na_4(H_2O)_{16}(H_2V_{10}O_{28})\cdot 6H_2O$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. Crystals tabular on {001} and generally stacked into elongate curved multiple crystals, to 0.5 mm.

Physical Properties: *Cleavage:* {001}, {100}, {010}; imperfect. *Parting:* Perfect on (001). *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ~1 VHN = 440 (20 g. load). D(meas.) = n.d. D(calc.) = 2.398

Optical Properties: Transparent to translucent. *Color:* Orange-yellow. *Streak:* Yellow. *Luster:* Subadamantine.
Optical Class: Biaxial (+). α = 1.735(5) β = 1.770(5) γ(calc.) = 1.825(5)
2V(meas.) = 77(6)° 2V(calc.) = n.d. *Dispersion:* Strong; $v < r$. *Orientation:* $X = b$; $Y \approx c$. *Pleochroism*: X = yellow; Y = orange; Z = yellow. Absorption: $Y > X > Z$.

Cell Data: *Space Group: C*2/*m*. a = 19.848(2) b = 10.1889(11) c = 13.1184(15) β = 130.187(9)° Z = 2

X-ray Powder Pattern: West Sunday mine, San Miguel County, Colorado, USA.
10.01 (100), 8.44 (72), 8.09 (46), 20997 (29), 2.795 (21), 2.1443 (18), 1.9707 (18)

Chemistry:

	(1)
Na_2O	6.77
K_2O	0.05
CaO	3.34
Al_2O_3	0.02
V_2O_5	62.1
H_2O	27.73
Total	100.01

(1) West Sunday mine, San Miguel County, Colorado, USA; electron microprobe analysis, H_2O from structure analysis, corresponding to $(Na_{3.20}K_{0.02}Ca_{0.87})_{\Sigma=4.09}[H_{1.06}(V_{9.99}Al_{0.01})_{\Sigma=10}O_{28}]\bullet 22H_2O$.

Occurrence: In efflorescencent crusts on mine walls and in fractures in sandstone, formed by the oxidation of montroseite–corvusite assemblages.

Association: Montroseite, corvusite, huemulite, rossite, calcite, hewettite, hughesite, munirite, paramontroseite, pascoite, sherwoodite, rakovanite.

Distribution: At the West Sunday mine, Slick Rock district, San Miguel County, Colorado, USA.

Name: Honors Professor Mickey Eugene Gunter (b. 1953), University of Idaho, Moscow, Idaho, USA, for his studies in optical mineralogy and the mineralogy of asbestos minerals.

Type Material: Natural History Museum of Los Angeles County, California, USA; 63506 and 63507.

References: (1) Kampf, A.R, J.M. Hughes, J. Marty, and B. Nash (2011) Gunterite, $Na_4(H_2O)_{16}(H_2V_{10}O_{28})\cdot 6H_2O$, a new mineral species with a doubly-protonated decavanadate polyanion: crystal structure and descriptive mineralogy. Can. Mineral., 49, 1243-1251. (2) (2013) Amer. Mineral., 98, 1631-1632 (abs. ref. 1).

Gupeiite Fe_3Si

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. As cores of spheres, to 0.5 mm, surrounded by other iron minerals.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 494–514 (50 and 100 g loads). D(meas.) = n.d. D(calc.) = 7.29 Strongly magnetic.

Optical Properties: Opaque. *Color:* Black to steel-gray; grayish white with a yellow tint under reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R: (402) 48.4, (439) 48.4, (480) 51.0, (495) 51.2, (546) 53.5, (590) 53.4, (624) 53.9, (644) 54.0, (657) 54.3

Cell Data: *Space Group:* $[Fm3m]$(by analogy to synthetic Fe_3Si). $a = 5.670(5)$ Z = 4

X-ray Powder Pattern: Yanshan Mountains, China.
1.156 (100), 2.00 (90), 1.003 (70), 1.415 (60), 3.26 (30), 2.83 (30), 1.706 (20)

Chemistry:

	(1)	(2)
Fe	84.8	85.64
Mn	0.70	
Ni	0.8	
Si	13.3	14.36
Total	99.6	100.00

(1) Yanshan Mountains, China; by electron microprobe, average of five analyses; corresponding to $(Fe_{2.97}Ni_{0.03}Mn_{0.02})_{\Sigma=3.02}Si_{0.98}$. (2) Fe_3Si.

Occurrence: Innermost in spheres, surrounded by nickel-iron minerals and their oxidation products, apparently of extraterrestrial origin, found in placers.

Association: Xifengite, kamacite, taenite, magnetite, wüstite, maghemite.

Distribution: In the Yanshan Mountains, Hebei Province, China.

Name: For an eastern passageway, Gupeikou, of the Great Wall of China.

Type Material: Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China.

References: (1) Yu Zuxiang (1984) Two new minerals gupeiite and xifengite in cosmic dusts from Yanshan. Acta Petrologica Mineralogica et Analytica, 3, 231–238 (in Chinese with English abs.). (2) (1986) Amer. Mineral., 71, 228 (abs. ref. 1).

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Gustavite $PbAgBi_3S_6(?)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tabular crystals, which may be slightly bent, up to 2 mm; as oriented intergrowths with benjaminite.

Physical Properties: *Cleavage:* Rare, parallel to the tabular faces; even more rarely perpendicular to the tabular faces. Hardness = n.d. VHN = 175–218 (100 g load). D(meas.) = n.d. D(calc.) = 7.01

Optical Properties: Opaque. *Color:* In polished section, white to grayish white. *Pleochroism:* White to gray. *Anisotropism:* Weak in air, distinct in oil, bluish black to grayish white.
R_1–R_2: n.d.

Cell Data: *Space Group:* $Bbmm$ or $Bb2_1m$. a = 13.510(8) b = 20.169(15) c = 4.092(8) Z = 4

X-ray Powder Pattern: Ivigtut, Greenland.
3.363 (100), 2.996 (100), 2.895 (100), 3.640 (80), 3.401 (80), 3.376 (80), 3.977 (50)

Chemistry:

	(1)	(2)	(3)	(4)
Pb	22.82	18.9	19.9	18.26
Ag	7.39	8.9	9.4	9.51
Bi	51.15	52.0	53.2	55.27
Sb		3.3		
S	17.13	17.7	17.4	16.96
Total	98.49	100.8	99.9	100.00

(1) Ivigtut, Greenland; by electron microprobe, corresponding to $Pb_{1.24}Ag_{0.77}Bi_{2.75}S_{6.00}$. (2) Bernic Lake, Canada; by electron microprobe, corresponding to $Pb_{0.99}Ag_{0.90}(Bi_{2.70}Sb_{0.30})_{\Sigma=3.00}S_{6.00}$. (3) Camsell River, Canada; by electron microprobe, corresponding to $Pb_{1.06}Ag_{0.96}Bi_{2.82}S_{6.00}$. (4) $PbAgBi_3S_6$.

Polymorphism & Series: Forms a series with lillianite.

Occurrence: A rare mineral of hydrothermal origin; also in pegmatites.

Association: Aikinite, bismuthinite, cosalite, pavonite, benjaminite, bismuth, chalcopyrite, tetrahedrite, pyrrhotite, stannite, arsenopyrite.

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland [TL]. In Canada, at the deposit of the Terra Mining and Exploration Co., Camsell River, Northwest Territories, and from the Tanco pegmatite, Bernic Lake, Manitoba. In the USA, from the Silver Bell mine, Red Mountain district, Ouray Co., and at the Old Lout mine, Poughkeepsie Gulch, near Ouray, San Juan Co., Colorado; from South Mountain, Owyhee Co., Idaho; at Darwin, Inyo Co., and Randsburg, San Bernardino Co., California; in the Outlaw mine, about 17 km north of Manhattan, Round Mountain district, Nye Co., Nevada. From the Julcani mine, Peru. In the Monteneme Sn–W deposit, Galicia??[no, cf eskimoite??], Spain. At the Salsigne mine, 15 km north of Carcassone, Aude, and in the La Roche-Balue quarry, west of Nantes, Loire Atlantique, France. At Rotgülden, Salzburg, Austria. In the Ardino deposit, Bulgaria. From the Kti-Teberda deposit, northern Caucasus Mountains, and several other poorly specified localities in the Far Eastern Region, Russia. Additional localities for lillianite–gustavite series minerals are known.

Name: To honor Gustav Adolf Hageman (1842–1916), chemical engineer for the Cryolite Firm, Ivigtut, Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1973.188; National Museum of Natural History, Washington, D.C., USA, 136172.

References: (1) Karup-Møller, S. (1970) Gustavite, a new sulfosalt mineral from Greenland. Can. Mineral., 10, 173–190. (2) (1971) Amer. Mineral., 56, 633–634 (abs. ref. 1). (3) Harris, D.C. and T.T. Chen (1975) Gustavite: two Canadian occurrences. Can. Mineral., 13, 411–414.

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Guyanaite $Cr^{3+}O(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$. Very rarely as prismatic crystals, to 0.1 mm; in microcrystalline aggregates; commonly in alluvial grains.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.53–4.81

Optical Properties: Semitransparent. *Color:* Reddish brown, golden brown, greenish brown, green, probably variable with particle size and degree of oxidation; gray with greenish tint in reflected light, with strong red to yellowish brown internal reflections. *Streak:* Yellow-brown, greenish brown.
Optical Class: Biaxial. *Pleochroism:* In browns. α = n.d. β = n.d. γ = n.d.
2V(meas.) = n.d.

Cell Data: *Space Group: Pnnm.* $a = 4.857–4.862$ $b = 4.295–4.314$ $c = 2.951–2.958$
Z = 2

X-ray Powder Pattern: Merume River, Guyana.
3.224 (vvs), 2.432 (vs), 1.636 (s), 1.719 (ms), 1.609 (ms), 1.516 (ms), 2.524 (m)

Chemistry:

	(1)	(2)	(3)
Ti_2O_3	0.86		
Al_2O_3	4.0	1.03	
Fe_2O_3	4.4	1.47	
Mn_2O_3	0.98		
V_2O_3		6.78	
Cr_2O_3	71.7	75.76	89.40
H_2O^+	[14.3]	[14.96]	10.60
Total	[96.3]	[100.00]	100.00

(1) Merume River, Guyana; H_2O calculated from stoichiometry, original total given as 96.2%; H_2O 8.7% determined by the Penfield method on a separate sample, probably low due to oxidation of Cr with loss of H^{1+}. (2) Outokumpu, Finland; by electron microprobe, average of seven analyses; H_2O by difference. (3) CrO(OH).

Polymorphism & Series: Trimorphous with bracewellite and grimaldiite.

Occurrence: In fine-grained intergrowth with other chromium oxide-hydroxide minerals (Merume River, Guyana); in chromium-rich tremolite skarns, metaquartzites, and chlorite veins (Outokumpu, Finland).

Association: Bracewellite, eskolaite, grimaldiite, mcconnellite (Merume River, Guyana).

Distribution: Along the Merume River and its tributaries, Mazaruni district, Guyana. From Outokumpu, Finland.

Name: For its occurrence in Guyana.

Type Material: The Natural History Museum, London, England, 1979,136.

References: (1) Milton, C., D.E. Appleman, M.H. Appleman, E.C.T. Chao, F. Cuttitta, J.I. Dinnin, E.J. Dwornik, B.L. Ingram, and H.J. Rose, Jr. (1976) Merumite, a complex assemblage of chromium minerals from Guyana. U.S. Geol. Surv. Prof. Paper 887, 1–29. (2) (1977) Amer. Mineral., 62, 593 (abs. ref. 1). (3) Vuorelainen, Y., T.A. Häkli, and M. Kataja (1968) A hydrated oxide of chromium as a pseudomorph after eskolaite, Outokumpu, Finland. Bull. Geol. Soc. Finland, 40, 125–129.

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Gwihabaite $[(NH_4), K]NO_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As slender prismatic crystals, composed of {110}, {100}, and {111} and elongated along [001], to 5 mm; as divergent aggregates or "cave flowers".

Physical Properties: Hardness = ∼2 D(meas.) = 1.77 D(calc.) = 1.80 Soluble in H_2O, deliquescent.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.458$ $\beta = 1.527$ $\gamma = 1.599$ 2V(meas.) = 90° 2V(calc.) = 87°

Cell Data: *Space Group: Pbnm.* $a = 7.075$ $b = 7.647$ $c = 5.779$ Z = 4

X-ray Powder Pattern: Gcwihaba Cave, Botswana.
3.194 (100), 3.212 (95), 2.595 (90), 3.364 (85), 3.863 (75), 2.400 (50), 3.805 (35)

Chemistry:

	(1)	(2)
N_2O_5	61.41	67.47
K_2O	10.40	
$(NH_4)_2O$	25.09	32.53
Total	96.90	100.00

(1) Gcwihaba Cave, Botswana; K by XRF, N and H by gas chromatography, original total reported as 98.90%; corresponds to $[(NH_4)_{0.81}K_{0.19}]_{\Sigma=1.00}(NO_3)_{1.00}$. (2) $(NH_4)NO_3$.

Occurrence: As crusts and efflorescences formed by bacterial action on bat guano in caves.

Association: Gypsum, syngenite, boussingaultite, dittmarite, weddellite, glushinskite, struvite, biphosphammite (Gcwihaba Cave, Botswana) struvite, biphosphammite (Wow Gdoom Pothole, Namibia); gypsum, wedellite, glushinskite, dittmarite (Temple of Doom Cave, South Africa).

Distribution: From Gcwihaba [!wihaba] Cave, 280 km west of Maun, northwestern Botswana. In the Temple of Doom Cave and Wow Gdoom Pothole, Namibia. At Hall's, Torch, and Chaos Caves, Transvaal, South Africa.

Name: For Gcwihaba Cave where the first specimens were collected, although the mineral name is spelled without the "c" (which stands for the "!" or "click" sound spoken by the San people who named the cave).

Type Material: Transvaal Museum, Pretoria, South Africa.

References: (1) Martini, J.E.J. (1996) Gwihabaite - $(NH_4, K)NO_3$, orthorhombic, a new mineral from Gcwihaba Cave, Botswana. Bull. South African Speleological Assoc., 36, 19–21. (2) (1999) Amer. Mineral., 84, 194 (abs. ref. 1). (3) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, 159.

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Gypsum $CaSO_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular to stubby prismatic crystals, thin to thick tabular on {010}, typically exhibiting {010}, {011}, {110}, {$\overline{1}$11}, {$\overline{1}$03}, with more than 20 other forms noted, coarsely striated ‖ [001], to 17 m; lenticular in rosettes, may be curved, bent; fibrous, earthy, concretionary, granular, massive. *Twinning:* Very common by contact on {100} forming cruciform and V-shaped twins; as butterfly or heart-shaped twins by contact on {$\overline{1}$01}; rare on {$\overline{2}$09}.

Physical Properties: *Cleavage:* {010}, perfect; {100}, distinct; {011}. *Fracture:* Splintery parallel [001], conchoidal on {100}. *Tenacity:* Flexible, inelastic. Hardness = 1.5–2, varies with direction. D(meas.) = 2.317(5) D(calc.) = 2.31

Optical Properties: Transparent to translucent. *Color:* Colorless, white; if colored by impurities, yellow, tan, blue, pink, brown, reddish brown, gray, black; colorless in transmitted light. *Streak:* White. *Luster:* Subvitreous, pearly on {010} cleavages, silky if fibrous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 52°$. *Dispersion:* $r > v$, strong, inclined. $\alpha = 1.521$ $\beta = 1.523$ $\gamma = 1.530$ 2V(meas.) = 58°

Cell Data: *Space Group:* $I2/a$. $a = 5.679(5)$ $b = 15.202(14)$ $c = 6.522(6)$ $\beta = 118.43°$ Z = 4

X-ray Powder Pattern: Synthetic; shows preferred orientation on {010}). (ICDD 33-311). 7.63 (100), 4.283 (100), 3.065 (75), 2.873 (45), 2.865 (35), 2.086 (25), 3.799 (17)

Chemistry:

	(1)	(2)
SO_3	46.00	46.50
CO_2	0.28	
CaO	32.36	32.57
H_2O	20.82	20.93
insol.	0.16	
Total	99.62	100.00

(1) Zaleschiki, Ukraine. (2) $CaSO_4 \cdot 2H_2O$.

Occurrence: A common constituent of sedimentary rocks, particularly marine salt deposits, and soils formed directly by evaporation or later by hydration of anhydrite. Formed by the reaction between sulfuric acid and carbonate rock in oxidizing sulfide deposits, and by the action of sulfurous volcanic gases on surrounding Ca-bearing rock. As efflorescences in mines and speleothems in caves.

Association: Halite, celestine, calcite, aragonite, anhydrite, dolomite, sulfur.

Distribution: The most common sulfate mineral. Localities listed here have provided especially fine or large specimens. From Italy, on Sicily, as at Racalmuto, Girgenti, and Cianciana. In Germany, in several mines in the Eisleben–Mansfeld–Sangershausen district, Saxony-Anhalt, and from near Königslutter, Lower Saxony. At Bex, Valais, Switzerland. In Austria, from Aussee, Styria, and Hall, Tirol. At Zaragoza, Zaragoza Province, Spain. From Montmartre, Paris, France. In Poland, large crystals from Tarnobrzeg. At Meskerabad, near Teheran, Iran. From Cloncurry, Queensland, Australia. In Mexico, huge crystals in a cave complex in the Naica Pb–Ag mine, and also in the San Antonio mine, Santa Eulalia, Chihuahua. Large crystals in the El Teniente mine, 67 km west of Rancagua, O'Higgins Province, Chile. In the USA, large crystals at South Wash and elsewhere in Wayne Co., Utah; from Great Salt Plains, Alfalfa Co., Oklahoma; exceptional speleothems in Lechuguilla Cave, Carlsbad Caverns National Park, New Mexico.

Name: From the Greek for *calcined gypsum* used as plaster.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 482–486. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 40–73. (3) Pedersen, B.F. and D. Semmingsen (1982) Neutron diffraction refinement of the structure of gypsum, $CaSO_4 \cdot 2H_2O$. Acta Cryst., 38, 1074–1077.

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Gyrolite $NaCa_{16}(Si_{23}Al)O_{60}(OH)_8 \cdot 14H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $\overline{1}$. As spherical to radial masses, to 5 cm; massive, platy or plumose aggregates; as fibrous layers. *Twinning:* At a microscopical scale by rotation of 120° and 240° ⊥ (001).

Physical Properties: *Cleavage:* Perfect basal; poor prismatic. *Tenacity:* Flakes flexible. Hardness = 3–4 D(meas.) = 2.388–2.390 D(calc.) = 2.40

Optical Properties: Transparent to translucent, opaque. *Color:* Colorless to white, may be grayish, tan, yellowish, brownish, or pale green from inclusions; colorless in thin section. *Luster:* Vitreous to pearly.
Optical Class: Uniaxial (–). $\omega = 1.540–1.550$ $\epsilon = 1.535–1.536$

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.74(1)$ $b = 9.74(1)$ $c = 22.40(2)$ $\alpha = 95.7(1)°$ $\beta = 91.5(1)°$ $\gamma = 120.0(1)°$ Z = 4

X-ray Powder Pattern: Bombay, India; {00*l*} reflections only are sharp, may resemble truscottite or reyerite.
22. (vs), 11.0 (s), 4.20 (s), 1.82 (s), 3.65 (ms), 2.80 (ms), 8.4–7.4 (md)

Chemistry:

	(1)	(2)
SiO_2	50.70	50.88
Al_2O_3	1.48	1.75
Fe_2O_3		0.25
MgO	0.18	0.74
CaO	33.24	31.34
Na_2O		1.34
H_2O	14.18	[13.68]
Total	99.78	[99.98]

(1) Isle of Skye, Scotland; corresponds to $Ca_{15.80}Mg_{0.12}(Si_{23.20}Al_{0.80})_{\Sigma=24.00}O_{60}(OH)_{7.04} \cdot 18.12H_2O$. (2) Qarusait, Greenland; by XRF and AA, H_2O by weight loss; corresponds to $Na_{1.18}Ca_{15.22}Mg_{0.50}Fe_{0.08}(Si_{23.07}Al_{0.93})_{\Sigma=24.00}O_{60}(OH)_{7.92} \cdot 16.72H_2O$.

Occurrence: As replacements of wall rocks and in vugs, amygdules, and veinlets in basalts; in hydrothermally altered rhyolites and sediments; in some ore deposits.

Association: Apophyllite, stilbite, laumontite, thomsonite, okenite, tobermorite, xonotlite, calcite.

Distribution: At Portree, Isle of Skye and 'S Airde Beinn, Isle of Mull, Scotland. From Ballhenry, Co. Antrim, Ireland. At Ortano, Elba, and at Monte Biaena, Pannone, Trentino-Alto Adige, Italy. At Ljósá, Eysturoy, and Gjónoyri, Streymoy, Faeroe Islands. From Qarusait and Tapaursak, Greenland. In India, from Nasik, Poona, on Bombay Island and around Bombay, Maharashtra. In Japan, at Sawayama Lake, Nagano Prefecture; Irakawa, Yamagata Prefecture; and Otemo, Niigata Prefecture. In the USA, from Fort Point, San Francisco Co., and in the New Almaden mine, Santa Clara Co., California; from Yellowstone National Park, Wyoming; in the Goose Creek quarry, Leesburg, Loudoun Co., Virginia. From 40 km southwest of Cape Blomiden, between Margaretville and Port George, Nova Scotia, Canada. A few other localities are known.

Name: From the Greek for *round*, in reference to its common habit.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 566. (2) Mackay, A.L. and H.F.W. Taylor (1953) Gyrolite. Mineral. Mag., 30, 80–91. (3) Merlino, S. (1988) Gyrolite: its crystal structure and crystal chemistry. Mineral. Mag., 52, 377–387.

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Gysinite-(Nd) $Pb(Nd,La)(CO_3)_2(OH)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As pseudo-octahedral crystals, to 1 mm, exhibiting {111} and {110}, isolated or in rounded aggregates of interpenetrant crystals; in thin films. *Twinning:* Possible penetration twins on {100} about an undetermined axis.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.12–5.18

Optical Properties: Translucent. *Color:* Pale pink to reddish pink. *Streak:* White to pale pink. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.745(5)$ $\beta = 1.805(5)$ $\gamma = 1.840(5)$ 2V(meas.) = 70° 2V(calc.) = 72.4°

Cell Data: *Space Group: Pmcn.* $a = 5.0028(8)$ $b = 8.555(1)$ $c = 7.2392(8)$ Z = 2

X-ray Powder Pattern: [Shinkolobwe,] Congo.
4.326 (100), 3.676 (100), 2.074 (60), 5.54 (50), 2.950 (50), 2.336 (50), 2.021 (50)

Chemistry:

	(1)	(2)
CO_2	20.1	
La_2O_3	5.8	15.01
Pr_2O_3		7.76
Nd_2O_3	38.9	17.84
Sm_2O_3		3.33
Eu_2O_3		1.49
Gd_2O_3		1.93
PbO	29.1	31.69
H_2O	[6.1]	
Total	[100.0]	

(1) [Shinkolobwe,] Congo; by electron microprobe, averages of 21 analyses, H_2O by difference; corresponds to $Pb_{0.59}(Nd_{1.04}La_{0.15})_{\Sigma=1.19}(CO_3)_{2.05}(OH)_{0.63}\cdot 1.2H_2O$. (2) Sa Duchessa mine, Sardinia, Italy; by electron microprobe, average of six analyses, C 5.46% and H 0.52% by elemental microanalysis, $(OH)^{1-}$ and H_2O confirmed by IR spectroscopy; corresponds to $Pb_{0.66}(Nd_{0.50}La_{0.44}Pr_{0.22}Sm_{0.09}Gd_{0.05}Eu_{0.04})_{\Sigma=1.34}(CO_3)_{2.13}(OH)_{1.06}\cdot 0.68H_2O$.

Occurrence: A rare secondary mineral in the oxidized portions of rare-earth-bearing lead deposits, the rare-earths perhaps supplied from altered uraninite.

Association: Schuilingite-(Nd), malachite, cerussite, wulfenite, kasolite, gold, bornite, garnet, "talc-chlorite" (Shinkolobwe, Congo); chrysocolla, agardite-(Y), philipsburgite, theisite (Sa Duchessa mine, Sardinia, Italy).

Distribution: Originally found on a museum specimen labelled as coming from Shinkolobwe; however the associated minerals indicate the specimen is more likely from the Kasompi mine, both in Katanga Province, Congo (Shaba Province, Zaire). At the Sa Duchessa mine, Oridda district, Sardinia, Italy. In the Glücksrad mine, Oberschulenberg, Harz Mountains, Germany.

Name: Honors Marcel Gysin (1891–1974), Professor of Mineralogy, University of Geneva, Geneva, Switzerland.

Type Material: Geneva Natural History Museum, Geneva, Switzerland, 410/85, 435/60.

References: (1) Sarp, H. and J. Bertrand (1985) Gysinite, $Pb(Nd,La)(CO_3)_2(OH)\cdot H_2O$, a new lead, rare-earth carbonate from Shinkolobwe, Shaba, Zaïre and its relationship to ancylite. Amer. Mineral., 70, 1314–1317. (2) Chabot, B. and H. Sarp (1985) Structure refinement of gysinite $La_{0.16}Nd_{1.18}Pb_{0.66}(CO_3)_2(OH)_{1.34}\cdot 0.66H_2O$. Zeits. Krist., 171, 155–158. (3) Olmi, F. and C. Sabelli (1991) Gysinite-(Nd), a mineral new to Italy, from Sa Duchessa, Sardinia. Neues Jahrb. Mineral., Monatsh., 185–191.

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Haapalaite $4(Fe,Ni)S \cdot 3(Mg,Fe^{2+})(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* n.d. As thin scales.

Physical Properties: Hardness = Very soft, less than that of graphite. VHN = 9–11 (3 g load). D(meas.) = n.d. D(calc.) = 3.57

Optical Properties: Opaque. *Color:* Bronze-red; in polished section, brown. *Luster:* Metallic, strong. *Pleochroism:* Distinct, light brown to grayish brown. *Anisotropism:* Very strong, bronze-red to grayish white.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 3.64(2)$ $c = 34.02(2)$ Z = [1.5]

X-ray Powder Pattern: Near Outokumpu, Finland.
11.34 (100), 5.67 (90), 3.18 (80b), 1.841 (70), 1.821 (70), 2.835 (40), 2.59 (40)

Chemistry:

	(1)
Fe	24.13
Ni	14.85
Cu	0.12
Co	0.01
MgO	18.77
FeO	6.39
CaO	0.00
Al_2O_3	0.15
S	22.04
H_2O	[13.82]
Total	[100.28]

(1) Near Outokumpu, Finland; by electron microprobe, average of three analyses, H_2O calculated for $2(OH)^{1-}$; corresponding to $4(Fe_{0.63}Ni_{0.37}) \cdot 3.22(Mg_{0.84}Fe^{2+}_{0.16})(OH)_{2.00}$.

Occurrence: As thin scales in the Kokka serpentine and in carbonate; rarely in chrysotile.

Association: Pentlandite, maucherite, chalcopyrite, magnetite, chromite, lizardite, calcite.

Distribution: In the Kokka serpentinite body, about 33 km north-northwest from the Outokumpu mine, Tapiola, Finland [TL].

Name: In honor of Paavo Haapala (1906–), Chief Geologist of the Outokumpu Company, Finland.

Type Material: Preserved by the Outokumpu Company, Finland.

References: (1) Huhma, M., Y. Vuorelainen, T.A. Häkli, and H. Papunen (1973) Haapalaite, a new nickel–iron sulfide of the valleriite type from East Finland. Bull. Geol. Soc. Finland, 45, 103–106. (2) (1973) Amer. Mineral., 58, 1111 (abs. ref. 1).

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Hafnon $HfSiO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Euhedral to irregular crystals and fragments, to 1 cm, heavily zoned with zircon, the outermost portions of which represent this species.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.97 (synthetic).

Optical Properties: Transparent to translucent. *Color:* Orange-red, brownish yellow, rarely colorless.
Optical Class: [Uniaxial.] ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $I4_1/amd$ (synthetic). a = 6.5725(7) c = 5.9632(4) Z = 4

X-ray Powder Pattern: Synthetic; cannot be distinguished from zircon.
3.29 (100), 2.512 (70), 4.43 (60), 1.705 (55), 2.638 (25), 2.057 (20), 2.324 (18)

Chemistry:

	(1)	(2)
SiO_2	28.32	27.20
ZrO_2	3.28	1.21
HfO_2	69.78	72.52
Total	101.38	100.93

(1) Muiâne mine, Mozambique; by electron microprobe, corresponding to $(Hf_{0.80}Zr_{0.06})_{\Sigma=0.86}Si_{1.14}O_4$. (2) Do.; by electron microprobe, corresponding to $(Hf_{0.86}Zr_{0.02})_{\Sigma=0.88}Si_{1.12}O_4$.

Occurrence: In tantalum-bearing granite pegmatites (Zambézia district, Mozambique); in a weathered pegmatite (Mt. Holland, Western Australia).

Association: Cookeite, albite (Zambézia district, Mozambique); quartz, potassic feldspar, muscovite, tourmaline, anthophyllite, phlogopite, apatite, cassiterite, ferrocolumbite, beryl, zircon, thorite, microlite, bismoclite, barite, manganotantalite, cesstibtantite, kimrobinsonite (Mt. Holland, Western Australia).

Distribution: In the Morro Conco, Moneia, and Muiâne mines, Morrua area, Zambézia district, Mozambique. At Bikita, Zimbabwe. From near Mt. Holland, Western Australia.

Name: For *hafnium* in the composition.

Type Material: n.d.

References: (1) Correia Neves, J.M., J.E. Lopes Nunes, and T.G. Sahama (1974) High hafnium members of the zircon-hafnon series from the granite pegmatites of Zambézia, Mozambique. Contr. Mineral. Petrol., 48, 73–80. (2) (1976) Amer. Mineral., 61, 175 (abs. ref. 1). (3) Salt, D.J. and G. Hornung (1967) Synthesis and X-ray study of hafnium silicate. J. Amer. Ceram. Soc., 50, 549–550. (4) Speer, J.A. and B.J. Cooper (1982) Crystal structure of synthetic hafnon, $HfSiO_4$, comparison with zircon and the actinide orthosilicates. Amer. Mineral., 67, 804–808.

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Hagendorfite $NaCaMn^{2+}(Fe^{2+}, Fe^{3+}, Mg)_2(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very rare as crystals, to 4 mm; commonly massive.

Physical Properties: *Cleavage:* Good on {001}; poor on {110}. Hardness = 4.5
D(meas.) = 3.71 D(calc.) = [3.84]

Optical Properties: Translucent. *Color:* Greenish black.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = yellowish brown, Y = green, Z = bluish green. *Orientation:* $Z = b$; $Y \wedge c$ = -22°. *Dispersion:* $r > v$. $\alpha = 1.735$ $\beta = 1.742$ $\gamma = 1.745$
2V(meas.) = 68°

Cell Data: *Space Group:* $I2_1/a$. $a = 10.933$ $b = 12.594$ $c = 6.515$ $\beta = 97.98°$ Z = 4

X-ray Powder Pattern: Hagendorf, Germany.
2.686 (10), 2.593 (8), 3.42 (7), 6.11 (6), 3.08 (6), 2.853 (6), 2.117 (6)

Chemistry:

	(1)
P_2O_5	42.26
Fe_2O_3	13.30
FeO	15.44
MnO	18.50
MgO	0.66
CaO	1.68
Na_2O	8.47
K_2O	0.17
Total	100.48

(1) Hagendorf, Germany; corresponding to $Na_{1.37}Ca_{0.14}K_{0.02}Mn^{2+}_{1.30}(Fe^{2+}_{1.08}Fe^{3+}_{0.83}Mg_{0.08})_{\Sigma=1.99}(P_{0.99}O_4)_3$.

Polymorphism & Series: Forms a series with varulite.

Mineral Group: Alluaudite group.

Occurrence: In complex granite pegmatites; in phosphatic nodules in shale.

Association: Triphylite, wolfeite, hematite (Hagendorf, Germany).

Distribution: From Hagendorf, Bavaria, Germany. At Rapid Creek, Yukon Territory, Canada. In the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, USA.

Name: For Hagendorf, Germany, the locality which yielded the first specimens.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 107297.

References: (1) Strunz, H. (1954) Hagendorfit, ein neues Mineral der Varulith-Hühnerkobelit-Reihe. Neues Jahrb. Mineral., Monatsh., 252–255 (in German). (2) (1955) Amer. Mineral., 40, 553 (abs. ref. 1). (3) Fisher, D.J. (1956) Hagendorfite unit cell. Bull. Geol. Soc. Amer., 67, 1694–1695. (4) Strunz, H. (1960) Karyinit, ein Arsenat vom Strukturtypus der Phosphate Hagendorfit und Alluaudit. Neues Jahrb. Mineral., Monatsh., 7–15 (in German). (5) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (6) Fecia di Cossato, Y.M. and P. Orlandi (1987) Nuovi dati sui fosfati della pegmatite di Mangualde (Portogallo). Rend. Soc. Ital. Mineral. Petrol., 42, 263–270 (in Italian with English abs.).

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Haggertyite $BaMgFe_4^{2+}Fe_2^{3+}Ti_5O_{19}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to 0.15 mm, acicular, and as flakes; may be intimately intergrown with another vanadium oxide hydrate; massive, in veinlets.

Physical Properties: Hardness = 4.7 D(meas.) = n.d. D(calc.) = [3.51]

Optical Properties: Opaque. *Color:* Black; yellowish gray to dark gray in reflected light. *Optical Class:* Biaxial. *Anisotropism:* Very strong; yellowish gray to bluish gray.
R_1–R_2: (440) 11.7–11.0, (460) 11.8–11.0, (480) 12.0–11.0, (500) 12.3–11.0, (520) 12.3–11.0, (540) 13.0–11.1, (560) 13.4–11.2, (580) 13.7–11.2, (600) 14.0–11.2, (620) 14.3–11.2, (640) 14.6–11.2, (660) 14.9–11.3, (680) 15.2–11.5, (700) 15.6–11.9

Cell Data: *Space Group: C*$2/m$. $a = 12.17(5)$ $b = 2.99(1)$ $c = 4.83(2)$ $\beta = 98°15(5)'$
Z = 2

X-ray Powder Pattern: Carlile, Wyoming, USA.
4.80 (100), 4.05 (50), 3.02 (25), 2.44 (25), 1.959 (18), 3.51 (12), 1.815 (12)

Chemistry:

	(1)	(2)
V_2O_5	99.61	
V_2O_4		44.86
V_2O_3		40.53
H_2O	n.d.	14.61
Total	99.61	100.00

(1) Russia, two localities; by electron microprobe, multiple determinations averaging V = 55.8%, here converted to $V_2^{5+}O_5$. (2) $V^{4+}V^{3+}O_2(OH)_3$.

Occurrence: In the oxidized zone of Colorado Plateau-type U–V deposits.

Association: Doloresite (USA); pyrite, selenium (Russia).

Distribution: In sandstone drill core at a depth of 55 m, from near Carlile, Crook Co., Wyoming; from the Runge mine, near Edgemont, Fall River Co., South Dakota; in the Grants district, McKinley Co., New Mexico; from the Jo Dandy mine, Paradox Valley, Uravan district, Montrose Co., Colorado; at the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada, USA. In Russia, at undefined localities in the Voronezh anticline, around Kursk. In the Syr Dar'ya basin, southern Kara-Tau Mountains, Kazakhstan. From an undefined locality in Turkmenistan.

Name: Honors Gunnar Hägg (1903–), chemist and crystallographer, of the University of Uppsala, Uppsala, Sweden.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162623.

References: (1) Evans, H.T., Jr. and M.E. Mrose (1958) The crystal structures of three new vanadium oxide minerals. Acta Cryst., 11, 56–58. (2) Evans, H.T., Jr. and M.E. Mrose (1960) A crystal chemical study of the vanadium oxide minerals, häggite and doloresite. Amer. Mineral., 45, 1144–1166. (3) Ryabeva, Y.G., L.S. Dubakina, A.A. Gorshkov, Z.A. Nekrasova, L.I. Taychikova, and T.A. Khruleva (1978) New data on häggite. Doklady Acad. Nauk SSSR, 243, 1295–1297 (in Russian).

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to 0.15 mm, acicular, and as flakes; may be intimately intergrown with another vanadium oxide hydrate; massive, in veinlets.

Physical Properties: Hardness = 4.7 D(meas.) = n.d. D(calc.) = [3.51]

Optical Properties: Opaque. *Color:* Black; yellowish gray to dark gray in reflected light. *Optical Class:* Biaxial. *Anisotropism:* Very strong; yellowish gray to bluish gray.
R_1–R_2: (440) 11.7–11.0, (460) 11.8–11.0, (480) 12.0–11.0, (500) 12.3–11.0, (520) 12.3–11.0, (540) 13.0–11.1, (560) 13.4–11.2, (580) 13.7–11.2, (600) 14.0–11.2, (620) 14.3–11.2, (640) 14.6–11.2, (660) 14.9–11.3, (680) 15.2–11.5, (700) 15.6–11.9

Cell Data: *Space Group:* $C2/m$. $a = 12.17(5)$ $b = 2.99(1)$ $c = 4.83(2)$ $\beta = 98°15(5)'$
$Z = 2$

X-ray Powder Pattern: Carlile, Wyoming, USA.
4.80 (100), 4.05 (50), 3.02 (25), 2.44 (25), 1.959 (18), 3.51 (12), 1.815 (12)

Chemistry:

	(1)	(2)
V_2O_5	99.61	
V_2O_4		44.86
V_2O_3		40.53
H_2O	n.d.	14.61
Total	99.61	100.00

(1) Russia, two localities; by electron microprobe, multiple determinations averaging V = 55.8%, here converted to $V_2^{5+}O_5$. (2) $V^{4+}V^{3+}O_2(OH)_3$.

Occurrence: In the oxidized zone of Colorado Plateau-type U–V deposits.

Association: Doloresite (USA); pyrite, selenium (Russia).

Distribution: In sandstone drill core at a depth of 55 m, from near Carlile, Crook Co., Wyoming; from the Runge mine, near Edgemont, Fall River Co., South Dakota; in the Grants district, McKinley Co., New Mexico; at the Gold Quarry mine, Eureka Co., Nevada, USA. In Russia, at undefined localities in the Voronezh anticline, around Kursk. In the Syr Dar'ya basin, southern Kara-Tau Mountains, Kazakhstan. From an undefined locality in Turkmenistan.

Name: Honors Gunnar Hägg (1903–), chemist and crystallographer, of the University of Uppsala, Uppsala, Sweden.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162623.

References: (1) Evans, H.T., Jr. and M.E. Mrose (1958) The crystal structures of three new vanadium oxide minerals. Acta Cryst., 11, 56–58. (2) Evans, H.T., Jr. and M.E. Mrose (1960) A crystal chemical study of the vanadium oxide minerals, häggite and doloresite. Amer. Mineral., 45, 1144–1166. (3) Ryabeva, Y.G., L.S. Dubakina, A.A. Gorshkov, Z.A. Nekrasova, L.I. Taychikova, and T.A. Khruleva (1978) New data on häggite. Doklady Acad. Nauk SSSR, 243, 1295–1297 (in Russian).

Haidingerite $Ca(AsO_3OH)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As short prismatic to equant crystals, to 1 mm; typically as botyroidal or fibrous coatings, scaly. *Twinning:* Rare on {110}.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Sectile, thin laminae slightly flexible. Hardness = 2–2.5 D(meas.) = 2.85–2.96 D(calc.) = 2.96–2.97

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous; pearly on cleavages.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, weak.
$\alpha = 1.590(3)$ $\beta = 1.602(3)$ $\gamma = 1.638(3)$ 2V(meas.) = 58(3)°

Cell Data: *Space Group: Pcnb.* $a = 6.904$–6.935 $b = 16.150$–16.161 $c = 7.935$–7.940
Z = 8

X-ray Powder Pattern: "Baden", Germany.
5.217 (FFFF), 2.981 (FFF), 8.059 (FF), 5.254 (FF), 3.843 (FF), 3.185 (FF), 3.151 (FF)

Chemistry:

	(1)	(2)
As_2O_5	57.52	58.03
CaO	28.39	28.32
H_2O	14.32	13.65
Total	100.23	100.00

(1) Jáchymov, Czech Republic. (2) $Ca(AsO_3OH)\cdot H_2O$.

Occurrence: Formed by dehydration of pharmacolite (Getchell mine, Nevada, USA).

Association: Pharmacolite, pitticite, weilite.

Distribution: At Jáchymov (Joachimsthal), Czech Republic. In Germany, from the Anton mine, Heubachtal, near Schiltach, and near Wittichen, Black Forest; at Richelsdorf, Hesse. At the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, France. From the Ruben mine, Kohlendorf, Poland. At the Khaydarkan deposit, Fergana Valley, Alai Range, Kyrgyzstan. In the White Caps mine, Manhattan district, Nye Co., and the Getchell mine, Potosi district, Humboldt Co., Nevada; from Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: Honors Wilhelm Karl von Haidinger (1795–1871), Austrian mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 708–709. (2) Cassien, H., P. Herpin, and F. Permingeat (1966) Structure cristalline de la haidingérite. Bull. Minéral., 89, 18–22 (in French). (3) Ferraris, G., D.W. Jones, and J. Yerkess (1972) A neutron and X-ray refinement of the crystal structure of $CaHAsO_4\cdot H_2O$ (haidingerite). Acta Cryst., 28, 209–214.

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Haigerachite $KFe_3^{3+}(H_2PO_4)_6(HPO_4)_2 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As bladed crystals, to 0.4 mm, flattened on {110} and striated on {001} ‖ {010} and on {100} ‖ [001]; dominant forms include {110}, {100}, {010}, {001}; as fine-grained coatings.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = [2.5–3] (by analogy to parsonsite). D(meas.) = 6.39 (synthetic). D(calc.) = 6.40 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow; pale yellow in transmitted light. *Streak:* Pale yellow. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = pale yellow; Z = nearly colorless.
Dispersion: $r > v$. *Absorption:* $X > Z$. $\alpha = 1.882(5)$ β = n.d. $\gamma = 1.915(5)$
2V(meas.) = ∼80°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.123$ $b = 10.469$ $c = 6.844$ $\alpha = 100°34'$ $\beta = 94°48'$ $\gamma = 91°16'$ Z = 2

X-ray Powder Pattern: Michael mine, Germany; nearly identical to parsonsite.
3.42 (10b), 2.85 (8), 4.42 (6), 3.03 (6), 4.26 (5), 3.33 (5b), 7.09 (3)

Chemistry: (1) Michael mine, Germany; microchemical and spectrographic analysis confirmed Pb, U, and As as major components, P absent; formula established by the similarity of the X-ray powder pattern with that of parsonsite and synthetic $Pb_2(UO_2)(AsO_4)_2$.

Occurrence: A secondary mineral found on a museum specimen from an oxidizing As–Pb-bearing deposit, formed by alteration of galena.

Association: Hügelite, widenmannite, mimetite, barite, galena, quartz.

Distribution: In Germany, from the Michael mine, Weiler, near Lahr, Black Forest, and on the Bühlskopf, near Ellweiler, Rhineland-Palatinate.

Name: Honors Dr. Arthur Francis Hallimond (1890–1968), British mineralogist, London, England, for his work with secondary uranium minerals.

Type Material: n.d.

References: (1) Walenta, K. (1965) Hallimondite, a new uranium mineral from the Michael mine near Reichenbach (Black Forest, Germany). Amer. Mineral., 50, 1143–1157.

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Haineaultite $(Na,Ca)_5Ca(Ti,Nb)_5(Si,S)_{12}O_{34}(OH,F)_8 \cdot 5H_2O$

Crystal Data: Orthorhombic. *Point Group:* 222. As fan-like aggregates of tabular to bladed crystals or as isolated prismatic crystals, elongate on [001] to 6 mm, variably showing {100}, {010}, {001}, and {011}.

Physical Properties: *Cleavage:* Distinct to good on {100}, {010}, and {001}. *Tenacity:* Brittle. *Fracture:* Blocky to splintery. Hardness = 3-4 D(meas.) = n.d. D(calc.) = 2.28

Optical Properties: Transparent to translucent. *Color:* Pale orange, lemon-yellow, less commonly tan or off-white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). α = 1.599(1) β = 1.610(1) γ = 1.696(1) 2V(meas) = 38(1)° 2V(calc) = 41(1)° *Dispersion: None. Orientation: X = b*; *Y = c*; *Z = a*. *Pleochroism*: *None*.

Cell Data: *Space Group: C*222. *a* = 7.204(4) *b* = 23.155(5) *c* = 6.953(2) Z = 1

X-ray Powder Pattern: Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada.
11.564 (100), 6.932 (90), 3.052 (75), 2.977 (70), 5.258 (40), 4.446 (40), 2.582 (40)

Chemistry:

	(1)		(1)
Na_2O	4.70	TiO_2	18.86
K_2O	2.09	ZrO_2	0.31
MgO	0.07	Nb_2O_5	5.56
CaO	9.99	SO_3	2.60
MnO	0.25	F	0.17
FeO	0.49	H_2O $_{(calc.)}$	10.11
SiO_2	42.70	$-O = F_2$	0.07
		Total	97.83

(1) Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada; average of 16 electron microprobe analyses, H_2O and OH^- confirmed by structure analysis and IR, corresponding to $(Na_{2.41}Ca_{1.83}K_{0.71})_{\Sigma=4.95}Ca(Ti_{3.76}Nb_{0.67}Fe_{0.11}Mn_{0.06}Zr_{0.04}Mg_{0.03})_{\Sigma=4.67}(Si_{11.30}S_{0.52})_{\Sigma=11.82}O_{34}(OH_{7.86}F_{0.14})_{\Sigma=8.00} \cdot 5H_2O$.

Mineral Group: Labuntsovite group.

Occurrence: A late-stage mineral in altered marble zenoliths and breccia in a complex peralkaline intrusion (nepheline and sodalite syenties).

Association: Quartz, calcite, sodic amphibole, pectolite, fluorapophyllite, vesuvianite, tainiolite, albite, fluorite, microcline, aegirine, and 17 less-abundant minerals.

Distribution: From the Poudrette quarry, Mont Saint-Hilaire, Rouville County, Quebec, Canada.

Name: Honors Gilles Haineault (b. 1946) of St-Mathieu de Beloeil, Quebec, a collector and dealer of minerals from Mont Saint-Hilaire.

Type Material: Canadian Museum of Nature, Ottawa; 81547.

References: (1) McDonald, A.M., and G.Y. Chao (2004) Haineaultite, a new hydrated sodium calcium titanosilicate from Mont Saint-Hilaire, Quebec: description, structure determination and genetic implications. Can. Mineral., 42, 769–780. (2) (2005) Amer. Mineral., 90, 271 (abs. ref. 1).

Hainite $Na_4Ca_8(Ti, Zr, Mn^{2+})_3Si_8O_{28}F_8$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals, < 1 mm, slender needles and plates, elongated along [001] with {010}, {100}, and {$\bar{1}$10}. *Twinning:* On {100}.

Physical Properties: *Cleavage:* {010}, rather perfect; {100}, faint. *Fracture:* Brittle. Hardness = 5 D(meas.) = 3.148 D(calc.) = 3.157

Optical Properties: Semitransparent. *Color:* Wine-yellow, honey-yellow, colorless; light wine-yellow in thin section. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Z = wine-yellow. *Dispersion:* $r > v$, strong. *Absorption:* $Z > Y > X$. $n =$ ∼1.7, birefringence ∼0.012. 2V(meas.) = Large.

Cell Data: *Space Group:* $P\bar{1}$. $a = 5.676(2)$ $b = 7.259(3)$ $c = 9.586(3)$ $\alpha = 101.08(4)°$ $\beta = 101.14(4)°$ $\gamma = 90.27(4)°$ Z = 1

X-ray Powder Pattern: Hradiště Mountain, Czech Republic.
2.961 (100), 3.073 (90), 1.896 (70), 3.961 (50), 2.628 (50), 2.493 (50), 1.822 (50)

Chemistry:

	(1)		(1)
SiO_2	32.07	Nb_2O_5	1.38
TiO_2	8.06	Ta_2O_5	0.22
ZrO_2	6.58	MnO	2.06
Al_2O_3	0.03	CaO	32.05
La_2O_3	0.60	Na_2O	7.46
Ce_2O_3	1.01	F	12.09
Fe_2O_3	1.25	$-O = F_2$	5.09
		Total	99.77

(1) Hradiště Mountain, Czech Republic; by electron microprobe, average of fourteen analyses; corresponds to $(Na_{3.52}Ca_{0.48})_{\Sigma=4.00}Ca_{8.00}RE_{0.15}(Ti_{1.52}Zr_{0.80}Mn_{0.45}Fe_{0.25}Nb_{0.09}Ta_{0.02}Al_{0.01})_{\Sigma=3.14}Si_{7.80}[O_{27.68}F_{8.32}]_{\Sigma=36.00}$.

Occurrence: In cavities and embedded in the groundmass of a phonolite.

Association: Aegirine.

Distribution: From Hradiště Mountain, near Mildenau, Czech Republic.

Name: For the locality, formerly named Hoher Hain, in the Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 20530.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 31–32. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 385. (3) Johan, Z. and F. Čech (1989) New data on hainite, $Na_2Ca_4[(Ti, Zr, Mn, Fe, Nb, Ta)_{1.50}\square_{0.50}](Si_2O_7)_2F_4$ and its crystallochemical relationship with götzenite, $Na_2Ca_5Ti(Si_2O_7)_2F_4$. Compt. Rendus Acad. Sci. Paris, 308, 1237–1242 (in French with English abs.). (4) (1990) Amer. Mineral., 75, 936 (abs. ref. 3).

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Haiweeite $Ca(UO_2)_2Si_6O_{15}\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ (probable). As spherulites consisting of minute, bladelike grains; also as single flakelike grains, flattened on {100}.

Physical Properties: *Cleavage:* Good on {100}. Hardness = 3.5 D(meas.) = 3.35 D(calc.) = [4.93] Fluoresces weakly dull green under UV; radioactive.

Optical Properties: Semitransparent. *Color:* Pale yellow to greenish yellow. *Luster:* Pearly on the cleavage.
Optical Class: Biaxial (–). *Pleochroism:* Y = pale yellow; Z = colorless. *Orientation:* $Y = b$. *Dispersion:* $r > v$, very strong. α = 1.533–1.571 β = 1.572–1.580 γ = 1.573–1.582 2V(meas.) = 15°–20°

Cell Data: *Space Group:* $P2/c$ (probable). $a = 15.4$ $b = 7.05$ $c = 7.10$ $\beta = 107°52'$ Z = [2]

X-ray Powder Pattern: Coso Mountains, California, USA.
9.14 (100), 4.56 (60), 4.42 (60), 3.19 (50), 3.11 (50), 7.05 (40), 3.54 (40)

Chemistry:

	(1)	(2)
SiO_2	33.1	33.42
UO_3	52.8	53.03
CaO	5.4	5.20
H_2O	8.7	8.35
Total	[100.0]	100.00

(1) Coso Mountains, California, USA; inseparably combined with metahaiweeite, average of four analyses, recalculated to 100.0% after deduction of insolubles, mainly quartz.
(2) $Ca(UO_2)_2Si_6O_{15}\cdot 5H_2O$.

Occurrence: On fracture surfaces in granite and in voids in neighboring loosely consolidated lake bed sediments (Coso Mountains, California, USA); along fractures in tourmaline-bearing granite and granite pegmatite (Perus, Brazil).

Association: Autunite, meta-autunite, uranophane, uranophane-beta, phosphuranylite, torbernite, meta-torbernite, chernikovite, uranian "opal" (Perus, Brazil).

Distribution: From the Haiwee Reservoir, Coso Mountains, Inyo Co., California, USA. At Perus, 25 km north of São Paulo, Brazil. On Portezuelo Hill, Ranquil district, Mendoza Province, Argentina. From Badgastein, Salzburg, Austria.

Name: For the Haiwee Reservoir, Coso Mountains, California, USA, above which the mineral was first found to occur.

Type Material: n.d.

References: (1) McBurney, T.C. and J. Murdoch (1959) Haiweeite, a new uranium mineral from California. Amer. Mineral., 44, 839–843. (2) de Camargo, W.G.R. and D.P. Svisero (1969) Haiweeite, a new occurrence in Brazil. Amer. Mineral., 54, 966–969.

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Hakite $(Cu,Hg)_{12}Sb_4(Se,S)_{13}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As anhedral grains, to 0.3 mm.

Physical Properties: Hardness = n.d. VHN = 306 (40 g load). D(meas.) = n.d. D(calc.) = 6.3

Optical Properties: Opaque. *Color:* Gray-brown; in polished section, creamy white to clear brown. *Luster:* Metallic.

R: (400) —, (420) 32.8, (440) 33.8, (460) 34.0, (480) 34.0, (500) 33.7, (520) 33.2, (540) 33.0, (560) 33.1, (580) 33.2, (600) 33.5, (620) 33.9, (640) 33.6, (660) —, (680) —, (700) —

Cell Data: *Space Group:* $I\bar{4}3m$ (probable). $a = 10.83$ $Z = 8$

X-ray Powder Pattern: Předbořice, Czech Republic.
3.140 (100), 1.925 (90), 1.639 (80), 2.910 (70), 1.985 (70), 2.568 (60), 1.764 (60)

Chemistry:

	(1)	(2)
Cu	26.6	26.6
Hg	15.3	14.3
Sb	15.5	19.1
As	3.2	0.7
Se	34.0	38.5
S	3.5	
Total	98.1	99.2

(1) Předbořice, Czech Republic; by electron microprobe, corresponding to $(Cu_{10.78}Hg_{1.84})_{\Sigma=12.62}(Sb_{3.06}As_{1.03})_{\Sigma=4.09}(Se_{10.37}S_{2.63})_{\Sigma=13.00}$. (2) Do.; corresponding to $(Cu_{10.61}Hg_{1.81})_{\Sigma=12.42}(Sb_{3.98}As_{0.24})_{\Sigma=4.22}Se_{12.36}$.

Mineral Group: Tetrahedrite group.

Occurrence: In epithermal calcite veins.

Association: Berzelianite, clausthalite, umangite, chalcopyrite, pyrite, uraninite, hematite, goethite, gold.

Distribution: In the Czech Republic, from the Předbořice uranium deposit, near Krásna Hora [TL], at Bukov, near Tisnova; and in the Petrovice uranium deposit, near Ždár. At the Niederschlema-Alberoda uranium deposit, Saxony, Germany. From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina.

Name: In honor of Jaroslav Hak (1931–), Czech mineralogist, Institute of Ore Research, Kutná Hora, Czech Republic.

Type Material: Charles University, Prague, Czech Republic; National School of Mines, Paris, France.

References: (1) Johan, Z. and M. Kvaček (1971) La hakite, un nouveau minéral du groupe de la tétraédrite. Bull. Soc. fr. Minéral., 94, 45–48 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1553 (abs. ref. 1).

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Halite NaCl

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. Crystals cubic, to 1 m, or octahedral; elongated along [100] or [111], skeletal with hopper-shaped faces. Rarely capillary or stalactitic; granular, compact, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 2.168 D(calc.) = 2.165 Soluble in H_2O, saline taste; rarely fluoresces red under SW UV.

Optical Properties: Transparent. *Color:* Colorless or white when pure; gray, yellow, orange, pink, red, blue, purple; colorless to faintly tinted in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic; weakly anisotropic due to stress. *Dispersion:* Moderately strong. $n = 1.5443$

Cell Data: *Space Group: Fm3m.* a = 5.6404(1) Z = 4

X-ray Powder Pattern: Synthetic.
2.821 (100), 1.994 (55), 1.628 (15), 3.258 (13), 1.261 (11), 1.1515 (7), 1.410 (6)

Chemistry:

	(1)	(2)
Na	39.00	39.34
K	0.12	
Mg	0.03	
Ca	0.08	
Cl	60.27	60.66
SO_4	0.27	
Total	99.77	100.00

(1) Cardona, Barcelona, Spain. (2) NaCl.

Occurrence: Typically in sedimentary rocks of evaporite association, may form immense beds; also as volcanic sublimates, efflorescences, cave deposits. Crystals are common in multiphase fluid inclusions; may be included in other minerals as a product of intermediate-grade metamorphism.

Association: Sylvite, polyhalite, kieserite, carnallite, gypsum, anhydrite, dolomite.

Distribution: Of worldwide occurrence. Well-studied deposits include: in Austria, around Hallstadt, Salzburg, and Hall, near Innsbruck, Tirol. From Bex, Vaud, Switzerland. In Germany, from Stassfurt-Leopoldshall, 34 km south of Magdeburg, Saxony-Anhalt. Deposits with large crystals at Wieliczka (Galicia) and Bochnia, Poland. At Girgenti and Racalmuto, Sicily, Italy. In the Salt Range, Punjab, India. In the USA, in the Michigan Basin, underlying Ohio, Michigan, and New York; as numerous salt domes along the Gulf Coast; and in the Permian Basin of Texas and New Mexico; large crystals at the Potash Corporation of America mine, Carlsbad potash district, Eddy Co., New Mexico.

Name: From the Greek for *salt*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 3–7. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 357–363. (3) Bragg, W.L. (1914) The structure of some crystals as indicated by their diffraction of X-rays. Proc. Royal Soc. London, A, 89, 248. (4) (1953) NBS Circ. 539, 2, 41.

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As bladed crystals, to 0.4 mm, flattened on {110} and striated on {001} || {010} and on {100} || [001]; dominant forms include {110}, {100}, {010}, {001}; as fine-grained coatings.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = [2.5–3] (by analogy to parsonsite). D(meas.) = 6.39 (synthetic). D(calc.) = 6.40 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow; pale yellow in transmitted light. *Streak:* Pale yellow. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = pale yellow; Z = nearly colorless. *Dispersion:* $r > v$. *Absorption:* $X > Z$. $\alpha = 1.882(5)$ $\beta =$ n.d. $\gamma = 1.915(5)$
2V(meas.) = ~80°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.123$ $b = 10.469$ $c = 6.844$ $\alpha = 100°34'$ $\beta = 94°48'$ $\gamma = 91°16'$ $Z = 2$

X-ray Powder Pattern: Michael mine, Germany; nearly identical to parsonsite.
3.42 (10b), 2.85 (8), 4.42 (6), 3.03 (6), 4.26 (5), 3.33 (5b), 7.09 (3)

Chemistry: (1) Michael mine, Germany; microchemical and spectrographic analysis confirmed Pb, U, and As as major components, P absent; formula established by the similarity of the X-ray powder pattern with that of parsonsite and synthetic $Pb_2(UO_2)(AsO_4)_2$.

Occurrence: A secondary mineral found on a museum specimen from an oxidizing As–Pb-bearing deposit, formed by alteration of galena.

Association: Hügelite, mimetite, barite, galena, quartz.

Distribution: In Germany, from the Michael mine, Weiler, near Lahr, Black Forest, and on the Bühlskopf, near Ellweiler, Rhineland-Palatinate.

Name: Honors Dr. Arthur Francis Hallimond (1890–1968), British mineralogist, London, England, for his work with secondary uranium minerals.

Type Material: n.d.

References: (1) Walenta, K. (1965) Hallimondite, a new uranium mineral from the Michael mine near Reichenbach (Black Forest, Germany). Amer. Mineral., 50, 1143–1157.

Halloysite $Al_2Si_2O_5(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* m. Massive, claylike. On a microscopic scale, tubular, average 0.04 μm; tubes split open and unroll to form laths or spatula shapes; spherical.

Physical Properties: *Cleavage:* {001}, probable. *Fracture:* Conchoidal. Hardness = 2–2.5 D(meas.) = 2.55–2.565 D(calc.) = [2.57]

Optical Properties: Semitransparent. *Color:* White; gray, green, blue, yellow, red from included impurities. *Luster:* Pearly, waxy, or dull.
Optical Class: Biaxial. n = 1.55–1.56 2V(meas.) = n.d.

Cell Data: *Space Group:* Cc. $a = 5.14(4)$ $b = 8.90(4)$ $c = 14.9(1)$ $\beta = 101.9°$ Z = [4]

X-ray Powder Pattern: Indiana, USA. (ICDD 29-1489).
10.0 (100), 4.36 (70), 3.35 (40), 2.54 (35), 1.480 (30), 1.672 (14), 1.281 (8)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	43.98	46.55	CaO	0.32	
TiO_2	0.01		Na_2O	0.14	
Al_2O_3	38.46	39.49	K_2O	0.48	
FeO	0.03		H_2O^+	14.59	13.96
MgO	trace		H_2O^-	2.58	
			Total	100.59	100.00

(1) Eureka, Utah, USA. (2) $Al_2Si_2O_5(OH)_4$.

Polymorphism & Series: Dickite, kaolinite, and nacrite are polymorphs.

Mineral Group: Kaolinite-serpentine group; called endellite in European literature.

Occurrence: A product of hydrothermal alteration or surface weathering of aluminosilicate minerals, as feldspars. Formed by dehydration of endellite above 110 °C.

Association: Kaolinite, endellite, allophane, alunite.

Distribution: Undoubtedly widespread. Probably at Angleur, Liège, Belgium, the "type" locality, now inaccessible. From Valença, Portugal. At Bergnersreuth, near Wunsiedel, Bavaria, Germany. In the USA, from Wagon Wheel Gap, Mineral Co., Colorado; at Gonzales, Gonzales Co., Texas; near Bedford, Lawrence Co., Indiana; at Horse Cove, Hart Co., Kentucky; in the Corundum Hill mine, Macon Co., North Carolina. Also from the Dragon Consolidated iron mine, Eureka, Tintic district, Juab Co., Utah; in a number of porphyry copper deposits in Arizona, as at Ray, Pinal Co., Globe-Miami, Gila Co., and others.

Name: To honor Baron Omalius d'Halloy (1707–1789), who first observed the mineral.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 688–689. (2) Alexander, L.T., G.T. Faust, S.B. Hendricks, H. Insley, and H.F. McMurdie (1943) Relationship of the clay minerals halloysite and endellite. Amer. Mineral., 28, 1–18. (3) Brindley, G.W. and K. Robinson, (1948) X-ray studies of halloysite and metahalloysite. Mineral. Mag., 28, 392–428. (4) Bates, T.F., F.A. Hildebrand, and A. Swineford (1950) Morphology and structure of endellite and halloysite. Amer. Mineral., 35, 463–484. (5) Grim, R.E. (1953) Clay Mineralogy, McGraw Hill, 370. (6) Faust, G.T. (1955) The endellite-halloysite nomenclature. Amer. Mineral., 40, 1110–1118. (7) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 194–212. (8) Mitra, G.B. and S. Bhattacherjee (1975) The structure of halloysite. Acta Cryst., 31, 2851–2857. (9) Kohyama, N., K. Fukushima, and A. Fukami (1978) Observation of the hydrated form of tubular halloysite by an electron microscope equipped with an environmental cell. Clays and Clay Minerals, 26, 25–40.

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Halotrichite $Fe^{2+}Al_2(SO_4)_4 \cdot 22H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals, only very rarely terminated, elongated along [001], to 1 cm; asbestiform, in divergent or matted aggregates, and as incrustations and efflorescences.

Physical Properties: *Cleavage:* On {010}, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = 1.89 D(calc.) = 1.95 Soluble in H_2O, astringent taste.

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale gray, pale yellow, pale green; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 38°$. $\alpha = 1.480$ $\beta = 1.486$ $\gamma = 1.490$
2V(meas.) = 35°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.1954(7)$ $b = 24.262(3)$ $c = 21.262(2)$
$\beta = 100.30(1)°$ Z = 4

X-ray Powder Pattern: Középső-György mine, Hungary.
4.78 (100), 3.484 (75), 6.02 (35), 4.29 (31), 3.751 (27), 4.93 (21), 3.947 (21)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	35.39	35.97	Na_2O	0.05	
Al_2O_3	10.61	11.45	K_2O	0.02	
Fe_2O_3	0.22		H_2O^+	13.48	
FeO	9.00	8.07	H_2O^-	30.30	
MnO	0.05		H_2O		44.51
MgO	0.13		Total	99.25	100.00

(1) Középső-György mine, Hungary; after subtraction of ferrohexahydrite impurity, corresponds to $(Fe^{2+}_{0.97}Mg_{0.02}Mn_{0.01})_{\Sigma=1.00}(Al_{1.98}Fe^{3+}_{0.02})_{\Sigma=1.00}(SO_4)_4 \cdot 22H_2O$. (2) $FeAl_2(SO_4)_4 \cdot 22H_2O$.

Polymorphism & Series: Forms a series with pickeringite.

Mineral Group: Halotrichite group.

Occurrence: As efflorescences in weathering sulfide deposits and oxidizing pyritic coals, with persistent accumulations in arid climates; as a precipitate around volcanic fumaroles and hot springs.

Association: Melanterite, copiapite, gypsum, epsomite, alunogen.

Distribution: Widespread but typically in small amounts; only a few of the classic localities will be mentioned. At the Solfatara di Pozzuoli, Campi Flegrei, near Naples, Campania, Italy. From the Középső-György mine, Recsk, Mátra Mountains, Hungary. At Falun, Sweden. From Huelgoat and Poullaouen, Finistère, France. At the Feengrotten, near Saalfeld, Thuringia, Germany. In the USA, from the Alum Mountain district, Grant Co., New Mexico; at the Sulfur Hole prospect, near Borate, about 10 km northeast of Yermo, Calico Hills, San Bernardino Co., and at hot springs around Mt. Lassen, Shasta Co., California; from the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah. In the Glace Bay coal deposits, Nova Scotia, Canada. In Chile, at Tierra Amarilla, southeast of Copiapó, Atacama; from Alcaparrosa, near Cerritos Bayos, southwest of Calama, and from Chuquicamata, Antofagasta. At volcanoes on the Kamchatka Peninsula, Russia.

Name: From the Latin, *halotrichum*, derived from the Old German, *Haarsalz*, for *hair salts*, in allusion to its common hairlike habit.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 523–527. (2) Lovas, G.A. (1986) Structural study of halotrichite from Recsk (Mátra Mts., N-Hungary). Acta Geologica Hungarica, 29(3–4), 389–398 (in English).

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Halurgite $Mg_2[B_4O_5(OH)_4]_2 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$ or m. As lamellar crystals with rhombic outline, to 3 mm, subparallel or in radial aggregates; most commonly granular, fine-grained massive.

Physical Properties: Hardness = 2.5–3 D(meas.) = 2.19 D(calc.) = 2.238 Slowly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, white. *Luster:* [Subvitreous.] *Optical Class:* Biaxial (+). *Orientation:* $Z \parallel$ long rhombus diagonal; $X \parallel$ short rhombus diagonal. $\alpha = 1.532(2)$ $\beta = 1.545(2)$ $\gamma = 1.572(2)$ 2V(meas.) = n.d. 2V(calc.) = 70°

Cell Data: *Space Group:* $P2/c$ or Pc. $a = 13.25(4)$ $b = 7.60(3)$ $c = 13.20(4)$ $\beta = 92°9(10)'$ Z = 4

X-ray Powder Pattern: Chelkar salt dome, Kazakhstan.
3.87 (10), 3.29 (10), 4.81 (9), 2.163 (9), 1.269 (8), 2.643 (7), 3.57 (6)

Chemistry:

	(1)	(2)
B_2O_3	61.90	62.00
MgO	17.80	17.95
H_2O	19.80	20.05
Total	99.50	100.00

(1) Chelkar salt dome, Kazakhstan. (2) $Mg_2[B_4O_5(OH)_4]_2 \cdot H_2O$.

Occurrence: Of rare occurrence in interstices and vugs in a rock salt diapir.

Association: Boracite, kaliborite, pinnoite, hilgardite, ginorite, bischofite, kieserite, preobrazhenskite, aksaite, strontioborite, metaborite, anhydrite, halite.

Distribution: From the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, Kazakhstan.

Name: Honors the Institute of Halurgy, St. Petersburg, Russia, for its studies of saline deposits.

Type Material: Institute of Halurgy; Mining Institute, St. Petersburg, 1488/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69833.

References: (1) Lovanova, V.V. (1962) A new borate, halurgite. Doklady Acad. Nauk SSSR, 143, 693–696 (in Russian). (2) (1962) Amer. Mineral., 47, 1217–1218 (abs. ref. 1). (3) Kondrat'eva, V.V. (1964) New X-ray data regarding halurgite and inderborite. Kristallografiya (Sov. Phys. Crystal.), 9(5), 735–736 (in Russian). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 95.

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Hambergite $Be_2BO_3(OH,F)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Typically well-crystallized, prismatic along [001] or dipyramidal, showing {110}, {021}, {010}, {100}, {210}, with another 20 forms known; {100} striated ‖ [001]; to 30 cm. *Twinning:* On {110}, commonly reticulated; contact twins may be markedly hemimorphic.

Physical Properties: *Cleavage:* On {010}, perfect; on {100}, good. *Tenacity:* Brittle. Hardness = 7.5 D(meas.) = 2.347–2.372 D(calc.) = 2.365

Optical Properties: Transparent to translucent. *Color:* Colorless, pale gray, pale yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, weak. $\alpha = 1.554$–1.560 $\beta = 1.587$–1.591 $\gamma = 1.628$–1.631 2V(meas.) = 87°

Cell Data: *Space Group: Pbca.* $a = 9.654(2)$–$9.776(3)$ $b = 12.194(2)$–$12.364(4)$ $c = 4.430(1)$–$4.440(2)$ $Z = 8$

X-ray Powder Pattern: Anjanabanoana, Madagascar.
3.81 (10), 3.13 (9), 4.53 (8), 3.19 (8), 2.40 (7), 2.21 (7), 2.13 (7)

Chemistry:

	(1)	(2)
B_2O_5	36.0	36.6
BeO	53.6	52.9
F	1.0	6.0
H_2O	8.8	6.7
$-O = F_2$	0.4	2.5
Total	99.0	99.7

(1) Anjanabanoana, Madagascar; corresponds to $Be_{2.04}B_{0.98}O_3[(OH)_{0.93}F_{0.05}]_{\Sigma=0.98}$. (2) Little Three mine, California, USA; corresponds to $Be_{2.00}B_{1.00}O_3[(OH)_{0.70}F_{0.30}]_{\Sigma=1.00}$.

Occurrence: An uncommon accessory mineral in granite pegmatites.

Association: Beryl, danburite, apatite, spodumene, zircon, fluorite, feldspar, quartz.

Distribution: From Helgeroa, Langesundsfjord, Norway. In the Czech Republic, from Ctidružice; Recice; Kracovice, near Tribic; Sušice; and elsewhere. From between San Ilario and San Piero in Campo, Elba, Italy. In Madagascar, from Imalo, near Mania; at Maharitra, on Mt. Bity; and large crystals from Anjanabanoana. In the USA, fine crystals from the Little Three mine, near Ramona, and the Himalaya mine, Mesa Grande district, San Diego Co., and in the Jensen quarry, Riverside Co., California; large crystals from the Zapot pegmatite, 25 km northeast of Hawthorne, Mineral Co., Nevada; at the Animikie Red Ace pegmatite, near Pine River, Florence Co., Wisconsin. In Pakistan, around Stak Nala and Drot, Gilgit-Skardu road, Northern Areas. In the Rangkul pegmatite field, eastern Pamir Mountains, Tajikistan. In Russia, from the Mokrusha mine, Ural Mountains, and in the Malkhan pegmatite field, Chite region, Transbaikal.

Name: Honors Professor Axel Hamberg (1863–1933), Swedish mineralogist and geographer.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 332865; Natural History Museum, Paris, France, 10734; National Museum of Natural History, Washington, D.C., USA, 116994.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 370–372. (2) Switzer, G., R.S. Clarke, Jr., J. Sinkankas, and H.W. Worthing (1965) Fluorine in hambergite. Amer. Mineral., 50, 85–95. (3) Burns, P.C., M. Novák, and F.C. Hawthorne (1995) Fluorine-hydroxyl variation in hambergite: a crystal-structure study. Can. Mineral., 33, 1205–1213. (4) Richards, R.P. (1996) Twinned hambergite from the Gilgit district, Northern Pakistan. Can. Mineral., 34, 615–621.

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Hammarite $Pb_2Cu_2Bi_4S_9$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As short prisms or needles.

Physical Properties: *Cleavage:* Good on {010}. *Fracture:* Flat conchoidal. Hardness = 3–4 VHN = 186 D(meas.) = 6.74 D(calc.) = 7.05

Optical Properties: Opaque. *Color:* Steel-gray with red tint. *Streak:* Black. *Luster:* Metallic.
R_1–R_2: (400) 39.7–43.6, (420) 39.8–43.7, (440) 39.8–43.8, (460) 39.9–44.0, (480) 40.1–44.1, (500) 40.3–44.4, (520) 40.2–44.6, (540) 40.1–44.6, (560) 40.0–44.7, (580) 39.9–44.7, (600) 39.8–44.6, (620) 39.6–44.4, (640) 39.4–44.1, (660) 39.1–43.7, (680) 38.8–43.3, (700) 38.6–42.9

Cell Data: *Space Group:* *Pbnm* or $Pbn2_1$. $a = 33.7726(8)$ $b = 11.5857(3)$ $c = 4.01$ $Z = 4$

X-ray Powder Pattern: Dzhida deposit, Russia.
3.63 (10b), 3.14 (10b), 4.01 (9b), 3.56 (8), 2.83 (8b), 2.00 (8), 1.973 (8)

Chemistry:

	(1)	(2)	(3)
Pb	27.40	23.13	24.87
Cu	7.60	7.69	7.63
Bi	47.59	49.00	50.18
S	17.01	17.57	17.32
rem.	0.04	2.71	
Total	99.64	100.10	100.00

(1) Gladhammar, Sweden; remnant is insoluble; corresponds to $Pb_{2.24}Cu_{2.03}Bi_{3.86}S_{9.00}$.
(2) Dzhida deposit, Russia; remnant Zn 1.78%, SiO_2 0.50%, Ag 0.17%, Sb 0.14%, Fe 0.05%, Sn 0.05%, Te 0.02%, Se 0.004%; corresponds to $Pb_{1.83}Cu_{1.99}Bi_{3.85}S_{9.00}$. (3) $Pb_2Cu_2Bi_4S_9$.

Occurrence: Of hydrothermal origin.

Association: Paděraite, pekoite, bismuthinite, chalcopyrite, grossular, andradite (Băiţa, Romania); pyrite, sphalerite (Dzhida deposit, Russia).

Distribution: From Gladhammar, Kalmar, Sweden [TL]. In the Dzhida Mo–W deposit, and from Inkur, Transbaikal, Russia. At Băiţa (Rézbánya), and from Baia Borşa, Baia Mare (Nagybánya), Romania. Found in the Loch Shin monzogranite, near Lairg, Scotland. From along the Avoca River, Co. Wicklow, Ireland. At the Felbertal tungsten mine, Salzburg, Austria. In the Victoria district, Doña Ana Co., New Mexico, and from the Outlaw mine, Round Mountain district, Nye Co., Nevada, USA. In the Julcani district, Peru.

Name: For the locality at Gladhammar, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 482. (2) Povilatis, M.M., N.N. Nozgova, Y.S. Borodaev, V.M. Senderova, and G.N. Ronami (1969) The first occurrence of hammarite in the USSR. Doklady Acad. Nauk SSSR, 187, 886–889 (in Russian). (3) Mumme, W.G., E. Welin, and B.J. Wuensch (1976) Crystal chemistry and proposed nomenclature for sulfosalts intermediate in the system bismuthinite–aikinite (Bi_2S_3–$CuPbBiS_3$). Amer. Mineral., 61, 15–20. (4) Horiuchi, H. and B.J. Wuensch (1976) The ordering scheme for metal atoms in the crystal structure of hammarite, $Cu_2Pb_2Bi_4S_9$. Can. Mineral., 14, 536–539. (5) Pring, A. (1995) Annealing of synthetic hammarite, $Cu_2Pb_2Bi_4S_9$, and the nature of cation-ordering processes in the bismuthinite-aikinite series. Amer. Mineral., 80, 1166–1173. (6) Topa, D., E. Makovicky, and W.H. Paar (2002) Composition ranges and exolution pairs for the members of the bismuthinite–aikinite series from Felbertal, Austria. Can. Mineral., 40, 849–869. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 220.

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Hanawaltite $Hg_6^{1+}Hg^{2+}O_3(Cl,OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$. Subhedral to anhedral crystals, platy to bladed, striated ‖ [001], to 0.3 mm.

Physical Properties: *Cleavage:* {001}, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = < 5 D(meas.) = n.d. D(calc.) = 9.51 Decrepitates on exposure to sunlight, photoreducing to mercury.

Optical Properties: Opaque to translucent on very thin edges. *Color:* Black to very dark brown-black; in reflected light, gray, may have red-orange internal reflections. *Streak:* Black to dark red-brown. *Luster:* Metallic.
Optical Class: Biaxial. *Pleochroism:* Weak; bright bluish white to grayish white.
Anisotropism: Bright metallic blue. *Bireflectance:* Moderate to strong.
R_1–R_2: (400) 26.2–37.6, (420) 25.2–34.8, (440) 24.2–32.5, (460) 23.3–30.6, (480) 22.4–29.0, (500) 21.8–27.7, (520) 21.2–26.7, (540) 20.8–25.9, (560) 20.5–25.2, (580) 20.3–24.6, (600) 20.1–24.1, (620) 20.0–23.7, (640) 20.2–23.3, (660) 20.3–23.1, (680) 20.2–22.9, (700) 20.0–22.8

Cell Data: *Space Group: Pbma.* $a = 11.790(3)$ $b = 13.881(4)$ $c = 6.450(2)$ $Z = 4$

X-ray Powder Pattern: Clear Creek mine, California, USA.
3.053 (100), 5.25 (80), 2.954 (70), 3.164 (60), 2.681 (50), 2.411 (50), 4.35 (40)

Chemistry:

	(1)
HgO	[14.27]
Hg_2O	[82.46]
Cl	3.33
S	0.00
H_2O	[0.34]
$-O = Cl_2$	0.75
Total	[99.65]

(1) Clear Creek mine, California, USA; by electron microprobe, calculated for Hg^{1+}:Hg^{2+} = 6:1 and H_2O for Cl+(OH) = 2.00; then corresponding to $Hg^{1+}_{6.00}Hg^{2+}_{1.00}[Cl_{1.43}(OH)_{0.57}]_{\Sigma=2.00}O_{3.00}$.

Occurrence: A rare alteration product of cinnabar, in a mercury deposit in silicate-carbonate rock hydrothermally altered from serpentinite.

Association: Calomel, mercury, cinnabar, montroydite, ferroan magnesite, quartz.

Distribution: Near the Clear Creek mercury mine, New Idria district, San Benito Co., California, USA.

Name: To honor Dr. Joseph Donald Hanawalt (1903–1987), American metallurgist, Ann Arbor, Michigan, USA, for his early work in X-ray powder diffraction.

Type Material: Canadian Geological Survey, Ottawa, Canada, 67396.

References: (1) Roberts, A.C., J.D. Grice, R.A. Gault, A.J. Criddle, and R.C. Erd (1996) Hanawaltite, $Hg_6^{1+}Hg^{2+}[Cl,(OH)]_2O_3$ – a new mineral from the Clear Creek claim, San Benito County, California: description and crystal structure. Powder Diffraction, 11, 45–50. (2) (1996) Amer. Mineral., 81, 1282 (abs. ref. 1).

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Hancockite $(Ca, Pb, Sr)_2(Al, Fe^{3+})_3(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As very small lath-shaped crystals, showing {001}, {100}, {101}, {$\bar{1}$01}, and {$\bar{1}$11}, striated parallel to their length and with rounded faces; subhedral grains, sometimes hollow. In drusy cellular aggregates and compact masses.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 4.03 D(calc.) = [4.03]

Optical Properties: Translucent. *Color:* Crystals yellowish brown, yellow-green; massive material dull brick-red, brownish red, or maroon. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless, pale rose, greenish yellow; Y = pale brownish yellow, yellow; Z = pale rose, greenish yellow, green. *Dispersion:* $r > v$, perceptible. *Absorption:* $Z > X$. $\alpha = 1.788(3)$ $\beta = 1.81(1)$ $\gamma = 1.830(3)$ 2V(meas.) = ∼50°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.958(20)$ $b = 5.665(10)$ $c = 10.304(20)$ $\beta = 114.4(4)°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA. (ICDD 17-212).
2.91 (100), 3.49 (50), 2.60 (50), 2.81 (40), 2.71 (40), 2.18 (40), 1.90 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	30.99	29.1	27.48	PbO	18.53	26.3	32.44
TiO_2			0.10	MgO	0.52	trace	0.00
Al_2O_3	17.89	16.3	14.52	CaO	11.50	10.0	9.20
Fe_2O_3	12.33	14.5	13.09	SrO	3.89	3.6	
Mn_2O_3	1.38	2.7		BaO			0.32
MnO	2.12		0.19	H_2O^+	1.62	[1.37]	[2.66]
				Total	100.77	[103.9]	[100.00]

(1) Franklin, New Jersey, USA; corresponds to $(Ca_{1.17}Pb_{0.47}Sr_{0.21}Mn^{2+}_{0.17})_{\Sigma=2.02}(Al_{1.95}Fe_{0.88}Mn^{3+}_{0.10}Mg_{0.07})_{\Sigma=3.00}(Si_{2.95}Al_{0.05})_{\Sigma=3.00}O_{12}OH$. (2) Do.; by electron microprobe, H_2O from theoretical $CaPbFeAl_2Si_3O_{12}(OH)$. (3) Jakobsberg, Sweden; by electron microprobe, H_2O by difference; corresponds to $(Ca_{1.07}Pb_{0.95}Mn_{0.02}Ba_{0.01})_{\Sigma=2.05}(Al_{1.87}Fe^{3+}_{1.08}Ti_{0.01})_{\Sigma=2.95}Si_{3.00}O_{12}OH$.

Mineral Group: Epidote group.

Occurrence: In a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA); in a metamorphosed manganese-iron orebody in skarns enclosed in dolomitic marble (Jakobsberg, Sweden).

Association: Andradite, franklinite, manganaxinite, clinohedrite, roeblingite, datolite, prehnite, willemite, barite, hendricksite, barian feldspar, phlogopite, lead, copper (Franklin, New Jersey, USA); melanotekite, hematite, garnet (Jakobsberg, Sweden).

Distribution: From Franklin, Sussex Co., New Jersey, USA. At Jakobsberg, Värmland, Sweden.

Name: For Elwood P. Hancock (1836–1916), of Burlington, New Jersey, USA, collector of minerals from Franklin.

Type Material: Yale University, New Haven, Connecticut, USA, 2.4751.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 32. (2) Penfield, S.L. and C.H. Warren (1899) Some new minerals from the zinc mines at Franklin, N.J., and note concerning the chemical composition of ganomalite. Amer. J. Sci., 8, 339–353. (3) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 98. (4) Dollase, W.A. (1971) Refinement of the crystal structures of epidote, allanite and hancockite. Amer. Mineral., 56, 447–464. (5) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727. (6) Holtstam, D. and J. Langhof (1994) Hancockite from Jakobsberg, Filipstad, Sweden: the second world occurrence. Mineral. Mag., 58, 172–174.

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Hanksite $KNa_{22}(SO_4)_9(CO_3)_2Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As short prismatic to tabular hexagonal crystals, to 20 cm, dominated by combinations of $\{10\bar{1}0\}$, $\{10\bar{1}2\}$, $\{10\bar{1}1\}$, and $\{0001\}$; $\{10\bar{1}0\}$ striated $\perp$ [0001].

Physical Properties: *Cleavage:* On $\{0001\}$, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 2.562 D(calc.) = 2.585 Soluble in H_2O, saline taste; fluoresces pale yellow under LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to pale yellow, may be grayish green due to clay inclusions; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to dull.
Optical Class: Uniaxial (–). $\omega = 1.481$ $\epsilon = 1.461$

Cell Data: *Space Group:* $P6_3/m$. $a = 10.465(21)$ $c = 21.191(43)$ $Z = 2$

X-ray Powder Pattern: Searles Lake, California, USA.
3.812 (100), 3.531 (75), 2.787 (72), 3.425 (60), 2.618 (47), 2.930 (31), 1.907 (22)

Chemistry:

	(1)	(2)
SO_3	45.78	46.05
CO_2	5.63	5.62
Na_2O	43.61	43.56
K	2.39	2.50
Cl	2.28	2.27
insol.	0.12	
Total	99.81	100.00

(1) Searles Lake, California, USA. (2) $KNa_{22}(SO_4)_9(CO_3)_2Cl$.

Occurrence: In lacustrine evaporite deposits.

Association: Halite, borax, trona, aphthitalite (Searles Lake, California, USA).

Distribution: In the USA, in California, large crystals from Searles Lake, San Bernardino Co.; at Soda Lake, San Luis Obispo Co.; from Mono Lake, Mono Co.; and in Death Valley, Inyo Co.

Name: Honors Henry Garber Hanks (1826–1907), for his service as first State Mineralogist of California, USA.

Type Material: Natural History Museum, Paris, France, 87.281; Natural History Museum, Vienna, Austria, E4854/8; National Museum of Natural History, Washington, D.C., USA, 81217.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 628–629. (2) Araki, T. and T. Zoltai (1973) The crystal structure of hanksite. Amer. Mineral., 58, 799–801.

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Hannayite $(NH_4)_2Mg_3(PO_3OH)_4 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As tabular crystals, elongated and striated ‖ [001], to 12 mm; in radial sprays of laths.

Physical Properties: *Cleavage:* Good on {001}; poor on {110}, {1$\overline{1}$0}, and {130}. Hardness = Soft. D(meas.) = n.d. D(calc.) = 2.03

Optical Properties: Transparent to translucent. *Color:* Pale yellow, pale brown, white; colorless in transmitted light.
Optical Class: Biaxial (–). *Dispersion:* $r < v$, weak. $\alpha = 1.504(2)$ $\beta = 1.522(2)$ $\gamma = 1.539(2)$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.70$ $b = 11.51$ $c = 6.70$ $\alpha = 76.0°$ $\beta = 99.8°$ $\gamma = 115.8°$ Z = 1

X-ray Powder Pattern: Synthetic.
6.96 (100), 3.46 (73), 5.15 (28), 4.64 (23), 3.29 (22), 3.75 (18), 3.00 (15)

Chemistry:

	(1)	(2)
P_2O_5	44.63	44.56
FeO	0.31	
MnO	0.09	
MgO	18.36	18.98
$(NH_4)_2O$	8.10	8.18
H_2O	28.51	28.28
Total	100.00	100.00

(1) Skipton lava tube caves, Australia. (2) $(NH_4)_2Mg_3(PO_3OH)_4 \cdot 8H_2O$.

Occurrence: As rare druses on guano-derived phosphate mineral crusts in caves.

Association: Biphosphammite, guanine, monetite, syngenite, aphthitalite, struvite, brushite, newberyite, dittmarite, schertelite.

Distribution: In Australia, from the Skipton lava tube caves, 40 km southwest of Ballarat, Victoria, and in the Murra-el-elevyn Cave, Cocklebiddy, Western Australia. At the Niah Great Cave, Sarawak, Malaysia.

Name: Honors James Ballantine Hannay (1855–1931), Scottish chemist, University of Manchester, Manchester, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 699–700. (2) Frazier, A.W., J.R. Lehr, and J.P. Smith (1963) The magnesium phosphates hannayite, schertelite and bobierrite. Amer. Mineral., 48, 635–641. (3) Bridge, P.J. (1973) Guano minerals from Murra-el-elevyn Cave, Western Australia. Mineral. Mag., 39, 467–469. (4) Catti, M. and M. Franchini-Angela (1976) Hydrogen bonding in the crystalline state. Structure of $Mg_3(NH_4)_2(HPO_4)_4 \cdot 8H_2O$ (hannayite), and crystal-chemical relationships with schertelite and struvite. Acta Cryst., 32, 2842–2848.

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Hannebachite $2CaSO_3 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As thin bladed crystals, flattened on {001}, elongated along [010], to 1 mm, dominated by {101} and {021} with some faces curved; typically in spraylike aggregates.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = ∼3.5 D(meas.) = 2.52 D(calc.) = 2.54

Optical Properties: Transparent. *Color:* Colorless; changes to milky white on exposure to humid air. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.596(2)$ $\beta = 1.600(2)$ $\gamma = 1.634(2)$ 2V(meas.) = 38(5)° 2V(calc.) = 38°

Cell Data: *Space Group: Pbna.* $a = 6.473(5)$ $b = 9.782(9)$ $c = 10.646(9)$ Z = 4

X-ray Powder Pattern: Hannebacher Ley volcano, Germany.
3.15 (100), 2.617 (90), 3.79 (80), 1.843 (50), 5.54 (40), 1.950 (40), 1.671 (40)

Chemistry:

	(1)	(2)
SO_2	49.5	49.60
CaO	43.1	43.42
H_2O	[7.4]	6.98
Total	[100.0]	100.00

(1) Hannebacher Ley volcano, Germany; average of 10 electron microprobe analyses, H_2O by TGA, presence of SO_3 confirmed by IR. (2) $2CaSO_3 \cdot H_2O$.

Occurrence: Lining cavities in blocks of melilite-nepheline-leucitite at the base of a volcano.

Association: Calcite, aragonite, gypsum, barite, celestine, thaumasite, chabazite, phillipsite, gismondine, whewellite, perovskite.

Distribution: From the Hannebacher Ley volcano, one km east-northeast of Hannebach, and at Kalem, near Birresborn, Eifel district, Germany.

Name: For the locality, Hannebacher Ley volcano, Germany, from which the first specimens were collected.

Type Material: Natural History Museum, Mainz, Germany, M1990/3093.

References: (1) Hentschel, G., E. Tillmanns, and W. Hofmeister (1985) Hannebachite, natural calciumsulfite hemihydrate, $CaSO_3 \cdot 1/2H_2O$. Neues Jahrb. Mineral., Monatsh., 241–250. (2) (1988) Amer. Mineral., 73, 928 (abs. ref. 1).

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Hapkeite $2/3Fe_2Si$

Crystal Data: Isometric. *Point Group:* 4/*m* $\bar{3}$ 2/*m*. As part of an irregular 0.035 mm diameter grain.

Physical Properties: *Cleavage:* n.d.. *Fracture:* n.d. *Tenacity:* n.d.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.83

Optical Properties: Opaque. *Color:* Yellowish white in reflected light. *Streak:* n.d.
Luster: Metallic.
R: (470) 47.1, (546) 48.8, (589) 50.0, (650) 50.9
Optical Class: Isotropic.

Cell Data: *Space Group: Pm*3*m*. *a* = 2.831(4) Z = 1

X-ray Powder Pattern: Lunar meteorite Dhofar 280.
2.831 (n.d.), 2.000 (n.d.), 1.631 (n.d.), 1.415 (n.d.), 1.267 (n.d.), 1.157 (n.d.), 1.000 (n.d.)

Chemistry:

	(1)
Fe	75.3
Si	18.4
Co	0.12
Ni	3.14
P	1.85
Cr	0.37
Total	99.2

(1) Lunar meteorite Dhofar 280; average of 5 electron microprobe analyses, corresponding to $(Fe_{1.27}Ni_{0.05}Cr_{0.01})_{\Sigma=1.33}(Si_{0.62}P_{0.06})_{\Sigma=0.68}$.

Occurrence: In a highland regolith breccia clast in the lunar meteorite Dhofar 280, formed by impact-induced, vapor-phase deposition under extreme reducing conditions in lunar soil.

Association: FeSi (fersilicite and ferdisilicite), vitrified plagioclase ("maskelynite"), FeNi.

Distribution: Lunar meteorite Dhofar 280 collected in Dhofar Province (Al Janubiyah Province), Oman.

Name: Honors Bruce Hapke (emeritus, University of Pittsburgh), who first predicted the presence of vapor-deposited elemental Fe as coatings on lunar soil grains.

Type Material: n.d.

References: (1) Anand, M., L.A. Taylor, M.A. Nazarov, J. Shu, H.-K. Mao, and R.J. Hemley (2004) Space weathering on airless planetary bodies: Clues from the lunar mineral hapkeite. Proc. Nat. Acad. Sci., 101, 6847-6851. (2) (2005) Amer. Mineral., 90, 518-519 (abs. ref. 1).

Haradaite $Sr_2V_2^{4+}O_2Si_4O_{12}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tubular aggregates, to 2 mm; massive.

Physical Properties: *Cleavage:* Perfect on {010}, distinct on {100} and {001}. Hardness = 4.5 D(meas.) = 3.80 D(calc.) = 3.83

Optical Properties: Transparent to translucent. *Color:* Bright green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless to very pale green; Y = colorless to light yellowish green; Z = bluish green. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, very strong. $\alpha = 1.713(2)$ $\beta = 1.721(2)$ $\gamma = 1.734(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group: Amam.* $a = 7.06$ $b = 14.64$ $c = 5.33$ Z = 4

X-ray Powder Pattern: Synthetic.
3.20 (100), 2.88 (90), 3.65 (40), 2.65 (40), 2.12 (40), 2.04 (35), 7.30 (30)

Chemistry:

	(1)		(1)
SiO_2	38.38	CaO	1.27
TiO_2	0.06	SrO	27.08
VO_2	26.16	BaO	4.90
Al_2O_3	0.36	Na_2O	0.01
FeO	0.12	K_2O	0.04
MnO	0.19	H_2O^+	1.24
CuO	0.20	H_2O^-	0.20
PbO	0.02	Total	100.23

(1) Yamato mine, Japan; corresponds to $(Sr_{3.26}Ba_{0.40}Ca_{0.28}Mn_{0.03}Fe_{0.02}K_{0.01})_{\Sigma=4.00}(V_{3.94}Al_{0.07}Ti_{0.01})_{\Sigma=4.02}(Si_{7.98}Al_{0.02})_{\Sigma=8.00}O_{28}$.

Occurrence: In coarse-grained rhodonite ore (Noda-Tamagawa mine, Japan); as veinlets cutting rhodonite-goldmanite ore (Yamato mine, Japan).

Association: Rhodonite, quartz.

Distribution: In Japan, in the Yamato mine and on Amamioshima Island, Kagoshima Prefecture; in the Noda-Tamagawa mine, Iwate Prefecture; and in the Matsuo mine, Kochi Prefecture. From the Gambatesa mine, near Chiavari, Val Graveglia, Liguria, Italy.

Name: For Zyunpei Harada (1898–1992), Emeritus Professor, Hokkaido University, Sapporo, Japan.

Type Material: National Science Museum, Tokyo, Japan, M15111.

References: (1) Watanabe, T., A. Kato, J. Ito, T. Yoshimura, H. Momoi, and K. Fukuda (1974) Haradaite, $Sr_2V_2(O_2)(Si_4O_{12})$, a new mineral from the Noda Tamagawa mine, Iwate Prefecture, and the Yamoto mine, Kagoshima Prefecture, Japan. IMA, 9th General Meeting, 97 (abs.). (2) (1975) Amer. Mineral., 60, 340 (abs. ref. 1). (3) Watanabe, T., A. Kato, J. Ito, T. Yoshimura, H. Momoi, and K. Fukuda (1974) Haradaite, $Sr_2V_2^{4+}[O_2Si_4O_{12}]$, from the Noda Tamagawa mine, Iwate Prefecture, and the Yamoto mine, Kagoshima Prefecture, Japan. Proc. Japan Acad., Ser. B, 58(2), 21–24 (in English). (4) (1975) Chem. Abs., 96, 146305 (abs. ref. 3). (5) Takéuchi, Y. and W. Joswig (1967) The structure of haradaite and a note on the Si:O bond lengths in silicates. Mineral. J. (Japan), 5, 98–123. (6) (1971) Amer. Mineral., 56, 1123 (abs. ref. 5). (7) Ito, J. (1965). Synthesis of vanadium silicates: haradaite, goldmanite and roscoelite. Mineral. J. (Japan), 4, 299–316.

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Hardystonite $Ca_2ZnSi_2O_7$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. In coarse, columnar masses; granular and as isolated grains.

Physical Properties: *Cleavage:* {001}, good; {100} and {110}, poor. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 3.396–3.443 D(calc.) = 3.42 A dull violet fluorescence can be observed in some samples under UV.

Optical Properties: Translucent. *Color:* White, pinkish, light brown; colorless in thin section. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.669$ $\epsilon = 1.657$

Cell Data: *Space Group:* $P\bar{4}2_1m$. $a = 7.8287(16)$ $c = 5.0140(4)$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA. (ICDD 12-453).
2.868 (100), 3.085 (60), 3.711 (50), 5.018 (35), 1.761 (35), 2.473 (30), 2.037 (18)

Chemistry:

	(1)	(2)	(3)
SiO_2	38.10	36.80	38.31
Al_2O_3		0.94	
Fe_2O_3	0.57	0.20	
MnO	1.50	0.76	
ZnO	24.30	25.56	25.94
PbO		0.56	
MgO	1.62	0.39	
CaO	33.85	34.61	35.75
Na_2O		0.29	
LOI	0.52		
Total	100.46	100.11	100.00

(1) Franklin, New Jersey, USA. (2) Do.; by electron microprobe. (3) $Ca_2ZnSi_2O_7$.

Mineral Group: Melilite group.

Occurrence: In granular ore in a metamorphosed stratiform zinc deposit.

Association: Vesuvianite, apatite, franklinite, willemite, rhodonite, calcite, dolomite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: For Hardyston Township in which Franklin is situated.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 113594, 113608.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 32–33. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 93–94. (3) Louisnathan, S.J. (1969) Refinement of the crystal structure of hardystonite, $Ca_2ZnSi_2O_7$. Zeits. Krist., 130, 427–437.

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Harkerite $Ca_{24}Mg_8Al_2(SiO_4)_8(BO_3)_6(CO_3)_{10}\cdot 2H_2O$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\bar{3}\ 2/m$. As simple pseudo-octahedral crystals, to 5 mm. *Twinning:* Observed, with four rhombohedral individuals each ideally oriented ‖ to one of the pseudocubic 3-fold axes.

Physical Properties: Hardness = n.d. D(meas.) = 2.95–2.96 D(calc.) = [3.02]

Optical Properties: Semitransparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Uniaxial, but typically sensibly isotropic; sections may separate into four fields with weak birefringence in the diagonal position. $n = 1.649–1.653$

Cell Data: *Space Group:* $R\bar{3}m$. $a = 10.439$ $c = 51.303$ $Z = 3$

X-ray Powder Pattern: Broadford area, Isle of Skye, Scotland.
2.61 (vs), 5.22 (s), 2.13 (s), 1.84 (s), 1.51 (s), 3.39 (m), 3.01 (m)

Chemistry:

	(1)	(2)	(3)
SiO_2	14.17	16.82	16.37
B_2O_3	7.77	7.0	7.11
Al_2O_3	2.84	3.13	3.47
Ce_2O_3		0.8	
Fe_2O_3	0.85	1.78	
FeO	0.46		
MnO	0.02	0.13	
MgO	11.15	10.01	10.98
CaO	46.23	44.13	45.85
SrO		0.2	
F		0.15	
Cl	1.36	0.06	
H_2O^+	0.81	1.25	1.23
H_2O^-	0.11		
CO_2	14.94	15.07	14.99
$-O = (F, Cl)_2$	0.31	0.07	
Total	100.40	100.46	100.00

(1) Camas Malag, Isle of Skye, Scotland. (2) Alban Hills, Italy; by electron microprobe, spectrophotometry, elemental analyzer, and mass spectrometer. (3) $Ca_{24}Mg_8Al_2(SiO_4)_8(BO_3)_6(CO_3)_{10}\cdot 2H_2O$.

Occurrence: In skarns in dolomitic limestones at the contact with granite (Camas Malag, Scotland); in volcanic ejecta (Alban Hills, Italy).

Association: Calcite, monticellite, diopside, magnetite, vesuvianite, cuspidine, phlogopite.

Distribution: At Camas Malag, near Broadford, Isle of Skye, Scotland. On the Chersky Ridge, Tas-haiatah, northeastern Siberia, Russia. From the Alban Hills, Lazio, Italy. Large crystals at Nordmark, Sweden.

Name: For Alfred Harker (1859–1939), British petrologist, Cambridge University, Cambridge, England.

Type Material: n.d.

References: (1) Tilley, C.E. (1951) The zoned contact-skarns of the Broadford area, Skye: a study of boron-fluorine metasomatism in dolomites. Mineral. Mag., 29, 621–667. (2) (1952) Amer. Mineral., 37, 359 (abs. ref. 1). (3) Ostrovskaya, I.V., N.N. Pertsev, and I.B. Nikitina (1966) Sakhaite, a new carbonate-borate of calcium and magnesium. Zap. Vses. Mineral. Obshch., 95, 193–202 (in Russian). (4) Giuseppetti, G., F. Mazzi, and C. Tadini (1977) The crystal structure of harkerite. Amer. Mineral., 62, 263–272. (5) Barbieri, M., C. Cozzupoli, M. Federico, M. Fornaseri, S. Merlino, P. Orlandi, and L. Tolomeo (1977) Harkerite from the Alban Hills, Italy. Lithos, 10, 133–141.

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Harmotome $(Ba,K)_{1-2}(Si,Al)_8O_{16}\cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals elongated ‖ [001] or tabular ‖ {010}; typically striated on {010} ‖ [001]. Commonly as interpenetrant twins, to 4 cm, alone, in groups, or radiating aggregates. *Twinning:* Repeated on {001}, {021}, {110}; three double twins may further twin to simulate a pseudotetragonal prism or dodecahedron.

Physical Properties: *Cleavage:* {010} distinct, {001} poor. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 2.41–2.47 D(calc.) = 2.448

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, yellow, pink, brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge a = 63°–67°$. *Dispersion:* Weak, crossed.
$\alpha = 1.503–1.508$ $\beta = 1.505–1.509$ $\gamma = 1.508–1.514$ 2V(meas.) = ∼80°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.8688(21)$ $b = 14.1295(7)$ $c = 8.7092(9)$
$\beta = 124.74°$ Z = 2

X-ray Powder Pattern: Korsnäs mine, Finland.
6.38 (100), 3.13 (80), 2.670 (70), 4.08 (60), 3.24 (60), 3.17 (60), 2.730 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	48.49	47.52	49.80
Al_2O_3	16.35	16.94	14.09
BaO	20.08	20.25	21.18
Na_2O	trace	1.09	
K_2O	2.07	1.00	
H_2O	13.00	13.45	14.93
Total	99.99	100.25	100.00

(1) St. Andreasberg, Germany. (2) Strontian, Scotland. (3) $BaSi_6Al_2O_{16}\cdot 6H_2O$.

Mineral Group: Zeolite group.

Occurrence: Of hydrothermal origin, in cavities in basalts, phonolites, trachytes; in gneisses, and in some ore veins.

Association: Zeolites, calcite, leucite, hyalophane, strontianite, quartz, kaolinite, barite, pyrite, sphalerite, galena.

Distribution: Many occurrences; some for well-studied material follow. In Germany, from St. Andreasberg, Harz Mountains; at Idar-Oberstein, Rhineland-Palatinate; and on the Silberberg, near Bodenmais, Bavaria. At Příbram, Czech Republic. From Sarrabus, Sardinia, Italy. Fine crystals from Strontian, Argyllshire, Scotland. From Kongsberg, Norway. At Kupferberg-Rudelstadt, Silesia, Poland. In the Korsnäs lead mine, south of Vaasa, Finland. In Russia, large crystals at Bukan, in the Kotuy River basin, Taimyr. In the USA, from Glen Riddle, Delaware Co., Pennsylvania; at Sing Sing, near Ossining, Westchester Co., New York. In the Beaver mine, Thunder Bay district, Ontario, Canada. At Batopilas, Chihuahua, Mexico.

Name: From the Greek *harmos*, for *a joint*, and *tome*, for *a cutting*, as the twinned crystals may be divided.

Type Material: Natural History Museum, Paris, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 581–583. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 386–400. (3) Sahama, T.G. and M. Lehtinen (1967) Harmotome from Korsnäs, Finland. Mineral. Mag., 36, 444–448. (4) Stuckenschmidt, E., H. Fuess, and Å. Kvick (1990) Investigation of the structure of harmotome by X-ray (293 K, 100 K) and neutron diffraction (15 K). Eur. J. Mineral., 861–874.

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Harrisonite $Ca(Fe^{2+},Mg)_6(SiO_4)_2(PO_4)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. In anhedral grains, to 2 mm; as rims on fluorapatite.

Physical Properties: *Cleavage:* Observed, very poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = < 5 D(meas.) = 4.02(3) D(calc.) = 4.01

Optical Properties: Translucent to transparent on thin edges. *Color:* Yellow-brown to orange-brown; pale yellow in thin section. *Streak:* Pale yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–); slightly biaxial due to strain. *Pleochroism:* Slight, in shades of pale yellow. $\omega = 1.770(5)$ $\epsilon = 1.759(3)$ 2V(meas.) = ∼5°

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.248(1)$ $c = 26.802(7)$ Z = 3

X-ray Powder Pattern: Arcedeckne Island, Canada.
3.119 (100), 2.558 (100), 2.689 (80), 2.505 (80), 1.560 (80), 5.00 (60), 1.903 (60)

Chemistry:

	(1)
SiO_2	15.99
FeO	52.27
MnO	0.11
MgO	3.89
CaO	7.65
P_2O_5	19.18
Total	99.09

(1) Arcedeckne Island, Canada; by electron microprobe, average of four analyses, Ti, Al, Cr, Na, K, Cl, F absent; corresponds to $Ca_{1.01}(Fe_{5.36}Mg_{0.71}Mn_{0.01})_{\Sigma=6.08}(Si_{0.98}O_4)_2(P_{0.99}O_4)_2$.

Occurrence: A minor but wide-spread constituent in a layered iron silicate-quartz-apatite body in gneisses, probably a shaly and phosphatic iron formation metamorphosed to the granulite facies.

Association: Fluorapatite, quartz, fayalite, ferrosilite, almandine, ilmenite, biotite, zircon, monazite-(Ce).

Distribution: From Arcedeckne Island, near the Boothia Peninsula, District of Franklin, Arctic Canada.

Name: To honor Dr. James Merritt Harrison (1915–1990), former Director of the Canadian Geological Survey.

Type Material: Canadian Geological Survey, Ottawa, 66402; Canadian Museum of Nature, Ottawa, Canada, 59685.

References: (1) Roberts, A.C., J.A.R. Stirling, J.D. Grice, T. Frisch, R.K. Herd, and J.L. Jambor (1993) Harrisonite, a new calcium iron silicate-phosphate from Arcedeckne Island, District of Franklin, Arctic Canada. Can. Mineral., 31, 775–780. (2) Grice, J.D. and A.C. Roberts (1993) Harrisonite, a well-ordered silico-phosphate with a layered crystal structure. Can. Mineral., 31, 781–785. (3) (1994) Amer. Mineral., 79, 1010–1011 (abs. refs. 1 and 2).

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Harstigite $Ca_6(Mn^{2+},Mg)Be_4(SiO_4)_2(Si_2O_7)_2(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals stout prismatic, to 2 cm, terminated by {110} and small {221}.

Physical Properties: *Fracture:* Small conchoidal to splintery. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 3.16 D(calc.) = 3.19

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, weak. $\alpha = 1.678$ $\beta = 1.68$ $\gamma = 1.683$ 2V(meas.) = 52°

Cell Data: *Space Group: Pnam.* $a = 9.793(2)$ $b = 13.636(3)$ $c = 13.830(3)$ Z = 4

X-ray Powder Pattern: Harstigen mine, Sweden.
2.695 (100), 2.817 (50), 2.788 (50), 2.268 (50), 4.35 (40), 3.222 (40), 3.545 (30)

Chemistry:

	(1)
SiO_2	40.00
MnO	7.05
BeO	11.49
MgO	0.94
CaO	37.82
F	0.15
H_2O	2.48
Total	99.93

(1) Harstigen mine, Sweden; corresponds to $Ca_{5.88}(Mn_{0.86}Mg_{0.20})_{\Sigma=1.06}Be_{4.00}Si_{5.80}O_{21.34}(OH)_{2.40}$.

Occurrence: A rare mineral found in open fissures in a metamorphosed manganese deposit.

Association: Hausmannite, dolomite, calcite, rhodonite, andradite, manganoan humite, barite.

Distribution: At the Harstigen mine, near Persberg, Värmland, Sweden.

Name: For the Harstigen mine, Sweden, where it was found.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 532–533. (2) Moore, P.B. (1968) Relations of the manganese-calcium silicates, gageite and harstigite. Amer. Mineral., 53, 309–315. (3) Moore, P.B. (1968) Relation of the manganese-calcium silicates, gageite and harstigite: a correction. Amer. Mineral., 53, 1418–1420. (4) Hesse, K.-F. and G. Stümpel (1986) Crystal structure of harstigite, $MnCa_6Be_4[SiO_4]_2[Si_2O_7]_2(OH)_2$. Zeits. Krist., 177, 143–148.

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Hartite $C_{20}H_{34}$

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Crystal Data: Triclinic. *Point Group:* 1. Rare in complex flattened to needlelike crystals, to 8 mm, with 26 forms noted; lamellar to coarse crystalline, in coatings.

Physical Properties: *Cleavage:* One, very good. *Tenacity:* Waxlike. Hardness = 1 D(meas.) = 1.036–1.06 D(calc.) = 1.064 M.P. 71 °C–71.5 °C.

Optical Properties: Translucent. *Color:* White, gray, yellowish gray, colorless.
Luster: Vitreous.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, perceptible. $\alpha = 1.546$ $\beta = 1.555$ $\gamma = 1.587$
2V(meas.) = 57(7)°

Cell Data: *Space Group:* $P1$. $a = 11.407(1)$ $b = 20.952(2)$ $c = 7.4060(8)$
$\alpha = 93.941(9)°$ $\beta = 100.750(8)°$ $\gamma = 80.499(9)°$ Z = 4

X-ray Powder Pattern: Bílina mine, Czech Republic.
5.54 (100), 10.38 (34), 6.59 (33), 6.11 (18), 5.58 (17), 3.446 (13), 3.850 (11)

Chemistry:

	(1)	(2)	(3)
C	87.47	87.45	87.51
H	12.05	12.55	12.49
Total	99.52	100.00	100.00

(1) Oberhart, Austria. (2) Bílina mine, Czech Republic. (3) $C_{20}H_{34}$, (+)-phyllocladane.

Occurrence: Rare, in lignite seams and fractures in fossil coalified and silicified tree trunks. Typically obtained by leaching lignite with organic solvents and reprecipitation.

Association: Siderite, "limonite" (Bílina mine, Czech Republic).

Distribution: In Austria, from Oberhart, near Gloggnitz, Lower Austria; at Rosenthal and Oberdorf, near Köflach, and from Göriach, near Turnau, Styria. In Italy, at Terni, Umbria, and from Castelnuovo di Valdarno, near Florence, Tuscany. In the Bílina coal mine, at the former village of Liptice, northwest of Bílina, and at the former village of Jenišův Újezd, west of Bílina, Czech Republic.

Name: For its discovery locality, Oberhart, Austria.

Type Material: Krahuletz Museum, Eggenburg, Austria.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1001. (2) Hintze, C. (1933) Handbuch der Mineralogie. Gruyter & Co., Berlin, 1(4.2), 1358–1360 (in German). (3) Bouška, V., Císařová. R. Skála, Z. Dvořák, J. Zelinka, and K. Žák (1998) Hartite from Bílina. Amer. Mineral., 83, 1340–1346.

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Hashemite $Ba(Cr,S)O_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As stubby doubly-terminated to tabular crystals, to 1 mm, showing {100}, {110}, {010}, {001}, and a number of other forms.

Physical Properties: *Cleavage:* {001}, perfect; {010}, {100}, good. Hardness = 3.5 D(meas.) = 4.54–4.59 D(calc.) = 4.46–4.52

Optical Properties: Semitransparent. *Color:* Brown, crystals typically zoned from pale yellowish brown to darker greenish brown in the core. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Dispersion:* $r < v$, extreme. $\alpha = 1.810–1.952$ $\beta = 1.813–1.960$ $\gamma = 1.824–1.977$ 2V(meas.) = 35°–57° 2V(calc.) = 55°–69°

Cell Data: *Space Group: Pnma.* $a = 9.1028(14)$ $b = 5.5276(7)$ $c = 7.3314(11)$ $Z = 4$

X-ray Powder Pattern: Jordan.
3.516 (100), 3.171 (80), 3.669 (60), 2.175 (45), 2.150 (45), 2.770 (40), 3.403 (35)

Chemistry:

	(1)	(2)
SO_3	2.18	11.75
CrO_3	37.0	26.15
BaO	60.8	62.55
Total	99.98	100.45

(1) Jordan; by electron microprobe, average of five analyses of dark crystals; corresponding to $Ba_{1.00}(Cr_{0.93}S_{0.07})_{\Sigma=1.00}O_4$. (2) Jordan; by electron microprobe, average of four analyses of pale crystals; corresponding to $Ba_{1.00}(Cr_{0.64}S_{0.36})_{\Sigma=1.00}O_4$.

Mineral Group: Barite group.

Occurrence: Disseminated in veinlets cutting phosphate carbonate rock, the stratigraphic correlative of the Mottled Zone of the Hatrurim Formation, Israel.

Association: Chromian ettringite, apatite, bultfonteinite, calcite.

Distribution: From stone quarries 60 km southeast of Amman, west-central Jordan.

Name: Honors the Hashemite Kingdom of Jordan, within which the species occurs.

Type Material: National Museum of Natural History, Washington, D.C., USA, 146183.

References: (1) Hauff, P.L., E.E. Foord, S. Rosenblum, and W. Hakki (1983) Hashemite, $Ba(Cr,S)O_4$, a new mineral from Jordan. Amer. Mineral., 68, 1223–1225. (2) Duesler, E.N. and E.E. Foord (1986) Crystal structure of hashemite, $BaCrO_4$, a barite structure type. Amer. Mineral., 71, 1217–1220. (3) Pasero, M. and P. Davoli (1987) Structure of hashemite, $Ba(Cr,S)O_4$. Acta Cryst., C43, 1467–1469.

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Hastingsite $\mathbf{NaCa_2[(Fe^{2+},Mg)_4Fe^{3+}](Si_6Al_2)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, to 4 cm. *Twinning:* Simple or multiple twinning common ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, with intersections at 56° and 124°; partings on {001}, {100}. *Tenacity:* [Brittle.] Hardness = 5–6 D(meas.) = 3.35–3.5 D(calc.) = [3.42]

Optical Properties: Semitransparent. *Color:* Black, dark green, green-brown, yellow; dark green in thin section. *Luster:* [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* X = yellow, greenish brown, yellowish green; Y = deep greenish blue, brownish green, very dark olive-green; Z = deep olive-green, smoky blue-green, very dark green. *Orientation:* $Y = b$; $Z \wedge c \simeq 12°$. *Dispersion:* $r < v$, moderate to strong.
$\alpha = 1.685$–1.702 $\beta = 1.71$–1.729 $\gamma = 1.71$–1.728 2V(meas.) = 10°–45°

Cell Data: *Space Group:* $C2/m$. $a = 9.8659(4)$ $b = 18.0139(8)$ $c = 5.3545(2)$ $\beta = 105.082(1)°$ Z = 2

X-ray Powder Pattern: Hastings Co., Ontario, Canada. (ICDD 20-469).
8.43 (100), 3.13 (70), 2.706 (60), 3.39 (50), 3.28 (50), 2.594 (50), 2.559 (50)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	33.50	37.68	MnO	0.26	0.66	F	0.25	
TiO_2	3.26	1.02	MgO	5.00	2.20	H_2O^+	1.37	
Al_2O_3	17.89	14.01	CaO	10.30	9.26	H_2O^-	0.04	
Fe_2O_3	6.65	7.97	Na_2O	3.14	3.31	P_2O_5	0.05	
FeO	16.49	20.63	K_2O	1.48	2.22	$-O = F_2$	0.10	
						Total	[99.58]	98.96

(1) Wolfe Belt, Kargus Ridge, Lyndoch, Ontario, Canada; original total given as 99.53%, corresponds to $(Ca_{1.74}Na_{0.95}K_{0.30})_{\Sigma=2.99}(Fe^{2+}_{2.17}Mg_{1.17}Fe^{3+}_{0.79}Al_{0.58}Ti_{0.39}Mn_{0.04})_{\Sigma=5.14}(Si_{5.27}Al_{2.73})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Hastings Co., Ontario, Canada; by electron microprobe, corresponds to $(Ca_{1.56}Na_{1.01}K_{0.45})_{\Sigma=3.02}(Fe^{2+}_{2.71}Fe^{3+}_{0.94}Al_{0.53}Mg_{0.52}Ti_{0.12}Mn_{0.09})_{\Sigma=4.91}(Si_{5.93}Al_{2.07})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with magnesio-hastingsite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) < 0.30$; $Fe^{3+} > Al^{vi}$; $(Na + K)_A \geq 0.5$; $(Ca + Na)_B \geq 1.34$; $Na_B < 0.67$; $Si < 6.25$; $Ti < 0.5$.

Occurrence: In nepheline syenite and granite; in schists, gneisses, tactites, and amphibolites.

Association: Scapolite, apatite, magnetite, spinel (gneiss); garnet, epidote, hedenbergite, quartz (tactite).

Distribution: Analyzed material from many localities worldwide. In Canada, at Bancroft, and elsewhere in Hastings Co., Ontario; near Crescent Lake, Cassiar Mountains, Yukon Territory. In the USA, at Franklin, Sussex Co., New Jersey; Cornwall, Orange Co., New York; and Iron Hill, Gunnison Co., Colorado. From Koraput, Orissa, and elsewhere in India. In the Sampo mine, Okayama Prefecture, and the Obira mine, Bungo, Oita Prefecture, Japan. From Kakanui, New Zealand. In the Marangudzi ring complex, Zimbabwe. At Almunge, Sweden.

Name: For a locality in Hastings Co., Ontario, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M13724.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 3.
(2) Hawthorne, F.C. and H.D. Grundy (1977) The crystal chemistry of the amphiboles. III: Refinement of the crystal structure of a sub-silicic hastingsite. Mineral. Mag., 41, 43–50.
(3) Leake, B.E. (1968) A catalog of analyzed calciferous and subcalciferous amphiboles together with their nomenclature and associated minerals. Geol. Soc. Amer. Special Paper 98, 210 p. [analysis 936].

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Hastite $CoSe_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As radiating starlike aggregates of crystals; small idiomorphic grains. *Twinning:* Common.

Physical Properties: Hardness = ∼6 VHN = n.d. D(meas.) = n.d. D(calc.) = 7.22

Optical Properties: Opaque. *Color:* Pale brownish red to dark reddish violet; yellowish red in radiating aggregates. *Pleochroism:* Strong, especially in oil. *Anisotropism:* Strong.
R_1–R_2: (400) 46.6–47.2, (420) 46.4–47.7, (440) 46.2–48.2, (460) 46.1–48.8, (480) 46.0–49.6, (500) 46.2–50.4, (520) 46.6–51.2, (540) 46.9–52.2, (560) 47.4–53.3, (580) 47.9–54.2, (600) 48.5–55.4, (620) 49.1–56.4, (640) 49.7–57.2, (660) 50.4–58.0, (680) 51.0–58.6, (700) 51.4–59.0

Cell Data: *Space Group: Pmnn.* $a = 3.60$ $b = 4.84$ $c = 5.72$ Z = 2

X-ray Powder Pattern: Trogtal quarry, Germany.
2.58 (10), 2.47 (10), 1.90 (10), 1.021 (10), 2.9 (3), 1.61 (3), 1.44 (3)

Chemistry: Composition inferred by similarity of X-ray pattern with marcasite.

Polymorphism & Series: Dimorphous with trogtalite.

Mineral Group: Marcasite group.

Occurrence: In hydrothermal veins.

Association: Trogtalite, bornhardtite, gold, clausthalite, selenium (Trogtal quarry, Germany).

Distribution: In Germany, from the Trogtal quarry, near Lautenthal, Harz Mountains [TL]. In the USA, at the La Sal mine, Beaver Mesa, Montrose Co., Colorado. From the San Francisco mine, La Rioja Province, Argentina.

Name: In honor of Dr. P.F. Hast, mining engineer.

Type Material: National Museum of Natural History, Washington, D.C., USA, 112811.

References: (1) Ramdohr, P. and M. Schmitt (1955) Vier neue natürliche Kobaltselenide vom Steinbruch Trogtal bei Lautenthal im Harz. Neues Jahrb. Mineral., Monatsh., 133–142 (in German). (2) (1956) Amer. Mineral., 41, 164 (abs. ref. 1).

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Hatchite $(Pb,Tl)_2(Ag,Cu)As_2S_5$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As euhedral crystals, to 0.7 mm.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 5.8

Optical Properties: Opaque to subtranslucent. *Color:* Lead-gray; dark red in transmitted light. *Streak:* Chocolate-brown.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 9.22(1)$ $b = 7.84(1)$ $c = 8.06(1)$
$\alpha = 66°25(15)'$ $\beta = 65°17(15)'$ $\gamma = 74°5(15)'$ Z = 2

X-ray Powder Pattern: Binntal, Switzerland.
3.314 (100), 2.863 (90), 3.401 (80), 3.569 (40), 4.54 (30), 4.28 (30), 3.750 (20)

Chemistry:

	(1)	(2)	(3)
Pb	25.5	24.6	24.97
Tl	25.5	24.5	24.64
Ag	8.8	10.9	13.00
Cu	3.0	0.95	
As	17.0	20.7	18.06
Sb	1.5		
S	18.6	19.0	19.33
Total	99.9	100.65	100.00

(1) Binntal, Switzerland; by electron microprobe, corresponds to $(Pb_{0.99}Tl_{1.01})_{\Sigma=2.00}(Ag_{0.66}Cu_{0.38})_{\Sigma=1.04}(As_{1.82}Sb_{0.10})_{\Sigma=1.93}S_{4.68}$. (2) Do.; corresponds to $(Pb_{1.00}Tl_{1.00})_{\Sigma=2.00}(Ag_{0.85}Cu_{0.12})_{\Sigma=0.97}As_{2.32}S_{4.97}$. (3) $(Pb,Tl)_2AgAs_2S_5$ with Pb:Tl = 1:1.

Occurrence: Of hydrothermal origin, in crystalline dolostone.

Association: Wallisite, hutchinsonite, jentschite, sicherite, edenharterite, bernardite, stalderite, lorandite, realgar, orpiment.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: To honor Dr. Frederick Henry Hatch (1864–1932), American geologist and mining engineer.

Type Material: The Natural History Museum, London, England, 1913,399.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 487. (2) Nowacki, W., G. Burri, P. Engel, and F. Marumo (1967) Über einige Mineralstufen aus dem Lengenbach (Binnatal) II. Neues Jahrb. Mineral., Monatsh., 43–48 (in German with English abs.). (3) Marumo, F., W. Nowacki, C. Bahezre, and G. Burri (1967) The crystal structure of hatchite. Zeits. Krist., 125, 249–265. (4) Berry, L.G. (1969) The crystallography of hatchite. Indian Mineralogist, 10, 165–173.

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Hatrurite Ca_3SiO_5

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Crystal Data: n.d. *Point Group:* n.d. Crystals pseudohexagonal, to about 50 μ.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Light gray; colorless in thin section. *Optical Class:* Biaxial (–). n = n.d.; birefringence ~0.006 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Hatrurim Formation, Israel; stronger lines overlapped by larnite. 3.03 (m), 1.767 (mw), 2.96 (vw), 1.759 (vw), 1.484 (vw), 1.452 (vw)

Chemistry:

	(1)
SiO_2	26.1
TiO_2	0.3
Al_2O_3	0.4
Fe_2O_3	0.2
MgO	trace
CaO	72.8
Total	99.8

(1) Hatrurim Formation, Israel; by electron microprobe, corresponds to $Ca_{2.97}Al_{0.01}Ti_{0.01}SiO_5$.

Occurrence: In a high-temperature contact metamorphic assemblage in a larnite-brownmillerite-mayenite rock, probably derived from fine-grained sediments.

Association: Nagelschmidtite, larnite, brownmillerite, mayenite.

Distribution: In the Hatrurim Formation, Israel.

Name: For the Hatrurim Formation in Israel.

Type Material: n.d.

References: (1) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 35–36. (2) (1978) Amer. Mineral., 63, 425–427 (abs. ref. 1).

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Hauchecornite $Ni_9Bi(Sb,Bi)S_8$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are tabular on {001}, also short prismatic and dipyramidal, to 4 mm.

Physical Properties: *Fracture:* Flat, conchoidal. Hardness = 5 VHN = 447–655 (50 g load). D(meas.) = 6.35–6.47 D(calc.) = 6.58

Optical Properties: Opaque. *Color:* Pale bronze-yellow, tarnishing darker. *Streak:* Gray-black. *Luster:* Lively metallic on fresh break. *Pleochroism:* Very weak in air; more distinct in oil. *Anisotropism:* Distinct.
R_1–R_2: (400) 35.8–37.9, (420) 37.2–39.3, (440) 38.6–40.7, (460) 40.0–42.2, (480) 41.4–43.8, (500) 42.7–45.4, (520) 44.0–46.9, (540) 45.2–48.2, (560) 46.3–49.3, (580) 47.3–50.2, (600) 48.2–51.0, (620) 49.0–51.7, (640) 49.7–52.3, (660) 50.4–52.9, (680) 51.0–53.4, (700) 51.5–53.9

Cell Data: *Space Group:* $P4/mmm$. $a = 7.300(3)$ $c = 5.402(2)$ $Z = 1$

X-ray Powder Pattern: Friedrich mine, Germany.
2.79 (10), 2.39 (6), 2.30 (6), 4.34 (5), 1.861 (5), 3.64 (4), 3.25 (4)

Chemistry:

	(1)	(2)	(3)
Ni	45.47	46.8	45.57
Co	0.76	0.3	
Fe	0.22		
Bi	24.11	22.3	27.05
Sb	6.48	7.8	5.25
As	0.67	0.2	
S	22.75	22.6	22.13
Total	100.46	100.0	100.00

(1) Friedrich mine, Germany; average of two analyses, corresponds to $(Ni_{8.74}Co_{0.14}Fe_{0.04})_{\Sigma=8.92}(Bi_{1.30}Sb_{0.60}As_{0.10})_{\Sigma=2.00}S_{8.00}$. (2) Do.; by electron microprobe, corresponds to $(Ni_{9.05}Co_{0.06})_{\Sigma=9.11}(Bi_{1.21}Sb_{0.73}As_{0.03})_{\Sigma=1.97}S_{8.00}$. (3) $Ni_9Bi(Sb,Bi)S_8$ with Bi:Sb = 3:1.

Mineral Group: Hauchecornite group.

Occurrence: Of hydrothermal origin.

Association: Millerite, bismuthian-arsenian ullmannite, antimonian gersdorffite, siegenite, bismuthinite, gold, galena, sphalerite, quartz.

Distribution: From the Friedrich mine, near Wissen, North Rhine-Westphalia, Germany [TL].

Name: Honors William Hauchecorn (1828–1900), Director of the Geological Survey and the Mining Academy, Berlin, Germany.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 89710.

References: (1) Peacock, M.A. (1950) Hauchecornite. Amer. Mineral., 35, 440–446. (2) Gait, R.I. and D.C. Harris (1972) Hauchecornite – antimonian arsenian, and tellurian varieties. Can. Mineral., 11, 819–825. (3) Kocman, V. and E.W. Nuffield (1974) The crystal structure of antimonian hauchecornite from Westphalia. Can. Mineral., 12, 269–274. (4) Just, J. (1980) Bismutohauchecornite – new name: hauchecornite redefined. Mineral. Mag., 43, 873–876.

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Hauckite $(Mg, Mn^{2+})_{24}Zn_{18}Fe_3^{3+}(SO_4)_4(CO_3)_2(OH)_{81}(?)$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As hexagonal crystals, extremely flattened on {0001}, with $\{01\bar{1}0\}$ and {0001}, to 1 mm; as almost spherical to imperfect rosettes.

Physical Properties: *Cleavage:* On {0001}, perfect. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 3.02, thought low due to adhering air bubbles. D(calc.) = 3.10

Optical Properties: Semitransparent. *Color:* Bright orange to pale yellow. *Streak:* Yellow to pale yellow. *Luster:* Vitreous to slightly pearly.
Optical Class: Uniaxial (+). *Pleochroism:* O = golden brown; E = pale yellow.
Absorption: $O > E$. $\omega = 1.630(2)$ $\epsilon = 1.638(2)$

Cell Data: *Space Group:* $6/mmm$ (Laue symmetry). $a = 9.17(4)$ $c = 30.21(9)$ Z = [1]

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
3.96 (100), 7.8 (90), 4.57 (60), 3.02 (60), 5.02 (50), 3.78 (50), 1.748 (30)

Chemistry:

	(1)
SO_3	7.4
CO_2	[2.1]
Al_2O_3	0.5
Fe_2O_3	6.0
MnO	17.1
ZnO	36.0
MgO	13.2
H_2O	[17.7]
Total	[100.0]

(1) Sterling Hill, New Jersey, USA; by electron microprobe, total Fe as Fe_2O_3, confirmed by microchemical test, total Mn as MnO, CO_2 and H_2O calculated for stoichiometry; corresponds to $(Mg_{13.5}Mn_{9.9}Fe^{2+}_{0.5}Zn_{0.2})_{\Sigma=24.1}Zn_{18.0}(Fe^{3+}_{2.6}Al_{0.4})_{\Sigma=3.0}(SO_4)_{3.8}(CO_3)_{2.0}(OH)_{80.8}$.

Occurrence: Very rare, found in several different parageneses in a metamorphosed stratiform zinc orebody.

Association: Mooreite, phlogopite, calcite; sussexite, pyrochroite, zincite; chlorophoenicite, calcite;

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: To honor Richard Philip Hauck (1935–), mineral collector of Bloomfield, New Jersey, USA, for his contributions to preserving scientifically significant specimens from Franklin and Sterling Hill, New Jersey, USA.

Type Material: Royal Ontario Museum, Toronto, Canada, M35860; American Museum of Natural History, New York City, New York, T45495; Harvard University, Cambridge, Massachusetts, 126591; National Museum of Natural History, Washington, D.C., USA, 142854, 164107.

References: (1) Dunn, P.J., D.R. Peacor, and B.D. Sturman (1980) Hauckite, $Fe_3^{3+}(Mg, Mn)_{24}Zn_{18}(SO_4)_4(CO_3)_2(OH)_{81}$, a new mineral from Sterling Hill, New Jersey. Amer. Mineral., 65, 192–195.

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Hauerite MnS_2

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Octahedral crystals common, also cubo-octahedral, to 5 cm; as globular aggregates.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 4 VHN = n.d. D(meas.) = 3.463 D(calc.) = 3.444

Optical Properties: Opaque to subtranslucent. *Color:* Reddish brown to brownish black; in polished section grayish white with very pale brownish hue, with red internal reflections; deep red in transmitted light. *Streak:* Brownish red. *Luster:* Metallic-adamantine.
Optical Class: Isotropic. $n = 2.69$ (Li).
R: (400) 24.9, (420) 24.7, (440) 24.6, (460) 24.5, (480) 24.4, (500) 24.3, (520) 24.1, (540) 23.7, (560) 23.3, (580) 22.8, (600) 22.2, (620) 21.6, (640) 21.2, (660) 20.9, (680) 20.7, (700) 20.7

Cell Data: *Space Group:* $Pa3$. $a = 6.104(2)$ $Z = 4$

X-ray Powder Pattern: Radussa, Sicily, Italy.
3.07 (100), 1.175 (80), 1.843 (70), 0.990 (70), 2.75 (50), 2.51 (50), 2.04 (50)

Chemistry:

	(1)	(2)	(3)
Mn	46.47	46.28	46.14
Fe	0.03		
S	53.27	53.51	53.86
SiO_2	0.16		
Total	99.93	99.79	100.00

(1–2) Raddusa, Sicily, Italy. (3) MnS_2.

Mineral Group: Pyrite group.

Occurrence: A low-temperature mineral commonly associated with solfataric waters, in clay deposits rich in sulfur, and from decomposed extrusive rocks.

Association: Sulfur, realgar, gypsum, calcite.

Distribution: From Slovakia, at Kalinka, near Banská Bystrica (Neusohl) [TL], and at Banská Štiavnica (Schemnitz). From Jeziorko and Grzybow, and in the Machow mine, Tarnobrzeg, Poland. In good crystals at the Destricella mine, Raddusa, Sicily, Italy. At the Ronneberg uranium deposit, Gera district, Thuringia, Germany. From the Yazovsk and Podgornensk deposits, Aktyubinsk, Ural Mountains, Russia. In the Lake Wakatipu district, and at Collingwood, New Zealand. In the USA, from Texas, at the Gulf and Big Hill salt domes, Matagorda Co.; the High Island salt dome, Galveston Co.; the Boling salt dome, Wharton Co.; and the Fannett salt dome, Jefferson Co.

Name: In honor of Joseph Ritter von Hauer (1778–1863), and his son Franz Ritter von Hauer (1822–1899), Austrian geologists.

Type Material: Natural History Museum, Vienna, Austria, A.h.894.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 293–294. (2) Chattopadhyay, T., H.G. von Schnering, R.F.D. Stansfield, and G.J. McIntyre (1992) X-ray and neutron diffraction study of the crystal structure of MnS_2. Zeits. Krist., 199, 13–24. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 89–90. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 221.

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Hausmannite $Mn^{2+}Mn_2^{3+}O_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m2/m2/m$. Crystals are pseudo-octahedral and striated ‖ [100], to 7.5 cm. Commonly granular or massive. *Twinning:* Repeated twins on {112}, producing fivelings or lamellar intergrowths.

Physical Properties: *Cleavage:* {001}, perfect; {112} and {011}, indistinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5 VHN = 437–572 (100 g load). D(meas.) = 4.84 D(calc.) = 4.84

Optical Properties: Opaque, transparent through thin edges. *Color:* Dark brown to black; deep reddish brown in transmitted light; gray in reflected light, with deep blood-red to reddish brown internal reflections. *Streak:* Dark reddish brown. *Luster:* Submetallic. *Optical Class:* Uniaxial (–). $\omega = 2.46(2)$ $\epsilon = 2.15(2)$ *Anisotropism:* Distinct. *Bireflectance:* Weak; O = light gray; E = dark gray. R_1–R_2: (400) 21.5–18.8, (420) 21.2–18.4, (440) 20.9–17.9, (460) 20.7–17.5, (480) 20.5–17.2, (500) 20.4–17.0, (520) 20.4–16.7, (540) 20.3–16.4, (560) 20.1–16.1, (580) 20.1–15.9, (600) 20.0–15.7, (620) 19.9–15.5, (640) 19.9–15.4, (660) 19.8–15.2, (680) 19.8–15.1, (700) 19.7–14.9

Cell Data: *Space Group: $I4_1/amd$.* $a = 5.765(1)$ $c = 9.442(2)$ $Z = 4$

X-ray Powder Pattern: Synthetic. 2.487 (100), 2.768 (85), 1.5443 (50), 3.089 (40), 4.924 (30), 1.7988 (25), 1.5762 (25)

Chemistry:

	(1)	(2)
MnO	91.38	93.01
MgO	trace	
CaO	trace	
BaO	0.26	
O	7.78	6.99
H_2O	0.62	
Total	100.04	100.00

(1) Batesville, Arkansas, USA. (2) $Mn^{2+}Mn_2^{3+}O_4$.

Occurrence: A primary mineral in hydrothermal veins. Also produced by metamorphism of manganiferous rocks.

Association: Rhodochrosite, pyrolusite, jacobsite, braunite, andradite, barite.

Distribution: Many localities, some economically important. In Germany, at Ilfeld, Harz Mountains; at Friedrichroda, Elgersburg, and Öhrenstock, near Ilmenau, Thuringia. From Långban, Jakobsberg, and the Harstigen mine, near Persberg, Värmland, and the Sjö mine, near Grythyttan, Örebro, Sweden. At the Tŷ Coch mine, Glamorgan, Wales. In the Wyndham Pit, near Egremont, Cumbria, England. In the USA, in Washington, on the Olympic Peninsula, abundant at a number of small deposits in Clallam, Jefferson, and Mason Cos.; in the Blue Jay mine, Trinity Co., California; from the Batesville district, Independence, Izard, and Stone Cos., Arkansas; in the Cannon mine, Stambaugh, Iron Co., Michigan. At the Magnet Cove mine, Hants, Nova Scotia, Canada. As fine crystals from the Miguel Burnier iron mine, near Ouro Prêto, Minas Gerais, Brazil. At the Iron Monarch quarry, Iron Knob, South Australia. Large crystals from the N'Chwaning mine, near Kuruman, Cape Province, South Africa. In the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia.

Name: Honors Johan Friedrich Ludwig Hausmann (1782–1859), Professor of Mineralogy, University of Göttingen, Göttingen, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 712–715. (2) Jarosch, D. (1987) Crystal structure refinement and reflectance measurements of hausmannite, Mn_3O_4. Mineral. Petrol., 37, 15–23. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 222. (4) (1972) NBS Mono. 25, 10, 38.

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Haüyne $\mathbf{(Na,Ca)_{4-8}Al_6Si_6(O,S)_{24}(SO_4,Cl)_{1-2}}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals dodecahedra or pseudo-octahedra, to 3 cm; in rounded grains. *Twinning:* On {111}, common, rarely as penetration twins; also as polysynthetic or contact twins.

Physical Properties: *Cleavage:* {110}, distinct. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.44–2.50 D(calc.) = n.d. May show reddish orange to purplish pink fluorescence under LW UV.

Optical Properties: Transparent to translucent. *Color:* Bright blue to greenish blue; white or shades of black, gray, brown, green, yellow, red, may be patchy; colorless or pale blue in thin section. *Streak:* Slightly bluish to colorless. *Luster:* Vitreous to greasy.
Optical Class: Isotropic; weakly birefringent when included. $n = 1.494–1.509$

Cell Data: *Space Group:* $P\bar{4}3n$. $a = 9.08–9.13$ $Z = 1$

X-ray Powder Pattern: Niedermendig, Germany.
3.72 (100), 2.623 (25), 6.47 (16), 2.873 (14), 2.141 (14), 1.781 (10), 2.428 (8)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	34.04	29.3	K_2O	5.44	3.71
Al_2O_3	28.27	29.0	Cl	0.76	
Fe_2O_3		0.07	H_2O	0.34	
FeO	0.69		CO_2	0.4	
MgO	0.48	0.15	SO_3	10.02	13.1
CaO	9.51	11.2	$-O = Cl_2$	0.17	
Na_2O	10.39	13.0	Total	100.17	99.53

(1) Monte Vulture, Italy; corresponds to $(Na_{3.55}Ca_{1.80}K_{1.22}Mg_{0.13})_{\Sigma=6.70}Al_{5.89}Fe_{0.11}Si_{6.00}O_{24}[(SO_4)_{1.33}Cl_{0.22}]_{\Sigma=1.55}$. (2) Anguillara, Italy; by electron microprobe, corresponds to $(Na_{4.76}Ca_{2.26}K_{0.90}Mg_{0.45})_{\Sigma=8.37}Al_{6.46}Fe_{0.01}Si_{5.53}O_{24}(SO_4)_{1.86}$.

Mineral Group: Sodalite group.

Occurrence: In phonolites and related leucite- or nepheline-rich igneous rocks; less commonly in nepheline-free extrusives.

Association: Nepheline, leucite, titanian andradite, melilite, augite, sanidine, biotite, phlogopite, apatite.

Distribution: In Italy, in Lazio, at many localities in the Alban Hills, as at Ariccia, Marino, Sacrofano, and Campagnaro; on Monte Somma, and near Melfi, on Monte Vulture, Campania; in the Pitigliano quarry, near Grosseto, Tuscany. From Mendig, Mayen, and elsewhere in the Eifel district, Germany. In the USA, from Winnett, Petroleum Co., Montana, and in the Edwards mine, St. Lawrence Co., New York. In the Niangniang Shan complex, Nanjing, Jiangsu Province, China. On the smaller island of Taiarupu, Tahiti. A few other localities are known.

Name: To honor Abbé René Just Haüy (1743–1822), French crystallographer and mineralogist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 431–432. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 289–302. (3) Taylor, D. (1967) The sodalite group of minerals. Contr. Mineral. Petrol., 16, 172–188. (4) Löhn, J. and H. Schulz (1968) Strukturverfeinerung am gestörten Hauyn, $(Na_5K_1Ca_2)Al_6Si_6O_{24}(SO_4)_{1.5}$. Neues Jahrb. Mineral., Abh., 109, 201–210 (in German with English abs.). (5) Burragato, F., A. Maras, and A. Rossi (1982) The sodalite group minerals in the volcanic areas of Latium. Neues Jahrb. Mineral., Monatsh., 433–445. (6) Hassan, I. and P. Buseck (1989) Cluster ordering and antiphase domain boundaries in hauyne. Can. Mineral., 27, 173–180.

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Hawleyite CdS

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. Very fine-grained powdery coatings.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 4.87

Optical Properties: Opaque to subtranslucent. *Color:* Bright yellow.
R: n.d.

Cell Data: *Space Group:* $F\overline{4}3m$. $a = 5.818$ $Z = 4$

X-ray Powder Pattern: Hector-Calumet mine, Galena Hill, Canada.
3.36 (100), 2.058 (80), 1.753 (60), 2.90 (40), 1.337 (30), 1.186 (30), 1.120 (30)

Chemistry: Composition established by semiquantitative spectroscopic analysis.

Polymorphism & Series: Dimorphous with greenockite.

Mineral Group: Sphalerite group.

Occurrence: As coatings on fine-grained sphalerite and siderite in vugs; probably of secondary origin, deposited from meteoric waters in vugs and along late fractures.

Association: Sphalerite, siderite, greenockite.

Distribution: In Canada, in the Hector-Calumet mine, Keno-Galena Hill area, Yukon Territory [TL], and in the Strathcona mine, Sudbury, Ontario. In the USA, near Hanover, Grant Co., New Mexico; at the Crestmore quarry, Riverside Co., California; from near Bethel Church, Pike Co., Indiana; and at Franklin, Sussex Co., New Jersey. From near Komna, Czech Republic. In the Los Blancos mine, Sierra de Cartagena, Murcia Province, Spain. From Ragada, Greece. At Tynagh, near Killimor, Co. Galway, Ireland. In the Fall Hill quarry, Ashover, Derbyshire, England. From the Noril'sk region, western Siberia, Russia. In the Coquimbana mine, Cerro Blanco district, Chile. From the Tui mine, Mt. Te Aroha, New Zealand. In the Kolar Gold Fields, Karnataka, India. Likely yet to be discovered at additional localities, as easily mistaken for greenockite.

Name: To honor Professor James Edwin Hawley (1897–1965), Canadian mineralogist, Queen's University, Kingston, Ontario, Canada.

Type Material: Canadian Geological Survey, Ottawa, Canada, 12164; Harvard University, Cambridge, Massachusetts, USA, 123839.

References: (1) Traill, R.J. and R.W. Boyle (1955) Hawleyite, isometric cadmium sulfide, a new mineral. Amer. Mineral., 40, 555–559.

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Hawthorneite $Ba(Cr_4Ti_3Fe^{2+}_2Fe^{3+}_2Mg)O_{19}$

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Crystal Data: Hexagonal. *Point Group:* $6/m2/m2/m$. As grains, to 100 μm, surrounded by lindsleyite, oriented in spinel.

Physical Properties: Hardness = ∼5.8 VHN = 772–835, 801 average (100 g load). D(meas.) = n.d. D(calc.) = 5.02

Optical Properties: Opaque. *Color:* [Black or brown]; light gray in reflected light. *Optical Class:* Uniaxial (–). *Dispersion:* $r < v$. *Anisotropism:* Weak to moderate; in browns and grays. *Bireflectance:* Weak to moderate.
R_1–R_2: (400) 19.5–18.1, (420) 19.1–17.8, (440) 18.8–17.5, (460) 18.4–17.2, (480) 18.1–17.0, (500) 17.9–16.8, (520) 17.7–16.6, (540) 17.6–16.5, (560) 17.4–16.4, (580) 17.3–16.3, (600) 17.2–16.2, (620) 17.2–16.2, (640) 17.1–16.1, (660) 17.0–16.0, (680) 17.0–16.0, (700) 16.9–15.9

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.871(2)$ $c = 23.06(2)$ $Z = 2$

X-ray Powder Pattern: Calculated.
2.616 (100), 2.765 (85), 2.414 (49), 1.468 (45), 2.936 (42), 1.617 (42), 1.660 (38)

Chemistry:

	(1)		(1)
Nb_2O_5	0.16	Cr_2O_3	34.05
Ta_2O_5	0.18	FeO	13.83
SiO_2	0.06	MnO	0.12
TiO_2	22.94	MgO	3.07
La_2O_3	0.10	BaO	12.52
Ce_2O_3	0.31	Na_2O	0.10
Fe_2O_3	11.31	K_2O	0.55
		Total	99.30

(1) Bultfontein mine, South Africa; by electron microprobe, average of 11 analyses, Fe^{2+}:Fe^{3+} calculated from charge balance; corresponds to $(Ba_{0.85}K_{0.12})_{\Sigma=0.97}(Cr_{4.68}Ti_{3.02}Fe^{2+}_{2.02}Fe^{3+}_{1.47}Mg_{0.80}Mn_{0.02}Nb_{0.01})_{\Sigma=12.02}O_{19}$.

Mineral Group: Magnetoplumbite group.

Occurrence: Formed during upper-mantle (75–100 km, 900–1100 °C, 20–30 kbar) metasomatism of chromian spinel in peridotite xenoliths in a kimberlite pipe.

Association: Olivine, enstatite, phlogopite, potassian richterite, diopside, magnesian chromian spinel, lindsleyite, mathiasite, niobian chromian rutile, magnesian chromian ilmenite.

Distribution: From the Bultfontein diamond mine, Kimberley, Cape Province, South Africa.

Name: For John Barry Hawthorne (1934–), formerly Chief Geologist (Diamonds), DeBeers Consolidated Mines, South Africa, in honor of his contributions to studies of the upper mantle.

Type Material: The Natural History Museum, London, England, 1988,71.

References: (1) Haggerty, S.E., I.E. Grey, I.C. Madsen, A.J. Criddle, C.J. Stanley, and A.J. Erlank (1989) Hawthorneite, $Ba[Ti_3Cr_4Fe_4Mg]O_{19}$: a new metasomatic magnetoplumbite-type mineral from the upper mantle. Amer. Mineral., 74, 668–673. (2) Grey, I.E., I.C. Madsen, and S.E. Haggerty (1987) Structure of a new upper-mantle, magnetoplumbite-type phase, $Ba[Ti_3Cr_4Fe_4Mg]O_{19}$. Amer. Mineral., 72, 633–636.

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Haxonite $(Fe, Ni)_{23}C_6$

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Crystal Data: Cubic. *Point Group:* n.d. As spiky plates and irregular patches, to 1 mm; in intricate intergrowths with taenite, schreibersite, and kamacite.

Physical Properties: Hardness = n.d. VHN = 850(50) D(meas.) = n.d. D(calc.) = 7.70
Strongly magnetic.

Optical Properties: Opaque. *Color:* Brilliant white; dark gray under reflected light.
Optical Class: Isotropic.
R: n.d.

Cell Data: *Space Group:* n.d. $a = 10.55$ Z = [4] (by analogy to $Mn_{23}C_6$ and $Cr_{23}C_6$).

X-ray Powder Pattern: Toluca meteorite.
2.356 (s), 2.151 (s), 1.863 (m), 1.242 (m), 1.755 (m/w), 1.218 (m/w), 1.060 (m/w)

Chemistry:

	(1)
Fe	89.5
Co	0.18
Ni	4.91
C	[5.4]
Total	[100.0]

(1) Canyon Diablo meteorite; by electron microprobe, C by difference, Cr and Cu each less than 0.05%.

Occurrence: In iron meteorites and carbonaceous chondrites.

Association: Kamacite, taenite, schreibersite, cohenite, pentlandite, magnetite.

Distribution: From the Toluca, Canyon Diablo, Edmonton (Kentucky), Tazewell, and many other iron meteorites, characteristic of group I and group IIIC-IIID; and in the Allan Hills carbonaceous chondrite ALHA 77307.

Name: Honors H.J. Axon, metallurgist at the University of Manchester, Manchester, England.

Type Material: n.d.

References: (1) Scott, E.R.D. (1971) New carbide, $(Fe, Ni)_{23}C_6$, found in iron meteorites. Nature, Physical Science, 229, 61–62. (2) (1972) Mineral. Abs., 23, 49 [haxonite] (abs. ref. 1). (3) (1974) Amer. Mineral., 59, 209 (abs. ref. 1). (4) Buchwald, V. (1975) Iron meteorites, Univ. of Calif. Press, 101–103. (5) Scott, E.R.D. and R.H. Jones (1990) Disentangling nebular and asteroidal features of CO3 carbonaceous chondrite meteorites. Geochim. Cosmochim. Acta, 54, 2485–2502.

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Haycockite $Cu_4Fe_5S_8$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* 222. Observed in polished section as tiny grains, to about 500 μm. *Twinning:* On {103}, polysynthetic, may be visible in polished section.

Physical Properties: Hardness = n.d. VHN = 206–231 (100 g load). D(meas.) = n.d. D(calc.) = 4.33

Optical Properties: Opaque. *Color:* Brass-yellow, much like chalcopyrite; does not tarnish easily. *Anisotropism:* Weak to moderate.
R_1–R_2: (400) 13.9–13.5, (420) 15.5–15.9, (440) 18.3–19.4, (460) 21.7–23.2, (480) 25.1–26.8, (500) 28.2–29.9, (520) 31.0–32.5, (540) 33.3–34.5, (560) 35.1–36.1, (580) 36.6–37.3, (600) 37.8–38.3, (620) 38.6–38.9, (640) 39.2–39.4, (660) 39.6–39.6, (680) 39.8–39.7, (700) 40.0–39.8

Cell Data: *Space Group:* $P222$, $P222_1$, $P2_12_12$, or $P2_12_12_1$. $a = 10.705(5)$ $b = 10.734(5)$ $c = 31.630(15)$ $Z = 12$

X-ray Powder Pattern: Mooihoek mine, South Africa.
3.07 (100), 1.876 (80), 1.889 (60), 1.612 (60), 1.089 (60), 0.937 (60), 1.214 (50)

Chemistry:

	(1)	(2)	(3)
Cu	32.16	31.26	32.18
Fe	35.03	36.12	35.35
Ni	0.40	0.23	
S	32.41	32.86	32.47
Total	100.14	100.46	100.00

(1) Mooihoek mine, South Africa; by electron microprobe, average of fifteen analyses, leading to $Cu_{1.00}Fe_{1.24}Ni_{0.01}S_{2.00}$. (2) Minnesota, USA; by electron microprobe, average of four analyses. (3) $Cu_4Fe_5S_8$.

Occurrence: In a hortonolite dunite (replacement) pegmatite in the Bushveld complex (Mooihoek mine, South Africa).

Association: Mooihoekite, copper, troilite, pentlandite, cubanite, magnetite (Minnesota, USA).

Distribution: In South Africa, in the Bushveld complex, Transvaal, from the Mooihoek mine, Lydenburg district [TL], and in the Townlands ultramafic pipe, Rustenburg. At Krzemianka, Poland. From the Talnakh area, Noril'sk region, western Siberia, Russia. In the USA, in the basal Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota. From near Madera, Sonora, Mexico.

Name: To honor Maurice Hall Haycock (1900–?), former Head, Mineralogy Section, Mineral Sciences Division, Department of Energy, Mines, and Resources, Mines Branch, Ottawa, Canada.

Type Material: Canadian Museum of Nature, Ottawa; Royal Ontario Museum, Toronto, Canada, M30992; Princeton University, Princeton, New Jersey; National Museum of Natural History, Washington, D.C., USA, 124965; Heidelberg University, Heidelberg, Germany.

References: (1) Cabri, L.J. and S.R. Hall (1972) Mooihoekite and haycockite, two new copper–iron sulfides and their relationship to chalcopyrite and talnakhite. Amer. Mineral., 57, 689–708. (2) Rowland, J.F. and S.R. Hall (1975) Haycockite, $Cu_4Fe_5S_8$: a superstructure in the chalcopyrite series. Acta Cryst., 31, 2105–2112. (3) Criddle, 225.

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Haydeeite $Cu_3Mg(OH)_6Cl_2$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ 2/*m*. As short prismatic crystals, to 1 mm, displaying {0001}, {10$\bar{1}$ 0}, {10$\bar{1}$ 1}.

Physical Properties: *Cleavage*: Perfect {0001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 2 VHN = 57.8 (15/25 g load). D(meas.) = 3.27(1) D(calc.) = 3.24

Optical Properties: Transparent. *Color*: Greenish blue. *Streak*: Bright greenish-blue. *Luster*: Vitreous.
Optical Class: Uniaxial (–). ω = 1.753(5) ε = 1.710(5)
Pleochroism: *O* = greenish blue; *E* = faint greenish-blue.

Cell Data: *Space Group*: $P\bar{3}\,m1$. a = 6.2733(4) c = 5.7472(5) Z = 1

X-ray Powder Pattern: Haydee mine, Atacama Desert, northern Chile.
5.745 (100), 2.872 (17), 1.915 (9), 2.455 (6), 1.972 (4), 2.750 (3), 2.540 (3)

Chemistry:

	(1)	(2)
CuO	61.83	61.52
MgO	10.06	10.39
Cl	17.91	18.28
H_2O	14.97	13.94
-O = Cl	4.05	4.12
Total	100.72	100.00

(1) Haydee mine, Atacama Desert, northern Chile; average of 10 electron microprobe and combustion element analyzer analyses, corresponding to $Cu_{2.95}Mg_{0.95}H_{6.30}Cl_{1.92}O_{6.08}$.
(2) $Cu_3Mg(OH)_6Cl_2$.

Distribution: Haydee mine, western border of the southern end of Salar Grande, 110 km SE of Iquique, Atacama Desert, Tarapacá Province, northern Chile.

Name: For the Haydee mine, where the first specimens were collected.

Type Material: Mineralogical Museum, University of Hamburg, Germany.

References: (1) Schlüter, J. and T. Malcherek (2007) Haydeeite, $Cu_3Mg(OH)_6Cl_2$, a new mineral from the Haydee mine, Salar Grande, Atacama desert, Chile. Neus Jb. Mineral. Abh., 184, 39–43. (3) (2008) Amer. Mineral., 93, 1942-1943 (abs. ref. 1).

Haynesite $(UO_2)_3(Se^{4+}O_3)_2(OH)_2 \cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals are bladed, flattened on {010} and elongated along [001], to 3 mm; as divergent sprays and rosettes.

Physical Properties: *Cleavage:* On {010}, good. Hardness = 1.5–2 D(meas.) = 4.1 D(calc.) = 4.07 Radioactive; fluoresces yellowish green under SW UV.

Optical Properties: Transparent to translucent. *Color:* Amber-yellow; yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; bright yellow to pale yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.618(2)$ $\beta = 1.738(3)$ $\gamma = 1.765(5)$ 2V(meas.) = 45° 2V(calc.) = 48°

Cell Data: *Space Group:* $Pncm$ or $Pnc2$. $a = 8.025(5)$ $b = 17.43(1)$ $c = 6.935(3)$ Z = 2

X-ray Powder Pattern: Repete mine, Utah, USA.
8.01 (100), 2.912 (80), 4.01 (70), 3.119 (70), 3.468 (60), 3.186 (50), 2.471 (40)

Chemistry:

	(1)	(2)
UO_3	71.81	72.22
SeO_2	17.91	18.68
H_2O	8.56	9.10
Total	[98.28]	100.00

(1) Repete mine, Utah, USA; by electron microprobe, average of 12 analyses, C and H by CHN analyzer, recalculated after removal of CaO 0.85% and CO_2 1.51% as calcite; then corresponds to $(UO_2)_{3.08}(SeO_2)_{1.98}(OH)_{2.20} \cdot 4.72H_2O$. (2) $(UO_2)_3(SeO_3)_2(OH)_2 \cdot 5H_2O$.

Occurrence: Rare in an oxidized uranium deposit in mudstones and sandstones.

Association: Andersonite, boltwoodite, ferroselite, gypsum, barite, calcite.

Distribution: From the Repete mine, 34 km southeast of Blanding, San Juan Co., Utah, USA.

Name: Honors Patrick Eugene Haynes (1953-), American geologist, mineral collector and dealer, who found the first specimens.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC3922.

References: (1) Deliens, M. and P. Piret (1991) La haynesite, sélénite hydraté d'uranyle, nouvelle espèce minérale de la Mine Repete, comté de San Juan, Utah. Can. Mineral., 29, 561–564 (in French with English abs.). (2) (1992) Amer. Mineral., 77, 447 (abs. ref. 1).

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Heazlewoodite Ni_3S_2

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Crystal Data: Hexagonal. *Point Group:* 32. Massive, fine-grained, compact; rarely in minute crystals. *Twinning:* Possibly the cause of mosaic structure seen in polished section.

Physical Properties: Hardness = 4 VHN = 230–254 (100 g load). D(meas.) = 5.82 D(calc.) = 5.87

Optical Properties: Opaque. *Color:* Pale bronze; in polished section, yellowish cream colored. *Luster:* Metallic. *Anisotropism:* Strong, brown to bluish gray.
R_1–R_2: (400) 24.0–25.4, (420) 31.2–31.9, (440) 38.2–38.5, (460) 43.6–44.0, (480) 47.5–48.5, (500) 49.9–51.7, (520) 51.4–54.1, (540) 52.4–55.6, (560) 53.1–56.7, (580) 53.7–57.5, (600) 54.3–58.2, (620) 54.8–58.8, (640) 55.3–59.2, (660) 55.9–59.6, (680) 56.3–60.1, (700) 56.8–60.4

Cell Data: *Space Group: R*32. $a = 5.741$ $c = 7.139$ $Z = 3$

X-ray Powder Pattern: Heazlewood, Tasmania, Australia.
1.828 (10), 1.817 (10), 2.88 (9), 1.661 (8), 4.11 (5), 2.04 (5), 2.39 (4)

Chemistry:

	(1)	(2)
Ni	72.13	73.30
Fe	0.55	
S	25.96	26.70
insol.	0.59	
Total	99.23	100.00

(1) Heazlewood, Tasmania, Australia. (2) Ni_3S_2.

Occurrence: In serpentinized dunites and lherzolites, and in ophiolites, probably of hydrothermal origin; in layered mafic intrusives nd chromitites, where it may be a low-temperature secondary mineral; in mantle xenoliths.

Association: Pentlandite, chalcopyrite, violarite, cubanite, millerite, mackinawite, orcelite, zaratite, shandite, awaruite, platinum group minerals, magnetite, chromite.

Distribution: In Australia, in Tasmania, from the Lord Brassey mine, near Heazlewood [TL], and at Trial Harbour. In the USA, from the Cedar Hill quarry, Lancaster Co., Pennsylvania; in Josephine Co., Oregon; and in California, crystals from the Dorleska mine, Trinity Co. In Canada, at Miles Ridge, Yukon Territory; and in Quebec, from the Marbridge mine, Malartic, La Motte Township; at the Jeffrey mine, Asbestos; and in a prospect pit near Mount Albert, Gaspé Peninsula. In the Kop Krom chrome mine, Kop Mountains, near Aşkale, Turkey. In Iran, at Tschagal, near Rabad Sefid. In Switzerland, from Poschiavo, Graubünden. At Hirt, near Friesach, Carinthia, Austria. From the Agoriani area, Othrys ophiolitic complex, Greece. At Vadu Dobrii, Romania. From Cap Corse, Corsica, France. In the Amianthus mine, Kaapsche Hoop, Barberton, Transvaal, South Africa. From the Ban Phuc deposit, Vietnam. In the Otoigawa district, Niigata Prefecture; from the Kamuikotan zone and the Horoman peridotite, Hokkaido; and elsewhere in Japan. In small amounts from a large number of other localities.

Name: For the locality near Heazlewood, Tasmania, Australia.

Type Material: National Museum of Natural History, Washington, D.C., USA, R641.

References: (1) Peacock, M.A. (1947) On heazlewoodite and the artificial compound Ni_3S_2. Univ. of Toronto Studies, Geol. Ser., 51, 59–69. (2) (1947) Amer. Mineral., 32, 484 (abs. ref. 1). (3) Fleet, M.E. (1977) The crystal structure of heazlewoodite, and the metallic bonds in sulfide minerals. Amer. Mineral., 62, 341–345. (4) Parise, J.B. (1980) Structure of heazlewoodite (Ni_3S_2). Acta Cryst., 36, 1179–1180. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 45. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 226.

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Hechtsbergite $Bi_2O(VO_4)(OH)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As rounded or etched crystals, dominantly {111}, with {112}, {113}, {$\bar{1}$01}, {$\bar{1}$02}, {$\bar{3}$02}, to 0.2 mm, commonly in aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 VHN = 320 (15 g load). D(meas.) = n.d. D(calc.) = 6.87

Optical Properties: Transparent to translucent. *Color:* Brown. *Streak:* Yellow. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c \simeq 35°$. $\alpha = 2.26(2)$ $\beta = [2.27]$ $\gamma = 2.30(2)$ 2V(meas.) = 50(5)°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.791(1)$ $b = 7.535(1)$ $c = 10.881(1)$ $\beta = 107.00(1)°$ Z = 4

X-ray Powder Pattern: Hechtsberg quarry, Germany.
3.267 (100), 3.150 (63), 4.279 (41), 2.734 (35), 2.036 (29), 2.549 (27), 2.133 (27)

Chemistry:

	(1)	(2)
As_2O_5	0.52	
V_2O_5	15.18	16.07
Bi_2O_3	83.02	82.34
H_2O	[1.59]	1.59
Total	[100.31]	100.00

(1) Hechtsberg quarry, Germany; by electron microprobe, H_2O from theory; corresponds to $Bi_{2.03}O_{1.08}[(VO_4)_{0.95}(AsO_4)_{0.03}]_{\Sigma=0.98}(OH)_{1.01}$. (2) $Bi_2O(VO_4)(OH)$.

Occurrence: In cavities in gneiss.

Association: Bismutite, namibite, eulytite, mixite, beyerite, chrysocolla.

Distribution: In the Hechtsberg quarry, near Hausach, Black Forest, Germany.

Name: For the Hechtsberg quarry, Germany, source of the first specimens.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany.

References: (1) Krause, W., H.-J. Bernhardt, G. Blass, H. Effenberger, and H.-W. Graf (1997) Hechtsbergite, $Bi_2O(OH)(VO_4)$, a new mineral from the Black Forest, Germany. Neues Jahrb. Mineral., Monatsh., 271–287. (2) (1998) Amer. Mineral., 83, 400–401 (abs. ref. 1).

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Hectorfloresite $Na_9(IO_3)(SO_4)_4$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As crystals, to 1.5 mm, prismatic along [010], typically doubly terminated and pseudohexagonal due to cyclic twinning, exhibiting {100}, {212}, {001}. *Twinning:* Multiple contact twins parallel [010], ubiquitous, on twin planes {001}, {601}, and $\{\overline{6}04\}$, giving a pseudohexagonal outline.

Physical Properties: *Cleavage:* Irregular parting $\perp$ and $\parallel$ to elongation.
Fracture: Conchoidal. *Tenacity:* Brittle. Hardness = ∼2 D(meas.) = 2.80(3) D(calc.) = 2.90

Optical Properties: Transparent to translucent. *Color:* White; colorless in transmitted light.
Luster: [Adamantine.]
Optical Class: Biaxial (–). *Dispersion:* $r < v$, barely perceptible. $\alpha = 1.493(2)$ $\beta = 1.521(2)$ $\gamma = 1.523(2)$ 2V(meas.) = 26(2)°

Cell Data: *Space Group:* $P2_1/a$. $a = 18.775(4)$ $b = 6.9356(7)$ $c = 14.239(2)$ $\beta = 108.91(2)°$ Z = 4

X-ray Powder Pattern: Alianza mine, Chile.
3.880 (100), 2.700 (80), 2.788 (30), 1.9420 (20), 4.69 (15), 6.17 (10), 1.6780 (10)

Chemistry:

	(1)	(2)
I_2O_5	23.2	21.79
SO_3	42.3	41.80
Na_2O	34.5	36.41
Total	100.0	100.00

(1) Alianza mine, Chile; by electron microprobe, average of eight analyses, presence of $(IO_3)^{1-}$ and $(SO_4)^{2-}$ confirmed by IR. (2) $Na_9(IO_3)(SO_4)_4$.

Occurrence: In dessication cavities in a nitrate deposit; may be more widespread than this single locality indicates.

Association: Glauberite, nitratine, blödite, darapskite, halite.

Distribution: From the Alianza nitrate mine, Oficina Victoria, Tarapacá, Chile.

Name: Honors Professor Hector Flores W. (1906–1984), Chilean economic geologist and teacher, University of Chile, Santiago, Chile.

Type Material: National Museum of Natural History, Washington, D.C., USA.

References: (1) Ericksen, G.E., H.T. Evans, Jr., M.E. Mrose, J.J. McGee, J.W. Marinenko, and J.A. Konnert (1989) Mineralogical studies of the nitrate deposits of Chile: VI. Hectorfloresite, $Na_9(IO_3)(SO_4)_4$, a new saline mineral. Amer. Mineral., 74, 1207–1214.

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Hectorite $Na_{0.3}(Mg, Li)_3Si_4O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thin laths, to 2 μm, and as aggregates of such laths.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven. Hardness = 1–2 D(meas.) = ~2.3 D(calc.) = n.d. Swells on addition of H_2O. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent, transparent in thin section. *Color:* White, cream, pale brown, mottled. *Luster:* Earthy to waxy, dull.
Optical Class: Biaxial (–). α = ~1.49 β = 1.50 γ = 1.52 2V(meas.) = Small.

Cell Data: *Space Group:* $C2/m$. a = 5.2 b = 9.16 c = 16.0 β = ~ 99° Z = n.d.

X-ray Powder Pattern: Hector, California, USA; spacings variable by humidity, intensities variable by orientation.
4.58 (100), 1.53 (100), 15.8 (80), 2.66 (80), 1.32 (80), 1.30 (80), 2.48 (60)

Chemistry:

	(1)	(2)
SiO_2	53.68	53.95
TiO_2		trace
Al_2O_3	0.60	0.14
Fe_2O_3		0.03
MgO	25.34	25.89
CaO	0.52	0.16
Li_2O	1.12	1.22
Na_2O	3.00	3.04
K_2O	0.07	0.23
Cl	0.31	
H_2O^+	8.24	5.61
H_2O^-	7.28	9.29
Total	100.16	99.56

(1) Hector, California, USA; corresponds to $(Na_{0.42}Ca_{0.04}K_{0.01})_{\Sigma=0.47}(Mg_{2.73}Li_{0.33})_{\Sigma=3.06}(Si_{3.89}Al_{0.05})_{\Sigma=3.94}O_{10}(OH)_2$. (2) Do.; corresponds to $(Na_{0.42}K_{0.02}Ca_{0.01})_{\Sigma=0.45}(Mg_{2.78}Li_{0.36})_{\Sigma=3.14}(Si_{3.89}Al_{0.01})_{\Sigma=3.90}O_{10}(OH)_2 \cdot 0.35H_2O$.

Mineral Group: Smectite group.

Occurrence: In a bentonite deposit, altered from clinoptilolite derived from volcanic tuff and ash with a high glass content, related to hot spring activity (Hector, California, USA).

Association: Calcite, clinoptilolite (Hector, California, USA).

Distribution: In the USA, five km south of Hector, San Bernardino Co., California; in the Lyles deposit, 38 km northeast of Hillside, Yavapai Co., Arizona; and at Disaster Peak, in the Montana Mountains, near McDermitt, Disaster district, Humboldt Co., Nevada. From around Puy Chalard, Puy-de-Dôme, France. In the Balıkesir colemanite deposit, Balıkesir Province, Turkey.

Name: For the locality at Hector, California, USA.

Type Material: n.d.

References: (1) Foshag, W.F. and A.O. Woodford (1936) Bentonitic magnesian clay-mineral from California. Amer. Mineral., 21, 238–244. (2) Strese, H. and U. Hofmann (1941) Synthesis of magnesium silicate gels with two-dimensional regular structure. Zeit. anorginsche allgemeine Chemie, 247, 65–95. (3) (1944) Amer. Mineral., 29, 73 (abs. ref. 2). (4) Nagelschmidt, G. (1938) On the atomic arrangement and variability of the members of the montmorillonite group. Mineral. Mag., 25, 140–155. (5) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 226–245.

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Hedenbergite $CaFe^{2+}Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As short prismatic crystals, to 5 cm. In columnar or acicular aggregates; granular, lamellar, massive. *Twinning:* Simple and polysynthetic twinning on {100} and {010}.

Physical Properties: *Cleavage:* Good on {110}, (110) $\wedge$ $(1\bar{1}0)$ ~87°; partings on {100} and {010}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6.5 D(meas.) = 3.56 D(calc.) = [3.65]

Optical Properties: Transparent to opaque. *Color:* Black, dark green, green-brown; brownish green in thin section. *Luster:* Vitreous or dull.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = pale green, bluish green; Y = green, bluish green; Z = green, yellow-green. *Orientation:* $Y = b$; $Z \wedge c = 48°$; $Z \wedge a = 34°$. *Dispersion:* $r > v$, strong. $\alpha = 1.732$ $\beta = 1.739$ $\gamma = 1.757$ 2V(meas.) = 63°

Cell Data: *Space Group:* $C2/c$. $a = 9.852(4)$ $b = 9.031(3)$ $c = 5.242(3)$ $\beta = 104.84(4)°$ Z = 4

X-ray Powder Pattern: Cordillera Blanca, Peru; magnesian. (ICDD 25-160).
2.995 (100), 2.528 (80), 2.970 (50), 1.638 (40), 1.629 (40), 3.26 (30), 2.890 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	48.00	48.50	48.44	MgO	2.12	0.83	
TiO_2		0.04		CaO	20.35	22.64	22.60
Al_2O_3	0.63	0.53		Na_2O	0.34		
Fe_2O_3	3.32	1.03		K_2O	0.18		
FeO	22.25	22.74	28.96	H_2O^-	1.72		
MnO	0.81	3.84		Total	99.72	100.15	100.00

(1) Tignitoio iron deposit, Elba, Italy; corresponds to $(Ca_{0.90}Mg_{0.13})_{\Sigma=1.03}(Fe^{2+}_{0.77}Fe^{3+}_{0.10}Mn_{0.03}Na_{0.03}Al_{0.01}K_{0.01})_{\Sigma=0.95}(Si_{1.98}Al_{0.02})_{\Sigma=2.00}O_6$. (2) Dal'negorsk, Russia; corresponds to $Ca_{1.00}(Fe^{2+}_{0.81}Mn_{0.13}Mg_{0.05}Al_{0.01})_{\Sigma=1.00}(Si_{1.99}Al_{0.01})_{\Sigma=2.00}O_6$. (3) $CaFeSi_2O_6$.

Polymorphism & Series: Forms two series, with diopside, and with johannsenite.

Mineral Group: Pyroxene group.

Occurrence: A common constituent of metamorphosed iron formations or other ferruginous siliceous sediments; common in Fe-Mn skarns. In alkalic granites, syenites, and in xenoliths in kimberlite.

Association: Grunerite (iron formations); arfvedsonite, quartz, fayalite (granites, syenites).

Distribution: A few localities for studied material include: in Sweden, at Nordmark, Värmland, and Yxsjö, Örebro. From Prägraten, Tirol, Austria. At Fürstenberg, Saxony, Germany. From Rio Marina, Elba, Italy. On Seriphos, Greece. In the USA, at Iron Hill, Gunnison Co., Colorado; fine crystals from the Laxey mine, South Mountain, Owyhee Co., Idaho; in the Pima district, Pima Co., and the Westinghouse mine, Santa Cruz Co., Arizona; at Hanover, Grant Co., New Mexico. In the Vesturhorn intrusion, southeast Iceland. Large crystals from Broken Hill, New South Wales, Australia. In the Obira mine, Bungo, Oita Prefecture, Japan. At Tirodi, Madhya Pradesh, and Kacharwali, Nagpur district, Maharashtra, India. Fine crystals from the Skardu area, Pakistan. At Dal'negorsk, Primorskiy Kray, Russia.

Name: To honor the Swedish chemist, M.A. Ludwig Hedenberg, who first described the species.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 352–364, esp. 356. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 198–293. (3) Maslenikov, A.V. and V.N. Zaitsev (1978) Refinement of the structure of natural hedenbergite. Zap. Vses. Mineral. Obshch., 107, 113–115 (in Russian). (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 191–193.

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Hedleyite $\mathbf{Bi_{2+x}Te_{1-x}}$ (x = 0.13 to 0.19)

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As foliated platy masses, to 6 mm.

Physical Properties: *Cleavage:* Perfect on {0001}, warped. *Tenacity:* Flexible lamellae. Hardness = 2 VHN = 31–42 (25 g load). D(meas.) = 8.81–8.91 D(calc.) = 8.91

Optical Properties: Opaque. *Color:* Tin-white, tarnishing iron-black; in polished section, white, between that of galena and silver. *Luster:* Metallic. *Anisotropism:* Slight, pale gray to dark gray.
R_1–R_2: (400) 59.0–61.8, (420) 59.3–62.5, (440) 59.9–63.3, (460) 60.5–64.0, (480) 61.0–64.6, (500) 61.3–65.0, (520) 61.6–65.7, (540) 61.7–66.2, (560) 61.8–66.7, (580) 62.0–67.3, (600) 62.3–67.7, (620) 62.6–68.1, (640) 62.9–68.5, (660) 63.1–68.6, (680) 63.4–68.7, (700) 63.6–68.9

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 4.4733(20)$ $c = 17.805(11)$ $Z = 3$

X-ray Powder Pattern: Good Hope claim, Hedley, Canada.
3.25 (10), 2.36 (5), 2.23 (4), 1.621 (4), 1.480 (4), 1.984 (3), 1.849 (3)

Chemistry:

	(1)	(2)	(3)	(4)
Bi	81.08	81.6	81.3	76.61
Te	18.06	17.5	19.2	23.39
Se		0.3	0.6	
S	0.08	0.1		
Total	99.22	99.5	101.1	100.00

(1) Good Hope claim, Hedley, Canada; average of two analyses, corresponds to $Bi_{2.19}(Te_{0.80}S_{0.01})_{\Sigma=0.81}$. (2) Millapaya, Bolivia; by electron microprobe, corresponds to $Bi_{2.19}(Te_{0.77}Se_{0.02}S_{0.02})_{\Sigma=0.81}$. (3) Vostok-2 deposit, Russia; by electron microprobe, corresponds to $Bi_{2.12}(Te_{0.82}Se_{0.04})_{\Sigma=0.86}$. (4) Bi_2Te.

Occurrence: Typically a late-stage hydrothermal mineral in quartz veins and massive sulfides associated with skarns and breccias; less commonly in pegmatites.

Association: Bismuth, bismuthinite, tellurobismuthite, tsumoite, joséite, hessite, maldonite, gold, arsenopyrite, pyrrhotite, chalcopyrite, galena, sphalerite, pyrite.

Distribution: In Canada, in British Columbia, from the Good Hope mineral claim, about six km southeast of Hedley, Osoyoos mining division [TL]; also at the Oregon mine, near Hedley; in the Upper Burwash Creek placer, Kluane Lake district, Yukon Territory; from the Bannockburn gold deposit, Eldorado, Ontario. In the McCoy mine, McCoy district, Lander Co., Nevada, USA. From Millapaya, Sorata, La Paz, Bolivia. In the Kumbel' skarn deposit, northern Kyrgyzstan. From Ugat, western Uzbekistan. At the Vostok-2 deposit, Lukkulaisvaara layered intrusion, Karelia, Russia. From the Osikonmaki gold deposit, Rantasalmi, at Ramepuro, and in Fe-Co-Au deposits of the Kuusamo schist belt, Finland. At the Radzimowice and Bardo Slaskie deposits, Silesia, Poland. From the Rifugio Borromeo deposit, Martello Valley, Trentino-Alto Adige, Italy. In the Ortosa Au–Bi–Te deposit, Asturias, Spain. From the Carrock mine, Caldbeck Fells, Cumbria, England. In the Kolar Gold Fields, Karnataka, India. A few other occurrences have been noted.

Name: For the locality being near Hedley, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M37250.

References: (1) Warren, H.V. and M.A. Peacock (1945) Hedleyite, a new bismuth telluride from British Columbia, with notes on wehrlite and some bismuth–tellurium alloys. Univ. of Toronto Studies, Geol. Ser., 49, 55–69. (2) (1945) Amer. Mineral., 30, 644 (abs. ref. 1). (3) Zav'ylov, E.N., V.D. Begizov, and G.N. Nechelyustov (1976) New data on hedleyite. Doklady Acad. Nauk SSSR, 230, 1439–1441 (in Russian). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 227.

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Hedyphane $Pb_3Ca_2(AsO_4)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As dipyramidal, tabular, or prismatic crystals, with $\{10\bar{1}0\}$, $\{10\bar{1}1\}$, $\{0001\}$, several modifying forms, to 3 cm; commonly massive.

Physical Properties: *Cleavage:* On $\{10\bar{1}1\}$, poor. *Fracture:* Subconchoidal. *Tenacity:* Moderately brittle. Hardness = 4.5 D(meas.) = 5.71–5.85 D(calc.) = 5.99 Pale yellow fluorescence in LW UV.

Optical Properties: Translucent. *Color:* Yellow, violet, white, colorless, gray, brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (+). $\omega = 1.948$ $\epsilon = 1.958$

Cell Data: *Space Group:* $P6_3/m$. $a = 10.053$–10.140 $c = 7.185$–7.284 Z = 2

X-ray Powder Pattern: Långban, Sweden.
3.014 (10), 2.929 (8), 1.943 (8), 3.586 (7), 4.135 (5), 8.77 (4), 5.070 (4)

Chemistry:

	(1)	(2)	(3)
P_2O_5	0.4	0.2	
As_2O_5	28.2	29.1	29.87
PbO	58.0	52.0	58.03
CaO	10.3	9.1	9.72
SrO	1.0	7.0	
BaO	0.1	0.5	
Cl	3.3	3.4	3.07
$-O = Cl_2$	0.7	0.8	0.69
Total	100.6	100.5	100.00

(1) Långban, Sweden; by electron microprobe, corresponding to $Ca_{2.05}(Pb_{2.90}Sr_{0.10})_{\Sigma=3.00}[(AsO_4)_{2.75}(PO_4)_{0.05}]_{\Sigma=2.80}Cl_{1.05}$. (2) Franklin, New Jersey, USA; by electron microprobe. (3) $Pb_3Ca_2(AsO_4)_3Cl$.

Mineral Group: Apatite group.

Occurrence: A rare secondary mineral in metamorphosed manganese deposits (Sweden); in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Barite, barylite, rhodonite, hausmannite, bixbyite, phlogopite, amphibole, calcite (Långban, Sweden); barylite, calcite, copper, rhodonite, barite, manganaxinite, willemite, cahnite (Franklin, New Jersey, USA).

Distribution: In Sweden, from Långban, Nordmark, and the Harstigen mine, near Persberg, Värmland, and the Sjö mine, near Grythyttan, Örebro. At Brandy Gill, Caldbeck Fells, Cumbria, England. In the Tynagh mine, near Loughrea, Co. Galway, Ireland. From Franklin, Sussex Co., New Jersey, and the Balmat #4 mine, Fowler, St. Lawrence Co., New York, USA. In the San Carlos mine, Santa Eulalia, Chihuahua, Mexico. Large crystals from Tsumeb, Namibia. In the Puttapa zinc mine, near Beltana, South Australia.

Name: From the Greek for *beautifully bright*, in allusion to the typical luster of specimens.

Type Material: Mining Academy, Freiberg, Germany, 45154; Harvard University, Cambridge, Massachusetts, USA, 90417.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 900–902. (2) Rouse, R.C., P.J. Dunn, and D.R. Peacor (1984) Hedyphane from Franklin, New Jersey and Långban, Sweden: cation ordering in an arsenate apatite. Amer. Mineral., 69, 920–927. (3) Dunn, P.J., R.C. Rouse, and J.A. Nelen (1985) Hydroxyl-bearing hedyphane from Långban, Sweden. Geol. Fören. Förhandl. Stockholm, 107, 325–327. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 650–651.

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Heideite $(Fe, Cr)_{1+x}(Ti, Fe)_2S_4$ (x = 0.15)

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Crystal Data: Monoclinic, probable. *Point Group:* $2/m$. As minute anhedral grains, to 100 μm.

Physical Properties: Hardness = 3.5–4.5 VHN = n.d. D(meas.) = 3.942 (synthetic) D(calc.) = 4.10 (synthetic)

Optical Properties: Opaque. *Color:* In polished section, creamy white.
Pleochroism: Moderately strong, from purple-gray to cream-gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I2/m$. $a = 5.97$ $b = 3.42$ $c = 11.4$ $\beta = 90.2°$ Z = 2

X-ray Powder Pattern: Synthetic heideite.
2.068 (100), 2.644 (90), 1.719 (50), 2.975 (15), 1.445 (10), 1.051 (5), 1.010 (5)

Chemistry:

	(1)	(2)
Ti	28.5	29.5
Fe	25.1	25.1
Cr	2.9	
S	44.9	45.2
Total	101.4	99.8

(1) Bustee meteorite; by electron microprobe, average of analyses of five grains, corresponding to $(Fe^{2+}_{0.99}Cr^{2+}_{0.16})_{\Sigma=1.15}(Ti^{3+}_{1.70}Fe^{2+}_{0.30})_{\Sigma=2.00}S_{4.00}$. (2) Synthetic heideite.

Occurrence: As minute anhedral grains (Bustee meteorite).

Association: Titanian troilite, ferroan alabandite, daubréelite, oldhamite, osbornite, niningerite, forsterite, iron (Bustee meteorite).

Distribution: From the Bustee enstatite achondrite meteorite [TL]. In the Kaidun [??type??ck??] meteorite.

Name: Honors Professor Fritz Heide (1891–1973), meteoriticist of Jena, Germany.

Type Material: n.d. [??where is Bustee??ASU provided samples to NM Inst??]

References: (1) Keil, K. and R. Brett (1974) Heideite, $(Fe, Cr)_{1+x}(Ti, Fe)_2S_4$, a new mineral in the Bustee enstatite achondrite. Amer. Mineral., 59, 465–470. (2) Plovnick, R.H., M. Vlasse, and A. Wold (1968) Preparation and structural properties of some ternary chalcogenides of titanium. Inorg. Chem., 7, 127–129.

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Heidornite $Na_2Ca_3B_5O_8(SO_4)_2(OH)_2Cl$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As doubly-terminated steeply dipyramidal crystals, to 7 cm, composed of {110}, $\{11\overline{1}\}$ and $\{11\overline{2}\}$.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 4–5 D(meas.) = 2.753(2) D(calc.) = 2.70

Optical Properties: Transparent. *Color:* Colorless. *Luster:* [Vitreous.] *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \wedge a = 23°$. *Dispersion:* $r < v$. $\alpha = 1.579(5)$ $\beta = 1.588(5)$ $\gamma = 1.604(5)$ 2V(meas.) = 73°–77° 2V(calc.) = 74°

Cell Data: *Space Group:* $C2/c$. $a = 10.21$ $b = 7.84$ $c = 18.79$ $\beta = 93.5°$ Z = 4

X-ray Powder Pattern: Near Nordhorn, Germany.
3.11 (vs), 3.77 (s), 2.74 (s), 2.96 (ms), 2.90 (m), 2.81 (m), 2.54 (m)

Chemistry:

	(1)	(2)
SO_3	26.55	26.26
B_2O_3	27.99	28.54
CaO	27.61	27.59
Na_2O	5.07	5.08
NaCl	9.40	9.58
H_2O^+	3.15	
H_2O^-	0.14	
H_2O		2.95
insol.	0.07	
Total	99.98	100.00

(1) Near Nordhorn, Germany. (2) $Na_2Ca_3B_5O_8(SO_4)_2(OH)_2Cl$.

Occurrence: Very rare, in a cavity in a marine evaporite deposit.

Association: Glauberite, anhydrite.

Distribution: From Frenswegen, northwest of Nordhorn, Lower Saxony, Germany.

Name: Honors Dr. F. Heidorn, Bentheim, Germany, for his scientific study of the Zechstein deposits.

Type Material: The Natural History Museum, London, England, 1957,370; Harvard University, Cambridge, Massachusetts, USA, 109587.

References: (1) von Engelhardt, W., H. Füchtbauer, and J. Zemann (1956) Heidornit $Na_2Ca_3[Cl•(SO_4)_2•B_5O_8(OH)_2]$ ein neues Bormineral aus dem Zechsteinanhydrit. Heidelberger Beitr. Mineralog. Petrog., 5, 177–186 (in German). (2) (1957) Amer. Mineral., 42, 120–121 (abs. ref. 1). (3) Burzlaff, H. (1967) Die Struktur des Heidornit $Ca_3Na_2Cl(SO_4)_2B_5O_8(OH)_2$. Neues Jahrb. Mineral., Monatsh., 157–169 (in German).

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Heinrichite $Ba(UO_2)_2(AsO_4)_2 \cdot 10-12H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. As tabular crystals, flattened on {001}, with square to rectangular outline, showing {001}, {100} and {110}, to 2 mm; in scaly aggregates.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {100}. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = n.d. D(calc.) = 3.61 Fluoresces bright green to greenish yellow under SW and LW UV; dehydrates rapidly to metaheinrichite. Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow to greenish yellow; pale yellow to colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Uniaxial (–), anomalously biaxial (–). *Pleochroism:* O = pale yellow; E = colorless. *Absorption:* $E < O$. $\omega = 1.605(2)$ $\epsilon = 1.573(2)$ 2V(meas.) = 20°–38°

Cell Data: *Space Group:* n.d. $a = 7.13$ $c = 20.56$ Z = 2

X-ray Powder Pattern: Black Forest, Germany.
3.57 (10), 8.89 (8), 5.03 (8), 3.38 (7), 2.25 (5), 2.11 (5), 2.53 (2)

Chemistry: (1) No chemical analysis has been made; the formula is based on the similarity of its X-ray pattern to that of zeunerite and synthetic $Ba(UO_2)_2(AsO_4)_2 \cdot 10H_2O$, and chemical analyses of metaheinrichite.

Mineral Group: Autunite group.

Occurrence: A secondary mineral in oxidized uranium deposits.

Association: Metaheinrichite, zeunerite, nováčekite, erythrite, pitticite, arseniosiderite, uraninite.

Distribution: From the White King mine, about 22 km northwest of Lakeview, Lake Co., Oregon, USA. In Germany, in the Black Forest, from the Sophia mine and on the Schmiedestollen dump, near Wittichen; at Reinerzau, near Alpirsbach; in the Michael mine, Weiler, near Lahr; near Schramberg and Triberg, Hammereisenbach, Menzenschwand; in the Anton mine, Heubachtal, near Schiltach; and in Bavaria, at Sailauf, northeast of Aschaffenburg. In the Riviéral mine, Lodève, Hérault, France.

Name: Honors Professor Eberhardt William Heinrich (1918–1991), mineralogist, University of Michigan, Ann Arbor, Michigan, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 121950.

References: (1) Gross, E.B., A.S. Corey, R.S. Mitchell, and K. Walenta (1958) Heinrichite and metaheinrichite, hydrated barium uranyl arsenate minerals. Amer. Mineral., 43, 1134–1143. (2) Walenta, K. (1965) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 2. Folge. Tschermaks Mineral. Petrog. Mitt., 9, 252–282, esp. 263–275 (in German).

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Hejtmanite $Ba(Mn^{2+},Fe^{2+})_2TiO(Si_2O_7)(OH,F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As laths and platy crystals, with dominant {100} and elongated along [001], up to 2 cm, and in groups.

Physical Properties: *Cleavage:* Perfect on {100}; poor parting on {0*kl*}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.97–4.06, average 4.02 D(calc.) = 4.29

Optical Properties: Transparent to translucent. *Color:* Brownish or golden to yellow. *Streak:* Brownish yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = light yellow-green; Y = dark golden yellow; Z = light yellow. *Orientation:* $X = b$; $Y \wedge c = 37.9°$; $Z \wedge a = 15.9°$. *Absorption:* $Y > Z = X$.
$\alpha = 1.814(1)$ $\beta = 1.846(1)$ $\gamma = 1.867(1)$ 2V(meas.) = 76.4° 2V(calc.) = 76.8°

Cell Data: *Space Group:* $P2_1/m$. $a = 11.748(4)$ $b = 13.768(5)$ $c = 10.698(4)$
$\beta = 112.27(2)°$ Z = 8

X-ray Powder Pattern: Mbolwe Hill, Zambia.
2.726 (100), 5.472 (32), 3.241 (21), 3.215 (21), 3.455 (17), 2.180 (16), 3.669 (14)

Chemistry:

	(1)		(1)
SiO_2	23.52	BaO	30.20
TiO_2	13.27	Na_2O	0.06
Al_2O_3	0.37	K_2O	0.30
Nb_2O_5	1.4	F	3.3
FeO	11.29	Cl	< 0.1
MnO	14.12	H_2O	[1.86]
MgO	0.13	$-O = (F,Cl)_2$	1.39
CaO	0.00	Total	[98.43]

(1) Mbolwe Hill, Zambia; by electron microprobe, Nb by energy-dispersive analysis, H_2O from stoichiometry; corresponds to $(Ba_{1.04}K_{0.03}Mg_{0.02}Na_{0.01})_{\Sigma=1.10}(Mn_{1.05}Fe_{0.82})_{\Sigma=1.87}(Ti_{0.87}Nb_{0.06})_{\Sigma=0.93}(Si_{2.06}Al_{0.04})_{\Sigma=2.10}O_8[(OH)_{1.09}F_{0.91}]_{\Sigma=2.00}$.

Polymorphism & Series: Forms a series with bafertisite.

Occurrence: In arfvedsonite veins in pegmatite cutting alkalic granite and syenite (Mbolwe Hill, Zambia).

Association: Manganoan arfvedsonite, albite, bastnäsite, chevkinite, manganoan ilmenite, apatite, aegirine (Mbolwe Hill, Zambia).

Distribution: On Mbolwe Hill, Mkushi River area, Central Province, Zambia. In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan.

Name: To honor Dr. Bohuslav Hejtman, Emeritus Professor of Petrology, Charles University, Prague, Czech Republic.

Type Material: Charles University and the National Museum, Prague, Czech Republic.

References: (1) Vrána, S., M. Rieder, and M.E. Gunter (1992) Hejtmanite, a manganese-dominant analogue of bafertisite, a new mineral. Eur. J. Mineral., 4, 35–43. (2) (1992) Amer. Mineral., 77, 1306 (abs. ref. 1).

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Heliophyllite $Pb_6As_2^{3+}O_7Cl_4(?)$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* n.d. As acute pyramidal crystals, horizontally striated, also tabular, radiating. Intergrown with ecdemite; in coarsely foliated or granular aggregates, ball-like, massive.

Physical Properties: *Cleavage:* {011}, nearly perfect. Hardness = ∼2 VHN = 96 D(meas.) = 6.89–7.14 D(calc.) = 7.33

Optical Properties: Translucent. *Color:* Yellow to greenish yellow. *Luster:* Vitreous on cleavages, greasy on fracture surfaces.
Optical Class: Biaxial (–); low birefringence. *Dispersion:* $r < v$, strong. α = n.d. β = n.d. γ = n.d. 2V(meas.) = 35–40°

Cell Data: *Space Group:* n.d. a = 10.794–10.823 b = 10.766–10.783 c = 25.560–25.580 Z = 8

X-ray Powder Pattern: Harstigen mine, Sweden. (ICDD 20-471).
2.84 (100), 2.70 (40), 3.66 (35), 2.06 (25), 1.647 (25b), 1.587 (25), 3.19 (20)

Chemistry:

	(1)	(2)	(3)
As_2O_3	10.85	12.28	12.01
Sb_2O_3	0.56	0.048	
(Fe, Mn)O	0.07		
FeO		0.60	
MnO		0.001	
ZnO		0.01	
PbO	81.03	80.21	81.32
MgO		0.007	
CaO	0.08	0.05	
Cl	8.05	8.05	8.61
P_2O_5		0.039	
$-O = Cl_2$	1.82	1.85	1.94
Total	98.82	99.45	100.00

(1) Harstigen mine, Sweden. (2) Xitieshan mine, China. (3) $Pb_6As_2O_7Cl_4$.

Occurrence: From metamorphosed Fe–Mn orebodies (Sweden); in the oxidation zone above a Pb–Zn deposit (Xitieshan mine, China); in metallic slag exposed to seawater (Laurium, Greece).

Association: Ecdemite, inesite (Sweden); mimetite, cerussite, calcite (Xitieshan mine, China).

Distribution: From the Harstigen mine, near Persberg; at Jakobsberg; and at Långban, Värmland, Sweden. From Laurium, Greece, in slag. At the Xitieshan Pb–Zn mine, Chaidamu, Qinghai Province, China.

Name: From the Greek for *sun* and *leaf*, in allusion to its color and habit.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1037–1038. (2) W. Li and G. Chen (1985) The discovery of heliophyllite in China. Acta Mineralogica Sinica, 5(3), 216–220 (in Chinese with English abs.). (3) (1987) Mineral. Abs., 38, 347 (abs. ref. 2).

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Hellandite $\mathbf{(Ca,Y)_6(Al,Fe^{3+})Si_4B_4O_{20}(OH)_4}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic ‖ [001], tabular ‖ [010], to 30 cm. *Twinning:* Contact and polysynthetic, ‖ {001} and {100}.

Physical Properties: *Cleavage:* Poor on {100}, {010}. Hardness = 4.5–6.5
D(meas.) = 2.95–3.63 D(calc.) = 3.161

Optical Properties: Semitransparent. *Color:* Nut-brown, brownish red; black, gray, green, yellow, cream. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 44°$–$53°$. $\alpha = 1.652$–1.656
$\beta = 1.657$–1.712 $\gamma = 1.662$–1.668 2V(meas.) = 48°–86°

Cell Data: *Space Group:* $P2/a$. $a = 18.99(1)$ $b = 4.715(5)$ $c = 10.30(1)$ $\beta = 111.4(1)°$
Z = 4

X-ray Powder Pattern: Kragerö, Norway.
2.812 (100), 4.69 (80), 2.635 (80), 2.603 (80), 3.436 (70), 3.198 (70), 3.068 (70)

Chemistry:

	(1)	(2)	(3)
SiO_2	26.65	25.57	24.41
TiO_2	0.39	< 0.2	< 0.02
ThO_2	1.46		0.57
B_2O_3	10.5	[14.85]	8.47
Al_2O_3	2.58	3.04	4.59
Y_2O_3	21.68	18.07	26.53
RE_2O_3	15.63	16.0	19.19
Fe_2O_3	3.07	3.77	2.29
FeO	0.07		
MnO	0.41	0.70	0.58
MgO	0.60		
CaO	11.51	15.22	9.28
H_2O^+	3.75	[4.50]	5.3
H_2O^-	1.89		2.0
Total	100.19	[101.92]	103.23

(1) Kragerö, Norway. (2) Predazzo, Italy; total Fe as Fe_2O_3, B_2O_3 and H_2O from stoichiometry. (3) Evans-Lou quarry, Canada; total Fe as Fe_2O_3.

Occurrence: In granite pegmatite (Kragerö, Norway; Wakefield Lake, Canada).

Association: Tourmaline, thorite, allanite, apatite, phenakite, zircon, titanite (Kragerö, Norway); quartz, chlorite, fergusonite, kainosite-(Y), tengerite, xenotime, wakefieldite, thorogummite (Evans-Lou quarry, Canada); microcline, albite, schorl, monazite, zircon (Crestmore, California, USA).

Distribution: From the Lindvikskollen pegmatite dike, near Kragerö, Norway. At Predazzo, Trentino-Alto Adige; Lago Vico, Viterbo, and near Vetralla, Lazio, Italy. In the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France. At Crestmore, Riverside Co., California, USA. In the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada.

Name: For geologist Amund Theodor Helland (1846–1918), of Oslo, Norway.

Type Material: n.d.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 50–51. (2) Oftedal, I. (1965) Über den Hellandit. Tschermaks Mineral. Petrog. Mitt., 10, 125–129 (in German with English abs.). (3) Hogarth, D.D., G.Y. Chao, and D.C. Harris (1972) New data on hellandite. Can. Mineral., 11, 760–776. (4) Mellini, M. and S. Merlino (1977) Hellandite: a new type of silicoborate chain. Amer. Mineral., 62, 89–99.

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Hellyerite $NiCO_3 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystal fragments and microcrystalline coatings, to 2 mm. *Twinning:* Fine lamellar twinning parallel to the perfect cleavage.

Physical Properties: *Cleavage:* One perfect direction; two directions, less perfect, at 112° to one another and both approximately perpendicular to the first. Hardness = 2.5 D(meas.) = 1.97 D(calc.) = [1.98]

Optical Properties: Semitransparent. *Color:* Pale blue. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* $X = Y$ = very pale greenish blue; Z = pale greenish blue. $\alpha = 1.455(2)$ $\beta = 1.503(2)$ $\gamma = 1.549(2)$ 2V(meas.) = 85°

Cell Data: *Space Group:* $C2/c$. $a = 10.770$ $b = 7.299$ $c = 18.681$ $\beta = 94.00°$ Z = 8

X-ray Powder Pattern: Lord Brassey mine, Tasmania, Australia.
9.4 (10), 6.06 (10), 3.65 (7), 3.40 (6), 2.38 (5), 3.11 (4), 2.78 (4)

Chemistry:

	(1)	(2)
NiO	32.9	32.93
CO_2	22.8	19.41
H_2O	45.0	47.66
Total	100.7	100.00

(1) Lord Brassey mine, Tasmania, Australia; CO_2 by LOI after H_2O determined by the Penfield method. (2) $NiCO_3 \cdot 6H_2O$.

Occurrence: Very rare, as coatings on shear surfaces in serpentinite.

Association: Zaratite, theophrastite, otwayite.

Distribution: From the Lord Brassey mine, near Heazlewood, Tasmania, Australia.

Name: Honors Henry Hellyer (1791–1832), first Surveyor-General of the Van Diemen's Land Company and explorer of northwestern Tasmania.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 108400.

References: (1) Williams, K.L., I.M. Threadgold, and A.W. Hounslow (1959) Hellyerite, a new nickel carbonate from Heazlewood, Tasmania. Amer. Mineral., 44, 533–538. (2) Threadgold, I.M. (1963) The crystal structure of hellyerite and nacrite. Dissertation Abs., 24(1), 252–253.

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Helmutwinklerite $PbZn_2(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. As crystals, tabular on {001}, to 5 mm, modified by {100}, {010}, {011}, {101}, {111}, {112}.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 D(meas.) = 5.3(1) D(calc.) = 5.21–5.29

Optical Properties: Translucent to transparent. *Color:* Colorless, light blue, sea-green. *Streak:* White. *Luster:* Vitreous, resinous on fracture surfaces. *Optical Class:* Biaxial (–). *Orientation:* X (11°,-145°); Y (82°,-35°); Z (82°,56°) [with a (90°,90°) and b (90°,0°) using (ϕ,ρ)]. *Dispersion:* $r < v$, distinct. $\alpha = 1.83(2)$ $\beta = [1.87]$ $\gamma = 1.89(2)$ 2V(meas.) = 70(5)° 2V(calc.) = 73°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.606(2)$ $b = 5.610(2)$ $c = 7.617(1)$ $\alpha = 70.19(2)°$ $\beta = 69.91(2)°$ $\gamma = 69.18(2)°$ Z = 1

X-ray Powder Pattern: Tsumeb, Namibia.
2.579 (100), 4.697 (80), 3.075 (75), 3.269 (70), 2.768 (50), 1.735 (50), 6.953 (40)

Chemistry:

	(1)	(2)	(3)
As_2O_5	34.35	36.42	35.26
CuO	1.48	1.62	
ZnO	27.50	23.54	24.97
PbO	31.28	34.20	34.24
H_2O	6.14	[5.53]	5.53
Total	100.75	[101.31]	100.00

(1) Tsumeb, Namibia; by electron microprobe, average of 10 analyses on two crystals, H_2O by the Karl Fischer method; corresponding to $Pb_{0.90}(Zn_{2.17}Cu_{0.12})_{\Sigma=2.29}(As_{0.96}O_4)_2 \cdot 2.19H_2O$. (2) Do.; by electron microprobe, average of 39 analyses, H_2O calculated from theory; corresponds to $Pb_{0.98}(Zn_{1.85}Cu_{0.13})_{\Sigma=1.98}(AsO_4)_{2.03} \cdot 2.00H_2O$. (3) $PbZn_2(AsO_4)_2 \cdot 2H_2O$.

Mineral Group: Tsumcorite group.

Occurrence: A very rare secondary mineral in corroded tennantite ore from a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tennantite, willemite, quartz.

Distribution: Found at Tsumeb, Namibia.

Name: Honors Professor Helmut G.F. Winkler (1915–1980), University of Göttingen, Göttingen, Germany, for his contributions to petrology, mineralogy, and crystallography.

Type Material: Göttingen University, Göttingen, Germany.

References: (1) Schnorrer-Köhler, G. (1980) Koritnigit and Helmutwinklerit – zwei neue Minerale von Tsumeb (SW-Afrika). Aufschluss, 31, 43–49 (in German). (2) (1980) Amer. Mineral., 65, 1067 (abs. ref. 1). (3) Süsse, P. and G. Schnorrer (1980) Helmutwinklerite, a new arsenate mineral from Tsumeb, S.W. Africa. Neues Jahrb. Mineral., Monatsh., 118–124. (4) Schmetzer, K., B. Nuber, and O. Medenbach (1985) Thometzekite, a new mineral from Tsumeb, Namibia, and symmetry relations in the tsumcorite-helmutwinklerite family. Neues Jahrb. Mineral., Monatsh., 446–452. (5) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Helvite $Mn_4^{2+}Be_3(SiO_4)_3S$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As tetrahedra, dodecahedra, and pseudo-octahedral crystals, up to 12 cm; as rounded grains.

Physical Properties: *Cleavage:* Distinct on {111}, {1$\bar{1}$1}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 741–873 D(meas.) = 3.20–3.44 D(calc.) = [3.23] Pyroelectric.

Optical Properties: Translucent. *Color:* Yellow, brown, red, gray-yellow, yellow-green. *Streak:* White. *Luster:* Vitreous to resinous.
Optical Class: Isotropic. n = 1.728–1.749

Cell Data: *Space Group:* $P\bar{4}3n$. a = 8.24–8.29 Z = 2

X-ray Powder Pattern: Butte, Montana, USA.
3.382 (100), 1.955 (80), 2.215 (70), 2.618 (65), 1.692 (65), 1.510 (50), 1.466 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	31.06	29.62	32.47
Al_2O_3	0.30	0.03	
FeO	0.18	13.25	
MnO	52.48	24.34	51.12
ZnO	0.55	16.09	
BeO	[13.52]	[13.21]	13.52
CaO		0.07	
S	5.51	5.91	5.78
$-O = S$	[2.75]	[2.95]	2.89
Total	[100.85]	[99.57]	100.00

(1) East Moultan mine, Butte, Montana, USA; by electron microprobe; BeO calculated assuming (Fe^{2+}, Mn, Zn, Mg, Ca):Be = 4:3. (2) Pitkäranta, Finland; by electron microprobe, BeO calculated as in (1). (3) $Mn_4Be_3(SiO_4)_3S$.

Polymorphism & Series: Forms two series, with danalite, and with genthelvite.

Occurrence: May be locally abundant in granites, granite pegmatites, gneisses, and contact zones and skarns.

Association: Garnet, magnetite, fluorite, chlorite, diopside, vesuvianite.

Distribution: From Schwarzenberg and Breitenbrunn, Saxony, Germany. Exceptionally large crystals from Yxsjö, Örebro, Sweden. At Luppikko, Karelia. In Russia, near Miass, Ilmen Mountains, Southern Ural Mountains. From the Inyl'chek Mountains, Tien Shan, southeastern Kyrgyzstan. At Kara-Oba, Kazakhstan. From the Langesundsfjord, at Hørtekollen, and several other localities in Norway. In Finland, at Pitkäranta. In the USA, at Butte, Silver Bow Co., Montana; from Amelia, Amelia Co., Virginia; in the American Tunnel, Silverton, San Juan Co., Colorado; on the east fork of Benedict Creek, Sawtooth Mountains, Boise Co., Idaho; from the Clark vein, Rincon, San Diego Co., California; at Iron Mountain, Sierra Co., New Mexico. In the Hongo mine, Iwate Prefecture; the Oashi mine, Tochigi Prefecture; the Yagisawa mine, Nagano Prefecture; and several other places in Japan. A few additional localities are known.

Name: From the Greek for *sun*, in allusion to its yellow color.

Type Material: Mining Academy, Freiberg, Germany, 22941.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 434–435. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 303–309. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 119–126. (4) Glass, J.J., R.H. Jahns, and R.E. Stevens (1944) Helvite and danalite from New Mexico and the helvite group. Amer. Mineral., 29, 163–191. (5) Dunn, P.J. (1976) Genthelvite and the helvine group. Mineral. Mag., 40, 627–636. (6) Hassan, I. and H.D. Grundy (1985) The crystal structures of helvite group minerals, $(Mn, Fe, Zn)_8(Be_6Si_6O_{24})S_2$. Amer. Mineral., 70, 186–192.

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Hematite α–Fe_2O_3

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}2/m$. Crystals complex rhombohedral, pseudocubic, prismatic, rarely scalenohedral, to 13 cm, with triangular striations on {0001} and {10$\bar{1}$1}; thin tabular, to micaceous or platy, commonly in rosettes; radiating fibrous, reniform, botryoidal or stalactitic masses, columnar; earthy, granular, oolitic, concretionary. *Twinning:* Penetration twins on {0001} or with {10$\bar{1}$0} as composition plane; also lamellar on {10$\bar{1}$1}.

Physical Properties: *Cleavage:* Parting on {0001} and {10$\bar{1}$1} due to twinning. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle; elastic in thin laminae. Hardness = 5–6 VHN = 1000–1100 (100 g load). D(meas.) = 5.26 D(calc.) = 5.255

Optical Properties: Opaque, transparent on thin edges. *Color:* Steel-gray, may have iridescent tarnish, dull to bright red; white to gray-white, with a bluish tint, in reflected light, with deep blood-red internal reflections. *Streak:* Cherry-red or reddish brown. *Luster:* Metallic or submetallic to dull.
Optical Class: Uniaxial (–). *Pleochroism:* O = brownish red; E = yellowish red. *Dispersion:* Very strong. *Absorption:* $O > E$. $\omega = 3.15–3.22$ $\epsilon = 2.87–2.94$ *Anisotropism:* Distinct.
R_1–R_2: (400) 32.0–34.5, (420) 31.0–34.0, (440) 30.0–33.5, (460) 29.1–32.7, (480) 28.4–32.2, (500) 27.8–31.6, (520) 27.2–31.0, (540) 27.0–30.6, (560) 26.8–30.4, (580) 26.4–30.0, (600) 25.5–29.2, (620) 24.8–28.3, (640) 24.1–27.5, (660) 23.5–26.7, (680) 23.1–26.1, (700) 22.8–25.6

Cell Data: *Space Group:* $R\bar{3}c$. $a = 5.038(2)$ $c = 13.772(12)$ $Z = 6$

X-ray Powder Pattern: Elba, Italy. (ICDD 24-72).
2.703 (100), 2.519 (70), 1.6966 (36), 3.686 (33), 1.8428 (31), 1.4873 (22), 1.4543 (21)

Chemistry:

	(1)		(1)
Fe_2O_3	98.14	FeO	1.29
Mn_2O_3	0.54	MnO	0.38
		Total	100.35

(1) Franklin, Sussex Co., New Jersey, USA.

Polymorphism & Series: Dimorphous with maghemite.

Mineral Group: Hematite group.

Occurrence: An accessory mineral in felsic igneous rocks, a late-stage sublimate in volcanic rocks, and in high-temperature hydrothermal veins. A product of contact metamorphism and in metamorphosed banded iron formations. A common cement in sedimentary rocks and a major constituent in oolitic iron formations. Abundant on weathered iron-bearing minerals.

Association: Ilmenite, rutile, magnetite (metamorphic and igneous); goethite, siderite, lepidocrocite (sedimentary).

Distribution: Widespread. Exceptional crystals from Switzerland, as at Fibbia, St. Gotthard, Uri; Binntal, Valais; Cavradi, Tavetsch, Graübunden; and many other places. At Ocna de Fier (Morávicza; Vaskő), Romania. From Rio Marina, Elba, Italy. At Cleator Moor, Cumbria, England. From Kragerøand Hiassen, Norway. In Brazil, large crystals from Mesa Redonda and Congonhas do Campo, Minas Gerais; at Itabira and in the Brumado mine, Bahia; at Miguel Burnier, Ouro Prêto. From the Kuruman district, Cape Province, South Africa. At Nador, Algeria. In the USA, in the Thomas Range, Juab Co., Utah, and near Quartzsite, La Paz Co., Arizona.

Name: From the Greek for *blood*, in allusion to its color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 527–534. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 21–27. (3) Blake, R.L., R.E. Hessevick, T. Zoltai, and L.W. Finger (1966) Refinement of the hematite structure. Amer. Mineral., 51, 123–129. (4) Maslen, E.N., V.A. Streltsov, N.R. Streltsova, and N. Ishizawa (1994) Synchrotron X-ray study of the electron density in α–Fe_2O_3. Acta Cryst., 50, 435–441.

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Hematolite $(Mn^{2+}, Mg, Al)_{15}(As^{3+}O_3)(As^{5+}O_4)_2(OH)_{23}$

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Crystal Data: Hexagonal. *Point Group:* 3. As thick tabular striated pseudorhombohedral trigonal pyramids $\{01\bar{1}5\}$, with triangular $\{0001\}$, typically bent, to 1 cm.

Physical Properties: *Cleavage:* Perfect on $\{0001\}$. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 3.44–3.49 D(calc.) = 3.50

Optical Properties: Translucent to nearly opaque. *Color:* Blood-red, garnet-red, brownish red, brown, black; reddish orange to yellowish brown in transmitted light. *Streak:* Pale chocolate-brown to reddish brown. *Luster:* Vitreous, pearly to submetallic on cleavages. *Optical Class:* Uniaxial (–). $\omega = 1.733(3)$ $\epsilon = 1.714(3)$

Cell Data: *Space Group:* $R3$. $a = 8.275(5)$ $c = 36.60(5)$ Z = 3

X-ray Powder Pattern: Moss mine, Sweden. (ICDD 33–868).
4.137 (100), 12.2 (36), 5.642 (29), 4.224 (22), 2.386 (19), 2.956 (18), 2.405 (16)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.20		CaO	0.32	
As_2O_5	15.67	15.65	Na_2O	0.08	
As_2O_3	6.36	6.74	K_2O	0.14	
Al_2O_3	6.26	6.94	H_2O^+	13.00	
Fe_2O_3	1.00		H_2O^-	0.72	
MnO	49.21	48.32	H_2O		14.11
MgO	7.10	8.24	Total	100.06	100.00

(1) Nordmark, Sweden. (2) $Mn_{10}Mg_3Al_2(As^{3+}O_3)(As^{5+}O_4)_2(OH)_{23}$.

Occurrence: In fissures in metamorphosed limestone in metamorphosed Fe–Mn orebodies.

Association: Manganosite, pyrochroite, magnetite, jacobsite, calcite, barite, fluorite.

Distribution: In Sweden, in the Moss mine, Nordmark, and from Långban, Värmland.

Name: From the Greek for *blood*, in allusion to the color.

Type Material: National Museum of Natural History, Washington, D.C., USA, C4228.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 777–778. (2) Wickman, F.E. (1950) From the notes of the late K. Johansson. IV–VI. Hematolite. Geol. Fören. Förhandl. Stockholm, 72, 64–68, esp. 66–67. (3) Moore, P.B. and T. Araki (1978) Hematolite: a complex dense-packed sheet structure. Amer. Mineral., 63, 150–159.

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Hematophanite $Pb_4Fe_3^{3+}O_8(OH, Cl)$

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Crystal Data: Tetragonal. *Point Group:* 4*mm*. As tablets, thin ⊥ {001}, to 5 mm, and in lamellar to granular aggregates.

Physical Properties: *Cleavage:* {001}, good; a parting inclined to {001} suspected. Hardness = 2–3 D(meas.) = 7.70 D(calc.) = 8.186

Optical Properties: Opaque, transparent through thin edges. *Color:* Deep reddish brown; blood-red in transmitted light. *Streak:* Orange. *Luster:* Submetallic.
Optical Class: Uniaxial (–); low birefringence.
R_1–R_2: n.d.

Cell Data: *Space Group: P4mm*. $a = 3.92$ $c = 15.31$ $Z = 1$

X-ray Powder Pattern: Långban, Sweden. (ICDD 27-271).
2.76 (100), 2.71 (100), 3.90 (60), 1.590 (60), 3.77 (40), 1.566 (40), 2.24 (35)

Chemistry:

	(1)		(1)
Fe_2O_3	22.01	Na_2O	0.38
$FeTiO_3$	0.20	K_2O	0.17
FeO	0.22	Cl	2.17
MnO	0.29	H_2O^+	0.73
PbO	73.26	$-O = Cl_2$	0.49
MgO	0.06	insol.	0.42
CaO	0.26	Total	99.68

(1) Jakobsberg, Sweden; average of two analyses, corresponding to $(Pb_{3.59}Na_{0.13}Ca_{0.05}K_{0.04})_{\Sigma=3.81}(Fe^{3+}_{3.01}Mn_{0.05}Fe^{2+}_{0.05}Mg_{0.02}Ti_{0.01})_{\Sigma=3.14}O_{8.49}H_{0.88}Cl_{0.67}$.

Occurrence: In a metamorphosed banded Fe–Mn ore deposit in dolostone (Jakobsberg, Sweden).

Association: Plumboferrite, jacobsite, andradite, copper, cuprite, cerussite, calcite (Jakobsberg, Sweden); copper, jacobsite, hematite, damaraite (Kombat mine, Namibia).

Distribution: From Jakobsberg and Långban, Värmland, Sweden. From Reichelsdorf, Hesse, Germany, in slag. In the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia.

Name: From the Greek for *blood* and *visible*, presumably for the blood-red color exhibited in transmitted light.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 728–729. (2) Rouse, R.C. (1973) Hematophanite, a derivative of the perovskite structure. Mineral. Mag., 39, 49–53. (3) Pannetier, J. and P. Batail (1981) $Pb_4Fe_3O_8Cl$: synthesis, crystal structure, and thermal expansion. J. Solid State Chem., 39, 15–21.

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Hemihedrite $Pb_{10}Zn(CrO_4)_6(SiO_4)_2F_2$

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Crystal Data: Triclinic. *Point Group:* 1. As euhedral crystals exhibiting hemihedral symmetry, up to 1 cm. *Twinning:* Three laws recognized; by reflection on $(\overline{2}\overline{2}3)$, $(0\overline{1}2)$, and $(0\overline{1}0)$, with composition surface (010).

Physical Properties: Hardness = 3 D(meas.) = 6.42 D(calc.) = 6.50

Optical Properties: Translucent to transparent. *Color:* Bright orange, henna-brown, to almost black. *Streak:* Saffron-yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Feeble, yellow to orange. *Dispersion:* Noticeable, resembles horizontal dispersion. *Absorption:* $Z > Y > X$. $\alpha = 2.105(5)$ $\beta = 2.32(2)$ $\gamma = 2.65(2)$ 2V(meas.) = 92° 2V(calc.) = 88°

Cell Data: *Space Group:* $P1$. $a = 9.497(1)$ $b = 11.443(2)$ $c = 10.841(2)$ $\alpha = 120°30'$ $\beta = 92°06'$ $\gamma = 55°50'$ Z = 1

X-ray Powder Pattern: Florence Lead-Silver mine, Arizona, USA.
3.301 (100), 4.872 (90), 4.364 (80), 3.164 (80), 3.102 (80), 2.924 (55), 2.849 (45)

Chemistry:

	(1)	(2)
SiO_2	3.2	3.93
CrO_3	19.5	19.64
ZnO	[3.8]	2.66
PbO	70.5	73.05
F	5.1	1.24
H_2O	n.d.	
$-O = F_2$	2.1	0.52
Total	[100.0]	100.00

(1) Florence Lead-Silver mine, Arizona, USA; average of several analyses, corrected for $PbMoO_4$ and $PbCO_3$ impurities, ZnO originally given as 3.93%; recalculated to 100.0%.
(2) $Pb_{10}Zn(CrO_4)_6(SiO_4)_2F_2$.

Polymorphism & Series: Forms a series with iranite.

Occurrence: Formed through oxidation of galena, sphalerite, and pyrite, in the oxide zone of hydrothermal lead-bearing veins.

Association: Cerussite, phoenicochroite, vauquelinite, willemite, wulfenite, galena, sphalerite, pyrite, tennantite, chalcopyrite (Florence Lead-Silver mine, Arizona, USA).

Distribution: From the Florence Lead-Silver mine, Tortilla Mountains, Pinal Co., and the Pack Rat claim, the Moon Anchor mine, and the Potter-Cramer property, Belmont Mountains, Maricopa Co., Arizona; also from near Boulder City, Clark Co., Nevada, USA. In the Seh-Changi mine, near Neyband, Khorassan, Iran.

Name: In allusion to its distinctive *hemihedral* morphology.

Type Material: The Natural History Museum, London, England, 1968,246; University of Arizona, Tucson, Arizona; National Museum of Natural History, Washington, D.C., USA, 141026.

References: (1) Williams, S.A. and J.W. Anthony (1970) Hemihedrite, a new mineral from Arizona. Amer. Mineral., 55, 1088–1102. (2) McLean, W.J. and J.W. Anthony (1970) The crystal structure of hemihedrite. Amer. Mineral., 55, 1103–1114. (3) Cesbron, F. and S.A. Williams (1980) Iranite–hemihedrite, bellite, phoenicochroite, vauquelinite et fornacite: synthèse et nouvelles données. Bull. Minéral., 103, 469–477 (in French with English abs.).

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Hemimorphite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Commonly crystallized, thin tabular $\perp$ {010}, striated $\parallel$ [001], to 10 cm; doubly-terminated crystals show hemimorphism. Typically in sheaflike or fan-shaped aggregates; stalactitic, mammillary, botryoidal; as compact fibrous and chalky coatings. *Twinning:* On {001}, rare, with antilogous poles in contact.

Physical Properties: *Cleavage:* Perfect on {110}, poor on {101}; {001}, rare. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 3.475 D(calc.) = 3.484 Strongly pyroelectric; may fluoresce bluish under SW UV.

Optical Properties: Translucent, transparent in small crystals. *Color:* Colorless, white; pale blue, pale green, gray, brown from impurities. *Streak:* White. *Luster:* Vitreous, subpearly, adamantine, rarely silky.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, strong. $\alpha = 1.614$ $\beta = 1.617$ $\gamma = 1.636$ 2V(meas.) = 46°

Cell Data: *Space Group:* $Imm2$. $a = 8.367(5)$ $b = 10.730(6)$ $c = 5.155(3)$ Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
3.104 (100), 6.60 (86), 3.288 (75), 3.296 (73), 5.36 (55), 2.400 (54), 2.559 (51)

Chemistry:

	(1)	(2)
SiO_2	25.01	24.94
ZnO	67.42	67.58
H_2O	8.32	7.48
Total	100.75	100.00

(1) Pulaski Co., Virginia, USA. (2) $Zn_4Si_2O_7(OH)_2 \cdot H_2O$.

Occurrence: A secondary mineral typically found in the oxidized zone of zinc-bearing mineral deposits.

Association: Smithsonite, sphalerite, galena, cerussite, anglesite, calcite, aurichalcite, rosasite, hydrozincite, chrysocolla.

Distribution: Only a few localities for fine examples can be mentioned. From Băiţa (Rézbánya), Romania. At Banská Štiavnica (Schemnitz), Slovakia. From Caldbeck Fells, Cumbria, England. At Moresnet, Belgium. In Germany, at Freiberg and Altenberg, Saxony. In the Sa Duchessa mine, Oridda district, Sardinia, Italy. Large crystals from Nerchinsk, Siberia, Russia. At Tchah Kuh, Esfahan, Iran. In the USA, at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in Arizona, from Bisbee, Cochise Co., and in the 79 mine, Gila Co.; in Utah, at the Emma mine, Little Cottonwood Canyon, Salt Lake Co.; in the Ibex and Wolftone mines, Leadville, Lake Co., Colorado; in the Elkhorn mine, Elkhorn district, Jefferson Co., Montana. In Mexico, large crystals from Santa Eulalia, Chihuahua, and in the Ojuela mine, Mapimí, Durango.

Name: In allusion to the mineral's *hemimorphic* morphology.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 546–549.
(2) Hill, R.J., G.V. Gibbs, and J.R. Craig (1977) A neutron-diffraction study of hemimorphite. Zeits. Krist., 146, 241–259. (3) (1953) NBS Circ. 539, 2, 62.

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Hemloite $(As^{3+}, Sb^{3+})_2(Ti, Fe^{3+}, V^{3+}, Fe^{2+})_{12}O_{23}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As subhedral to anhedral grains, to 600 μm.

Physical Properties: *Fracture:* Curved to irregular. Hardness = 6.5–7 VHN = 858–967, 913 average (100 g load). D(meas.) = n.d. D(calc.) = 4.613

Optical Properties: Opaque. *Color:* Black; gray in reflected light. *Streak:* Black.
Luster: Metallic to submetallic.
Optical Class: Biaxial. *Dispersion:* Weak. *Anisotropism:* Very weak; dark gray to dark brown.
R_1–R_2: (400) 18.9–20.5, (420) 18.6–19.8, (440) 18.2–19.1, (460) 17.8–18.7, (480) 17.6–18.4, (500) 17.4–18.2, (520) 17.2–18.0, (540) 17.1–17.8, (560) 17.0–17.7, (580) 17.0–17.6, (600) 16.9–17.5, (620) 16.9–17.4, (640) 16.8–17.4, (660) 16.8–17.3, (680) 16.8–17.3, (700) 16.8–17.2

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.158(1)$ $b = 7.552(1)$ $c = 16.014(3)$ $\alpha = 89.06(1)°$ $\beta = 104.32(2)°$ $\gamma = 84.97(1)°$ $Z = 2$

X-ray Powder Pattern: Hemlo deposit, Canada.
2.924 (100), 2.722 (90), 2.665 (90), 2.799 (80), 3.045 (70), 2.498 (70), 1.774 (60)

Chemistry:

	(1)
TiO_2	39.0
Al_2O_3	1.3
Fe_2O_3	27.0
V_2O_3	12.7
As_2O_3	12.0
Sb_2O_3	5.7
Total	97.7

(1) Hemlo deposit, Canada; by electron microprobe, Fe^{2+}:Fe^{3+} and OH calculated from charge balance; corresponds to $(As^{3+}_{1.42}Sb^{3+}_{0.46})_{\Sigma=1.88}(Ti_{5.74}Fe^{3+}_{3.60}V^{3+}_{2.00}Fe^{2+}_{0.38}Al_{0.30})_{\Sigma=12.02}O_{23}(OH)$.

Occurrence: In a hydrothermal gold deposit.

Association: Quartz, barian microcline, pyrite, molybdenite, sphalerite, arsenopyrite, vanadian muscovite, rutile, titanite.

Distribution: From the Hemlo gold deposit, in the Page-Williams mine, three km east of Hemlo, Thunder Bay district, Ontario, Canada.

Name: For the Hemlo deposit, Ontario, Canada, where it occurs.

Type Material: The Natural History Museum, London, England, 1986,512 and E.1210; Canadian Geological Survey, Ottawa, Canada, 65544.

References: (1) Harris, D.C., B.F. Hoskins, I.E. Grey, A.J. Criddle, and C.J. Stanley (1989) Hemloite $(As, Sb)_2(Ti, V, Fe, Al)_{12}O_{23}OH$: a new mineral from the Hemlo gold deposit, Hemlo, Ontario, and its crystal structure. Can. Mineral., 27, 427–440. (2) (1990) Amer. Mineral., 75, 1432–1433 (abs. ref. 1).

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Hemusite $Cu_4^{1+}Cu_2^{2+}Sn^{4+}Mo^{4+}S_8$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$, 432, or $\bar{4}3m$. As rounded grains and aggregates of irregular shape, to 0.05 mm.

Physical Properties: Hardness = ∼4 VHN = 145; 210–215 D(meas.) = n.d. D(calc.) = 4.469–4.55

Optical Properties: Opaque. *Color:* Gray; in polished section, violet-gray to ash-gray. R: (400) 22.9, (420) 23.1, (440) 23.5, (460) 24.3 (480) 24.9, (500) 25.6, (520) 26.0, (540) 26.2, (560) 26.2, (580) 26.2, (600) 26.3, (620) 26.5, (640) 26.8, (660) 27.0, (680) 27.0, (700) 26.9

Cell Data: *Space Group:* $Fm3m$, $F432$, or $F\bar{4}3m$. $a = 10.80$–10.83 $Z = 4$

X-ray Powder Pattern: Chelopech, Bulgaria. 3.11 (10), 1.919 (5), 1.858 (3), 1.632 (3) 3.61 (2), 2.87 (2), 2.55 (2)

Chemistry:

	(1)	(2)	(3)
Cu	43.6	43.80	44.73
Sn	12.8	12.09	13.92
Fe	2.6	0.60	
Mn		0.08	
Zn		0.08	
Cd		0.04	
Mo	11.7	10.38	11.26
Ag		0.06	
As	0.1		
Bi		1.42	
Se		1.06	
Te		0.50	
S	28.0	29.82	30.09
Total	98.8	99.88	100.00

(1) Chelopech, Bulgaria; by electron microprobe, corresponds to $Cu_{5.98}Sn_{0.94}Fe_{0.40}As_{0.01}Mo_{1.06}S_{7.61}$. (2) Kawazu mine, Japan; by electron microprobe, corresponds to $(Cu_{5.91}Fe_{0.09}Zn_{0.01}Ag_{0.01})_{\Sigma=6.02}(Sn_{0.87}Bi_{0.06}Te_{0.03})_{\Sigma=0.96}Mo_{0.93}(S_{7.97}Se_{0.12})_{\Sigma=8.09}$. (3) $Cu_4^{1+}Cu_2^{2+}SnMoS_8$.

Occurrence: Of hydrothermal origin, early formed in the mineral association (Chelopech, Bulgaria); in a polymetallic deposit in carboniferous porphyritic andesites (Kochbulak deposit, Uzbekistan).

Association: Enargite, luzonite, colusite, stannoidite, reniérite, tennantite, chalcopyrite, pyrite (Chelopech, Bulgaria).

Distribution: At the Chelopech deposit, Sofia, Bulgaria [TL]. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In Japan, in the Kawazu mine, Shizuoka Prefecture, and at the Iriki mine, Kagoshima Prefecture.

Name: After an ancient name for the Balkan Mountains, on the southern slope of which the Chelopech deposit occurs; probably of Thracian origin.

Type Material: University of Sofia, Sofia; Geological Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria.

References: (1) Terziev, G.I. (1971) Hemusite – a complex copper-tin-molybdenum sulfide from the Chelopech ore deposit, Bulgaria. Amer. Mineral., 56, 1847–1854. (2) Shimizu, M., A. Kato, and S. Matsubara (1988) Hemusite and paraguanajuatite from the Kawazu mine, Shizuoka Prefecture, Japan. Mineral. J. (Japan), 13, 92–100. (3) Shimizu, M., C.J. Stanley, A.J. Criddle, A. Kato, and S. Matsubara (1991) New compositional and optical data for antimonian and bismuthian varieties of hemusite from Japan. Mineral. Petrol., 45, 11–17.

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Hendersonite $(Ca,Sr)_x(V^{5+},V^{4+})_{12}O_{32}\cdot 12H_2O$ (x = ~2.6)

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Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$ or $mm2$. As microscopic fibers or blades, more rarely as elongated six-sided platy crystals; in bundles of fibers or subparallel aggregates.

Physical Properties: *Cleavage:* Perfect ‖ crystal platiness. *Tenacity:* Fibers smear easily. Hardness = 2.5 D(meas.) = 2.77–2.79 D(calc.) = 2.805

Optical Properties: Semitransparent. *Color:* Dark greenish black to black, turning brown on exposure to air. *Streak:* Dark brownish green. *Luster:* Vitreous, pearly to subadamantine. *Optical Class:* Biaxial (–). *Pleochroism:* Moderate; X = yellowish green; Y = green; Z = yellowish brown to brown. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, weak. $\alpha = < 2.01$ $\beta = > 2.01$ $\gamma = > 2.01$ 2V(meas.) = Medium.

Cell Data: *Space Group:* $Pnam$ or $Pna2_1$. $a = 12.40(4)$ $b = 18.92(8)$ $c = 10.77(3)$ Z = 3

X-ray Powder Pattern: Eastside mines, New Mexico, USA.
9.43 (100), 3.108 (36), 4.70 (17), 2.257 (16), 6.20 (11), 5.18 (11), 2.309 (11)

Chemistry:

	(1)	(2)
V_2O_5	64.6	63.44
V_2O_4	8.1	8.01
CaO	9.5	
SrO	1.3	
CaO + SrO		8.84
H_2O	14.6	14.45
insol.	0.6	4.28
Total	98.7	99.02

(1) J.J. mine, Colorado, USA; H_2O^- 7.7% determined separately; corresponds to $(Ca_{2.52}Sr_{0.20})_{\Sigma=2.72}V_{12.00}O_{32}\cdot 12.04H_2O$. (2) Eastside mines, New Mexico, USA; H_2O^- 7.52% determined separately; corresponds to $(Ca,Sr)_{2.40}V_{12.12}O_{32}\cdot 12.12H_2O$.

Occurrence: In thin seams and veinlets through sandstone at the interface between partially oxidized and unoxidized ore in Colorado Plateau-type U–V deposits.

Association: Paramontroseite, simplotite, melanovanadite, sherwoodite, corvusite, pyrite, marcasite (J.J. mine, Colorado, USA).

Distribution: In the USA, from the J.J. mine, Paradox Valley, Uravan district, Montrose Co., Colorado; and near the Nelson mine, Eastside mines, Carrizo Mountains, San Juan Co., New Mexico.

Name: Honors Dr. Edward Porter Henderson (1898–1992), formerly Curator of Meteorites at the Smithsonian Institution, Washington, D.C., USA, who contributed to the knowledge of the mineralogy of U–V deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 115888, 121955, 162609.

References: (1) Lindberg, M.L., A.D. Weeks, M.E. Thompson, D.P. Elston, and R. Meyrowitz (1962) Hendersonite, a new calcium vanadyl vanadate from Colorado and New Mexico. Amer. Mineral., 47, 1252–1272. (2) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 513–515.

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Hendricksite $K(Zn, Mg, Mn^{2+})_3(Si_3Al)O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Euhedral crystals, to 14 cm, rare. Forms interlocking aggregates and anhedral plates, to over 30 cm, commonly bent, or showing other signs of mechanical deformation.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 2.5–3 D(meas.) = 2.86–3.43 D(calc.) = 3.30–3.37

Optical Properties: Translucent. *Color:* Coppery brown, bronze-brown, dark reddish brown to reddish black.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; $Y = Z$ = light chestnut-brown. *Orientation:* $X = b$; $Z \wedge c = 36°$. *Dispersion:* $r < v$, slight. *Absorption:* $Z = Y > X$.
$\alpha = 1.598–1.624$ $\beta = 1.658–1.686$ $\gamma = 1.660–1.697$ 2V(meas.) = 2°–8°

Cell Data: *Space Group:* $C2/m$. $a = 5.340(2)$ $b = 9.254(2)$ $c = 10.235(3)$ $\beta = 100.07(2)°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA; 1M.
10.20 (100), 3.398 (60), 5.094 (36), 2.546 (35), 1.696 (17), 2.652 (13), 1.554 (10)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	31.58	31.9	BaO	0.65	0.3
TiO_2	0.32	0.35	Li_2O		0.04
Al_2O_3	13.72	13.6	Na_2O	0.24	0.1
Fe_2O_3	2.25	4.9	K_2O	7.91	8.6
FeO	0.34		F	0.45	
MnO	12.28	12.5	$H_2O^+ + F$		3.95
ZnO	22.97	19.8	H_2O^+	3.65	
MgO	3.69	2.7	H_2O^-		0.95
CaO		0.02	$-O = F_2$	0.19	
			Total	[99.86]	[99.71]

(1) Franklin, New Jersey, USA; original total given as 99.57%, corresponds to $(K_{0.85}Na_{0.04}Ba_{0.02})_{\Sigma=0.91}(Zn_{1.43}Mn_{0.88}Mg_{0.46}Fe^{3+}_{0.14}Ti_{0.04}Al_{0.02}Fe^{2+}_{0.02})_{\Sigma=3.00}(Si_{2.66}Al_{1.34})_{\Sigma=4.00}O_{10}[(OH)_{1.98}F_{0.02}]_{\Sigma=2.00}$. (2) Do.; original total given as 99.6%, corresponds to $(K_{0.94}Na_{0.02}Li_{0.02}Ba_{0.01})_{\Sigma=0.99}(Zn_{1.24}Mn_{0.90}Mg_{0.34}Fe^{3+}_{0.32}Al_{0.08}Ti_{0.02})_{\Sigma=2.90}(Si_{2.72}Al_{1.28})_{\Sigma=4.00}O_{10}[(OH), F]_{\Sigma=2.05}$.

Polymorphism & Series: 1M, $2M_1$, 3A polytypes.

Mineral Group: Mica group.

Occurrence: Restricted to irregular lens- or sheetlike skarn bodies in a metamorphosed stratiform zinc deposit.

Association: Andradite, rhodonite, calcite, barium feldspars, franklinite, willemite, axinite, hancockite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: For Dr. Sterling B. Hendricks (1902–), American crystallographer and chemist, a student of micas.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 89818, 133712; The Natural History Museum, London, England, 1966,209.

References: (1) Frondel, C. and J. Ito (1966) Hendricksite, a new species of mica. Amer. Mineral., 51, 1107–1123. (2) Evans, B.W. and R.G.J. Strens (1966) Zinc mica from Franklin Furnace, New Jersey. Nature, 211, 619. (3) Robert, J.-L. and M. Gaspérin (1985) Crystal structure refinement of hendricksite, a Zn- and Mn-rich trioctahedral potassium mica: a contribution to the crystal chemistry of zinc-bearing minerals. Tschermaks Mineral. Petrog. Mitt., 34, 1–14.

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Heneuite $CaMg_5(PO_4)_3(CO_3)(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As cleavable nodular masses, to several cm.

Physical Properties: *Cleavage:* Good on {001}. Hardness = 5.5 D(meas.) = 3.016(7) D(calc.) = 3.016

Optical Properties: Transparent to translucent. *Color:* Pale blue-green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.586(2)$ $\beta = 1.620(2)$ $\gamma = 1.630(2)$ 2V(meas.) = ∼50° 2V(calc.) = 56°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.311(1)$ $b = 10.843(1)$ $c = 8.676(1)$ $\alpha = 95.01(1)°$ $\beta = 93.41(1)°$ $\gamma = 101.04(1)°$ Z = 2

X-ray Powder Pattern: Tingelstadtjern, Norway.
2.70 (100), 2.87 (90), 2.79 (80), 2.836 (42), 3.67 (40), 2.845 (40), 2.60 (37)

Chemistry:

	(1)	(2)
P_2O_5	38.6	40.67
As_2O_5	1.05	
CO_2	8.23	8.41
FeO	0.39	
MgO	37.9	38.49
CaO	10.9	10.71
Na_2O	0.16	
H_2O^+	2.54	1.72
H_2O^-	0.05	
Total	99.82	100.00

(1) Tingelstadtjern, Norway; after adjusting H_2O^+ to 1.8%, corresponds to $(Ca_{1.04}Na_{0.03})_{\Sigma=1.07}(Mg_{5.02}Fe_{0.03})_{\Sigma=5.05}[(PO_4)_{2.90}(AsO_4)_{0.05}]_{\Sigma=2.95}(CO_3)_{1.00}(OH)_{1.07}$. (2) $CaMg_5(PO_4)_3(CO_3)(OH)$.

Occurrence: In a serpentine–magnesite deposit developed in a regional metamorphic terrain.

Association: Althausite, apatite, magnesite, serpentine.

Distribution: From the Tingelstadtjern quarry, Modum, Norway.

Name: Honors Professor Henrich Neumann (1914–1983), Mineralogical-Geological Museum, University of Oslo, Oslo, Norway.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway; National Museum of Natural History, Washington, D.C., USA, 164471.

References: (1) Raade, G., M.H. Mladeck, and V.K. Din (1986) Heneuite, $CaMg_5(CO_3)(PO_4)_3(OH)$, a new mineral from Modum, Norway. Neues Jahrb. Mineral., Monatsh., 343–350. (2) (1988) Amer. Mineral., 73, 440 (abs. ref. 1). (3) Rømming, C. and G. Raade (1986) The crystal structure of heneuite, $CaMg_5(CO_3)(PO_4)_3(OH)$. Neues Jahrb. Mineral., Monatsh., 351–359.

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Henmilite $Ca_2CuB_2(OH)_{12}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Prismatic pinacoidal crystals exhibit {100}, {010}, {101}, {102}, {110}, {$0\overline{1}1$}, {$\overline{1}\overline{4}2$}, to 3 mm; massive.

Physical Properties: *Tenacity:* "Fragile". Hardness = < 2.5 D(meas.) = 2.51 D(calc.) = 2.523

Optical Properties: Transparent. *Color:* Blue-violet. *Streak:* Pale violet to nearly white. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = pale pink; Y = pale purple; Z = very pale blue. *Orientation:* Inclined extinction. $\alpha = 1.585(2)$ $\beta = [1.608]$ $\gamma = 1.615(2)$ 2V(meas.) = ∼58°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.7617(5)$ $b = 7.9774(6)$ $c = 5.6488(4)$ $\alpha = 109.611(6)°$ $\beta = 91.473(7)°$ $\gamma = 83.686(7)°$ Z = 1

X-ray Powder Pattern: Fuka, Japan.
5.25 (vs), 4.35 (s), 3.709 (s), 3.302 (s), 2.494 (sb), 2.427 (sb), 2.346 (s)

Chemistry:

	(1)	(2)
B_2O_3	19.49	18.85
CuO	21.56	21.53
CaO	29.24	30.36
H_2O	29.57	29.26
Total	99.86	100.00

(1) Fuka, Japan; corresponds to $Ca_{1.91}Cu_{0.99}B_{2.05}(OH)_{12}$. (3) $Ca_2CuB_2(OH)_{12}$.

Occurrence: Very rare, in cavities in borate veins in contact-metasomatized limestone.

Association: Pentahydroborite, tenorite, sillenite, bultfonteinite, cuspidine, thaumasite, brucite, calcite.

Distribution: From Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: Honors Professor Kitinosuke Henmi (1919–1997), and his daughter Dr. Chiyoko Henmi (1949–), Department of Earth Science, Okayama University, Okayama, Japan, in recognition of their mineralogical work on the skarn deposit at Fuka, Japan.

Type Material: National Science Museum, Tokyo, Japan, M-24641; National Museum of Natural History, Washington, D.C., USA, 165482.

References: (1) Nakai, I., H. Okada, K. Masutomi, E. Koyama, and K. Nagashima (1986) Henmilite, $Ca_2Cu(OH)_4[B(OH)_4]_2$, a new mineral from Fuka, Okayama Prefecture, Japan. Part I. Occurrence and description. Part II. Crystal structure. Amer. Mineral., 71, 1234–1239. (2) Kusachi, I. (1992) New data on mineralogical properties of henmilite. J. Mineral. Soc. Japan, 21, 127–130 (in Japanese with English abs.).

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Hennomartinite $SrMn_2^{3+}Si_2O_7(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely in feltlike masses; as irregular aggregates, to 1 mm, embedded in other minerals.

Physical Properties: Hardness = ∼4 D(meas.) = n.d. D(calc.) = 3.68

Optical Properties: Translucent. *Color:* Yellow-brown; yellow-brown in thin section.
Luster: Vitreous.
Optical Class: Biaxial. *Pleochroism:* Strong; from yellowish brown to dark red-brown.
$n = > 1.82$. α = n.d. β = n.d. γ = n.d. 2V(meas.) = 63(1)°

Cell Data: *Space Group: Cmcm.* $a = 6.255(1)$ $b = 9.034(2)$ $c = 13.397(2)$ Z = 4

X-ray Powder Pattern: Wessels mine, South Africa; intensities calculated.
2.833 (100), 2.695 (98), 4.804 (86), 2.807 (82), 2.401 (68), 3.373 (66), 2.715 (58)

Chemistry:

	(1)
SiO_2	28.22
TiO_2	0.00
Al_2O_3	0.00
Fe_2O_3	0.53
Mn_2O_3	37.82
CaO	0.02
SrO	24.32
BaO	0.46
H_2O	[8.62]
Total	[99.99]

(1) Wessels mine, South Africa; by electron microprobe, average of 13 analyses, Li and F not detected by ion microprobe, H_2O from ideal stoichiometry; corresponds to $(Sr_{0.98}Ba_{0.01})_{\Sigma=0.99}(Mn^{3+}_{2.01}Fe^{3+}_{0.03})_{\Sigma=2.04}Si_{1.97}O_7(OH)_2 \cdot H_2O$.

Occurrence: From a hand specimen, in veinlets of sérandite-pectolite cutting sugilite, probably of hydrothermal origin in a bedded manganese deposit.

Association: Sérandite-pectolite, sugilite, braunite, taikanite, kornite.

Distribution: In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For Henno Martin, German geologist, who has worked on the Precambrian geology of the general area where the mineral occurs.

Type Material: Natural History Museum, Bern, Switzerland, B5564.

References: (1) Armbruster, T., R. Oberhänsli, V. Bermanec, and R. Dixon (1993) Hennomartinite and kornite, two new Mn^{3+} rich silicates from the Wessels mine, Kalahari, South Africa. Schweiz. Mineral. Petrog. Mitt., 73, 349–355. (2) (1994) Amer. Mineral., 79, 763–764 (abs. ref. 1). (3) Armbruster, T., R. Oberhänsli, and V. Bermanec (1992) Crystal structure of $SrMn_2[Si_2O_7](OH)_2 \cdot H_2O$, a new mineral of the lawsonite type. Eur. J. Mineral., 4, 17–22.

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Henritermierite $Ca_3(Mn^{3+},Al)_2(SiO_4)_2(OH)_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As pseudo-octahedral crystals, to 3 mm, and as aggregates of small grains. *Twinning:* Common on {101}, sectored.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = 3.34(2) D(calc.) = 3.40

Optical Properties: Translucent. *Color:* Clove-brown to apricot-brown; lemon-yellow to pale yellow in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+); may be anomalously biaxial. *Pleochroism:* Weak; O = very pale yellow; E = lemon-yellow. $\omega = 1.765(5)$ $\epsilon = 1.800(5)$ 2V(meas.) = Small.

Cell Data: *Space Group:* $I4_1/acd$. $a = 12.39(1)$ $c = 11.91(1)$ Z = 8

X-ray Powder Pattern: Tachgagalt mine, Morocco.
2.75 (vvs), 2.516 (vs), 4.37 (s), 3.09 (s), 2.98 (s), 2.684 (ms), 1.614 (ms)

Chemistry:

	(1)
SiO_2	24.65
Al_2O_3	5.95
Fe_2O_3	0.95
MnO	22.38
CaO	35.45
active O_2	2.56
H_2O^+	7.85
H_2O^-	0.08
Total	99.87

(1) Tachgagalt mine, Morocco; corresponds to $Ca_{2.97}(Mn^{3+}_{1.48}Al_{0.54}Fe_{0.06})_{\Sigma=2.08}Si_{1.93}O_{7.90}(OH)_{4.10}$.

Occurrence: As small grains filling interstices between crystals of other minerals in a manganese ore deposit (Tachgagalt mine, Morocco).

Association: Marokite, hausmannite, gaudefroyite, calcite (Tachgagalt mine, Morocco); hausmannite, manganite, hematite, calcite, barite, andradite (N'Chwaning mine, South Africa).

Distribution: In the Tachgagalt manganese mine, Anti-Atlas Mountains, Morocco. From the N'Chwaning and Wessels mines, near Kuruman, Cape Province, South Africa.

Name: For Henri F.E. Termier (1897–), Professor of Geology at the Sorbonne, Paris, France.

Type Material: National School of Mines, Paris, France.

References: (1) Gaudefroy C., M. Orliac, F. Permingeat, and A. Parfenoff (1969) L'henritermiérite, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 92, 185–190 (in French with English abs.). (2) Aubry, A., Y. Dusausoy, A. Laffaille, and J. Protas (1969) Détermination et étude de la structure cristalline de l'henritermiérite, hydrogrenat de symétrie quadratique. Bull. Soc. fr. Minéral., 92, 126–133 (in French with English abs.). (3) (1969) Amer. Mineral., 54, 1739 (abs. refs. 1 and 2).

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Henryite $Cu_4Ag_3Te_4$

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Crystal Data: Cubic. *Point Group:* n.d. As anhedral grains, to 0.8 mm.

Physical Properties: Hardness = n.d. VHN = 109–115 (100 g load). D(meas.) = n.d. D(calc.) = 7.86

Optical Properties: Opaque. *Color:* In reflected light, pale blue.
R: (400) 41.8, (420) 40.2, (440) 38.7, (460) 37.4, (480) 36.2, (500) 35.1, (520) 34.0, (540) 33.1, (560) 32.3, (580) 31.4, (600) 30.4, (620) 29.4, (640) 28.4, (660) 27.4, (680) 26.5, (700) 25.7

Cell Data: *Space Group:* n.d. a = 12.20(2) Z = 8

X-ray Powder Pattern: Bisbee, Arizona, USA.
2.157 (10), 3.050 (8), 7.04 (6), 2.348 (6), 4.31 (5), 3.522 (5), 2.728 (5)

Chemistry:

	(1)	(2)
Cu	22.3	23.36
Ag	30.2	29.74
Te	47.5	46.90
Total	100.0	100.00

(1) Bisbee, Arizona, USA; by electron microprobe, average of five analyses; corresponding to $Cu_{3.77}Ag_{3.01}Te_{4.00}$. (2) $Cu_4Ag_3Te_4$.

Occurrence: Of hydrothermal origin, with other Cu–Ag tellurides.

Association: Hessite, petzite, sylvanite, altaite, rickardite, pyrite.

Distribution: From the Campbell mine, Bisbee, Cochise Co., Arizona, USA [TL].

Name: In honor of Professor Norman Fordyce McKerron Henry (1909–1983), mineralogist and ore microscopist, University of Cambridge, Cambridge, England.

Type Material: The Natural History Museum, London, England, 1982,209; National Museum of Natural History, Washington, D.C., USA, 162714.

References: (1) Criddle, A.J., C.J. Stanley, J.E. Chisholm, and E.E. Fejer (1983) Henryite, a new copper–silver telluride from Bisbee, Arizona. Bull. Minéral., 106, 511–517. (2) (1985) Amer. Mineral., 70, 216 (abs. ref. 1).

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Henrymeyerite $BaFeTi_7O_{16}$

Crystal Data: Tetragonal. *Point Group*: 4/*m*. Crystals, prismatic acicular, to 0.2 mm, exhibiting {100}, {110} and {101}.

Physical Properties: *Cleavage*: none reported. *Fracture*: Splintery.
Tenacity: Very brittle. Hardness = 5-6 (estimated) D(meas.) = 4.0(1) D(calc.) = 4.20(1)

Optical Properties: Opaque. *Color*: Black; in reflected light grayish brown.
Streak: Reddish brown. *Luster*: Adamantine. *Bireflectance*: weak; brownish to grayish white.
Optical Class: n.d.
R_1-R_2: (420) 13.0-14.2, (440) 12.2-13.4, (460) 12.0-13.0, (480) 11.9-12.8, (500) 11.8-12.7, (520) 11.8-12.6, (540) 11.6-12.6, (560) 11.5-12.6, (580) 11.4-12.7, (600) 11.4-12.9, (620) 11.4-13.2, (640) 11.4-13.5, (660) 11.3-13.8, (680) 11.3-14.1, (700) 11.2-14.4 , (720) 11.2-14.5

Cell Data: *Space Group*: *I*4/*m*. a = 10.219(3) c = 2.963(1) Z = 1

X-ray Powder Pattern: Calculated from structure refinement.
3.232 (100), 2.236 (40), 2.486 (34), 1.598 (33), 1.901 (31), 1.405 (26), 1.703 (22)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.37	1.84	Na_2O	0.40	0.4
Al_2O_3	-	0.14	K_2O	0.05	0.2
TiO_2	67.78	66.43	La_2O_3	0.50	0
CaO	0.02	0.19	Ce_2O_3	0.56	0
FeO	9.20	8.06	Nb_2O_5	1.00	0.49
MgO	-	0.86	Total	98.13	96.77
BaO	18.25	18.16			

(1) Kovodor, Kola Peninsula, Russia; average of 8 electron microprobe analyses, total iron as Fe^{2+}, corresponding to $(Ba_{0.96}Na_{0.10}K_{0.01}REE_{0.05})_{\sum= 1.12}(Fe^{2+}{}_{1.03}Ti_{6.82}Nb_{0.06}Si_{0.04})_{\sum=7.95}O_{16}$.
(2) Oasis Dzetti, Prince Charles Mountains, eastern Antarctica; total iron as Fe^{2+}, corresponding to $(Ba_{0.95}Ca_{0.03}K_{0.03}Na_{0.10})_{\sum=1.11}(Fe_{0.90}\ Mg_{0.17})_{\sum=1.07}(Ti_{6.65}Nb_{0.03}Si_{0.24}Al_{0.02})_{\sum=6.94}O_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: In late-stage veins associated with metasomatized phoscorite-carbonatite rocks of an alkaline ultramafic complex (Kovodor, Russia); in carbonate-metasomatized lherzolitic and harzburgitic mantle xenoliths (Prince Charles Mountains, Antarctica).

Association: Dolomite, fluorapatite, niobian anatase (?), tetra-ferriphlogopite, rimkorolgite, catapleiite, collinsite, pyrite (Kovodor, Russia); ferroan magnesite, clinohumite, mica, calcite, dolomite, chlorapatite (Prince Charles Mountains, Antarctica).

Distribution: From the Kovodor and Seblyavr Complexes, Kola Peninsula, Russia; near Oasis Dzetti, Prince Charles Mountains, Eastern Antarctica.

Name: Honors Professor Henry O.A. Meyer (1937–1995) for his contributions to the petrology and mineralogy of mantle-derived xenoliths and kimberlitic rocks.

Type Material: Geological Museum of the Kola Science Center, Apatity, Russia.

References: (1) Mitchell, R.H., V.N. Yakovenchuk, A.R. Chakhmouradian, P.C. Burns and Y.A. Pakhomovsky (2000) Henrymeyerite, a new hollandite-type Ba-Fe titanate from the Kovodor Complex, Russia. Can. Mineral., 38, 617-626. (2) Kogarko L.N., G. Kurat and T. Ntaflos (2007) Henrymeyerite in the metasomatized upper mantle of eastern Antarctica, Can. Mineral., 45, 497-501. (3) (2001) Amer. Mineral., 86, 197–198 (abs. ref. 1).

Hentschelite $CuFe_2^{3+}(PO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As wedge-shaped crystals, elongated along [102], to 1 mm, composed of $\{\bar{1}11\}$, $\{11\bar{1}\}$, $\{011\}$, $\{01\bar{1}\}$, in parallel composites, and as pseudo-octahedra; in spherulites with radial structure. *Twinning:* Common, contact twins by rotation around [102], yielding a triangular composite.

Physical Properties: *Fracture:* Irregular. Hardness = 3.5 D(meas.) = n.d. D(calc.) = 3.79

Optical Properties: Translucent. *Color:* Dark green to greenish black. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = blue-green; Y = yellow-green or yellowish brown. *Orientation:* $Y = b$; $X \wedge a = 61(2)°$; $X \simeq [101]$. *Dispersion:* $r \gg v$, strong. $\alpha = 1.843(3)$ $\beta = 1.848(3)$ $\gamma = 1.945(3)$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P2_1/n$. $a = 6.984(3)$ $b = 7.786(3)$ $c = 7.266(3)$ $\beta = 117.68(2)°$ Z = 2

X-ray Powder Pattern: Reichenbach, Germany.
3.331 (100), 3.287 (58), 4.798 (38), 1.665 (24), 1.644 (18), 4.960 (17), 6.091 (15)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	33.24	35.24	35.56	Fe_2O_3	36.37	42.31	40.00
As_2O_5	2.11	0.67		CuO	19.89	15.24	19.93
SiO_2	0.03			H_2O	4.40		4.51
Al_2O_3	1.52	0.23		Total	97.56	93.69	100.00

(1) Reichenbach, Germany; by electron microprobe, average of ten analyses, total Fe as Fe_2O_3, H_2O calculated for neutrality as OH^-; corresponding to $Cu_{1.03}(Fe^{3+}_{1.87}Al_{0.12})_{\Sigma=1.99}[(PO_4)_{1.92}(AsO_4)_{0.08}]_{\Sigma=2.00}(OH)_2$. (2) Spring Creek mine, Australia; by electron microprobe, total Fe as Fe_2O_3, H_2O by DTA, Fe^{2+} estimated by analogy to the ideal structural formula of the lazulite group, then corresponding to $(Cu_{0.84}Fe^{2+}_{0.15})_{\Sigma=0.99}(Fe^{3+}_{1.93}Al_{0.02})_{\Sigma=1.95}[(PO_4)_{2.05}(AsO_4)_{0.03}]_{\Sigma=2.08}(OH)_{1.79}$. (3) $CuFe_2(PO_4)_2(OH)_2$.

Mineral Group: Lazulite group.

Occurrence: A rare secondary mineral in some oxidized copper deposits.

Association: Mimetite, beudantite, phosphogartrellite, goethite, quartz (Reichenbach, Germany); rockbridgeite, chalcosiderite, goethite, cuprite (West Phoenix mine, England); cuprite, copper, malachite, barite (Spring Creek mine, Australia); phosphosiderite, lipscombite, metatorbernite (El Criollo mine, Argentina).

Distribution: From Reichenbach, near Bensheim, Hesse, Germany. In the West Phoenix mine, near Liskeard, and the Phoenix United mines, Linkinhorne, Cornwall, England. At the Bendada pegmatite, near Guarda, Portugal. From the Spring Creek copper mine, near Wilmington, South Australia. In the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina.

Name: Honors Dr. Gerhard Hentschel (1930–), Geological Survey of Hesse, Wiesbaden, Germany.

Type Material: Natural History Museum, Mainz; Mineralogical Museum, University of Würzburg, Würzburg, Germany.

References: (1) Sieber, N.H.W., E. Tillmanns, and O. Medenbach (1987) Hentschelite, $CuFe_2(PO_4)_2(OH)_2$, a new member of the lazulite group, and reichenbachite, $Cu_5(PO_4)_2(OH)_4$, a polymorph of pseudomalachite, two new copper phosphate minerals from Reichenbach, Germany. Amer. Mineral., 72, 404–408. (2) Sieber, N.H.W., E. Tillmanns, and W. Hofmeister (1987) Structure of hentschelite, $CuFe_2(PO_4)_2(OH)_2$, a new member of the lazulite group. Acta Cryst., C43, 1855–1857. (3) Birch, W.D. and W.G. Mumme (1988) Hentschelite and perloffite from the Spring Creek copper mine, South Australia. Mineral. Mag., 52, 408–411.

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Hephaistosite $TlPb_2Cl_5$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals tabular on {010}, to 0.1 mm, displaying {010}, {101}, {100}, {001}, {011}, {110}.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.932

Optical Properties: Transparent. *Color*: Pale yellow. *Streak*: n.d. *Luster*: n.d. *Optical Class*: n.d. n = 2.0(1)

Cell Data: *Space Group*: $P2_1/c$. a = 8.9477(6) b = 7.9218(7) c = 12.4955(5) β = 90.092(4)° Z = 4

X-ray Powder Pattern: La Fossa crater, Vulcano, Aeolian Islands, Italy.
3.696 (100), 3.971 (83), 2.109 (45), 2.569 (42), 1.848 (41), 2.851 (38), 2.236 (25)

Chemistry:

	(1)	(2)
Tl	23.78	25.67
K	0.01	
Pb	51.78	52.06
Cl	21.40	22.27
Br	1.34	
F	0.17	
Total	98.48	100.00

(1) La Fossa crater, Vulcano, Aeolian Islands, Italy; average of 8 EDS electron microprobe analyses, corresponding to $Tl_{0.94}Pb_{2.01}(Cl_{4.85}Br_{0.14}F_{0.07})_{\Sigma=5.06}$. (2) $TlPb_2Cl_5$.

Occurrence: On fragments of altered pyroclastic breccia in a high temperature (400° C) fumarole, most likely formed as a sublimate.

Association: Bismuthinite, cotunnite, challacolloite, pseudocotunnite.

Distribution: La Fossa crater, Vulcano, Aeolian Islands, Italy.

Name: For *Hephaistos*, the Greek god of fire, whose workshops were believed to be located at Vulcano.

Type Material: Reference Collection, Dipartimento di Chimica Strutturale e Stereochimica Inorganica, Università degli Studi, Milan, Italy, 2006-2.

References: (1) Campostrini, I., F. Demartin, C.M. Grammaccioli, and P. Orlandi (2008) Hephaistosite, $TlPb_2Cl_5$, a new thallium mineral species from La Fossa crater, Vulcano, Aeolian Islands, Italy. Can. Mineral., 46, 701–708. (2) (2009) Amer. Mineral., 94, 399-400 (abs. ref. 1).

Herbertsmithite $Cu_3Zn(OH)_6Cl_2$

Crystal Data: Hexagonal. *Point Group:* $\bar{3}$ 2/*m*. As rhombohedra to 1 mm.

Physical Properties: *Cleavage:* Good {10$\bar{1}$ 1}. *Fracture:* n.d. *Tenacity:* n.d.
Hardness = 3-3.5 D(meas.) = 3.75-3.95 D(calc.) = 3.75

Optical Properties: Transparent. *Color:* Dark green to blue-green. *Streak:* n.d.
Luster: Vitreous.
*Optical Class: U*niaxial (-). ε = 1.817(2) ω = 1.825(2)
Pleochroism: Green to greenish blue, weak. *Absorption: O > E*.

Cell Data: *Space Group: R* $\bar{3}$ *m.* *a* = 6.834(1) *c* = 14.075(2) Z = 3

X-ray Powder Pattern: Mina Los Tres Presidentes, Chile.
2.764 (100), 5.466 (55), 2.266 (36), 1.709 (18), 4.702 (14), 2.730 (13), 1.820 (13)

Chemistry:

	(1)
CuO	56.1
ZnO	18.2
Cl	17.2
H_2O	12.5
$-O = Cl_2$	3.9
Total	100.1

(1) Mina LosTres Presidentes, Chile; average of 5 electron microprobe analyses, H_2O by TGA; corresponding to $Cu_{3.02}Zn_{0.96}(OH)_{5.91}H_{0.03}Cl_{2.08}$.

Polymorphism & Series: Forms a solid-solution series with Zn-stabilized paratacamite.

Occurrence: A secondary mineral in the oxidation zone of polymetallic mineral deposits.

Association: Gypsum, opal, dioptase (Chile); wulfenite, hemimorphite, chrysocolla, rosasite, iranite, diaboléite (Iran).

Distribution: Mina Los Tres Presidentes, Sierra Gorda, Chile; at the Kali Kafi and Chah Khouni mines, Anarak, Iran.

Name: Honors G.F. Herbert Smith (1872-1953), British Museum (Natural History), who discovered paratacamite.

Type Material: Natural History Museum, London, England; BM 2003.33.

References: (1) Braithwaite, R.S.W., K. Mereiter, W.H. Paar, and A.M. Clark (2004) Herbertsmithite, $Cu_3Zn(OH)_6Cl_2$, a new species, and the definition of paratacamite. Mineral. Mag., 68, 527-539. (2) (2005) Amer. Mineral., 90, 519 (abs. ref. 1).

Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Massive, granular, or embedded in other minerals. *Twinning:* On {111} as both twin and composition plane, the spinel law, simple, multiple, and lamellar.

Physical Properties: *Cleavage:* Parting on {111}, probable. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7.5–8 D(meas.) = 4.40 D(calc.) = [4.26]

Optical Properties: Opaque, translucent through thin edges. *Color:* Dark green to black; dark green in thin section. *Streak:* Dark grayish green to dark green. *Luster:* Vitreous. *Optical Class:* Isotropic. n = 1.80–1.83

Cell Data: *Space Group: Fd3m* (synthetic). a = 8.15579(6) Z = 8

X-ray Powder Pattern: Synthetic.
2.459 (100), 2.884 (58), 1.442 (50), 1.570 (41), 0.8324 (22), 2.039 (17), 1.665 (17)

Chemistry:

	(1)	(2)	(3)
SiO_2		2.0	
Al_2O_3	60.7	56.0	58.66
Cr_2O_3		8.0	
FeO	34.7	24.9	41.34
MnO	0.2		
MgO	4.3	10.3	
CaO	0.1		
Total	100.0	101.2	100.00

(1) Plössberg, Germany. (2) Lake Lherz, France. (3) $FeAl_2O_4$.

Mineral Group: Forms three series, with spinel, with gahnite, and with chromite.

Mineral Group: Spinel group.

Occurrence: In high-grade metamorphosed ferruginous argillaceous sediments and in some mafic and ultramafic igneous rocks. Also in placers.

Association: Magnetite, corundum, ilmenite, sillimanite, andalusite.

Distribution: Numerous localities; a few well-studied occurrences include: from Načetín and Hoslau, near Ronsberg, Czech Republic. At Schenkenzell, Black Forest; at Plössberg, Bodenmais, Bavaria; and at Mendig, Eifel district, Germany. From Lake Lherz, Ariège, France. On the Island of Mull, Scotland. In the Khibiny massif, Kola Peninsula, Russia. From near Erode, Coimbatore, Madras, India. From between Farafangana and Vangaindrano, Madagascar. At Peekskill, Westchester Co., New York; near Whittles, Pittsylvania Co., Virginia; and from Rice, near San Carlos, Gila Co., Arizona, USA. From Cuauhtémoc, Chihuahua, Mexico. Found near Moorina, Tasmania.

Name: From the Latin, *Silva Hercynia*, for the Bohemian Forest, Czech Republic, where the mineral was first found.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 689–697. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 56–67. (3) Propach, G. (1971) Hercynit und Ilmenit aus dem Korund-Spinell-Fels von Plössberg (Opf.). Neues Jahrb. Mineral., Abh., 115, 120–122. (4) Hill, R.J. (1984) X-ray powder diffraction profile refinement of synthetic hercynite. Amer. Mineral., 69, 937 942. (5) Larsson, L., H.St.C. O'Neill, and H. Annersten (1994) Crystal chemistry of synthetic hercynite ($FeAl_2O_4$) from XRD structural refinements and Mössbauer spectroscopy. Eur. J. Mineral., 6, 39–51.

Herderite $CaBe(PO_4)F$

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Crystal Data: [Monoclinic, pseudo-orthorhombic] (by analogy to hydroxylherderite). *Point Group:* $2/m$. Crystalline.

Physical Properties: Hardness = 5–5.5 D(meas.) = 3.02 D(calc.) = n.d. Fluoresces violet under UV; cathodoluminesces and phosphoresces pinkish orange under X-rays.

Optical Properties: Transparent. *Color:* Light green; colorless in transmitted light.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* r > v, moderate. α = 1.556–1.59 β = 1.578–1.61 γ = 1.589–1.62 2V(meas.) = n.d. 2V(calc.) = 70°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Cannot be distinguished from hydroxylherderite; similar to datolite.

Chemistry: (1) Electron microprobe analysis of a gemstone from "Brazil" shows F 7.0% (so with F> 5.86%, the series midpoint).

Polymorphism & Series: Forms a series with hydroxylherderite.

Occurrence: Probably from a complex granite pegmatite.

Association: n.d.

Distribution: Originally found in Germany, at Ehrenfriedersdorf, Saxony, but the analysis showing F > OH is suspect and any material from this locality seems unavailable. A gemstone from "Brazil" is the only known fluorine-dominant herderite proven by modern analytical methods.

Name: To honor Siegmund August Wolfgang von Herder (1776–1838), mining official, Freiberg, Saxony, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 820–822. (2) Dunn, P.J. and W. Wight (1976) Green gem herderite from Brazil. J. Gemmology, 15, 27–28. (3) Leavens, P.B., P.J. Dunn, and R.V. Gaines (1978) Compositional and refractive index variations of the herderite – hydroxyl-herderite series. Amer. Mineral., 63, 913–917.

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Herzenbergite SnS

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. Fine-grained, massive.

Physical Properties: *Cleavage:* {001}. Hardness = ∼2 VHN = n.d. D(meas.) = 5.22 D(calc.) = 5.19

Optical Properties: Opaque. *Color:* Black; in polished section, white, with internal reflections in dark red-brown. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Very low, light to darker blue-white. *Anisotropism:* Intense in oil, with yellow to red colors.
R_1–R_2: (400) 45.9–52.9, (420) 45.6–53.6, (440) 45.2–53.8, (460) 44.6–53.2, (480) 44.0–52.2, (500) 43.7–51.2, (520) 43.6–50.6, (540) 43.2–49.9, (560) 42.3–48.8, (580) 41.4–47.6, (600) 40.7–46.6, (620) 40.3–45.8, (640) 40.0–45.0, (660) 39.9–44.2, (680) 39.6–43.7, (700) 39.3–43.1

Cell Data: *Space Group: Pbnm.* $a = 4.3291(2)$ $b = 11.1923(4)$ $c = 3.9838(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
2.835 (100), 2.931 (70), 3.244 (65), 3.423 (50), 2.797 (50), 2.305 (50), 1.9921 (50)

Chemistry:

	(1)	(2)
Sn	80.0	78.73
S	20.2	21.27
Total	100.2	100.00

(1) Maria-Teresa mine, Bolivia; by electron microprobe. (2) SnS.

Occurrence: Of hydrothermal origin, later than the deposition of cassiterite.

Association: Cassiterite, stannite, romarchite, ottemannite, černýite, berndtite, pyrite, chalcopyrite, sphalerite, arsenopyrite, quartz.

Distribution: Fom the Maria-Teresa mine, near Huari, between Oruro and Uyuni, Bolivia [TL]. At the Stiepelmann mine, near Arandis, Namibia. From Shinkiura and in the Hoei tin mine, Oita Prefecture, Japan. In Russia, from the Goluboye deposit, Primorskiy Kray; at the Baimka placer deposit, western Chukotka; and in the Druzhba deposit, Sakha. In Sweden, from Järkvissle, 55 km northwest of Sundsvall, Västernorrland, and at Björkskogsnaes, Hällefors. In the Barquilla deposit, Salamanca Province, Spain.

Name: To honor Robert Herzenberg (1885–1956), Latvian–German chemist of Oruro, Bolivia.

Type Material: The Natural History Museum, London, England, 1933,93; Harvard University, Cambridge, Massachusetts, USA, 92713.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 259–260. (2) Del Bucchia, S., J.-C. Jumas, and M. Maurin (1981) Contribution à l'etude de composés sulfurés d'etain(II): affinement de la structure de SnS. Acta Cryst., 37, 1903–1905 (in French with English abs.). (3) Sugaki, A., A. Kitakaze, and H. Kitazawa (1985) Synthesized tin and tin-silver sulfide minerals. Synthetic sulfide minerls (XII). Sci. Rep. Tohoku Univ., 16, 199–211. [??X-ray or use ICDD 39-354??] (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 659–660. [ck latest??] (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 236.

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Hessite Ag_2Te

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals pseudocubic, highly modified and generally irregularly developed and distorted, to 1.7 cm. Also massive, compact, or fine-grained. *Twinning:* Twin lamellae visible in polished section.

Physical Properties: *Cleavage:* {100}, indistinct. *Fracture:* Even, smooth. *Tenacity:* Sectile. Hardness = 2–3 VHN = 22–24 (100 g load). D(meas.) = 8.24–8.45 D(calc.) = 8.395

Optical Properties: Opaque. *Color:* Lead-gray to steel-gray, tarnishing to black. *Luster:* Metallic. *Anisotropism:* Distinct, from dark orange to dark blue.
R_1–R_2: (400) 40.7–42.6, (420) 40.3–41.8, (440) 40.0–41.1, (460) 39.7–40.6, (480) 39.7–40.1, (500) 39.9–39.7, (520) 40.3–39.4, (540) 40.8–39.4, (560) 41.3–39.3, (580) 41.9–39.4, (600) 42.4–39.3, (620) 42.8–39.3, (640) 43.2–39.3, (660) 43.5–39.3, (680) 43.6–39.2, (700) 43.5–39.0

Cell Data: *Space Group:* $P2_1/c$. $a = 8.164(1)$ $b = 4.468(1)$ $c = 8.977(1)$ $\beta = 124.16°$ $Z = 4$

X-ray Powder Pattern: Boteş, Romania.
2.31 (100), 2.87 (80), 2.25 (70), 3.01 (60), 2.14 (60), 1.389 (40), 3.19 (20)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	62.42	61.16	61.52	62.86
Au			1.01	
Pb		1.90		
Te	36.96	36.11	37.77	37.14
rem.	0.24	0.83		
Total	99.62	100.00	100.30	100.00

(1) Zavodinskii mine, Kazakhstan. (2) San Sebastián, Mexico. (3) Boteş, Romania. (4) Ag_2Te.

Polymorphism & Series: Inverts to a cubic form above 155 °C.

Occurrence: In hydrothermal medium- and low-temperature veins; also in small quantities in some massive pyrite deposits.

Association: Calaverite, sylvanite, altaite, petzite, empressite, rickardite, gold, tellurium, pyrite, galena, tetrahedrite, chalcopyrite.

Distribution: In Romania, from Săcărîmb (Nagyág) [TL], Băiţa (Rézbánya), and in exceptional crystals and masses from Boteş, near Zlatna. In Kazakhstan, from the Zavodinskii mine, near Ziryanovsk, Altai Mountains. In the Bereznyakov gold deposit and the Yaman-Kasy Cu–Zn–pyrite deposits, Southern Ural Mountains, Russia. At Sulitjelma, northern Norway. From Kalgoorlie, Western Australia. In the Emperor mine, Vatukoula, and in the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands. At the Bulawan deposit, Negros Occidental, Phillipines. In Chile, from the Condorriaco mine, near Coquimbo, and in the Wendy open pit, El Indio-Tambo district, east of La Serena, Coquimbo. In the USA, from Gold Hill, Boulder Co., and in the Eagle mine, Gilman district, Eagle Co., Colorado; in California, from the Stanislaus mine, Carson Hill district, Calaveras Co.; the McAlpine mine, Sonora, and the Jamestown mine, Tuolumne Co.; and Nevada City, Nevada Co.; in Arizona, from the Campbell mine, Bisbee, and at Tombstone, Cochise Co. In small amounts at numerous localities in Ontario, British Columbia, and Quebec, Canada, and other localities world-wide.

Name: To honor Germain Henri Hess (1802–1850), Swiss-Russian physician and chemist, of St. Petersburg, Russia.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 184–186. (2) Van der Lee, A. and J.L. de Boer (1959) Redetermination of the structure of hessite, Ag_2Te – III. Acta Cryst., C49, 1444–1446. (3) Thompson, R.M. (1949) The telluride minerals and their occurrence in Canada. Amer. Mineral., 34, 342–382. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 237.

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Hetaerolite $ZnMn_2^{3+}O_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m2/m2/m$. As pyramidal crystals, to 1 cm; also as botryoidal to stalactitic aggregates, and fibrous. As exsolution lamellae in franklinite. *Twinning:* On {112}, producing fivelings, very rare.

Physical Properties: *Cleavage:* {001}, indistinct; two additional, probably on {112} and {011}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6 VHN = 528–707 (100 g load). D(meas.) = 5.18 D(calc.) = [5.21]

Optical Properties: Opaque, transparent through thin edges. *Color:* Brownish black to black; deep reddish brown in transmitted light; gray under reflected light. *Streak:* Dark brown. *Luster:* Metallic to submetallic.
Optical Class: Uniaxial (–). *Absorption:* Faint; $E > O$. $\omega = 2.34(2)$ $\epsilon = 2.14(2)$
Anisotropism: Strong.
R_1–R_2: (400) 19.3–25.8, (420) 18.3–24.0, (440) 17.3–22.2, (460) 16.5–21.0, (480) 15.8–20.1, (500) 15.4–19.4, (520) 15.0–18.9, (540) 14.7–18.4, (560) 14.5–18.1, (580) 14.2–17.8, (600) 14.0–17.6, (620) 13.9–17.4, (640) 13.7–17.2, (660) 13.6–17.0, (680) 13.5–16.9, (700) 13.4–16.8

Cell Data: *Space Group:* $I4_1/amd$. a = 5.75 c = 9.22–9.23 Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.462 (100), 2.707 (90), 3.040 (80), 1.5209 (70), 2.855 (50), 1.5634 (50), 2.019 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.18			ZnO	32.46	32.6	34.02
Mn_2O_3	64.21	67.2	65.98	MgO	0.49		
Fe_2O_3	0.24	0.17		H_2O	0.19		
MnO	1.86			Total	99.63	99.97	100.00

(1) Sterling Hill, New Jersey, USA; corresponds to $(Zn_{0.94}Mn^{2+}_{0.06})_{\Sigma=1.00}(Mn^{3+}_{1.93}Fe^{3+}_{0.10}Si_{0.01})_{\Sigma=2.04}O_{3.92}\bullet 0.02H_2O$. (2) Kennack Sands, England; by electron microprobe, total Mn as Mn_2O_3, total Fe as Fe_2O_3; corresponds to $Zn_{0.95}Mn_{2.03}O_4$. (3) $ZnMn^{3+}_2O_4$.

Occurrence: A secondary mineral associated with other manganese minerals, primarily in hydrothermal ore deposits.

Association: Franklinite, chalcophanite, hodgkinsonite, willemite, hemimorphite, manganite, romanechite, calcite.

Distribution: In the USA, from Sterling Hill, Ogdensburg, and Franklin, Sussex Co., New Jersey; in Arizona, in Cochise Co., at the Lucky Cuss mine, Tombstone, and the Campbell and Junction mines, Bisbee; the 79 mine, Banner district, Gila Co.; and the Domeroy property, Pioneer district, Pinal Co. From the Contact mine, Grant Co., New Mexico; in the Mohawk mine, San Bernardino Co., California; and the Wolftone mine, Leadville, Lake Co., Colorado. In Romania, at Rodna. At Moresnet, Belgium. On Mont Chemin, Valais, Switzerland. From Kennack Sands, Cornwall, England. In the Maruyama and Oe mines, Aomori Prefecture, Japan. From the EZ mine, near Beltana, South Australia. Other occurrences are known.

Name: From the Greek for *companion*, for its occasional association with chalcophanite.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 134145.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 715–717. (2) Frondel, C. and E.W. Heinrich (1942) New data on hetaerolite, hydrohetaerolite, coronadite, and hollandite. Amer. Mineral., 27, 48–56. (3) Frondel, C. and C. Klein, Jr. (1965) Exsolution in franklinite. Amer. Mineral., 50, 1670–1680. (4) Bevins, R.E., R.F. Symes, J.M. Horák, and V. Holyer (1987) Hetaerolite from Eastern Cliff, Kennack Sands, Cornwall: the first British occurrence. Mineral. Mag., 51, 172–173. (5) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 597–599.

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Heterogenite $Co^{3+}O(OH)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}2/m$ or $6/m2/m2/m$. Crystals very rare, hexagonal, prismatic, to 1 mm; commonly massive, globular to reniform, stalactitic; as thin coatings, earthy. *Twinning:* Commonly observed in polished section.

Physical Properties: *Cleavage:* In crystals, {0001}. *Fracture:* Conchoidal. Hardness = 3–5 VHN = 420–640 (100 g load). D(meas.) = 3.07–4.32; 4.72 (synthetic). D(calc.) = 4.92

Optical Properties: Opaque. *Color:* Black, blackish brown, reddish brown; in reflected light, white with brownish tinge. *Streak:* Dark brown. *Luster:* Dull to vitreous.
Optical Class: Uniaxial. *Anisotropism:* Strong; bluish to yellowish white, browns.
Bireflectance: Very strong.
R_1–R_2: (400) 15.0–30.4, (420) 15.8–30.4, (440) 16.6–30.4, (460) 16.7–29.8, (480) 16.6–28.8, (500) 16.3–27.8, (520) 16.2–27.0, (540) 16.3–26.4, (560) 16.6–26.0, (580) 16.7–25.6, (600) 16.7–25.3, (620) 16.5–25.0, (640) 16.4–24.8, (660) 16.2–24.5, (680) 16.0–24.2, (700) 15.8–23.8 (3R).

Cell Data: *Space Group:* $R\overline{3}m$,synthetic (3R), with $a = 2.855$ $c = 13.156$ Z = 3, or
Space Group: $P6_3/mmc$(2H), with $a = 2.855(5)$ $c = 8.805(5)$ Z = 2

X-ray Powder Pattern: Katanga (Shaba Province), Congo (3R).
4.40 (vvs), 2.315 (vs), 1.427 (ms), 1.804 (s), 2.428 (m), 1.356 (m), 1.979 (mw)

X-ray Powder Pattern: Mindigi, Congo (2H).
4.39 (vvs), 1.236 (vs), 2.472 (ms), 1.262 (ms), 2.158 (s), 1.644 (s), 2.381 (mw)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Al_2O_3	0.2			NiO	0.3	2.0	
Fe_2O_3	0.5			CuO	3.6		
Co_2O_3	74.7	88.1	90.20	H_2O	[20.7]	9.9	9.80
CoO	0.0			Total	[100.0]	100.0	100.00

(1) Katanga (Shaba Province), Congo; H_2O by difference. (2) Mindigi, Congo; by electron microprobe, H_2O by TGA. (3) CoO(OH).

Polymorphism & Series: 3R and 2H polytypes.

Occurrence: A weathering product of smaltite (Schneeberg, Germany); an alteration product of linnaeite, constituting an important ore of cobalt (Shaba Province, Congo); widespread in residual soils above ultramafic rocks (New Caledonia).

Association: Smaltite, pharmacosiderite, calcite (Schneeberg, Germany); linnaeite, sphaerocobaltite, malachite, cuprite (Shaba Province, Congo).

Distribution: Localities for well-characterized material include: at Schneeberg, Saxony; at the Anton mine, Heubachtal, and Wittichen, Black Forest; and at Richelsdorf, Hesse, Germany. From Congo (Zaire), in Katanga (Shaba) Province, in the Star of the Congo mine, near Lubumbashi; from Shinkolobwe; and at Mindigi. From Tsumeb, Namibia. At Bou Azzer, Morocco. In the Pabellón mine, Rio Copiapó, Atacama, Chile. In the USA, from Goodsprings, Clark Co., Nevada. At the Nanganobori Co–Ni mine, Yamaguchi Prefecture, Japan. Found in Rocky's Reward pit, near Agnew, Western Australia. Many occurrences in New Caledonia.

Name: From the Greek for *of another kind*, as differing in composition from similar minerals.

Type Material: Mining Academy, Freiberg, Germany, 11752; Royal Museum of Central Africa, Tervuren, Belgium, RGM10800.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 652 [heterogenite, trieuite, boodtite], 650–651 [stainierite]. (2) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 1057–1059 [heterogenite-stainierite]. (3) Hey, M. (1962) Cobaltic hydroxide in nature. Mineral. Mag., 33, 253–259. (4) Deliens, M. and H. Goethals (1973) Polytypism of heterogenite. Mineral. Mag., 39, 152–157. (5) Llorca, S. and P. Monchoux (1991) Supergene cobalt minerals from New Caledonia. Can. Mineral., 29, 149–161.

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Heteromorphite $Pb_7Sb_8S_{19}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are pyramidal, tending to be elongated parallel to pyramid edges; also rounded, striated forms; twisted, distorted, and composed of subparallel individuals; massive.

Physical Properties: *Cleavage:* Good on {112}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = n.d. D(meas.) = 5.73 D(calc.) = 5.86

Optical Properties: Opaque. *Color:* Iron-black. *Streak:* Black. *Luster:* Metallic. R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/c$. $a = 13.628(5)$ $b = 11.943(4)$ $c = 21.285(8)$ $\beta = 90°55(7)'$ Z = 4

X-ray Powder Pattern: Wolfsberg, Germany.
3.30 (100), 3.40 (80), 3.25 (80), 3.75 (70), 3.10 (70), 2.970 (70b), 2.884 (70)

Chemistry:

	(1)	(2)
Pb	47.86	47.81
Zn	0.60	
Sb	31.20	32.11
S	19.90	20.08
Total	99.56	100.00

(1) Arnsberg, Germany. (2) $Pb_7Sb_8S_{19}$.

Occurrence: Of hydrothermal origin.

Association: Sphalerite, plagionite, semseyite.

Distribution: In Germany, from Arnsberg, North Rhine-Westphalia [TL], and Wolfsberg, Harz Mountains. At Příbram, Czech Republic. In the Kara Kamar deposit, Tajikistan. From Yecora, five km west of Iglesia, Sonora, Mexico.

Name: From the Greek for *different* and *form*, in allusion to the difference between this mineral and a proposed dimorphous species.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 465–466. (2) Jambor, J.L. (1969) Sulphosalts of the plagionite group. Mineral. Mag., 37, 442–446. (3) Edenharter, A. (1980) Die Kristallstruktur von Heteromorphit, $Pb_7Sb_8S_{19}$. Zeits. Krist., 151, 193–202 (in German with English abs.).

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Heterosite $(Fe^{3+}, Mn^{3+})PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As cleavable blocky masses.

Physical Properties: *Cleavage:* Good on {100}; poor on {010}; surfaces may be curved. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 3.40 D(calc.) = [3.67]

Optical Properties: Translucent to opaque. *Color:* Deep rose to purple, black. *Streak:* Pale purple. *Luster:* Satiny on fresh surfaces, dull to earthy.
Optical Class: Biaxial (–). *Pleochroism:* Intense; X = yellow brown, $Y = Z$ = reddish purple; optic axis sections show anomalous green interference colors. *Orientation:* $X = a$. *Absorption:* $Z \geq Y > X$. $\alpha = 1.86(1)$ $\beta = 1.89(1)$ $\gamma = 1.91(1)$ 2V(meas.) = 37°

Cell Data: *Space Group: Pmnb.* $a = 5.83(1)$ $b = 9.79(1)$ $c = 4.769(5)$ Z = 4

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA. (ICDD 34–134).
2.452 (100), 4.31 (90), 3.46 (85), 2.92 (85), 4.94 (60), 2.412 (40), 2.96 (35)

Chemistry:

	(1)	(2)
P_2O_5	43.45	47.20
Fe_2O_3	38.36	26.55
Mn_2O_3	12.08	26.25
MgO	trace	
CaO	1.37	
Li_2O	trace	
Na_2O	trace	
H_2O	4.82	
insol.	0.19	
Total	100.27	100.00

(1) Hill City, South Dakota, USA. (2) $(Fe, Mn)PO_4$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with purpurite.

Occurrence: A secondary mineral in the oxidized zone of complex granite pegmatites, replacing primary phosphate minerals, principally triphylite.

Association: Triphylite, ferrisicklerite, many secondary Fe–Mn phosphates.

Distribution: Widespread in weathered phosphate-bearing pegmatites. Some prominent localities include: in France, in Haute-Vienne, from near Limoges, Huréaux, and in the La Vilate quarry, near Chanteloube. At Hagendorf, and Hühnerkobel, near Zwiesel, Bavaria, Germany. From the Norrö pegmatite, on Rånö Island; Skrumpetorp, Östergötand; and in the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. At Sukula and Tammela, Finland. In the USA, from the Fletcher and Palermo #1 mines, near North Groton, Grafton Co., New Hampshire; at Newry, Oxford Co., Maine; around Hill City, Pennington Co., and elsewhere in South Dakota. In the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, and several other localities in Minas Gerais, Brazil. At the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. From the Angarf-Sud pegmatite, Tazenakht Plain, Anti-Atlas Mountains, Morocco.

Name: From the Greek for *another*, probably because it was the second manganese-bearing species described from the type locality.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 675–677. (2) Eventoff, W., R. Martin, and D.R. Peacor (1972) The crystal structure of heterosite. Amer. Mineral., 57, 45–51.

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Heulandite $(Ca, Na_2)Al_2Si_7O_{18}\cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly tabular ‖ {010}, and elongated, widest at the center, hence called "coffin-shaped," to 12 cm; also granular to massive. *Twinning:* With {100} as twin and contact plane.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.10–2.20 D(calc.) = 2.17

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, yellow, red, pink, orange, brown, black; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on {010}.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge a = 0°$–$34°$; $Y \wedge c = 0°$–$32°$.
Dispersion: $r > v$, distinct, crossed. $\alpha = 1.491$–1.505 $\beta = 1.493$–1.503 $\gamma = 1.500$–1.512
2V(meas.) = 0°–55° 2V(calc.) = 34°

Cell Data: *Space Group:* $C2/m$. $a = 17.77(2)$ $b = 17.95(2)$ $c = 7.435(7)$
$\beta = 116.46(5)°$ Z = 4

X-ray Powder Pattern: Giebelsbach, Switzerland.
3.917 (100), 2.959 (90), 8.84 (80), 7.80 (70), 5.096 (70), 3.420 (70), 2.805 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	60.06	57.17	BaO	0.75	0.31
Al_2O_3	13.65	17.03	Na_2O	1.07	1.39
Fe_2O_3	1.16	0.04	K_2O	0.66	0.73
MgO	0.38	0.02	H_2O^+	12.43	
CaO	4.44	7.13	H_2O^-	3.11	
SrO	1.35	0.19	H_2O		16.71
			Total	99.06	100.72

(1) Col Aut, Buffaure, Trentino-Alto Adige, Italy; corresponds to $(Ca_{0.56}Na_{0.24}K_{0.10}Sr_{0.09}Mg_{0.07}Ba_{0.03})_{\Sigma=1.09}Al_{1.89}Fe_{0.10}Si_{7.05}O_{18}\cdot 6.08H_2O$. (2) Faeroe Islands; corresponds to $(Ca_{0.89}Na_{0.32}K_{0.11}Ba_{0.02}Sr_{0.01})_{\Sigma=1.35}Al_{2.34}Si_{6.68}O_{18}\cdot 6.50H_2O$.

Mineral Group: Zeolite group.

Occurrence: In cavities in basalts; in highly weathered andesites and diabases; as a devitrification product of volcanic glasses and tuffs.

Association: Zeolites, datolite, apophyllite, calcite.

Distribution: Many localities, even for fine specimens. Exceptional crystals from the Teigarhorn, Berufjord, Iceland. At Haldarsvik, on Streymoy, Faeroe Islands. Around Glasgow, Dumbartonshire, Scotland. At Giebelsbach, near Fiesch, Valais, Switzerland. In the USA, at Paterson, Passaic Co., and Bergen Hill, Hudson Co., New Jersey; at Goble, Columbia Co., and elsewhere in Oregon; at Skookumchuck Dam, near Bucoda, Thurston Co., Washington. From Cape Blomiden, Nova Scotia, Canada. From near Bento Gonçalves, Rio Grande do Sul, Brazil. Large crystals from the Nasik, Poona, and Bombay districts, Maharashtra, India. At Tambar Springs, near Gunnedah, New South Wales, Australia.

Name: For the English mineral collector and dealer John Henry Heuland (1778–1856).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 573–576. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 377–384. (3) Alietti, A. (1972) Polymorphism and crystal chemistry of heulandites and clinoptilolites. Amer. Mineral., 57, 1448–1462. (4) Alberti, A. (1972) On the crystal structure of the zeolite heulandite. Tschermaks Mineral. Petrog. Mitt., 18, 129–146. (5) Hambley, T.W. and J.C. Taylor (1984) Neutron diffraction studies on natural heulandite and partially dehydrated heulandite. J. Solid State Chem., 54, 1–9. (6) Merkle, A.B. and M. Slaughter (1968) Determination and refinement of the structure of heulandite (1968) Amer. Mineral., 53, 1120–1138.

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Heulandite-Ba $(Ba,Ca,Sr,K,Na)_5Al_9Si_{27}O_{72}\cdot 22H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As thick tabular, trapezoidal crystals, to 4 mm, displaying {100}, {010}, {001}, {$\bar{1}$ 11} and {20$\bar{1}$ }; as aggregates to several cm.

Physical Properties: *Cleavage*: Perfect on {010}. *Fracture*: Uneven to subconchoidal. *Tenacity*: Brittle. Hardness = 3.5 D(meas.) = 2.35(1) D(calc.) = 2.350

Optical Properties: Transparent to translucent. *Color*: Colorless to white, pale yellowish white or beige. *Streak*: White. *Luster*: Vitreous, pearly on {010} cleavage surfaces. *Optical Class*: Biaxial (+). α = 1.5056(5) β = 1.5064(5) γ = 1.5150(5) 2V(meas.) = 38(1)° 2V(calc.) = 34.1° *Pleochroism*: None. *Dispersion:* Distinct, *r* > *v*. Orientation: *X* ^ *c* varies between 39 and 51°; *Z* = *b*.

Cell Data: *Space Group*: *C*2/*m*. *a* = 17.738(3) *b* = 17.856(2) *c* = 7.419(1) β = 116.55(2)° *Z* = 1

X-ray Powder Pattern: Northern Ravnås prospect, Kongsberg ore district, Norway. 2.973 (100), 3.978 (97), 7.941 (66), 4.650 (66), 2.807 (65), 5.116 (59), 3.181 (56)

Chemistry:

	(1)
SiO_2	54.26
Al_2O_3	15.27
MgO	<0.1
CaO	2.65
SrO	1.03
BaO	12.76
Na_2O	0.34
K_2O	0.58
H_2O	13.1
Total	99.99

(1) Northern Ravnås prospect, Kongsberg ore district, Norway; average of 14 electron microprobe analyses, H_2O by thermogravimetric analysis and confirmed by IR spectroscopy, corresponding to $(Ba_{2.49}Ca_{1.41}Sr_{0.30}K_{0.37}Na_{0.33})_{\Sigma=4.90}Al_{8.96}Si_{27.00}O_{72.00}\cdot 21.75H_2O$.

Occurrence: A late stage mineral in hydrothermal quartz-calcite veins.

Association: Acanthite, barite, chalcopyrite, fluorite, galena, sphalerite, silver, brewsterite, other heulandite-series zeolites, calcite, harmotome.

Distribution: From the Northern Ravnås prospect, southern Vinoren, Kongsberg ore district, Flesberg community, Buskerud county, and from the Bratteskjerpet mine, Saggrenda, and at Sjoa in Sel community, Oppland county, Norway.

Name: For its chemical composition and relationship to other heulandite minerals.

Type Material: Geological Museum, University of Oslo, Norway (33929).

References: (1) Larsen, A.O., F.S. Nordrum, N. Döbelin, T. Armbruster, O.V. Petersen, and M. Erambert. (2005) Heulandite-Ba, a new zeolite species from Norway. Eur. J. Mineral., 17, 143-153. (2) (2005) Amer. Mineral., 90, 1945-1946 (abs. ref. 1).

Hewettite $CaV_6^{5+}O_{16}\cdot 9H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As needles and fibers, elongated and intertwined ‖ [010], to 2 cm; in nodular aggregates, as fracture fillings, and coatings.

Physical Properties: Hardness = Extremely soft. D(meas.) = 2.51–2.61 D(calc.) = 2.67 Reversibly dehydrates to metahewettite.

Optical Properties: Transparent. *Color:* Deep red, to chocolate-brown on exposure; red to orange in transmitted light. *Luster:* Silky to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = Y = light yellow-orange; Z = dark red.
Orientation: $Z = c$. $\alpha = 1.77$ $\beta = 2.18$ $\gamma = 2.35$–2.4 2V(meas.) = Medium.

Cell Data: *Space Group:* $P2_1/m$. $a = 12.290(1)$ $b = 3.590(1)$ $c = 11.174(2)$ $\beta = 97.24(1)^\circ$ Z = 1

X-ray Powder Pattern: Monument No. 2 mine, Arizona, USA.
11.03 (100), 5.53 (35), 2.164 (25), 3.091 (20), 3.660 (14), 5.63 (12), 2.574 (12)

Chemistry:

	(1)	(2)
MoO_3	0.99	
V_2O_5	71.20	71.43
V_2O_4	0.43	
CaO	7.15	7.34
H_2O	21.04	21.23
Total	100.81	100.00

(1) Minasragra, Peru. (2) $CaV_6O_{16}\cdot 9H_2O$.

Occurrence: As an alteration product of patronite (Minasragra, Peru); an alteration product of less-oxidized vanadium minerals in Colorado Plateau-type U–V deposits.

Association: Metahewettite, corvusite, montroseite, rauvite, steigerite, fervanite, navajoite, carnotite, tyuyamunite (Colorado Plateau deposits, USA).

Distribution: From Minasragra, 46 km from Cerro de Pasco, Peru. In the USA, in the Jo Dandy mine, Bull Canyon district, Paradox Valley, Uravan district, Montrose Co., Colorado; in Utah, from the Cactus Rat mine group, Yellow Cat district, 24 km southeast of Thompson, Grand Co.; in Arizona, long fibers from the Monument No. 2 mine, Monument Valley, also in the Carrizo and Lukachukai Mountains, Apache Co., and in the Monument No. 1 and Mitten No. 2 mines, Navajo Co.; in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada. From the Edgemont district, Fall River Co., South Dakota; and in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas. In several mines of the Kurumsak and Balasauskandyk districts, northwestern Kara-Tau Mountains, Kazakhstan.

Name: For Donnel Foster Hewett (1881–1971), geologist with the U.S. Geological Survey, who described the mineralogy of Minasragra, Peru.

Type Material: National Museum of Natural History, Washington, D.C., USA, 87459.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1060–1061. (2) Bayliss, P. (1982) X-ray powder data for hewettite. Mineral. Mag., 46, 503–504. (3) Evans, H.T., Jr. (1989) The crystal structure of hewettite. Can. Mineral., 27, 181–188. (4) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 513–514.

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Hexahydrite $MgSO_4 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very rare crystals, thick tabular {001}; typically coarse columnar to thin fibrous, to 10 cm; massive. *Twinning:* On {001}; on {110}.

Physical Properties: *Cleavage:* On {100}, perfect. *Fracture:* Conchoidal. Hardness = 2–2.5 (by analogy to epsomite). D(meas.) = 1.757 D(calc.) = 1.745 Soluble in H_2O, bitter salty taste.

Optical Properties: Transparent to opaque. *Color:* Colorless to white, may be pale green; colorless in transmitted light. *Luster:* Pearly to vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 25°$. $\alpha = 1.426$ $\beta = 1.453$ $\gamma = 1.456$ 2V(meas.) = 38°

Cell Data: *Space Group:* $C2/c$. $a = 10.110(5)$ $b = 7.212(4)$ $c = 24.41(1)$ $\beta = 98.30(5)°$ Z = 8

X-ray Powder Pattern: Synthetic. (ICDD 24–719).
4.39 (100), 5.45 (50), 5.10 (45), 4.04 (45), 4.16 (35), 4.88 (30), 2.941 (30)

Chemistry:

	(1)	(2)
SO_3	34.52	35.04
MgO	17.15	17.64
H_2O	46.42	47.32
insol.	1.78	
Total	99.87	100.00

(1) Bonaparte River, Canada. (2) $MgSO_4 \cdot 6H_2O$.

Mineral Group: Hexahydrite group.

Occurrence: By dehydration of epsomite; as efflorescences on magnesian rock exposures and in mine workings; as speleothems in caves; may be widespread as an evaporative precipitate in saline lakes and soils; rarely a fumarolic precipitate.

Association: Epsomite, siderotil.

Distribution: Likely more widespread than the following list of localities indicates. In Canada, from along the Bonaparte River between Scottie and Carquill Creeks, Clinton district, British Columbia; along Rapid Creek, Yukon Territory. In the USA, from near Oroville, Okanogan Co., Washington; in the Campbell mine, Bisbee, Cochise Co. and the San Manuel mine, Pinal Co., Arizona; long fibers from the Nevada Dominion adit, Pyramid district, Washoe Co., Nevada; in the Long Park #15 mine, Montrose Co., Colorado; at Sterling Hill, Sussex Co., New Jersey; from Alum Cave Bluff, Sevier Co., Tennessee. In the North Ballaird Bore No. 3, Balsalloch Farm, near Ballantrae, Ayrshire, Scotland. In Germany, at Wathlingen, Lower Saxony, and elsewhere. From Kladno and Kelčany, Czech Republic. At Boleslaw, Poland. In Turkey, from the Great Konya Basin, near Çakmak, Konya Province. At the Saki salt lakes, Crimea, Ukraine. A volcanic sublimate at volcanoes on the Kamchatka Peninsula, Russia. In the Epsom Pot Cave, Transvaal, South Africa. At the Santa Bárbara sulfur mine, El Palmar district, Jujuy Province, Argentina.

Name: With the Greek prefix, *hexa*, in recognition of a magnesium sulfate *hydrate* with six essential water molecules.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 494–495. (2) Zalkin, A., H. Ruben, and D.H. Templeton (1964) The crystal structure and hydrogen bonding of magnesium sulfate hexahydrate. Acta Cryst., 17, 235–240.

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Hexahydroborite $Ca[B(OH)_4]_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As flattened prismatic crystals, to 2 mm.

Physical Properties: *Cleavage:* Two ∥ elongation, perfect; another ⊥ elongation, imperfect. Hardness = ∼2.5 D(meas.) = 1.84–1.87 D(calc.) = 1.88 Photoluminescent in shades of pale blue.

Optical Properties: Transparent. *Color:* Colorless; develops a pale blue tarnish on exposure. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X \wedge c = 14°$. *Dispersion:* $r > v$, very strong.
$\alpha = 1.498–1.502$ $\beta = 1.503–1.505$ $\gamma = 1.510–1.509$ 2V(meas.) = 83°

Cell Data: *Space Group:* $P2/a$. $a = 8.006(2)$ $b = 6.649(2)$ $c = 8.012(2)$ $\beta = 104.21(2)°$
Z = 2

X-ray Powder Pattern: Solongo deposit, Russia.
7.73 (10), 3.37 (9b), 3.118 (9), 2.550 (9), 2.792 (8), 2.469 (8), 2.283 (8)

Chemistry:

	(1)	(2)
B_2O_3	28.50	29.78
MgO	0.51	
CaO	25.03	23.99
H_2O	45.96	46.23
Total	[100.00]	100.00

(1) Solongo deposit, Russia; $(OH)^{1-}$ and H_2O confirmed by IR, recalculated to 100% after deduction of diopside and calcite impurities from an original total of 101.30%; then corresponds to $(Ca_{1.04}Mg_{0.03})_{\Sigma=1.07}B_{1.91}(OH)_{7.87} \cdot 2.02H_2O$. (2) $Ca[B(OH)_4]_2 \cdot 2H_2O$.

Occurrence: A rare component of boron-enriched skarn deposits in metasomatized limestones.

Association: Pentahydroborite, frolovite, kurchatovite, sakhaite (Solongo deposit, Russia); olshanskyite, calcite (Fuka, Japan).

Distribution: From the Solongo boron deposit, Buryatia, Russia. At the Sayak-IV boron deposit, northeast Balkhash region, Kazakhstan. From Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For the composition, originally thought to contain six waters of hydration (later found by crystal-structure analysis to be incorrect).

Type Material: Russian Institute of Mineral Resources, Moscow; Moscow University, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80438.

References: (1) Simonov, M.A., S.V. Malinko, N.V. Belov, Y.V. Kazanskaya, Y.K. Yegorov-Tismenko, M.B. Fedorenko, Y.L. Belokoneva, N.A. Yamnova, and N.N. Kuznetsova (1977) Hexahydroborite – a new mineral, $Ca[B(OH)_4]_2 \cdot 2H_2O$. Zap. Vses. Mineral. Obshch., 106, 691–697 (in Russian). (2) (1978) Amer. Mineral., 63, 1283 (abs. ref. 1). (3) Simonov, M.A., N.A. Yamnova, E.V. Kazanskaya, Y.K. Yegorov-Tismenko, and N.V. Belov (1976) Crystal structure of a new natural calcium borate, hexahydroborite, $CaB_2O_4 \cdot 6H_2O = Ca[B(OH)_4]_2 \cdot 2H_2O$. Doklady Acad. Nauk SSSR, 228, 1337–1340 (in Russian). (4) Kusachi, I., Y. Takechi, S. Kobayashi, J. Yamakawa, Y. Nakamuta, K.-H. Lee, and S. Motomizu, (1999) Hexahydroborite from Fuka, Okayama Prefecture, Japan. Mineral. J. (Japan), 21, 9–14.

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Hexatestibiopanickelite $(Ni, Pd)(Te, Sb)$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$ (probable). Massive.

Physical Properties: Hardness = 2.0–2.2 VHN = 75–108 (2 g load). D(meas.) = n.d. D(calc.) = 8.904

Optical Properties: Opaque. *Color:* Pale yellow to yellowish white.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$ (probable) $a = 3.983(3)$ $c = 5.339(3)$ Z = 2

X-ray Powder Pattern: Locality "Y", China.
2.890 (10), 2.109 (8), 1.990 (7), 1.108 (6), 1.580 (5), 1.635 (4),1.452 (3)

Chemistry:

	(1)
Ni	20.
Pd	16.
Sb	31.
Bi	0.1
Te	33.
Total	100.1

(1) Locality "Y", China; by electron microprobe, corresponding to $(Ni_{0.69}Pd_{0.31})_{\Sigma=1.00}(Te_{0.50}Sb_{0.49}Bi_{0.01})_{\Sigma=1.00}$.

Mineral Group: Nickeline group.

Occurrence: In ore concentrates from Cu–Ni sulfide deposits.

Association: Testibiopalladite.

Distribution: In southwestern China, at locality "Y" – a code name.

Name: Presumably named for the crystal system and composition.

Type Material: n.d.

References: (1) Platinum Metal Mineral Research Group, Microprobe Analysis Laboratory, X-Ray Powder Photograph Laboratory, and Mineral Dressing Laboratory, Kweiyang Institute of Geochemistry, Academia Sinica (1974) Tellurostibnide of palladium and nickel and other new minerals and varieties of platinum metals. Geochimica, 3, 169–181 (in Chinese with English abs.). (2) (1976) Amer. Mineral., 61, 182 (abs. ref. 1). (3) Bayliss, P. (1990) Revised unit-cell dimensions, space group, and chemical formula of some metallic minerals. Can. Mineral., 28, 751–755.

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Heyite $Pb_5Fe_2^{2+}O_4(VO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals elongate along [010] and tabular on {100}, to 0.4 mm; common forms {100}, {001}, {$\bar{1}$01}, and {110}; as composite "bow tie" groups. *Twinning:* Common on {110}, forming a "Y"-shaped doublet or "K"-shaped triplet.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 4
D(meas.) = 6.3(2) D(calc.) = 6.284

Optical Properties: Transparent. *Color:* Marigold-orange, orange-brown; yellow-orange in transmitted light. *Streak:* Amber-yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 36°$. *Dispersion:* $r > v$, weak.
$\alpha = 2.185(1)$ $\beta = 2.219(1)$ $\gamma = 2.266(1)$ 2V(meas.) = 89° 2V(calc.) = 82°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.910(4)$ $b = 6.017(4)$ $c = 7.734(4)$
$\beta = 111°53(4)'$ Z = 1

X-ray Powder Pattern: Betty Jo claim, Nevada, USA.
3.248 (100), 2.970 (69), 2.767 (61), 4.873 (46), 3.674 (35), 2.306 (33), 3.010 (29)

Chemistry:

	(1)	(2)
P_2O_5	n.d.	
V_2O_5	13.00	12.62
FeO	8.65	9.97
MnO	n.d.	
ZnO	0.83	
PbO	77.52	77.41
LOI	0.00	
Total	[100.00]	100.00

(1) Betty Jo claim, Nevada, USA; by electron microprobe, average of three analyses, normalized from a total of 97.3% to 100%, total Fe as FeO; corresponding to $Pb_{5.01}(Fe_{1.71}Zn_{0.17})_{\Sigma=1.88}O_{3.80}(VO_4)_{2.06}$. (2) $Pb_5Fe_2O_4(VO_4)_2$.

Occurrence: A very rare secondary mineral in the oxidized portions of a polymetallic sulfide deposit (Betty Jo claim, Nevada, USA); along a fault through a stockwork disseminated gold deposit (Gold Quarry mine, Nevada, USA).

Association: Tungstenian wulfenite, pyromorphite, mimetite, cerussite, shattuckite, chrysocolla, quartz (Betty Jo claim, Nevada, USA).

Distribution: From the Betty Jo claim, about 13 km southeast of Ely, Nevada district, White Pine Co., in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., and at the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada, USA. From the Kusu vanadium deposit, 85 km south of Kinshasa, Bas-Congo Province, Congo (Bas-Zaire Province, Zaire).

Name: Honors Dr. Max Hutchinson Hey (1904–1984), eminent British mineralogist and chemist, British Museum (Natural History), London, England.

Type Material: The Natural History Museum, London, England, 1972,194; National Museum of Natural History, Washington, D.C., USA, 127424, 135056.

References: (1) Williams, S.A. (1973) Heyite, $Pb_5Fe_2(VO_4)_2O_4$, a new mineral from Nevada. Mineral. Mag., 39, 65–68. (2) (1974) Amer. Mineral., 59, 382 (abs. ref. 1). (3) Symes, R.F. and S.A. Williams (1973) Heyite and brackebuschite compared. Mineral. Mag., 39, 69–73.

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Heyrovskýite $Pb_4AgBi_3S_9$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As prismatic to acicular crystals, elongate [001] and flattened {010}, striated on {010} parallel to [001], to 2 cm.

Physical Properties: *Cleavage:* Poor on {*hk*0}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 166–234 (50 g load), strongly anisotropic. D(meas.) = 7.17 D(calc.) = 7.18

Optical Properties: Opaque. *Color:* Tin-white. *Streak:* Grayish black. *Luster:* Metallic, tarnishes black. *Pleochroism:* Weak to distinct, white to pale gray. *Anisotropism:* Strong, dark gray to white.
R_1–R_2: (470) 43.3–47.3, (546) 40.6–44.6, (589) 39.8–43.9, (650) 39.6–43.7

Cell Data: *Space Group: Cbmm.* $a = 13.600(3)$ $b = 30.485(12)$ $c = 4.110(1)$ $Z = 4$

X-ray Powder Pattern: Hůrky, Czech Republic.
3.435 (100), 2.962 (80), 2.098 (35), 1.790 (22), 3.343 (20), 3.006 (15), 2.067 (15)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb	53.65	41.24	54.50	Bi	28.35	35.52	27.48
Ag	2.5	6.73	2.84	Sb		0.04	
Cu	0.05			Se		0.03	
Cd		0.07		S	14.4	15.96	15.18
				Total	98.95	99.97	100.00

(1) Hůrky, Czech Republic; by electron microprobe, corresponding to $Pb_{5.19}Ag_{0.46}Cu_{0.02}Bi_{2.72}S_{9.00}$. (2) La Roche-Balue quarry, France; by electron microprobe, average of five analyses; corresponding to $Pb_{3.60}Cd_{0.04}Ag_{1.13}Cd_{0.04}Bi_{3.32}Sb_{0.01}S_{9.00}$. (3) $Pb_4AgBi_3S_9$.

Occurrence: In high-temperature quartz veins.

Association: Pyrite, sphalerite, galena, molybdenite, cosalite, bismuth, galenobismutite, chalcopyrite, covellite, bursaite, arsenopyrite, siderite, quartz, albite, microcline.

Distribution: In the Czech Republic, near Hůrky, about 65 km west of Prague [TL]. From the Toroiaga mine, Baia Borą district, and at Ocna de Fier (Morávicza; Vaskő), Romania. In the Furka Pass, Uri, and at Goppenstein, Lotschentnal, Valais, Switzerland. From Rauriser Goldberg, Salzburg, Austria. In the La Roche-Balue quarry, west of Nantes, Loire Atlantique, France. At the Clara mine, near Oberwolfach, Black Forest, Germany. In Italy, on Vulcano, in the Lipari Islands. From the Corrie Buie deposit, south Loch Tayside, Scotland. In the Balıkesir Balya deposit, Balıkesir Province, Turkey. From the Spokoinoe deposit, eastern Transbaikal, and at the Shumilovsk Sn–W deposit, western Transbaikal, Russia. From 27 km west of Castlegar, British Columbia, Canada. In the USA, from Darwin, Inyo Co., California; at the Reward prospects, Ravenswood district, Lander Co., Nevada; in the Idarado mine, Ouray Co., and the Alaska mine, Poughkeepsie Gulch, near Ouray, San Juan Co., Colorado. At the Yakuki mine, Fukushima Prefecture, Japan. From the Juno mine, Tennant Creek, Northern Territory, Australia.

Name: In honor of Jaroslav Heyrovský (1890–1967), Czech Nobel Laureate in chemistry.

Type Material: Charles University, Prague, Czech Republic, 14265.

References: (1) Klomínský, J., M. Rieder, C. Kieft, and L. Mráz (1971) Heyrovskýite, $6(Pb_{0.86}Bi_{0.08}(Ag,Cu)_{0.04})S \bullet Bi_2S_3$ from Hůrky, Czechoslovakia, a new mineral of genetic interest. Mineralium Deposita, 6, 133–147. (2) (1972) Amer. Mineral., 57, 325 (abs. ref. 1). (3) Mozgova, N.N., Y.S. Borodaev, L.E. Syritso, and D.P. Romanov (1976) New data on goongarrite (warthaite) and about the identity of heyrovskýite with goongarrite. Neues Jahrb. Mineral., Abh., 127, 62–83. (4) Makovicky, E., W.G. Mumme, and B.F. Hoskins (1991) The crystal structure of Ag-Bi-bearing heyrovskyite. Can. Mineral., 29, 553–559.

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Hezuolinite $(Sr,REE)_4Zr(Ti,Fe^{3+},Fe^{2+})_2Ti_2O_8(Si_2O_7)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m.* As grains to several 100 μm. *Twinning*: Polysynthetic twins were observed.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 5.5-6 VHN = 683-964 (100 g load). D(meas.) = 4.28 D(calc.) = 4.30

Optical Properties: Translucent. *Color*: Black. *Streak*: Dark brown. *Luster*: Resinous. *Optical Class*: Biaxial (–). $n > 1.8$ $2V = 75°$ *Dispersion*: Strong, $r > v$. *Pleochroism*: Strong, X = pale brown, Y = brown, Z = dark brown.

Cell Data: *Space Group*: $C2/m$. $a = 13.973(3)$ $b = 5.6984(11)$ $c = 11.988(2)$ $\beta = 114.10(1)°$ $Z = 2$

X-ray Powder Pattern: Saima alkaline complex, Fengcheng County, Liaoning Province, China. 2.98 (100), 3.02 (90), 1.96 (90), 2.18 (80), 2.84 (70), 2.72 (50), 2.51 (50)

Chemistry:

	(1)		(1)
SiO_2	21.90	Na_2O	0.35
TiO_2	24.42	ThO_2	0.80
Al_2O_3	0.16	UO_2	0.01
FeO	1.84	La_2O_3	7.12
Fe_2O_3	2.61	Ce_2O_3	8.16
MnO	0.07	Pr_2O_3	0.45
MgO	0.01	Nd_2O_3	1.34
Nb_2O_5	0.28	Sm_2O_3	0.10
ZrO_2	9.18	Eu_2O_3	0.16
HfO_2	0.39	Gd_2O_3	0.06
SrO	20.12	Total	101.99
CaO	2.46		

(1) Saima alkaline complex, Liaoning Province, China; average of 25 electron microprobe analyses, oxidation ratio for iron from Mössbauer spectroscopy; corresponding to $(Sr_{2.15}Ce_{0.55}La_{0.49}Ca_{0.49}Na_{0.12}Nd_{0.09}Pr_{0.03}Th_{0.03}Sm_{0.01}Eu_{0.01})_{\Sigma=3.98}(Zr_{0.82}Fe^{2+}_{0.14}Hf_{0.02}Mn_{0.01})_{\Sigma=1.00}$ $(Ti_{1.38}Fe^{3+}_{0.36}Fe^{2+}_{0.14}Al_{0.04}Nb_{0.02})_{\Sigma=1.94}Ti_2O_8(Si_{2.01}O_7)_2$.

Mineral Group: Chevkinite group.

Occurrence: In a series of alkaline volcanic and intrusive igneous rocks, associated with aegirine nepheline syenite.

Association: Microcline, nepheline, aegirine, biotite, eudialyte, rinkite, titanite.

Distribution: From the Saima alkaline complex, Fengcheng County, Liaoning Province, NE China.

Name: Honors He Zuolin (1900-1967), for his contributions to optical mineralogy and rare-earths mineralogy in China. Hezuolinite corresponds to the previously discredited "saimaite".

Type Material: Museum of the Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China (KDX016).

References: (1) Yang, Z., G. Giester, K. Ding, and E. Tillmanns (2012) Hezuolinite, $(Sr,REE)_4Zr(Ti,Fe^{3+},Fe^{2+})_2Ti_2O_8(Si_2O_7)_2$, a new mineral species of the chevkinite group from Saima alkaline complex, Liaoning Province, NE China. European Journal of Mineralogy, 24(1), 189-196. (2) (2014) Amer. Mineral., 99, 2153-2154 (abs. ref. 1).

Crystal Data: Orthorhombic (probable). *Point Group:* $2/m\ 2/m\ 2/m$. As grains, to 700 μ, filling veinlets.

Physical Properties: *Cleavage:* One direction, good, perhaps a parting. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.04 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless to pale green when fresh, orange when oxidized, in transmitted light; greenish internal reflections, red when oxidized, in reflected light. *Optical Class:* Biaxial; low birefringence. *Pleochroism:* Slight. *Orientation:* Extinction ~parallel; length-fast. n = 1.6–1.7 2V(meas.) = n.d.

Cell Data: *Space Group: Pnam* (probable). a = 6.31(6) b = 9.20(4) c = 7.10(7) Z = 4

X-ray Powder Pattern: Strathcona mine, Canada.
2.33 (10), 2.86 (6), 2.12 (5), 1.652 (5), 5.62 (4), 5.16 (2), 1.87 (2)

Chemistry:

	(1)	(2)	(3)
Si	0.10		
Fe	49.02	53.9	56.36
Mn	1.49		
Mg	2.62		
Cl	17.39	18.2	17.89
OH	[29.92]	[27.9]	25.75
Total	[100.54]	[100.0]	100.00

(1) Hibbing, Minnesota, USA; by electron microprobe, average of eight analyses from two samples, original total given as 100.56%; Fe^{2+} and $(OH)^{1-}$ indicated by several methods, OH by difference; corresponds to $(Fe_{1.72}Mg_{0.21}Mn_{0.06}Si_{0.01})_{\Sigma=2.00}[Cl_{0.87}(OH)_{0.12}]_{\Sigma=0.99}(OH)_{3.00}$. (2) Strathcona mine, Canada; by electron microprobe, OH by difference; corresponds to $Fe_{2.00}Cl_{1.06}(OH)_{3.40}$. (3) $Fe_2Cl(OH)_3$.

Occurrence: In serpentinized troctolite and peridotite (Hibbing, Minnesota, USA); in fractures in chlorine-rich portions of a Cu–Ni orebody (Strathcona mine, Canada); in terrestrially weathered iron meteorites.

Association: Akaganéite, magnetite, maghemite, goethite, serpentine, olivine, plagioclase, biotite (Hibbing, Minnesota, USA); chalcopyrite, pentlandite (Sudbury, Canada).

Distribution: From drill cores in the Duluth complex, near Hibbing, St. Louis Co., Minnesota, USA. In the Strathcona mine, Sudbury, Ontario, Canada. From the Noril'sk region, western Siberia, Russia.

Name: For Hibbing, Minnesota, USA, from near where the mineral was first characterized.

Type Material: Department of Natural Resources, Hibbing, Minnesota, USA.

References: (1) Saini-Eidukat, B., H. Kucha, and H. Keppler (1994) Hibbingite, γ–$Fe_2(OH)_3Cl$, a new mineral from the Duluth Complex, Minnesota, with implications for the oxidation of Fe-bearing compounds and the transport of metals. Amer. Mineral., 79, 555–561. (2) Springer, G. (1989) Chlorine-bearing and other uncommon minerals in the Strathcona deep copper zone, Sudbury district, Ontario. Can. Mineral., 27, 311–313.

Hibonite $(Ca, Ce, La)(Al, Ti, Mg)_{12}O_{19}$

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Crystal Data: Hexagonal. *Point Group:* $6/m2/m2/m$. Prisms, platy on {0001}, or steep pyramidal, to 4 cm, showing six sectors on {0001}.

Physical Properties: *Cleavage:* {0001}, good; parting on $\{10\bar{1}0\}$. *Fracture:* Subconchoidal. Hardness = 7.5–8 D(meas.) = 3.84(1) D(calc.) = [4.09] Slightly radioactive.

Optical Properties: Semitransparent. *Color:* Brownish black to black; reddish brown in thin fragments; blue in meteorites. *Streak:* Brown. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism: O* = brownish gray; *E* = gray. $\omega = 1.807(2)$
$\epsilon = 1.79(1)$

Cell Data: *Space Group:* $P6_3/mmc$. a = 5.57–5.61 c = 22.01–22.20 Z = 2

X-ray Powder Pattern: Mahenge, Tanzania.
2.505 (10), 2.648 (8), 2.812 (6), 2.131 (6), 2.030 (5), 1.404 (5), 2.311 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	1.50	0.75	Nd_2O_3		0.2
TiO_2	8.50	5.6	Fe_2O_3	0.45	2.7
Al_2O_3	74.00	72.8	FeO	2.30	7.3
La_2O_3		1.8	MgO	3.20	0.27
Ce_2O_3	3.50	2.1	CaO	6.50	6.2
			Total	99.95	99.72

(1) Esiva, Madagascar; all RE taken as Ce, corresponds to $(Ca_{0.80}RE_{0.15})_{\Sigma=0.95}(Al_{10.16}Ti_{0.74}Mg_{0.56}Fe^{2+}_{0.22}Si_{0.18}Fe^{3+}_{0.04})_{\Sigma=11.90}O_{18.95}$. (2) Mahenge, Tanzania; by electron microprobe, average of 14 analyses, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Ca_{0.80}Ce_{0.09}La_{0.08}Nd_{0.01})_{\Sigma=0.98}(Al_{10.38}Fe^{2+}_{0.74}Ti_{0.51}Fe^{3+}_{0.25}Si_{0.09}Mg_{0.05})_{\Sigma=12.02}O_{19}$.

Mineral Group: Magnetoplumbite group.

Occurrence: In metamorphosed limestone, pyroxenite, gneiss, and granulite of the amphibolite to granulite facies; also alluvial. A common accessory in Ca–Al-rich inclusions in some carbonaceous chondrites.

Association: Calcic plagioclase, corundum, spinel, thorianite, titanite (Esiva, Madagascar); anorthite, grossular, titanite, zoisite, clinozoisite (Mahenge, Tanzania); vesuvianite, hercynite, corundum, andalusite, kyanite, diopside, rutile, titanite, magnetite (Shoriya Mountains, Russia).

Distribution: From Esiva, near Taolañaro (Fort Dauphin), and near Ambindandrakemba, Madagascar. In Tanzania, in the Furura granulite complex, southwest of Mahenge. In the Shoriya Mountains, about 400 km southeast of Novosibirsk, western Siberia, and several other less-well-defined places in Russia. From Punalur, Kerala, India. Noted in some carbonaceous chondrite meteorites, as Allende, Murchison, etc.

Name: For Paul Hibon, who discovered the mineral.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, USA, 106213.

References: (1) Curien, H., C. Guillemin, J. Orcel, and M. Sternberg (1956) La hibonite, nouvelle espèce minérale. Compt. Rendus Acad. Sci. Paris, 242, 2845–2847 (in French). (2) (1957) Amer. Mineral., 42, 119 (abs. ref. 1). (3) Maaskant, P., J.J.M.M.M. Coolen, and E.A.J. Burke (1980) Hibonite and coexisting zoisite and clinozoisite in a calc-silicate granulite from southern Tanzania. Mineral. Mag., 43, 995–1003. (4) Kato, K. and H. Saalfeld (1968) Verfeinerung der Kristallstruktur von $CaO \cdot 6Al_2O_3$. Neues Jahrb. Mineral., Abh., 109, 192–200 (in German with English abs.).

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Hibschite $\mathbf{Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}}$ (x = 0.2 to 1.5)

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Crystal Data: Cubic. *Point Group:* [$4/m\ \overline{3}\ 2/m$.] As shells (up to 60 μm thick) replacing andradite or other minerals.

Physical Properties: *Tenacity:* Very brittle. Hardness = 6 D(meas.) = 3.05–3.08 D(calc.) = [3.05–3.28]

Optical Properties: Semitransparent. *Color:* Colorless or pale yellow. *Optical Class:* Isotropic; may be anomalously biaxial. n = 1.670–1.677

Cell Data: *Space Group:* [$Ia3d$.] a = 12.02–12.22 Z = [8]

X-ray Powder Pattern: Mariánská Hora, Czech Republic. 2.736 (s), 3.045 (ms), 2.227 (m), 1.984 (m), 3.263 (mw), 1.634 (mw), 4.994 (w)

Chemistry:

	(1)	(2)
SiO_2	27.30	21.24
Al_2O_3	23.97	19.38
Fe_2O_3	0.30	4.08
MnO	0.19	
MgO	2.01	0.92
CaO	37.00	39.83
H_2O+	9.20	
H_2O-	0.20	
H_2O		[11.41]
SO_3		3.14
Total	100.17	[100.00]

(1) Bug River, Russia. (2) Mariánská Hora, Czech Republic; by electron microprobe, H_2O by difference; corresponds to $Ca_{3.00}(Al_{1.61}Fe_{0.22}Mg_{0.10})_{\Sigma=1.93}(Si_{1.50}S_{0.17})_{\Sigma=1.67}[O_{6.64}(OH)_{5.36}]_{\Sigma=12.00}$.

Polymorphism & Series: Forms a series with grossular and katoite.

Mineral Group: Garnet group.

Occurrence: In a calcareous marl (Mariánská Hora, Czech Republic); in zeolite-calcite rocks and low-grade metamorphosed marls (Hatrurim Formation, Israel).

Association: Quartz, tremolite, gypsum (Mariánská Hora, Czech Republic); calcite, aragonite, vaterite, portlandite, ettringite, tobermorite, jennite, afwillite (Hatrurim Formation, Israel).

Distribution: At Mariánská Hora (Marienberg), near Ústí nad Lábem (Aussig), Czech Republic. At Aubenas, Ardèche, France. In the Hatrurim Formation, Israel. From Nikortzminda, Caucasus Mountains, Georgia. Along the Bug River, locality not further specified, in Russia. At Crestmore, Riverside Co., California, USA. From Velardeña, Durango, Mexico. From the Tokatoka district, about 150 km north of Auckland, New Zealand.

Name: After Professor Josef Emanuel Hibsch (1852–1940), German Agricultural Academy, Tetschen, Czech Republic.

Type Material: Natural History Museum, Vienna, Austria, J4774.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 52. (2) Nalivkina, É.B. (1960) Hibschite from the Bug River. Zap. Vses. Mineral. Obshch., 89, 714–718 (in Russian). (3) (1964) Mineral. Abs., 16, 454 (abs. ref. 2). (4) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 32–35. (5) Passaglia, E. and R. Rinaldi (1984) Katoite, a new member of the $Ca_3Al_2(SiO_4)_3$ – $Ca_3Al_2(OH)_{12}$ series and a new nomenclature for the hydrogrossular group of minerals. Bull. Minéral., 107, 605–618. (6) Rinaldi, R. and E. Passaglia (1989) Hibschite topotype: crystal chemical characterization. Eur. J. Mineral., 1, 639–644.

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Hidalgoite $PbAl_3(AsO_4)(SO_4)(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Commonly as compact porcelaneous to porous masses; in tiny spherulitic aggregates.

Physical Properties: *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.71–3.96 D(calc.) = 4.15–4.27

Optical Properties: Translucent. *Color:* White, pale green, pistachio-green, emerald-green. *Streak:* White. *Luster:* Dull in aggregates.
Optical Class: Uniaxial (+). *Dispersion:* Strong. $\omega = 1.713–1.730$ $\epsilon = 1.715–1.735$

Cell Data: *Space Group: R3m.* a = 7.04(2) $c = 16.99(2)$ Z = 3

X-ray Powder Pattern: San Pascual mine, Mexico.
2.981 (10), 5.73 (9), 3.51 (9), 1.911 (8), 2.257 (7), 1.761 (6), 1.496 (6)

Chemistry:

	(1)	(2)	(3)
SO_3	15.03	4.2	12.81
As_2O_5	16.27	20.3	18.38
Sb_2O_5	0.20		
SiO_2	0.32		
Al_2O_3	24.25	23.0	24.46
Fe_2O_3	0.57	1.5	
CuO		0.4	
ZnO	0.88	0.4	
PbO	32.84	36.2	35.70
H_2O	9.70	13.8	8.65
Total	100.06	99.8	100.00

(1) San Pascual mine, Mexico; H_2O by a modified Penfield method. (2) Gold Hill mine, Utah, USA; H_2O by loss on ignition. (3) $PbAl_3(AsO_4)(SO_4)(OH)_6$.

Mineral Group: Beudantite group.

Occurrence: A rare secondary mineral of the oxide zone of polymetallic sulfide deposits.

Association: Beudantite, tourmaline, "limonite" (San Pascual mine, Mexico); mansfieldite, carbonate-cyanotrichite (Cap Garonne mine, France).

Distribution: From the San Pascual mine, nine km northwest of Zimapán, Hidalgo, Mexico. In the USA, from the Gold Hill mine, Tooele Co., Utah; in the Mohawk mine, Clark Mountains, San Bernardino Co., California; and from Tombstone, Cochise Co., and in the Silver Crown mine, Yavapai Co., Arizona. At the Cap Garonne mine, near le Pradet, Var, France. In the Falotta mine, Oberhalbstein, Graubünden, Switzerland. At Ramsbeck, North Rhein-Westphalia, Germany. From the Penberthy Croft mine, St. Hilary, Cornwall, England. In Australia, from the Adelaide mine, Dundas, Tasmania, and at Broken Hill, New South Wales. From Tsumeb, Namibia.

Name: For Hidalgo, the state in Mexico that produced the first specimens.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 106373–106375; National Museum of Natural History, Washington, D.C., USA, 112726, 112727.

References: (1) Smith, R.L., F.S. Simons, and A.C. Vlisidis (1953) Hidalgoite, a new mineral. Amer. Mineral., 38, 1218–1224. (2) Guillemin, C., (1955) Sur une variété d'hidalgoïte du Cap Garonne (Var). Bull. Minéral., 78, 27–32 (in French). (3) Clarkson, J.F., W.L. Roberts, and A.L. Lingard (1971) Hidalgoite from Gold Hill, Utah. Mineral. Record, 2, 212–213.

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Hieratite K_2SiF_6

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Crystal Data: Cubic. *Point Group:* $4/m\bar{3}2/m$. As cubo-octahedra and octahedra; stalactitic concretionary, spongy to dense.

Physical Properties: *Cleavage:* {111}, perfect. Hardness = ∼2.5 D(meas.) = 2.665 (synthetic). D(calc.) = 2.668 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, white to gray; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.340$

Cell Data: *Space Group:* $Fm3m$(synthetic). $a = 8.133$ Z = 4

X-ray Powder Pattern: Synthetic.
4.699 (100), 2.349 (70), 2.877 (65), 2.034 (50), 1.438 (16), 1.565 (14), 1.661 (12)

Chemistry:

	(1)	(2)
K	35.4	35.50
Si	12.7	12.75
F	51.9	51.75
Total	100.0	100.00

(1) Vulcano, Italy. (2) K_2SiF_6.

Occurrence: As a deposit around volcanic fumaroles.

Association: Sassolite, mirabilite, glauberite, selenian sulfur, realgar, alums (Vulcano, Italy); avogadrite, malladrite (Vesuvius, Italy).

Distribution: In Italy, on Vulcano, Lipari Islands, and from Vesuvius, Campania.

Name: From the Greek *Hiera*, an ancient name for Vulcano.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 103–104. (2) (1955) NBS Circ. 539, 5, 50.

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Hilairite $Na_2ZrSi_3O_9 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* 32. As nearly equidimensional rhombohedral crystals, displaying $\{11\bar{2}0\}$ and $\{01\bar{1}2\}$, to 4 mm. *Twinning:* Multiple twinning by rotation about $[2\bar{2}01]$ and about [0001], common; typically multiply twinned after both laws, involving four, eight, or more individuals.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = > 4
D(meas.) = 2.724(4) D(calc.) = 2.739

Optical Properties: Transparent to opaque. *Color:* Pale to dark brown, yellow, colorless, white, flesh-pink, rose-red. *Streak:* White. *Luster:* Vitreous to porcelaneous.
Optical Class: Uniaxial (–). $\omega = 1.609(1)$ $\epsilon = 1.596(1)$

Cell Data: *Space Group: R*32. $a = 10.556(1)$ $c = 15.855(2)$ Z = 6

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
5.28 (100), 6.00 (60), 3.168 (50), 3.046 (40), 1.759 (40), 2.994 (30), 2.639 (30)

Chemistry:

	(1)
SiO_2	42.08
TiO_2	0.04
ZrO_2	29.72
Al_2O_3	0.03
FeO	0.03
MnO	0.02
MgO	0.01
CaO	0.20
Na_2O	13.43
K_2O	0.52
H_2O	13.54
Total	99.62

(1) Mont Saint-Hilaire, Canada; by electron microprobe, H_2O by TGA; corresponding to $(Na_{1.85}K_{0.05}Ca_{0.02})_{\Sigma=1.92}Zr_{1.03}Si_{2.99}O_{9.30} \cdot 3.21H_2O$.

Occurrence: In miarolitic cavities and altered pegmatite dikes in nepheline syenite in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Catapleiite, elpidite, gaidonnayite, aegirine, analcime, albite, microcline, chlorite, calcite, epididymite, natrolite, fluorite, pyrite, sphalerite, galena (Mont Saint-Hilaire, Canada).

Distribution: In Canada, at Mont Saint-Hilaire, and in the Strange Lake complex, Quebec. From Bratthagen, near Larvik, Norway. On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia. At Poços de Caldas, Minas Gerais, Brazil.

Name: For the locality at Mont Saint-Hilaire, Quebec, Canada.

Type Material: Canadian Museum of Nature, Ottawa; Royal Ontario Museum, Toronto, Canada, 34803.

References: (1) Chao, G.Y., D.H. Watkinson, and T.T. Chen (1974) Hilairite, $Na_2ZrSi_3O_9 \cdot 3H_2O$, a new mineral from Mont St. Hilaire, Quebec. Can. Mineral., 12, 237–240.
(2) Ilyushin, G.D, A.A. Voronkov, N.N. Nevskii, V.V. Ilyukhin, and N.V Belov (1981) Crystal structure of hilairite, $Na_2ZrSiO_3O_9 \cdot 3H_2O$. Sov. Phys. Doklady Acad. Nauk SSSR, 260, 1118–1120 (in Russian).

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Hilarionite $Fe^{3+}_2(SO_4)(AsO_4)(OH)\cdot 6H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*, *m*, or 2. As sub-parallel to divergent aggregates of prismatic to acicular crystals, to 0.5 mm, also as crusts or as spherulites, to 1 mm.

Physical Properties: *Cleavage*: Good parallel to elongation. *Fracture*: Uneven or splintery. *Tenacity*: Ductile, flexible fibers. Hardness = 2 D(meas.) = 2.40(5) D(calc.) = 2.486

Optical Properties: Translucent. *Color*: Light green (with olive or grayish tint) to yellowish green, colorless in transmitted light. *Streak*: n.d. *Luster*: Vitreous to silky. *Optical Class*: Biaxial(+). α = 1.575(2) β = n.d. γ = 1.640(2) 2V = Large. *Dispersion*: Strong, *r* > *v*. *Orientation:* *Z* is close to elongation.

Cell Data: *Space Group*: *C*2/*m*, *Cm*, or *C*2. *a* = 18.53(4) *b* = 17.43(3) *c* = 7.56(1) β = 94.06(15)° Z = 8

X-ray Powder Pattern: Hilarion mine, Lavrion ore district, Atliki Prefecture, Greece. 12.66 (100), 5.00 (10), 4.70 (10), 4.33 (7), 7.60 (6), 2.887 (5), 3.215 (4)

Chemistry:

	(1)
MnO	0.03
CuO	0.18
ZnO	0.17
Fe_2O_3	33.83
P_2O_5	0.22
As_2O_5	18.92
SO_3	22.19
H_2O	26.3
Total	101.82

(1) Hilarion mine, Lavrion ore district, Atliki Prefecture, Greece; average of 7 electron microprobe analyses, Fe^{+3} confirmed by Mössbauer spectroscopy, H_2O determined by Alimarin method, complex anions confirmed by IR spectroscopy; corresponding to $(Fe^{3+}_{1.90}Cu_{0.01}Zn_{0.01})_{\Sigma=1.92}[(SO_4)_{1.24}(AsO_4)_{0.74}(PO_4)_{0.01}]_{\Sigma=1.99}(OH)_{1.01}\cdot 6.03H_2O$.

Occurrence: A secondary mineral in the oxidized zone of a sulfide-rich (pyrite, sphalerite, chalcopyrite, galena) orebody.

Association: Goethite, gypsum, bukovskyite, jarosite, melanterite, chalcanthite, allophane, azurite, hematite, unidentified hydrous copper sulfates.

Distribution: At the Hilarion mine, near Agios Konstantinos (Kamariza), Lavrion ore district, Atliki Prefecture, Greece.

Name: For the mine that produced the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (92988) and the Mineralogical Museum, Athens University, Greece.

References: (1) Pekov, I.V., N.V. Chukanov, V.O. Yapaskurt, V.S. Rusakov, D.I. Belakovskiy, A.G. Turchkova, P. Voudouris, A. Magganas, and A. Katerinopoulos (2013) Hilarionite, $Fe^{3+}_2(SO_4)(AsO_4)(OH)\cdot 6H_2O$, a new supergene mineral from Lavrion, Greece. Zapiski Rossiyskogo Mineralogicheskogo Obtschestva, 142(5), 30-42 (in Russian with English abstract).
(2) (2014) Amer. Mineral., 99, 1515 (abs. ref. 1).

Hilgardite $Ca_2B_5O_9Cl \cdot H_2O$

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Crystal Data: Monoclinic or triclinic. *Point Group:* m or 1. Distorted triangular crystals are tabular on {010} and hemimorphic, to 2 cm, with 18 forms described.

Physical Properties: *Cleavage:* On {010}, perfect; on {100}, good. *Fracture:* Conchoidal. Hardness = 5 D(meas.) = 2.67–2.71 D(calc.) = 2.688–2.694 Piezoelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, slightly reddish brown; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 1.5°$. *Dispersion:* $r > v$, moderate.
$\alpha = 1.623–1.630$ $\beta = 1.628–1.636$ $\gamma = 1.656–1.664$ 2V(meas.) = 34(2)°

Cell Data: *Space Group:* *Aa* (4M polytype), with $a = 11.438(2)$ $b = 11.318(2)$ $c = 6.318(1)$ $\beta = 90.06(1)°$ Z = 4, or *Space Group:* $P1$ (1A polytype), with $a = 6.452(1)$ $b = 6.559(1)$ $c = 6.286(1)$ $\alpha = 61.60(1)°$ $\beta = 118.72(1)°$ $\gamma = 105.86(1)°$ Z = 1

X-ray Powder Pattern: Choctaw salt dome, Louisiana, USA (4M polytype).
2.859 (100), 2.839 (100), 2.113 (80), 2.109 (80), 2.096 (80b), 1.985 (80), 2.755 (60)

X-ray Powder Pattern: Choctaw salt dome, Louisiana, USA (1A polytype).
2.87 (100), 2.83 (100), 2.755 (80), 2.12 (80), 2.033 (80), 5.7 (60), 3.14 (60)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
B_2O_3	50.22	[52.1]	52.48	Cl	10.59	10.2	10.69
CaO	35.14	31.3	33.81	H_2O	6.44	[5.4]	5.43
SrO		1.5		$-O = Cl_2$	2.39	2.3	2.41
				Total	[100.00]	[98.2]	100.00

(1) Choctaw salt dome, Louisiana, USA; recalculated to 100% after removal of insoluble 1.89%; corresponds to $Ca_{2.02}B_{4.65}O_9Cl_{0.98} \cdot 1.15H_2O$. (2) New Brunswick, Canada; by electron microprobe, B and H_2O calculated for stoichiometry. (3) $Ca_2B_5O_9Cl \cdot H_2O$.

Polymorphism & Series: 4M, 1Tc, 3Tc, and 1A polytypes are known.

Occurrence: In marine evaporite deposits.

Association: Boracite, anhydrite, danburite, dolomite, magnesite, pyrite, hauerite, calcite, quartz, sulfur, gypsum (Choctaw salt dome, Louisiana, USA); boracite, szaibélyite (New Brunswick, Canada).

Distribution: In the USA, from the Choctaw salt dome, Iberville Parish, Louisiana, and in Wayne Co., Mississippi; in the Louann Salt Formation, Clarke Co., Alabama. From the Penobsquis and Salt Springs evaporite deposits, near Sussex, New Brunswick, Canada. At the Königshall-Hindenburg potash mine, Reyershausen, near Göttingen, Lower Saxony, Germany. In the Boulby potash mine, northwest of Whitby, Yorkshire, England. In the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, Kazakhstan. From the Ilga Basin, eastern Siberia, Russia. In the Sedom Formation, on Mount Sedom, Dead Sea, Israel.

Name: Honors Eugene Woldemar Hilgard (1833–1916), German–American geologist, one of the first to study the Louisiana salt diapir deposits.

Type Material: Harvard University, Cambridge, Massachusetts, 100899, 100947, 106583; National Museum of Natural History, Washington, D.C., USA, R7822.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 382–384. (2) Ghose, S. (1985) A new nomenclature for the borate minerals in the hilgardite ($Ca_2B_5O_9Cl \cdot H_2O$)–tyretskite ($Ca_2B_5O_9OH \cdot H_2O$) group. Amer. Mineral., 70, 636–637. (3) Rachlin, A.L., J.A. Mandarino, B.L. Murowchick, R.A. Ramik, P.J. Dunn, and M.E. Back (1986) Mineralogy of hilgardite-4M from evaporites in New Brunswick. Can. Mineral., 24, 689–693. (4) Burns, P.C. and F.C. Hawthorne (1994) Refinement of the structure of hilgardite-1A. Acta Cryst., C50, 653–655. (5) Braitsch, O. (1959) 1Tc-Strontiohilgardite [= strontian hilgardite-1Tc], $(Ca,Sr)_2[B_5O_8(OH)_2Cl]$ und seine Stelling in der Hilgarditgruppe, $X_2[B_5O_8(OH)_2Cl]$. Beiträge Mineral. u. Petrog., 6, 233–247.

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Hillebrandite $Ca_2SiO_3(OH)_2$

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Crystal Data: Monoclinic (?), pseudo-orthorhombic. *Point Group:* $2/m$. Acicular fibrous crystals, to 0.5 mm; radial spherulitic.

Physical Properties: *Cleavage:* {010}. Hardness = 5–6 D(meas.) = 2.66–2.69 D(calc.) = [2.65]

Optical Properties: Transparent to translucent. *Color:* White, colorless, pale greenish; colorless in thin section.
Optical Class: Biaxial (–). *Orientation:* $Z = c$. *Dispersion:* $r < v$, strong, producing characteristic abnormal blue interference colors. $\alpha = 1.605(5)$ $\beta = \sim 1.61$ $\gamma = 1.612(3)$ 2V(meas.) = 60°–80°

Cell Data: *Space Group:* $P2_1/a$ (?). $a = 16.60$ $b = 7.26$ $c = 11.85$ $\beta = 90°$ Z = 12

X-ray Powder Pattern: Velardeña, Mexico.
2.92 (vvs), 4.76 (vs), 3.33 (vs), 3.02 (s), 2.82 (s), 2.76 (s), 2.37 (s)

Chemistry:

	(1)	(2)
SiO_2	32.59	31.58
TiO_2	0.02	
Al_2O_3	0.23	
Fe_2O_3	0.15	
MnO	0.01	
MgO	0.04	
CaO	57.76	58.95
Na_2O	0.03	
K_2O	0.05	
F	0.00	
H_2O	9.36	9.47
CO_2	0.00	
Total	100.24	100.00

(1) Velardeña, Mexico; total Fe as Fe_2O_3. (2) $Ca_2SiO_3(OH)_2$.

Occurrence: In limestone affected by high-grade contact metamorphism.

Association: Wollastonite, garnet (Velardeña, Mexico); calcite, vesuvianite, grossular (Carlingford, Ireland); foshagite (Crestmore, California, USA).

Distribution: In the Terneras mine, Velardeña, Durango, Mexico. In the USA, from Crestmore, Riverside Co., California. At Carlingford, Co. Louth, Ireland. In the Güneyce-İkizdere area, Trabzon Province, Turkey. From Mt. Chapchachi, north of the Caspian Sea, Kazakhstan. At Nugrah, Saudi Arabia. In the Hatrurim Formation, Israel. From Kushiro, Hiroshima Prefecture, and in the Mihari mine and at Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For William Francis Hillebrand (1853–1925), American geochemist and analytical chemist.

Type Material: National Museum of Natural History, Washington, D.C., USA, 86531.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 52. (2) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 59–62. (3) Mamedov, K.H. and N.V. Belov (1958) Crystal structure of hillebrandite. Doklady Acad. Nauk SSSR, 123, 741–743 (in Russian).

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Hillite $Ca_2(Zn,Mg)(PO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As delicate needles, to several mm long.

Physical Properties: Hardness = n.d. D(meas.) = 1.43 D(calc.) = 1.467

Optical Properties: Semitransparent. *Color:* Yellow, yellowish green.
Optical Class: [Biaxial (+).] *Orientation:* $X \parallel$ elongation. $\alpha = \sim 1.75$ $\beta = \sim 1.75$ $\gamma = \sim 2.0$
2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/a$. $a = 15.81$ $b = 3.967$ $c = 7.876$ $\beta = 102.67°$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 28-2002).
3.52 (100), 7.69 (95), 3.36 (80), 6.16 (50), 3.84 (35), 3.14 (14), 3.79 (10)

Chemistry: (1) Modern identification would depend on coincidence of X-ray powder diffraction pattern with that of synthetic material (anthraquinone).

Occurrence: Very rare, in crusts around the surface vents of a burning coal deposit.

Association: Sal ammoniac, sulfur.

Distribution: On Mt. Pyramide, Spitsbergen, Norway.

Name: Honors Adolf Hoel (1879–1964), leader of the discovery expedition to Spitsbergen during which the mineral was found.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway, 21981.

References: (1) Oftedal, I. (1922) Minerals from the burning coal seam at Mt. Pyramide, Spitsbergen. Resultater av de Norske Statsunderstøttede Spitsbergenekspeditioner, 1(3), 9–14.
(2) (1923) Mineral. Abs., 2, 10 (abs. ref. 1).

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Hingganite-(Ce) $(Ce, Y)BeSiO_4(OH)$

Crystal Data: Monoclinic. Point Group: 2/*m*. As rims on prismatic crystals of hingannite-(Y).

Physical Properties: Hardness = 5-6 D(meas.) = n.d. D(calc.) = [4.82]
Cleavage: None detected.

Optical Properties: Transparent. *Color:* Pale tan. *Streak*: White.
Luster: Vitreous. Nonfluorescent.
Optical Class: Biaxial (+). α = 1.745(5) γ = 1.770(5) 2V > 75°

Cell Data: Space Group: $P2_1/a$ [by analogy to hingganite-(Y)]. a = 9.8973(1) b = 7.6282(8) c = 4.7505(6) β = 90.416(8)° Z = 2

X-ray Powder Pattern: Iwaguro Sekizai quarry, Japan.
2.85 (100), 3.13 (86), 2.56 (46), 6.06 (42), 3.74 (37), 3.44 (34), 2.21 (33)

Chemistry:

	(1)	(2)	(3)
SiO_2	22.27	25.47	23.27
B_2O_3	trace		
Y_2O_3	10.91	0.72	
La_2O_3	3.40	11.11	
Ce_2O_3	16.77	28.32	63.56
RE_2O_3	30.73	7.33	
FeO	5.65	3.61	
BeO	[9.27]	[10.60]	9.69
CaO	0.39	7.07	
H_2O	[1.90]	[2.88]	3.49
Total	[101.29]	97.10	100.00

(1) Iwaguro Sekizai quarry, Japan; by electron microprobe, BeO calculated so Be:Si = 1:1; RE_2O_3 = Nd_2O_3 9.79%, Pr_2O_3 [3.5%], Sm_2O_3 4.70%, Eu_2O_3 trace, Gd_2O_3 4.18%, Tb_2O_3 [0.5%], Dy_2O_3 3.82%, Ho_2O_3 1.08%, Er_2O_3 1.84%, Tm_2O_3 trace, Yb_2O_3 1.02%, Lu_2O_3 [0.3%]; corresponds to $(Ce_{0.54}Y_{0.51}RE_{1.07})_{\sum=2.12}Fe_{0.41}Be_{1.96}Si_{1.96}O_{8.87}(OH)_{1.13}$. (2) Iwaguro Sekizai quarry, Japan; by electron microprobe, Be and B confirmed by SIMS; RE_2O_3 = Pr_2O_3 2.11, Nd_2O_3 4.70, Sm_2O_3 0.39, Gd_2O_3 0.08, Tb_2O_3 trace, Dy_2O_3 0.05, Ho_2O_3 trace, Er_2O_3 trace, Tm_2O_3 trace, Yb_2O_3 trace, Lu_2O_3 trace; corresponds to $(Ce_{0.82}La_{0.32}Nd_{0.13}Pr_{0.06}Y_{0.03}Sm_{0.01}Gd_{0.002}Dy_{0.001}Ca_{0.60})_{\sum=1.15}S_{1.97}Fe_{0.24}$ $Be_{2.02}(SiO_4)_{2.02}(OH)_{1.52}$. (3) $CeBeSiO_4(OH)$.

Mineral Group: Gadolinite group.

Occurrence: In drusy pegmatite.

Association: Quartz, potassium feldspar, albite, zinnwaldite, cassiterite, stokesite, fluorite, chlorite, titanite,

Distribution: In the Iwaguro Sekizai quarry, Tahara, Gifu Prefecture, Japan.

Name: For the predominance of cerium and relation to *hingganite-(Y).*

Type Material: National Science Museum, Tokyo, Japan (NSM-M28552).

References: (1) Miyawaki, R., I. Nakai, K. Nagashima, A. Okamoto, and T. Isobe (1987) The first occurrences of hingganite, hellandite and wodginite in Japan. Kobutsugaku Zasshi, 18(1), 17-30 (in Japanese). (2) (1990) Amer. Mineral., 75, 432 (abs. ref. 1). (3) Miyawaki, R., S. Matsubara, K. Yokoyama, and A. Okamoto (2007) Hingannite-(Ce) and hingannite-(Y) from Tahara, Hirukawa-mura, Gifu Prefecture, Japan: The description on a new mineral species of the Ce-analogue of hingannite-(Y) with a refinement of the crystal structure of hingannite-(Y). J. Mineral. Petrol. Sciences, 102, 1–7. (4) (2008) Amer. Mineral., 93, 1688 (abs. ref. 3).

Hingganite-(Y) (Y, Yb, Er)$BeSiO_4(OH)$

Crystal Data: Monoclinic. Point Group: 2/*m*. Stout prismatic crystals, to 1.5 mm, may be in fanlike to sheaflike aggregates; typically granular.

Physical Properties: Hardness = [5-5.5] VHN = 415-467 D(meas.) = 4.42-4.57 D(calc.) = 4.45 *Cleavage*: None detected.

Optical Properties: Transparent. *Color:* Milky white, light yellow, light green, light blue; colorless in transmitted light. *Luster*: Vitreous.
Optical Class. Biaxial (+). *Orientation*: *Y* = b; *Z* ^ c = 6°-13°; *Z* ^ a = 14°.
Dispersion: r < *v*; strong. α = 1.744-1.748 β = 1.753-1.765 γ = 1.765-1.783
2V(meas.) = 80°

Cell Data: Space Group: $P2_1/c$. *a* = 4.790 *b* = 7.545 *c* = 9.989 β = 91° Z = 4

X-ray Powder Pattern: Heilungkiang Province, China.
3.148 (10), 2.685 (10), 2.569 (6), 4.790 (5), 3.462 (5), 1.985 (5), 1.880 (5)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	25.20	26.43	Yb_2O_3	17.02		BeO	10.41	10.50
TiO_2	0.10		RE_2O_3	12.39		MgO	0.09	
Al_2O_3	1.70	0.10	Fe_2O_3	1.63	1.46	CaO	0.96	2.38
Y_2O_3	26.11	24.83	FeO	0.89		$(K;Na)_2O$	1.17	
Ce_2O_3	28.47		PbO	0.38	0.52	H_2O	2.94	[3.92]
						Total	100.05	[99.55]

(1) Greater Khingan Range, China; corresponds to $(Y_{0.33}Ce_{0.21}La_{0.16}Nd_{0.10}RE_{0.13})_{\sum=0.93}[(K:Na)_{0.07}Fe^{3+}_{0.05}Ca_{0.04}Fe^{2+}_{0.03}]_{\sum=0.19}(Be_{1.00}Al_{0.08})_{\sum=1.08}Si_{1.02}O_{4.38}(OH)_{0.80}$. (2) Kola Peninsula, Russia; by electron microprobe, H_2O by difference, RE_2O_3 = Tb_2O_3 0.33%, Dy_2O_3 2.13%, Ho_2O_3 0.21%, Er_2O_3 6.47%, Tm_2O_3 1.38%, Lu_2O_3 1.87%. (3) Heilungkiang Province, China, by XRF and wet chemical analysis, analytical results not available; stated to correspond to $(Y_{0.33}Ce_{0.19}Nd_{0.10}La_{0.05}RE_{0.20}Fe^{3+}_{0.05}Fe^{2+}_{0.03}Na_{0.03})_{\sum=0.98}(Be_{0.97}Al_{0.03})_{\sum=1.00}(Si_{0.98}Al_{0.05})_{\sum=1.03}O_{4.00}[(OH)_{0.77}O_{0.23}]_{\sum=1.00}$.

Mineral Group: Gadolinite group.

Occurrence: In a RE, Be-bearing granophyre (Greater Khingan Range, China); in "amazonite"-rich pegmatite in a differentiated alkalic massif (Kola Peninsula, Russia).

Association: Hingganite-(Ce), quartz, potassium feldspar, albite, zinnwaldite, cassiterite, stokesite, fluorite, chlorite, titanite (Tahara area, Japan); aegirine, zircon, quartz (Mt. Malosa, Malawi).

Distribution: From an unspecified locality in the Greater Khingan Range, Heilungkiang Province, China. In the Trimouns talc deposit, six km northeast of Luzenac, Ariμege, France. From the [Keivy massif,] Kola Peninsula, and at Tastyg, Tuva, Russia. In the Iwaguro Sekizai quarry, Tahara area, Gifu Prefecture, Japan. On North Sugarloaf Mountain, Bethlehem, Grafton Co., New Hampshire, USA. On Mt. Malosa, Zomba district, Malawi.

Name: Presumably for the occurrence in the Greater Khingan (Hinggan) Range, China, and predominance of yttrium.

Type Material: Geology Bureau, Chinese Academy of Geological Sciences, Beijing, China.

References: (1) Xiaoshi Ding, Ge Bai, Zhongxian Yuan, and Luren Sun (1981) Yttroceberysite, a new Ce-Be-rich silicate. Geol. Rev. China, 27, 459-465 (in Chinese with English abs.). (2) (1988) Amer. Mineral., 73, 442 (abs. ref. 1). (3) Xiaoshi Ding, Ge Bai, Zhongxian Yuan, and Jinding Liu (1984) Hingganite [(Y, Ce)$BeSiO_5(OH)$]. new data. Yanshi Kuangwu Ji Ceshi, 3(1),46-48 (in Chinese). (4) (1987) Chem. Abs., 106, 70456 (abs. ref. 3). (5) Lulu Ximen and Peng Zhizlong (1985) Crystal structure of xinganite. Acta Mineral. Sinica, 5, 289-293 (in Chinese with English

abs.). (6) (1988) Amer. Mineral., 73, 441-442 (abs. ref. 5). (7) (1988) Amer. Mineral., 73, 935 (errata). (8) Voloshin, A.V., Y.A. Pakhomovskii, Y.P. Men'shikov, A.S. Povarennykh, E.N. Matvinenko, and O.V. Yakubovich (1983) Hingganite-(Yb), a new mineral from amazonite pegmatites of the Kola Peninsula. Doklady Acad. Nauk SSSR, 270, 1188-1192 (in Russian). (9) (1984) Amer. Mineral., 69, 811 (abs. ref. 8). (10) Petersen, O.V. and M. Grossmann (1994) Some pegmatite minerals from the Zomba district, Malawi. Mineral. Record, 24, 29-35, 38.
(11) Miyawaki, R., I. Nakai, K. Nagashima, A. Okamoto, and T. Isobe (1987) The first occurrences of hingganite, hellandite and wodginite in Japan. Kobutsugaku Zasshi, 18(1), 17-30 (in Japanese). (12) (1990) Amer. Mineral., 75, 432 (abs. ref. 11). (13) Miyawaki, R., S. Matsubara, K. Yokoyama, and A. Okamoto (2007) Hingannite-(Ce) and hingannite-(Y) from Tahara, Hirukawa-mura, Gifu Prefecture, Japan. The description on a new mineral species of the Ce-analogue of hingannite-(Y) with a refinement of the crystal structure of hingannite-(Y). J. Mineral. Petrol. Sciences, 102, 1–7. (14) (2008) Amer. Mineral., 93, 1688 (abs. ref. 13).

Hingganite-(Yb) $(Yb,Y)BeSiO_4(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals, to 2 mm, in spherical aggregates.

Physical Properties: Hardness = 6–7 D(meas.) = n.d. D(calc.) = 4.83

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X \wedge c = 20°$; $Z \wedge c = 23°$. $\alpha = 1.725$ $\beta = 1.738$ $\gamma = 1.760$ 2V(meas.) = 65°

Cell Data: *Space Group:* $P2_1/a$. a = 9.888(5) $b = 7.607(3)$ $c = 4.740(2)$ $\beta = 90.45(4)°$ Z = 4

X-ray Powder Pattern: Kola Peninsula, Russia.
3.13 (10), 2.85 (10), 2.572 (8), 2.542 (8), 1.977 (8), 6.07 (7)

Chemistry:

	(1)
SiO_2	22.11
Y_2O_3	8.56
Yb_2O_3	34.07
RE_2O_3	19.37
BeO	10.90
CaO	1.14
H_2O	[3.74]
Total	[99.89]

(1) Kola Peninsula, Russia; by electron microprobe, H_2O stated to be by difference; RE_2O_3 = Tb_2O_3 0.05%, Dy_2O_3 2.47%, Ho_2O_3 1.03%, Er_2O_3 8.22%, Tm_2O_3 3.10%, Lu_2O_3 4.50%; corresponds to $(Yb_{0.45}Y_{0.20}RE_{0.30}Ca_{0.05})_{\Sigma=1.00}Be_{1.13}Si_{0.96}O_{3.92}(OH)_{1.08}$.

Mineral Group: Gadolinite group.

Occurrence: Formed by very late-stage replacement reactions in "amazonite"-rich pegmatites.

Association: Plumbian microlite [plumbomicrolite], fluorite, keiviite-(Yb), bastnäsite.

Distribution: From Mt. Ploskaya, Keivy massif, Kola Peninsula, Russia.

Name: For the predominance of *ytterbium* and its relation to *hingganite*-(Y).

Type Material: Central Siberian Geological Museum, Novosibirsk, 5768; Mining Institute, St. Petersburg, 1590/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84278–84280.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, Y.P. Men'shikov, A.S. Povarennykh, E.N. Matvinenko, and O.V. Yakubovich (1983) Hingganite-(Yb), a new mineral from amazonite pegmatites of the Kola Peninsula. Doklady Acad. Nauk SSSR, 270, 1188–1192 (in Russian). (2) (1984) Amer. Mineral., 69, 811 (abs. ref. 1). (3) Yakubovich, O.V., E.N. Matvinenko, A.V. Voloshin, and M.A. Simonov (1983) The crystal structure of hingganite-(Yb), $(Y_{0.51}TR_{0.36}Ca_{0.13})\cdot Fe_{0.065}Be[SiO_4](OH)$. Kristallografiya (Sov. Phys. Crystal.), 28, 457–460 (in Russian).

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Hinsdalite $(Pb,Sr)Al_3(PO_4)(SO_4)(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As rhombohedra $\{10\overline{1}1\}$, hexagonal plates, tabular on {0001}, or pseudocubic crystals, to 2 cm; massive or granular.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 4.5 D(meas.) = 3.65 D(calc.) = 4.07

Optical Properties: Translucent. *Color:* Colorless, pale green, pearly white. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (+); may exhibit biaxial sectors. $\omega = 1.671$ $\epsilon = 1.689$

Cell Data: *Space Group:* $R\overline{3}m$. a = 6.99 c = 16.8 Z = 3

X-ray Powder Pattern: Golden Fleece mine, Colorado, USA.
2.78 (100), 2.96 (80), 5.59 (65), 5.70 (50), 2.222 (50), 3.50 (40), 1.896 (25)

Chemistry:

	(1)	(2)
SO_3	14.13	15.36
P_2O_5	14.50	13.61
Al_2O_3	26.47	29.33
PbO	31.75	21.40
SrO	3.11	9.94
H_2O	10.25	10.36
Total	100.21	100.00

(1) Golden Fleece mine, Colorado, USA. (2) $(Pb,Sr)Al_3(PO_4)(SO_4)(OH)_6$ with Pb:Sr = 1:1.

Mineral Group: Beudantite group.

Occurrence: A rare secondary mineral in the oxidized zone of polymetallic sulfide deposits.

Association: Barite, pyrite, galena, tetrahedrite, rhodochrosite (Golden Fleece mine, Colorado, USA).

Distribution: In the USA, large crystals from the Golden Fleece mine, near Lake City, Hinsdale Co., Colorado; in the Mineral Park mine, Mohave Co., Arizona; and at the Daisy Creek prospect, 25 km north of Thompson Falls, Sanders Co., Montana. In the Sylvester mine, Zeehan, and the Comet mine, Dundas, Tasmania; from Broken Hill, New South Wales, Australia. At Penkiln Burn, 13 km north-northeast of Newton Stewart, Kirkcudbrightshire, Scotland. In the Colettes massif, about 45 km southeast of Montluçon, Allier, France. From Bad Ems, Rhineland-Palatinate, Germany.

Name: For Hinsdale Co., Colorado, USA, source of the first specimens.

Type Material: Harvard University, Cambridge, Massachusetts, 101680, 101682, 101683; National Museum of Natural History, Washington, D.C., USA, 86987, 92971.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1004. (2) Stanley, C.R. (1987) Hinsdalite and other products of oxidation at the Daisy Creek stratabound copper-silver prospect, northwestern Montana. Can. Mineral., 25, 213–220. (3) Nicolas, J. and A. De Rosen (1963) Phosphates hydrothermaux de basse température et kaolinisation: la gorceixite du massif des Colettes (Allier) et les minéraux associés (hinsdalite). Bull. Minéral., 86, 379–385 (in French).

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Hiortdahlite $(Ca,Na)_3(Zr,Ti)Si_2O_7(O,F)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals tabular parallel to {100}, with {010} and {101}. *Twinning:* Polysynthetic twinning on {010} and {100}, common.

Physical Properties: *Cleavage:* Distinct on {110} and {1$\overline{1}$0}, the two intersecting at nearly 90°. *Tenacity:* Very brittle. Hardness = 5.5 D(meas.) = 3.25–3.31 D(calc.) = [3.21–3.24]

Optical Properties: Semitransparent. *Color:* Light yellow to honey-yellow, yellowish brown, green. *Luster:* Vitreous on crystal faces, greasy on fractures.
Optical Class: Biaxial (+). *Pleochroism:* X = nearly colorless; Y = bright yellow; Z = wine-yellow. *Dispersion:* $r < v$, strong. *Absorption:* $Z > Y > X$. α = 1.639–1.658 β = 1.643–1.664 γ = 1.646–1.671 2V(meas.) = 80°–86°

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.95(3)$ $b = 10.31(2)$ $c = 7.29(3)$ $\alpha = 90°19(10)'$ $\beta = 109°2(15)'$ $\gamma = 90°5(10)'$ Z = [4], or *Space Group:* $P\overline{1}$. $a = 11.0149(9)$ $b = 10.9409(9)$ $c = 7.3534(3)$ $\alpha = 109.350(3)°$ $\beta = 109.879(4)°$ $\gamma = 83.434(4)°$ Z = [4]

X-ray Powder Pattern: Kipawa River, Canada.
2.87 (100), 3.00 (90), 3.28 (45), 1.70 (40), 1.84 (30), 2.03 (25), 1.80 (25)

Chemistry:

	(1)		(1)		(1)
SiO_2	32.20	RE_2O_3	2.08	SrO	0.03
TiO_2	0.30	Fe_2O_3	0.27	Na_2O	6.85
ZrO_2	18.76	Nb_2O_5	0.56	K_2O	0.02
HfO_2	0.27	U_3O_8	0.09	F	6.69
SnO_2	0.02	MnO	0.30	H_2O^+	0.42
Al_2O_3	0.07	MgO	0.09	$-O = F_2$	2.81
Y_2O_3	3.50	CaO	29.57	Total	99.28

(1) Kipawa River, Canada; corresponding to $(Ca_{2.01}Na_{0.85}Y_{0.12}RE_{0.04})_{\Sigma=3.02}(Zr_{0.58}Nb_{0.02}Mn_{0.02}Ti_{0.01}Fe_{0.01}Mg_{0.01}Al_{0.01})_{\Sigma=0.66}Si_{2.05}O_7[F_{1.34}O_{0.41}(OH)_{0.18}]_{\Sigma=1.93}$.

Polymorphism & Series: Topological variants I and II, both triclinic.

Occurrence: A rare mineral in alkalic rocks, their pegmatites, and metamorphosed equivalents; in miarolitic cavities in sanidinites.

Association: Feldspar, biotite, meliphanite, titanite (Langesundsfjord, Norway); aegirine, astrophyllite, nepheline (Korgeredaba massif, Russia).

Distribution: In Norway, on Mittel Arø, Lille Arø, and Stokkø Islands, in the Langesundsfjord. In Italy, at Monte Somma and Vesuvius, Campania. From Mayen, Eifel district, Germany. At the Kangerdlugssuaq Fjord, Greenland. In Russia, in the Korgeredaba massif, Sangilen, Tuva. From the [Sheffield Lake complex,] Kipawa River, Villedieu Township, Quebec, Canada. On the Los Islands, Guinea. From the Jingera complex, New South Wales, Australia.

Name: After Professor Thorstein Hallager Hiortdahl (1839–1925), mineralogist of Kristiania (now Oslo), Norway.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 377–378. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 379–381 (3) Aarden, H.M. and J. Gittins (1974) Hiortdahlite from Kipawa River, Villedieu Township, Temiscaming County, Quebec, Canada. Can. Mineral., 12, 241–247. (4) Eggleton, R.A., G.E. Halford, and S.D. Beams (1979) Hiortdahlite from Jingera, New South Wales. J. Geol. Soc. Aust., 26, 81–85. (5) Merlino, S. and N. Perchiazzi (1985) The crystal structure of hiortdahlite I. Tschermaks Mineral. Petrog. Mitt., 34, 297–310. (6) Merlino, S. and N. Perchiazzi (1987) The crystal structure of hiortdahlite II. Mineral. Petrol., 37, 25–35.

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Hisingerite $Fe_2^{3+}Si_2O_5(OH)_4 \cdot 2H_2O$

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Crystal Data: Amorphous to poorly crystalline. *Point Group:* n.d. Commonly massive, compact; may be minutely spherical.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3
D(meas.) = 2.43–2.67 D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Black, dark brown; dark green masses may turn brown in light; in thin section, greenish brown or golden yellow. *Streak:* Yellowish brown. *Luster:* Resinous, vitreous, greasy.
Optical Class: Isotropic; locally anisotropic. n = 1.50–1.66

Cell Data: *Space Group:* n.d.

X-ray Powder Pattern: Riddarhyttan, Sweden; easily confused with neotocite.
4.45 (s), 3.53 (s), 2.56 (s), 1.71 (s), 1.54 (s)

Chemistry:

	(1)	(2)
SiO_2	35.08	34.15
Al_2O_3	1.38	
Fe_2O_3	40.28	45.38
FeO	2.23	
MgO	0.35	
CaO	0.36	
H_2O	20.78	20.47
Total	100.46	100.00

(1) Riddarhyttan, Sweden. (2) $Fe_2Si_2O_5(OH)_4 \cdot 2H_2O$.

Occurrence: A secondary mineral, formed from the weathering, or late-stage deuteric or hydrothermal alteration, of iron-bearing silicates or sulfides; by late-stage hydrothermal activity during sulfide ore deposition.

Association: Olivine, pyroxene, pyrite, chalcopyrite, pyrrhotite.

Distribution: In small amounts, easily overlooked, from many localities worldwide. Some for described material are: at Riddarhyttan, Västmanland, and Långban, Värmland, Sweden. From Fagul Cetatii, Balan, Romania. At Salberg, Norway. Found near Helsingfors, Finland. From Llallagua, Bolivia. In the USA, in the Hibbing district, St. Louis Co., Minnesota; in Arizona, at the Castle Dome mine, Gila Co., and on the Mildren and Steppe claims, Cababi district, Pima Co.; at the Gap Nickel mine, Lancaster Co., Pennsylvania. In Canada, from the Wilcox mine, Parry Sound, Ontario; at the Tetrault mines, near Montauban-les-mines, Quebec; and from Goldfields, Saskatchewan. In the Kawayama mine, Yamaguchi Prefecture; the Sano mine, Wakayama Prefecture; the Suzuyama mine, Kagoshima Prefecture; and other localities in Japan.

Name: For the Swedish chemist and mineralogist, Vilhelm Hisinger (1766–1852).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 702–703. (2) Whelan, J.A. and S.S. Goldich (1961) New data for hisingerite and neotocite. Amer. Mineral., 46, 1412–1423. (3) Eggleton, R.A., J.H. Pennington, R.S. Freeman, and I.M. Threadgold (1983) Structural aspects of the hisingerite-neotocite series. Clay Minerals, 18, 21–31. (4) Farmer, V.C. (1992) Possible confusion between so-called ferrihydrites and hisingerites. Clay Minerals, 27, 373–378.

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Hocartite $Ag_2(Fe,Zn)SnS_4$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As grains, to less than 1 mm in diameter, and intergrowths. *Twinning:* Polysynthetic twinning, common.

Physical Properties: Hardness = ∼4 VHN = 209–234 (25 g load). D(meas.) = n.d. D(calc.) = 4.77

Optical Properties: Opaque. *Color:* In polished section, brownish gray. *Pleochroism:* Weak, gray-brown to gray-violet. *Anisotropism:* Distinct, orange to greenish.
R_1–R_2: (400) 25.8–26.0, (420) 25.8–25.9, (440) 25.5–25.7, (460) 25.1–25.4, (480) 24.7–25.0, (500) 24.4–24.7, (520) 24.1–24.5, (540) 23.8–24.3, (560) 23.7–24.0, (580) 23.6–24.0, (600) 23.5–24.1, (620) 23.8–24.3, (640) 24.2–24.4, (660) 24.2–24.3, (680) 23.9–24.0, (700) 23.5–23.6

Cell Data: *Space Group:* $I\bar{4}2m$. $a = 5.74$ $c = 10.96$ $Z = 2$

X-ray Powder Pattern: Tacama, Bolivia.
3.26 (100), 1.98 (80), 1.72 (70), 2.03 (50), 2.87 (40), 2.74 (30), 1.666 (30)

Chemistry:

	(1)	(2)	(3)
Ag	36.0	42.3	41.61
Fe	7.6	10.0	10.77
Zn	4.2		
Cu	1.8	0.2	
Sn	25.0	23.4	22.89
S	26.0	24.0	24.73
Total	100.6	99.9	100.00

(1) Tacama, Bolivia; by electron microprobe, corresponding to $(Ag_{1.65}Cu_{0.14})_{\Sigma=1.79}(Fe_{0.67}Zn_{0.32})_{\Sigma=0.99}Sn_{1.04}S_{4.00}$. (2) Himmelsfürst mine, Germany; by electron microprobe, corresponding to $(Ag_{2.10}Cu_{0.02})_{\Sigma=2.02}Fe_{0.96}Sn_{1.05}S_{4.00}$. (3) Ag_2FeSnS_4.

Polymorphism & Series: Forms a series with pirquitasite.

Mineral Group: Stannite group.

Occurrence: Of relatively high-temperature origin, typically in hydrothrmal tin-bearing deposits.

Association: Cassiterite, cylindrite, franckeite, suredaite, stannite, canfieldite, tetrahedrite, pyrargyrite, silver, sphalerite, wurtzite, siderite, fluorite.

Distribution: In Bolivia, from Tacama [TL], Hocaya, Colquechaca, Potosí, and Chocaya. In the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. At Fournial, Cantal, France [TL]. From the Himmelsfürst mine, Erbisdorf, near Freiberg, Saxony, Germany. In the Chat-Karagai tin deposit, Tallas Alatan, Russia. At the Huangshaping Pb–Zn deposit, Giuyang, Hunan Province, China. From the Toyoha mine, Hokkaido, Japan. In the USA, at Bisbee, Cochise Co., Arizona, and in the Dean mine, southeast of Battle Mountain, Lewis district, Lander Co., Nevada.

Name: Honors Raymond Hocart (1896–1983), Professor of Mineralogy, University of Paris, Paris, France.

Type Material: National School of Mines, Paris, France.

References: (1) Caye, R., Y. Laurent, P. Picot, R. Pierrot, and C. Lévy (1968) La hocartite, Ag_2SnFeS_4, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 91, 383–387 (in French with English abs.). (2) (1969) Amer. Mineral., 54, 573 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 239.

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Hochelagaite $(Ca, Na, Sr)Nb_4O_{11}\cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Intimately intergrown with franconite, in bladed crystals, to 0.03 mm, radiating in globules, to 150 μm, commonly with a granular core; in radial spherical aggregates and matted fibrous masses.

Physical Properties: *Tenacity:* Brittle; flexible when fibrous. Hardness = ∼4 D(meas.) = 2.89(1) D(calc.) = 2.883 May show a weak pale yellow fluorescence under SW and LW UV.

Optical Properties: Semitransparent. *Color:* White. *Streak:* White. *Luster:* Vitreous to silky.
Optical Class: Biaxial (–). *Orientation:* Z = elongation; $X \perp$ blades. $\alpha = 1.72(1)$ $\beta = [1.81(1)]$ $\gamma = 1.82(1)$ 2V(meas.) = 35(5)°

Cell Data: *Space Group:* n.d. $a = 19.98(2)$ $b = 12.88(1)$ $c = 6.446(6)$ $\beta = 93.41(8)°$ Z = 4

X-ray Powder Pattern: Francon quarry, Canada.
10.0 (10), 3.115 (8), 3.208 (7), 5.39 (5), 4.96 (5b), 2.799 (4), 1.979 (3b)

Chemistry:

	(1)
Nb_2O_5	75.3
Ta_2O_5	0.0
SiO_2	1.3
TiO_2	1.4
Al_2O_3	0.4
CaO	7.3
SrO	0.3
Na_2O	0.8
H_2O	[13.2]
Total	[100.0]

(1) Francon quarry and Mont Saint-Hilaire, Canada; by electron microprobe, average of eight analyses, H_2O by difference, considered to be partially dehydrated from 8–9 H_2O required to match measured densities; corresponds to $(Ca_{0.84}Na_{0.16}Sr_{0.02})_{\Sigma=1.02}(Nb_{3.70}Si_{0.14}Ti_{0.11}Al_{0.05})_{\Sigma=4.00}O_{10.71}\cdot 5.47H_2O$. (2) Saint-Amable, Canada; by electron microprobe, corresponding to $(Ca_{0.87}Na_{0.13})_{\Sigma=1.00}(Nb_{3.81}Ti_{0.19}Mg_{0.05})_{\Sigma=4.05}O_{10.89}\cdot 8H_2O$.

Occurrence: In vugs of a dawsonite-bearing sill in a limestone deposit (Francon quarry, Canada); in cavities in altered pegmatite dikes, hornfels, sodalite syenite, or miarolitic cavities, associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in miarolitic cavities in a syenite sill (near Saint-Amable, Canada).

Association: Franconite, weloganite, calcite, quartz (Francon quarry, Canada).

Distribution: In the Francon quarry, Montreal Island, Montreal, at Mont Saint-Hilaire, and near Saint-Amable, Quebec, Canada. From Vardeåsen, Langesundsfjord, Norway.

Name: For *Hochelaga*, an early name for Montreal, Canada and its surrounds, within which the mineral occurs.

Type Material: Geological Survey of Canada, Ottawa, 64285–64288; Royal Ontario Museum, Toronto, Canada, M37547, M37548.

References: (1) Jambor, J.L., A.P. Sabina, A.C. Roberts, M. Bonardi, D.R. Owens, and B.D. Sturman (1986) Hochelagaite, a new calcium-niobium oxide mineral from Montreal, Quebec. Can. Mineral., 24, 449–453. (2) (1987) Amer. Mineral., 72, 1024 (abs. ref. 1). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 314–315. (4) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 101.

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Hodgkinsonite $Mn^{2+}Zn_2(SiO_4)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As euhedral crystals, stout prismatic and terminated by steep pyramids, also dominated by pyramidal forms, to 2 cm. Granular to massive in veinlets.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = < 5 D(meas.) = 4.06–4.08 D(calc.) = 4.07 Fluoresces weak pinkish red in LW UV.

Optical Properties: Transparent to translucent. *Color:* Bright pink or red to reddish brown and orange, rarely yellow; black from tarnish or inclusions.
Optical Class: Biaxial (–). *Pleochroism:* In shades of lavender and pale purple. *Orientation:* $Y = b$; $Z \wedge c = 38°$. *Dispersion:* $r > v$, strong. $\alpha = 1.720–1.724$ $\beta = 1.741–1.742$ $\gamma = 1.746$ 2V(meas.) = 50°–60°

Cell Data: *Space Group:* $P2_1/a$. $a = 8.171(2)$ $b = 5.316(2)$ $c = 11.761(2)$ $\beta = 95°15(5)'$ Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.864 (100), 2.957 (90), 1.547 (85), 2.567 (65), 1.412 (65), 2.115 (60), 1.594 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	19.86	19.6	19.27
FeO		0.2	
MnO	20.68	22.7	22.75
ZnO	52.93	50.9	52.20
MgO	0.04	0.4	
CaO	0.93	0.3	
H_2O^+	5.77	5.76	5.78
Total	100.21	99.86	100.00

(1) Franklin, New Jersey, USA; average of three analyses. (2) Do.; by electron microprobe, average of eight samples, H_2O by the Penfield method. (3) $MnZn_2SiO_4(OH)_2$.

Occurrence: As seams in massive willemite-franklinite granular ore in a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA).

Association: Barite, willemite, franklinite, tephroite, pyrochroite, calcite, manganoan garnet, copper.

Distribution: From Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For H.H. Hodgkinson, Assistant Underground Superintendent of the Franklin mine, who discovered the mineral.

Type Material: Harvard University, Cambridge, Massachusetts, 89875, 89880, 89881; National Museum of Natural History, Washington, D.C., USA, 87231.

References: (1) Palache, C. and W.T. Schaller (1913) Hodgkinsonite, a new mineral from Franklin Furnace, New Jersey. J. Wash. Acad. Sci., 3(19), 474–478. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 108–111. (3) Roberts, W.M.B. and F.M. Quodling (1962) X-ray, optical, and morphological observations on hodgkinsonite from Franklin Furnace. Mineral. Mag., 33, 343–346. (4) Rentzeperis, P.J. (1963) The crystal structure of hodgkinsonite, $Zn_2Mn[(OH)_2SiO_4]$. Zeits. Krist., 119, 117–138. (5) Dunn, P.J. and R.C. Bostwick (1982) Hodgkinsonite from Franklin and Sterling Hill, New Jersey: a review. Mineral. Record, 13, 229–232.

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Hodrušhite $Cu_4Bi_6S_{11}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely as needlelike, columnar or platy crystals, vertically striated, to 5 mm. Commonly as irregular grains and fine-grained aggregates. *Twinning:* Polysynthetic.

Physical Properties: *Tenacity:* Very brittle. Hardness = 3–4 VHN = 187–213, 200 average. D(meas.) = 6.35 D(calc.) = 6.451

Optical Properties: Opaque. *Color:* Steel-gray with slightly yellowish tint on fresh surface, tarnishes quickly to brownish orange; in polished section, creamy with very slight pinkish tint. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Very feeble, in grays.
R_1–R_2: (400) 36.2–39.8, (420) 36.2–40.4, (440) 36.2–41.0, (460) 36.3–41.6, (480) 36.4–42.0, (500) 36.6–42.4, (520) 36.9–42.6, (540) 37.4–42.8, (560) 37.6–43.0, (580) 37.8–43.2, (600) 37.9–43.3, (620) 38.0–43.5, (640) 38.0–43.7, (660) 38.0–43.7, (680) 37.9–43.6, (700) 37.8–43.4

Cell Data: *Space Group:* $A2/m$. $a = 27.205(50)$ $b = 3.927(15)$ $c = 17.575(50)$ $\beta = 92°9(10)'$ $Z = 4$

X-ray Powder Pattern: Banská Hodruša, Slovakia.
3.102 (vs), 3.62 (s), 2.715 (s), 3.22 (m/s), 3.48 (m), 1.722 (m), 1.450 (w/m)

Chemistry:

	(1)	(2)	(3)
Cu	13.88	13.30	13.66
Fe	0.44	0.34	
Pb		0.65	
Cd		0.06	
Ag		1.01	
Bi	64.92	64.41	67.39
S	18.98	18.90	18.95
Total	98.22	98.67	100.00

(1) Banská Hodruša, Slovakia; by electron microprobe, corresponding to $Cu_{4.06}Fe_{0.15}Bi_{5.77}S_{11.00}$. (2) Ocna de Fier, Romania; by electron microprobe, average of ten analyses; corresponding to $Cu_{3.90}Ag_{0.18}Fe_{0.12}Pb_{0.06}Cd_{0.01}Bi_{5.74}S_{11.00}$. (3) $Cu_4Bi_6S_{11}$.

Occurrence: In a polymetallic ore deposit of subvolcanic type, in a quartz vein system developed in propylitized pyroxenite andesite (Banská Hodruša, Slovakia).

Association: Quartz, hematite, chalcopyrite, wittichenite (?), pavonite (Banská Hodruša, Slovakia).

Distribution: From the Rosalia mine, Banská Hodruša, near Banská Štiavnica (Schemnitz), Slovakia [TL]. In the Paulus mine, Ocna de Fier (Morávicza; Vaskő); at Băiţa (Rézbánya); and from Valea Seacă, Romania. In the USA, at the Black Metals (Jackrabbit) mine, Bristol district, Lincoln Co., Nevada; from the Alice mine, Clear Creek Co., Colorado; and in the Campbell mine, Bisbee, Cochise Co. From the Julcani district, Peru.

Name: For the mining community of Banská Hodruša, Slovakia.

Type Material: n.d.

References: (1) Koděra, M., V. Kupčík, and E. Makovický (1970) Hodrushite—a new sulfosalt. Mineral. Mag., 37, 641–648. (2) (1971) Amer. Mineral., 56, 633 (abs. ref. 1). (3) Makovicky, E. and W.H. McLean (1972) Electron microprobe analysis of hodrushite. Can. Mineral., 11, 504–513. (4) Kupčik, V. and E. Makovický (1968) Die Kristallstruktur des Minerales $(Pb, Ag, Bi)Cu_4Bi_5S_{11}$. Neues Jahrb. Mineral., Monatsh., 236–237 (in German). (5) Cook, N.J. and C.L. Ciobanu (2003) Lamellar minerals of the cuprobismutite series and related paděraite: a new occurrence and implications. Can. Mineral., 41, 441–456.

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As delicate needles, to several mm long.

Physical Properties: Hardness = n.d. D(meas.) = 1.43 D(calc.) = 1.467

Optical Properties: Semitransparent. *Color:* Yellow, yellowish green.
Optical Class: [Biaxial (+).] *Orientation:* $X \parallel$ elongation. $\alpha = \sim 1.75$ $\beta = \sim 1.75$ $\gamma = \sim 2.0$
2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/a$. $a = 15.81$ $b = 3.967$ $c = 7.876$ $\beta = 102.67°$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 28-2002).
3.52 (100), 7.69 (95), 3.36 (80), 6.16 (50), 3.84 (35), 3.14 (14), 3.79 (10)

Chemistry: (1) Modern identification would depend on coincidence of X-ray powder diffraction pattern with that of synthetic material (anthraquinone).

Occurrence: Very rare, in crusts around the surface vents of a burning coal deposit.

Association: Sal ammoniac, sulfur.

Distribution: On Mt. Pyramide, Spitsbergen, Norway.

Name: Honors Adolf Hoel (1879–1964), leader of the discovery expedition to Spitsbergen during which the mineral was found.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway, 21981.

References: (1) Oftedal, I. (1922) Minerals from the burning coal seam at Mt. Pyramide, Spitsbergen. Resultater av de Norske Statsunderstøttede Spitsbergenekspeditioner, 1(3), 9–14.
(2) (1923) Mineral. Abs., 2, 10 (abs. ref. 1).

Hoganite $Cu(C_2H_3O_2)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Isolated crystals are short prismatic, thick tabular, showing {110}, {10$\overline{1}$}, {01$\overline{1}$}, {2$\overline{1}\overline{1}$}, {1$\overline{1}\overline{2}$}, to 0.6 mm.

Physical Properties: *Cleavage:* On {001}, perfect; on {110}, distinct (synthetic). *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = n.d. D(calc.) = 1.910

Optical Properties: Transparent. *Color:* Dark bluish green. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (+) (synthetic). *Pleochroism:* Strong; X = blue; Y = pale blue; Z = pale bluish green. *Dispersion:* $r < v$, medium. *Absorption:* $X > Y > Z$. $\alpha = 1.533(2)$ $\beta = 1.541(3)$ $\gamma = 1.554(2)$ 2V(meas.) = 85(5)° 2V(calc.) = 76.8°

Cell Data: *Space Group:* $C2/c$. $a = 13.162(3)$ $b = 8.555(2)$ $c = 13.850(3)$ $\beta = 117.08(3)°$ Z = 8

X-ray Powder Pattern: Potosi pit, Australia.
6.921 (100), 3.532 (28), 6.176 (14), 3.592 (11), 5.382 (10), 2.278 (10), 5.872 (9)

Chemistry:

	(1)	(2)
Cu	31.6	31.83
Fe	0.4	
C	23.85	24.06
H	3.95	4.04
O	[40.2]	40.07
Total	[100.0]	100.00

(1) Potosi pit, Australia; by AA, C and H by CHN analyzer, average of two analyses, O by difference; corresponds to $Cu_{1.00}Fe_{0.01}C_{4.00}H_{7.89}O_{5.07}$; equivalence to the synthetic compound was established by crystal-structure analysis. (2) $Cu(C_2H_3O_2)_2 \cdot H_2O$.

Occurrence: Formed in ferruginous gossan by reaction of oxidized zone metallic minerals with decaying vegetable matter provided by leaf litter and possibly mine timbers.

Association: Paceite, linarite, malachite, azurite, cuprian smithsonite, cerussite, goethite, hematite, quartz.

Distribution: From the Potosi Ag–Pb–Zn pit, two km northeast of Broken Hill, New South Wales, Australia.

Name: To honor Graham P. Hogan (1957–), Broken Hill, Australia, miner and collector of Broken Hill minerals, who found the first specimens.

Type Material: Broken Hill Geocentre, Broken Hill; Australian Museum, Sydney; Museum of Victoria, Melbourne, Australia, M47465.

References: (1) Hibbs, D.E., U. Kolitsch, P. Leverett, J.L. Sharpe, and P.A. Williams (2002) Hoganite and paceite, two new acetate minerals from the Potosi mine, Broken Hill, Australia. Mineral. Mag., 66, 459–464. (2) de Meester, P., S.R. Fletcher, and A.C. Skapski (1973) Refined crystal structure of tetra-μ-acetato-bisaquodicopper(II). J. Chem. Soc., Dalton Transactions, 2575–2578.

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Høgtuvaite $\mathbf{(Ca,Na)_2(Fe^{2+},Fe^{3+},Ti)_6(Si,Be,Al)_6O_{20}}$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\bar{1}$. As prismatic crystals, to 4 cm, with well-developed striations ∥ elongation; rarely in radiating groups. *Twinning:* Polysynthetic, ubiquitous, twin axis ⊥ pseudomonoclinic (010).

Physical Properties: *Cleavage:* Two good, intersecting at ∼55°; a parting ⊥ elongation. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 3.85–3.88 D(calc.) = 3.92–3.98

Optical Properties: Opaque; transparent to translucent only in ultrathin sections. *Color:* Black. *Streak:* Dark green. *Luster:* Subadamantine to nonmetallic. *Optical Class:* Biaxial (–) (?). *Pleochroism:* Very strong; X = bronze; Z = green. $\alpha = 1.78$ (α') β = n.d. $\gamma = 1.82$ (γ') 2V(meas.) = Large.

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.317(1)$ $b = 10.724(1)$ $c = 8.855(1)$ $\alpha = 105.77(1)°$ $\beta = 96.21(1)°$ $\gamma = 124.77(1)°$ Z = 2

X-ray Powder Pattern: Near Mo i Rana, Norway.
2.529 (100), 8.48 (90), 2.098 (63), 2.925 (59), 2.676 (48), 2.075 (47), 3.125 (46)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	31.60	30.09	MgO	0.42	2.74
TiO_2	2.77	6.02	CaO	10.44	13.38
SnO_2	0.53		Na_2O	1.52	1.35
Al_2O_3	2.64	3.55	K_2O	0.00	0.30
Fe_2O_3	[19.03]	11.12	H_2O^+		0.35
FeO	[28.06]	26.91	H_2O^-		0.07
MnO	0.27	1.26	F	0.00	
BeO	2.65	2.32	LOI		0.22
			Total	[99.93]	[99.68]

(1) Near Mo i Rana, Norway; by electron microprobe and ICP, average of four samples, Fe^{2+}:Fe^{3+} by wet chemical analysis and Mössbauer spectroscopy; corresponding to $(Ca_{1.63}Na_{0.43})_{\Sigma=2.06}(Fe^{2+}_{3.42}Fe^{3+}_{2.08}Ti_{0.30}Mg_{0.09}Mn_{0.03}Sn_{0.03})_{\Sigma=5.95}(Si_{4.60}Be_{0.92}Al_{0.45})_{\Sigma=5.97}O_{20}$. (2) Ilmen Mountains, Russia; original total given as 100.28%; corresponding to $(Ca_{2.09}Na_{0.38}K_{0.03})_{\Sigma=2.50}(Fe^{2+}_{3.29}Fe^{3+}_{1.22}Ti_{0.66}Mg_{0.30}Mn_{0.08})_{\Sigma=5.55}(Si_{4.39}Be_{0.81}Al_{0.61})_{\Sigma=5.81}O_{20}$.

Mineral Group: Aenigmatite group.

Occurrence: As a late-stage metamorphic mineral in peraluminous granitic gneisses and mafic pegmatites associated with a beryllium deposit (near Mo i Rana, Norway).

Association: Quartz, albite, microcline, biotite, phenakite, zircon, fluorite, calcite, many minor beryllium and sulfide minerals (near Mo i Rana, Norway).

Distribution: Found about 16 km northwest of Mo i Rana, Norway. In the Ilmen Mountains, Southern Ural Mountains, Russia.

Name: For Høgtuva Mountain, near the type locality in Norway.

Type Material: University of Oslo, Oslo, Norway; National Museum of Natural History, Washington, D.C., USA.

References: (1) Grauch, R.I., I. Lindahl, H.T. Evans, Jr., D.M. Burt, J.J. Fitzpatrick, E.E. Foord, P.-R. Graff, and J. Hysingjord (1994) Høgtuvaite, a new beryllian member of the aenigmatite group from Norway, with new X-ray data on aenigmatite. Can. Mineral., 32, 439–448. (2) Yakubovich, O.V., Y.A. Malinovskii, and O.V. Polyakov (1990) Crystal structure of makarochkinite [høgtuvaite]. Kristallografiya (Sov. Phys. Crystal.), 35, 1388–1394 (in Russian). (3) (1992) Amer. Mineral., 77, 448 (abs. ref. 2).

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Hohmannite $Fe_2^{3+}O(SO_4)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are short prismatic along [001], to 1 mm, typically with dull or rounded and striated faces; as granular aggregates.

Physical Properties: *Cleavage:* {010}, perfect; {110} and {1$\overline{1}$0}, less perfect (referred to morphological axes; relation to X-ray axes uncertain). Hardness = 3 D(meas.) = 2.255 D(calc.) = 2.250 Decomposes in hot H_2O; rapidly dehydrates to metahohmannite on exposure to air.

Optical Properties: Transparent to translucent. *Color:* Chestnut-brown to burnt orange, pale amaranth-red. *Streak:* Yellow-orange. *Luster:* Vitreous, brilliant.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; Y = pale greenish yellow; Z = dark greenish yellow. *Orientation:* $Y \wedge c = 23°$. *Dispersion:* $r > v$, extreme. $\alpha = 1.553$–1.559 $\beta = 1.643$ $\gamma = 1.655$–1.657 2V(meas.) = 40°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.148(1)$ $b = 10.922(1)$ $c = 7.183(3)$ $\alpha = 90.29(6)°$ $\beta = 90.79(4)°$ $\gamma = 107.36(2)°$ Z = 2

X-ray Powder Pattern: Sierra Gorda district, Chile.
7.92 (FFF), 8.69 (FF), 10.36 (F), 3.46 (F), 5.31 (mF), 3.12 (mF), 3.95 (mf)

Chemistry:

	(1)	(2)
SO_3	33.80	34.52
Fe_2O_3	33.92	34.42
H_2O	30.76	31.06
insol.	1.15	
Total	99.63	100.00

(1) Sierra Gorda district, Chile. (2) $Fe_2O(SO_4)_2 \cdot 8H_2O$.

Occurrence: An uncommon low-temperature precipitate in oxidized iron sulfide deposits.

Association: Metahohmannite, copiapite, amarantite, sideronatrite (Sierra Gorda district, Chile); chalcanthite, picromerite, amarantite, fibroferrite, copiapite (Chuquicamata, Chile); metahohmannite, sulfur, cinnabar (Redington mine, California, USA).

Distribution: In Chile, in Antofagasta, from near Caracoles, Sierra Gorda district, and at Alcaparrosa, near Cerritos Bayos, both southwest of Calama; at Quetena, west of Calama; and from Chuquicamata. At the Redington mine, Knoxville, Napa Co., California, USA. From Saghand, Yazd, Iran. In the Plaka mine, near Laurium, Greece.

Name: Honors Thomas Hohmann (1843–1897), mining engineer of Valparaiso, Chile who discovered the first specimens.

Type Material: Mining Academy, Freiberg, Germany, 18623.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 613–614. (2) Scordari, F. (1978) The crystal structure of hohmannite, $Fe_2(H_2O)_4[(SO_4)_2O] \cdot 4H_2O$ and its relationship to amarantite, $Fe_2(H_2O)_4[(SO_4)_2O] \cdot 3H_2O$. Mineral. Mag., 42, 144–146 and M9–M11. (3) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Minéral., 87, 125–143, esp. 134–135 (in French).

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Holdawayite $Mn_6^{2+}(CO_3)_2(OH)_7(Cl,OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous along [001]; commonly in granular aggregates, or massive, with individual grains to 2 cm.

Physical Properties: *Cleavage:* On {100}, perfect. *Fracture:* Irregular.
Tenacity: Moderately brittle. Hardness = ∼3 D(meas.) = 3.19(4) D(calc.) = 3.24

Optical Properties: Transparent to translucent. *Color:* Pale to dark pink if fresh, turning brown on exposure, developing a dark sooty coating. *Streak:* Pale pink. *Luster:* Vitreous, silky in fibrous aggregates.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 45(3)°$. *Dispersion:* $r < v$, moderate.
$\alpha = 1.644(1)$ $\beta = 1.719(1)$ $\gamma = 1.721(1)$ 2V(meas.) = 12(3)° 2V(calc.) = 18°

Cell Data: *Space Group:* $C2/m$. $a = 23.437(5)$ $b = 3.3137(3)$ $c = 16.618(6)$
$\beta = 111.15(2)°$ Z = 4

X-ray Powder Pattern: Kombat mine, Namibia.
10.93 (100), 5.459 (80), 3.879 (70), 2.690 (60b), 2.589 (50b), 7.77 (40), 2.926 (40)

Chemistry:

	(1)
CO_2	14.2
B_2O_3	1.2
FeO	0.2
MnO	64.6
MgO	4.4
CaO	0.5
Cl	4.4
H_2O	11.47
$-O = Cl_2$	1.0
Total	100.0

(1) Kombat mine, Namibia; by electron microprobe, C by Leco analyzer, H_2O by the Penfield method, B may be due to sussexite contamination; corresponds to $(Mn_{5.24}Mg_{0.62}Ca_{0.06}Fe_{0.02})_{\Sigma=5.94}[(CO_3)_{1.86}(BO_3)_{0.20}]_{\Sigma=2.06}[(OH)_{7.34}Cl_{0.74}]_{\Sigma=8.08}$.

Occurrence: Locally abundant as a rare vein mineral in low-grade metamorphosed Mn-rich sedimentary rocks intercalated with sedimentary iron deposits.

Association: Kutnohorite, ribbeite, alleghanyite, manganoan jacobsite, pyrochroite, sussexite, galena, copper, hydroxylapatite, calcian rhodochrosite, hematite, siderite, dolomite, calcite (Kombat mine, Namibia).

Distribution: From the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia. At Răzore, Preluca Mountains, Romania.

Name: Honors Dr. Michael Jon Holdaway (1936–), Professor of Petrology, Southern Methodist University, Dallas, Texas, USA.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 51510, 51511; National Museum of Natural History, Washington, D.C., USA, 163209.

References: (1) Peacor, D.R., E.J. Essene, R.C. Rouse, P.J. Dunn, J.A. Nelen, J.D. Grice, J. Innes, and O. von Knorring (1988) Holdawayite, a new manganese hydroxyl-carbonate from the Kombat mine, Namibia. Amer. Mineral., 73, 632–636. (2) Peacor, D.R. and R.C. Rouse (1988) Holdawayite, $Mn_6(CO_3)_2(OH)_7(Cl,OH)$, a structure containing anions in zeolite-like channels. Amer. Mineral., 73, 637–642.

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Holdenite $(Mn^{2+},Mg)_6Zn_3(AsO_4)_2(SiO_4)(OH)_8$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As complex crystals tabular on {100}, with {110}, {7.16.2}, {211}, {131}, to 1 cm. In aggregates of highly irregular microcrystals; fibrous, fine-grained, massive.

Physical Properties: *Cleavage:* {010}, poor. *Fracture:* Subconchoidal. Hardness = 4
D(meas.) = 4.11(1) D(calc.) = 4.11

Optical Properties: Transparent to translucent. *Color:* Pink, orange, yellowish to deep red; pink in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z =$ a. *Dispersion:* $r > v$, distinct.
$\alpha = 1.769$ $\beta = 1.770$ $\gamma = 1.785$ 2V(meas.) = 30°20′ 2V(calc.) = 28°58′

Cell Data: *Space Group: Abma.* a = 11.99(1) $b = 31.46(4)$ $c = 8.697(6)$ Z = 8

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.838 (10), 3.582 (8), 2.583 (8), 1.531 (8), 2.464 (7), 3.406 (6), 5.740 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	6.4	5.9	5.92
As_2O_5	21.4	22.3	22.65
MnO	38.1	39.1	38.09
ZnO	23.9	23.4	24.06
MgO	3.5	2.5	2.18
H_2O	[7.1]	[7.1]	7.10
Total	[100.4]	[100.3]	100.00

(1) Franklin, New Jersey, USA; by electron microprobe, H_2O from theoretical composition.
(2) Sterling Hill, New Jersey, USA; by electron microprobe, H_2O from theoretical composition.
(3) $(Mn_{5.45}Mg_{0.55})_{\Sigma=6.00}Zn_3(AsO_4)_2(SiO_4)(OH)_8$.

Occurrence: A secondary mineral in veinlets, on slip surfaces, and as interstitial fillings within a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA).

Association: Franklinite, willemite, pyrochroite, barite, kolicite, sussexite, kraisslite, zincite, sphalerite, galena, calcite, rhodochrosite.

Distribution: From Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For the mining engineer Albert Fairchild Holden (1866–1913), of Salt Lake City, Utah, USA, in whose collection the mineral was first noticed.

Type Material: Harvard University, Cambridge, Massachusetts, 89996; National Museum of Natural History, Washington, D.C., USA, 95434, 162601.

References: (1) Palache, C. and E.V. Shannon (1927) Holdenite, a new arsenate of manganese and zinc, from Franklin, New Jersey. Amer. Mineral., 12, 144–148. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 775–777. (3) Moore, P.B. and T. Araki (1977) Holdenite, a novel cubic close-packed structure. Amer. Mineral., 62, 513–521. (4) Dunn, P.J. (1981) Holdenite from Sterling Hill and new chemical data. Mineral. Record, 12, 373–375.

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Hollandite $Ba(Mn^{4+},Mn^{3+})_8O_{16}$

Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Crystals short prismatic with flat pyramidal termination, to several cm; radial fibrous, massive. *Twinning:* Common on {101} or $\{10\bar{1}\}$.

Physical Properties: *Cleavage:* Prismatic, distinct. *Tenacity:* Brittle. Hardness = 6 VHN = 488–560 || [001], 620–689 ⊥ [001] (100 g load). D(meas.) = 4.95 D(calc.) = [4.93]

Optical Properties: Opaque. *Color:* Black, grayish black to silvery gray; in reflected light, white. *Streak:* Black. *Luster:* Metallic, splendent.
Optical Class: Biaxial. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: (400) 31.3–37.7, (420) 31.2–37.4, (440) 31.1–37.1, (460) 30.5–36.5, (480) 29.7–35.9, (500) 29.1–35.0, (520) 28.5–34.2, (540) 27.8–33.1, (560) 27.1–32.2, (580) 26.6–31.5, (600) 26.3–30.9, (620) 26.1–30.4, (640) 25.8–30.0, (660) 25.6–29.5, (680) 25.3–29.0, (700) 25.0–28.4

Cell Data: *Space Group:* $I2/m$. $a = 10.013(1)$ $b = 2.8801(2)$ $c = 9.733(1)$ $\beta = 90.970(4)°$ $Z = 1$

X-ray Powder Pattern: Langenberg, Germany; easily mistaken for coronadite.
3.13 (10), 2.40 (9), 3.47 (8), 2.15 (8), 1.55 (7), 1.83 (6), 6.98 (5)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2		0.58	MnO	5.12	
MnO_2	65.63	62.91	PbO		4.45
Al_2O_3	0.94	1.45	BaO	17.59	13.81
Fe_2O_3	10.56	12.63	Na_2O		0.58
Mn_2O_3		4.57	K_2O		0.23
			Total	99.84	[101.21]

(1) Kajlidongri, India; corresponds to $Ba_{0.95}[Mn^{4+}_{6.23}Mn^{2+}_{0.59}(Fe,Al)_{1.24}]_{\Sigma=8.06}O_{16}$. (2) Stuor Njvoskes, Sweden; by electron microprobe, average of several analyses, Mn^{4+}:Mn^{3+} calculated for charge balance; corresponds to $(Ba_{0.75}Pb_{0.16}Na_{0.10}K_{0.04})_{\Sigma=1.05}(Mn^{4+}_{6.08}Fe^{3+}_{1.32}Mn^{3+}_{0.50}Al_{0.23}Si_{0.08})_{\Sigma=8.21}O_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: A primary mineral in contact metamorphic manganese ores, and a secondary weathering product of earlier manganese-bearing minerals.

Association: Bixbyite, braunite, piemontite, other manganese oxides.

Distribution: In India, at Kajlidongri and Sitapar, Chhindwara district, Madhya Pradesh; in the Nagpur and Balaghat districts, Maharashtra; at Banswara, Rajasthan; and elsewhere. From Sörhårrås, Ultevis, Sweden. In Norway, from Tangen, Hurdal. At Langenberg, Saxony, Germany. From Inken, Tiovine region, Morocco. In the USA, in the Artillery Mountains, Mohave Co., and in the Apache mine, Sierra Ancha district, Gila Co., Arizona.

Name: For Dr. Thomas Henry Holland (1868–1947), Director of the Indian Geological Survey.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 743–744. (2) Frondel, C. and E.W. Heinrich (1942) new data on hetaerolite, hydrohetaerolite, coronadite, and hollandite. Amer. Mineral., 27, 48–56. (3) Frondel, C., U.B. Marvin, and J. Ito (1960) New data on birnessite and hollandite. Amer. Mineral., 45, 871–875. (4) Post, J.E., R.B. Von Dreele, and P.R. Buseck (1982) Symmetry and cation displacements in hollandites: structure refinements of hollandite, cryptomelane, and priderite. Acta Cryst., 38, 1056–1065. (5) Miura, H. (1987) The crystal structure of hollandite. Mineral. J. (Japan), 13, 119–129, 397–398. (6) Post, J.E. and D.L. Bish (1989) Rietveld refinement of crystal structures using powder X-ray diffraction data. In: D.L. Bish and J.E. Post, Eds., Modern powder diffraction. Reviews in mineralogy, vol. 20, 277–308, esp. 296–300.

Hollingworthite $(Rh, Pt, Pd)AsS$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Euhedral to anhedral grains, to 40 μm.

Physical Properties: Hardness = > 6, greater than that of sperrylite. VHN = ~650–700 (100 g load). D(meas.) = n.d. D(calc.) = [7.86]

Optical Properties: Opaque. *Color:* In polished section, medium gray, slightly bluish in oil. R: (400) — , (420) 50.0, (440) 51.3, (460) 51.9, (480) 51.9, (500) 51.6, (520) 51.3, (540) 50.8, (560) 50.2, (580) 49.7, (600) 49.2, (620) 48.5, (640) 47.8, (660) 47.2, (680) 46.4, (700) 45.6

Cell Data: *Space Group: Pa*3. $a = 5.769–5.797$ Z = 4

X-ray Powder Pattern: Onverwacht mine, South Africa (ruthenian).
3.31 (10), 2.87 (10), 1.74 (1), 2.04 (9), 1.112 (9), 2.57 (8), 1.29 (8)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Rh	30.8	25.0	47.62	Ru		4.0	
Pt	10.3	20.0		Fe			0.56
Pd	8.7			As	32.6	35.0	37.02
Ir	3.1	5.0		S	13.9	11.0	14.99
				Total	99.4	100.0	100.19

(1) Driekop mine, South Africa; by electron microprobe, corresponding to $(Rh_{0.68}Pd_{0.18}Pt_{0.12}Ir_{0.04})_{\Sigma=1.02}As_{0.99}S_{0.99}$. (2) Noril'sk, Russia; by electron microprobe, corresponding to $(Rh_{0.60}Pt_{0.25}Ru_{0.10}Ir_{0.06})_{\Sigma=0.98}As_{1.15}S_{0.84}$. (3) Shetland Islands; by electron microprobe, corresponding to $(Rh_{0.97}Fe_{0.02})_{\Sigma=0.99}As_{1.03}S_{0.98}$.

Polymorphism & Series: Forms a series with irarsite.

Mineral Group: Cobaltite group.

Occurrence: In platinum deposits in dunite pipes, layered ultramafic intrusives, and chromatites; in Cu–Ni sulfide ores.

Association: Sperrylite, geversite, erlichmanite, irarsite, Pt–Fe alloys (South Africa); chalcopyrite, cobaltite, gersdorffite, pyrrhotite (Canada); Au–Ag alloy, braggite, sperrylite, cobaltite, pyrrhotite, pentlandite, pyrite, chalcopyrite (Stillwater complex, Montana, USA).

Distribution: Increasingly recognized as an economically important platinum-group mineral. In South Africa, in the Merensky Reef, Bushveld complex, Transvaal, from the Driekop [TL], Onverwacht, and Tweefontein mines. In the Upper and Banded zones of the Stillwater complex, Montana; from the Yuba River, Nevada Co., California; and at Goodnews Bay, Alaska, USA. In Canada, at Sudbury and Werner Lake, Ontario. From the Noril'sk region, western Siberia, and around Nizhni Tagil, Ural Mountains, Russia. In Finland, from the Hitura Ni–Cu deposit, and in the Siikakämä intrusion. At the Maja e Sukës chromite deposit, Tropoja massif, Albania. From the Cliff and Harold's Grave quarries, Shetland Islands. Numerous other trace occurrences are now known.

Name: To honor Professor Sidney Ewart Hollingworth (1899–1966), eminent British geologist, University College, London, England.

Type Material: National School of Mines, Paris, France.

References: (1) Stumpfl, E.F. and A.M. Clark (1965) Hollingworthite, a new rhodium mineral, identified by electron probe microanalysis. Amer. Mineral., 50, 1068–1074. (2) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 108–109, 154. (3) Tarkian, M. and H.M. Prichard (1987) Irarsite-hollingworthite solid-solution series and other associated Ru-, Os-, Ir-, and Rh-bearing PGM's from the Shetland ophiolite complex. Mineralium Deposita, 22, 178–184. (4) Genkin, A.D., N.N. Zhuravlev, N.V. Troneva, and I.V. Murav'eva (1966) Irarsite, a new sulfarsenide of iridium, rhodium, ruthenium, and platinum. Zap. Vses. Mineral. Obshch., 95, 700–712 (in Russian).

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Holmquistite $\mathbf{Li_2[(Mg,Fe^{2+})_3Al_2]Si_8O_{22}(OH)_2}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic or acicular crystals, to 10 cm, typically striated on {210}. In columnar sheaflike aggregates, massive.

Physical Properties: *Cleavage:* Perfect on {210}, intersecting at ∼54° and ∼126°; partings on {001}, {112}, and {113}. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.95–3.13 D(calc.) = 3.09

Optical Properties: Transparent to translucent. *Color:* Black, dark violet to light sky-blue; pale yellow to violet in thin section. *Streak:* White, with sky-blue tinge. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Strong in shades of violet when dark-colored. *Orientation:* $X = a$; $Y = b$; $Z \wedge c = 0°$–$4°$. *Dispersion:* $r > v$, weak. *Absorption:* $Z > Y > X$. $\alpha = 1.622$–1.642 $\beta = 1.642$–1.660 $\gamma = 1.646$–1.666 2V(meas.) = 45°–52° 2V(calc.) = 78(8)°

Cell Data: *Space Group: Pnma.* $a = 18.30$ $b = 17.69$ $c = 5.30$ Z = 4

X-ray Powder Pattern: Barraute, Canada.
8.107 (100), 3.00 (90), 4.43 (70), 3.34 (60), 3.61 (50), 2.538 (50), 2.797 (40)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	59.58	59.73	MnO	0.41	0.20	K_2O	0.27	0.15
TiO_2		0.17	MgO	11.66	10.16	F	0.21	0.24
Al_2O_3	7.19	11.21	CaO	0.06	0.56	H_2O^+	2.23	2.08
Fe_2O_3	9.35	2.97	Li_2O	3.54	3.56	H_2O^-	0.03	0.02
FeO	4.88	8.92	Na_2O	0.50	0.18	$-O = F_2$	0.10	0.10
						Total	[99.81]	100.05

(1) Utö, Sweden; original total given as 99.82%, corresponding to $(Li_{1.90}Na_{0.13}K_{0.05}Ca_{0.01})_{\Sigma=2.09}(Mg_{2.32}Fe^{2+}_{0.54}Mn_{0.05})_{\Sigma=2.91}(Al_{1.08}Fe^{3+}_{0.94})_{\Sigma=2.02}(Si_{7.95}Al_{0.05})_{\Sigma=8.00}O_{22}[(OH)_{1.99}F_{0.09}]_{\Sigma=2.08}$.
(2) Barraute, Canada; corresponding to $(Li_{1.90}Ca_{0.08}Na_{0.05}K_{0.03})_{\Sigma=2.06}(Mg_{2.01}Fe^{2+}_{0.99}Mn_{0.02})_{\Sigma=3.02}(Al_{1.67}Fe^{3+}_{0.30}Ti_{0.02})_{\Sigma=1.99}(Si_{7.92}Al_{0.08})_{\Sigma=8.00}O_{22}[(OH)_{1.84}F_{0.10}]_{\Sigma=1.94}$.

Polymorphism & Series: Dimorphous with clinoholmquistite; forms a series with ferroholmquistite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: 0.1 $Mg/(Mg + Fe^{2+})$ 0.89; $(Ca + Na)_B < 1.34$; $Li \geq 1.0$.

Occurrence: As metasomatic replacements near the outer margins of lithium-rich pegmatites.

Association: Quartz, clinoholmquistite, tourmaline, spodumene, plagioclase, biotite, clinozoisite, "hornblende."

Distribution: At Utö, Sweden. From Brandrücken, Austria. In the USA, from Hiddenite, Alexander Co., and the Foote mine, Kings Mountain, Cleveland Co., North Carolina; in the Harding pegmatite, Dixon, Taos Co., New Mexico; and around Keystone, Pennington Co., South Dakota. At Barraute, and near St. Benoit, Quebec, and in the Tanco pegmatite, Bernic Lake, Manitoba, Canada. In the Benson pegmatite mine, Mtoko-Fungwe area, Zimbabwe. From the Vredefort Ring crater, Orange Free State, South Africa. At Greenbushes, Western Australia.

Name: To honor the Swedish petrologist, Per Johan Holmquist (1866–1946), of Stockholm.

Type Material: n.d.

References: (1) Osann, A. (1913) Über Holmquistit, einen Lithionglaucophan von der Insel Utö. Sitzungsber. Heidelberg. Akad. Wiss., Abt. A., Abh. 23. (2) Deer, W.A., R.A. Howie, and

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Holtedahlite $Mg_{12}(PO_4)_5(PO_3OH, CO_3)(OH, O)_6$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Massive, in patches to 1 cm.

Physical Properties: *Fracture:* Uneven. Hardness = 4.5–5 D(meas.) = 2.94(2) D(calc.) = 2.936

Optical Properties: Transparent. *Color:* Colorless, grayish from inclusions of magnetite. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.599(1)$ $\epsilon = 1.597(1)$

Cell Data: *Space Group:* $P31m$. $a = 11.203(3)$ $c = 4.977(1)$ $Z = 1$

X-ray Powder Pattern: Tingelstadtjern quarry, Norway.
2.438 (100), 3.722 (90), 3.475 (50), 3.234 (30), 2.796 (30), 2.177 (30), 1.859 (30)

Chemistry:

	(1)
P_2O_5	41.19
CO_2	2.06
MnO	0.06
MgO	50.01
Na_2O	0.22
F	0.34
H_2O	6.22
$-O = F_2$	0.14
Total	99.96

(1) Tingelstadtjern quarry, Norway; by electron microprobe, $(OH)^{1-}$, CO_2, and PO_4 confirmed by IR and elemental analyser; corresponds to $(Mg_{11.84}Na_{0.07})_{\Sigma=11.91}(PO_4)_5[(PO_3OH)_{0.54}(CO_3)_{0.44}]_{\Sigma=0.98}[(OH)_{5.83}F_{0.17}]_{\Sigma=6.00}$.

Polymorphism & Series: Dimorphous with althausite.

Occurrence: In a serpentine–magnesite deposit (Tingelstadtjern quarry, Norway); a common accessory mineral, of likely pneumatolytic origin, in an igneous magnetite–apatite deposit (Gole Gohar, Iran).

Association: Althausite, szaibelyite, apatite, talc, magnetite, magnesite (Tingelstadtjern quarry, Norway).

Distribution: From the Tingelstadtjern quarry, Modum, Norway. Into the millions of tons at the Gole Gohar iron deposit, Bafq district, Iran.

Name: Honors Olaf Holtedahl (1885–1975), Professor of Geology, University of Oslo, Oslo, Norway.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway; National Museum of Natural History, Washington, D.C., USA, 128674.

References: (1) Raade, G. and M.H. Mladeck (1979) Holtedahlite, a new magnesium phosphate from Modum, Norway. Lithos, 12, 283–287. (2) (1980) Amer. Mineral., 65, 809–810 (abs. ref. 1). (3) Rømming, C. and G. Raade (1989) The crystal structure of natural and synthetic holtedahlite. Mineral. Petrol., 40, 91–100. (4) Raade, G. (1990) Hydrothermal syntheses of $Mg_2(PO_4)OH$ polymorphs. Neues Jahrb. Mineral., Monatsh., 289–300. (5) Mücke, A. and R. Younessi (1994) Magnetite-apatite deposits (Kiruna-type) along the Sanandaj-Sirjan zone in the Bafq area, Iran, associated with ultramafic and calcalkaline rocks and carbonatites. Mineral. Petrol., 50, 219–244.

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Holtite $\mathbf{Al_6(Al,Ta)(BO_3)[(Si,Sb,As)O_4]_3(O,OH)_3}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In blocky crystals, to 2 cm; as pseudohexagonal needles, elongated along [100], typically S-shaped; finely crystalline. *Twinning:* Multiple on {011}.

Physical Properties: *Cleavage:* Good on {001}, may be parting. Hardness = 8.5 D(meas.) = 3.60–3.90 D(calc.) = [3.92] Fluoresces dull orange under SW UV and bright yellow under LW UV.

Optical Properties: Semitransparent. *Color:* Light buff to cream-buff or deep olive-buff, brown, russet. *Streak:* Light buff. *Luster:* Resinous, vitreous, dull when weathered. *Optical Class:* Biaxial (–). *Pleochroism:* Various shades of yellow to colorless. *Orientation:* $X = a$. *Dispersion:* $r < v$. $\alpha = 1.705$–1.746 $\beta = 1.728$–1.759 $\gamma = 1.730$–1.761 2V(meas.) = 20°–55°

Cell Data: *Space Group: Pnma.* $a = 4.6914(5)$ $b = 11.896(2)$ $c = 20.383(4)$ Z = 4

X-ray Powder Pattern: Greenbushes, Western Australia.
10.28 (100), 2.94 (40), 5.89 (34), 5.93 (32), 5.08 (32), 2.338 (26), 5.12 (24)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	20.30	26.74	BeO	0.05	
TiO_2	0.09		MgO		0.10
B_2O_3	1.82	4.67	CaO		0.10
Al_2O_3	46.43	43.44	Li_2O		0.59
Fe_2O_3	0.27	0.20	Na_2O		0.35
Sb_2O_3	13.89		K_2O		0.45
Sb_2O_5	4.61	6.49	Rb_2O		0.11
As_2O_5		2.92	Cs_2O		0.57
Nb_2O_5	0.76	0.15	H_2O^+	0.38	1.13
Ta_2O_5	11.24	11.70	H_2O^-	0.08	
MnO	0.05		Total	99.97	99.71

(1) Greenbushes, Western Australia; B_2O_3 thought to be low; corresponding to $Al_{24.50}Ta_{1.36}Nb_{0.16}Fe^{3+}_{0.10}Be_{0.05}Ti_{0.03}Mn_{0.02}B_{1.40}Si_{9.09}Sb^{3+}_{2.56}Sb^{5+}_{0.76}O_{66.62}(OH)_{1.13}$. (2) Kola Peninsula, Russia; corresponding to $Al_{23.23}Ta_{1.49}Nb_{0.03}Fe_{0.09}Mg_{0.06}Ca_{0.06}Ti_{0.03}B_{3.84}Si_{10.64}Sb^{5+}_{1.15}As^{5+}_{0.72}O_{69.57}(OH)_{2.09}$.

Occurrence: As coatings on stibiotantalite and replacing tantalite in a pegmatite (Greenbushes, Western Australia); in pegmatites cutting amphibolites (Voron'i massif, Russia).

Association: Stibiotantalite, tantalite, tourmaline, microlite, quartz (Greenbushes, Western Australia); stibiotantalite, microlite, tantite (Voron'i massif, Russia).

Distribution: At Bunbury Gully, Greenbushes, Western Australia. From the Voron'i massif, Kola Peninsula, Russia.

Name: For Harold Edward Holt (1908–1967), Prime Minister of Australia (1966–1967).

Type Material: Government Chemical Laboratories, Perth, Australia, MDC550.

References: (1) Pryce, M.W. (1971) Holtite: a new mineral allied to dumortierite. Mineral. Mag., 38, 21–25. (2) (1972) Amer. Mineral., 57, 1556 (abs. ref. 1). (3) Voloshin, A.V., V.V. Gordienko, E.M. Gel'man, M.L. Zorina, N.A. Elina, E.A. Kul'chitskaya, Y.P. Men'shikov, L.I. Polezhaeva, R.I. Ryzhova, P.B. Sokolov, and G.I. Utochkina (1977) Holtite (first find in the USSR) and its interaction with other tantalum minerals in rare metal pegmatites. Zap. Vses. Mineral. Obshch., 106, 337–347 (in Russian). (4) Hoskins, B.F., W.G. Mumme, and M.W. Pryce (1989) Holtite, $(Si_{2.25}Sb_{0.75})B[Al_6(Al_{0.43}Ta_{0.27}\square_{0.30})O_{15}(O,OH)_{2.25}]$: crystal structure and crystal chemistry. Mineral. Mag., 53, 457–463.

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Holtstamite $Ca_3(Al,Mn^{3+})_2(SiO_4)_{3-x}(H_4O_4)_x$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As rounded composite grains to 3 mm; individual crystals, to 0.2 mm, are pseudo-octahedral by twinning. *Twinning:* Around [111].

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 6 D(meas.) = n.d. D(calc.) = 3.25

Optical Properties: Transparent. *Color*: Pale brownish yellow. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (+). ω = 1.718(2) ε = 1.746(2) *Pleochroism*: Weak; *O* = pale orange; *E* = lemon yellow. *Absorption*: *E* > *O*.

Cell Data: *Space Group*: $I4_1/acd$. *a* = 12.337(3) *c* = 11.930(5) *Z* = 8

X-ray Powder Pattern: Wessels mine, Kalahari manganese field, South Africa.
2.743 (100), 1.614 (56), 2.757 (55), 2.685 (54), 2.501 (47), 2.978 (45), 3.082 (44)

Chemistry:

	(1)
SiO_2	26.26
Al_2O_3	10.77
Mn_2O_3	11.64
Fe_2O_3	6.30
CaO	36.76
$[H_2O]$	7.87
Total	99.61

(1) Wessels mine, Kalahari manganese field, South Africa; average of 15 electron microprobe analyses, H_2O calculated, OH^- confirmed by IR spectroscopy, Mn^{3+} confirmed by optical absorption spectroscopy; corresponding to $Ca_3(Al_{0.96}Mn^{3+}_{0.68}Fe^{3+}_{0.37})_{\Sigma=2.01}(SiO_4)_{2.00}(H_4O_4)_{0.99}$.

Polymorphism and Series: Polymorphous with hibschite; is the Al-analogue of henritermierite. Forms a solid solution series with henritermierite; crystals commonly compositionally zoned with cores of henritermierite and rims of holtstamite.

Occurrence: In a manganese-rich calc-silicate contact metamorphic rock.

Association: Mn^{3+}-bearing vesuvianite, calcite, henritermierite

Distribution: Wessels mine, Kalahari manganese field, South Africa.

Name: Honors Dr. Dan Holtstam (b. 1963) for his contributions to Swedish mineralogy and specifically Mn deposits of the Långban type.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden (960380).

References: (1) Hålenius, U., U. Häussermann, and H. Harryson. (2005) Holtstamite, $Ca_3(Al,Mn^{3+})_2(SiO_4)_{3-x}(H_4O_4)_x$, a new tetragonal hydrogarnet from Wessels Mine, South Africa. Eur. J. Mineral., 17, 375-382. (2) (2005) Amer. Mineral., 90, 1946 (abs. ref. 1).

Homilite $Ca_2(Fe^{2+},Mg)B_2Si_2O_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly tabular on {001}, also with {100} prominent; pseudo-octahedral by development of {110} and {012} or $\{\bar{1}11\}$, to 5 cm. *Twinning:* On {001} and {100}; also on {034} to produce cruciform twins.

Physical Properties: *Cleavage:* Indistinct. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.34–3.38 D(calc.) = 3.451

Optical Properties: Opaque, translucent only in thin fragments. *Color:* Black to blackish brown. *Streak:* Grayish. *Luster:* Resinous to vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = bluish green; Y = deep brownish red to brownish gray; Z = smoky gray or brownish yellow. *Orientation:* $Z = b$; $Y \wedge c = -1°$. *Dispersion:* $r > v$, distinct, with strong horizontal dispersion. *Absorption:* $Y > X > Z$. $\alpha = 1.715$ $\beta = 1.725$ $\gamma = 1.738$ 2V(meas.) = 80°

Cell Data: *Space Group:* $P2_1/a$. $a = 9.786(2)$ $b = 7.621(2)$ $c = 4.776(1)$ $\beta = 90.61(2)°$ Z = 2

X-ray Powder Pattern: Store-Arø Island, Langesundsfjord, Norway. (ICDD 17-211).
3.10 (100), 2.52 (100), 2.83 (90), 2.97 (70), 2.18 (70), 2.23 (60), 1.86 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	31.87	31.58	30.01
B_2O_3	[18.08]	[21.46]	18.62
Al_2O_3	1.50		
Fe_2O_3	2.15		
FeO	16.25	17.03	19.22
MnO		0.50	
MgO	0.52		
CaO	27.28	29.43	32.15
Na_2O	1.50		
LOI	0.85		
Total	[100.00]	[100.00]	100.00

(1) Langesundsfjord, Norway; B_2O_3 by difference. (2) Do.; by electron microprobe, B_2O_3 by difference. (3) $Ca_2FeB_2Si_2O_{10}$.

Mineral Group: Gadolinite group.

Occurrence: In pegmatite.

Association: Allanite, meliphanite, titanite, zircon, aegirine, löllingite, astrophyllite, melanocerite, nordenskiöldine, wöhlerite, hiortdahlite, molybdenite.

Distribution: On Stokkø, Store-Arø, and Øvre-Arø Islands, in the Langesundsfjord, Norway.

Name: From the Greek for *to occur together*, in allusion to its association with meliphanite and "erdmannite" (allanite).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 505–507.
(2) Miyawaki, R., I. Nakai, and K. Nagashima (1985) Structure of homilite, $Ca_{2.00}(Fe_{0.90}Mn_{0.03})B_{2.00}Si_{2.00}O_{9.86}(OH)_{0.14}$. Acta Cryst., C41, 13–15.

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Honessite $Ni_6Fe_2^{3+}(SO_4)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. As "obscurely" fibrous, powdery coatings.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Green or brown.
Optical Class: [Uniaxial.] $n = 1.615$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* n.d. $a = 3.083(4)$ $c = 26.71(9)$ Z = n.d.

X-ray Powder Pattern: Unst, Scotland.
8.84 (100), 4.43 (40), 2.62 (20), 1.54 (15), 1.52 (15), 2.65 (10), 2.39 (10)

Chemistry:

	(1)	(2)	(3)
SO_3	10.8	3.4	8.86
Fe_2O_3	10.5	15.3	17.66
FeO	2.4		
CoO	3.6		
NiO	42.6	37.5	49.57
CaO	2.7		
H_2O^+	19.7		
H_2O^-	4.7		
H_2O			23.91
insol. + SiO_2	0.9		
Total	97.9		100.00

(1) Linden, Iowa, USA. (2) Unst, Scotland; by electron microprobe, $(SO_4)^{2-}$ confirmed by IR, low amount may be due to $(CO_3)^{2-}$ in reevesite admixture; corresponds to $Ni_{5.8}Fe_{2.2}(SO_4)_{0.5}(OH)_{16}\cdot 4H_2O$. (3) $Ni_6Fe_2(SO_4)(OH)_{16}\cdot 4H_2O$.

Occurrence: A rare oxidation product of nickel sulfide minerals.

Association: Millerite, violarite, bravoite (Linden, Wisconsin, USA); reevesite, hydrohonessite, theophrastite (Unst, Scotland).

Distribution: In the USA, from the Linden Pb–Zn deposit, near Linden, Iowa Co., and at Hall's Gap, Lincoln Co., Wisconsin. At the Kamariza mine, Laurium, Greece. In the Hagdale quarry, Unst, Shetland Islands, Scotland.

Name: Honors Professor Arthur Pharoah Honess (1887–1942), American mineralogist, Pennsylvania State University, State College, Pennsylvania, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 117698.

References: (1) Heyl, A.V., C. Milton, and J.M. Axelrod (1959) Nickel minerals from near Linden, Iowa County, Wisconsin. Amer. Mineral., 44, 995–1009. (2) Bish, D.L. and A. Livingstone (1981) The crystal chemistry and paragenesis of honessite and hydrohonessite: the sulphate analogues of reevesite. Mineral. Mag., 44, 339–343.

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Hongshiite PtCu

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Crystal Data: Hexagonal. *Point Group:* 32, $3m$ or $\overline{3}\,2/m$. Rarely platy; massive, irregular in grains, to 1.5 mm.

Physical Properties: *Cleavage:* On $\{10\overline{1}1\}$. *Tenacity:* Brittle, somewhat ductile and malleable. Hardness = 4 VHN = 204 ‖ $[10\overline{1}0]$, 277 ‖ [0001] (50 g load). D(meas.) = 15.71 D(calc.) = 15.63

Optical Properties: Opaque. *Color:* Lead-gray, steel-gray, may be tarnished brown; in reflected light, bright white with a slight brownish tint. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Weak to moderate, dull gray to dull reddish brown; copery brown to bright blue. R_1–R_2: (400) 56.3–56.7, (420) 57.5–58.7, (440) 58.6–60.2, (460) 59.4–61.4, (480) 60.2–62.4, (500) 60.7–63.3, (520) 61.4–64.2, (540) 62.1–65.0, (560) 63.0–65.6, (580) 63.9–66.3, (600) 64.7–67.0, (620) 66.2–68.2, (640) 67.0–68.8, (660) 68.3–70.0, (680) 69.1–70.4, (700) 69.7–70.8

Cell Data: *Space Group:* $R32$, $R3m$, or $R\overline{3}m$. $a = 10.713$ $c = 13.192$ Z = 48

X-ray Powder Pattern: China.
2.199 (10), 1.895 (8), 1.148 (8), 1.350 (5), 1.325 (5), 0.856 (5), 4.35 (3)

Chemistry:

	(1)	(2)	(3)
Pt	74.93	75.00	75.43
Cu	24.52	24.35	24.57
Au		0.33	
Pd		0.16	
Total	99.45	99.84	100.00

(1) China; by electron microprobe, average of analyses on four grains. (2) Itabira district, Brazil; by electron microprobe. (3) PtCu.

Occurrence: In an actinolized diopside-type of platinum deposit (China); in high-grade hematitic veins in itabirite, typically rimmed by platinum from which copper has been leached (Brazil); in Alpine-type ultramafic intrusives and related placers.

Association: Cooperite, sperrylite, vysotskite, isomertieite, magnetite, bornite, polydymite, diopside, actinolite, epidote (China); sperrylite, isomertieite, atheneite, sudovicovite, palladian gold, platinum, platinian tetra-auricupride (Brazil)

Distribution: In China [originally described from the "Yen" district, a code name, previously given as the "Hong", "Huang", or "Hung" district], in Hebei Province, from near Hongshi village, Fengning Co. [TL]. In Russia, in a placer in the Upper Miask River, Southern Ural Mountains; from the Konder massif, Aldan Shield, Sakha; and in placers on the Pustaya River, Kamchatka. From Fox Gulch, Goodnews Bay, Alaska, USA. In a placer on the North Saskatchewan River, near Edmonton, Alberta, Canada. From placers along the Santiago River, Esmeraldas Province, Ecuador. In the Cauê and Conceição iron mines, Itabira district, Minas Gerais, Brazil.

Name: For its occurrence near Hongshi village, China.

Type Material: Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China.

References: (1) Yu Tsu-Hsiang [Yu Zuxiang], Lin Shu-Jen, Chao Pao, Fang Ching-Sung, and Huang Chi-Shun (1974) A preliminary study of some new minerals of the platinum group and another associated new one in platinum-bearing intrusions in a region of China. Acta Geol. Sinica, 48(2), 202–218 (in Chinese with English abs.). (2) (1976) Amer. Mineral., 61, 185 (abs. ref. 1). (3) Yu Zuxiang (1982) New data for hongshiite. Bull. Institute of Geology, Chinese Academy of Geological Sciences, 4, 78–81 (in Chinese with English abs.) [Yu Zuxiang formerly Yu Tsu-Hsiang]. (4) (1984) Amer. Mineral., 69, 411–412 (abs. ref. 3). (5) Yu Zuxiang (2001) New data for hongshiite. Acta Geol. Sinica, 75(3), 400–403 (in Chinese with English abs.). (6) Kwitko, R., A.R. Cabral, B. Lehmann, J.H.G. Laflamme, L.J. Cabri, A.J. Criddle, and H.F. Galbiatti (2002) Hongshiite, PtCu, from itabirite-hosted Au–Pd–Pt mineralization (jacutinga), Itabira district, Minas Gerais, Brazil. Can. Mineral., 40, 711–723. (7) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 109.

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Hopeite $Zn_3(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic along [001] or tabular on {010}, showing {010}, {110}, {031}, {131}, to 6 mm; in divergent aggregates or as crusts; compact reniform.

Physical Properties: *Cleavage:* Perfect on {010}; good on {100}; poor on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 3.05–3.065 D(calc.) = 3.116

Optical Properties: Transparent to translucent. *Color:* Colorless, grayish white, pale yellow; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, pearly on {010} cleavages. *Optical Class:* Biaxial (–); sections ∥ {100} are optically sectorially zoned. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.574–1.589$ $\beta = 1.582–1.598$ $\gamma = 1.582–1.599$ $2V(meas.) = 37°$

Cell Data: *Space Group: Pnma.* $a = 10.597(3)$ $b = 18.318(8)$ $c = 5.031(1)$ $Z = 4$

X-ray Powder Pattern: Kabwe, Zambia. (ICDD 37-465).
4.568 (100), 2.853 (65), 9.12 (60), 3.460 (25), 3.388 (25), 4.410 (20), 1.939 (19)

Chemistry:

	(1)	(2)
P_2O_5	31.8	30.98
ZnO	52.1	53.29
H_2O	16.1	15.73
Total	100.0	100.00

(1) Kabwe, Zambia. (2) $Zn_3(PO_4)_2 \cdot 4H_2O$.

Polymorphism & Series: Dimorphous with parahopeite.

Occurrence: A rare, late-stage mineral in some hydrothermal zinc deposits and complex granite pegmatites; incrusting bone breccia in a limestone cave.

Association: Tarbuttite, hemimorphite, spencerite, smithsonite, vanadinite (Kabwe, Zambia); triphylite, ferrisicklerite, leucophosphite, laueite, robertsite, hydroxylapatite, sphalerite (Tip Top mine, South Dakota, USA).

Distribution: Found at Vieille Montagne (Altenberg), Moresnet district, Belgium. In Germany, at Bad Ems, Rhineland-Palatinate; from Hagendorf, Bavaria; and at Oberschulenberg, Harz Mountains. Large crystals at Kabwe (Broken Hill), Zambia. From the Hudson Bay mine, about eight km southeast of Salmo, British Columbia, Canada. In the USA, at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; and in the Iron Cap Pb–Zn mine, near Aravaipa, Graham Co., Arizona.

Name: Honors Thomas Charles Hope (1766–1844), Professor of Chemistry, University of Edinburgh, Edinburgh, Scotland.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 734–737. (2) Hill, R.J. and J.B. Jones (1976) The crystal structure of hopeite. Amer. Mineral., 61, 987–995.

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Hörnesite $Mg_3(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, elongated along [001] and flattened on {010}, with a few other forms, to 1.5 mm; radial, foliated, columnar.

Physical Properties: *Cleavage:* Perfect on {010}, poor on {100}. *Tenacity:* Flexible. Hardness = 1 D(meas.) = 2.57–2.73 D(calc.) = 2.57

Optical Properties: Transparent. *Color:* White; colorless in transmitted light. *Luster:* Resinous to waxy, pearly on cleavages. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 31°$. $\alpha = 1.563$ $\beta = 1.571$ $\gamma = 1.596$ 2V(meas.) = 60°

Cell Data: *Space Group:* $C2/m$. $a = 10.26(2)$ $b = 13.44(2)$ $c = 4.74(1)$ $\beta = 104.9(1)°$ Z = 2

X-ray Powder Pattern: Băiţa (Rézbánya), Romania. 6.692 (100), 3.005 (50), 2.712 (50), 3.217 (30), 2.779 (30), 2.734 (30), 1.692 (25)

Chemistry:

	(1)	(2)
As_2O_5	46.33	46.45
MgO	25.54	24.43
H_2O	29.07	29.12
Total	100.94	100.00

(1) "Banat, Hungary" [probably Oraviţa or Csiklova, Romania]. (2) $Mg_3(AsO_4)_2 \cdot 8H_2O$.

Polymorphism & Series: Forms a series with erythrite.

Mineral Group: Vivianite group.

Occurrence: In limestone blocks, thermally metamorphosed, in a volcanic tuff (Fiano, Italy).

Association: Fluoborite, fluorite, hydromagnesite (Fiano, Italy).

Distribution: In Romania, from Oraviţa (Oravicza), Băiţa (Rézbánya), and Săcărîmb (Nagyág). At Jáchymov (Joachimsthal), Czech Republic. From Glatschach and Hirt, Carinthia, Austria. In Germany, in the Bauhaus district, Richelsdorf Mountains, Hesse. From Långban, Värmland, Sweden. At Fiano, near Naples, Italy. From Huercal-Overa, Almería Province, Spain. In the USA, at the Kalkar quarry, Santa Cruz, Santa Cruz Co., California; in a cave in Peach Springs Canyon, Mohave Co., Arizona; at the White Caps mine, Manhattan district, Nye Co., Nevada. From the Córrego do Urucum pegmatite, near Galiléia, Minas Gerais, Brazil.

Name: Honors Moritz Hörnes (1815–1868), Curator of the Imperial Cabinet, Vienna, Austria.

Type Material: Natural History Museum, Vienna, Austria, A.a.415.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 755–756. (2) Koritnig, S. and P. Süsse (1966) Gitterkonstanten und Raumgruppe des Hörnesit, $Mg_3[AsO_4]_2 \cdot 8H_2O$. Neues Jahrb. Mineral., Monatsh., 349–351 (in German with English abs.).

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Horomanite $(Fe,Ni,Co,Cu)_9S_8$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As grains, to 0.1 mm.

Physical Properties: *Cleavage*: Pronounced. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3 VHN = 135 (50 g load). D(meas.) = n.d. D(calc.) = 6.44

Optical Properties: Opaque. *Color*: White with a yellowish tint macroscopically and in reflected light. *Streak*: n.d. *Luster*: Metallic.
Optical Class: n.d. *Pleochroism*: Very weak, white with a yellowish tint to white.
Anisotropism: Weak, dark-gray to slightly light-gray.
R_1-R_2: (436) 34.7-37.8, (497) 40.0-43.2, (543) 43.2-46.4, (586) 45.4-48.5, (648) 47.8-50.7

Cell Data: *Space Group*: *P*4/*mmm*. *a* = 8.707(1) *c* = 10.436(6) *Z* = 4

X-ray Powder Pattern: Horoman massif, Samani-cho, Samani-gun, Hokkaido, Japan.
3.080 (100), 1.825 (60), 1.805 (54), 1.947 (51), 2.955 (32), 1.984 (25), 6.16 (10)

Chemistry:

	(1)
Cu	0.43
Fe	41.82
Ni	23.76
Co	0.52
S	33.29
Total	99.82

(1) Horoman massif, Samani-cho, Samani-gun, Hokkaido, Japan; average of 15 electron microprobe analyses, corresponding to $(Fe_{5.77}Ni_{3.12}Co_{0.07}Cu_{0.05})_{\Sigma=9.01}S_8$.

Occurrence: Filling space between silicate minerals in lherzolites of a peridotite massif.

Association: Samaniite and sugakiite as intergrowths; bornite, talnakhite, copper, troilite, heazlewoodite, pentlandite, magnetite, olivine, clino- and orthopyroxenes.

Distribution: Horoman peridotite massif, Samani-cho, Samani-gun, Hokkaido, Japan.

Name: For the ultramafic massif (*Horoman)* from which the first specimens were collected.

Type Material: Tohoku University Museum, Japan.

References: (1) Kitakaze, A., H. Itoh, and R. Komatsu (2011) Horomanite, $(Fe,Ni,Co,Cu)_9S_8$, and samaniite, $Cu_2(Fe,Ni)_7S_8$, new mineral species from the Horoman peridotite massif, Hokkaido, Japan. Journal of Mineralogical and Petrological Sciences, 106, 204-210. (2) (2014) Amer. Mineral., 99, 552-553 (abs. ref. 1).

Horsfordite Cu_5Sb

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Crystal Data: n.d. *Point Group:* n.d. Massive.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–5 VHN = n.d. D(meas.) = 8.81 D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Silver-white, easily tarnished; in polished section, slightly cream-colored to silver-blue and grayish white. *Luster:* Metallic, brilliant.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Cu	73.37	72.29
Sb	26.86	27.71
Total	100.23	100.00

(1) Turkey, near Lesbos; average of three analyses. (2) Cu_5Sb.

Occurrence: In "an extensive vein underlying the entire area of a Turkish village".

Association: n.d.

Distribution: On the Turkish mainland, near the Greek Aegean island of Lesbos (Mytilene).

Name: In honor of Professor Eben Norton Horsford (1818–1893), American chemist, Harvard University, Cambridge, Massachusetts, USA.

Type Material: n.d. [no type material can be located at Harvard University, Cambridge, Massachusetts, or the University of Cincinnati, Cincinnati, Ohio, USA, where it was described].

References: (1) Laist, A. and T.H. Norton (1888) On the occurrence in nature of copper antimonide. Amer. J. Chem., 10, 60–61. (2) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 44. (3) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 173.

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Horváthite-(Y) $NaY(CO_3)F_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As stacks of crystals, platy on {100}, or as blocky cylindrical aggregates of radiating striated crystals, prismatic along [010], showing {100}, {001}, {010}, minor {110}, {011}, {101}, to 1 mm.

Physical Properties: *Cleavage:* On {100}, very good; on {010}, good. *Tenacity:* Brittle. Hardness = 4 D(meas.) = > 3.3 D(calc.) = 3.61

Optical Properties: Transparent to translucent. *Color:* Colorless to pale beige. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = colorless; $Y \simeq Z$ = pale brown. *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.457(1)$ $\beta = 1.543(1)$ $\gamma = 1.622(1)$ 2V(meas.) = 82(1)° 2V(calc.) = 83°

Cell Data: *Space Group: Pmcn.* $a = 6.959(2)$ $b = 9.170(2)$ $c = 6.301(1)$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
3.477 (100), 5.19 (90), 2.800 (50), 2.087 (50), 2.057 (50), 1.966 (50), 1.849 (50)

Chemistry:

	(1)
CO_2	[19.83]
Y_2O_3	45.07
Gd_2O_3	0.45
Tb_2O_3	0.12
Dy_2O_3	2.49
Ho_2O_3	0.81
Er_2O_3	3.02
Yb_2O_3	1.64
CaO	1.86
Na_2O	12.62
F	17.22
$-O = F_2$	7.23
Total	[97.90]

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of two analyses, CO_2 calculated for stoichiometry; corresponding to $(Na_{0.90}Ca_{0.07})_{\Sigma=0.97}(Y_{0.89}Er_{0.04}Dy_{0.03}Yb_{0.02}Gd_{0.01}Ho_{0.01})_{\Sigma=1.00}(CO_3)F_{2.01}$.

Occurrence: A very rare, late-forming mineral in an altered pegmatite dike in nepheline syenite, part of an alkalic igneous complex.

Association: Microcline, aegirine, dawsonite, rhodochrosite, sodalite, natrolite, albite, serandite, siderite, taeniolite, catapleiite, astrophyllite, genthelvite.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Elsa Horváth (1947–) and László Horváth (1937–), husband and wife collectors of Mont Saint-Hilaire, Canada minerals.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81536.

References: (1) Grice, J.C. and G.Y. Chao (1997) Horváthite-(Y), rare-earth fluorocarbonate, a new mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 35, 743–749. (2) (1998) Amer. Mineral., 83, 401 (abs. ref. 1).

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Hotsonite $Al_5(PO_4)(SO_4)(OH)_{10}\cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals are lathlike or acicular, to 15 μm; as cryptocrystalline chalklike incrustations and veins.

Physical Properties: *Fracture:* Earthy. Hardness = 2.5 in aggregates. D(meas.) = 2.060–2.068 D(calc.) = 2.06

Optical Properties: Translucent. *Color:* White; colorless in transmitted light. *Luster:* Silky to dull, earthy.
Optical Class: Biaxial. *Orientation:* Length-fast. $\alpha = 1.519$ β = n.d. $\gamma = 1.521$
2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 11.288(59)$ $b = 11.658(60)$ $c = 10.550(67)$
$\alpha = 112°32(3)'$ $\beta = 107°31(3)'$ $\gamma = 64°27(3)'$ Z = 1

X-ray Powder Pattern: Koenabib, South Africa.
10.05 (100), 8.45 (40), 4.63 (20), 5.20 (10), 5.01 (10), 4.43 (10), 3.67 (10)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	16.80	13.73	12.51	CaO	0.24	0.89	
P_2O_5	9.85	9.06	11.09	Na_2O	0.21		
SiO_2	0.35	0.16		K_2O	0.0		
TiO_2		0.01		H_2O^+		31.29	
Al_2O_3	39.15	39.60	39.82	H_2O^-		4.28	
Fe_2O_3	0.03	0.18		H_2O	33.30		36.58
MgO	0.28	0.41		insol.		0.33	
				Total	100.21	99.94	100.00

(1) Koenabib, South Africa; by X-ray fluorescence, average of four analyses, H_2O by a modified Penfield method, P_2O_5 and SO_3 by wet chemical methods. (2) Blyavinski mine, Russia. (3) $Al_5(PO_4)(SO_4)(OH)_{10}\cdot 8H_2O$.

Occurrence: A weathering product derived from natroalunite and zaherite in an arid climate (Koenabib, South Africa).

Association: Zaherite, natroalunite, sillimanite (Koenabib, South Africa).

Distribution: Found in the Hotson 6 quarry, Koenabib, 65 km west of Pofadder, Cape Province, South Africa. From the Blyavinski mine, Ural Mountains, Russia.

Name: For Hotson 42, the farm in South Africa on which the first specimens were collected.

Type Material: National Museum, Bloemfontein, South Africa, K2359; National Museum of Natural History, Washington, D.C., USA, 162230.

References: (1) Beukes, G.J., A.E. Schoch, W.A. Van der Westhuizen, L.D.C. Bok, and H. de Bruiyn (1984) Hotsonite, a new hydrated aluminum-phosphate-sulfate from Pofadder, South Africa. Amer. Mineral., 69, 979–983. (2) de Bruiyn, H., G.J. Beukes, W.A. Van der Westhuizen, and E.A.W. Tordiffe (1989) Unit cell dimensions of the hydrated aluminum phosphate-sulphate minerals sanjuanite, kribergite, and hotsonite. Mineral. Mag., 53, 385–386. (3) Ivanov, O.K., L.L. Shiryaeva, L.A. Khoroshilova, and V.G. Petrisheva (1990) Hotsonite – confirmation of discovery and new data (Blyavinski mine, Urals). Zap. Vses. Mineral. Obshch., 119(1), 121–126 (in Russian).

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Howardevansite $NaCuFe_2^{3+}(VO_4)_3$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As tabular crystals with dominant forms {100}, {010}, {001}, {$1\overline{1}0$}, {101}, {$\overline{1}01$}, and {$0\overline{1}1$}, to 80 μm.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.814

Optical Properties: Opaque, translucent on thin edges. *Color:* Black; deep red-brown through thin edges; medium gray in reflected light. *Streak:* Red-brown. *Luster:* Metallic. *Optical Class:* Biaxial. *Anisotropism:* Moderate.
R_1–R_2: (481) 15.5–20.1, (547) 15.0–18.4, (591) 14.1–17.2, (644) 13.5–17.1

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.198(2)$ $b = 9.773(1)$ $c = 6.6510(8)$ $\alpha = 103.82(1)°$ $\beta = 101.99(1)°$ $\gamma = 106.74(1)°$ Z = 2

X-ray Powder Pattern: Izalco volcano, El Salvador.
3.167 (100), 3.093 (100), 1.659 (70), 3.27 (60), 2.676 (60), 2.603 (60), 1.433 (60)

Chemistry:

	(1)	(2)
V_2O_5	49.17	50.24
TiO_2	0.80	
Al_2O_3	2.01	
Fe_2O_3	23.92	29.40
Mn_2O_3	0.73	
CuO	17.29	14.65
Na_2O	5.6	5.71
K_2O	0.60	
Total	100.12	100.00

(1) Izalco volcano, El Salvador; by electron microprobe, average of 30 analyses, total Fe as Fe_2O_3, total Mn as Mn_2O_3; corresponding to $(Na_{0.98}K_{0.07})_{\Sigma=1.05}Cu_{1.06}(Fe_{1.63}Al_{0.21}Cu_{0.12}Mn_{0.05}Ti_{0.05})_{\Sigma=2.06}(V_{0.98}O_4)_3$. (2) $NaCuFe_2(VO_4)_3$.

Occurrence: Forms by sublimation around fumaroles on an andesitic volcano.

Association: Thenardite, lyonsite.

Distribution: Occurs on the Izalco volcano, El Salvador.

Name: Honors Dr. Howard Tasker Evans, Jr. (1919–2000), American mineralogist and crystallographer, U.S. Geological Survey, Reston, Virginia, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 130752; National Museum of Natural History, Washington, D.C., USA, 165494.

References: (1) Hughes, J.M., J.W. Drexler, C.F. Campana, and M.L. Malinconico (1988) Howardevansite, $NaCu^{2+}Fe_2^{3+}(VO_4)_3^{3-}$, a new fumarolic sublimate from Izalco volcano, El Salvador: descriptive mineralogy and crystal structure. Amer. Mineral., 73, 181–186.

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Howieite $Na(Fe^{2+},Mn)_{10}(Fe^{3+},Al)_2Si_{12}O_{31}(OH)_{13}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$ or 1. As bladed crystals, to 1 cm; in plumose aggregates and rosettes.

Physical Properties: *Cleavage:* Good on {010}, fair on {100}, poor on $\{2\bar{1}0\}$.
Hardness = n.d. D(meas.) = 3.378 D(calc.) = [3.34]

Optical Properties: Transparent to translucent. *Color:* Dark green to black.
Luster: Greasy.
Optical Class: Biaxial (–). *Pleochroism:* Marked; X = golden; Y = dark lilac gray; Z = green.
Dispersion: $r < v$, strong. $\alpha = 1.701$ $\beta = 1.720$ $\gamma = 1.734$ 2V(meas.) = 65°

Cell Data: *Space Group:* $P\bar{1}$ or $P1$. $a = 10.170(4)$ $b = 9.774(4)$ $c = 9.589(4)$
$\alpha = 91.22(5)°$ $\beta = 70.76(5)°$ $\gamma = 108.09(5)°$ Z = 1

X-ray Powder Pattern: Laytonville, California, USA. (ICDD 19-571).
9.18 (100), 7.91 (80), 3.25 (65), 2.62 (60), 2.68 (45), 2.78 (40), 3.06 (35)

Chemistry: (1) Laytonville district, California, USA; analysis not given, stated to correspond to $(Na_{1.03}Ca_{0.02})_{\Sigma=1.05}(Fe^{2+}_{6.41}Mn_{2.98}Mg_{0.45})_{\Sigma=9.84}(Fe^{3+}_{1.57}Al_{0.62})_{\Sigma=2.19}(Si_{11.96}Ti_{0.04})_{\Sigma=12.00}[O_{31.31}(OH)_{12.69}]_{\Sigma=44.00}$.

Occurrence: An essential mineral in some of the metamorphosed shales, siliceous ironstones, and impure limestones of the Franciscan Formation (Laytonville district, California, USA).

Association: Deerite, zussmanite, stilpnomelane, spessartine, riebeckite, quartz, aegirine, grunerite, aragonite, manganoan siderite, ferroan kutnohorite (Laytonville district, California, USA).

Distribution: In the USA, in California, from the Laytonville quarry, and at Covelo, Mendocino Co.; at Ward Creek, Sonoma Co.; in Panoche Pass, San Benito Co.; at Pacheco Pass, Santa Clara and Merced Cos.; and in the Powers quarry, Coos Co., Oregon. From Brezovica, Yugoslavia. In the Tanemaya mine, Kumamoto Prefecture, Japan.

Name: For Professor Robert Andrew Howie (1923–), British mineralogist and petrologist, London University, London, England.

Type Material: National Museum of Natural History, Washington, D.C., USA, 109453, 144184; The Natural History Museum, London, England, 1964,544.

References: (1) Agrell, S.O., M.G. Bown, and D. McKie (1965) Deerite, howieite and zussmanite, three new minerals from the Franciscan of the Laytonville District, Mendocino Co., California. MSA meeting, Bozeman, Montana, July 26–31, 1964. Amer. Mineral., 50, 278 (abs.). (2) Wenk, H.R. (1974) Howieite, a new type of chain silicate. Amer. Mineral., 59, 86–97. (3) Muir Wood, R. (1979) The iron-rich blueschist facies minerals: 2. Howieite. Mineral. Mag., 43, 363–370.

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Howlite $Ca_2B_5SiO_9(OH)_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular, flattened on {100}, with {100} dominant and terminated by {011} and {001}, to 1 cm. Most commonly nodular. When massive, chalky to porcelaneous.

Physical Properties: *Fracture:* For porcelaneous types, nearly even and smooth.
Hardness = 3.5 D(meas.) = 2.53–2.59 D(calc.) = 2.61

Optical Properties: Translucent in thin fragments. *Color:* White; in thin section, colorless.
Luster: Subvitreous, glimmering.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c \simeq 51°$. α = 1.583–1.586
β = 1.596–1.598 γ = 1.605 2V(meas.) = 73°

Cell Data: *Space Group:* $P2_1/c$. a = 12.820(3) b = 9.351(1) c = 8.608(2)
β = 104.84(2)° Z = 4

X-ray Powder Pattern: Sterling Borax mine, California, USA.
6.2 (100), 3.10 (90), 3.90 (80), 2.04 (70), 2.07 (50), 1.794 (50), 12.4 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	15.33	15.50	15.35
B_2O_3	44.52	44.38	44.48
CaO	27.94	28.45	28.66
Na_2O	0.53		
K_2O	0.13		
H_2O	11.55	11.58	11.51
rem.		0.09	
Total	[100.00]	100.00	100.00

(1) Windsor, Canada; recalculated to 100.00% after deduction of 4.32% gypsum. (2) Daggett, California, USA; remainder is Na_2O and MgO. (3) $Ca_2B_5SiO_9(OH)_5$.

Occurrence: In borate deposits.

Association: Colemanite, ulexite, bakerite.

Distribution: In Canada, near Windsor; at Wentworth; large crystals on the shore of Bras D'Or Lake, 2.5 km south of Iona, Cape Breton Island, Nova Scotia. In the USA, in California, in the Sterling Borax mine, Tick Canyon, near Lang, Los Angeles Co.; near Calico, San Bernardino Co.; in Gower Gulch and at the Billie mine, near Ryan, Inyo Co.; at the Russell and other borate mines north of Lockwood Valley, Ventura Co.; and in the Kramer deposit, Kern Co. From Magdalena, Sonora, Mexico. At Susurluk, Turkey. From Baljevac na Ibru, near Kraljevo, and near Bela Stena, Yugoslavia.

Name: For Henry How (1828–1879), Canadian chemist, geologist, and mineralogist, University of King's College, Windsor, Nova Scotia, Canada, who first described the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 362–363. (2) Murdoch, J. (1957) Crystallography and X-ray measurements of howlite from California. Amer. Mineral., 42, 521–524. (3) Griffen, D.T. (1988) Howlite, $Ca_2SiB_5O_9(OH)_5$: structure refinement and hydrogen bonding. Amer. Mineral., 73, 1138–1144.

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Hsianghualite $Li_2Ca_3Be_3(SiO_4)_3F_2$

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Crystal Data: Cubic. *Point Group:* 432. Crystals modified by the dodecahedron, to 1.5 cm; granular, massive.

Physical Properties: *Tenacity:* Brittle. Hardness = 6.5 VHN = 896 D(meas.) = 2.97–3.00 D(calc.) = 2.944

Optical Properties: Transparent to translucent. *Color:* Milk-white to colorless.
Luster: Vitreous.
Optical Class: Isotropic. $n = 1.613$

Cell Data: *Space Group:* $I4_132$. $a = 12.897(4)$ $Z = 8$

X-ray Powder Pattern: Hunan Province, China.
2.746 (100), 2.209 (100), 2.090 (90), 1.753 (70), 3.443 (60), 1.691 (52), 1.228 (45)

Chemistry:

	(1)	(2)
SiO_2	35.66	36.64
Al_2O_3	0.50	
Fe_2O_3	0.22	0.06
BeO	15.78	16.30
MgO	0.18	0.17
CaO	34.60	35.18
Li_2O	5.85	5.60
Na_2O	0.13	0.03
K_2O	0.06	0.03
F	7.81	7.27
LOI	1.28	
$-O = F_2$	3.2	3.06
Total	98.87	98.22

(1) Hunan Province, China; corresponds to $Li_{1.95}Ca_{3.07}Be_{3.13}(SiO_4)_3F_{2.00}$. (2) Do.; corresponds to $Li_{1.85}Ca_{3.08}Be_{3.20}(SiO_4)_3F_{2.06}$.

Occurrence: In phlogopite veins in a fluorine-rich metamorphosed Devonian limestone intruded by a beryllium-bearing granite.

Association: Fluorite, zinnwaldite, chrysoberyl, taaffeite, liberite.

Distribution: On Hsianghua Ridge, Linwu Co., Hunan Province, China.

Name: For the place of discovery; the word means *fragrant flower* in Chinese.

Type Material: n.d.

References: (1) Wen-Hui Huang, Shao-Hua Tu, K'ung-Hai Wang, Chun-Lin Chao, and Cheng-Chih Yu (1958) Hsiang-hua-shih [hsianghualite], a new beryllium mineral. Ti-chih-yueh-k'an, 7, 35 (in Chinese). (2) (1959) Amer. Mineral., 44, 1327–1328 (abs. ref. 1). (3) Beus, A.A. (1960) Geochemistry of beryllium and genetic types of beryllium deposits., 69–71. (4) (1961) Amer. Mineral., 46, 244 (abs. ref. 3). (5) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 127–129.

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Huanghoite-(Ce) $BaCe(CO_3)_2F$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As platy to granular crystals and in aggregates, to 10 cm.

Physical Properties: *Cleavage:* On {0001}, distinct. *Fracture:* Irregular. Hardness = 4.5 D(meas.) = 4.51–4.67 D(calc.) = 4.84

Optical Properties: Translucent. *Color:* Honey-yellow to yellowish green, orange.
Luster: Greasy.
Optical Class: Uniaxial (–). *Pleochroism:* Weak; in shades of greenish yellow. $\omega = 1.765$–1.770 $\epsilon = 1.588$–1.610

Cell Data: *Space Group:* $R\overline{3}m$. $a = 5.072(1)$ $c = 38.46(1)$ $Z = 6$

X-ray Powder Pattern: Bayan Obo deposit, China.
3.21 (10), 1.937 (10), 2.01 (9), 3.91 (7), 2.50 (7), 1.616 (7), 1.557 (7)

Chemistry:

	(1)	(2)
CO_2	20.90	21.13
Ce_2O_3		39.41
RE_2O_3	38.40	
BaO	36.46	36.82
F	4.00	4.56
H_2O	0.93	
$-O = F_2$	1.68	1.92
Total	99.01	100.00

(1) Bayan Obo deposit, China; Ce > La confirmed by X-ray spectographic analysis.
(2) $BaCe(CO_3)_2F$.

Occurrence: An uncommon mineral in hydrothermal veins associated with rare-earth-bearing carbonatite deposits in alkaline igneous complexes.

Association: Aegirine, fluorite, magnetite, hematite, monazite, bastnäsite, parisite, aeschynite, calcite (Bayan Obo, China); "chlorite", barite, strontianite, pyrite, hematite, ankerite, dolomite (Siberia, Russia).

Distribution: From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. In Russia, from an unspecified carbonatite in Siberia, and in the Khibiny massif, Kola Peninsula. From the Aley carbonatite, east of Williston Lake, British Columbia, Canada. At the Qaqarssuk carbonatite, near Sukkertoppen, Greenland.

Name: For the Huang Ho (Yellow River), China, 150 km south of the Bayan Obo deposit, China, where the first specimens were collected.

Type Material: National Museum of Natural History, Washington, D.C., USA, 144184.

References: (1) Semenov, E.I. and P'ei-Shan Chang (1961) Huanghoite, a new rare-earth mineral. Scientia Sinica, 10, 1007–1011 (in Russian). (2) (1963) Amer. Mineral., 48, 1179 (abs. ref. 1). (3) Kapustin, Y.L. (1972) First find of huanghoite in the USSR. Doklady Acad. Nauk SSSR, 202, 422–425 (in Russian). (4) Z. Yang and F. Pertlik (1993) Huanghoite-(Ce), $BaCe(CO_3)_2F$, from Khibina, Kola Peninsula, Russia: redetermination of the crystal structure with a discussion on space group symmetry. Neues Jahrb. Mineral., Monatsh., 163–171. (5) Mercier, N. and M. Leblanc (1993) Crystal growth and structures of rare earth fluorocarbonates: I. Structures of $BaSm(CO_3)_2F$ and $Ba_3La_2(CO_3)_5F_2$: revision of the corresponding huanghoite and cebaite type structures. Eur. J. Solid State Inorg. Chem., 30, 195–205.

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Huangite $Ca_{0.5}Al_3(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As imperfect zoned crystals, to 70 μm, and in rounded aggregates.

Physical Properties: *Cleavage:* On {0001}, perfect. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.80

Optical Properties: Transparent to translucent. *Color:* White to pale yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.983(4)$ $c = 33.517(9)$ Z = 6

X-ray Powder Pattern: El Indio mine, Chile.
2.97 (100), 4.91 (75), 2.231 (51), 1.899 (43), 1.375 (40), 1.745 (37), 2.455 (35)

Chemistry:

	(1)
SO_3	38.78
P_2O_5	0.23
Al_2O_3	38.62
Fe_2O_3	0.10
CaO	6.17
SrO	0.04
BaO	0.13
Na_2O	0.43
K_2O	0.67
F	0.11
H_2O	13.60
$-O = F_2$	0.05
Total	98.83

(1) El Indio mine, Chile; by electron microprobe, average of seven analyses; corresponds to $(Ca_{0.44}Na_{0.06}K_{0.06})_{\Sigma=0.56}(Al_{2.99}Fe_{0.01})_{\Sigma=3.00}(S_{0.96}O_{3.88})_2[(OH)_{5.98}F_{0.02}]_{\Sigma=6.00}$.

Mineral Group: Alunite group.

Occurrence: A product of acid sulfate hydrothermal alteration of rhyolite tuffs and andesites.

Association: Kaolinite, pyrite, woodhouseite (El Indio mine, Chile); alunite, natroalunite, minamiite (Okumanza, Japan).

Distribution: From the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. At Okumanza, near the Kusatsu-Shirane volcano, Gumma Prefecture, Japan.

Name: Honors Yunhui Huang (1926–), Chinese mineralogist, Institute of Mineral Deposit Geology and Mineral Resources, Beijing, China, in part for her contributions to the study of contact-metamorphic beryllium deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 170208, 170209.

References: (1) Li, G., D.R. Peacor, E.J. Essene, D.R. Brosnahan, and R.E. Beane (1992) Walthierite, $Ba_{0.5}\square_{0.5}Al_3(SO_4)_2(OH)_6$, and huangite, $Ca_{0.5}\square_{0.5}Al_3(SO_4)_2(OH)_6$, two new minerals of the alunite group from the Coquimbo region, Chile. Amer. Mineral., 77, 1275–1284.
(2) Matsubara, S., A. Kato, K. Kiyota, and F. Matsuyama (1998) Huangite from Okumanza, Gunma [*sic*] Prefecture, Japan. Mineral. J. (Japan), 20, 1–8.

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Huanzalaite $MgWO_4$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As grains, to 0.01 mm; as aggregates, to 0.4 mm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.953

Optical Properties: Transparent. *Color*: Orange to reddish brown; bluish under SW and LW UV light. *Streak*: White.
Luster: Adamantine to vitreous.
Optical Class: n.d. n(calc.) = 2.20

Cell Data: *Space Group*: *P2/c*. a = 4.7027(15) b = 5.6894(11) c = 4.9413(9) β = 90.70(2)° Z=2

X-ray Powder Pattern: Huanzala mine, Bolognesi Province, Ancash Department, Peru. 3.73 (100), 2.91 (94), 2.93 (83), 4.70 (74), 3.63 (39), 2.47 (39), 2.18 (32)

Chemistry:

	(1)	(2)
WO_3	84.81	85.19
MgO	12.49	14.81
MnO	1.78	
FeO	1.39	
CaO	0.02	
Total	100.47	100.00

(1) Huanzala mine, Bolognesi Province, Ancash Department, Peru; average of 10 electron microprobe analyses, corresponding to $(Mg_{0.85}Mn_{0.07}Fe_{0.05})_{\Sigma=0.97}W_{1.01}O_4$. (2) $MgWO_4$.

Mineral Group: Wolframite group.

Occurrence: As inclusions in scheelite in the Mg-metasomatized contact skarns of an intrusive granodiorite and quartz porphyry.

Association: Scheelite, enargite, pyrite, sphalerite, quartz, calcite, 'sericite', chlorite, dolomite, sellaite, talc, phlogopite.

Distribution: Huanzala mine, Huallanca district, Bolognesi Province, Ancash Department, Peru.

Name: For the first described locality, the Huanzala mine, Peru.

Type Material: National Museum of Nature and Science, Tokyo, Japan (catalog no. NSM-MF15366).

References: (1) Miyawaki, R., K.Yokoyama, T. Matsubara, I. Furuta, A. Gomi, and R. Murakami (2010) Huanzalaite, $MgWO_4$, a new mineral species from the Huanzala Mine, Peru. Can. Mineral., 48, 105–112. (2) (2010) Amer. Mineral., 95, 1598 (abs. ref. 1).

Hübnerite $Mn^{2+}WO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are typically prismatic and striated along [001], to 15 cm; also tabular to bladed, flattened on {100}; show {010}, {110}, {100}, {310}, {112}, {001}, {102}, {011}, and a multiplicity of other forms; in radiating groups or in parallel. *Twinning:* Common as simple contact twins with composition plane {100}, or rarely {001}; as interpenetrant twins; lamellar.

Physical Properties: *Cleavage:* Perfect on {010}; partings on {100} and {102}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–4.5, directional. D(meas.) = 7.12–7.18 D(calc.) = 7.234

Optical Properties: Transparent to translucent. *Color:* Yellowish brown to reddish brown, blackish brown, black, rarely red; white to gray in reflected light with deep blood-red internal reflections. *Streak:* Yellow to reddish brown, greenish gray. *Luster:* Metallic-adamantine towards resinous.
Optical Class: Biaxial (+). *Pleochroism:* Perceptible; X = yellow to green, red-orange; Y = yellowish brown to greenish yellow, red-orange to red; Z = green; brick-red to red. *Orientation:* $X = b$; $Z \wedge c = 17°–21°$. *Absorption:* $Z > Y > X$. $\alpha = 2.17–2.20$ $\beta = 2.22$ $\gamma = 2.30–2.32$ 2V(meas.) = Large. 2V(calc.) = 73(5)° *Anisotropism:* Distinct.
R_1–R_2: (400) 17.1–19.8, (420) 16.3–19.3, (440) 15.5–18.8, (460) 15.1–18.3, (480) 14.6–17.5, (500) 14.4–17.2, (520) 14.2–17.0, (540) 13.9–16.7, (560) 13.8–16.5, (580) 13.7–16.3, (600) 13.6–16.2, (620) 13.5–16.1, (640) 13.5–16.0, (660) 13.4–15.9, (680) 13.4–15.8, (700) 13.3–15.7

Cell Data: *Space Group:* $P2/c$. $a = 4.8238(7)$ $b = 5.7504(10)$ $c = 4.9901(8)$ $\beta = 91.18(1)°$ Z = 2

X-ray Powder Pattern: Synthetic.
2.996 (100), 2.954 (95), 4.84 (65), 3.78 (60), 3.70 (55), 2.497 (55), 2.880 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.62		MnO	23.40	23.43
WO_3	75.58	76.57	CaO	0.13	
$(Nb,Ta)_2O_5$	0.05		Total	100.02	100.00
FeO	0.24				

(1) Uncompahgre district, Colorado, USA. (2) $MnWO_4$.

Polymorphism & Series: Forms a series with ferberite.

Occurrence: Typical of high-temperature hydrothermal vein deposits and pneumatolytically altered granites yielding greisen; in granite pegmatites; also in alluvial and eluvial deposits.

Association: Cassiterite, arsenopyrite, molybdenite, tourmaline, topaz, rhodochrosite, fluorite.

Distribution: May be an ore of tungsten at some localities. In the USA, from the Erie and Enterprize veins, Ellsworth (Mammoth) district, Nye Co., Nevada; at numerous deposits in Colorado, as the Adams mine, Bonita Mountain, near Silverton, and from Gladstone, San Juan Co., in the Sweet Home mine, Alma district, Park Co., and large crystals from the Quartz Creek district, Gunnison Co.; in the Blue Wing district, Lemhi Co., Idaho; large crystals from the Little Dragoon Mountains, Cochise Co., Arizona; in the Nogal and White Oaks districts, Lincoln Co., New Mexico. In Peru, superb large crystals from the Huallapón mine, Pasto Bueno, Ancash Province. From Wheal Gorland, Gwennap, and in the Hingston Down quarry, Cornwall, England. At Baia Sprie (Felsőbánya), Romania. From Horní Slavkov (Schlaggenwald), Czech Republic. In France, at Valcroze, Lozère, and Adervielle, Hautes-Pyrénées. At the Duoluoshan mine, Huaiji County, Guangdong Province, China.

Name: Honors Adolph Hübner, metallurgist of Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1064–1072. (2) Weitzel, H. (1976) Kristallstrukturverfeinerung von Wolframiten und Columbiten. Zeits. Krist., 144, 238–258 (in German with English abs.).
(3) (1963) NBS Mono. 25, 2, 24.

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Huemulite $Na_4MgV_{10}^{5+}O_{28}\cdot 24H_2O$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. In aggregates of fine fibers and thin films; botryoidal, massive.

Physical Properties: Hardness = 2.5–3, recrystallized. D(meas.) = 2.39(5) D(calc.) = 2.404, recrystallized. Easily soluble in H_2O, from which it can be recrystallized by slow evaporation.

Optical Properties: Semitransparent. *Color:* Yellowish orange to orange. *Streak:* Yellow. *Luster:* Dull.
Optical Class: Biaxial (–) (recrystallized synthetic). *Pleochroism:* X = light yellow; Y = golden yellow; Z = yellowish orange. *Dispersion:* $r > v$, strong. $\alpha = 1.679(3)$ $\beta = 1.734(3)$ $\gamma = 1.742(3)$ 2V(meas.) = 25°–30°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$, (recrystallized). $a = 11.770(19)$ $b = 11.838(8)$ $c = 9.018(9)$ $\alpha = 107°13(5)'$ $\beta = 112°10(6)'$ $\gamma = 101°30(5)'$ Z = 1

X-ray Powder Pattern: Malargüe district, Argentina.
7.62 (100), 10.6 (90), 9.1 (60), 10.2 (55), 8.22 (35), 2.833 (35), 3.054 (30)

Chemistry:

	(1)	(2)	(3)
V_2O_5	40.21	59.8	60.38
MnO	0.02		
MgO	1.18	3.0	2.68
CaO	3.53		
Na_2O	3.94	8.4	8.23
K_2O	0.52		
H_2O^+	8.80	29.2	28.71
H_2O^-	12.00		
SO_3	4.45		
insol.	25.43		
Total	100.08	100.4	100.00

(1) Malargüe district, Argentina; dissolved in H_2O, CaO and SO_3 are gypsum. (2) Recrystallized. (3) $Na_4MgV_{10}O_{28}\cdot 24H_2O$.

Occurrence: Formed after opening Cu–U deposits in sandstones and conglomerates; the vanadium may be derived from associated asphalt.

Association: Hummerite, rossite, thenardite, gypsum, epsomite.

Distribution: In the Agua Botada, Huemul, and Agua Botada Sur mines, Malargüe district, Mendoza Province, Argentina.

Name: For the Huemul mine, Argentina, where it occurs.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120076.

References: (1) Gordillo, C.E., E. Linares, R.O. Toubes, and H. Winchell (1966) Huemulite, $Na_4MgV_{10}O_{28}\cdot 24H_2O$, a new hydrous sodium and magnesium vanadate from Huemul mine, Mendoza Province, Argentina. Amer. Mineral., 51, 1–13.

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Hügelite $Pb_2(UO_2)_3O_2(AsO_4)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Prismatic crystals, flattened on {100}, elongated and striated along [001], showing {001}, {100}, {011}, {110}, to 3 mm.

Physical Properties: *Cleavage:* On {100}, good; on {110}, probable. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = ∼5.1 D(calc.) = 5.80 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow-orange to yellowish brown, brown. *Streak:* Pale yellow. *Luster:* Greasy to adamantine.
Optical Class: Biaxial (+) to uniaxial (+). *Pleochroism:* Moderately strong; X = yellow; Y = yellow with orange tint; Z = colorless to pale yellow. *Orientation:* $Y = c$. *Dispersion:* $r \ll v$; extreme, showing anomalous interference colors and incomplete extinction. $\alpha = 1.898(5)$ $\beta = 1.915(5)$ γ = n.d. 2V(meas.) = Small [red] to large [blue]; 0°–25°.

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. a = 8.13(20) $b = 17.27(20)$ $c = 7.01(20)$ $\beta = 109.0°$ Z = 2

X-ray Powder Pattern: Michael mine, Germany.
3.73 (10b), 3.06 (9), 3.00 (7), 2.89 (7), 1.833 (7), 4.33 (6b), 2.70 (6)

Chemistry: (1) Michael mine, Germany; microchemical tests show Pb, U, As as the main components, H_2O determined as 5.3%; from X-ray data, presumed to be the arsenate analog of dumontite.

Occurrence: A rare secondary mineral in cavities in hornstone breccia.

Association: Hallimondite, widenmannite, zeunerite, mimetite, cerussite.

Distribution: From the Michael mine, Weiler, near Lahr, Black Forest, Germany.

Name: To honor Baron Friedrich von Hügel (1852–1925), Austrian-British theologian.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 815. (2) Walenta, K. (1979) Über den Hügelite. Tschermaks Mineral. Petrog. Mitt., 26, 11–19 (in German with English abs.). (3) Piret, P. and J. Piret-Meunier (1988) Nouvelle détermination de la structure cristalline de la dumontite $Pb_2[(UO_2)_3O_2(PO_4)_2] \cdot 5H_2O$. Bull. Minéral., 111, 439–442 (in French with English abs.).

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Hughesite $Na_3Al(V_{10}O_{28})\cdot 22H_2O$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As platy, spear-shaped or blocky crystals, to 2 mm.

Physical Properties: *Cleavage*: Perfect on (001). *Fracture*: n.d. *Tenacity*: Brittle.
Hardness = 1 (estimated) D(meas.) = n.d. D(calc.) = 2.29
Highly soluble in water, acetone and alcohol; dehydrates under conditions of low humidity.

Optical Properties: Transparent to translucent. *Color*: Orange to golden orange. *Streak*: Yellow.
Luster: Subadamantine.
*Optical Class: B*iaxial (–). $\alpha = 1.698(5)$ $\beta = 1.740(5)$ $\gamma = 1.770(5)$ 2V(meas.) = 84(2)°
Dispersion: Strong, $r > v$. *Pleochroism*: $X = Y$ = light golden yellow, Z = dark golden yellow.
Absorption: $X = Y < Z$.

Cell Data: *Space Group*: $P\bar{1}$. $a = 8.668(4)$ $b = 10.295(4)$ $c = 12.908(5)$ $\alpha = 105.826(9)°$
$\beta = 97.899(9)°$ $\gamma = 103.385(9)°$ $Z = 1$

X-ray Powder Pattern: Sunday mine, San Miguel County, Colorado, USA.
12.24 (100), 8.246 (38), 9.408 (30), 8.994 (28), 2.724 (23), 3.354 (18), 7.561 (15)

Chemistry:

	(1)	(2)
Na_2O	8.00	6.41
Al_2O_3	4.63	3.52
V_2O_5	78.51	62.73
H_2O	[8.86]	27.34
Total	[100.00]	100.00

(1) Sunday mine, San Miguel County, Colorado, USA; average of 4 electron microprobe analyses of partially dehydrated material, H_2O by difference, corresponding to $Na_{2.99}Al_{1.05}(V_{10}O_{28})\cdot 5.70H_2O$.
(2) $Na_3Al(V_{10}O_{28})\cdot 22H_2O$.

Occurrence: As efflorescent crusts on the sandstone walls of mine workings and in rock fractures, through the oxidation of primary vanadium oxides (corvusite and montroseite) that react with acidic, oxidizing groundwater in roll-front type U deposits, usually in organic-carbon-rich zones.

Association: Rossite, lasalite, hewettite, sherwoodite, corvusite, montroseite, rakovanite, gunterite.

Distribution: Sunday mine, Gypsum Valley, San Miguel County, Slick Rock District, Colorado, USA.

Name: Honors John Michael Hughes (b. 1952), Professor of Mineralogy, University of Vermont, USA, for his long and outstanding career in mineralogy, including his extensive work on the pascoite family of minerals and vanadium bronzes.

Type Material: National Museum of Natural History, Washington D.C., USA, (NMNH 174253).

References: (1) Rakovan, J., G.R. Schmidt, M.E. Gunter, B. Nash, J. Marty, A.R. Kampf, and W.S. Wise (2011) Hughesite, $Na_3Al(V_{10}O_{28})\cdot 22H_2O$, a new member of the pascoite family of minerals from the Sunday Mine, San Miguel County, Colorado. Canadian Mineralogist, 49, 1253-1265.
(2) (2014) Amer. Mineral., 99, 870-871 (abs. ref. 1).

Hulsite $(Fe^{2+}, Mg)_2(Fe^{3+}, Sn)BO_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As rough rectangular tabular crystals, showing {100}, {010}, {001}, {110}, to 1 cm; in aggregates of parallel prismatic individuals. *Twinning:* Simple twins by 120° rotation.

Physical Properties: *Cleavage:* On {110}, good. Hardness = ∼3 D(meas.) = 4.28–4.57 D(calc.) = 4.62

Optical Properties: Opaque. *Color:* Black with greenish, brownish, or reddish tinge. *Streak:* Black. *Luster:* Submetallic to vitreous.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2/m$. $a = 10.695(4)$ $b = 3.102(1)$ $c = 5.431(1)$ $\beta = 94.21(3)°$ Z = 2

X-ray Powder Pattern: Brooks Mountain, Alaska, USA.
2.664 (100), 5.35 (70), 2.585 (70), 2.039 (50), 4.99 (35), 2.491 (35), 2.370 (20)

Chemistry:

	(1)
B_2O_3	12.98
TiO_2	0.30
SnO_2	12.03
Al_2O_3	1.27
Fe_2O_3	20.02
FeO	42.21
MnO	0.74
MgO	10.45
Total	100.00

(1) Brooks Mountain, Alaska, USA; corresponds to $(Fe^{2+}_{1.43}Mg_{0.63}Mn_{0.03})_{\Sigma=2.09}(Fe^{3+}_{0.61}Sn_{0.19}Al_{0.06}Ti_{0.01})_{\Sigma=0.87}BO_5$.

Mineral Group: Ludwigite group.

Occurrence: Very rare, in a contact-metamorphosed limestone, close by an intrusive granite.

Association: Calcite, vesuvianite, magnetite, garnet, fluorite, diopside.

Distribution: From a prospect pit on the northwest flank of Brooks Mountain, Seward Peninsula, Alaska, USA.

Name: Honors Alfred Hulse Brooks (1871–1924), geologist in charge of the Division of Alaskan Mineral Resources, U.S. Geological Survey.

Type Material: Natural History Museum, Paris, France, 110240; The Natural History Museum, London, England, 1912,612; Harvard University, Cambridge, Massachusetts, 96246, 96247; National Museum of Natural History, Washington, D.C., USA, 86791, 86989.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 326. (2) Clark, J.R. (1965) Crystallographic data for the iron borate mineral, hulsite. Amer. Mineral., 50, 249–254. (3) Konnert, J.A., D.A. Appleman, J.R. Clark, L.W. Finger, T. Kato, and Y. Miúra (1976) Crystal structure and cation distribution of hulsite, a tin-iron borate. Amer. Mineral., 61, 116–122. (4) Yamnova, N.A., M.A. Simonov, and N.V. Belov (1975) Crystal structure of the Fe,Mg borate hulsite $(Fe^{2+}, Mg, Fe^{3+}, Sn)_3BO_3O_2$. Kristallografiya (Sov. Phys. Crystal.), 20, 156–159 (in Russian). (5) Knopf, A. and W.T. Schaller (1908) Two new boron minerals of contact-metamorphic origin. Amer. J. Sci., 25, 323–331.

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Humberstonite $K_3Na_7Mg_2(SO_4)_6(NO_3)_2 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As hexagonal crystals, platy on {0001}, with $\{10\overline{1}1\}$, to 0.3 mm; typically in massive aggregates.

Physical Properties: *Cleavage:* Perfect on {0001}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 2.252 D(calc.) = 2.252 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.474(2)$ $\epsilon = 1.436(2)$

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.9055(3)$ $c = 24.3949(9)$ Z = 3

X-ray Powder Pattern: Oficina Alemania, Chile.
3.39 (100), 2.724 (70), 8.14 (60), 8.80 (35), 4.53 (35), 2.583 (35), 1.866 (35)

Chemistry:

	(1)	(2)
SO_3	42.99	42.31
N_2O_5	9.14	9.51
MgO	7.47	7.10
Na_2O	18.43	19.11
K_2O	12.17	12.45
H_2O^+	9.78	
H_2O^-	0.40	
H_2O		9.52
Total	100.38	100.00

(1) Oficina Alemania, Chile; after removal of $NaNO_3$ impurity with acetone, $(SO_4)^{2-}$ and $(NO_3)^{1-}$ confirmed by IR. (2) $K_3Na_7Mg_2(SO_4)_6(NO_3)_2 \cdot 6H_2O$.

Occurrence: Formed by repeated natural leaching of nitrate ore with reprecipitation in irregular pods above the local regolith.

Association: Blödite, nitratine, kieserite.

Distribution: In Chile, from near Oficina Alemania and ten km west of Oficina María Elena; an ore in the Taltal nitrate district, Antofagasta; locally abundant in near-surface nitrate layers throughout the Atacama Desert.

Name: Honors James Thomas Humberstone (1850–1939), industrial chemist whose contributions permit economical extraction of nitrate from the Chilean deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120898.

References: (1) Mrose, M.E., J.J. Fahey, and G.E. Ericksen (1970) Mineralogical studies of the nitrate deposits of Chile. III. Humberstonite, $K_3Na_7Mg_2(SO_4)_6(NO_3)_2 \cdot 6H_2O$, a new saline mineral. Amer. Mineral., 55, 1518–1533. (2) Burns, P.C. and F.C. Hawthorne (1994) The crystal structure of humberstonite, a mixed sulfate-nitrate mineral. Can. Mineral., 32, 381–385.

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Humboldtine $Fe^{2+}C_2O_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare small crystals are prismatic along [001] or platy, showing {100}, {001}, {110}, {101}; typically in botryoidal incrusting masses with fibrous to earthy internal structure.

Physical Properties: *Cleavage:* {110}, perfect; {100} and {010}, imperfect.
Hardness = 1.5–2 D(meas.) = 2.28 D(calc.) = 2.307

Optical Properties: Transparent to translucent. *Color:* Yellow to amber-yellow. *Luster:* Dull to resinous.
Optical Class: Biaxial (+). *Pleochroism:* X = very pale yellowish green; Y = pale greenish yellow; Z = bright yellow. *Orientation:* $X = a$, $Y = b$, $Z = c$. $\alpha = \sim 1.494$ $\beta = 1.561$ $\gamma = 1.692$ 2V(meas.) = Large.

Cell Data: *Space Group:* $I2/c$ (synthetic). $a = 9.707(1)$ $b = 5.556(1)$ $c = 9.921(1)$ $\beta = 104.50(1)°$ Z = 4

X-ray Powder Pattern: Synthetic.
4.80 (100), 4.70 (65), 3.004 (50), 2.654 (30), 3.880 (25), 3.597 (25), 2.616 (25)

Chemistry:

	(1)	(2)
C_2O_3	40.18	40.03
FeO	40.72	39.94
MgO	trace	
H_2O	[19.10]	20.03
Total	[100.00]	100.00

(1) Capo d'Arco, Elba, Italy. (2) $FeC_2O_4 \cdot 2H_2O$ (ferrous oxalate).

Occurrence: Typically coating fractures in brown coal deposits; very rarely in granite pegmatites and hydrothermal mineral deposits.

Association: Gypsum, tschermigite (coal seams); cassiterite, tourmaline, quartz (pegmatites and hydrothermal).

Distribution: In the Czech Republic, from Korozluky (Korozoluk), southwest of Bílina (Bilin), at Čermniky (Tschermig), Lužice (Luschitz), and Lomnice, near Sokolov (Lant, near Falkenau). In Germany, at Grossalmerode, Hesse; from Potschappel, south of Dresden, Saxony; at Sailauf, northeast of Aschaffenburg, Spessart Mountains, Bavaria. In the Pendarves mine, Camborne, Cornwall, England. At Capo d'Arco and Capo Calamita, Elba, Italy. From Kettle Point and in the Francon quarry, Montreal Island, Montreal, Quebec, Canada. From Santa Maria de Itabira, Minas Gerais, Brazil.

Name: Honors Friedrich Heinrich Alexander von Humboldt (1769–1859), German naturalist and explorer.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1102–1103. (2) Mazzi, F. and C. Garavelli (1957) La struttura della oxalite: $FeC_2O_4 \cdot 2H_2O$. Per. Mineral., 26, 269–303 (in Italian with English abs.). (3) (1972) NBS Mono. 25, 10, 24.

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Humite $(Mg, Fe^{2+})_7(SiO_4)_3(F, OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals typically highly modified, to 1 cm; granular.

Physical Properties: *Cleavage:* {100}, poor. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.20–3.32 D(calc.) = 3.201

Optical Properties: Transparent to translucent. *Color:* White, yellow, dark orange, brown; colorless to yellow-brown in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = very pale yellow to dark yellow; $Y = Z$ = colorless, pale yellow. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$. $\alpha = 1.607$–1.643 $\beta = 1.619$–1.655 $\gamma = 1.639$–1.675 2V(meas.) = 65°–84°

Cell Data: *Space Group: Pmcn.* $a = 20.8526(4)$ $b = 4.7408(1)$ $c = 10.2580(2)$ $Z = 4$

X-ray Powder Pattern: Synthetic $Mg_7(SiO_4)_3F$.
2.256 (100), 2.438 (70), 1.4786 (70), 1.7387 (65), 3.64 (50), 2.691 (50), 2.572 (40)

Chemistry:

	(1)	(2)
SiO_2	35.79	36.43
TiO_2	2.00	0.10
Al_2O_3	0.79	
Fe_2O_3	0.33	
FeO	3.31	5.03
MnO	0.84	0.65
MgO	54.51	53.84
CaO	0.00	0.01
F	2.77	4.07
H_2O^+	0.91	[1.69]
H_2O^-	0.00	
$-O = F_2$	1.17	[1.71]
Total	100.08	[100.11]

(1) Lohja, Finland; corresponds to $(Mg_{6.75}Fe^{2+}_{0.23}Ti_{0.12}Al_{0.08}Mn_{0.06}Fe^{3+}_{0.02})_{\Sigma=7.26}(Si_{0.99}O_4)_3[F_{0.73}(OH)_{0.50}]_{\Sigma=1.23}$. (2) Sillböle, Finland; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $(Mg_{6.60}Fe_{0.35}Mn_{0.04})_{\Sigma=6.99}(SiO_4)_3[F_{1.06}(OH)_{0.93}O_{0.01}]_{\Sigma=2.00}$.

Mineral Group: Humite group.

Occurrence: Typically in contact metamorphic zones in limestones and dolostones associated with felsic, or more rarely, alkalic plutonic rocks, especially where metasomatism has introduced Fe, B, and F.

Association: Grossular, wollastonite, forsterite, monticellite, cuspidine, fluoborite, ludwigite, spinel, brucite, calcite, dolomite, serpentine, diopside, corundum, phlogopite, pyrrhotite.

Distribution: At Monte Somma and Vesuvius, Campania, Italy. At Lohja, Sillböle, and Hermala, Finland. In the Norberg area, and at the Ladu mine, Persberg, Värmland, Sweden. From Sorfinnset, Glomfjord, Norway. In the Tilly Foster mine, Brewster, Putnam Co., New York, and at Franklin, Sussex Co., New Jersey, USA. From Llanos de Juanar, Málaga Province, Spain. At Anzahamazonono, Madagascar.

Name: After Sir Abraham Hume (1749–1838), English connoisseur and collector of works of art, gems, and minerals.

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Type Material: Natural History Museum, Paris, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 535–536. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 380–417. (3) Ribbe, P.H. and G.V. Gibbs (1971) Crystal structures of the humite minerals: III. Mg/Fe ordering in humite and its relation to other ferromagnesian silicates. Amer. Mineral., 56, 1155–1173. (4) (1962) NBS Mono. 25, 1, 30.

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Hummerite $K_2Mg_2V_{10}^{5+}O_{28}\cdot 16H_2O$

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Crystal Data: Triclinic (after recrystallization). *Point Group:* $\overline{1}$. Massive, in veins and efflorescences.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.53] Soluble in H_2O, from which it may be recrystallized.

Optical Properties: Translucent. *Color:* Bright orange.
Optical Class: Biaxial (–) (recrystallized). *Dispersion:* Strong. α = n.d. $\beta = 1.81$ γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.735(2)$ $b = 11.085(2)$ $c = 8.831(1)$ $\alpha = 106.01(1)^\circ$ $\beta = 108.04(1)^\circ$ $\gamma = 65.81(1)^\circ$ Z = [2]

X-ray Powder Pattern: Hummer mine, Colorado, USA.
8.2 (10), 7.4 (7), 2.73 (6), 7.0 (5), 3.31 (4), 3.13 (4), 2.11 (4)

Chemistry: No chemical analysis has been performed; characterized by correspondence of properties with synthetic material.

Occurrence: Leached from vanadium oxide ores and deposited in veins in clay and as efflorescences on sandstone.

Association: Huemulite, rossite, thenardite, gypsum, epsomite (Malargüe district, Argentina).

Distribution: In the USA, in the Hummer mine, Jo Dandy group, and the North Star mine, Paradox Valley, Uravan district, Montrose Co., Colorado; in the Mesa No. 1 mine, Lukachukai Mountains, Apache Co., Arizona; from the Grants district, McKinley Co., New Mexico; in the Corvusite mine, Beaver Mesa, La Sal Mountains, Grand Co., Utah; and in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada. From the Malargüe district, Mendoza Province, Argentina.

Name: For the Hummer mine, Colorado, USA, where it occurs.

Type Material: Harvard University, Cambridge, Massachusetts, 102345; National Museum of Natural History, Washington, D.C., USA, 106899.

References: (1) Weeks, A.D., E.A. Cisney, and A.M. Sherwood (1951) Hummerite and montroseite, two vanadium minerals from Montrose County, Colorado. Proceedings of the 31st Annual Meeting. Amer. Mineral., 36, 326–327 (abs.). (2) Evans, H.T., Jr., M.E. Mrose, and R. Marvin (1955) Constitution of the natural and artificial decavanadates. Proceedings of the 35th Annual Meeting. Amer. Mineral., 40, 314–315 (abs.). (3) Griffen, D.T. (1990) The crystal structure of hummerite, with comments on the crystallochemical stability of the decavanadate isopolyanion. Geology Studies, 36, 1–14. (4) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 50.

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Hunchunite Au_2Pb

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Anhedral grains, in aggregates to 0.5 mm.

Physical Properties: Hardness = n.d. VHN = 128–149, 140 average (5 g load).
D(meas.) = n.d. D(calc.) = 15.99

Optical Properties: Opaque. *Color:* Silver-gray; silver-gray in reflected light, tarnishing to dull gray. *Luster:* Metallic.
Optical Class: Isotropic.
R: (480) 58.4, (546) 59.5, (589) 60.0, (656) 60.0

Cell Data: *Space Group:* $Fd3m$ (by analogy to synthetic Au_2Pb). $a = 7.933$ $Z = 8$

X-ray Powder Pattern: Hunchun River, China.
2.391 (100), 2.810 (30), 1.196 (26), 2.301 (24), 1.526 (23), 4.595 (21), 1.402 (19)

Chemistry:

	(1)	(2)
Au	64.78	65.53
Ag	2.18	34.47
Pb	32.91	
Total	99.87	100.00

(1) Hunchun River, China; by electron microprobe, average of seven analyses; corresponding to $(Au_{1.94}Ag_{0.12})_{\Sigma=2.06}Pb_{0.94}$. (2) Au_2Pb.

Occurrence: In gold concentrates from placers.

Association: Gold, lead, anyuiite, pyrite, pyrrhotite, magnetite, ilmenite.

Distribution: From the Sandogou placers, along the Hunchun River, Jilin Province, China [TL].

Name: For its occurrence along the Hunchun River, China.

Type Material: National Geological Museum, Beijing, China.

References: (1) Wu Shangquan, Yang Yi, and Song Qun (1992) A new gold mineral – hunchunite. Acta. Mineral. Sinica,12(4), 319–322 (in Chinese with English abs.). (2) (1994) Amer. Mineral., 79, 1210 (abs. ref. 1). (3) Perlitz, ?? (1934) ??title?? Strukture Bereicht, 3, 612??str??

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Hungchaoite $MgB_4O_5(OH)_4 \cdot 7H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $\overline{1}$. As tabular crystals, to 0.5 mm, composed of {100}, {1$\overline{1}$0}, {2$\overline{1}$0}, {1$\overline{1}$1}, {001}, {$\overline{1}$11}, and several others.

Physical Properties: *Cleavage:* {$\overline{1}$11}, perfect; {$\overline{11}$1}, good; {010}, imperfect. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 1.706(5) D(calc.) = 1.703

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X \wedge a = 28°$ (in acute axial angle); $Z \wedge b = 37°$; $Y \wedge c = –66°$. *Dispersion:* $r < v$, distinct. $\alpha = 1.445(2)$ $\beta = 1.485(2)$ $\gamma = 1.490(2)$ 2V(meas.) = 15(2)° 2V(calc.) = 36°

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.807(1)$ $b = 10.657(1)$ $c = 7.897(1)$ $\alpha = 103.39(1)°$ $\beta = 108.53(1)°$ $\gamma = 97.18(1)°$ Z = 2

X-ray Powder Pattern: Death Valley, California, USA.
6.71 (100), 3.356 (92), 5.36 (85), 4.093 (78), 2.912 (73), 4.079 (64), 7.14 (59)

Chemistry:

	(1)	(2)
B_2O_3	39.58	40.75
MgO	11.86	11.80
H_2O	49.74	47.45
Total	101.18	100.00

(1) China; original total given as 100.00%. (2) $MgB_4O_5(OH)_4 \cdot 7H_2O$.

Occurrence: In lacustrine saline borate deposits (China); an efflorescence on weathered colemanite and priceite veins (Death Valley, California, USA).

Association: Ulexite, hydroboracite, szaibélyite, gypsum (China); ginorite, mcallisterite, sborgite, sassolite, nobleite, ulexite, gypsum, kurnakovite, inderite, montmorillonite, analcime (Death Valley, California, USA).

Distribution: From China, at an unspecified locality [the Qinghai-Xizang Plateau, Tibet]. From the Hard Scramble claim and elsewhere in the Furnace Creek district, Death Valley, Inyo Co., California, USA.

Name: Honors Professor Chang Hung-chao (1877–1951), Chinese geologist and mineralogist.

Type Material: n.d.

References: (1) I-Hua Chu, Hsien-Te Hsieh, Tze-Chiang Chien, and Lai-Pao Liu (1964) Preliminary report on the occurrence of a new magnesium borate – hungchaoite, $MgO \cdot 2B_2O_3 \cdot 9H_2O$, in China. Scientia Sinica, 13, 525–527 (in Russian). (2) (1965) Amer. Mineral., 50, 262 (abs. ref. 1). (3) C. Wan and S. Ghose (1977) Hungchaoite, $Mg(H_2O)_5B_4O_5(OH)_4 \cdot 2H_2O$: a hydrogen-bonded molecular complex. Amer. Mineral., 62, 1135–1143. (4) Erd, R.C., J.F. McAllister, and G.D. Eberlein (1979) New data on hungchaoite, the second world occurrence, Death Valley region, California. Amer. Mineral., 64, 369–375.

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Huntite $CaMg_3(CO_3)_4$

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Crystal Data: Hexagonal. *Point Group:* 32. As platy rhomboidal crystals, to 1 μm, aggregated into compact chalklike masses.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = < 3
D(meas.) = 2.696 D(calc.) = 2.875

Optical Properties: Translucent. *Color:* White; colorless in transmitted light. *Streak:* White. *Luster:* Dull.
Optical Class: Uniaxial (–). $\omega = 1.622$ $\epsilon = 1.615$

Cell Data: *Space Group:* $R32$. $a = 9.5027(6)$ $c = 7.812(6)$ Z = 3

X-ray Powder Pattern: Currant Creek, Nevada, USA.
2.833 (100), 1.972 (30), 2.888 (20), 1.765 (20), 1.757 (20), 2.604 (12), 2.432 (10)

Chemistry:

	(1)	(2)	(3)
CO_2	48.85	48.18	49.87
SiO_2	0.06		
FeO	0.00	0.03	
MnO	trace	0.03	
MgO	34.09	33.27	34.25
CaO	15.42	13.24	15.88
SrO		1.86	
H_2O^+	0.86	n.d.	
H_2O^-	0.47	0.67	
insol.		1.90	
Total	99.75	[99.18]	100.00

(1) Ala-Mar deposit, Nye Co., Nevada, USA. (2) Geelong, Australia; original total given as 99.26%. (3) $CaMg_3(CO_3)_4$.

Occurrence: Filling vugs and coating fractures in rock; as flowstone and incrustations in caves; typically precipitated by evaporative concentration of meteoric solutions weathering magnesite- or dolomite-bearing rocks, or serpentinites and ophiolites.

Association: Magnesite, dolomite, aragonite, calcite, hydromagnesite.

Distribution: In the USA, in Nevada, from the Ala-Mar deposit, Currant Creek district, and the Gabbs mine, Gabbs district, Nye Co., and the Nevada Magnesite and Snowball deposits, White Pine Co.; in the Chief Consolidated mine, Eureka, Eureka Co., Utah; at the Kalkar quarry, Santa Cruz, Santa Cruz Co., California; in the Line Pit, Lancaster Co., Pennsylvania. In Australia, from Tea Tree Gully, South Australia; at Katherine, Northern Territory; and from Deer Park and Geelong, Victoria. In the Kurgashinkan Pb–Zn deposit, Uzbekistan. Studied from cave deposits at: Carlsbad Cavern, New Mexico, USA. From Castleguard Cave, Columbia Icefields, Alberta, Canada. In the Dorog and Beremend Crystal Cave, Hungary. From the Pestera Fagului Cave, Romania. In the Gunung Mulu National Park, Sarawak, Malaysia. A number of other minor localities are known.

Name: Honors Professor Walter Frederick Hunt (1882–1975), University of Michigan, Ann Arbor, Michigan, USA, and chemist with the U.S. Geological Survey.

Type Material: Harvard University, Cambridge, Massachusetts, 106372; National Museum of Natural History, Washington, D.C., USA, 112519.

References: (1) Faust, G.T. (1953) Huntite, $Mg_3Ca(CO_3)_4$, a new mineral. Amer. Mineral., 38, 4–24. (2) Shayan, A. (1984) Strontium in huntites from Geelong and Deer Park, Victoria, Australia. Amer. Mineral., 69, 528–530. (3) Dollase, W.A. and R.J. Reeder (1986) Crystal structure refinement of huntite, $CaMg_3(CO_3)_4$, with X-ray powder data. Amer. Mineral., 71, 163–166. (4) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, esp. p. 150–151. (5) Graf, D.L. and W.F. Bradley (1962) The crystal structure of huntite. Acta Cryst., 15, 238–242.

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Huréaulite $Mn_5^{2+}(PO_4)_2(PO_3OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals long to short prismatic, elongated along [001], with {100}, {110}, or tabular {100}, to 3 cm, may be equant; in bundled fascicles, less commonly fibrous, scaly, compact, massive.

Physical Properties: *Cleavage:* On {100}, good. Hardness = 3.5 D(meas.) = 3.15–3.19 D(calc.) = 3.19

Optical Properties: Transparent to translucent. *Color:* Light pink, rose-violet, pale rose, amber, orange, red-orange, red, brownish orange, reddish to yellowish brown. *Streak:* Nearly white. *Luster:* Vitreous, inclined towards greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = yellow to pale rose; Z = reddish yellow to reddish brown. *Orientation:* $X = b$; $Z \wedge c = 75°$. *Dispersion:* $r < v$, very strong, crossed. $\alpha = 1.647$–1.654 $\beta = 1.654$–1.662 $\gamma = 1.660$–1.667 2V(meas.) = 75°–82°

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 17.587(4)$ $b = 9.127(3)$ $c = 9.497(5)$ $\beta = 96.68(3)°$ Z = 4

X-ray Powder Pattern: Stewart mine, Pala, California, USA. (ICDD 34-146).
3.152 (100), 8.09 (70), 2.992 (65), 8.75 (40), 2.630 (40), 4.545 (35), 3.198 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	38.00	38.09	38.96	MgO		0.30	
FeO	11.10	20.65		CaO		0.38	
MnO	32.85	28.72	48.68	H_2O	18.00	[11.86]	12.36
				Total	99.95	[100.00]	100.00

(1) Huréaux, France. (2) São Jose de Safira, Brazil; by electron microprobe, average of three analyses, total Fe as FeO, H_2O by difference. (3) $Mn_5(PO_4)_2(PO_3OH)_2 \cdot 4H_2O$.

Occurrence: A late-stage secondary mineral formed by alteration of primary phosphates in complex granite pegmatites.

Association: Lithiophilite, triphylite, heterosite, rockbridgeite, cacoxenite, vivianite, fairfieldite, dickinsonite, eosphorite, stewartite, strengite, phosphosiderite, roscherite, many rarer phosphates.

Distribution: Many localities. In France, from Huréaux, St. Sylvestre, and in the La Vilate quarry, near Chanteloube, Haute-Vienne. At the Mangualde pegmatite, near Mesquitela, Portugal. In Germany, fine crystals from Hagendorf, at Pleystein, and Hühnerkobel, near Zwiesel, Bavaria. In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. From the Viitaniemi pegmatite, near Eräjärvi, Finland. In the USA, from the Strickland quarry, Portland, Middlesex Co., and at Branchville, Fairfield Co., Connecticut; in the Fletcher and Palermo #1 mines, near North Groton, Grafton Co., New Hampshire; from the Emmons quarry, Greenwood, Oxford Co., and many other places in Maine; in the Bull Moose and Tip Top mines, near Custer, and the White Elephant mine, near Pringle, Custer Co., and elsewhere in South Dakota. In Brazil, at the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares; fine examples from the Criminoso mine, near São Jose de Safira, and the Joca mine, Galiléia, Minas Gerais. At the Buranga pegmatite, near Gatumba, Rwanda. Extraordinary crystals from Shengus, Gilgit district, Pakistan.

Name: For its first-noted occurrence near Huréaux, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 700–702. (2) Fransolet, A.-M. (1976) L'huréaulite: ses propriétés minéralogiques et son rôle dans l'évolution génétique des phases $Li(Fe,Mn)PO_4$. Bull. Soc. fr. Minéral., 99, 261–273 (in French with English abs.). (3) Moore, P.B. and T. Araki (1973) Hureaulite, $Mn_5^{2+}(H_2O)_4[PO_4(OH)]_2[PO_4]_2$: its atomic arrangement. Amer. Mineral., 58, 302–307. (4) Dunn, P.J., P.B. Leavens, B.D. Sturman, R.V. Gaines, and C. do P. Barbosa (1979) Hureaulite and barbosalite from Lavra do Criminosa, Minas Gerais, Brazil. Mineral. Record, 10, 147–151. (5) Gerault, Y., A. Riou, and Y. Cudennec (1987) Phosphate hydrogénphosphate hydrate de manganése. Acta Cryst., C43, 1829–1830 (in French with English abs.).

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Hurlbutite $CaBe_2(PO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Stout prismatic crystals, dominant {001}, {110}, smaller {010}, {201}, to 2.5 cm; as spheres with a radial fibrous structure.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6
D(meas.) = 2.877(5) D(calc.) = [2.90]

Optical Properties: Transparent to translucent. *Color:* Colorless to greenish white.
Streak: White. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, weak.
$\alpha = 1.595(3)$ $\beta = 1.601(3)$ $\gamma = 1.604(3)$ 2V(meas.) = 70° 2V(calc.) = 70°18′

Cell Data: *Space Group:* $P2_1/a$. $a = 8.299(1)$ $b = 8.782(2)$ $c = 7.798(3)$ $\beta = 90.5°$
Z = 4

X-ray Powder Pattern: G.E. Smith mine, New Hampshire, USA.
3.67 (10), 3.03 (9), 2.78 (9), 2.21 (9), 3.50 (7), 2.50 (7), 3.28 (6)

Chemistry:

	(1)	(2)
P_2O_5	56.19	57.22
BeO	21.30	20.17
CaO	21.84	22.61
insol.	0.76	
Total	100.09	100.00

(1) G.E. Smith mine, New Hampshire, USA; corresponds to $Ca_{0.98}Be_{2.13}(PO_4)_{1.98}$.
(2) $CaBe_2(PO_4)_2$.

Occurrence: A late-stage mineral in complex granite pegmatites; observed as an alteration product of beryl.

Association: Triphylite, siderite, muscovite, albite, quartz (G.E. Smith mine, New Hampshire, USA); montebrasite, beryllonite, lithiophilite (Viitaniemi pegmatite, Finland); tiptopite, englishite, montgomeryite (Tip Top mine, South Dakota, USA).

Distribution: In the USA, large crystals from the G.E. Smith mine, Newport, Sullivan Co., and at the Beauregard pegmatite, Gilsum, Cheshire Co., New Hampshire; in the Black Mountain quarry, Rumford, Oxford Co., Maine; at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota. In the Viitaniemi pegmatite, near Eräjärvi, Finland. At the Norrö pegmatite, on Rånö Island, and from near Kapelludden, Utö Island, Sweden. From Otov, near Ronsperk, Czech Republic. At the Grand Slam, Kondo, and Lion Hill mines, Urungwe, and on the Jaffie tin claims, Wankie, Zimbabwe. Several other localities are reported.

Name: To honor Prof. Cornelius Searle Hurlbut, Jr. (1906–), American mineralogist, Harvard University, Cambridge, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 103923, 104958, 104602, 134548.

References: (1) Mrose, M.E. (1952) Hurlbutite, $CaBe_2(PO_4)_2$, a new mineral. Amer. Mineral., 37, 931–940. (2) Lindbloom, J.T., G.V. Gibbs, and P.H. Ribbe (1974) The crystal structure of hurlbutite: a comparison with danburite and anorthite. Amer. Mineral., 59, 1267–1271.

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Hutchinsonite $(Pb,Tl)_2As_5S_9$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are prismatic to acicular ‖ [001], to 1 cm; also as radiating tufts.

Physical Properties: *Cleavage:* Good on {010}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5–2 VHN = 170 D(meas.) = 4.6–4.7 D(calc.) = 4.58

Optical Properties: Opaque, translucent in thin fragments. *Color:* Scarlet-vermilion to deep cherry-red, with strong red internal reflections; transmits red light in thin fragments. *Luster:* Adamantine to submetallic.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, extreme. $\alpha = 3.078(18)$ $\beta = 3.176(3)$ $\gamma = 3.188(3)$ 2V(meas.) = 37° (589). *Anisotropism:* Strong. R_1–R_2: (400) 32.6–36.9, (420) 31.8–35.9, (440) 31.2–35.2, (460) 30.5–34.3, (480) 29.5–33.2, (500) 29.0–32.1, (520) 29.1–31.3, (540) 28.8–30.4, (560) 28.0–29.4, (580) 26.9–28.4, (600) 26.0–27.6, (620) 25.3–26.8, (640) 24.8–26.4, (660) 24.3–26.0, (680) 23.9–25.6, (700) 23.6–25.3

Cell Data: *Space Group: Pbca.* $a = 1.809(6)$ $b = 35.48(1)$ $c = 8.167(3)$ Z = 8

X-ray Powder Pattern: Binntal, Switzerland.
2.74 (100), 3.79 (70), 3.05 (60), 4.44 (50), 2.39 (30), 2.22 (30), 1.907 (30)

X-ray Powder Pattern: Quiruvilca, Peru. (ICDD 42-1388).
17.5 (100), 3.050 (100), 3.701 (80), 2.700 (70), 5.34 (60), 4.37 (60), 3.819 (60)

Chemistry:

	(1)	(2)	(3)
Pb	12.5	19.3	19.28
Tl	25.0	17.3	19.02
Ag	9.0	0.0	
As	30.5	31.1	34.85
Sb		1.9	
S	26.0	29.3	26.85
Total	103.0	98.9	100.00

(1) Binntal, Switzerland. (2) Quiruvilca, Peru; by electron microprobe, corresponds to $Pb_{0.98}Tl_{0.89}(As_{4.36}Sb_{0.17})_{\Sigma=4.53}S_{9.61}$. (3) $PbTlAs_5S_9$.

Occurrence: Of hydrothermal origin.

Association: Orpiment, realgar, getchellite, pyrite, sphalerite, hatchite, jentschite, sicherite, edenharterite, bernardite, stalderite, ernigglite, chabournite.

Distribution: In Switzerland, from the Lengenbach quarry, Binntal, Valais [TL]. At the Segen Gottes mine, near Wiesloch, Black Forest, Germany. Very well crystallized from the La Libertad mine, Quiruvilca, Peru. At the Toya-Takarada mine, Hokkaido, Japan. From the Nanhua Sn–Tl deposit, Yunnan Province, China.

Name: To honor Arthur Hutchinson (1866–1937), Professor of Mineralogy, Cambridge University, Cambridge, England.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 468–469. (2) Takéuchi, Y., S. Ghose, and W. Nowacki (1965) The crystal structure of hutchinsonite, $(Tl,Pb)_2As_5S_9$. Zeits. Krist., 121, 321–348. (3) White, J.S. and J.A. Nelen (1985) Hutchinsonite from Quiruvilca, Peru. Mineral. Record, 16, 459–460. (??)?? Matsushita, ?? and ?? Takéuchi (1994) ??title?? Zeits. Krist., 209, 475–?? must, and renumber; (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 160–161. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 242.

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Huttonite $ThSiO_4$

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Crystal Data: Monoclinic; rarely metamict. *Point Group:* $2/m$. As anhedral grains, may be flattened on {100}, to 0.2 mm.

Physical Properties: *Cleavage:* Distinct on {001}; another poor cleavage is of unspecified orientation. *Fracture:* Conchoidal. Hardness = [4.5] VHN = 318 (150 g load). D(meas.) = 7.1 D(calc.) = 7.18 Fluoresces dull white with a pink tinge under SW UV; radioactive.

Optical Properties: Transparent to translucent. *Color:* Colorless to very pale cream. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \simeq c$. *Dispersion:* $r < v$, moderate. $\alpha = 1.898(3)$ $\beta = [1.900]$ $\gamma = 1.922$ 2V(meas.) = 25(1)°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.80(3)$ $b = 6.96(3)$ $c = 6.54(3)$ $\beta = 104°55(10)'$ Z = 4

X-ray Powder Pattern: Gillespie's Beach, New Zealand.
3.09 (100), 2.89 (90), 4.23 (75), 3.29 (75), 4.71 (60), 4.08 (50), 3.53 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	19.7	12.8	18.54
ThO_2	76.6	69.9	81.46
UO_2	0.0	1.0	
RE_2O_3	2.6	4.5	
Fe_2O_3	1.2		
FeO		< 0.09	
MnO	trace		
CaO	0.0	2.5	
MgO	0.0		
F		1.0	
OH		[1.8]	
H_2O	0.0	[0.0]	
P_2O_5	trace	7.1	
Total	100.1	[100.6]	100.00

(1) Gillespie's Beach, New Zealand. (2) Bogatynia area, Poland; by electron microprobe, $RE_2O_3 = La_2O_3$ 0.9%, Ce_2O_3 2.7%, Pr_2O_3 0.15%, Nd_2O_3 0.9%; corresponds to $Th_{0.78}Ca_{0.13}RE_{0.09}U_{0.01}[(Si_{0.63}P_{0.22})_{\Sigma=0.85}O_4](OH)_{0.31}F_{0.16}$. (3) $ThSiO_4$.

Polymorphism & Series: Dimorphous with thorite.

Mineral Group: Monazite group.

Occurrence: In beach sands (New Zealand).

Association: Scheelite, titanian cassiterite, uranothorite, ilmenite, gold (New Zealand); cheralite, thorogummite, thorian ningyoite (Bogatynia area, Poland).

Distribution: From Harihari, Saltwater Creek, Okirito, Five Mile Beach, Bruce Bay, north and south of the mouth of the Waikukupa River, and Gillespie's Beach, South Westland, New Zealand. From the Bogatynia area, Lower Silesia, Poland. On Mont Most, Great St. Bernard, Val d'Aosta, Italy. In the Holiday mine, Hawthorne, Fitting district, Mineral Co., Nevada, USA. From Kuttankuli (Kuttakuzhi), about 42 km east-southeast of Trivandrum, Kerala State, India.

Name: For Colin Osborne Hutton (1910–1971), New Zealand-American mineralogist of Stanford University, Palo Alto, California, USA.

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Type Material: The Natural History Museum, London, England, 1950,340; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 106265.

References: (1) Pabst, A. and C.O. Hutton (1951) Huttonite, a new monoclinic thorium silicate. Amer. Mineral., 36, 60–69. (2) Taylor, M. and R.C. Ewing (1978) The crystal structures of the $ThSiO_4$ polymorphs: huttonite and thorite. Acta Cryst., 34, 1074–1079. (3) Kucha, H. (1980) Continuity in the monazite-huttonite series. Mineral. Mag., 43, 1031–1034.

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Hyalophane $(K, Ba)Al(Si, Al)_3O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals similar to adularia or orthoclase, to 20 cm; also granular or massive. *Twinning:* Commonly simple twins according to the Carlsbad, Manebach, or Baveno laws.

Physical Properties: *Cleavage:* Perfect on {001}, good on {010}, intersecting at 90°. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.58–2.82 D(calc.) = [2.88]

Optical Properties: Transparent to translucent. *Color:* Colorless, white, also flesh-red; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = -25°$ to $-45°$; $X \wedge a = 1°$ to $-19°$. *Dispersion:* $r > v$, weak. $\alpha = 1.520–1.542$ $\beta = 1.524–1.545$ $\gamma = 1.526–1.547$ 2V(meas.) = 48°–79°

Cell Data: *Space Group:* $C2/m$. $a = 8.557$ $b = 13.040$ $c = 7.200$ $\beta = 115.69°$ Z = 4

X-ray Powder Pattern: Busovača, Bosnia-Herzegovina. (ICDD 19-2).
3.24 (100), 3.31 (90), 3.00 (70), 3.46 (50), 3.78 (45), 2.57 (45b), 2.91 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	59.85	49.54	CaO	0.86	0.19
TiO_2		trace	BaO	6.92	19.01
Al_2O_3	20.64	23.14	Na_2O	0.93	1.65
Fe_2O_3		0.11	K_2O	11.07	6.37
MgO	0.21	0.04	H_2O	0.24	
			Total	100.72	100.05

(1) Slyudyanka, Russia; corresponding to $(K_{0.67}Ba_{0.13}Na_{0.09}Ca_{0.04}Mg_{0.01})_{\Sigma=0.94}(Si_{2.85}Al_{1.16})_{\Sigma=4.01}O_8$. (2) Busovača, Bosnia-Herzegovina; by electron microprobe, corresponding to $(K_{0.43}Ba_{0.39}Na_{0.17}Ca_{0.01})_{\Sigma=1.00}(Si_{2.59}Al_{1.42})_{\Sigma=4.01}O_8$.

Polymorphism & Series: Intermediate member of the series orthoclase-celsian.

Mineral Group: Feldspar group.

Occurrence: Typically associated with metamorphosed manganiferous rocks or in mineral deposits rich in manganese.

Association: Manganiferous epidote, rhodonite, rhodochrosite, spessartine, manganiferous tremolite, plagioclase, analcime.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland. At Jakobsberg, Långban, and in the Harstigen mine, near Persberg, Värmland, and in the Sjö mine, near Grythyttan, Örebro, Sweden. From Slyudyanka, near Lake Baikal, Siberia, Russia. Large crystals from Zagradski Creek, near Busovača, Bosnia-Herzegovina. At Aberfeldy, Scotland. In the USA, from Franklin, Sussex Co., New Jersey, and Johnsburg, Warren Co., New York. At Nisikkatch Lake, Saskatchewan, Canada. From Piggery Creek, Broken Hill, New South Wales, Australia. In the Kaso mine, Tochigi Prefecture, and at Minakami, Gumma Prefecture, Japan. From Otjosondu, Namibia. A few other localities are known.

Name: From the Greek for *glass* and *to appear*, in reference to its transparency in crystals.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 321–322. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 166–178. (3) De Pieri, R., S. Quareni, and K.M. Hall (1977) Refinement of the structures of low and high hyalophanes. Acta Cryst., 33, 3073–3076. (4) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 360–363.

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Hyalotekite $(Ba, Pb, Ca)_6(B, Si, Al)_2(Si, Be)_{10}O_{28}(F, Cl)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Coarsely crystalline, massive.

Physical Properties: *Cleavage:* Easy in two directions at ~90°; indistinct in a third direction in the same zone as the other two. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 3.81–3.82 D(calc.) = 3.83 Fluoresces blue, light brownish orange, or yellow in SW UV; bright yellow or blue cathodoluminescence.

Optical Properties: Transparent in very thin plates. *Color:* White to pearly gray.
Luster: Vitreous to greasy.
Optical Class: Biaxial (+). *Dispersion:* $r < v$, weak to strong. α = 1.646–1.656 β = 1.649–1.660 γ = 1.659–1.671 2V(meas.) = 57°–60.5° 2V(calc.) = 55.4°–62.5°

Cell Data: *Space Group:* $I\bar{1}$. a = 11.310(2) b = 10.955(2) c = 10.317(3) α = 90.43(2)° β = 90.02(2)° γ = 90.16(2)° Z = 2

X-ray Powder Pattern: Långban, Sweden. (ICDD 19-572).
3.45 (100), 3.53 (80), 2.94 (80), 3.81 (70), 2.297 (65), 2.143 (65), 7.7 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	39.47	40.74	SrO		0.07
B_2O_3	3.73	4.46	BaO	20.08	27.30
Al_2O_3	0.18	0.03	Na_2O	0.17	0.77
Fe_2O_3	0.06	0.05	K_2O	0.89	0.74
MnO	0.29	0.00	Rb_2O		0.01
CuO	0.09		F	0.99	0.77
PbO	25.11	17.46	Cl	0.06	
BeO	0.75	0.57	LOI	0.59	
MgO	0.09	< 0.01	$-O = F_2$	[0.43]	0.32
CaO	7.82	6.81	Total	[99.94]	99.43

(1) Långban, Sweden; original total given as 100.37%, corresponds to $(Ca_{2.07}Ba_{1.94}Pb_{1.67}K_{0.28}Na_{0.08})_{\Sigma=6.04}(B_{1.60}Si_{0.19}Al_{0.05}Mn_{0.06}Mg_{0.03}Cu_{0.02}Fe_{0.01})_{\Sigma=1.96}(Si_{9.56}Be_{0.44})_{\Sigma=10.00}O_{28}(F_{0.78}Cl_{0.02})_{\Sigma=0.80}$. (2) Dara-i-Pioz massif, Tajikistan; by electron and ion microprobe, corresponds to $(Ba_{2.58}Ca_{1.76}Pb_{1.13}Na_{0.36}K_{0.23}Sr_{0.01})_{\Sigma=6.07}(B_{1.85}Si_{0.14}Mg_{0.03}Fe_{0.01})_{\Sigma=2.03}(Si_{9.67}Be_{0.33})_{\Sigma=10.00}O_{28.5}F_{0.58}$.

Occurrence: Sparingly in feldspar in a metamorphosed Fe–Mn deposit (Långban, Sweden); in reedmergnerite pegmatite in an alkaline massif (Dara-i-Pioz massif, Tajikistan).

Association: Quartz, calcite, hematite, barylite, barite, manganoan pectolite, ferrian potassic feldspar, calderitic andradite, melanotekite, barian hedyphane, plumboan taramellite, rhodonite, manganoan aegirine (Långban, Sweden); feldspars, reedmergnerite, aegirine, pyrochlore, eudialyte, polylithionite (Dara-i-Pioz massif, Tajikistan).

Distribution: At Långban, Värmland, Sweden. From the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan.

Name: From the Greek for *glass* and *to melt*, in allusion to its easy fusibility.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 422. (2) Moore, P.B., T. Araki, and S. Ghose (1982) Hyalotekite, a complex lead borosilicate: its crystal structure and the lone-pair effect of Pb(II). Amer. Mineral., 67, 1012–1020. (3) Grew, E.S., M.G. Yates, D.I. Belakovskiy [Belakovskii], R.C. Rouse, S.-C. Su, and N. Marquez (1994) Hyalotekite from reedmergnerite-bearing peralkaline pegmatite, Dara-i-Pioz, Tajikistan, and from Mn skarn, Långban, Sweden: a new look at an old mineral. Mineral. Mag., 58, 285–297.

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Hydroastrophyllite $(H_3O,K,Ca)_3(Fe^{2+},Mn)_{5-6}Ti_2Si_8(O,OH)_{31}$

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Crystal Data: Triclinic. *Point Group:* n.d. In aggregates of blocky crystals.

Physical Properties: *Cleavage:* Two sets. Hardness = n.d. D(meas.) = 3.151 D(calc.) = [2.82]

Optical Properties: Semitransparent. *Color:* Dark brown. *Optical Class:* Biaxial (–). *Pleochroism:* X = bright yellow; Y = orange-yellow; Z = dull yellow. *Absorption:* $Z > Y > X$. $\alpha = 1.660$ $\beta = 1.720$ $\gamma = 1.728$ 2V(meas.) = 40°

Cell Data: *Space Group:* n.d. $a = 11.86$ $b = 11.98$ $c = 5.42$ $\alpha = 103°25'$ $\beta = 95°9'$ $\gamma = 112°12'$ Z = [1]

X-ray Powder Pattern: Sichuan Province, China.
3.51 (10), 10.55 (9), 2.643 (8), 2.118 (6), 1.768 (6), 2.584 (5)

Chemistry:

	(1)		(1)
SiO_2	25.72	MgO	0.51
TiO_2	9.63	CaO	2.40
MnO_2	3.37	BaO	0.32
Al_2O_3	3.92	Na_2O	0.53
Fe_2O_3	24.24	K_2O	1.28
Nb_2O_5	5.01	F	1.83
Ta_2O_5	0.82	H_2O^+	6.65
FeO	0.05	H_2O^-	5.74
MnO	8.05	$-O = F_2$	0.77
		Total	99.30

(1) Sichuan Province, China; corresponds to $[(H_3O)_{1.96}Ca_{0.51}K_{0.31}Na_{0.20}Ba_{0.02}]_{\Sigma=3.00}(Fe^{3+}_{3.48}Mn^{2+}_{1.30}Mn^{4+}_{0.44}Mg_{0.14})_{\Sigma=5.36}(Ti_{1.38}Nb_{0.43}Ta_{0.04})_{\Sigma=1.85}(Si_{4.92}Al_{0.88})_{\Sigma=5.80}[O_{20.01}(OH)_{9.89}F_{1.10}]_{\Sigma=31.00}$.

Mineral Group: Astrophyllite group.

Occurrence: A product of weathering of an alkalic pegmatite.

Association: n.d.

Distribution: From an undefined locality in Sichuan Province, China.

Name: Presumably for the high water content, and its relation to *astrophyllite*.

Type Material: n.d.

References: (1) Hubei [Hupei] Geological College (1974) The crystal chemistry of astrophyllite group minerals. Sci. Geol. Sin., 1, 18–33 (in Chinese). (2) (1975) Amer. Mineral., 60, 736–737 (abs. ref. 1).

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Hydrobasaluminite $Al_4(SO_4)(OH)_{10}\cdot 12-36H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As rhomb-shaped platelets, to 5 μm, in claylike, powdery, earthy, or porcelaneous masses.

Physical Properties: *Tenacity:* Plastic in aggregates. Hardness = n.d. D(meas.) = 1.86 D(calc.) = n.d. Dehydrates irreversibly to basaluminite under low humidity conditions.

Optical Properties: Transparent to translucent. *Color:* Colorless to pale yellow. *Optical Class:* Biaxial (+). $\alpha = 1.466$ $\beta =$ n.d. $\gamma = 1.477$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 14.911(5)$ $b = 9.993(2)$ $c = 13.640(5)$ $\beta = 112.40(4)^\circ$ Z = n.d.

X-ray Powder Pattern: Crook Hill Brickyard, England; moist powder.
12.59 (100), 4.693 (11), 3.960 (11), 3.681 (11b), 6.30 (10), 5.26 (10), 5.91 (9)

Chemistry:

	(1)
P_2O_5	0.02
SO_3	13.36
SiO_2	0.30
Al_2O_3	35.20
Fe_2O_3	0.06
H_2O	50.77
Total	99.71

(1) Shoals, Indiana, USA; corresponds to $Al_{4.14}(SO_4)_{1.00}(OH)_{10.42}\cdot 11.67H_2O$.

Occurrence: Infilling vertical fissures in the weathering zone of siderite–chamosite ironstones (Irchester, England); in cave passages in argillaceous dolostone by the reaction of sulfuric acid with kaolinite (Cottonwood Cave, New Mexico, USA); a reaction product between migrating aluminum-bearing acid sulfate solutions and carbonate concretions (Chickerell, England).

Association: Basaluminite, gypsum, aragonite, halloysite, gibbsite, allophane, "limonite" (Irchester, England); gibbsite, amorphous silica (New Mexico, USA).

Distribution: In England, from the Lodge pit, Irchester, Northamptonshire; on Clifton Hill, Brighton, Sussex; and at the Crook Hill Brickyard, Chickerell, near Weymouth, Dorset. In the USA, from three km west of Shoals, Martin Co., Indiana; in Cottonwood Cave, Guadalupe Mountains, New Mexico; from the Holbrook pit and in the Southwest mine, Bisbee, Cochise Co., Arizona. In Alum Cave, Vulcano, Lipari Islands, Italy.

Name: As the hydrated analog of *basaluminite*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 586. (2) Sunderman, J.A. and C.W. Beck (1969) Hydrobasaluminite from Shoals, Indiana. Amer. Mineral., 54, 1363–1373. (3) Clayton, T. (1980) Hydrobasaluminite and basaluminite from Chickerell, Dorset. Mineral. Mag., 43, 931–937.

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Hydrobiotite

$[K(Mg,Fe^{2+})_3(Al,Fe^{3+})Si_3O_{10}(OH,F)_2]\cdot[(Mg,Fe^{2+},Al)_3(Si,Al)_4O_{10}(OH)_2\cdot 4H_2O]$

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Crystal Data: [Monoclinic] (by analogy to biotite and vermiculite). *Point Group:* [2/*m*.] In cleavage plates and flakes.

Physical Properties: *Cleavage:* [{001}, perfect.] *Tenacity:* [Brittle to flexible, elastic.] Hardness = [~2] D(meas.) = 2.49–2.64 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Blackish, brownish; golden yellow, pinkish. *Luster:* [Dull.]
Optical Class: Biaxial (–). *Pleochroism:* X = light brown; $Y = Z$ = brown. *Absorption:* $X > Y = Z$. α = n.d. β = 1.560–1.562; 1.575 γ = 1.565–1.567 2V(meas.) = 10°–13°

Cell Data: *Space Group:* [$C2/m$.] a = n.d. b = n.d. c = 24.5–25.5 β = n.d. Z = n.d.

X-ray Powder Pattern: Northeastern Transvaal, South Africa.
12.23 (60), 3.493 (50), 4.909 (30), 2.725 (20), 2.041 (16) 3.071 (15), 24.3 (7)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	35.60		SrO	0.01	
TiO_2	1.13		BaO	0.17	
Al_2O_3	11.85		Na_2O	0.16	
Fe_2O_3	10.28		K_2O	3.17	
Cr_2O_3	0.03		Rb_2O	0.01	
FeO	0.81		F	0.21	
MnO	0.08		H_2O^+	7.56	
MgO	20.17		H_2O^-	7.20	
CaO	1.44		P_2O_5	0.07	
			$-O = F_2$	0.09	
			Total	99.86	

(1) Libby. Montana; corresponds to $(Mg_{2.38}Fe^{3+}_{0.61}K_{0.32}Ca_{0.12}Ti_{0.07}Fe^{2+}_{0.05}Na_{0.03}Ba_{0.01})_{\Sigma=3.59}(Si_{2.82}Al_{1.18})_{\Sigma=4.00}O_{10}[(OH)_{1.95}F_{0.05}]_{\Sigma=2.00}\cdot 3.01H_2O$.

Polymorphism & Series: A 1:1 regular interstratification of biotite and vermiculite.

Mineral Group: Mica group.

Occurrence: As an alteration product of other micas.

Association: Vermiculite, biotite, apatite, zircon.

Distribution: Perhaps at Křemže, Czech Republic. A few other localities for well-characterized material include: in the USA, in the Rainy Creek complex, near Libby, Lincoln Co., Montana, and from the Enoree area, Spartanburg Co., South Carolina. At Phalaborwa, Transvaal, South Africa.

Name: For its resemblance to *biotite*, but hydrated.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 632 [biotite], 664 [vermiculite]. (2) Gruner, J.W. (1934) The structures of vermiculites and their collapse by dehydration. Amer. Mineral., 19, 557–575. (3) Boettcher, A.L. (1966) Vermiculite, hydrobiotite, and biotite in the Rainy Creek igneous complex near Libby, Montana. Clay Minerals, 6, 283–296. (4) Brindley, G.W., P.E. Zalba, and C.M. Bethke (1983) Hydrobiotite, a regular 1:1 interstratification of biotite and vermiculite layers. Amer. Mineral., 68, 420–425.

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Hydroboracite $CaMgB_6O_8(OH)_6 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As slender crystals, prismatic along [001] and flattened on {010}, to 10 cm; in fanlike to radial spherical aggregates and in swallowtail composites; as drusy coatings; compact, fine-grained.

Physical Properties: *Cleavage:* {010}, perfect; {100}, distinct. Hardness = 2–3; 5–6 in some specimens. D(meas.) = 2.15–2.17 D(calc.) = 2.170 Partly soluble in boiling H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous, silky if fibrous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 33°$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.520–1.523$ $\beta = 1.534–1.535$ $\gamma = 1.569–1.571$ 2V(meas.) = 60°–66°

Cell Data: *Space Group:* $P2/c$. $a = 11.769(2)$ $b = 6.684(2)$ $c = 8.235(4)$ $\beta = 102.59(2)°$ Z = 2

X-ray Powder Pattern: Bigadiç district, Turkey.
5.78 (100), 6.69 (85), 3.32 (74), 1.914 (16), 4.47 (14), 2.436 (14), 4.36 (13)

Chemistry:

	(1)	(2)
B_2O_3	49.04	50.53
SiO_2	0.33	
CO_2	1.65	
$(Al,Fe)_3O_3$	0.38	
MgO	9.84	9.75
CaO	13.63	13.57
alkalies	0.15	
H_2O	25.45	26.15
Total	100.47	100.00

(1) Inder deposit, Kazakhstan. (2) $CaMgB_6O_8(OH)_6 \cdot 3H_2O$.

Occurrence: Typically formed by groundwater alteration of colemanite; may be primary.

Association: Colemanite, hydroboracite, tunellite.

Distribution: Originally described from an unknown locality in the "Caucasus", at that time a general name for the areas south of European Russia. From the Inder boron deposit, Kazakhstan. At the Niedersachswerfen anhydrite deposit, near Nordhausen, Harz Mountains, Germany. In the USA, from the Thompson mine, near Ryan, in the Terry deposit, and at the Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., in the Kramer borate deposit, Boron, Kern Co., and elsewhere in California. From the Potash Corporation of America mine, Penobsquis evaporite deposit, and in the Salt Springs evaporite deposit, near Sussex, New Brunswick, Canada. In Turkey, from several deposits in the Bigadiç borate district, Balıkesir Province; at the Killik, Hisarcık, and Espey borate mines, near Emet, Kütahya Province. Fine examples from Kara Göl, Zanjan, Iran. From Pampa Pique III, about one km north of Oficina Lautaro, Taltal district, Antofagasta, Chile. At Pastos Grandes, and in the Monte Amarillo and Apalacheana mines, Sijes district, Salta Province, Argentina.

Name: In allusion to essential water and a supposed relation to *boracite*.

Type Material: Lost.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 353–354. (2) Sabelli, C. and A. Stoppioni (1978) Refinement of the crystal structure of hydroboracite. Can. Mineral., 16, 75–80. (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 97–98.

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Hydrocalumite $Ca_2Al(OH)_6[Cl_{1-x}(OH)_x]\cdot 3H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Pseudohexagonal crystals, tabular on {001}, bounded by {120}, {$\bar{1}$20}, and {10$\bar{1}$}, to 1 cm; massive. *Twinning:* Common on {32$\bar{2}$} as contact twins.

Physical Properties: *Cleavage:* {001}, perfect; another inclined at ∼60° to {100}, poor. Hardness = 3 D(meas.) = 2.09–2.15 D(calc.) = 2.09–2.15 Strongly pyroelectric.

Optical Properties: Transparent. *Color:* Colorless to light green; colorless in thin section. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 3°$. $\alpha = 1.528–1.535$ $\beta = 1.552–1.553$ $\gamma = 1.556–1.557$ 2V(meas.) = 24°–40°

Cell Data: *Space Group:* $P2/c$. $a = 9.953–10.047$ $b = 11.466–11.523$ $c = 16.271–16.292$ $\beta = 104.20°–104.46°$ Z = 8

X-ray Powder Pattern: Scawt Hill, Ireland.
7.92 (vvs), 3.99 (vs), 2.87 (s), 2.46 (s), 1.657 (ms), 2.70 (m), 2.24 (m)

Chemistry:

	(1)	(2)	(3)
Al_2O_3	18.1	18.8	18.6
MgO			1.0
CaO	40.0	41.5	38.3
Na_2O			0.1
Cl			6.2
$H_2O + CO_2$	40.3		
H_2O		38.5	34.1
CO_2		1.8	1.0
Total	98.4	100.6	99.3

(1–2) Scawt Hill, Ireland. (3) Boisséjour, France; corresponding to $(Ca_{1.92}Mg_{0.07}Na_{0.01})_{\Sigma=2.00}$ $Al(OH)_6[Cl_{0.48}(OH)_{0.37}(CO_3)_{0.06}]_{\Sigma=0.91}\cdot 4H_2O$.

Occurrence: A rare late-stage hydrothermal mineral in skarns formed from contact metamorphism of limestone or in xenoliths in lava.

Association: Afwillite, portlandite, ettringite, larnite, plombièrite, hydrogrossular, calcite.

Distribution: At Scawt Hill, near Larne, Co. Antrim, Ireland. From Boisséjour, near Ceyrat, Puy-de-Dôme, France. At Campomorto, Montalto di Castro, Lazio, Italy. From the Bellerberg, Rothenberg, and Emmelberg volcanos, near Mayen, Eifel district, Germany. At Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia. In the Daba marbles, Jordan.

Name: For a HYDROus mineral containing CAlcium and ALUMinum.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 667–668. (2) Buttler, F.G., L.S. Dent Glasser and H.F.W. Taylor (1959) Studies on $4CaO\cdot Al_2O_3\cdot 13H_2O$ and the related natural mineral hydrocalumite. J. Amer. Ceramic Soc., 42, 121–126. (3) Grünhagen, H. and J. Mergoil (1963) Découverte d'hydrocalumite et afwillite associées à l'ettringite dan les porcélanites de Bousséjour près Ceyrat (Puy-de-Dôme). Bull. Soc. fr. Minéral., 86, 149–157 (in French). (4) Fischer, R., H.-J. Kuzel, and H. Schellhorn (1980) Hydrocalumit: Mischkristalle von "Friedelschem Salz" $CaO\cdot Al_2O_3\cdot CaCl_2\cdot 10H_2O$ und Tetracalciumaluminat-hydrat $CaO\cdot Al_2O_3\cdot Ca(OH)_2\cdot 12H_2O$? Neues Jahrb. Mineral., Monatsh., 322–334 (in German with English abs.). (5) E. Passaglia and M. Sacerdoti (1988) Hydrocalumite from Montalto di Castro, Viterbo, Italy. Neues Jahrb. Mineral., Monatsh., 454–461. (6) Sacerdoti, M. and E. Passaglia (1988) Hydrocalumite from Latium, Italy; its crystal structure and relationship with related synthetic phases. Neues Jahrb. Mineral., Monatsh., 462–475.

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Hydrocerussite $Pb_3(CO_3)_2(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* n.d. As steep hexagonal $\{h0\overline{h}l\}$ pyramidal to tabular crystals, to 4 cm; in lenticular to thin scaly crystal aggregates; cleavable massive.

Physical Properties: *Cleavage:* On {0001}, perfect. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 6.80–6.82 D(calc.) = 6.873

Optical Properties: Transparent to translucent. *Color:* Colorless to white, gray, may display greenish tint; colorless in transmitted light. *Luster:* Adamantine, pearly on {0001}. *Optical Class:* Uniaxial (–). $\omega = 2.09$ $\epsilon = 1.94$

Cell Data: *Space Group:* n.d. $a = 5.239(5)$ $c = 23.65(2)$ $Z = 3$

X-ray Powder Pattern: Synthetic; near to plumbonacrite.
2.623 (10), 3.611 (9), 3.286 (9), 4.47 (6), 4.247 (6), 2.231 (5), 1.696 (4)

Chemistry:

	(1)	(2)
CO_2	11.21	11.35
PbO	86.52	86.33
Cl	0.27	
H_2O	2.23	2.32
$-O = Cl_2$	0.06	
Total	100.17	100.00

(1) Mendip Hills, England. (2) $Pb_3(CO_3)_2(OH)_2$.

Occurrence: An uncommon secondary mineral in the oxidized portions of lead deposits.

Association: Lead (Långban, Sweden); cerussite, leadhillite, matlockite, paralaurionite, diaboleite, leadhillite, galena (Mammoth-St. Anthony mine, Arizona, USA).

Distribution: From Långban, Värmland, Sweden. At Tvedalen, near Larvik, Norway. In England, relatively abundant on the Higher Pitts Farm, Mendip Hills, and as large crystals in the Merehead quarry, near Shepton Mallet, Somerset; at many mines in Caldbeck Fells, Cumbria. From Wanlockhead, Dumfriesshire and Leadhills, Lanarkshire, Scotland. At the Kamariza mine, Laurium, Greece. In the Ilímaussaq intrusion, Greenland. From Tsumeb, Namibia. In the Seh-Changi mine, near Neyband, Khorassan, Iran. At Mont Saint-Hilaire, Quebec, Canada. In the USA, in Arizona, exceptional crystals from the Mammoth-St. Anthony mine, Tiger, Pinal Co.; at the C & B mine, Gila Co.; in the Bunker Hill mine, Shoshone Co., Idaho. Additional minor localities are known.

Name: In allusion to the essential chemical components, water and the lead and carbonate of *cerussite*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 270–271. (2) Olby, J.K. (1966) The basic lead carbonates. J. Inorg. Nucl. Chem., 28, 2507–2512.

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Hydrochlorborite $Ca_2B_4O_4Cl(OH)_7 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As well-formed tabular {001} crystals, with wedgelike terminations, to 13 mm; {001}, {110}, {$\overline{2}$11} define the typical habit, with four other forms reported; in dense masses.

Physical Properties: *Cleavage:* On {001}, good. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 1.83–1.85 D(calc.) = 1.841 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous to dull. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 25°$. *Dispersion:* $r < v$. $\alpha = 1.499–1.501$ $\beta = 1.502–1.504$ $\gamma = 1.520–1.521$ 2V(meas.) = 45°–45.8°

Cell Data: *Space Group:* $I2/a$. $a = 22.783(3)$ $b = 8.745(1)$ $c = 17.066(1)$ $\beta = 96.705(1)°$ Z = 8

X-ray Powder Pattern: Salar Carcote, Chile.
8.48 (100), 6.01 (24), 3.604 (9), 2.798 (8), 2.825 (7), 2.186 (7), 8.18 (6)

Chemistry:

	(1)	(2)	(3)
SO_3	trace		
B_2O_5	29.50	29.2	29.75
FeO		0.04	
MgO	0.00	0.01	
CaO	23.31	24.0	23.96
Na_2O	trace		
K_2O	0.00		
Cl	7.62	7.2	7.58
H_2O	41.91	41.5	40.42
$-O = Cl_2$	1.72	1.62	1.71
Total	100.62	100.33	100.00

(1) China; corresponds to $Ca_{1.94}B_{3.94}O_4Cl(OH)_7 \cdot 7.8H_2O$. (2) Salar Carote, Chile; corresponds to $Ca_{2.04}B_{4.00}O_4Cl_{0.97}(OH)_7 \cdot 7.5H_2O$. (3) $Ca_2B_4O_4Cl(OH)_7 \cdot 7H_2O$ established by crystal-structure analysis.

Occurrence: A rare dry-season evaporite mineral in playa sediment (Salar Carcote, Chile).

Association: Ulexite, halite, gypsum (China).

Distribution: From China, at an unspecified locality [the Qinghai-Xizang Plateau, Tibet]. From Salar Carote, Antofagasta, Chile.

Name: In allusion to the essential chemical components, water, chlorine and borate.

Type Material: National Museum of Natural History, Washington, D.C., USA, 131036.

References: (1) Chien Tzu-Chiang and Chen Shu-Chen (1965) Brief note on preliminary results of study of a new borate mineral – hydrochlorborite: ($Ca_4B_5O_{15}Cl_2 \cdot 22H_2O$). Scientica Sinica, 14, 945–946 (in Russian). (2) (1965) Amer. Mineral., 50, 2099 (abs. ref. 1). (3) Hurlbut, C.S., Jr., L.F. Aristarain, and R.C. Erd (1977) Hydrochlorborite from Antofagasta, Chile. Amer. Mineral., 62, 147–150. (4) Brown, G.E. and J.R. Clark (1978) Crystal structure of hydrochlorborite, $Ca_2[B_3O_3(OH)_4 \cdot OB(OH)_3]Cl \cdot 7H_2O$, a seasonal evaporite mineral. Amer. Mineral., 63, 814–823.

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Hydrodelhayelite $KCa_2AlSi_7O_{17}(OH)_2 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Habit not stated.

Physical Properties: *Cleavage:* {010}, very perfect; {100} and {001}, imperfect. Hardness = ∼4 D(meas.) = 2.168 D(calc.) = 2.22

Optical Properties: Semitransparent. *Color:* Grayish white. *Luster:* Vitreous. *Optical Class:* Biaxial. $\alpha = 1.503$ β = n.d. $\gamma = 1.518$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pnm2_1$. $a = 6.6483$ $b = 23.8462$ $c = 7.0727$ $Z = 2$

X-ray Powder Pattern: Khibiny massif, Russia.
2.923 (100), 3.069 (75), 2.800 (55), 3.319 (43), 6.79 (38)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	55.53	55.56	Na_2O	0.22	
TiO_2	0.01		K_2O	6.18	6.22
Al_2O_3	8.46	6.74	F	0.00	
Fe_2O_3	0.65		Cl	0.15	
MnO	0.18		H_2O^+	9.62	
MgO	0.21		H_2O^-	5.58	
CaO	12.72	14.82	H_2O		16.66
SrO	0.22		$-O = Cl_2$	0.09	
			Total	99.64	100.00

(1) Mt. Rasvumchorr, Khibiny massif, Russia. (2) $KCa_2AlSi_7O_{17}(OH)_2 \cdot 6H_2O$.

Occurrence: A secondary alteration product of delhayelite from ijolite-urtite pegmatites in a differentiated alkalic massif.

Association: Delhayelite, lamprophyllite, eudialyte, hisingerite, aegirine, orthoclase.

Distribution: On Mts. Rasvumchorr and Yukspor, in the Khibiny massif, Kola Peninsula, Russia.

Name: For its relation to *delhayelite*, and the water in its composition.

Type Material: Mining Institute, St. Petersburg, 1178/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79785.

References: (1) Dorfman, M.D. and M.I. Chiragov (1979) Hydrodelhayelite, a product of supergene alteration of delhayelite. New data on minerals of the USSR, 28, 172–175. (2) (1980) Mineral. Mag., 31, 496 (abs. ref. 1). (3) (1987) Amer. Mineral., 72, 1024 (abs. ref. 1). (4) Chiragov, M.I. and M.G. Dorfman (1981) Crystal chemistry of minerals in the delhayelite group. Doklady Acad. Nauk SSSR, 260, 458–461 (in Russian).

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Hydrodresserite $BaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Typically as spherical or hemispherical aggregates of divergent crystals, acicular along [001], to 1 mm; individual crystals display prominent {010}, and narrow {$2\overline{1}0$} and {102}.

Physical Properties: *Cleavage:* Perfect on {010} and {$2\overline{1}0$}. Hardness = 3–4
D(meas.) = 2.80(2) D(calc.) = 2.817 Easily dehydrates to dresserite.

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* White.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* X (65°,88°); Y (–27°,46°); Z (158.25°,44.5°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. $\alpha = 1.502(2)$ $\beta = 1.594(1)$ $\gamma = 1.595(1)$
2V(meas.) = 17(1)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.7545(5)$ $b = 10.4069(5)$ $c = 5.6322(3)$
$\alpha = 95.695(5)°$ $\beta = 92.273(5)°$ $\gamma = 115.643(4)°$ Z = 2

X-ray Powder Pattern: Francon quarry, Canada.
8.52 (10), 3.42 (7), 3.10 (6), 4.26 (5), 8.75 (4), 9.30 (3), 5.32 (3)

Chemistry:

	(1)	(2)
CO_2	21.8	20.31
Al_2O_3	23.7	23.53
BaO	35.0	35.38
H_2O	20.3	20.78
Total	100.8	100.00

(1) Francon quarry, Canada; by electron microprobe, corresponding to $Ba_{0.98}Al_{1.99}(CO_3)_{2.12}(OH)_{3.68} \cdot 2.97H_2O$. (2) $BaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$.

Occurrence: Very rare, in vugs in metamorphosed limestone, near the contact zone of a dawsonite-rich silicocarbonatite sill.

Association: Dresserite, weloganite, quartz.

Distribution: From the Francon quarry, Montreal Island, Montreal, Quebec, Canada.

Name: For essential water and characteristic dehydration to *dresserite* under low humidity conditions.

Type Material: Geological Survey of Canada, Ottawa, 13936; Royal Ontario Museum, Toronto, Canada, M34547, M34600.

References: (1) Jambor, J.L., A.P. Sabina, and B.D. Sturman (1977) Hydrodresserite, a new Ba-Al carbonate from a silicocarbonatite sill, Montreal Island, Quebec. Can. Mineral., 15, 399–404. (2) (1979) Amer. Mineral., 64, 654 (abs. ref. 1). (3) Szymański, J.T. (1982) The crystal structure of hydrodresserite, $BaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$. Can. Mineral., 20, 253–262.

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Hydroglauberite $Na_{10}Ca_3(SO_4)_8 \cdot 6H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. As felted aggregates of fibrous crystals, striated ‖ elongation, to 0.1 mm, in dense masses.

Physical Properties: *Cleavage:* Three noted, one of which is parallel to elongation. Hardness = n.d. D(meas.) = 1.510 D(calc.) = n.d. Soluble in H_2O, slightly bitter, salty taste.

Optical Properties: Translucent. *Color:* White. *Luster:* Silky in aggregates. *Optical Class:* Biaxial (–). *Orientation:* Positive elongation, parallel extinction. $\alpha = 1.488$ (α') β = n.d. $\gamma = 1.500$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kushkanatau salt deposit, Uzbekistan.
3.08 (100), 9.20 (90), 2.78 (90b), 4.60 (80), 2.90 (70), 4.20 (60), 3.52 (60)

Chemistry:

	(1)	(2)
SO_3	52.16	52.21
MgO	0.00	
CaO	13.59	13.72
Na_2O	25.40	25.26
K_2O	0.19	
Cl	0.58	
H_2O	8.20	8.81
$-O = Cl_2$	[0.13]	
Total	[99.99]	100.00

(1) Kushkanatau salt deposit, Uzbekistan; original total given as 100.12%.
(2) $Na_{10}Ca_3(SO_4)_8 \cdot 6H_2O$.

Occurrence: An uncommon alteration product of glauberite.

Association: Glauberite, halite, mirabilite, polyhalite, thénardite, blödite (Kushkanatau salt deposit, Uzbekistan); gypsum, mirabilite, halite (Salar de Pintados, Chile).

Distribution: From the Kushkanatau salt deposit, lower Amu Darya River, Kara-Kalpakia, Uzbekistan. In the Cesano geothermal field, Latium, Italy. From Kalkberg, near Lüneburg, Lower Saxony, Germany. At the Salar de Pintados, near La Guaica, Tarapacá, Chile. From near San Simon, Cochise Co., Arizona, USA.

Name: For the essential water content and chemical similarity to *glauberite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72170, 72171; National Museum of Natural History, Washington, D.C., USA, 148423.

References: (1) Slyusareva, M.N. (1969) Hydroglauberite, a new mineral of the hydrous sulfate group. Zap. Vses. Mineral. Obshch., 98, 59–62 (in Russian). (2) (1970) Amer. Mineral., 55, 321 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 98.

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Hydrohalite $NaCl \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Elongated crystals, to 1 cm, intergrown with halite.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [1.65] Melts under its own vapor pressure at –0.1 °C, converting to halite.

Optical Properties: Transparent. *Color:* Colorless to white.
Optical Class: Biaxial. *Orientation:* Extinction 35° from a prism face; length-slow. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d. *Anisotropism:* Moderately strong.

Cell Data: *Space Group:* $P2_1/c$ probable (synthetic at 105 K). $a = 6.3313(5)$ $b = 10.1178(9)$ $c = 6.5029(6)$ $\beta = 114.407(7)°$ Z = 4

X-ray Powder Pattern: Synthetic; taken at –5 °C.
2.98 (10), 2.67 (10), 2.52 (10), 3.82 (9), 2.24 (9), 3.87 (8), 2.88 (6)

Chemistry: Natural material has not been analyzed.

Occurrence: Formed from sea water or in bottom sediments of hypersaline lakes at near-freezing temperatures.

Association: Halite, gypsum.

Distribution: From Hallein, Salzburg, Austria. In Lake Bonney, Taylor Valley, Victoria Land, Antarctica.

Name: As a hydrate of *halite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 15. (2) Klewe, B. and B. Pedersen (1974) The crystal structure of sodium chloride dihydrate. Acta Cryst., 30, 2363–2371. (3) Craig, J.R., R.D. Fortner, and B.L. Weand (1974) Halite and hydrohalite from Lake Bonney, Taylor Valley, Antarctica. Geology, 1, 389–390. (4) Craig, J.R., J.F. Light, B.C. Parker, and M.G. Mudrey, Jr. (1975) Identification of hydrohalite. Antarctic J. U.S., 10, 178–179.

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Hydrohetaerolite $Zn_2Mn_4^{3+}O_8 \cdot H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are fibrous, elongated ‖ [110]; radiating, in botryoidal crusts, finely granular, massive.

Physical Properties: *Cleavage:* Parallel fiber elongation. Hardness = 5–6 D(meas.) = 4.64 D(calc.) = [5.57]

Optical Properties: Opaque, transparent on thin edges. *Color:* Dark brown to brownish black; dark brown in transmitted light; creamy gray in reflected light. *Streak:* Dark brown. *Luster:* Submetallic.
Optical Class: Uniaxial (–). $\omega = 2.26(2)$ $\epsilon = 2.10(2)$

Cell Data: *Space Group:* $I4_1/amd$. $a = 5.735(1)$ $c = 9.005(1)$ Z = 2

X-ray Powder Pattern: Wolftone mine, Colorado, USA.
2.47 (10), 2.66 (8), 3.02 (7), 1.508 (7), 1.570 (5), 2.87 (4), 1.434 (4)

Chemistry:

	(1)	(2)	(3)
SiO_2	2.69	1.71	
Fe_2O_3		0.77	
Mn_2O_3	56.00	60.44	63.59
ZnO	37.56	33.43	32.78
H_2O^+		1.42	3.63
H_2O^-		2.47	
H_2O	4.36		
Total	100.61	100.24	100.00

(1) Wolftone mine, Colorado, USA; average of two analyses; corresponding to $Zn_{2.26}(Mn^{3+}_{3.50}Si_{0.22})_{\Sigma=3.77}O_{7.94} \cdot 1.20H_2O$. (2) Franklin, New Jersey, USA; corresponding to $Zn_{2.02}(Mn^{3+}_{3.77}Si_{0.14}Fe^{3+}_{0.04})_{\Sigma=3.97}O_{8.03} \cdot 1.06H_2O$. (3) $Zn_2Mn_4O_8 \cdot H_2O$.

Occurrence: In oxidized manganese-bearing zinc deposits.

Association: Chalcophanite, hemimorphite, smithsonite (Leadville, Colorado, USA); chalcophanite (Franklin, New Jersey, USA).

Distribution: In the USA, from the Wolftone mine, Leadville, Lake Co., Colorado; at Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in the Mohawk mine, San Bernardino Co., California; in Arizona, from the Campbell mine, Bisbee, and the Emerald mine, Tombstone, Cochise Co. In England, from the Copperthwaite vein, Swaledale, North Yorkshire. At Silvermines, Co. Tipperary, Ireland. On Mont Chemin, Valais, Switzerland. In the Orzel Bialy mine, Upper Silesia, Poland. In Japan, from the Maruyama mine, Aomori Prefecture.

Name: For a HYDROus mineral, and its relation to *hetaerolite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 112011.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 717–718. (2) Frondel, C. (1942) New data on hetaerolite, hydrohetaerolite, coronadite, and hollandite. Amer. Mineral., 27, 48–56. (3) Wadsley, A.D. (1955) Hydrohausmannite [feitknechtite + hausmannite] and hydrohetaerolite. Amer. Mineral., 40, 349–353. (4) McAndrew, J. (1956) Observations on hydrohetaerolite. Amer. Mineral., 41, 268–275.

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Hydrohonessite $Ni_6Fe_2^{3+}(SO_4)(OH)_{16}\cdot 7H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. As microscopic hexagonal flakes, to 10 μm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.96

Optical Properties: Transparent to translucent. *Color:* Bright yellow; bright yellow in transmitted light. *Luster:* [Adamantine.]
Optical Class: Uniaxial (–). $\omega = 1.63$ $\epsilon = 1.59$

Cell Data: *Space Group:* n.d. $a = 3.09$ $c = 10.80$ Z = n.d.

X-ray Powder Pattern: Otter Shoot mine, Western Australia.
11.0 (10), 5.56 (5), 3.68 (4), 2.709 (3), 2.595 (2), 2.394 (2), 2.152 (1)

Chemistry: (1) Otter Shoot mine, Kambalda, and Carr Boyd Rocks mine, Australia; by electron microprobe, partial analysis yielded Ni 25.7%, Fe 10.3%, SO_4 15.6%, which, after a number of crystal-structure assumptions, is stated to correspond to $Ni_{6.4}Fe^{3+}_{2.6}(SO_4)_{2.3}(OH)_{16}\cdot 7.0H_2O$.

Occurrence: Incrusting fractures in the oxidized portions of Ni–Fe sulfide deposits (Otter Shoot mine and Carr Boyd mine, Australia); or in chromitite (Unst, Scotland; Linden, Wisconsin, USA).

Association: Honessite, reevesite, magnesite, gaspéite, pecoraite, goethite, gypsum (Otter Shoot mine and Carr Boyd mine, Australia); honessite, reevesite, theophrastite (Unst, Scotland); wupatkiite, nickel-boussingaultite, pickeringite (Cameron district, Arizona, USA).

Distribution: In Australia, from the Otter Shoot nickel mine, Kambalda, 56 km south of Kalgoorlie; at the Carr Boyd Rocks nickel mine, Yerilla district, 80 km north-northeast of Kalgoorlie; and in the 132 North nickel mine, four km southwest of Widgiemooltha, Western Australia. At the Hagdale quarry, Unst, Shetland Islands, Scotland. In the USA, from near Linden, Iowa Co., Wisconsin; in a prospect 13 km east-southeast of Gray Mountain, Cameron district, Coconino Co., Arizona.

Name: As the hydrated analog of *honessite*.

Type Material: Western Australian Museum, Perth, Australia, M.77a.1991, M.77b.1991; National Museum of Natural History, Washington, D.C., USA, 150420.

References: (1) Nickel, E.H. and J.E. Wildman (1981) Hydrohonessite — a new hydrated Ni–Fe hydroxy-sulphate mineral; its relationship to honessite, carrboydite, and minerals of the pyroaurite group. Mineral. Mag., 44, 333–337. (2) Bish, D.L. and A. Livingstone (1981) The crystal chemistry and paragenesis of honessite and hydrohonessite: the sulphate analogues of reevesite. Mineral. Mag., 44, 339–343. (3) (1982) Amer. Mineral., 67, 623 (abs. ref. 1 and 2).

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Hydromagnesite $Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As acicular to bladed crystals, flattened on {100}, terminated by {011} with {100} striated ‖ [001] by repetition of {110} and {100}, to 10 cm; in divergent sprays, massive, chalky. *Twinning:* Polysynthetic lamellar twinning on {100}, common.

Physical Properties: *Cleavage:* {010}, perfect. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.24–2.25 D(calc.) = 2.25

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous; silky to pearly to dull in aggregates.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 47°09'$. $\alpha = 1.523(3)$ $\beta = 1.527(3)$ $\gamma = 1.545(1)$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.105(5)$ $b = 8.954(2)$ $c = 8.378(4)$ $\beta = 114.44(5)°$ Z = 2

X-ray Powder Pattern: Soghan mine, Iran.
5.79 (100), 2.899 (82), 9.20 (39), 6.40 (38), 2.298 (33), 4.186 (31), 3.317 (28)

Chemistry:

	(1)	(2)
CO_2	37.10	37.64
MgO	43.16	43.10
H_2O	19.65	19.26
Total	99.91	100.00

(1) Emarese, Italy. (2) $Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$.

Occurrence: Incrusting and filling fractures in altered ultramafic rocks and serpentinites; in low-temperature hydrothermally altered dolomitic xenoliths and marble; common in caves as a component of "moonmilk" and speleothems.

Association: Calcite, dolomite, aragonite, brucite, magnesite, artinite, pyroaurite, periclase, "opal", chromite.

Distribution: Widespread, with numerous minor localities. Studied material from: in the USA, from Hoboken, Hudson Co., New Jersey; at Wood's Chrome and Low's mines, near Texas, Lancaster Co., Pennsylvania; in Nevada, abundant at Luning, Mineral Co., and near Gabbs, Gabbs district, Nye Co.; numerous localities in California, as at the Crestmore quarry, Riverside Co.; to 25% in a surface zone, about 55 km northwest of Coalinga, Fresno Co.; near Red Mountain, Stanislaus Co.; at Fort Point, San Francisco Co. In Canada, in the Cariboo, Atlin, and Kamloops districts, British Columbia. In the São Felix do Minato mine, Bahia, Brazil. From Kraubath, Salzburg, Austria. In Italy, from Emarese and Montjovet, Val d'Aosta, Piedmont; at Predazzo, Trentino-Alto Adige, on Monte Somma, Campania. In Iran, exceptional crystals from the Soghan mine, south of Kerman, Esfandaque district; and in the Dovez open pit, near the Shariar mine, Minab district. From the Shabani and Mtoroshanga areas, Zimbabwe. In the Vestfold Hills, East Antarctica. The most common carbonate after calcite and aragonite in caves worldwide.

Name: In allusion to its content of water and similarity to *magnesite*.

Type Material: Natural History Museum, Paris, France, 97592.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 271–274. (2) Bariand, P., F. Cesbron, H. Vachey, and M. Sadrzadeh (1973) Hydromagnesite from Soghan, Iran. Mineral. Record, 4, 18–20. (3) Akao, M. and S. Iwai (1977) The hydrogen bonding of hydromagnesite. Acta Cryst., 33, 1273–1275. (4) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, 151.

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Hydrombobomkulite $(Ni, Cu)Al_4[(NO_3)_2, SO_4](OH)_{12} \cdot 13-14H_2O$

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Crystal Data: [Monoclinic.] (by analogy to mbobomkulite). *Point Group:* n.d. As powdery nodules and microcrystalline coatings; on dehydration exfoliates into "tiny" hexagonal plates.

Physical Properties: *Cleavage:* [On {001}, perfect.] *Tenacity:* Friable in aggregates. Hardness = ["Very soft".] D(meas.) = n.d. D(calc.) = n.d. Dehydrates readily to mbobomkulite.

Optical Properties: Translucent. *Color:* Blue; colorless in transmitted light. *Optical Class:* [Biaxial, weakly birefringent.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 10.145$ $b = 17.155$ $c = 20.870$ $\beta = 90.55°$ Z = 8

X-ray Powder Pattern: Mbobo Mkulu Cave, South Africa.
10.45 (100), 5.229 (50), 3.485 (30), 2.489 (15), 6.233 (10), 4.899 (10), 4.172 (10)

Chemistry: (1) Mbobo Mkulu Cave, South Africa; desiccation of hydrombobomkulite with 32.10% weight loss of H_2O, then identity of X-ray pattern with that of mbobomkulite establishes the formula.

Occurrence: By the interaction of solutions of nickel sulfate from weathering Cu–Ni-bearing sulfides with aluminosilicate minerals and nitrate derived from bat guano (Mbobo Mkulu Cave, South Africa); in a sedimentary U–V deposit (Jomac mine, Utah, USA).

Association: Allophane, mbobomkulite, chalcoalumite (Mbobo Mkulu Cave, South Africa); oswaldpeetersite, cuprite, antlerite, goethite, lepidocrocite, mbobomkulite, sklodowskite, gypsum (Jomac mine, Utah, USA).

Distribution: From the Mbobo Mkulu Cave, near Ngodwana, Eastern Transvaal, South Africa. At the Jomac mine, White Canyon district, San Juan Co., Utah, USA.

Name: As the hydrated equivalent of *mbobomkulite*.

Type Material: Museum of the Geological Survey, Pretoria, South Africa.

References: (1) Martini, J.E.J. (1980) Mbobomkulite, hydrombobomkulite and nickelalumite, new minerals from Mbobo Mkulu Cave, Eastern Transvaal. Ann. Geol. Surv. South Africa, 14(2), 1–10. (2) (1982) Amer. Mineral., 67, 415–416 (abs. ref. 1).

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Hydronium jarosite $(H_3O)Fe_3^{3+}(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As microscopic plates or rhombohedra; reniform, scaly, earthy.

Physical Properties: *Cleavage:* [On {0001}, distinct.] (by analogy to jarosite). *Fracture:* [Uneven to conchoidal.] *Tenacity:* [Brittle.] Hardness = 4–4.5 D(meas.) = 2.50–2.90 D(calc.) = 3.01

Optical Properties: Translucent. *Color:* Bright yellow to pale yellow. *Luster:* Dull to resinous.
Optical Class: Uniaxial (–). *Pleochroism:* O = deep yellow; E = pale yellow. $\omega = 1.816$ $\epsilon = 1.728$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.3559$ $c = 17.0097$ Z = 3

X-ray Powder Pattern: Synthetic. (ICDD 31-650).
5.10 (100), 3.13 (90), 3.09 (65), 1.839 (30), 1.990 (20), 5.67 (18), 5.97 (16)

Chemistry:

	(1)	(2)
SO_3	32.71	33.31
Fe_2O_3	48.90	49.83
Na_2O	0.43	
K_2O	0.52	
H_2O	15.09	16.86
insol.	2.35	
Total	100.00	100.00

(1) Thorez mine, Poland; corresponds to $[(H_3O)_{0.88}Na_{0.07}K_{0.05}]_{\Sigma=1.00}Fe_3(SO_4)_2(OH)_6$.
(2) $(H_3O)Fe_3(SO_4)_2(OH)_6$.

Mineral Group: Alunite group.

Occurrence: In the oxidized zone of rapidly weathering sulfide-bearing rocks; may be of post-mining formation. A relatively uncommon member of the group because the ubiquitous abundance of alkali ions in surface waters normally precludes its stability.

Association: Melanterite, goethite.

Distribution: Material confirmed by modern techniques from: in Poland, at the Staszic mine, Holy Cross Mountain, near Kielce, and at Rudawka, Rymanowska, Carpathian Mountains; in the Thorez mine, Walbrzych, Lower Silesia. From Jáchymov (Joachimsthal), Czech Republic. At the Kamariza mine, Laurium, Greece. Found north of Ballybunion, Co. Kerry, Ireland. In the Malka mine, southeast of Pyatigorsk, Caucasus Mountains, Russia. At Paddy's River mine, Australian Capital Territory. In the USA, from the Black Brush deposit, Cherry Creek area, Pinal Co., Arizona; at the Bristol silver mine, Lincoln Co., New Mexico; in Nevada, from the Boss mine, Goodsprings district, Clark Co.; the Goldstrike mine, Lynn district, and the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co.; and at Majuba Hill, Pershing Co.; from the Centennial Eureka mine, Tintic Co., Juab Co., Utah. More localities undoubtedly could be confirmed.

Name: As the H_3O^+, *hydronium*, analog of *jarosite*.

Type Material: Academy of Mining and Metallurgy, Krakow, Poland.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 566–567 [carphosiderite = hydronium jarosite, part]. (2) Kubisz, J. (1960) Hydronium jarosite – $(H_3O)Fe_3(SO_4)_2(OH)_6$. Bull. Acad. Polonaise Sci, Sér. géol. géogr., 8, 95–99. (3) (1961) Amer. Mineral., 46, 243 (abs. ref. 2). (4) Brophy, G.P. and M.F. Sheridan (1965) Sulfate studies IV: the jarosite-natrojarosite-hydronium jarosite solid solution series. Amer. Mineral., 50, 1595–1607. (5) Ripmeester, J.A., C.I. Ratcliffe, J.E. Dutrizac, and J.L. Jambor (1986) Hydronium ion in the alunite-jarosite group. Can. Mineral., 435–447.

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Hydrophilite $CaCl_2(?)$

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Crystal Data: Orthorhombic (synthetic), pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$. In pseudocubic crystals, modified by {111} and {011}; as a crystalline to mealy crust.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.175 (synthetic). Hygroscopic, deliquescent, soluble in H_2O; intensely bitter taste.

Optical Properties: Transparent to translucent. *Color:* White, may be stained violet. *Optical Class:* Biaxial (+) (synthetic). $\alpha = 1.600(3)$ $\beta = 1.605(3)$ $\gamma = 1.613(3)$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* *Pnnm* (synthetic). $a = 6.261(2)$ $b = 6.429(2)$ $c = 4.167(1)$ Z = 2

X-ray Powder Pattern: Synthetic.
3.050 (100), 4.48 (85), 2.331 (50), 2.858 (35), 2.244 (30), 2.356 (25), 1.906 (25)

Chemistry: An analysis of natural material is not available.

Occurrence: In a boracite deposit, as a coating on gypsum.

Association: Anhydrite, gypsum, halite.

Distribution: From Lüneburg, Lower Saxony, Germany. Reported from a few additional localities. All occurrences require modern confirmation.

Name: From the Greek for *water* and *friend*, in allusion to the mineral's hygroscopic property.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 161. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 41–42. (3) Hey, M. (1980) What was hydrophilite? Mineral. Mag., 43, 682. (4) Slawson, C.B. (1929) Note on hydrophilite. Amer. Mineral., 14, 161–162. (5) van Bever, A.K. and W. Nieuwenkamp (1935) Die Kristallstruktur von Calciumchlorid, $CaCl_2$. Zeits. Krist., 90, 374–376 (in German). (6) (1974) NBS Mono. 25, 11, 18.

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Hydroromarchite $Sn_3^{2+}O_2(OH)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. In thin crusts intermixed with romarchite.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.40]

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P4/mnc$ (synthetic). $a = 7.98(1)$ $c = 9.17(1)$ Z = 2

X-ray Powder Pattern: Boundary Falls, Canada. (ICDD 25-1303).
3.50 (100), 2.77 (90), 2.96 (80), 3.26 (50), 1.92 (50), 1.90 (50), 2.48 (40)

Chemistry: Boundary Falls, Canada; X-ray spectrographic scans detected only tin.

Occurrence: As an alteration product on tin pannikins immersed in a river.

Association: Romarchite.

Distribution: At Boundary Falls, Winnipeg River, Ontario, Canada, where tin pannikins had been dropped by a voyageur between 1801 and 1821.

Name: As a HYDROus mineral related to *romarchite*.

Type Material: Royal Ontario Museum, Toronto, Canada, M28744.

References: (1) Organ, R.M. and J.A. Mandarino (1971) Romarchite and hydroromarchite, two new stannous minerals. Can. Mineral., 10, 916 (abs.). (2) (1972) Amer. Mineral., 57, 1555 (abs. ref. 1). (3) Howie, R.A. and W. Moser (1973) Crystal data and formula for hydrous tin(II) oxide: a note. Amer. Mineral., 58, 552.

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Hydroscarbroite $Al_{14}(CO_3)_3(OH)_{36}\cdot nH_2O$

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Crystal Data: n.d. *Point Group:* n.d. [Compact, massive.] (by analogy to scarbroite)

Physical Properties: *Tenacity:* [Friable, clayey.] Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Dehydrates irreversibly to scarbroite.

Optical Properties: Semitransparent. *Color:* [White.] *Luster:* [Dull.]
Optical Class: n.d. n = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Scarborough, England; after removal of lines due to scarbroite impurity.
9.0 (vvs), 4.713 (m), 4.386 (m), 1.167 (m), 6.77 (wm), 6.69 (wm), 5.72 (wm)

Chemistry: From work done on a mixture of scarbroite and hydroscarbroite; the fully hydrated form "may well be $Al_2(CO_2)_3\cdot 12Al(OH)_3$ with a large amount of H_2O."

Occurrence: In vertical fissures in sandstone, intermixed with scarbroite.

Association: Scarbroite, gibbsite, kaolinite, calcite, quartz.

Distribution: From South Bay, near Scarborough, Yorkshire, and at Weston Favell, Northamptonshire, England.

Name: As a higher hydrate of *scarbroite*.

Type Material: n.d.

References: (1) Duffin, W.J. and J. Goodyear (1960) A thermal and X-ray investigation of scarbroite. Mineral. Mag., 32, 353–362. (2) Brindley, G.W. and J.J. Comer (1960) Electron-optical data for crystals of scarbroite. Mineral. Mag., 32, 363–365. (3) (1960) Amer. Mineral., 45, 910 (abs. refs. 1 and 2). (4) King, R.J. (1982) A new occurrence of scarbroite in Britain. Jour. Russell Soc., 1(1), 9–18.

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Hydrotalcite $Mg_6Al_2(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Typically subhedral crystals, platy on {0001}, lamellar-fibrous, rarely euhedral prismatic, to 4 mm; commonly foliated, massive.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Flexible but not elastic. Hardness = 2 D(meas.) = 2.03–2.09 D(calc.) = 2.11 Greasy feel.

Optical Properties: Transparent. *Color:* White, may have a brownish tint; colorless in transmitted light. *Streak:* White. *Luster:* Satiny to greasy or waxy.
Optical Class: Uniaxial (–); may be biaxial due to strain. ω = 1.510–1.518 ϵ = 1.494–1.504 2V(meas.) = Small.

Cell Data: *Space Group:* $R\overline{3}m$. a = 3.054–3.070 c = 22.81–23.23 Z = 3/8

X-ray Powder Pattern: Snarum, Norway; nearly identical to pyroaurite. (ICDD 14-191). 7.69 (100), 3.88 (70), 2.58 (20), 2.30 (20), 1.96 (20), 1.53 (20), 1.50 (20)

Chemistry:

	(1)	(2)
Al_2O_3	14.42	16.88
Fe_2O_3	2.44	
MgO	39.52	40.04
H_2O	36.28	35.79
CO_2	7.33	7.29
insol.	0.56	
Total	100.55	100.00

(1) Snarum, Norway; probably intermixed with manasseite. (2) $Mg_6Al_2(CO_3)(OH)_{16}\cdot 4H_2O$.

Polymorphism & Series: Dimorphous with manasseite.

Mineral Group: Hydrotalcite group.

Occurrence: A secondary mineral in serpentinite.

Association: Manasseite, serpentine, dolomite.

Distribution: From Snarum, Norway. At Tonezza, Vicenza, Italy. From Věžná, Czech Republic. Found at Goles, Bosnia-Herzegovina. On Gladner Hill, Styria, Austria. In Canada, from the Kilmar mine, Argenteuil Co., Quebec; numerous other localities are noted but not distinguished from manasseite. In the USA, around Amity, Orange Co., and Somerville, St. Lawrence Co., New York; and at Franklin, Sussex Co., New Jersey; additional localities are known but material may be intermixed with manasseite. Well-crystallized in the Kovdor massif, and in the Vuoriyarvi carbonatite complex, Kola Peninsula, and probably elsewhere in Russia.

Name: As a HYDROus mineral with a resemblance to *talc*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 653–655. (2) Allmann, R. and H.P. Jepsen (1969) Die Struktur des Hydrotalkits. Neues Jahrb. Mineral., Monatsh., 544–551 (in German with English abs.).

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Hydrotungstite $WO_2(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Platy crystals bounded by {210}, {100}, and {010}, to 75 μm, in fine reticulated intergrowths. *Twinning:* On {210}, polysynthetic, may be gridlike, universal.

Physical Properties: *Cleavage:* {010}, imperfect. Hardness = 2 D(meas.) = 4.60 D(calc.) = [4.66]

Optical Properties: Semitransparent. *Color:* Dark green, becoming yellowish on exposure to air. *Luster:* Vitreous to dull.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = yellow-green; Z = dark green. *Orientation:* $Y = b$; $X \wedge c = 3°$. *Dispersion:* $r < v$. *Absorption:* $Z > Y > X$. $\alpha = 1.70(2)$ $\beta = 1.95(2)$ $\gamma = 2.04(2)$ 2V(meas.) = ∼52°

Cell Data: *Space Group:* $P2/m$ (probable). $a = 7.379(5)$ $b = 6.901(5)$ $c = 3.748(5)$ $\beta = 90°22(10)'$ Z = 2

X-ray Powder Pattern: San Antonio mine, Bolivia.
6.95 (vvs), 3.27 (vs), 3.73 (s), 3.46 (ms), 1.96 (ms), 2.63 (m), 2.54 (m)

Chemistry:

	(1)	(2)	(3)
WO_3	80.31	86.47	86.55
SiO_2	6.65		
Fe_2O_3	0.08		
H_2O	12.52	13.53	13.45
Total	99.56	[100.00]	100.00

(1) Calacalani mine, Bolivia. (2) Analysis (1), recalculated to 100% after deduction of ferberite and quartz. (3) $WO_2(OH)_2 \cdot H_2O$.

Occurrence: An alteration product of ferberite in the oxidized zone of a hydrothermal tungsten deposit, where it was an ore mineral (Calacalani mine, Bolivia).

Association: Ferberite, tungstite.

Distribution: In Bolivia, from the Oruro district, at the San Antonio de Calacalani mine, near Colquiri, and in the Juliani mine. At Panasqueira, Portugal. From the Grancarica scheelite deposit, southwest of Velingrad, Bulgaria.

Name: For its content of H_2O and relation to *tungstite*.

Type Material: Harvard University, Cambridge, Massachusetts, 98896; National Museum of Natural History, Washington, D.C., USA, 104901.

References: (1) Kerr, P.F. and F. Young (1944) Hydrotungstite, a new mineral from Oruro, Bolivia. Amer. Mineral., 29, 192–210. (2) Mitchell, R.S. (1963) X-ray data for hydrotungstite. Amer. Mineral., 48, 935–939. (3) Sahama, T.G. and M. Lehtinen (1971) Refinement of the X-ray data for hydrotungstite from Calacalani, Bolivia. Bull. Geol. Soc. Finland, 43, 89–91. (4) Sahama, T.G. (1981) The secondary tungsten minerals, a review. Mineral. Record, 12, 81–87.

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Hydrowoodwardite $Cu_2Al_2(SO_4)(OH)_8 \cdot nH_2O$.

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ (probable). As porous botryoidal crusts and small stalactitic aggregates.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle upon partial dehydation. Hardness = n.d. D(meas.) = 2.33(8) D(calc.) = 2.48 Slowly and reversibly dehydrates to woodwardite.

Optical Properties: Translucent. *Color:* Blue to pale blue. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: [Uniaxial.] $n = 1.549(5)$–$1.565(5)$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$ (probable). $a = 3.070(7)$ $c = 31.9(2)$ $Z = 3$

X-ray Powder Pattern: St. Briccius mine, Germany.
10.5 (100), 5.26 (17), 3.50 (6), 2.60 (5b), 1.524 (4b), 2.46 (2b), 2.23 (2b)

Chemistry:

	(1)
SO_3	15.50
SiO_2	5.60
Al_2O_3	19.20
CuO	28.39
ZnO	0.41
Na_2O	0.10
H_2O	30.10
Total	[99.30]

(1) St. Briccius mine, Germany; by ICP-MS, SiO_2 from admixed amorphous silica, H_2O by TGA, $(SO_4)^{2-}$, $(OH)^{1-}$ and H_2O confirmed by IR, original total given as 99.3%; corresponds to $(Cu_{1.92}Zn_{0.04})_{\Sigma=1.96}Al_{2.04}(SO_4)_{1.04}(OH)_{7.96} \cdot 5.08H_2O$. (2) St. Christoph mine, Germany; analysis not given, $(CO_3)^{2-}$ from stoichiometry and presence confirmed by IR; then stated to correspond to $(Cu_{1.96}Zn_{0.04})_{\Sigma=2.00}(UO_2)_{0.04}Al_{2.00}[(SO_4)_{0.64}(CO_3)_{0.36}]_{\Sigma=1.00}(OH)_8 \cdot nH_2O$.

Occurrence: Rare in the oxidized portions of base metal sulfide mines.

Association: Woodwardite, schulenbergite, namuwite, brianyoungite, langite, linarite, allophane, amorphous silica.

Distribution: In Germany, in Saxony, from the St. Briccius mine, Königswalde, near Annaberg; in the Gelbe Birke mine, Schwarzenberg; at the St. Johannes mine, Wolkenstein, near Marienberg; and from the St. Christoph mine, Bärenhecke. At Simdde Dyllhan, Drws-y-Coed, near Nantlle, Gwynedd, Wales.

Name: As the hydrated analog of *woodwardite*.

Type Material: Mining Academy, Freiberg, Germany, 76639.

References: (1) Witzke, T. (1999) Hydrowoodwardite, a new mineral of the hydrotalcite group from Königswalde near Annaberg, Saxony/Germany and other localities. Neues Jahrb. Mineral., Monatsh., 75–86. (2) (1999) Amer. Mineral., 84, 1465 (abs. ref. 1). (3) Nickel, E. (1976) New data on woodwardite. Mineral. Mag., 43, 644–647.

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Hydroxyapophyllite $KCa_4Si_8O_{20}(OH,F)\cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are equant or tabular on {001}, to 15 cm, with {100}, {001}, and {111}; some crystals striated on {100} ‖ [001]. *Twinning:* Multiply twinned.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* [Uneven] (by analogy to fluorapophyllite). *Tenacity:* [Brittle.] Hardness = 4.5–5 D(meas.) = 2.37 D(calc.) = 2.36

Optical Properties: Transparent to translucent, opaque. *Color:* Colorless to white; may be pink, light green, or light yellow. *Streak:* White. *Luster:* Vitreous on {100} and pearly on {001}.
Optical Class: Uniaxial (+). $\omega = 1.536–1.542$ $\epsilon = 1.537–1.543$

Cell Data: *Space Group:* $P4/mnc$. $a = 8.978(3)$ $c = 15.83(1)$ $Z = 2$

X-ray Powder Pattern: Jefferson, North Carolina, USA.
3.965 (100), 2.990 (67), 1.588 (26), 4.554 (23), 2.494 (22), 7.90 (13), 7.82 (13)

Chemistry:

	(1)	(2)	(3)
SiO_2	51.93	52.59	53.10
Al_2O_3	0.30	0.12	
CaO	25.78	25.44	24.78
K_2O	4.76	5.00	5.20
Na_2O	0.09	0.00	
H_2O	16.76	16.89	16.92
Total	99.62	100.04	100.00

(1) Jefferson, North Carolina, USA; by electron microprobe, H_2O by the Penfield method.
(2) Kimberley, South Africa; by electron microprobe, H_2O by the Penfield method.
(3) $KCa_4Si_8O_{20}(OH)\cdot 8H_2O$.

Polymorphism & Series: Forms a series with fluorapophyllite.

Occurrence: Typically a secondary mineral in amygdules or druses in basalts.

Association: Zeolites, fluorapophyllite, datolite, pectolite, calcite.

Distribution: In the USA, in the Ore Knob mine, Jefferson, Ashe Co., and the Foote mine, Kings Mountain, Cleveland Co., North Carolina; at Great Notch and Paterson, Passaic Co., and Franklin, Sussex Co., New Jersey; from the Fairfax quarry, Centreville, Fairfax Co., Virginia. From the Valenciana and La Luz mines, Guanajuato, Mexico. In India, around Bombay, Poona, and Nasik, Maharashtra. From Kimberley, and in large crystals, from near Kuruman, Cape Province, South Africa. In Norway, from the Mofjellet mine, Mo i Rana. These occurrences have been authenticated, which requires chemical analysis; there are undoubtedly additional ones.

Name: For the predominance of *hydroxyl* and relation to other *apophyllite* species.

Type Material: The Natural History Museum, London, England, 1977,58; Geological Survey of Canada, Ottawa, 14099; Royal Ontario Museum, Toronto, Canada; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 115268.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 566–569.
(2) Dunn, P.J., R.C. Rouse, and J.A. Norberg (1978) Hydroxyapophyllite, a new mineral, and a redefinition of the apophyllite group. I. Description, occurrences, and nomenclature. Together with: Rouse, R.C, D.R. Peacor, and P.J. Dunn: II. Crystal structure. Amer. Mineral., 63, 196–202. (3) Dunn, P.J. and W.E. Wilson (1978) Nomenclature revisions in the apophyllite group: hydroxyapophyllite, apophyllite, fluorapophyllite. Mineral. Record, 9, 95–98.

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Hydroxycancrinite $Na_8Al_6Si_6O_{24}(OH, CO_3)_2 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6. Massive aggregates, with grains to 1.5 cm.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}0\}$. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 2.32(2) D(calc.) = 2.26

Optical Properties: Transparent. *Color:* Light blue; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.494(2)$ $\epsilon = 1.501(2)$

Cell Data: *Space Group:* $P6_3$. $a = 12.740(3)$ $c = 5.182(2)$ $Z = 1$

X-ray Powder Pattern: Lovozero massif, Russia; resembles cancrinite.
3.26 (100), 3.68 (70), 4.70 (60), 2.756 (50), 2.433 (30), 6.43 (25), 4.17 (20)

Chemistry:

	(1)
SiO_2	36.32
Al_2O_3	31.15
Fe_2O_3	0.18
MnO	0.03
MgO	0.11
CaO	0.92
Na_2O	23.43
K_2O	0.45
H_2O	5.41
CO_2	1.59
Total	99.59

(1) Lovozero massif, Russia, corresponding to $(Na_{7.46}Ca_{0.16}K_{0.10}Mg_{0.03}Fe^{3+}_{0.02})_{\Sigma=7.77}(Al_{6.03}Si_{5.97})_{\Sigma=12.00}O_{24}[(OH)_{1.23}(CO_3)_{0.36}]_{\Sigma=1.59} \cdot 2.35H_2O$.

Mineral Group: Cancrinite group.

Occurrence: In veins in ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Natrolite, steenstrupine, vuonnemite, epistolite, mountainite, ilmajokite, nastrophite.

Distribution: On Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: For predominant *hydroxyl* in its composition, and its relation to *cancrinite*.

Type Material: Vernadsky Geological Museum, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Khomyakov, A.P., T.N. Nadezhina, R.K. Rastsvetaeva, and E.A. Pobedimskaya (1992) Hydroxycancrinite $Na_8[Al_6Si_6O_{24}](OH)_2 \cdot 2H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 121(1), 100–105 (in Russian). (2) (1993) Amer. Mineral., 78, 1315 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 111 (abs. ref. 1). (4) Nadezhina, T.N., R.K. Rastsvetaeva, E.A. Pobedimskaya, and A.P. Khomyakov (1991) Crystal structure of natural hydroxyl-containing cancrinite. Kristallografiya (Sov. Phys. Crystal.), 36, 591–595 (in Russian). (5) Hassan, I. and H.D. Grundy (1991) The crystal structure of basic cancrinite, ideally $Na_8[Al_6Si_6O_{24}](OH)_2 \cdot 3H_2O$. Can. Mineral., 29, 377–383.

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Hydroxylapatite $Ca_5(PO_4)_3(OH)$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As tabular to prismatic crystals, to 30 cm; usually as stalagmites, nodules, in crystalline to massive crusts.

Physical Properties: *Cleavage:* Poor on {0001} and $\{10\bar{1}0\}$. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.14–3.21 D(calc.) = 3.16

Optical Properties: Transparent to translucent. *Color:* White, wax-yellow, sea-green, brown, black. *Luster:* Vitreous to subresinous, earthy.
Optical Class: Uniaxial (–). *Pleochroism:* Weak to moderate; colorless to pale colors.
Absorption: $E > O$. $\omega = 1.642$–1.658 $\epsilon = 1.637$–1.654

Cell Data: *Space Group:* $P6_3/m$. $a = 9.4166$ $c = 6.8745$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 9-432).
2.814 (100), 2.778 (60), 2.720 (60), 3.44 (40), 1.841 (40), 1.943 (30), 2.631 (25)

Chemistry:

	(1)	(2)
P_2O_5	42.05	42.39
MnO	0.07	
MgO	0.10	
CaO	55.84	55.82
F	0.16	
Cl	trace	
H_2O	1.86	1.79
$-O = (F, Cl)_2$	0.07	
Total	100.01	100.00

(1) Holly Springs, Georgia, USA; corresponding to $(Ca_{5.05}Mg_{0.01})_{\Sigma=5.06}(PO_4)_3[(OH)_{1.04}F_{0.08}]_{\Sigma=1.12}$. (2) $Ca_5(PO_4)_3(OH)$.

Mineral Group: Apatite group; OH > F or Cl.

Occurrence: Much less common than fluorapatite. Formed by the reaction of limestone with phosphatic solutions derived from guano. In talc schists associated with serpentinite. As a fracture-localized alteration of montebrasite in a complex granite pegmatite.

Association: Brushite, calcite (caves); talc, serpentine (schists); montebrasite, crandallite, muscovite (pegmatite).

Distribution: From Chämleten (Kemmleten), near Hospental, Uri, Switzerland. In the Kaiserstuhl, Baden-Württemberg, Germany. At Punta della Rossa, Val Devero, Ossola, Italy. In the USA, in the Verde Antique quarry, Holly Springs, Cherokee Co., Georgia; from the Midnight Owl pegmatite, White Picacho district, Maricopa Co., Arizona. Large crystals in the Gardiner complex, beyond the head of Kangerdlugssuaq Fiord, East Greenland. On Mona Island, West Indies, Caribbean Sea. From caves worldwide; studied material from Low Water Bridge Cave, Greene Co., Missouri, USA.

Name: For dominant *hydroxyl* and membership in the *apatite* group; see fluorapatite.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 879–889. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 297–334. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 81–84. (4) Sommerauer, J. and K. Katz-Lehnert (1985) A new partial substitution mechanism of CO_3^{2-}/CO_3OH^{3-} and $SiO^4{}_4$ for the PO_4^{3-} group in hydroxyapatite from the Kaiserstuhl alkaline complex (SW-Germany). Contr. Mineral. Petrol., 91, 360–368. (5) Hughes, J.M., M. Cameron, and K.D. Crowley (1989) Structural variation in natural F, OH, and Cl apatites. Amer. Mineral., 74, 870–876.

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Hydroxylbastnäsite-(Ce) $(Ce, La)(CO_3)(OH, F)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}m2$. Tabular crystals exhibit {0001} and {$11\overline{2}0$}, to 0.5 mm; granular to short prismatic, reniform, and in sheaflike aggregates. *Twinning:* On {$11\overline{2}0$}.

Physical Properties: *Cleavage:* {$11\overline{2}0$}, imperfect. *Fracture:* Uneven. Hardness = ∼4
D(meas.) = 4.745 D(calc.) = [4.79]

Optical Properties: Translucent to nearly opaque. *Color:* Colorless, wax-yellow, dark brown; colorless in transmitted light. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (+). $\omega = 1.760(3)$ $\epsilon = 1.870(6)$

Cell Data: *Space Group:* $P\overline{6}2c$. $a = 7.23(2)$ $c = 9.98(5)$ $Z = 6$

X-ray Powder Pattern: Vuoriyarvi complex, Kola Peninsula, Russia [close to bastnäsite-(Ce)].
2.92 (10), 3.59 (9), 2.09 (9), 1.923 (9), 2.05 (8), 1.698 (7), 1.319 (7)

Chemistry:

	(1)		(1)		(1)
SO_3	0.40	Ce_2O_3	37.50	CaO	0.40
P_2O_5	0.23	Nd_2O_3	3.43	BaO	0.70
CO_2	19.70	Sm_2O_3	1.59	Na_2O	0.13
SiO_2	0.30	$(Y + Dy)_2O_3$	1.47	F	1.15
TiO_2	0.04	Fe_2O_3	2.17	H_2O^+	3.96
ThO_2	0.50	MnO	0.06	H_2O^-	0.11
La_2O_3	26.86	MgO	0.16	$-O = F_2$	0.50
				Total	100.36

(1) Vuoriyarvi complex, Kola Peninsula, Russia; after deduction of about 5% impurities such as quartz, anatase, dolomite, barite, rhabdophane, and goethite, corresponds to $(Ce_{0.53}La_{0.38}Nd_{0.05}Sm_{0.02}Y_{0.02})_{\Sigma=1.00}(CO_3)_{1.03}[(OH)_{0.86}F_{0.14}]_{\Sigma=1.00}$.

Polymorphism & Series: Forms a series with bastnäsite-(Ce).

Occurrence: In calcite–dolomite carbonatite veins in pyroxenite of an alkalic ultramafic complex (Vuoriyarvi complex, Kola Peninsula, Russia); in a vug in perthitic pegmatite (Kamihori, Japan); in veins and lenses in marble (Desmont mine, Canada).

Association: Barite, strontianite, ancylite, fluorite, pyrrhotite, pyrite, chalcopyrite, magnetite, anatase, monazite, burbankite, quartz (Vuoriyarvi complex, Kola Peninsula, Russia); beryl, zircon, xenotime, allanite, fergusonite, gadolinite, ilmenite (Kamihori, Japan); stillwellite, calcite, apatite, titanite, thorite, thorianite, uranothorite, scapolite, tourmaline (Desmont mine, Canada).

Distribution: From the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. In the Ossling quarry, between Kamenz and Hoyerswenda, Saxony, Germany. At Kamihori, Miyazaki Prefecture, Japan. In the Desmont mine, two km northwest of Wilberforce, Ontario, Canada.

Name: For a member of the *bastnäsite* group with $(OH)^{1-} > F^{1-}$ and with *cerium* the dominant rare earth element.

Type Material: n.d.

References: (1) Kirillov, A.S. (1964) A new variety of bastnäsite – hydroxyl-bastnäsite. Doklady Acad. Nauk SSSR, 159, 1048–1050 (in Russian). (2) (1965) Amer. Mineral., 50, 805 (abs. ref. 1). (3) (1965) Mineral. Abs., 17, 303–304 (abs. ref. 1). (4) Kirillov, A.S. (1966) Hydroxyl-bastnäsite, a new mineral variety. Zap. Vses. Mineral. Obshch., 95, 51–59 (in Russian). (5) (1966) Amer. Mineral., 51, 1819–1820 (abs. ref. 4). (6) Minakawa, T., T. Adachi, and M. Matsuda (1992) The first occurrence of hydroxylbastnäsite-(Ce) in Japan. Geoscience Magazine, 41, 155–159 (in Japanese). (7) (1996) Mineral. Abs., 47, 248 (abs. ref. 6). (8) Sabina, A.P. (1982) Some rare minerals of the Bancroft area. Mineral. Record, 13, 223–228. (9) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 99.

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Hydroxylbastnäsite-(Nd) $(Nd, Ce, La)(CO_3)(OH, F)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}m2$. Stacked platy crystals, to 0.2 mm, in massive intergrowths.

Physical Properties: *Cleavage:* On {0001}, a parting. Hardness = 1–2 in aggregates. D(meas.) = n.d. D(calc.) = 4.89

Optical Properties: Translucent. *Color:* White. *Streak:* White. *Luster:* Dull in aggregates. *Optical Class:* Uniaxial (+). $\omega = 1.715(2)$ $\epsilon = 1.81(1)$

Cell Data: *Space Group:* $[P\overline{6}2c]$ (by analogy to other bastnäsite species). $a = 7.191(1)$ $c = 9.921(2)$ Z = 6

X-ray Powder Pattern: Near Nikšić, Yugoslavia.
2.911 (100), 4.95 (88), 3.596 (79), 2.042 (51), 1.914 (30), 2.077 (29), 2.481 (16)

Chemistry:

	(1)		(1)
CO_2	20.63	Eu_2O_3	1.3
Y_2O_3	0.2	Gd_2O_3	1.4
La_2O_3	27.1	CaO	0.3
Ce_2O_3	0.3	F	3.3
Pr_2O_3	8.5	H_2O	2.26
Nd_2O_3	31.5	$-O = F_2$	1.39
Sm_2O_3	4.4	Total	99.80

(1) Near Nikšić, Yugoslavia; by electron microprobe, CO_2 and H_2O by TGA and mass spectrometer, presence of $(CO_3)^{2-}$ and H_2O confirmed by IR; corresponds to $(Nd_{0.41}La_{0.36}Pr_{0.11}Sm_{0.06}Gd_{0.02}Eu_{0.02}Ca_{0.01})_{\Sigma=0.97}[(OH)_{0.55}F_{0.38}]_{\Sigma=0.93}(CO_3)_{1.03}$.

Polymorphism & Series: Dimorphous with kozoite-(Nd).

Occurrence: As a rare authigenic mineral in a bauxite deposit developed on limestone.

Association: "Bauxite".

Distribution: From the Zagrad bauxite deposit, near Nikšić, Montenegro, Yugoslavia.

Name: For a member of the *bastnäsite* group with $(OH)^{1-} > F^{1-}$ and with *neodymium* the dominant rare earth element.

Type Material: University of Belgrade, Belgrade, Yugoslavia, Zagrad 10,8397; Hungarian Academy of Sciences, Budapest, Hungary; Royal Ontario Museum, Toronto, Canada.

References: (1) Maksimović, Z. and G. Pantó (1985) Hydroxyl-bastnaesite-(Nd), a new mineral from Montenegro, Yugoslavia. Mineral. Mag., 49, 717–720. (2) Farkas, L., Z. Maksimović, and G. Pantó (1985) X-ray powder data and unit cell of natural hydroxyl-bastnaesite-(Nd). Neues Jahrb. Mineral., Monatsh., 298–304. (3) (1988) Amer. Mineral., 73, 440–441 (abs. refs. 1 and 2).

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Hydroxylborite $Mg_3(BO_3)(OH)_3$

Crystal Data: Hexagonal. *Point Group*: 6/*m*. As prismatic crystals dominated by {10$\bar{1}$ 0}, to 1.5 mm; in radial aggregates.

Physical Properties: *Cleavage*: Imperfect on {0001}. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 3.5 D(meas.) = 2.89(1) D(calc.) = 2.872

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (-). ω = 1.566(1) ε = 1.531(1)

Cell Data: *Space Group*: $P6_3/m$. a = 8.912(8) c = 3.112(4) Z = 2

X-ray Powder Pattern: Visyachy area, Sakha-Yakutia Republic, Russia.
2.422 (100), 4.45 (82), 2.573 (65), 2.128 (60), 7.69 (52), 2.551 (49), 2.141 (44)

Chemistry:

	(1)	(2)
MgO	65.71	66.16
B_2O_3	18.43	19.05
F	45.45	
H_2O	9.73	14.79
$-O=F_2$	4.31	
Total	99.79	100.00

(1) Visyachy area, Sakha-Yakutia Republic, Russia; average of 3 electron microprobe analyses, H_2O by Penfeld method, IR confirms OH, corresponding to $Mg_{3.03}(B_{0.98}[(OH)_{2.00}F_{1.00}]O_{3.00}$.
(2) $Mg_3(BO_3)(OH)_3$.

Occurrence: As disseminations and veinlets in boron-mineralized calcsilicate marbles.

Association: Calcite, dolomite, Mg-rich ludwigite, kotoite, szaibelyite, clinohumite, magnetite, serpentine, chlorite.

Distribution: Visyachy area, Titovsky deposit, Chersky Range, Dogdo Basin, Sakha-Yakutia Republic, Russia.

Name: For its chemical composition, as a hydroxyl dominant analog of fluoborite.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (91968); Geological Museum of All-Russia Institute of Mineral Resources, Moscow (M-1663).

References: (1) Rudnev, V.V., N.V. Chukanov, G.N. Nechelyustov, and N.A. Yamnova (2007) Hydroxylborite, $Mg_3(BO_3)(OH)_3$, a new mineral, and the isomorphous fluoborite hydroxylborite series. Zap. Ross. Mineral. Obshch., 136(1), 69–82 (in Russian, English abstract); (2007) Geology of Ore Deposits, 49, 710–719 (in English). (2) (2009) Amer. Mineral., 94, 1078 (abs. ref. 1).

Hydroxylchondrodite $Mg_5(SiO_4)_2(OH)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As coarse tabular or lens-like crystals, to 1.5 cm, and in aggregates to 2 cm. *Twinning:* Thin polysynthetic on {001}.

Physical Properties: *Cleavage*: None; parting on {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 6 D(meas.) = 3.21(1) D(calc.) = 3.183

Optical Properties: Translucent. *Color*: Reddish brown. *Streak*: Pale yellow. *Luster*: Vitreous. *Optical Class*: Biaxial (+). α = 1.662(3) β = 1.669(2) γ = 1.688(2) 2V(meas.) = 80(10)° 2V(calc.) = 63° *Orientation*: $Z = b$. *Pleochroism*: Strong, X = brown; Y = light brown with grayish green tint; Z = pale grayish greenish brown. *Absorption*: $X > Y > Z$.

Cell Data: *Space Group*: $P2_1/c$. a = 7.8847(12) b = 4.7235(8) c = 10.2869(15) β = 109.19(1)° Z = 2

X-ray Powder Pattern: Chuvashskie Mountains, Zlatoust region, South Urals, Russia. 1.740 (100), 2.260 (74), 2.518 (59), 2.621 (44), 2.763 (37), 2.673 (37), 3.023 (36)

Chemistry:

	(1)
MgO	52.74
FeO	1.51
TiO_2	7.08
SiO_2	34.38
P_2O_5	0.47
F	1.29
H_2O	3.48
$–O=F_2$	0.54
Total	100.41

(1) Chuvashskie Mountains, Zlatoust region, South Urals, Russia; average of 11 electron microprobe analyses, H_2O by the Alimarin method; corresponding to $(Mg_{4.52}Ti_{0.31}Fe_{0.07})_{\Sigma=4.90}(Si_{1.98}P_{0.02})_{\Sigma=2.00}O_8[(OH)_{1.33}O_{0.44}F_{0.23}]_{\Sigma=2.00}$.

Mineral Group: Humite group.

Occurrence: In the contact zone between magnesium skarn and marble.

Association: Calcite, clinochlore, dolomite, tremolite, diopside, andradite-grossular, magnetite, perovskite, hydroxylclinohumite, titanite.

Distribution: Perovskite pit, western slope of the Chuvashskie Mountains, Zlatoust region, South Urals, Russia.

Name: Reflects the mineral's identity as the OH (*hydroxyl*) analogue of *chondrodite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3986/1).

References: (1) Pekov I.V., E.I. Gerasimova, N.V. Chukanov, Y.K. Kabalov, N.V. Zubkova, A.E. Zadov, V.O. Yapaskurt, V.M. Gekimyants, and D.Y. Pushcharovskii (2011) Hydroxylchondrodite $Mg_5(SiO_4)_2(OH)_2$: A new mineral of the humite group and its crystal structure. Doklady Akademii Nauk, 436(4), 526-532 (in Russian). English translation: Doklady Earth Sciences, 2011, 436(2), 230-236. (2) (2014) Amer. Mineral., 99, 245 (abs. ref. 1).

Hydroxylellestadite $Ca_{10}(SiO_4)_3(SO_4)_3(OH,F)_2$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As cleavable aggregates, to 2 cm.

Physical Properties: Hardness = 4.5 D(meas.) = 3.01(8) D(calc.) = ∼3.080

Optical Properties: Translucent. *Color:* Pale purplish. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.654(1)$ $\epsilon = 1.650(1)$

Cell Data: *Space Group:* $P2_1/m$, pseudo-$P6_3/m$. $a = 9.476(2)$ $b = 9.508(2)$ $c = 6.919(1)$ $\beta = 119.53(2)^\circ$ Z = [2]

X-ray Powder Pattern: Chichibu mine, Japan.
2.839 (100), 2.739 (60), 2.655 (45), 2.801 (44), 1.853 (43), 3.462 (40), 1.484 (20)

Chemistry:

	(1)		(1)
SiO_2	17.30	P_2O_5	0.66
Al_2O_3	trace	F	0.28
Fe_2O_3	0.21	Cl	0.91
MnO	0.04	H_2O^+	2.04
MgO	trace	H_2O^-	0.72
CaO	54.51	CO_2	1.65
SrO	0.28	SO_3	21.56
Na_2O	0.34	$-O = (F,Cl)_2$	0.32
K_2O	0.07	Total	100.25

(1) Chichibu mine, Japan; corresponds to $(Ca_{9.66}Na_{0.11}Sr_{0.03}Fe_{0.03}K_{0.02})_{\Sigma=9.85}[(SiO_4)_{2.86}(SO_4)_{2.68}(CO_3OH)_{0.37}(PO_4)_{0.09}]_{\Sigma=6.00}[(OH)_{1.88}Cl_{0.26}F_{0.15}]_{\Sigma=2.29}$.

Polymorphism & Series: Forms a series with fluorellestadite.

Mineral Group: Ellestadite group.

Occurrence: In pre-ore contact metamorphic skarns.

Association: Diopside, wollastonite, xanthophyllite, vesuvianite, calcite.

Distribution: In the Chichibu mine, Saitama Prefecture, Japan.

Name: For *hydroxyl* in the chemical composition and analogy to *ellestadite*.

Type Material: National Science Museum, Tokyo, Japan, M15761.

References: (1) Harada, K., K. Nagashima, K. Nakao, and A. Kato (1971) Hydroxylellestadite, a new apatite from Chichibu mine, Saitama Prefecture, Japan. Amer. Mineral., 56, 1507–1518.
(2) Sudarsanan, K. (1980) Structure of hydroxylellestadite. Acta Cryst., 36, 1636–1639.
(3) Rouse, R.C. and P.J. Dunn (1982) A contribution to the crystal chemistry of ellestadite and the silicate sulfate apatites. Amer. Mineral., 67, 90–96.

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Hydroxylherderite $CaBe(PO_4)(OH)$

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Crystal Data: Monoclinic, pseudo-orthorhombic or pseudohexagonal. *Point Group:* $2/m$. As stout prismatic crystals, elongated along [001] or [100], may be thick tabular {001}, typically with complex but rounded form development, to 17 cm; botryoidal to spherical, radial fibrous, in aggregates. *Twinning:* On {100} or {001} or both, as "fishtail" contact twins, common.

Physical Properties: *Cleavage:* On {110}, irregular. *Fracture:* Subconchoidal. Hardness = 5–5.5 D(meas.) = 2.95 D(calc.) = 2.94–2.97 May fluoresce weak yellow under SW UV, perhaps with bright yellow-orange phosphorescence.

Optical Properties: Transparent to translucent. *Color:* Colorless, gray, brown, pale yellow, greenish white, light blue, purple; colorless in transmitted light; may be blue-green or blue in daylight, lavender or light violet in incandescent light. *Luster:* Vitreous to subvitreous, resinous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge c \simeq 87°$; $Z \wedge c \simeq -3°$. *Dispersion:* $r > v$, inclined. $\alpha = 1.59–1.615$ $\beta = 1.61–1.634$ $\gamma = 1.62–1.643$ 2V(meas.) = 70°–77°

Cell Data: *Space Group:* $P2_1/a$. $a = 9.789(2)$ $b = 7.661(1)$ $c = 4.804(1)$ $\beta = 90.02(1)°$ Z = 4

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA; cannot be distinguished from herderite, and very similar to datolite. (ICDD 29-1403).
3.132 (100), 2.865 (70), 2.208 (60), 2.994 (50), 3.43 (40), 2.551 (30), 1.880 (25)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	44.05	44.14	43.80	H_2O	5.85	3.22	2.78
BeO	16.13	[15.45]	15.43	$-O = F_2$		2.34	2.47
CaO	34.04	34.25	34.60	insol.	0.44		
F	trace	5.31	5.86	Total	100.51	[100.03]	100.00

(1) Paris, Maine, USA. (2) Virgem da Lapa, Brazil; by electron microprobe, H_2O by the Penfield method, BeO calculated from stoichiometry. (3) $CaBe(PO_4)(OH, F)$ with OH:F = 1:1.

Polymorphism & Series: Forms a series with herderite.

Occurrence: A late-stage mineral in miarolitic cavities in complex granite pegmatites, of hydrothermal or probable pneumatolytic origin; may form from the alteration of beryl or beryllonite.

Association: Elbaite, topaz, cassiterite, albite, microcline, muscovite, lepidolite, quartz.

Distribution: Many localities, but uncommon at most. Some for analyzed material include: in the USA, in Maine, at Paris, Hebron, Greenwood, Stoneham, and Newry, Oxford Co., at Topsham, Sagadahoc Co., Poland and Auburn, Androscoggin Co., and elsewhere; in the Fletcher and Palermo #1 mines, near North Groton, Grafton Co., and at the Keyes mine, Orange, Grafton Co., New Hampshire; from the Blue Chihuahua pegmatite, near Oak Grove, San Diego Co., California. In Germany, at the Epprechtstein and Waldheim quarries, Fichtelgebirge, Bavaria. In the Viitaniemi pegmatite, near Eräjärvi, Finland. From Mursinsk, Ural Mountains, Russia. At Ungursuay, Kazakhstan. In Brazil, large crystals from the Xandá mine, Virgem da Lapa, and at the Golconda mine, near Governador Valadares, Minas Gerais.

Name: For predominance of *hydroxyl* over fluorine in its composition and relation to *herderite*.

Type Material: Yale University, New Haven, Connecticut, USA, Brush 1971, 1972, 1974, 1975.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 820–822. (2) Leavens, P.B., P.J. Dunn, and R.V. Gaines (1978) Composition and refractive index variations of the herderite – hydroxyl-herderite series. Amer. Mineral., 63, 913–917. (3) Dunn, P.J., C.W. Wolfe, P.B. Leavens, and W.E. Wilson (1979) Hydroxyl-herderite from Brazil and a guide to species nomenclature for the herderite/hydroxyl-herderite series. Mineral. Record, 10, 5–11. (4) Lager, G.A. and G.V. Gibbs (1974) A refinement of the crystal structure of herderite, $CaBePO_4OH$. Amer. Mineral., 59, 919–925.

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Hydroxymanganopyrochlore $(Mn^{2+},Th,Na,REE)_2(Nb,Ti)_2O_6(OH)$

Crystal Data: Cubic. *Point Group*: $4/m\,\bar{3}\,2/m$. Crystals octahedral, to 0.7 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.398

Optical Properties: Translucent. *Color*: Dark brown, black, with red reflexes. *Streak*: n.d. *Luster*: n.d.
Optical Class: n.d. *n*(calc.) = 2.29

Cell Data: *Space Group*: *Fd*3*m*. *a* = 10.2523(2) *Z* = 8

X-ray Powder Pattern: Mendig, Laacher See area, Eifel volcanic region, Germany.
2.969 (100), 1.816 (47), 2.569 (40), 1.548 (40), 1.481 (14), 1.178 (14), 2.358 (12)

Chemistry:

	(1)
Na_2O	2.48
CaO	3.65
MnO	8.22
Fe_2O_3	3.39
La_2O_3	3.22
Ce_2O_3	6.76
Nd_2O_3	0.92
TiO_2	15.43
ThO_2	22.58
UO_2	2.42
Nb_2O_5	29.42
F	0.49
H_2O	[1.34]
$-O=F_2$	0.21
Total	100.11

(1) Mendig, Laacher See area, Eifel volcanic region, Germany; average of 7 electron microprobe analyses, H_2O calculated for charge balance; corresponding to $(Mn_{0.51}Th_{0.37}Na_{0.35}Ca_{0.29}Ce_{0.18}La_{0.09}Nd_{0.02}U_{0.04})_{\Sigma=1.85}(Nb_{0.97}Ti_{0.85})_{\Sigma=2.01}O_6[(OH)_{0.65}O_{0.24}F_{0.11}]$.

Mineral Group: Pyrochlore group.

Occurrence: In small miarolitic cavities in sanidinite as a late pneumatolytic phase.

Association: Sanidine, nosean, biotite, tephroite, jacobsite, and spinellides of the gahnite–hercynite series.

Distribution: From a pumice quarry, near Mendig, Laacher See area, Eifel volcanic region, Rheinland-Pfalz, Germany.

Name: Reflects the mineral's identity as a member of the *pyrochlore* group with dominant OH (*hydroxyl*) and Mn^{2+} respectively in the Y and A structural sites.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Chukanov, N.V., G. Blass, N.V. Zubkova, I.V. Pekov, D.Y. Pushcharovskii, and H. Prinz (2013) Hydroxymanganopyrochlore: A New Mineral from the Eifel Volcanic Region, Germany. Doklady Akademii Nauk, 449(2), 215-218. English translation: Doklady Earth Sciences, 2013, 449(1), 342-345. (2) (2014) Amer. Mineral., 99, 245-246 (abs. ref. 1).

Hydrozincite $Zn_5(CO_3)_2(OH)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Uncommonly as lathlike or bladed crystals, flattened on {100} and elongated along [001], with pointed terminations, to 6 mm; fibrous, stalactitic, reniform, pisolitic, isolated spheroidal and in aggregates, earthy, chalky, massive. *Twinning:* Contact twins on {100}.

Physical Properties: *Cleavage:* On {100}, perfect. *Tenacity:* Very brittle. Hardness = 2–2.5 D(meas.) = 4.00(3) D(calc.) = 4.01 Fluoresces pale blue to lilac under UV.

Optical Properties: Transparent. *Color:* Colorless, white, gray, pale shades of yellow, brown, pink, green, spherules may be concentrically color banded; colorless in transmitted light. *Luster:* Pearly, silky to dull or earthy in aggregates.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c \simeq 40°$. *Dispersion:* $r < v$, strong.
$\alpha = 1.635$–1.640 $\beta = 1.736$ $\gamma = 1.740$–1.750 2V(meas.) = n.d. 2V(calc.) = 40°

Cell Data: *Space Group:* $C2/m$. $a = 13.62$ $b = 6.30$ $c = 5.42$ $\beta = 95°50'$ Z = 2

X-ray Powder Pattern: Goodsprings, Nevada, USA.
6.77 (10), 2.480 (7), 2.72 (6), 3.14 (5), 1.688 (4), 2.85 (3), 1.908 (3b)

Chemistry:

	(1)	(2)
CO_2	[16.41]	16.03
ZnO	74.67	74.12
H_2O	8.92	9.85
Total	[100.00]	100.00

(1) Goodsprings, Nevada, USA; CO_2 by difference. (2) $Zn_5(CO_3)_2(OH)_6$.

Occurrence: Uncommonly formed in the oxidized portions of zinc-bearing deposits, at the expense of sphalerite or smithsonite, and as incrustations in mine workings and caves.

Association: Smithsonite, hemimorphite, willemite, cerussite, aurichalcite, calcite, "limonite".

Distribution: Widespread. A few localities affording good specimens include: from Bleiberg, Carinthia, Austria. On Monte Malfidano, near Buggerru, and in the Gutturu Pala mine, north of Iglesias, Sardinia, Italy. In commercial amounts at Picos de Europa, near Santander, and at Udias, Cantabria Province, Spain. In the USA, from Friedensville, Lehigh Co., Pennsylvania; Linden, Iowa Co., Wisconsin; at Joplin, Jasper Co., Missouri; around Galena, Cherokee Co., Kansas; abundant at Goodsprings, Clark Co., Nevada; from the Tintic district, Juab Co., Utah; pure masses in the Texas-Arizona mine, Gunnison Hills, Cochise Co., Arizona. Fine crystals from the Ojuela mine, Mapimí, Durango, Mexico. From the Tchah Kuh mine, Esfahan, and the Dareh-Bandjir and Mehdi-Abad mines, near Anjireh, Iran. In Australia, at Paddy's River mine, Australian Capital Territory; in the Billy Springs mine, near Mt. Fitton, Flinders Ranges, South Australia; and at Broken Hill, New South Wales. From Island Ford Cave, Virginia, USA. In the Shopov's cave system, Bulgaria.

Name: For the non-carbonate essential chemical components, water and *zinc*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 247–249. (2) Ghose, S. (1964) The crystal structure of hydrozincite, $Zn_5(OH)_6(CO_3)_2$. Acta Cryst., 17, 1051–1057. (3) Jambor, J.L. and G. Pouliot (1965) X-ray crystallography of aurichalcite and hydrozincite. Can. Mineral., 8, 385–389.

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Hypercinnabar HgS

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Crystal Data: Hexagonal. *Point Group:* n.d. Intimately associated with metacinnabar.

Physical Properties: *Fracture:* Subconchoidal to uneven. Hardness = 3 VHN = 51.5(8.0) (25 g load). D(meas.) = 7.43 D(calc.) = 7.54

Optical Properties: Translucent. *Color:* Black with purple cast; in polished section, grayish white. *Streak:* Dark black-purple. *Luster:* Adamantine. *Anisotropism:* Distinct in oil. R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 7.01(3)$ $c = 14.13(7)$ Z = 12

X-ray Powder Pattern: Synthetic. (ICDD 19-798).
3.08 (100), 1.980 (100), 1.892 (100), 2.80 (90), 3.43 (80), 3.70 (70), 2.97 (60)

Chemistry: Composition established by similarity of X-ray pattern with synthetic material.

Polymorphism & Series: Trimorphous with cinnabar and metacinnabar.

Occurrence: Intimately associated with metacinnabar, which it generally resembles.

Association: Metacinnabar.

Distribution: In the USA, from the Mt. Diablo mine, Contra Costa Co., California [TL]; at the White Caps mine, Manhattan district, Nye Co., Nevada.

Name: In allusion to the fact that the stability field of the species extends to higher temperatures than that of cinnabar or metacinnabar.

Type Material: n.d.

References: (1) Potter, R.W. and H.L. Barnes (1978) Phase relations in the binary Hg–S. Amer. Mineral., 63, 1143–1152.

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Håleniusite-(La) (La,Ce)OF

Crystal Data: Isometric. *Point Group:* 4/*m* $\bar{3}$ 2/*m*. As powdery coatings.

Physical Properties: *Cleavage:* n.d. *Fracture:* n.d. *Tenacity:* n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 6.5
Non-fluorescent in SW UV and LW UV.

Optical Properties: Translucent. *Color:* Yellow. *Streak:* n.d. *Luster:* [Earthy].
Optical Class: n.d.; probably isotropic. n(calc) ≈ 1.9

Cell Data: Space Group: *Fm3m*. a = 5.6282(5) *Z* = 4

X-ray Powder Pattern: Bastnäs deposit, Sweden.
3.25 (100), 1.991 (61), 1.6969 (46), 2.815 (31), 1.292 (15), 1.1486 (12), 1.6246 (9)

Chemistry:

	(1)
La_2O_3	39.29
Ce_2O_3	39.00
Pr_2O_3	4.06
Nd_2O_3	7.60
Sm_2O_3	0.28
Gd_2O_3	0.27
Y_2O_3	0.08
SiO_2	0.38
CaO	0.02
F	11.70
-O = F	4.93
Total	97.75

(1) Bastnäs deposit, Sweden; electron microprobe and EDS analyses, IR spectroscopy confirms absence of OH^- and CO_3^{2-}; corresponding to $(La_{0.431}Ce_{0.425}Nd_{0.082}Pr_{0.044}Si_{0.011}Sm_{0.003}Gd_{0.003}Y_{0.001}Ca_{0.001})_{\Sigma=1.001}F_{1.10}O_{0.95}$.

Occurrence: Formed by alteration of primary bastnäsite-(La), most likely by a decarbonation reaction.

Association: Ferriallanite-(Ce), bastnåsite-(La), quartz.

Distribution: At the Bastnäs deposit, Skinnskatteberg District, Västmanland County, Sweden.

Name: Honors Professor Ulf Hålenius (b.1951), head of the Department of Mineralogy, Swedish Museum of Natural History, for his contributions to mineral sciences.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; (no. 20030025).

References: (1) Holstam, D., J., Grins, and P.Nysten (2004) Håleniusite-(La) from the Bastnäs deposit, Västmanland, Sweden: A new REE oxy-fluoride mineral species. Can. Mineral. 42(4), 1097-1103. (2) (2005) Amer. Mineral., 90, 769 (abs. ref. 1).

Iangreyite $Ca_2Al_7(PO_4)_2(PO_3OH)_2(OH,F)_{15}\cdot 8H_2O$

Crystal Data: Hexagonal. *Point Group:* 32. As hexagonal tablets (sometimes warped), to 0.4 mm, exhibiting forms {001} and {100}; in subparallel stacked aggregates.

Physical Properties: *Cleavage:* Perfect, {001}. *Fracture:* Irregular. *Tenacity:* Brittle; somewhat flexible. Hardness = 3 D(meas.) = 2.46(3) D(calc.) = 2.451

Optical Properties: Transparent to translucent. *Color:* Colorless to white or cream, white, yellowish, or light pink. *Streak:* White.
Luster: Vitreous, pearly (aggregates).
Optical Class: Uniaxial (+). ω = 1.544(2) ε = 1.554(2)

Cell Data: *Space Group: P*321. a = 6.988(1) c = 16.707(3) Z = 1

X-ray Powder Pattern: Silver Coin mine, Nevada, USA.
16.739 (100), 2.967 (45), 2.219 (19), 6.054 (18), 1.744 (17), 5.687 (13), 1.896 (13)

Chemistry:	(1)	(2)		(1)	(2)
Na_2O	0.27	0.04	ZnO	0.10	0.05
K_2O	1.01	0.45	Al_2O_3	31.80	29.55
CaO	7.62	11.28	SiO_2	0.19	2.42
FeO	0.16	0.82	As_2O_5	0.00	0.04
BaO	0.45	0.26	P_2O_5	25.90	24.05
SrO	0.10	1.13	SO_3	0.40	0.05
MgO	0.34	0.04	F	9.53	8.23
PbO	0.00	0.04	- O = F	2.81	3.46
CuO	0.06	0.06	$H_2O_{diff.}$	24.87	24.96
MnO	0.00	0.00	Total	100.00	100.00

(1) Silver Coin mine, Nevada, USA; average of 7 electron microprobe analyses, H_2O by difference, presence of H_2O, OH, and PO_4 confirmed by IR and Raman spectroscopy; corresponding to $Ca_{1.42}K_{0.22}Na_{0.09}Ba_{0.03}Sr_{0.01}Al_{6.51}Mg_{0.09}Fe_{0.02}Cu_{0.01}Zn_{0.01}P_{3.81}F_{5.24}\ H_{30.21}O_{33.76}$.
(2) Krásno ore district, Horní Slavkov, Czech Republic; average of 12 electron microprobe analyses, corresponding to $Ca_{2.15}K_{0.10}Na_{0.01}Ba_{0.02}Sr_{0.12}Al_{6.28}\ Mg_{0.01}Fe_{0.12}Cu_{0.08}\ Zn_{0.01}P_{3.64}Si_{0.43}F_{4.65}H_{29.62}O_{34.35}$.

Occurrence: A weathering product derived from the breakdown of phosphate minerals (e.g. F-rich perhamite, "fluorapatite") by acidic ground waters derived from the oxidation of sulfide minerals.

Association: Meurigite-Na, plumbogummite, kidwellite, lipscombite, strengite, chalcosiderite, wardite, leucophosphite, wavellite, goethite, barite, quartz, and F-rich perhamite (Silver Coin mine, Nevada, USA); "fluorapatite" (Czech Republic).

Distribution: From the Silver Coin mine, Valmy, Iron Point district, Humboldt County, Nevada, USA; at the 5th level of the Huber shaft, Krásno ore district, near Horní Slavkov, Czech Republic.

Name: Honors Dr. Ian Edward Grey (b. 1944), formerly Chief Research Scientist at CSIRO Minerals, Melbourne, Australia, for his contributions to mineralogy, crystallography and the minerals-processing industry.

Type Material: Mineral Sciences Department, Natural History Museum of Los Angeles County, California, USA (57661 and 62519); Department of Mineralogy and Petrology, National Museum Prague, Czech Republic (P1P 20/2009).

References: (1) Mills, S.J., A.R. Kampf, J. Sejkora, P.M. Adams, W.D. Birch, and J. Plášil (2011) Iangreyite: a new secondary phosphate mineral closely related to perhamite. Mineral. Magazine, 75, 327-336. (2) (2013) Amer. Mineral., 98, 280 (abs. ref. 1).

Ianthinite $UO_2 \cdot 5UO_3 \cdot 10H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As plates or laths flattened on {001} and elongated along [010], also acicular or prismatic, to 2 mm. As veins or rosettes of acicular crystals; in crusts and aggregates.

Physical Properties: *Cleavage:* {001}, perfect; {100}, good. *Fracture:* Conchoidal. *Tenacity:* Flexible lamellae. Hardness = 2–3 D(meas.) = 5.16(5) D(calc.) = [5.00] Radioactive; transforms immediately to schoepite on exposure to air.

Optical Properties: Transparent to translucent. *Color:* Violet-black; on exposure to air, turns violet-brown, pale brown, then greenish yellow or yellow; dark violet in transmitted light. *Streak:* Dull violet-brown. *Luster:* Vitreous to submetallic.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless; Y = violet; Z = dark violet. *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.674(3)$ $\beta = 1.90(2)$ $\gamma = 1.92(2)$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 11.52(5)$ $b = 7.15(2)$ $c = 30.3(1)$ Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
7.63 (FF), 3.81 (m), 3.24 (m), 3.59 (fm), 3.35 (fm), 2.61 (f), 2.53 (f)

Chemistry:

	(1)	(2)
$UO_{2.84}$	90.10	
UO_3		76.06
UO_2		14.36
H_2O	[9.90]	9.58
Total	[100.00]	100.00

(1) Shinkolobwe, Congo; H_2O by difference, corresponds to $UO_2 \cdot 5UO_3 \cdot 10.56H_2O$.
(2) $UO_2 \cdot 5UO_3 \cdot 10H_2O$.

Occurrence: A rare secondary mineral in the unoxidized portions of uranium deposits.

Association: Uraninite, schoepite, becquerelite, kasolite, parsonsite, dewindtite, fourmarierite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In the Marshall Pass district, Gunnison and Saguache Co., Colorado, and in the Lucky Strike mine, La Sal Mountains, San Juan Co., Utah, USA. From Wölsendorf, Bavaria, and Menzenschwand, Black Forest, Germany. At Sabugal, Portugal. In France, from La Crouzille, Haute-Vienne; Bigay, and Les Bois Noirs, Puy-de-Dôme; Limouzat-St. Priest-la-Prugne, Loire; Les Brosses, near Grury, Saône-et-Loire; and in the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault.

Name: From the Greek for *violet*, in allusion to its color when fresh.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 633–634. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 56–60. (3) Guillemin, C. and J. Protas (1959) Ianthinite et wyartite. Bull. Soc. fr. Minéral., 82, 80–86.

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Ice H_2O

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals hexagonal, prismatic, to 0.5 m; as "snow" crystals, stellate, skeletal, flattened on [0001]; as "hail", rounded and concentrically zoned; stalactitic, compact, massive; as "frost", columnar, arborescent, feathery. *Twinning:* On {0001}; glides on {0001}.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = 0.9167 D(calc.) = [0.93] A liquid above 0 °C; diamagnetic.

Optical Properties: Transparent to translucent. *Color:* Colorless, white from inclusions, pale blue to pale green in thick layers. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.30907$ $\epsilon = 1.31052$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 4.498$ $c = 7.338$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.90 (100), 3.66 (100), 2.25 (90), 3.4 (80), 2.07 (60), 1.92 (50), 2.67 (35)

Chemistry: H_2O of varying degrees of purity.

Occurrence: Formed at low temperatures by sublimation in the atmosphere and in layers over open bodies of water; in glacial flows and thick masses of near-continental dimensions.

Association: None.

Distribution: Worldwide; especially in polar icecaps and glaciers.

Name: From Middle English *is, iis*, in turn from Old English *is*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 495–498. (2) Bentley, W.A. and W.J. Humphreys (1931) Snow crystals. McGraw-Hill, New York, 227 p. (3) Nakaya, U. (1954) Snow crystals. Harvard Univ. Press, Cambridge, 510 p. (4) Bertie, J.E., L.D. Calvert, and E. Whalley (1963) Transformations of ice II, ice III, and ice IV at atmospheric pressure. J. Chem. Phys., 38, 840–846. (5) Hall, D. and M.K. Wood (1985) A molecular-packing analysis of the crystal structures of ice. Acta Cryst., 41, 169–172.

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Idaite Cu_3FeS_4(?)

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Crystal Data: Hexagonal. *Point Group:* n.d. Massive, as rare discrete anhedral grains, as rims on chalcopyrite and as fracture fillings in chalcopyrite; also as exsolution lamellae in bornite.

Physical Properties: Hardness = 2.5–3.5 VHN = n.d. D(meas.) = 4.20 D(calc.) = 4.21

Optical Properties: Opaque. *Color:* Coppery red to pinchbeck-brown, bornitelike but not tarnished. *Luster:* Metallic. *Anisotropism:* Strong, reddish orange to reddish brown.
R_1–R_2: (400) 13.9–17.7, (420) 14.8–18.5, (440) 15.7–19.3, (460) 16.9–21.0, (480) 18.4–23.2, (500) 20.5–25.5, (520) 23.2–27.8, (540) 26.1–29.4, (560) 28.9–30.6, (580) 30.6–31.4, (600) 31.9–31.6, (620) 32.8–31.9, (640) 33.5–32.2, (660) 34.1–32.8, (680) 34.7–33.2, (700) 35.2–33.7

Cell Data: *Space Group:* n.d. $a = 3.90$ $c = 16.95$ $Z = 1$

X-ray Powder Pattern: Ida mine, Khan, Namibia.
3.14 (100), 2.82 (100), 1.89 (100), 1.85 (100), 1.564 (100), 2.70 (80), 1.317 (80)

Chemistry:

	(1)	(2)
Cu	51.34	50.87
Fe	14.5	14.90
S	33.66	34.23
Total	99.50	100.00

(1) Skouriotissa, Cyprus; by electron microprobe, average of five analyses. (2) Cu_3FeS_4.

Occurrence: A lamellar decomposition product of bornite, commonly associated with fine spindles of chalcopyrite; apparently of secondary origin, a first product of enrichment.

Association: Chalcopyrite, bornite, pyrite, sphalerite, chalcocite, pyrrhotite, mackinawite (Skouriotissa, Cyprus).

Distribution: Now noted at numerous localities world-wide. In Namibia, from the Ida mine, Khan River Valley, Swakopmund district [TL]; and at Tsumeb. Found near Bou Azzer, Morocco. At Nchanga, Zambia. From Skouriotissa, Cyprus. In Switzerland, near Grimentz, Valais. From the Clara mine, near Oberwolfach, Black Forest, Germany. At the Repparfjord copper deposit, Finnmark, Norway. From Gruvberget, Sweden. At Sasca Montană and Ciresu, Mehedinti Mountains, Romania. From the Radka deposit, Pazardzhik, and the Chelopech deposit, Sofia, Bulgaria. In the USA, at upper White Canyon, San Juan Co., Utah. From Canada, at Algoma, Jarvis Township, Ontario. In Brazil, at Caraiba, Bom Fin, Bahia. In Chile, from several mines in the Copiapó district, Atacama, and at El Indio, east of Coquimbo. In the Kaikita mine, Aomori Prefecture; the Ojamine mine, Yamagata Prefecture; and other localities in Japan.

Name: For the Ida mine in Namibia.

Type Material: n.d.

References: (1) Frenzel, G. (1958) Ein neues Mineral: Idait. Neues Jahrb. Mineral., Monatsh., 142 (in German). (2) (1958) Amer. Mineral., 43, 1219 (abs. ref. 1). (3) Frenzel, G. (1959) Ein neues Mineral: Idait, natürliches Cu_5FeS_6. Neues Jahrb. Mineral., Abh., 93, 87–114 (in German). (4) (1959) Amer. Mineral., 44, 1327 (abs. ref. 3). (5) Yund, R.A. (1963) Crystal data for synthetic $Cu_{5.5x}Fe_xS_{6.5x}$ (idaite). Amer. Mineral., 48, 472–476. (6) Sillitoe, R.H. and A.H. Clark (1969) Copper and copper-iron sulfides as the initial products of supergene oxidation, Copiapó mining district, northern Chile. Amer. Mineral., 54, 1684–1710. (7) Constantinou, G. (1975) Idaite from the Skouriotissa massive sulfide orebody, Cyprus: Its composition and conditions of formation. Amer. Mineral., 60, 1013–1018. (8) Rice, C.M., D. Atkin, J.F.W. Bowles, and A.J. Criddle (1979) Nukundamite, a new mineral, and idaite. Mineral. Mag., 43, 194–200.

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Idrialite $C_{22}H_{14}$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Small irregular square or six-sided crystals; tabular crystals are precipitated from a chloroform extraction of cinnabar ore.

Physical Properties: *Cleavage:* {001}, perfect; {100}, poor. *Fracture:* Conchoidal. Hardness = 1–1.5 D(meas.) = 1.22–1.236 D(calc.) = 1.286 M.P. 319 °C; fluoresces pale blue under UV.

Optical Properties: Semitransparent. *Color:* Pale brown to pale greenish yellow. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* X = pale yellow; $Y = Z$ = yellow. *Orientation:* $X = b$; $Y = a$, $Z = c$. *Dispersion:* $r > v$, weak. $\alpha = 1.557$ $\beta = 1.734$ $\gamma = 2.07$ 2V(meas.) = 84°

Cell Data: *Space Group:* n.d. $a = 8.07$ $b = 6.42$ $c = 27.75$ Z = 4

X-ray Powder Pattern: Idrija mine, Slovenia.
4.94 (100), 3.40 (80), 4.04 (60), 2.48 (30), 7.08 (20), 4.43 (20), 2.06 (20)

Chemistry: (1) Identification depends on correspondence of X-ray powder patterns and other data with that of synthetic material (dimethylbenzphenanthrene).

Occurrence: Probably formed by pyrolysis of organic material near hot springs or by hydrothermal fluids.

Association: Cinnabar, pyrite, gypsum, quartz, "clay" (Idrija mine, Slovenia); metacinnabar, realgar, "opal" (Skaggs Springs, California, USA).

Distribution: From the Idrija (Idria) mercury mine, 38 km west of Ljubljana, northwestern Slovenia. In the USA, in California, at Skaggs Springs, Sonoma Co.; from the Great Western, Mirabel, Helen, and Research mines, Lake Co.; in the Knoxville mine, Napa Co.

Name: For the Idrija (Idria) mine, Slovenia, from which the first specimens were collected.

Type Material: n.d.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1013. (2) Strunz, H. and B. Contag (1965) Evenkit, Flagstaffit, Idrialin und Reficit. Neues Jahrb. Mineral., Monatsh., 19–25 (in German). (3) Blumer, M. (1975) Curtisite, idrialite, and pendletonite, polycyclic aromatic hydrocarbon minerals: their composition and origin. Chem. Geol., 16, 245–256.

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Iimoriite-(Y) $Y_2(SiO_4)(CO_3)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As masses up to 3 cm.

Physical Properties: *Cleavage:* Distinct on {011}. Hardness = 5.5–6 D(meas.) = 4.47 D(calc.) = 4.91

Optical Properties: Semitransparent. *Color:* Buff-tan, light purplish gray; in thin section, colorless. *Streak:* White. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–). $\alpha = 1.75$–1.79 $\beta = 1.82$–1.83 $\gamma = 1.83$ 2V(meas.) = 31° 2V(calc.) = 31.5°

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.573(1)$ $b = 6.651(1)$ $c = 6.454(1)$ $\alpha = 116.44°$ $\beta = 92.34°$ $\gamma = 95.63°$ Z = 2

X-ray Powder Pattern: Bokan Mountain, Alaska, USA.
2.881 (100), 2.954 (80), 2.784 (40), 3.023 (36), 2.841 (35), 2.705 (29), 3.20 (27)

Chemistry:

	(1)
SiO_2	19.0
TiO_2	0.05
Y_2O_3	45.7
RE_2O_3	22.8
Fe_2O_3	0.4
CaO	0.1
MnO	0.01
H_2O^+	0.39
H_2O^-	0.10
CO_2	11.3
P_2O_5	< 0.2
Total	99.85

(1) Bokan Mountain, Alaska, USA; primarily by emission spectrographic analysis; corresponds to $(Y_{1.44}RE_{0.49}Fe^{3+}_{0.20}Ca_{0.02})_{\Sigma=2.15}Si_{1.12}O_4[(CO_3)_{0.91}(H_2O)_{0.14}]_{\Sigma=1.05}$.

Occurrence: In quartz-microcline pegmatite (Fusamata, Japan); in veins in peralkalic riebeckite-aegirine granite (Bokan Mountain, Alaska, USA).

Association: Biotite, monazite, fergusonite, uraninite, thalenite (Fusamata, Japan); quartz, albite, siderite, pyrite, fluorite, sphalerite, galena, zircon (Bokan Mountain, Alaska, USA).

Distribution: In Japan, at Fusamata and Suishoyama, Fukushima Prefecture, and Soraku, Kyoto Prefecture. On the I and L No. 4 claim, Bokan Mountain, Prince of Wales Island, Alaska, USA. From the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France.

Name: For Takeo Iimori and Satoyasu Iimori (1885–?), Japanese mineralogists, and *yttrium* in the composition.

Type Material: National Science Museum, Tokyo, Japan, M16288; National Museum of Natural History, Washington, D.C., USA, 120635.

References: (1) Kato, A. and K. Nagashima (1970) In: Introduction to Japanese minerals, Geol. Surv. Japan, 39, 85–86. (2) (1973) Amer. Mineral., 58, 140 (abs. ref. 1). (3) Foord, E.E., M.H. Staatz, and N.M. Conklin (1984) New data for iimoriite. Amer. Mineral., 69, 196–199.

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Ikaite $CaCO_3 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular {001} or pseudomorphous after a rhombohedral carbonate mineral, to 5 cm; may also be massive in porous mounds.

Physical Properties: *Tenacity:* Friable in aggregates. Hardness = n.d. D(meas.) = 1.77 D(calc.) = [1.833] Readily dehydrates to calcite above 8 °C.

Optical Properties: Translucent. *Color:* Brown.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 17°$. α = 1.455–1.460 β = 1.535–1.538 γ = 1.545 2V(meas.) = 38°–45°

Cell Data: *Space Group:* $C2/c$. $a = 8.792(2)$ $b = 8.310(2)$ $c = 11.021(2)$ $\beta = 110.53(5)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 37-416).
5.171 (100), 2.643 (85), 2.629 (70), 2.804 (50), 2.464 (33), 4.162 (29), 2.774 (27)

Chemistry:

	(1)	(2)
CO_2	21.12	21.14
CaO	26.92	26.94
H_2O	51.34	51.92
Total	99.38	100.00

(1) Sub-bottom sediment, Bransfield Strait, Antarctica; CO_2 and H_2O partitioned from weight loss according to stoichiometry. (2) $CaCO_3 \cdot 6H_2O$.

Occurrence: Forms in sea water and lake water in anerobic, organic-rich periglacial and glaciomarine environments near 0 °C, readily converting to calcite at higher temperatures.

Association: n.d.

Distribution: Likely more widespread than the following studied localities would indicate. From the waters of the Ika Fjord, eight km south of Ivigtut, Greenland. In sub-bottom sediment, Bransfield Strait, King George Basin, Antarctica. In the Zaire deep-sea fan, Atlantic Ocean. In sediments of the Nankai Trough, south of Japan. Seasonally at the tufa mounds of Mono Lake, Mono Co., California, USA.

Name: For the Ika Fjord, Greenland, where the first specimens were collected.

Type Material: n.d.

References: (1) Pauly, H. (1963) Ikait, nyt mineral der danner skaer. Naturens Verden (Copenhagen), June issue, 168–192. (in Danish). (2) (1964) Amer. Mineral., 49, 439 (abs. ref. 1). (3) Suess, E., W. Balzer, K.-F. Hesse, P.J. Müller, C.A. Ungerer and G. Wefer (1982) Calcium carbonate hexahydrate from organic-rich sediments of the Antarctic Shelf: precursors of glendonites. Science, 216, 1128–1131. (4) Jansen, J.H.F., C.F. Woensdregt, M.J. Kooistra, and S.J. van der Gaast (1987) Ikaite pseudomorphs in the Zaire deep-sea fan: an intermediate between calcite and porous calcite. Geology, 15, 245–248. (5) Hesse, K.F., H. Küppers, and E. Suess (1983) Refinement of the structure of ikaite, $CaCO_3 \cdot 6H_2O$. Zeits. Krist., 163, 227–231. (6) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 228 [mention of synthetic under "pentahydrocalcite"].

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Ikunolite $Bi_4(S,Se)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. Plates, to 3 cm, foliated massive; as minute grains.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Very flexible. Hardness = 2 VHN = n.d. D(meas.) = 7.8 D(calc.) = 7.97

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, white with faintly creamy tint. *Streak:* Dark gray. *Luster:* Metallic. *Anisotropism:* Nearly isotropic in basal section, moderately anisotropic, pale gray to gray, in diagonal section.
R_1–R_2: (400) 46.7–48.4, (420) 46.6–48.4, (440) 46.5–48.4, (460) 46.4–48.4, (480) 46.2–48.5, (500) 46.2–48.5, (520) 46.1–48.5, (540) 46.0–48.5, (560) 46.0–48.5, (580) 45.9–48.6, (600) 45.8–48.7, (620) 45.8–48.8, (640) 45.7–48.8, (660) 45.5–48.7, (680) 45.3–48.6, (700) 45.0–48.4

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.15$ $c = 39.19$ Z = 3

X-ray Powder Pattern: Ikuno mine, Japan.
3.022 (100), 4.34 (50), 2.205 (30), 6.56 (20), 3.536 (20), 2.076 (20), 1.865 (20)

Chemistry:

	(1)	(2)
Bi	79.69	87.9
Se	1.98	4.8
S	8.89	7.4
rem.	[9.44]	
Total	[100.00]	100.1

(1) Ikuno mine, Japan; remainder, by difference, is ferberite and quartz; corresponds to $Bi_{3.78}(S_{2.75}Se_{0.25})_{\Sigma=3.00}$. (2) Ashio mine, Japan; by electron microprobe, corresponds to $Bi_{4.33}(S_{2.38}Se_{0.62})_{\Sigma=3.00}$.

Occurrence: In a quartz vein (Ikuno mine, Japan).

Association: Ferberite, bismuth, bismuthinite, joséite, molybdenite, arsenopyrite, cassiterite, chalcopyrite, quartz (Ikuno mine, Japan).

Distribution: In Japan, from the Ikuno [TL] and Akenobe mines, Hyogo Prefecture, and at the Ashio mine, Tochigi Prefecture. From Kingsgate, New South Wales, Australia. In Sweden, at the Falu mine, Falun, Kopparberg. In the Osikonmaki gold deposit, Rantasalmi, Finland. From the Mullenbach uranium deposit, Black Forest, Germany. In the Vysokogorsk tin deposit, Primorskiy Kray, and from the Kara-Oba Mo–W deposit, Bet-Pak-Dal Desert, central Kazakhstan.

Name: For the Ikuno mine, Japan, where it was first found.

Type Material: National Science Museum, Tokyo, Japan, M15837; The Natural History Museum, London, England.

References: (1) Kato, A. (1959) Ikunolite, a new bismuth mineral from the Ikuno mine, Japan. Mineral. J. (Japan), 2, 397–407. (2) (1960) Amer. Mineral., 45, 477–478. (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 243.

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Ilesite $(Mn^{2+}, Zn, Fe^{2+})SO_4 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 1 mm, commonly aggregated as vein fillings and incrustations.

Physical Properties: Hardness = [2–3] (by analogy to rozenite group members). D(meas.) = 2.26 (synthetic $MnSO_4 \cdot 4H_2O$). D(calc.) = 2.26 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Green, becoming white through dehydration. *Optical Class:* Biaxial (–) (synthetic $MnSO_4 \cdot 4H_2O$). *Orientation:* $Y = b$; $Z \wedge c = 5°$. $\alpha = 1.508$ $\beta = 1.518$ $\gamma = 1.522$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* $P2_1/n$ (synthetic $MnSO_4 \cdot 4H_2O$). $a = 5.94(1)$ $b = 13.76(2)$ $c = 8.01(1)$ $\beta = 90°48(10)'$ Z = 4

X-ray Powder Pattern: Synthetic $MnSO_4 \cdot 4H_2O$. (ICDD 32-651).
4.55 (100), 5.5 (90), 4.01 (90), 2.99 (90), 3.46 (80), 3.28 (80), 3.01 (70)

Chemistry:

	(1)
SO_3	36.07
FeO	4.18
MnO	22.31
ZnO	5.97
H_2O	31.60
Total	100.13

(1) Hall Valley, Colorado, USA; corresponds to $(Mn_{0.70}Zn_{0.17}Fe_{0.13})_{\Sigma=1.00}SO_4 \cdot 4H_2O$.

Mineral Group: Rozenite group.

Occurrence: A rare secondary mineral in the oxidized zones of sulfide deposits.

Association: Pyrite, sphalerite, galena (McDonnell claim, Colorado, USA); rozenite, epsomite, copiapite, gypsum, melanterite, chvaleticeite (Chvaletice, Czech Republic).

Distribution: In the USA, from the McDonnell claim, Montezuma district, Hall Valley, Park Co., and at the Penn mine, Summit Co., Colorado. In the Silver King mine, Galena Hill, Yukon Territory, Canada. From Chvaletice, Czech Republic. At the Jokoku mine, southwest Hokkaido, Japan.

Name: Honors Malvern Wells Iles (1852–1890), American metallurgist of Denver, Colorado, USA, who made the first chemical analysis of the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 486–487. (2) Bauer, W.H. (1962) Zur Kristallchemie der Salzhydrate. Die Kristallstrukturen von $MgSO_4.4H_2O$ (Leonhardtit) und $FeSO_4.4H_2O$ (Rozenit). Acta Cryst., 15, 815–826. (3) Pasăva, J., K. Breiter, M. Huka, and J. Korecký (1986) Chvaleticeite, $(Mn, Mg)SO_4 \cdot 6H_2O$, a new mineral. Neues Jahrb. Mineral., Monatsh., 121–125.

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Ilímaussite-(Ce) **$Ba_2Na_4CeFe^{3+}Nb_2Si_8O_{28}\cdot 5H_2O$**

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\overline{6}m2$, or $6mm$. As lamellar aggregates up to 15 mm. *Twinning:* Polysynthetic twinning may be observed.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼4 D(meas.) = 3.6 D(calc.) = 3.7

Optical Properties: Transparent to translucent. *Color:* Brownish yellow. *Luster:* Resinous. *Optical Class:* Uniaxial (+). $\omega = 1.689$ $\epsilon = 1.695$

Cell Data: *Space Group:* $P6_3/mcm$, $P\overline{6}c2$, or $P6_3cm$. a = 10.80(4) $c = 20.31(7)$ Z = 3

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
2.67 (10), 3.25 (6), 3.12 (5), 2.98 (4), 2.24 (3), 2.50 (2), 2.022 (2b)

Chemistry:

	(1)	(2)
SiO_2	31.28	31.81
TiO_2	1.64	
Ce_2O_3		10.86
RE_2O_3	10.60	
Fe_2O_3	3.18	5.29
Nb_2O_5	13.20	17.59
BaO	23.62	20.29
Na_2O	7.00	8.20
K_2O	3.80	
H_2O		5.96
LOI	6.43	
Total	100.75	100.00

(1) Ilímaussaq intrusion, Greenland; alkalis by flame photometry, RE in proportions $Ce_{55}La_{23.6}Nd_{14.7}Pr_{6.7}$. (2) $Ba_2Na_4CeFeNb_2Si_8O_{28}\cdot 5H_2O$.

Occurrence: In a hydrothermal ussingite-analcime vein cutting sodalite syenite in an alkalic massif.

Association: Chkalovite, epistolite.

Distribution: At Nákâlâq, in the Ilímaussaq intrusion, southern Greenland.

Name: For the Ilímaussaq intrusion, where it was discovered.

Type Material: n.d.

References: (1) Semenov, E.I., M.E. Kazakova, and V.J. Bukin (1968) Ilimaussite, a new rare-earth-niobium-barium silicate from Ilímaussaq, South Greenland. Medd. Grønland, 181(7), 3–7. (2) (1969) Amer. Mineral., 54, 992–993 (abs. ref. 1).

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Ilinskite $NaCu_5O_2(Se^{4+}O_3)_2Cl_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As pointed crystals, tabular on {010}, to 0.35 mm, with many minor forms, elongated and striated along [001]; in sheaflike aggregates.

Physical Properties: *Cleavage:* {100}, perfect. *Tenacity:* Brittle. Hardness = n.d. VHN = 10 (15 g load). D(meas.) = n.d. D(calc.) = 4.08

Optical Properties: Transparent. *Color:* Emerald-green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Marked; $X = Z$ = green; Y = yellow-green. *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.845(5)$ $\beta = 1.965(5)$ $\gamma = 1.975(5)$ $2V(meas.) = 20(5)^\circ$ $2V(calc.) = 31^\circ$

Cell Data: *Space Group: Pbnm.* $a = 10.482(1)$ $b = 17.732(2)$ $c = 6.432(1)$ $Z = 4$

X-ray Powder Pattern: Tolbachik volcano, Russia.
5.24 (100), 8.84 (60), 3.251 (40), 2.955 (27), 2.626 (25), 2.513 (12), 9.01 (10)

Chemistry:

	(1)	(2)
SeO_2	31.27	30.27
CuO	53.54	54.26
Na_2O	3.76	4.23
K_2O	0.94	
Cl	13.93	14.51
$-O = Cl_2$	3.14	3.27
Total	100.30	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of nine analyses; corresponds to $(Na_{0.88}K_{0.14})_{\Sigma=1.02}Cu_{4.86}O_{2.16}(Se_{1.02}O_3)_2Cl_{2.84}$. (2) $NaCu_5O_2(SeO_3)_2Cl_3$.

Occurrence: A rare volcanic sublimate around fumaroles.

Association: Cotunnite, sofiite, halite, gold, tolbachite, melanothallite, chalcocyanite, burnsite, georgbokiite, chloromenite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Georgii Alekseevich Il'inskii (1927–1996), mineralogist, Saint Petersburg University, Saint Petersburg, Russia.

Type Material: Mining Institute, Saint Petersburg, 2090/1; Saint Petersburg State University, Saint Petersburg, Russia, 1/18304.

References: (1) Vergasova, L.P., T.F. Semonova, R.R. Shuvalov, S.K. Filatov, and V.V. Anan'yev (1997) Ilinskite, $NaCu_5O_2(SeO_3)_2Cl_3$ – a new mineral of volcanic exhalations. Doklady Acad. Nauk SSSR, 353, 641–644 (in Russian). (2) (1998) Amer. Mineral., 83, 186 (abs. ref. 1).

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Ilmajokite $(Na, Ce, Ba)_2TiSi_3O_5(OH)_{10} \cdot nH_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As bunches of crystals to 2 mm, granular deposits, and crusts.

Physical Properties: *Cleavage:* Perfect on rhombic prism and pinacoid, intersecting at 72°. *Tenacity:* Brittle. Hardness = 1 D(meas.) = 2.20(2) D(calc.) = n.d. Water-soluble.

Optical Properties: Transparent to translucent. *Color:* Bright yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). $\alpha = 1.573$ $\beta = 1.576$ $\gamma = 1.579$ 2V(meas.) = 90°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 39.80(4)$ $b =$ n.d. $c = 29.83(5)$ $\beta = 96°38'$ Z = n.d.

X-ray Powder Pattern: Lovozero massif, Russia.
11.5 (10), 4.3 (10), 2.44 (10), 10.2 (9), 3.1 (9), 10.9 (7), 3.7 (7)

Chemistry:

	(1)		(1)
SiO_2	35.55	CaO	0.04
TiO_2	16.95	SrO	0.02
ZrO_2	0.03	BaO	2.65
Al_2O_3	0.28	Na_2O	12.40
RE_2O_3	4.93	K_2O	0.40
Fe_2O_3	0.07	H_2O^+	16.78
Nb_2O_5	0.02	H_2O^-	7.76
Ta_2O_5	0.01	CO_2	1.46
		Total	99.36

(1) Lovozero massif, Russia; $RE_2O_3 = La_2O_3$ 26.8%, Ce_2O_3 51.2%, Pr_2O_3 3.6%, Nd_2O_3 17.8%, Sm_2O_3 17.8%; after deduction of CO_2 as nahcolite, corresponds to $(Na_{8.8}RE_{0.7}Ba_{0.5})_{\Sigma=10.0}$ $Ti_5(Si_{13.9}Al_{0.1})_{\Sigma=14.0}O_{22}(OH)_{44} \cdot nH_2O$.

Occurrence: On the walls of cavities in the central natrolite zone of pegmatites in a differentiated alkalic massif.

Association: Sphalerite, halite, mountainite, nahcolite, aegirine.

Distribution: On Mt. Karnsurt, Lovozero massif, Kola Peninsula, Russia.

Name: For the locality near the Il'majok River, Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, 3152, 3153; Mining Institute, St. Petersburg, 1061/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74041, 74080, 74490, 74491; National School of Mines, Paris, France.

References: (1) Bussen, I.V., L.F. Gannibal, E.A. Goiko, A.N. Mer'kov, and A.P. Nedorezova (1972) Ilmajokite, a new mineral from the Lovozero Tundra. Zap. Vses. Mineral. Obshch., 101, 75–79 (in Russian). (2) (1973) Amer. Mineral., 58, 139–140 (abs. ref. 1). (3) Goiko, E.A., I.V. Bussen, L.F. Gannibal, and E.A. Lipatova (1974) Ilmajokite. Uch. Zap. Leningr. Gos. Univ., Ser. Biol. Nauk 278, 174–181 (in Russian). (4) (1976) Chem. Abs., 84, 7517 (abs. ref. 3).

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Ilmenite $Fe^{2+}TiO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As thick tabular crystals, with dominant base, to rhombohedral, to 25 cm. Skeletal, granular, massive; as lamellar exsolutions in hematite or magnetite. *Twinning:* Simple on {0001}; lamellar on $\{10\overline{1}1\}$.

Physical Properties: *Cleavage:* {0001} and $\{10\overline{1}1\}$, partings. *Fracture:* Conchoidal to subconchoidal. *Tenacity:* Brittle. Hardness = 5–6 VHN = 566–698 (100 g load). D(meas.) = 4.72 D(calc.) = 4.789 Weakly magnetic.

Optical Properties: Opaque. *Color:* Iron-black; gray with a brownish tint in reflected light. *Streak:* Black to reddish brown. *Luster:* Metallic to submetallic.
Optical Class: Uniaxial (–). *Anisotropism:* Strong; in shades of gray. *Bireflectance:* Strong; *O* = pinkish brown, *E* = dark brown.
R_1–R_2: (400) 20.0–21.2, (420) 19.5–20.8, (440) 19.0–20.4, (460) 18.5–20.1, (480) 18.1–20.0, (500) 18.0–19.8, (520) 18.0–19.8, (540) 18.0–19.7, (560) 18.0–19.6, (580) 18.0–19.8, (600) 18.1–19.9, (620) 18.2–19.9, (640) 18.3–19.9, (660) 18.4–20.0, (680) 18.5–20.1, (700) 18.6–20.4

Cell Data: *Space Group:* $R\overline{3}$ (synthetic). $a = 5.08854(7)$ $c = 14.0924(3)$ Z = 6

X-ray Powder Pattern: Synthetic.
2.754 (100), 2.544 (70), 1.7261 (55), 1.8683 (40), 1.4686 (35), 3.737 (30), 2.237 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.02		Cr_2O_3	0.01	
TiO_2	52.61	52.65	FeO	42.77	47.35
Al_2O_3	0.06		MnO	0.46	
Fe_2O_3	2.22		MgO	2.30	
V_2O_3	0.13		Total	100.58	100.00

(1) Marcy massif, Adirondacks, New York, USA; by electron microprobe, Fe^{2+}:Fe^{3+} from charge balance; corresponds to $(Fe^{2+}_{0.88}Mg_{0.08}Fe^{3+}_{0.04}Mn_{0.01})_{\Sigma=1.01}Ti_{0.98}O_3$. (2) $FeTiO_3$.

Polymorphism & Series: Forms three series, with ecandrewsite, with geikielite, and with pyrophanite.

Mineral Group: Ilmenite group.

Occurrence: A common accessory mineral disseminated in igneous rocks, as granites, gabbros, and kimberlites; in granite pegmatites, carbonatites, and high-grade metamorphic rocks; may attain economic concentration in layered mafic intrusions and in "black sand" placer deposits.

Association: Magnetite, hematite, rutile, ulvöspinel, pyrrhotite, apatite.

Distribution: Widespread; well-crystallized from numerous localities. In the Vishnevy-Il'men Mountains, Southern Ural Mountains, Russia, large crystals; from the Lovozero massif, Kola Peninsula. In Norway, at Tellnes and Snarum; large crystals from Kragerøand Arendal. From Binntal, Valais, Switzerland. At St. Cristophe, Bourg d'Oisans, Isère, France. In the USA, at Quincy, Norfolk Co., Massachusetts; from Litchfield, Litchfield Co., Connecticut; large crystals from the Lake Sanford area, Essex Co., New York. At Allard Lake, Quebec; Bancroft, Ontario; and elsewhere in Canada. From Arkaroola Bore, Flinders Ranges, and near Bimbowrie, South Australia.

Name: For the early-noted occurrence in the Il'men Mountains, Russia.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 534–541. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 28–33. (3) Ashwal, L.D. (1982) Mineralogy of mafic and Fe–Ti oxide-rich differentiates of the Marcy anorthosite massif, Adirondacks, New York. Amer. Mineral., 67, 14–27. (4) Wechsler, B.A. and C.T. Prewitt (1984) Crystal structure of ilmenite ($FeTiO_3$) at high temperature and at high pressure. Amer. Mineral., 69, 176–185. (5) Ohgaki, K., M. Ohgaki, K. Tanaka, F. Marumo, and H. Takei (1989) Electron-density distribution in ilmenite-type crystals, IV. Iron (II) titanium (IV) trioxide, $FeTiO_3$. Mineral. J. (Japan), 14, 179–190. (6) (1978) NBS Mono. 25, 15, 34.

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Ilmenorutile $(Ti, Nb, Fe^{2+})O_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As dipyramidal, prismatic crystals, to 10 cm, with striated prism faces. Typically intergrown with unmixed columbite or, more rarely, ilmenite. *Twinning:* Common on {101}, rarely on {301}.

Physical Properties: *Cleavage:* {110}, distinct; {100}, imperfect. *Fracture:* Conchoidal. Hardness = 6–6.5 VHN = 860–933 D(meas.) = 4.35–4.92 D(calc.) = [4.73]

Optical Properties: Opaque, translucent through thin edges. *Color:* Black; dark yellow-green to red or reddish brown in transmitted light; pale cream in reflected light. *Streak:* Dark greenish brown to greenish black. *Luster:* Adamantine, resinous.
Optical Class: Uniaxial (+). *Pleochroism:* Strong; E = brown; O = dark bluish green or greenish blue. *Absorption:* $E > O$. $n = > 2.6$ *Anisotropism:* Strong. *Bireflectance:* Weak. R_1–R_2: n.d.

Cell Data: *Space Group:* $P4_2/mnm$. a = 4.62–4.64 c = 2.98–3.00 Z = 2

X-ray Powder Pattern: Ilmen Mountains, Russia; almost identical to strüverite.
1.695 (10), 3.269 (8), 2.497 (6), 1.626 (6), 1.047 (6), 1.456 (4), 1.386 (4)

Chemistry:

	(1)	(2)
Nb_2O_5	28.75	22.07
Ta_2O_5	1.65	1.50
TiO_2	59.49	60.31
FeO	9.31	14.62
insol.		∼1.
Total	99.20	[99.50]

(1) Věžná, Czech Republic; corresponds to $(Ti_{0.71}Nb_{0.20}Fe^{2+}_{0.12})_{\Sigma=1.03}O_2$. (2) Ampangabé, Madagascar; corresponds to $(Ti_{0.70}Nb_{0.15}Fe^{2+}_{0.19})_{\Sigma=1.04}O_2$.

Polymorphism & Series: Forms a series with strüverite; Nb:Ta > 1.

Occurrence: A late primary mineral in granite pegmatites; also in carbonatites; in alluvial placers.

Association: Columbite, ilmenite, titanite, pyrochlore, zircon, topaz, albite, microcline.

Distribution: Well-studied material from: Miass, Ilmen Mountains, also in the Vishnevy Mountains, Southern Ural Mountains, Russia. Near Iveland, Evje, Tvedestrand, and elsewhere in Norway. From Penikoja, Somero, Finland. At Věžná, near Rožná, and Údraž, near Písek, Czech Republic. On Elba, Italy, at Grotta del Guerrino. In the Gunheath china clay pit, St. Austell, Cornwall, England. From near Salak North, Kuala Kangsar, Perak, Malaya. In Japan, at Teshirogi, and in the Uzi mine, Fukushima Prefecture. From Nampoca, Alto Ligonha, Mozambique. At Ampangabé, Madagascar. Other localities are reported, some of which require modern confirmation.

Name: For the occurrence in the Ilmen Mountains, Russia, and relation to *rutile*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 554–561 [rutile, part]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 407–412. (3) Černý, P., F. Čech, and P. Povondra (1964) Review of ilmenorutile-strüverite minerals. Neues Jahrb. Mineral., Abh., 101, 142–172. (4) Černý, P., B.J. Paul, F.C. Hawthorne, and R. Chapman (1981) A niobian rutile–disordered columbite intergrowth from the Huron claim pegmatite, southeastern Manitoba. Can. Mineral., 19, 541–548.

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Ilsemannite $Mo_3O_8 \cdot nH_2O(?)$

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Crystal Data: Amorphous. *Point Group:* n.d. As earthy masses, crusts, massive; commonly as stains and admixtures with other minerals.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Solublizes in H_2O giving a deep molybdenum-blue solution.

Optical Properties: Translucent. *Color:* Black, bluish black, blue. *Streak:* Pale blue. *Optical Class:* n.d. n = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry: Adequate analyses of natural material are not available, usually being of mixtures. The mineral is thought to be identical with synthetic molybdic oxide.

Occurrence: A secondary mineral formed by the oxidation of molybdenum-bearing minerals.

Association: Jordisite, molybdenite, molybdite, wulfenite, melanterite, halotrichite, gypsum, oxidized uranium minerals.

Distribution: In Austria, at Bleiberg, Carinthia. Other localities noted for material seemingly meeting the properties characterizing the species include: from the Himmelsfürst mine, Erbisdorf, near Freiberg, Saxony, Germany. In the USA, at Marysvale, Ohio district, Piute Co., Utah; from the Kiggins mine, about 80 km southeast of Portland, Clackamas Co., Oregon; at Quinn Draw, Shannon Co., and in the Runge mine, about 10 km north of Edgemont, Fall River Co., South Dakota; about six km west of Gibson, Shasta Co., and in the Kern River Canyon district, Kern Co., California. From Cripple Creek, Teller Co., Northgate, Jackson Co., the Placerville district, San Miguel Co., and a number of other places in Colorado; at Poison Spring, Esmeralda Co., and in the Getchell mine, Humboldt Co., Nevada; in the Monument Valley No. 2 mine, Monument Valley, Apache Co., from the Cameron area, Coconino Co., and elsewhere in Arizona. In the Merced mine, Sierra de Berejillo, Durango, Mexico. From Kingsgate, New South Wales, Australia.

Name: Honors Johann Christoph Ilsemann (1727–1822), Mining Commissioner at Clausthal, Germany, for his studies on molybdenite.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 603–604. (2) Staples, L.W. (1951) Ilsemannite and jordisite. Amer. Mineral., 36, 609–614.

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Ilvaite $CaFe_2^{2+}Fe^{3+}OSi_2O_7(OH)$

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Crystal Data: Orthorhombic or monoclinic. *Point Group:* $2/m\ 2/m\ 2/m$ or $2/m$. Crystals prismatic, striated ‖ {001}, to 25 cm; columnar, radiating, or compact massive.

Physical Properties: *Cleavage:* Distinct on {001} and {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.99–4.05 D(calc.) = 4.064

Optical Properties: Opaque, translucent in fine fragments. *Color:* Iron-black or dark grayish black. *Streak:* Black, inclining to green or brown. *Luster:* Submetallic. *Optical Class:* Biaxial (+). *Pleochroism:* In thin section, intense; X = dark green; Y = yellow-brown to dark brown; Z = dark brown; in reflected light, light gray to bluish gray, pinkish red to violet. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, strong. *Absorption:* $X > Y > Z$. $\alpha = 1.727$ $\beta = 1.870$ $\gamma = 1.883$ 2V(meas.) = 20°–30° R_1–R_2: (400) 8.7–10.4, (420) 8.6–10.3, (440) 8.5–10.2, (460) 8.2–10.1, (480) 7.9–10.0, (500) 7.6–9.9, (520) 7.3–9.8, (540) 7.0–9.8, (560) 6.7–9.8, (580) 6.3–9.8, (600) 5.8–9.8, (620) 5.5–9.8, (640) 5.2–9.8, (660) 5.0–9.8, (680) 5.1–9.7, (700) 5.4–9.6 *Anisotropism:* Very strong.

Cell Data: *Space Group: Pbnm.* $a = 8.800$ $b = 13.019$ $c = 5.852$ Z = 4, or *Space Group:* $P2_1/a$. $a = 13.0103(5)$ $b = 8.8039(4)$ $c = 5.8517(3)$ $\beta = 90.209(5)°$ Z = 4

X-ray Powder Pattern: Gruba, Oberhalbstein Valley, Graubünden, Switzerland; monoclinic. 2.676 (100), 2.849 (93), 2.840 (93), 7.305 (70), 2.865 (70), 2.721 (70), 2.714 (70)

Chemistry:

	(1)	(2)
SiO_2	29.30	29.40
Fe_2O_3	20.30	19.53
FeO	33.50	35.15
MnO	1.97	
CaO	13.71	13.72
H_2O	1.90	2.20
Total	100.68	100.00

(1) Ilímaussaq intrusion, Greenland. (2) $CaFe_2^{2+}Fe^{3+}OSi_2O_7(OH)$.

Polymorphism & Series: Orthorhombic and monoclinic forms are known.

Occurrence: In contact metasomatic rocks and iron deposits; in metamorphosed limestones and dolostones with other calc-silicate minerals.

Association: Quartz, magnetite, hedenbergite, sphalerite, fluorite.

Distribution: Many localities, even for fine material. From Elba, at Rio Marina and Capo Calamita; on Mt. Mulatto, near Predazzo, Trentino-Alto Adige, Italy. Very large crystals from Seriphos, Cyclades Islands, Greece. In Germany, at St. Andreasberg, Harz Mountains; near Herborn, Hesse; and Schneeberg, Saxony. In Norway, at Fossum, near Skeen. At Thyrill, Iceland. From the Kangerdluarssuk Plateau, in the Ilímaussaq intrusion, southern Greenland. In the Kamioka mine, Gifu Prefecture, and the Obira mine, Bungo, Oita Prefecture, Japan. Fine crystals at Dal'negorsk, Primorskiy Kray, Russia. In the USA, splendid crystals from the Laxey mine, South Mountain, Owyhee Co., Idaho; from Middlemarch Pass, Dragoon Mountains, Cochise Co., Arizona; on Copper Mountain, Prince of Wales Island, Alaska.

Name: From the Latin name, *Ilva*, for the Island of Elba, on which it was first found.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 541–542. (2) Dietrich, V. (1972) Ilvait, Ferroantigorit und Greealith als Begleiter oxidisch-sulfidischer Vererzungen in den Oberhalbsteiner Serpentiniten. Schweiz. Mineral. Petrog. Mitt., 52, 57–74 (in German with English abs.). (3) Ghose, S., A.W. Hewat, and M. Marezio (1984) A neutron powder diffraction study of the crystal and magnetic structures of ilvaite from 305 K to 5 K – a mixed valence iron silicate with an electronic transition. Phys. Chem. Minerals, 11, 67–74. (4) Finger, L.W. and R.M. Hazen (1987) Crystal structure of monoclinic ilvaite and the nature of the monoclinic-orthorhombic transition at high pressure. Zeits. Krist., 179, 415–430.

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Imandrite $Na_{12}Ca_3Fe_2^{3+}Si_{12}O_{36}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Anhedral grains, to 3 mm; as rims around eudialyte.

Physical Properties: Hardness = ∼4 D(meas.) = 2.93 D(calc.) = 2.92

Optical Properties: Semitransparent. *Color:* Honey-yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). $\alpha = 1.605$ $\beta = 1.608$ $\gamma = 1.612$ 2V(meas.) = 75°

Cell Data: *Space Group: Pmnn.* $a = 10.331(1)$ $b = 10.546(1)$ $c = 7.426(4)$ Z = 1

X-ray Powder Pattern: Khibiny massif, Russia.
2.63 (100), 1.853 (70), 3.33 (60), 3.73 (50), 1.520 (50)

Chemistry:

	(1)	(2)
SiO_2	50.95	50.75
TiO_2	0.95	
ZrO_2	1.43	
Fe_2O_3	5.47	11.24
MnO	2.30	
MgO	0.26	
CaO	12.00	11.84
Na_2O	26.66	26.17
Total	100.02	100.00

(1) Khibiny massif, Russia; by electron microprobe, total Fe as Fe_2O_3. (2) $Na_{12}Ca_3Fe_2Si_{12}O_{36}$.

Mineral Group: Lovozerite group.

Occurrence: In apatite-bearing alkalic pegmatitic rocks in a differentiated alkalic massif.

Association: Eudialyte, aegirine, orthoclase, alkalic amphibole, pectolite.

Distribution: From a drill core in the Khibiny massif, Vounnemiok River area, west of Lake Imandra, Kola Peninsula, Russia.

Name: For Lake Imandra on the Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity,5530; Mining Institute, St. Petersburg, 1298/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80181; The Natural History Museum, London, England, 1994,10.

References: (1) Khomyakov, A.P., N.M. Chernitsova, S.M. Sandomirskaya, and G.L. Vasil'eva (1979) Imandrite, a new mineral of the lovozerite family. Mineral. Zhurnal, 1(1), 89–93 (in Russian). (2) (1980) Amer. Mineral., 65, 810 (abs. ref. 1). (3) (1980) Mineral. Mag., 31, 496 (abs. ref. 1). (4) Chernitsova, N.M., Z.V. Pudovkina, A.A. Voronkov, V.V. Ilyukhin, and Y.A. Pyatenko (1980) Imandrite $Na_{12}Ca_3Fe_2[Si_6O_{18}]_2$ as a representative of a new branch in the lovozerite structural family. Doklady Acad. Nauk SSSR, 252, 618–621 (in Russian). (5) (1980) Chem. Abs., 93, 141277 (abs. ref. 4).

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Imhofite $Tl_6As_{15.33}S_{26}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thin plates, which may be aggregated into radial or spherical forms, less than 1 mm.

Physical Properties: Hardness = ∼2 VHN = 38 D(meas.) = n.d. D(calc.) = 4.39

Optical Properties: Translucent. *Color:* Copper-red; in polished section, pure white, inclining to cream colored compared to galena, with strong bright red internal reflections. *Anisotropism:* Very strong.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/n$. $a = 8.755(5)$ $b = 24.425(15)$ $c = 5.739(3)$ $\beta = 108.28(5)^\circ$ Z = 2

X-ray Powder Pattern: Binntal, Switzerland.
2.675 (100), 2.88 (90), 3.96 (70), 3.67 (65), 4.10 (40), 3.58 (40), 3.18 (40)

Chemistry:

	(1)	(2)
Tl	33.6	38.22
Cu	1.67	
As	30.2	35.80
S	33.7	25.98
Total	99.17	100.00

(1) Binntal, Switzerland; by electron microprobe. (2) $Tl_6As_{15.33}S_{26}$ as determined by crystal structure analysis.

Occurrence: Of hydrothermal origin.

Association: Realgar, lead sulfantimonides.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: To honor Josef Imhof (1902–1969), professional mineral collector of Binn, Switzerland.

Type Material: Mineralogical-Petrographical Institute, University of Bern, Bern, Switzerland, L3491-64.

References: (1) Burri, G., F. Graeser, F. Marumo, and W. Nowacki (1965) Imhofit, ein neues Thallium–Arsenosulfosalz aus dem Lengenbach (Binnatal, Kanton Wallis). Chimia (Switzerland), 19, 499–500 (in German). (2) (1966) Amer. Mineral., 51, 531–532 (abs. ref. 1). (3) Nowacki, W. (1967) Über neue Mineralien aus dem Lengenbach. Jahrb. Naturhist. Mus. Bern, 1963–1965, 293–299 (in German). (4) (1969) Amer. Mineral., 54, 1498 (abs. ref. 3). (5) Divjaković, V. and W. Nowacki (1976) Die Kristallstruktur von Imhofit, $Tl_{5.6}As_{15}S_{25.3}$. Zeits. Krist., 144, 323–333 (in German with English abs.). (6) Balić-Žunić, T. and E. Makovicky (1993) Contributions to the crystal chemistry of thallium sulfosalts I. The O-D nature of imhofite. Neues Jahrb. Mineral., Abh., 165, 317–330.

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Imiterite Ag_2HgS_2

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to 1 cm, and anhedral grains.

Physical Properties: Hardness = n.d. VHN = 86 (100 g load). D(meas.) = n.d. D(calc.) = 7.846(4)

Optical Properties: Opaque. *Color:* Pale gray, steel-gray; pale greyin reflected light. *Luster:* Brilliant metallic. *Pleochroism:* Bluish to pinkish. *Anisotropism:* Strong, from bluish gray to reddish brown. *Bireflectance:* Strong.
R_1–R_2: (400) — , (420) 29.8–33.8, (440) 33.4–38.3, (460) 32.1–36.4, (480) 31.3–34.8, (500) 30.6–33.7, (520) 29.9–32.8, (540) 29.5–32.1, (560) 29.2–31.5, (580) 28.9–31.1, (600) 28.8–30.8, (620) 28.6–30.5, (640) 28.5–30.3, (660) 28.2–29.9, (680) 27.9–29.7, (700) 27.5–29.4

Cell Data: *Space Group:* $P2_1/c$. $a = 4.0394(8)$ $b = 8.0050(6)$ $c = 6.5812(8)$ $\beta = 107.12(2)^\circ$ $Z = 2$

X-ray Powder Pattern: Imiter mine, Morocco.
2.768 (100), 2.746 (100), 2.461 (80), 3.466 (50), 1.467 (35), 4.88 (30), 3.138 (30)

Chemistry:

	(1)	(2)	(3)
Ag	42.89	43.3	44.90
Hg	42.64	41.8	41.75
S	13.34	13.0	13.35
Total	98.87	98.1	100.00

(1) Imiter mine, Morocco; by electron microprobe, average of 20 analyses; corresponding to $Ag_{1.91}Hg_{1.02}S_{2.00}$. (2) Ramsbeck, Germany; by electron microprobe, corresponding to $Ag_{1.96}Hg_{1.02}S_{2.00}$. (3) Ag_2HgS_2.

Occurrence: In a pyritic deposit (Imiter mine, Morocco); in a hydrothermal vein deposit (Ramsbeck, Germany).

Association: Chalcopyrite, sphalerite, acanthite, polybasite, galena, arsenopyrite (Imiter mine, Morocco); acanthite, pyrite, marcasite, polybasite, calcite (Ramsbeck, Germany).

Distribution: From the Imiter mine, Djebel Sarhro, Anti-Atlas Mountains, Morocco [TL]. At Ramsbeck, North Rhine-Westphalia, Germany.

Name: For the Imiter mine locality in Morocco.

Type Material: Bureau de Recherches Géologiques et Minières (B.R.G.M.), Orléans; National School of Mines, Paris, France.

References: (1) Guillou, J.-J., J. Monthel, P. Picot, F. Pillard, J. Protas, and J.-C. Samama (1985) L'imitérite, Ag_2HgS_2, nouvelle espèce minérale; propriététes structure cristalline. Bull. Minéral., 108, 457–464 (in French with English abs.). (2) (1986) Amer. Mineral., 71, 1277–1278 (abs. ref. 1). (3) Walenta, K. and H. Hess (1985) Imiterit, ein silber- und quecksilberhaltiges Sulfidmineral von Ramsbeck im Sauerland. Aufschluss, 36, 209–215 (in German with English abs.).

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Imogolite $Al_2SiO_3(OH)_4$

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Crystal Data: n.d. *Point Group:* n.d. Conchoidal to earthy; as microscopic threadlike particles, and bundles of fine tubes, each about 20 Å in diameter.

Physical Properties: *Fracture:* Conchoidal, earthy. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 2.70 D(calc.) = 2.70

Optical Properties: Transparent to translucent. *Color:* White, blue, green, brown, black. *Luster:* Vitreous, resinous, waxy.
Optical Class: Isotropic. n = 1.47–1.51

Cell Data: *Space Group:* n.d. c = 8.4; 5.1 $\perp$ c Z = n.d.

X-ray Powder Pattern: Uemura, Japan; by electron diffraction.
21.0 (100b), 4.12 (100), 1.40 (100), 11.7 (80b), 7.8 (80b), 3.75 (80b), 2.32 (80b)

Chemistry: An analysis of natural material does not appear to be available.

Occurrence: In soils derived from volcanic ash.

Association: Allophane, quartz, cristobalite, gibbsite, vermiculite, "limonite".

Distribution: Probably quite widespread in volcanic-ash-derived soils. In the Misutsuchi bed, Iijima, Nagano Prefecture; the Kanumatsuchi bed, Kanuma, Tochigi Prefecture; and from Uemura, Kumamoto Prefecture, Japan.

Name: For the name, *Imogo*, of the brownish yellow volcanic ash soil of Japan in which it occurs.

Type Material: n.d.

References: (1) Yoshinaga, N. and S. Aomine (1962) Allophane in some Ando soils. Soil Sci. and Plant Nutrition (Japan), 8, 6–13. (2) (1963) Amer. Mineral., 48, 434 (abs. ref. 1). (3) Russell, J.D, W.J. McHardy, and A.R. Fraser (1969) Imogolite: a unique aluminosilicate. Clay Minerals, 8, 87–99. (4) Cradwick, P.D.G., V.C. Farmer, J.D. Russell, C.R. Masson, K. Wada, and N. Yoshinaga (1972) Imogolite, a hydrated aluminum silicate of tubular structure. Nature, Phys. Sci., 240, 187–189. (5) Wada, S.I. and K. Wada (1977) Density and structure of allophane. Clay Minerals, 12, 289–298. (6) Goodman, B.A., J.D. Russell, B. Montez, E. Oldfield, and R.J. Kirkpatrick (1985) Structural studies of imogolite and allophanes by aluminum-27 and silicon-29 nuclear magnetic resonance spectroscopy. Phys. Chem. Minerals, 12, 342–346. (7) Bayliss, P. (1987) Mineral nomenclature: imogolite. Mineral. Mag., 51, 327. (8) (1988) Amer. Mineral., 73, 198 (abs. ref. 7).

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Inaglyite $PbCu_3(Ir,Pt)_8S_{16}$

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Crystal Data: Hexagonal. *Point Group:* 6, $6/m$ $2/m$ $2/m$, 622, or $\overline{6}m2$. Irregular grains, to 150 μm; as inclusions in isoferroplatinum, intergrown with erlichmanite and malanite, and rimming iridosmine and laurite.

Physical Properties: *Cleavage:* In two directions. *Tenacity:* Brittle. Hardness = n.d. VHN = 347–726, 575 average. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Steel-gray. *Luster:* Metallic. *Anisotropism:* Weak. R_1–R_2: (400) — , (420) 41.6–42.8, (440) 41.0–42.3, (460) 40.8–42.0, (480) 40.4–41.8, (500) 40.2–41.6, (520) 40.1–41.6, (540) 40.1–41.6, (560) 40.1–41.8, (580) 40.2–42.2, (600) 40.4–42.4, (620) 40.5–42.6, (640) 40.6–42.7, (660) 40.9–42.8, (680) 41.1–43.1, (700) 41.4–43.2

Cell Data: *Space Group:* $P6_3$, $P6$, $P6/mmm$, $P622$, or $P\overline{6}2m$. $a = 7.03(1)$ $c = 16.44(1)$ Z = [1]

X-ray Powder Pattern: Inaglyi massif, Russia.
2.98 (10), 5.7 (9), 2.438 (8), 1.753 (7), 1.699 (5), 1.292 (5), 1.082 (5)

Chemistry:

	(1)
Ir	39.6
Pt	20.9
Rh	2.25
Pb	8.91
Fe	0.32
Cu	6.97
Ni	0.06
S	20.3
Total	99.31

(1) Inaglyi massif, Russia; by electron microprobe, corresponding to $Pb_{1.07}(Cu_{2.72}Fe_{0.14}Ni_{0.02})_{\Sigma=2.88}(Ir_{5.12}Pt_{2.66}Rh_{0.54})_{\Sigma=8.32}S_{15.72}$.

Occurrence: With other platinum group minerals in ultramafic intrusives.

Association: Isoferroplatinum, erlichmanite, malanite, iridosmine, laurite (Inaglyi massif, Russia).

Distribution: In Russia, from the Inaglyi massif, Aldan region, Sakha [TL], and the Aleksandrov Log platinum deposit, Mt. Solov'eva, Nizhni Tagil massif, Ural Mountains.

Name: For the occurrence in the Inaglyi massif, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1499/1.

References: (1) Rudashevskiy, N.S., A.G. Mochalov, V.D. Begizov, Y.P. Men'shikov, and N.I. Shumskaya (1984) Inaglyite, $PbCu_3(Ir,Pt)_8S_{16}$, a new mineral. Zap. Vses. Mineral. Obshch., 113, 712–717 (in Russian). (2) (1986) Amer. Mineral., 71, 228 (abs. ref. 1).

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Incaite $Pb_4Sn_4FeSb_2S_{15}$

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Crystal Data: Monoclinic, perhaps triclinic. *Point Group:* $2/m$, m, or 2; perhaps $\overline{1}$ or 1. As very fine lamellae, typically intergrown with cylindrite.

Physical Properties: *Cleavage:* Excellent on {100}. Hardness = Very soft. VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* In polished section, pale gray. *Anisotropism:* Distinct in greenish brown and brownish gray.
R_1–R_2: (480) 29.8–33.7, (540) 29.0–33.2, (600) 28.6–32.9, (640) 28.1–32.5

Cell Data: *Space Group:* Two subcells are recognized, both $A2/m$, Am, or $A2$; the first (pseudotetragonal) has: $a = 17.29(2)$ $b = 5.79(1)$ $c = 5.83(2)$ $\beta = 94.14(30)°$ and the second (pseudohexagonal) has: $a = 17.25(2)$ $b = 3.66(1)$ $c = 6.35(2)$ $\beta = 91.13(20)°$
Z = n.d.

X-ray Powder Pattern: Poopó, Bolivia.
2.862 (100), 2.029 (80), 3.43 (70), 4.31 (60), 3.83 (40), 3.23 (40), 3.12 (40)

Chemistry:

	(1)	(2)
Pb	36.53	39.77
Ag	2.15	
Sn	23.09	22.79
Fe	2.35	2.68
Sb	12.70	11.68
S	23.20	23.08
Total	100.02	100.00

(1) Poopó, Bolivia; by electron microprobe, average of five analyses; corresponding to $(Pb_{3.67}Ag_{0.37})_{\Sigma=4.04}Sn_{4.07}Fe_{0.88}Sb_{2.23}S_{15.00}$. (2) $Pb_4Sn_4FeSb_2S_{15}$.

Occurrence: In hydrothermal Ag–Sn ores (Poopó, Bolivia).

Association: Cylindrite, stannite, miargyrite (Poopó, Bolivia).

Distribution: From Poopó, Bolivia [TL]. Found near Mejillones, north of Antofagasta, Chile. In the Hoei tin mine, Oita Prefecture, Japan.

Name: For the Incas, first recorded miners of the Ag–Sn ores in the Poopó–Oruro district, Bolivia.

Type Material: Redpath Museum, McGill University, Montreal, Canada, 898.

References: (1) Makovicky, E. (1974) Mineralogical data on cylindrite and incaite. Neues Jahrb. Mineral., Monatsh., 235–256. (2) (1975) Amer. Mineral., 60, 486–487 (abs. ref. 1). (3) Makovicky, E. (1976) Crystallography of cylindrite. Part I. Crystal lattices of cylindrite and incaite. Neues Jahrb. Mineral., Abh., 126, 304–326.

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Inderborite $CaMg[B_3O_3(OH)_5]_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As well-formed prismatic crystals, to 10 cm, with a dozen forms noted; coarsely crystalline aggregates.

Physical Properties: *Cleavage:* On {100}, good. *Fracture:* Conchoidal. Hardness = 3.5 D(meas.) = 1.93–2.00 D(calc.) = [1.92] Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 2.5°$. α = 1.482–1.496 β = 1.512–1.521 γ = 1.530–1.54 2V(meas.) = 77°–86°

Cell Data: *Space Group:* $C2/c$. a = 12.137(2) b = 7.433(1) c = 19.234(3) β = 90.29(1)° Z = 4

X-ray Powder Pattern: Inder deposit, Kazakhstan.
3.35 (100), 3.26 (80), 3.07 (80), 2.45 (80), 2.29 (80), 1.801 (80), 6.13 (50)

Chemistry:

	(1)	(2)
B_2O_3	41.70	41.49
MgO	8.00	8.01
CaO	11.27	11.14
H_2O	39.48	39.36
Total	100.45	100.00

(1) Inder deposit, Kazakhstan. (2) $CaMg[B_3O_3(OH)_5]_2 \cdot 6H_2O$.

Occurrence: With other borates in the caprock of a salt diapir (Inder deposit, Kazakhstan); in lacustrine borate deposits (Sarıkaya, Turkey).

Association: Inyoite, colemanite, ulexite, szaibélyite (Inder deposit, Kazakhstan).

Distribution: Large crystals from the Inder borate deposit, Kazakhstan. In Turkey, at Sarıkaya, near Kirka, Eskiçehir Province; in the Günevi mine, Bigadiç borate district, Balıkesir Province. In the USA, from the Furnace Creek district, Death Valley, Inyo Co., California. At the Santa Rosa mine, Sijes district, Salta Province, Argentina.

Name: For the locality that produced the first specimens, the Inder deposit, Kazakhstan, and *boron*, an essential chemical component.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 43443–43447.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 355–356. (2) Burns, P.C. and F.C. Hawthorne (1994) Structure and hydrogen bonding in inderborite, a heteropolyhedral sheet structure. Can. Mineral., 32, 533–539. (3) Ikornikova-Lemmlein, N.Y. (1944) A study of a new hydrous hexaborate, inderborite. Zap. Vses. Mineral. Obshch., 73, 193–200 (in Russian).

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Inderite $MgB_3O_3(OH)_5 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As long prismatic crystals with nearly square cross-section, to 30 cm, dominated by {110}, {120}, and {001}; may be as aggregates of minute needles; reniform nodular, massive.

Physical Properties: *Cleavage:* {010}, perfect; $\{1\bar{1}0\}$, good. Hardness = 3
D(meas.) = 1.80 D(calc.) = 1.794

Optical Properties: Translucent to transparent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous to pearly on cleavages, dull, greasy.
Optical Class: Biaxial (+). *Orientation:* $X \simeq b$; $Z \wedge c = 9°$. *Dispersion:* $r > v$, weak.
$\alpha = 1.488$ $\beta = 1.491$ $\gamma = 1.505$ 2V(meas.) = 37°–43°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.0350(9)$ $b = 13.1145(13)$ $c = 6.8221(3)$
$\beta = 104.552(8)°$ Z = 4

X-ray Powder Pattern: Jenifer mine, Boron, California, USA. (ICDD 36–423).
5.052 (100), 3.357 (68), 5.72 (60), 6.61 (44), 2.662 (44), 2.558 (44), 5.84 (40)

Chemistry:

	(1)	(2)
B_2O_3	37.33	37.32
MgO	14.41	14.40
H_2O	48.28	48.28
insol.	0.08	
Total	100.10	100.00

(1) Jenifer mine, California, USA. (2) $MgB_3O_3(OH)_5 \cdot 5H_2O$.

Polymorphism & Series: Dimorphous with kurnakovite.

Occurrence: Relatively rare as a primary mineral in lacustrine borate deposits.

Association: Hydroboracite (Inder deposit, Kazakhstan); kurnakovite (Sarıkaya, Turkey); borax, ulexite, orpiment, realgar (Boron, California, USA).

Distribution: From Kyzyl Tau Mountain, Inder boron deposit, Kazakhstan. In the USA, in California, large crystals in the Boron open pit, and from the Baker and Jenifer mines, Kramer borate deposit, Kern Co.; at the Hard Scramble claim, Furnace Creek district, Death Valley, Inyo Co. In the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. From Sarıkaya, near Kirka, Eskiçehir Province, Turkey.

Name: For Inder Lake, Kazakhstan, near which the first specimens were collected.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 360–361. (2) Frondel, C., V. Morgan, and J.L.T. Waugh (1956) Lesserite [= inderite], a new borate mineral. Amer. Mineral., 41, 927–928. (3) Schaller, W.T. and M.E. Mrose (1960) The naming of the hydrous magnesium borate minerals from Boron, California – a preliminary note. Amer. Mineral., 45, 732–733. (4) Baysal, O. (1973) New hydrous magnesium-borate minerals in Turkey: kurnakovite, inderite, inderborite. Bull. Min. Res. & Explor. Inst. Turkey, Ankara, 80, 93–103. (5) (1974) Mineral. Abs., 25, 133 (abs. ref. 4). (6) Corazza, E. (1976) Inderite: crystal structure refinement and relationship with kurnakovite. Acta Cryst., 32, 1329–1333.

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Indialite $(Mg, Fe^{2+})_2Al_4Si_5O_{18}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As small hexagonal grains and clusters of spiral-shaped grains, some with tentacles or multiple terminations.

Physical Properties: Hardness = 7–7.5 D(meas.) = 2.512 (synthetic $Mg_2Al_4Si_5O_{18}$). D(calc.) = 2.59

Optical Properties: Transparent. *Color:* Colorless in thin section. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\epsilon = 1.532–1.535$ $\omega = 1.537–1.539$

Cell Data: *Space Group:* $P6/mcc$. $a = 9.800(3)$ $c = 9.345(3)$ $Z = 2$

X-ray Powder Pattern: Synthetic $Mg_2Al_4Si_5O_{18}$.
8.48 (100), 3.027 (85), 3.138 (65), 3.379 (55), 4.094 (50), 4.89 (30), 1.6882 (30)

Chemistry:

	(1)	(2)
SiO_2	48.6	47.33
Al_2O_3	34.7	32.96
FeO	7.8	12.30
MnO		0.35
MgO	9.3	5.64
Na_2O		0.36
Total	100.4	98.94

(1) Bokaro coalfield, India; by electron microprobe, corresponding to $(Mg_{1.40}Fe_{0.66})_{\Sigma=2.06}Al_{4.11}Si_{4.89}O_{18}$. (2) Unazuki, Japan; by electron microprobe, corresponding to $(Fe_{1.07}Mg_{0.88}Na_{0.07}Mn_{0.03})_{\Sigma=2.05}Al_{4.06}Si_{4.95}O_{18}$.

Polymorphism & Series: Dimorphous with cordierite.

Occurrence: Formed by fusion and recrystallization of sedimentary rocks as a result of the burning of underlying coal seams (Bokaro coalfield, India); in cordierite veins in a polymetamorphosed pelitic rock (Unazuki, Japan).

Association: Enstatite, magnetite, labradorite, corundum, glass (Bokaro coalfield, India); cordierite, andalusite, sillimanite, biotite, quartz (Unazuki, Japan).

Distribution: In the Bokaro coal seam, southwest of Hazaribagh, Bihar, India. From the Unazuki area, Toyama Prefecture, Japan. At Pyramid Lake, Washoe Co., Nevada, USA. From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany.

Name: For the country of first occurrence, India.

Type Material: n.d.

References: (1) Miyashiro, A. and T. Iiyama (1954) A preliminary note on a new mineral, indialite, polymorphic with cordierite. Proc. Japan Acad., 30, 746–751. (2) (1955) Amer. Mineral., 40, 787 (abs. ref. 1). (3) Miyashiro, A., T. Iiyama, M. Yamasaki, and T. Miyashiro (1955) The polymorphism of cordierite and indialite. Amer. J. Sci., 253, 185–208. (4) Meagher, E.P. and G.V. Gibbs (1977) The polymorphism of cordierite: II. The crystal structure of indialite. Can. Mineral., 15, 43–49. (5) Venkatesh, V. (1952) Development and growth of cordierite in para-lavas. Amer. Mineral., 37, 831–847. (6) Daniels, P. (1990) What is the true space group of high-cordierite? Zeits. Krist., 190, 271–276. (7) (1961) NBS Mono. 25, 1, 29.

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Indigirite $Mg_2Al_2(CO_3)_4(OH)_2 \cdot 15H_2O$

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Crystal Data: n.d. *Point Group:* n.d. As plates and fibers to 1 mm; in radiating rosettelike aggregates.

Physical Properties: *Tenacity:* Flexible. Hardness = ∼2 D(meas.) = 1.6(1) D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Snow-white. *Luster:* Vitreous to silky. *Optical Class:* Biaxial. *Orientation:* Positive elongation, parallel extinction. $\alpha = 1.472(2)$ β = n.d. $\gamma = 1.502(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Sarylakh deposit, Russia.
5.80 (10), 7.62 (9), 5.24 (9), 2.70 (9), 2.60 (9), 4.56 (8), 1.625 (5)

Chemistry:

	(1)	(2)
SO_3	0.45	
CO_2	24.18	27.22
Al_2O_3	14.58	15.76
Fe_2O_3	0.64	
MgO	12.08	12.46
CaO	0.45	
H_2O	44.36	44.56
insol.	1.60	
Total	98.34	100.00

(1) Sarylakh deposit, Russia; $(CO_3)^{2-}$, $(OH)^{1-}$, H_2O confirmed by IR; after deduction of insoluble as quartz, CaO and SO_3 as gypsum, and Fe_2O_3 as "limonite", corresponds to $Mg_{2.00}Al_{2.00}(CO_3)_{3.86}(OH)_{2.00} \cdot 15.36H_2O$. (2) $Mg_2Al_2(CO_3)_4(OH)_2 \cdot 15H_2O$.

Occurrence: A rare filling in cracks in shale in the oxidized portions of a hydrothermal vein Au–Sb deposit.

Association: Gypsum, gibbsite, kaolinite, hexahydrite, melanterite, amorphous Fe oxide, stibnite, quartz.

Distribution: From the Sarylakh Au–Sb deposit, upper Indigirka River, northeast Sakha, Russia.

Name: For the Indigirka River, Russia, near where the first specimens were collected.

Type Material: Geological Museum, Yakutsk Scientific Center, Yakutsk, mk-192; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76565, 76566.

References: (1) Indolev, L.N., Y.Y. Zhdanov, K.I. Kashertseva, V.S. Suknev, and K.I. Delyanidi (1971) Hydrous carbonate of magnesium and aluminum – the new mineral indigirite. Zap. Vses. Mineral. Obshch., 100, 178–183 (in Russian). (2) (1972) Amer. Mineral., 57, 326–327 (abs. ref. 1).

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Indite $Fe^{2+}In_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, as grains, to 0.5 mm.

Physical Properties: Hardness = n.d. VHN = 309 D(meas.) = n.d. D(calc.) = 4.588

Optical Properties: Opaque. *Color:* Iron-black; in polished section, white. *Luster:* Metallic. R: (400) 26.3, (420) 26.9, (440) 27.5, (460) 27.9, (480) 28.0, (500) 27.8, (520) 27.4, (540) 27.0, (560) 26.6, (580) 26.2, (600) 25.9, (620) 25.6, (640) 25.4, (660) 25.1, (680) 24.8, (700) 24.5

Cell Data: *Space Group: Fd3m.* a = 10.618(3) Z = 8

X-ray Powder Pattern: Dzhalinda deposit, Russia.
3.20 (100), 1.877 (90), 1.085 (80), 2.05 (70), 1.028 (70), 3.76 (50), 1.384 (50)

Chemistry:

	(1)	(2)
Fe	8.84	13.50
In	59.3	55.50
S	31.85	31.00
Total	99.99	100.00

(1) Dzhalinda deposit, Russia; by microspectrographic analysis, corresponding to $Fe_{0.64}In_{2.08}S_{4.00}$.
(2) $FeIn_2S_4$.

Mineral Group: Linnaeite group.

Occurrence: Of primary hydrothermal origin, replacing botryoidal cassiterite.

Association: Cassiterite, dzhalindite.

Distribution: In the Dzhalinda deposit, Little Khingan Ridge, Far Eastern Region, Russia [TL].

Name: For the indium in its composition.

Type Material: Mining Institute, St. Petersburg, 106a/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 62579.

References: (1) Genkin, A.D. and I.V. Murav'eva (1963) Indite and dzhalindite – new indium minerals. Zap. Vses. Mineral. Obshch., 92, 445–457 (in Russian). (2) (1964) Amer. Mineral., 49, 439 (abs. ref. 1). (3) Hill, R.J., J.R. Craig, and G.V. Gibbs (1978) Cation ordering in the tetrahedral sites of the thiospinel $FeIn_2S_4$ (indite). J. Phys. Chem. Solids, 39, 1105–1111.

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Indium In

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Massive, as grains, to 1 mm.

Physical Properties: Hardness = n.d. VHN = 130–159, 142 average. D(meas.) = n.d. D(calc.) = 7.29

Optical Properties: Opaque. *Color:* Gray with yellowish tint; in polished section, pale rose. *Luster:* Metallic. *Anisotropism:* Weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I4/mmm$. $a = 3.2517$ $c = 4.9459$ Z = 2

X-ray Powder Pattern: Synthetic.
2.715 (100), 2.298 (36), 1.683 (24), 1.395 (23), 2.471 (21), 1.470 (16), 1.0904 (12)

Chemistry: Composition established by microspectrographic analysis.

Occurrence: In greisenized and albitized granite (Orlovskoye deposit, Russia).

Association: Silver (Orlovskoye deposit, Russia).

Distribution: In Russia, from the Orlovskoye tantalum deposit, eastern Transbaikal [TL], and an undefined locality in the Ukrainian Shield.

Name: From its indigo blue emission spectrum.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis54.

References: (1) Ivanov, V.V. (1964) Native indium. In: Geochemistry, mineralogy, and genetic types of deposits of rare elements, 2, 568–569. Izdatelstvo "Nauka" Moscow (1964) (in Russian). (2) (1967) Amer. Mineral., 52, 299 (abs. ref. 1). (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 584–585. (4) (1954) NBS Circ. 539, 3, 12.

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Inesite $\mathbf{Ca_2Mn_7^{2+}Si_{10}O_{28}(OH)_2 \cdot 5H_2O}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals slender laths, may be chisel-shaped, to 7 cm, typically forming radiating fan-shaped clusters; fibrous, in veinlets, and massive.

Physical Properties: *Cleavage:* Perfect on {010}, good on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.03–3.04 D(calc.) = 3.03

Optical Properties: Transparent to translucent. *Color:* Rose-red, pink, orange-pink, orange-red-brown, deep wine-red; changes to ginger-brown on exposure. *Streak:* White. *Luster:* Vitreous to silky.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = 74°$; $Y \wedge c = 32°$; $Z \wedge c = 62°$.
Dispersion: $r > v$, weak, distinct. $\alpha = 1.6178–1.6183$ $\beta = 1.6384–1.6390$ $\gamma = 1.6519–1.6526$
2V(meas.) = 74°–77°

Cell Data: *Space Group:* $P\bar{1}$. $a = 8.889(2)$ $b = 9.247(2)$ $c = 11.975(3)$ $\alpha = 88.15(2)°$ $\beta = 132.07(2)°$ $\gamma = 96.64(2)°$ Z = 1

X-ray Powder Pattern: Broken Hill, Australia.
9.16 (100), 2.92 (80), 2.84 (80), 2.73 (70), 2.19 (60), 4.59 (50), 4.01 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	45.67	45.00	45.60
Al_2O_3		0.32	
FeO	0.92	1.73	
MnO	35.10	37.48	37.69
MgO	0.86	0.47	
CaO	9.33	6.78	8.51
K_2O		0.01	
H_2O	8.66	8.27	8.20
Total	100.54	[100.06]	100.00

(1) Quinault, Washington, USA. (2) Equity mine, Colorado, USA; original total given as 100.10%. (3) $Ca_2Mn_7Si_{10}O_{28}(OH)_2 \cdot 5H_2O$.

Occurrence: A late-stage hydrothermal mineral in manganese deposits.

Association: Rhodochrosite, bementite, hausmannite (Hale Creek mine, California, USA); datolite, pectolite, apophyllite, ruizite, orientite, quartz (Wessels mine, South Africa).

Distribution: In Germany, from Nanzenbach, near Dillenburg, Hesse. At Långban and in the Harstigen mine, near Persberg, Värmland, Sweden. From Săcărâmb (Nagyág), Romania. At Banská Štiavnica (Schemnitz), Slovakia. From the Wessels and N'Chwaning mines, near Kuruman, Cape Province, South Africa. In the USA, from Quinault, Grays Harbor Co., and in the Crescent mine, Olympic Peninsula, Clallam Co., Washington; in the Equity mine, near Creede, Mineral Co., Colorado; at the Hale Creek mine, near Red River, Trinity Co., and several other places in California. At Broken Hill, New South Wales, Australia. In Japan, at the Yugashima, Seikoshi, and Kawazu mines, Shizuoka Prefecture; the Innai mine, Akita Prefecture; the Kocho mine, Kochi Prefecture; and the Todoroki mine, Hokkaido.

Name: From the Greek for *flesh fibers*, in allusion to its color and structure.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 564.
(2) Richmond, W.E. (1942) Inesite, $Mn_7Ca_2Si_{10}O_{28}(OH)_2 \cdot 5H_2O$. Amer. Mineral., 27, 563–568.
(3) Ryall, W.R. and I.M. Threadgold (1968) Inesite from the Broken Hill lode, New South Wales, Australia. Amer. Mineral., 53, 1614–1634. (4) Che'ng Wan and S. Ghose (1978) Inesite, a hydrated calcium manganese silicate with five-tetrahedral-repeat double chains. Amer. Mineral., 63, 563–571. (5) Van Loenen, R.E. (1980) Inesite, a new U.S. occurrence near Creede, Mineral County, Colorado. Mineral. Record, 11, 35–36.

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Ingersonite $Ca_3Mn^{2+}Sb_4^{5+}O_{14}$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. As crystals with imperfect hexagonal cross sections or as laths, to 0.4 mm; in massive aggregates.

Physical Properties: *Cleavage:* {0001}, perfect; imperfect rhombohedral cleavage. *Fracture:* Uneven. Hardness = n.d. VHN = 974–1097 (100 g load). D(meas.) = n.d. D(calc.) = 5.42

Optical Properties: Transparent to translucent. *Color:* Brownish yellow; medium to light yellow in transmitted light; light gray with yellow and white internal reflections in reflected light. *Streak:* Brownish yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (–).
R_1–R_2: (400) 11.16–11.40, (420) 10.94–11.13, (440) 10.74–10.88, (460) 10.52–10.66, (480) 10.34–10.48, (500) 10.18–10.32, (520) 10.05–10.19, (540) 9.96–10.09, (560) 9.91–10.04, (580) 9.89–10.01, (600) 9.89–10.02, (620) 9.90–10.03, (640) 9.90–10.03, (660) 9.91–10.03, (680) 9.91–10.03, (700) 9.91–10.03

Cell Data: *Space Group:* $P\overline{3}m$, $P3m1$, $P31m$, $P32$, $P3_12$, or $P3_22$. $a = 7.287(3)$ $c = 17.679(9)$ $Z = 3$

X-ray Powder Pattern: Långban, Sweden.
2.965 (100), 1.549 (60), 1.820 (50), 1.810 (50), 2.565 (40), 1.543 (40), 0.9894 (30)

Chemistry:

	(1)	(2)	(3)
Sb_2O_5	74.7	72.6	73.01
FeO	0.2	0.3	
MnO	9.4	9.1	8.01
MgO	0.0	0.3	
CaO	15.9	19.9	18.98
Total	100.2	102.2	100.00

(1–2) Långban, Sweden; by electron microprobe, F present between 1.4% and 3%, total not corrected for $-O = F_2$; (2) corresponds to $Ca_{3.01}Mn_{0.99}(Sb_{3.80}Mn_{0.09}Mg_{0.06}Fe_{0.04})_{\Sigma=3.99}O_{13.70}F_x$. (3) $Ca_3MnSb_4O_{14}$.

Occurrence: In dump material from a metamorphosed Fe–Mn orebody.

Association: Filipstadite, jacobsite, calcite, clinohumite (?).

Distribution: At Långban, Värmland, Sweden.

Name: Honors Dr. Fred Earl Ingerson (1906–1993), geochemist with the U.S. Geological Survey and Emeritus Professor, University of Texas, Austin, Texas, USA.

Type Material: The Natural History Museum, London, England, 1986,410, E.1177; National Museum of Natural History, Washington, D.C., USA, 163012.

References: (1) Dunn, P.J., D.R. Peacor, A.J. Criddle, and C.J. Stanley (1988) Ingersonite, a new calcium-manganese antimonate related to pyrochlore, from Långban, Sweden. Amer. Mineral., 73, 405–412.

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Ingodite $Bi_2(S, Te)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. Massive, presumably.

Physical Properties: *Cleavage:* Perfect. *Tenacity:* Brittle. Hardness = Soft.
VHN = 60.9–64.6 D(meas.) = n.d. D(calc.) = 7.88

Optical Properties: Opaque. *Color:* Silver-white. *Luster:* Metallic. *Pleochroism:* Noticeable in air, from creamy to grayish white. *Anisotropism:* Moderate.
R_1–R_2: (460) 55.5–51.4, (540) 57.7–52.5, (580) 57.8–52.4, (660) 56.9–51.6

Cell Data: *Space Group:* $P\overline{3}m$, $P3m1$, $P31m$, or $P321$. $a = 4.2477(24)$ $c = 23.075(22)$
$Z = 3$

X-ray Powder Pattern: Ingoda deposit, Russia or Brandy Gill, England.
3.10 (10), 2.27 (5), 1.647 (5), 2.13 (4), 1.929 (3), 1.254 (3), 1.224 (3)

Chemistry:

	(1)	(2)
Bi	73.3	72.36
Pb	0.6	
Te	19.3	22.09
Se	0.1	
S	6.3	5.55
Total	99.6	100.00

(1) Ingoda deposit, Russia or Brandy Gill, England; by electron microprobe, corresponds to $Bi_{2.00}Pb_{0.02}(S_{1.12}Te_{0.86}Se_{0.01})_{\Sigma=1.99}$. (2) $Bi_2(S, Te)$ with S:Te = 1:1.

Occurrence: In feldspar-quartz veins and greisen (Ingoda deposit, Russia).

Association: Bismuthinite, joséite, tetradymite (Ingoda deposit, Russia); gold, bismuthinite, baksanite, joséite-A (Tyrnyauz deposit, Russia).

Distribution: In Russia, from the Verkhne-Ingodinskoye (Ingoda) tin deposit, near the source of the Ingoda River, central Transbaikal [TL]; and otherwise unspecified localities in Kamchatka and the Southern Ural Mountains; in the Tyrnyauz W–Mo deposit, left bank of the Baksan River Valley, northern Caucasus Mountains. At Brandy Gill, Cumbria, England [TL]. From Băiţa (Rézbánya), Romania. At the Bluebird mine, Little Dragoon Mountains, Cochise Co., Arizona, USA.

Name: For the Ingoda deposit, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis1803.

References: (1) Zav'yalov, E.N. and V.D. Begizov (1981) The new bismuth mineral ingodite, Bi_2TeS. Zap. Vses. Mineral. Obshch., 110, 594–600 (in Russian). (2) Zav'yalov, E.N. and V.D. Begizov (1981) Once again on the problem of grünlingite. Zap. Vses. Mineral. Obshch., 110, 633–635 (in Russian). (3) (1982) Amer. Mineral., 67, 855 (abs. refs. 1 and 2). (4) Zav'yalov, E.N., V.D. Begizov, and V.Y. Tedchuk (1984) Additional data on the chemical composition of ingodite. Zap. Vses. Mineral. Obshch., 113, 31–35 (in Russian). (5) Bayliss, P. (1991) Crystal chemistry and crystallography of some minerals in the tetradymite group. Amer. Mineral., 257–265.

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Innelite $Na_2CaBa_4Ti_3O_4(Si_2O_7)_2(SO_4)_2$

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Crystal Data: Triclinic. *Point Group:* 1. As plates, to 1 cm, rarely with faces, with {001} and {010} the most common; in radiating groups. *Twinning:* Polysynthetic Manebach twinning.

Physical Properties: *Cleavage:* Perfect on {010}, {110}, $\{1\bar{1}0\}$, good on {001}. *Tenacity:* Brittle. Hardness = 4.75 VHN = 435 D(meas.) = 3.96 D(calc.) = [3.81] Piezoelectric; slightly electromagnetic.

Optical Properties: Transparent to translucent. *Color:* Pale yellow to brown. *Luster:* Vitreous on cleavages, slightly resinous on fractures. *Optical Class:* Biaxial (+). *Pleochroism:* $X = Y$ = light yellow; Z = pale brownish yellow. *Orientation:* $Z \simeq a$. *Dispersion:* $r > v$, strong; sections cut $\perp$ {001} show anomalous bluish interference color. $\alpha = 1.726(1)$ $\beta = 1.737(1)$ $\gamma = 1.766(1)$ 2V(meas.) = 82(2)°

Cell Data: *Space Group:* $P1$. $a = 14.76$ $b = 7.14$ $c = 5.38$ $\alpha = 90°$ $\beta = 95°$ $\gamma = 99°$ Z = 1

X-ray Powder Pattern: Inagli massif, Russia.
3.92 (10), 3.04 (6), 2.95 (6), 1.964 (6), 1.845 (6), 1.735 (6), 6.31 (5)

Chemistry:

	(1)		(1)
SiO_2	18.78	BaO	44.16
TiO_2	18.50	Na_2O	5.63
Al_2O_3	0.23	K_2O	0.72
Fe_2O_3	0.66	F	0.40
FeO	0.57	H_2O^+	0.88
MnO	1.04	H_2O^-	0.09
MgO	0.83	SO_3	7.19
CaO	0.72	$-O = F_2$	0.17
		Total	100.23

(1) Inagli massif, Russia; corresponds to $(Na_{2.33}Mg_{0.27}Ca_{0.16}Fe^{2+}_{0.11}Fe^{3+}_{0.10})_{\Sigma=2.97}$ $(Ba_{3.69}K_{0.20}Mn_{0.19})_{\Sigma=4.08}Ti_{2.96}(Si_2O_7)_2(S_{0.58}O_4)_2[O_{2.75}(OH)_{1.25}F_{0.27}]_{\Sigma=4.27}$.

Occurrence: In miarolitic cavities of aegirine-eckermannite-microcline pegmatites in dunites; in pulaskite and shonkinite.

Association: Natrolite, albite, lorenzenite, batisite.

Distribution: In the Inagli massif, 30 km west of Aldan, and the Yakokut massif, near Schelochnoy Spring, Yakutia, Russia.

Name: From the Yakut name, *Inneli*, for the Inagli River, Yakutia, Russia.

Type Material: Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; Mining Institute, St. Petersburg, 846a/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; National Museum of Natural History, Washington, D.C., USA, 143822.

References: (1) Kravchenko, S.M., E.V. Vlasova, M.E. Kazakova, V.V. Ilokhin, and K.K. Abrashev (1961) Innelite, a new barium silicate. Doklady Acad. Nauk SSSR, 141, 1198–1199 (in Russian). (2) (1962) Amer. Mineral., 47, 805–806 (abs. ref. 1). (3) Chernov, A.N., V.V. Ilyukhin, B.A. Maksimov, and N.V. Belov (1971) Crystal structure of innelite, $Na_2Ba_3(Ba,K,Mn)(Ca,Na)Ti(TiO_2)_2[Si_2O_7]_2(SO_4)_2$. Kristallografiya (Sov. Phys. Crystal.), 16, 87–92 (in Russian).

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Insizwaite $Pt(Bi, Sb)_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As small rounded grains, to 120 μm.

Physical Properties: Hardness = n.d. VHN = 488–540, 519 average (25 g load). D(meas.) = n.d. D(calc.) = 12.8

Optical Properties: Opaque. *Color:* In polished section, white. *Luster:* Metallic.
R: (400) 55.7, (420) 56.4, (440) 57.2, (460) 57.8, (480) 58.4, (500) 58.8, (520) 59.2, (540) 59.5, (560) 59.8, (580) 60.1, (600) 60.3, (620) 60.4, (640) 60.4, (660) 60.3, (680) 60.3, (700) 60.3

Cell Data: *Space Group: Pa*3. $a = 6.691$ $Z = 4$

X-ray Powder Pattern: Synthetic $PtBi_2$.
2.996 (100), 2.017 (90), 2.732 (80), 1.788 (60), 3.343 (50), 1.459 (50), 0.772 (50)

Chemistry:

	(1)	(2)
Pt	36.1	31.2
Pd		1.4
Ni		0.17
Sn		1.3
Bi	52.0	55.2
Sb	12.9	2.4
Te		7.7
Total	101.0	100.5

(1) Insizwa deposit, South Africa; by electron microprobe, average of five analyses; corresponding to $Pt_{1.00}(Bi_{1.35}Sb_{0.57})_{\Sigma=1.92}$. (2) Sudbury, Canada; by electron microprobe; corresponding to $(Pt_{0.90}Pd_{0.08}Ni_{0.02})_{\Sigma=1.00}(Bi_{1.49}Te_{0.34}Sb_{0.11}Sn_{0.06})_{\Sigma=2.00}$.

Mineral Group: Pyrite group.

Occurrence: Of hydrothermal origin, in a vein cutting massive pyrrhotite ore (Insizwa deposit, South Africa); in Cu–Ni sulfide ore (Sudbury, Canada).

Association: Pentlandite, cubanite, hessite, altaite, argentopentlandite, chalcopyrite, mackinawite, niggliite, froodite, parkerite, galena, sphalerite, magnetite, pyrrhotite.

Distribution: From the Insizwa Cu–Ni deposit, Waterfall Gorge, East Cape, South Africa [TL]. In the Coleman mine, Sudbury, and the Strathcona mine, Falconbridge, Ontario, Canada. At Fox Gulch, Goodnews Bay, Alaska, USA. From the Noril'sk region, western Siberia, Russia.

Name: For the Insizwa deposit, South Africa, where it was discovered.

Type Material: Geological Survey of Canada, Ottawa, 10400; Canadian Museum of Nature, Ottawa, Canada.

References: (1) Cabri, L.J. and D.C. Harris (1972) The new mineral insizwaite ($PtBi_2$) and new data on niggliite (PtSn). Mineral. Mag., 38, 794–800. (2) (1973) Amer. Mineral., 58, 805 (abs. ref. 1). (3) Brese, N.A. and H.G von Schnering (1994) Bonding trends in pyrites and a reinvestigation of the structures of $PdAs_2$, $PdSb_2$, $PtSb_2$ and $PtBi_2$. Z. Anorg. Allg. Chem., 620, 393–404. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 109–110, 162. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 251.

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Inyoite $CaB_3O_3(OH)_5 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically as crystals, short prismatic along [001], tabular on {001}, exhibiting prominent {110} and {001} and a dozen other minor forms, to 2.5 cm; in cockscomb aggregates of pseudorhombohedral crystals; also coarse spherulitic, granular.

Physical Properties: *Cleavage:* {001}, good; {010}, distinct. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 1.875 D(calc.) = 1.87 Soluble in H_2O.

Optical Properties: Transparent, translucent on dehydration. *Color:* Colorless, white on dehydration. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 37°$; $Z \wedge c = -53°$. *Dispersion:* $r < v$, slight. $\alpha = 1.490–1.495$ $\beta = 1.501–1.505$ $\gamma = 1.516–1.520$ 2V(meas.) = 70°–86°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.621(1))$ $b = 12.066(1)$ $c = 8.408(1)$ $\beta = 114°1.2°$ Z = 4

X-ray Powder Pattern: Monte Azul mine, Argentina.
7.67 (100), 2.526 (25), 3.368 (22), 1.968 (22), 2.547 (21), 3.450 (20), 2.799 (19)

Chemistry:

	(1)	(2)
B_2O_3	37.44	37.62
CaO	20.42	20.20
H_2O^+	9.46	
H_2O^-	32.46	
H_2O		42.18
rem.	0.55	
Total	100.33	100.00

(1) Hillsborough, Canada; remnant is gypsum. (2) $CaB_3O_3(OH)_5 \cdot 4H_2O$.

Occurrence: Along fractures and nodular in sedimentary borate deposits; may be authigenic in playa sediments.

Association: Meyerhofferite, colemanite, priceite, hydroboracite, ulexite, gypsum.

Distribution: In the USA, in California, from an adit on Mount Blanco, Furnace Creek district, Death Valley, Inyo Co., and in the Kramer borate deposit, Boron, Kern Co. From Hillsborough and Wentworth, New Brunswick, Canada. In large amounts in the Inder boron deposit, Kazakhstan. From many deposits in the Bigadiç borate district, Balıkesir Province, Turkey. In Argentina, from the Loma Blanca deposit, eight km southwest of Coranzulí, Jujuy Province; in the Tincalayu borax deposit, Salar del Hombre Muerto, and at the Monte Azul mine, south of Sijes, Salta Province. From Laguna Salinas, about 65 km east of Arequipa, Arequipa Province, Peru.

Name: For Inyo Co., California, USA, wherein the first specimens were collected.

Type Material: National Museum of Natural History, Washington, D.C., USA, 87237, 93639.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 358–360. (2) Christ, C.L. (1953) Studies of borate minerals (II): X-ray crystallography of inyoite and meyerhofferite; X-ray and morphological crystallography of $2CaO \cdot 3B_2O_3 \cdot 9H_2O$. Amer. Mineral., 38, 912–918. (3) Muessig, S. (1958) First known occurrence of inyoite in a playa, at Laguna Salinas, Peru. Amer. Mineral., 43, 1144–1147. (4) Clark, J.R. (1959) Studies of borate minerals. IV. The crystal structure of inyoite, $CaB_3O_3(OH)_5 \cdot 4H_2O$. Acta Cryst., 12, 162–170. (5) Aristarain, L. and R. Erd (1971) Inyoita, $2CaO.3B_2O_3.13H_2O$, de la Puna, Argentina. Annal. Soc. Cient. Argent., 191(5–6), 191–211 (in Spanish with English abs.).

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Iodargyrite AgI

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Crystal Data: Hexagonal. *Point Group:* $6mm$. As prismatic to tabular hexagonal crystals, commonly hemimorphic, may have complex pyramid development, possibly with a cavity on {0001}, to 1.5 cm. Also lamellar or scaly ∥ {0001}; barrel-shaped to globular, in rosettes, massive. *Twinning:* On $\{30\overline{3}4\}$, may produce fourlings.

Physical Properties: *Cleavage:* {0001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Sectile, flexible. Hardness = 1.5 D(meas.) = 5.69 D(calc.) = 5.709

Optical Properties: Transparent. *Color:* Colorless, becoming yellow on exposure to light; greenish yellow, brown, pearl-gray; colorless in transmitted light, with abnormal green interference colors. *Streak:* Yellow, shining. *Luster:* Resinous to adamantine, pearly on cleavage surfaces. *Optical Class:* Uniaxial (+); anomalously biaxial due to deformation. *Dispersion:* Very large. $\omega = 2.21$ $\epsilon = 2.22$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P6_3mc$ (synthetic). $a = 4.594(1)$ $c = 7.513(2)$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 9-374).
3.75 (100), 2.296 (85), 3.98 (60), 1.959 (50), 3.51 (40), 2.119 (30), 2.731 (18)

Chemistry: Modern analyses are not available; early analyses confirm AgI.

Occurrence: A secondary mineral in the oxidized portions of silver-bearing deposits.

Association: Silver, acanthite, chlorargyrite, bromargyrite, cerussite, "limonite".

Distribution: Many localities; some for abundant or well-crystallized material include: in Mexico, at Abarradón, near Mazapil, Zacatecas. In the USA, at Tonopah, Nye Co., and Goldfield, Esmeralda Co., Nevada; from Lake Valley, Sierra Co., New Mexico; in the Commonwealth mine, Pearce, Cochise Co., and elsewhere in Arizona. In Chile, at Chañarcillo, south of Copiapó, Atacama; at Caracoles, Sierra Gorda district, Antofagasta; and at Algodones, near Coquimbo. Large amounts at Broken Hill, New South Wales, Australia. In Germany, from the Schöne Aussicht mine, Dernbach, Rhineland-Palatinate, and at Reichenbach, Odenwald, Hesse. From Hiendelaencina, Guadalajara Province, Spain. At Montmins, Allier, France. From Dzhezkazgan, Kazakhstan.

Name: From IODine and the Greek for *silver*, ARGYRos, in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 22–25 [iodyrite]. (2) Berthold, H.J. and P.M. Kaese (1989) Anharmonische Verfeinerung der thermischen Parameter des $\beta-$AgI bei 294 K und 400 K. Zeits. Krist., 186, 38–40 (in German). (3) (1959) NBS Circ. 539, 8, 51.

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Iowaite $Mg_6Fe_2^{3+}Cl_2(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As platy crystals, to 2.5 cm, in masses in veins.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Waxy, becoming friable after contact with air. Hardness = 1.5–2.5 D(meas.) = 2.09 D(calc.) = 2.04 Greasy or soapy feel.

Optical Properties: Opaque to translucent. *Color:* Bluish green, becoming pale green with a rusty red tint on exposure to air (alteration to pyroaurite), yellowish to colorless, may be zoned; colorless in transmitted light. *Streak:* White. *Luster:* Greasy.
Optical Class: Uniaxial (–); commonly anomalously biaxial. *Pleochroism:* Intense; O = pale yellow; E = deep blue-green. ω = 1.543–1.561 ϵ = 1.533–1.543 2V(meas.) = 5°

Cell Data: *Space Group:* $R\overline{3}m$. a = 3.1183(9) c = 24.113(8) Z = 3/8

X-ray Powder Pattern: Sioux Co., Iowa, USA.
8.109 (100), 4.047 (40), 2.363 (27), 2.019 (23), 2.639 (17), 1.530 (13), 1.560 (8)

Chemistry:

	(1)	(2)
Fe_2O_3	24.6	23.74
MgO	35.3	35.95
Cl	7.0	10.54
$H_2O^{200°C}$	11.	
H_2O		32.14
CO_2	0.4	
$-O = Cl_2$		2.37
Total		100.00

(1) Phalaborwa mine, South Africa; by electron microprobe, total Fe as Fe_2O_3, $H_2O^{200°C}$ by TGA. (2) $Mg_6Fe_2Cl_2(OH)_{16}\cdot 4H_2O$.

Mineral Group: Hydrotalcite group.

Occurrence: An alteration product of serpentine.

Association: Chrysotile, dolomite, brucite, calcite, magnesite, pyrite, pyroaurite (Sioux Co., Iowa, USA); magnetite, chondrodite, clinochlore, brucite, hydrotalcite, phlogopite, fluoborite, apatite, celestine, antigorite, calcite, dolomite (Phalaborwa mine, South Africa).

Distribution: In drill core from the Precambrian basement of Sioux Co., Iowa, USA. In the Phalaborwa mine, Transvaal, South Africa. Large crystals from the Komsomolsk mine, Talnakh, Noril'sk region, western Siberia, Russia. In the Almalyk district, Uzbekistan. From sea floor sediments in the Bonin-Mariana area, Pacific Ocean. At the Mount Keith nickel deposit, 400 km north-northwest of Kalgoorlie, Western Australia.

Name: For its occurrence in the state of Iowa, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 121706.

References: (1) Kohls, D.W. and J.L. Rodda (1967) Iowaite, a new hydrous magnesium hydroxide-ferric oxychloride from the Precambrian of Iowa. Amer. Mineral., 52, 1261–1271. (2) Allmann, R. and J.D.H. Donnay (1969) About the structure of iowaite. Amer. Mineral., 54, 296–299. (3) Braithwaite, R.S.W., P.J. Dunn, R.G. Pritchard, and W.H. Paar (1994) Iowaite, a re-investigation. Mineral. Mag., 58, 79–85.

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Iquiqueite $K_3Na_4Mg(CrO_4)B_{24}O_{39}(OH)\cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As hexagonal platelets, composed of $\{10\bar{1}0\}$ and {0001}, to 100 μm; typically stacked in compound groups or columnar to vermiform aggregates.

Physical Properties: *Cleavage:* {0001}, perfect; $\{10\bar{1}0\}$, imperfect. *Tenacity:* Brittle. Hardness = 1.5–2 D(meas.) = 2.05(9) D(calc.) = 2.05 Slightly hygroscopic; slowly soluble in H_2O.

Optical Properties: Translucent. *Color:* Bright yellow. *Streak:* Yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial (–); may be anomalously biaxial, thought due to misaligned stacking. ω = 1.496–1.502 ϵ = 1.447–1.448

Cell Data: *Space Group:* $P31c$. $a = 11.6369(14)$ $c = 30.158(7)$ Z = 3

X-ray Powder Pattern: Tarapacá Province, Chile.
3.02 (100), 2.856 (100), 10.11 (85), 6.04 (85), 3.28 (85), 3.22 (85), 2.910 (80)

Chemistry:

	(1)	(2)
B_2O_3	57.0	56.98
CrO_3	6.8	6.82
MgO	2.9	2.75
Na_2O	8.2	8.45
K_2O	10.5	9.64
H_2O	14.6	15.36
Total	100.0	100.00

(1) Tarapacá Province, Chile; recalculated after removal of a variety of likely impurities, corresponds to $K_{3.2}Na_{3.8}Mg_{1.1}(CrO_4)B_{24}O_{39.6}\cdot 11.9H_2O$. (2) $K_3Na_4Mg(CrO_4)B_{24}O_{39}(OH)\cdot 12H_2O$.

Occurrence: A widespread but very minor constituent of nitrate deposits in saline cemented alluvium and fractured bedrock.

Association: Nitratine, halite, niter, darapskite, blödite, glauberite, dietzeite, brüggenite, lopezite, ulexite, gypsum (Tarapacá Province, Chile); nitratine, halite, sylvite, darapskite, lopezite, tarapacáite (Salar del Miraje, Chile).

Distribution: In Chile, the first samples appear to have originated from the vicinity of Zapiga, Tarapacá; later found at Salar del Miraje, Maria Elena, Tamarugal Pampa, Antofagasta.

Name: For Iquique, a major historic port for nitrate exports from Tarapacá, Chile.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163774.

References: (1) Ericksen, G.E., M.R. Mrose, J.W. Marinenko, and J.J. McGee (1986) Mineralogical studies of the nitrate deposits of Chile. V. Iquiqueite, $Na_4K_3Mg(CrO_4)B_{24}O_{39}(OH)\cdot 12H_2O$, a new saline mineral. Amer. Mineral., 71, 830–836. (2) Färber, G., T. Witzke, G. Neumeier, and S. Weiss (1998) Iquiqueit aus der Atacama-Wüste in Chile. LAPIS, 23(10), 51 (in German).

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Iranite $\mathbf{Pb_{10}Cu(CrO_4)_6(SiO_4)_2(F,OH)_2}$

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Crystal Data: Triclinic. *Point Group:* 1 (probable). As equant to flattened euhedral crystals, to 1 mm, showing prominent $\{\bar{1}00\}$, $\{010\}$, $\{011\}$, and also $\{\bar{1}0\bar{1}\}$, $\{00\bar{1}\}$, $\{10\bar{2}\}$. *Twinning:* Common on $(12\bar{1})$.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.8

Optical Properties: Semitransparent. *Color:* Brown to orange. *Streak:* Saffron-yellow. *Luster:* Resinous.
Optical Class: Biaxial. *Pleochroism:* On (100), brownish orange ∥ elongation; yellow-orange ⊥ elongation. *Orientation:* Extinction 5° ∧ elongation. α = 2.25–2.30 β = n.d. γ = 2.40–2.50 2V(meas.) = Very large.

Cell Data: *Space Group:* $P1$ (probable). $a = 9.57$ $b = 11.42$ $c = 10.84$ $\alpha = 120°23'$ $\beta = 92°27'$ $\gamma = 56°6'$ Z = [1]

X-ray Powder Pattern: Sébarz mine, Iran.
3.60 (10), 3.49 (10), 3.28 (10), 3.18 (10), 3.08 (10), 4.84 (8), 4.42 (8)

Chemistry:

	(1)	(2)	(3)	(4)
SiO_2			3.9	3.94
CrO_3	28.8		20.1	19.65
CuO		1.85	2.8	2.60
ZnO		0.58	2.4	
PbO	66.2		72.7	73.09
F				1.24
H_2O^+				
$-O = F_2$				0.52
Total			101.9	100.00

(1) Sébarz mine, Iran; by electron microprobe, partial analysis. (2) Seh-Changi mine, Iran; partial analysis. (3) Tchah Khuni mine, Iran; by electron microprobe. (4) $Pb_{10}Cu(CrO_4)_6(SiO_4)_2F_2$.

Polymorphism & Series: Forms a series with hemihedrite.

Occurrence: In the oxidized portions of lead-bearing hydrothermal veins.

Association: Dioptase, fornacite, wulfenite, mimetite, cerussite, diaboleite.

Distribution: In Iran, from the Sébarz and Tchah Khuni mines, Anarak district; in the Seh-Changi mine, near Neyband, Khorassan. From the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, and the Bozo #1 mine, Skull Creek, Moffat Co., Colorado, USA.

Name: For the country of first occurrence, Iran.

Type Material: University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France; The Natural History Museum, London, England, 1969,52.

References: (1) Bariand, P. and P. Herpin (1963) Une nouvelle espèce minérale: l'iranite, chromate hydraté de plomb. Bull. Soc. fr. Minéral., 86, 133–135 (in French). (2) (1963) Amer. Mineral., 48, 1417 (abs. ref. 1). (3) Adib, D., J. Ottemann, and B. Nuber (1972) Further data on khuniite [iranite-hemihedrite] from the Tschah Khuni mine, Anarak, Iran. Neues Jahrb. Mineral., Monatsh., 328–335. (4) Williams, S.A. (1974) The naturally occurring chromates of lead. Bull. British Museum (Nat. Hist.) Mineral. 2, 377–419. (5) (1976) Amer. Mineral., 61, 186 (abs. ref. 4). (6) Bariand, P. and J.F. Poullen (1980) Rare chromates from Seh-Changi, Iran. Mineral. Record, 11, 293–297. (7) Cesbron, F. and S.A. Williams (1980) Iranite-hémihédrite, bellite, phoenicochroite, vauquelinite et fornacite: synthèse et nouvelles données. Bull. Minéral., 103, 469–477.

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Iraqite-(La) $K(Ca,Na)_4(La,Ce,Th)_2(Si,Al)_{16}O_{40}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Anhedral, massive.

Physical Properties: *Cleavage:* Three orthogonal, two good and one poor. *Fracture:* Uneven. Hardness = 4.5 VHN = 245–314 D(meas.) = [3.27] (slightly corrected for impurities). D(calc.) = 3.28

Optical Properties: Semitransparent. *Color:* Pale greenish yellow; in thin section, colorless. *Streak:* Whitish. *Luster:* Dull to pearly.
Optical Class: Uniaxial (–); anomalously biaxial. *Orientation:* Extinction angles to 7°.
$\omega = 1.590$ $\epsilon = 1.585$

Cell Data: *Space Group:* $[P4/mcc]$ (by analogy to ekanite). $a = 7.61(1)$ $c = 14.72(2)$ Z = 1

X-ray Powder Pattern: Shakhi-Rash Mountain, Iraq.
5.28 (100), 3.31 (100), 2.64 (100), 7.36 (80), 3.38 (80), 3.40 (60), 2.17 (40)

Chemistry:

	(1)		(1)
SiO_2	51.7	CaO	12.00
ZrO_2	0.17	Na_2O	0.27
ThO_2	9.54	K_2O	2.76
UO_2	0.65	F	0.07
Al_2O_3	0.77	H_2O^+	3.51
RE_2O_3	15.06	H_2O^-	0.90
Fe_2O_3	0.22	CO_2	1.00
CuO	0.07	P_2O_5	0.01
PbO	0.35	S	0.14
MgO	0.02	$-O = F_2$	0.03
		Total	99.18

(1) Shakhi-Rash Mountain, Iraq; Zr, Th, RE by XRF, U by delayed neutron activation; $RE_2O_3 = La_2O_3$ 6.78%, Ce_2O_3 6.44%, Pr_2O_3 0.44%, Nd_2O_3 0.88%, Sm_2O_3 0.17%, Gd_2O_3 0.10%, Yt_2O_3 [*sic*] 0.25%; after deduction of calcite 2.27% and pyrite 0.26%, corresponds to $K_{1.07}[Ca_{3.49}(La,Ce)_{0.35}Na_{0.16}]_{\Sigma=4.00}[(La,Ce)_{1.33}Th_{0.66}]_{\Sigma=1.99}(Si_{15.69}Al_{0.27})_{\Sigma=15.96}(O_{39.93}F_{0.07})_{\Sigma=40.00}$.

Occurrence: In granite in contact with dolomitic marble containing olivine and diopside.

Association: n.d.

Distribution: At Shakhi-Rash Mountain, Hero Town, Qala-Diza, Iraq.

Name: For the country of origin, *Iraq*, and *lanthanum* in the composition.

Type Material: The Natural History Museum, London, England, 1973,481; National School of Mines, Paris, France.

References: (1) Livingstone, A., D. Atkin, D. Hutchison, and H.M. Al-Hermezi (1976) Iraqite, a new rare-earth mineral of the ekanite group. Mineral. Mag., 40, 441–445. (2) (1976) Amer. Mineral., 61, 1054 (abs. ref. 1).

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Irarsite $(Ir, Ru, Rh, Pt)AsS$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As grains, to 1 mm, and intergrown with hollingworthite or laurite.

Physical Properties: *Tenacity:* Brittle. Hardness = Not scratched with a steel needle. VHN = 976 D(meas.) = n.d. D(calc.) = 11.92

Optical Properties: Opaque. *Color:* Iron-black; in polished section, grayish white with a bluish tint. *Luster:* Metallic.
R: (400) 47.6, (420) 47.3, (440) 47.0, (460) 46.8, (480) 46.6, (500) 46.4, (520) 46.2, (540) 45.9, (560) 45.6, (580) 45.4, (600) 45.1, (620) 44.9, (640) 44.6, (660) 44.3, (680) 44.0, (700) 43.7

Cell Data: *Space Group: Pa*3. $a = 5.777$ Z = 1

X-ray Powder Pattern: Onverwacht mine, South Africa.
3.32 (100), 2.87 (100), 1.74 (100), 2.04 (90), 1.112 (90), 2.57 (80), 1.021 (80)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Ir	23.0	43.5	62.35	Pd		0.4	
Ru	9.4	5.5		Cu		0.6	
Rh	7.2	1.4		As	34.5	26.0	26.60
Pt	12.6	11.7		S	11.6	9.6	11.47
				Total	98.3	98.7	100.42

(1) Driekop mine, South Africa; by electron microprobe, corresponding to $(Ir_{0.29}Ru_{0.23}Rh_{0.17}Pt_{0.16})_{\Sigma=0.85}As_{1.12}S_{0.88}$. (2) Papua New Guinea; by electron microprobe, corresponding to $(Ir_{1.01}Ru_{0.03}Fe_{0.02}Os_{0.01})_{\Sigma=1.07}As_{0.89}S_{1.11}$. (3) Ioma placer, Shetland Islands; by electron microprobe, corresponding to $Ir_{0.91}As_{1.00}S_{1.00}$.

Polymorphism & Series: Forms a series with hollingworthite.

Mineral Group: Cobaltite group.

Occurrence: In chromite in hortonolite dunite (South Africa); as inclusions in chrompicotites (Bulgaria); and as rims around Pt-group alloys.

Association: Platinum, ruthenian hollingworthite, sperrylite, laurite, iridarsenite, ruthenarsenite, rutheniridosmine, chalcopyrite, chalcocite, pyrrhotite, cobaltite, gersdorffite, pentlandite, nickeline, magnetite, chromite, olivine.

Distribution: In South Africa, in the Merensky Reef, Bushveld complex, Transvaal, from the Onverwacht [TL] and Driekop mines. At the Hitura Ni–Cu deposit, western Finland. From Vourinos, Greece. In the Pletene chromite deposit, Bulgaria. From the Kapitanov chromite deposit, near Zvenyhorodka, Ukraine. At Chromwerk, Kraubath ultramafic massif, Styria, Austria. In the Cliff and Harold's Grave quarries, Shetland Islands. In the USA, from the American River, Sacramento Co., and in the Stanislaus River near Knight's Ferry, Stanislaus Co., California; from Fox Gulch, Goodnews Bay, Alaska. In Canada, at Werner Lake and Sudbury, Ontario, and the Pipe mine, in Manitoba. From the Anduo chromite deposit, Tibet, China. At the Baimka placers, Chukota, Far Eastern Region, Russia. From the Ioma placer, Waria River, Yodda goldfield, Papua New Guinea.

Name: For IRidium and ARSenic in the composition.

Type Material: n.d.

References: (1) Genkin, A.D., N.N. Zhuravlev, N.V. Troneva, and I.V. Murav'eva (1966) Irarsite, a new sulfarsenide of iridium, rhodium, ruthenium, and platinum. Zap. Vses. Mineral. Obshch., 95, 700–712 (in Russian). (2) (1967) Amer. Mineral., 52, 1580 (abs. ref. 1). (3) Tarkian, M. and H.M. Prichard (1987) Irarsite-hollingworthite solid-solution series and other associated Ru-, Os-, Ir-, and Rh-bearing PGM's from the Shetland ophiolite complex. Mineralium Deposita, 22, 178–184. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 110–111. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 252.

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Irhtemite $Ca_4Mg(AsO_4)_2(HAsO_3OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Commonly as crystals, in spherulitic aggregates, to 1 mm; may be powdery.

Physical Properties: Hardness = n.d. D(meas.) = 3.09 D(calc.) = 3.153

Optical Properties: Transparent. *Color:* Colorless, white, pale rose with traces of cobalt. *Luster:* Silky.
Optical Class: Biaxial (+). *Orientation:* Elongation negative, extinction angle = 25°.
$\alpha = 1.634$ $\beta =$ n.d. $\gamma = 1.642$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 16.736(5)$ $b = 9.483(3)$ $c = 10.840(5)$
$\beta = 97°15(20)'$ Z = 4

X-ray Powder Pattern: Irhtem mine, Morocco.
2.97 (10), 3.24 (9), 2.82 (9), 5.08 (4), 3.68 (4), 9.42 (3), 6.85 (3)

Chemistry:

	(1)	(2)
As_2O_5	55.5	56.45
MgO	4.4	4.95
CaO	28.2	27.54
H_2O	11.5	11.06
Total	99.6	100.00

(1) Salsigne mine, 15 km north of Carcassone, Aude, France; artificially dehydrated picropharmacolite, corresponding to $Ca_{4.16}Mg_{0.90}H_2(AsO_4)_4 \cdot 5.28H_2O$. (2) $Ca_4MgH_2(AsO_4)_4 \cdot 4H_2O$.

Occurrence: Probably a dehydration product of picropharmacolite in hydrothermal ore deposits.

Association: Sainfeldite, erythrite (Irhtem mine, Morocco).

Distribution: From the Irhtem (Ightem) mine, Bou Azzer district, Anti-Atlas Mountains, Morocco. In Germany, in the Bauhaus district, Richelsdorf Mountains, Hesse.

Name: For its occurrence in the Irhtem (Ightem) mine, Morocco.

Type Material: National School of Mines, Paris, France.

References: (1) Pierrot, R. and H.-J. Schubnel (1972) L'irhtemite, un nouvel arséniate hydraté de calcium et magnésium. Bull. Minéral., 92, 365–370 (in French with English abs.). (2) (1974) Amer. Mineral., 59, 209 (abs. ref. 1).

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Iridarsenite $(Ir, Ru)As_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As irregular inclusions, to 60 μm, in a matrix of rutheniridosmine.

Physical Properties: Hardness = n.d. VHN = 488 and 686 (100 g load) on two grains. D(meas.) = n.d. D(calc.) = 10.9

Optical Properties: Opaque. *Color:* In polished section, medium gray with brownish tint. *Luster:* Metallic. *Pleochroism:* Weak to none. *Anisotropism:* Weak but distinct, from medium gray to pale orange-brown.
R_1–R_2: (470) 47.2–46.9, (546) 45.4–46.1, (589) 44.9–46.6, (650) 41.4–44.0

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 6.05$ $b = 6.06$ $c = 6.18$ $\beta = 113°17'$ $Z = 4$

X-ray Powder Pattern: Papua New Guinea.
3.90 (100), 2.840 (70), 2.069 (60), 2.610 (50), 1.910 (50), 1.943 (40), 1.875 (40)

Chemistry:

	(1)	(2)
Ir	40.7	52.2
Ru	10.3	1.7
Os	1.3	0.4
Pt	0.5	1.1
Rh	0.9	0.2
Pd		0.1
As	46.2	44.0
S		0.2
Total	99.0	99.9

(1) Papua New Guinea; by electron microprobe, corresponds to $(Ir_{0.69}Ru_{0.33}Os_{0.02})_{\Sigma=1.04}As_{2.00}$.
(2) Do.; by electron microprobe, average of four other grains; corresponds to $(Ir_{0.92}Ru_{0.06}Os_{0.01}Pt_{0.02}Rh_{0.01})_{\Sigma=1.02}(As_{1.97}S_{0.03})_{\Sigma=2.00}$.

Occurrence: In nuggets or fragments of natural Os–Ir–Ru alloys.

Association: Irarsite, ruthenarsenite, rutheniridosmine.

Distribution: From an unspecified locality [probably the Waria River, Bowutu Mountains, or the Yodda Goldfield] in Papua New Guinea [TL]. In the Merensky Reef, Bushveld complex, Witwatersrand, Transvaal, South Africa. From near Zlatoust, Ural Mountains, Russia. In placers at Anduo, Tibet, China. From Fox Gulch, Goodnews Bay, Alaska, USA.

Name: For the IRIDium and ARSENic in the composition.

Type Material: Geological Survey of Canada, 12160; Canadian Museum of Nature, Ottawa, Canada.

References: (1) Harris, D.C. (1974) Ruthenarsenite and iridarsenite, two new minerals from the Territory of Papua and New Guinea and associated irarsite, laurite, and cubic iron-bearing platinum. Can. Mineral., 12, 280–284. (2) (1976) Amer. Mineral., 61, 177 (abs. ref. 1). (3) Harris, D.C. and L.J. Cabri (1973) The nomenclature of the natural alloys of osmium, iridium and ruthenium based on new compositional data of alloys from world-wide occurrences. Can. Mineral., 12, 104–112. (4) Quensel, J.C. and R.D. Heyding (1962) Transition metal arsenides V. A note on the rhodium/arsenic system and the monoclinic diarsenides of the cobalt family. Canadian J. Chem., 40, 814–818.

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Iridium (Ir, Os, Ru)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Generally cubic, commonly in rounded or angular grains. *Twinning:* On {111} in polysynthetic groups.

Physical Properties: *Cleavage:* Indistinct on {001}. *Fracture:* Hackly. *Tenacity:* Somewhat malleable. Hardness = 6–7 VHN = 946–988 D(meas.) = 22.65–22.84 D(calc.) = 22.66

Optical Properties: Opaque. *Color:* Silver-white with yellow tinge, gray on fracture. *Luster:* Very high metallic.

R: (400) 67.4, (420) 68.1, (440) 68.8, (460) 69.3, (480) 69.6, (500) 69.9, (520) 70.2, (540) 70.7, (560) 71.6, (580) 71.9, (600) 72.5, (620) 73.2, (640) 73.4, (660) 73.8, (680) 74.4, (700) 74.4

Cell Data: *Space Group: Fm3m.* a = 3.8394 Z = 4

X-ray Powder Pattern: Synthetic.
2.2170 (100), 1.9197 (50), 1.1574 (45), 0.7838 (45), 1.3575 (40), 0.8808 (40), 0.8586 (40)

Chemistry:

	(1)	(2)	(3)
Ir	76.85	64.7	49.6
Pt	19.64		21.8
Pd	0.89		
Ru		1.6	23.9
Os		33.4	2.1
Cu	1.78	0.6	0.5
Fe		0.3	0.2
Total	99.16	100.6	98.1

(1) Nizhni Tagil, Russia; corresponds to $(Ir_{0.74}Pt_{0.19}Cu_{0.05}Pd_{0.02})_{\Sigma=1.00}$. (2) Sorashigawa placer, Japan; by electron microprobe, corresponds to $(Ir_{0.62}Os_{0.32}Ru_{0.03}Cu_{0.02}Fe_{0.01})_{\Sigma=1.00}$. (3) Do.; by electron microprobe, corresponds to $(Ir_{0.41}Ru_{0.38}Pt_{0.18}Os_{0.02}Cu_{0.01})_{\Sigma=1.00}$.

Occurrence: As exsolution particles in Pt–Fe alloys.

Association: Platinum, Pt–Fe alloys.

Distribution: From Nizhni Tagil, Ural Mountains, Russia. In Japan, at the Sorashigawa placer, ?? Prefecture, elsewhere??. In Canada, from Bear Creek, in the Tulameen River district, British Columbia, and at the Wellgreen Ni–Cu–PGE deposit, Yukon Territory. In the USA, from Goodnews Bay, Alaska, and in the Boss mine, Goodsprings district, Clark Co., Nevada. On the Witwatersrand, South Africa. In the Ioma placer, Waria River, Yodda goldfield, Papua New Guinea

Name: From the Latin *iris*, *rainbow*, as the element's compounds are typically highly colored.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 110–111. (2) Harris, D.C. and L.J. Cabri (1973) The nomenclature of the natural alloys of osmium, iridium and ruthenium based on new compositional data of alloys from world-wide occurrences. Can. Mineral., 12, 104–112. (3) Harris, D.C. and L.J. Cabri (1991) Nomenclature of platinum-group element alloys: review and revision. Can. Mineral., 29, 231–237. (4) (1955) NBS Circ. 539, 4, 9–10. (5) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 111–112. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 253.

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Iridosmine (Os, Ir)

Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Rounded to sub-rounded grains, rarely hexagonal in cross-section; as laths in iron-bearing platinum.

Physical Properties: *Cleavage:* Perfect but difficult on {0001}. *Tenacity:* Slightly malleable to brittle. Hardness = 6–7 VHN = 974–1064 (100 g load). D(meas.) = n.d. D(calc.) = 22.15

Optical Properties: Opaque. *Color:* White, with a bluish gray tinge in reflected light. *Streak:* Gray. *Luster:* Metallic. *Anisotropism:* Weak to moderate.
R_1–R_2: (400) 62.6–63.6, (420) 63.2–64.2, (440) 63.8–64.8, (460) 64.3–65.3, (480) 64.6–65.6, (500) 64.8–66.0, (520) 64.6–66.2, (540) 64.3–66.2, (560) 64.0–66.0, (580) 63.5–65.7, (600) 63.1–65.4, (620) 62.8–65.4, (640) 62.6–65.4, (660) 62.4–65.5, (680) 62.2–65.6, (700) 62.0–65.8

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.724(3)$ $c = 4.333(7)$ Z = [2]

X-ray Powder Pattern: Spruce Creek, Canada.
2.168 (100), 2.071 (80), 1.231 (80), 0.8478 (70), 0.8136 (70), 0.9135 (60), 0.8736 (60)

Chemistry:

	(1)	(2)
Os	55.5	55.7
Ir	42.0	43.5
Ru	1.3	1.5
Pt	0.3	
Pd		
Rh	0.2	
Fe	0.3	0.2
Cu		0.4
Total	99.6	101.3

(1) Ruby Creek, Canada; by electron microprobe. (2) Sorashigawa placer, Japan; by electron microprobe.

Occurrence: In magmatic segregation deposits, and concentrated into placers on their reduction by weathering.

Association: Osmiridium, irarsite, laurite, isoferroplatinum, platinum, rutheniridosmine.

Distribution: In Canada, in British Columbia, from Ruby Creek, Atlin district; Spruce Creek; and Granite Creek, in the Tulameen River area. From the Sorashigawa placer and other localities in Japan. From the Heazlewood Complex and the Adamsfield district, Tasmania, Australia. In the Guma Water placers, Sierra Leone. From near Vershilo, Bourgas district, Bulgaria. From Vourinos, Greece. At Anduo, Tibet, China. In the Inagli and Konder massifs, Aldan Shield, Yakutia; and a number of other less well defined localities in the USSR.

Name: For the composition, intermediate between iridium and osmium.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 111–113. (2) Harris, D.C. and L.J. Cabri (1973) The nomenclature of the natural alloys of osmium, iridium and ruthenium based on new compositional data of alloys from world-wide occurrences. Can. Mineral., 12, 104–112. (3) (1975) Amer. Mineral., 60, 946 (abs. ref. 2). (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 112–113.

Iriginite $(UO_2)Mo_2^{6+}O_7 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In very fine-grained aggregates.

Physical Properties: *Fracture:* Conchoidal to uneven. Hardness = 4–5 D(meas.) = 3.84, low due to impurities. D(calc.) = 4.241 Radioactive.

Optical Properties: Semitransparent. *Color:* Canary-yellow. *Luster:* Vitreous to dull. *Optical Class:* Biaxial. *Orientation:* Parallel extinction. $\alpha = 1.730(3)$ $\beta = \sim 1.82$ $\gamma = \sim 1.93$ 2V(meas.) = Large.

Cell Data: *Space Group: Pbcm* (synthetic). $a = 6.705(1)$ $b = 12.731(2)$ $c = 11.524(2)$ Z = 4

X-ray Powder Pattern: Aleksandrovskii Golets deposit, Russia.
3.222 (10), 1.129 (8), 2.625 (6), 2.142 (6), 1.836 (6), 1.249 (6), 1.206 (6)

Chemistry:

	(1)	(2)	(3)
UO_3	41.91	46.45	45.55
UO_2	0.00		
MoO_3	38.62	42.80	45.84
CaO	0.46		
H_2O	9.70	10.75	8.61
insol.	9.04		
Total	99.73	[100.00]	100.00

(1) Aleksandrovskii Golets deposit, Russia; H_2O taken as loss on ignition. (2) Analysis (1) recalculated to 100% after deduction of CaO as unessential and insoluble; then corresponding to $(UO_2)Mo_{1.84}O_{6.52} \cdot 3.70H_2O$. (3) $(UO_2)Mo_2O_7 \cdot 3H_2O$.

Occurrence: In granulated albite, in part replacing brannerite (Aleksandrovskii Golets deposit, Russia); in a stream channel in sandstone (Hart Table, South Dakota, USA); may be of post-mining origin.

Association: Ferrimolybdite, ilsemannite, metauranocircite, uranyl sulfates, gypsum.

Distribution: Found in considerable abundance in some deposits. From the Aleksandrovskii Golets Mo–U deposit, upper Chetkanda River, Chara district, Udokan Range, northern Transbaikal, Russia. Found in the Shunak Mountains, 60 km west of the Mointy railroad station, and at the Kyzylsai Mo–U deposit, Chu-Ili Mountains, southwestern Balkhash region, Kazakhstan. In the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France. In the USA, at Hart Table, southwest of Scenic, Pennington Co., South Dakota; east of Cameron, Coconino Co., Arizona; and at the Clyde Long property, Elk Park area, San Juan Co., Colorado. From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In the Hervey's Range deposit, 55 km west of Townsville, Queensland, Australia.

Name: A euphonious construction, devoid of connotation.

Type Material: Mining Institute, St. Petersburg, Russia, 1257/2.

References: (1) Getseva, R.V. and K.T. Salev'eva (1956) Handbook for the determination of uranium minerals. Moscow, 197 (in Russian). (2) Soboleva, M.V. and I.A. Pudovkina (1957) Uranium minerals handbook. Moscow, 249–251 (in Russian). (3) (1958) Amer. Mineral., 43, 378 and 379 (abs. refs. 1 and 2). (4) Epshtein, G.Y. (1959) On the molybdates of uranium – moluranite and iriginite. Zap. Vses. Mineral. Obshch., 88, 564–570 (in Russian). (5) Stephenson, D.A. (1964) Iriginite from South Dakota. Amer. Mineral., 49, 408–414. (6) Krivovichev, S.Y. and P.C. Burns (2000) The crystal chemistry of uranyl molybdates. II. The crystal structure of iriginite. Can. Mineral., 38, 847–851.

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Iron Fe

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Typically in small blebs but also in masses up to 25 tons; crystals rare. *Twinning:* On {111}; also on {112} if in lamellar masses.

Physical Properties: *Cleavage:* {001}; parting on {112}. *Fracture:* Hackly. *Tenacity:* Malleable. Hardness = 4 VHN = 160 (100 g load). D(meas.) = 7.3–7.87 D(calc.) = 7.874 Magnetic.

Optical Properties: Opaque. *Color:* Steel-gray to iron-black; in polished section, white. *Luster:* Metallic.

R: (400) 56.8, (420) 57.2, (440) 57.6, (460) 57.8, (480) 57.9, (500) 58.0, (520) 58.1, (540) 58.1, (560) 58.1, (580) 58.1, (600) 58.1, (620) 58.2, (640) 58.2, (660) 58.4, (680) 58.6, (700) 58.8

Cell Data: *Space Group:* $Im3m$. $a = 2.8664$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.0268 (100), 1.1702 (30), 1.4332 (20), 0.9064 (12), 1.0134 (10), 0.8275 (6)

Chemistry:

	(1)	(2)
Fe	93.16	99.16
Ni	2.01	
Co	0.80	
Cu	0.12	
C	2.34	0.065
P	0.32	0.207
S	0.41	
Cl	0.02	
SiO_2		0.37
Total	99.18	99.802

(1) Blaafjeld, Greenland. (2) Cameron, Missouri, USA.

Occurrence: Rare in igneous rocks, especially basalts; in carbonaceous sediments; in volcanic fumaroles; and in petrified wood, mixed with "limonite" and organic matter.

Association: Pyrite, magnetite, troilite, wüstite, cohenite.

Distribution: In Greenland, at Fortune Bay, Mellemfjord, Asuk, and elsewhere on the west coast; on Disko Island, near Uivfaq and Kitdlît. From Ben Bhreck, Scotland. At Bühl, near Weimar, Hesse, Germany. In Poland, near Rouno, Wolyn district. In Russia, at Grushersk, in the Don district; from the Hatanga region, Siberia; in the Huntukungskii massif, Krasnoyarsk Kray; and on the Tolbachik fissure volcano, Kamchatka Peninsula. In the USA, at Cameron, Clinton Co., Missouri; and near New Brunswick, Somerset Co., New Jersey. In Canada, in Ontario, from Cameron Township, Nipissing district, and on St. Joseph Island, Lake Huron. Noted in small amounts at a number of additional localities.

Name: An Old English word for the metal; the chemical symbol from the Latin *ferrum*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 114–116. (2) Ulff-Møller, F. (1985) Solidification history of the Kitdlît lens: immiscible metal and sulphide liquids from a basaltic dyke on Disko, central west Greenland. J. Petrol., 26, 64–91. (3) (1955) NBS Circ. 539, 4, 3.

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Irtyshite $Na_2(Ta, Nb)_4O_{11}$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6. Massive, in veinlets, to 0.2 mm wide, and as granular inclusions.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. VHN = 1030 (40 g load). D(meas.) = n.d. D(calc.) = 7.03 Bright yellow-green cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Adamantine.
Optical Class: Uniaxial. *Anisotropism:* Noted. *Bireflectance:* Noted.
R_1–R_2: (486) 18.0–19.0, (553) 18.6–19.5, (589) 18.9–19.6, (656) 18.5–18.7

Cell Data: *Space Group:* $P6_3/m$ or $P6_3$ (?). $a = 6.231$ $c = 36.77$ Z = 6

X-ray Powder Pattern: Near the Irtysh River, Kazakhstan.
3.029 (10), 3.082 (9), 2.780 (9), 6.13 (7), 5.18 (6), 2.481 (6), 1.929 (4)

Chemistry:

	(1)
Ta_2O_5	80.00
Nb_2O_5	12.07
SnO_2	0.58
MnO	trace
PbO	0.41
CaO	0.20
Na_2O	6.46
Total	99.72

(1) Near the Irtysh River, Kazakhstan; by electron microprobe, average of three analyses; corresponds to $(Na_{1.83}Ca_{0.03}Pb_{0.02})_{\Sigma=1.88}(Ta_{3.19}Nb_{0.80}Sn_{0.03})_{\Sigma=4.02}O_{11}$.

Occurrence: As veinlets in altered thoreaulite, and inclusions in ixiolite and lithiotantite, in granite pegmatites.

Association: Thoreaulite, ixiolite, lithiotantite.

Distribution: From the Ungursai tantalum deposit, Kalba Mountains, near the Irtysh River, eastern Kazakhstan.

Name: For the Irtysh River, Kazakhstan, near which it occurs.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 43776.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, L.V. Bulgak, and G.A. Perlina (1985) Irtyshite, a new mineral from granite pegmatites. Mineral. Zhurnal, 7(3), 83–87 (in Russian). (2) (1986) Amer. Mineral., 71, 1545 (abs. ref. 1). (3) (1986) Mineral. Abs., 37, 530 (abs. ref. 1).

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Ishikawaite $(U, Fe, Y, Ca)(Nb, Ta)O_4(?)$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As prismatic crystals, tabular on {100}, with nine forms noted, to 1 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5–6 D(meas.) = 6.2–6.4 D(calc.) = n.d. Radioactive.

Optical Properties: Opaque. *Color:* Black. *Streak:* Dark brown. *Luster:* Waxy, resinous to vitreous.
Optical Class: Isotropic.
R: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	36.80	39.5	Al_2O_3	0.87	
Ta_2O_5	15.00	5.13	RE_2O_3	8.40	9.17
SiO_2	0.30		FeO	11.78	9.47
TiO_2	0.21	0.59	MnO	0.40	2.10
SnO_2	1.20	1.52	MgO	1.07	
ThO_2		6.39	CaO	0.86	0.11
UO_2	21.88	23.6	H_2O^+	0.89	
			Total	99.66	97.6

(1) Ishikawa district, Japan. (2) Honeycomb Hill, Utah, USA; by electron microprobe, RE_2O_3 = Y_2O_3 1.05%, La_2O_3 0.03%, Ce_2O_3 0.41%, Nd_2O_3 0.73%, Sm_2O_3 0.33%, Gd_2O_3 0.50%, Tb_2O_3 0.21%, Dy_2O_3 1.37%, Er_2O_3 1.27%, Yb_2O_3 2.87%, Lu_2O_3 0.40%.

Occurrence: In pegmatite, and alluvium (Ishikawa district, Japan); as microinclusions in vitrophyre clasts in highly differentiated, rare-element rich, pyroclastic rhyolites (Honeycomb Hills, Utah, USA).

Association: Samarskite (Ishikawa district, Japan).

Distribution: From the Ishikawa district, Fukushima Prefecture, Japan. Reported from other localities in Japan and elsewhere, but confirmation is impossible, lacking type material. Material from the Honeycomb Hills, Juab Co., Utah, USA, for example, seems very similar but is regarded as uranoan samarskite.

Name: For the occurrence in the Ishikawa district, Japan.

Type Material: Destroyed.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 766. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 533. (3) Nambu, M., Ed. (1970) Introduction to Japanese minerals, Geol. Surv. Japan, 104–105. (4) Congdon, R.D. and W.P. Nash (1991) Eruptive pegmatite magma: rhyolite of the Honeycomb Hills, Utah. Amer. Mineral., 76, 1261–1278.

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Isocubanite $CuFe_2S_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Euhedral grains and cubo-octahedra, to 400 μm, intergrown with chalcopyrite; rimming cubanite.

Physical Properties: Hardness = n.d. VHN = 175 (100 g load). D(meas.) = n.d. D(calc.) = [3.93]

Optical Properties: Opaque. *Color:* Bronze; in reflected light, pinkish brown. *Luster:* Metallic.
R: (400) 20.9, (420) 22.7, (440) 24.6, (460) 26.9, (480) 29.2, (500) 31.4, (520) 33.2, (540) 34.8, (560) 36.2, (580) 37.4, (600) 38.2, (620) 39.1, (640) 39.7, (660) 40.3, (680) 40.9, (700) 41.3

Cell Data: *Space Group: Fm3m.* $a = 5.303(3)$ $Z = [4/3]$

X-ray Powder Pattern: East Pacific Rise (21°N).
3.059 (100), 1.876 (70), 1.602 (50), 2.647 (20), 1.327 (20)

Chemistry:

	(1)	(2)
Cu	21.23	23.42
Fe	41.64	41.15
Zn	0.96	
S	35.57	35.43
Total	99.40	100.00

(1) East Pacific Rise (21°N); by electron microprobe. (2) $CuFe_2S_3$.

Polymorphism & Series: Dimorphous with cubanite, from which it can be formed by heating to between 200 °C and 270 °C.

Occurrence: In mixtures of sulfides formed around modern undersea "black smoker" chimneys; in hydrothermal copper sulfide deposits; in pumice from volcanic eruptions.

Association: Chalcopyrite, pyrrhotite, pyrite, sphalerite, wurtzite, anhydrite.

Distribution: From the East Pacific Rise (21°N [TL], 23°N, 13°N) and the Mid-Atlantic Ridge (14°45′N, 29°N, 36°14′N). On Axial Seamount, Juan de Fuca Ridge, northeast Pacific Ocean. In the Atlantis II Deep of the Red Sea. At Kilauea, Hawaii, USA. From the Talnakh area, Noril'sk region, western Siberia, Russia. At Tunaberg, Sweden. In the Mooihoek mine, Lydenburg district, Transvaal, South Africa. From the Strathcona mine, Sudbury, Ontario, Canada.

Name: For the cubic structure and relation to cubanite.

Type Material: National School of Mines, Paris, France.

References: (1) Caye, R., B. Cervelle, F. Cesbron, E. Oudin, P. Picot, and F. Pillard (1988) Isocubanite, a new definition of the cubic polymorph of cubanite $CuFe_2S_3$. Mineral. Mag., 52, 509–514. (2) (1989) Amer. Mineral., 74, 503 (abs. ref. 1). (3) Mozgova, N.N., S.N. Nenasheva, Y.S. Borodayev, and A.J. Tsepin (1996) Compositional range and isomorphism of isocubanite. Geochem. Internat., 33, 1–21. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 259.

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Isoferroplatinum Pt_3Fe

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rarely as crystals, to 3 mm, also skeletal and cubic grains, which may exhibit stepped facets, and as wormlike intergrowths and veinlets.

Physical Properties: Hardness = n.d. VHN = 503–572 (100 g load). D(meas.) = n.d. D(calc.) = 18.41

Optical Properties: Opaque. *Color:* Bright white in reflected light. *Luster:* Metallic. R: (400) 61.2, (420) 61.2, (440) 61.1, (460) 61.3, (480) 62.3, (500) 63.3, (520) 63.8, (540) 64.3, (560) 64.9, (580) 65.9, (600) 66.4, (620) 67.5, (640) 67.9, (660) 68.7, (680) 69.2, (700) 69.5

Cell Data: *Space Group:* $Pm3m$. a = 3.866 Z = 1

X-ray Powder Pattern: Gusevogorskii pluton, Russia. 1.164 (10), 2.22 (7), 1.364 (6), 1.926 (4), 1.114 (4)

Chemistry:

	(1)	(2)
Pt	90.2	91.29
Fe	7.6	8.71
Cu	0.94	
Ni	0.06	
Total	98.8	100.00

(1) Tulameen River, Canada; by electron microprobe, corresponding to $Pt_{3.01}(Fe_{0.88}Cu_{0.10}Ni_{0.01})_{\Sigma=0.99}$. (2) Pt_3Fe.

Occurrence: In Pt–Fe and Cu–Ni sulfide deposits in ultramafic rocks, also in chromatites, and placers derived from them.

Association: Platinum, iridium, osmium, Pt–Fe alloy, braggite, sperrylite, inclusions of many other PGE minerals, gold, pyrite.

Distribution: In Canada, in British Columbia, from the Tulameen [TL] and Similkameen Rivers. In the Stillwater complex, Montana, and at Fox Gulch, Goodnews Bay, Alaska, USA. From the Department of Chocó, Cauca, Colombia. In the Inagli and Konder massifs, Aldan Shield, Sakha; the Noril'sk region, western Siberia; along the Vilyui River and on the Kamchatka Peninsula; in the Gusevogorskii pluton and the Kytlym and Uktus complexes, Ural Mountains; and at a number of other minor localities in Russia. From the Birbir River, Ethiopia. In the Onverwacht and Tweefontein pipes, Merensky Reef, Bushveld complex, Transvaal, South Africa. On the Riam Kanan River, Borneo. From the Qilian Mountains, Qinghai Province, China. At Round Hill, near Orepuki, New Zealand. Numerous additional localities have been recognized.

Name: For the cubic (ISOmetric) structure, and iron (FERRum) and PLATINUM in its composition.

Type Material: n.d.

References: (1) Cabri, L.J. and C.E. Feather (1975) Platinum–iron alloys: a nomenclature based on a study of natural and synthetic alloys. Can. Mineral., 13, 117–126. (2) (1976) Amer. Mineral., 61, 338–339 (abs. ref. 1). (3) Begizov, V.D., L.F. Borisenko, and Y.D. Uskov (1975) Sulfides and natural solid solutions of platinum metals from ultramafic rocks of the Gusevogorskii pluton, Urals. Doklady Acad. Nauk SSSR, 225, 1408–1411 (in Russian). (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 113–114. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 260.

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Isokite $CaMg(PO_4)F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are flattened on {010}, elongated along [100], and obliquely terminated by {101}, {100}, $\{10\overline{1}\}$, $\{10\overline{2}\}$; generally as spherulites of bladed to fibrous crystals, to 3 mm.

Physical Properties: *Cleavage:* Very good on {010}. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 3.15–3.27 D(calc.) = 3.29 Fluoresces blue under LW UV.

Optical Properties: Translucent. *Color:* White, buff, pale pink. *Luster:* Silky (fibers), slightly pearly (plates).
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 32°$. *Dispersion:* $r > v$. $\alpha = 1.590(2)$ $\beta = 1.595(2)$ $\gamma = 1.615(2)$ 2V(meas.) = 51.5(2)°

Cell Data: *Space Group:* $C2/c$. $a = 6.52(5)$ $b = 8.75(5)$ $c = 7.51(5)$ $\beta = 121°28(12)'$ Z = 4

X-ray Powder Pattern: Nkombwa Hill, Zambia; nearly identical to panasqueiraite.
3.185 (vvs), 3.023 (vvs), 2.630 (vvs), 2.301 (s), 1.720 (s), 2.784 (m), 2.586 (m)

Chemistry:

	(1)	(2)
P_2O_5	38.68	39.79
RE_2O_3	0.16	
FeO	0.42	
MnO	0.13	
MgO	21.93	22.60
CaO	30.61	31.44
SrO	1.66	
BaO	0.22	
F	9.86	10.65
H_2O^+	0.48	
$-O = F_2$	4.15	4.48
Total	[100.00]	100.00

(1) Nkombwa Hill, Zambia; from an original total of 100.07%, after deduction of 2.14% ankeritic dolomite and 0.99% strontian apatite, then corresponds to $(Ca_{0.98}Sr_{0.03})_{\Sigma=1.01}(Mg_{0.98}Fe_{0.01})_{\Sigma=0.99}(P_{0.98}O_{3.94})[F_{0.93}(OH)_{0.10}]_{\Sigma=1.03}$. (2) $CaMg(PO_4)F$.

Occurrence: A late stage metasomatic mineral in ankeritic carbonatite (Nkombwa Hill, Zambia); replacing wagnerite in a pegmatite dike in sillimanite grade gneiss (Benson mines, New York, USA); an alteration product of triplite in granite pegmatites (Mangualde and Ribeira, Portugal; Horní Slavkov, Czech Republic).

Association: Dolomite, strontian fluorapatite, monazite, daqingshanite-(Ce), strontianite, quartz, phlogopite, pyrochlore (Nkombwa Hill, Zambia).

Distribution: On Nkombwa Hill, 24 km east of Isoka, Zambia. At the Benson Mines, near Star Lake, St. Lawrence Co., New York, USA. From Horní Slavkov (Schlaggenwald), Czech Republic. In Portugal, at the Mangualde pegmatite, near Mesquitela, from Folgorinho, and in the Ribeira and Panasqueira Sn–W deposits. From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. At Brumado, Bahia, Brazil.

Name: For Isoka, Zambia, the town near which the first specimens were collected.

Type Material: The Natural History Museum, London, England, 1957,3 and 1957,4.

References: (1) Deans, T. and J.D.C. McConnell (1955) Isokite, $CaMgPO_4F$, a new mineral from Northern Rhodesia. Mineral. Mag., 30, 681–690. (2) (1956) Amer. Mineral., 41, 167 (abs. ref. 1). (3) Jaffe, H.W., L.M. Hall, and H.T. Evans, Jr. (1992) Wagnerite and isokite from the Benson Mines, west-central Adirondack Highlands, New York. Mineral. Mag., 56, 227–233.

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Isolueshite $(Na, La, Ca)(Nb, Ti)O_3$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. In subhedral to anhedral grains, to 0.1 mm, in monomineralic aggregates, to cm size.

Physical Properties: Hardness = 6–6.5 VHN = 681–772 (100 g load). D(meas.) = 4.85 D(calc.) = 4.89 Strongly magnetic.

Optical Properties: Opaque. *Color:* Greenish black; light olive-gray in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Uniaxial. *Anisotropism:* Moderate; yellowish to brownish gray.
R_1–R_2: (420) 20.0–19.4, (440) 19.9–19.3, (460) 20.3–19.5, (480) 20.4–19.6, (500) 20.8–19.8, (520) 21.2–20.1, (540) 21.4–20.3, (560) 21.3–20.4, (580) 21.2–20.1, (600) 21.0–20.0, (620) 20.9–19.7, (640) 20.5–19.6, (660) 20.4–19.2, (680) 20.2–19.1

Cell Data: *Space Group:* $I4_1/amd$. $a = 6.025(1)$ $c = 8.539(1)$ $Z = 4$

X-ray Powder Pattern: Gozaisho mine, Japan.
2.570 (100), 3.016 (40), 1.506 (40), 1.509 (35), 4.929 (30), 1.640 (30), 2.135 (16)

Chemistry:

	(1)
SiO_2	0.47
TiO_2	0.30
Al_2O_3	0.32
Fe_2O_3	44.42
Mn_2O_3	22.70
MnO	30.34
MgO	0.61
SrO	0.04
Na_2O	0.02
K_2O	0.02
Total	99.24

(1) Gozaisho mine, Japan; corresponds to $(Mn^{2+}_{0.98}Mg_{0.04})_{\Sigma=1.02}(Fe^{3+}_{1.28}Mn^{3+}_{0.66}Si_{0.02}Al_{0.01}Ti_{0.01})_{\Sigma=1.98}O_4$.

Polymorphism & Series: Dimorphous with jacobsite.

Occurrence: In a regionally metamorphosed bedded manganese deposit.

Association: Rhodonite, braunite, rhodochrosite, hematite, spessartine, quartz.

Distribution: From the Gozaisho mine, Iwaki, Fukushima Prefecture, Japan.

Name: For its occurrence near Iwaki, Japan.

Type Material: National Science Museum, Tokyo, Japan, M21865; National Museum of Natural History, Washington, D.C., USA, 132923.

References: (1) Matsubara, S., A. Kato, and K. Nagashima (1979) Iwakiite, $Mn^{+2}(Fe^{+3}, Mn^{+3})_2O_4$, a new tetragonal spinelloid mineral from the Gozaisho mine, Fukushima Prefecture, Japan. Mineral. J. (Japan), 9, 383–391. (2) (1980) Amer. Mineral., 65, 406 (abs. ref. 1). (3) Jarosch, D. (1988) Crystal structure of iwakiite. Zeits. Krist., 185, 605.

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Isomertieite $Pd_{11}Sb_2As_2$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Grains, to 0.8 mm, rarely showing crystal outlines.

Physical Properties: Hardness = n.d. VHN = 587–597, 592 average (100 g load). D(meas.) = n.d. D(calc.) = 10.33

Optical Properties: Opaque. *Color:* In polished section, pale yellow. *Anisotropism:* Weak, in shades of dull brown.
R: (400) 43.2, (420) 44.1, (440) 45.5, (460) 47.2, (480) 49.2, (500) 51.2, (520) 53.1, (540) 54.8, (560) 56.2, (580) 57.4, (600) 58.6, (620) 59.4, (640) 60.1, (660) 60.5, (680) 60.8, (700) 61.1

Cell Data: *Space Group: Fd3m.* $a = 12.283$ $Z = 8$

X-ray Powder Pattern: Itabira district, Brazil.
2.167 (100), 2.356 (90), 1.533 (70), 1.253 (70), 1.188 (70), 0.996 (70), 1.446 (60)

Chemistry:

	(1)	(2)	(3)
Pd	72.53	74.07	74.85
Au	0.37	1.05	
Cu	1.08	0.13	
Sb	14.61	15.65	15.57
As	10.42	9.53	9.58
Total	99.01	100.43	100.00

(1) Itabira district, Brazil; by electron microprobe, corresponding to $(Pd_{10.66}Cu_{0.27}Au_{0.03})_{\Sigma=10.96}Sb_{1.88}As_{2.17}$. (2) Hope's Nose, England; by electron microprobe, average of two grains; corresponding to $(Pd_{10.89}Au_{0.08}Cu_{0.03})_{\Sigma=11.00}Sb_{2.01}As_{0.99}$. (3) $Pd_{11}Sb_2As_2$.

Polymorphism & Series: Dimorphous with mertieite-I.

Occurrence: In heavy-metal concentrates from Precambrian iron-precious metal deposits (Itabira district, Brazil).

Association: Arsenopalladinite, atheneite, palladseite, hematite, gold (Itabira district, Brazil); chalcopyrite, millerite, kotulskite, arsenopalladinite, hematite (Lac des Iles complex, Canada); hongshiite, cooperite, sperrylite, vysotskite, magnetite, bornite, polydymite, diopside, actinolite, epidote ("Yen" district, China).

Distribution: In Brazil, in gold placers from the Itabira district, Minas Gerais [TL] and in the Serra Pelada Au–Pd–Pt deposit, Pará. At the Lac des Iles complex, Ontario, Canada. In the Konttijärvi intrusion, northern Finland. At Hope's Nose, Torquay, Devon, England. In China, in the "Yen" district – a code name. In Russia, from around Zlatoust, Ural Mountains, and in the Lukkulaisvaara layered intrusion, Karelia. Along the Waiau River, western Southland, New Zealand.

Name: For its structural and compositional relation to mertieite-I.

Type Material: The Natural History Museum, London, England, 1934,72; National Museum of Natural History, Washington, D.C., USA, 142504.

References: (1) Clark, A.M., A.J. Criddle, and E.E. Fejer (1974) Palladium arsenide–antimonides from Itabira, Minas Gerais, Brazil. Mineral. Mag., 39, 528–543. (2) (1974) Amer. Mineral., 59, 1330 (abs. ref. 1). (3) Shi, Ni-Cheng, Zhe-Sheng Ma, Nai-Xian Zhang, and Xui-Shou Ding (1978) Crystal structure of isomertieite (fengluanite). K'o Hsueh T'ung Pao, 23, 499–501 (in Chinese). (4) (1978) Chem. Abs., 89, 187292 (abs. ref. 3). (5) Clark, A.M. and A.J. Criddle (1982) Palladium minerals from Hope's Nose, Torquay, Devon. Mineral. Mag., 46, 371–377.

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Itoite $\mathbf{Pb_3Ge^{4+}O_2(SO_4)_2(OH)_2(?)}$

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Crystal Data: Orthorhombic (by analogy to anglesite). *Point Group:* n.d. As a very fine-grained incrustation or alteration of fleischerite.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.67

Optical Properties: Transparent to translucent. *Color:* White; colorless in transmitted light. *Luster:* Silky.
Optical Class: [Biaxial.] n = 1.84–1.85 α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* [*Pnma*] (*by analogy to anglesite*). $a = 8.47$ $b = 5.38$ $c = 6.94$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia; close to anglesite.
2.065 (10), 3.326 (9), 3.003 (9), 4.240 (8), 3.209 (7), 3.794 (6), 3.604 (6)

Chemistry: (1) Tsumeb, Namibia; presence of essential Pb, Ge, $(SO_4)^{2-}$ confirmed by qualitative analysis; the composition proposed is that of anglesite with replacement of 1/3 $(SO_4)^{2-}$ by $[GeO_2(OH)_2]^{2-}$.

Occurrence: Very rare, in an oxidized zone of a polymetallic germanium-bearing sulfide deposit, as an alteration product of fleischerite, perhaps produced by grinding for X-ray analysis.

Association: Fleischerite, mimetite, cerussite, anglesite, plumbojarosite, tennantite, dolomite.

Distribution: From Tsumeb, Namibia.

Name: Honors Professor Tei-ichi Ito (1898–1980), Japanese mineralogist and crystallographer, University of Tokyo, Tokyo, Japan.

Type Material: Technical University, Berlin, Germany, 57/1405; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 162597.

References: (1) Frondel, C. and H. Strunz (1960) Fleischerit und Itoit, zwei neue Germanium-Mineralien von Tsumeb. Neues Jahrb. Mineral., Monatsh., 132–142 (in German with English abs.). (2) (1960) Amer. Mineral., 45, 1313 (abs. ref. 1).

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. In subhedral to anhedral grains, to 0.1 mm, in monomineralic aggregates, to cm size.

Physical Properties: Hardness = 6–6.5 VHN = 681–772 (100 g load). D(meas.) = 4.85 D(calc.) = 4.89 Strongly magnetic.

Optical Properties: Opaque. *Color:* Greenish black; light olive-gray in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Uniaxial. *Anisotropism:* Moderate; yellowish to brownish gray.
R_1–R_2: (420) 20.0–19.4, (440) 19.9–19.3, (460) 20.3–19.5, (480) 20.4–19.6, (500) 20.8–19.8, (520) 21.2–20.1, (540) 21.4–20.3, (560) 21.3–20.4, (580) 21.2–20.1, (600) 21.0–20.0, (620) 20.9–19.7, (640) 20.5–19.6, (660) 20.4–19.2, (680) 20.2–19.1

Cell Data: *Space Group:* $I4_1/amd$. $a = 6.025(1)$ $c = 8.539(1)$ $Z = 4$

X-ray Powder Pattern: Gozaisho mine, Japan.
2.570 (100), 3.016 (40), 1.506 (40), 1.509 (35), 4.929 (30), 1.640 (30), 2.135 (16)

Chemistry:

	(1)
SiO_2	0.47
TiO_2	0.30
Al_2O_3	0.32
Fe_2O_3	44.42
Mn_2O_3	22.70
MnO	30.34
MgO	0.61
SrO	0.04
Na_2O	0.02
K_2O	0.02
Total	99.24

(1) Gozaisho mine, Japan; corresponds to $(Mn^{2+}_{0.98}Mg_{0.04})_{\Sigma=1.02}(Fe^{3+}_{1.28}Mn^{3+}_{0.66}Si_{0.02}Al_{0.01}Ti_{0.01})_{\Sigma=1.98}O_4$.

Polymorphism & Series: Dimorphous with jacobsite.

Occurrence: In a regionally metamorphosed bedded manganese deposit.

Association: Rhodonite, braunite, rhodochrosite, hematite, spessartine, quartz.

Distribution: From the Gozaisho mine, Iwaki, Fukushima Prefecture, Japan.

Name: For its occurrence near Iwaki, Japan.

Type Material: National Science Museum, Tokyo, Japan, M21865; National Museum of Natural History, Washington, D.C., USA, 132923.

References: (1) Matsubara, S., A. Kato, and K. Nagashima (1979) Iwakiite, $Mn^{+2}(Fe^{+3}, Mn^{+3})_2O_4$, a new tetragonal spinelloid mineral from the Gozaisho mine, Fukushima Prefecture, Japan. Mineral. J. (Japan), 9, 383–391. (2) (1980) Amer. Mineral., 65, 406 (abs. ref. 1). (3) Jarosch, D. (1988) Crystal structure of iwakiite. Zeits. Krist., 185, 605.

Iwateite $Na_2BaMn(PO_4)_2$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$. As granular to irregular inclusions, to100 μm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 4.06

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: n.d.
Pleochroism: Very weak.
Optical Class: n.d.

Cell Data: *Space Group*: $P\bar{3}$. a = 5.3642(10) c = 7.039(2) Z = 1

X-ray Powder Pattern: Tanohata mine, Iwate Prefecture, Japan.
2.806 (100), 1.9388 (91), 2.683 (74), 4.646 (67), 3.877 (48), 2.506 (46), 7.0315 (39)

Chemistry:

	(1)	(2)
Na_2O	14.66	14.47
BaO	35.52	35.81
SrO	2.43	
MnO	13.26	16.57
MgO	1.55	
P_2O_5	32.65	33.15
Total	100.07	100.00

(1) Tanohata mine, Japan; average of 10 electron microprobe analyses, PO_4 confirmed by Raman spectroscopy; corresponding to $Na_{2.026}(Ba_{0.993}Sr_{0.101})_{\Sigma=1.094}(Mn_{0.801}Mg_{0.164})_{\Sigma=0.965}P_{1.971}O_8$.
(2) $Na_2BaMn(PO_4)_2$.

Occurrence: In a Ba- and Sr-bearing manganese deposit.

Association: Sérandite.

Distribution: From the No. 3 (Matsumaezawa) deposit, Tanohata mine, Tanohata Village, Iwate Prefecture, Japan.

Name: For the Japanese Prefecture (*Iwate*) that contains the locality that produced the first specimens.

Type Material: National Museum of Nature and Science, Tokyo, Japan (NSM-M43779).

References: (1) Nishio-Hamane, D., T. Minakawa, and H. Okada (2014) Iwateite, $Na_2BaMn(PO_4)_2$, a new mineral from the Tanohata mine, Iwate Prefecture, Japan. Journal of Mineralogical and Petrological Sciences, 109(1), 34-37. (2) (2015) Amer. Mineral., 100, 335-336 (abs. ref. 1).

Ixiolite $(Ta, Nb, Sn, Fe, Mn)O_2$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As crudely prismatic crystals, to 10 cm; commonly as irregular grains. *Twinning:* On {013}, uncommon.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 836–967 (100 g load). D(meas.) = 6.94–7.23 D(calc.) = [7.34] Significant Sn, along with Mn, Fe, and Ti in its composition, is essential to the definition of this species, the disordered counterpart of wodginite, to which it alters on heating.

Optical Properties: Opaque. *Color:* Blackish gray to steel-gray. *Streak:* Dark brown. *Luster:* Submetallic.

R_1–R_2: n.d.

Cell Data: *Space Group:* $P2/c$. $a = 9.481(3)$ $b = 11.494(5)$ $c = 5.158(2)$ $\beta = 90°8(2)'$ Z = 16

X-ray Powder Pattern: Skogböle, Finland; may be confused with columbite.
2.98 (100), 3.65 (32), 1.459 (29), 1.722 (24), 2.51 (20), 1.746 (17), 2.57 (13)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
WO_3	0.30	1.87	SnO_2	12.27	11.38	MnO	5.40	9.19
Nb_2O_5	10.50	6.12	Al_2O_3	0.16		MgO		0.01
Ta_2O_5	61.47	63.79	Sc_2O_3		0.16	CaO	0.11	
SiO_2	0.12		As_2O_3		0.04	H_2O^+	0.16	
TiO_2	0.38	2.68	Sb_2O_3		0.02	H_2O^-	0.08	
ZrO_2	0.60	0.20	FeO	8.08	2.98	Total	99.63	98.44

(1) Skogböle, Finland; corresponds to $(Ta_{0.44}Fe_{0.18}Sn_{0.13}Nb_{0.12}Mn_{0.12}Zr_{0.01}Ti_{0.01})_{\Sigma=1.01}O_2$.
(2) Bradlo, Czech Republic; by electron microprobe, total Fe as FeO, corresponding to $(Ta_{0.46}Mn_{0.21}Sn_{0.12}Nb_{0.07}Fe_{0.07}Ti_{0.05}W_{0.01})_{\Sigma=0.99}O_2$.

Occurrence: An accessory mineral in granite pegmatites.

Association: Microcline, tapiolite, cassiterite, microlite, niobian rutile.

Distribution: Found at Skogböle, Kemiö (Kimito) Island, Finland. From Bradlo, Czech Republic. At the Swanson mine, East Hampton, Middlesex Co., Connecticut, USA. In the Yellowknife district, Northwest Territories, Canada. At Bikita, Zimbabwe. In the Kalbinskiy Range, eastern Kazakhstan. From Wodgina, Pilbara, Western Australia. At an undefined locality in the Xinjiang Uygur Autonomous Region, China.

Name: For *Ixion*, of Greek mythology, who was related to Tantalus, in allusion to the mineral's relation to tantalite.

Type Material: University of Finland, Helsinki, Finland, 1014; Wroclaw University, Wroclaw, Poland, II–4874; Royal Ontario Museum, Toronto, Canada, M6591.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 778. (2) Nickel, E.H., J.F. Rowland, and R.C. McAdam (1963) Ixiolite – a columbite substructure. Amer. Mineral., 48, 961–979. (3) Wise, M.A. and P. Černý (1986) The status of ixiolite. Int. Mineral. Assoc. General Meeting Abs., 265. (4) Černý, P. and D. Němec (1995) Pristine vs. contaminated trends in Nb,Ta-oxide minerals of the Jihlava pegmatite district, Czech Republic. Mineral. Petrol., 55, 117–129.

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Izoklakeite $\mathbf{Pb_{27}(Cu,Fe)_2(Sb,Bi)_{19}S_{57}}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Aggregates of acicular crystals, to 1 mm.

Physical Properties: *Cleavage:* {001}, good. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.7–4.2 VHN = 150–212 (50 g load). D(meas.) = 6.47 D(calc.) = 6.505

Optical Properties: Opaque. *Color:* Lead-gray. *Streak:* Gray-black. *Luster:* Metallic. *Pleochroism:* From pale greenish white to darker greenish white or gray. *Anisotropism:* Distinct, from greenish gray to dark gray to brownish gray.
R_1–R_2: (400) 44.6–48.5, (420) 44.1–48.4, (440) 43.5–48.0, (460) 42.5–47.4, (480) 42.2–46.9, (500) 41.6–46.2, (520) 41.0–45.7, (540) 40.6–45.2, (560) 40.1–44.8, (580) 39.8–44.4, (600) 39.6–44.1, (620) 39.3–43.8, (640) 39.1–43.5, (660) 38.8–43.2, (680) 38.5–42.9, (700) 38.2–42.5

Cell Data: *Space Group: Pnnm.* $a = 33.88(2)$ $b = 38.02(2)$ $c = 4.070(2)$ $Z = 1$

X-ray Powder Pattern: Izok Lake, Canada.
3.398 (100), 2.149 (60), 3.305 (40), 2.038 (40b), 2.878 (40), 1.745 (40), 3.159 (30)

Chemistry:

	(1)	(2)		(1)	(2)
Pb	46.6	50.01	Sb	13.3	11.67
Cu	1.0	0.88	Bi	20.5	19.20
Fe	0.2	0.19	S	17.0	16.91
Ag	2.0	0.59	Total	100.6	99.45

(1) Izok Lake, Canada; by electron microprobe, average of three analyses; corresponds to $Pb_{22.96}Ag_{1.89}(Cu_{1.61}Fe_{0.37})_{\Sigma=1.98}(Sb_{11.15}Bi_{10.02})_{\Sigma=21.17}S_{54.13}$. (2) Vena mines, Sweden; by electron microprobe, average of 19 analyses; corresponds to $Pb_{25.64}Ag_{0.58}(Cu_{1.47}Fe_{0.36})_{\Sigma=1.83}(Sb_{10.18}Bi_{9.76})_{\Sigma=19.94}S_{56.02}$.

Polymorphism & Series: Forms a series with giessenite.

Occurrence: In a massive Zn–Cu–Pb sulfide deposit (Izok Lake, Canada); from a Cu–Co sulfide deposit in skarn (Vena mines, Sweden).

Association: Galena, pyrrhotite, pyrite, jaskólskiite (Izok Lake, Canada); galena, jaskólskiite, pyrrhotite, bismuth, antimony, antimonian bismuthinite, kobellite (Vena mines, Sweden).

Distribution: From Izok Lake, Northwest Territories, Canada [TL]. At the Vena mines, near Askersund, Örebro, Sweden. From near Lake Zervreila, Vals, Graubünden, Switzerland. At Bazoges, Vendée, and in the Chalanches mine, near Allemont, Isère, France. In the Toroiaga mine, Baia Borą district, Romania. From the Srednegolgotaiskoe gold deposit, eastern Transbaikalia, Siberia, Russia. At the Otome mine, Yamanashi Prefecture, Japan. From Mangchang, Guangxi Autonomous Region, China.

Name: For the locality at Izok Lake, Canada.

Type Material: The Natural History Museum, London, England, 1983,75; Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada; National Museum of Natural History, Washington, D.C., USA, 165272.

References: (1) Harris, D.C., A.C. Roberts, and A.J. Criddle (1986) Izoklakeite, a new mineral species from Izok Lake, Northwest Territories. Can. Mineral., 24, 1–5. (2) (1987) Amer. Mineral., 72, 222 (abs. ref. 1). (3) Zakrzewski, M.A. and E. Makovicky (1986) Izoklakeite from Vena, Sweden, and the kobellite homologous series. Can. Mineral., 24, 7–18. (4) Makovicky, E. and W.G. Mumme (1986) The crystal structure of izoklakeite, $Pb_{51.3}Sb_{20.4}Bi_{19.5}Ag_{1.2}Cu_{2.9}Fe_{0.7}S_{114}$. The kobellite homologous series and its derivatives. Neues Jahrb. Mineral., Abh., 153, 121–145. (5) Armbruster, T. and W. Hummel (1987) (Sb,Bi,Pb) ordering in sulfosalts: crystal-structure refinement of a Bi-rich izoklakeite. Amer. Mineral., 72, 821–831. (6) Moëlo, Y., G. Roger, D. Maurel-Palacin, E. Marcoux, and A. Loroussi (1995) Chemistry of some Pb-(Cu,Fe)-(Sb,Bi) sulfosalts from France and Portugal. Implications for the crystal chemistry of lead sulfosalts in the Cu-poor part of the Pb_2S_2–Cu_2–Sb_2S_3–Bi_2S_3 system. Mineral. Petrol., 53, 229–250.

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Jáchymovite $(UO_2)_8(SO_4)(OH)_{14}\cdot 13H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As crusts of acicular crystals, to 0.1 mm.

Physical Properties: *Cleavage:* On {010}, very good. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.79 Radioactive; fluoresces yellow under SW and LW UV.

Optical Properties: Translucent. *Color:* Yellow. *Streak:* Pale yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Y = pale yellow; Z = yellow. $\alpha = 1.715(2)$ $\beta = 1.718(2)$ $\gamma = 1.720(2)$ 2V(meas.) = n.d. 2V(calc.) = 78°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 18.553(8)$ $b = 9.276(2)$ $c = 13.532(7)$ $\beta = 125.56(2)°$ Z = 2

X-ray Powder Pattern: Jáchymov, Czech Republic.
7.56 (100), 7.13 (48), 3.771 (34), 3.554 (20), 3.206 (13), 3.234 (10), 2.052 (8)

Chemistry:

	(1)	(2)
SO_3	2.79	2.93
UO_3	84.20	83.86
H_2O	13.32	13.21
Total	100.31	100.00

(1) Jáchymov, Czech Republic; H_2O by TGA, corresponds to $(UO_2)_{8.01}(SO_4)_{0.95}(OH)_{14.12}\cdot 13.06H_2O$. (2) $(UO_2)_8(SO_4)(OH)_{14}\cdot 13H_2O$.

Occurrence: Found on a museum specimen from the heavily oxidized portions of a uraninite-bearing vein in dolomite.

Association: Gypsum, uranopilite, uraninite.

Distribution: From Jáchymov (Joachimsthal), Czech Republic.

Name: For the uranium deposit at Jáchymov, Czech Republic, where the specimen was collected.

Type Material: Natural History Museum, Prague, Czech Republic, P1N-68905.

References: (1) Čejka, J., J. Sejkora, Z. Mrázek, Z. Urbanec, and T. Jarchovský (1996) Jáchymovite, $(UO_2)_8(SO_4)(OH)_{14}\cdot 13H_2O$, a new uranyl mineral from Jáchymov, the Krušné hory Mts., Czech Republic, and its comparison with uranopilite. Neues Jahrb. Mineral., Abh., 170, 155–170. (2) (1997) Amer. Mineral., 82, 207–208 (abs. ref. 1).

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Jacobsite $(Mn^{2+}, Fe^{2+}, Mg)(Fe^{3+}, Mn^{3+})_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rarely in octahedral crystals, to 4 mm, which may exhibit exsolved hausmannite or galaxite; coarse to fine granular, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law, flattened on {111} or lamellar.

Physical Properties: *Cleavage:* {111}, probably a parting. Hardness = 5.5–6.5 VHN = 665–707 (100 g load). D(meas.) = 4.76 D(calc.) = 5.03 Weakly magnetic.

Optical Properties: Opaque, translucent on thin edges. *Color:* Black to brownish black; grayish white with olive tint in reflected light, with brown internal reflections. *Streak:* Brown. *Luster:* Metallic, splendent to semimetallic, dull.
Optical Class: Isotropic. $n = \sim 2.3$
R: (400) 19.0, (420) 18.8, (440) 18.6, (460) 18.4, (480) 18.2, (500) 18.1, (520) 18.0, (540) 17.8, (560) 17.6, (580) 17.4, (600) 17.2, (620) 17.0, (640) 16.8, (660) 16.6, (680) 16.5, (700) 16.4

Cell Data: *Space Group:* $Fd3m$ (synthetic $MnFe_2O_4$). $a = 8.499$ $Z = 8$

X-ray Powder Pattern: Synthetic $MnFe_2O_4$.
2.563 (100), 1.5031 (40), 3.005 (35), 1.6355 (35), 1.1063 (30), 2.124 (25), 4.906 (20)

Chemistry:

	(1)	(2)
TiO_2	0.09	0.38
Al_2O_3		8.14
Fe_2O_3	73.96	59.5
FeO	2.57	0.5
MnO	13.94	32.1
MgO	9.26	0.03
Total	99.82	100.6

(1) Jakobsberg, Sweden. (2) Bald Knob, North Carolina, USA; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Mn^{2+}_{0.99}Fe^{2+}_{0.02}Mg_{0.01})_{\Sigma=1.02}(Fe^{3+}_{1.62}Al_{0.35}Ti_{0.01})_{\Sigma=1.98}O_4$.

Polymorphism & Series: Forms a series with magnetite, dimorphous with iwakiite.

Mineral Group: Spinel group.

Occurrence: A primary mineral or an alteration product of other manganese-bearing minerals in some metamorphosed manganese deposits.

Association: Hausmannite, galaxite, braunite, pyrolusite, coronadite, hematite, magnetite.

Distribution: In Sweden, from Jakobsberg and Långban, Värmland, and Väster Silfberg, Dalarne; and in the Sjö mine, near Grythyttan, Örebro. From the Benallt mine, near Rhiw, Lleyn Peninsula, Wales. In the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, and from the Otjiwarongo district, Namibia. At the N'Chwaning mine, near Kuruman, Cape Province, South Africa, in crystals large for the species. From Broken Hill, New South Wales, and at the Iron Monarch quarry, Iron Knob, South Australia. From mines around Kodur, Andhra Pradesh, India. In Japan, from the Kiuragi mine, Saga Prefecture, the Noda-Tamagawa mine, Iwate Prefecture, the Kunimiyama mine, Kochi Prefecture, and many others. From the Urandi district, Bahia, Brazil. In the USA, from Bald Knob, near Sparta, Alleghany Co., North Carolina. A few additional localities are known.

Name: For its original occurrence at Jakobsberg (formerly Jacobsberg), Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 698–707. (2) Wickman, F.E. (1947) A redetermination of the space-group of jacobsite. Geol. Fören. Förhandl. Stockholm, 69, 363–365. (3) Essene, E.J. and D.R. Peacor (1983) Crystal chemistry and petrology of coexisting galaxite and jacobsite and other spinel solutions and solvi. Amer. Mineral., 68, 449–455. (4) (1960) NBS Circ. 539, 9, 36.

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Jacquesdietrichite $Cu_2[BO(OH)_2](OH)_3$

Crystal Data: Orthorhombic. *Point Group:* 2/*m* 2/*m* 2/*m*. As blades, intergrown tablets, and scales, to 0.5 mm; {001} dominant, bounded by {100} and {010}.

Physical Properties: *Cleavage:* Perfect {100}, good on {010} and {001}. *Fracture:* Irregular. *Tenacity:* Blades flexible. Hardness = 2 D(meas.) = 3.28(5) D(calc.) = 3.303

Optical Properties: Transparent. *Color:* Bright blue. *Streak:* Pale blue. *Luster:* Vitreous. *Optical Class:* Biaxial (-). α = 1.627(2) β = 1.699(2) γ = 1.769(2) 2V(calc.) = 86° *Dispersion*: None. *Orientation:* $X = a$; $Y = c$; Z = b. *Pleochroism:* Pronounced, X = deep blue; Y = medium blue; Z = pale blue.

Cell Data: *Space Group: Pnma*. a = 9.455(2) b = 5.866(2) c = 8.668(2) Z = 4

X-ray Powder Pattern: Tachgagalt mine, Morocco.
4.734 (100), 3.941 (90), 2.489 (50), 1.922 (50), 2.545 (45), 3.192 (40), 1.838 (40)

Chemistry:

	(1)	(2)
CuO	72.68	66.6
CaO	0.11	
SiO_2	1.00	
B_2O_3	14.57	14.6
H_2O	18.85	18.8
Total	107.21	100.0

(1) Tachgagalt mine, Morocco; average of 8 electron microprobe analyses, B_2O_3 and H_2O calculated from structure analysis, Ca and Si considered impurities and disregarded; corresponding to $Cu_{3.02}Zn_{0.96}(OH)_{5.91}H_{0.03}Cl_{2.08}$. (2) $Cu_2[BO(OH)_2](OH)_3$.

Occurrence: Probably formed as a secondary, low-temperature product of hydrothermal reworking of boron-bearing manganese-oxide ore (gaudefroyite).

Association: Henritermierite, gaudefroyite, calcite.

Distribution: From Vein #2, Tachgagalt mine, near Ouarzazate, Anti-Atlas Mountains, Morocco.

Name: Honors French geologist Jacques Emile Dietrich (b. 1926), who collected the first specimens.

Type Material: Natural History Museum of Los Angeles County, California, USA; 52461.

References: (1) Kampf, A.R. and G. Favreau (2004) Jacquesdietrichite, $Cu_2[BO(OH)_2](OH)_3$, a new mineral from the Tachgagalt mine, Morocco: Description and crystal structure. Eur. J. Mineral., 16, 361-366. (2) (2005) Amer. Mineral., 90, 519 (abs. ref. 1).

Jacutingaite Pt_2HgSe_3

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ 2/*m*. As a single 50 μm grain, in an athenite-potarite-hematite aggregate.

Physical Properties: *Cleavage*: Very good on {001}. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = ~ 3.5 VHN = 119-245 (10 g load) [Synthetic]. D(meas.) = 10.9 D(calc.) = 10.35

Optical Properties: Opaque. *Color*: Gray, light gray in reflected light [Synthetic]. *Streak*: Gray [Synthetic]. *Luster*: Metallic.
Optical Class: n.d. *Pleochroism*: Bluish gray to rusty brown. *Anisotropism:* Weak to distinct.
R_1-R_2: (470) 47.4-51.1, (546) 48.2-50.5, (589) 48.0-49.6, (650) 47.1-47.8

Cell Data: *Space Group*: $P\bar{3}\,m1$. a = 7.3477(2) c = 5.2955(1) Z = 2

X-ray Powder Pattern: Synthetic Pt_2HgSe_3.
5.292 (100), 1.765 (37), 2.035 (18), 2.727 (16), 1.324 (11), 1.0448 (11), 1.0449 (11)

Chemistry:

	(1)
Pt	37.3
Pd	5.91
Hg	25.72
Ag	0.16
Cu	0.82
Se	31.48
Total	101.39

(1) Cauê deposit, Itabira District, Minas Gerais, Brazil; average of 3 electron microprobe analyses; corresponding to $(Pt_{1.46}Pd_{0.42}Cu_{0.10}Ag_{0.01})_{\Sigma=1.99}Hg_{0.98}Se_{3.04}$.

Occurrence: In heavy-mineral concentrate from a friable, hematite-rich auriferous vein that cuts metamorphosed banded iron formation.

Association: Potarite, atheneite, hematite.

Distribution: Cauê iron-ore deposit, Itabira District, Minas Gerais, Brazil.

Name: After vein-type gold mineralization rich in specular hematite, known as "jacutinga" in Minas Gerais, Brazil.

Type Material: GeoMuseum, Technical University of Clausthal, Germany (# 26580).

References: (1) Vymazalová, A., F. Laufek, M. Drábek, A.R. Cabral, J. Haloda, T. Sidorinová, B. Lehmann, H.F. Galbiatti, and J. Drahokoupil (2012) Jacutingaite, Pt_2HgSe_3, a new platinum-group mineral species from the Cauê iron-ore deposit, Itabira District, Minas Gerais, Brazil. Can. Mineral., 50(2), 431-440. (2) Drábek, M., A. Vymazalová, and A.R. Cabral (2012) The system Hg-Pt-Se at 400°C: phase relations involving jacutingaite. Can. Mineral., 50(2), 441-446.
(3) (2014) Amer. Mineral., 99, 2154 (abs. refs. 1 & 2).

Jadarite $LiNaSiB_3O_7(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As elongate, tabular plates and grains, to 5-10 μm; in massive aggregates several meters thick. Twinning observed in some crystals with extinction under polarized light at 8°.

Physical Properties: *Cleavage*: None observed. *Fracture*: Uneven to conchoidal. *Tenacity*: Brittle. Hardness = 4-5 VHN = 343-426 (200 g load). D(meas.) = 2.45 D(calc.) = 2.46

Optical Properties: Translucent to opaque. *Color*: White, dark grey in reflected light, abundant white internal reflections. *Streak*: White. Weak pink-orange fluorescence under short- and long-wave ultraviolet radiation. *Luster*: Porcelaneous.
Optical Class: Biaxial. *Bireflectance:* Weak. α = 1.536(1) γ = 1.563(1)

Cell Data: *Space Group*: $P2_1/n$ [possible]. a = 6.818(2) b = 13.794(2) c = 6.756(2) β = 111.10(2)° Z = 4

X-ray Powder Pattern: Jadar Basin, Serbia.
2.946 (100), 3.180 (82), 3.152 (74), 2.241 (74), 4.666 (62), 3.027 (40), 3.716 (39)

Chemistry:

	(1)	(2)
Li_2O	7.3	6.81
Na_2O	15.0	14.12
SiO_2	26.4	27.38
B_2O_3	47.2	47.59
H_2O	4.3	4.11
Total	100.2	100.00

(1) Jadar Basin, Serbia; wet chemical, ICPAES and CHN analyses, IR spectroscopy confirms presence of OH, BO_3 and perhaps BO_4, corresponding to $Li_{1.08}Na_{1.07}Si_{0.97}B_3O_{6.99}(OH)_{1.06}$.
(2) $LiNaSiB_3O_7(OH)$.

Occurrence: In a sequence of interbedded oil-shales, dolomicrites and pyroclastic tuffaceous deposits of lacustrine basin fill and marine origin.

Association: Calcite, dolomite, K-feldspar, rutile, albite, ilmenite, pyrite, fine-grained muscovite, searlesite.

Distribution: From drill core collected in the Jadar Basin, Serbia (44° 32′ N, 19° 18′ E).

Name: For the Jadar Basin in Serbia, where the first samples were collected.

Type Material: Natural History Museum, London, England, BM 2006, 16; Systematic Reference Series of the National Mineral Collection of Canada, Geological Survey of Canada, Ottawa, Canada, NMCC 068101; the Natural History Museum, Budapest, Hungary and the Belgrade Natural History Museum, Belgrade, Serbia.

References: (1) Stanley, C.J., G.C. Jones, M.S. Rumsey, C. Blake, A.C. Roberts, J.A.R. Stirling, G.J.C. Carpenter, P.S. Whitfield, J.D. Grice, and Y. LePage (2007) Jadarite, $LiNaSiB_3O_7(OH)$, a new mineral species from the Jadar Basin, Serbia. Eur. J. Mineral., 19, 575–580. (2) (2008) Amer. Mineral., 93, 703 (abs. ref. 1). (3) Whitfield, P.S., Y. LePage, J.D. Grice, C.J. Stanley, G.C. Jones, M.S. Rumsey, C. Blake, A.C. Roberts, J.A.R. Stirling, and G.J.C. Carpenter (2007) $LiNaSiB_3O_7(OH)$ - novel structure of the new borosilicate mineral jadarite, determined from laboratory powder diffraction data. Acta Cryst. B., B63, 396-401.

Jadeite $Na(Al, Fe^{3+})Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals rare, prismatic with {110}, {111}, and {100} as dominant forms, showing cleavage faces to 1 cm. Commonly massive, or fibrous, granular, compact. *Twinning:* Single and lamellar twinning on {100} and {001}.

Physical Properties: *Cleavage:* Good on {110}, (110) ∧ (1$\bar{1}$0) ∼87°. *Fracture:* Splintery. *Tenacity:* Very tough when massive. Hardness = 6–7 D(meas.) = 3.24–3.43 D(calc.) = 3.330

Optical Properties: Translucent. *Color:* Apple-green, emerald-green, bluish green, leek-green, greenish white, white, may show green spots, rarely blue or violet; colorless in thin section. *Streak:* White. *Luster:* Subvitreous, pearly on cleavages.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 32°–55°$. *Dispersion:* $r > v$, moderate to strong. $\alpha = 1.640–1.681$ $\beta = 1.645–1.684$ $\gamma = 1.652–1.692$ 2V(meas.) = 60°–96°

Cell Data: *Space Group:* $C2/c$. $a = 9.418$ $b = 8.562$ $c = 5.219$ $\beta = 107.58°$ Z = 4

X-ray Powder Pattern: Clear Creek, California, USA.
2.831 (100), 2.922 (75), 4.29 (45), 3.10 (30), 2.069 (30), 2.417 (25), 2.490 (20)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	59.06	61.66	MgO	0.17	0.98
TiO_2	0.08	0.05	CaO	0.35	1.38
Al_2O_3	24.62	21.81	Na_2O	14.95	12.27
Fe_2O_3	0.41	0.32	K_2O	0.01	0.57
FeO	0.18	0.24	H_2O^+	0.07	0.44
MnO	0.03	0.05	H_2O^-	0.03	0.10
			Total	99.96	99.87

(1) New Idria district, California, USA; corresponds to $(Na_{0.98}Ca_{0.01})_{\Sigma=0.99}(Al_{0.98}Fe^{3+}_{0.01}Mg_{0.01})_{\Sigma=1.00}Si_{2.00}O_6$. (2) Cloverdale, California, USA; corresponds to $(Na_{0.80}Ca_{0.05}K_{0.02})_{\Sigma=0.87}(Al_{0.87}Mg_{0.05}Fe^{3+}_{0.01}Fe^{2+}_{0.01})_{\Sigma=0.94}Si_{2.08}O_6$.

Mineral Group: Pyroxene group.

Occurrence: In high-pressure metamorphic rocks of the glaucophane facies; a component of eclogite.

Association: Albite, quartz, muscovite, omphacite, glaucophane, calcite, aragonite, analcime, zeolites.

Distribution: In small amounts at many places; the origin of many specimens is obscure. Some well-known localities are: around Tawmaw, Myitkyina-Mogaung district, Kachin State, northern Myanmar (Burma). In the Ohmi area, along the Hashidate and Kotake Rivers, Niigata Prefecture, and at Shibukawa, Gumma Prefecture, Japan. Around Lake Baikal, Siberia, Russia. In the USA, in California, as crystals in boulders along the Russian River, about 3.5 km north of the Sonoma-Mendocino Co. line, near Cloverdale; at Clear Creek, near New Idria, San Benito Co.; and at several places in Mendocino Co. At Manzanal, in the Motagua Valley, near the Sierra de las Minas, Guatemala.

Name: From *jade*, a material commonly containing jadeite, in turn from the Spanish *Piedra de yjada*, or *colic stone*, for its supposedly curative powers for nephritic colic.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 369–371. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 461–481. (3) Wolfe, C.W. (1955) Crystallography of jadeite crystals from near Cloverdale, California. Amer. Mineral., 40, 248–260. (4) Prewitt, C.T. and C.W. Burnham (1966) The crystal structure of jadeite, $NaAlSi_2O_6$. Amer. Mineral., 51, 956–975. (5) Coleman, R.G. and J.R. Clark (1968) Pyroxenes in the blueschist facies of California. Amer. J. Sci., 266, 43–59.

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Jaffeite **$Ca_6Si_2O_7(OH)_6$**

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As euhedral to subhedral crystals elongated $\parallel$ [0001], to 0.4 mm, showing hexagonal cross sections, and with {0001} and {$10\overline{1}0$}.

Physical Properties: *Cleavage:* {$10\overline{1}0$}, imperfect, suspected. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.65(3) D(calc.) = 2.58(2)

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.596(2)$ $\epsilon = 1.604(2)$

Cell Data: *Space Group:* [$P\overline{3}$] (by analogy to synthetic $Ca_6Si_2O_7(OH)_6$). $a = 10.026(5)$ $c = 7.482(4)$ Z = 2

X-ray Powder Pattern: Kombat mine, Namibia.
8.66 (100), 2.996 (90), 2.833 (90), 2.887 (70), 3.279 (50), 2.466 (30), 2.083 (30)

Chemistry:

	(1)
SiO_2	23.96
CaO	64.98
H_2O	[11.06]
Total	[100.00]

(1) Kombat mine, Namibia; by electron microprobe, average of three analyses, includes Mn and Cl < 0.1%, H_2O by difference; corresponds to $Ca_{5.86}Si_{2.02}O_{13}H_{6.21}$.

Occurrence: Closely associated with or enclosed by defernite within low-grade metamorphic rocks.

Association: Defernite, hausmannite, apatite, brucite, hillebrandite, vesuvianite, glaucochroite, galena, copper.

Distribution: At the Kombat mine, 49 km south of Tsumeb, Namibia.

Name: In honor of Professor Howard W. Jaffe of the University of Massachusetts, Amherst, Massachusetts, USA.

Type Material: Museum of Natural History, Geneva, Switzerland, 500/32; National Museum of Natural History, Washington, D.C., USA, 163802.

References: (1) Sarp, H. and D.R. Peacor (1989) Jaffeite, a new hydrated calcium silicate from the Kombat mine, Namibia. Amer. Mineral., 74, 1203–1206.

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Jagoite $(Pb, Na)_3(Fe^{3+}, Mg)Si_3O_{10}(Cl, OH)$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Fine-grained micaceous aggregates of plates.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Plates are flexible.
Hardness = 3 D(meas.) = 5.43 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Yellow-green. *Streak:* Yellow.
Luster: Vitreous, shining on cleavages.
Optical Class: Uniaxial (–). $n = \sim 2.0$; birefringence = 0.025.

Cell Data: *Space Group:* $P\bar{6}2c$. a = 8.528(8) $c = 33.33(3)$ Z = [6]

X-ray Powder Pattern: Långban, Sweden.
3.40 (100), 2.80 (80), 4.16 (50), 2.99 (50), 2.50 (40), 2.60 (30), 2.47 (30)

Chemistry:

	(1)		(1)
SiO_2	22.35	MgO	0.60
TiO_2	0.10	CaO	0.65
Al_2O_3	0.50	Na_2O	0.61
Fe_2O_3	7.00	K_2O	0.37
FeO	0.00	Cl	3.25
MnO	0.88	H_2O^+	0.17
PbO	64.26	H_2O^-	0.19
BeO	0.12	$-O = Cl_2$	0.73
		Total	100.32

(1) Långban, Sweden; corresponds to $(Pb_{2.43}Na_{0.17}Ca_{0.10}K_{0.07})_{\Sigma=2.77}(Fe^{3+}_{0.74}Mg_{0.12}Mn_{0.10}Ti_{0.01})_{\Sigma=0.97}(Si_{3.14}Al_{0.08}Be_{0.04})_{\Sigma=3.26}O_{9.98}[Cl_{0.77}(OH)_{0.16}]_{\Sigma=0.93}$.

Occurrence: In hematite ore in a metamorphosed Fe–Mn orebody.

Association: Melanotekite, quartz.

Distribution: At Långban, Värmland, Sweden.

Name: For John Bernard Jago Trelawney (1909–2001), American mineral collector of Palo Alto, California, USA, and benefactor of mineral collections in the USA.

Type Material: n.d.

References: (1) Blix, R., O. Gabrielson, and F.E. Wickman (1957) Jagoite, a new lead-silicate mineral from Långban in Sweden. Arkiv Mineral. Geol., 2, 315–317. (2) (1958) Amer. Mineral., 43, 387 (abs. ref. 1). (3) Mellini, M. and S. Merlino (1981) The crystal structure of jagoite. Amer. Mineral., 66, 852–858.

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Jagowerite $BaAl_2(PO_4)_2(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As crystalline masses, to 2.5 cm.

Physical Properties: *Cleavage:* Good on {100} and {011}; fair on {$0\overline{1}1$}. Hardness = 4.5 D(meas.) = 4.01 D(calc.) = 4.05 Fluoresces greenish white under LW UV.

Optical Properties: Translucent. *Color:* Light green. *Luster:* Vitreous.
Optical Class: Biaxial (+) [*sic*]. $\alpha = 1.672(3)$ $\beta = 1.693(3)$ $\gamma = 1.710(3)$
2V(meas.) = 80(5)°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 6.049(2)$ $b = 6.964(3)$ $c = 4.971(2)$
$\alpha = 116.51(4)°$ $\beta = 86.06(4)°$ $\gamma = 112.59(3)°$ Z = 1

X-ray Powder Pattern: Yukon Territory, Canada.
3.00 (100), 3.26 (60), 2.94 (55), 5.55 (40), 2.21 (35), 1.90 (35), 2.91 (30)

Chemistry:

	(1)	(2)
P_2O_5	31.41	34.18
Al_2O_3	25.87	24.55
Fe_2O_3	0.26	
BaO	38.41	36.93
S	0.15	
H_2O^+	4.09	4.34
Total	100.19	100.00

(1) Yukon Territory, Canada; molecular H_2O shown absent by IR; recalculated after deduction of quartz impurity, then corresponds to $Ba_{1.07}(Al_{2.15}Fe_{0.01})_{\Sigma=2.16}[(P_{0.94}S_{0.01})_{\Sigma=0.95}O_4]_2(OH)_2$.
(2) $BaAl_2(PO_4)_2(OH)_2$.

Occurrence: In quartz veins filling tension fractures in carbonaceous argillite.

Association: Pyrite, hinsdalite.

Distribution: From a locality about 25 km north of the Hess River, N.T.S. area 105–N–7, Yukon Territory, Canada.

Name: Honors John Arthur Gower (1921–1972), Professor of Mineralogy, University of British Columbia, Vancouver, Canada.

Type Material: Department of Geological Sciences, University of British Columbia, Vancouver, Canada, S-75-4220; The Natural History Museum, London, England, 1978,450; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 128337.

References: (1) Meagher, E.P., M.E. Coates and A.E. Aho (1973) Jagowerite: a new barium phosphate mineral from the Yukon Territory. Can. Mineral., 12, 135–136. (2) (1976) Amer. Mineral., 61, 175 (abs. ref. 1). (3) Meagher, E.P., C.S. Gibbons, and J. Trotter (1974) The crystal structure of jagowerite: $BaAl_2P_2O_8(OH)_2$. Amer. Mineral., 59, 291–295.

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Jahnsite-(CaMnFe) $\mathbf{CaMn^{2+}Fe_2^{2+}Fe_2^{3+}(PO_4)_4(OH)_2 \cdot 8H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed crystals and warty crystal aggregates, to 3 mm; in "splinters" intergrown with rockbridgeite.

Physical Properties: *Cleavage:* [Good on {001}] [by analogy to jahnsite-(CaMnMg)]. *Fracture:* Splintery. *Tenacity:* [Brittle.] Hardness = [4] D(meas.) = 2.86 D(calc.) = [2.88]

Optical Properties: Translucent. *Color:* Yellow-brown. *Luster:* [Vitreous to subadamantine.]
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow-brown; Y = yellow-brown; Z =dark yellow-brown. *Dispersion:* $r > v$, strong. $\alpha = 1.682$ $\beta = 1.695$ $\gamma = 1.707$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2/a$. $a = 15.01(3)$ $b = 7.15(2)$ $c = 9.87(2)$ $\beta = 111°14(10)'$ Z = 2

X-ray Powder Pattern: Fletcher mine, New Hampshire, USA.
9.150 (100), 2.808 (55), 4.602 (40), 3.483 (30), 3.451 (30), 4.961 (25), 1.874 (20)

Chemistry:

	(1)
P_2O_5	29.6
Fe_2O_3	22.8
MnO	10.2
MgO	2.7
CaO	2.6
Na_2O	0.4
Total	

(1) Fletcher mine, New Hampshire, USA; partial electron microprobe analysis, total Fe as Fe_2O_3, total Mn as MnO; which approximates $(Ca_{0.50}Mn^{2+}_{0.36}Na_{0.14})_{\Sigma=1.00}Mn^{2+}_{1.00}(Fe^{2+}_{0.96}Mg_{0.72}Mn^{2+}_{0.20}Fe^{3+}_{0.12})_{\Sigma=2.00}Fe^{3+}_{2.00}(PO_4)_4(OH)_2 \cdot 8H_2O$.

Mineral Group: Whiteite group; $Fe^{3+} >$ Al in the M(3) structural site.

Occurrence: A late-stage hydrothermal decomposition product of primary phosphate minerals in complex granite pegmatites.

Association: Rockbridgeite (Fletcher mine, New Hampshire, USA); frondelite, bermanite, huréaulite, strunzite, johnsomervilleite (Sapucaia mine, Brazil).

Distribution: In the USA, from the Fletcher and Palermo # 1 mines, near North Groton, Grafton Co., New Hampshire; in the Dunton quarry and the Bell pit, Newry, Oxford Co., Maine. At Hagendorf, Bavaria, Germany. From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil.

Name: By analogy to *jahnsite*-(CaMnMg); the suffix indicates sequentially the dominant atom in the X, M(1), and M(2) structural positions.

Type Material: National Museum of Natural History, Washington, D.C., USA, 127153.

References: (1) Moore, P.B. and J. Ito (1978) I. Whiteite, a new species, and a proposed nomenclature for the jahnsite-whiteite complex series. Mineral. Mag., 42, 309–316.
(2) Moore, P.B. (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. Amer. Mineral., 59, 48–53. (3) Moore, P.B. and T. Araki (1974) Jahnsite, $CaMn^{2+}Mg_2(H_2O)_8Fe^{3+}_2(OH)_2[PO_4]_4$: a novel stereoisomerism of ligands about octahedral corner-chains. Amer. Mineral., 59, 964–973.

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Jahnsite-(CaMnMg) $\mathbf{CaMn^{2+}(Mg,Fe^{2+})_2Fe_2^{3+}(PO_4)_4(OH)_2 \cdot 8H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular to elongated prismatic crystals, striated on $\{\overline{2}01\}$ and $\{100\} \parallel [010]$, to 1 cm; common forms include {001}, {100}, {201}, $\{\overline{2}01\}$, $\{\overline{1}01\}$, {011}, {110}, $\{\overline{1}11\}$. May be acicular; in twinned parallel aggregates; as warty granular masses. *Twinning:* By reflection on {001}, producing a pseudo-orthorhombic appearance.

Physical Properties: *Cleavage:* Good on {001}. *Tenacity:* Brittle. Hardness = 4
D(meas.) = 2.706–2.718 D(calc.) = 2.715

Optical Properties: Transparent to translucent. *Color:* Nut-brown, purplish brown, yellow, yellow-orange, greenish yellow, red-brown, red-orange, pale green. *Luster:* Vitreous to subadamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = pale purple; Y = deep purplish brown; Z = yellow with a tinge of green. *Orientation:* $Z = b$; $Y \wedge c \simeq 18°$. *Absorption:* $Y >> Z > X$.
$\alpha = 1.640(3)$ $\beta = 1.658(3)$ $\gamma = 1.670(3)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2/a$. $a = 14.94(2)$ $b = 7.14(1)$ $c = 9.93(1)$ $\beta = 110.16(8)°$
Z = 2

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
9.27 (10), 2.825 (8b), 4.91 (6b), 3.522 (5), 2.950 (5), 5.66 (4), 4.63 (4)

Chemistry:

	(1)		(1)
P_2O_5	32.2	MgO	9.4
Al_2O_3	2.1	CaO	6.6
Fe_2O_3	15.1	H_2O^+	18.8
MnO	8.0	Total	92.2

(1) Tip Top mine, South Dakota, USA; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, H_2O by the Penfield method; corresponding to $Ca_{1.00}Mn^{2+}_{1.15}Mg_{1.75}(Fe^{3+}_{1.65}Al_{0.40})_{\Sigma=2.05}(OH)_{2.05}(PO_4)_4 \cdot 7.9H_2O$.

Mineral Group: Whiteite group; $Fe^{3+} >$ Al in the M(3) structural site.

Occurrence: A late-stage hydrothermal decomposition product of primary triphylite-lithiophilite in complex granite pegmatites.

Association: Leucophosphite, huréaulite, collinsite, ferrisicklerite, robertsite, rockbridgeite, triphylite, tavorite, messelite, vivianite (Custer Co., South Dakota, USA); laueite, strunzite (Palermo #1 mine, New Hampshire, USA); graftonite, johnsomervilleite, mitridatite, phosphosiderite, rockbridgeite, vivianite, apatite, garnet (Glen Chosaidh, Scotland).

Distribution: In the USA, from the Tip Top, White Elephant, Bull Moose, Big Chief, and Linwood mines, near Custer, Custer Co., South Dakota. In the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. From Glen Chosaidh, Loch Quoich, Inverness-shire, Scotland.

Name: Honors Professor Richard Henry Jahns (1915–1983), specialist in pegmatite mineralogy, Stanford University, California, USA; the suffix indicates sequentially the dominant atom in the X, M(1), and M(2) structural positions.

Type Material: National Museum of Natural History, Washington, D.C., USA.

References: (1) Moore, P.B. (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. Amer. Mineral., 59, 48–53. (2) Moore, P.B. and T. Araki (1974) Jahnsite, $CaMn^{2+}Mg_2(H_2O)_8Fe_2^{3+}(OH)_2[PO_4]_4$: a novel stereoisomerism of ligands about octahedral corner-chains. Amer. Mineral., 59, 964–973. (3) Moore, P.B. and J. Ito (1978) I. Whiteite, a new species, and a proposed nomenclature for the jahnsite-whiteite complex series. Mineral. Mag., 42, 309–316.

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Jahnsite-(CaMnMn) $\mathbf{CaMn^{2+}Mn_2^{2+}Fe_2^{3+}(PO_4)_4(OH)_2 \cdot 8H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As equant crystals flattened on {001}, to 0.5 mm. *Twinning:* Common on {001}.

Physical Properties: *Cleavage:* Poor on {001}, a parting. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = ∼4 D(meas.) = 2.78(8) D(calc.) = 2.798

Optical Properties: Transparent. *Color:* Brownish yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Slight; X = pale yellow-green; Y = brown-green; Z = yellow-green. *Orientation:* $Z = b$; $X \wedge c = 20°$. *Absorption:* $Y > Z > X$. $\alpha = 1.643(1)$ $\beta = 1.659(1)$ $\gamma = 1.671(1)$ 2V(meas.) = 80(2)° 2V(calc.) = 81°

Cell Data: *Space Group:* $P2/a$ or Pa. $a = 14.877(8)$ $b = 7.152(7)$ $c = 9.966(6)$ $\beta = 109.77(5)°$ Z = 2

X-ray Powder Pattern: Mangualde pegmatite, Portugal.
9.40 (10), 2.870 (8), 4.704 (3), 5.74 (2), 5.02 (2), 4.971 (2), 3.532 (2)

Chemistry:

	(1)
P_2O_5	34.3
Al_2O_3	0.7
Fe_2O_3	21.5
MnO	20.2
MgO	0.5
CaO	5.8
H_2O	18.5
Total	101.5

(1) Mangualde pegmatite, Portugal; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, H_2O by TGA-EGA; corresponding to $Ca_{0.86}Mn^{2+}_{0.80}(Mn^{2+}_{1.56}Fe^{2+}_{0.34}Mg_{0.10})_{\Sigma=2.00}(Fe^{3+}_{1.89}Al_{0.11})_{\Sigma=2.00}(PO_4)_4(OH)_{1.66} \cdot 7.67H_2O$.

Mineral Group: Whiteite group; $Fe^{3+} >$ Al in the M(3) structural site.

Occurrence: A late stage hydrothermal decomposition product of primary phosphate minerals in complex granite pegmatites.

Association: Phosphosiderite, zodacite, varulite, microcline (Mangualde pegmatite, Portugal).

Distribution: From the Mangualde pegmatite, near Mesquitela, Portugal. In the Bell pit, Newry, and on Mt. Mica, near Paris, Oxford Co., Maine, USA.

Name: By analogy to *jahnsite*-(CaMnMg); the suffix indicates sequentially the dominant atom in the X, M(1), and M(2) structural positions.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 53784; National Museum of Natural History, Washington, D.C., USA, 149953.

References: (1) Grice, J.D., P.J. Dunn, and R.A. Ramik (1990) Jahnsite-(CaMnMn), a new member of the whiteite group from Mangualde, Beira, Portugal. Amer. Mineral., 75, 401–404.

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Jalpaite Ag_3CuS_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As coarse, irregular and foliated masses, to 5 cm, and as grains and veinlets in other sulfides.

Physical Properties: *Cleavage:* Prismatic, good. *Fracture:* Subconchoidal. *Tenacity:* Sectile, malleable. Hardness = 2–2.5 VHN = 22.8–29.7 (100 g load). D(meas.) = 6.82–6.85 D(calc.) = 6.827

Optical Properties: Opaque. *Color:* Pale metallic gray, tarnishes lustrous dark gray, locally to a chalcopyritelike iridescence; pale gray with bluish tint in reflected light. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Distinct in oil, brownish gray to pure gray. *Anisotropism:* Distinct, in greenish blues and pale green.
R_1–R_2: (400) 33.5–34.6, (420) 34.4–34.9, (440) 35.1–34.8, (460) 35.4–34.2, (480) 35.2–33.4, (500) 34.4–32.8, (520) 33.7–32.4, (540) 33.0–31.9, (560) 32.4–31.3, (580) 31.9–30.8, (600) 31.4–30.5, (620) 30.9–30.4, (640) 30.4–30.1, (660) 29.9–29.9, (680) 29.5–29.5, (700) 29.0–29.0

Cell Data: *Space Group:* $I4_1/amd$. $a = 8.663(0.8)$ $c = 11.743(1)$ $Z = 8$

X-ray Powder Pattern: Boulder Co., Colorado, USA.
2.345 (100), 2.794 (90), 2.740 (80), 2.422 (80), 2.114 (70), 4.298 (60), 2.006 (60)

Chemistry:

	(1)	(2)	(3)
Ag	71.51	71.7	71.71
Cu	13.12	14.05	14.08
Fe	0.79		
S	14.36	[14.2]	14.21
Total	99.78	[100.0]	100.00

(1) Jalpa, Mexico. (2) Silver Plume, Colorado, USA; average of four analyses, S by difference. (3) Ag_3CuS_2.

Occurrence: Formed under low-temperature (below 117 °C) hydrothermal conditions.

Association: Acanthite, mckinstryite, galena, sphalerite, pyrite, chalcopyrite, stromeyerite, polybasite, pearceite, tetrahedrite–tennantite, silver.

Distribution: In Mexico, at the La Leonora mine, Jalpa, Zacatecas [TL], and at La Mesa, Chihuahua. In the USA, in Colorado, at the Payrock mine, Silver Plume, Clear Creek Co.; the Bulldog Mountain mine, Creede, Mineral Co.; the Hock Hocking mine, near Alma, Park Co.; also from Boulder Co., at the E.C. Hite mine, and the Caribou mine, near Nederland. From the Savage and Yellow Jacket mines, Comstock district, Storey Co., Nevada; at Mogollon, Catron Co., New Mexico. From Kongsberg, Norway. In France, at Barreins, Aude. From Bohutin, near Příbram, and in the Vrancice deposit, Czech Republic. In the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia. From Keel, Aedagh, Co. Longford, Ireland. At Boarezzo, Lombardy, Italy. In the ??S?? Zavodinskii mine, near Ziryanovsk, Altai Mountains, Kazakhstan. From the Sado mine, Niigata Prefecture, and the Koryu mine, Hokkaido, Japan. In Australia, from Broken Hill, New South Wales. A number of additional localities have lately been recognized.

Name: For the Mexican locality at Jalpa.

Type Material: Mining Academy, Freiberg, Germany, 4705; National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 176–178 ("argentite", part). (2) Johan, Z. (1967) Etude de la jalpaite. Acta Univ. Carolinae, Geol., 2, 113–122 (in French). (3) (1968) Amer. Mineral., 53, 1778 (abs. ref. 2). (4) Grybeck, D. and J.J. Finney (1968) New occurrences of and data for jalpaite. Amer. Mineral., 53, 1530–1542. (5) Baker, C.L., F.A. Lincoln, and A.W.S. Johnson (1992) Crystal structure determination of Ag_3CuS_2 from powder X-ray diffraction data. Austr. J. Chem., 45, 1441–1449. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 266.

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Jamborite $(Ni^{2+}, Ni^{3+}, Fe)(OH)_2(OH, S, H_2O)(?)$

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Crystal Data: Hexagonal (probable). *Point Group:* n.d. As aggregates of parallel fibers and lamellae, some bent, replacing millerite needles; cryptocrystalline massive.

Physical Properties: Hardness = n.d. D(meas.) = 2.67 D(calc.) = 2.69

Optical Properties: Semitransparent. *Color:* Green.
Optical Class: Uniaxial (–); appears isotropic in fine aggregates. $\omega = 1.607(2)$ $\epsilon = 1.602(2)$

Cell Data: *Space Group:* n.d. $a = 3.07$ $c = 23.3$ $Z = 3/8$

X-ray Powder Pattern: Italy.
7.78 (10), 2.592 (6), 1.530 (5), 3.89 (4), 1.500 (3), 2.320 (1), 1.321 (1)

Chemistry: (1) Italy; by electron microprobe, original analysis Ni 42.0–49.4%, thought to be both Ni^{2+} and Ni^{3+}; Co 1.9%, Fe 0.9%, Mg < 0.2%, S 3.5%.

Occurrence: In small cavities in ophiolitic rocks (Italy); in serpentinites (Shinshiro, Japan).

Association: Millerite, calcite, dolomite, quartz (Italy); gaspéite, glaukosphaerite, mcguinnessite (Shinshiro, Japan).

Distribution: In Italy, from Ca'dei Ladri and Monteacuto Ragazza, 50 km southwest of Bologna, and Catelluccio di Moscheda, Modena, Emilia-Romagna. In the Sterling mine, Antwerp, Jefferson Co., New York; the Volstead quarry, Hillview, Greene Co., Illinois; and at Hall's Gap, Lincoln Co., Kentucky, USA. Found at Shinshiro, Aichi Prefecture, Japan.

Name: To honor John Leslie Jambor (1936–), Canadian mineralogist with the Geological Survey of Canada.

Type Material: University of Bologna, Bologna, Italy.

References: (1) Morandi, N. and G. Dalrio (1973) Jamborite: a new nickel hydroxide mineral from the Northern Apennines, Italy. Amer. Mineral., 58, 835–839. (2) Matsubara, S. and A. Kato (1993) Gaspeite, glaucosphaerite, mcguinnessite and jamborite in serpentinites from Shinshiro City, Aichi Prefecture, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 88(11), 515–524 (in Japanese).

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Jamesite $\mathbf{Pb_2ZnFe_2^{3+}(Fe^{3+},Zn)_4(AsO_4)_4(OH)_8(OH,O)_2}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As crystals, tabular on {010} and elongated along [100], to 0.5 mm; in spherical radial aggregates.

Physical Properties: Hardness = ∼3 D(meas.) = n.d. D(calc.) = 5.084

Optical Properties: Transparent. *Color:* Red-brown. *Streak:* Pale brown.
Luster: Subadamantine.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X = Y$ = pale brown; Z = deep red-brown.
Orientation: $Y \wedge a \simeq 5°$ on (001); $Y \wedge a = 15°$ on (010). *Dispersion:* $r > v$. $\alpha = 1.960(5)$ $\beta = 1.995(5)$ $\gamma = 2.020(5)$ 2V(meas.) = 75(5)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.583$–5.622 $b = 9.542$–9.593 $c = 10.219$–10.279 $\alpha = 109.80°-109.81°$ $\beta = 90.54°-90.57°$ $\gamma = 97.69°-97.71°$ Z = 1

X-ray Powder Pattern: Tsumeb, Namibia.
3.40 (10), 3.04 (9), 9.67 (8), 4.70 (8), 3.26 (8), 2.92 (6), 2.04 (6)

Chemistry:

	(1)	(2)
SO_3	trace	
As_2O_5	36.2	27.94
Al_2O_3		0.09
Fe_2O_3	25.5	23.30
Ga_2O_3		0.27
MnO	trace	
CuO	trace	0.21
ZnO	11.1	10.39
PbO	27.1	27.40
H_2O	n.d.	[5.06]
Total	99.9	[94.66]

(1) Tsumeb, Namibia; by electron microprobe, total Fe as Fe_2O_3, $(OH)^{1-}$ assumed for charge balance; corresponding to $Pb_{1.92}Zn_{2.15}Fe^{3+}_{5.06}(AsO_4)_{4.00}(OH)_{11.32}$. (2) Do.; by electron microprobe, average of two analyses, total Fe as Fe_2O_3, H_2O calculated by crystal-structure analysis; corresponds to $Pb_{2.01}Zn_{1.00}Fe^{3+}_{2.00}(Fe^{3+}_{2.78}Zn_{1.09}Ga_{0.05}Cu_{0.04}Al_{0.03})_{\Sigma=3.99}(AsO_4)_{3.99}[(OH)_{9.20}O_{0.80}]_{\Sigma=10.00}$.

Occurrence: A secondary mineral in oxidized lead ore in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Duftite, tsumcorite, goethite.

Distribution: From Tsumeb, Namibia.

Name: Honors Christopher James, one of the first mining engineers at the Tsumeb mine, Namibia.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany, NM05; National Museum of Natural History, Washington, D.C., USA, 143995.

References: (1) Keller, P., H. Hess, and P.J. Dunn (1981) Jamesit, $Pb_2Zn_2Fe^{3+}_5O_4(AsO_4)_5$, ein neues Mineral von Tsumeb, Namibia. Chem. Erde, 40, 105–109 (in German with English abs.). (2) (1981) Amer. Mineral., 66, 1275 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1999) Local $Pb^{2+}-\square$disorder in the crystal structure of jamesite, $Pb_2ZnFe^{3+}_2(Fe^{3+}_{2.8}Zn_{1.2})(AsO_4)_4(OH)_8[(OH)_{1.2}O_{0.8}]$, and revision of the chemical formula. Can. Mineral., 37, 53–60.

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Jamesonite $Pb_4FeSb_6S_{14}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals elongated ‖ [001], acicular and fibrous, to 10 cm; striated ‖ [001]; rarely in rings and spheres. As feltlike masses; massive, columnar, also radial and plumose. *Twinning:* On {100}; lamellae very commonly observed in polished section.

Physical Properties: *Cleavage:* Good on {001}; reported on {010} and {120}. *Tenacity:* Brittle. Hardness = 2.5 VHN = 66–86 (100 g load). D(meas.) = 5.63 D(calc.) = 5.76

Optical Properties: Opaque. *Color:* Gray-black, may tarnish iridescent; in polished section, gray-black. *Luster:* Metallic. *Pleochroism:* Distinct. *Anisotropism:* Strong. R_1–R_2: (400) 38.4–45.1, (420) 38.1–44.9, (440) 37.7–44.8, (460) 37.6–45.0, (480) 37.4–45.1, (500) 37.3–45.0, (520) 37.0–44.7, (540) 36.6–44.3, (560) 36.1–43.8, (580) 35.7–43.2, (600) 35.3–42.6, (620) 34.8–41.9, (640) 34.2–41.0, (660) 33.6–40.1, (680) 33.0–39.2, (700) 32.5–38.5

Cell Data: *Space Group:* $P2_1/a$. $a = 15.57$ $b = 18.98$ $c = 4.03$ $\beta = 91°48'$ Z = 2

X-ray Powder Pattern: Itos mine, Oruro, Bolivia.
3.44 (100), 2.84 (90), 2.75 (80), 3.18 (50), 3.09 (50), 2.06 (50), 3.87 (40)

Chemistry:

	(1)	(2)	(3)
Pb	40.14	42.2	40.15
Fe	2.64	2.5	2.71
Cu	0.18		
Sb	34.25	35.3	35.39
S	22.34	20.5	21.75
Total	99.55	100.5	100.00

(1) Cornwall, England; average of three analyses. (2) Tresungers mine, St. Endellion, England; by electron microprobe. (3) $Pb_4FeSb_6S_{14}$.

Polymorphism & Series: Dimorphous with parajamesonite; forms a series with benavidesite.

Occurrence: Typically a late-stage hydrothermal mineral in Pb–Ag–Zn veins formed at low to medium temperatures.

Association: Other lead sulfosalts, pyrite, sphalerite, galena, tetrahedrite, stibnite, quartz, siderite, calcite, dolomite, rhodochrosite.

Distribution: From numerous localities, but only a few have provided rich material. From Cornwall, England, around St. Endellion [TL] and St. Kew. In Germany, at Freiberg, Saxony; and near Magdesprung, Selke Valley, and Clausthal, Harz Mountains. From Příbram, Czech Republic. At Aranyidka, Baia Sprie (Felsőbánya), and Herja (Kisbánya), Baia Mare (Nagybánya) district, Romania. From Trepča, Serbia. At Sala, Västmanland, Sweden. From Machacamarca, Poopó, and Huanuni, Oruro, Bolivia. In Mexico, from the Noche Buena mine, near Mazapil; the Santa Rita mine, Nieves; and in relatively thick crystals from the Noria mine, near Sombrerete, Zacatecas. In the USA, in Idaho, at Slate Creek, Shoshone Co. From the Dachang district, Guangxi Autonomous Region, China.

Name: In honor of Robert Jameson (1774–1854), Scottish mineralogist, Edinburgh, Scotland, who first described the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 451–455. (2) Niizeki, N. and M.J. Buerger (1957) The crystal structure of jamesonite, $FePb_4Sb_6S_{14}$. Zeits. Krist., 109, 161–183. (3) L.L.Y. Chang, X. Li, and C. Zheng (1987) The jamesonite – benavidesite series. Can. Mineral., 25, 667–672. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 150. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 267.

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Janggunite $\mathbf{Mn^{4+}_{5-x}(Mn^{2+},Fe^{3+})_{1+x}O_8(OH)_6}$ (x = 0.2)

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Crystal Data: Orthorhombic. *Point Group:* n.d. As flaky crystals, to 0.13 mm, elongated ‖ cleavage and flattened on {010}, probable; in radiating groups, dendritic or arborescent masses, and in colloform bands and very fine-grained aggregates.

Physical Properties: *Cleavage:* One direction, perfect. *Tenacity:* Very fragile [*sic*]. Hardness = 2–3 D(meas.) = 3.59 D(calc.) = 3.58

Optical Properties: Opaque. *Color:* Black; grayish white to gray in reflected light. *Streak:* Brownish black to dark brown. *Luster:* Dull.
Optical Class: Biaxial. *Pleochroism:* Distinct; whitish to light gray in oil. *Anisotropism:* Very strong; yellowish brown with bluish tint, to gray. *Bireflectance:* Observed.
R_1–R_2: 13–15

Cell Data: *Space Group:* n.d. $a = 9.324$ $b = 14.05$ $c = 7.956$ Z = 4

X-ray Powder Pattern: Janggun mine, South Korea.
9.34 (s), 7.09 (s), 3.547 (s), 3.101 (s), 4.62 (m), 4.17 (m), 2.469 (m)

Chemistry:

	(1)
MnO_2	74.91
Fe_2O_3	4.19
MnO	11.33
PbO	0.03
H_2O^+	9.46
Total	99.92

(1) Janggun mine, South Korea; Fe and Pb by electron microprobe, total Fe as Fe_2O_3, H_2O as OH verified by IR; corresponds to $Mn^{4+}_{4.86}(Mn^{2+}_{0.90}Fe^{3+}_{0.30})_{\Sigma=1.20}O_{8.09}(OH)_{5.92}$.

Occurrence: Formed at a late stage of oxidation in a cementation zone of a manganese deposit.

Association: Nsutite, todorokite, calcite, rhodochrosite.

Distribution: In the Janggun mine, Bonghwa district, South Korea.

Name: For the Janggun mine, South Korea, its first locality.

Type Material: National Museum of Natural History, Washington, D.C., USA, 143150.

References: (1) Kim, S.J. (1977) Janggunite, a new manganese hydroxide mineral from the Janggun mine, Bonghwa, Korea. Mineral. Mag., 41, 519–523. (2) (1978) Amer. Mineral., 63, 794 (abs. ref. 1).

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Janhaugite $\mathbf{Na_3Mn_3^{2+}Ti_2Si_4O_{15}(OH,F,O)_3}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As sprays of prismatic crystals, to 1.5 cm, slightly bent, flattened on {010} and striated ‖ [001]; in lamellar aggregates; as subhedral grains. *Twinning:* Rarely on {100}.

Physical Properties: *Cleavage:* Distinct on {010}. *Tenacity:* Very brittle. Hardness = 5
D(meas.) = 3.60(5) D(calc.) = 3.71

Optical Properties: Semitransparent. *Color:* Reddish brown. *Streak:* Light brown.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = nearly colorless; Y = beige. *Orientation:* $Z = b$; $X \wedge c = 12°$–$18°$. $\alpha = 1.770(4)$ $\beta = 1.828(4)$ $\gamma = [1.910]$ 2V(meas.) = 70°–90°

Cell Data: *Space Group:* $P2_1/n$. $a = 10.668(2)$ $b = 9.787(4)$ $c = 13.931(3)$
$\beta = 107.82(2)°$ Z = 4

X-ray Powder Pattern: Gjerdingen, Norway.
2.839 (100), 2.833 (90), 2.782 (90), 3.202 (60), 1.744 (50), 3.920 (40), 2.742 (40)

Chemistry:

	(1)
SiO_2	29.79
TiO_2	15.18
ZrO_2	5.98
Nb_2O_5	5.00
Ta_2O_5	0.26
FeO	5.52
MnO	22.26
CaO	1.45
Na_2O	11.02
K_2O	0.19
F	2.69
H_2O	[1.63]
$-O = F_2$	1.13
Total	[99.84]

(1) Gjerdingen, Norway; by electron microprobe, average of three analyses, H_2O calculated; corresponds to $(Na_{2.75}Ca_{0.20}K_{0.03})_{\Sigma=2.98}(Mn_{2.43}Fe_{0.60})_{\Sigma=3.03}(Ti_{1.32}Zr_{0.38}Nb_{0.29}Ta_{0.01})_{\Sigma=2.00}(Si_{3.84}Ti_{0.15})_{\Sigma=3.99}O_{15}[(OH)_{1.40}F_{1.10}O_{0.50}]_{\Sigma=3.00}$.

Occurrence: In both the groundmass and miarolitic cavities in sodium-rich granite.

Association: Pyrophanite, elpidite, monazite, dalyite, kupletskite.

Distribution: From Gjerdingen, 30 km north of Oslo, Norway.

Name: Honors Jan Haug, an amateur mineralogist who first observed the mineral.

Type Material: University of Oslo, Oslo, Norway.

References: (1) Raade, G. and M.H. Mladeck (1983) Janhaugite, $Na_3Mn_3Ti_2Si_4O_{15}(OH,F,O)_3$, a new mineral from Norway. Amer. Mineral., 68, 1216–1219. (2) Annehed, H., L. Fälth, and G. Raade (1985) The crystal structure of janhaugite, a sorosilicate of the cuspidine family. Neues Jahrb. Mineral., Monatsh., 7–18.

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Jankovićite $Tl_5Sb_9(As,Sb)_4S_{22}$

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Crystal Data: Triclnic. *Point Group:* $\overline{1}$. Granular, may be tabular, to 1 mm.
Twinning: May exhibit polysynthetic lamellae.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Sunconchoidal.
Tenacity: Brittle. Hardness = ∼2 VHN = 98 (50 g load). D(meas.) = n.d. D(calc.) = 5.12

Optical Properties: Opaque. *Color:* Black, with abundant red internal reflections.
Streak: Brown-violet. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Distinct to strong; gray-blue to blue-green.
Bireflectance: Low to medium; white to grayish-bluish white.
R_1–R_2: (400) 34.7–37.4, (420) 34.6–37.2, (440) 34.5–37.1, (460) 34.2–36.8, (480) 33.8–36.6, (500) 33.4–36.2, (520) 32.8–35.8, (540) 32.2–35.1, (560) 31.6–34.4, (580) 30.8–33.5, (600) 30.1–32.5, (620) 29.3–31.4, (640) 28.5–30.3, (660) 27.7–29.1, (680) 26.8–27.8, (700) 25.8–26.4

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.393(4)$ $b = 8.711(5)$ $c = 17.58(1)$ $\alpha = 103.81(3)$ $\beta = 91.81(3)$ $\gamma = 109.51(3)$ $Z = 1$

X-ray Powder Pattern: Alšar, Macedonia.
3.459 (100), 3.0755 (65), 3.884 (64), 2.2868 (57), 3.1774 (54), 2.8019 (44), 1.7364 (38)

Chemistry:

	(1)
Tl	31.51
As	7.95
Sb	37.69
S	22.30
Total	99.45

(1) Alšar, Macedonia; by electron microprobe, average of five analyses; corresponds to $Tl_{4.87}Sb_{9.79}As_{3.35}S_{21.99}$.

Occurrence: In a hydrothermal Tl–Sb–As deposit, formed at low temperatures.

Association: Realgar, stibnite, pyrite.

Distribution: From the Crven Dol mine, Alšar (Allchar), near Rošden, Macedonia [TL].

Name: To honor Prefessor S. Janković (1925–), who has worked in the Allchar region.

Type Material: Natural History Museum, Belgrade, Serbia; Natural History Museum, Vienna, Austria.

References: (1) Cvetković, L., V.A. Boronikhin, M.K. Pavićević, D. Krajnović, I. Gržetić, E. Libowitzky, G. Giester, and E. Tillmanns (1995) Jankovićite, $Tl_5Sb_9(\underline{As},Sb)_4S_{22}$, a new Tl-sulfosalt from Allchar, Macedonia. Mineral. Petrol., 53, 125–131. (2) (1996) Amer. Mineral., 81, 250 (abs. ref. 1). (3) Lobowitzky, E., G. Giester, nd E. Tillmanns (1995) The crystal structure of jankovićite, $Tl_5Sb_9(\underline{As},Sb)_4S_{22}$. (4) Makovicky, E. and T. Balić-Žunić (1998) Contributions to the crystal chemistry of thallium sulfosalts. IV. Modular description of Tl–As–Sb sulfosalts rebulite and jankovicite [*sic*]. Neues Jahrb. Mineral., Abh., 174, 181–210.

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Jarlite $\mathbf{Na(Sr,Na)_7MgAl_6F_{32}(OH,H_2O)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular on {100} and elongated along [010], with many forms and curved faces, to 1 mm; commonly in flat radiating or spherulitic aggregates, may be entirely spherical; massive.

Physical Properties: *Fracture:* Uneven. Hardness = 4–4.5 D(meas.) = 3.87(1) D(calc.) = 3.80

Optical Properties: Semitransparent. *Color:* Colorless, white to gray; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–) or (+). *Orientation:* $Y = b$; $X \wedge c = -6(2)^\circ$; $Z \wedge c = 84(2)^\circ$.
$\alpha = 1.429$ $\beta = 1.433$ $\gamma = 1.436$ 2V(meas.) = 90(10)°

Cell Data: *Space Group:* $C2/m$. $a = 15.942(4)$ $b = 10.821(5)$ $c = 7.241(2)$ $\beta = 101.86(2)^\circ$ Z = 2

X-ray Powder Pattern: Ivigtut, Greenland.
2.97 (10), 3.18 (9), 2.15 (7), 3.10 (6), 1.812 (6), 3.62 (4), 3.44 (4)

Chemistry:

	(1)
Na	3.23
Li	0.08
Fe	0.17
Mg	0.90
Ca	0.55
Ba	0.99
Sr	35.60
Al	12.16
F	43.23
H_2O^+	2.91
H_2O^-	0.08
Total	99.90

(1) Ivigtut, Greenland; corresponds to $Na_{1.00}(Sr_{5.67}Na_{0.96}Ca_{0.19}Li_{0.16}Ba_{0.10})_{\Sigma=7.08}Mg_{0.52}(Al_{6.28}Fe_{0.04})_{\Sigma=6.32}F_{31.75}(H_2O)_{2.25}$.

Occurrence: In vugs in a cryolite deposit with other fluorides.

Association: Cryolite, gearksutite, chiolite, thomsenolite, ralstonite, prosopite, stenonite, acuminite, bøgvadite, jørgensenite, fluorite, topaz, barite.

Distribution: From the Ivigtut cryolite deposit, Greenland.

Name: For Carl Frederik Jarl (1872–1951), formerly President of the Danish Cryolite Company, who first noted the mineral.

Type Material: Holotype probably lost; University of Copenhagen, Copenhagen, Denmark; The Natural History Museum, London, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 118–119. (2) Hawthorne, F.C. (1983) The crystal structure of jarlite. Can. Mineral., 21, 553–560. (3) Petersen, O.V. and O. Johnsen (1985) The crystal habit of jarlite. Neues Jahrb. Mineral., Monatsh., 543–549. (4) Pauly, H., F.C. Hawthorne, P.C. Burns, and G.D. Ventura (1997) Jørgensenite, $Na_2(Sr,Ba)_{14}Na_2Al_{12}F_{64}(OH,F)_4$, a new aluminofluoride mineral from Ivigtut, Greenland. Can. Mineral., 35, 175–179.

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Jarosewichite $\mathbf{Mn_3^{2+}Mn^{3+}(AsO_4)(OH)_6}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, 222, or $mm2$. Crystals are prismatic, barrel-shaped, elongated along [100], flattened on {010}, with {021}, giving six-sided sections, to 1 mm; typically as divergent sprays of prismatic crystals.

Physical Properties: Hardness = ∼4 D(meas.) = 3.66(4) D(calc.) = 3.70

Optical Properties: Translucent through thin edges. *Color:* Very dark red, appearing black. *Streak:* Reddish orange. *Luster:* Subvitreous on fractured surfaces.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = medium brownish red; Z = dark brownish red. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Absorption:* $Z > X$. $\alpha = 1.780(5)$ $\beta = 1.795(5)$ $\gamma = 1.805(5)$ 2V(meas.) = n.d. 2V(calc.) = 78°

Cell Data: *Space Group:* $Cmmm$, $Cmm2$ or $C222$. $a = 6.56(3)$ $b = 25.20(10)$ $c = 10.00(5)$ Z = 8

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.669 (100), 3.91 (60), 1.788 (50), 2.503 (30), 1.558 (30), 6.29 (20), 1.576 (20)

Chemistry:

	(1)	(2)
As_2O_5	24.0	24.95
Mn_2O_3	17.7	17.13
FeO	0.4	
MnO	42.3	46.19
ZnO	1.2	
MgO	2.1	
CaO	0.2	
H_2O	[12.1]	11.73
Total	[100.0]	100.00

(1) Franklin, New Jersey, USA; by electron microprobe, total As as As_2O_5 from associated species, Mn^{2+}:Mn^{3+} assigned as 3:1, H_2O by difference; corresponding to $Mn^{3+}_{1.00}(Mn^{2+}_{2.74}Mg_{0.24}Zn_{0.07}Fe_{0.03}Ca_{0.02})_{\Sigma=3.10}(AsO_4)_{0.95}(OH)_{6.35}$. (2) $Mn_3^{2+}Mn^{3+}(AsO_4)(OH)_6$.

Occurrence: In a mine-dump specimen, incrusting vugs in zinc ore from a metamorphosed stratiform zinc orebody.

Association: Flinkite, cahnite, allactite, hausmannite, andradite, franklinite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: Honors Eugene Jarosewich (1926–), Chief Chemist, Department of Mineral Sciences, Smithsonian Institution, Washington, D.C., USA.

Type Material: Harvard University, Cambridge, Massachusetts, 109463; National Museum of Natural History, Washington, D.C., USA, 148972.

References: (1) Dunn, P.J., D.R. Peacor, P.B. Leavens, and W.B. Simmons (1982) Jarosewichite and a related phase: basic manganese arsenates of the chlorophoenicite group from Franklin, New Jersey. Amer. Mineral., 67, 1043–1047.

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Jarosite $\mathbf{KFe_3^{3+}(SO_4)_2(OH)_6}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As well-formed crystals, pseudocubic rhombohedral $\{01\overline{1}2\}$ or tabular on {0001}, to 25 cm; typically as minutely crystalline crusts, also fibrous, nodular, granular, pulverulent, earthy.

Physical Properties: *Cleavage:* On {0001}, distinct. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3.5 D(meas.) = 2.91–3.26 D(calc.) = 3.127 Strongly pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Amber-yellow to dark brown. *Streak:* Pale yellow. *Luster:* Subadamantine to vitreous, resinous on fractures. *Optical Class:* Uniaxial (–), typically anomalously biaxial. *Pleochroism:* O = reddish brown; E = colorless. $\omega = 1.791–1.820$ $\epsilon = 1.705–1.715$ 2V(meas.) = Small.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.29$ $c = 17.16$ Z = 3

X-ray Powder Pattern: Synthetic. (ICDD 22–827).
3.08 (100), 3.11 (75), 5.09 (70), 5.93 (45), 1.977 (45), 1.825 (45), 3.65 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	32.02	31.97	H_2O	10.61	10.79
Fe_2O_3	48.63	47.83	insol.	0.29	
Na_2O	0.55		Total	99.85	100.00
K_2O	7.75	9.41			

(1) Saint Félix de Pallières, France; corresponds to $(K_{0.82}Na_{0.04})_{\Sigma=0.86}Fe_{3.05}(SO_4)_2(OH)_6$.
(2) $KFe_3(SO_4)_2(OH)_6$.

Polymorphism & Series: Forms a series with natrojarosite.

Mineral Group: Alunite group.

Occurrence: A secondary mineral in oxidized portions of sulfide-bearing rocks, typically altering from pyrite; less common as a low-temperature, primary hydrothermal mineral, including as deposits around hot springs.

Association: Alunite, pyrite.

Distribution: Widespread. A few localities for studied material include: in Spain, in the Barranco del Jaroso, Sierra Almagrera, Almería Province. At Horní Slavkov (Schlaggenwald), Czech Republic. From the Frisches Glück mine, Fürstenberg, near Schwarzenberg, Saxony, Germany. In the Kamariza mine, Laurium, Greece. In the USA, from Marysvale, Ohio district, Piute Co., and at the Mammoth mine, Tintic, Juab Co., Utah; in the Vulture mine, near Wickenburg, Maricopa Co., at Tombstone, Cochise Co., and many other places in Arizona; from the Meadow Valley mines, Pioche district, Lincoln Co., Nevada. Immense crystals from the La Domitila mine, Sierra Peña Blanca uranium district, Sierra del Cuervo, Chihuahua, Mexico. In Chile, at Chuquicamata, from Quetena, west of Calama, and at Alcaparrosa, near Cerritos Bayos, southwest of Calama, Antofagasta. At volcanoes on the Kamchatka Peninsula, Russia.

Name: For the Barranco del Jaroso, Spain, from where the first scientifically studied specimens were obtained.

Type Material: Mining Academy, Freiberg, Germany, 17.966.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 560–562 [carphosiderite, part]. (2) Brophy, G.P. and M.F. Sheridan (1965) Sulfate studies IV: The jarosite-natrojarosite-hydronium jarosite solid solution series. Amer. Mineral., 50, 1595–1607. (3) Menchetti, S. and C. Sabelli (1976) Crystal chemistry of the alunite series: crystal structure refinement of alunite and synthetic jarosite. Neues Jahrb. Mineral., Monatsh., 406–417. (4) Kato, T. and Y. Miúra (1977) The crystal structures of jarosite and svanbergite. Mineral. J. (Japan), 8, 419–430.

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Jaskólskiite $\mathbf{Pb_{2+x}Cu_x(Sb,Bi)_{2-x}S_5}$ (x = 0.15–0.2)

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As needlelike crystals with poor terminations, less than 1 mm long, isolated or in irregular aggregates.

Physical Properties: Hardness = 4 VHN = 165–179 (100 g load). D(meas.) = n.d. D(calc.) = 6.47–6.59

Optical Properties: Opaque. *Color:* Lead-gray; gray in polished section. *Streak:* Dark gray. *Luster:* Metallic. *Pleochroism:* Moderate, in yellow tints. *Anisotropism:* Strong, without distinct colors.
R_1–R_2: (400) 38.4–44.9, (420) 38.4–44.6, (440) 38.1–44.1, (460) 37.8–43.6, (480) 37.4–43.1, (500) 37.0–42.6, (520) 36.7–42.3, (540) 36.5–42.0, (560) 36.3–41.7, (580) 36.1–41.5, (600) 36.0–41.3, (620) 35.8–41.0, (640) 35.5–40.7, (660) 35.2–40.2, (680) 34.8–39.8, (700) 34.4–39.3

Cell Data: *Space Group: Pbnm.* $a = 11.312$–11.331 $b = 19.829$–19.871 $c = 4.088$–4.100 Z = 4

X-ray Powder Pattern: Vena mines, Sweden.
3.710 (100), 2.970 (80), 3.333 (60), 2.761 (60), 3.595 (50), 2.751 (50), 2.050 (50)

Chemistry:

	(1)	(2)
Pb	50.74	48.5
Cu	1.31	0.8
Sb	15.74	14.6
Bi	14.35	17.4
S	17.52	17.6
Total	99.65	98.9

(1) Vena mines, Sweden; by electron microprobe, average of 16 analyses, corresponding to $Pb_{2.22}Cu_{0.19}(Sb_{1.17}Bi_{0.62})_{\Sigma=1.79}S_{5.00}$. (2) Izok Lake, Canada; by electron microprobe, corresponding to $Pb_{2.13}Cu_{0.11}(Sb_{1.09}Bi_{0.76})_{\Sigma=1.85}S_{5.00}$.

Occurrence: In aggregates of sulfosalts and sulfides in polymetallic hydrothermal veins.

Association: Galena, pyrrhotite, chalcopyrite, arsenopyrite, cobaltite, pyrite, sphalerite, bismuth, antimony, cubanite, freibergite, izoklakeite, gudmundite, gersdorffite, meneghinite.

Distribution: From the Vena mines, near Askersund, Örebro, Sweden [TL]. At the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia. From the Apollo mine, near Raubach, Siegerland, Germany. In the Srednegolgotaiskoe gold deposit, eastern Transbaikalia, Siberia, Russia. From Izok Lake, Northwest Territories, Canada.

Name: To honor Professor Stanislaw Jaskólski (1896–1981), Polish mineralogist, Akademia Górniczo-Hutnicza, Kraków, Poland.

Type Material: Wroclaw University, Wroclaw, Poland, II–6801; Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands, 150-J-2; National Museum of Natural History, Washington, D.C., USA, 162203, 162481.

References: (1) Zakrzewski, M.A. (1984) Jaskólskiite, a new Pb–Cu–Sb sulfosalt from the Vena deposit, Sweden. Can. Mineral., 22, 481–485. (2) Makovicky, E. and W.G. Mumme (1984) The crystal structure of izoklakeite, dadsonite and jaskolskiite. Acta Cryst., A40, supplement, C-246. (3) (1985) Amer. Mineral., 70, 872 (abs. refs. 1 and 2). (4) Harris, D.C., A.C. Roberts, and A.J. Criddle (1984) Jaskólskiite from Izok Lake, Northwest Territories. Can. Mineral., 22, 486–491. (5) Makovicky, E. and R. Nørrestam (1985) The crystal structure of jaskolskiite, $Cu_xPb_{2+x}(Sb,Bi)_{2-x}S_5$ (x=0.2), a member of the meneghinite homologous series. Zeits. Krist., 171, 179–194.

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Jasmundite $Ca_{11}(SiO_4)_4O_2S$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As equant crystals, with forms {110}, {101}, {100} and {001}; in irregular grains up to several mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼5 D(meas.) = 3.03 D(calc.) = 3.23

Optical Properties: Semitransparent. *Color:* Dark brown, greenish brown, brownish green; light brown in thin section. *Streak:* White. *Luster:* Resinous.
Optical Class: Uniaxial (+). $\omega = 1.715$ $\epsilon = 1.728$

Cell Data: *Space Group:* $I\bar{4}m2$. $a = 10.461(1)$ $c = 8.813(1)$ $Z = 2$

X-ray Powder Pattern: Bellerberg volcano, Germany.
2.832 (> 100), 3.242 (42), 2.615 (35), 1.849 (34), 1.5491 (21), 2.756 (17), 1.920 (16)

Chemistry:

	(1)	(2)
SiO_2	27.3	27.52
Al_2O_3	0.4	
FeO	0.8	
MgO	0.9	
CaO	67.6	70.64
S^{2-}	2.7	3.67
$-O = S$	1.4	1.83
Total	98.3	100.00

(1) Bellerberg volcano, Germany; by electron microprobe, average of seven analyses; corresponds to $(Ca_{10.6}Mg_{0.2}Fe_{0.1}Al_{0.05})_{\Sigma=10.95}Si_{4.0}O_{18.25}S_{0.75}$. (2) $Ca_{11}(SiO_4)_4O_2S$.

Occurrence: In metamorphosed limestone inclusions in basalt.

Association: Mayenite, brownmillerite, larnite, portlandite, ettringite, calcite, vaterite, tobermorite, thaumasite.

Distribution: From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany.

Name: Honors Professor Karl Jasmund, retired Director of the Mineralogical-Petrographic Institute, University of Cologne, Cologne, Germany.

Type Material: Mineralogical-Petrographic Institute, University of Cologne, Cologne, Germany; Department of Chemistry, University of Aberdeen, Aberdeen, Scotland.

References: (1) Dent Glasser, L.S. and C.K. Lee (1981) The structure of jasmundite, $Ca_{22}(SiO_4)_8O_4S_2$. Acta Cryst., 37, 803–806. (2) Hentschel, G., L.S. Dent Glasser, and C.K. Lee (1983) Jasmundite, $Ca_{22}(SiO_4)_8O_4S_2$, a new mineral. Neues Jahrb. Mineral., Monatsh., 337–342. (3) (1984) Amer. Mineral., 69, 566–567 (abs. refs. 1 and 2).

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Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As irregular grains and aggregates to 1 cm. *Twinning*: Straight twin lamellae observed.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.87

Optical Properties: Opaque. *Color*: Dark gray, off-white in reflected light. *Streak*: Gray. *Bireflectance*: Weak, white to whitish creamy. *Anisotropism*: Distinct, pale bluish green to pale greenish blue. *Luster*: Metallic.
Optical Class: n.d.
R_1-R_2: (470) 30.4-35.1; (546) 29.8-34.7; (589) 29.1-34.1; (650) 28.2-33.1

Cell Data: *Space Group*: $P\bar{1}$. a = 8.2917(5) b = 19.101(1) c = 19.487(1) α = 89.731(1)° β = 83.446(1)° γ = 89.944(1)° Z = 1

X-ray Powder Pattern: Calculated pattern.
3.281 (100), 3.294 (80), 3.847 (33), 2.8602 (33), 2.8498 (26), 3.227 (25), 3.179 (25)

Chemistry:

	(1)
Cu	0.55
Ag	17.52
Pb	9.44
Tl	0.10
As	12.77
Sb	33.61
S	25.77
Total	99.67

(1) Jas Roux, France; average of 12 electron microprobe analyses; corresponding to $Ag_{14.64}Cu_{0.79}Pb_{4.10}Tl_{0.05}Sb_{24.87}As_{15.37}S_{72.18}$.

Occurrence: An early hydrothermal (epithermal) mineral along veins in silicified meta-sedimentary rocks.

Association: Coated by a myrmekitic aggregate of stibnite, baumhauerite-boscardinite, and smithite and associated with realgar, pyrite, sphalerite, and other lead sulfosalts.

Distribution: Jas Roux, in the Pelvoux Massif, Hautes-Alpes département, France.

Name: For the locality that produced the first specimens.

Type Material: Department of Materials Engineering and Physics, University of Salzburg, Austria; Mineral Collection, Institute of Mineralogy, Materials Physics and Cosmochemistry, Pierre and Marie Curie University, Paris, and in the Museum of Mineralogy, Mines Paris Tech, France.

References: (1) Topa, D., E. Makovicky, G. Favreau, V. Bourgoin, J-C. Boulliard, G. Zagler, and H. Putz (2013) Jasrouxite, a new Pb-Ag-As-Sb member of the lillianite homologous series from Jas Roux, Hautes-Alpes, France. European Journal of Mineralogy, 25, 1031-1038. (2) Makovicky, E and D. Topa (2014) The crystal structure of jasrouxite, a Pb-Ag-As-Sb member of the lillianite homologous series. European Journal of Mineralogy, 26, 145-155. (3) (2014) Amer. Mineral., 99, 2440 (abs. refs. 1 & 2).

Jeanbandyite $(Fe^{3+}, Mn^{2+})Sn^{4+}(OH)_6$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m$. In crystals, showing dominant {111}, {001}, and {100}; {111} may be striated ‖ {100}, to 0.5 mm; in crude pseudo-octahedral aggregates, epitaxial on wickmanite or overgrown on natanite.

Physical Properties: *Cleavage:* {001} and {100}, fair. Hardness = ∼3.5
D(meas.) = 3.81(5) D(calc.) = 3.81

Optical Properties: Transparent to translucent. *Color:* Orange-brown to red-brown, pale yellow; light orange-brown in transmitted light. *Streak:* Yellow-brown. *Luster:* Vitreous to subadamantine.
Optical Class: Uniaxial (–). $\omega = 1.837(5)$ $\epsilon = 1.833(5)$

Cell Data: *Space Group:* $P4_2/n$. $a = 7.648(7)$ $c = 7.648(7)$ $Z = 4$

X-ray Powder Pattern: Llallagua, Bolivia.
3.83 (100), 2.71 (70), 1.710 (60), 1.562 (35), 4.41 (20), 1.912 (20), 2.205 (15)

Chemistry:

	(1)
SiO_2	0.79
SnO_2	49.61
Fe_2O_3	22.07
MnO	5.82
MgO	0.61
H_2O	[21.10]
Total	[100.00]

(1) Llallagua, Bolivia; by electron microprobe, average of eight analyses; Fe confirmed as principally Fe^{3+} microchemically, H_2O by difference; corresponds to $(Fe^{3+}_{0.71}Mn^{2+}_{0.21}Mg_{0.04})_{\Sigma=0.96}(Sn_{0.84}Si_{0.03})_{\Sigma=0.87}(OH)_6$.

Mineral Group: Stottite group.

Occurrence: In the oxide zone of polymetallic hydrothermal deposits.

Association: Wickmanite, fluorapatite, stannite, pyrite, jamesonite, cassiterite, wolframite, bismuthinite, franckeite, crandallite, quartz (Llallagua, Bolivia); natanite, pyrrhotite, siderite, quartz (Santa Eulalia, Mexico).

Distribution: From Llallagua, Bolivia. At Santa Eulalia, Chihuahua, Mexico. In the Mt. Pleasant tin mine, New Brunswick, Canada.

Name: Honors Jean A. Bandy, Wickenburg, Arizona, USA, who, with her husband Mark Bandy, translated Agricola's *De Natura Fossilium* from original Latin.

Type Material: Natural History Museum, Los Angeles, California, 18309; Harvard University, Cambridge, Massachusetts, 119125; National Museum of Natural History, Washington, D.C., USA, 149348.

References: (1) Kampf, A.R. (1982) Jeanbandyite, a new member of the stottite group from Llallagua, Bolivia. Mineral. Record, 13, 235–239. (2) (1983) Amer. Mineral., 68, 471–472 (abs. ref. 1).

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Jedwabite $Fe_7(Ta,Nb)_3$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

Note: new in MFG 99 (1998) MR, 29, 472

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Jeffreyite $(Ca, Na)_2(Be, Al)Si_2(O, OH)_7$

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Crystal Data: Orthorhombic. *Point Group:* 222. As thin micaceous pseudotetragonal plates, to 1.2 mm, composed of {001} and {110}. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Perfect on {001} and {110}. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = 2.99(2) D(calc.) = 2.98

Optical Properties: Transparent. *Color:* Colorless, but commonly with a brown coating. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.625(2)$ $\beta = 1.641(2)$ $\gamma = 1.643(2)$ 2V(meas.) = 40(2)° 2V(calc.) = 39°

Cell Data: *Space Group:* $C222_1$. $a = 14.90(1)$ $b = 14.90(1)$ $c = 40.41(8)$ Z = 64

X-ray Powder Pattern: Jeffrey mine, Canada.
2.774 (100), 2.993 (90), 2.541 (60), 1.755 (50), 5.00 (40), 2.360 (40), 2.229 (40)

Chemistry:

	(1)
SiO_2	46.7
Al_2O_3	2.8
BeO	8.1
CaO	37.4
Na_2O	2.3
H_2O	1.8
Total	99.1

(1) Jeffrey mine, Canada; by electron microprobe, average of nine analyses, Be by AA, H_2O by TGA; corresponds to $(Ca_{1.69}Na_{0.19})_{\Sigma=1.88}(Be_{0.82}Al_{0.14})_{\Sigma=0.96}Si_{1.97}[O_{6.49}(OH)_{0.51}]_{\Sigma=7.00}$.

Polymorphism & Series: Dimorphous with gugiaite.

Occurrence: In a cavity in a highly calcium-metasomatized granite dike.

Association: Grossular.

Distribution: In the Jeffrey mine, Asbestos, Quebec, Canada.

Name: For the type locality, the Jeffrey mine, Quebec, Canada.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 48740.

References: (1) Grice, J.D. and G.W. Robinson (1984) Jeffreyite, $(Ca, Na)_2(Be, Al)Si_2(O, OH)_7$, a new mineral species and its relation to the melilite group. Can. Mineral., 22, 443–446. (2) (1985) Amer. Mineral., 70, 872 (abs. ref. 1).

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As bladed crystals, elongated along [010], to 6 mm, or as fibrous aggregates.

Physical Properties: *Cleavage:* Distinct on {001}. Hardness = n.d. D(meas.) = 2.32-2.33 D(calc.) = 2.325

Optical Properties: Transparent to translucent. *Color:* White; colorless in thin section. *Luster:* Vitreous.

Optical Class: Biaxial (-). *Orientation:* $X \perp$ {001} cleavage; $Y \wedge b = 35°$-$40°$.
α = 1.548-1.552 β = 1.562-1.564 γ = 1.570-1.571 2V(meas.) = 74°

Cell Data: *Space Group*: $P\bar{1}$. a = 10.576(2) b = 7.265(2) c = 10.931(3) α = 101.30(1)° β = 96.98(1)° γ = 109.65(1)° Z = 1

X-ray Powder Pattern: Crestmore, California, USA.
10.5 (vvs), 2.92 (vs), 3.04 (s), 2.83 (s), 2.66 (s), 6.46 (ms), 3.47 (ms)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	34.2	33.20	Na_2O		0.00
TiO_2		0.02	K_2O		0.01
Al_2O_3		0.09	H_2O^+		18.53
FeO		0.01	H_2O^-		1.69
MnO		0.02	H_2O	19.2	
MgO		0.03	P_2O_5		0.04
CaO	46.6	46.85	Total	100.0	100.49

(1) Crestmore, California, USA; by electron microprobe; H_2O by TGA; corresponds to $Ca_{8.76}H_{2.00}Si_{6.00}O_{17.6}(OH)_{8.00}{\bullet}6.24H_2O$. (2) Fuka, Japan; by electron microprobe, H_2O by gravimetry; corresponds to $Ca_{9.00}H_{2.00}(Si_{5.95}Al_{0.02})_{\Sigma=5.97}O_{17.93}(OH)_{8.00}{\bullet}6.07H_2O$. (3) Structure analysis and IR and Raman spectroscopy suggest the revised formula $Ca_9Si_6O_{18}(OH)_6{\cdot}8H_2O$.

Occurrence: A late-stage mineral, partially filling open spaces and in veins in fractured contact metamorphic rocks.

Association: Tobermorite, scawtite, calcite (Crestmore, California, USA); afwillite, oyelite, spurrite (Fuka, Japan).

Distribution: From Crestmore, Riverside Co., California, USA. At Campomorto, Montalto di Castro, Lazio, Italy. In Germany, from the Bellerberg volcano, two km north of Mayen, Eifel district, and fine crystals from the Zeilberg, near Maroldsweisach, Bavaria. In the Hatrurim Formation, Israel. In the Wessels mine, near Kuruman, Cape Province, South Africa. In Japan, from Fuka, near Bicchu, Okayama Prefecture.

Name: For Colonel Clarence M. Jenni (1896-1974?), Director of the Geological Museum, University of Missouri, Rollo, Missouri, USA, the mineral's discoverer.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119007.

References: (1) Carpenter, A.B., R.A. Chalmers, J.A. Gard, K. Speakman, and H.F.W. Taylor (1966) Jennite, a new mineral. Amer. Mineral., 51, 56-74. (2) Gard, J.A., H.F.W. Taylor, G. Cliff, and G.W. Lorimer (1977) A reexamination of jennite. Amer. Mineral., 62, 365-368. (3) Kusachi, I., C. Henmi, and K. Henmi (1989) Afwillite and jennite from Fuka, Okayama Province, Japan. Mineral. J. (Japan), 14, 279-292. (4) Bonaccorsi, E., S. Merlino, and H.F.W. Taylor (2004) The crystal structure of jennite, $Ca_9Si_6O_{18}(OH)_6{\cdot}8H_2O$. Cement Concrete Res. 34, 1481-1488. (5) (2005) Amer. Mineral., 90, 772 (abs. ref. 4).

Jensenite $Cu_3Te^{6+}O_6 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As well-formed pseudorhombohedral crystals, nearly equant, dominated by $\{\bar{1}01\}$ and $\{110\}$, with six minor forms, to 0.4 mm.

Physical Properties: *Cleavage:* On $\{\bar{1}01\}$, fair. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = n.d. D(calc.) = 4.76

Optical Properties: Transparent. *Color:* Emerald-green; grey in reflected light with bright green internal reflections at grain boundaries. *Streak:* Green. *Luster:* Adamantine. *Optical Class:* Isotropic, nearly. $n = 1.92$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d. *Bireflectance:* Weak.

R_1–R_2: (420) 11.0–11.3, (440) 10.8–11.2, (460) 10.7–11.1, (480) 10.7–11.0, (500) 10.7–10.8, (520) 10.6–10.7, (540) 10.4–10.5, (560) 10.15–10.3, (580) 9.9–10.0, (600) 9.6–9.8, (620) 9.4–9.6, (640) 9.25–9.4, (660) 9.15–9.3, (680) 9.0–9.2, (700) 9.1–9.2

Cell Data: *Space Group:* $P2_1/n$. $a = 9.224(2)$ $b = 9.180(1)$ $c = 7.600(1)$ $\beta = 102.38(1)^\circ$ $Z = 4$

X-ray Powder Pattern: Centennial Eureka mine, Utah, USA.
6.428 (100), 3.217 (70), 2.530 (50), 2.601 (40), 2.144 (35), 1.750 (35), 4.523 (30)

Chemistry:

	(1)	(2)
TeO_3	38.91	39.00
CuO	50.91	53.00
ZnO	0.31	
H_2O	[8.00]	8.00
Total	[98.13]	100.00

(1) Centennial Eureka mine, Utah, USA; by electron microprobe, average of two analyses, H_2O confirmed by IR and crystal-structure analysis; corresponds to $(Cu_{2.92}Zn_{0.02})_{\Sigma=2.94}$ $Te_{1.01}O_{5.97} \cdot 2.03H_2O$. (2) $Cu_3TeO_6 \cdot 2H_2O$.

Occurrence: Very rare in an oxidized Cu–Te-bearing sulfide deposit.

Association: Mcalpineite, xocomecatlite, leisingite, cesbronite, quartz.

Distribution: Collected on the dumps of the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: Honors Martin C. Jensen (1959–), Reno, Nevada, USA, student of the mineralogy of Utah and Nevada, USA, who collected the first specimens.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 67424.

References: (1) Roberts, A.C., J.D. Grice, L.A. Groat, A.J. Criddle, R.A. Gault, R.C. Erd, and E.A. Moffatt (1996) Jensenite, $Cu_3Te^{6+}O_6 \cdot 2H_2O$, a new mineral species from the Centennial Eureka mine, Tintic district, Juab County, Utah. Can. Mineral., 34, 49–54. (2) Grice, J.D., L.A. Groat, and A.C. Roberts (1996) Jensenite, a cupric tellurate framework structure with two coordinations of copper. Can. Mineral., 34, 55–59. (3) (1996) Amer. Mineral., 81, 1282–1283 (abs. refs. 1 and 2).

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Jentschite **$PbTlAs_2SbS_6$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are platy to long prismatic, showing {010}, {130}, {001}, {041}, {$\bar{1}$01}, {$\bar{1}$21}, {$\bar{1}$51}, to 2 mm, in aggregates. *Twinning:* Polysynthetic on {010} and contact twins on {100}.

Physical Properties: *Cleavage:* Perfect on {$\bar{1}$01}. *Fracture:* Uneven to conchoidal. *Tenacity:* Extremely brittle. Hardness = 2–2.5 VHN = 38–51 (10 g load). D(meas.) = n.d. D(calc.) = 5.24

Optical Properties: Opaque; translucent in thin fragments. *Color:* Black; in transmitted light, dark red with red internal reflections; pale gray in reflected light. *Streak:* Dark red. *Luster:* Metallic to submetallic. *Anisotropism:* Distinct.
R_1–R_2: (470) 29.7–35.4, (543) 28.8–33.1, (587) 26.7–30.3, (657) 26.6–29.9

Cell Data: *Space Group:* $P2_1/n$. $a = 8.0958(5)$ $b = 23.917(2)$ $c = 5.8876(5)$ $\beta = 108.063(8)^\circ$ Z = 4

X-ray Powder Pattern: Binntal, Switzerland.
2.823 (100), 3.587 (86), 2.778 (84), 3.998 (74), 2.670 (58), 3.816 (54), 5.346 (32)

Chemistry:

	(1)	(2)	(3)
Pb	21.44	24.45	23.67
Tl	23.92	23.94	23.34
As	19.16	21.69	17.11
Sb	12.53	7.68	13.91
S	22.42	22.29	21.97
Total	99.47	[100.05]	100.00

(1) Binntal, Switzerland; by electron microprobe, average of 15 analyses; corresponds to $Pb_{0.89}Tl_{1.01}As_{2.20}Sb_{0.89}S_{6.02}$. (2) Do.; by electron microprobe, average of 24 analyses, original total given as 100.1%; corresponds to $Pb_{1.01}Tl_{1.00}As_{2.48}Sb_{0.54}S_{5.96}$. (3) $PbTlAs_2SbS_6$.

Occurrence: Very rare in a hydrothermal deposit in dolostone.

Association: Realgar, orpiment, hutchinsonite, hatchite, wallisite, edenharterite, bernardite, sicherite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: In honor of Franz Jentsch (1868–1908), an early prolific collector of Lengenbach minerals.

Type Material: Natural History Museum; Mineralogical Institute, University of Basel, Basel, Switzerland.

References: (1) Graeser. S. and A. Edenharter (1997) Jentschite ($TlPbAs_2SbS_6$) – a new sulphosalt mineral from Lengenbach, Binntal (Switzerland). Mineral. Mag., 61, 131–137. (2) (1997) Amer. Mineral., 82, 1261 (abs. ref. 1). (3) Berlepsch, P. (1996) Crystal structure and crystal chemistry of the homeotypes edenharterite ($TlPbAs_3S_6$) and jentschite ($TlPbAs_2SbS_6$) from Lengenbach, Binntal (Switzerland). Schweiz. Mineral. Petrogr. Mitt., 76, 147–157.

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Jeppeite $(K, Ba)_2(Ti, Fe^{3+})_6O_{13}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In finely prismatic to acicular single crystals, elongated along [010], to 1 cm, showing {100}, {20$\overline{1}$}, and {010}, typically overgrown on priderite.

Physical Properties: *Cleavage:* Perfect on {100}; good on {20$\overline{1}$}. *Tenacity:* Brittle. Hardness = 5–6 VHN = 664–773 $\perp$ [010] (100 g load). D(meas.) = 3.94 D(calc.) = 3.972

Optical Properties: Opaque. *Color:* Black; gray in reflected light, may have pale golden internal reflections. *Streak:* Pale brown. *Luster:* Submetallic.
Optical Class: Biaxial. *Pleochroism:* X = Capri blue; Y = dark greenish brown to almost opaque; Z = dark olive-buff. *Orientation:* $X \wedge a = 10°$; $Y = b$; $Z = c$. *Absorption:* $Y > Z > X$. α = [2.13] β = [2.21] γ = [2.35] 2V(meas.) = n.d. *Bireflectance:* Weak.
R_1–R_2: (400) 16.1–19.5, (420) 15.5–18.9, (440) 15.0–18.4, (460) 14.5–18.0, (480) 14.2–17.6, (500) 13.9–17.3, (520) 13.6–17.0, (540) 13.4–16.8, (560) 13.2–16.6, (580) 13.1–16.5, (600) 13.0–16.4, (620) 12.9–16.2, (640) 12.9–16.2, (660) 12.9–16.1, (680) 12.8–16.0, (700) 12.8–16.0

Cell Data: *Space Group:* $C2/m$. a = 15.453(2) b = 3.8368(7) c = 9.123(2) $\beta = 99.25(1)°$ Z = 2

X-ray Powder Pattern: Wolgidee Hills, Western Australia.
3.07 (10), 2.990 (10), 2.812 (10), 1.919 (8), 2.091 (6), 2.074 (6), 1.412 (5)

Chemistry:

	(1)	(2)
TiO_2	69.29	68.01
ZrO_2		0.00
Fe_2O_3	4.74	4.94
MgO		0.47
BaO	17.35	16.93
SrO		0.50
Na_2O		0.50
K_2O	8.47	8.54
Total	99.85	99.89

(1) Wolgidee Hills, Western Australia; by electron microprobe, average of seven analyses, Fe confirmed by magnetic measurements as Fe^{3+}; corresponding to $(K_{1.15}Ba_{0.73})_{\Sigma=1.88}(Ti_{5.56}Fe^{3+}_{0.38})_{\Sigma=5.94}O_{13}$. (2) Do; by electron microprobe, corresponding to $(K_{1.17}Ba_{0.71}Na_{0.10}Mg_{0.08}Sr_{0.03})_{\Sigma=2.09}(Ti_{5.47}Fe^{3+}_{0.40})_{\Sigma=5.87}O_{13}$.

Occurrence: In some abundance, in a large weathered lamproite plug.

Association: Priderite, celadonite, chlorite, titanite, shcherbakovite, wadeite, perovskite, apatite, richterite, calcite.

Distribution: In the Wolgidee Hills, West Kimberley district, Western Australia.

Name: For Dr. John Frederik Biccard Jeppe (1920–), geologist of Nedlands, Western Australia, discoverer of the mineral.

Type Material: Western Australian Musesum, Perth, Australia, MDC6401; The Natural History Museum, London, England, 1983,604–609 and E.870–871.

References: (1) Pryce, M.W., L.C. Hodge, and A.J. Criddle (1984) Jeppeite, a new K–Ba–Fe titanate from Walgidee [*sic*] Hills, Western Australia. Mineral. Mag., 48, 263–266. (2) Bagshaw, A.N., B.H. Doran, A.H. White, and A.C. Willis (1977) Crystal structure of a natural potassium-barium hexatitanite [jeppeite] isostructural with $K_2Ti_6O_{13}$. Aust. J. Chem., 30, 1195–1200. (3) (1985) Amer. Mineral., 70, 872–873 (abs. refs. 1 and 2). (4) Birch, W.D. (1985) A note on large crystals of priderite, jeppeite, wadeite and other minerals from Walgidee [Wolgidee] Hills, Western Australia. Australian Mineralogist, 50, 298–302.

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Jeremejevite $Al_6(BO_3)_5(F,OH)_3$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals are typically hexagonal prismatic $\{11\bar{2}0\}$, may be tapered by vincinal forms, with pyramidal $\{10\bar{1}1\}$ termination, to 10 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 6.5–7.5 D(meas.) = 3.29(1) D(calc.) = 3.284 [F^{1-} end-member]; 3.198 [$(OH)^{1-}$ end-member]. Piezoelectric.

Optical Properties: Transparent. *Color:* Colorless, pale yellowish brown, pale to dark cornflower-blue; colorless to pale blue in transmitted light, typically sector zoned.
Luster: Vitreous.
Optical Class: Uniaxial (–), may be anomalously biaxial (–) in sector-zoned crystals.
Pleochroism: Colorless to pale blue-violet if colored. *Dispersion:* $r > v$, distinct.
ω = 1.644–1.647 ϵ = 1.637 α = 1.637 β = 1.644–1.647 γ = 1.644–1.652
2V(meas.) = 18°–33°

Cell Data: *Space Group:* $P6_3/m$. $a = 8.5591(3)$ $c = 8.1814(6)$ Z = 2

X-ray Powder Pattern: Mt. Soktui, Russia.
4.282 (100), 3.791 (57), 2.055 (44), 2.196 (35), 2.650 (33), 2.470 (30), 1.391 (30)

Chemistry:

	(1)	(2)
SiO_2	0.03	0.17
B_2O_3	33.51	33.81
Al_2O_3	59.90	59.79
Fe_2O_3	0.01	0.14
F	10.18	10.23
H_2O	n.d.	n.d.
$-O = F_2$	4.29	4.31
Total	99.34	99.83

(1) Mt. Soktui, Russia; by electron microprobe. (2) Cape Cross, Namibia; by electron microprobe, $(OH)^{1-}$ calculated for charge balance; corresponds to $Al_{6.00}Fe_{0.01}(B_{0.99}O_3)_5[F_{2.76}(OH)_{0.24}]_{\Sigma=3.00}$.

Occurrence: A rare late hydrothermal mineral formed in granitic pegmatites.

Association: Albite, tourmaline, quartz, gypsum (Cape Cross, Namibia).

Distribution: Large crystals from Mt. Soktui, Nerschinsk district, Adun-Chilon Mountains, Siberia, Russia. In the Kukurt massif, Pamir Mountains, Tajikistan. In Namibia, gem crystals from a prospect near Cape Cross, at Mile 72, about 100 km north of Swakopmund, and from Ameib, Erongo Mountains. At Wannerköpfe and Emmelberg, near Üdersdorf, Eifel district, Germany.

Name: Honors Pavel Vladimirovich Eremeev (Jeremejev, *German*) (1830–1899), Russian mineralogist and crystallographer, who first recognized this species.

Type Material: Mining Institute, St. Petersburg, Russia, 412/1.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 330–332. (2) Herting, S. and H. Strunz (1978) Jeremejewit von Cape Cross in SW-Afrika. Aufschluss, 29, 45–53 (in German). (3) Foord, E.E., R.C. Erd, and G.R. Hunt (1981) New data for jeremejevite. Can. Mineral., 19, 303–310. (4) Sokolova, E.V., Y.K. Yegorov-Tismenko, S.V. Kargal'tsev, V.A. Klyakhin, and V.S. Urusov (1987) Refinement of the crystalline structure of synthetic fluorous jeremejevite $Al_6[BO_3]_5F_3$. Moscow Univ. Geol. Bull., 42, 79–81. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 106–107.

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Jeromite $As(S,Se)_2(?)$

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Crystal Data: Amorphous to X-rays. *Point Group:* n.d. Globular coating on rock fragments.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque, translucent in thin edges. *Color:* Black; cherry-red in transmitted light.
R: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
As	46.8
Sb	trace
Se	7.5
Te	trace
S	40.8
insol.	4.9
Total	100.0

(1) Jerome, Arizona, USA; corresponds to $As_{0.91}(S_{1.86}Se_{0.14})_{\Sigma=2.00}$.

Occurrence: Coating rock fragments beneath iron hoods placed over vents from which gasses rich in SO_2 issued, a product of burning sulfide ores.

Association: n.d.

Distribution: From the United Verde mine, Jerome, Yavapai Co., Arizona, USA [TL].

Name: For Jerome, Arizona, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 144. (2) Lausen, C. (1928) Hydrous sulphates formed under fumarolic conditions at the United Verde mine. Amer. Mineral., 13, 227–229.

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Jerrygibbsite $Mn_9^{2+}(SiO_4)_4(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ (probable), or $2/m\ 2/m\ 2/m$. As interlocking anhedral crystals, to 2 mm.

Physical Properties: *Cleavage:* Imperfect on {001}. Hardness = ~5.5 D(meas.) = 4.00(2) D(calc.) = 4.045

Optical Properties: Transparent and translucent lamellae alternating ‖ {001}.
Color: Violet-pink, with a brownish tinge; light pink in thin section. *Streak:* Light pink.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, moderate.
$\alpha = 1.772(4)$ $\beta = 1.783(4)$ $\gamma = 1.789(4)$ 2V(meas.) = 72°

Cell Data: *Space Group:* $Pbn2_1$ (probable), or $Pbnm$. $a = 4.875(2)$ $b = 10.709(6)$ $c = 28.18(2)$ Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.557 (100), 1.806 (100), 2.869 (78), 2.752 (49), 2.702 (46), 2.362 (39), 2.661 (34)

Chemistry:

	(1)
SiO_2	27.1
FeO	0.3
MnO	64.1
ZnO	3.9
MgO	1.4
CaO	0.4
F	0.0
H_2O	2.13
Total	99.3

(1) Franklin, New Jersey, USA; by electron microprobe, H_2O by the Penfield method; corresponds to $(Mn_{7.86}Zn_{0.59}Mg_{0.24}Ca_{0.16}Fe_{0.14})_{\Sigma=8.99}(SiO_4)_4(OH)_2$.

Polymorphism & Series: Dimorphous with sonolite.

Mineral Group: Leucophoenicite group.

Occurrence: In a metamorphosed stratiform Zn-Mn deposit.

Association: Franklinite, willemite, zincite, sonolite, leucophoenicite, tephroite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: In honor of Professor Gerald V. Gibbs, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 125030; National Museum of Natural History, Washington, D.C., USA, C3209, R18772, 149037; The Natural History Museum, London, England1983,236.

References: (1) Dunn, P.J., D.R. Peacor, W.B. Simmons, and E.J. Essene (1984) Jerrygibbsite, a new polymorph of $Mn_9(SiO_4)_4(OH)_2$ from Franklin, New Jersey, with new data on leucophoenicite. Amer. Mineral., 69, 546–552. (2) Kato, T., Y. Ito, and N. Hashimoto (1989) The crystal structures of sonolite and jerrygibbsite. Neues Jahrb. Mineral., Monatsh., 410–430, 1989.

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Jervisite $(Na, Ca, Fe^{2+})(Sc, Mg, Fe^{2+})Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As sprays of elongated platy crystals, < 1 mm.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.31]

Optical Properties: Semitransparent. *Color:* Light green. *Luster:* Vitreous. *Optical Class:* Biaxial. $\alpha = 1.663$ β = n.d. $\gamma = 1.684$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$. $a = 9.853(11)$ $b = 9.042(10)$ $c = 5.312(7)$ $\beta = 106°37(7)'$ Z = 4

X-ray Powder Pattern: Baveno, Italy.
3.038 (s), 2.979 (m), 2.543 (m), 1.647 (m), 6.51 (w), 4.51 (w), 3.389 (w)

Chemistry:

	(1)	(2)
SiO_2	50.42	54.59
TiO_2	0.55	
Al_2O_3	0.42	
Sc_2O_3	18.48	31.33
FeO	8.59	
MnO	0.44	
MgO	2.80	
CaO	7.25	
Na_2O	5.55	14.08
Total	94.50	100.00

(1) Baveno, Italy; by electron microprobe, average of multiple analyses; corresponds to $(Na_{0.43}Ca_{0.31}Fe^{2+}_{0.14}Mn_{0.01})_{\Sigma=0.89}(Sc_{0.66}Mg_{0.17}Fe^{2+}_{0.15}Al_{0.02}Ti_{0.02})_{\Sigma=1.02}Si_2O_{6.02}$. (2) $NaScSi_2O_6$.

Mineral Group: Pyroxene group.

Occurrence: In miarolitic cavities in granite.

Association: Cascandite, quartz, orthoclase, albite.

Distribution: In the Diverio quarry, Mt. Mottarone, near Baveno, Piedmont, Italy.

Name: Honors William P. Jervis, Curator of the Museo Industriale Italiano di Torino, Torino, Italy.

Type Material: Municipal Museum of Natural History, Milan, Italy, 23270.

References: (1) Mellini, M., S. Merlino, P. Orlandi, and R. Rinaldi (1982) Cascandite and jervisite, two new scandium silicates from Baveno, Italy. Amer. Mineral., 67, 599–603.
(2) Hawthorne, F.C. and H.D. Grundy (1973) Refinement of the crystal structure of $NaScSi_2O_6$. Acta Cryst., 29, 2615–2616.

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Jianshuiite $(Mg, Mn^{2+})Mn_3^{4+}O_7 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ or 3. Very fine granular, to 5 μm, in porous aggregates; massive.

Physical Properties: Hardness = Soft. D(meas.) = 3.50–3.60 D(calc.) = 3.598

Optical Properties: Opaque. *Color:* Brown to brownish black; grayish white in reflected light, with brown internal reflections.
Optical Class: Uniaxial. *Anisotropism:* Distinct.
R: (470) 23.0, (546) 19.9, (589) 19.1, (650) 18.6

Cell Data: *Space Group:* [$R\overline{3}$ or $R3$] (by analogy to the chalcophanite group). a = [7.54] c = [20.82] Z = [6]

X-ray Powder Pattern: Lu Village, China; nearly indistinguishable from chalcophanite and aurorite.
6.965 (100), 2.230 (23), 3.483 (11), 4.086 (8), 2.449 (7), 2.396 (6), 5.539 (3)

Chemistry:

	(1)	(2)
SiO_2	1.20	3.94
MnO_2	67.65	68.49
Al_2O_3	0.78	0.91
Fe_2O_3	0.52	1.41
MnO	8.02	0.92
MgO	5.29	8.52
CaO	1.97	2.03
H_2O^+	13.37	12.60
P_2O_5	0.59	1.63
Total	99.39	100.45

(1) Lu Village, China; corresponds to $(Mg_{0.51}Mn^{2+}_{0.44}Ca_{0.08})_{\Sigma=1.03}Mn^{4+}_{3.03}O_{7.10} \cdot 2.90H_2O$. (2) Do.; corresponds to $(Mg_{0.85}Mn^{2+}_{0.05}[Ca_{0.08}])_{\Sigma=0.98}Mn^{4+}_{3.15}O_{7.20} \cdot 2.80H_2O$.

Occurrence: A hypogene mineral in manganese ore (Lu Village, China); authigenic in manganese oxide concretions in siltstone (San Felipe, Mexico).

Association: Hydrated manganese oxides (Lu Village, China); magnetite, maghemite, goethite, hematite, calcite, quartz, mica, clay minerals (San Felipe, Mexico).

Distribution: In China, near Lu Village, Jianshui Co., Yunnan Province. From 56 km south of San Felipe, Baja California, Mexico.

Name: For its occurrence in Jianshui Co., Yunnan Province, China.

Type Material: Geology Exhibit Museum, Yunnan; Museum of Geology, Beijing, China.

References: (1) Yan Guyian, Zhang Shanghua, Zhao Mingkai, Ding Jianping, and Li Deyu (1992) Jianshuiite: a new magnesium mineral of the chalcophanite group. Acta Mineral. Sinica, 12(1), 69–77 (in Chinese with English abs.). (2) (1994) Amer. Mineral., 79, 185 (abs. ref. 1). (3) Potter, R.M., and G.R. Rossman (1979) A magnesium analogue of chalcophanite in manganese-rich concretions from Baja California. Amer. Mineral., 64, 1227–1229. (4) Grice, J.D., B. Gartrell, R.A. Gault, and J. Van Velthuizen (1994) Ernienickelite, $NiMn_3O_7 \cdot 3H_2O$, a new mineral species from the Siberia complex, Western Australia: comments on the chalcophanite group. Can. Mineral., 32, 333–337.

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Jimboite $Mn_3^{2+}(BO_3)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Platy anhedral crystals, to 5 mm; in veinlets and granular. *Twinning:* Composition and twin plane {101}; may exhibit glide twinning.

Physical Properties: *Cleavage:* On {110}, perfect; {101}, a parting. Hardness = 5.5 D(meas.) = 3.98–4.02 D(calc.) = 3.98

Optical Properties: Semitransparent. *Color:* Pale purplish brown; nearly colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.792$ $\beta = 1.794$ $\gamma = 1.821$ 2V(meas.) = 35°

Cell Data: *Space Group: Pnmn.* $a = 5.638(5)$ $b = 8.714(3)$ $c = 4.633(7)$ Z = 2

X-ray Powder Pattern: Kaso mine, Japan.
2.33 (100), 2.77 (90), 4.09 (70), 1.580 (70), 3.59 (60), 2.59 (50), 1.791 (50)

Chemistry:

	(1)	(2)
SiO_2	3.3	
CO_2	6.1	
B_2O_3	18.6	24.65
Al_2O_3	0.1	
FeO	1.6	
MnO	65.3	75.35
MgO	3.3	
CaO	0.5	
H_2O	0.1	
insol.	1.4	
Total	100.3	100.00

(1) Kaso mine, Japan; after deducting rhodochrosite and tephroite impurity, corresponds to $(Mn_{2.67}Mg_{0.23}Fe_{0.06})_{\Sigma=2.96}(B_{1.01}O_{3.00})_2$. (2) $Mn_3(BO_3)_2$.

Occurrence: Likely formed by metasomatic reactions between boron-bearing hydrothermal solutions and rhodochrosite in banded manganese deposits.

Association: Rhodochrosite, tephroite, galaxite, jacobsite, alabandite, galena, pyrrhotite, chalcopyrite.

Distribution: In Japan, from the Kaso mine, Kanuma, Tochigi Prefecture; the Rito mine, Seta, Gumma Prefecture; the Fuji mine, Fukui Prefecture, and elsewhere.

Name: Honors Professor Kotora Jimbo (1867–1924), founder of the Mineralogical Institute, University of Tokyo, Tokyo, Japan.

Type Material: National Science Museum, Tokyo, Japan, M15-112; The Natural History Museum, London, England.

References: (1) Watanabe, T., A. Kato, T. Matsumoto, and J. Ito (1963) Jimboite, $Mn_3(BO_3)_2$, a new mineral from the Kaso mine, Tochigi Prefecture, Japan. Proc. Japan. Acad., 39(3), 170–175 (in English). (2) (1963) Amer. Mineral., 48, 1416–1417 (abs. ref. 1). (3) Sadanaga, R., T. Nishimura, and T. Watanabe (1965) The structure of jimboite, $Mn_3(BO_3)_2$ and relationship with the structure of kotoite. Mineral. J. (Japan), 4, 380–388. (4) Bondareva, O.S., M.A. Simonov, and N.V. Belov (1978) The crystal structure of synthetic jimboite $Mn_3(BO_3)_2$. Kristallografiya (Sov. Phys. Crystal.), 23, 491–493 (in Russian).

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Jimthompsonite $(Mg, Fe^{2+})_5Si_6O_{16}(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As radiating sprays of crystals, to 5 cm; as fibrous intergrowths parallel to {010} in anthophyllite and cummingtonite.

Physical Properties: *Cleavage:* Perfect on {210}, intersecting at 38° and 142°; breakage on {100} and {010} may be partings. Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.02]

Optical Properties: Transparent. *Color:* Colorless to very light pinkish brown; colorless in thin section.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, weak.
$\alpha = 1.605(5)$ $\beta = 1.626(5)$ $\gamma = 1.633(5)$ 2V(meas.) = 62(2)°

Cell Data: *Space Group: Pbca.* $a = 18.6263(3)$ $b = 27.2303(6)$ $c = 5.2970(3)$ Z = 8

X-ray Powder Pattern: Calculated. (ICDD 31-638).
8.812 (100), 13.6 (57), 3.092 (53), 2.601 (42), 3.250 (38), 2.547 (28), 3.814 (27)

Chemistry:

	(1)
SiO_2	57.78
Al_2O_3	0.29
FeO	12.22
MnO	0.72
MgO	25.14
CaO	0.38
Na_2O	0.12
H_2O	[2.92]
Total	[99.57]

(1) Chester, Vermont, USA; by electron microprobe; H_2O assuming (OH) sites filled by $(OH)^{1-}$.

Polymorphism & Series: Dimorphous with clinojimthompsonite.

Occurrence: In the black wallrock between chlorite and actinolite zones of a metamorphosed ultramafic body.

Association: Chesterite, clinojimthompsonite, anthophyllite, cummingtonite, talc.

Distribution: In the Carleton talc quarry, near Chester, Windsor Co., Vermont, USA.

Name: For Professor James Burleigh Thompson, Jr. (1921–), eminent petrologist of Harvard University, Cambridge, Massachusetts, USA.

Type Material: Royal Ontario Museum, Toronto, Canada, M36083; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 145689.

References: (1) Veblen, D.R. and C.W. Burnham (1978) New biopyriboles from Chester, Vermont: I. Descriptive mineralogy. Amer. Mineral., 63, 1000–1009. (2) Veblen, D.R. and C.W. Burnham (1978) New biopyriboles from Chester, Vermont: II. The crystal chemistry of jimthompsonite, clinojimthompsonite, chesterite, and the amphibole-mica reaction. Amer. Mineral., 63, 1053–1073. (3) Veblen, D.R. and P.R. Buseck (1979) Chain-width order and disorder in biopyriboles. Amer. Mineral., 64, 687–700.

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Jinshajiangite $\mathbf{Na_2KBaCa(Fe^{2+},Mn^{2+})_8Ti_4Si_8O_{32}(O,F,H_2O)_6}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As tabular crystals, up to 2 cm.

Physical Properties: *Cleavage:* Perfect on {010} and {100}. *Fracture:* Uneven.
Hardness = n.d. VHN = 430 D(meas.) = 3.61 D(calc.) = 3.56

Optical Properties: Semitransparent. *Color:* Blackish red, brownish red, golden red.
Streak: Light yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = light golden yellow; Y = brownish yellow; Z = brownish red. *Orientation:* $X \wedge c = 13°$. *Dispersion:* $r < v$. *Absorption:* $X = Y > Z$.
$\alpha = 1.729$ $\beta = 1.802$ $\gamma = 1.852$ 2V(meas.) = 72° 2V(calc.) = 76°

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 10.732$ $b = 13.847$ $c = 20.817$
$\beta = 95°3'$ Z = 2

X-ray Powder Pattern: Near the Jinshajiang River, China.
3.44 (10), 3.15 (8), 2.570 (8), 10.2 (7), 2.85 (7), 2.63 (7), 1.715 (5b)

Chemistry:

	(1)		(1)
SiO_2	27.10	MgO	0.28
TiO_2	15.90	CaO	2.94
$(Zr,Hf)O_2$	0.70	SrO	0.08
Al_2O_3	0.36	BaO	9.80
RE_2O_3	0.30	Na_2O	3.15
Fe_2O_3	1.64	K_2O	2.31
Nb_2O_5	1.03	F	2.66
Ta_2O_5	0.07	H_2O^+	0.33
FeO	19.07	H_2O^-	0.36
MnO	12.93	$-O = F_2$	1.12
		Total	99.89

(1) Near the Jinshajiang River, China; corresponds to $Na_{1.81}K_{0.87}Ba_{1.14}Ca_{0.93}RE_{0.10}Sr_{0.01}(Fe^{2+}_{4.73}Mn_{3.25}Mg_{0.12})_{\Sigma=8.10}(Ti_{3.55}Fe^{3+}_{0.37}Nb_{0.14}Zr_{0.10})_{\Sigma=4.16}(Si_{8.04}Al_{0.12})_{\Sigma=8.16}O_{32}[O_{2.83}F_{2.49}(H_2O)_{0.56}(OH)_{0.12}]_{\Sigma=6.00}$.

Occurrence: In an arfvedsonite dike in alkalic syenites.

Association: Albite, arfvedsonite, aegirine, pyrochlore, monazite, chevkinite.

Distribution: Found near the Jinshajiang River, western Sichuan Province, China.

Name: For the Jinshajiang River, China.

Type Material: Institute of Geochemistry, Academy Sinica, Guiyang, Ghizhou Province, China.

References: (1) Hong Wenxing and Fu Pingqiu (1982) Jinshajiangite, a new Ba-Mn-Fe-Ti-bearing silicate mineral. Geochemistry (China), 1, 458–464 (in English). (2) (1984) Amer. Mineral., 69, 567 (abs. ref. 1). (3) Chao, G.Y. (1991) Perraultite, a new hydrous Na-K-Ba-Mn-Ti-Nb silicate species from Mont Saint-Hilaire, Quebec. Can. Mineral., 29, 355–358.

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Jixianite $Pb(W,Fe^{3+})_2(O,OH)_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Very rarely as octahedra, to 160 μm; commonly microcrystalline or granular, in honeycomb and crustlike aggregates.

Physical Properties: Hardness = ~3 D(meas.) = 6.04 D(calc.) = 7.89 Weakly magnetic.

Optical Properties: Transparent. *Color:* Red to brownish red; in reflected light, yellowish brown or greenish yellow. *Streak:* Yellow. *Luster:* Resinous, strong.
Optical Class: Isotropic; may show weak anisotropism. n = 2.262–2.315

Cell Data: *Space Group:* $Fd3m$. a = 10.3594(6) Z = 8

X-ray Powder Pattern: Jixian, China.
2.982 (10), 1.833 (8), 1.562 (7), 2.585 (6), 5.97 (5), 1.189 (5), 1.159 (5)

Chemistry:

	(1)	(2)
WO_3	50.39	50.13
MoO_3	0.01	
Fe_2O_3	6.53	
FeO	0.71	8.86
CuO	0.27	trace
PbO	38.72	40.15
MgO	0.20	
H_2O^+	3.68	
Total	100.51	99.14

(1) Jixian, China; after deduction of wulfenite, corresponds to $(Pb_{1.14}Fe^{2+}_{0.07}Cu_{0.02})_{\Sigma=1.23}(W_{1.43}Fe^{3+}_{0.54}Mg_{0.03})_{\Sigma=2.00}[O_{6.00}(OH)_{0.72}]_{\Sigma=6.72}\cdot 0.98H_2O$. (2) Do.; by electron microprobe, total Fe as FeO.

Occurrence: In the oxidized zone of hypothermal to mesothermal tungsten-bearing quartz veins peripheral to a quartz monzonite stock.

Association: Bismuthinite, quartz, wolframite, cassiterite, pyrite, chalcopyrite, scheelite, wulfenite, stolzite, silver, copper.

Distribution: In the Pan-shan stock, Jixian, Hebei Province, China.

Name: For the locality at Jixian, China.

Type Material: The Geological Museum, State Bureau of Geology, [Beijing], China.

References: (1) Liu Jianchang (1979) Jixianite $Pb(W,Fe^{3+})_2(O,OH)_7$ – a new tungsten mineral. Acta Geol. Sinica, 53, 45–49 (in Chinese with English abs.). (2) (1979) Amer. Mineral., 64, 1330 (abs. ref. 1).

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Joaquinite-(Ce) **$NaBa_2Ce_2Fe^{2+}Ti_2Si_8O_{26}(OH)\cdot H_2O$**

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* 2. As equant or tabular crystals, flattened ⊥ [001], up to 1.2 cm; intimately intergrown with orthojoaquinite-(Ce). *Twinning:* On {001}, polysynthetic, common.

Physical Properties: *Cleavage:* {001}, good. Hardness = 5.5 D(meas.) = 3.89–3.98 D(calc.) = [3.93]

Optical Properties: Transparent to translucent. *Color:* Honey-yellow to brown. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; $X = Y$ = colorless; Z = pale yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, perceptible. *Absorption:* $Z > Y > X$. $\alpha = 1.748$–1.753 $\beta = 1.767$ $\gamma = 1.822$–1.823 2V(meas.) = 30°–55°

Cell Data: *Space Group:* $C2$. $a = 10.516(3)$ $b = 9.686(3)$ $c = 11.833(4)$ $\beta = 109.67(3)°$ Z = 2

X-ray Powder Pattern: San Benito Co., California, USA.
2.943 (100), 4.43 (95), 2.890 (85), 3.29 (60), 2.606 (60), 3.05 (40), 2.978 (40)

Chemistry:

	(1)		(1)
SiO_2	34.97	MgO	0.05
TiO_2	11.83	CaO	0.21
ThO_2	0.27	SrO	3.20
Y_2O_3	0.70	BaO	22.44
RE_2O_3	18.46	Na_2O	1.87
FeO	4.09	K_2O	0.03
MnO	0.00	H_2O	[1.88]
		Total	[100.00]

(1) San Benito Co., California, USA; by electron microprobe, average of six points on five grains, intergrown with orthojoaquinite-(Ce) of presumably nearly identical composition; RE_2O_3 = La_2O_3 2.14%, Ce_2O_3 10.69%, Pr_2O_3 1.25%, Nd_2O_3 3.21%, Sm_2O_3 0.70%, Gd_2O_3 0.26%, Dy_2O_3 0.21%, Er_2O_3 0.00%, H_2O by difference; corresponds to $Na_{0.83}K_{0.01}Ba_{2.01}Ca_{0.05}Mg_{0.02}(Ce_{0.90}RE_{0.72}Sr_{0.42})_{\Sigma=2.04}Fe_{0.78}Ti_{2.04}Th_{0.02}Si_{8.00}O_{24.68}(OH)_{3.32}$.

Polymorphism & Series: Dimorphous with orthojoaquinite-(Ce).

Mineral Group: Joaquinite group.

Occurrence: In a natrolite vein cutting a glaucophane schist inclusion in a serpentinite body (San Benito Co., California, USA); in fenitized gneisses and alkalic syenites (Seal Lake, Canada).

Association: Orthojoaquinite-(Ce), benitoite, neptunite, natrolite (San Benito Co., California, USA); aegirine, barylite, eudidymite, neptunite (Seal Lake, Canada).

Distribution: At the Gem mine and to its north, on Santa Rita peak; at Mina Numero Uno and on the Victor claim, San Benito Co., California; from Granite Mountain, near Little Rock, Pulaski Co., Arkansas, USA. In Canada, at Seal Lake, Labrador, Newfoundland, and Mont Saint-Hilaire, Quebec. Along the Narssaq river, near Kvanefjeld, in the Ilímaussaq intrusion, southern Greenland.

Name: For Joaquin Ridge, near the original locality at the Gem mine, California, USA.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 90840.

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References: (1) Louderback, G.D. (1909) Benitoite, its paragenesis and mode of occurrence. Univ. of Calif., Bull. Dept. of Geol., 5, 331–380. (2) Palache, C. and W.F. Foshag (1932) The chemical nature of joaquinite. Amer. Mineral., 17, 308–312. (3) Laird, J. and A.L. Albee (1972) Chemical composition and physical, optical, and structural properties of benitoite, neptunite, and joaquinite. Amer. Mineral., 57, 85–102. (4) Dowty, E. (1975) Crystal structure of joaquinite. Amer. Mineral., 60, 872–878. (5) Wise, W.S. (1982) Strontiojoaquinite and bario-orthojoaquinite: two new members of the joaquinite group. Amer. Mineral., 67, 809–816.

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Joesmithite $\mathbf{PbCa_2(Mg,Fe^{3+},Fe^{2+})_5(Si_6Be_2)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic, crudely doubly terminated, highly-modified crystals, elongated along [001] and flattened on {100}, up to 1 cm. Principal forms are {110}, {100}, {010}, {011}, {$\bar{1}$12}, and {$\bar{1}$13}.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = 5.5 D(meas.) = 3.83(1) D(calc.) = 3.91

Optical Properties: Opaque to transparent in thin fragments. *Color:* Black; olive-brown in thin fragments. *Streak:* Pale brown. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* $X = Z$ = olive; Y = brown with olive tint.
Absorption: $Y > X = Z$. $\alpha = 1.747(5)$ $\beta = 1.765(5)$ $\gamma = 1.78(1)$ 2V(meas.) = 60°–70°

Cell Data: *Space Group:* $P2/a$. $a = 9.915(2)$ $b = 17.951(4)$ $c = 5.243(1)$ $\beta = 105.95(2)°$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
3.33 (10), 2.564 (6), 2.530 (6), 2.740 (5.5), 3.70 (5), 2.903 (5), 2.676 (5)

Chemistry:

	(1)		(1)
SiO_2	35.4	CaO	9.9
Al_2O_3	0.5	BaO	0.3
Fe_2O_3	12.3	Na_2O	0.5
FeO	2.6	K_2O	0.0
MnO	2.3	H_2O^+	[1.5]
PbO	20.7	F	0.3
BeO	[4.2]	$-O = F_2$	0.1
MgO	9.6	Total	[100.0]

(1) Långban, Sweden; by electron microprobe, average of four analyses, presence of Be confirmed by ion microprobe; Fe^{2+}:Fe^{3+} calculated from charge balance, BeO from stoichiometry, H_2O by difference; corresponds to $(Pb_{0.98}Ba_{0.02})_{\Sigma=1.00}(Ca_{1.86}Na_{0.16})_{\Sigma=2.02}(Mg_{2.52}Fe^{3+}_{1.63}Fe^{2+}_{0.38}Mn_{0.34}Al_{0.10})_{\Sigma=4.97}(Si_{6.22}Be_{1.78})_{\Sigma=8.00}O_{22}[(OH)_{1.81}F_{0.19}]_{\Sigma=2.00}$.

Mineral Group: Amphibole (calcic) group: $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$.

Occurrence: A rare mineral in a metamorphosed Fe–Mn orebody.

Association: Hematite, magnetite, manganoan aegirine, quartz, barite, calcite.

Distribution: At Långban, Värmland, Sweden.

Name: For Professor Joseph Victor Smith (1928–), English-American mineralogist and petrologist of the University of Chicago, Chicago, Illinois, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120064, 162612.

References: (1) Moore, P.B. (1968) Joesmithite, a new amphibole-like mineral from Långban. Arkiv Mineral. Geol., 4, 487–492. (2) Moore, P.B. (1968) The crystal structure of joesmithite: a preliminary note. Mineral. Mag., 36, 876–879. (3) (1969) Amer. Mineral., 54, 577–578 (abs. ref. 1 and 2). (4) Moore, P.B. (1969) Joesmithite: a novel amphibole crystal chemistry. Min. Soc. Am. Spec. Pap. 2, 111–115. (5) Moore, P.B. (1988) The joesmithite enigma: note on the $6s^2$ Pb^{2+} lone pair. Amer. Mineral., 73, 843–844. (6) Moore, P.B., A.M. Davis, D.G. Van Derveer, and P.K. Sen Gupta (1993) Joesmithite, a plumbous amphibole revisited and comments on bond valences. Mineral. Petrol., 48, 97–113.

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Johachidolite $CaAlB_3O_7$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Equant subhedral crystals, to 1 mm, typically granular.

Physical Properties: *Cleavage:* On {201}, a parting. *Fracture:* Subconchoidal.
Hardness = 7.5 D(meas.) = 3.37–3.45 D(calc.) = 3.437 Blue fluorescence under SW UV, with weak phosphorescence.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale yellow.
Luster: Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, strong.
$\alpha = 1.712$–1.717 $\beta = 1.717$–1.720 $\gamma = 1.724$–1.729 2V(meas.) = 70(2)° 2V(calc.) = 72°

Cell Data: *Space Group: Cmma.* $a = 7.968(1)$ $b = 11.724(1)$ $c = 4.374(1)$ Z = 4

X-ray Powder Pattern: Johachido district, North Korea.
2.632 (100), 1.964 (49), 1.820 (27), 2.434 (25), 2.001 (25), 1.754 (21), 3.506 (18)

Chemistry:

	(1)	(2)
P_2O_5	0.03	
SiO_2	0.34	
B_2O_3	24.21	49.38
Al_2O_3	28.34	24.11
Fe_2O_3	0.09	
MnO	0.23	
CaO	24.77	26.51
Na_2O	8.27	
F	12.21	
H_2O^+	6.52	
H_2O^-	0.07	
$-O = F_2$	5.14	
Total	99.94	100.00

(1) Johachido district, North Korea; apparently of a mixture. (2) $CaAlB_3O_7$, established by crystal-structure analysis and presence of Ca and Al with absence of F by electron microprobe.

Occurrence: In a nepheline dike cutting limestone (Johachido district, North Korea).

Association: Scapolite, diopside, albite, nepheline, apatite, phlogopite (Johachido district, North Korea).

Distribution: From the Johachido district, Kankyo Hodu Prefecture, North Korea. A cut stone considered of natural origin is attributed to the Mogok region, Myanmar.

Name: For the Johachido district, North Korea, which produced the first specimens.

Type Material: Unknown; National Museum of Natural History, Washington, D.C., USA, 105479 was used for species redefinition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 384. (2) Aristarain, L.F. and R.C. Erd (1977) Johachidolite redefined: a calcium aluminum borate. Amer. Mineral., 62, 327–329. (3) Moore, P.B. and T. Araki (1972) Johachidolite, $CaAl[B_3O_7]$, a borate with very dense atomic structure. Nature, 240, 63–65. (4) Harding, R.R., J.G. Francis, C.J.E. Oldershaw, and A.H. Rankin (1999) Johachidolite - a new gem. J. Gemmology, 26(5), 324–329.

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Johannite $Cu(UO_2)_2(SO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. Crystals thick tabular {100} and elongated along on [001], or prismatic, in subparallel to drusy aggregates, to 6 mm; as scales or lathlike fibers, in spheroidal aggregates and efflorescent coatings. *Twinning:* Simple and repeated lamellar twinning with composition plane {010} about twin axis [001].

Physical Properties: *Cleavage:* On {100}, good. Hardness = 2–2.5 D(meas.) = 3.32 D(calc.) = 3.44 Radioactive; decomposed by H_2O, tastes bitter or sour.

Optical Properties: Transparent to translucent. *Color:* Dark emerald-green, dark green, grass-green, apple-green, yellowish green; pale green in transmitted light. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = colorless; Y = pale yellow; Z = greenish yellow or canary-yellow. *Orientation:* X (–101°,85°); Y (37°,8°); Z (169°,85°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. *Dispersion:* $r < v$ or $r > v$, strong. α = 1.572–1.577 β = 1.592–1.597 γ = 1.612–1.616 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.903(2)$ $b = 9.499(2)$ $c = 6.812(2)$ $\alpha = 109.87(1)°$ $\beta = 112.01(1)°$ $\gamma = 100.40(1)°$ Z = 1

X-ray Powder Pattern: Great Bear Lake, Canada.
7.73 (10), 6.16 (9), 3.41 (8), 3.87 (7), 3.13 (7), 3.04 (7), 4.38 (6)

Chemistry:

	(1)	(2)
SO_3	16.59	16.44
UO_2	61.34	58.74
CuO	8.07	8.17
H_2O	13.84	16.65
Total	99.84	100.00

(1) Jáchymov, Czech Republic. (2) $Cu(UO_2)_2(SO_4)_2(OH)_2 \cdot 8H_2O$.

Occurrence: A rare secondary mineral in the oxidized portions of sulfide-bearing uraninite deposits, commonly of post-mine formation.

Association: Gypsum, zippeite, uranopilite, brochantite, chalcanthite.

Distribution: From the Eliáš mine, Jáchymov (Joachimsthal), Czech Republic. At Johanngeorgenstadt, Saxony, and Wölsendorf, Bavaria, Germany. From South Wheal Basset, Illogan, and the Geevor mine, St. Just, Cornwall, England. In France, from the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, and at the Limouzat mine, St.-Priest-la-Prugne, Loire. From the Taboshar uranium deposit, Kara-Mazar Mountains, Tajikistan. In the Mounana uranium mine, Franceville, Gabon. In the USA, from the Kirk, Wood, and other mines, Central City, Gilpin Co., in the Schwartzwalder mine, near Golden, Jefferson Co., and elsewhere in Colorado; in Utah, at the Oyler mine, Henry Mountains district, the Frey No. 4 mine, and the Happy Jack mine, White Canyon district, San Juan Co., and at Marysvale, Ohio district, Piute Co.; from Arizona, in the Hillside mine, about 5.5 km north of Bagdad, Yavapai Co.; on the Ram claims, Pinto Mountains, Riverside Co., California. From Great Bear Lake, Northwest Territory, Canada.

Name: Honors Austrian Archduke Johann Baptist Josef Fabian Sebastian (1782–1859), founder of the Landesmuseum, Graz, Austria.

Type Material: Natural History Museum, Vienna, Austria, A.a.186.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 606–607. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 130–135. (3) Mereiter, K. (1982) Die Kristallstruktur des Johannits, $Cu(UO_2)_2(OH)_2(SO_4)_2 \cdot 8H_2O$. Tschermaks Mineral. Petrog. Mitt., 30, 47–57 (in German with English abs.). (4) Čejka, J., Z. Urbanec, J. Čejka Jr., and Z. Mrázek (1988) Contribution to the thermal analysis and crystal chemistry of johannite $Cu[(UO_2)_2(SO_4)_2(OH)_2] \cdot 8H_2O$. Neues Jahrb. Mineral., Abh., 159, 297–309.

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Johannsenite $CaMn^{2+}Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 10 cm. In columnar, radiating, and spherulitic aggregates of fibers and prisms. *Twinning:* Simple and lamellar twinning common on {100}.

Physical Properties: *Cleavage:* Good on {110}, (110) $\wedge$ $(1\bar{1}0)$ ~87°; partings on {100}, {001}, and {010}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6
D(meas.) = 3.27–3.54 D(calc.) = [3.52]

Optical Properties: Translucent to opaque. *Color:* Clove-brown, gray, colorless, blue, green; colorless in thin section.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = -46°$ to $-55°$. *Dispersion:* $r < v$ or $r > v$, weak to moderate. α = 1.699–1.710 β = 1.710–1.719 γ = 1.725–1.738
2V(meas.) = 58°–72°

Cell Data: *Space Group:* $C2/c$. $a = 9.978(9)$ $b = 9.156(9)$ $c = 5.293(5)$ $\beta = 105°29(2)'$
Z = 4

X-ray Powder Pattern: Borieva deposits, Erzebezirk Maden, Bulgaria. (ICDD 18-299).
3.02 (100), 2.547 (80), 2.600 (60), 2.564 (50), 2.243 (50), 1.633 (50), 6.58 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	47.62	48.81	CaO	22.18	21.87
TiO_2		0.01	Na_2O		0.07
Al_2O_3	0.91	0.74	K_2O		0.02
Fe_2O_3	0.04	0.79	H_2O^+	0.40	0.32
FeO	0.70	1.54	H_2O^-	0.09	0.35
MnO	27.47	22.58	CO_2	0.24	
MgO	0.53	2.29	P_2O_5		0.01
			Total	100.18	99.40

(1) Tetela de Ocampo, Mexico; corresponds to $(Ca_{0.97}Mg_{0.03})_{\Sigma=1.00}(Mn^{2+}_{0.96}Fe^{2+}_{0.02}Al_{0.02})_{\Sigma=1.00}(Si_{1.97}Al_{0.03})_{\Sigma=2.00}O_6$. (2) Aravaipa district, Arizona, USA; corresponds to $(Ca_{0.96}Na_{0.01})_{\Sigma=0.97}(Mn^{2+}_{0.78}Mg_{0.14}Fe^{2+}_{0.05}Al_{0.03}Fe^{3+}_{0.02})_{\Sigma=1.02}(Si_{1.99}Al_{0.01})_{\Sigma=2.00}O_6$.

Polymorphism & Series: Forms two series, with diopside, and with hedenbergite.

Mineral Group: Pyroxene group.

Occurrence: In metasomatized limestones and manganiferous skarns; in quartz or calcite veins cutting rhyolite.

Association: Rhodonite, manganese oxides.

Distribution: From Tetela de Ocampo, Puebla, and Pachuca, Hidalgo, Mexico. In the USA, at Franklin, Sussex Co., New Jersey; from the Bohemia district, Lane Co., Oregon; at the Aravaipa district, Graham Co., Arizona; and in the Empire Zinc Co. mine, Hanover, Grant Co., New Mexico. From Schio, Vicenza, and Campiglia, Tuscany, Italy. In the Akatani mine, Niigata Prefecture; the Nakatatsu mine, Fukui Prefecture; the Onagusa mine, Katsuyam, Okayama Prefecture; and elsewhere in Japan. A number of other localities are known.

Name: To honor Professor Albert Johannsen (1871–1962), petrologist, University of Chicago, Chicago, Illinois, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R3118, 97484.

References: (1) Schaller, W.T. (1938) Johannsenite, a new manganese pyroxene. Amer. Mineral., 23, 575–582. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 415–422. (3) Freed, R.L. and D.R. Peacor (1967) Refinement of the crystal structure of johannsenite. Amer. Mineral., 52, 709–720.

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Johillerite $NaCu(Mg,Zn)_3(AsO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tabular on {010} and elongated along [001], to 2 mm; typically in radiating aggregates.

Physical Properties: *Cleavage:* Perfect on {010}; good on {100} and {001}. Hardness = ∼3 D(meas.) = 4.15 D(calc.) = 4.17 (Mg:Zn = 2.65:0.35)

Optical Properties: Transparent. *Color:* Blue-violet. *Streak:* White to very pale violet. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = red-violet; Y = blue-violet; Z = blue-green. *Orientation:* $Y = b$; $X \wedge c \simeq 16°$. $\alpha = 1.715(4)$ $\beta = 1.743(4)$ $\gamma = 1.783(4)$ 2V(meas.) = 80(5)°

Cell Data: *Space Group:* $C2/c$. $a = 11.870(3)$ $b = 12.755(3)$ $c = 6.770(2)$ $\beta = 113.42(3)°$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
2.75 (10), 3.25 (8), 4.06 (5), 2.64 (5), 1.660 (5), 3.50 (4), 1.952 (4)

Chemistry:

	(1)
As_2O_5	55.8
CuO	15.8
ZnO	5.4
MgO	18.3
Na_2O	5.4
Total	100.7

(1) Tsumeb, Namibia; by electron microprobe, corresponds to $Na_{1.03}Cu_{1.18}(Mg_{2.70}Zn_{0.39})_{\Sigma=3.09}(As_{0.72}O_4)_3$.

Occurrence: A very rare secondary mineral in oxidized copper ore.

Association: Cuprian adamite, conichalcite, chalcocite, tennantite.

Distribution: Found at Tsumeb, Namibia.

Name: Honors Professor Johannes-Erich Hiller (1911–1972), mineralogist, University of Stuttgart, Stuttgart, Germany.

Type Material: University of Stuttgart, Stuttgart, Germany, NM11; National Museum of Natural History, Washington, D.C., USA, 146969.

References: (1) Keller, P., H. Hess, and P.J. Dunn (1982) Johillerit, $Na(Mg,Zn)_3Cu(AsO_4)_3$, ein neues Mineral aus Tsumeb, Namibia. Tschermaks Mineral. Petrog. Mitt., 29, 169–175 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 1075 (abs. ref. 1). (3) Keller, P. and H. Hess (1988) Die Kristallstrukturen von O'Danielit, $Na(Zn,Mg)_3H_2(AsO_4)_3$, und Johillerit, $Na(Mg,Zn)_3Cu(AsO_4)_3$. Neues Jahrb. Mineral., Monatsh., 395–404 (in German with English abs.).

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Johnbaumite $Ca_5(AsO_4)_3(OH, F)$

Crystal Data: Hexagonal. *Point Group:* 6/*m.* Anhedral, granular, to 8 mm, or massive.

Physical Properties: *Cleavage:* Distinct on {1010}. *Tenacity:* Brittle. Hardness = ~ 4.5 D(meas.) = 3.68(3) D(calc.) = 3.73 Fluoresces medium pinkish orange under SW UV; exhibits pale pink cathodoluminescence.

Optical Properties: Translucent. *Color:* Grayish white; colorless in thin section. *Streak:* White. *Luster:* Adamantine to greasy on fracture surfaces, vitreous on cleavage surfaces. *Optical Class:* Uniaxial (–). ω = 1.687–1.716 ε = 1.684–1.698

Cell Data: *Space Group:* [*P*63/*m*] (by analogy to the apatite group). a = 9.70–9.80 c = 6.93–6.97 Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.895 (100), 2.820 (70), 2.798 (70), 3.98 (50), 3.47 (50), 2.683 (45), 1.879 (45)

Chemistry:

	(1)	(2)
P_2O_5	1.7	
As_2O_5	52.2	54.28
FeO	0.2	
MgO	0.1	
CaO	43.5	44.14
F	0.2	1.50
Cl	0.1	
H_2O	1.3	0.71
$-O = (F, Cl)_2$	0.1	0.63
Total	99.2	100.00

(1) Franklin, New Jersey, USA; by electron microprobe, H_2O by DTA–TGA; corresponding to $(Ca_{4.86}Fe_{0.02}Mg_{0.02})_{\sum=4.90}[(As_{0.95}P_{0.05})_{\sum=1.00}O_{3.99}]_3[(OH)_{0.90}F_{0.06}Cl_{0.02}]_{\sum=0.98}$.
(2) $Ca_5(AsO_4)_3(OH, F)$ with OH:F = 1:1.

Mineral Group: Apatite group.

Occurrence: A very rare mineral, part of a metamorphic skarn assemblage in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Yeatmanite, diopside, andradite, franklinite, copper, roméite (Franklin, New Jersey, USA); tilasite (Långban, Sweden).

Distribution: From Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. In Russia, at undisclosed deposits in the Ural Mountains and Siberia [Novofrolovskoye copper deposit, Turinsk district, near Krasnoturinsk, Northern Ural Mountains; Yuliya Svintsovaya Pb–Zn deposit, 20 km east-northeast of Son railway station, western Siberia]. At Långban, Värmland, Sweden.

Name: Honors John L. Baum (1916–), Hamburg, New Jersey, USA, Curator of the Franklin Mineral Museum, and collector of the first specimen containing the mineral.

Type Material: Royal Ontario Museum, Toronto, Canada; The Natural History Museum, London, England; Harvard University, Cambridge, Massachusetts, 116461; National Museum of Natural History, Washington, D.C., USA, 144444.

References: (1) Dunn, P.J., D.R. Peacor, and N. Newberry (1980) Johnbaumite, a new member of the apatite group from Franklin, New Jersey. Amer. Mineral., 65, 1143–1145. (2) Malinko, S.V., G.S. Rumyantsev, and G.A. Sidorenko (1966) Svabite [= johnbaumite] from contact-metamorphic deposits of Siberia and the Urals. Doklady Acad. Nauk SSSR, 166, 1195–1198 (in Russian).

Johninnesite $\mathbf{Na_2Mn_9^{2+}(Mg,Mn^{2+})_7(AsO_4)_2(Si_6O_{17})_2(OH)_8}$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. As fibrous aggregates, may be plumose, to 4.5 cm; individuals are elongated along [001]. *Twinning:* An indeterminate twinninglike intergrowth was observed.

Physical Properties: *Cleavage:* Good on {100}, poor on {010}. *Tenacity:* Friable in aggregate. Hardness = n.d. D(meas.) = 3.48(4) D(calc.) = 3.51

Optical Properties: Transparent. *Color:* Light yellowish brown; colorless in transmitted light. *Streak:* Light brownish yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, distinct. $\alpha = 1.6742(4)$ $\beta = 1.6968(3)$ $\gamma = 1.6999(3)$ 2V(meas.) = 41.9(2)° 2V(calc.) = 40.9°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 10.44(2)$ $b = 11.064(6)$ $c = 9.62(1)$ $\alpha = 107.43(7)°$ $\beta = 82.7(1)°$ $\gamma = 111.6(1)°$ Z = 1

X-ray Powder Pattern: Kombat mine, Namibia.
2.676 (100), 9.8 (60), 3.23 (60), 5.99 (40), 3.38 (40), 2.479 (40), 1.539 (40b)

Chemistry:

	(1)	(2)
SiO_2	35.5	34.68
As_2O_5	10.6	11.05
FeO	0.1	
MnO	40.7	40.94
MgO	8.2	7.75
Na_2O	3.1	2.98
H_2O	2.6	2.60
Total	100.8	100.00

(1) Kombat mine, Namibia; by electron microprobe, total As as As_2O_5, total Mn as MnO, H_2O by the Penfield method. (2) $Na_2Mg_4Mn_{12}As_2Si_{12}O_{43}(OH)_6$.

Occurrence: In low-temperature hydrothermal veins cutting metamorphosed Fe-Mn ores.

Association: Kentrolite, rhodonite, richterite, barite, calcite.

Distribution: From the Kombat mine, 49 km south of Tsumeb, Namibia.

Name: Honors John Innes, mineralogist of the Tsumeb Corporation, for his contributions to the mineralogy of the Tsumeb and Kombat mines.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163207.

References: (1) Dunn, P.J., D.R. Peacor, S.-C. Su, J.A. Nelen, and O. von Knorring (1986) Johninnesite, a new sodium manganese arsenosilicate from the Kombat Mine, Namibia. Mineral. Mag., 50, 667–670. (2) (1988) Amer. Mineral., 73, 928 (abs. ref. 1).

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Johnsomervilleite $\mathbf{Na_2Ca(Fe^{2+},Mg,Mn^{2+})_7(PO_4)_6}$

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Crystal Data: Hexagonal; may be metamict. *Point Group:* $\overline{3}$ (probable). As grains or blebs, to 2 cm; in dendritic or coralloidal groups.

Physical Properties: *Cleavage:* Perfect, on {0001}, probable. *Fracture:* Subconchoidal to splintery. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.35 D(calc.) = 3.41

Optical Properties: Translucent. *Color:* Very dark brown to blackish gray, pitch-black; brown in transmitted light. *Streak:* Pale brown; gray-brown with an olive tint. *Luster:* Vitreous. *Optical Class:* Biaxial (+), anomalous; isotropic if metamict. $n = 1.646(1)$ (metamict). $\alpha = 1.655$ $\beta = \sim 1.655$ $\gamma =$ n.d. 2V(meas.) = 10°

Cell Data: *Space Group:* $[R\overline{3}]$ (by analogy to fillowite). $a = 15.00$ $c = 42.75$ Z = 18

X-ray Powder Pattern: Loch Quoich, Scotland.
2.764 (100), 3.70 (70), 3.55 (70), 2.965 (70), 11.20 (50), 2.501 (40), 1.852 (20)

Chemistry:

	(1)
P_2O_5	44.7
FeO	26.2
MnO	5.2
MgO	12.9
CaO	6.2
Na_2O	4.7
Total	99.9

(1) Loch Quoich, Scotland; by electron microprobe, average of eight analyses, total Fe as FeO, total Mn as MnO; corresponding to $Na_{1.43}Ca_{1.05}(Fe_{3.47}Mg_{3.05}Mn_{0.70})_{\Sigma=7.22}(PO_4)_6$.

Occurrence: As one of several primary accessory minerals forming clusters in podiform metamorphic segregations in kyanite-sillimanite-grade gneiss (Loch Quoich, Scotland); a primary mineral in a complex granite pegmatite in staurolite-grade mica schist (Sapucaia mine, Brazil); in type IIIAB iron meteorites.

Association: Graftonite, apatite, jahnsite, phosphosiderite, vivianite, rockbridgeite, mitridatite, almandine-spessartine, muscovite, plagioclase, quartz (Loch Quoich, Scotland); triphylite, frondelite, huréaulite, bermanite, jahnsite, rockbridgeite, phosphosiderite, vivianite, autunite, zircon, tourmaline, microcline, albite, quartz (Sapucaia mine, Brazil).

Distribution: From near the entrance to Glen Cosaidh, Loch Quoich, Inverness-shire, Scotland. In the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. At the Kiluli pegmatite, Rwanda.

Name: Honors John M. Somerville (1908–1978), who collected the first specimens.

Type Material: Royal Scottish Museum, Edinburgh, Scotland; The Natural History Museum, London, England, 1981,70.

References: (1) Livingstone, A. (1980) Johnsomervilleite, a new transition-metal phosphate mineral from the Loch Quoich area, Scotland. Mineral. Mag., 43, 833–836. (2) (1981) Amer. Mineral., 66, 437 (abs. ref. 1). (3) Cassedanne, J.P. and J.O. Cassedanne (1985) Découverte d'un phosphate métamicte dans la pegmatite du Sapucaia (Minas Gerais). Anais da Academia brasileira de Ciências, 57(3), 325–337 (in French with English abs.).

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Johntomaite $\mathbf{BaFe_2^{2+}Fe_2^{3+}(PO_4)_3(OH)_3}$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As prismatic crystals, to 6 mm, elongated along [010] and flattened on {001}; forms include {001}, {100}, {111}, {110}; in radial aggregates.

Physical Properties: *Cleavage:* Good on {001} and {100}; poor on {010}. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 3.40(3) D(calc.) = 3.44

Optical Properties: Opaque, transparent on thin edges. *Color:* Very dark reddish brown. *Streak:* Medium greenish yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Very strong; X = blue-green; Y = yellow to pale brown; Z = brown. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Absorption:* $X \gg Z \gg Y$. $\alpha = 1.748(5)$ $\beta = 1.763(5)$ $\gamma = 1.84(1)$ 2V(meas.) = 53(2)°

Cell Data: *Space Group:* $[Pb2_1m]$ (by analogy to olmsteadite). $a = 7.516(4)$ $b = 10.023(8)$ $c = 6.502(4)$ Z = 1

X-ray Powder Pattern: Champion mine, South Dakota, USA.
6.01 (100), 3.005 (80), 3.054 (70), 2.862 (70), 6.51 (40), 2.563 (40), 7.54 (30)

Chemistry:

	(1)
P_2O_5	27.3
Nb_2O_5	21.5
Ta_2O_5	5.1
Fe_2O_3	12.5
FeO	3.3
MnO	14.8
MgO	0.5
K_2O	8.6
H_2O	6.5
Total	100.1

(1) Champion mine, South Dakota, USA; by electron microprobe, oxidation state of Fe determined by titration, total Mn as MnO, H_2O by thermoanalyzer-mass spectrometer; corresponding to $K_{0.92}(Mn_{1.04}Fe^{3+}_{0.71}Fe^{2+}_{0.23}Mg_{0.06})_{\Sigma=2.04}(Nb_{0.81}Ta_{0.12}Fe^{3+}_{0.08})_{\Sigma=1.01}O_2(PO_4)_{1.93}[(H_2O)_{1.42}(OH)_{0.78}]_{\Sigma=2.20}$.

Occurrence: A rare secondary mineral derived from the dissolution of triphylite-lithiophilite and columbite-tantalite in a complex granite pegmatite.

Association: Fluorapatite, childrenite–eosphorite, rockbridgeite–frondelite, huréaulite, fairfieldite, ludlamite, jahnsite–whiteite, goethite, manganese oxides, quartz.

Distribution: In the Expectation pegmatite at the Champion mine, about 2.5 km southeast of Keystone, Pennington Co., South Dakota, USA.

Name: Honoring Richard JOHNson (1936–1998) and Frank WALKup (1943–1993), mineral preparators, National Museum of Natural History, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162676.

References: (1) Dunn, P.J., D.R. Peacor, D.B. Sturman, R.A. Ramik, W.L. Roberts, and J.A. Nelen (1986) Johnwalkite, the Mn-analogue of olmsteadite, from South Dakota. Neues Jahrb. Mineral., Monatsh., 115–120. (2) (1987) Amer. Mineral., 72, 223 (abs. ref. 1).

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Johnwalkite $K(Mn^{2+}, Fe^{3+}, Fe^{2+})_2(Nb, Ta)O_2(PO_4)_2(H_2O, OH)_2$

Crystal Data: Orthorhombic. *Point Group:* $mm2$. As prismatic crystals, to 6 mm, elongated along [010] and flattened on {001}; forms include {001}, {100}, {111}, {110}; in radial aggregates.

Physical Properties: *Cleavage:* Good on {001} and {100}; poor on {010}. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 3.40(3) D(calc.) = 3.44

Optical Properties: Opaque, transparent on thin edges. *Color:* Very dark reddish brown. *Streak:* Medium greenish yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Very strong; X = blue-green; Y = yellow to pale brown; Z = brown. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Absorption:* $X \gg Z \gg Y$. $\alpha = 1.748(5)$ $\beta = 1.763(5)$ $\gamma = 1.84(1)$ 2V(meas.) = 53(2)°

Cell Data: *Space Group:* $[Pb2_1m]$ (by analogy to olmsteadite). $a = 7.516(4)$ $b = 10.023(8)$ $c = 6.502(4)$ $Z = 1$

X-ray Powder Pattern: Champion mine, South Dakota, USA.
6.01 (100), 3.005 (80), 3.054 (70), 2.862 (70), 6.51 (40), 2.563 (40), 7.54 (30)

Chemistry:

	(1)
P_2O_5	27.3
Nb_2O_5	21.5
Ta_2O_5	5.1
Fe_2O_3	12.5
FeO	3.3
MnO	14.8
MgO	0.5
K_2O	8.6
H_2O	6.5
Total	100.1

(1) Champion mine, South Dakota, USA; by electron microprobe, oxidation state of Fe determined by titration, total Mn as MnO, H_2O by thermoanalyzer-mass spectrometer; corresponding to $K_{0.92}(Mn_{1.04}Fe^{3+}_{0.71}Fe^{2+}_{0.23}Mg_{0.06})_{\Sigma=2.04}(Nb_{0.81}Ta_{0.12}Fe^{3+}_{0.08})_{\Sigma=1.01}O_2(PO_4)_{1.93}[(H_2O)_{1.42}(OH)_{0.78}]_{\Sigma=2.20}$.

Occurrence: A rare secondary mineral derived from the dissolution of triphylite-lithiophilite and columbite-tantalite in a complex granite pegmatite.

Association: Fluorapatite, childrenite–eosphorite, rockbridgeite–frondelite, huréaulite, fairfieldite, ludlamite, jahnsite–whiteite, goethite, manganese oxides, quartz.

Distribution: In the Expectation pegmatite at the Champion mine, about 2.5 km southeast of Keystone, Pennington Co., South Dakota, USA.

Name: Honoring Richard JOHNson (1936–1998) and Frank WALKup (1943–1993), mineral preparators, National Museum of Natural History, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162676.

References: (1) Dunn, P.J., D.R. Peacor, D.B. Sturman, R.A. Ramik, W.L. Roberts, and J.A. Nelen (1986) Johnwalkite, the Mn-analogue of olmsteadite, from South Dakota. Neues Jahrb. Mineral., Monatsh., 115–120. (2) (1987) Amer. Mineral., 72, 223 (abs. ref. 1).

Jokokuite $Mn^{2+}SO_4 \cdot 5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Massive stalactitic, to 5 cm long.

Physical Properties: Hardness = ∼2.5 D(meas.) = 2.03 D(calc.) = 2.094 Readily soluble in H_2O; dehydrates to ilesite in dry air.

Optical Properties: Transparent to translucent. *Color:* Pale pink; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* Very weak. $\alpha = 1.498(3)$ $\beta = 1.510(3)$ $\gamma = 1.517(3)$ 2V(meas.) = 70°–80°

Cell Data: *Space Group:* $[P\overline{1}]$ (by analogy to chalcanthite). $a = 6.37$ $b = 10.77$ $c = 6.13$ $\alpha = 98°46'$ $\beta = 109°58'$ $\gamma = 77°50'$ Z = 2

X-ray Powder Pattern: Jokoku mine, Japan.
5.84 (100), 2.727 (72), 4.98 (61), 5.66 (56), 1.622 (31), 2.290 (27), 3.28 (25)

Chemistry:

	(1)	(2)
SO_3	33.06	33.21
FeO	1.13	
MnO	27.34	29.42
ZnO	0.94	
MgO	0.00	
CaO	0.00	
H_2O	37.68	37.37
Total	100.15	100.00

(1) Jokoku mine, Japan; corresponds to $(Mn_{0.94}Fe_{0.04}Zn_{0.03})_{\Sigma=1.01}(S_{1.00}O_4) \cdot 5.07H_2O$.
(2) $MnSO_4 \cdot 5H_2O$.

Mineral Group: Chalcanthite group.

Occurrence: As efflorescences in oxidized portions of mine workings, apparently deposited from mine waters at 25 °C.

Association: Gypsum, szmikite, ilesite, rozenite, siderotil, ferrohexahydrite, mallardite, melanterite, goslarite (Jokoku mine, Japan).

Distribution: In the Jokoku and Inakuraishi mines, Hokkaido, Japan. At Chvaletice, Czech Republic.

Name: For the Jokoku mine, Japan, where the first specimens were collected.

Type Material: Tohoku University, Sendai; National Science Museum, Tokyo, Japan, M-21492; National Museum of Natural History, Washington, D.C., USA, 136582.

References: (1) Nambu, M., K. Tanida, and T. Kitamura (1978) Jôkokuite, $MnSO_4 \cdot 5H_2O$, a new mineral from the Jôkoku mine, Hokkaido, Japan. Mineral. J. (Japan), 9, 28–38. (2) (1979) Amer. Mineral., 64, 655 (abs. ref. 1).

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Joliotite $(UO_2)(CO_3)\cdot nH_2O$ ($x \leq 2$)

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, 222, or $mm2$. As crystals, scaly and flattened on {100}, exhibiting {100}, {010}, and {011}; typically in radial spherulitic aggregates, to 0.1 mm.

Physical Properties: *Cleavage:* {100}, probable. Hardness = 1–2 D(meas.) = 4.04 D(calc.) = 4.55 Radioactive; fluoresces pale green to pale yellow under SW and LW UV.

Optical Properties: Translucent. *Color:* Citron-yellow. *Streak:* Yellow. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; Z = yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.596$–1.604 $\beta = 1.636$ $\gamma = 1.637$–1.651 2V(meas.) = Small.

Cell Data: *Space Group:* $Pmmm$, $P222$, or $Pmm2$. $a = 8.16$ $b = 10.35$ $c = 6.32$ Z = 4

X-ray Powder Pattern: Menzenschwand, Germany.
8.09 (10), 3.42 (9b), 3.18 (8b), 4.10 (5), 1.882 (4), 2.11 (3), 4.48 (2)

Chemistry:

	(1)	(2)
CO_2	12.5	12.02
UO_3	73.7	78.14
(Pb + Ba)O	1.2	
H_2O		9.84
Total		100.00

(1) Menzenschwand, Germany; by electron microprobe, average of two partial analyses.
(2) $(UO_2)(CO_3)\cdot 2H_2O$.

Occurrence: A rare secondary mineral in the oxidized portions of a uranium deposit.

Association: Billietite, rutherfordine, studtite, barite, "limonite".

Distribution: From Menzenschwand, Black Forest, Germany.

Name: Honors the French physicist Jean Frédéric Joliot (1900–1958), Institute du Radium, University of Paris, Paris, France, an early worker on radioactivity.

Type Material: n.d.

References: (1) Walenta, K. (1976) Widenmannit und Joliotit, zwei neue Uranylkarbonatmineralien aus dem Schwarzwald. Schweiz. Mineral. Petrog. Mitt., 56, 167–185 (in German with English abs.). (2) (1977) Mineral. Abs., 28, 208 (abs. ref. 1).

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Jolliffeite NiAsSe

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Grains, to 240 μm.

Physical Properties: Hardness = > 3 (harder than clausthalite). D(meas.) = n.d. D(calc.) = 7.10

Optical Properties: Opaque. *Color:* White in reflected light.
R_1–R_2: (400) 50.1–50.4, (420) 50.3–50.6, (440) 50.5–50.7, (460) 50.7–50.8, (480) 50.8–50.9, (500) 50.9–51.0, (520) 51.0–51.1, (540) 51.1–51.1, (560) 51.1–51.2, (580) 51.2–51.3, (600) 51.3–51.3, (620) 51.1–51.4, (640) 51.4–51.3, (660) 51.4–51.3, (680) 51.3–51.3, (700) 51.2–51.1

Cell Data: *Space Group: Pa*3. $a = 5.831(1)$ Z = 4

X-ray Powder Pattern: Shirley Peninsula, Canada.
2.602 (100), 2.378 (80), 1.757 (80), 2.916 (50), 1.559 (50), 1.617 (40), 2.062 (30)

Chemistry:

	(1)
Ni	22.6
Co	6.0
As	36.9
Se	34.9
S	0.51
Total	100.9

(1) Shirley Peninsula, Canada; by electron microprobe, corresponds to $(Ni_{0.81}Co_{0.21})_{\Sigma=1.02}As_{1.03}(Se_{0.92}S_{0.03})_{\Sigma=0.95}$.

Mineral Group: Cobaltite group.

Occurrence: From a drill core in a fracture zone near a dolomite–peridotite contact.

Association: Clausthalite, Pb–Bi–Ag selenides, gold, "pitchblende".

Distribution: From the Fish Hook Bay area, Shirley Peninsula, north shore of Lake Athabaska, 18 km south of Uranium City, Saskatchewan, Canada [TL].

Name: To honor Professor Alfred Watson Jolliffe (1907–1988), Canadian geologist, Queen's University, Kingston, Ontario, Canada, for his contributions to mineral exploration of northern Saskatchewan, Canada.

Type Material: Canadian Geological Survey, Ottawa, Canada, 65747.

References: (1) Cabri, L.J., J.H.G. Laflamme, A.C. Roberts. A.J. Criddle, and L.J. Hulbert (1991) Jolliffeite and unnamed CoAsSe: two new arsenoselenides from the north shore of Lake Athabasca, Saskatchewan. Can. Mineral., 29, 411–418. (2) (1992) Amer. Mineral., 77, 447 (abs. ref. 1).

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Jonesite $\mathbf{Ba_4(K,Na)_2Ti_4Al_2Si_{10}O_{36}\cdot 6H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals are slender blades, with prismatic {210}, {310}, and terminated by the dome {101}. Commonly as rosettes of many such crystals, to 3 mm.

Physical Properties: *Cleavage:* Distinct on {010}. *Fracture:* Irregular. Hardness = 3–4 D(meas.) = 3.25(1) D(calc.) = 3.239 Fluoresces dull orange under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.641(1)$ $\beta = 1.660(1)$ $\gamma = 1.682(1)$ 2V(meas.) = 76°–78°

Cell Data: *Space Group:* $B22_12$. $a = 13.730(5)$ $b = 25.904(5)$ $c = 10.608(3)$ Z = 4

X-ray Powder Pattern: Gem mine, California, USA.
12.95 (100), 3.031 (45), 2.652 (30), 2.228 (20), 3.008 (18), 2.073 (18), 2.596 (17)

Chemistry:

	(1)		(1)
SiO_2	32.54	MgO	0.111
TiO_2	17.31	CaO	0.045
B_2O_3	0.008	SrO	0.051
Al_2O_3	5.52	BaO	34.88
Fe_2O_3	0.16	Na_2O	0.67
Nb_2O_5	0.022	K_2O	2.70
MnO	0.035	H_2O	5.9
		Total	99.952

(1) Gem mine, California, USA; weighted average of 20 electron microprobe and ion probe analyses; corresponds to $(Ba_{4.19}Mg_{0.05}Fe_{0.04}Mn_{0.01}Ca_{0.01}Sr_{0.01})_{\Sigma=4.31}(K_{1.06}Na_{0.40})_{\Sigma=1.46}$ $Ti_{3.99}Al_{1.99}Si_{9.97}O_{36}\cdot 6H_2O$.

Occurrence: In fractures and cavities of brecciated greenstone enclosed in blueschist.

Association: Neptunite, benitoite, joaquinite, natrolite.

Distribution: In the USA, at the Gem mine, San Benito Co., California.

Name: For Francis Tucker Jones (1905–1993), Research Chemical Microscopist of Berkeley, California, USA, who discovered the mineral.

Type Material: University of California, Santa Barbara, California, 7325; American Museum of Natural History, New York, New York, USA.

References: (1) Wise, W.S., A. Pabst, and J.R. Hinthorne (1977) Jonesite, a new mineral from the Benitoite Gem mine, San Benito County, California. Mineral. Record, 8, 453–456.

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Jordanite $Pb_{14}(As,Sb)_6S_{23}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular with pseudohexagonal aspect, to 4 cm. Rarely reniform. *Twinning:* On {001} common, may be lamellar on $\{\bar{2}01\}$, rare on $\{\bar{1}01\}$ and {101}.

Physical Properties: *Cleavage:* Perfect on {010}; parting on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = 106–141 (50 g load). D(meas.) = 6.44 D(calc.) = 6.38

Optical Properties: Opaque. *Color:* Lead-gray, commonly tarnished, iridescent. *Streak:* Black. *Luster:* Metallic.
R_1–R_2: (400) 41.8–44.6, (420) 41.0–43.7, (440) 40.2–42.8, (460) 39.7–42.2, (480) 39.3–41.8, (500) 38.9–41.4, (520) 38.5–41.0, (540) 38.1–40.7, (560) 37.8–40.3, (580) 37.5–40.0, (600) 37.3–39.6, (620) 37.1–39.2, (640) 36.7–38.6, (660) 36.3–38.0, (680) 35.8–37.6, (700) 35.3–37.1

Cell Data: *Space Group:* $P2_1/m$. $a = 8.918(1)$ $b = 31.899(4)$ $c = 8.462(1)$ $\beta = 117.79(1)°$ Z = 2

X-ray Powder Pattern: Binntal, Switzerland.
3.51 (10), 3.16 (9), 3.04 (8), 2.87 (8), 3.68 (7), 3.35 (7), 2.96 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb	69.22	72.2	70.96	Sb		2.3	
Tl		1.0		S	18.36	16.4	18.04
As	12.42	7.6	11.00	Total	[100.00]	99.5	100.00

(1) Binntal, Switzerland; recalculated to 100.00% from an original total of 99.12%. (2) Do.; by electron microprobe. (3) $Pb_{14}As_6S_{23}$.

Polymorphism & Series: Forms a series with geocronite.

Occurrence: In metamorphosed Pb–As occurrences in dolostone (Binntal, Switzerland); in low-temperature epithermal veins (Aomori Prefecture, Japan); in epithermal gold-quartz veins (Săcărîmb, Romania); from "black smoker" undersea chimneys.

Association: Tennantite, seligmannite, dufrenoysite, boulangerite, semseyite, quadratite, guettardite, zinkenite, tsugaruite, kirkiite, enargite, sphalerite, galena.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL]. At Beuthen, Upper Silesia, Poland. In Germany, from Wiesloch, near Heidelberg, Black Forest. At Săcărîmb (Nagyág), Romania. From Horní Benešov, Czech Republic. In the Pitone and Ceragiola marble quarries, near Seravezza, Tuscany, Italy. At the Aghios Philippos Pb–Zn deposit, near Kirki, Greece. From Sulitjelma, and at the Bleikvassli Pb–Zn–Cu deposit, Nordland, Norway. At the Langdal deposit, Boliden district, Västerbotten, Sweden. In the Penberthy Croft mine, St. Hilary, Cornwall, England. In Japan, from the Yunosawa and Okoppe mines, Aomori Prefecture. In the USA, at the Zuni mine and Brobdingnag prospect, near Silverton, San Juan Co., Colorado; in the Keystone mine, Birmingham, Blair Co., Pennsylvania; and in the Balmat-Edwards mine, Balmat, St. Lawrence Co., New York. Along the East Pacific Rise (21°N) and on Axial Seamount, Juan de Fuca Ridge, northeast Pacific Ocean.

Name: Honors Dr. H. Jordan (1808–1887), of Saarbrücken, Germany, who provided the original specimens for study.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 398–401. (2) Fisher, D.J. (1940) Discussion of the formula of jordanite. Amer. Mineral., 25, 297–298. (3) Jambor, J.L. (1968) New lead sulfantimonides from Madoc, Ontario. Part 3–syntheses, paragenesis, origin. Can. Mineral., 9, 505–521. (4) Ito, T. and W. Nowacki (1974) The crystal structure of jordanite, $Pb_{28}As_{12}S_{46}$. Zeits. Krist., 139, 161–185. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 131–132. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 271.

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Jordisite MoS_2

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Crystal Data: Amorphous to X-rays; nearly so to electrons. *Point Group:* n.d. Massive, as associations of colloidal-sized particles and disseminations.

Physical Properties: *Tenacity:* Sectile. Hardness = Soft. VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Gray-black to lead-gray. *Luster:* Submetallic, dull. R: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Himmelsfürst mine, Germany; by selected area electron diffraction. ∼6 (diffuse)

Chemistry: Established as MoS_2 on very impure materials.

Polymorphism & Series: Trimorphous with molybdenite and molybdenite-3R.

Occurrence: As veinlets and coatings of probable medium- to low-temperature hydrothermal origin.

Association: Ilsemannite, molybdenite, uraninite, coffinite, kerogen, cinnabar, pyrite, fluorite, apatite, stilbite, calcite, quartz.

Distribution: In Germany, from the Himmelsfürst mine, Erbisdorf, near Freiberg, Saxony [TL]. In Austria, at Bleiberg, Carinthia. From Hromnice, Czech Republic. In the USA, in the Sun Valley mine, east of Jacob Lake, Coconino Co., Arizona; in Oregon, at the Kiggins mercury mine on the Oak fork of the Clackamas River, about 80 km southeast of Portland, Clackamas Co.; at Ambrosia Lake, McKinley Co., New Mexico; in the Schwalder mine, Ralston Creek district, Jefferson Co., and near Lake Como, Hinsdale Co., Colorado; from near Marysvale, Piute Co., Utah; in the Goldstrike mine, Lynn district, Eureka Co., Nevada; from the Lucky Mc mine, Gas Hills, Fremont Co., Wyoming. In Chile, from Carrizal Alto, Atacama. At the Agostinho deposit, Poços de Caldas Plateau, Minas Gerais, Brazil.

Name: In honor of Eduard Friedrich Alexander Jordis (1868–1917), colloidal chemist.

Type Material: Mining Academy, Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 331. (2) Staples, L.W. (1951) Ilsemannite and jordisite. Amer. Mineral., 36, 609–614. (3) Clark, A.H. (1971) Molybdenite-2H, molybdenite-3R and jordisite from Carrizal Alto, Atacama, Chile. Amer. Mineral., 56, 1832–1835. (4) Diemann, E. (1976) Zur Struktur des natürlichen amorphen Molybdänsulfids (Jordisit) Naturwiss., 63, 386–386 (in German). (5) Kao, L.-S., D.R. Peacor, R.M. Coveney, Jr., G. Zhao, K.E. Dungey, M.D. Curtis, and J.E. Penner-Hahn (2001) A C/MoS_2 mixed-layer phase (MoSC) occurring in metalliferous black shales from southern China, and new data on jordisite. Amer. Mineral., 86, 852–861.

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Jørgensenite $\mathbf{Na(Sr,Ba)_7(Na,Mg)Al_6F_{32}(OH,F)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [010], to 1 cm; commonly in flat fan-shaped or columnar aggregates, intimately intergrown with jarlite or stenonite; massive.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4
D(meas.) = 3.89(1) D(calc.) = 3.94

Optical Properties: Semitransparent. *Color:* Colorless to white; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$. $\alpha = 1.436(1)$ $\beta = 1.442(1)$ $\gamma = 1.442(1)$
2V(meas.) = 0°–5(5)° ($2V_z$) 2V(calc.) = 0°

Cell Data: *Space Group:* $C2/m$. $a = 16.046(1)$ $b = 10.971(1)$ $c = 7.281(1)$
$\beta = 101.734(6)°$ Z = 2

X-ray Powder Pattern: Ivigtut, Greenland.
3.453 (10), 3.193 (10), 3.643 (9), 3.112 (9), 2.989 (9), 2.173 (9), 7.844 (8)

Chemistry:

	(1)
Na	3.25
K	0.30
Mg	0.38
Ca	0.28
Ba	8.63
Sr	32.76
Al	10.97
F	42.50
H_2O	[1.22]
Total	100.29

(1) Ivigtut, Greenland; by electron microprobe, average of 11 analyses, H_2O calculated from stoichiometry, $(OH)^{1-}$ confirmed by microbeam IR spectroscopy; corresponds to $Na_{1.00}(Sr_{5.52}Ba_{0.92}Na_{0.32}K_{0.12}Ca_{0.10})_{\Sigma=6.98}(Na_{0.77}Mg_{0.23})_{\Sigma=1.00}Al_6F_{33.00}(OH)_{1.00}$.

Occurrence: In vugs and as fissure fillings in a cryolite deposit with other fluorides.

Association: Jarlite, stenonite, thomsenolite, gearksutite, topaz, muscovite.

Distribution: From the Ivigtut cryolite deposit, Greenland.

Name: For Vilhelm Jørgensen (1844–1925), cofounder, in 1870, of the cryolite factory at Ivigtut, Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1996.168.

References: (1) Pauly, H., F.C. Hawthorne, P.C. Burns, and G.D. Ventura (1997) Jørgensenite, $Na_2(Sr,Ba)_{14}Na_2Al_{12}F_{64}(OH,F)_4$, a new aluminofluoride mineral from Ivigtut, Greenland. Can. Mineral., 35, 175–179.

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Joséite Bi_4TeS_2

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Ribbonlike sheets and plates, to 5 cm, rarely with straight edges.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Flexible. Hardness = 2 VHN = 29–43 (25 g load). D(meas.) = 8.18 D(calc.) = [8.67] ??ck

Optical Properties: Opaque. *Color:* Silver-white; white in polished section. *Luster:* High metallic, tarnishing lead-gray, iridescent, steel-blue to iron-black. *Anisotropism:* Nearly isotropic in basal sections, transverse sections moderately anisotropic in greenish gray to dark greenish gray. R_1–R_2: (400) 51.7–53.7, (420) 51.6–53.9, (440) 51.6–54.0, (460) 51.6–54.4, (480) 51.6–54.7, (500) 51.6–55.0, (520) 51.6–55.2, (540) 51.5–55.4, (560) 51.3–55.4, (580) 51.1–55.5, (600) 50.9–55.4, (620) 50.6–55.3, (640) 50.3–55.1, (660) 50.0–54.8, (680) 49.7–54.6, (700) 49.3–54.3

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.24(1)$ $c = 39.69(6)$ $Z = 3$

X-ray Powder Pattern: Glacier Gulch, Canada.
3.07 (10), 2.24 (5), 2.11 (5), 1.744(3), 1.537 (3), 4.38 (2), 3.61 (2)

Chemistry:

	(1)	(2)	(3)	(4)
Bi	79.15	81.23	82.7	81.34
Te	15.93	14.67	12.0	12.42
Se	1.48	2.84		
S	3.15	1.46	6.0	6.24
Total	99.71	100.20	100.7	100.00

(1) San José, Brazil; corresponds to $Bi_{4.00}Te_{1.32}Se_{0.20}S_{1.04}$. (2) Do.; corresponds to $Bi_{4.00}Te_{1.18}Se_{0.37}S_{0.47}$. (3) Glacier Gulch, Canada; corresponds to $Bi_{4.00}Te_{0.95}S_{1.89}$. (4) Bi_4TeS_2.

Occurrence: In bismuth-rich hydrothermal deposits.

Association: Gold, bismuth, bismuthinite, galenobismutite, hessite, cosalite, laitakarite, tetradymite, joséite-B.

Distribution: From San José, near Marianna, Minas Gerais, Brazil [TL]. In Canada, at Glacier Gulch, Hudson Bay Mountain, near Smithers; and the Windpass mine, near Chu Chua, British Columbia; and in Yukon Territory, from placers in Clear Creek, McQuesten district, and in Highet Creek, Mayo district. In Spain, at Serrania de Ronda, Málaga Province. From the Carrock mine, Caldbeck Fells, and the Coniston mines, Cumbria, and at Penlee Quarry, Cornwall, England. From Băiţa (Rézbánya), Romania. In the Sosukchan deposit, northeastern Sakha, and the Tyrnyauz W–Mo deposit, left bank of the Baksan River Valley, northern Caucasus Mountains, Russia. At Kingsgate, New South Wales, and Maldon, Victoria, Australia. From Chilu, Fuijan Province, China. In the Tsumo mine, about 50 km northwest of Hiroshima City, Akita Prefecture, Japan. Additional localities are increasingly becoming known.

Name: For the locality at San José in Brazil.

Type Material: National Museum of Natural History, Washington, D.C., USA, R400.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 166–167. (2) R.M. Thompson (1949) The telluride minerals and their occurrence in Canada. Amer. Mineral., 34, 342–382. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 272.

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Joséite-B Bi_4Te_2S

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Coarse plates.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Ductile. Hardness = n.d. VHN = n.d. D(meas.) = 8.3 D(calc.) = 8.39

Optical Properties: Opaque. *Color:* Steel-gray; creamy white in reflected light. *Anisotropism:* Distinct, gray to dark brown.
R_1–R_2: (400) 54.5–55.4, (420) 54.5–55.7, (440) 54.6–56.0, (460) 54.8–56.5, (480) 55.1–57.1, (500) 55.4–57.8, (520) 55.8–58.6, (540) 56.2–59.3, (560) 56.5–59.8, (580) 56.7–60.2, (600) 56.8–60.5, (620) 56.7–60.6, (640) 56.6–60.5, (660) 56.3–60.4, (680) 56.0–60.1, (700) 55.7–59.8

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.33$ $c = 40.75$ $Z = 3$

X-ray Powder Pattern: Glacier Gulch, Canada.
3.16 (10), 2.16 (5), 2.29 (4), 1.779 (3), 4.52 (2), 1.943 (2), 1.566 (2)

Chemistry:

	(1)	(2)	(3)
Bi	75.14	75.1	74.42
Pb	0.68	0.6	
Fe	0.52		
Te	19.25	21.5	22.72
S	3.64	2.7	2.86
insol.	0.30		
Total	99.53	99.9	100.00

(1) Glacier Gulch, Canada; corresponding to $Bi_{4.00}Fe_{0.10}Pb_{0.04}Te_{1.68}S_{1.26}$. (2) Nagybörzsöny, Hungary; by electron microprobe, corresponds to $Bi_{4.00}Pb_{0.03}Te_{1.88}S_{0.94}$. (3) Bi_4Te_2S.

Occurrence: In quartz and skarn (Hedley, Canada).

Association: Bismuth, gold, joséite, bismuthinite, ikunolite, hedleyite, pyrrhotite, arsenopyrite, molybdenite.

Distribution: In Canada, in British Columbia, from Glacier Gulch, Hudson Bay Mountain, near Smithers [TL]; and on the Good Hope claim, near Hedley, Osoyoos mining division. At the Stepnyak gold deposit, Kazakhstan. In the Sosukchan deposit, northeastern Sakha; in the Shumilovsk Sn–W deposit, and the gold placer Krasnyi Klyuch, Baikal region, eastern Siberia, Russia. At Kingsgate, New South Wales, Australia. From Natsukidani, Oita Prefecture, the Tsugahira mine, Kyushu, and in the Tsumo mine, about 50 km northwest of Hiroshima City, Akita Prefecture, Japan. At the tellurium Dashuigou deposit, Sichuan Province, and in the Qibaoshan deposit, Hunan Province, China. From Smolotely, near Příbram, Czech Republic. At the Propada and Bardce deposits, Malko Tarnovo district, Bulgaria. From Nagybörzsöny, Hungary. At Săcărîmb (Nagyág), Romania. From Tunaberg, Sweden. In the Carrock mine, Caldbeck Fells, Cumbria, and the Penlee quarry, Cornwall, England.

Name: For the relation to joséite; "B" to distinguish it from joséite, formerly joséite-A.

Type Material: n.d.

References: (1) Peacock, M.A. (1941) On joseite, grünlingite, oruetite. Univ. Toronto Studies, Geol. Ser. 46, 83–105. (2) R.M. Thompson (1949) The telluride minerals and their occurrence in Canada. Amer. Mineral., 34, 342–382. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 273.

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Jouravskite $Ca_3Mn^{4+}(SO_4)(CO_3)(OH)_6 \cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6. As stubby hexagonal pyramidal crystals, exhibiting $\{10\bar{1}0\}$ and $\{10\bar{1}2\}$, to 0.3 mm, imbedded in marokite, in sugary masses and blotches.

Physical Properties: *Cleavage:* On $\{10\bar{1}0\}$, good. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 1.81–1.95 D(calc.) = 1.88–1.93

Optical Properties: Transparent to translucent. *Color:* Greenish yellow to greenish orange, pink (aluminous); bright yellow in transmitted light. *Luster:* [Vitreous.]
Optical Class: Uniaxial (–). *Pleochroism:* Barely perceptible. $\omega = 1.548–1.556$ $\epsilon = 1.540$

Cell Data: *Space Group:* $P6_3/m$ or $P6_3$. $a = 10.997–11.06$ $c = 10.50–10.610$ Z = 2

X-ray Powder Pattern: Tachgagalt, Morocco.
9.6 (FFF), 5.53 (F), 3.81 (F), 3.42 (mF), 2.73 (mF), 2.52 (mF), 2.17 (mF)

Chemistry:

	(1)	(2)	(3)
SO_3	10.20	8.7	12.33
CO_2	7.45	7.2	6.78
SiO_2		0.7	
Al_2O_3		2.2	
MnO	12.33	8.9	13.38
CaO	25.67	26.8	25.90
O	2.45	1.9	
H_2O	41.90	42.7	41.61
Total	100.00	99.1	100.00

(1) Tachgagalt, Morocco. (2) Do.; by electron microprobe, total Mn as MnO, H_2O by the Penfield method; excluding impurities and converting Mn^{2+} to Mn^{4+} with excess O, corresponds to $Ca_3(Mn^{4+}_{0.78}Al_{0.26})_{\Sigma=1.04}(SO_4)_{0.68}(CO_3)_{1.02}(OH)_6 \cdot 12H_2O$.
(3) $Ca_3Mn(SO_4)(CO_3)(OH)_6 \cdot 12H_2O$.

Occurrence: Rare in the oxidized portions of manganese deposits; an aluminian variety formed by the action of volcanic fumaroles.

Association: Manganite, calcite, marokite, gaudefroyite, henritermierite, despujolsite, barite (Tachgagalt, Morocco).

Distribution: From Tachgagalt, 17 km south of Ouarzazate, Anti-Atlas Mountains, Morocco. In the N'Chwaning mine, near Kuruman, Cape Province, South Africa.

Name: Honors Georges Jouravsky (1896–1964), Chief Geologist, Geological Survey of Morocco, for his work on the mineral deposits of Morocco.

Type Material: Natural History Museum, Paris, 175.152; National School of Mines, Paris, France.

References: (1) Gaudefroy, C. and F. Permingeat (1965) La jouravskite, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 88, 254–262 (in French). (2) (1965) Amer. Mineral., 50, 2102–2103 (abs. ref. 1). (3) Granger, M.M. and J. Protas (1969) Détermination et étude de la structure cristalline de la jouravskite $Ca_3Mn^{IV}(SO_4)(CO_3)(OH)_6 \cdot 12H_2O$. Acta Cryst., 25, 1943–1951. (4) Gaudefroy, C., J.E. Dietrich, M. Orliac, and F. Permingeat (1972) Une variété aluminifère de jouravskite à Tachgagalt (Anti-Atlas, Maroc). Notes Serv. géol. Maroc, 32 (241), 19–24 (in French).

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Juabite $\mathbf{Ca^{2+}Cu_{10}(Te^{4+}O_3)_4(AsO_4)_4(OH)_2 \cdot 4H_2O}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As masses of platy crystals, tabular on {010}, with minor {100}, {$\overline{1}$01}, and {101}, to 0.3 mm.

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = n.d. D(calc.) = 4.50

Optical Properties: Transparent to translucent. *Color:* Emerald-green to pale green; brownish white in reflected light with turquoise-blue internal reflections. *Streak:* Pale green. *Luster:* Vitreous to adamantine on cleavages.
Optical Class: Biaxial. n = [1.71–1.73]

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.9903(7)$ $b = 10.1197(8)$ $c = 8.9959(7)$ $\alpha = 102.654(1)°$ $\beta = 92.432(1)°$ $\gamma = 70.432(1)°$ Z = 1

X-ray Powder Pattern: Centennial Eureka mine, Utah, USA.
3.097 (100), 9.28 (70), 4.65 (70), 3.018 (60), 2.658 (50), 2.468 (50), 1.740 (50)

Chemistry:

	(1)	(2)
As_2O_5	23.17	22.53
TeO_2	29.99	31.30
FeO	0.26	
CuO	38.51	39.00
CaO	2.52	2.75
H_2O	[4.39]	4.42
Total	[98.84]	100.00

(1) Centennial Eureka mine, Utah, USA; by electron microprobe, total Fe as FeO, H_2O calculated from stoichiometry; corresponds to $(Ca_{0.92}Fe_{0.07})_{\Sigma=0.99}Cu_{9.94}(Te_{0.96}O_3)_4(As_{1.04}O_4)_4(OH)_2 \cdot 4H_2O$.
(2) $CaCu_{10}(TeO_3)_4(AsO_4)_4(OH)_2 \cdot 4H_2O$.

Occurrence: A very rare secondary mineral formed by the reaction of enargite and tellurium-enriched solutions.

Association: Enargite, beudantite, quartz.

Distribution: Found on a dump at the Centennial Eureka mine, 1.5 km southwest of Eureka, Tintic district, Juab Co., Utah, USA.

Name: For Juab Co., Utah, USA, where the first specimen was collected.

Type Material: The Natural History Museum, London, England, 1997,1; Canadian Geological Survey, Ottawa, Canada, 67959.

References: (1) Roberts, A.C., R.A. Gault, M.C. Jensen, A.J. Criddle, and E.A. Moffatt (1997) Juabite, $Cu_5(Te^{6+}O_4)_2(As^{5+}O_4)_2 \cdot 3H_2O$, a new mineral species from the Centennial Eureka mine, Juab County, Utah. Mineral. Mag., 61, 139–144. (2) (1997) Amer. Mineral., 82, 1262 (abs. ref. 1). (3) Burns, P.C., C.M. Clark, and R.A, Gault (2000) Juabite, $CaCu_{10}(Te^{4+}O_3)_4(AsO_4)_4(OH)_2(H_2O)_4$: crystal structure and revision of the chemical formula. Can. Mineral., 38, 809–816.

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Juanitaite $(Cu, Ca, Fe^{2+})_{10}Bi(AsO_4)_4(OH)_{11} \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As flakes or as rosettes of thin, sometimes bent, tabular crystals, to 1 cm; forms observed include {010}, {201}, {100}.

Physical Properties: *Cleavage:* Perfect, micaceous, on {010}. Hardness = 1
D(meas.) = 2.843 D(calc.) = 2.849

Optical Properties: Translucent. *Color:* Yellow to greenish yellow. *Streak:* Yellow.
Luster: Silky in aggregates, vitreous.
Optical Class: Biaxial (–) (?). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, strong.
α = n.d. $\beta = 1.658$ $\gamma = 1.664$ 2V(meas.) = ∼60°

Cell Data: *Space Group:* $Pcmm$, $Pcm2_1$, or $Pc2m$. $a = 11.98(8)$ $b = 20.37(10)$
$c = 9.95(8)$ Z = 2

X-ray Powder Pattern: Hagendorf, Germany.
9.96 (10b), 5.09 (5), 3.37 (5), 3.30 (5), 3.79 (4), 4.91 (3), 3.08 (3)

Chemistry:

	(1)	(2)
P_2O_5	31.0	30.64
Al_2O_3	0.08	
Fe_2O_3	28.4	30.64
MnO	2.80	
ZnO	14.6	15.62
MgO	0.06	
CaO	5.89	5.38
Na_2O	0.04	
K_2O	0.01	
H_2O^+	8.70	
H_2O^-	9.10	
H_2O		17.72
Total	100.68	100.00

(1) Hagendorf, Germany; corresponds to $Ca_{2.18}Zn_{3.71}Mn^{2+}_{0.82}Fe^{3+}_{7.35}(PO_4)_{9.03}(OH)_9 \cdot 16H_2O$.
(2) $Ca_2Zn_4Fe_8(PO_4)_9(OH)_9 \cdot 16H_2O$.

Occurrence: A late-forming mineral in a complex granite pegmatite.

Association: Mitridatite, manganese oxides.

Distribution: From Hagendorf, Bavaria, Germany.

Name: Honors Dr. Gerhard Jung, Albbruck, Germany, who found the first specimen.

Type Material: n.d.

References: (1) Moore, P.B. and J. Ito (1980) Jungit und Matulait: Zwei neue taflige Phosphat-Mineralien. Aufschluss, 31, 55–61 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 1067 (abs. ref. 1). (3) (1981) Amer. Mineral., 66, 1280 (correction).

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Juanite $Ca_{10}Mg_4Al_2Si_{11}O_{39}\cdot 4H_2O(?)$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. As slender fibers in sheaflike aggregates, to about 1 mm; massive.

Physical Properties: Hardness = 5.5 D(meas.) = 3.01–3.3 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Nearly white to pistachio-green. *Luster:* Dull. *Optical Class:* Biaxial (+). $\alpha = 1.640(3)$ β = n.d. $\gamma = 1.647(3)$ 2V(meas.) = 50° (?)

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kuznetsk, Kazakhstan.
3.27 (100), 2.98 (100), 1.93 (100), 2.90 (90), 1.97 (80), 3.58 (50), 3.41 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	42.05	37.72	42.45
TiO_2	0.00	0.00	
Al_2O_3	5.19	10.79	6.55
Fe_2O_3	3.26	5.18	
FeO		1.08	
MnO	0.09	0.16	
MgO	9.52	4.99	10.35
CaO	34.68	34.0	36.02
Na_2O	1.06	1.01	
K_2O	0.14		
H_2O	4.45	0.00	4.63
P_2O_5		0.03	
LOI		5.87	
Total	100.44	100.83	100.00

(1) Iron Hill, Colorado, USA. (2) Kuznetsk, Kazakhstan. (3) $Ca_{10}Mg_4Al_2Si_{11}O_{39}\cdot 4H_2O$.

Occurrence: Formed by hydrothermal alteration of a coarse-grained melilite rock (uncompahgrite) previously subjected to deuteric alteration (Iron Hill, Colorado, USA); in skarns at a contact zone with carbonates in a gabbro-urtite massif (Kuznetsk, Kazakhstan).

Association: Perovskite, phlogopite, magnetite, titaniferous garnet, melilite, diopside, vesuvianite, brugnatellite, hastingsite, tremolite, aegirine, cebollite (Iron Hill, Colorado, USA); melilite, pyroxene, wollastonite, vesuvianite, cebollite, calcite (Kuznetsk, Kazakhstan).

Distribution: In the Iron Hill carbonatite, Powderhorn-Cebolla district, Gunnison Co., Colorado, USA. From the Kiya-Shaltyrsk massif, Kuznetsk, Ala-Tau Range, Tien Shan, Kazakhstan. In the Kovdor massif, Kola Peninsula, Russia.

Name: For the San Juan Mountains, Colorado, USA, where the mineral was discovered.

Type Material: Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 105990.

References: (1) Larsen, E.S. and E.A. Goranson (1932) The deuteric and later alterations of the uncompahgrite of Iron Hill, Colorado. Amer. Mineral., 17, 343–356. (2) Rodygina, V. (1971) First find of juanite and cebollite in the Kuznetsk Ala-Tau. Geol. Geofiz., 12, 62–70. (3) (1972) Chem. Abs., 76, 156622 (abs. ref. 2).

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Julgoldite-(Fe^{2+}) **$Ca_2Fe^{2+}(Fe^{3+},Al)_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals flat prismatic to bladed, to 2 mm, elongated along [010] and flattened ∥ {100}. In fan-shaped, plumose crystal groups; granular. *Twinning:* Twin plane {001}, typically repeated, common.

Physical Properties: *Cleavage:* Perfect on {100} and {001}. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.58–3.60 D(calc.) = 3.56

Optical Properties: Transparent. *Color:* Deep black, greenish black to green in small fragments; in thin section, brilliant interference colors in greens or blues. *Streak:* Greenish olive with a bluish tinge. *Luster:* Nearly submetallic.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = pale brown; Y = pale brownish green; Z = deep emerald-green. *Orientation:* $Y = b$. *Absorption:* $Z \gg Y > X$. $\alpha = 1.776(4)$ $\beta = 1.814(4)$ $\gamma = 1.836(4)$ 2V(meas.) = 50°–70° 2V(calc.) = 73°

Cell Data: *Space Group:* $A2/m$. $a = 8.922(4)$ $b = 6.081(3)$ $c = 19.432(9)$ $\beta = 97.60(6)°$ Z = 4

X-ray Powder Pattern: Scotland.
2.958 (100), 2.780 (80), 2.574 (80), 1.519 (80), 4.817 (70), 3.859 (70), 2.501 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	34.0	32.04	MnO	0.2	
TiO_2	0.1		MgO	0.2	0.23
Al_2O_3	1.3	0.68	CaO	22.0	19.93
Fe_2O_3	29.6	30.28	BaO	0.01	
FeO	8.7	9.5	H_2O	4.69	[7.34]
			Total	100.8	[100.00]

(1) Långban, Sweden; by emission spectroscopy, corresponds to $(Ca_{8.8}Mn_{0.1})_{\Sigma=8.9}(Fe^{2+}_{2.7}Fe^{3+}_{1.2}Mg_{0.1})_{\Sigma=4.0}(Fe^{3+}_{7.2}Al_{0.6})_{\Sigma=7.8}Si_{12.7}O_{44.7}(OH)_{11.7}$. (2) Auchinstarry quarry, Scotland; by electron microprobe, Fe^{2+}:Fe^{3+} by Mössbauer spectroscopy, H_2O by difference; corresponds to $Ca_{8.01}Fe^{3+}_{8.55}Al_{0.30}Fe^{2+}_{3.00}Mg_{0.13}Si_{12.03}O_{48.47} \cdot (H_2O)_{9.18}$.

Polymorphism & Series: Forms two series, with pumpellyite-(Fe^{2+}), and with pumpellyite-(Mg).

Mineral Group: Pumpellyite group.

Occurrence: In hematite-magnetite ore (Långban, Sweden); in quartz-diabase (Scotland).

Association: Apophyllite, barite, hematite, magnetite, ilvaite, calcite, quartz, chlorite, prehnite, epistilbite, stilbite, pectolite, laumontite, babingtonite, titanite.

Distribution: At Långban, Värmland, Sweden. Between Tafjord and Fjøra, Sunnmøre district, Norway. In the Ratho quarry, near Edinburgh, and the Auchinstarry quarry, Kilsyth, Scotland. In Germany, from the Wolfmühl quarry, Waldgrehweiler, Rhineland-Palatinate. From Hale Creek, Trinity Co., California, and in the Clark mine, Copper Harbor, Keweenaw Co., Michigan, USA. At Sawda, near Jalgoan, and Bombay, Maharashtra, India. In the Marlin Norite quarry, Bushveld complex, South Africa.

Name: For Professor Julian Royce Goldsmith (1918–), mineralogist and geochemist, University of Chicago, Chicago, Illinois, USA, and its *ferrous iron* content.

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Type Material: Swedish Museum of Natural History, Stockholm, Sweden; Harvard University, Cambridge, Massachusetts, 109641, 109642; National Museum of Natural History, Washington, D.C., USA, 137014.

References: (1) Moore, P.B. (1971) Julgoldite, the Fe^{+2}–Fe^{+3} dominant pumpellyite; a new mineral from Långban, Sweden. Lithos, 4, 93–99. (2) (1971) Amer. Mineral., 56, 2157–2158 (abs. ref. 1). (3) Allmann, R. and G. Donnay (1973) The crystal structure of julgoldite. Mineral. Mag., 39, 271–281. (4) Passaglia, E. and G. Gottardi (1973) Crystal chemistry and nomenclature of pumpellyites and julgoldites. Can. Mineral., 12, 219–223. (5) Livingstone, A. (1976) Julgoldite, new data and occurrences; a second recording. Mineral. Mag., 40, 761–763.

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Julienite $Na_2Co(SCN)_4 \cdot 8H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Minute needles, elongated along [001], aggregated in crusts. *Twinning:* On {110} as twin plane, or around [001].

Physical Properties: *Cleavage:* ‖ elongation. Hardness = n.d. D(meas.) = 1.648 D(calc.) = 1.61 Readily soluble in H_2O, forming a pink solution.

Optical Properties: Translucent. *Color:* Blue. *Streak:* Blue.
Optical Class: Uniaxial (+). $\omega = 1.556$ $\epsilon = 1.645$

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 18.941(2)$ $b = 19.209(2)$ $c = 5.460(1)$ $\beta = 91.64(1)°$ Z = 4

X-ray Powder Pattern: Chamibumba, Congo.
0.935 (100), 0.903 (100), 3.55 (85), 3.23 (85), 1.375 (85), 1.220 (85), 6.50 (58)

Chemistry:

	(1)	(2)
Na	10.35	9.55
Co	12.5	12.24
SCN	47.6	48.27
H_2O	29.87	29.94
Total	100.32	100.00

(1) Chamibumba, Congo. (2) $Na_2Co(SCN)_4 \cdot 8H_2O$.

Occurrence: A very rare incrustation on talc schist.

Association: Cobaltian "wad".

Distribution: From Chamibumba, near Kambove, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Henry Julien (?–1920), Belgian scientist who discovered the mineral.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1106–1107. (2) Mereiter, K. and A. Preisinger (1982) The structure of sodium tetraisothiocyanatocobaltate(II) octahydrate $Na_2[Co(NCS)_4].8H_2O$. Acta Cryst., 38, 1084–1088. (3) Schoep, A. and V. Billiet (1935) Contribution à l'étude du réseau de la julienite [$Na_2Co(CSN)_4 \cdot 8H_2O$]. Zeits. Krist., 91, 229–234 (in French).

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As flakes or as rosettes of thin, sometimes bent, tabular crystals, to 1 cm; forms observed include {010}, {201}, {100}.

Physical Properties: *Cleavage:* Perfect, micaceous, on {010}. Hardness = 1
D(meas.) = 2.843 D(calc.) = 2.849

Optical Properties: Translucent. *Color:* Yellow to greenish yellow. *Streak:* Yellow.
Luster: Silky in aggregates, vitreous.
Optical Class: Biaxial (–) (?). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, strong.
α = n.d. $\beta = 1.658$ $\gamma = 1.664$ 2V(meas.) = ~60°

Cell Data: *Space Group:* $Pcmm$, $Pcm2_1$, or $Pc2m$. $a = 11.98(8)$ $b = 20.37(10)$
$c = 9.95(8)$ $Z = 2$

X-ray Powder Pattern: Hagendorf, Germany.
9.96 (10b), 5.09 (5), 3.37 (5), 3.30 (5), 3.79 (4), 4.91 (3), 3.08 (3)

Chemistry:

	(1)	(2)
P_2O_5	31.0	30.64
Al_2O_3	0.08	
Fe_2O_3	28.4	30.64
MnO	2.80	
ZnO	14.6	15.62
MgO	0.06	
CaO	5.89	5.38
Na_2O	0.04	
K_2O	0.01	
H_2O^+	8.70	
H_2O^-	9.10	
H_2O		17.72
Total	100.68	100.00

(1) Hagendorf, Germany; corresponds to $Ca_{2.18}Zn_{3.71}Mn^{2+}_{0.82}Fe^{3+}_{7.35}(PO_4)_{9.03}(OH)_9 \cdot 16H_2O$.
(2) $Ca_2Zn_4Fe_8(PO_4)_9(OH)_9 \cdot 16H_2O$.

Occurrence: A late-forming mineral in a complex granite pegmatite.

Association: Mitridatite, manganese oxides.

Distribution: From Hagendorf, Bavaria, Germany.

Name: Honors Dr. Gerhard Jung, Albbruck, Germany, who found the first specimen.

Type Material: n.d.

References: (1) Moore, P.B. and J. Ito (1980) Jungit und Matulait: Zwei neue taflige phosphat-mineralien. Aufschluss, 31, 55–61 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 1067 (abs. ref. 1). (3) (1981) Amer. Mineral., 66, 1280 (correction).

Junitoite $CaZn_2Si_2O_7 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Only as crystals, to 5 mm, with excellent faces and good evidence of hemihedrism; as sprays of individuals.

Physical Properties: *Cleavage:* Good on {100}; poor on {010} and {011}. *Tenacity:* Brittle to semi-sectile as a result of alteration. Hardness = 4.5 D(meas.) = 3.5(1) D(calc.) = 3.516 Strongly pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, milk-white, or colored in various tints as a result of alteration. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, very weak.
$\alpha = 1.656$ $\beta = 1.664$ $\gamma = 1.672$ 2V(meas.) = n.d. 2V(calc.) = 86°

Cell Data: *Space Group:* $Ama2$. $a = 12.510(7)$ $b = 6.318(3)$ $c = 8.561(6)$ $Z = 4$

X-ray Powder Pattern: Christmas, Arizona, USA.
3.528 (100), 2.816 (100), 2.540 (100), 2.352 (70), 1.540 (60), 4.703 (50), 2.521 (50)

Chemistry:

	(1)	(2)
SiO_2	31.0	33.65
ZnO	44.8	45.59
CaO	15.5	15.71
H_2O	5.8	5.05
Total	97.1	100.00

(1) Christmas, Arizona, USA. (2) $CaZn_2Si_2O_7 \cdot H_2O$.

Occurrence: In a retrogressively altered tactite zone, closely related to the breakdown of sphalerite in the ores.

Association: Kinoite, apophyllite, calcite, xonotlite, smectite.

Distribution: In the USA, from the Christmas copper mine, Gila Co., Arizona.

Name: For Dr. Jun Ito (1926–1978), Japanese-American mineral chemist, Harvard University, Cambridge, Massachusetts, USA.

Type Material: University of Arizona, Tucson, Arizona; Harvard University, Cambridge, Massachusetts, 119097; National Museum of Natural History, Washington, D.C., USA, 136688; University of Paris, Paris; National School of Mines, Paris, France; The Natural History Museum, London, England, 1980,535.

References: (1) Williams, S.A. (1976) Junitoite, a new hydrated calcium zinc silicate from Christmas, Arizona. Amer. Mineral., 61, 1255–1258. (2) Hamilton, R.D. and J.J. Finney (1985) The structure of junitoite, $CaZn_2Si_2O_7 \cdot H_2O$. Mineral. Mag., 49, 91–95.

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Junoite **$Pb_3Cu_2Bi_8(S,Se)_{16}$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular crystals, to 150 μm, and irregular grains.

Physical Properties: *Cleavage:* One good. Hardness = n.d. VHN = 114–213
D(meas.) = n.d. D(calc.) = 6.77

Optical Properties: Opaque. *Color:* In polished section, creamy white. *Pleochroism:* Strong, from cream to gray with green and mauve tints. *Anisotropism:* Strong.
R_1–R_2: (400) 34.7–42.8, (420) 34.8–42.7, (440) 35.0–42.5, (460) 35.0–42.5, (480) 35.0–42.5, (500) 34.8–42.4, (520) 34.7–42.7, (540) 34.6–42.2, (560) 34.6–42.3, (580) 34.6–42.5, (600) 34.6–42.7, (620) 34.8–42.8, (640) 34.9–42.6, (660) 35.0–42.4, (680) 35.0–42.1, (700) 35.0–41.9

Cell Data: *Space Group:* $C2/m$. $a = 26.66(1)$ $b = 4.06(1)$ $c = 17.03(1)$ $\beta = 127.20(2)^\circ$
$Z = 2$

X-ray Powder Pattern: Juno mine, Australia.
3.55 (100), 3.90 (80), 2.919 (70), 3.23 (50), 2.970 (50), 3.39 (40), 2.213 (40)

Chemistry:

	(1)	(2)
Pb	19.3	18.8
Cu	4.1	3.9
Ag	0.1	0.4
Bi	54.7	52.3
Se	7.6	14.7
S	13.5	10.1
Total	102.1	100.2

(1) Juno mine, Australia; by electron microprobe, corresponding to $Pb_{2.88}Cu_{1.99}Ag_{0.03}Bi_{8.09}(Se_{2.98}S_{13.02})_{\Sigma=16.00}$. (2) Kidd Creek mine, Canada; by electron microprobe, corresponding to $Pb_{2.89}Cu_{1.86}Ag_{0.12}Bi_{7.99}(Se_{5.94}S_{10.06})_{\Sigma=16.00}$.

Occurrence: Of hydrothermal origin.

Association: Gold, selenian heyrovskýite, krupkaite, proudite, chalcopyrite, magnetite (Juno mine, Australia); chalcopyrite, sphalerite, cobaltite, këesterite, mawsonite (Kidd Creek, Canada); pekoite, tetradymite, aikinite, gladite, cassiterite (Kochbulak deposit, Uzbekistan).

Distribution: From the Juno mine, Tennant Creek, Northern Territory, Australia [TL]. At the Kidd Creek mine, near Timmins, Ontario, Canada. From the Linka mine, Spencer Hot Springs district, Lander Co., Nevada, USA. In the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. At the Baoshan mine, Hunan Province, and the Funiushan copper skarn deposit, near Nanjing, Jiangsu Province, China. From the Felbertal tungsten mine, Salzburg, Austria.

Name: For the Juno mine, Australia, where it was first found.

Type Material: Geology Department, University of New England, Armidale, Australia, R27790.

References: (1) Mumme, W.G. (1975) Junoite, $Cu_2Pb_3Bi_8(S,Se)_{16}$, a new sulfosalt from Tennant Creek, Australia: its crystal structure and relationship with other bismuth sulfosalts. Amer. Mineral., 60, 548–558. (2) Large, R.R. and W.G. Mumme (1975) Junoite, "wittite" and related seleniferous bismuth sulfosalts from Juno mine, Northern Territory, Australia. Econ. Geol., 70, 369–383. (3) (1975) Amer. Mineral., 60, 737 (abs. ref. 2). (4) Pringle, G.J. and R.I. Thorpe (1980) Bohdanowiczite, junoite and laitakarite from the Kidd Creek mine, Timmins, Ontario. Can. Mineral., 18, 353–360. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 274.

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Juonniite $CaMgSc(PO_4)_2(OH)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Platy crystals, subparallel, curved, to 12 μm, in spherulites.

Physical Properties: Hardness = 4–4.5 VHN = 315–355, 330 average (20 g load). D(meas.) = 2.43(3) D(calc.) = 2.44

Optical Properties: Translucent. *Color:* Bright orange, pale yellow, yellowish brown, gray, colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.574(1)$ $\beta = 1.579(1)$ $\gamma = 1.582(2)$ 2V(meas.) = n.d. 2V(calc.) = 70.2°

Cell Data: *Space Group:* [*Pbca*] (by analogy to overite). $a = 15.03(5)$ $b = 18.95(4)$ $c = 7.59(1)$ Z = 8

X-ray Powder Pattern: Kovdor massif, Kola Peninsula, Russia.
9.49 (100), 2.912 (44), 2.890 (35), 3.440 (31), 2.942 (27), 4.75 (17), 2.018 (15)

Chemistry:

	(1)	(2)
P_2O_5	36.16	36.55
TiO_2	0.38	
Sc_2O_3	13.17	17.76
FeO	1.07	
MnO	1.28	
MgO	12.08	10.38
CaO	12.33	14.44
SrO	0.53	
BaO	1.58	
H_2O	[21.42]	20.87
Total	[100.00]	100.00

(1) Kovdor massif, Kola Peninsula, Russia; by electron microprobe, average of nine analyses, total Fe as FeO, total Mn as MnO, H_2O by difference; PO_4, $(OH)^{1-}$, H_2O confirmed by IR; corresponds to $(Ca_{0.86}Mn_{0.07}Ba_{0.04}Sr_{0.02})_{\Sigma=0.99}Mg_{1.00}(Sc_{0.75}Mg_{0.18}Fe_{0.05}Ti_{0.02})_{\Sigma=1.00}(PO_4)_2(OH)_{0.83}\cdot 4.25H_2O$. (2) $CaMgSc(PO_4)_2(OH)\cdot 4H_2O$.

Occurrence: A rare mineral in cavities and contacts with ore minerals in a metasomatized carbonatite stockwork.

Association: Dolomite, magnesite, bobierrite, kovdorskite, manasseite, hydrotalcite, apatite, strontiowhitlockite, pyrite, strontian collinsite, rimkorolgite, talc, baddeleyite, zircon, gypsum.

Distribution: From the Zheleznyi iron mine, Kovdor alkalic massif, Kola Peninsula, Russia.

Name: From the Finnish name (Juonni) for the Yona River, in allusion to the locality of first occurrence of the species.

Type Material: St. Petersburg Mining Institute, St. Petersburg, Russia.

References: (1) Liferovich, R.P., V.N. Yakovenchuk, Y.A. Pakhomovskii, A.N. Bogdanova, and S.N. Britvin (1997) Juonniite, a new scandium mineral from calcite-dolomite carbonatites of the Kovdor massif. Zap. Vses. Mineral. Obshch., 126(4), 80–88 (in Russian with English abs.). (2) (1998) Amer. Mineral., 83, 908 (abs. ref. 1).

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Jurbanite $Al(SO_4)(OH)\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As short prismatic crystals, dominated by {110} and {011}, to 0.3 mm; commonly in stalactites and crusts.

Physical Properties: *Tenacity:* Brittle. Hardness = ~2.5 D(meas.) = 1.786(8) D(calc.) = 1.828 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = -5°$. $\alpha = 1.459(2)$ $\beta = 1.473(2)$ $\gamma = 1.483(2)$ 2V(meas.) = 80° 2V(calc.) = 80°

Cell Data: *Space Group:* $P2_1/n$. $a = 8.3965(6)$ $b = 12.479(2)$ $c = 8.1549(9)$ $\beta = 101.917(6)°$ Z = 4

X-ray Powder Pattern: San Manuel mine, Arizona, USA.
3.723 (100), 4.013 (90), 6.80 (80b), 4.954 (80), 4.494 (80), 5.74 (70), 3.922 (70)

Chemistry: (1) San Manuel mine, Arizona, USA; qualitative emission spectroscopy confirmed major Al and very minor Fe, Mg, Mn, Si, Cu and Ca; stoichiometry established by the congruity of X-ray diffraction patterns of natural and synthetic material.

Polymorphism & Series: Dimorphous with rostite.

Occurrence: As rare secondary crusts in humid tunnels in oxidized portions of sulfide deposits in aluminous rocks; apparently deposited directly from mine water at about 27 °C and 100% humidity (San Manuel mine, Arizona, USA).

Association: Epsomite, hexahydrite, pickeringite, starkeyite (San Manuel mine, Arizona, USA); rostite, gypsum, pickeringite, metavoltine, ferrinatrite, sideronatrite, tamarugite, uklonskovite (Cetine mine, Italy).

Distribution: From the San Manuel mine, Mammoth district, Pinal Co., Arizona, USA. At the Cetine mine, 20 km southwest of Siena, Tuscany, Italy.

Name: Honors Joseph John Urban (1915–1997), Tucson, Arizona, USA, mineral collector who first observed the natural material.

Type Material: National Museum of Natural History, Washington, D.C., USA, 144003.

References: (1) Anthony, J.W. and W.J. McLean (1976) Jurbanite, a new post-mine aluminum sulfate mineral from San Manuel, Arizona. Amer. Mineral., 61, 1–4. (2) Sabelli, C. (1985) Refinement of the crystal structure of jurbanite, $Al(SO_4)(OH)\cdot 5H_2O$. Zeits. Krist., 173, 33–39.

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Kaatialaite $Fe^{3+}(H_2AsO_4)_3 \cdot 3–5H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2 or $2/m$. As acicular crystals, to 50 μm, in aggregates; as powdery coatings on löllingite.

Physical Properties: Hardness = n.d. D(meas.) = 2.64(2) (synthetic). D(calc.) = 2.64 H_2O is variable according to relative humidity; becomes cloudy on exposure to light.

Optical Properties: Semitransparent. *Color:* White, gray, greenish gray to yellow. *Luster:* Earthy.
Optical Class: Biaxial (+). *Orientation:* Z $\wedge$ c $\simeq 3°$. α = 1.573–1.581 β = 1.573–[1.582] γ = 1.626–1.636 2V(meas.) = 13°–15°

Cell Data: *Space Group:* $P2_1$ or $P2_1/n$ (synthetic $Fe(H_2AsO_4)_3 \cdot 5H_2O$). a = 15.25–15.363 b = 19.60–19.844 c = 4.72–4.752 β = 91.77°–91.90° Z = 4

X-ray Powder Pattern: Kaatiala pegmatite, Finland.
8.35 (vs), 9.91 (s), 7.72 (s), 6.09 (m), 3.76 (m), 3.53 (m), 3.408 (m)

Chemistry:

	(1)	(2)
As_2O_5	[51.9]	59.9
CO_2	1.73	
As_2O_3	[14.2]	
Al_2O_3	0.58	
Fe_2O_3	11.2	13.8
MgO	0.24	
CaO	3.00	
H_2O	16.2	25.8
Total	[99.05]	99.5

(1) Kaatiala pegmatite, Finland; by AA, As determined after volatilization of arsenolite impurity, H_2O and CO_2 by elemental analyzer; after deduction of small amounts of Ca, Mg, As_2O_3, CO_2 as impurities, corresponds to $(Fe_{0.93}Al_{0.08})_{\Sigma=1.01}(H_2AsO_4)_{3.00} \cdot 5.97H_2O$. (2) Niederbeerbach, Germany; corresponds to $Fe_{1.00}(H_2AsO_4)_{3.02} \cdot 5.26H_2O$.

Occurrence: A secondary mineral in a granite pegmatite (Kaatiala pegmatite, Finland); in an oxidized Ag–As vein in gabbro (Niederbeerbach, Germany).

Association: Arsenolite, löllingite, calcite, gypsum (Kaatiala pegmatite, Finland).

Distribution: From the Kaatiala pegmatite, near Kuortane, Finland. In Germany, at Glasberg, Niederbeerbach, Odenwald, Hesse; Wittichen, Black Forest; St. Andreasberg, Harz Mountains; and Lauta, near Marienberg, Saxony. From Jáchymov (Joachimsthal), Czech Republic. In the U.S. mine, Gold Hill, Tooele Co., Utah, USA.

Name: For the Kaatiala pegmatite, Finland, in which it was first found.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway; The Natural History Museum, London, England.

References: (1) Raade, G., M.H. Mladeck, R. Kristiansen, and V.K. Din (1984) Kaatialaite, a new ferric arsenate mineral from Finland. Amer. Mineral., 69, 383–387. (2) Schmetzer, K. and O. Medenbach (1986) Kaatialaite from Nieder-Beerbach, Odenwald – a second occurrence. Neues Jahrb. Mineral., Monatsh., 337–342. (3) Boudjada, A. and J.C. Guitel (1981) Structure cristalline d'un orthoarséniate acide de fer(III) pentahydraté: $Fe(H_2AsO_4)_3.5H_2O$. Acta Cryst., 37, 1402–1405 (in French with English abs.).

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Kadyrelite $Hg_6^{1+}H(Br,Cl)_3O_2$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. In grains, to 0.5 mm.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 143–192, 175 average (25 g load). D(meas.) = n.d. D(calc.) = 8.79

Optical Properties: Transparent. *Color:* Bright to dull orange; bright yellow-orange in transmitted light; grayish white in reflected light, with intense orange internal reflections, tarnishing to bluish then brownish. *Streak:* Yellow-orange. *Luster:* Vitreous to adamantine. *Optical Class:* Isotropic. $n = > 2$
R: (436) 27.7, (460) 25.3, (500) 21.2, (546) 19.4, (589) 18.1, (620) 17.8, (656) 16.6

Cell Data: *Space Group:* [$Ia3d$] (by analogy to eglestonite). $a = 16.22$ Z = [16]

X-ray Powder Pattern: Kadyrel deposit, Russia.
3.32 (100), 1.912 (85), 2.57 (65), 4.06 (30), 2.63 (20), 2.344 (20), 1.731 (20)

Chemistry:

	(1)	(2)
Hg	84.36	85.39
O	[1.70]	1.70
Cl	2.93	3.77
Br	10.19	8.50
I	0.01	
H_2O		0.64
Total	[99.19]	100.00

(1) Kadyrel deposit, Russia; by electron microprobe, average of five analyses.
(2) $Hg_6H(Br,Cl)_3O_2$ with Br:Cl = 1:1.

Polymorphism & Series: Forms a series with eglestonite.

Occurrence: In cavities in carbonate veins in a mercury deposit.

Association: Eglestonite, calomel, kuzminite, corderoite, lavrentievite.

Distribution: In the Kadyrel mercury deposit, Pii-Khem district, right bank of the Oorash-Khem River Valley, Tuva, Siberia, Russia [TL].

Name: For the Kadyrel deposit, Russia, where it occurs.

Type Material: Central Siberian Geological Museum, Siberian Division, Academy of Sciences, Novosibirsk, VI-29/1; Mining Institute, St. Petersburg, Russia, 1992/1–2.

References: (1) Vasil'ev, V.I. (1987) Kadyrelite $Hg_4(Br,Cl)_2O$ – a new oxyhalide of mercury from the Kadyrelsky ore occurrence. Zap. Vses. Mineral. Obshch., 116, 733–737 (in Russian). (2) (1989) Amer. Mineral., 74, 503 (abs. ref. 1). (3) Mereiter, K., J. Zeeman, and A.W. Hewat (1992) Eglestonite, $[Hg_2]_3Cl_3O_2H$: confirmation of the chemical formula by neutron powder diffraction. Amer. Mineral., 77, 839–842.

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Kaersutite $NaCa_2[(Mg,Fe^{2+})_4Ti](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly as well-formed phenocrysts with rhombic basal sections; prismatic, to 10 cm; as granular aggregates. *Twinning:* Simple or multiple twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; partings on {100}, {001}. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.2–3.28 D(calc.) = [3.11]

Optical Properties: Semitransparent. *Color:* Dark brown to black, typically zoned; yellow-brown, green-brown, or red-brown in thin section. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = yellow, yellow-brown; Y = red, red-brown; Z = deep brown, dark red-brown. *Orientation:* $Y = b$; $Z \wedge c = 0°$–19°. *Dispersion:* $r > v$. *Absorption:* $Z \geq Y > X$. α = 1.670–1.689 β = 1.690–1.741 γ = 1.700–1.772 2V(meas.) = 66°–82°

Cell Data: *Space Group:* $C2/m$. a = 9.8903(3) b = 18.0596(5) c = 5.3152(2) β = 105.4(1)° Z = 2

X-ray Powder Pattern: Boulder Dam area, Arizona, USA. (ICDD 17-478). 2.693 (100), 3.11 (80), 8.38 (65), 3.36 (65), 2.548 (65), 2.589 (55), 1.439 (55)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	39.50	39.88	MgO	12.90	14.10
TiO_2	10.33	4.69	CaO	10.91	13.05
Al_2O_3	11.12	14.25	Na_2O	3.82	1.86
Fe_2O_3	0.06	9.58	K_2O	1.43	1.80
FeO	9.44	0.10	F		0.14
MnO	0.10	0.10	H_2O^+	0.59	0.53
			Total	100.20	100.08

(1) Qaersut, Greenland; corresponds to $(Na_{1.11}K_{0.28})_{\Sigma=1.39}Ca_{1.76}(Mg_{2.89}Fe^{2+}_{1.19}Ti_{1.17}Fe^{3+}_{0.01}Mn_{0.01})_{\Sigma=5.27}(Si_{5.93}Al_{1.97})_{\Sigma=7.90}O_{22}(OH)_{0.59}$. (2) Vlčí Hora, Czech Republic; by microanalysis, corresponds to $(Na_{0.53}K_{0.41})_{\Sigma=0.94}Ca_{2.06}(Mg_{3.10}Fe^{3+}_{1.06}Ti_{0.52}Al_{0.34}Fe^{2+}_{0.01}Mn_{0.01})_{\Sigma=5.04}(Si_{5.87}Al_{2.13})_{\Sigma=8.00}O_{22}[(OH)_{1.94}F_{0.06}]_{\Sigma=2.00}$.

Polymorphism & Series: Forms a series with ferrokaersutite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.50$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si < 6.5$; $Ti \geq 0.5$.

Occurrence: Common as phenocrysts in alkalic volcanic rocks; in gabbroic and peridotitic nodules in alkalic basalts; in syenites, monzonites, carbonatite tuffs, and alkalic gabbros.

Association: Titanian augite, rhönite, olivine, ilmenite, spinel, plagioclase, titanian pargasite.

Distribution: In Greenland, from Østerfjeld, near Qaersut, at Nûgssuaq, and elsewhere in the Kangerdlugssuaq Fjord and Skaergaard areas. On Linosa, Pelagian Islands, south of Sicily, Italy. From Vlčí Hora, Czech Republic. From near Boulder Dam, Mohave Co., and near San Carlos, Gila Co., Arizona, USA. At Mont Saint-Hilaire, Quebec, Canada. From Chikaishi, Oki Island, Shimane Prefecture, and at Mushozu and Numazu, Iki Island, Nagasaki Prefecture, Japan. At Kakanui, New Zealand. A number of other localities are known.

Name: For the occurrence near Qaersut (formerly Kaersut), Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 386, 392. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 321–327. (3) Pechar, F., H. Fuess, and W. Joswig (1989) Refinement of the crystal structure of kaersutite (Vlčí Hora, Bohemia) from neutron diffraction. Neues Jahrb. Mineral., Monatsh., 137–143.

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Kahlerite $Fe^{2+}(UO_2)_2(AsO_4)_2 \cdot 10-12H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As thin tablets, flattened on {001}, displaying {111}, {021}, {012}, {011}, {010}, to 2 mm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.22 Radioactive.

Optical Properties: Semitransparent. *Color:* Lemon-yellow to yellowish green. *Optical Class:* Uniaxial, nearly, to anomalously biaxial (–). α = n.d. $\beta = 1.632(5)$ $\gamma = 1.633(5)$ 2V(meas.) = 9°–33°

Cell Data: *Space Group:* $P4_2/n$. $a = 14.30$ $c = 21.97$ Z = 8

X-ray Powder Pattern: Synthetic $Fe(UO_2)_2(AsO_4)_2 \cdot 12H_2O$.
3.53 (100), 11.1 (80), 5.55 (50), 3.59 (50), 1.603 (40), 1.763 (30), 3.20 (20)

Chemistry: (1) Hüttenberg, Austria; qualitative analysis confirms a ferrous uranium arsenate hydrate.

Mineral Group: Autunite group.

Occurrence: A very rare secondary mineral in the oxidized zone of a uraninite-bearing iron deposit (Hüttenberg, Austria).

Association: Arsenosiderite, scorodite, symplesite, pitticite, löllingite (Hüttenberg, Austria); lavendulan, zeunerite, metazeunerite, malachite, cornubite, mixite, tyrolite, wulfenite, metakahlerite (Southwick Cliffs, Scotland).

Distribution: From Hüttenberg, Carinthia, Austria. On the Sophia and St. Joseph mine dumps, near Wittichen, and at Menzenschwand, Black Forest, Germany. From the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, France. At Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland.

Name: Honors Dr. Franz Kahler, geologist, Carinthian Landesmuseum, Klagenfurt, Austria.

Type Material: Carinthian Landesmuseum, Klagenfurt, Austria; Cambridge University, Cambridge, England.

References: (1) Meixner, H. (1953) Kahlerit, ein neues Mineral der Uranglimmergruppe, aus der Hüttenberger Lagerstätte, Kärnten. Der Karinthin, 23, 277–280 (in German). (2) (1954) Amer. Mineral., 39, 1038 (abs. ref. 1). (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 204–205. (4) Walenta, K. (1964) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 1. Folge. Tschermaks Mineral. Petrog. Mitt., 9, 111–174, esp. 172 (in German).

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Kainite $KMg(SO_4)Cl{\cdot}3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are equant to thick tabular on {100}, showing {100}, {010},{011}, {421}, {$\bar{4}$21}, many other forms, to 10 cm; commonly in aggregates of crystals, fibrous, in crusts, granular massive.

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* Smooth to splintery. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 2.15 D(calc.) = 2.24 Soluble in H_2O; taste salty and bitter.

Optical Properties: Transparent to translucent. *Color:* Colorless, may be gray, blue, violet, yellow, pink from inclusions; colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* If blue, may show X = violet; Y = blue; Z = yellow. *Orientation:* $X = a$; $Y = b$; $Z \wedge c = 13°$. *Dispersion:* $r > v$, very weak. $\alpha = 1.494$ $\beta = 1.505$ $\gamma = 1.516$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $C2/m$. a = 19.72(2) $b = 16.23(1)$ $c = 9.53(1)$ $\beta = 94°55(5)'$ Z = 16

X-ray Powder Pattern: Calculated from the crystal structure. (ICDD 25-1237). 7.372 (100), 3.080 (86), 7.771 (83), 8.115 (69), 3.029 (66), 3.048 (42), 4.616 (37)

Chemistry:

	(1)	(2)
SO_3	32.50	32.16
MgO	16.72	16.19
Na_2O	1.39	
K_2O	16.02	18.91
Cl	13.51	14.24
H_2O	20.95	21.71
insol.	1.74	
$-O = Cl_2$	3.05	3.21
Total	99.78	100.00

(1) Eddy Co., New Mexico, USA; recalculated to oxides from a partial elemental analysis.
(2) $KMg(SO_4)Cl{\cdot}3H_2O$.

Occurrence: A secondary mineral in marine potash deposits, formed due to metamorphism or resolution by ground waters; rarely a volcanic sublimate.

Association: Sylvite, halite, carnallite, kieserite, polyhalite, langbeinite, picromerite.

Distribution: An ore of potassium and magnesium. In Germany, from Stassfurt, 34 km south of Magdeburg, Saxony-Anhalt, and many other places nearby; in the Werra-Fulda district, Hesse and Thuringia; on the Asse Mountain, near Wolfenbüttel, and at the Kaliwerk Hansa Empelde, near Hannover, Saxony. From Racalmuto, Realmonte, and elsewhere on Sicily, Italy. Large deposits in the Kalusz and Stebnyk areas, Carpathian Mountains, Ukraine. At volcanos on the Kamchatka Peninsula, Russia. From Lake Inder, Kazakhstan. In the USA, in the Carlsbad potash district, Eddy Co., New Mexico.

Name: From the Greek for *recent*, alluding to its recent origin.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 594–596. (2) Robinson, P.D., H.H. Fang, and Y. Ohya (1972) The crystal structure of kainite. Amer. Mineral., 57, 1325–1332.

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Kainosite-(Y) $Ca_2(Y,Ce)_2Si_4O_{12}(CO_3)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals short, equant, to slender, prismatic, elongated along [001], up to 2 cm; most crystals display a granular core. Also as sheaflike aggregates of crystals.

Physical Properties: *Cleavage:* Good on {110}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.52 D(calc.) = 3.542

Optical Properties: Transparent to translucent. *Color:* Colorless, white, straw-yellow, yellow-brown, chestnut-brown, may be tipped with rose or pink. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. α = 1.662–1.665 β = 1.682–1.689 γ = 1.687–1.691 2V(meas.) = 40° 2V(calc.) = 49.5°

Cell Data: *Space Group: Pmnb.* $a = 13.011(1)$ $b = 14.310(1)$ $c = 6.757(1)$ Z = 4

X-ray Powder Pattern: Bancroft, Canada.
6.52 (100), 2.764 (100), 3.29 (80), 3.19 (75), 3.45 (70), 2.170 (70), 1.929 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	35.24	34.55	CaO	16.78	16.69
TiO_2	0.02		Na_2O	0.04	
ThO_2	0.03		K_2O	0.01	
Al_2O_3	1.20	1.02	H_2O^+	2.59	[2.68]
Y_2O_3	25.27	25.63	H_2O^-	0.06	
RE_2O_3	12.62	12.65	CO_2	4.60	6.55
Fe_2O_3	0.57	0.23	FeS_2	0.98	
			Total	100.01	[100.00]

(1) Bancroft, Canada; RE and Th by XRF, Fe reported as Fe_2O_3 above that required to form pyrite with S 0.52%; $RE_2O_3 = Ce_2O_3$ 0.38%, Nd_2O_3 0.19%, Sm_2O_3 0.27%, Gd_2O_3 2.44%, Dy_2O_3 3.10%, Er_2O_3 3.53%, Yb_2O_3 2.71%; corresponds to $Ca_{2.02}(Y_{1.50}RE_{0.50})_{\Sigma=2.00}(Si_{4.02}Al_{0.08})_{\Sigma=4.10}O_{12}(CO_3)_{0.70}\cdot 1.93H_2O$. (2) Baveno, Italy; Ca, Y, RE by gamma-ray spectrometry, Si, Al, Fe by AA, CO_2 by gas volumetric analysis, H_2O by difference; $RE_2O_3 = La_2O_3$ 0.24%, Ce_2O_3 0.39%, Pr_2O_3 0.09%, Nd_2O_3 0.20%, Sm_2O_3 0.29%, Eu_2O_3 0.08%, Tb_2O_3 0.68%, Ho_2O_3 0.22%, Tm_2O_3 0.20%, Lu_2O_3 0.21%, Gd_2O_3 1.89%, Dy_2O_3 3.08%, Er_2O_3 2.65%, Yb_2O_3 2.71%; corresponds to $Ca_2(Y_{1.53}RE_{0.45}Fe_{0.02})_{\Sigma=2.00}Si_{3.87}O_{12}(CO_3)\cdot H_2O$.

Occurrence: In vugs in pegmatites in granites and alkalic complexes.

Association: Chamosite, pyrite, quartz, calcite, sphalerite, fluorite, uraninite, zircon, molybdenite (Bancroft, Canada); diopside, magnetite, clinochlore, apatite (Nordmark, Sweden).

Distribution: At Igeltjern, on Hitterö Island, Flekkefjord, Norway. In the Ko mine, Nordmark, Värmland, Sweden. In Switzerland, at Grubhorn, Baltschiedertal, Valais; near Guttannen, Uri; Piz Gannaretsch, Val Curnera, in the Gotthard freeway tunnel, Ticino; at Tavetsch, Graubünden; and elsewhere. From Hopffeldboden, in the Obersulzbachtal, Salzburg, Austria. At Baveno, Piedmont, Italy. In the Dodo mine, about 100 km west-northwest of Saranpaul, Subpolar Ural Mountains, Russia. In the USA, from near Cotopaxi, Fremont Co., Colorado; in Washington Pass, Okanogan Co., Washington; and east of Porthill, Boundary Co., Idaho. In Canada, from North Burgess Township, Lanark Co., and from the Bicroft mine, near Bancroft, Ontario; in the Evans-Lou quarry, near Wakefield Lake, and at Mont Saint-Hilaire, Quebec; and in a commercial deposit at the Strange Lake complex, northern Quebec and Labrador, Newfoundland.

Name: From the Greek for *unusual*, for its rarity and exotic composition.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 698.
(2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 246–247. (3) Pouliot, G., J.A. Maxwell, and S.C. Robinson (1964) Cenosite from Bancroft, Ontario. Can. Mineral., 8, 1–10.
(4) Giuseppetti, G., C. Tadini, and M. Oddone (1989) Cenosite-(Y) from Baveno, Novara (Italy): crystal structure. Neues Jahrb. Mineral., Monatsh., 153–164.

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Kalborsite $K_6BAl_4Si_6O_{20}Cl(OH)_4$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As grains up to 2 mm.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = ∼6 VHN = 733–897, 838 average. D(meas.) = 2.5 D(calc.) = 2.48

Optical Properties: Translucent to transparent. *Color:* Colorless with a slight brownish rose tint. *Luster:* Vitreous to pearly on cleavages.
Optical Class: Uniaxial (+). $\omega = 1.525$ $\epsilon = 1.525$; birefringence < 0.001.

Cell Data: *Space Group:* $P\bar{4}2_1c$. $a = 9.851(5)$ $c = 13.060(5)$ Z = 2

X-ray Powder Pattern: Mt. Rasvumchorr, Russia.
3.08 (10), 2.79 (9), 3.44 (8), 2.94 (8), 3.26 (5), 2.24 (5), 2.08 (5)

Chemistry:

	(1)
SiO_2	38.54
B_2O_3	4.98
Al_2O_3	21.18
K_2O	30.06
Cl	3.71
H_2O	[3.81]
$-O = Cl_2$	0.84
Total	[101.44]

(1) Mt. Rasvumchorr, Russia; by electron microprobe, average of three analyses, H_2O from stoichiometry; corresponds to $K_{6.04}B_{1.35}(Al_{3.93}Si_{6.07})_{\Sigma=10.00}O_{22.58}Cl_{0.99}(OH)_4$.

Occurrence: Forms rims around lovozerite in segregations of pectolite, in rischorrite pegmatite from a differentiated alkalic massif.

Association: Pectolite, lovozerite.

Distribution: On Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: For potassium, KALium, BORate, and SIlicon in the composition.

Type Material: Mining Institute, St. Petersburg, 1300/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81596.

References: (1) Khomyakov, A.P., S.M. Sandomirskaya, and Y.A. Malinovskii (1980) Kalborsite, $K_6BAl_4Si_6O_{20}(OH)_4Cl$, a new mineral. Doklady Acad. Nauk SSSR, 252, 1465–1468 (in Russian). (2) Malinovskii, Y.A. and N.V. Belov (1980) Crystal structure of kalborsite. Doklady Acad. Nauk SSSR, 252, 611–615 (in Russian). (3) (1981) Amer. Mineral., 66, 879 (abs. refs. 1 and 2).

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Kaliborite $KHMg_2B_{12}O_{16}(OH)_{10}\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Small crystals exhibit {100}, {111}, {110}, with a few additional forms, typically with uneven face development; in powdery aggregates, granular, massive.

Physical Properties: *Cleavage:* On {001}, $\{\overline{1}01\}$, perfect; on {100}, good. Hardness = 4–4.5 D(meas.) = 2.128 D(calc.) = [2.110] Slightly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to white, uncommonly reddish brown; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 64°30'$. $\alpha = 1.508$ $\beta = 1.526$–1.527 $\gamma = 1.549$–1.550 $2V(meas.) = 80°38'$

Cell Data: *Space Group:* $C2/c$. $a = 18.572(6)$ $b = 8.466(3)$ $c = 14.689(5)$ $\beta = 100.02(3)°$ $Z = 4$

X-ray Powder Pattern: Leopoldshall, Germany.
7.22 (100), 6.215 (100), 3.104 (71), 2.488 (71), 3.837 (50), 3.770 (50), 3.359 (50)

Chemistry:

	(1)	(2)
B_2O_3	[57.46]	58.30
MgO	12.06	11.25
K_2O	6.48	6.57
H_2O	24.00	23.88
Total	[100.00]	100.00

(1) Schmidtmannshall, Germany; B_2O_3 by difference. (2) $KHMg_2B_{12}O_{16}(OH)_{10}\cdot 4H_2O$.

Occurrence: An uncommon component in marine potash deposits; rarely in efflorescences.

Association: Boracite, pinnoite, kainite (Germany); anhydrite, halite (Inder deposit, Kazakhstan).

Distribution: In Germany, in Saxony-Anhalt, from Schmidtmannshall, near Aschersleben; Neustassfurt and Leopoldshall, in Stassfurt, 34 km south of Magdeburg. At Sallent-Balsareny, Barcelona Province, Spain. From Monte Sambuco, Calascibetta, Sicily, Italy. At the Inder borate deposit, Kazakhstan. In the USA, from the Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., California.

Name: For potassium, KALIum, and BORate in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 367–368. (2) Mrose, M.E. and W.T. Schaller (1965) The identity of paternoite with kaliborite ($K_2O\cdot 4MgO\cdot 11B_2O_3\cdot 18H_2O$). Amer. Mineral., 50, 1079–1083. (3) Burns, P.C. and F.C. Hawthorne (1994) Kaliborite: an example of a crystallographically symmetrical hydrogen bond. Can. Mineral., 32, 885–894.

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Kalicinite $KHCO_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As a massive aggregate of minute crystals.

Physical Properties: *Cleavage:* {100}, {001}, {101}. Hardness = "Soft".
D(meas.) = 2.168 (synthetic). D(calc.) = 2.15 Soluble in H_2O.

Optical Properties: Transparent. *Luster:* Dull. *Color:* Colorless to white, pale yellow; colorless in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 30°$. $\alpha = 1.380$ $\beta = 1.482$ $\gamma = 1.578$
2V(meas.) = 81.5°

Cell Data: *Space Group:* $P2_1/a$. $a = 15.1725(11)$ $b = 5.6283(5)$ $c = 3.7110(4)$
$\beta = 104.631(6)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 12-292).
3.67 (100), 2.630 (90), 2.863 (85), 2.816 (80), 2.97 (75), 2.377 (35), 1.832 (30)

Chemistry: (1) Identification depends on agreement of optical and X-ray data with synthetic material.

Occurrence: As a result of the decomposition of a dead tree.

Association: n.d.

Distribution: From Chippis, Valais, Switzerland.

Name: For potassium, *kalium*, in the composition.

Type Material: Natural History Museum, Paris, France, 99.775.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 136–137. (2) Thomas, J.O., R. Tellgren, and I. Olovsson (1974) Hydrogen bond studies. LXXXIV. An X-ray diffraction study of the structures of $KHCO_3$ and $KDCO_3$ at 298, 219, and 95 K. Acta Cryst., 30, 1155–1166.

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Kalininite $ZnCr_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Irregular slablike aggregates, to 0.5 mm.

Physical Properties: Hardness = n.d. VHN = 468 (50 g load). D(meas.) = n.d. D(calc.) = 4.045 Strongly magnetic.

Optical Properties: Opaque. *Color:* Black, may be tarnished to colors; in reflected light, light creamy. *Luster:* Adamantine.
R: (400) — , (420) — , (440) 34.4, (460) 35.2, (480) 35.3, (500) 35.4, (520) 35.4, (540) 35.2, (560) 35.3, (580) 35.2, (600) 34.8, (620) 34.1, (640) 33.8, (660) 32.7, (680) 32.5, (700) —

Cell Data: *Space Group:* $Fd3m$. a = 9.997 Z = 8

X-ray Powder Pattern: Southern Baikal region, Russia.
1.757 (10), 1.019 (10), 2.98 (9), 1.910 (8), 2.47 (7), 3.48 (5), 1.153 (5)

Chemistry:

	(1)	(2)
Zn	18.89	21.96
Cu	2.73	
Cr	34.10	34.94
V	0.61	
Sb	0.73	
S	42.22	43.10
Total	99.28	100.00

(1) Southern Baikal region, Russia; by electron microprobe, average of nine analyses on three grains; corresponding to $Zn_{0.87}Cu_{0.13}Cr_{1.98}V_{0.04}Sb_{0.02}S_{3.97}$. (2) $ZnCr_2S_4$.

Mineral Group: Linnaeite group.

Occurrence: In a garnet-pyroxene mixture in diopside-quartz-calcite rocks.

Association: Karelianite, eskolaite, diopside, quartz, calcite, barite, zircon, chromian-vanadian tremolite, goldmanite–uvarovite, pyrite.

Distribution: From the Pereval marble quarry, near Slyudyanka, Sayan Mountains, southern Baikal region, eastern Siberia, Russia [TL].

Name: For Pavel Vasil'evich Kalinin (1905–1981), Russian mineralogist and petrologist, Moscow Geological Exploration Institute, investigator of the southern Baikal region.

Type Material: Mining Institute, St. Petersburg, 1098/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 88049.

References: (1) Reznickii, L.Z., E.V. Skl'arov, and Z.F. Ustschapovskaya (1985) Kalininite, $ZnCr_2S_4$ – a new natural sulphospinel. Zap. Vses. Mineral. Obshch., 114, 622–627 (in Russian). (2) (1987) Amer. Mineral., 72, 223 (abs. ref. 1). (3) Wittlinger, J., S. Werner, and H. Schulz (1997) On the amorphisation of $ZnCr_2S_4$ spionel under high pressure: x-ay diffraction studies. Phys. Chem. Minerals, 24, 597–600. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow,

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Kalinite $KAl(SO_4)_2 \cdot 11-12H_2O(?)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically fibrous, in crusts or massive.

Physical Properties: Hardness = 2–2.5 D(meas.) = 1.75 D(calc.) = 2.00 Soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* White to pale blue.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 13°$. *Dispersion:* Weak. $\alpha = 1.430$ $\beta = 1.452$ $\gamma = 1.458$ 2V(meas.) = 52(1)°

Cell Data: *Space Group:* $C2/c$. $a = 19.92(16)$ $b = 9.27(3)$ $c = 8.304(13)$ $\beta = 98.79(19)°$ Z = 4

X-ray Powder Pattern: Alma mine, California, USA. (ICDD 41-1362).
4.80 (100), 4.31 (86), 3.494 (79), 4.12 (71), 4.94 (64), 4.60 (50), 2.679 (29)

Chemistry: (1) No modern analyses appear extant.

Occurrence: A rare secondary mineral observed in the oxidized zone of mineral deposits, as efflorescences on alum slates, in caves, and as a volcanic sublimate.

Association: Jarosite, pisanite (Quetena, Chile).

Distribution: All localities require modern characterization as many older samples have been found to be cubic potassium alum. From Mount Wingen, New South Wales, Australia. At Quetena, west of Calama, Antofagasta, Chile. In the USA, from Turkey Creek, Jefferson Co., Colorado; at the Alum mine, Silver Peak district, Esmeralda Co., Nevada; in the Alma pyrite mine, Alameda Co., California. Found on volcanoes in the Lipari Islands and Sicily, Italy, and on the Kamchatka Peninsula, Russia.

Name: For its potassium, *kalium*, content. Here applied to a partially characterized fibrous birefringent mineral, distinct from cubic potassium alum.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 471. (2) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 951.

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Kaliophilite $KAlSiO_4$

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Crystal Data: Hexagonal. *Point Group:* 622. In bundles of slender acicular to threadlike crystals.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Brittle. Hardness = 6
D(meas.) = 2.493–2.649 D(calc.) = [2.65]

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Silky, brilliant.
Optical Class: Uniaxial (–). $\omega = 1.536$ $\epsilon = 1.531$

Cell Data: *Space Group:* $P6_322$. $a = 26.930$ $c = 8.522$ Z = 54

X-ray Powder Pattern: Vesuvius, Italy.
3.09 (100), 2.593 (30), 2.131 (25), 4.26 (15), 3.76 (12), 3.02 (12), 2.814 (12D)

Chemistry:

	(1)	(2)	(3)
SiO_2	39.2	38.87	37.99
TiO_2		0.00	
Al_2O_3	33.36	31.89	32.23
FeO		0.07	
MnO		0.00	
CaO	0.47	0.05	
Na_2O	2.88	0.77	
K_2O	24.13	28.76	29.78
Total	100.04	100.41	100.00

(1) Monte Somma, Italy. (2) Do.; by electron microprobe. (3) $KAlSiO_4$.

Polymorphism & Series: Polymorphous with kalsilite, panunzite, and trikalsilite.

Occurrence: In blocks of biotite-pyroxenite volcanic ejecta.

Association: Biotite, pyroxene, augite, melilite, calcite (Monte Somma, Italy); clinopyroxene, garnet, leucite, haüyne, latiumite (Albano, Italy).

Distribution: In Italy, from Monte Somma and Vesuvius, Campania; at Albano and Marino, Colle Cimino, near Rome, Lazio.

Name: From the Greek for potassium, *kalium*, and for *friend*, recognizing potassium's presence.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 427.
(2) Bannister, M.A. (1931) A chemical, optical, and X-ray study of nepheline and kaliophilite. Mineral. Mag., 22, 569–608. (3) Smith, J.V. and O.F. Tuttle (1957) The nepheline–kalsilite system: I. X-ray data for the crystalline phases. Amer. J. Sci., 255, 282–305. (4) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 231–270. (5) Abbott, R.N., Jr. (1984) $KAlSiO_4$ stuffed derivatives of tridymite: phase relationships. Amer. Mineral., 69, 449–457.

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Kalipyrochlore $(H_2O)(Nb,Ti)_2(O,OH)_6 \cdot H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, to 1 cm, which may be corroded.

Physical Properties: *Fracture:* [Uneven] (by analogy to the pyrochlore group). *Tenacity:* [Brittle.] Hardness = 4–4.5 D(meas.) = 3.40–3.48 D(calc.) = 3.40–3.44

Optical Properties: Transparent. *Color:* Greenish. *Luster:* [Vitreous to resinous.] *Optical Class:* Isotropic. n = 1.93–1.99

Cell Data: *Space Group: Fd3m.* a = 10.604(1) Z = 8

X-ray Powder Pattern: n.d.

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
U_3O_8	0.10	0.08		PbO	0.01	0.02	
Nb_2O_5	78.60	80.05	75.69	MgO	0.11	0.11	
Ta_2O_5	0.06	0.11		MnO	0.08	0.06	
V_2O_5	0.02	0.03		CaO	0.41	0.13	0.12
TiO_2	4.10	4.12	5.01	BaO	0.28	0.38	
ZrO_2	0.66	0.37		SrO	2.60	1.73	1.75
SnO_2		0.06		Na_2O	0.35	0.58	
ThO_2	0.12	0.17		K_2O	2.73	2.76	2.12
Al_2O_3	0.18			F	0.38	0.11	
RE_2O_3	0.43	0.50		H_2O^+	8.54	8.37	[16.05]
Fe_2O_3	0.20	0.13		$-O = F_2$	[0.16]	[0.05]	
FeO	0.06	0.07		Total	[99.86]	[99.89]	[100.74]

(1) Lueshe, Congo; original total given as 100.192%, corrected for goyazite 7.8%, ilmenite 2.0%, (rutile, brookite, anatase) 1.3%, calcite 0.9%, kaolinite 0.55%, goethite 0.3%, $H_2O^{+130^\circ C}$. (2) Do.; original total given as 100.066%, corrected for goyazite 7.5%, ilmenite 1.9%, (rutile, anatase) 1.1%, calcite 1.6%, kaolinite 0.4%, goethite 0.2%, $H_2O^{+130^\circ C}$. (3) Do.; by electron microprobe, H_2O from crystal-structure analysis; corresponds to $[(H_2O)_{0.99}Sr_{0.05}Ca_{0.01}]_{\Sigma=1.05}(Nb_{1.80}Ti_{0.20})_{\Sigma=2.00}[O_{4.06}(OH)_{1.94}]_{\Sigma=6.00}[(H_2O)_{0.86}K_{0.14}]_{\Sigma=1.00}$.

Mineral Group: Pyrochlore group and subgroup; $K_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: In alluvial deposits and residual soils from a carbonatite deposit, formed from pyrochlore by the leaching of Na, Ca, and F in waters rich in K ions.

Association: Na–Ca pyrochlores, lueshite, columbite, fersmite, ilmenite, rutile, barian goyazite.

Distribution: In the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire).

Name: Originally for a member of the *pyrochlore* group with significant potassium, KALIum, although recent work shows only a minor amount of that element in natural material.

Type Material: National Museum of Natural History, Washington, D.C., USA, 136440.

References: (1) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410, esp. 405–406 [kalipyrochlore]. (2) Van Wambeke, L. (1978) Kalipyrochlore, a new mineral of the pyrochlore group. Amer. Mineral., 63, 528–530. (3) Ercit, T.S., F.C. Hawthorne, and P. Černý (1994) The structural chemistry of kalipyrochlore, a "hydropyrochlore". Can. Mineral., 32, 415–420.

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Kalistrontite $K_2Sr(SO_4)_2$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}m$. Platy crystals, showing $(10\bar{1}0\}$ and {0001}, to 2.2 cm.

Physical Properties: *Cleavage:* On {0001}, perfect. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 3.30 D(calc.) = 3.32 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.569(2)$ $\epsilon = 1.549(2)$

Cell Data: *Space Group:* $R\bar{3}m$ (synthetic). $a = 5.45(3)$ $c = 20.7(1)$ Z = 3

X-ray Powder Pattern: Alshtan, Russia.
3.14 (100), 1.904 (9), 2.73 (8), 1.236 (8), 1.041 (7), 6.7 (6), 2.06 (6)

Chemistry:

	(1)	(2)	(3)	(4)
SO_3	45.45	47.73	43.72	44.73
R_2O_3	0.02			
MgO	0.13	0.14	0.34	
CaO	5.15	5.41	3.99	
SrO	23.20	24.35	25.08	28.95
Na_2O	4.15	2.18	1.50	
K_2O	19.22	20.19	22.22	26.32
Cl	1.56		1.72	
H_2O	0.90		0.28	
insol.	0.07		0.63	
$-O = Cl_2$	0.35		0.14	
Total	99.50	[100.00]	99.34	100.00

(1) Alshtan, Russia. (2) Analysis (1) recalculated after deduction of included halite and anhydrite; corresponds to $(K_{0.85}Na_{0.14})_{\Sigma=0.99}(Sr_{0.94}Mg_{0.01})_{\Sigma=0.95}(SO_4)_2$. (3) Pleismar, Germany. (4) $K_2Sr(SO_4)_2$.

Occurrence: In a drillhole into anhydrite beds, probably formed by the reaction of sylvite with strontium-bearing solutions (Alshtan, Russia); an alteration product of celestine (Pleismar, Germany); in a lake-bed evaporite (Omongwa Pan, Namibia).

Association: Halite, anhydrite, dolomite, sylvite, clay (Alshtan, Russia); halite, sylvite, anhydrite (Pleismar, Germany); gypsum (Omongwa Pan, Namibia).

Distribution: From near Alshtan, Sterlitamak district, southwestern Ural Mountains, Russia. In Germany, at Bohrung, near Pleismar, Saxony-Anhalt, and from Kalkberg, near Lüneburg, Lower Saxony. From Stebnyk, Ukraine. In the Cesano geothermal field, Latium, Italy. At the Omongwa Pan, southwestern Kalahari, Namibia.

Name: For potassium, KALIum, and STRONTium in the composition.

Type Material: Mining Institute, St. Petersburg, 1397/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69943.

References: (1) Voronova, M.L. (1962) Kalistrontite – a new potassium strontium sulfate. Zap. Vses. Mineral. Obshch., 91, 712–717 (in Russian). (2) (1963) Amer. Mineral., 48, 708–709 (abs. ref. 1). (3) Bader, E. and G. Böhm (1966) Kalistrontit, im Flöz Stassfurt des Rossleben-Unstrut-Reviers. Chem. Erde, 25, 253–257 (in German). (4) (1977) NBS Mono 25, 14.

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Kalsilite $KAlSiO_4$

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Crystal Data: Orthorhombic, probably, twinned to a pseudohexagonal aspect. *Point Group:* 622, apparent. As anhedral embedded grains and as patchy to fine intergrowths with nepheline or potassic feldspar; massive. *Twinning:* Ubiquitous on a microscopic scale, on $\{10\bar{1}0\}$, $\{33\bar{6}5\}$, and $\{11\bar{2}2\}$.

Physical Properties: *Cleavage:* Poor on $\{10\bar{1}0\}$, $\{0001\}$. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 2.59–2.62 D(calc.) = [2.62]

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray; in thin section, colorless. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (–). $\omega = 1.535–1.554$ $\epsilon = 1.530–1.539$

Cell Data: *Space Group:* $P6_322$ apparent. $a = 5.16$ $c = 8.69$ Z = 2

X-ray Powder Pattern: Synthetic.
3.118 (100), 2.579 (50), 3.973 (45), 2.175 (17), 2.472 (15), 4.351 (12), 2.432 (10)

Chemistry:

	(1)	(2)
SiO_2	39.6	37.99
Al_2O_3	21.3	32.23
Fe_2O_3	5.9	
MgO	3.7	
CaO	5.0	
Na_2O	1.6	
K_2O	20.1	29.78
Total	97.2	100.00

(1) Mafuru crater, Uganda. (2) $KAlSiO_4$.

Polymorphism & Series: Polymorphous with kaliophilite, panunzite, and trikalsilite.

Occurrence: In the groundmass of some potassium-rich and silica-deficient lavas and tuffs; rare in syenites; may be formed by the breakdown of silica-rich leucite in alkalic ultramafic rocks; from a granulite-facies emery deposit.

Association: Olivine, melilite, clinopyroxene, phlogopite, nepheline, leucite.

Distribution: In the Mafuru and Katunga craters, Uganda. From Congo (Zaire), in the Baruta crater, Nyiragongo area, Kivu Province. From Italy, at Monte Somma and Vesuvius, Campania; Ariccia, near Rome, Lazio; and in the San Venanzo and Pian di Celle volcanos, Umbria. At Ödersdorf, Eifel district, Germany. In the Batbjerg alkalic ultramafic intrusion, Kangerdlugssuaq Glacier, Greenland. From the Khibiny massif, Kola Peninsula; the Murun massif, southwest of Olekminsk, Yakutia; and in the Tazheran alkalic massif, west of Lake Baikal, eastern Siberia, Russia. From the Punalar district, Kerala, India. In the Colima graben, about 50 km south-southwest of Guadalajara, Jalisco, Mexico. A few other localities are known.

Name: For potassium, Kalium, ALuminum, and SILicate in the composition.

Type Material: The Natural History Museum, London, England, 1942,42; Harvard University, Cambridge, Massachusetts, 101998; National Museum of Natural History, Washington, D.C., USA, 105856.

References: (1) Bannister, F.A. and M.H. Hey (1942) Kalsilite, a polymorph of $KAlSiO_4$ from Uganda. Mineral. Mag., 26, 218–224. (2) Smith, J.V. and O.F. Tuttle (1957) The nepheline-kalsilite system. I. X-ray data for the crystalline phases. Amer. J. Sci., 255, 282–305. (3) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 231–269. (4) Perrotta, A.J. and J.V. Smith (1965) The crystal structure of kalsilite, $KAlSiO_4$. Mineral. Mag., 35, 588–595. (5) Capobianco, C. and M. Carpenter (1989) Thermally induced changes in kalsilite ($KAlSiO_4$). Amer. Mineral., 74, 797–811.

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Kamacite α–(Fe, Ni)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As plates and lamellar masses and in regular intergrowth with taenite. May occur in crystals, to 30 cm; in extended plates and ribbons in Widmanstätten bands.

Physical Properties: Hardness = n.d. VHN = 145–165 (100 g load). D(meas.) = n.d. D(calc.) = [7.90] Magnetic.

Optical Properties: Opaque. *Color:* Steel-gray to iron-black. *Luster:* Metallic.
R: n.d.

Cell Data: *Space Group:* $Fm3m$ (disordered phase). a = ∼8.60 Z = 54

X-ray Powder Pattern: Linville nickel-rich ataxite.
2.031 (100), 1.170 (70), 1.967 (60), 1.435 (30), 3.032 (10), 2.953 (10), 1.481 (10)

Chemistry:

	(1)	(2)
Fe	93.75	93.09
Ni	5.43	6.69
Co	0.58	0.25
C		0.02
P	0.19	
S	0.08	
Total	100.03	100.05

(1) North Chile hexahedrite. (2) Welland octahedrite.

Occurrence: A major constituent of iron meteorites (siderites) and present in varying amounts in most other meteorites except certain of the stony meteorites (aerolites).

Association: Taenite, graphite, cohenite, moissanite, schreibersite, troilite, daubréelite, oldhamite, other meteorite minerals.

Distribution: Terrestrial occurrences at Blaafjeld, near Ovifak, Disko Island, Greenland. In Germany, from Bühl, near Weimar, Hesse. On the Putorana Plateau, Taimyr Peninsula, Russia. Otherwise from meteorites.

Name: From the Greek for *shaft* or *lath*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 114–116. (2) Ramsden, A.R. and E.N. Cameron (1966) Kamacite and taenite superstructures and a metastable tetragonal phase in iron meteorites. Amer. Mineral., 51, 37–55.

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Kamaishilite $Ca_2Al_2SiO_6(OH)_2$

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Crystal Data: Tetragonal. *Point Group:* n.d. As grains up to about 0.1 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.82]

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Isotropic, nearly. $n = 1.629$

Cell Data: *Space Group:* Body-centered cell. $a = 8.850$ $c = 8.770$ Z = 4

X-ray Powder Pattern: Kamaishi mine, Japan.
3.607 (100), 2.799 (85), 2.777 (40), 2.547 (40), 1.557 (35), 2.085 (30)

Chemistry:

	(1)
SiO_2	20.03
Al_2O_3	34.15
FeO	0.21
MgO	0.02
CaO	37.42
H_2O^+	6.1
H_2O^-	0.2
Total	98.13

(1) Kamaishi mine, Japan; by electron microprobe, H_2O by wet chemical analysis; corresponds to $(Ca_{1.99}Fe_{0.01})_{\Sigma=2.00}Al_{2.00}Si_{0.99}O_{5.98}(OH)_{2.02}$.

Polymorphism & Series: Dimorphous with bicchulite.

Occurrence: In vesuvianite skarn in a marble, apparently altering from vesuvianite.

Association: Vesuvianite, perovskite, calcite, magnetite, chalcopyrite.

Distribution: At the Kamaishi mine, Iwate Prefecture, Japan.

Name: For the Kamaishi mine, Japan.

Type Material: National Science Museum, Tokyo, Japan, M23560.

References: (1) Uchida, E. and J.T. Iiyama (1981) On kamaishilite, $Ca_2Al_2SiO_6(OH)_2$, a new mineral (tetragonal), dimorphous with bicchulite, from the Kamaishi mine, Japan. Proc. Japan Acad., 57B, 239–243 (in English). (2) (1982) Amer. Mineral., 67, 855 (abs. ref. 1).

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Kambaldaite $NaNi_4(CO_3)_3(OH)_3 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6. As hexagonal prisms $\{10\bar{1}0\}$, terminated by $\{0001\}$ and $\{11\bar{2}1\}$, to about 50 μm, as individual crystals or in radiating spherical nodules; in cryptocrystalline veins, concretionary, chalky, massive.

Physical Properties: Hardness = ∼3 D(meas.) = 3.18 D(calc.) = 3.193

Optical Properties: Transparent to translucent. *Color:* Bright grass-green to emerald-green, crystals may be zoned with a clear core and translucent margins; pale green if massive.
Streak: Pale green. *Luster:* Silky on fractures.
Optical Class: Uniaxial (+). *Pleochroism:* O = pale green; E = emerald-green. $\omega = 1.65$ $\epsilon = 1.69$

Cell Data: *Space Group:* $P6_3$. $a = 10.340(3)$ $c = 6.097(2)$ $Z = 2$

X-ray Powder Pattern: Kambalda, Western Australia.
9.03 (10), 4.490 (9), 3.613 (4), 2.681 (4), 2.584 (4), 2.519 (4), 2.263 (4)

Chemistry:

	(1)	(2)
SO_3	0.3	
SiO_2	0.2	
CO_2	27.5	24.32
Al_2O_3	0.4	
NiO	52.9	55.04
MgO	1.3	
Na_2O	3.0	5.71
H_2O	12.5	14.93
Total	98.1	100.00

(1) Kambalda, Western Australia; by electron microprobe, C and H by microanalysis; corresponds to $Na_{0.52}(Ni_{3.90}Mg_{0.18})_{\Sigma=4.08}[(C_{1.15}Al_{0.01}Si_{0.01})_{\Sigma=1.17}O_{3.46}]_3(OH)_{1.98} \cdot 2.84H_2O$.
(2) $NaNi_4(CO_3)_3(OH)_3 \cdot 3H_2O$.

Occurrence: A secondary mineral in goethitic residues formed by oxidation of violarite–pyrite in the presence of wallrock carbonates and saline groundwater (Kambalda, Western Australia).

Association: Gaspéite, reevesite, aragonite, pyrite, goethite (Kambalda, Western Australia).

Distribution: In Australia, from the Otter Shoot, Kambalda, 56 km south of Kalgoorlie, and in the 132 North nickel mine, 4 km southwest of Widgiemooltha, Western Australia.

Name: For Kambalda, Western Australia, its locality of discovery.

Type Material: Western Australian Museum, Perth, M.62.1991; Museum Victoria, Melbourne, M37494; Australian Museum, Sydney, Australia, D48054; The Natural History Museum, London, England, 1985,497; National Museum of Natural History, Washington, D.C., USA, 162706.

References: (1) Nickel, E.H. and B.W. Robinson (1985) Kambaldaite–a new hydrated Ni–Na carbonate mineral from Kambalda, Western Australia. Amer. Mineral., 70, 419–422.
(2) Engelhardt, L.M., S.R. Hall, and A.H. White (1985) Crystal structure of kambaldaite, $Na_2Ni_8(CO_3)_6 \cdot 6H_2O$. Amer. Mineral., 70, 423–427.

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Kamchatkite $KCu_3(SO_4)_2OCl$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Rodlike crystals, elongated along [001], rectangular or rhombic in cross-section, to 3 mm, exhibiting {110}, {100}, {010}, {001}.

Physical Properties: *Cleavage:* On {011} and {100}, perfect. *Tenacity:* "Fragile". Hardness = 3.5 D(meas.) = 3.48(1) D(calc.) = 3.58 Soluble in H_2O; decomposes in air in a few weeks due to hydration.

Optical Properties: Transparent. *Color:* Greenish yellow-brown; yellow in transmitted light. *Streak:* Yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.695(2)$ $\beta = 1.718(2)$ $\gamma = 1.759(2)$ 2V(meas.) = n.d. 2V(calc.) = 75°

Cell Data: *Space Group:* $Pna2_1$. $a = 9.741(5)$ $b = 12.858(6)$ $c = 7.001(3)$ Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia.
7.76 (100), 3.501 (65), 2.591 (41), 3.217 (30), 2.682 (30), 2.274 (23), 2.898 (20)

Chemistry:

	(1)	(2)
SO_3	33.96	33.83
CuO	48.62	50.42
ZnO	0.62	
PbO	0.17	
Na_2O	0.20	
K_2O	10.48	9.95
Cl	6.20	7.49
H_2O^+	0.00	
H_2O^-	1.75	
insol.	0.20	
$-O = Cl_2$	1.40	1.69
Total	100.80	100.00

(1) Tolbachik volcano, Russia; by AA, flame photometry, and volume-weight analysis; after deduction of H_2O and calculation of O^{2+} for charge balance, corresponds to $(K_{1.06}Na_{0.03})_{\Sigma=1.09}(Cu_{2.92}Zn_{0.04})_{\Sigma=2.96}(SO_4)_{2.03}O_{1.04}Cl_{0.84}$. (2) $KCu_3(SO_4)_2OCl$.

Occurrence: A volcanic sublimate formed between 120 °C and 140 °C.

Association: Ponomarevite, tolbachite, klyuchevskite, hematite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: For its occurrence on the Kamchatka Peninsula, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1947/1.

References: (1) Vergasova, L.P., S.K. Filatov, Y.K. Serafimova, and T.V. Varaksina (1988) Kamchatkite $KCu_3OCl(SO_4)_2$ – a new mineral from volcanic sublimates. Zap. Vses. Mineral. Obshch., 117, 459–461 (in Russian with English abs.). (2) (1990) Amer. Mineral., 75, 1210 (abs. ref. 1). (3) Varaksina, T.V., V.S. Fundamensky, and S.K. Filatov (1990) The crystal structure of kamchatkite, a new naturally occurring oxychloride sulphate of potassium and copper. Mineral. Mag., 54, 613–616.

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Kamiokite $Fe_2^{2+}Mo_3^{4+}O_8$

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Crystal Data: Hexagonal. *Point Group:* 6*mm*. As thick tabular hexagonal crystals, to 3 mm, hemimorphic pyramidal with {0001}, {10$\overline{1}$0}, {10$\overline{1}$1}, and smaller {10$\overline{1}\overline{1}$}; also granular.

Physical Properties: *Cleavage:* {0001}, perfect. *Fracture:* Even. Hardness = 3–4.5 VHN = 545–678, 600 average (50 g load); 380–410, 385 average (25 g load). D(meas.) = 5.96 D(calc.) = 6.02

Optical Properties: Opaque. *Color:* Iron-black; gray with an olive tint in reflected light. *Streak:* Black. *Luster:* Metallic to submetallic.
Optical Class: Uniaxial (–). *Anisotropism:* Strong; light brownish gray to dark greenish gray. *Bireflectance:* Strong; gray to olive-gray.
R_1–R_2: (400) 19.0–25.4, (420) 18.6–25.0, (440) 18.2–24.6, (460) 17.8–24.2, (480) 17.4–23.8, (500) 17.1–23.5, (520) 16.8–23.2, (540) 16.6–23.0, (560) 16.4–22.7, (580) 16.1–22.5, (600) 15.9–22.3, (620) 15.8–22.2, (640) 15.8–22.3, (660) 15.9–22.4, (680) 16.0–22.6, (700) 16.3–22.7

Cell Data: *Space Group:* $P6_3mc$. $a = 5.781(1)$ $c = 10.060(1)$ Z = 2

X-ray Powder Pattern: Kamioka mine, Japan.
5.03 (100), 3.55 (90), 2.509 (75b), 2.430 (55), 2.006 (40), 2.785 (35), 1.5678 (35)

Chemistry:

	(1)	(2)	(3)
SiO_2		0.95	
TiO_2		1.06	
MoO_2	71.25	64.08	72.76
VO_2		2.31	
Al_2O_3		0.86	
Fe_2O_3		4.81	
FeO	27.04	23.11	27.24
MnO	0.41		
ZnO		0.45	
CuO		2.48	
Total	98.70	100.11	100.00

(1) Kamioka mine, Japan; by electron microprobe, average of three analyses; original analysis Fe 21.02%, Mn 0.32%, Mo 53.43%, here calculated to oxides; corresponding to $(Fe_{2.01}Mn_{0.03})_{\Sigma=2.04}Mo_{2.98}O_8$. (2) Mohawk mine, Michigan, USA; by electron microprobe, average of seven analyses, Fe^{2+}:Fe^{3+} from structural considerations; corresponds to $(Fe^{2+}_{1.54}Cu_{0.16}Fe^{3+}_{0.15}Si_{0.08}Al_{0.04}Zn_{0.03})_{\Sigma=2.00}(Mo_{2.52}Fe^{3+}_{0.15}V_{0.14}Fe^{2+}_{0.08}Ti_{0.07}Al_{0.04})_{\Sigma=3.00}O_8$. (3) $Fe_2Mo_3O_8$.

Occurrence: In quartz-molybdenite stockwork veins associated with granite porphyry dikes (Japan); in fissure veins filled during low-grade regional metamorphism of basalt (Michigan, USA).

Association: Molybdenite, potassic feldspar, fluorite, ilmenite, scheelite, quartz (Kamioka mine, Japan); domeykite, algodonite, nickeline, maucherite, koutekite, safflorite, silver, molybdenite, calcite (Michigan, USA); magnetite, ilmenite, molybdenite, graphite (Carajas deposit, Brazil).

Distribution: From the Kamioka Ag–Pb–Zn mine, Gifu Prefecture, Japan. In the USA, in the Mohawk and Ahmeek mines, Keweenaw Co., Michigan. From the Carajas deposit, locality not otherwise specified, Brazil.

Name: For the occurrence at the Kamioka mine, Japan.

Type Material: Geological Survey of Japan, Tsukuba, M17968; National Science Museum, Tokyo, Japan.

References: (1) Sasaki, A., S. Yui, and M. Yamaguchi (1985) Kamiokite, $Fe_2Mo_3O_8$, a new mineral. Mineral. J. (Japan), 12, 393–399. (2) (1988) Amer. Mineral., 73, 191 (abs. ref. 1). (3) Johan, Z. and P. Picot (1986) Kamiokite, $Fe_2Mo_3O_8$, a tetravalent molybdenum oxide: new data and occurrences. Tschermaks Mineral. Petrog. Mitt., 35, 67–75. (4) Endo, Y., Y. Kanazawa, and A. Sasaki (1986) External form of kamiokite crystals. Bull. Geol. Survey of Japan, 37, 367–371. (5) Kanazawa, Y. and A. Sasaki (1986) Structure of kamiokite. Acta Cryst., C42, 9–11.

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Kamitugaite $PbAl(UO_2)_5(PO_4, AsO_4)_2(OH)_9 \cdot 9.5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As thin tablets elongated along [100], with {010} dominant, {001} less developed, and terminated by {100} and {101}, to 0.5 mm.

Physical Properties: *Cleavage:* Good on {010} and {001}. Hardness = 3 (probable). D(meas.) = 4.03 D(calc.) = 4.47 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Bright yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless; Y = yellow. *Orientation:* $X \simeq b^*$; $Y \wedge a = 1°$–$2°$; $Z \perp a$ and b^*. α = [1.709] β = 1.735(2) γ = 1.744(2)
2V(meas.) = 60(3)°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.98(2)$ $b = 15.96(2)$ $c = 9.068(6)$
$\alpha = 95.1(2)°$ $\beta = 96.1(2)°$ $\gamma = 89.0(2)°$ Z = 2

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
7.95 (100), 3.972 (80), 3.271 (40), 3.175 (40), 15.92 (30), 3.493 (30), 4.307 (25)

Chemistry:

	(1)
UO_3	71.76
P_2O_5	5.48
As_2O_5	2.12
Al_2O_3	2.39
PbO	9.86
H_2O	[8.39]
Total	[100.00]

(1) Kobokobo pegmatite, Congo; by electron microprobe, average of three analyses, H_2O by difference; corresponding to $Pb_{0.90}Al_{0.96}(UO_2)_{5.10}[(P_{0.79}As_{0.19})_{\Sigma=0.98}O_4]_2(OH)_9 \cdot 9.5H_2O$.

Occurrence: A rare secondary mineral in the oxidized uraniferous zone of a complex granite pegmatite.

Association: Dumontite, studtite, triangulite, threadgoldite, phuralumite, upalite, mundite, metatorbernite, muscovite, albite, quartz.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: For Kamituga, Congo, the mining center on which exploitation of Kobokobo depended.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG13985, RMG13986.

References: (1) Deliens, M. and P. Piret (1984) La kamitugaïte, $PbAl(UO_2)_5[(P, As)O_4]_2(OH)_9 \cdot 9.5H_2O$, nouveau minéral de Kobokobo, Kivu, Zaïre. Bull. Minéral., 107, 15–19 (in French with English abs.). (2) (1985) Amer. Mineral., 70, 437 (abs. ref. 1).

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Kamotoite-(Y) $Y_2U_4^{6+}(CO_3)_3O_{12}\cdot 14.5H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As wedge-terminated bladed crystals, to 2 cm, striated perpendicular to elongation [100], and as crusts. *Twinning:* By reflection on {001}, common.

Physical Properties: *Cleavage:* {001} and {010}, good. *Tenacity:* Sectile. Hardness = n.d. D(meas.) = 3.93 D(calc.) = 3.94 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Bright lemon-yellow.
Luster: Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale yellow-green; Z = bright yellow. *Orientation:* $X = b$; $Z = a$; $Y \wedge c = 25°$. *Absorption:* $Z > Y > X$. $\alpha = 1.604(2)$ $\beta = 1.667(2)$ $\gamma = 1.731(3)$ 2V(meas.) = n.d. 2V(calc.) = 87°

Cell Data: *Space Group:* $P2_1/a$. $a = 21.22(1)$ $b = 12.93(1)$ $c = 12.39(1)$ $\beta = 115.3(1)°$ Z = 4

X-ray Powder Pattern: Kamoto mine, Congo.
6.48 (100), 8.49 (80), 3.054 (60), 3.49 (40), 2.762 (40), 2.132 (40b), 1.749 (40)

Chemistry:

	(1)
UO_3	63.39
Y_2O_3	6.19
Nd_2O_3	2.36
Sm_2O_3	1.91
Gd_2O_3	2.10
Dy_2O_3	1.64
CO_2	7.24
H_2O	[14.30]
Total	[99.13]

(1) Kamoto mine, Congo; by electron microprobe, average of 19 analyses on several specimens; CO_2 by chromatography, H_2O taken as loss on ignition less CO_2 on separate samples; corresponds to $(Y_{1.00}Nd_{0.26}Gd_{0.22}Sm_{0.20}Gd_{0.16})_{\Sigma=1.84}U_{4.07}(CO_3)_{3.02}O_{11.95}\cdot 14.55H_2O$.

Occurrence: Formed in the oxidized zone above a uranium-bearing Cu–Co deposit.

Association: Uraninite, uranophane, curite, schoepite, becquerelite, rutherfordine, kasolite, soddyite, schulingite-(Nd), astrocyanite-(Ce), shabaite-(Nd), françoisite-(Nd), masuyite, malachite.

Distribution: From the Kamoto mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire).

Name: For the occurrence at the Kamoto mine, Congo (Zaire), and its *yttrium* content.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG14025, RMG14350; National Museum of Natural History, Washington, D.C., USA, 163786.

References: (1) Deliens, M. and P. Piret (1986) La kamotoïte-(Y), un nouveau carbonate d'uranyle et de terres rares de Kamoto, Shaba, Zaïre. Bull. Minéral., 109, 643–647 (in French with English abs.). (2) (1988) Amer. Mineral., 73, 191 (abs. ref. 1).

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Kampfite $Ba_{12}(Si_{11}Al_5)O_{31}(CO_3)_8Cl_5$

Crystal Data: Monoclinic. *Point Group*: *m*. As irregular masses, to 1 cm.

Physical Properties: *Cleavage*: Perfect, {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3 D(meas.) = n.d. D(calc.) = 3.809

Optical Properties: Translucent. *Color*: Light blue-gray. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (-) [Probable]. α = 1.641(1) β = 1.642(1) γ (calc) = 1.642
2V = 20(5)° *Dispersion:* $r < v$, slight.

Cell Data: *Space Group*: *Cc*. a = 31.2329(7) b = 5.2398(1) c = 9.0966(3)
β = 106.933(2)° Z = 1

X-ray Powder Pattern: Rush Creek, California, USA.
14.67 (100), 3.883 (100), 2.616 (70), 2.988 (60), 3.357 (50), 2.887 (50), 1.969 (50)

Chemistry:

	(1)	(2)
Na_2O	0.08	0.06
CaO	0.06	-
SrO	-	0.10
BaO	57.72	56.74
SiO_2	20.14	19.75
Al_2O_3	7.76	8.06
CO_2	[5.69]	10.74
H_2O	[1.16]	-
Cl	5.60	5.33
$-O = Cl_2$	1.26	1.20
Total	96.95	99.69

(1) Rush Creek, California, USA; average of 3 electron microprobe analyses, H_2O and CO_3 confirmed by IR spectroscopy and calculated, corresponding to $(Ba_{5.83}Na_{0.04}Ca_{0.02})_{\Sigma=5.89}(Si_{5.18}Al_{2.36})_{\Sigma=7.54}O_{15.08}(CO_3)_2Cl_2[(H_2O)Cl_{0.45}]_{\Sigma=1.45}$. (2) Rush Creek, California, USA; average of 10 electron microprobe analyses of crystal used for structure determination, micro-IR spectroscopy did not detect H_2O; corresponding to $(Ba_{12.12}Na_{0.06}Sr_{0.03})_{\Sigma=12.21}(Si_{10.77}Al_{5.18}Ti_{0.05})_{\Sigma=16.00}C_{8.00}O_{55.14}Cl_{4.93}$.

Occurrence: In quartz-sanbornite bodies in contact metamorphic gneiss near a granodiorite pluton.

Association: Celsian, fresnoite, macdonaldite, titantaramellite, traskite, witherite, pyrrhotite.

Distribution: Esquire no. 1 claim, Rush Creek, eastern Fresno County, California, USA.

Name: Honors mineralogist Anthony Robert Kampf (b. 1948), Curator and Section Head of Minerals, Los Angeles County Museum of Natural History, California, USA.

Type Material: M.Y. Williams Museum, University of British Columbia, Vancouver, and Mineral Collection, Geological Survey of Canada, Ottawa, Canada.

References: (1) Basciano, L.C., L.A. Groat, A.C. Roberts, J.D. Grice, G.E. Dunning, E.E. Foord, I.M. Kjarsgaard, and R.E. Walstrom (2001) Kampfite, a new barium silicate carbonate mineral species from Fresno County, California. Can. Mineral. 39, 1053–1058. (2) Basciano, L.C., and L.A. Groat (2007) The crystal structure of kampfite. Can. Mineral., 45, 935–943. (3) (2002) Amer. Mineral., 87, 766 (abs. ref. 1). (4) (2008) Amer. Mineral., 93, 705-706 (abs. ref. 2).

Kamphaugite-(Y) $CaY(CO_3)_2(OH)\cdot H_2O$

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Crystal Data: Tetragonal. *Point Group:* 422. Crystals are rough, platy on {001}, with a square or octagonal outline, commonly in subparallel aggregates forming rosettes or spherules, to 4 mm; also as fine-grained masses and coatings.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–3
D(meas.) = 3.19(5) D(calc.) = 3.11

Optical Properties: Transparent to translucent. *Color:* White to colorless, may be pale brown, pale yellow, or grayish brown. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+), anomalously biaxial (+). *Orientation:* $X = c$. $\omega = 1.611$–1.620 $\epsilon = 1.636$–1.642 $\alpha = 1.627(2)$ $\beta = 1.663(2)$ $\gamma = 1.663(2)$ 2V(meas.) = $\sim 15°$

Cell Data: *Space Group:* $P4_12_12$. $a = 7.434(1)$ $c = 21.793(3)$ $Z = 8$

X-ray Powder Pattern: Hørtekollen deposit, Norway.
6.140 (100), 2.631 (90), 4.381 (80), 3.516 (60), 2.831 (50), 1.891 (30), 2.723 (20)

Chemistry:

	(1)	(2)
CO_2	29.6	31.00
Y_2O_3	30.5	39.75
Nd_2O_3	1.4	
Sm_2O_3	0.8	
Gd_2O_3	1.6	
Dy_2O_3	2.1	
Er_2O_3	1.2	
Yb_2O_3	1.1	
CaO	18.4	19.74
H_2O	12.1	9.51
Total	98.8	100.00

(1) Hørtekollen deposit, Norway; by electron microprobe, average of five analyses, BeO 0.8% by AA from helvite subtracted, CO_2 and H_2O by CHN analyzer; corresponds to $Ca_{0.98}(Y_{0.80}RE_{0.14})_{\Sigma=0.94}(CO_3)_2(OH)_{0.77}\cdot 1.61H_2O$. (2) $CaY(CO_3)_2(OH)\cdot H_2O$.

Occurrence: A late, low-temperature mineral formed in a contact-metamorphic skarn (Hørtekollen deposit, Norway); in metasomatically altered alkali granite (Kazakhstan); in a quartz–barite vein in a carbonatized volcano (South Africa).

Association: Kuliokite-(Y) (Norway); gagarinite (Kazakhstan); kainosite-(Y), hingganite-(Y) (Cal Francese, Sardinia, Italy); caysichite-(Y), donnayite-(Y), decrespignyite-(Y) (Paratoo mine, Australia).

Distribution: In Norway, from the Hørtekollen deposit, Lier, Buskerud; at the Høydalen granite pegmatite, Tørdal, Telemark; and in the Tangen granite pegmatite, near Kragerø. From the Cala Francese, Sardinia, Italy. At an undisclosed locality [Verkhne-Espe alkaline massif, Tarbagatai Range], Kazakhstan. From an undefined locality [Mt. Ploskaya, Keivy massif], Kola Peninsula, Russia. At Szarvaskő, Bükk Mountains, Hungary. On the Goudini volcano, Transvaal, South Africa. In the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada. At the Gronci-Ellis granite quarry, Mount Desert, Hancock Co., Maine, USA. From the Paratoo copper mine, 30 km southwest of Yunta, Olary district, South Australia.

Name: To honor Erling Kamphaug (1931–), Norwegian mineral collector, who supplied the first specimens.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway, 14769.

References: (1) Raade, G. and K. Brastad (1993) Kamphaugite-(Y), a new hydrous Ca-(Y,REE)-carbonate mineral. Eur. J. Mineral., 5, 679–683. (2) Rømming, C., A.K. Kocharian, and G. Raade (1993) The crystal structure of kamphaugite-(Y). Eur. J. Mineral., 5, 685–690. (3) (1994) Amer. Mineral., 79, 387–388 (abs. refs. 1–2).

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Kanemite $NaHSi_2O_4(OH)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals platy with {010} dominant; in spherulites, to 2 mm, isolated and as aggregations.

Physical Properties: *Cleavage:* Perfect on {010}, good on {100}. Hardness = ∼4 D(meas.) = 1.926(4) D(calc.) = 1.933

Optical Properties: Translucent to transparent. *Color:* White to brown. *Luster:* Silky. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.451(2)$ $\beta = 1.470(2)$ $\gamma = 1.478(2)$ 2V(meas.) = 46(2)°

Cell Data: *Space Group: Pnmb.* $a = 7.282(2)$ $b = 20.507(5)$ $c = 4.956(1)$ $Z = 4$

X-ray Powder Pattern: Andjia, Chad.
10.33 (10), 4.014 (10), 3.435 (9), 2.480 (8), 3.162 (7), 3.093 (7), 2.386 (6)

Chemistry:

	(1)	(2)
SiO_2	56.68	57.5
Al_2O_3	0.40	
CaO	0.20	0.5
Na_2O	13.25	13.2
K_2O	0.10	1.2
$H_2O(>280°)$	4.25	
$H_2O(170°-280°)$	8.45	
$H_2O(<170°)$	16.30	
H_2O		27.5
Total	99.63	99.9

(1) Andjia, Chad; corresponding to $(Na_{0.93}K_{0.07})_{\Sigma=1.00}H_{1.03}(Si_{2.06}Al_{0.01})_{\Sigma=2.07}O_{4.13}(OH)_{2.04} \cdot 1.97H_2O$. (2) Lake Bogoria, Kenya; by AA, H_2O by TGA.

Occurrence: In evaporites in an interdunary depression (Andjia, Chad).

Association: Gaylussite, trona (Andjia, Chad); magadiite, analcime, mordenite (Lake Bogoria, Kenya).

Distribution: In the Kanem region, near Andjia, Chad. From Lake Bogoria, Rift Valley, Kenya.

Name: After Kanem, a region on the northeastern edge of Lake Chad, Chad, where the mineral was discovered.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 123219, 142501.

References: (1) Johan, Z. and G.F. Maglione (1972) La kanemite, nouveau silicate de sodium hydraté de néoformation. Bull. Soc. fr. Minéral., 95, 371–382 (in French with English abs.). (2) (1974) Amer. Mineral., 59, 210 (abs. ref. 1). (3) Perinet, G., J.-J. Tiercelin, and C.E. Barton (1982) Présence de kanemite dans les sédiments récents du lac Bogoria, Rift Gregory, Kenya. Bull. Minéral., 105, 633–639 (in French with English abs.). (4) Beneke, K. and G. Lagaly (1977) Kanemite – innercrystalline reactivity and relations to other sodium silicates. Amer. Mineral., 62, 763–771.

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Kaňkite **$Fe^{3+}AsO_4 \cdot 3.5H_2O$**

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Crystal Data: Monoclinic. *Point Group:* n.d. As spherulites and botyroidal crusts of fibrous to elongated tabular spearlike crystals, less than 10 μm.

Physical Properties: *Fracture:* Uneven. Hardness = 2–3 D(meas.) = 2.60–2.70 D(calc.) = 2.732

Optical Properties: Translucent. *Color:* Yellowish green, paler greenish yellow on exposure to air; very pale grayish yellow to pale yellow in transmitted light. *Streak:* Grayish yellow. *Luster:* Dull to vitreous.
Optical Class: Biaxial. *Orientation:* Length-fast. $\alpha = 1.664(2)$ β = n.d. $\gamma = 1.680(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 18.803(15)$ $b = 17.490(18)$ $c = 7.633(5)$ $\beta = 92.71(5)^\circ$ Z = 16

X-ray Powder Pattern: Kaňk, Czech Republic.
12.8 (100), 4.764 (34), 2.630 (29), 7.56 (25), 4.258 (25), 3.697 (22b), 7.22 (21)

Chemistry:

	(1)	(2)	(3)
SO_3	0.41	2.25	
As_2O_5	43.92	41.11	44.57
Fe_2O_3	31.84	35.02	30.97
H_2O^+	13.91		
H_2O^-	9.91		
H_2O		21.00	24.46
Total	[99.99]	99.38	100.00

(1) Kaňk, Czech Republic; presence of SO_4, AsO_4, and H_2O confirmed by IR; original total 100.40%, after deduction of gypsum and quartz impurities, corresponds to $Fe_{1.02}(As_{0.97}S_{0.07})_{\Sigma=1.04}O_4 \cdot 3.37H_2O$. (2) Suzukura mine, Japan; corresponds to $Fe_{1.07}(As_{0.87}S_{0.07})_{\Sigma=0.94}O_4 \cdot 2.85H_2O$. (3) $Fe(AsO_4) \cdot 3.5H_2O$.

Occurrence: A rare secondary mineral in highly weathered mine dumps containing arsenopyrite (Kaňk, Czech Republic).

Association: Scorodite, pitticite, parascorodite, zýkaite, arsenopyrite, gypsum, "limonite", quartz (Kaňk, Czech Republic); scorodite, parascorodite, vajdakite, arsenic, pyrite, proustite (Svornost mine, Czech Republic).

Distribution: From the Šafary and Kuntery mine dumps, near Kaňk, Kutná Hora district, and in the Svornost mine, Jáchymov (Joachimsthal), Czech Republic. In Germany, at Munzig, near Meissen, and at Brand-Erbisdorf, Saxony; from Menzenschwand, Black Forest. In England, at the King's Wood mine, Buckfastleigh, Devon, and from the South Terras mine, St. Stephen-in-Brannel, Cornwall. At the Suzukura mine, seven km north-northeast of Enzan, Yamanashi Prefecture, Japan.

Name: For the locality that yielded the first specimens, Kaňk, Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 20135; National Museum of Natural History, Washington, D.C., USA, 144939.

References: (1) Čech, F., J. Jansa, and F. Novák (1976) Kaňkite, $FeAsO_4 \cdot 3\frac{1}{2}H_2O$, a new mineral. Neues Jahrb. Mineral., Monatsh., 426–436. (2) (1977) Amer. Mineral., 62, 594 (abs. ref. 1). (3) Kato, A., S. Matsubara, K. Nagashima, I. Nakai, and M. Shimizu (1984) Kaňkite from the Suzukura mine, Enzan city, Yamanashi Prefecture, Japan. Mineral. J. (Japan), 12, 6–14.

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Kanoite $(Mn^{2+},Mg)_2Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, (probable). As grains up to 0.1 mm. *Twinning:* Polysynthetic on {100}, common.

Physical Properties: *Cleavage:* Perfect on {110}, (110) $\wedge$ $(1\bar{1}0)$ ~88°. Hardness = 6
D(meas.) = 3.66 D(calc.) = 3.60

Optical Properties: Semitransparent. *Color:* Light pinkish brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 42°$. $\alpha = 1.715(2)$ $\beta = 1.717(2)$ $\gamma = 1.728(2)$ 2V(meas.) = 40°–42°

Cell Data: *Space Group:* $P2_1/c$ (probable). $a = 9.739$ $b = 8.939$ $c = 5.260$ $\beta = 108.56°$ Z = 4

X-ray Powder Pattern: Tatehira, Japan.
3.211 (100), 3.021 (90), 2.910 (90), 2.921 (80), 2.493 (40), 1.627 (40), 2.573 (30)

Chemistry:

	(1)
SiO_2	50.20
Al_2O_3	0.04
Fe_2O_3	0.39
FeO	2.64
MnO	31.19
MgO	15.08
CaO	[0.61]
Na_2O	0.03
K_2O	0.03
Total	[100.21]

(1) Tatehira, Japan; by electron microprobe, average of three analyses; Fe_2O_3, FeO, Na_2O, and K_2O by wet chemical analysis; original CaO 0.57% and original total given as 100.17%; corresponds to $(Mn^{2+}_{1.04}Mg_{0.88}Fe^{2+}_{0.09}Ca_{0.02}Fe^{3+}_{0.01})_{\Sigma=2.04}Si_{1.97}O_6$.

Polymorphism & Series: Dimorphous with donpeacorite.

Mineral Group: Pyroxene group.

Occurrence: In a seam cutting a pyroxmangite-cummingtonite metamorphic rock.

Association: Spessartine, manganoan cummingtonite, pyroxmangite.

Distribution: From near Tatehira, Oshima Peninsula, Hokkaido, Japan.

Name: To honor Dr. Hiroshi Kano, Professor of Petrology, Akita University, Akita, Japan.

Type Material: Shimane University, Matuse; National Science Museum, Tokyo, Japan, M21331.

References: (1) Kobayashi, H. (1977) Kanoite, $(Mn^{2+},Mg)_2[Si_2O_6]$, a new clinopyroxene in the metamorphic rock from Tatehira, Oshima Peninsula, Hokkaido, Japan. J. Geol. Soc. Japan, 83, 537–542. (2) (1978) Amer. Mineral., 63, 598 (abs. ref. 1).

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Kanonaite $(Mn^{3+}, Al)AlSiO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As anhedral nodular porphyroblasts, to 1.2 cm.

Physical Properties: *Cleavage:* Poor on {110}. Hardness = 6.5 VHN = 906–1017 (100 g load). D(meas.) = n.d. D(calc.) = 3.395

Optical Properties: Transparent to translucent. *Color:* Greenish black. *Streak:* Gray-green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = yellow-green; Y = bluish green; Z = deep golden yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.702$ $\beta = 1.730$ $\gamma = 1.823$
2V(meas.) = 53(3)°

Cell Data: *Space Group: Pnnm.* $a = 7.959(2)$ $b = 8.047(2)$ $c = 5.616(1)$ Z = 4

X-ray Powder Pattern: Kanona, Zambia.
5.669 (100), 2.827 (94), 3.577 (90), 2.517 (90), 2.212 (83), 4.590 (75), 2.299 (69)

Chemistry:

	(1)	(2)
SiO_2	32.2	32.48
TiO_2	0.01	
Al_2O_3	33.9	31.60
Fe_2O_3	0.66	2.57
Mn_2O_3	32.2	33.48
CuO	0.01	
ZnO	0.13	
PbO	0.01	
MgO	0.04	
CaO	0.01	
BaO	0.04	
Total	99.21	100.13

(1) Kanona, Zambia; by electron microprobe; corresponds to $(Mn^{3+}_{0.76}Al_{0.23}Fe^{3+}_{0.02})_{\Sigma=1.01}Al_{1.00}Si_{0.99}O_5$. (2) Salmchâteau, Belgium; by electron microprobe, corresponds to $(Mn^{3+}_{0.79}Al_{0.15}Fe^{3+}_{0.06})_{\Sigma=1.00}Al_{1.00}Si_{1.00}O_5$.

Polymorphism & Series: Forms a series with andalusite.

Occurrence: Formed under low-grade metamorphic conditions, in a gahnite schist (Kanona, Zambia); in a schist (Salmchâteau, Belgium).

Association: Gahnite, magnesian chlorite, coronadite, braunite (Kanona, Zambia); quartz, muscovite, paragonite, chlorite, hematite, braunite, rutile, apatite (Salmchâteau, Belgium).

Distribution: From 13 km north of Kanona, Serenje, Zambia. On the Salm River, one km north of Salmchâteau, near Ottré, Ardennes Mountains, Belgium.

Name: For Kanona, near the locality in Zambia.

Type Material: Charles University, Prague, Czech Republic, 17352; National Museum of Natural History, Washington, D.C., USA, 144523.

References: (1) Vrána, S., M. Rieder, and J. Podlaha (1978) Kanonaite, $(Mn^{3+}_{0.76}Al_{0.23}Fe^{3+}_{0.02})^{[6]}Al^{[5]}[O|SiO_4]$, a new mineral isotypic with andalusite. Contr. Mineral. Petrol., 66, 325–332.
(2) (1979) Amer. Mineral., 64, 655 (abs. ref. 1). (3) Kramm, U. (1979) Kanonaite-rich viridines from the Venn-Stavelot massif, Belgian Ardennes. Contr. Mineral. Petrol., 69, 387–395.
(4) Weiss, Z., S.W. Bailey, and M. Rieder (1981) Refinement of the crystal structure of kanonaite, $(Mn^{3+}, Al)^{[6]}(Al, Mn^{3+})^{[5]}O[SiO_4]$. Amer. Mineral., 66, 561–567. (5) Gunter, M. and F.D. Bloss (1982) Andalusite-kanonaite series: lattice and optical parameters. Amer. Mineral., 67, 1218–1228.

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Kanonerovite $MnNa_3P_3O_{10}\cdot 12H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Wedgelike crystals are tabular on {001}, also showing {111}, {$\overline{1}$11}, to 2 mm, in sprays.

Physical Properties: Hardness = Soft. D(meas.) = 2.35 D(calc.) = 2.379

Optical Properties: Transparent to translucent. *Color:* Colorless, white, beige. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.566$ $\beta = 1.574$ $\gamma = 1.582$ 2V(meas.) = n.d. 2V(calc.) = 91°–95°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.0102(3)$ $b = 10.2050(7)$ $c = 10.5040(7)$ $\alpha = 71.82(1)°$ $\beta = 89.62(1)°$ $\gamma = 69.90(1)°$ Z = 2

X-ray Powder Pattern: Waidhaus, Germany.
9.917 (100), 4.957 (50), 6.541 (36), 3.001 (30), 3.095 (28), 1.653 (25), 3.312 (23)

Chemistry:

	(1)
P_2O_5	37.96
Al_2O_3	24.49
FeO	6.07
MnO	11.30
MgO	0.64
H_2O	[19.54]
Total	[100.00]

(1) Waidhaus, Germany; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by difference; corresponds to $(Mn_{0.66}Fe_{0.35}Mg_{0.06})_{\Sigma=1.07}Al_{2.00}(P_{1.12}O_4)_2(OH)_2 \cdot 3.56H_2O$.

Polymorphism & Series: Dimorphous with mangangordonite.

Occurrence: A rare secondary mineral in a zoned granite pegmatite.

Association: Variscite, paravauxite, albite, mica, quartz.

Distribution: From the Silbergrube quarry, near Waidhaus, and at Hagendorf, Bavaria, Germany.

Name: To honor Jürgen Kastning, mineral collector and dealer, Reinbek, near Hamburg, Germany, who found the original material.

Type Material: Mineralogical Museum, University of Hamburg, Hamburg, Germany.

References: (1) Schlüter, J., K.-H. Klaska, K. Friese, and G. Adiwidjaja (1999) Kastningite, $(Mn, Fe, Mg)Al_2(PO_4)_2(OH)_2 \cdot 8H_2O$, a new phosphate mineral from Waidhaus, Bavaria, Germany. Neues Jahrb. Mineral., Monatsh., 40–48. (2) (1999) Amer. Mineral., 84, 1465–1466 (abs. ref. 1).

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Kaolinite $Al_2Si_2O_5(OH)_4$

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Crystal Data: Triclinic. *Point Group:* 1. Rarely as crystals, thin platy or stacked, to 2 mm. More commonly as microscopic pseudohexagonal plates and clusters of plates, aggregated into compact, claylike masses.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible but inelastic. Hardness = 2–2.5 D(meas.) = 2.61–2.68 D(calc.) = 2.63

Optical Properties: Transparent to translucent as single crystals. *Color:* White to tan, may be variously colored by impurities. *Luster:* Pearly to dull earthy.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = -13°$ to $-10°$; $Y \wedge a = 1°$–$4°$.
Dispersion: $r > v$, weak. $\alpha = 1.553$–1.565 $\beta = 1.559$–1.569 $\gamma = 1.560$–1.570
2V(meas.) = 24°–50°

Cell Data: *Space Group:* $P1$. $a = 5.15$ $b = 8.95$ $c = 7.39$ $\alpha = 91.8°$ $\beta = 104.5°-105.0°$ $\gamma = 90°$ Z = [2]

X-ray Powder Pattern: Scalby, Yorkshire, England (1A).
7.16 (vvs), 3.573 (vvs), 4.336 (vs), 2.491 (s), 2.289 (s), 2.558 (ms), 2.379 (ms)

Chemistry:

	(1)
SiO_2	45.80
Al_2O_3	39.55
Fe_2O_3	0.57
FeO	0.18
MgO	0.14
CaO	0.41
K_2O	0.03
H_2O^+	13.92
H_2O^-	0.17
Total	100.77

(1) Mikawo mine, Niigata Prefecture, Japan; corresponds to $(Al_{2.00}Fe^{3+}_{0.02}Mg_{0.01}Ca_{0.02})_{\Sigma=2.05}Si_2O_5(OH)_{3.99}$.

Polymorphism & Series: Dickite, halloysite, and nacrite are polymorphs.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Replaces other aluminosilicate minerals during hydrothermal alteration and weathering. A common constituent of the clay-size fraction of sediments, where it may be formed by direct precipitation.

Association: Quartz, feldspar, muscovite.

Distribution: Pure material from many localities, including: at Kauling, Kiangsi Province, China. In numerous china-clay pits in Cornwall and Devon, England. At Limoges, Haute-Vienne, France. Near Dresden, Kemmlitz, and Zettlitz, Saxony, and elsewhere in Germany. Large deposits in the Donets Basin, Ukraine. In the USA, at Macon, Bibb Co., Georgia; at the Dixie Clay Company mine, and in the Lamar Pit, near Bath, Aikin Co., South Carolina; near Webster, Jackson Co., North Carolina; near Murfreesboro, Pike Co., and at Greenwood, Sebastian Co., Arkansas; from Mesa Alta, Rio Arriba Co., New Mexico. At Huberdeau, Quebec, and near Walton, Nova Scotia, Canada.

Name: From a corruption of the Chinese *Kauling*, *high ridge*, for a Chinese occurrence.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 684–687. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 194–212. (3) Brindley, G.W. and K. Robinson (1946) The structure of kaolinite. Mineral. Mag., 27, 242–253. (4) Goodyear, J. and W.J. Duffin (1961) An X-ray examination of an exceptionally well crystallized kaolinite. Mineral. Mag., 32, 902–907. (5) Young, R.A. and A.W. Hewat (1988) Verification of the triclinic crystal structure of kaolinite. Clays and Clay Minerals, 36, 225–232.

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Kapustinite $Na_{5.5}Mn_{0.25}ZrSi_6O_{16}(OH)_2$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As equant grains to 4 cm; in clusters to 8 cm.

Physical Properties: *Cleavage:* None. *Fracture:* Conchoidal. *Tenacity:* Brittle.
Hardness = 6 D(meas.) = 2.78(1) D(calc.) = 2.815

Optical Properties: Transparent to translucent. *Color:* Dark cherry-red. *Streak:* Pale lilac.
Luster: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.585(2)$ $\beta = \gamma = 1.589(2)$ 2V(meas) = <5° 2V(calc) = 0°
Dispersion: None. *Pleochroism*: *None*.

Cell Data: *Space Group: C*2/*m*. $a = 10.693(4)$ $b = 10.299(4)$ $c = 7.373(4)$ $\beta = 91.91(5)°$ Z = 2

X-ray Powder Pattern: Kedykverpakhk Mountain, Kola Peninsula, Russia.
2.651 (100), 3.270 (92), 2.580 (91), 3.342 (84), 5.313 (51), 3.690 (43), 1.849 (39)

Chemistry:

	(1)		(1)
Na_2O	24.42	Ce_2O_3	0.20
K_2O	0.02	Nd_2O_3	0.24
MgO	0.02	SiO_2	52.82
CaO	0.18	TiO_2	0.54
MnO	2.36	ZrO_2	16.38
ZnO	0.05	UO_2	0.28
Fe_2O_3	0.36	H_2O	2.80
Y_2O_3	0.17	Total	100.84

(1) Kedykverpakhk Mountain, Kola Peninsula, Russia; electron microprobe analysis, H_2O by Penfield method, corresponding to $Na_{5.38}Y_{0.01}Ce_{0.01}Nd_{0.01}U_{0.01}Ca_{0.02}Mn_{0.23}Fe_{0.03}Ti_{0.05}Zr_{0.91}Si_6O_{15.91}(OH)_{2.12}$.

Mineral Group: Lovozerite group, zirsinalite–lovozerite subgroup.

Occurrence: In hyperagpaitic pegmatite in an alkaline massif.

Association: Microcline, aegirine, kazakovite, ussingite, sodalite, analcime, natrosilite, villiaumite.

Distribution: From the Palitra pegmatite, Kedykverpakhk Mountain, Lovozero alkaline massif, Kola Peninsula, Russia.

Name: Honors mineralogist Yu. L. Kapustin (1933–2002), who extensively studied alkaline massifs.

Type Material: A.E. Fersman Mineralogical Museum, Moscow, Russia.

References: (1) Pekov, I.V., N.V. Chukanov, N.A. Yamnova, Yu.K. Egorov-Tismenko, and A.E. Zadov (2003) Kapustinite, $Na_{5.5}Mn_{0.25}ZrSi_6O_{16}(OH)_2$, a new mineral from the Lovozero massif (Kola Peninsula) and new data on the genetic crystallochemistry of the Lovozerite group. Zapiski Vseross. Mineral. Obshch., 132(6), 1–14 (in Russian, English abs.). (2) Yamnova, N.A., Yu.K. Egorov-Tismenko, I.V. Pekov, and L.V. Shchegol'kova (2004) Crystal structure of kapustinite $Na_{5.5}Mn_{0.25}Zr[Si_6O_{16}(OH)_2]$, a new mineral of the lovozerite group. Doklady Akad. Nauk, 396, 680–685 (in Russian). (3) (2005) Amer. Mineral., 90, 271-272 (abs. refs. 1& 2). (4) Pekov, I.V., S.V. Krivovichev, A.A. Zolotarev, V.N. Yakovenchuk, T. Armbruster and Y.A. Pakhomovsky (2009) Crystal chemistry and nomenclature of the lovozerite group. Eur. J. Mineral., 21, 1061–1071.

Karasugite $SrCaAl(F,OH)_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals very thin bladed, twinned and flattened on {100} and elongated along [001], to 0.25 mm, in rosettes and fan-shaped aggregates. *Twinning:* On {100} as composition and twin plane.

Physical Properties: *Cleavage:* Perfect on {100}, may be a parting. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.06–3.11 D(calc.) = 3.206

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge c \simeq 7°$. $\alpha = 1.4240(5)$ $\beta = 1.4320(5)$ $\gamma = 1.4415(5)$ 2V(meas.) = 94.5(2.0)° 2V(calc.) = 94°

Cell Data: *Space Group:* $P2_1/c$. $a = 8.215(5)$ $b = 11.989(3)$ $c = 6.076(3)$ $\beta = 96.22(1)°$ Z = 4

X-ray Powder Pattern: Karasug deposit, Russia.
4.25 (10), 3.64 (8), 3.06 (8), 2.125 (8), 6.76 (7), 3.15 (7), 3.03 (7)

Chemistry:

	(1)	(2)
Na	0.04	0.43
K	0.05	0.33
Ca	14.32	13.05
Sr	29.91	29.12
Al	10.08	9.13
O	[15.12]	7.05
H	[0.95]	[0.44]
F	29.53	40.20
Total	[100.00]	[99.75]

(1) Karasug deposit, Russia; by electron microprobe, average of four analyses, $(OH)^{1-}$ by difference and charge balance; corresponds to $Sr_{1.02}Ca_{0.96}Al_{1.01}[F_{4.19}(OH)_{2.54}]_{\Sigma=6.73}$. (2) Do.; by electron microprobe, average of 12 analyses, O directly determined, $(OH)^{1-}$ by difference and charge balance; corresponds to $Sr_{1.02}(Ca_{0.90}Na_{0.05}K_{0.02})_{\Sigma=0.97}Al_{0.94}[F_{5.85}(OH)_{1.22}]_{\Sigma=7.07}$.

Occurrence: A secondary mineral formed in fissures in the oxidation zone of veins of iron ores in tectonic breccias.

Association: Gearksutite, tikhonenkovite, fluorite, barian celestine, "limonite", hematite, quartz.

Distribution: In the Karasug F–RE–barite–fluorite deposit, 15 km north of Karasug, western Tannu-Ola Mountains, Tuva, Siberia, Russia.

Name: For its occurrence in the Karasug deposit, Russia.

Type Material: University of Copenhagen, Copenhagen, Denmark; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Petersen, O.V., A.P. Khomyakov, E.S. Leonardsen, H.I. Micheelsen, and O. Johnsen (1994) Karasugite, $SrCaAl[F,(OH)]_7$, a new mineral species from the Karasug Fe–REE–barite–fluorite deposit, Tannu-Ola Range, South Siberia, Russia. Neues Jahrb. Mineral., Monatsh., 209–216. (2) (1995) Amer. Mineral., 80, 185 (abs. ref. 1).

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Karchevskyite $Mg_{18}Al_9(OH)_{54}Sr_2(CO_3,PO_4)_9(H_2O,H_3O)_{11}$

Crystal Data: Hexagonal. *Point Group*: n.d. As thin bent plates; as spherulites, to 1.5 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: Flexible. Hardness = 2 D(meas.) = 2.21(2) D(calc.) = 2.18(1)

Optical Properties: Transparent. *Color*: Colorless; white in aggregates.
Luster: Vitreous, pearly on cleavage surfaces.
Optical Class: Uniaxial (-). $\omega = 1.542(2)$ $\varepsilon = 1.534(2)$ Anomalously biaxial, with 2V = 20°.

Cell Data: *Space Group*: $P\bar{3}$, *P*3, $P\bar{3}$ 1*m*, *P*31*m*, $P\bar{3}$ *m*1, *P*3*m*1, *P*312, or *P*321.
$a = 16.055(6)$ $c = 25.66(1)$ $Z = 3$

X-ray Powder Pattern: Zhelezny open-pit mine, Kovdor massif, Kola Peninsula, Russia.
8.52 (100), 3.665 (90), 3.547 (90), 4.27 (60), 3.081 (60), 6.41 (40), 5.13 (30)

Chemistry:

	(1)
Al_2O_3	18.3
MgO	29.7
CaO	0.2
SrO	7.4
P_2O_5	1.3
CO_2	14.5
H_2O	28.6
Total	100.0

(1) Zhelezny open-pit mine, Kovdor carbonatite massif, Kola Peninsula, Russia; average of 10 electron microprobe analyses, H_2O by difference, IR confirms OH, CO_3, H_3O and H_2O, corresponding to $Mg_{18.00}Al_{9.00}(OH)_{54}(Sr_{1.79}Mg_{0.48}Ca_{0.09})_{\Sigma=2.36}(CO_3)_{8.26}(PO_4)_{0.46}(H_2O)_{6.34}(H_3O)_{4.18}$.

Occurrence: A late-stage hydrothermal mineral, finely intergrown with quintinite-3T, in cavities in dolomite in a carbonatite complex.

Association: Dolomite, magnetite, quintinite-3T, strontium carbonate-fluorapatite.

Distribution: Zhelezny open-pit mine, Kovdor carbonatite massif, Kola Peninsula, Russia.

Name: Honors Russian mineralogist Pavel Karchevsky (1976–2002) for significant contributions to the study of carbonatites.

Type Material: Mineralogical Museum, St. Petersburg State University, and at the A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia.

References: (1) Britvin, S.N., N.V. Chukanov, G.K. Bekenova, M.A. Yagovkina, A.V. Antonov, A.N. Bogdanova, and N.I. Krasnova (2007) Karchevskyite, $[Mg_{18}Al_9(OH)_{54}][Sr_2(CO_3,PO_4)_9(H_2O,H_3O)_{11}]$, a new mineral species of the layered double hydroxide family. Zap. Ross. Mineral. Obshch., 136(5), 20–23 (in Russian, English abstract), Geol. Ore Deposits, 50, 556–564 (2008; in English). (2) (2010) Amer. Mineral., 95, 1598-1599 (abs. ref. 1).

Karelianite V_2O_3

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Crystal Data: Hexagonal. *Point Group:* $[\overline{3}\ 2/m]$ (by analogy to the hematite group). As prismatic grains, to 0.5 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 8–9 VHN = 1790 (50 g load). D(meas.) = n.d. D(calc.) = [4.95]

Optical Properties: Opaque. *Color:* Black; brownish olive-gray in reflected light.
Streak: Black.
Optical Class: Uniaxial. *Anisotropism:* Strong; reddish brown to gray. *Bireflectance:* Weak.
R: (400) 14.3, (420) 14.4, (440) 14.5, (460) 14.8, (480) 15.2, (500) 15.8, (520) 16.3, (540) 16.8, (560) 17.2, (580) 17.6, (600) 18.0, (620) 18.3, (640) 18.7, (660) 19.2, (680) 19.8, (700) 20.6

Cell Data: *Space Group:* $R\overline{3}c$. a = 4.99 c = 13.98 Z = 6

X-ray Powder Pattern: Outokumpu mine, Finland; close to hematite.
1.70 (100), 2.71 (90), 2.49 (80), 3.67 (70), 1.44 (40), 1.84 (25), 2.20 (20)

Chemistry:

	(1)
Fe_2O_3	4.1
V_2O_3	92.9
Cr_2O_3	3.7
MnO	1.5
Total	102.2

(1) Outokumpu mine, Finland; by electron microprobe.

Mineral Group: Hematite group.

Occurrence: In sulfide-rich portions of glacial boulders derived from high-grade metamorphic rocks, as schists and quartzites (Outokumpu mine, Finland); in primary unoxidized U–V ores (Mounana mine, Gabon); in vanadiferous anthraxolite bitumen (Guangxi, China).

Association: Pyrrhotite, chalcopyrite, pyrite, tremolite, graphite, titanite, quartz (Outokumpu mine, Finland); corvusite, montroseite, uraninite, quartz (Mounana mine, Gabon); millerite, violarite, montroseite (Guangxi, China).

Distribution: At the Outokumpu mine, northern Karelia, Finland. From the Roter Bär mine, St. Andreasberg, Harz Mountains, Germany. In Russia, near Lake Baikal, Siberia, in the Slyudyanka complex, Sayan Mountains, and 4.5 km south of Olkhon Gate Strait. In the Shanglin and Hechi bitumens, Guangxi, Zhuang Autonomous Region, China. From the Mounana uranium mine, Franceville, Gabon. At the Urcal deposit, La Rioja Province, Argentina. In the Hemlo gold mine, Thunder Bay district, Ontario, Canada.

Name: For the Karelian schist belt, the region of Finland where the mineral occurs.

Type Material: National Museum of Natural History, Washington, D.C., USA, 121785 and 121786.

References: (1) Long, J.V.P., Y. Vuorelainen, and O. Kouvo (1963) Karelianite, a new vanadium mineral. Amer. Mineral., 48, 33–41. (2) Finger, L.W. and R.M. Hazen (1980) Crystal structure and isothermal compression of Fe_2O_3, Cr_2O_3, and V_2O_3 to 50 kbars. J. Appl. Phys., 51, 5362–5367.

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Karibibite $Fe_2^{3+}As_4^{3+}(O,OH)_9$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As sharply pointed, spindle-shaped bundles of radiating fibers, to 1 mm, with anhedral individuals, < 1 μ thick. Also massive, cross-vein fibrous, or as reticulated coatings.

Physical Properties: *Cleavage:* Possibly on {100} or {010}, as indicated by preferred orientation of fibers. *Tenacity:* Flexible. Hardness = Very soft. D(meas.) = 4.07 D(calc.) = 4.04 Paramagnetic; may fluoresce yellow under SW UV.

Optical Properties: Transparent. *Color:* Brownish yellow, pale to brownish orange. *Streak:* Bright yellow.
Optical Class: Biaxial (–). *Pleochroism:* Weak; light brownish yellow to straw-yellow.
Orientation: $Z \parallel$ fiber axis. $\alpha = 1.96$ $\beta =$ n.d. $\gamma = > 2.10$ 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. $a = 27.91(4)$ $b = 6.53(2)$ $c = 7.20(3)$ Z = 6

X-ray Powder Pattern: Karibib, Namibia.
2.384 (100), 3.176 (80), 2.802 (80), 3.088 (70), 3.496 (50), 2.672 (45), 6.35 (40)

Chemistry:

	(1)	(2)
Fe_2O_3	29.1	28.69
As_2O_3	68.8	71.14
H_2O^+	1.7	
H_2O^-	0.2	
H_2O		0.28
Total	99.8	100.11

(1) Karibib, Namibia; absence of arsenate groups confirmed by IR; corresponds to $Fe^{3+}_{1.95}As^{3+}_{3.72}O_{7.98}(OH)_{1.02}$. (2) Urucum pegmatite, Brazil.

Occurrence: In granite pegmatites.

Association: Löllingite, eosphorite, scorodite, quartz (Karibib, Namibia); löllingite, scorodite, schneiderhöhnite, parasymplesite, quartz (Bou Azzer, Morocco).

Distribution: From the Rubicon pegmatite, and perhaps others, in the Karibib district, Namibia. In the Kiura mine, Oita Prefecture, Japan. From Bou Azzer, Morocco. In the Córrego do Urucum pegmatite, near Galiléia, and the Mulundu pegmatite, locality not further specified, Minas Gerais, Brazil. From an unidentified pegmatite in eastern Kazakhstan.

Name: For the Karibib pegmatite district, Namibia, where the species occurs.

Type Material: Department of Earth Sciences, University of Leeds, Leeds, England; Department of Geology, University of Helsinki, Helsinki, Finland.

References: (1) von Knorring, O., T.G. Sahama, and P. Rehtijärvi (1973) Karibibite, a new FeAs mineral from South West Africa. Lithos, 6, 265–271. (2) (1974) Amer. Mineral., 59, 382 (abs. ref. 1). (3) Cassedanne, J.P. (1986) The Urucum pegmatite, Minas Gerais, Brazil. Mineral. Record, 17, 307–314.

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Karlite $Mg_7(BO_3)_3(OH)_4Cl$

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Crystal Data: Orthorhombic. *Point Group:* 222. As needles, elongated along [001], composed of subparallel crystallites showing {110} and {001}, to 0.5 mm; always in rosettelike and fibrous aggregates.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 5.5 D(meas.) = 2.80–2.85 D(calc.) = 2.85

Optical Properties: Semitransparent. *Color:* White, pale green, may have a brown oxidization crust; colorless in transmitted light. *Streak:* White. *Luster:* Silky.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.589$ $\beta = 1.632$ $\gamma = [1.634]$ 2V(meas.) = 22°–25°

Cell Data: *Space Group:* $P2_12_12$. $a = 17.631(1)$ $b = 17.965(1)$ $c = 3.1041(2)$ Z = 4

X-ray Powder Pattern: Schlegeistal, Austria.
2.829 (100), 2.2522 (94), 12.53 (83), 3.947 (72), 2.6211 (72), 6.27 (67), 1.1907 (67)

Chemistry:

	(1)		(1)
SiO_2	0.02	K_2O	0.01
B_2O_3	22.92	F	0.16
Al_2O_3	2.96	Cl	3.26
FeO	2.27	H_2O^+	10.40
MnO	0.17	H_2O^-	0.63
MgO	58.90	$-O = (F, Cl)_2$	0.82
CaO	0.14	Total	[101.03]
Na_2O	0.01		

(1) Schlegeistal, Austria; by electron microprobe, total Fe as FeO, total Mn as MnO, B_2O_3 determined photometrically, H_2O by TGA, only $(OH)^{1-}$ present by IR, original total given as 100.40%; corresponds to $(Mg_{6.60}Al_{0.26}Fe_{0.14}Mn_{0.01}Ca_{0.01})_{\Sigma=7.02}(B_{0.99}O_{2.97})_3[(OH)_{4.37}O_{0.26}Cl_{0.42}F_{0.04}]_{\Sigma=5.09}$. (2) Do.; by electron microprobe, analysis not given; stated to correspond to $(Mg_{6.05}Al_{0.30}Fe^{3+}_{0.10}Fe^{2+}_{0.05})_{\Sigma=6.50}(BO_3)_3(OH)_4Cl_{0.40}$.

Occurrence: Probably formed by Alpine metamorphism, in a calcsilicate–carbonate lens in amphibolites (Schlegeistal, Austria).

Association: Calcite, dolomite, "chlorite", clinohumite, brucite, ludwigite (Schlegeistal, Austria); sakhaite (Siberia, Russia).

Distribution: Found in the Furtschaglkar, in the Schlegeistal, Zillertal, Tirol, Austria. From the Cerdagne district, Pyrénées-Orientales, France. At an undefined locality [Titovskoye boron deposit, Tas-Khayakhtakh Mountains, Sakha] in Russia

Name: To honor Dr. Franz Karl (1918–1972), Professor of Mineralogy and Petrography, Christian Albrechts University, Kiel, Germany, for his studies of the geology of the eastern Alps.

Type Material: Mineralogical Institute and Museum, University of Kiel, Kiel; Institute for Mineralogy and Crystallography, Technical University, Berlin, Germany, 85/72; Natural History Museum, Vienna, Austria, L7676; Natural History Museum, Paris, France; National Museum of Natural History, Washington, D.C., USA, 149050–149052.

References: (1) Franz, G., D. Ackermand, and E. Koch (1981) Karlite, $Mg_7(BO_3)_3(OH, Cl)_5$ a new borate mineral and associated ludwigite from the Eastern Alps. Amer. Mineral., 66, 872–877. (2) Bonazzi, P., S. Menchetti, C. Sabelli, and R. Trosti-Ferroni (1986) Karlite: crystal structure and chemical composition. Neues Jahrb. Mineral., Monatsh., 253–262.

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Karnasurtite-(Ce)

$(Ce, La, Th)(Ti, Nb)$
$(Al, Fe^{3+})(Si, P)_2O_7(OH)_4 \cdot 3H_2O(?)$

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Crystal Data: Amorphous; hexagonal (?). *Point Group:* n.d. Platy crystals up to 1 cm; as aggregates and individual grains.

Physical Properties: *Cleavage:* Good in one direction, imperfect in another. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 2.89–2.95 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Honey-yellow when fresh to pale yellow when altered; in thin section, pale yellow. *Streak:* Yellow. *Luster:* Greasy. *Optical Class:* Uniaxial (–); may be anomalously slightly biaxial. $\omega = 1.617$ $\epsilon = 1.595$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Mt. Karnasurt, Russia; X-ray amorphous; on heating to 900°, it yields a pattern close to that of monazite.
3.10 (7), 2.88 (7), 3.29 (6), 3.49 (5), 1.723 (5), 2.44 (4), 2.14 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	20.47	24.91	CaO	1.66	3.20
TiO_2	12.14	12.33	BaO	0.68	
ZrO_2		1.20	Na_2O	0.91	
ThO_2	6.22	6.04	K_2O	0.76	
Al_2O_3	7.46	5.52	F	0.91	
La_2O_3		8.55	H_2O^+	7.22	7.29
Ce_2O_3	17.58	8.11	H_2O^-	10.84	12.29
Fe_2O_3	1.10	1.07	P_2O_5	3.29	6.81
Nb_2O_5	8.20	2.20	$-O = F_2$	0.38	
MgO	0.91	0.60	Total	99.97	100.12

(1) Mt. Karnasurt, Russia; corresponds to $(Ce_{0.54}Na_{0.15}Ca_{0.14}Th_{0.12}K_{0.08}Ba_{0.02})_{\Sigma=1.05}(Ti_{0.76}Nb_{0.31})_{\Sigma=1.07}(Al_{0.73}Mg_{0.11}Fe^{3+}_{0.07})_{\Sigma=0.91}(Si_{1.70}P_{0.23})_{\Sigma=1.93}O_7[(OH)_{3.46}F_{0.23}]_{\Sigma=3.69} \cdot 3H_2O$.
(2) Mt. Punkaruaiv, Russia.

Occurrence: In the intermediate replacement zone, composed largely of microcline, of a zoned pegmatite stock in a differentiated alkalic massif (Mt. Karnasurt, Russia).

Association: Manganoan pectolite, natrolite, epididymite, polylithionite, ussingite.

Distribution: On Mts. Karnasurt and Punkaruaiv, Lovozero massif, Kola Peninsula, Russia.

Name: For the locality, Mt. Karnasurt, Kola Peninsula, Russia, and its high *cerium* content.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 59412, vis3348; National Museum of Natural History, Washington, D.C., USA, 143823.

References: (1) Kuz'menko, M.V. and S.I. Kozhanov (1959) The new mineral karnasurtite. Trudy Inst. Mineral., Geokhim. i Kristallokhim. Redkikh Elementov, 2, 95–98 (in Russian). (2) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1959) The Lovozero alkali massif. Akad. Nauk SSSR, 423–425 (in Russian). (3) (1960) Amer. Mineral., 45, 1133–1134 (abs. refs. 1 and 2).

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Karpatite $C_{24}H_{12}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are acicular, thin tabular parallel to [001], showing {001}, {100}, {$\overline{2}$01}, many other forms, to 1 cm; typically in bladed groups and fibrous radiating aggregates.

Physical Properties: *Cleavage:* On {001}, {100}, {$\overline{2}$01}, perfect. *Fracture:* Splintery. *Tenacity:* Flexible, nearly plastic. Hardness = ∼1 D(meas.) = 1.35–1.40 D(calc.) = 1.29–1.42 Flammable; fluoresces sky-blue under LW and SW UV.

Optical Properties: Subtranslucent. *Color:* Yellow, yellowish brown on exposure.
Luster: Vitreous.
Optical Class: Biaxial (–) or (+). *Orientation:* $X = b$; $Z \wedge c = 21°$. *Dispersion:* $r \gg v$, extreme.
$\alpha = 1.780(2)$ $\beta = 1.977$–1.982 $\gamma = 2.05$–2.15 2V(meas.) = 96°–115°

Cell Data: *Space Group:* $P2_1/c$ or $P2/c$ (synthetic). $a = 10.035$ $b = 4.695$ $c = 16.014$ $\beta = 112°$ Z = 2

X-ray Powder Pattern: Olenevo, Ukraine.
9.40 (10), 3.52 (9), 7.52 (8), 3.97 (7), 3.05 (6), 7.25 (5), 3.43 (4)

Chemistry:

	(1)	(2)
C	96.04	95.97
H	4.04	4.03
O		
Total	100.08	100.00

(1) Olenevo, Ukraine. (2) $C_{24}H_{12}$ (coronene).

Occurrence: In cavities at the contact of diorite porphyry with argillites (Olenevo, Ukraine); a low-temperature hydrothermal mineral (California, USA).

Association: Idrialite, amorphous organic material, calcite, barite, quartz, cinnabar, metacinnabar (Olenevo, Ukraine); cinnabar, quartz (California, USA).

Distribution: From near Olenevo, Transcarpathian region, western Ukraine. At Tamvotney, Kamchatka Peninsula, Russia. From the Picacho mercury mine, south of New Idria, San Benito Co., California, USA.

Name: From the Russian *Karpaty*, for the place of discovery in the Transcarpathian district, Ukraine.

Type Material: n.d.

References: (1) Piotrovsky, G.L. (1955) Karpatite – a new organic mineral from Transcarpathia. Lvovskoe geol. Obshch., Mineral. Sbornik, 9, 120–127 (in Russian). (2) (1957) Amer. Mineral., 42, 120 (abs. ref. 1). (3) Frank-Kamenetskii, V.A., S.K. Filatov, and Y.A. Giller (1967) The crystal structure and chemical formula of carpathite. Mineral. Sbornik L'vov Gos. Univ., 21, 275–278 (in Russian). (4) (1969) Amer. Mineral., 54, 329 (abs. ref. 3). (5) Murdoch, J. (1967) Pendletonite [= karpatite], a new hydrocarbon mineral from California. Amer. Mineral., 52, 611–616. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 110.

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Karpinskite $(Mg,Ni)_2Si_2O_5(OH)_2(?)$

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Crystal Data: Monoclinic (?). *Point Group:* n.d. As minute plates and monoclinic prisms, to 0.8 mm; appears to be cryptocrystalline.

Physical Properties: Hardness = 2.5–3 D(meas.) = 2.53–2.63 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Colorless, light blue to deep greenish blue.
Luster: Dull to weakly greasy.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = 0°$–$12°$. α = 1.553–1.570 β = n.d.
γ = 1.569–1.594 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Nizhni Tagil massif, Russia.
11., 7.71, 4.76, 3.75, 1.555 [strongest lines]

Chemistry:

	(1)
SiO_2	47.55
Al_2O_3	0.48
NiO	21.12
CuO	0.01
MgO	17.56
CaO	0.80
H_2O^+	6.50
H_2O^-	3.50
LOI	2.30
Total	99.82

(1) Nizhni Tagil massif, Russia; corresponds to $(Mg_{1.30}Ni_{0.70})_{\Sigma=2.00}Si_2O_5(OH)_2$.

Occurrence: As veinlets in "kerolitized" serpentinite.

Association: n.d.

Distribution: In the Nizhni Tagil massif, Ural Mountains, Russia.

Name: For Alexander Petrovich Karpinsky (1847–1936), Russian geologist and President of the Russian Academy of Sciences, Moscow, Russia.

Type Material: n.d.

References: (1) Rukavishnikova, I.A. (1956) Some magnesium-nickel hydrous silicates of the Nizhne-Tagilsk serpentine massif. Kora Vyvetrivaniya [The crust of weathering], 2, 124–178 (in Russian). (2) (1957) Amer. Mineral., 42, 584 (abs. ref. 1).

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Kasatkinite $Ba_2Ca_8B_5Si_8O_{32}(OH)_3 \cdot 6H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m* or *m*. As subparallel or sheaf-like aggregates and spherulites of acicular crystals, ~ 500 × 5 μm, rarely 600 × 20 μm.

Physical Properties: *Cleavage:* None observed. *Tenacity:* Brittle, individual fibers are elastic and resilient, aggregates are tough (similar to nephrite). *Fracture:* Uneven to jagged.
Hardness = 4-4.5 D(meas.) = 2.95(5) D(calc.) = 2.89

Optical Properties: Translucent to nearly opaque. *Color:* Colorless, snow-white (aggregates); colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to silky.
Optical Class: Biaxial (+). α = 1.600(5) b = 1.603(2) γ = 1.626(2) 2V(meas.) = 30(20)°
2V(calc.) = 40° *Pleochroism:* None.

Cell Data: Space Group: $P2_1/c$, $P2/c$, or Pc. a = 5.745(3) b = 7.238(2) c = 20.79(1)
β = 90.82(5)° Z = 1

X-ray Powder Pattern: Bazhenovskoe chrysotile-asbestos deposit, Middle Urals, Russia.
3.009 (100), 2.925 (65), 2.633 (33), 2.116 (29), 5.89 (24), 3.36 (24), 3.48 (23), 10.52 (14)

Chemistry:

	(1)
Na_2O	0.23
K_2O	0.57
CaO	28.94
BaO	16.79
B_2O_3	11.57
Al_2O_3	0.28
SiO_2	31.63
F	0.05
H_2O	9.05
$-O=F_2$	0.02
Total	99.09

(1) Bazhenovskoe chrysotile-asbestos deposit, Middle Urals, Russia; average of 17 electron microprobe analyses, IR spectroscopy and the ^{11}B MAS NMR spectrum confirm the presence of BO_4, H_2O by TGA; corresponds to $Na_{0.11}K_{0.18}Ba_{1.66}Ca_{7.84}B_{5.05}Al_{0.08}Si_{8.00}O_{31.80}(OH)_{3.06}F_{0.04} \cdot 6.10H_2O$.

Occurrence: Of hydrothermal origin in cavities in rhodingite.

Association: Prehnite, pectolite, calcite, clinochlore; or grossular, diopside, chrysotile, pectolite, minerals of the tobermorite and hydrotalcite families.

Distribution: From the Bazhenovskoe chrysotile-asbestos deposit (eastern part of the open pit Yuzhnyi), near Asbest, Middle Urals, Russia.

Name: Honors Russian amateur mineralogist and mineral collector Anatoly V. Kasatkin (b. 1970).

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; 41291/1.

References: (1) Pekov, I.V., N.V. Chukanov, Ya.E. Filinchuk, A.E. Zadov, N.N. Kononkova, S.G. Epanchintsev, P. Kaden, A. Kutzer, and J. Göttlicher (2012) Kasatkinite, $Ba_2Ca_8B_5Si_8O_{32}(OH)_3 \cdot 6H_2O$, a new mineral from the Bazhenovskoe deposit (Middle Urals, Russia). Zap. Ross. Mineral. Obshch., 141(3), 39-49 (in Russian, English abstract). (2) (2013) Amer. Mineral., 98, 2201-2202 (abs. ref. 1).

Kashinite $(Ir, Rh)_2S_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As subhedral granular crystals, to 0.2 mm; on the rims of platinum or iridosmine grains.

Physical Properties: *Fracture:* Flinty. *Tenacity:* Brittle, weakly elastic. Hardness = n.d. VHN = 1529(477) (50 g load). D(meas.) = n.d. D(calc.) = 9.10

Optical Properties: Opaque. *Color:* Grayish black; light gray in reflected light. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Moderate to strong, with reddish violet tints.
R_1–R_2: (400) — , (420) — , (440) 43.7–45.9, (460) 45.1–45.5, (480) 46.1–45.5, (500) 46.8–45.6, (520) 47.2–45.7, (540) 47.5–45.8, (560) 47.6–46.0, (580) 47.6–46.2, (600) 47.4–46.3, (620) 47.1–46.5, (640) 46.8–46.6, (660) 46.6–46.8, (680) 46.3–46.9, (700) 46.0–47.0

Cell Data: *Space Group: Pbcn.* $a = 8.464$ $b = 6.001$ $c = 6.146$ Z = 4

X-ray Powder Pattern: Nizhni Tagil, Russia.
2.99 (10), 1.736 (6b), 2.14 (4), 1.758 (4), 1.136 (4b), 1.028 (4), 0.982 (4)

Chemistry:

	(1)	(2)	(3)
Ir	53.6	52.4 – 75.8	57.9
Rh	21.5	1.7 – 22.9	15.7
Pt	0.8		0.2
Ru	0.5		
Fe	0.1		0.1
Cu	0.7	0.0 – 0.8	0.7
S	24.0	21.6 – 24.8	23.0
Total	97.6		97.6

(1) Russia; by electron microprobe, average of five analyses; corresponds to $(Ir_{1.12}Rh_{0.84}Ru_{0.02}Pt_{0.02})_{\Sigma=2.00}S_{3.00}$. (2) Nizhni Tagil, Russia; by electron microprobe, range of 18 analyses. (3) China; by electron microprobe, average of analyses on four grains; corresponds to $(Ir_{1.26}Rh_{0.64}Cu_{0.05}Fe_{0.01})_{\Sigma=1.96}S_{3.00}$.

Occurrence: In placer deposits derived from ultramafic rocks.

Association: Iridosmine, platinum, osmiridium, laurite, erlichmanite, cuproiridisite, cherepanovite, rhodian pentlandite, irarsite, Fe–Pt alloy, sulfides of Fe, Cu, Ir, Rh, chromite.

Distribution: In Russia, from the Aleksandrov Log platinum deposit, Mt. Solov'eva, Nizhni Tagil massif, Ural Mountains [TL]; at the Ray-Iz ophiolite complex, Polar Ural Mountains; in the Vaimka River placers, Aluchinskii massif, and the Baimka placers, Aluchin horst, Chukota region, Far Eastern Region. At an unspecified placer in China. From Chromwerk, Kraubath ultramafic massif, Styria, Austria. At Goodnews Bay, Alaska, USA.

Name: To honor Stepan Aleksandrovich Kashin (1900–1981), Central Institute of Geological Exploration for Base and Precious Metals, Moscow, Russia, a Russian investigator of ore deposits in the Ural Mountains.

Type Material: Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Begizov, V.D., E.N. Zabyalov, N.S. Rudashevskii, and L.N. Vyal'sov (1985) Kashinite $(Ir, Rh)_2S_3$ – a new sulfide of iridium and rhodium. Zap. Vses. Mineral. Obshch., 114, 617–622 (in Russian). (2) (1987) Amer. Mineral., 72, 223 (abs. ref. 1). (3) Anon. (1985) A study of kashinite $(Ir, Rh)_2S_3$. Acta Mineralogica Sinica, 5, 6–9 (in Chinese with English abs.). (4) (1986) Mineral. Abs., 37, 236 (abs. ref. 3). (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 277. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 111.

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Kaskasite $(Mo,Nb)S_2 \cdot (Mg_{1-x}Al_x)(OH)_{2+x}$

Crystal Data: Hexagonal. *Point Group*: 3*m*, 32, or $\bar{3}$ 2/*m*. As lamellar or flaky, mica-like crystals flattened on [001], to 1.5 mm; epitaxial and coplanar with {001} of pyrrhotite; as irregular lamellae, sometimes with crude hexagonal outline; striations on {001} cross at 60°.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Laminated. *Tenacity*: Flexible, inelastic. VHN = 34-38 (5 g load). Hardness = ~1 D(meas.) = n.d. D(calc.) = 3.83

Optical Properties: Opaque. *Color*: Iron black; light to dark gray in reflected light.
Streak: Black. *Luster*: Metallic. *Anisotropism:* Strong. *Pleochroism*: Strong, light gray with a yellowish hue to gray.
Optical Class: n.d.
R_1-R_2: (470) 8.6-21.5, (546) 9.2-21.6, (589) 9.2-21.5, (650) 8.9-21.3

Cell Data: *Space Group*: $P\bar{3}\,m1$, $P3m1$, or $P321$. [a = 3.220(2) c = 11.47(2) sulfide sub-lattice] [a = 3.073(2) c = 11.50(2) hydroxide sub-lattice] One-layer polytypes. Z = 1

X-ray Powder Pattern: Mt. Kaskasnyunchorr, Khibiny alkaline complex, Kola Peninsula, Russia.
5.72 (100), 11.46 (97), 2.786 (51), 1.613 (33), 1.557 (10), 2.627 (7), 2.219 (7)

Chemistry:

	(1)		(1)
Mg	5.94	Nb	13.39
Al	3.67	Mo	23.18
Ca	0.04	W	7.59
V	0.16	S	27.09
Mn	0.23	O	15.66
Fe	1.44	H	[0.99]
		Total	99.08

(1) Mt. Kaskasnyunchorr, Russia; average of 5 electron microprobe analyses, H calculated so that all O are OH-, presence of OH^- confirmed by Raman spectroscopy; corresponding to $(Mo_{0.57}Nb_{0.34}W_{0.10}V_{0.01})_{\Sigma=1.02}S_2 \cdot (Mg_{0.58}Al_{0.32}Fe_{0.06}Mn_{0.01})_{\Sigma=0.97}(OH)_{2.32}$.

Mineral Group: Valleriite group.

Polymorphism & Series: Forms a series with manganokaskasite.

Occurrence: Of hydrothermal origin in fenites formed by the influence of a peralkaline fluid acting as a source of Nb on a large xenolith of alumina-rich metamorphic rocks (metapelites) located inside a huge intrusion of agpaitic nepheline syenite.

Association: Orthoclase, anorthoclase, nepheline, fluorophlogopite, corundum, pyrrhotite, pyrite, rutile, monazite-(Ce), graphite, edgarite, molybdenite, tungstenite, alabandite.

Distribution: From Mt. Kaskasnyunchorr, Khibiny alkaline complex, Kola Peninsula, Russia.

Name: For Mount Kaskasnyunchorr, the locality that produced the first specimens, whose name is based on the word for "juniper" - *kaskas* - in the Saami language of the Kola aboriginal people.

Type Material: The A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 94231).

References: (1) Pekov, I.V., V.O. Yapaskurt, Y.S. Polekhovsky, M.F. Vigasina, and O.I. Siidra (2014) Ekplexite $(Nb,Mo)S_2 \cdot (Mg_{1-x}Al_x)(OH)_{2+x}$, kaskasite $(Mo,Nb)S_2 \cdot (Mg_{1-x}Al_x)(OH)_{2+x}$ and manganokaskasite $(Mo,Nb)S_2 \cdot (Mn_{1-x}Al_x)(OH)_{2+x}$, three new valleriite-group mineral species from the Khibiny alkaline complex, Kola peninsula, Russia. Mineral. Mag., 78(3), 663-679. (2) (2015) Amer. Mineral., 100, 658-659 (abs. ref. 1).

Kasolite $Pb(UO_2)SiO_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals stout prismatic, flattened on {001} and lathlike by extension along [010], to several mm. As groups of divergent crystals, rosettes, and radial fibrous aggregates; in dense gumlike crusts and compact, colloform masses.

Physical Properties: *Cleavage:* Perfect on {001}, indistinct on {100} and {010}. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 5.83–6.5 D(calc.) = 6.256 Radioactive.

Optical Properties: Transparent to translucent, opaque. *Color:* Ocher-yellow to brownish yellow; amber-brown when transparent; rarely lemon-yellow to green or reddish orange. *Streak:* Pale yellow-brown. *Luster:* Subadamantine to greasy, dull to earthy when massive. *Optical Class:* Biaxial (+). *Pleochroism:* Weak, rarely; $X = Y$ = very pale yellow; Z = colorless to slightly grayish. *Orientation:* $X = b$; $Z \simeq c$. α = 1.877–1.900 β = 1.880–1.910 γ = 1.935–1.970 2V(meas.) = 43°

Cell Data: *Space Group:* $P2_1/a$. a = 13.24 b = 6.94 c = 6.70 $\beta = 104°20'$ Z = 4

X-ray Powder Pattern: Kasolo, Congo.
3.26 (10), 2.93 (9), 4.19 (8b), 3.53 (7), 6.61 (6), 3.07 (5), 1.962 (5)

Chemistry:

	(1)	(2)
SiO_2	9.42	10.23
UO_3	49.28	48.70
Fe_2O_3	0.41	
PbO	36.2	38.00
MgO	0.03	
CaO	0.06	
H_2O	3.59	3.07
CO_2	0.85	
Total	99.84	100.00

(1) Kasolo, Congo. (2) $Pb(UO_2)SiO_4 \cdot H_2O$.

Occurrence: An oxidization product of uraninite.

Association: Uraninite, torbernite, curite, dewindtite (Kasolo, Congo); rutherfordine, sklodowskite, curite (Nabarlek, Australia).

Distribution: From Shinkolobwe, and the Musonoi mine, Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). At Mounana, Gabon. In Germany, at Wölsendorf, Bavaria. In France, at Kersegalec, Lignol, Morbihan; Grury, Saône-et-Loire; and at Reliez and Bigay, Lachaux, Puy-de-Dôme. At Loe Warren, St. Just, Cornwall, England. In the Nabarlek and Koongarra uranium deposits, Northern Territory, and at Wodgina, Pilbara district, Western Australia. In the USA, in the Ruggles pegmatite, near Grafton, Grafton Co., New Hampshire; from the Green Monster mine, Goodsprings district, Clark Co., and the 4-D mine, Marietta district, Mineral Co., Nevada; and in the Ross-Adams mine, Bokan Mountain, Prince of Wales Island, Alaska. In Canada, at Great Bear Lake, Northwest Territories, and at Lake Athabasca, Saskatchewan, from the Nicholson mines. In the Santo Domingo mine, Santa Eulalia, Chihuahua, Mexico. A number of other minor localities are known.

Name: For the occurrence at Shinkolobwe, near Kasolo Hill, Congo (Zaire).

Type Material: Natural History Museum, Paris, France, 121.287.

References: (1) Schoep, A. (1921) Sur la kasolite, nouveau minéral radioactif. Compt. Rendus Acad. Sci. Paris, 173, 1476–1477 (in French). (2) (1922) Amer. Mineral., 7, 128–129 (abs. ref. 1). (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 315–319. (4) Stohl, F.V. and D.K. Smith (1981) The crystal chemistry of the uranyl silicate minerals. Amer. Mineral., 66, 610–625.

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Kassite $CaTi_2O_4(OH)_2$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* n.d. As six-sided crystals, flattened on {010}, and as rosettes of platy crystals, to 0.5 mm, and smaller spherules. *Twinning:* Common, on {101} and {181}.

Physical Properties: *Cleavage:* {010}, perfect; {101}, distinct. *Tenacity:* Very brittle. Hardness = 5 D(meas.) = 3.42 D(calc.) = 3.418 Paramagnetic. Some data presented here may be that of cafetite.

Optical Properties: Translucent. *Color:* Brownish pink to pale yellow. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; colorless to pale yellow. *Orientation:* $X = c$; $Z = b$. *Dispersion:* $r > v$; very strong. $\alpha = 1.95(1)$ $\beta = 2.13$ $\gamma = 2.21$ 2V(meas.) = 58°

Cell Data: *Space Group:* n.d. $a = 8.99$–9.08 $b = 9.55$–[9.56] $c = 5.23$–5.26 Z = 4

X-ray Powder Pattern: Afrikanda massif, Russia.
3.30 (10), 1.761 (10), 4.77 (5), 3.63 (4), 2.29 (4), 1.501 (4), 7.2 (3)

Chemistry:

	(1)	(3)
SiO_2	0.55	
TiO_2	65.59	68.32
Al_2O_3	0.98	
Fe_2O_3	1.92	
CaO	23.03	23.98
SrO	0.05	
Na_2O	0.11	
K_2O	0.04	
F	0.04	
H_2O^+	8.04	7.70
H_2O^-	trace	
$-O = F_2$	0.02	
Total	100.33	100.00

(1) Afrikanda massif, Russia; after deduction of SiO_2 as titanite, corresponds to $[Ca_{0.95}(H_3O)_{0.04}Na_{0.01}]_{\Sigma=0.96}(Ti_{1.92}Fe_{0.06}Al_{0.05})_{\Sigma=2.03}O_{3.96}(OH)_{2.04}$. (2) Josephine Creek, Oregon, USA; by electron microprobe, analysis not given; stated to correspond to $Ca(Ti_{1.87}Fe_{0.13})_{\Sigma=2.00}O_{3.87}(OH)_{2.13}$. (3) $CaTi_2O_4(OH)_2$.

Occurrence: Lining miarolitic cavities in alkalic pegmatites (Afrikanda massif, Russia); in nepheline syenite (Diamond Jo quarry, Arkansas, USA).

Association: Cafetite, perovskite, titanite (Afrikanda massif, Russia); perovskite, rutile, ilmenite, titanite (Josephine Creek, Oregon, USA).

Distribution: From the Afrikanda pyroxenite massif, Kola Peninsula, Russia. In the USA, from the Diamond Jo quarry, Magnet Cove, Hot Spring Co., Arkansas; and in a mantle xenolith from Josephine Creek, Josephine Co., Oregon. At the Wuyang iron deposit, Henan Province, China.

Name: Honors Academician Nikolai Grigor'evich Kassin (1885–1949), the geologist who discovered the Afrikanda massif, Russia.

Type Material: Mineralogcal Museum, St. Petersburg University, St. Petersburg, Russia, 17402.

References: (1) Kukharenko, A.A., M.P. Orlova, A.G. Bulakh, E.A. Bagdasarov, O.M. Rimskaya-Korsakova, Y.I. Nefedov, G.A. Ilyinskiy, A.C. Sergeyev, and N.B. Abakumova (1965) The Caledonian complex of the ultrabasic alkalic rocks and carbonatites of the Kola Peninsula and northern Karelia. Izdat. "Nedra" Moscow, 368–375 (in Russian). (2) (1967) Amer. Mineral., 52, 559–560 (abs. ref. 1). (3) Evans, H.T., Jr., E.J. Dwornik, and C. Milton (1986) Kassite from the Diamond Jo quarry, Magnet Cove, Hot Spring County, Arkansas: the problem of cafetite and kassite. Amer. Mineral., 71, 1045–1048. (4) Self, P.G. and P.R. Buseck (1991) Structure model for kassite, $CaTi_2O_4(OH)_2$. Amer. Mineral., 76, 283–287.

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Kastningite $(Mn^{2+}, Fe^{2+})Al_2(PO_4)_2(OH)_2 \cdot 8H_2O$

Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Wedgelike crystals are tabular on {001}, also showing {111}, {$\bar{1}$11}, to 2 mm, in sprays.

Physical Properties: Hardness = Soft. D(meas.) = 2.35 D(calc.) = 2.379

Optical Properties: Transparent to translucent. *Color:* Colorless, white, beige. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.566$ $\beta = 1.574$ $\gamma = 1.582$ 2V(meas.) = n.d. 2V(calc.) = 91°–95°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.0102(3)$ $b = 10.2050(7)$ $c = 10.5040(7)$ $\alpha = 71.82(1)°$ $\beta = 89.62(1)°$ $\gamma = 69.90(1)°$ $Z = 2$

X-ray Powder Pattern: Waidhaus, Germany.
9.917 (100), 4.957 (50), 6.541 (36), 3.001 (30), 3.095 (28), 1.653 (25), 3.312 (23)

Chemistry:

	(1)
P_2O_5	37.96
Al_2O_3	24.49
FeO	6.07
MnO	11.30
MgO	0.64
H_2O	[19.54]
Total	[100.00]

(1) Waidhaus, Germany; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by difference; corresponds to $(Mn_{0.66}Fe_{0.35}Mg_{0.06})_{\Sigma=1.07}Al_{2.00}(P_{1.12}O_4)_2(OH)_2 \cdot 3.56H_2O$.

Polymorphism & Series: Dimorphous with mangangordonite.

Occurrence: A rare secondary mineral in a zoned granite pegmatite.

Association: Variscite, paravauxite, albite, mica, quartz.

Distribution: From the Silbergrube quarry, near Waidhaus, and at Hagendorf, Bavaria, Germany.

Name: To honor Jürgen Kastning, mineral collector and dealer, Reinbek, near Hamburg, Germany, who found the original material.

Type Material: Mineralogical Museum, University of Hamburg, Hamburg, Germany.

References: (1) Schlüter, J., K.-H. Klaska, K. Friese, and G. Adiwidjaja (1999) Kastningite, $(Mn, Fe, Mg)Al_2(PO_4)_2(OH)_2 \cdot 8H_2O$, a new phosphate mineral from Waidhaus, Bavaria, Germany. Neues Jahrb. Mineral., Monatsh., 40–48. (2) (1999) Amer. Mineral., 84, 1465–1466 (abs. ref. 1).

Katoite $\mathbf{Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}}$ (x = 1.5 to 3.0)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Octahedra crystals, typically rounded, to 0.3 mm, in thin crusts of columnar aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.76

Optical Properties: Transparent to translucent. *Color:* Milky white; in transmitted light, colorless.
Optical Class: Isotropic; may be weakly birefringent. $n = 1.632(1)$

Cell Data: *Space Group: Ia3d.* a = 12.358(2) Z = 8

X-ray Powder Pattern: Campomorto quarry, Italy.
2.763 (100), 2.257 (58), 2.004 (58), 3.089 (50), 5.046 (37), 1.6507 (37), 3.303 (32)

Chemistry:

	(1)
SiO_2	10.58
Al_2O_3	24.01
MgO	0.07
CaO	42.27
H_2O	20.8
SO_3	2.27
Total	[100.00]

(1) Campomorto quarry, Italy; by electron microprobe, H_2O by TGA, recalculated slightly to 100.00%; corresponds to $Ca_{2.96}(Al_{1.85}Mg_{0.01})_{\Sigma=1.86}(Si_{0.69}S_{0.11})_{\Sigma=0.80}[(OH)_{9.07}O_{2.93}]_{\Sigma=12.00}$.

Polymorphism & Series: Forms a series with grossular and hibschite.

Mineral Group: Garnet group.

Occurrence: A hydrothermal mineral in cavities in a phonolitic lava flow that erupted through an argillaceous marl.

Association: Tobermorite, afwillite, gehlenite, hydrocalumite, "opal," portlandite, apophyllite, cordierite, jennite, strätlingite, chabazite, gismondine, phillipsite, vertumnite, ettringite, garnet, wollastonite, gypsum, calcite, quartz, hematite.

Distribution: In the Campomorto quarry, near Montalto di Castro, Lazio, Italy.

Name: In honor of Akira Kato, mineralogist of the National Science Museum, Tokyo, Japan.

Type Material: Municipal Museum of Natural History, Milan, Italy; National Museum of Natural History, Washington, D.C., USA, 163797.

References: (1) Passaglia, E. and R. Rinaldi (1984) Katoite, a new member of the $Ca_3Al_2(SiO_4)_3$ – $Ca_3Al_2(OH)_{12}$ series and a new nomenclature for the hydrogrossular group of minerals. Bull. Minéral., 107, 605–618. (2) (1985) Amer. Mineral., 70, 873 (abs. ref. 1).

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Katophorite $\mathbf{Na[NaCa][(Fe^{2+},Mg)_4Al](Si_7Al)O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic, granular, also as fibrous aggregates or dendrites and skeletal crystals. Commonly rimming other minerals. *Twinning:* ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at ∼56° and ∼124°; parting on {010}. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.2–3.5 D(calc.) = [3.31]

Optical Properties: Transparent to translucent. *Color:* Black, dark green-black, bluish black; reddish yellow, bluish green in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; reddish yellow, reddish brown, and dark green to black. *Orientation:* $Z = b$. *Dispersion:* $r > v$. *Absorption:* $Z > Y > X$. α = 1.639–1.681 β = 1.658–1.688 γ = 1.600–1.690 2V(meas.) = ∼0°–50°

Cell Data: *Space Group:* $C2/m$. a = 10.019(2) b = 18.036(7) c = 5.286(3) β = 104.98(3)° Z = 2

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.04	45.98	MnO	1.11	1.12
TiO_2	2.09	1.92	MgO	6.42	5.21
Al_2O_3	3.86	2.79	CaO	8.08	5.76
Cr_2O_3	0.09		Na_2O	4.18	4.85
FeO	25.58	28.97	K_2O	1.34	1.23
			Total	100.79	97.83

(1) Baie-des-Moutons complex, Canada; by electron microprobe, corresponds to $(Na_{0.54}K_{0.26})_{\Sigma=0.80}(Ca_{1.31}Na_{0.69})_{\Sigma=2.00}(Fe^{2+}_{3.25}Mg_{1.45}Ti_{0.23}Mn_{0.15})_{\Sigma=5.08}(Si_{7.29}Al_{0.69}Ti_{0.01}Cr_{0.01})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Rallier-du-Baty Peninsula, Kerguelen Island; by electron microprobe, corresponds to $(Na_{0.80}K_{0.25})_{\Sigma=1.05}(Ca_{0.98}Na_{0.70}Fe^{2+}_{0.32})_{\Sigma=2.00}(Fe^{2+}_{3.54}Mg_{1.24}Mn_{0.15}Ti_{0.07})_{\Sigma=5.00}(Si_{7.32}Al_{0.52}Ti_{0.16})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with magnesiokatophorite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) < 0.5$; $(Na + K)_A \geq 0.5$; 0.67 Na_B 1.33; $(Ca + Na)_B \geq 1.34$; 6.5 Si 7.49.

Occurrence: In alkalic volcanic and plutonic igneous rocks; in blueschist facies jadeitites.

Association: Arfvedsonite, aegirine, nepheline, pyroxenes, eckermannite, chromite.

Distribution: May occur in the Oslo (Christiania) district, Norway, from where it was originally described. On the Rallier-du-Baty Peninsula, Kerguelen Island, in the south Indian Ocean. In the Baie-des-Moutons complex, La Tabatière, Quebec, Canada. At Tawmaw, Kachin State, northern Myanmar (Burma).

Name: From the Greek for *a carrying down*, in allusion to its volcanic origin.

Type Material: n.d.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 14 [catophorite]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 359–363. (3) Giret, A., B. Bonin, and J.-M. Leger (1980) Amphibole compositional trends in oversaturated and undersaturated alkaline plutonic ring complexes. Can. Mineral., 18, 481–495. (4) Lalonde, A.E. and R.F. Martin (1983) The Baie-des-Moutons syenitic complex, La Tabatière, Québec, II. The ferromagnesian minerals. Can. Mineral., 21, 81–91. (5) Hawthorne, F.C. (1983) The crystal chemistry of the amphiboles. Can. Mineral., 21, 173–480, esp. 363. (6) Mével, C. and J.-R. Kiénast (1986) Jadeite-kosmochlor solid solution and chromian sodic amphiboles in jadeitites and associated rocks from Tawmaw (Burma), Bull. Minéral., 109, 617–633. (7) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 241–242.

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Katoptrite $(Mn^{2+}, Mg)_{13}(Al, Fe^{3+})_4Sb_2^{5+}Si_2O_{28}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly tabular on {010}; elongated along [100], [101], or equant. As minute grains or anhedral masses, to 1 cm.

Physical Properties: *Cleavage:* Perfect micaceous on {001}. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 4.56 D(calc.) = 4.65

Optical Properties: Opaque, translucent in thin flakes. *Color:* Iron-black to jet-black; fire-red in thin section. *Luster:* Metallic, brilliant.
Optical Class: Biaxial (–). *Pleochroism:* Strong; red-brown to orange. *Orientation:* $X \simeq \perp \{001\}$; $Y = b$; $Z \wedge a \simeq -3°$. *Dispersion:* $r > v$, strong, inclined. $\alpha = 1.92$ $\beta = 1.95$ $\gamma = 1.95$ 2V(meas.) = Small.

Cell Data: *Space Group:* $C2/m$. $a = 5.617(2)$ $b = 23.02(2)$ $c = 9.079(6)$ $\beta = 101°23(3)'$ Z = 2

X-ray Powder Pattern: Brattfors mine, Sweden.
2.957 (100), 8.88 (65), 2.600 (50), 4.43 (45), 2.488 (45), 2.810 (40), 1.944 (35)

Chemistry:

	(1)	(2)
SiO_2	7.75	8.0
Al_2O_3	9.50	10.9
Fe_2O_3	3.58	
Sb_2O_5	20.76	22.4
FeO	2.44	2.5
MnO	52.61	54.3
ZnO		0.0
MgO	3.06	3.7
CaO	0.58	< 0.05
H_2O	0.11	
Total	100.39	101.8

(1) Långban, Sweden; average of four analyses. (2) Do.; by electron microprobe; corresponds to $(Mn^{2+}_{11.7}Mg_{1.4})_{\Sigma=13.1}(Al_{3.3}Fe_{0.5})_{\Sigma=3.8}Sb^{5+}_{2.1}Si_{2.0}O_{28}$.

Occurrence: In metamorphosed limestone (Brattfors mine, Sweden).

Association: Magnetite, garnet, manganosite (Brattfors mine, Sweden).

Distribution: In Sweden, in the Brattfors, Moss, and Jakobsberg mines, near Nordmark, and at Långban, Värmland; in the Sjö mine, near Grythyttan, Örebro.

Name: From the Greek for *mirror*, for the perfectly reflecting cleavage surfaces.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1029–1030. (2) Moore, P.B. (1966) Catoptrite [katoptrite] and yeatmanite – stuffed pyrochroite structures? Amer. Mineral., 51, 1494–1500. (3) Moore, P.B., T. Araki, and G.D. Brunton (1976) Catoptrite [katoptrite], $(Mn^{2+}_5Sb^{5+}_2)^{VI}(Mn^{2+}_8Al_4Si_2)^{IV}O_{28}$, a novel close-packed oxide sheet structure. Neues Jahrb. Mineral., Abh., 127, 47–61.

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Kawazulite $Bi_2(Te, Se, S)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As very thin foils, to 4 mm across.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Flexible. Hardness = 1.5 VHN = 100 (50 g load). D(meas.) = > 7.5 D(calc.) = 8.08

Optical Properties: Opaque. *Color:* Silver-white to tin-white. *Streak:* Pale steel-gray. *Luster:* Metallic. *Pleochroism:* Pinkish creamy white to white with creamy tint. *Anisotropism:* Strong, bluish gray to brownish gray to gray. *Bireflectance:* Weak to moderate. R_1–R_2: (400) 45.8–50.6, (420) 46.6–51.4, (440) 47.7–52.0, (460) 48.7–53.3, (480) 49.6–54.3, (500) 50.3–55.2, (520) 50.9–56.0, (540) 51.4–56.3, (560) 51.7–56.6, (580) 52.0–56.7, (600) 52.2–56.8, (620) 52.3–56.8, (640) 52.3–56.6, (660) 52.2–56.4, (680) 52.1–56.3, (700) 51.9–56.2

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.235$–4.240 $c = 29.59$–29.66 $Z = 3$

X-ray Powder Pattern: Kawazu mine, Japan.
3.12 (100), 2.31 (50), 2.12 (50), 4.92 (40), 3.64 (30), 2.61 (20), 1.757 (20)

Chemistry:

	(1)	(2)
Bi	55.4	58.9
Te	31.9	25.9
Se	9.9	12.9
S	0.1	1.9
Total	97.3	99.6

(1) Kawazu mine, Japan; by electron microprobe, corresponding to $Bi_{2.07}(Te_{1.95}Se_{0.97}S_{0.03})_{\Sigma=2.95}$.
(2) Suttsu mine, Japan; by electron microprobe, corresponding to $Bi_{2.01}(Te_{1.42}Se_{1.15}S_{0.42})_{\Sigma=2.99}$.

Mineral Group: Tetradymite group.

Occurrence: Of hydrothermal origin, in a quartz veins (Kawazu and Suttsu mines, Japan); in a breccia pipe cutting dacitic ignimbrites (Mazenod Lake, Canada).

Association: Selenian tellurium (Kawazu mine, Japan); tellurobismuthite, uraninite, hematite, yarrowite (Mazenod Lake, Canada); selenian bismuthinite, selenian pavonite, cassiterite, chalcopyrite, pyrite (Suttsu mine, Japan).

Distribution: In Japan, from the Kawazu mine, three km north of Shimoda, Izu Peninsula, Shizuoka Prefecture [TL], and at the Suttsu mine, Hokkaido. From the Dianne Cu–U claims, Mazenod Lake, Northwest Territories, Canada. In the USA, at the Lone Pine mine, near Silver City, Grant Co., New Mexico; in the Ward mine, south of Ely, Ward district, White Pine Co., and at Montreal Canyon, Fitting district, Mineral Co., Nevada. From Jilové, Czech Republic. At Ocna de Fier (Morávicza; Vaskő), Romania.

Name: For the Kawazu mine, Japan.

Type Material: National Science Museum, Tokyo, Japan, M16403; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 121926, 160136.

References: (1) Kato, A. (1970) In: Introduction to Japanese minerals. Geol. Sur. Japan, 1970, 87–88. (2) (1972) Amer. Mineral., 57, 1312 (abs. ref. 1). (3) Shimizu, M., S.T. Schmidt, C.J. Stanley, and K. Tsunoda (1995) Kawazulite and unnamed $Bi_3(Te, Se, S)_4$ in Ag – Bi – Te – Se – S mineralization from the Suttsu mine, Hokkaido, Japan. Neues Jahrb. Mineral., Abh., 169, 305–308. (4) Nakajima, S. (1963) The crystal structure of $Bi_2Te_{3-x}Se_x$. J. Chem. Phys. Solids, 24, 479–485.

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Kazakhstanite $Fe_5^{3+}V_3^{4+}V_{12}^{5+}O_{39}(OH)_9 \cdot 9H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Crystals platy, dominated by {001}, in round or oval grains, to 1 mm, in aggregates up to 1.5 cm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ~2.5 VHN = 62–69 (10 g load). D(meas.) = 3.4–3.6 D(calc.) = 3.52

Optical Properties: Opaque. *Color:* Black. *Streak:* Black, with slight brownish tint. *Luster:* Adamantine, dull in aggregates.
Optical Class: Biaxial.
R: (400) —, (420) —, (440) 16.4, (460) 15.8, (480) 15.0, (500) 14.3, (520) 13.6, (540) 13.1, (560) 12.8, (580) 12.3, (600) 12.1, (620) 12.0, (640) 12.0, (660) 11.9, (680) 11.8, (700) 11.8

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 11.84(1)$ $b = 3.6500(4)$ $c = 21.27(1)$ $\beta = 100(0.1)^\circ$ $Z = 1$

X-ray Powder Pattern: Kara-Tau Mountains, Kazakhstan.
10.51 (10), 3.484 (6), 2.606 (4), 2.915 (3), 2.756 (3), 3.184 (2), 2.095 (2)

Chemistry:

	(1)	(2)
V_2O_5	55.10	55.04
V_2O_4	12.88	12.55
Fe_2O_3	19.88	20.14
CaO	0.09	
K_2O	0.14	
H_2O^+	12.50	12.27
P_2O_5	0.17	
Total	100.76	100.00

(1) Kara-Tau Mountains, Kazakhstan; Fe_2O_3 given as Fe_4O_3, stated to correspond to $Fe_5^{3+}V_3^{4+}V_{12}^{5+}O_{39}(OH)_9 \cdot 8.55H_2O$. (2) $Fe_5V_3^{4+}V_{12}^{5+}O_{39}(OH)_9 \cdot 9H_2O$.

Occurrence: In thin veins or cementing breccia in the weathering zone of vanadiferous black shales (Kara-Tau Mountains, Kazakhstan); in a hydrothermal gold deposit (Gold Quarry mine, Nevada, USA).

Association: Bokite (Kara-Tau Mountains, Kazakhstan); fervanite, schubnelite, hewettite, tyuyamunite, cacoxenite, variscite, fluellite (Gold Quarry mine, Nevada, USA).

Distribution: From the Kurumsak, Balasauskandyk, and Ran vanadium deposits, northwestern Kara-Tau Mountains, and at Mt. Dzhebagly, Talass Alatau Range, southern Kazakhstan. In the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada, USA.

Name: For its occurrences in Kazakhstan.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p457/1.

References: (1) Ankinovich, E.A., G.K. Bekenova, and N.I. Podlipaeva (1989) A new hydrous ferrovanadian mineral kazakhstanite $Fe_5^{3+}V_3^{4+}V_{12}^{5+}O_{39}(OH)_9 \cdot 8.55H_2O$ from a carbonaceous-siliceous formation in NW Karatau (southern Kazakhstan). Zap. Vses. Mineral. Obshch., 118(5), 95–100 (in Russian). (2) (1991) Amer. Mineral., 76, 667 (abs. ref. 1). (3) (1992) Amer. Mineral., 77, 213 (erratum). (4) Jensen, M.C., J.C. Rota, and E.E. Foord (1995) The Gold Quarry mine, Carlin-Trend, Eureka, Nevada. Mineral. Record, 26, 449–469, esp. 459.

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Kazakovite $Na_6Mn^{2+}TiSi_6O_{18}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Crystals, to 2 mm, show the forms $\{11\bar{2}1\}$ and $\{11\bar{2}4\}$; as disseminated grains. *Twinning:* Twinning axis normal to $\{11\bar{2}4\}$; simple, complex, and polysynthetic twins.

Physical Properties: *Fracture:* Uneven to subconchoidal. Hardness = 4 D(meas.) = 2.84–2.90 D(calc.) = 2.97

Optical Properties: Semitransparent. *Color:* Yellow; pale yellow in thin section.
Luster: Vitreous to greasy.
Optical Class: Uniaxial (–). $\omega = 1.648–1.650$ $\epsilon = 1.625–1.638$

Cell Data: *Space Group:* $R\bar{3}m$. $a = 10.174$ $c = 13.053$ Z = 3

X-ray Powder Pattern: Mt. Karnasurt, Russia.
2.60 (10), 2.52 (8), 1.816 (8), 3.60 (7), 1.480 (7), 3.28 (6), 3.17 (6)

Chemistry:

	(1)
SiO_2	52.44
TiO_2	7.62
Al_2O_3	0.84
Fe_2O_3	2.30
Nb_2O_5	1.40
MnO	4.40
MgO	0.10
CaO	0.40
Na_2O	25.50
K_2O	0.47
H_2O^+	3.66
H_2O^-	0.14
P_2O_5	0.70
Total	99.97

(1) Mt. Karnasurt, Russia; corresponds to $(Na_{5.51}K_{0.07}Ca_{0.05})_{\Sigma=5.63}Mn^{2+}_{0.42}(Ti_{0.64}Fe_{0.20}Nb_{0.07}Mg_{0.02}Al_{0.02})_{\Sigma=0.95}(Si_{5.84}Al_{0.09}P_{0.07})_{\Sigma=6.00}O_{18}$.

Mineral Group: Lovozerite group.

Occurrence: In sodalite-rich syenites in an alkalic massif (Lovozero massif, Russia).

Association: Nordite, belovite, vuonnemite, alkalic feldspars, ussingite (Lovozero massif, Russia); villiaumite, delhayelite, lamprophyllite, lomonosovite, feldspars, nepheline, aegirine (Khibiny massif, Russia).

Distribution: On Mts. Karnasurt and Alluaiv, Lovozero massif, and in the Khibiny massif, Kola Peninsula, Russia.

Name: For Mariya Efimovna Kazakova (1913–1982), Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia, analytical chemist who provided the mineral's analysis.

Type Material: Mining Institute, St. Petersburg, 1081/2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75513, 76106, vis3466.

References: (1) Khomyakov, A.P., E.I. Semenov, E.M. Es'kova, and A.A. Voronkov (1974) Kazakovite – a new mineral of the lovozerite group. Zap. Vses. Mineral. Obshch., 103, 342–345 (in Russian). (2) (1975) Amer. Mineral., 60, 161–162 (abs. ref. 1). (3) (1975) Mineral. Abs., 26, 126 (abs. ref. 1). (4) Povarennykh, A.S. and Y.P. Men'shikov (1977) Kazakovite from the Khibiny Mountains and IR spectra of some titano- and zirconosilicates. Geol. Zh., 37, 115–120 (in Russian). (5) (1977) Chem. Abs., 87, 41912 (abs. ref. 4). (6) Voronkov, A.A., Z.V. Pudovkina, V.A. Blinov, V.V. Ilyukhin, and Y.A. Pyatenko (1979) Crystal structure of kazakovite $Na_6Mn\{Ti[Si_6O_{18}]\}$. Doklady Acad. Nauk SSSR, 245, 106–109 (in Russian).

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Keckite $\mathbf{Ca(Mn^{2+},Zn)_2Fe_3^{3+}(PO_4)_4(OH)_3 \cdot 2H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [001], to 2 mm; in tufted or fan-shaped groups. *Twinning:* Reported, probably on {111} and {110}.

Physical Properties: *Cleavage:* Poor on {001}, and poorer on {100}. *Tenacity:* Flexible but not elastic. Hardness = 4.5 D(meas.) = 2.60 D(calc.) = 2.649

Optical Properties: Translucent. *Color:* Dirty gray-brown to brown, yellow-brown.
Luster: Dull.
Optical Class: Biaxial (–); undulatory extinction. *Pleochroism:* X = reddish brown; Y = yellow; Z = paler yellow. *Orientation:* $Z = b$; $X \wedge c = 15$–$22°$. *Absorption:* $X \gg Y \geq Z$. α = n.d. $\beta = 1.692$ $\gamma = 1.699$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/a$. $a = 15.02(1)$ $b = 7.19(5)$ $c = 19.74(2)$ $\beta = 110°30(1)'$ Z = 2

X-ray Powder Pattern: Hagendorf, Germany.
2.86 (10), 9.3 (8), 4.98 (5), 3.51 (5d), 2.59 (4), 1.879 (4), 4.63 (3)

Chemistry:

	(1)
P_2O_5	35.75
Fe_2O_3	30.02
MnO	14.85
ZnO	2.24
MgO	0.66
CaO	5.88
H_2O	[10.60]
Total	[100.00]

(1) Hagendorf, Germany; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, H_2O by difference, $(OH)^{1-}$ determined by IR; corresponding to $(Ca_{0.83}Mg_{0.13})_{\Sigma=0.96}(Mn_{1.66}Zn_{0.22})_{\Sigma=1.88}$ $Fe^{3+}_{2.99}(PO_4)_4(OH)_{2.65} \cdot 2.03H_2O$.

Mineral Group: Whiteite group.

Occurrence: A weathering product of phosphate minerals in a complex granite pegmatite.

Association: Rockbridgeite, phosphophyllite, scholzite, fairfieldite, vivianite, reddingite, huréaulite, strengite, apatite.

Distribution: In Germany, in Bavaria, from Hagendorf, at the Silbergrube quarry, near Waidhaus, and at Hühnerkobel, near Zwiesel. In the Bendada pegmatite, near Guarda, Portugal.

Name: Honors Erich Keck, Etzenricht, Germany, collector of Hagendorf minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145616, 145617.

References: (1) Mücke, A. (1979) Keckit, $(Ca,Mg)(Mn,Zn)_2Fe_3^{3+}[(OH)_3|(PO_4)_4] \cdot 2H_2O$, ein neues Mineral von Hagendorf/Opf. und seine genetische Stellung. Neues Jahrb. Mineral., Abh., 134, 183–192 (in German with English abs.). (2) (1979) Amer. Mineral., 64, 1330-1331 (abs. ref. 1).

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Kegelite $Pb_8Al_4Si_8O_{20}(SO_4)_2(CO_3)_4(OH)_8$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$, 2, or m. As pseudohexagonal plates with dominant {100}, to 0.3 mm, forming spherical aggregates.

Physical Properties: *Cleavage:* {100}, perfect. *Tenacity:* Extremely flexible. Hardness = n.d. D(meas.) = ∼4.5 D(calc.) = 4.76

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Biaxial (–). $n = 1.81 \parallel \{100\}$. 2V(meas.) = n.d.

Cell Data: *Space Group:* $A2/m$, $A2$, or Am. $a = 21.04(1)$ $b = 15.55(1)$ $c = 8.986(6)$ $\beta = 91.0(1)^\circ$ Z = 3

X-ray Powder Pattern: Tsumeb, Namibia.
21.0 (100), 2.591 (90), 3.82 (80), 7.01 (50), 3.006 (50), 2.339 (50), 3.74 (40)

Chemistry:

	(1)
SiO_2	17.0
Al_2O_3	7.1
FeO	trace
MnO	0.0
CuO	1.5
ZnO	trace
PbO	60.9
CaO	0.0
H_2O	2.6
CO_2	7.0
SO_3	5.5
Total	101.6

(1) Tsumeb, Namibia; by electron microprobe, CO_2 by a C analyzer, H_2O and SO_3 by TGA and EGA; corresponding to $Pb_{7.55}Cu_{0.52}Al_{3.85}Si_{7.83}O_{19.22}(SO_4)_{1.90}(CO_3)_{4.40}(OH)_{7.98}$.

Occurrence: In a deep oxidation zone in a polymetallic mineral deposit.

Association: Quartz, galena, mimetite, hematite, leadhillite, anglesite, fleischerite, melanotekite, alamosite.

Distribution: From Tsumeb, Namibia.

Name: For Friedrich Wilhelm Kegel (?–1948), Director of mining operations (1922–1938) at Tsumeb, Namibia.

Type Material: National Museum of Natural History, Washington, D.C., USA, 134514, 147460.

References: (1) Medenbach, O. and K. Schmetzer (1975) Kegelite – ein neues Bleisilikat von Tsumeb. Naturwiss., 62, 137 (in German with English abs.). (2) (1976) Amer. Mineral., 61, 175–176 (abs. ref. 1). (3) Medenbach, O. and K. Schmetzer (1976) Kegelite – ein neues Bleisilikat von Tsumeb. Neues Jahrb. Mineral., Monatsh., 110–114 (in German). (4) (1977) Amer. Mineral., 62, 175 (abs. ref. 3). (5) Dunn, P.J., R.S.W. Braithwaite, A.C. Roberts, and R.A. Ramik (1990) Kegelite from Tsumeb, Namibia: a redefinition. Amer. Mineral., 75, 702–704. (6) Braithwaite, R.S.W. (1991) Kegelite: infrared spectroscopy and a structural hypothesis. Mineral. Mag., 55, 127–134.

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Keilite $(Fe^{2+}, Mg)S$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Granular, to several hundred μm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.59–3.67

Optical Properties: Opaque. *Color:* Gray.
Optical Class: Isotropic.
R: (400) 27.0, (420) 27.1, (440) 27.6, (460) 27.2, (480) 27.1, (500) 26.6, (520) 26.6, (540) 26.6, (560) 26.5, (580) 26.7, (600) 25.9, (620) 26.2, (640) 26.1, (660) 25.9, (680) 26.0, (700) 25.9

Cell Data: *Space Group:* $Fm3m$ (by analogy to synthetic MgS). a = 5.17–5.18 Z = 4

X-ray Powder Pattern: Abee meteorite.
2.584 (vs), 1.829 (s)

Chemistry:

	(1)	(2)
Fe	40.14	38.71
Mg	10.05	16.84
Mn	3.37	
Ca	1.98	
Cr	1.91	
Zn	0.24	
Ti	0.06	
Ni	0.01	
S	41.39	44.45
Total	99.15	100.00

(1) Abee meteorite; by electron microprobe, corresponding to $(Fe_{0.56}Mg_{0.32}Mn_{0.05}Ca_{0.04}Cr_{0.03})_{\Sigma=1.00}S_{1.00}$. (2) (Fe, Mg)S with Fe:Mg = 1:1.

Mineral Group: Galena group.

Occurrence: An accessory mineral in enstatite chondrite meteorites.

Association: Niningerite, enstatite, kamacite, troilite.

Distribution: From the Abee [TL], Adhi-Kot, Saint-Sauveur, LEW 88180, RKP A80259, LEW 87119, LEW 88714, Y-791790, Y-791811, Y-86760, Y8404 meteorites.

Name: In honor of Dr. Klaus Keil (1934–), Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, Hawaii, USA, for his research on chondritic meteorites.

Type Material: University of Hawaii, Honolulu, Hawaii, USA, 13.

References: (1) Shimizu, M., H. Yoshida, and J.A, Mandarino (2002) The new mineral species keilite, (Fe, Mg)S, the iron-dominant analog of niningerite. Can. Mineral., 40, 1687–1692. (2) (??) Amer. Mineral., ??, ?? (abs. ref. 1).

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Keithconnite $Pd_{20}Te_7$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As grains, to 220 μm, and inclusions in platinum-group element nuggets.

Physical Properties: Hardness = n.d. VHN = 394–424, 410 average (15 g load). D(meas.) = n.d. D(calc.) = 11.72

Optical Properties: Opaque. *Color:* In polished section, cream colored, where isolated; dull cream with brownish tint with kotulskite; gray next to telluropalladinite. *Pleochroism:* Not detectable in air; very slight in oil. *Anisotropism:* Moderate to strong.
R_1–R_2: (400) 40.8–40.6, (420) 41.6–41.1, (440) 41.8–41.5, (460) 42.0–42.0, (480) 42.3–42.6, (500) 42.9–43.4, (520) 43.6–44.1, (540) 44.4–44.9, (560) 45.3–45.8, (580) 46.0–46.6, (600) 46.8–47.5, (620) 48.0–48.8, (640) 49.3–49.9, (660) 50.6–50.9, (680) 52.0–52.1, (700) 53.5–53.4

Cell Data: *Space Group:* $R\overline{3}$. $a = 11.458(10)$ $c = 11.296(12)$ $Z = 3$

X-ray Powder Pattern: Stillwater complex, Montana, USA.
2.26 (100), 2.16 (90), 0.791 (40), 1.32 (30), 0.885 (30), 2.22 (20), 1.40 (20)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Pd	68.7	67.31	70.44	Pb	1.6		
Pt		3.19		As		0.32	
Rh		0.13		Bi	1.0		
Fe		0.11		Te	29.1	30.45	29.56
				Total	100.4	101.51	100.00

(1) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $Pd_{19.81}Pb_{0.24}Bi_{0.15}Te_{7.00}$. (2) Pustaya River, Russia; by electron microprobe, corresponding to $Pd_{18.55}Pt_{0.48}Fe_{0.06}Rh_{0.04}As_{0.12}Te_{7.00}$. (3) $Pd_{20}Te_7$.

Occurrence: Rare with other platinum-group minerals in layered ultrabasic complexes and their placers.

Association: Merenskyite, kotulskite, telluropalladinite, moncheite, vysotskite, gold, magnetite (Stillwater complex, Montana, USA).

Distribution: From the Stillwater complex, Montana, USA [TL]. In the Bird River sill, Manitoba, Canada. From the Department of Chocó, Cauca, Colombia. At the Kirakkajuppura deposit, Penikat layered complex, northeast of Kemi, Finland. From the Pustaya River placers, Kamchatka, Russia. In placers in the Veluće ophiolite complex, Serbia. Found in rocks of the Mine Series, Katanga Province, Congo (Shaba Province, Zaire). In the Manampotsy district, Madagascar. In Burma, from the Chindwin River placers.

Name: Honors H. Keith Conn (1923–), the geologist largely responsible for the discovery of Pt–Pd mineralization of parts of the Stillwater complex, Montana.

Type Material: Canadian Geological Survey, Ottawa, 12187, 12188; Royal Ontario Museum, Toronto, Canada, M35867; National Museum of Natural History, Washington, D.C., USA, 114975.

References: (1) Cabri, L.J., J.F. Rowland, J.H.G. Laflamme, and J.M. Stewart (1979) Keithconnite, telluropalladinite, and other Pd–Pt tellurides from the Stillwater Complex, Montana. Can. Mineral., 17, 589–594. (2) (1981) Amer. Mineral., 66, 1275 (abs. ref. 1). (3) Wopersnow, W. and K. Schubert (1977) ??title?? J. Less-Common Metals, 51, 35–??. ??must?? (4) Bayliss, P. (1990) Revised unit-cell dimensions, space group, and chemical formula of some metallic minerals. Can. Mineral., 28, 751–755. (5) Tolstykh, N.D., E.G. Sidorov, K.V.O. Laajoki, A.P. Krivenko, and M. Podlipskiy (2000) The asociation of platinum group minerals in placers of the Pustaya River, Kamchatka, Russia. Can. Mineral., 38, 1251–1264. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 280.

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Keiviite-(Y) $(Y,Yb)_2Si_2O_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, up to 1 mm.

Physical Properties: *Fracture:* Uneven. Hardness = 4–5 D(meas.) = 4.45 D(calc.) = 4.48 Yellow-green cathodoluminescence.

Optical Properties: Semitransparent. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 4°$; $Y \wedge a = 7°$. *Dispersion:* $r < v$.
$\alpha = 1.713(1)$ $\beta = 1.748(1)$ $\gamma = 1.758(1)$ 2V(meas.) = 56(2)° 2V(calc.) = 55°

Cell Data: *Space Group:* $[C2/m]$ [by analogy to keiviite-(Yb)]. $a = 6.845(5)$ $b = 8.960(5)$ $c = 4.734(3)$ $\beta = 101.65(5)°$ Z = 2

X-ray Powder Pattern: Mt. Ploskaya, Russia; nearly identical to keiviite-(Yb).
3.23 (10), 4.65 (9), 3.04 (8), 2.280 (7), 5.40 (5), 2.729 (5), 2.692 (5)

Chemistry:

	(1)	(2)
SiO_2	30.85	30.49
Y_2O_3	40.86	45.86
Gd_2O_3	0.08	0.62
Tb_2O_3	0.10	0.00
Dy_2O_3	1.53	2.92
Ho_2O_3	0.85	1.27
Er_2O_3	6.50	4.40
Tm_2O_3	1.99	1.11
Yb_2O_3	15.36	11.81
Lu_2O_3	2.61	1.05
CaO	0.00	0.30
Total	100.73	99.83

(1–2) Mt. Ploskaya, Russia; by electron microprobe; when averaged with another intermediate analysis, corresponds to $(Y_{1.55}Yb_{0.20}Er_{0.10}Dy_{0.08}Ca_{0.04}Tm_{0.02}Lu_{0.02}Ho_{0.02}Gd_{0.01})_{\Sigma=2.04}Si_{1.98}O_7$.

Polymorphism & Series: Forms a series with keiviite-(Yb).

Occurrence: In fissures in quartz and fluorite in "amazonite" pegmatites.

Association: Keiviite-(Yb), thalenite, xenotime, bastnäsite, kuliokite-(Y), quartz, fluorite.

Distribution: From Mt. Ploskaya, Keivy massif, Kola Peninsula, Russia.

Name: For the relation to *keiviite*-(Yb) and the *yttrium* content.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5958/6; Mining Institute, St. Petersburg, 1343-1/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia,

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, and F.N. Tyusheva (1985) Keiviite-(Y) – a new yttrian diorthosilicate, and thalenite from amazonite pegmatites of the Kola Peninsula. Diortho- and triorthosilicates of yttrium. Mineral. Zhurnal, 7(6), 79–94 (in Russian with English abs.). (2) (1988) Amer. Mineral., 73, 191–192 (abs. ref. 1).

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Keiviite-(Yb) $(Yb,Y)_2Si_2O_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As elongated platy and prismatic crystals, to 0.8 mm. *Twinning:* Polysynthetic, common.

Physical Properties: *Cleavage:* Perfect on {110}, imperfect on {001}. Hardness = n.d. D(meas.) = 5.95 D(calc.) = 5.99 Faint green cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 3°$–$5°$; $Y \wedge a = 7°$–$8°$. *Dispersion:* $r < v$, strong. $\alpha = 1.723$ $\beta = 1.758$ $\gamma = 1.768$ 2V(meas.) = 58°

Cell Data: *Space Group:* $C2/m$. $a = 6.840(2)$ $b = 8.916(4)$ $c = 4.745(1)$ $\beta = 102.11(3)°$ Z = 2

X-ray Powder Pattern: Mt. Ploskaya, Russia; nearly identical to keiviite-(Y). 3.24 (10), 3.20 (10), 3.03 (9), 4.64 (8), 2.720 (7), 2.674 (7), 2.262 (7)

Chemistry:

	(1)	(2)
SiO_2	23.47	26.71
Y_2O_3	1.02	15.42
Gd_2O_3	0.06	0.15
Tb_2O_3	0.04	0.04
Dy_2O_3	1.23	3.86
Ho_2O_3	0.65	1.23
Er_2O_3	6.24	9.85
Tm_2O_3	3.10	3.19
Yb_2O_3	55.06	34.57
Lu_2O_3	8.97	5.22
FeO	0.00	0.09
CaO	0.03	0.07
Total	99.87	100.40

(1–2) Mt. Ploskaya, Russia; by electron microprobe; when averaged with three other intermediate analyses, corresponds to $(Yb_{1.43}Lu_{0.23}Er_{0.17}Tm_{0.08}Y_{0.05}Dy_{0.03}Ho_{0.02})_{\Sigma=2.01}Si_{1.99}O_7$.

Polymorphism & Series: Forms a series with keiviite-(Y).

Occurrence: In microcline-bearing pegmatites; two generations of the mineral are present.

Association: Fluorite, bastnäsite, hingganite, wulfenite.

Distribution: From Mt. Ploskaya, Keivy massif, Kola Peninsula, Russia.

Name: For Keivy on the Kola Peninsula, Russia, and *ytterbium* in its composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5769; Mining Institute, St. Petersburg, 1343/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82998.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, and F.N. Tyusheva (1983) Keiviite $Yb_2Si_2O_7$, a new ytterbium silicate from amazonitic pegmatites of the Kola Peninsula. Mineral. Zhurnal, 5(5), 94–99 (in Russian with English abs.). (2) (1984) Amer. Mineral., 69, 1191 (abs. ref. 1).

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Keldyshite $Na_2ZrSi_2O_7 \cdot nH_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As irregular grains, to 4 mm, or granular aggregates. *Twinning:* Very fine polysynthetic twinning seen under the microscope.

Physical Properties: *Cleavage:* Two poor, intersecting ~90°. *Fracture:* Irregular. *Tenacity:* Very brittle. Hardness = 3.8–4.3 VHN = 157–231 D(meas.) = 3.22–3.30 D(calc.) = 3.26

Optical Properties: Translucent, transparent in thin fragments. *Color:* White; colorless in thin section. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). $\alpha = 1.670$ β = n.d. $\gamma = 1.710$ 2V(meas.) = 78°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.0(1)$ $b = 5.34(2)$ $c = 6.96(3)$ $\alpha = 92(1)°$ $\beta = 116(1)°$ $\gamma = 88(1)°$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
3.97 (10), 4.11 (7), 1.542 (7), 1.097 (6), 1.013 (6), 2.95 (5), 2.66 (5)

Chemistry:

	(1)	(2)
SiO_2	39.39	39.69
TiO_2	0.60	0.32
ZrO_2	40.35	39.53
$Fe_2O_3 + FeO$	0.31	0.26
CaO		1.37
Na_2O	16.03	18.35
K_2O	0.94	trace
H_2O^+	0.95	
H_2O^-	0.35	
Total	98.92	99.52

(1) Lovozero massif, Russia; average of three partial analyses. (2) Do.; corresponds to $(Na_{1.79}Ca_{0.07})_{\Sigma=1.86}(Zr_{0.97}Ti_{0.01}Fe_{0.01})_{\Sigma=0.99}Si_2O_{6.94}$.

Occurrence: A primary mineral in foyaites composed of partly albitized microcline, nepheline, sodalite, aegirine, and alkali amphibole, in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Eudialyte, lorenzenite (Lovozero massif, Russia).

Distribution: In the vicinity of the Tavaiok and Angoundasiok Rivers and on Mt. Alluaiv, Lovozero massif, and at Tachtarvumchorr, Khibiny massif, Kola Peninsula, Russia. From Lågendalen, near Larvik, Norway.

Name: For Russian mathematician Mstislav Vsevolodovich Keldysh (1911–1978), President of the Academy of Sciences, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64710, 64711.

References: (1) Gerasimovskii, V.I. (1962) Keldyshite, a new mineral. Doklady Acad. Nauk SSSR, 142, 916–918 (in Russian). (2) (1962) Amer. Mineral., 47, 1216 (abs. ref. 1). (3) Khomyakov, A.P., M.E. Kazakova, and A.A. Voronkov (1969) New data on keldyshite. Doklady Acad. Nauk SSSR, 189, 166–168 (in Russian). (4) (1970) Amer. Mineral., 55, 1072–1073 (abs. ref. 3). (5) (1972) Amer. Mineral., 57, 1317 (corr. ref. 4). (6) Khalikov, A.D., A.P. Khomyakov, and S.A. Makhmudov (1978) Crystal structure of keldyshite. Doklady Acad. Nauk SSSR, 238, 573–575 (in Russian). (7) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 390–391.

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Kellyite $(Mn^{2+}, Mg, Al)_3(Si, Al)_2O_5(OH)_4$

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Crystal Data: Hexagonal. *Point Group:* 6. As irregular to platy tablets and laths, to 3 mm.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. D(meas.) = 3.07 D(calc.) = 3.11

Optical Properties: Transparent. *Color:* Yellow; light yellow in thin section. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless to greenish yellow; $Y = Z$ = pale yellow to reddish brown. *Orientation:* $X \perp (0001)$. *Dispersion:* $r > v$, moderate. $\alpha = 1.639(1)$ $\beta = 1.646(1)$ $\gamma = 1.646(1)$ 2V(meas.) = 30°–16°

Cell Data: *Space Group:* $P6_3$. $a = 5.438(8)$ $c = 14.04(1)$ Z = [4]

X-ray Powder Pattern: Bald Knob, North Carolina, USA.
3.51 (100), 7.0 (90), 2.53 (60), 2.67 (40), 2.34 (40), 1.954 (30), 1.570 (30)

Chemistry:

	(1)
SiO_2	17.60
TiO_2	< 0.05
Al_2O_3	28.55
Fe_2O_3	2.18
MnO	38.84
MgO	2.97
H_2O	[10.82]
Total	[100.96]

(1) Bald Knob, North Carolina, USA; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $(Mn_{1.82}Al_{0.84}Mg_{0.24}Fe_{0.09})_{\Sigma=2.99}(Al_{1.02}Si_{0.98})_{\Sigma=2.00}O_5(OH)_4$.

Polymorphism & Series: two-layer hexagonal and six-layer rhombohedral polytypes noted.

Mineral Group: Kaolinite-serpentine group.

Occurrence: In banded Ca-Mn carbonate-rich rocks (Bald Knob mine, North Carolina, USA); in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Kutnohorite, galaxite, jacobsite, manganoan chlorite, alleghanyite, sonolite (Bald Knob mine, North Carolina, USA); aegirine, analcime, calcite, catapleiite, microcline, natrolite (Mont Saint-Hilaire, Canada).

Distribution: In the Bald Knob mine, near Sparta, Alleghany Co., North Carolina, USA. From Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Professor William Crowe Kelly (1929–), geologist, of the University of Michigan, Ann Arbor, Michigan, USA.

Type Material: Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA, 127101, 137140, 137141.

References: (1) Peacor, D.R., E.J. Essene, W.B. Simmons, Jr., and W.C. Bigelow (1974) Kellyite, a new Mn-Al member of the serpentine group from Bald Knob, North Carolina, and new data on grovesite. Amer. Mineral., 59, 1153–1156.

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Kelyanite $Hg_{36}Sb_3O_{28}(Cl,Br)_9$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As irregular grains, to 2 mm.

Physical Properties: Hardness = 3–3.5 VHN = 247 (20 g load). D(meas.) = 8.51–8.63, 8.57 average. D(calc.) = 8.51

Optical Properties: Translucent. *Color:* Reddish brown; grayish white in reflected light, with deep brownish red to raspberry-red internal reflections. *Streak:* Resinous to vitreous. *Optical Class:* Biaxial. $n = > 2.0$ 2V(meas.) = n.d. *Pleochroism:* Reddish brown to pale brown. *Anisotropism:* Noted. *Bireflectance:* Weak.
R_1–R_2: (460) 20.5–19.9, (546) 18.9–18.1, (620) 17.8–17.1

Cell Data: *Space Group:* $C2/m$, $C2/c$, Cm, Cc, or $C2$. $a = 23.50(12)$ $b = 13.62(6)$ $c = 10.31(5)$ $\beta = 97.01(12)^\circ$ $Z = 2$

X-ray Powder Pattern: Kelyana mine, Russia.
3.30 (10), 3.78 (6), 2.72 (6), 2.53 (6), 3.24 (5), 2.364 (5), 1.954 (5)

Chemistry:

	(1)
Hg	85.6
Sb	4.70
O	5.35
Cl	3.31
Br	0.91
Total	99.87

(1) Kelyana mine, Russia; by electron microprobe, average of 12 analyses; corresponding to $Hg_{35.99}Sb_{3.28}O_{28.07}(Cl_{7.82}Br_{0.93})_{\Sigma=8.75}$, probably $Hg_{20}^{2+}Hg_{16}^{1+}Sb_3^{3+}O_{28}(Cl,Br)_9$.

Occurrence: In the oxidation zone of a stibnite-cinnabar ore deposit.

Association: Calomel, eglestonite, mercury, shakhovite, antimony oxides.

Distribution: In the Kelyana Sb–Hg mine, North Muya Range, Buryatia, Transbaikal region, Siberia, Russia.

Name: For the Kelyana mine, Russia, where it was first found.

Type Material: Central Siberian Geological Museum, Siberian Division, Academy of Sciences, Novosibirsk, VI-20/1; Mining Institute, St. Petersburg, 1203/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80163.

References: (1) Vasil'ev, V.I., Y.G. Lavrent'ev, and N.A. Pal'chik (1982) Kelyanite, $Hg_{36}Sb_3(Cl,Br)_9O_{28}$, a new mineral. Zap. Vses. Mineral. Obshch., 111, 330–334 (in Russian). (2) (1983) Amer. Mineral., 68, 1248–1249 (abs. ref. 1). (3) (1983) Mineral. Abs., 34, 183 (abs. ref. 1).

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Kemmlitzite $(Sr,Ce)Al_3(AsO_4)(SO_4)(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As pseudocubic rhombohedral crystals, to 0.15 mm, rarely modified by {0001}.

Physical Properties: *Cleavage:* Poor on {0001}. Hardness = 5.5 D(meas.) = 3.63 D(calc.) = 3.601 Low magnetic susceptibility.

Optical Properties: Transparent to translucent. *Color:* Pale gray-brown with a yellow tint, brownish; in transmitted light, colorless to brown-yellow, commonly zoned.
Optical Class: Uniaxial (+). $\omega = 1.701(1)$ $\epsilon = 1.707(1)$

Cell Data: *Space Group:* $[R\overline{3}m]$ (by analogy to beudantite). $a = 7.027(1)$ $c = 16.51(1)$ Z = 3

X-ray Powder Pattern: Kemmlitz, Germany.
2.959 (10), 3.514 (9), 1.903 (9), 2.203 (8), 1.757 (8), 5.71 (7), 1.292 (6)

Chemistry:

	(1)
SO_3	5.99
P_2O_5	5.69
As_2O_5	21.57
SiO_2	2.18
Al_2O_3	27.24
RE_2O_3	12.60
Fe_2O_3	0.78
MgO	0.90
CaO	0.90
SrO	8.27
H_2O	12.04
Total	98.16

(1) Kemmlitz, Germany; $RE_2O_3 = Ce_2O_3$ 57.00%, La_2O_3 26.35%, Nd_2O_3 15.77%, Sm_2O_3 0.88%; AsO_4, SO_4, PO_4, $(OH)^{1-}$, and H_2O confirmed by IR; corresponding to $(Sr_{0.42}RE_{0.40}Mg_{0.12}Ca_{0.08})_{\Sigma=1.02}(Al_{2.79}Fe^{3+}_{0.05})_{\Sigma=2.84}(AsO_4)_{0.98}[(PO_4)_{0.42}(SO_4)_{0.39}(SiO_4)_{0.19}]_{\Sigma=1.00}(OH)_{5.22}\bullet 0.88H_2O$.

Mineral Group: Beudantite group.

Occurrence: In a kaolinized quartz porphyry, in a heavy-fraction separate of undetermined origin as to primary or secondary formation.

Association: Kaolinite, zircon, anatase, apatite, 13 other less-abundant heavy minerals.

Distribution: From the Kemmlitz kaolin deposit, near Oschatz, Saxony, Germany.

Name: For the locality of the first specimens, Kemmlitz, Germany.

Type Material: National Museum, Prague, Czech Republic, 53508; National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, USA, 109097.

References: (1) Hak, J., Z. Johan, M. Kvaček, and W. Liebscher (1969) Kemmlitzite, a new mineral of the woodhouseite group. Neues Jahrb. Mineral., Monatsh., 201–212. (2) (1970) Amer. Mineral., 55, 320–321 (abs. ref. 1).

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Kempite $Mn_2^{2+}Cl(OH)_3$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As minute crystals, prismatic along [001], exhibiting {110}, {011}, {121}, and less commonly {010}, {100}.

Physical Properties: Hardness = ∼3.5 D(meas.) = ∼2.94 D(calc.) = 2.96

Optical Properties: Semitransparent. *Color:* Emerald-green; green in transmitted light. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.684(1)$ $\beta = 1.695(1)$ $\gamma = 1.698(1)$ 2V(meas.) = n.d. 2V(calc.) = 54°52′

Cell Data: *Space Group:* n.d. (ICDD 25-1158). $a = 6.49$ $b = 9.52$ $c = 7.12$ Z = 4

X-ray Powder Pattern: Alum Rock Canyon, California, USA. (ICDD 25-1158).
2.386 (100), 5.70 (80), 5.36 (70), 2.965 (70), 1.690 (35), 2.895 (20), 2.842 (20)

Chemistry:

	(1)	(2)
Mn	50.59	55.96
O	[21.40]	12.22
Cl	16.41	18.06
H_2O	11.60	13.76
Total	[100.00]	100.00

(1) Alum Rock Canyon, California, USA; O by difference, recalculated to 100% after deduction of insoluble material. (2) $Mn_2Cl(OH)_3$.

Occurrence: In an erratic boulder with other manganese-bearing species.

Association: Pyrochroite, hausmannite, rhodochrosite, tephroite, "psilomelane".

Distribution: In Alum Rock Canyon, eight km east of San Jose, Santa Clara Co., California, USA.

Name: Honors economic geologist James Furman Kemp (1859–1926), Professor of Geology, Columbia University, New York City, New York, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R1352.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 73–74.

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Kenhsuite γ–$Hg_3S_2Cl_2$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. Crystals elongated ‖ [010], lath-shaped on {001}, to 18 cm; typically in radiating agregates, may be tufted and hairlike. *Twinning:* On {$\overline{4}$11}.

Physical Properties: *Cleavage:* Perfect on {001}; parting on {010}. *Tenacity:* Sectile, thin fragments flexible. Hardness = 1–1.5 VHN = 30–90 (5 g load). D(meas.) = 4.68 D(calc.) = 4.88

Optical Properties: Translucent. *Color:* Cherry-red; red in thin fragments. *Streak:* Brownish red. *Luster:* Adamantine to semimetallic.
Optical Class: Biaxial (+). *Orientation:* $Z = b$. $\alpha = 2.99$ $\beta = 3.14$ $\gamma = 3.48$
Anisotropism: Very strong to extreme.
R_1–R_2: (400) 31.1–37.5, (420) 30.0–36.4, (440) 29.0–35.2, (460) 28.0–34.0, (480) 27.2–33.0, (500) 26.4–32.2, (520) 25.7–31.3, (540) 25.2–30.6, (560) 24.8–30.0, (580) 24.4–29.4, (600) 24.0–29.0, (620) 23.8–28.6, (640) 23.5–28.2, (660) 23.4–28.0, (680) 23.2–27.8, (700) 23.1–27.7

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.147(1)$ $b = 10.709(1)$ $c = 5.785(1)$ $\alpha = 102.78(2)°$ $\beta = 110.63(2)°$ $\gamma = 101.00(1)°$ Z = 4

X-ray Powder Pattern: Zimbabwe. (ICDD 11-91).
2.92 (100), 3.13 (90), 2.69 (70), 4.06 (60), 1.782 (60), 5.29 (50), 2.49 (50)

Chemistry:

	(1)	(2)
Sb	75.2	75.24
O	4.8	4.94
S	19.9	19.82
Total	99.9	100.00

(1) Globe and Phoenix mine, Zimbabwe; by electron microprobe. (2) Sb_2OS_2.

Occurrence: A secondary mineral, as an alteration of stibnite, in antimony deposits.

Association: Stibnite, antimony, sénarmontite, valentinite, cervantite, stibiconite.

Distribution: In small amounts in many deposits. From Bräunsdorf, near Freiberg, Saxony, Germany. Fine examples from the Kriznica mine, near Pernek, and in the Pezinok mine, Malé Karpaty Mountains, Slovakia. At Příbram, Czech Republic. In the Chalanches mine, near Allemont, Isère, France. From the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. At Kadamdja, Kyrgyzstan. In the Santa Cruz and San Francisco mines, Poopó, Oruro, Bolivia. Exceptional radiating groups from the Globe and Phoenix mine, Kwekwe (Que Que), Zimbabwe. At Sombrerete, Zacatecas, Mexico. From Canada, in the Lac Nicolet mine, South Ham, Quebec, and at other localities. In the USA, at the Mohave mine, Kern Co., California; noted at nearly 30 localities in Nevada, all minor. From Broken Hill, New South Wales, Australia. Outstanding examples from ??, China.

Name: From *kermes* (after Persian *qurmizq, crimson*) for red amorphous antimony trisulfide.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 279–280. (2) Cervelle, B. (1971) Détermination par microréflectométrie de propriétés optiques d'un cristal monoclinique absorbant (kermésite Sb_2S_2O). Bull. Soc. fr. Minéral., 94, 486–491 (in French). (3) Bonazzi, P., S. Menchetti, and C. Sabelli (1987) Structure refinement of kermesite: symmetry, twinning, and comparison with stibnite. Neues Jahrb. Mineral., Monatsh., 557–567.

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Kentrolite $Pb_2Mn_2^{3+}O_2Si_2O_7$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tiny, short prismatic crystals with {010}, {110}, and {111} common; as sheaflike groupings and massive.

Physical Properties: *Cleavage:* Distinct on {110}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 6.19 D(calc.) = [6.29]

Optical Properties: Semitransparent. *Color:* Dark reddish brown, with deep red internal reflections; tarnishes black on the surface. *Streak:* Yellowish brown. *Luster:* Vitreous to submetallic, greasy, dull.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = bright yellowish pink; Y = reddish brown; Z = deep brownish red. *Orientation:* X = a. *Dispersion:* $r < v$, strong. *Absorption:* $Z > Y > X$. $\alpha = 2.10$ $\beta = 2.20$ $\gamma = 2.31$ 2V(meas.) = 88°
R_1–R_2: (400) 14.7–18.7, (420) 14.4–18.1, (440) 14.1–17.5, (460) 13.9–16.9, (480) 13.6–16.4, (500) 13.4–16.0, (520) 13.2–15.7, (540) 13.0–15.4, (560) 12.9–15.2, (580) 12.8–15.0, (600) 12.6–14.9, (620) 12.5–14.8, (640) 12.5–14.7, (660) 12.4–14.5, (680) 12.4–14.4, (700) 12.3–14.3

Cell Data: *Space Group: Pbcn.* $a = 6.961(2)$ $b = 11.018(3)$ $c = 9.964(5)$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
2.90 (100), 2.86 (100), 2.74 (100), 3.71 (80), 3.51 (80), 3.24 (80), 2.84 (80)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	15.95	16.45	16.59	Mn_2O_3	22.26	13.55	21.79
TiO_2		0.38		ZnO		0.05	
Al_2O_3		0.30		PbO	59.79	59.59	61.62
Fe_2O_3		6.62		MgO		0.05	
				Total	98.00	96.99	100.00

(1) "Chile." (2) Långban, Sweden; by electron microprobe, corresponding to $Pb_{1.98}(Mn_{1.28}Fe_{0.61}Al_{0.04}Ti_{0.04}Mg_{0.01})_{\Sigma=1.98}Si_{2.02}O_9$. (3) $Pb_2Mn_2O_2Si_2O_7$.

Polymorphism & Series: Forms a series with melanotekite.

Occurrence: In a cavity in calcite in a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA); in veinlets cutting franklinite ore in bedded manganese deposits (Ushkatyn deposits, Kazakhstan).

Association: Quartz, barite, apatite ("Chile"); braunite, richterite, barite (Långban, Sweden); calcite, willemite, franklinite (Franklin, New Jersey, USA); garnet, tephroite, franklinite, braunite (Ushkatyn deposits, Kazakhstan).

Distribution: The unknown type locality is "southern Chile." From Långban; Jakobsberg; the Harstigen mine, near Persberg; and the Klintgruvan mine, near Kryibo, Värmland, Sweden. From Bona de Padru, near Ozieri, Sardinia, Italy. At Higher Pitts Farm, Priddy, Somerset, England. In the Kombat mine, 49 km south of Tsumeb, Namibia. In South Africa, in the Wessels mine, near Kuruman, Cape Province. From the Ushkatyn deposits, Atasui area, Kazakhstan. At Franklin, Sussex Co., New Jersey, USA.

Name: From the Greek for *spike* or *thorn*, for its prismatic habit.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 544, 1039. (2) Gabrielson, O. (1961) The crystal structures of kentrolite and melanotekite. Arkiv Mineral. Geol., 3, 141–151. (3) Glasser, F.P. (1967) New data on kentrolite and melanotekite: ternary phase relations in the system $PbO-Fe_2O_3-SiO_2$. Amer. Mineral., 52, 1085–1093. (4) Moore, P.B., P.K. Sen Gupta, J. Shen, and E.O. Schlemper (1991) The kentrolite-melanotekite series, $4Pb_2(Mn,Fe)_2^{3+}O_2[Si_2O_7]$: chemical crystallographic relations, lone-pair splitting, and cation relation to $8URe_2$. Amer. Mineral., 76, 1389–1399.

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Kenyaite $Na_2Si_{22}O_{41}(OH)_8 \cdot 6H_2O$

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Crystal Data: Monoclinic, probable. *Point Group:* n.d. As nodular concretions, commonly with chert cores.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.33]

Optical Properties: Transparent to translucent. *Color:* [White.]
Optical Class: n.d. $n = \sim 1.48$

Cell Data: *Space Group:* n.d. $a = 7.79(5)$ $b = 19.72(5)$ $c = 7.30(5)$ $\beta = 95°54(5)'$
$Z = 1$

X-ray Powder Pattern: Lake Magadi, Kenya; pattern varies with interlayer Na:H_2O.
19.68 (100), 3.428 (85), 3.198 (55), 9.925 (50), 3.320 (45), 4.965 (35), 4.689 (28)

Chemistry:

	(1)	(2)
SiO_2	83.50	84.52
TiO_2	0.02	
Al_2O_3	0.22	
Fe_2O_3	0.09	
MnO	trace	
MgO	0.04	
CaO	0.11	
Na_2O	3.96	3.96
K_2O	0.04	
H_2O^+	4.90	
H_2O^-	7.10	
H_2O		11.52
Total	99.98	100.00

(1) Lake Magadi, Kenya. (2) $Na_2Si_{22}O_{41}(OH)_8 \cdot 6H_2O$.

Occurrence: As concretions, with chert cores, embedded in magadiite; perhaps as a reaction product between the two (Lake Magadi, Kenya); in altered volcanic rocks (Trinity Co., California, USA).

Association: Magadiite, quartz.

Distribution: From Lake Magadi, Rift Valley, Kenya. In Niger, at Kafra. In the USA, from five km north of Trinity Lake, Trinity Co., California.

Name: For the locality in Kenya.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 121336, 121337.

References: (1) Eugster, H.P. (1967) Hydrous sodium silicates from Lake Magadi, Kenya: precursors of bedded chert. Science, 157, 1177–1180. (2) (1968) Amer. Mineral., 53, 510 (abs. ref. 1). (3) McAtee, J.L., Jr., R. House, and H.P. Eugster (1968) Magadiite from Trinity County, California. Amer. Mineral., 53, 2061–2069. (4) Beneke, K. and G. Lagley (1983) Kenyaite – synthesis and properties. Amer. Mineral., 68, 818–826.

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\bar{1}$. Crystals elongated || [010], lath-shaped on {001}, in radiating aggegates to 5 cm, sometimes tufted and hair-like.

Physical Properties: *Cleavage:* Perfect on {001}; parting on {010}. *Tenacity:* Sectile, thin splinters flexible. Hardness = 1–1.5 VHN = 30–90 (5 g load). D(meas.) = 4.68 D(calc.) = 4.69

Optical Properties: Translucent. *Color:* Cherry-red; red in thin splinters. *Streak:* Brownish red. *Luster:* Adamantine to semimetallic.
Optical Class: Biaxial (+). *Orientation:* $Z = b$ = elongation. $\alpha = > 2.72$ $\beta = > 2.72$ $\gamma = > 2.72$ *Anisotropism:* Very strong to extreme.
R_1–R_2: (400) 31.1–37.5, (420) 30.0–36.4, (440) 29.0–35.2, (460) 28.0–34.0, (480) 27.2–33.0, (500) 26.4–32.2, (520) 25.7–31.3, (540) 25.2–30.6, (560) 24.8–30.0, (580) 24.4–29.4, (600) 24.0–29.0, (620) 23.8–28.6, (640) 23.5–28.2, (660) 23.4–28.0, (680) 23.2–27.8, (700) 23.1–27.7

Cell Data: *Space Group:* $C2/m$ (apparent). $a = 10.784$ $b = 4.065$ $c = 10.206$ $\beta = 101°31'$ Z = 4

X-ray Powder Pattern: Zimbabwe. (JCPDS 11-91).
2.92 (100), 3.13 (90), 2.69 (70), 4.06 (60), 1.782 (60), 5.29 (50), 2.49 (50)

Chemistry:

	(1)	(2)
Sb	75.2	75.24
S	19.9	19.82
O	4.8	4.94
Total	99.9	100.00

(1) Globe and Phoenix mine, Zimbabwe; by electron microprobe. (2) Sb_2S_2O.

Occurrence: A secondary mineral, as an alteration of stibnite, in antimony deposits.

Association: Stibnite, antimony, senarmontite, valentinite, cervantite, stibiconite.

Distribution: In small amounts in many deposits. At Braunsdorf, near Freiberg, Saxony, Germany. From Pernek, Pezinok, and Příbram, Czechoslovakia. In the Chalanches mine, near Allemont, Iseré, France. From the Cetine mine, near Siena, Tuscany, Italy. At Kadamdja, Kirgizia, USSR. In the Santa Cruz and San Francisco mines, Poopó, Oruro, Bolivia. From Broken Hill, New South Wales, Australia. Exceptional radiating groups from the Globe and Phoenix mine, Que Que, Zimbabwe. At Sombrerete, Zacatecas, Mexico. From Canada, in the Lac Nicolet mine, South Ham Township, Wolfe Co., Quebec, and at other localities.

Name: From *kermes* (after Persian *qurmizq, crimson*) for red amorphous antimony trisulfide.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 279–280. (2) Kupčik, V. (1967) Die Kristallstruktur des Kermesits, Sb_2S_2O. Naturwiss., 54, 114 (in German). (3) Cervelle, B. (1971) Détermination par microréflectométrie de propriétés optiques d'un cristal monoclinique absorbant (kermésite Sb_2S_2O). Bull. Soc. fr. Minéral., 94, 486–491 (in French). (4) Criddle, A.J. and C.J. Stanley, Eds. (1986) The quantitative data file for ore minerals. British Museum (Natural History), London, England, 184.

Kernite $Na_2B_4O_6(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly nearly equant, with over 30 forms noted; typically as cleavable masses, to 3.5 m, bent or warped; massive. *Twinning:* On {011}.

Physical Properties: *Cleavage:* On {100} and {001}, perfect; on $\{\bar{1}02\}$, fair. *Fracture:* Splintery. *Tenacity:* Flexible and elastic in cleavage fragments. Hardness = 2.5 D(meas.) = 1.906(3) D(calc.) = 1.905 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, white if surficially altered to tincalconite. *Streak:* White. *Luster:* Vitreous, satiny on fibrous cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 70.5°$. *Dispersion:* $r > v$, slight to distinct. $\alpha = 1.454$ $\beta = 1.472$ $\gamma = 1.488$ 2V(meas.) = 80°

Cell Data: *Space Group:* $P2_1/c$. $a = 7.0172(2)$ $b = 9.1582(2)$ $c = 15.6774(5)$ $\beta = 108.861(2)°$ Z = 4

X-ray Powder Pattern: Tincalayu deposit, Argentina.
7.40 (100), 6.64 (85), 3.253 (34), 3.132 (29), 2.882 (29), 2.472 (27), 3.705 (23)

Chemistry:

	(1)	(2)
B_2O_3	50.76	50.95
Na_2O	22.63	22.68
H_2O	26.50	26.37
Total	99.89	100.00

(1) Kern Co., California, USA. (2) $Na_2B_4O_6(OH)_2 \cdot 3H_2O$

Occurrence: An important ore mineral of borax in sedimentary borate deposits, deposited under warm conditions or formed by metamorphism.

Association: Borax, inyoite, ulexite, colemanite.

Distribution: From the Kramer borate deposit, Boron, Kern Co., California, USA. In the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. From the Kirka borate deposit, Kütahya Province, Turkey.

Name: For Kern Co., California, USA, in which Boron is located.

Type Material: Harvard University, Cambridge, Massachusetts, 88508; National Museum of Natural History, Washington, D.C., USA, 95643.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 335–337. (2) Cooper, W.F., F.K. Larsen, and P. Coppens (1973) Electron population analysis of accurate diffraction data. V. Structure and one-center charge refinement of the light-atom mineral kernite, $Na_2B_4O_6(OH)_2 \cdot 3H_2O$. Amer. Mineral., 58, 21–31. (3) Hurlbut, C.S., Jr., L.F. Aristarain, and R.C. Erd (1973) Kernite from Tincalayu, Salta, Argentina. Amer. Mineral., 58, 308–313.

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Kesterite $Cu_2(Zn, Fe)SnS_4$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $\overline{4}$. Massive.

Physical Properties: Hardness = 4.5 VHN = 328–348 (100 g load). D(meas.) = 4.54–4.59 D(calc.) = 4.524

Optical Properties: Opaque. *Color:* Greenish black. *Streak:* Black. *Luster:* Metallic. R_1–R_2: (400) 23.7–24.5, (420) 24.4–25.2, (440) 24.9–25.8, (460) 25.4–26.0, (480) 25.6–26.0, (500) 25.6–25.9, (520) 25.2–25.7, (540) 24.9–25.6, (560) 24.6–25.5, (580) 24.5–25.5, (600) 24.4–25.4, (620) 24.3–25.3, (640) 24.2–25.1, (660) 24.2–25.1, (680) 24.3–25.2, (700) 24.6–25.4

Cell Data: *Space Group:* $I\overline{4}$. $a = 5.427$ $c = 10.871$ Z = 2

X-ray Powder Pattern: Kester deposit, Russia.
3.15 (100), 1.929 (70), 1.645 (50), 1.113 (40), 2.73 (30), 1.248 (30), 0.860 (30)

Chemistry:

	(1)	(2)
Cu	30.56	29.40
Zn	11.16	10.18
Fe	1.68	3.12
Sn	25.25	28.07
S	28.40	29.19
rem.	0.98	
Total	98.03	99.96

(1) Kester deposit, Russia; remainder Mn 0.07%, Sb 0.90%, Se 0.01%; corresponding to $Cu_{2.17}(Zn_{0.77}Fe_{0.14})_{\Sigma=0.91}Sn_{0.96}S_{4.00}$. (2) St. Michael's Mount, England; by electron microprobe corresponding to $Cu_{2.03}(Zn_{0.68}Fe_{0.24})_{\Sigma=0.92}Sn_{1.04}S_{4.00}$.

Occurrence: In quartz-sulfide hydrothermal veinlets in tin deposits.

Association: Arsenopyrite, stannoidite, chalcopyrite, chalcocite, sphalerite, tennantite.

Distribution: From the Kester deposit, Arga-Ynnakh-Khai granite massif, Yana-Adycha River region, Sakha, Russia [TL]. In the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. From the Dachang district, Guangxi Autonomous Region, China. In the Ikuno mine, Hyogo Prefecture, and the Toyoha mine, Hokkaido, Japan. At Cínovec (Zinnwald), Czech Republic. From St. Michael's Mount, Marazion, and in the Cligga mine, Perranzabuloe, Cornwall, England. From Chizeuil, Saône-et-Loire, France. At Kirki, Thrace, Greece. In Canada, from the Snowflake mine, Revelstoke mining division, British Columbia; at the Brunswick tin mine, 55 km southwest of Fredericton, New Brunswick; and in the Kidd Creek mine, near Timmins, Ontario. In the USA, from the Hugo mine and in the Peerless pegmatite, near Keystone, Pennington Co., South Dakota; at the Cove mine, McCoy district, Lander Co., Nevada; in the Campbell mine, Bisbee, Cochise Co., Arizona. From the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. At Oruro, Bolivia. A few other minor occurrences are known.

Name: For the locality in Russia at the Kester deposit.

Type Material: Mineralogical Museum, St. Petersburg University, 16188, 16324–16326, 16351, 16352; Mining Institute, St. Petersburg, Russia, 163a/2.

References: (1) Ivanov, V.V. and Y.A. Pyatenko (1958) On the so-called këwhile sterite [kesterite]. Zap. Vses. Mineral. Obshch., 88, 165–168 (in Russian). (2) (1959) Amer. Mineral., 44, 1329 (abs. ref. 1). (3) Hall, S.R., J.T. Szymański, and J.M. Stewart (1978) Kesterite, $Cu_2(Zn, Fe)SnS_4$, and stannite, $Cu_2(Fe, Zn)SnS_4$, structurally similar but distinct minerals. Can. Mineral., 16, 131–137. (4) Kissin, S.A. and D.R. Owens (1979) New data on stannite and related tin sulfide minerals.

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Can. Mineral., 17, 125–135. (5) Moore, F. and R.A. Howie (1984) Tin-bearing sulphides from St Michael's Mount and Cligga Head, Cornwall. Mineral. Mag., 48, 389–396. (6) Bonazzi, P., L. Bindi, G.P. Bernardini, and S. Menchetti (2003) A model for the mechanism of incorporation of Cu, Fe and Zn in the stannite-këesterite series, Cu_2FeSnS_4–Cu_2ZnSnS_4. Can. Mineral., 41, 639–649. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 283. (8) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 113.

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Kettnerite $CaBiO(CO_3)F$

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Crystal Data: Orthorhombic, pseudotetragonal by twinning. *Point Group:* $2/m\ 2/m\ 2/m$. Crystal plates, to 0.3 mm, showing {001}, {111}, {10•10}; in spherical aggregates. *Twinning:* At a very fine scale.

Physical Properties: Hardness = "Soft". D(meas.) = 5.80 D(calc.) = [5.85]

Optical Properties: Semitransparent. *Color:* Brown, brownish yellow, lemon-yellow. *Optical Class:* Biaxial or uniaxial. $n = > 2.05$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group: Pmmn.* a = 3.7976(2) b = 3.7976(2) c = 13.569(4) Z = 2

X-ray Powder Pattern: Krupka, Czech Republic.
2.89 (10), 1.732 (9), 1.589 (9), 1.893 (8), 1.200 (8), 2.104 (7), 1.278 (6)

Chemistry:

	(1)	(2)
CO_2	12.6	12.79
Bi_2O_3	67.9	67.71
CaO	8.3	8.15
CaF_2	10.6	11.35
H_2O	0.5	
Total	99.9	100.00

(1) Krupka, Czech Republic; by microchemical analysis. (2) $CaBiO(CO_3)F$.

Occurrence: In a quartz vein cutting pegmatitic potassian feldspar (Krupka, Czech Republic).

Association: Fluorite, bismuth, bismuthinite, hematite, topaz (Krupka, Czech Republic); perite, hemimorphite, embolite, fluorite, chrysocolla, quartz (Blue Bell claims, California, USA).

Distribution: From Krupka, Krušné hory Mountains, and at Jáchymov (Joachimsthal), Czech Republic. From Niederschlema and from the Waldschacht, near Schneeberg, Saxony, and in the Clara mine, near Oberwolfach, Black Forest, Germany. In the USA, from near Bowie, Cochise Co., Arizona; at the Apache mine, Hidalgo Co., New Mexico; from the Blue Bell claims, near Baker, San Bernardino Co., California. At Kudul, Tajikistan.

Name: Honoring Radim Kettner (1891–1968), Professor of Geology, Charles University, Czech Republic.

Type Material: National Museum, Prague, Czech Republic, 43298.

References: (1) Zak, L. and V. Syneček (1956) Kettnerite. $(CaF)(BiO)CO_3$, a new mineral of the phosgenite-bismutite group: preliminary note. Časopis mineral. geol., 1(3), 195–197 (in Czech with English abs.). (2) (1957) Amer. Mineral., 42, 121 (abs. ref. 1). (3) Zak, L. and V. Syneček (1957) Bismuth minerals from Krupka (Graupen) in the Krušné hory (Erzgebirge). Univ. Carolina, Geol. 3(1), 1–46 (in Czech with English summary). (4) (1958) Amer. Mineral., 43, 121 (abs. ref. 3). (5) Grice, J.D., M.A. Cooper, and F.C. Hawthorne (1999) Crystal-structure determination of twinned kettnerite. Can. Mineral., 37, 923–927.

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Keyite $Cu_3(Zn,Cu)_4Cd_2(AsO_4)_6 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tapered crystals, prismatic along [001] to tabular on {010}; as subparallel sheaflike aggregates, to 2 mm; dominant forms include {010}, {210}, {110}, and {011}.

Physical Properties: *Cleavage:* Good on {001}. Hardness = 3.5–4 D(meas.) = > 4.2 D(calc.) = 5.106

Optical Properties: Translucent. *Color:* Deep sky-blue. *Streak:* Pale blue. *Optical Class:* Biaxial. *Pleochroism:* Strong; X = pale blue; Y = greenish blue; Z = deep blue. *Orientation:* $Y = b$; $X \wedge c = 11°$, variable with wavelength. *Dispersion:* Strong. *Absorption:* $Z > Y > X$. $\alpha = 1.80$ β = n.d. $\gamma = 1.87$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $I2/a$. $a = 11.654(3)$ $b = 12.780(5)$ $c = 6.840(3)$ $\beta = 99.11(3)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
2.795 (vvs), 3.29 (vs), 2.876 (vs), 6.41 (ms), 1.644 (ms), 3.15 (m), 1.700 (m)

Chemistry:

	(1)	(2)
As_2O_5	45.36	46.00
MnO	1.07	0.94
CdO	14.08	14.44
CuO	18.81	16.61
ZnO	17.90	19.93
PbO	0.63	1.46
CaO	0.80	0.53
H_2O	[2.38]	[2.40]
Total	[101.03]	[102.31]

(1) Tsumeb, Namibia; by electron microprobe, average of six analyses on five crystals; no H_2O detected; with H_2O from crystal-structure analysis, corresponds to $Cu_3(Zn_{3.33}Cu_{0.58})_{\Sigma=3.91}(Cd_{1.66}Mn_{0.23}Ca_{0.21}Pb_{0.03})_{\Sigma=2.13}(AsO_4)_{5.98} \cdot 2H_2O$. (2) Do.; by electron microprobe, H_2O determined from crystal-structure analysis; corresponds to $Cu_3(Zn_{3.68}Cu_{0.14})_{\Sigma=3.82}(Cd_{1.69}Mn_{0.20}Ca_{0.14}Pb_{0.10})_{\Sigma=2.13}(AsO_4)_{6.02} \cdot 2H_2O$.

Occurrence: A secondary mineral in the oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Cuprian adamite, schulténite, metazeunerite, zincian olivenite, tennantite.

Distribution: From Tsumeb, Namibia.

Name: Honors Charles Locke Key (1935–), Windhoek, Namibia, American mineral dealer who furnished the first specimen.

Type Material: The Natural History Museum, London, England, 1973,236, 1975,660; Harvard University, Cambridge, Massachusetts, USA, 119917.

References: (1) Embrey, P.G., E.E. Fejer, and A.M. Clark (1977) Keyite: a new mineral from Tsumeb. Mineral. Record, 8(3), 87–90. (2) (1977) Amer. Mineral., 62, 1259 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1996) The crystal structure of keyite, $Cu_3^{2+}(Zn,Cu^{2+})_4Cd_2(AsO_4)_6(H_2O)_2$, an oxysalt mineral with essential cadmium. Can. Mineral., 34, 623–630.

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Keystoneite $Mg_{0.5}NiFe^{3+}(Te^{4+}O_3)_3 \cdot 4.5H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6. As acicular hexagonal crystals, to 0.2 mm, in parallel aggregates and radiating sprays.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.40

Optical Properties: Semitransparent. *Color:* Golden yellow. *Streak:* Pale yellow-green. *Luster:* Adamantine.
Optical Class: Uniaxial (+). $\omega = 1.85(1)$ $\epsilon = [1.99(1)]$

Cell Data: *Space Group:* $P6_3/m$ or $P6_3$. $a = 9.344(2)$ $c = 7.607(3)$ Z = 2

X-ray Powder Pattern: Keystone mine, Colorado, USA.
2.77 (10), 8.12 (9), 4.05 (8), 1.720 (6), 2.95 (5), 2.84 (5), 1.498 (5)

Chemistry:

	(1)
TeO_2	65.5
Fe_2O_3	5.1
MnO	1.0
NiO	12.7
MgO	4.3
Na_2O	0.3
K_2O	0.1
H_2O	[11.0]
Total	[100.0]

(1) Keystone mine, Colorado, USA; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, H_2O calculated by difference; corresponds to $(Mg_{0.41}Na_{0.07}K_{0.02})_{\Sigma=0.50}Ni_{1.00}(Fe^{3+}_{0.47}Mg_{0.38}Ni_{0.26}Mn^{2+}_{0.10})_{\Sigma=1.21}(Te_{1.01}O_3)_3 \cdot 4.52H_2O$.

Occurrence: A rare secondary mineral formed in the oxidized zone of a complex polymetallic hydrothermal mineral deposit.

Association: Melonite, tellurium, paratellurite, magnolite, coloradoite, calaverite, gold, stibnite, pyrite, "limonite", manganese oxides, quartz.

Distribution: From the Keystone mine, Magnolia district, Boulder Co., Colorado, USA.

Name: For its occurrence at the Keystone mine, Colorado, USA.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 56561.

References: (1) Back, M.E., A.C. Roberts, Y. LePage, and J.A. Mandarino (1988) Keystoneite, a new tellurite from the Keystone mine, Colorado, U.S.A. Geol. Assoc. Canada – Mineral. Assoc. Canada, Prog. Abs., 13, A4. (2) Miletich, R. (1995) Crystal chemistry of the microporous tellurite minerals zemannite and kinichilite, $Mg_{0.5}[Me^{2+}Fe^{3+}(TeO_3)_3] \cdot 4.5H_2O$, ($Me^{2+}$ = Zn, Mn). Eur. J. Mineral., 7, 509–523.

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Khademite $Al(SO_4)F \cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals exhibit large {010}, {001}, modified by {101}, {110}, {111}, {313}, to 1 mm; may form thick crusts.

Physical Properties: Hardness = n.d. D(meas.) = 1.925 D(calc.) = 1.942

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = [1.44]$ $\beta = 1.460$ $\gamma = 1.487$ 2V(meas.) = 68(1)°

Cell Data: *Space Group: Pcab.* $a = 11.181(4)$ $b = 13.048(5)$ $c = 10.885(4)$ Z = 8

X-ray Powder Pattern: Saghand, Iran.
4.247 (100), 4.179 (71), 2.730 (59), 3.901 (52), 2.030 (21), 3.351 (16), 2.741 (16)

Chemistry:

	(1)	(2)	(3)
SO_3	35.2		34.64
Al_2O_3	21.6	23.06	22.06
F	n.d.	5.53	4.11
H_2O	41.7		40.92
$-O = F_2$			1.73
Total	98.5		100.00

(1) Saghand, Iran; SO_3 and H_2O by TGA, corresponding to $Al_{1.00}(SO_4)_{1.04}(OH)_{0.92} \cdot 4.99H_2O$; however crystal-structure analysis obviates the presence of $(OH)^{1-}$. (2) Lone Pine mine, New Mexico, USA; partial analysis, Al_2O_3 calculated from Al 8.3%. (3) $Al(SO_4)(F, OH) \cdot 5H_2O$ with F:OH = 1:1.

Occurrence: Rarely formed in the oxidized zone of hydrothermal base-metal deposits.

Association: Copiapite, amarantite, parabutlerite, butlerite, jarosite (Saghand, Iran); wilcoxite, lannonite, gypsum (Lone Pine mine, New Mexico, USA).

Distribution: From Saghand, Yazd, Iran. At the Rammelsberg mine, near Goslar, Harz Mountains, Germany. In the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. From the Schoeller mine, Libušin, near Kladno, Czech Republic. In the Lone Pine mine, Wilcox district, near Silver City, Catron Co., New Mexico, USA.

Name: To honor Nasrollah Khadem (1910–), Director of the Geological Survey of Iran.

Type Material: n.d.

References: (1) Bariand, P., J.-P. Berthelon, F. Cesbron, and M. Sadrzadeh (1973) Un nouveau sulfate hydraté d'aluminium: la khademite de Saghand (Iran). Compt. Rendus Acad. Sci. Paris, 277D, 1585–1588 (in French). (2) Bachet, B., F. Cesbron, and R. Chevalier (1981) Structure cristalline de la khadémite $Al(SO_4)F \cdot 5H_2O$. Bull. Minéral., 104, 19–22 (in French with English abs.). (3) Williams, S.A. and F.P. Cesbron (1983) Wilcoxite and lannonite, two new fluosulphates from Catron Co., New Mexico. Mineral. Mag., 47, 37–40. (4) Cesbron, F. and P. Bayliss (1988) Mineral nomenclature: khademite. Mineral. Mag., 52, 133–134.

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. As the outer portions of cubic suessite crystals, skeletal, to 0.3 mm; in spheroidal aggregates.

Physical Properties: *Fracture:* Irregular. Hardness = > 9 VHN = 2290–2230 (100 g load). D(meas.) = n.d. D(calc.) = 10.01

Optical Properties: Opaque. *Color:* Dark gray. *Luster:* Metallic.
Optical Class: Isotropic.
R: (440) 46.2, (460) 46.4, (480) —, (500) 47.2, (520) 47.2, (540) 47.2, (560) 47.4, (580) 47.5, (600) 47.7, (620) 47.9, (640) 48.4, (660) 49.7, (680) 50.3, (700) 50.6

Cell Data: *Space Group:* $Fm3m$. a = 4.319(5) Z = 8

X-ray Powder Pattern: Chinorsaisk massif, Tadzhikistan.
2.163 (10), 1.299 (10), 1.535 (8), 2.504 (6), 1.247 (4), 1.079 (2)

Chemistry:

	(1)
Si	0.10
Ti	69.04
Fe	1.71
V	6.74
C	[20.05]
Total	[97.64]

(1) Chatkal Range, Russia; by electron microprobe, average of five analyses, C calculated; corresponding to $(Ti_{0.90}V_{0.08}Fe_{0.02})_{\Sigma=1.00}C_{1.04}$.

Occurrence: In amygdaloidal basaltic porphyries (Chatkal Range, Russia); in spheroidal groups in granodiorites that have undergone silica metasomatism (Chinorsaisk massif, Tadzhikistan).

Association: Suessite (Chatkal Range, Russia); magnetite, iron, carbonaceous material (Chinorsaisk massif, Tadzhikistan).

Distribution: From undefined localities [Ir-Tash stream basin] in the Arashan Mountains, Chatkal Range, and in the Chinorsaisk massif, Zeravshan Range, Tadzhikistan.

Name: Honors Ibragim Khamrabaevich Khamrabaeva (1920–), Director, Institute of Geology and Geophysics, Tashkent, Uzbekistan.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Novgorodova, M.I., R.G. Yusupov, M.T. Dmitrieva, A.I. Tsepin, A.V. Sivtsov, and A.I. Gorshkov (1984) Khamrabaevite, (Ti,V,Fe)C, a new mineral. Zap. Vses. Mineral. Obshch., 113, 697–703 (in Russian). (2) (1985) Amer. Mineral., 70, 1329 (abs. ref. 1). (3) (1986) Mineral. Abs., 37, 98 (abs. ref. 1). (4) Bowman, A.L. (1961) The variation of lattice parameter with carbon content of tantalum carbide. J. Phys. Chem., 65, 1596–1602.

Khanneshite $(Na, Ca)_3(Ba, Sr, Ce, Ca)_3(CO_3)_5$

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Crystal Data: Hexagonal. *Point Group:* 6*mm*. As elongated hexagonal crystals, to 1 cm, in radially fibrous or fine-grained aggregates.

Physical Properties: *Cleavage:* One, parallel elongation, indistinct; and a transverse parting. *Tenacity:* Brittle. Hardness = "Soft". D(meas.) = 3.8–3.9 D(calc.) = 3.94

Optical Properties: Semitransparent. *Color:* Pale yellow to nearly colorless. *Optical Class:* Uniaxial (–). $\omega = 1.620$–1.623 $\epsilon = 1.608$–1.610

Cell Data: *Space Group:* $P6_3mc$. $a = 10.65(1)$ $c = 6.58(1)$ $Z = 2$

X-ray Powder Pattern: Khanneshin complex, Afghanistan.
2.66 (100), 3.08 (62), 2.19 (55), 3.78 (50), 2.09 (42), 1.691 (40), 5.34 (30)

Chemistry:

	(1)	(2)	(3)
CO_2	28.48	28.85	[30.59]
RE_2O_3	10.41	11.18	
La_2O_3			4.07
Ce_2O_3			10.46
Pr_2O_3			1.01
Nd_2O_3			3.60
CaO	6.40	9.25	5.37
SrO	7.16	8.32	9.04
BaO	36.38	31.92	22.99
Na_2O	8.63	8.39	11.86
K_2O	0.95	0.77	0.00
H_2O	1.59	1.32	
Total	[100.00]	[100.00]	98.99

(1) Khanneshin complex, Afghanistan; recalculated to 100% from an original total of 99.98% after deduction of admixed barite, dolomite, and "chlorite" 1.98%; RE = Y 7.5%, La 20.3%, Ce 44.0%, Pr 6.0%, Nd 9.5%, Sm 6.0%, Eu 0.1%, Gd 4.8%, Tb 0.5%, Dy 0.3%, Ho 0.2%, Er 0.8%, Yb 0.5%; corresponds to $(Na_{2.13}Ca_{0.87})_{\Sigma=3.00}(Ba_{1.82}Sr_{0.53}RE_{0.49}K_{0.15})_{\Sigma=2.99}(CO_3)_{4.96} \bullet 0.67H_2O$. (2) Do.; recalculated to 100% from an original total of 100.87% after deduction of admixed barite, dolomite, and "chlorite" 2.55%; RE= Y 5.8%, La 20.9%, Ce 51.2%, Pr 4.7%, Nd 7.3%, Sm 4.7%, Eu 0.1%, Gd 3.7%, Dy 0.4%, Ho 0.1%, Er 0.9%, Yb 0.2%; corresponds to $(Na_{2.02}Ca_{0.98})_{\Sigma=3.00}(Ba_{1.55}Sr_{0.60}RE_{0.51}Ca_{0.25}K_{0.12})_{\Sigma=3.03}(CO_3)_{4.89} \bullet 0.55H_2O$. (3) Khibiny massif, Kola Peninsula, Russia; corresponds to $(Na_{2.75}Ca_{0.23})_{\Sigma=2.98}(Ba_{1.08}Sr_{0.63}Ca_{0.46}Ce_{0.46}La_{0.18}Nd_{0.15}Pr_{0.04})_{\Sigma=3.00}(CO_3)_{5.00}$.

Occurrence: Disseminated in hydrothermally-altered fine-grained carbonatite (Khanneshin complex, Afghanistan); in a drillcore in a carbonatite veinlet from a differentiated alkalic massif (Khibiny massif, Kola Peninsula, Russia).

Association: Dolomite, calkinsite-(Ce), carbocernaite, mckelveyite, barite, "chlorite" (Khanneshin complex, Afghanistan); calcite, dawsonite, magnetite (Khibiny massif, Kola Peninsula, Russia).

Distribution: From the Khanneshin carbonatite complex, Afghanistan. At Tuliylukht Bay, Khibiny massif, Kola Peninsula, Russia.

Name: For the Khanneshin complex, Afghanistan, its first-noted occurrence.

Type Material: Mining Institute, St. Petersburg; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Yeremenko, G.K. and V.A. Bel'ko (1982) Khanneshite, $(Na, Ca)_3(Ba, Sr, RE, Ca)_3(CO_3)_5$ – a new mineral of the burbankite group. Zap. Vses. Mineral. Obshch., 111, 321–324 (in Russian). (2) (1983) Amer. Mineral., 68, 1249 (abs. ref. 1). (3) Pekov, I.V., N.V. Chukanov, and Y.V. Belovitskaya (1998) Khanneshite and petersenite-(Nd) from Khibiny massif. Zap. Vses. Mineral. Obshch., 127(2), 92–100 (in Russian with English abs.).

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Kharaelakhite $(Cu, Pt, Pb, Fe, Ni)_9S_8$

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Crystal Data: Orthorhombic (?). *Point Group:* 222, $mm2$, or $2/m\ 2/m\ 2/m$. As elongated crystals, to 120 μm, and thin rims on braggite–cooperite.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 7.78

Optical Properties: Opaque. *Color:* In reflected light, grayish with a brownish lilac tint. *Luster:* n.d. *Anisotropism:* Distinct, from pink-lilac to bluish. *Bireflectance:* Weak.
R_1–R_2: (400) — , (420) — , (440) 37.1–39.6, (460) 36.8–40.3, (480) 36.6–40.9, (500) 36.6–41.4, (520) 36.8–41.8, (540) 37.1–42.2, (560) 37.1–42.2, (580) 37.9–42.8, (600) 38.3–43.0, (620) 38.6–43.3, (640) 38.8–43.7, (660) 39.0–44.4, (680) 39.0–44.4, (700) 38.1–44.8

Cell Data: *Space Group:* $P222$, $Pmm2$, or $Pmmm$. $a = 9.713(5)$ $b = 8.333(5)$ $c = 14.50(1)$ $Z = 4$

X-ray Powder Pattern: Talnakh deposit, Russia.
3.03 (10), 1.854 (8), 1.591 (6), 1.077 (6), 1.865 (4), 1.205 (3), 1.069 (3)

Chemistry:

	(1)
Pt	34.00
Pd	0.19
Cu	12.55
Pb	24.28
Fe	5.59
Ni	4.21
S	19.18
Total	100.00

(1) Talnakh deposit, Russia; by electron microprobe, average of four analyses; corresponds to $(Cu_{2.64}Pt_{2.33}Pb_{1.57}Fe_{1.34}Ni_{0.96}Pd_{0.02})_{\Sigma=8.86}S_{8.00}$.

Occurrence: In hydrothermal chalcopyrite ores.

Association: Braggite–cooperite, chalcopyrite, bornite, millerite.

Distribution: From the Komsomol'skii mine, Talnakh deposit, Noril'sk region, western Siberia, Russia [TL].

Name: For the Kharaelakh Plateau, Noril'sk region, Russia.

Type Material: Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84282.

References: (1) Genkin, A.D., T.L. Evstigneeva, L.N. Vyalsov, and I.P. Laputina (1985) Kharaelakhite $(Pt, Cu, Pb, Fe, Ni)_9S_8$ – a new sulfide of platinum, copper and lead. Mineral. Zhurnal, 7, 78–83 (in Russian with English abs.). (2) (1989) Amer. Mineral., 74, 1215–1216 (abs. ref. 1).

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Khatyrkite $(Cu, Zn)Al_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As prismatic crystals, to 400 μm, and intimately intergrown with cupalite in small grains.

Physical Properties: *Cleavage:* {100}, distinct. *Tenacity:* Malleable. Hardness = 5.5 VHN = 511–568 (100 g load). D(meas.) = n.d. D(calc.) = 4.42

Optical Properties: Opaque. *Color:* Steel-gray yellow; in reflected light, isotropic sections are pale blue, anisotropic sections are blue to creamy pink. *Luster:* Metallic. *Anisotropism:* Distinct, grayish yellow to brownish red.
R_1–R_2: (400) — , (420) — , (440) 70.1–75.8, (460) 70.3–75.6, (480) 71.5–75.9, (500) 73.0–76.5, (520) 74.5–76.4, (540) 76.1–76.1, (560) 77.4–75.3, (580) 78.4–74.3, (600) 79.2–73.2, (620) 79.7–72.0 (640) 79.8–70.7, (660) 79.9–69.5, (680) 79.8–68.5 (700) 79.5–67.5

Cell Data: *Space Group:* $I4/mcm$. a = 6.07(1) c = 4.89(1) Z = 4

X-ray Powder Pattern: Listvenitovyi Stream, Russia.
4.27 (10), 2.119 (8), 2.372 (7), 1.920 (7), 3.04 (5), 1.894 (4), 2.156 (2)

Chemistry:

	(1)
Cu	53.93
Zn	1.28
Al	45.11
Total	100.32

(1) Listvenitovii Stream, Russia; by electron microprobe, average of analyses on nine grains; corresponding to $(Cu_{1.02}Zn_{0.02})_{\Sigma=1.04}Al_{2.00}$.

Occurrence: In black slick washed from greenish gray cover weathering from serpentine.

Association: Cupalite, two unnamed zinc aluminides.

Distribution: From near the Listvenitovyi Stream, Khatyrka ultramafic zone of the Koryak–Kamchata fold area, Koryak Mountains, Magadan district, Russia [TL].

Name: For the occurrence in the Khatyrka ultramafic zone, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1687/1.

References: (1) Razin, L.V., N.S. Rudashevskii, and L.N. Vyal'sov (1985) New natural intermetallic compounds of aluminum, copper and zinc – khatyrkite $CuAl_2$, cupalite CuAl and zinc aluminides – from hyperbasites of dunite–harzburgite formation. Zap. Vses. Mineral. Obshch., 114, 90–100 (in Russian). (2) (1986) Amer. Mineral., 71, 1278 (abs. ref. 1). (3) Friauf, J.B. (1927) The crystal structures of two intermetallic compounds [Cu_2Mg and $CuAl_2$]. J. Amer. Chem. Soc., 49(2), 3107–3114. (4) Havinga, E.E., H. Damsma, and P. Hokkeling (1972) Compounds and pseudo-binary alloys with the $CuAl_2(C16)-$type structure. I. Preparation and X-ray results. J. Less-Common Metals, 27, 169–186.

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Khibinskite $K_2ZrSi_2O_7$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As irregular grains, to 3 mm, in small ovoids zoned with eudialyte.

Physical Properties: Hardness = 4.5–5.5 D(meas.) = 3.40 D(calc.) = 3.33

Optical Properties: Translucent. *Color:* Pale yellowish to white. *Luster:* Dull or greasy. *Optical Class:* Biaxial (–). $\alpha = 1.665$ $\beta = 1.715$ $\gamma = 1.715$ 2V(meas.) = 6°–16°

Cell Data: *Space Group:* $B2/m$ (synthetic). $a = 19.188$ $b = 14.072$ $c = 11.075$ $\gamma = 117°04'$ Z = 16

X-ray Powder Pattern: Khibiny massif, Russia.
2.76 (100), 2.95 (70), 1.630 (65), 2.133 (50), 1.381 (50), 1.252 (45), 1.595 (40)

Chemistry:

	(1)
SiO_2	33.8
TiO_2	0.6
ZrO_2	37.8
CaO	trace
K_2O	27.0
Total	99.2

(1) Khibiny massif, Russia; by electron microprobe, corresponds to $K_{1.98}(Zr_{1.06}Ti_{0.03})_{\Sigma=1.09}Si_{1.94}O_{7.05}$.

Occurrence: In aegirine-rich metasomatic rocks in a differentiated alkalic massif.

Association: Eudialyte, zircon.

Distribution: From the Khibiny massif, in the Hackmann Valley, Kola Peninsula, Russia.

Name: For the locality in the Khibiny massif, Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5089; Mining Institute, St. Petersburg, 1078/1; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76326–76328; National School of Mines, Paris, France; The Natural History Museum, London, England, 1994,11.

References: (1) Khomyakov, A.P. and A.A. Voronkov (1973) New zirconium silicates in the Lovozero and Khibina massifs. Trudy Mineral. Muzeya Akad. Nauk SSSR, 22, 215–217 (in Russian). (2) (1974) Amer. Mineral., 59, 1140 (abs. ref. 1). (3) Khomyakov, A.P., A.A. Voronkov, S.I. Lebedeva, V.P. Bykov, and K.V. Yurkiva (1974) Khibinskite, $K_2ZrSi_2O_7$, a new mineral. Zap. Vses. Mineral. Obshch., 103, 110–116 (in Russian). (4) (1975) Amer. Mineral., 60, 340 (abs. ref. 3). (5) Nosyrev, N.A., E.N. Treushnikov, A.A. Voronkov, V.V. Ilyukhin, R.M. Ganiev, and N.V. Belov (1976) Crystal structure of synthetic khibinskite. Doklady Acad. Nauk SSSR, 231, 1351–1353 (in Russian). (6) (1977) Chem. Abs., 86, 64045 (abs. ref. 5).

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Khinite $PbCu_3Te^{6+}O_6(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are dipyramidal, curved and corroded, to 0.15 mm.

Physical Properties: *Cleavage:* On {001}, fair. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 6.5–7.0 D(calc.) = 6.69

Optical Properties: Semitransparent. *Color:* Dark green, bottle-green. *Streak:* Green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = emerald-green; $Y = Z$ = yellowish green. *Absorption:* $Z = Y > X$. $\alpha = 2.110(4)$ $\beta = 2.112(4)$ $\gamma = 2.165(4)$ 2V(meas.) = 20°

Cell Data: *Space Group: Fddd.* $a = 5.740(5)$ $b = 9.983(9)$ $c = 23.96(9)$ Z = 8

X-ray Powder Pattern: Tombstone, Arizona, USA.
2.491 (10), 3.451 (9), 4.866 (8), 2.996 (7), 2.204 (7), 2.818 (6), 1.916 (6)

Chemistry:

	(1)	(2)	(3)
TeO_3	24.5	26.4	26.79
CuO	33.2	35.8	36.41
PbO	32.4	35.0	34.05
H_2O		[2.75]	2.75
Total		[100.0]	100.00

(1) Tombstone, Arizona, USA; insoluble quartz and chlorargyrite present but in an amount too small to be weighed. (2) Analysis (1) recalculated to 100.0% with theoretical H_2O as determined by crystal-structure analysis; corresponding to $Pb_{1.04}Cu_{3.00}Te_{1.00}O_6(OH)_2$. (3) $PbCu_3TeO_6(OH)_2$.

Polymorphism & Series: Dimorphous with parakhinite.

Occurrence: A very rare secondary mineral formed under acid oxidizing conditions from gold–telluride ores in massive vein quartz.

Association: Chlorargyrite, dugganite, quetzalcoatlite, tlapallite, gold, chrysocolla, tenorite, quartz.

Distribution: From the dump of the Old Guard mine, and at the Lucky Cuss, Emerald, and Empire mines, Tombstone, Cochise Co., Arizona, USA.

Name: To honor BaSaw Khin (1931–), Burmese–American mineralogist, Phelps Dodge Corporation.

Type Material: The Natural History Museum, London, England, 1980,541.

References: (1) Williams, S.A. (1978) Khinite, parakhinite, and dugganite, three new tellurates from Tombstone, Arizona. Amer. Mineral., 63, 1016–1019. (2) Burns, P.C., M.A. Cooper, and F.C. Hawthorne (1995) Parakhinite, $Cu_3^{2+}PbTe^{6+}O_6(OH)_2$: crystal structure and revision of chemical formula. Can. Mineral., 33, 33–40.

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Kiddcreekite Cu_6SnWS_8

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Crystal Data: Cubic. *Point Group:* n.d. As irregular grains, to 100 μm, as rims on scheelite, and included in colusite and chalcopyrite.

Physical Properties: Hardness = n.d. VHN = 183 (100 g load). D(meas.) = n.d. D(calc.) = 4.88

Optical Properties: Opaque. *Color:* Pale gray-brown; pale gray in reflected light. *Luster:* Metallic.

R: (400) 22.7, (420) 23.2, (440) 23.6, (460) 23.7, (480) 23.3, (500) 22.6, (520) 22.1, (540) 22.5, (560) 23.3, (580) 23.9, (600) 24.1, (620) 24.0, (640) 23.7, (660) 23.2, (680) 22.6, (700) 22.2

Cell Data: *Space Group:* n.d. $a = 10.856(2)$ $Z = 4$

X-ray Powder Pattern: Kidd Creek mine, Canada.
6.29 (100), 1.919 (60), 3.138 (50), 5.41 (30), 3.270 (30), 1.839 (30), 2.712 (20)

Chemistry:

	(1)	(2)	(3)
Cu	39.6	40.6	40.55
Fe		0.7	
Sn	12.3	11.9	12.62
V		0.1	
W	20.4	19.0	19.55
Sb		0.5	
Se	2.1		
S	24.7	26.8	27.28
Total	99.1	99.6	100.00

(1) Kidd Creek mine, Canada; by electron microprobe, corresponding to $Cu_{6.10}Sn_{1.02}W_{1.09}(S_{7.54}Se_{0.26})_{\Sigma=7.80}$. (2) Bisbee, Arizona, USA; by electron microprobe, corresponding to $Cu_{6.02}Fe_{0.12}Sb_{0.04}Sn_{0.94}V_{0.02}W_{0.98}S_{7.88}$. (3) Cu_6SnWS_8.

Occurrence: In massive copper sulfide ores.

Association: Scheelite, carrollite, clausthalite, tennantite, tungstenite, sphalerite (Kidd Creek mine, Canada); pyrite, colusite, stützite, altaite (Bisbee, Arizona, USA).

Distribution: From the Kidd Creek mine, near Timmins, Ontario, Canada [TL]. In the Campbell mine, Bisbee, Cochise Co., Arizona, and at Butte, Silver Bow Co., Montana, USA. From the Bitian Cu–Au–Ag deposit, Fujian Province, China

Name: For the Kidd Creek mine, Canada.

Type Material: The Natural History Museum, London, England, 1982,2-3; Canadian Geological Survey, Ottawa, 64076-78; Royal Ontario Museum, Toronto, Canada, M39791.

References: (1) Harris, D.C., A.C. Roberts, R.I. Thorp, A.J. Criddle, and C.S. Stanley (1984) Kiddcreekite, a new mineral species from the Kidd Creek mine, Timmins, Ontario and from the Campbell orebody, Bisbee, Arizona. Can. Mineral., 22, 227–232. (2) (1985) Amer. Mineral., 70, 437 (abs. ref. 1).

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Kidwellite $\mathbf{NaFe_9^{3+}(PO_4)_6(OH)_{10}\cdot 5H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. Acicular crystals are elongated along [010] and flattened on {100}, to 50 μm; typically in mats, tufts, or rosettes of feathery crystals; as spheroidal to botyroidal masses and crusts.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = 3 D(meas.) = > 3.3 D(calc.) = 3.34

Optical Properties: Transparent to translucent. *Color:* Bright yellow to greenish yellow, pale chartreuse-green, greenish white; colorless in transmitted light. *Streak:* Yellow. *Luster:* Silky. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$. $\alpha = 1.787(5)$ $\beta = 1.800(5)$ $\gamma = 1.805(5)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $A2/m$, Am, or $A2$. $a = 20.61(7)$ $b = 5.15(1)$ $c = 13.75(6)$ $\beta = 112.64(15)^\circ$ Z = 2

X-ray Powder Pattern: Fodderstack Mountain, Arkansas, USA.
9.41 (100), 3.413 (55), 3.813 (40), 3.193 (40), 4.017 (35), 3.173 (35), 6.43 (30)

Chemistry:

	(1)	(2)
P_2O_5	31.3	31.41
SiO_2	0.27	
Al_2O_3	0.98	
Fe_2O_3	52.3	53.01
MnO	0.02	
MgO	0.01	
Na_2O	1.60	2.29
H_2O^+	13.3	
H_2O^-	0.3	
H_2O		13.29
Total	[100.08]	100.00

(1) Fodderstack Mountain, Arkansas, USA; original total given as 100.07%, corresponds to $Na_{0.71}(Fe^{3+}_{8.91}Al_{0.26})_{\Sigma=9.17}(PO_4)_6(OH)_{10}\cdot 5H_2O$. (2) $NaFe_9(PO_4)_6(OH)_{10}\cdot 5H_2O$.

Occurrence: As a late-stage replacement of earlier phosphate minerals.

Association: Rockbridgeite, beraunite, strengite, laubmannite, dufrénite, chalcosiderite, goethite.

Distribution: In the USA, in Arkansas, from the Coon Creek and York mines, Polk Co; on Fodderstack Mountain, Montgomery Co.; and on Buckeye Mountain, at Three Oak Gap; in Alabama, from Indian Mountain, Cherokee Co.; at Irish Creek, Rockbridge Co., Virginia. In Germany, from the Rotläufchen mine, Waldgirmes, near Giessen, and the Eleonore mine, Hesse; and in the Clara mine, near Oberwolfach, Black Forest. At the Phoenix United mines, Linkinhorne, Cornwall, England. In Australia, from Broken Hill, New South Wales; in the Iron Monarch quarry, Iron Knob, South Australia; and at the Lake Boga granite quarry, near Swan Hill, Victoria. In the Okatjimukuju pegmatite, near Karibib, Namibia.

Name: Honors Albert Laws Kidwell (1919–), Houston, Texas, USA, for his study of Arkansas phosphate deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137024.

References: (1) Moore, P.B. and J. Ito (1978) Kidwellite, $NaFe_9^{3+}(OH)_{10}(PO_4)_6\cdot 5H_2O$, a new species. Mineral. Mag., 42, 137–140. (2) (1979) Amer. Mineral., 64, 242–243 (abs. ref. 1). (3) Braithwaite, R.S.W. and H. Corke (1980) Kidwellite from Cornwall. Mineral. Mag., 43, 952–953.

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Kieftite $CoSb_3$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As euhedral to subhedral crystals, showng {100}, {110}, {111}, to 400 μm, in aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 420–514, 464 average (100 g load). D(meas.) = 7.2 D(calc.) = 7.63 (for $CoSb_3$).

Optical Properties: Opaque. *Color:* Tin-white in reflected light. *Streak:* Gray. *Luster:* Metallic.
R: (470) 59.0, (546) 58.7, (589) 58.7, (650) 58.7

Cell Data: *Space Group:* $Im3$. a = 9.0411(3) Z = 8

X-ray Powder Pattern: Tunaberg, Sweden.
2.86 (10), 2.02 (8), 0.933 (8), 1.331 (7), 2.42 (6), 1.77 (6), 1.55 (6)

Chemistry:

	(1)
Co	12.8
Ni	0.7
Cu	0.2
Fe	0.3
Sb	85.8
Cl	0.3
Total	100.1

(1) Tunaberg, Sweden; by electron microprobe, average of 30 analyses; corresponding to $(Co_{0.91}Ni_{0.05}Fe_{0.02}Cu_{0.02})_{\Sigma=1.00}(Sb_{2.97}Cl_{0.03})_{\Sigma=3.00}$.

Occurrence: In a polymetallic sulfide skarn deposit.

Association: Chalcopyrite, dyscrasite, bornite, galena, bismuth, silver, gudmundite, tetrahedrite.

Distribution: From Tunaberg, Sweden [TL].

Name: Honors Dr. Cornelis Kieft (1924–), for his contributions to ore mineralogy.

Type Material: Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands.

References: (1) Dobbe, R.T.M., W.J. Lustenhouwer, M.A. Zakrzewski, K. Goubitz, J. Fraanje, and H. Schenk (1994) Kieftite, $CoSb_3$, a new member of the skutterudite group from Tunaberg, Sweden. Can. Mineral., 32, 179–183. (2) (1995) Amer. Mineral., 80, 185 (abs. ref. 1).

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Kieserite $MgSO_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are uncommon, dipyramidal $\{\overline{1}11\}$, with {110} and perhaps another dozen forms, to 10 cm; typically coarse- to fine-grained, massive. *Twinning:* On {001}, contact; polysynthetic about [110].

Physical Properties: *Cleavage:* On {110}, {111}, perfect; on $\{\overline{1}11\}$, $\{\overline{1}01\}$, {011}, imperfect. *Tenacity:* Friable to firm. Hardness = 3.5 D(meas.) = 2.571 D(calc.) = 2.571 Slowly soluble in H_2O.

Optical Properties: Translucent. *Color:* Colorless, pale gray, pale yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = -76.5°$. *Dispersion:* $r > v$, moderate. $\alpha = 1.520$ $\beta = 1.533$ $\gamma = 1.584$ 2V(meas.) = 55°

Cell Data: *Space Group:* $C2/c$. $a = 6.912(2)$ $b = 7.624(2)$ $c = 7.642(2)$ $\beta = 118.09(2)°$ Z = 4

X-ray Powder Pattern: Klodawa, Poland. (ICDD 13-102).
3.41 (10), 4.84 (9), 3.33 (9), 2.527 (9), 2.055 (9), 3.05 (8), 2.567 (8)

Chemistry:

	(1)	(2)
SO_3	57.93	57.85
MgO	29.00	29.13
H_2O	13.07	13.02
Total	100.00	100.00

(1) Stassfurt, Germany. (2) $MgSO_4 \cdot H_2O$.

Mineral Group: Kieserite group.

Occurrence: Typically in marine salt deposits; rarely as a volcanic sublimate or efflorescence.

Association: Halite, carnallite, polyhalite, anhydrite, boracite, sulfoborite, leonite, epsomite, celestine.

Distribution: In Germany, from the Stassfurt-Westeregeln district, with large crystals from the Bartensleben mine, Saxony-Anhalt; in the Hildesia mine, near Hannover, and at Wathlingen, Lower Saxony, and many other places. From Hallstatt, Austria. At Stebnyk and Kalusz, Ukraine. From Klodawa, near Kutno, Poland. At Sleights, Eskdale, Yorkshire, England. From Monte Sambuco, Sicily, Italy. At Ozinky, southwest of Saratov, Russia. In the Mayo mine, Salt Range, Punjab, India. In the USA, from the Carlsbad potash district, Eddy Co., New Mexico, extending into west Texas; in the Paradox Basin, Grand Co., Utah.

Name: Honoring Dietrich Georg Kieser (1779–1862), President, Jena Academy, Jena, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 477–479. (2) Hawthorne, F.C., L.A. Groat, M. Raudsepp, and T.S. Ercit (1987) Kieserite, $Mg(SO_4)(H_2O)$, a titanite-group mineral. Neues Jahrb. Mineral., Abh., 157, 121–132. (3) Hintze, C. (1929) Handbuch der Mineralogie. Gruyter & Co., Berlin, 1(3), 4324–4332 (in German).

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Kilchoanite $Ca_3Si_2O_7$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. No crystal forms observed as typically a replacement of rankinite; massive, to 2 mm.

Physical Properties: Hardness = n.d. D(meas.) = 2.992(2) D(calc.) = [3.00]

Optical Properties: Semitransparent. *Color:* Colorless; in thin section, interference colors are typically weak ultra-blue or ultra-brown.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, distinct to strong. $\alpha = 1.646$–1.647 $\beta = 1.648$ $\gamma = 1.650$ 2V(meas.) = 46°–60°

Cell Data: *Space Group:* $Imam$ or $Ima2$. $a = 11.42(5)$ $b = 5.09(5)$ $c = 21.95(5)$ Z = 8

X-ray Powder Pattern: Kilchoan, Scotland.
2.89 (s1), 3.07 (s2), 2.68 (s3), 3.56 (ms), 2.36 (ms), 1.964 (ms), 5.17 (m)

Chemistry: (1) Kilchoan, Scotland; an analysis, not given, from which CO_2 was deducted as spurrite, yielded $(Ca_{2.93}Fe^{3+}_{0.01})_{\Sigma=2.94}(Si_{1.96}Al_{0.04})_{\Sigma=2.00}[O_{6.94}(OH)_{0.06}]_{\Sigma=7.00}$. (2) Fuka, Japan; an analysis, not available, yielded $(Ca_{3.13}Fe^{2+}_{0.01}Na_{0.01}K_{0.01})_{\Sigma=3.16}(Si_{1.91}Al_{0.02})_{\Sigma=1.93}O_7$.

Polymorphism & Series: Dimorphous with rankinite.

Occurrence: In limestones thermally metamorphosed by invasion of gabbro; thought to have formed during retrograde metamorphism following decarbonation of limestone and thus under low pressure of CO_2 (Kilchoan, Scotland; Carlingford, Ireland).

Association: Rankinite, spurrite, tilleyite, melilite, cuspidine, grossular, wollastonite, vesuvianite (Kilchoan, Scotland); rankinite, larnite, spurrite (Golden Gully, New Zealand).

Distribution: From near Kilchoan, Ardnamurchan, Argyllshire, Scotland. At Carlingford, Co. Louth, Ireland. In New Zealand, at Golden Gully, Tokatoka district, about 150 km north of Auckland. In Japan, from Fuka, near Bicchu, Okayama Prefecture. In the Ozerskii massif, near Lake Baikal, eastern Siberia, Russia.

Name: For Kilchoan, Scotland, where it was first found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119424, 119425.

References: (1) Agrell, S.O. and P. Gay (1961) Kilchoanite, a polymorph of rankinite. Nature, 189, 743. (2) (1961) Amer. Mineral., 46, 1203 (abs. ref. 1). (3) (1962) Amer. Mineral., 47, 420 (corr. ref. 1). (4) Taylor, H.F. (1971) The crystal structure of kilchoanite, $Ca_6(SiO_4)(Si_3O_{10})$, with some comments on related phases. Mineral. Mag., 38, 26–31. (5) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 272–277 [rankinite].

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Killalaite $Ca_3Si_2O_7 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are well-formed, elongated along [010], to 2 mm. *Twinning:* Complex penetration twinning, the composition plane of which includes [010]; they display characteristic rhombic cross sections showing crossed "bow tie" twins under crossed nicols.

Physical Properties: *Cleavage:* Perfect on {100}; poor on {010} and {001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.94

Optical Properties: Translucent. *Color:* [White]; colorless in thin section. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c \simeq 16°$. $\alpha = 1.634$–1.635 $\beta = 1.646$ $\gamma = 1.642$–1.648 2V(meas.) = 26(2)° 2V(calc.) = 38°

Cell Data: *Space Group:* $P2_1/m$. $a = 6.807$ $b = 15.459$ $c = 6.811$ $\beta = 97.76°$ Z = 4

X-ray Powder Pattern: Killala Bay, Ireland.
2.824 (100), 3.03 (80), 2.724 (60), 2.275 (45), 2.224 (45), 1.413 (40), 1.688 (35)

Chemistry:

	(1)	(2)
SiO_2	39.8	39.22
CaO	57.0	54.90
H_2O	[3.2]	5.88
Total	[100.0]	100.00

(1) Killala Bay, Ireland; by electron microprobe, H_2O by difference, MgO, FeO, and Al_2O_3 each $< 0.1\%$. (2) $Ca_3Si_2O_7 \cdot H_2O$.

Occurrence: A secondary mineral in cavities and veins in hydrothermally altered and thermally metamorphosed limestones.

Association: Calcite, afwillite, spurrite, wollastonite (Killala Bay, Ireland); larnite, magnetite, perovskite, spinel, spurrite (Carneal, Ireland).

Distribution: From near Inishcrone, along the east shore of Killala Bay, Co. Sligo, and at Carneal, Co. Antrim, Ireland. In Turkey, from the Güneyce-İkizdere region, Trabzon Province.

Name: For the locality at Killala Bay, Ireland.

Type Material: Ulster Museum, Belfast, Ireland; The Natural History Museum, London, England, 1973,484; National Museum of Natural History, Washington, D.C., USA, 128672.

References: (1) Nawaz, R. (1974) Killalaite, a new mineral from Co. Sligo, Ireland. Mineral. Mag., 39, 544–548. (2) (1974) Amer. Mineral., 59, 1331 (abs. ref. 1). (3) Nawaz, R. (1977) A second occurrence of killalaite. Mineral. Mag., 41, 546–548. (4) Taylor, H.F.W. (1977) The crystal structure of killalaite. Mineral. Mag., 41, 363–369. (5) Sarp, H., J. Deferne, and E. Sarman (1982) Second occurrence of killalaite in a skarn from the Guneyce-Ikizdere region (eastern Pontids, Turkey). Arch. Sci., 35(3), 275–278. (6) (1983) Chem. Abs., 98, 188 (abs. ref. 5).

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Kimrobinsonite $(Ta, Nb)(OH)_3(O, CO_3)$

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Crystal Data: Cubic. *Point Group:* n.d. In masses of cryptocrystalline individuals.

Physical Properties: *Tenacity:* Friable. Hardness = Soft. VHN = 70 (20 g load). D(meas.) = n.d. D(calc.) = 6.865

Optical Properties: Semitransparent. *Color:* White. *Streak:* White. *Luster:* Dull chalky. *Optical Class:* Isotropic. n = [2.23] (by rule of Gladstone and Dale).

Cell Data: *Space Group:* n.d. $a = 3.812(1)$ Z = 1

X-ray Powder Pattern: Mt. Holland, Western Australia.
3.808 (10), 2.696 (7), 1.702 (5), 1.555 (4), 1.907 (3), 2.202 (2), 1.270 (2)

Chemistry:

	(1)
Nb_2O_5	6.6
Ta_2O_5	78.5
Sb_2O_3	0.7
FeO	0.4
Na_2O	0.7
H_2O	[8.9]
CO_2	[4.2]
Total	[100.0]

(1) Mt. Holland, Western Australia; by electron microprobe, H_2O 5.9% and CO_2 2.8% by CHN microanalysis on a somewhat impure sample, recalculated to 100% for analytical shortfall of volatiles; then corresponding to $(Ta_{0.82}Nb_{0.11}Na_{0.05}Fe_{0.01}Sb_{0.01})_{\Sigma=1.00}(OH)_{2.27}[O_{1.02}(CO_3)_{0.22}]_{\Sigma=1.24}$.

Occurrence: The weathering product of an undetermined Ta–Sb pegmatite mineral.

Association: Cesstibtantite, manganotantalite, antimonian microlite.

Distribution: From near Mt. Holland, Western Australia.

Name: Honors Kim Robinson (1951–), Australian geologist of Perth, Australia, who discovered the specimen in which the mineral occurs.

Type Material: Western Australian Museum, Perth, M.59.1991; Museum Victoria, Melbourne, Australia, M37922; The Natural History Museum, London, England, 1986,250; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 163342.

References: (1) Nickel, E.H. and B.W. Robinson (1985) Kimrobinsonite, a new tantalum mineral from Western Australia, and its association with cesstibtantite. Can. Mineral., 23, 573–576. (2) (1987) Amer. Mineral., 72, 1024 (abs. ref. 1).

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Kimuraite-(Y) $CaY_2(CO_3)_4 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. As spherulitic aggregates of scaly tabular crystals, to 100 μm.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 2.5 D(meas.) = 2.6(1) D(calc.) = 2.98 Bright reddish purple to purple fluorescence under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Pale purple to pinkish white. *Luster:* Vitreous to silky on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, weak.
$\alpha = 1.584(2)$ $\beta = 1.612(2)$ $\gamma = 1.626(2)$ 2V(meas.) = 70(5)°

Cell Data: *Space Group:* $Immm$, $Imm2$, $I2_12_12_1$, or $I222$. $a = 9.2545(8)$ $b = 23.976(4)$ $c = 6.0433(7)$ Z = 4

X-ray Powder Pattern: Kirigo, Japan.
12.06 (100), 6.02 (40), 3.76 (30), 5.93 (20), 4.01 (20), 2.05 (12), 4.87 (10)

Chemistry:

	(1)		(1)
CO_2	29.13	Dy_2O_3	2.44
Y_2O_3	29.41	Ho_2O_3	0.62
La_2O_3	0.50	Er_2O_3	1.69
Ce_2O_3	0.02	Tm_2O_3	0.17
Pr_2O_3	0.37	Yb_2O_3	0.56
Nd_2O_3	2.97	Lu_2O_3	0.06
Sm_2O_3	0.95	CaO	9.23
Eu_2O_3	0.39	H_2O	18.32
Gd_2O_3	2.49	Total	99.68
Tb_2O_3	0.36		

(1) Kirigo, Japan; by ICP, H_2O and CO_2 by conventional analyses, corresponding to $Ca_{0.99}(Y_{1.57}Nd_{0.11}Gd_{0.08}Dy_{0.08}Er_{0.05}Sm_{0.03}Ho_{0.02}La_{0.02}Ho_{0.02}Pr_{0.02}Tb_{0.01}Eu_{0.01}Tm_{0.01})_{\Sigma=2.03}(CO_3)_4 \cdot 6.12H_2O$.

Occurrence: In fissures in an alkali olivine basalt.

Association: Lanthanite-(Nd), lanthanite-(La), lokkaite-(Y), kozoite-(Nd),

Distribution: From Kirigo and Niikoba, Higashi-Matsuura district, Saga Prefecture, Japan.

Name: To honor Professor Kenjiro Kimura (1896–?), Tokyo University, Tokyo, Japan, for his contributions to the mineralogy of rare-earth minerals.

Type Material: National Science Museum, Tokyo, Japan, M-24513; National Museum of Natural History, Washington, D.C., USA, 164269.

References: (1) Nagashima, K., R. Miyawaki, J. Takase, I. Nakai, K. Sakurai, S. Matsubara, A. Kato, and S. Iwano (1986) Kimuraite, $CaY_2(CO_3)_4 \cdot 6H_2O$, a new mineral from fissures in an alkali olivine basalt from Saga Prefecture, Japan, and new data on lokkaite. Amer. Mineral., 71, 1028–1033.

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Kimzeyite $\mathbf{Ca_3(Zr,Ti)_2(Si,Al,Fe^{3+})_3O_{12}}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As dodecahedra modified by trapezohedra, up to 5 mm; also in rounded grains.

Physical Properties: Hardness = ∼7 D(meas.) = 4.0 D(calc.) = 4.03

Optical Properties: Transparent. *Color:* Dark brown; light brown in thin section.
Streak: Light brown. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.94(1)$

Cell Data: *Space Group: Ia3d.* a = 12.46 Z = 8

X-ray Powder Pattern: Magnet Cove, Arkansas, USA.
1.667 (10), 2.539 (9), 2.79 (8), 3.12 (6), 4.42 (4), 1.728 (4), 1.395 (4)

Chemistry:

	(1)	(2)
SiO_2	9.6	16.63
TiO_2	5.6	6.95
ZrO_2	29.9	27.38
Al_2O_3	11.0	9.37
Fe_2O_3	13.4	
Nb_2O_5	1.0	
FeO	0.8	6.43
MgO	0.5	3.32
CaO	29.8	30.25
Total	101.6	100.33

(1) Magnet Cove, Arkansas, USA; corresponding to $(Ca_{3.11}Fe^{2+}_{0.07}Mg_{0.07})_{\Sigma=3.25}(Zr_{1.42}Ti_{0.40}Nb_{0.05})_{\Sigma=1.87}(Al_{1.26}Fe^{3+}_{0.98}Si_{0.94})_{\Sigma=3.18}O_{12}$. (2) Stromboli, Italy; by electron microprobe, average of three analyses; corresponding to $(Ca_{2.94}Mg_{0.06})_{\Sigma=3.00}(Zr_{1.21}Ti_{0.47}Mg_{0.32})_{\Sigma=2.00}(Si_{1.51}Al_{1.00}Fe^{3+}_{0.49})_{\Sigma=3.00}O_{12}$.

Mineral Group: Garnet group.

Occurrence: In a carbonatite associated with ijolite (Magnet Cove, Arkansas, USA); in a shoshonitic basaltic lava (Stromboli, Italy).

Association: Apatite, calcite, monticellite, magnetite, perovskite, anhydrite, vesuvianite, biotite, pyrite (Magnet Cove, Arkansas, USA).

Distribution: In the Kimzey quarry, Magnet Cove, Hot Spring Co., Arkansas, USA. On Stromboli, Lipari Islands, Italy.

Name: For Joe Kimzey, the mineral's discoverer, and the Kimzey family, of Magnet Cove, Arkansas, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 117124.

References: (1) Milton, C., B.L. Ingram, and L.V. Blade (1961) Kimzeyite, a zirconium garnet from Magnet Cove, Arkansas. Amer. Mineral., 46, 533–548. (2) Munno, R., G. Rossi, and C. Tadini (1980) Crystal chemistry of kimzeyite from Stromboli, Aeolian Islands, Italy. Amer. Mineral., 65, 188–191.

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Kingite $Al_3(PO_4)_2(OH,F)_3 \cdot 9H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As platelets or irregular fragments, to 1 μm, aggregated in nodules; as crusts of intergrown spheroids resembling fish roe.

Physical Properties: Hardness = n.d. D(meas.) = 2.21–2.30 D(calc.) = 2.465

Optical Properties: Translucent. *Color:* White, colorless, greenish yellow. *Luster:* Vitreous to dull.
Optical Class: Biaxial. $n = 1.514$

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.15(1)$ $b = 10.00(1)$ $c = 7.24(2)$
$\alpha = 98.6(1)^\circ$ $\beta = 93.6(1)^\circ$ $\gamma = 93.2(1)^\circ$ Z = 2

X-ray Powder Pattern: Near Robertstown, Australia.
9.1 (100), 3.45 (80), 3.48 (65), 5.28 (52), 3.17 (39), 3.108 (30), 5.43 (28)

Chemistry:

	(1)	(2)
P_2O_5	28.93	29.20
Al_2O_3	32.25	31.47
F	0.85	3.91
H_2O^+	38.32	37.07
$-O = F_2$	0.35	1.65
Total	[100.00]	100.00

(1) Near Robertstown, Australia; after deduction of Na 0.47% and Cl as halite impurity.
(2) $Al_3(PO_4)_2(OH)_2F \cdot 9H_2O$.

Occurrence: Of secondary origin, precipitated in fractured rock by meteoric water.

Association: Halite, talc, quartz, "limonite" (near Robertstown, Australia); "opal", sanidine (Wilson Springs mine, Arkansas, USA).

Distribution: In Australia, from the Fairview phosphate quarry, about 21 km north of Robertstown, in a quarry near Clinton, and at Tom's quarry, near Kapunda, South Australia. In the USA, from the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas; in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada. In Germany, in the Weckersdorf quarry, near Schleitz, and Ronneburg, Thuringia.

Name: Honors Mr. D. King (1926–1990), geologist, Department of Mines, Adelaide, South Australia, who collected the first specimens.

Type Material: Natural History Museum, Paris, France, 175.300; Harvard University, Cambridge, Massachusetts, 109441; National Museum of Natural History, Washington, D.C., USA, 112693.

References: (1) Norrish, K., L.E.R. Rogers, and R.E. Shapter (1957) Kingite, a new hydrated aluminum phosphate mineral from Robertstown, South Australia. Mineral. Mag., 31, 351–357. (2) (1957) Amer. Mineral., 42, 580–581 (abs. ref. 1). (3) Kato, T. (1970) Cell dimensions of the hydrated phosphate, kingite. Amer. Mineral., 55, 515–517. (4) Howard, J.M. and D.R. Owens (1995) Minerals of the Wilson Springs vanadium mines, Potash Sulphur Springs, Arkansas. Rocks & Minerals, 70(3), 154–170.

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Kingsmountite $(Ca,Mn^{2+})_4(Fe^{2+},Mn^{2+})Al_4(PO_4)_6(OH)_4 \cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2 (probable). As imperfect bladed crystals, usually in radial hemispherical aggregates, to 2 mm.

Physical Properties: Hardness = ~2.5 D(meas.) = 2.51(3) D(calc.) = 2.58

Optical Properties: Translucent. *Color:* White to very pale brown. *Streak:* White. *Luster:* Pearly to fibrous.
Optical Class: Biaxial (–). *Orientation:* $Y \perp$ lath flattening; X and $Z \parallel$ lath flattening; $Z \wedge$ lath length = 35(5)°. $\alpha = 1.573(3)$ $\beta = 1.581(3)$ $\gamma = 1.583(3)$ 2V(meas.) = 62(5)°

Cell Data: *Space Group:* $[C2]$ (by analogy to montgomeryite). $a = 10.029(6)$ $b = 24.46(1)$ $c = 6.258(4)$ $\beta = 91.16(7)°$ Z = 2

X-ray Powder Pattern: Foote mine, North Carolina, USA.
5.15 (100), 2.624 (60), 12.23 (50), 2.950 (40), 6.33 (30), 3.31 (30), 2.915 (30)

Chemistry:

	(1)
P_2O_5	35.9
Al_2O_3	16.7
FeO	4.1
MnO	8.1
MgO	0.2
CaO	14.9
H_2O	20.6
Total	100.5

(1) Foote mine, North Carolina, USA; by electron microprobe, average of three analyses, total Fe as FeO, total Mn as MnO, H_2O by DTA/TGA, Mn^{2+} assigned to fill Ca deficiency and Fe^{3+} calculated to fill Al deficiency; then corresponding to $(Ca_{3.15}Mn_{0.85})_{\Sigma=4.00}(Fe^{2+}_{0.56}Mn^{2+}_{0.50}Mg_{0.06})_{\Sigma=1.12}(Al_{3.88}Fe^{3+}_{0.12})_{\Sigma=4.00}(PO_4)_{6.00}(OH)_4 \cdot 11.6H_2O$.

Mineral Group: Montgomeryite group.

Occurrence: A secondary mineral formed from alteration of primary phosphates by descending oxidizing ground water in complex granite pegmatites.

Association: Mitridatite, birnessite (Foote mine, North Carolina, USA); whitlockite, cyrilovite (Tip Top mine, South Dakota, USA); eosphorite, laueite, lun'okite, fairfieldite, mitridatite (Mt. Vasin-Myl'k, Russia).

Distribution: In the USA, at the Foote mine, near Kings Mountain, Cleveland Co., North Carolina; from the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; in the Twin Creeks mine, Potosi district, Humboldt Co., Nevada. On Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia. In the Bendada pegmatite, near Guarda, Portugal. From the Silbergrube quarry, near Waidhaus, and at Hagendorf, Bavaria, Germany.

Name: For the town, KINGS MOUNTain, North Carolina, USA, near which the mineral was first collected.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120972, 120973.

References: (1) Dunn, P.J., D.R. Peacor, J.S. White, and R.A. Ramik (1979) Kingsmountite, a new mineral isostructural with montgomeryite. Can. Mineral., 17, 579–582. (2) (1981) Amer. Mineral., 66, 1275–1276 (abs. ref. 1).

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Kinichilite $Mg_{0.5}(Mn^{2+}, Zn)Fe^{3+}(Te^{4+}O_3)_3 \cdot 4.5H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As imperfect hexagonal prisms, to 2 mm, with curved {0001}.

Physical Properties: *Tenacity:* "Fragile". Hardness = "Soft". D(meas.) = n.d. D(calc.) = 4.11

Optical Properties: Translucent. *Color:* Dark brown. *Streak:* Brown.
Luster: Subadamantine.
Optical Class: Uniaxial (+). *Pleochroism:* Weak; pale brown to yellowish brown. $\omega = > 1.8$ $\epsilon = > 1.8$

Cell Data: *Space Group:* $P6_3/m$. $a = 9.451(7)$ $c = 7.687(9)$ $Z = 2$

X-ray Powder Pattern: Kawazu mine, Japan.
4.079 (100), 8.15 (90), 2.790 (85), 2.861 (50), 3.824 (35), 2.966 (30), 1.735 (20)

Chemistry:

	(1)	(2)
TeO_2	58.4	65.05
SeO_2	0.14	
Fe_2O_3	9.7	10.85
MnO	5.5	4.82
ZnO	5.9	5.53
MgO	2.77	2.74
Na_2O	0.02	
H_2O	n.d.	11.01
Total		100.00

(1) Kawazu mine, Japan; by electron microprobe, total Fe as Fe_2O_3, Fe^{3+} confirmed by Mössbauer spectroscopy; corresponds to $Mg_{0.55}(Mn^{2+}_{0.62}Zn_{0.54})_{\Sigma=1.16}Fe^{3+}_{0.97}(TeO_3)_{2.92} \cdot 4.5H_2O$.
(2) $Mg_{0.5}(Mn, Zn)Fe(TeO_3)_3 \cdot 4.5H_2O$ with Mn:Zn = 1:1.

Occurrence: A very rare mineral in low-temperature hydrothermal Au–Ag–Te quartz veins.

Association: Quartz.

Distribution: From the Kawazu mine, three km north of Shimoda, Izu Peninsula, Shizuoka Prefecture, Japan.

Name: Honors Dr. Kin-ichi Sakurai (1912–), prominent collector and amateur mineralogist, for his descriptions of tellurium minerals from the Kawazu mine, Japan.

Type Material: National Science Museum, Tokyo, Japan, M-23380; National Museum of Natural History, Washington, D.C., USA, 164269.

References: (1) Hori, H., E. Koyama, and K. Nagashima (1981) Kinichilite, a new mineral from the Kawazu mine, Shimoda city, Japan. Mineral. J. (Japan), 10, 333–337. (2) (1982) Amer. Mineral., 67, 623 (abs. ref. 1). (3) Miletich, R. (1995) Crystal chemistry of the microporous tellurite minerals zemannite and kinichilite, $Mg_{0.5}[Me^{2+}Fe^{3+}(TeO_3)_3] \cdot 4.5H_2O$, ($Me^{2+} = Zn, Mn$). Eur. J. Mineral., 7, 509–523.

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Kinoite $Ca_2Cu_2Si_3O_8(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As well-formed crystals, to 1.5 mm, tabular on [100], somewhat elongated along [001]; also in veinlets, massive.

Physical Properties: *Cleavage:* Excellent on {010}; distinct on {100} and {001}. Hardness = 4–5 D(meas.) = 3.16(3) D(calc.) = [3.20]

Optical Properties: Transparent to translucent. *Color:* Deep azurite-blue. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = pale greenish blue; Y = blue; Z = deep blue. *Orientation:* $X = b$; $Z \wedge c \simeq 0°$. *Dispersion:* $r < v$, distinct. *Absorption:* $Z > Y > X$. $\alpha = 1.638$–1.640 $\beta = 1.663$–1.665 $\gamma = 1.676$–1.680 2V(meas.) = 68° 2V(calc.) = 64°–80°

Cell Data: *Space Group:* $P2_1/m$. $a = 6.991(2)$ $b = 12.884(3)$ $c = 5.655(2)$ $\beta = 96°11(2)'$ Z = 2

X-ray Powder Pattern: Santa Rita Mountains, Arizona, USA.
4.72 (100), 3.052 (81), 6.44 (74), 2.116 (41), 3.138 (30), 2.315 (30), 3.951 (26)

Chemistry:

	(1)	(2)
SiO_2	35.90	36.97
CuO	31.10	32.63
MgO	0.15	
CaO	23.55	23.01
H_2O	8.16	7.39
Total	98.86	100.00

(1) Santa Rita Mountains, Arizona, USA. (2) $Ca_2Cu_2Si_3O_8(OH)_4$.

Occurrence: In vugs and veinlets in skarn (Santa Rita Mountains, Arizona, USA); in amygdules in basaltic lava flows (Calumet, Michigan, USA).

Association: Apophyllite, copper (Santa Rita Mountains, Arizona, USA); quartz, calcite, copper, silver, epidote, pumpellyite, chlorite (Calumet, Michigan, USA).

Distribution: In the USA, in Arizona, between Helvetia and Rosemont, Santa Rita Mountains, Pima Co., and in the Christmas copper mine, Gila Co.; in the Bawana mine, about six km northwest of Milford, Beaver Co., Utah; and in Michigan, in the Laurium and La Salle mines, Calumet, Houghton Co. and at the Northwestern mine, Keweenaw Co.

Name: For Fr. Eusebio Francisco Kino (1645–1711), Jesuit pioneer of the Sonora-Arizona-California frontier.

Type Material: Harvard University, Cambridge, Massachusetts, 109439; National Museum of Natural History, Washington, D.C., USA, 122395.

References: (1) Anthony, J.W. and R.B. Laughon (1970) Kinoite, a new hydrous copper calcium silicate mineral from Arizona. Amer. Mineral., 55, 709–715. (2) Laughon, R.B. (1971) The crystal structure of kinoite. Amer. Mineral., 56, 193–200. (3) Bauer, W.H. (1971) The prediction of bond length variations in silicon-oxygen bonds. Amer. Mineral., 56, 1573–1599. (4) Ruotsala, A.P. and M.L. Wilson (1977) Kinoite from Calumet, Michigan. Amer. Mineral., 62, 1032–1033.

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Kinoshitalite $(Ba,K)(Mg,Mn,Al)_3Si_2Al_2O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Forms small scales, < 1 mm.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle. Hardness = 2.5–3
D(meas.) = 3.30 D(calc.) = 3.33

Optical Properties: Semitransparent. *Color:* Yellow-brown to colorless; light yellow to colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = very light yellow to light yellow; $Y = Z$ = light yellow with brownish tinge. *Absorption:* $Y \simeq Z > X$. $\alpha = 1.619$ $\beta = 1.628$–1.633 $\gamma = 1.635$
2V(meas.) = 23°

Cell Data: *Space Group:* $C2/m$. $a = 5.345(3)$ $b = 9.250(4)$ $c = 10.256(8)$
$\beta = 99.99(6)°$ Z = 2

X-ray Powder Pattern: Noda-Tamagawa mine, Japan.
3.37 (100), 2.52 (55), 2.020 (55), 5.05 (50), 10.1 (45), 1.684 (15), 3.16 (5)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	24.58	23.43	BaO	17.85	27.60
TiO_2	0.16		Na_2O	0.68	0.11
Al_2O_3	22.06	19.25	K_2O	3.30	0.24
Fe_2O_3	0.71	1.87	F	0.21	
Mn_2O_3	3.24		H_2O^+	2.90	
FeO	0.04		H_2O^-	0.20	
MnO	7.38	2.62	H_2O		3.50
MgO	16.60	21.95	$-O = F_2$	0.09	
CaO	0.05	0.05	Total	99.87	100.62

(1) Noda-Tamagawa mine, Japan; corresponds to $(Ba_{0.58}K_{0.35}Na_{0.11}Ca_{0.01})_{\Sigma=1.05}(Mg_{2.06}Mn^{2+}_{0.52}Al_{0.22}Mn^{3+}_{0.21}Fe^{3+}_{0.04}Ti_{0.01})_{\Sigma=3.06}Si_{2.05}Al_{1.94}O_{10}[(OH)_{1.62}O_{0.33}F_{0.06}]_{\Sigma=2.01}$. (2) Netra, India; by electron microprobe, total Fe as Fe_2O_3; corresponding to $(Ba_{0.93}K_{0.03}Na_{0.02}Ca_{0.01})_{\Sigma=0.99}(Mg_{2.80}Mn_{0.19}Fe_{0.08})_{\Sigma=3.07}Si_{2.01}(Al_{1.94}Fe_{0.05})_{\Sigma=1.99}O_{10}(OH)_2$.

Polymorphism & Series: 1M, $2M_1$ polytypes.

Mineral Group: Mica group.

Occurrence: In hausmannite-tephroite ore (Noda-Tamagawa mine, Japan); in manganese-rich rocks invaded by silicic pegmatite and carbonate veins (Netra, India).

Association: Hausmannite, tephroite, celsian, quartz, spessartine, rhodonite, chalcopyrite, pyrrhotite, rhodochrosite, hübnerite, sonolite (Noda-Tamagawa mine, Japan); braunite, hausmannite, bixbyite, alkalic feldspar, hematite, calcite, dolomite, quartz (Netra, India).

Distribution: In the Noda-Tamagawa mine, Iwate Prefecture, and at Hokkejino, Kyoto Prefecture, Japan. From Netra, Balaghat district, Madhya Pradesh, India. On Trumbull Peak, near Incline, Mariposa Co., California, USA. From Långban, Värmland, Sweden.

Name: For Dr. Kameki Kinoshita (1896–1974), investigator of ore deposits in Japan.

Type Material: National Science Museum, Tokyo, Japan, M19511; National School of Mines, Paris, France.

References: (1) Yoshii, M., K. Maeda, T. Kato, T. Watanabe, S. Yui, A. Kato, and K. Nagashima (1973) Kinoshitalite, a new mineral from the Noda-Tamagawa mine, Iwate Prefecture. Chigaku Kenkyu (Geosci. Mag.), 24, 181–190 (in Japanese). (2) (1975) Amer. Mineral., 60, 486–487 (abs. ref. 1). (3) Kato, T., Y. Miúra, M. Yoshii, and K. Maeda (1979) The crystal structures of 1M-kinoshitalite, a new barium brittle mica and 1M-manganese trioctahedral micas. Mineral. J. (Japan), 9, 392–408. (4) Dasgupta, S., S. Chakraborti, P. Sengupta, P.K. Bhattacharya, H. Banerjee, and M. Fukuoka (1989) Compositional characteristics of kinoshitalite from the Sausar group, India. Amer. Mineral., 74, 200–202.

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Kintoreite $\mathbf{PbFe_3^{3+}(PO_4)_2(OH,H_2O)_6}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals are rhombohedral, $\{11\overline{2}2\}$, to 2 mm; as hemispheres and globular crusts.

Physical Properties: *Cleavage:* Good on {0001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4 D(meas.) = > 4.2 D(calc.) = 4.34

Optical Properties: Transparent to translucent. *Color:* Cream to yellowish green. *Streak:* Pale yellowish green. *Luster:* Vitreous to adamantine (crystals); greasy to waxy (aggregates).
Optical Class: Uniaxial (–). *Pleochroism:* Light yellowish green to medium yellow.
n = 1.935–1.955

Cell Data: *Space Group:* $[R\overline{3}m]$ (by analogy to crandallite). a = 7.3310(7) c = 16.885(2) Z = 3

X-ray Powder Pattern: Kintore open cut, Broken Hill, Australia.
3.07 (100), 5.96 (90), 3.67 (60), 2.538 (50), 2.257 (50), 1.979 (50), 2.971 (40)

Chemistry:

	(1)
SO_3	2.02
P_2O_5	13.30
As_2O_5	6.43
CO_2	0.73
Al_2O_3	0.02
Fe_2O_3	34.01
CuO	0.25
ZnO	1.58
PbO	31.37
BaO	0.09
H_2O	9.0
Total	[98.80]

(1) Kintore open cut, Broken Hill, Australia; by electron microprobe, average of six analyses, original total given as 98.90%, total Fe as Fe_2O_3, H_2O and CO_2 by CHN analyzer; corresponding to $Pb_{0.97}(Fe_{2.95}Zn_{0.13}Cu_{0.02})_{\Sigma=3.10}[(PO_4)_{1.30}(AsO_4)_{0.39}(SO_4)_{0.18}(CO_3)_{0.11}]_{\Sigma=1.98}(OH)_{5.45}\bullet 0.74H_2O$.

Mineral Group: Crandallite group.

Occurrence: A rare secondary mineral in the oxidized zone of a Pb–Zn deposit.

Association: Segnitite, pyromorphite, mimetite, libethenite, hinsdalite, rockbridgeite–dufrénite, apatite, goethite.

Distribution: In Australia, from the Kintore and Block 14 open cuts, Broken Hill, New South Wales. In Germany, from the Clara mine, near Oberwolfach, and the Igelschlatt mine, near Grafenhausen, Black Forest.

Name: For the site from which the best specimens were first collected, the Kintore open cut, Broken Hill, Australia.

Type Material: The South Australia Museum, Adelaide, G14354; Museum Victoria, Melbourne, Australia, M42891.

References: (1) Pring, A., W.D. Birch, J. Dawe, M. Taylor, M. Deliens, and K. Walenta (1995) Kintoreite, $PbFe_3(PO_4)_2(OH,H_2O)_6$, a new mineral of the jarosite-alunite family, and lusungite discredited. Mineral. Mag., 59, 143–148. (2) (1995) Amer. Mineral., 80, 1073–1074 (abs. ref. 1). (3) Kharisun, M.R. Taylor, and D.J.M. Bevan (1997) The crystal structure of kintoreite, $PbFe_3(PO_4)_2(OH,H_2O)_6$. Mineral. Mag., 61, 123–129.

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Kipushite $(Cu, Zn)_6(PO_4)_2(OH)_6 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, elongated along $[10\overline{1}]$, exhibiting {111} with uneven, rounded faces and terminated by {100}, to 5 mm; additional forms include {102}, $\{01\overline{2}\}$, $\{11\overline{1}\}$. More commonly as aggregates of subparallel prismatic crystals.

Physical Properties: *Fracture:* Uneven. Hardness = 4 D(meas.) = 3.8 D(calc.) = 3.904

Optical Properties: Transparent to translucent. *Color:* Emerald-green. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = blue; Z = bright blue.
$\alpha = 1.693(2)$ $\beta = 1.738(2)$ $\gamma = 1.740(2)$ 2V(meas.) = Small. 2V(calc.) = 23°

Cell Data: *Space Group:* $P2_1/c$. $a = 12.197(2)$ $b = 9.156(2)$ $c = 10.667(2)$
$\beta = 96.77(2)°$ Z = 4

X-ray Powder Pattern: Kipushi, Congo.
4.03 (100), 2.554 (90), 2.970 (60), 1.531 (60b), 12.2 (50), 3.386 (45), 6.06 (40)

Chemistry:

	(1)
P_2O_5	20.9
CuO	43.0
ZnO	24.4
H_2O	11.1
Total	99.4

(1) Kipushi, Congo; by electron microprobe, average of 14 analyses on two crystals, H_2O by TGA; $(OH)^{1-}$ calculated for charge balance, corresponding to $(Cu_{3.77}Zn_{2.09})_{\Sigma=5.86}(PO_4)_{2.06}(OH)_{5.54} \cdot 1.5H_2O$.

Occurrence: A secondary mineral in the oxidized zone of a Cu–Zn deposit (Kipushi, Congo).

Association: Pseudomalachite, malachite, hemimorphite, pyromorphite, veszelyite, vauquelinite, libethenite, reichenbachite, quartz, iron oxides (Kipushi, Congo).

Distribution: From Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). In the USA, in the Black Pine mine, near Philipsburg, Granite Co., Montana, and at the Snowstorm mine, near Battle Mountain, Lander Co., Nevada. From Broken Hill, New South Wales, Australia.

Name: For Kipushi, Congo, where the first specimens were collected.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG14026.

References: (1) Piret, P., M. Deliens, and J. Piret-Meunier (1985) Occurrence and crystal structure of kipushite, a new copper-zinc phosphate from Kipushi, Zaire. Can. Mineral., 23, 35–42. (2) (1986) Amer. Mineral., 71, 228–229 (abs. ref. 1). (3) Braithwaite, R.S.W. and G. Ryback (1988) Philipsburgite from the Caldbeck Fells and kipushite from Montana, and their infrared spectra. Mineral. Mag., 52, 529–533.

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Kirchhoffite $CsBSi_2O_6$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As equant grains to 80 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 6-6.5 D(meas.) = 3.62(2) D(calc.) = 3.639

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class:* Uniaxial (+). ω = 1.592(2) ε = 1.600(2)

Cell Data: *Space Group*: $I4_1/acd$. a = 13.019(2) c = 12.900(3) Z = 16

X-ray Powder Pattern: Darai-Pioz alkaline massif, Tajikistan.
3.26 (100), 3.48 (82), 2.770 (67), 2.294 (41), 2.109 (34), 5.32 (32), 1.768 (22)

Chemistry:

	(1)
SiO_2	40.47
B_2O_3	11.27
K_2O	0.11
Cs_2O	48.16
Rb_2O	0.09
Total	100.10

(1) Darai-Pioz alkaline massif, Tajikistan; average of 50 electron microprobe analyses, B_2O_3 and Rb_2O by SIMS, corresponding to $(Cs_{1.02}K_{0.01})_{\Sigma=1.03}B_{0.96}Si_{2.02}O_6$.

Mineral Group: Analcime group.

Occurrence: In a massif composed of a variety of granitic, alkaline granitic and syenitic pegmatites, various hydrothermal rocks (albitites, fenites) and carbonatites.

Association: Quartz, pectolite, and subordinate fluorite, sokolovaite, baratovite, aegirine, polylithionite, stillwellite-(Ce), neptunite, pekovite, senkevichite, mendeleevite-(Ce).

Distribution: In glacial moraine, upper reaches of the Darai-Pioz River, near the junction of the Turkestan, Zeravshan, and Alai ridges, Darai-Pioz alkaline massif, Garm District, Tajikistan.

Name: Honors Professor Gustav Robert Kirchhoff (1824-1887), the German physicist at the universities of Breslau and Berlin, one of the founders of spectral analysis and co-discoverer (with Robert Bunsen) of cesium and rubidium.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3923/1).

References: (1) Agakhanov, A.A., L.A. Pautov, V.Yu. Karpenko, E. Sokolova, and F.C. Hawthorne (2012) Kirchhoffite, $CsBSi_2O_6$, a new mineral species from the Darai-Pioz alkaline massif, Tajikistan: description and crystal structure. Canadian Mineralogist, 50, 523-529. (2) (2014) Amer. Mineral., 99, 871 (abs. ref. 1).

Kirkiite $Pb_{10}(As,Bi)_6S_{19}$

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Crystal Data: Hexagonal and monoclinic, pseudohexagonal. *Point Group:* $6/m$ and $2/m$ (actual); 622 ($6/m$ $2/m$ $2/m$ apparent). Crystals are prismatic, to 100 μm, composed of stacked pseudohexagonal plates; as subhedral grains. *Twinning:* Polysynthetically twinned, common.

Physical Properties: Hardness = n.d. VHN = 150 (100 g load). D(meas.) = n.d. D(calc.) = 6.82

Optical Properties: Opaque. *Color:* Steel-gray; pale gray to white in reflected light. *Anisotropism:* Weak to strong. *Bireflectance:* Very weak.
R_1–R_2: (400) — , (420) 40.2–45.3, (440) 40.9–45.7, (460) 40.9–45.2, (480) 40.8–45.1, (500) 40.4–44.5, (520) 39.9–43.9, (540) 39.4–43.5, (560) 39.0–43.1, (580) 38.6–42.6, (600) 38.3–42.3, (620) 39.0–42.1, (640) 37.8–41.8, (660) 37.5–41.5, (680) 37.2–41.0, (700) 36.9–40.9

Cell Data: *Space Group:* $P6_322$ (apparent) $a = 8.69(5)$ $c = 26.06(10)$ Z = 2, actual *Space Group:* $P6_3/m$ $a = 8.70(5)$ $c = 25.97(10)$ Z = 2, or *Space Group:* $P2_1/m$ $a = 8.47(5)$ $b = 7.84(5)$ $c = 25.97(10)$ $\beta = 118.03°$ Z = 2

X-ray Powder Pattern: Kirki, Greece.
3.260 (100), 3.070 (70), 3.475 (60), 2.854 (60), 2.190 (50), 3.65 (50), 1.815 (50)

Chemistry:

	(1)	(2)	(3)
Pb	59.4	59.25	58.65
Bi	15.2	15.62	17.75
As	6.2	7.20	6.36
Sb	0.5		
S	17.4	17.15	17.24
Se		0.96	
Total	98.7	100.18	100.00

(1) Kirki, Greece; by electron microprobe, average of six analyses; corresponding to $Pb_{10.15}(As_{2.93}Bi_{2.57}Sb_{0.14})_{\Sigma=5.64}S_{19.21}$. (2) Vulcano, Italy; by electron microprobe, average of 12 analyses; corresponding to $Pb_{9.97}(As_{3.35}Bi_{2.61})_{\Sigma=5.96}(S_{18.65}Se_{0.42})_{\Sigma=19.07}$. (2) $Pb_{10}(As,Bi)_6S_{19}$ with As:Bi = 1:1.

Occurrence: In a hydrothermal Pb–Zn deposit (Kirki, Greece); in a volcanic fumarole, formed at about 470 °C (Vulcano, Italy).

Association: Cosalite, bismuthinite, bismuthian jordanite, seligmannite, levyclaudite, sphalerite, pyrite, galena (Kirki, Greece); sphalerite, cannizzarite (Vulcano, Italy).

Distribution: From the Aghios Philippos Pb–Zn deposit, near Kirki, Thrace, Greece [TL]. At the La Fossa crater, Vulcano, Lipari Islands, Italy.

Name: For Kirki, Greece.

Type Material: n.d.

References: (1) Moëlo, Y., E. Oudin, E. Makovicky, S. Karup-Møller, F. Pillard, M. Bornuat, and E. Evanghelou (1985) La kirkiite, $Pb_{10}Bi_3As_3S_{19}$, une nouvelle espèce minérale homologue de la jordanite. Bull. Minéral., 108, 667–677 (in French with English abs.). (2) (1986) Amer. Mineral., 71, 1278–1279 (abs. ref. 1). (3) Borodaev, Y.S., A. Garavelli, O.V. Kuzmina, N.N. Mozgova, N.I. Organova, N.V. Trubkin, and F. Vurro (1998) Rare sulfosalts from Vulcano, Aeolian Islands, Italy. I. Se-bearing kirkiite, $Pb_{10}(Bi,As)_6(S,Se)_{19}$. Can. Mineral., 36, 1105–1114.

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Kirschsteinite $CaFe^{2+}SiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In crystals, to 0.5 mm; as skeletal rims on other minerals; crystalline massive.

Physical Properties: Hardness = n.d. D(meas.) = 3.434 D(calc.) = 3.596

Optical Properties: Transparent. *Color:* Pale green; colorless in thin section. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.660$–1.689 $\beta = 1.720$ $\gamma = 1.694$–1.728 2V(meas.) = 51(1)° 2V(calc.) = 53°–61°

Cell Data: *Space Group:* [*Pbnm*] (by analogy to the olivine group). $a = 4.859$ $b = 11.132$ $c = 6.420$ Z = 4

X-ray Powder Pattern: Mt. Shaheru, Congo.
2.949 (100), 2.680 (85), 2.604 (80), 3.658 (70), 1.830 (60), 2.414 (40), 5.569 (35)

Chemistry:

	(1)	(2)
SiO_2	32.71	31.96
TiO_2	0.23	
Al_2O_3	0.26	
Fe_2O_3	0.66	
FeO	29.34	38.21
MnO	1.65	
MgO	4.95	
CaO	29.30	29.83
Na_2O	0.34	
K_2O	0.36	
H_2O^+	0.25	
H_2O^-	0.06	
P_2O_5	0.07	
Total	100.18	100.00

(1) Mt. Shaheru, Congo. (2) $CaFeSiO_4$.

Polymorphism & Series: Forms a series with monticellite.

Occurrence: In melilite-nephelinite lava (Mt. Shaheru, Congo); in calcareous skarn (Tazheran massif, Russia).

Association: Melilite, nepheline, clinopyroxene, kalsilite, götzenite, combeite, sodalite, magnetite, perovskite, apatite, "hornblende," biotite (Mt. Shaheru, Congo); titanian augite, wollastonite, melilite, garnet, calcite, cuspidine, diopside, perovskite, troilite, graphite (Tazheran massif, Russia).

Distribution: On Mt. Shaheru, the extinct southern cone of Mt. Nyiragongo, Kivu Province, Congo (Zaire). In the Wessels mine, near Kuruman, Cape Province, South Africa. From the Tazheran alkalic massif, west of Lake Baikal, eastern Siberia, Russia. In the Angra dos Reis meteorite.

Name: For Dr. Egon Kirschstein, German geologist, a pioneer in the geological exploration of Kivu Province, Congo (Zaire).

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM8037; Harvard University, Cambridge, Massachusetts, USA.

References: (1) Sahama, T.G. and K. Hytönen (1957) Kirschsteinite, a natural analogue to synthetic iron monticellite, from the Belgian Congo. Mineral. Mag., 31, 698–699. (2) (1958) Amer. Mineral., 43, 790 (abs. ref. 1). (3) Konev, A.A., Z.F. Ushchapovskaya, and V.S. Lebedeva (1970) First find of magnesian kirschsteinite in the USSR. Doklady Acad. Nauk SSSR, 190, 932–935 (in Russian).

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Kitagohaite Pt_7Cu

Crystal Data: Isometric. *Point Group*: 4/*m* $\bar{3}$ 2/*m.* As grain cores or rims on grains to ~0.5 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Malleable. Hardness = 3.5 VHN = 206-237 (100 g load). D(meas.) = n.d. D(calc.) = 19.958

Optical Properties: Opaque. *Color*: Grayish white, white in reflected light. *Streak*: Gray. *Luster*: Metallic.
Optical Class: Isotropic.
R: (470) 63.2, (546) 66.6, (589) 68.2, (650) 70.1

Cell Data: *Space Group*: *Fm*$\bar{3}$ *m.* *a* = 7.7891(3) Z = 4

X-ray Powder Pattern: Kitagoha river, Lubero region, Democratic Republic of the Congo.
2.246 (100), 1.377 (77), 1.123 (31), 1.174 (27), 0.893 (13), 1.948 (8), 3.871 (3)

Chemistry:

	(1)	(2)
Pt	95.49	95.55
Cu	4.78	4.45
Total	100.26	100.00

(1) Kitagoha river, Lubero region, Democratic Republic of the Congo; average of 13 electron microprobe analyses; corresponding to $Pt_{6.93}Cu_{1.07}$. (2) Pt_7Cu.

Occurrence: In heavy mineral concentrates from river sediment perhaps derived from hydrothermal quartz vein deposits of unknown type.

Association: Commonly rimmed by hongshiite, with luberoite, quartz, zircon, hematite.

Distribution: From the Kitagoha river basin, Lubero region, Democratic Republic of the Congo; also reported from sediment in the Lemmenjoki and Ivalojoki river systems, Finnish Lapland.

Name: For the Kitagoha river, Democratic Republic of the Congo. The river's name probably comes from 'kitahuha', which in the local Bantu language means 'the river that does not make noise'.

Type Material: Clausthal University of Technology, Clausthal-Zellerfeld, Germany (# 11331).

References: (1) Cabral, A.R., R. Skála, A. Vymazalová, A. Kallistová, B. Lehmann, J. Jedwab, and T. Sidorinová (2014) Kitagohaite, Pt_7Cu, a new mineral from the Lubero region, North Kivu, Democratic Republic of the Congo. Mineral. Mag., 78(3), 739-745. (2) (2015) Amer. Mineral., 100, 336 (abs. ref. 1).

Kitkaite NiTeSe

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As crystals, to 5 mm; massive.

Physical Properties: *Cleavage:* Good on {001}. Hardness = n.d. VHN = 110
D(meas.) = 7.19 D(calc.) = 7.22

Optical Properties: Opaque. *Color:* Pale yellow. *Luster:* Metallic. *Anisotropism:* Distinct, from pale gray to pink or purple.

R_1–R_2: (400) 49.4–53.0, (420) 50.3–52.0, (440) 51.5–51.6, (460) 52.9–51.6, (480) 54.4–52.2, (500) 55.9–52.9, (520) 57.4–54.0, (540) 58.9–55.2, (560) 60.2–56.5, (580) 61.4–57.8, (600) 62.5–59.1, (620) 63.3–60.2, (640) 64.1–61.1, (660) 64.6–61.8, (680) 65.2–62.4, (700) 65.7–62.9

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 3.716(5)$ $c = 5.126(5)$ $Z = 1$

X-ray Powder Pattern: Kuusamo, Finland.
2.729 (100), 2.007 (45), 1.510 (35), 2.567 (25), 1.860 (25), 1.535 (20), 5.13 (15)

Chemistry:

	(1)	(2)	(3)
Ni	22.42	23.6	22.13
Co	0.40	0.1	
Fe		0.2	
Cu	0.07	0.1	
Te	47.46	44.0	48.10
Se	30.22	31.3	29.77
S		0.4	
Total	100.57	99.7	100.00

(1) Kuusamo, Finland; corresponding to $(Ni_{1.01}Co_{0.02})_{\Sigma=1.03}Te_{0.99}Se_{1.01}$. (2) Do.; by electron microprobe, corresponding to $(Ni_{1.07}Fe_{0.01}Co_{0.01})_{\Sigma=1.09}Te_{0.92}Se_{1.05}S_{0.03}$. (3) NiTeSe.

Mineral Group: Melonite group.

Occurrence: In narrow carbonate-bearing fissure veinlets in albite.

Association: Clausthalite, hematite, selenian polydymite, selenian linnaeite, pyrite.

Distribution: From Kuusamo, northeastern Finland [TL].

Name: For the Kitka River, Finland, in the valley of which the mineral was found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120267.

References: (1) Häkli, T.A., Y. Vuorelainen, and T.G. Sahama (1965) Kitkaite (NiTeSe), a new mineral from Kuusamo, northeast Finland. Amer. Mineral., 50, 581–586. (2) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 289.

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Kittatinnyite $Ca_4Mn_2^{2+}Mn_4^{3+}Si_4O_{16}(OH)_8 \cdot 18H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $6mm$, or $\overline{6}m2$. As very thin, distorted crystals, to 0.2 mm, flattened on {0001}, and in subparallel aggregates.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Brittle. Hardness = ∼4
D(meas.) = 2.61 D(calc.) = 2.62

Optical Properties: Translucent to opaque. *Color:* Bright to golden yellow; in thin section, medium yellow. *Streak:* Light yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* Very weak in medium yellow. *Absorption:* $E \geq O$.
$\omega = 1.727(3)$ $\epsilon =$ n.d.

Cell Data: *Space Group:* $P6_3/mmc$, $P6_3mc$, or $P\overline{6}2c$. a = 6.498(4) $c = 22.78(2)$ Z = 1

X-ray Powder Pattern: Franklin, New Jersey, USA.
11.2 (100), 5.61 (60), 2.733 (60), 2.822 (50), 2.525 (40), 2.279 (40), 5.03 (30)

Chemistry:

	(1)	(2)
SiO_2	18.2	18.23
Mn_2O_3	23.6	23.95
As_2O_5	0.8	
FeO	0.0	
MnO	10.6	10.76
CuO	0.0	
ZnO	0.3	
MgO	0.0	
CaO	17.3	17.01
H_2O	[29.2]	30.05
Total	[100.0]	100.00

(1) Franklin, New Jersey, USA; by electron microprobe, Mn^{2+}:Mn^{3+} from charge balance, H_2O by difference. (2) $Ca_4Mn_2^{2+}Mn_4^{3+}Si_4O_{16}(OH)_8 \cdot 18H_2O$.

Occurrence: A secondary mineral coating fractures in a metamorphosed stratiform zinc deposit.

Association: Bostwickite, calcite, franklinite, fluorite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: Derived from *kittatinny*, which in the language of the Algonquin Indians meant *endless hills*, in allusion to the topography of the Franklin area.

Type Material: Harvard University, Cambridge, Massachusetts, 113514; National Museum of Natural History, Washington, D.C., USA, C4222.

References: (1) Dunn, P.J. and D.R. Peacor (1983) Kittatinnyite and wallkilldellite, silicate/arsenate analogues containing calcium and manganese, from Franklin and Sterling Hill, New Jersey. Amer. Mineral., 68, 1029–1032.

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Kladnoite $C_6H_4(CO)_2NH$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Forms elongated crystals, with prominent {100}, {110}, {230}, {120}.

Physical Properties: Hardness = n.d. D(meas.) = 1.47 D(calc.) = 1.469 M.P. 234(1) °C.

Optical Properties: Semitransparent. *Color:* Colorless, white, pale yellow.
Optical Class: Biaxial (+). *Orientation:* $Y \wedge c \simeq 16°$. $\alpha = 1.501$ $\beta = 1.519$ $\gamma = 1.755$
2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 22.83(1)$ $b = 7.651(4)$ $c = 3.810(2)$
$\beta = 91.36(2)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 28-2013).
5.70 (100), 6.35 (95), 3.28 (30), 11.4 (18), 3.74 (14), 3.38 (14), 3.13 (14)

Chemistry: (1) Stated to be identical to phthalimide.

Occurrence: Formed as a result of fires in coal heaps.

Association: n.d.

Distribution: From the Scholler coal mine, Libušín, Kladno coal basin, about 30 km west-northwest of Prague, and at Radvanice, Czech Republic.

Name: For its occurrence in the Kladno district, Czech Republic.

Type Material: n.d.

References: (1) Rost, R. (1942) Supplements to the mineralogy of the burning (coal) heaps in the region of Kladno. Rozpravy České Akad., 52(25), 4 pp. (2) (1946) Amer. Mineral., 31, 605 (abs. ref. 1). (3) Mazat, E. (1972) Die Kristallstruktur des Phtalimids (Kladnoite) Acta Cryst., 28, 415–418 (in German with English abs.).

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Klebelsbergite $Sb_4^{3+}O_4(SO_4)(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are platy, flattened on {010}, or acicular, elongated along [001], to 1 cm; rarely isolated, typically in bladed radial to tufted aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 200 (10 g load). D(meas.) = 4.62(6) D(calc.) = 4.67–4.69 May be weakly magnetic if iron is present as an impurity.

Optical Properties: Semitransparent. *Color:* Colorless, pale yellow, yellow-orange, pink. *Streak:* White to yellow. *Luster:* Vitreous to silky.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. α = n.d. $\beta = \sim 1.95$ γ = n.d. 2V(meas.) = $\sim 70°$

Cell Data: *Space Group:* $Pc2_1b$. $a = 11.279(2)$ $b = 14.909(3)$ $c = 5.7648(6)$ Z = 4

X-ray Powder Pattern: Baia Sprie, Romania.
3.131 (vs), 6.22 (s), 3.892 (s), 3.545 (s), 3.150 (s), 2.830 (s), 2.435 (s)

Chemistry:

	(1)	(2)
SO_3	8.0	11.75
Sb_2O_5	84.8	85.60
Fe_2O_3	0.7	
H_2O		2.65
Total		100.00

(1) Baia Sprie, Romania; by electron microprobe, partial analysis, here converted from an elemental analysis, valence determination of Fe by microchemistry found $Fe^{3+} \gg Fe^{2+}$, $(OH)^{1-}$ determined present by IR. (2) $Sb_4O_4(SO_4)(OH)_2$.

Occurrence: An alteration product of stibnite in antimony deposits.

Association: Stibnite, valentinite, cervantite, kermesite, stibiconite, coquandite, peretaite, onoratoite, cetineite.

Distribution: In Romania, from Baia Sprie (Felsőbánya). In Italy, in Tuscany, at the Cetine mine, 20 km southwest of Siena; in the Pereta mine, Scansano; and at Micciano, near Larderello.

Name: Honoring Kunó Klebelsberg (1875–1932), Hungarian Minister of Education.

Type Material: Hungarian Natural History Museum, Budapest, Hungary, A85135; National Museum of Natural History, Washington, D.C., USA, R6365, B12631, B12640, B12647, 137949.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 583. (2) Nakai, I. and D.E. Appleman (1980) Klebelsbergite, $Sb_4O_4(OH)_2SO_4$: redefinition and synthesis. Amer. Mineral., 65, 499–505. (3) Cipriani, N., S. Menchetti, and C. Sabelli (1980) Klebelsbergite and another antimony mineral from Pereta, Tuscany, Italy. Neues Jahrb. Mineral., Monatsh., 223–229. (4) Menchetti, S. and C. Sabelli (1980) The crystal structure of klebelsbergite, $Sb_4O_4(OH)_2(SO_4)$. Amer. Mineral., 65, 931–935.

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Kleemanite $ZnAl_2(PO_4)_2(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As thin veins, to 2 mm thick, and matted coatings of very fine-bladed acicular crystals. *Twinning:* Multiple twinning parallel to fiber elongation probable.

Physical Properties: Hardness = 3 D(meas.) = 2.84 D(calc.) = 2.76

Optical Properties: Transparent. *Color:* Colorless to pale brownish yellow. *Luster:* Bright [*sic*].
Optical Class: Biaxial. *Orientation:* Inclined extinction up to 40° in opposite directions in adjacent crystals. $\alpha = 1.598(2)$ $\beta =$ n.d. $\gamma = 1.614(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2/m$, $P2_1/m$, $P2$, or $P2_1$. $a = 7.274$–7.290 $b = 7.185$–7.194 $c = 9.788$–9.762 $\beta = 110.20°$–$110.244°$ Z = 2

X-ray Powder Pattern: Iron Monarch quarry, Australia.
4.76 (10), 3.09 (8), 9.09 (6), 3.30 (6), 5.66 (5), 3.88 (5), 3.64 (5)

Chemistry:

	(1)	(2)	(3)
P_2O_5	35.7	34.76	35.72
Al_2O_3	24.4	24.38	25.66
Fe_2O_3	1.1		
Mn_2O_3	1.3		
FeO		0.67	
ZnO	20.7	20.79	20.48
H_2O	18.2	19.79	18.14
Total	101.4	100.39	100.00

(1) Iron Monarch quarry, Australia; Al, Fe, Mn, and Zn by AA, total Fe as Fe_2O_3, total Mn as Mn_2O_3, H_2O by TGA; corresponding to $Zn_{1.01}(Al_{1.90}Mn_{0.07}Fe_{0.06})_{\Sigma=2.03}(PO_4)_2(OH)_{2.08} \cdot 2.98H_2O$. (2) Baokeng, China; by electron microprobe, average of five analyses, H_2O by TGA; corresponding to $Zn_{1.02}(Al_{1.96}Fe_{0.04})_{\Sigma=2.00}(PO_4)_{1.95}(OH)_{2.01} \cdot 3.14H_2O$. (3) $ZnAl_2(PO_4)_2(OH)_2 \cdot 3H_2O$.

Occurrence: A rare secondary mineral in the weathering zone of manganiferous iron ore.

Association: Jacobsite (Iron Monarch quarry, Australia); turquoise (Broken Hill, Australia).

Distribution: In Australia, in the Iron Monarch quarry, Iron Knob, South Australia, and at Broken Hill, New South Wales. In the Baokeng manganese deposit, Guangdong Province, China.

Name: Honors Dr. Alfred William Kleeman (1913–1982), mineralogist, University of Adelaide, Adelaide, Australia.

Type Material: Museum Victoria, Melbourne, M34218; Division of Mineral Chemistry, CSIRO, Melbourne, Australia, MC637; National Museum of Natural History, Washington, D.C., USA, 145805.

References: (1) Pilkington, E.S., E.R. Segnit, and J. Watts (1979) Kleemanite, a new zinc aluminum phosphate. Mineral. Mag., 43, 93–95. (2) (1979) Amer. Mineral., 64, 1331 (abs. ref. 1). (3) Lai Lairen and Sun Yanyan (1993) The discovery of kleemanite, a zinc aluminum phosphate in China. Yanshi Kuangwuxue Zazhi [Acta Petrologica et Mineralogica], 12(3), 279–283 (in Chinese with English abs.).

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Kleinite $Hg_2N(Cl,SO_4)\cdot nH_2O$

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Crystal Data: Hexagonal or triclinic. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals short prismatic to equant, to 3 mm, showing prominent $\{10\overline{1}0\}$, $\{20\overline{2}1\}$, and $\{0001\}$.

Physical Properties: *Cleavage:* $\{0001\}$, uneven; $\{10\overline{1}0\}$, imperfect. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 7.9–8.0 D(calc.) = [7.87]

Optical Properties: Transparent to translucent. *Color:* Pale yellow, canary-yellow to orange, may be zoned, yellow cores with reddish orange rims; tenebrescent, deepening in color in daylight, the original color restored in darkness; yellow to colorless in transmitted light. *Streak:* Sulfur-yellow. *Luster:* Adamantine to greasy.
Optical Class: Biaxial (–); uniaxial (+) $\geq$ 130 °C; isotropic $\geq \sim$190 °C. *Dispersion:* $r < v$, very strong. $\omega = 2.19$ $\epsilon = 2.21$ $\alpha = 2.16$ $\beta = 2.18$ $\gamma = 2.18$ 2V(meas.) = Small to 80°.

Cell Data: *Space Group:* $C6/mmc$. $a = 13.56$ $c = 11.13$ Z = [18]

X-ray Powder Pattern: Terlingua, Texas, USA.
2.914 (10), 2.615 (10), 3.884 (6), 2.013 (6), 1.434 (4), 1.242 (4), 5.228 (2)

Chemistry:

	(1)
Hg	85.86
N	2.57
Cl	7.30
H_2O	1.03
SO_4	3.10
Total	99.86

(1) Terlingua, Texas, USA; averages of numerous partial analyses, corresponds to $Hg_{2.00}N_{0.86}[Cl_{0.96}(SO_4)_{0.15}]_{\Sigma=1.11}\cdot 0.53H_2O$.

Occurrence: In hydrothermal mercury deposits.

Association: Terlinguaite, gypsum, barite, calcite, other mercury minerals (Terlingua, Texas, USA); mosesite, calomel, montroydite (McDermitt mine, Nevada, USA).

Distribution: In the USA, from Terlingua, Brewster Co., Texas; the New Idria district, San Benito Co., California; and in the McDermitt and Cordero mercury mines, Opalite district, Humboldt Co., Nevada.

Name: To honor Carl Klein (1842–1907), Professor of Mineralogy, University of Berlin, Berlin, Germany.

Type Material: Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 86639–86641, 86647.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 87–89. (2) Bird, P.H. (1932) A new occurrence and X-ray study of mosesite. Amer. Mineral., 17, 541–553. (3) Heritsch, H. (1949) I. Röntgenuntersuchungen an Kleinit. Tschermaks Mineral. Petrog. Mitt., 1, 300–312 (in German). (4) Foord, E.E. and B.A. Mills (1978) Biaxiality in 'isometric' and 'dimetric' crystals. Amer. Mineral., 63, 316–325.

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Klockmannite CuSe

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As granular aggregates, some with thick and thin tabular grains.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 2–3 VHN = 82–104 (100 g load). D(meas.) = 5.99 (synthetic). D(calc.) = 6.12

Optical Properties: Opaque. *Color:* Slate-gray, tarnishing to blue-black. *Luster:* Metallic when freshly broken, soon becoming dull. *Anisotropism:* Strong; brownish gray to gray-white. R_1–R_2: (400) 16.2–38.9, (420) 16.6–40.2, (440) 16.9–40.8, (460) 17.0–40.6, (480) 17.0–40.2, (500) 17.0–39.6, (520) 16.8–38.9, (540) 16.4–38.0, (560) 15.8–37.0, (580) 15.0–36.0, (600) 14.3–34.7, (620) 13.9–33.6, (640) 13.9–32.5, (660) 14.5–31.5, (680) 15.8–30.5, (700) 17.7–29.9

Cell Data: *Space Group:* $P6_3/mmc$. $a = 3.938$ $c = 17.25$ $Z = 6$

X-ray Powder Pattern: Synthetic.
2.88 (100), 3.18 (90), 1.969 (80), 3.34 (60), 1.821 (60), 1.623 (50), 2.00 (40)

Chemistry:

	(1)	(2)
Cu	44.7	44.59
Ag	0.3	
Se	54.1	55.41
Total	99.1	100.00

(1) Locality uncertain; by electron microprobe. (2) CuSe.

Occurrence: Of hydrothermal origin, in deposits rich in copper and tellurium.

Association: Clausthalite, umangite, eucairite, berzelianite, crookesite, chalcomenite.

Distribution: In Argentina, from the Sierra de Umango [TL], and in the Santa Brigida mine and at Tuminico, Sierra de Cacho, La Rioja Province; from Cerro de Cacheuta, Mendoza Province. At Lerbach, Tilkerode, and Zorge, Harz Mountains, Germany. From Skrikerum, Kalmar, Sweden. In the Czech Republic, at Bukov, near Tisnova; in the Petrovice uranium deposit, near Ždár; and the Předbořice uranium deposit, near Krásna Hora. In the Pinky Fault uranium deposit, Lake Athabasca, Saskatchewan, and at the Ranwick uranium mine, north of Sault Ste Marie, Ontario, Canada. From Mexico, at the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora. In Australia, at the Dianne mine, near Mareeba, Queensland.

Name: For Professor Friedrich Ferdinand Hermann Klockmann (1858–1937), German mineralogist, Technical High School, Aachen, Germany.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 251. (2) Earley, J.W. (1949) Studies of natural and artificial selenides: I. Klockmannite, CuSe. Amer. Mineral., 34, 435–440. (3) Berry, L.G. (1954) The crystal structure of covellite, CuS and klockmannite, CuSe. Amer. Mineral., 39, 504–509. (4) Effenberger, H. and F. Pertlik (1981) Ein beitrag zur Kristallstruktur von α–CuSe (Klockmannit). Neues Jahrb. Mineral., Monatsh., 197–205 (in German with English abs.). (5) Milman, V. (2002) Klockmannite, CuSe: structure, properties and phase stability from *ab initio* modeling. Acta Cryst., 437–447. (6) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 68. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 290.

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Klyuchevskite $K_3Cu_3(Fe^{3+}, Al)O_2(SO_4)_4$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals are acicular, elongated along [010], to 0.5 mm; in random aggregates.

Physical Properties: *Cleavage:* On {*h*0*l*}, perfect. Hardness = n.d. VHN = 167 (3 g load). D(meas.) = 3.00–3.15 D(calc.) = 2.98 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Dark green to olive-green. *Streak:* Pale green. *Luster:* Submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = olive-green; Y = green; Z = dark olive-green. *Orientation:* $Y = b$. $\alpha = 1.549(1)$ $\beta = 1.550(1)$ $\gamma = 1.680(1)$ 2V(meas.) = n.d. 2V(calc.) = 11°

Cell Data: *Space Group:* $I2$. $a = 18.667(7)$ $b = 4.94(2)$ $c = 18.405(7)$ $\beta = 101.5(2)°$ Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia; similar to alumoklyuchevskite.
9.03 (100), 9.17 (95), 3.762 (55), 7.20 (35), 3.409 (28), 4.502 (25), 3.678 (23)

Chemistry:

	(1)	(2)
SO_3	40.98	41.06
Al_2O_3	1.38	
Fe_2O_3	7.86	10.24
CuO	31.15	30.59
ZnO	0.04	
PbO	0.71	
Na_2O	0.00	
K_2O	18.17	18.11
Cl	0.13	
$-O = Cl_2$	0.03	
Total	100.39	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of 25 grains; corresponds to $K_{3.00}(Cu_{3.05}Pb_{0.02})_{\Sigma=3.07}(Fe_{0.77}Al_{0.21})_{\Sigma=0.98}O_2(S_{1.00}O_4)_{4.00}$. (2) $K_3Cu_3FeO_2(SO_4)_4$.

Occurrence: In cavities in volcanic fumaroles.

Association: Alarsite, fedotovite, lammerite, nabokoite, atlasovite, langbeinite, ponomarevite, tolbachite, kamchatkite, hematite, tenorite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: For the locality, as one of the Klyuchevskaya group of volcanoes.

Type Material: Mining Institute, St. Petersburg, Russia, 979/1.

References: (1) Vergasova, L.P., S.K. Filatov, M.G. Goskaya, V.V. Ananev, and A.S. Sharov (1989) Klyuchevskite $K_3Cu_3Fe^{3+}O_2(SO_4)_4$ – a new mineral from volcanic sublimates. Zap. Vses. Mineral. Obshch., 118, 65–69 (in Russian). (2) (1990) Amer. Mineral., 75, 1210–1211 (abs. ref. 1). (3) Gorskaya, M.G., S.K. Filatov, I.V. Rozhdestvenskaya, and L.P. Vergasova (1992) The crystal structure of klyuchevskite, $K_3Cu_3(Fe, Al)O_2(SO_4)_4$, new mineral from volcanic sublimates. Mineral. Mag., 56, 411–416.

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Knasibfite $K_3Na_4[SiF_6]_3[BF_4]$

Crystal Data: Orthorhombic. *Point Group*: *mm*2. As well-formed prismatic crystals, to 0.1 mm, displaying {001}, {100}, {010}, {110}, {011}, {101}.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = 2.75(1) D(calc.) = 2.77

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Nearly isotropic. $n = 1.32$

Cell Data: *Space Group*: *Imm*2. $a = 5.521(1)$ $b = 17.115(4)$ $c = 9.186(2)$ Z = 2

X-ray Powder Pattern: La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy.
4.044 (100), 8.558 (50), 2.280 (50), 3.175 (30), 8.107 (25), 4.726 (25), 4.134 (25)

Chemistry:

	(1)	(2)
K	16.78	16.24
Si	11.36	11.67
F	57.83	57.87
Na	13.14	12.73
B	1.50	1.50
Total	100.61	100.00

(1) La Fossa crater, Vulcano, Sicily, Italy; average of 10 EDS analyses, B calculated from the structure, corresponding to $K_{3.09}Na_{4.11}Si_{2.91}B_{1.00}F_{21.89}$.
(2) $K_3Na_4[SiF_6]_3[BF_4]$.

Occurrence: On altered pyroclastic breccia in an active low-temperature volcanic fumarole.

Association: Hieratite, avogadrite, demartinite.

Distribution: La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy.

Name: An acronym based on the chemical symbols for its essential components.

Type Material: Dipartimento di Chimica Strutturale e Stereochimica Inorganica, Università degli Studi, Milan, Italy, 2006-03.

References: (1) Demartin, F., C.M. Gramaccioli, I. Campostrini, and P. Orlandi (2008) Knasibfite, $K_3Na_4[SiF_6]_3[BF_4]$, a new hexafluorosilicate–tetrafluoroborate from La Fossa crater, Vulcano, Aeolian Islands, Italy. Can. Mineral., 46, 447–453. (2) (2008) Amer. Mineral., 93, 1943 (abs. ref. 1).

Knorringite $Mg_3Cr_2^{3+}(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive and as minute grains.

Physical Properties: Hardness = ∼7 D(meas.) = 3.756 D(calc.) = 3.852

Optical Properties: Semitransparent. *Color:* Bluish green, greenish. *Luster:* Vitreous. *Optical Class:* Isotropic. $n = 1.803$

Cell Data: *Space Group: Ia3d.* $a = 11.65$ Z = 8

X-ray Powder Pattern: Kao kimberlite pipe, Lesotho.
2.92 (100), 2.61 (100), 2.382 (80), 1.560 (80), 2.489 (60), 2.288 (60), 1.894 (60)

Chemistry:

	(1)	(2)
SiO_2	39.92	39.78
TiO_2	0.11	
Al_2O_3	9.74	
Cr_2O_3	17.47	33.54
Fe_2O_3	1.20	
FeO	6.53	
MnO	0.60	
MgO	16.97	26.68
CaO	8.14	
Total	100.68	100.00

(1) Kao kimberlite pipe, Lesotho; by electron microprobe, corresponding to $(Mg_{1.90}Ca_{0.66}Fe^{2+}_{0.41}Mn_{0.17})_{\Sigma=3.14}(Cr_{1.04}Al_{0.86}Fe^{3+}_{0.07})_{\Sigma=1.97}Si_{3.01}O_{12}$. (2) $Mg_3Cr_2(SiO_4)_3$.

Polymorphism & Series: Forms a series with pyrope.

Mineral Group: Garnet group.

Occurrence: A rare component of ultramafic kimberlite nodules (Kao kimberlite pipe, Lesotho).

Association: Olivine, enstatite, chromian diopside, chromian pyrope, chromian spinel, ilmenite, perovskite, zircon, diamond, omphacite, rutile, carbonates, micas (Kao kimberlite pipe, Lesotho).

Distribution: In the Kao kimberlite pipe, Lesotho. From the Red Ledge mine, Nevada Co., California, USA.

Name: To honor Dr. Oleg von Knorring (1915–1994), Department of Earth Sciences, Leeds University, Leeds, England.

Type Material: n.d.

References: (1) Nixon, P.H. and G. Hornung (1968) A new chromium garnet end member, knorringite, from kimberlite. Amer. Mineral., 53, 1833–1840. (2) Nixon, P.H., O. von Knorring, and J.M. Rooke (1963) Kimberlites and associated inclusions of Basutoland: a mineralogical and geochemical study. Amer. Mineral., 48, 1090–1132.

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Koashvite $Na_6(Ca,Mn)(Fe^{3+},Ti)Si_6O_{18}\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Habit not stated.

Physical Properties: *Fracture:* Conchoidal. Hardness = 6 VHN = 680–740 (20 g load). D(meas.) = 2.98–3.02 D(calc.) = 3.069

Optical Properties: Transparent. *Color:* Pale yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Dispersion:* $r > v$, weak. $\alpha = 1.637$ $\beta = 1.643$ $\gamma = 1.648$ 2V(meas.) = 83°

Cell Data: *Space Group: Pmnb.* $a = 10.179(1)$ $b = 20.899(2)$ $c = 7.335(1)$ Z = 4

X-ray Powder Pattern: Mt. Koashva, Russia.
2.581 (100), 1.820 (70), 3.66 (50), 3.28 (50), 1.504 (50), 2.620 (40), 1.476 (40)

Chemistry:

	(1)
SiO_2	51.00
TiO_2	5.07
Fe_2O_3	5.42
MnO	4.20
MgO	trace
CaO	6.00
Na_2O	25.60
K_2O	0.38
H_2O	2.27
Total	99.94

(1) Mt. Koashva, Russia; corresponds to $(Na_{5.88}K_{0.06})_{\Sigma=5.94}(Ca_{0.76}Mn_{0.42})_{\Sigma=1.18}(Fe^{3+}_{0.48}Ti_{0.45})_{\Sigma=0.93}Si_{6.05}O_{17.88}\cdot 0.90H_2O$.

Mineral Group: Lovozerite group.

Occurrence: As veinlets replacing lomonosovite in an ultra-agpaitic pegmatite in an alkalic massif.

Association: Lomonosovite, pectolite, villiaumite, natrophosphate.

Distribution: On Mt. Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: For the locality, Mt. Koashva, Kola Peninsula, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75148; National School of Mines, Paris, France.

References: (1) Kapustin, Y.L., Z.V. Pudovkina, A.V. Bykova, and G.V. Lyubomilova (1974) Koashvite, a new mineral. Zap. Vses. Mineral. Obshch., 103, 559–566 (in Russian). (2) (1975) Amer. Mineral., 60, 487 (abs. ref. 1). (3) Chernitsova, N.M., Z.A. Pudovkina, A.A. Voronkov, and Y.A. Pyatenko (1980) Crystal structure of koashvite $Na_6(Ca,Mn)_{1+0.5x}(Fe^{3+}_xTi_{1-x})[Si_6O_{18}]$. Mineral. Zhurnal, 2(5), 40–44 (in Russian). (4) (1981) Chem. Abs., 94, 39866 (abs. ref. 3).

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Kobeite-(Y) $(Y, U)(Ti, Nb)_2(O, OH)_6(?)$

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Crystal Data: Cubic; metamict. *Point Group:* n.d. As long to short prismatic crystals, striated parallel to elongation, to 5 cm; in parallel to radiating groups, and dendritic aggregates.

Physical Properties: *Cleavage:* Perpendicular to the length, probably a parting. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 4.60 D(calc.) = [4.13] Strongly radioactive.

Optical Properties: Transparent to translucent. *Color:* Black to dark brown; coffee-brown to brownish yellow in thin section. *Streak:* Reddish brown. *Luster:* Vitreous to resinous. *Optical Class:* Isotropic. $n = 2.205(5)$

Cell Data: *Space Group:* n.d. $a = 5.021–5.057$ Z = [1]

X-ray Powder Pattern: Shiraishi pegmatite, Japan; after heating one hour at 620 °C in air. 2.89 (10), 1.776 (8), 1.514 (7), 2.506 (4), 1.154 (3b), 1.126 (3b), 1.027 (2b)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8	5.39	5.84	Ce_2O_3	1.83	1.64
$(Nb, Ta)_2O_5$	7.25	8.01	Fe_2O_3	8.32	9.55
SiO_2	1.99	1.59	MnO	2.16	1.48
TiO_2	26.21	26.02	MgO	0.50	0.79
ZrO_2	14.91	17.08	CaO	0.53	0.73
ThO_2	1.25	1.31	H_2O^+	3.87	2.81
Al_2O_3	0.33	0.35	H_2O^-	0.47	0.42
Y_2O_3	24.40	21.98	Total	[99.41]	99.60

(1) Shiraishi pegmatite, Japan; total Fe as Fe_2O_3; H_2O^+ as loss on ignition; original total given as 99.73%. (2) Ushio mine, Japan; H_2O^+ as loss on ignition.

Occurrence: In granite pegmatites (Japan); in a stream cobble of graphic granite (Paringa River, New Zealand).

Association: Anatase, parisite, zircon, monazite, chevkinite, xenotime, allanite, biotite, albite, quartz, muscovite (Shiraishi pegmatite, Japan); plagioclase, allanite, zircon, fergusonite, magnetite, ilmenite, pyrite (Ushio mine, Japan); plagioclase, microcline, epidote, muscovite, chlorite, quartz (Paringa River, New Zealand).

Distribution: In Japan, from the Shiraishi pegmatite, Oyama, and in the Ushio mine, Omiya, Kyoto Prefecture; from Senogawa-machi, Hiroshima Prefecture. In a cobble found in the Paringa River, about 1.2 km upstream from the Weheka-Paringa highway bridge, South Westland, New Zealand.

Name: For Kobe-Mura [presently Oyama-cho], Japan, from where it was first noted.

Type Material: n.d.

References: (1) Takubo, J., Y. Ukai, and T. Minato (1950) Studies on the minerals containing rare elements. (part 11) A new mineral [kobeite] found at Shirashi, Kobe-mura, Nakagun, Kyoto Prefecture, Japan. J. Geol. Soc. Japan, 56(663), 509–513 (in Japanese with English abs.). (2) (1951) Amer. Mineral., 36, 942 (abs. ref. 1). (3) Hutton, C.O. (1957) Kobeite from Paringa River, South Westland, New Zealand. Amer. Mineral., 42, 342–353. (4) Masutomi, K., K. Nagashima, and A. Kato (1961) Kobeite from the Ushio mine, Kyoto Prefecture, Japan, and re-examination of kobeite. Mineral. J. (Japan), 3, 139–147. (5) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 226–227. (6) Nambu, M., Ed. (1970) Introduction to Japanese minerals. Geol. Surv. Japan, 64–65.

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Kobellite $Cu_2Pb_{10}(Bi,Sb)_{16}S_{35}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Bladed, to 2 mm; commonly fibrous, massive, granular.

Physical Properties: *Cleavage:* Good on {010}. Hardness = 2.5–3 VHN = n.d. D(meas.) = 6.48 D(calc.) = 6.51

Optical Properties: Opaque. *Color:* Blackish lead-gray to steel-gray; in polished section, white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Distinct. R_1–R_2: (400) 48.6–51.8, (420) 48.0–51.1, (440) 47.5–50.5, (460) 47.0–49.9, (480) 46.6–49.3, (500) 46.1–48.7, (520) 45.6–48.1, (540) 45.0–47.5, (560) 44.6–46.9, (580) 44.1–46.4, (600) 43.8–45.9, (620) 43.5–45.7, (640) 43.3–45.5, (660) 43.1–45.4, (680) 42.9–45.3, (700) 42.7–45.2

Cell Data: *Space Group: Pnnm* or *Pnmm*. $a = 22.62$ $b = 34.08$ $c = 4.02$ $Z = 2$

X-ray Powder Pattern: Vena mines, Sweden.
3.54 (100), 3.41 (90), 2.72 (50), 3.98 (40), 3.27 (40), 2.85 (20), 2.150 (20)

Chemistry:

	(1)	(2)		(1)	(2)
Pb	33.2	38.0	Bi	37.6	28.5
Cu	1.0		Sb	9.6	15.0
Ag	0.5		S	18.6	18.0
Fe	0.6		Total	101.1	99.5

(1) Vena mines, Sweden; by electron microprobe; corresponds to $Cu_{0.96}Pb_{9.80}Fe_{0.66}Ag_{0.28}(Bi_{11.00}Sb_{4.82})_{\Sigma=15.82}S_{35.00}$. (2) Raleigh, North Carolina, USA; by electron microprobe, corresponds to $Pb_{11.44}(Bi_{8.56}Sb_{7.73})_{\Sigma=16.29}S_{35.00}$.

Polymorphism & Series: Forms a series with tintinaite.

Occurrence: A high-temperature hydrothermal mineral.

Association: Cobaltite, arsenopyrite, chalcopyrite (Vena mines, Sweden); bismuthinite, jamesonite, tetrahedrite (Raleigh, North Carolina, USA).

Distribution: In Sweden, from the Vena mines, near Askersund, Örebro [TL], and at Boliden, Västerbotten. From the Srednegolgotaiskoe gold deposit, Transbaikalia, Siberia, Russia. In the Ustarasai bismuth deposit, near Brichmulla village, Pskem Range, south Tien Shan, northeastern Uzbekistan. At the Salsigne mine, 15 km north of Carcassone, Aude, France. In the Aljustrel deposit, Portugal. From Smolotely, near Příbram, Czech Republic. At St. Andreasberg, Harz Mountains, Germany. From Ciclova, Romania. At Zeehan, Tasmania, Australia. In the USA, from the Superior stone quarry, Raleigh, Wake Co., North Carolina; in the Cofer deposit, near Mineral, Louisa Co., Virginia; at the Silver Bell mine, Red Mountain district, Ouray Co., Colorado. In Canada, from the Deer Park mine, in the Rossland area, and in the Dodger tungsten mine, Salmo, British Columbia; at the Tintina silver mines, Watson Lake, Yukon Territory.

Name: In honor of Wolfgang Franz von Kobell (1803–1882), German mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 447–448. (2) Harris, D.C., J.L. Jambor, G.R. Lachance, and R.I. Thorpe (1968) Tintinaite, the antimony analogue of kobellite. Can. Mineral., 9, 371–382. (3) Miehe, G. (1971) The crystal structure of kobellite. Nature, Phys. Sci., 231, 133–134. (4) Moëlo, Y., J.L. Jambor, and D.C. Harris (1984) Tintinaïte et sulfosels associés de Tintina (Yukon): la cristallochimie de la série de la kobellite. Can. Mineral., 22, 219–226 (in French with English abs.). (5) Zakrzewski, M.A. and E. Makovicky (1986) Izoklakeite from Vena, Sweden, and the kobellite homologous series. Can. Mineral., 24, 7–18. (6) Makovicky, E. and W.G. Mumme (1986) The crystal structure of izoklakeite, $Pb_{51.3}Sb_{20.4}Bi_{19.5}Ag_{1.2}Cu_{2.9}Fe_{0.7}S_{114}$. The kobellite homologous series and its derivatives. Neues Jahrb. Mineral., Abh., 153, 121–145. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 291.

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Kobokoboite $Al_6(PO_4)_4(OH)_6 \cdot 11H_2O$

Crystal Data: Triclinic. *Point Group*: 1 or $\bar{1}$. As crusts of hexagonal crystals, bladed to platy on (001), to 50 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = 2 (estimated). D(meas.) = 2.21(3) D(calc.) = 2.287

Optical Properties: Translucent to transparent. *Color*: White. *Streak*: White. *Luster*: Pearly. *Optical Class:* Biaxial (-). α (calc.) = 1.556 β = 1.558(2) γ = 1.562(2) 2V (meas.) = 60-80° Orientation: $X \approx c$.

Cell Data: *Space Group*: $P1$ or $P\bar{1}$. a = 7.460(1) b = 7.737(1) c = 12.385(5) α = 102.79(2)° β = 90.20(3)° γ = 116.33(2)° Z = 1

X-ray Powder Pattern: Kobokobo pegmatite, Democratic Republic of the Congo. 11.990 (100), 6.868 (45), 3.552 (39), 6.006 (33), 3.081 (29), 3.714 (27), 3.028 (22)

Chemistry:

	(1)	(2)
Na_2O	0.06	
CaO	0.18	
Mn	0.01	
Fe_2O_3	1.31	
Al_2O_3	35.16	36.33
P_2O_5	33.25	33.71
H_2O	29.52	29.96
F	0.76	
-O=F	0.32	.
Total	99.93	100.00

(1) Kobokobo pegmatite, Democratic Republic of the Congo; average of 9 electron microprobe analyses, H_2O by CHN method, corresponding to $(Al_{5.85}Fe^{3+}_{0.14}Ca_{0.03}Na_{0.02})_{\Sigma=6.04}(PO_4)_{3.97}[(OH)_{5.80}F_{0.34}]_{\Sigma=6.14} \cdot 10.98H_2O$. (2) $Al_6(PO_4)_4(OH)_6 \cdot 11H_2O$.

Occurrence: A secondary mineral formed by weathering of the upper branch of a zoned albite-beryl-microcline pegmatite of the LCT family, rare-element class, Li subclass, beryl type, beryl–columbite/beryl–phosphate subtype.

Association: Frondelite, keckite, planerite, variscite, wavellite ("coeruleolactite"), muscovite-2M_2, evansite, apatite-(CaOH).

Distribution: Kobokobo pegmatite, South Kivu Province, Democratic Republic of the Congo.

Name: For the pegmatite body (*Kobokobo*) from which the first specimens were collected.

Type Material: Museum Victoria, Melbourne, Australia, (M49194).

References: (1) Mills, S.J., W.D. Birch, A.R. Kampf, and L. van Wambeke (2010) Kobokoboite, $Al_6(PO_4)_4(OH)_6 \cdot 11H_2O$, a new mineral from the Kobokobo pegmatite, Democratic Republic of the Congo. European Journal of Mineralogy, 22, 305-308. (2) (2014) Amer. Mineral., 99, 553-554 (abs. ref. 1).

Kochkarite $PbBi_4Te_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$, $\overline{4}3m$, or 432. Crystals are cubo-octahedral, to 100 μm; massive.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5–4 VHN = 220–267, 247 average (20 g load). D(meas.) = 13.0 D(calc.) = 13.1

Optical Properties: Opaque. *Color:* Tin-white on fresh fracture, quickly altering in moist air to brownish black; creamy white in reflected light. *Luster:* Metallic.
R: (400) — , (420) 59.0, (440) 61.4, (460) 63.8, (480) 66.8, (500) 69.4, (520) 71.2, (540) 72.1, (560) 72.8, (580) 73.6, (600) 74.0, (620) 74.6, (640) 75.3, (660) 76.0, (680) 76.9, (700) 77.8

Cell Data: *Space Group:* $Im3m$, $I432$, or $I\overline{4}3m$. Synthetic material is $I\overline{4}3m$.
a = 9.414–9.418 Z = 4

X-ray Powder Pattern: Krokhalin deposit, Russia.
2.22 (100), 2.52 (42), 2.98 (25), 2.09 (25), 2.01 (25), 1.279 (25b), 1.524 (18b)

Chemistry:

	(1)	(2)	(3)
Cu	26.6	26.76	26.98
Ag		2.19	
Hg	72.6	70.21	73.02
Total	99.2	99.16	100.00

(1) Krokhalin deposit, Russia; by electron microprobe, average of nine analyses; corresponding to $Cu_{6.97}Hg_{6.03}$. (2) Gould-Curry mine, Nevada, USA; by electron microprobe, silver considered to be a contaminent; then corresponding to $Cu_{7.10}Hg_{5.90}$. (3) Cu_7Hg_6.

Polymorphism & Series: Dimorphous with belendorffite.

Occurrence: In the heavy mineral fraction of concentrates (Krokhalin deposit, Russia).

Association: Copper, stibnite, berthierite, pyrite, arsenopyrite, quartz (Krokhalin deposit, Russia); moschellandsbergite, mercury (Mexico); moschellandsbergite (Gould-Curry mine, Nevada, USA); cinnabar, azurite, malachite (Marcelita, Chile).

Distribution: From the Krokhalin Au–Sb deposit, 60 km southeast of Yagodnoye, basin of the Kolyma River, Magadan region, Sakha, Russia [TL]. In the Gould-Curry mine, Comstock Lode, Virginia City, Storey Co., Nevada, USA. At an undefined locality in Mexico. From a prospect near Marcelita, about 70 km southeast of Copiapó, Atacama, Chile.

Name: For the locality near the Kolyma River, Russia.

Type Material: Institute of Mineralogy and Geochemistry of Rare Elements; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80178, vis176.

References: (1) Markova, E.A., N.M. Chernitsova, Y.S. Borodaev, L.S. Dubakina, and O.E. Yushko-Zakharova (1980) The new mineral kolymite, Cu_7Hg_6. Zap. Vses. Mineral. Obshch., 109, 206–211 (in Russian). (2) (1981) Amer. Mineral., 66, 218 (abs. ref. 1). (3) Cipriani, C. and G. Mazzetti (1989) Kolymite (copper amalgam): report of second and third occurrences. Eur. J. Mineral., 1, 719–720.

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Kochsándorite $CaAl_2(CO_3)_2(OH)_4 \cdot H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m 2/m 2/m*. As acicular to bladed crystals, with {100} and {110} dominant, typically in radial aggregates to 200-300 μm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Very brittle. Hardness = 2-2.5 D(meas.) = 2.486(20) D(calc.) = 2.514 Fluoresces pale yellow under SW and LW UV. Dissolves quickly in dilute HCl with effervescence.

Optical Properties: Transparent to translucent. *Color*: White to colorless. *Streak*: White. *Luster*: Vitreous, silky in aggregates.
Optical Class: Biaxial (-). α = 1.597(3) β = n.d. γ = 1.603(6) 2V(meas.) = n.d. 2V(calc.) = n.d. *Orientation*: n.d. *Dispersion*: Weak, $r < v$.

Cell Data: *Space Group*: *Pnma*. a = 15.564(6) b = 5.591(4) c = 9.112(4) Z = 4

X-ray Powder Pattern: Mány, Tatabánya coalfield, Hungary.
5.9154 (100), 7.8607 (87), 4.3718 (86), 7.7830 (62), 2.9570 (48), 2.9455 (44), 1.9021 (26)

Chemistry:

(1) Mány, Tatabánya coalfield, northeastern Transdanubian Mountains, Hungary; analyses by prompt gamma activation analysis (PGAA), energy-dispersive X-ray spectrometry (EDS), H_2O by thermogravimetry, CO_2 by mass spectrometry correspond to $Ca_{0.9}Al_2(CO_3)_{1.9}(OH)_4 \cdot 1.3H_2O$.

Mineral Group: Dundasite group.

Occurrence: A secondary mineral formed by the contemporaneous weathering of böhmite, pyrite and calcite in brown coal beds.

Association: Intimately intergrown with gibbsite, commonly associated with calcite and gypsum; quartz, pyrite, böhmite, dolomite, calcite, gibbsite, kaolinite, illite, alumohydrocalcite, gypsum, felsöbányaite.

Distribution: From the I/A shaft of the coal mine in Mány, Tatabánya coalfield, northeastern Transdanubian Mountains, Hungary.

Name: Honors Sándor Koch (1896-1983), Professor in the Department of Mineralogy, Petrography and Geochemistry, József Attila University (now University of Szeged), Hungary.

Type Material: Hungarian Natural History Museum, Budapest (568/2004), Herman Ottó Museum, Miskolc (2004-72) and Minerals of the Carpathian Basin (Lajos Kövecses-Varga collection), Siófok, Hungary (12004/1-3).

References: (1) Sajó, I.E. and S. Szakáll (2007) Kochsándorite, a new Ca-Al carbonate mineral species from the Mány coal deposit, Hungary. Can. Mineral., 45, 479-483. (2) (2007) Amer. Mineral., 92, 1777 (abs. ref. 1).

Koechlinite Bi_2MoO_6

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $mm2$. As thin, square to rectangular, striated plates and laths flattened on {010}; as spheroidal aggregates of laths, to 0.4 mm. Also as massive or earthy incrustations. *Twinning:* With {101} as twin plane, penetration and contact twins on {101} and contact twins on {010}.

Physical Properties: *Cleavage:* {010}, perfect; {0*kl*}, imperfect. *Tenacity:* Very brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 8.26

Optical Properties: Transparent. *Color:* Greenish yellow, white to light gray; greenish yellow in transmitted light. *Streak:* Pale greenish yellow. *Luster:* Silky.
Optical Class: Biaxial (–). *Pleochroism:* Weak; in greenish yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, strong. $\alpha = 2.52$ $\beta = 2.61$ $\gamma = 2.67$ 2V(meas.) = Large.

Cell Data: *Space Group:* $Pna2_1$ (synthetic). $a = 5.4822(3)$ $b = 16.1986(8)$ $c = 5.5091(3)$ Z = 4

X-ray Powder Pattern: Daniel mine, Schneeberg, Germany.
3.131 (10), 1.647 (9), 1.918 (8), 1.628 (7), 2.733 (6), 1.936 (6), 1.570 (6)

Chemistry:

	(1)	(2)	(3)
Bi_2O_3	77.1	74.96	76.40
MoO_3	22.4	25.04	23.60
H_2O	0.2		
Total	[99.7]	[100.00]	100.00

(1) Daniel mine, Schneeberg, Germany; average of three partial analyses, after deduction of quartz; corresponds to $Bi_{2.06}Mo_{0.97}[O_{5.99}(OH)_{0.01}]_{\Sigma=6.00}$. (2) Torgovsk mine, Russia; recalculated to 100% after removal of ∼25% bismuthinite, wulfenite, and quartz; corresponds then to $Bi_{1.92}Mo_{1.04}O_6$. (3) Bi_2MoO_6.

Occurrence: As a rare alteration product in the oxidation zone of Bi–Mo deposits.

Association: Bismuth, skutterudite, quartz (Daniel mine, Schneeberg, Germany); molybdenite, bismuthinite, aikinite, bismite, wulfenite, quartz (Torgovsk mine, Russia).

Distribution: In the Daniel mine, Schneeberg, Saxony, and the Clara mine, near Oberwolfach, Black Forest, Germany. From Cínovec (Zinnwald), Czech Republic. At the Sa Duchessa mine, Oridda district, Sardinia, Italy. From the Kerrouchene tungsten mine, Middle Atlas Mountains, Morocco. At the Torgovsk Bi–Mo–W mine, Polar Ural Mountains, Russia. In the USA, at the Outlaw mine, Mariposa Canyon, Round Mountain district, Nye Co., Nevada, and from the Climax mine, Lake Co., Colorado. In Australia, at the Dunallan mine, Coolgardie, and near Poona, Western Australia; and at Bygoo and Elsmore, New South Wales. At the Ebisu mine, Gifu Prefecture, and the Kamo mine, Okayama Prefecture, Japan. From Chilu, Fujian Province, China. Several other minor localities are known.

Name: Honors Rudolf Ignatz Koechlin (1862–1939), Austrian mineralogist and Curator of the Vienna Natural History Museum, Vienna, Austria.

Type Material: Harvard University, Cambridge, Massachusetts, 64801; National Museum of Natural History, Washington, D.C., USA, R6411, 93646.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1092–1093. (2) Frondel, C. (1943) New data on agricolite, koechlinite, and the bismuth arsenates. Amer. Mineral., 28, 536–540. (3) Yushkin, N.P. (1969) The first find of koechlinite in the USSR. Doklady Acad. Nauk SSSR, 189, 852–855 (in Russian). (4) Teller, R.G., J.F. Brazdil, R.K. Grasselli, and J.D. Jorgensen (1984) The structure of γ-bismuth molybdate, Bi_2MoO_6, by powder neutron diffraction. Acta Cryst., C40, 2001–2005.

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Koenenite $Na_4Mg_9Al_4Cl_{12}(OH)_{22}$

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Crystal Data: Hexagonal; a mixed-layer structure. *Point Group:* $\overline{3}$ $2/m$. In crusts of acute scalenohedra and rhombohedra; as rosettes of tablets; as fibrous inclusions in other salts.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Flexible, in thin foliae. Hardness = 1.5–2 D(meas.) = 1.82–2.08, 1.97–1.98 after leaching in cold H_2O. D(calc.) = [1.82] Partially leached by cold H_2O, decomposed by hot H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless, pale yellow to deep red due to inclusions; reddish brown to colorless in thin section. *Luster:* Pearly on cleavage surfaces. *Optical Class:* Uniaxial (+); may be anomalously biaxial. *Pleochroism:* O = red-brown; E = colorless. $\omega = 1.52$ $\epsilon = 1.55$ 2V(meas.) = $< 10°$

Cell Data: *Space Group:* $R\overline{3}m$ $[Na_4(Ca,Mg)_2Cl_{12}]^{4-}$ with $a = 4.072(2)$ $c = 32.64(0.015)$ and *Space Group:* $P\overline{3}m1$ $[Mg_7Al_4(OH)_{22}]^{4+}$ with $a = 3.052(2)$ $c = 10.88(0.005)$ Z = [1]

X-ray Powder Pattern: Siegfried-Giesen mine, Lower Saxony, Germany; after partial leaching in cold H_2O.
11.7 (vs), 10.7 (vs), 1.924 (vs), 1.522 (vs), 5.45 (s), 3.68 (s), 3.34 (s)

Chemistry:

	(1)	(2)	(3)
SiO_2		0.63	
Al_2O_3	18.25	23.98	16.74
Fe_2O_3		0.96	
MnO		0.17	
MgO	23.44	32.49	29.78
CaO		0.18	
$MgCl_2$	36.85		
Na_2O			10.17
Cl		15.52	34.92
H_2O	21.46	25.30	16.27
$-O = Cl_2$		[3.50]	7.88
Total	[100.00]	[95.73]	100.00

(1) Justus I mine, Germany; recalculated to 100% after removal of alkali chlorides.
(2) Jiangcheng, China; after partial leaching in H_2O, leading to $Mg_7Al_4Cl_4(OH)_{22} \cdot H_2O$.
(3) $Na_4Mg_9Al_4Cl_{12}(OH)_{22}$.

Occurrence: In marine evaporite deposits.

Association: Hematite, carnallite, sylvite, halite, kieserite, anhydrite.

Distribution: At the Justus I, Glückauf-Sarstedt, Wathlingen, and other mines in the Zechstein potash beds, Lower Saxony, and at Stassfurt, 34 km south of Magdeburg, Saxony-Anhalt, Germany. From Pilluana, on the Big Huallaga River, about 25 km south of Tarapoto, Peru. In drill cores from the Prairie Evaporite Formation, Saskatchewan, Canada. At Jiangcheng, Yunnan Province, China.

Name: Honors Adolph von Koenen (1837–1915), German geologist of Göttingen, Germany, who discovered the first specimens.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 86–87. (2) Kühn, R. (1951) Zur Kenntnis des Koenenits. Neues Jahrb. Mineral., Monatsh., 1–16 (in German). (3) Richardson, C.B. (1957) Koenenite from Peru. Mineral Explorer, 1(3), 1. (4) Allmann, R., H.-H. Lohse, and E. Hellner (1968) Die Kristallstruktur des Koenenits, eine Doppelschichtstruktur mit zwei inkommensurablen Teilgittern. Zeits. Krist., 126, 7–22 (in German with English abs.). (5) Jinding Liu and Qun Liu (1984) Koenenite from Jiangcheng, Yunnan, China. Yanshi Kuangwu Ji Ceshi, 3(2), 131–137 (in Chinese). (6) (1985) Chem. Abs., 102, 177 (abs. ref. 5).

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Kogarkoite $Na_3(SO_4)F$

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Crystal Data: Monoclinic, pseudorhombohedral. *Point Group:* $2/m$. As tabular to pseudorhombohedral crystals, to 2 cm, and in grains and earthy aggregates. *Twinning:* Common, by rotation about [102] (pseudohexagonal [0001]), giving intergrown and contact trillings.

Physical Properties: Hardness = 3.5 D(meas.) = 2.66(6) D(calc.) = 2.679 Slowly soluble in H_2O; fluoresces cream to pale blue under SW UV and green under LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, pale sky-blue, pale pink, lilac. *Streak:* White. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+), nearly uniaxial (+). *Pleochroism:* Slight. $\omega = 1.435$ $\epsilon = 1.439$ $\alpha = 1.439(1)$ $\beta = 1.439(1)$ $\gamma = 1.442(1)$ 2V(meas.) = 0° to very small.

Cell Data: *Space Group:* $P2_1/m$ (synthetic). $a = 18.079(2)$ $b = 6.958(1)$ $c = 11.443(2)$ $\beta = 107.71°$ Z = 12

X-ray Powder Pattern: Synthetic.
3.48 (100), 2.991 (85), 2.718 (85), 2.705 (85), 2.1419 (85), 3.80 (70), 2.564 (70)

Chemistry:

	(1)	(2)
SO_3	43.41	43.51
Na_2O	50.1	50.52
K_2O	0.07	
F	10.10	10.32
Cl	0.02	
$-O = (F, Cl)_2$	4.26	4.35
Total	99.44	100.00

(1) Mt. Alluaiv, Kola Peninsula, Russia; here recalculated to oxides. (2) $Na_3(SO_4)F$.

Occurrence: A sublimate from steam around a hot spring (Hortense Hot Spring, Colorado, USA); in nepheline syenite pegmatite veins in a differentiated alkalic massif (Mt. Alluaiv, Kola Peninsula, Russia); in sodalite–syenite xenoliths associated with an intrusive alkalic gabbro–syenite complex (Mont Saint-Hilaire, Canada).

Association: Burkeite, trona, halite, fluorite, calcite, phillipsite (Hortense Hot Spring, Colorado, USA); villiaumite, thermonatrite, sidorenkite, nepheline, feldspar, aegirine, lorenzenite, apatite, lamprophyllite (Mt. Alluaiv, Kola Peninsula, Russia).

Distribution: In the USA, from Hortense Hot Spring and at Wright's Well, Chalk Creek, west of Buena Vista, Chaffee Co., Colorado; from Point of Rocks, Colfax Co., New Mexico. At Mont Saint-Hilaire, Quebec, Canada. On Mts. Alluaiv and Kedykverpakhk, Lovozero massif, Kola Peninsula, Russia. From Lake Magadi, Kenya. At Lake Natron, Tanzania.

Name: Honoring Liya Nikolaevna Kogarko (1936–), Russian geochemist and petrologist, investigator of alkaline rocks.

Type Material: National Museum of Natural History, Washington, D.C., USA, 127420, 128029, 128030.

References: (1) Pabst, A. and W.N. Sharp (1973) Kogarkoite, a new natural phase in the system Na_2SO_4–NaF–NaCl. Amer. Mineral., 58, 116–127. (2) Fanfani, L., G. Giuseppetti, C. Tadini, and P.F. Zanazzi (1980) The crystal structure of kogarkoite, Na_3SO_4F. Mineral. Mag., 43, 753–759. (3) Kogarko, L.N. (1961) Chlorine-free schairerite from the nepheline syenites of the Lovozero massif (Kola Peninsula). Doklady Acad. Nauk SSSR, 139, 839–841. (4) Khomyakov, A.P. (1995) Mineralogy of hyperagpaitic alkaline rocks. Clarendon Press, Oxford, 168–169.

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Kokchetavite $KAlSi_3O_8$

Crystal Data: Hexagonal. *Point Group*: n.d. Crystals platy or prismatic, to 7 μm, with well developed (0001) steps and $(10\bar{1}\ 0)$ planes.

Physical Properties: *Cleavage:* n.d. *Tenacity:* n.d. *Fracture:* n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 2.45

Optical Properties: n.d. *Color:* n.d. *Streak:* n.d. *Luster:* n.d.
Optical Class: Biaxial (n.d.).

Cell Data: Space Group: n.d. a =5.27(1) c = 7.82(1) Z = 1

X-ray Powder Pattern: Kokchetav Massif, northern Kazakhstan. (selective area diffraction pattern) 7.82(001), 4.56(100), 3.93(101), 2.98(102), 2.63(110), 2.51(111), 2.26(103), 1.80(104), 1.72(210), 1.68(211)

Chemistry:

	(1)
SiO_2	64.6
Al_2O_3	18.0
K_2O	15.5
Na_2O	< 0.3
Total	100.1

(1) Kokchetav Massif, northern Kazakhstan; average of several EDS analyses, Raman spectroscopic analysis similar to sanidine, IR spectroscopy confirms absence of OH^- and H_2O; stated to be close to $KAlSi_3O_8$.

Polymorphism & Series: A metastable polymorph of orthoclase, microcline and sanidine.

Mineral Group: Feldspar group.

Occurrence: As inclusions in clinopyroxene and garnet within ultrahigh-grade granitic and biotite gneiss (estimated 900-1000^o C and 5.8-6.5 GPa).

Association: Diopside, grossular-rich garnet, phengite mica, potassium feldspar, pyrrhotite, cristobalite, quartz, titanite, zircon, talc.

Distribution: From Kumdy-Kol, Kokchetav Massif, northern Kazakhstan.

Name: For the locality of the first specimens, the Kokchetav Massif.

Type Material: National Museum of Natural Science, Taichung, (Taiwan) Republic of China (NMNS004438-P010220).

References: (1) Hwang, S.-L., P. Shen, H.-T. Chu,T.-F. Yui, J.G. Liou, N.V. Sobolev, R.-U. Zhang, V.S. Shatsky, and A.A. Zayachkovsky (2004) Kokchetavite: a new potassium-feldspar polymorph from the Kokchetav ultrahigh-pressure terrain. Contrib. Mineral. Petrol., 148, 380-389. (2) (2005) Amer. Mineral., 90, 1228-1229 (abs. ref. 1). (3) Hwang, S.-L., T.-F. Yui, H.-T. Chu, P. Shen, J.G. Liou, and N.V. Sobolev (2013) Oriented kokchetavite compound rods in clinopyroxene of Kokchetav ultrahigh-pressure rocks. Journal of Asian Earth Sciences, 63, 56–69.

Kokinosite $Na_2Ca_2(V_{10}O_{28})\cdot 24H_2O$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As tablets or blades with stepped faces, to 1 mm, also as irregularly stepped crystal masses to several millimeters.

Physical Properties: *Cleavage*: Good on {$01\bar{1}$}. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = ~1.5 D(meas.) = n.d. D(calc.) = 2.35

Optical Properties: Translucent. *Color*: Yellow-orange, sometimes with an orange-brown tint. *Streak*: Yellow. *Luster*: Subadamantine.
Optical Class: Biaxial (-). α = 1.725(3) β = 1.770(5) γ = 1.785(3) 2V(meas.) = 56.6(3)° 2V(calc.) = 58.7° *Orientation*: $X \wedge a = 15°$, $Y \approx b$. *Pleochroism*: $X = Z$ = orange-yellow, Y = orange. *Absorption*: $X = Z < Y$. *Dispersion*: Moderate, $r < v$.

Cell Data: *Space Group*: $P\bar{1}$. a = 8.74899(19) b = 10.9746(3) c = 12.8216(9) α = 114.492(8)° β = 105.093(7)° γ = 91.111(6)° Z = 1

X-ray Powder Pattern: St. Jude mine, Slick Rock district, San Miguel County, Colorado, USA. 9.88 (100), 7.92 (35), 8.42 (33), 6.01 (31), 11.24 (30), 2.814 (28), 1.9613 (26)

Chemistry:

	(1)	(2)	(3)
Na_2O	4.64	3.85	4.09
K_2O	0.04	0.03	
CaO	8.08	6.70	7.40
SrO	1.01	0.84	
V_2O_5	72.43	60.06	59.99
H_2O	n.d.	28.52	28.52
Total	86.20	100.00	100.00

(1) St. Jude mine, San Miguel County, Colorado, USA; average of 10 electron microprobe analyses, loss of H_2O during analysis. (2) Analysis (1) with H_2O calculated from stoichiometry and analytical results normalized; corresponding to $(Na_{1.88}K_{0.01})_{\Sigma=1.89}(Ca_{1.81}Sr_{0.12})_{\Sigma=1.93}(V_{10}O_{28})\cdot 24H_2O$.
(3) $Na_2Ca_2(V_{10}O_{28})\cdot 24H_2O$.

Occurrence: In a moist part of the oxidation zone of a corvusite-montroseite-bearing sandstone.

Association: Gypsum, huemulite, metarossite, pascoite, rossite, wernerbaurite.

Distribution: From the St. Jude mine, Gypsum Valley, Slick Rock district, San Miguel County, Colorado, USA.

Name: Honors Michael (Mike) Kokinos (b. 1927) of Shingle Springs, California, USA., member of the Micromounters' Hall of Fame, and for his role as a mentor in the collecting community.

Type Material: The Natural History Museum of Los Angeles County, Los Angeles, California, USA (# 64004, 64074, 64075, 64076, 64077, 64078).

References: (1) Kampf, A.R., J.M. Hughes, B. Nash, and J. Marty (2014) Kokinosite $Na_2Ca_2(V_{10}O_{28})\cdot 24H_2O$, a new decavanadate mineral species from the St. Jude mine, Colorado: crystal structure and descriptive mineralogy. Can. Mineral., 52, 15-25. (2) (2014) Amer. Mineral., 99, 2440-2441 (abs. ref. 1).

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As equant to prismatic crystals, typically skeletal, to 70 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~ 4.5 VHN = 272-458 (20 g load). D(meas.) = n.d. D(calc.) = 3.39

Optical Properties: Translucent. *Color*: Yellowish brown to reddish brown, light gray with yellow-brown to red internal reflections in reflected light. *Streak*: Yellowish brown.
Luster: Adamantine. *Anisotropism:* Weak.
Optical Class: n.d.
R_1-R_2: (470) 15.3-16.8, (546) 14.1-15.9, (589) 13.8-15.3, (650) 13.4-14.8

Cell Data: *Space Group*: $P\bar{1}$. a = 8.1758(7) b = 9.8292(9) c = 6.6940(6)
α = 105.041(8)° β = 102.040(8)° γ = 106.025(8)° Z = 1

X-ray Powder Pattern: Bezymyannyi volcano, Russia.
3.17 (100), 3.09 (94), 3.75 (44), 7.47 (28), 2.039 (28), 3.26 (27), 2.802 (25)

Chemistry:

	(1)	(2)
Na_2O	0.76	
K_2O	0.05	
MgO	9.43	8.05
CaO	3.57	5.60
MnO	0.46	
NiO	0.11	
Al_2O_3	3.04	
Fe_2O_3	23.88	31.88
TiO_2	2.42	
SiO_2	0.20	
P_2O_5	0.98	
V_2O_5	53.86	54.47
Total	98.76	100.00

(1) Bezymyannyi volcano, Russia; average of 3 electron microprobe analyses; corresponding to $Na_{0.24}K_{0.01}Ca_{0.63}Mg_{2.30}Mn_{0.06}Ni_{0.01}Al_{0.59}Fe^{3+}_{2.94}Ti_{0.30}Si_{0.03}P_{0.14}V_{5.83}O_{24}$. (2) $CaMg_2Fe^{3+}_4(VO_4)_6$.

Mineral Group: Howardevansite group.

Occurrence: A sublimate from fumarolic gas deposited on andesitic scoria.

Association: Bannermanite, biotite, quartz, (Ti,V)-rich magnetite.

Distribution: From the Bezymyannyi volcano, Kamchatka Peninsula, Russia.

Name: Honors Professor Nikolay Ivanovich Koksharov (1818-1892), Academician of the Russian Academy of Sciences and former Director of the Russian Mineralogical Society, for his contributions to the mineralogical sciences.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 94125).

References: (1) Pekov I.V., N.V. Zubkova, V.O. Yapaskurt, P.M. Kartashov, Y.S. Polekhovsky, M.N. Murashko, and D.Y. Pushcharovsky (2014) Koksharovite, $CaMg_2Fe_4^{3+}(VO_4)_6$, and grigorievite, $Cu_3Fe_2^{3+}Al_2(VO_4)_6$, two new howardevansite-group minerals from volcanic exhalations. European Journal of Mineralogy, 26(5), 667-677. (2) (2015) Amer. Mineral., 100, 660-661 (abs. ref. 1).

Koktaite $(NH_4)_2Ca(SO_4)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are acicular to lamellar, fibrous, showing {100}, {110}, {001}, {011}, {101}, as very fine-grained aggregates. *Twinning:* Common on {100}.

Physical Properties: Hardness = n.d. D(meas.) = 2.09 D(calc.) = 2.114 Soluble in H_2O, leaving a residue of gypsum.

Optical Properties: Semitransparent. *Color:* Colorless to white.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z' \wedge c$ (on {110}) = 2°. $\alpha = 1.524$ $\beta = 1.532$ $\gamma = 1.536$ 2V(meas.) = 72°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.17$ $b = 7.15$ $c = 6.34$ $\beta = 102.75°$ Z = 2

X-ray Powder Pattern: Žeravice, Czech Republic. (ICDD 11-475).
9.83 (100), 3.30 (65), 4.96 (40), 5.83 (25), 3.00 (25), 3.56 (20), 2.89 (20)

Chemistry: (1) Optical data and X-ray pattern are found to be identical with synthetic $(NH_4)_2Ca(SO_4)_2 \cdot H_2O$.

Occurrence: On waste piles of a lignite mine.

Association: Gypsum, mascagnite, tschermigite.

Distribution: From Žeravice, near Kyjov, Czech Republic.

Name: To honor Jaroslav Kokta (1904–1970), Czech chemist who analyzed the synthetic compound.

Type Material: Moravian Museum, Brno, Czech Republic, A6109; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 137963.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 444.

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Kolarite $PbTeCl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. As flamelike aggregates and veinlets, to 20 μm across, in rims and intergrowths with other tellurides and sulfides.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 9.14

Optical Properties: Opaque. *Color:* Gray in reflected light.
Optical Class: Biaxial.
R_1–R_2: (400) 25.0–26.1, (420) 25.3–26.2, (440) 25.6–26.5, (460) 25.9–27.0, (480) 26.5–27.5, (500) 27.0–27.9, (520) 27.4–28.3, (540) 27.7–28.6, (560) 28.1–29.0, (580) 28.3–29.2, (600) 28.5–29.4, (620) 28.6–29.6, (640) 28.6–29.6, (660) 28.6–29.5, (680) 28.6–29.5, (700) 28.6–29.5

Cell Data: *Space Group:* $Pmmm$, $Pmm2$, or $P222$. $a = 5.93(5)$ $b = 3.25(5)$ $c = 3.89(5)$
Z = 1

X-ray Powder Pattern: Champion Reef mine, India; by electron diffraction.
3.27 (100), 2.35 (50), 3.91 (40), 2.00 (40), 1.86 (30), 1.79 (30), 1.50 (30)

Chemistry:

	(1)	(2)
Pb	50.05	51.07
Te	32.87	31.45
S	0.00	
Cl	16.88	17.48
Total	[99.80]	100.00

(1) Champion Reef mine, India; by electron microprobe, original total given as 99.60%; leading to $Pb_{1.00}Te_{1.06}Cl_{1.94}$. (2) $PbTeCl_2$.

Occurrence: Of primary origin, in a hydrothermal gold-quartz vein containing sulfides and selenides.

Association: Galena, altaite, cotunnite, radhakrishnaite, volynskite, hessite, pyrrhotite, chalcopyrite, ullmannite, hawleyite, cadmian tetrahedrite, cadmian sphalerite.

Distribution: From the Champion Reef mine, Kolar Gold Fields, Karnataka, India.

Name: For its occurrence in the Kolar deposit, India.

Type Material: Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Genkin, A.D., Y.G. Safonov, V.N. Vasudev, B. Krishna Rao, V.A. Boronikhin, L.N. Vyalsov, A.I. Gorshkov, and A.V. Mokhov (1985) Kolarite $PbTeCl_2$ and radhakrishnaite $PbTe_3(Cl,S)_2$, new mineral species from the Kolar gold deposit, India. Can. Mineral., 23, 501–506. (2) (1986) Amer. Mineral., 71, 1545 (abs. ref. 1).

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Kolbeckite $ScPO_4 \cdot 2H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are typically short prismatic along [001], with prominent {110}, {011}, smaller {010}, {001}, {101}, {130}, to 4 mm; less commonly as platy crystals in radiating aggregates. *Twinning:* On {100}, common; may exhibit diagonal sutures on {001}.

Physical Properties: *Cleavage:* On {010}, distinct; on {100} and {001}, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–5 D(meas.) = 2.36 D(calc.) = 2.35

Optical Properties: Transparent. *Color:* Colorless, pale yellow; Cyan-blue, blue-gray, apple-green when impure. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). *Pleochroism:* Strong in colored material. *Orientation:* $Y = b$; $X \simeq c$; $Z \simeq a$. *Dispersion:* $r > v$, very weak. $\alpha = 1.572$–1.575 (α') $\beta = 1.590$ $\gamma = 1.598$–1.601 (γ') 2V(meas.) = 60(10)°

Cell Data: *Space Group:* $P2_1/n$. $a = 5.42$–5.45 $b = 10.08$–10.26 $c = 8.88$–8.93 $\beta = 90°40'$–$90°51'$ Z = 4

X-ray Powder Pattern: Schlarbaum quarry, Austria. (ICDD 38–431).
4.78 (100), 4.44 (100), 2.878 (70), 2.614 (60), 2.849 (50), 3.708 (40), 5.1 (30)

Chemistry:

	(1)	(2)	(3)
P_2O_5	40.10	40.5	40.33
V_2O_5		0.01	
SiO_2		0.05	
Al_2O_3		0.4	
Sc_2O_3	39.07	41.3	39.19
Fe_2O_3		0.03	
H_2O	20.36	[17.7]	20.48
Total	99.53	[100.0]	100.00

(1) Fairfield, Utah, USA; Sc_2O_3 originally reported as Al_2O_3, later confirmed as Sc by X-ray fluorescence. (2) Do.; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponds to $(Sc_{1.05}Al_{0.01})_{\Sigma=1.06}P_{1.00}O_4[(H_2O)_{1.62}(OH)_{0.18}]_{\Sigma=1.80}$. (3) $ScPO_4 \cdot 2H_2O$.

Occurrence: A very rare secondary mineral in some hydrothermal metallic veins and phosphate deposits.

Association: Chlorite, quartz (Sadisdorf mine, Germany); miargyrite, diaphorite (Baia Sprie, Romania); wardite, crandallite, variscite (Fairfield, Utah, USA); mahlmoodite (Wilson Springs mine, Arkansas, USA); lithiophorite, vernadite, gypsum (Putty Beach, Australia).

Distribution: In Germany, at the Sadisdorf copper mine, near Schmiedeberg, Saxony. From Baia Sprie (Felsőbánya), Romania. In the Schlarbaum quarry, near Gleichenberg, Styria, Austria. In the USA, from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah; in Arkansas, in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., and as large crystals from the Christy Pit, Magnet Cove, Hot Spring Co.; at the Flambeau mine, southwest of Ladysmith, Rusk Co., Wisconsin. From Sakpur, Kathiawar Peninsula, Gujarat, India. At the Tigrinoye deposit, Sikhote-Alin Range, Primorskiy Kray, Russia. On Putty Beach, near Woy Woy, New South Wales, Australia.

Name: To honor Dr. Friedrich Ludwig Wilhelm Kolbeck (1860–1943), German mineralogist, Mining Academy, Freiberg, Germany.

Type Material: Mining Academy, Freiberg, Germany, 50268; National Museum of Natural History, Washington, D.C., USA, 10632.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1015–1016; 965–966 [sterrettite = kolbeckite]. (2) Mrose, M.E. and B. Wappner (1959) New data on the hydrated scandium phosphate minerals: sterrettite, "eggonite", and kolbeckite. Bull. Geol. Soc. Amer., 70, 1648–1649 (abs.). (3) Hey, M.H., C. Milton, and E.J. Dwornik (1982) Eggonite (kolbeckite, sterrettite), $ScPO_4 \cdot 2H_2O$. Mineral. Mag., 46, 493–497.

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Kolfanite $Ca_2Fe_3^{3+}O_2(AsO_4)_3 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As flattened crystals, compact radiating in nodules, to 1.5 mm, and in incrustations.

Physical Properties: *Cleavage:* One, parallel to flattening. *Tenacity:* Brittle. Hardness = n.d. VHN = 73 (100 g load). D(meas.) = 3.3 D(calc.) = 3.75

Optical Properties: Semitransparent. *Color:* Red; orange to yellow in transmitted light. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; $Y = Z$ = dark orange. $\alpha = 1.810$ $\beta = 1.923$ $\gamma = 1.933$ 2V(meas.) = 5°–7°

Cell Data: *Space Group:* n.d. $a = 17.86(4)$ $b = 19.66(5)$ $c = 11.11(3)$ $\beta = 96°$ Z = 12

X-ray Powder Pattern: Mt. Vasin-Myl'k, Russia.
8.90 (10), 2.72 (10), 3.29 (9), 2.95 (9), 2.216 (8), 1.646 (8), 5.64 (5)

Chemistry:

	(1)	(2)
P_2O_5	0.96	
As_2O_5	43.30	47.07
Sb_2O_5	2.20	
SiO_2	1.20	
Al_2O_3	0.05	
Fe_2O_3	32.09	32.70
CaO	14.97	15.31
H_2O	5.10	4.92
Total	99.87	100.00

(1) Mt. Vasin-Myl'k, Russia; by electron microprobe, total Fe as Fe_2O_3, H_2O by TGA; corresponds to $Ca_{1.95}(Fe_{2.93}Al_{0.01})_{\Sigma=2.94}(As_{2.74}Si_{0.14}P_{0.10}Sb_{0.10})_{\Sigma=3.08}O_{14} \cdot 2.06H_2O$.
(2) $Ca_2Fe_3O_2(AsO_4)_3 \cdot 2H_2O$.

Occurrence: An alteration product of holtite in a hydrothermally altered granite pegmatite.

Association: Mitridatite, arseniosiderite, laueite, apatite, montebrasite.

Distribution: From Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia.

Name: An abbreviation for the Russian KOL'skii Filial Akademii Nauk SSSR [Kola Branch of the Academy of Sciences of the USSR].

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5537; Mining Institute, St. Petersburg, 1654/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82769.

References: (1) Voloshin, A.V., Y.P. Men'shikov, L.I. Polezhaeva, and A.A. Lentsi (1982) Kolfanite, a new mineral from granite pegmatite, Kola Peninsula. Mineral. Zhurnal, 4(2), 90–95 (in Russian with English abs.). (2) (1983) Amer. Mineral., 68, 280 (abs. ref. 1). (3) (1982) Mineral. Abs., 33, 431 (abs. ref. 1).

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Kolicite $Mn_7^{2+}Zn_4(AsO_4)_2(SiO_4)_2(OH)_8$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 0.5 mm, of pinacoidal habit, predominantly tabular; as fractured grains.

Physical Properties: *Fracture:* Even. *Tenacity:* Brittle. Hardness = ∼4.5
D(meas.) = 4.17(2) D(calc.) = 4.20

Optical Properties: Semitransparent. *Color:* Bright yellowish orange. *Streak:* Light orange. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless or pale yellow; Y = yellowish orange; Z = light yellow. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, strong. *Absorption:* $Z = Y > X$. $\alpha = 1.779(2)$ $\beta = 1.786(2)$ $\gamma = 1.790(2)$ 2V(meas.) = 78(2)°
2V(calc.) = 74°

Cell Data: *Space Group: Cmca.* $a = 18.59(3)$ $b = 8.789(5)$ $c = 12.04(1)$ Z = 4

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
2.970 (100), 1.540 (70), 3.58 (60), 2.608 (50), 2.815 (40), 2.479 (40), 2.342 (40)

Chemistry:

	(1)
SiO_2	10.4
As_2O_5	18.9
FeO	0.4
MnO	39.2
ZnO	26.0
MgO	0.8
H_2O	5.5
Total	101.2

(1) Sterling Hill, New Jersey, USA; by electron microprobe, H_2O by TGA; corresponds to $(Mn_{6.70}Mg_{0.24}Fe_{0.06})_{\Sigma=7.00}Zn_{3.87}(AsO_4)_2(Si_{1.05}O_4)_2(OH)_8$.

Occurrence: Incrusting willemite-franklinite ore from metamorphosed stratiform zinc orebodies.

Association: Willemite, franklinite, sonolite, friedelite, holdenite, calcite.

Distribution: At Sterling Hill, Ogdensburg, and at Franklin, Sussex Co., New Jersey, USA.

Name: For John Kolic, of Rockaway, New Jersey, USA, who first discovered the mineral.

Type Material: Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 143765.

References: (1) Dunn, P.J., D.R. Peacor, and B.D. Sturman (1979) Kolicite, a new manganese zinc silicate arsenate from Sterling Hill, Ogdensburg, New Jersey. Amer. Mineral., 64, 708–712.
(2) Peacor, D.R. (1980) The crystal structure of kolicite, $Mn_7(OH)_4[As_2Zn_4Si_2O_{16}(OH)_4]$. Amer. Mineral., 65, 483–487.

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Kolovratite $Ni_xZn_y(VO_4)_z \cdot nH_2O$

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Crystal Data: n.d. *Point Group:* n.d. As fibrous and felted aggregates, in botryoidal crusts and thin incrustations.

Physical Properties: *Fracture:* Even to conchoidal. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = n.d. D(calc.) = n.d. Slightly radioactive.

Optical Properties: Semitransparent. *Color:* Citrine-yellow, greenish yellow. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: n.d. ; low birefringence. *Orientation:* Parallel extinction. $n = 1.577(5)$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kara-Chagyr, Kyrgyzstan.
11.6 (s), 5.83 (s), 3.88(s), 2.62 (mw), 2.57 (mw), 2.39 (mwb), 1.52 (mw)

Chemistry:

	(1)	(2)
V_2O_5	12.	29.1 – 31.5
NiO	12.	9.1 – 10.7
CuO		0.5 – 0.8
ZnO	15.	4.9 – 7.0

(1) Kara-Chagyr, Kyrgyzstan; partial analysis, H_2O present in a closed tube test. (2) Agalyk U–V deposit, Uzbekistan; by electron microprobe, partial analysis.

Occurrence: In quartz schists and carbonaceous slates.

Association: n.d.

Distribution: In Kyrgyzstan, from Kara-Chagyr, near the Tyuya-Muyun Cave, Alai Mountains, and over a broad area in the Fergana Valley, as at Iski-Naukat, Charku, and at Uch-Kurgan. At the Agalyk U–V deposit, Kara-Tyube Mountains, 15 km south of Samarkand, Uzbekistan.

Name: In honor of Lev Stanislovich Kolovrat-Chervinskii (1884–1921), Russian physicist and radiologist, Mineralogical Laboratory, Russian Academy of Science, St. Petersburg, Russia, who studied the Tyuya-Muyun uranium deposit, Kyrgyzstan.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1048–1049. (2) Jambor, J.L. and G.R. Lachance (1962) On kolovratite. Can. Mineral., 7, 311–314. (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 116.

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Kolwezite $(Cu,Co)_2(CO_3)(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. In spherical aggregates, to 1 cm, and microcrystalline crusts.

Physical Properties: Hardness = ∼4 D(meas.) = 3.97(1) D(calc.) = 3.94

Optical Properties: Semitransparent. *Color:* Blackish brown to pale beige, greenish.
Streak: Beige.
Optical Class: Biaxial. $\alpha = 1.688(2)$ β = n.d. $\gamma = 1.90$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.50$ $b = 12.15$ $c = 3.189$ $\alpha = 93.32°$ $\beta = 90.74°$ $\gamma = 91.47°$ Z = 4

X-ray Powder Pattern: Musonoi mine, Congo.
3.69 (100), 6.08 (80), 5.08 (80), 2.599 (70), 3.02 (40), 2.958 (40), 2.531 (40)

Chemistry:

	(1)
CO_2	19.44
CoO	22.98
CuO	48.40
H_2O	8.78
Total	99.60

(1) Musonoi mine, Congo; by X-ray fluorescence, CO_2 by gas evolution, CO_2 + H_2O by TGA; corresponding to $(Cu_{1.33}Co_{0.67})_{\Sigma=2.00}(CO_3)_{0.98}(OH)_{2.07}$.

Mineral Group: Rosasite group.

Occurrence: An uncommon secondary mineral in the oxidation zone of some Cu–Co hydrothermal ore deposits.

Association: Cobaltian malachite, cobaltian dolomite, heterogenite.

Distribution: From the Musonoi and Kamoto Cu–Co mines, near Kolwezi, and the Mupine, and Mashamba West mines, Katanga Province, Congo (Shaba Province, Zaire).

Name: For its occurrence at Kolwezi, Congo.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG12975; National Museum of Natural History, Washington, D.C., USA, R17228.

References: (1) Deliens, M. and P. Piret (1980) La kolwézite, un hydroxycarbonate de cuivre et de cobalt analogue à la glaukosphaerite et à la rosasite. Bull. Minéral., 103, 179–184 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 1067 (abs. ref. 1).

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$, $\bar{4}3m$, or 432. Intergrown with copper aggregates, with individual crystals of cubo-octahedral form, less than 5 μm in size.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 220–267, 247 average (20 g load). D(meas.) = 13.0 D(calc.) = 13.1

Optical Properties: Opaque. *Color:* Tin-white on fresh fracture, quickly altering in moist air to brownish black. *Luster:* Metallic.
R: (400) — , (420) 59.0, (440) 61.4, (460) 63.8, (480) 66.8, (500) 69.4, (520) 71.2, (540) 72.1, (560) 72.8, (580) 73.6, (600) 74.0, (620) 74.6, (640) 75.3, (660) 76.0, (680) 76.9, (700) 77.8

Cell Data: *Space Group:* $Im3m$, $I432$, or $I\bar{4}3m$. Synthetic material is $I\bar{4}3m$. $a = 9.418(4)$ Z = 4

X-ray Powder Pattern: Magadan region, USSR.
2.22 (100), 2.52 (42), 2.98 (25), 2.09 (25), 2.01 (25), 1.279 (25b), 1.524 (18b)

Chemistry:

	(1)	(2)
Cu	26.6	26.98
Hg	72.6	73.02
Total	99.2	100.00

(1) Magadan region, USSR; by electron microprobe, average of nine analyses, corresponding to $Cu_{6.97}Hg_{6.03}$. (2) Cu_7Hg_6.

Occurrence: Found in the heavy mineral fraction of concentrates (Magadan region, USSR).

Association: Copper, stibnite, berthierite, pyrite, arsenopyrite, quartz (Magadan region, USSR).

Distribution: At the Krokhalin antimony deposit, Magadan region, basin of the Kolyma River, Yakutia, USSR. At a prospect near Marcelita, about 70 km southeast of Copiapó, Chile.

Name: For the locality near the Kolyma River, USSR.

Type Material: Institute of Mineralogy and Geochemistry of Rare Elements; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, USSR.

References: (1) Markova, E.A., N.M. Chernitsova, Y.S. Borodaev, L.S. Dubakina, and O.E. Yushko-Zakharova (1980) The new mineral kolymite, Cu_7Hg_6. Zap. Vses. Mineral. Obshch., 109, 206–211 (in Russian). (2) (1981) Amer. Mineral., 66, 218 (abs. ref. 1).

Komarovite $(Ca,Mn)Nb_2(Si_2O_7)(O,F)_3 \cdot 3.5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Platy, foliated, massive.

Physical Properties: *Cleavage:* Fair on {001}. Hardness = 1.5–2 D(meas.) = 3.0 D(calc.) = 2.96

Optical Properties: Transparent to translucent. *Color:* Pale rose. *Streak:* White. *Luster:* Dull.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.750(2)$ $\beta = 1.766(2)$ $\gamma = 1.85(2)$ 2V(meas.) = 48°

Cell Data: *Space Group:* n.d. $a = 21.30(7)$ $b = 14.00(5)$ $c = 17.19(7)$ Z = 18

X-ray Powder Pattern: Mt. Karnasurt, Russia.
3.16 (100), 12.2 (70), 1.783 (45), 3.118 (42), 6.35 (35), 2.740 (35), 2.715 (35)

Chemistry:

	(1)
SiO_2	23.50
TiO_2	2.50
Al_2O_3	1.00
Fe_2O_3	1.50
Nb_2O_5	47.00
MnO	5.00
CaO	4.70
Na_2O	0.85
K_2O	0.30
F	1.21
H_2O	12.00
$-O = F_2$	0.51
Total	99.05

(1) Mt. Karnasurt, Russia; corresponding to $(Ca_{0.43}Mn_{0.36}Na_{0.14}K_{0.03})_{\Sigma=0.96}(Nb_{1.82}Ti_{0.16}Al_{0.10}Fe_{0.10})_{\Sigma=2.18}Si_2O_9(O_{0.88}F_{0.33})_{\Sigma=1.21} \cdot 3.5H_2O$.

Occurrence: With late albite and redeposited fine-grained natrolite in alkalic rocks in a differentiated alkalic massif.

Association: Natrolite, albite.

Distribution: On Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: For the Russian cosmonaut, Vladimir Mikhailovich Komarov (1927–1967).

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73302.

References: (1) Portnov, A.M., G.K. Krivokoneva, and T.I. Stolyarova (1971) Komarovite, a new niobosilicate of calcium and manganese. Zap. Vses. Mineral. Obshch., 100, 599–602 (in Russian). (2) (1972) Amer. Mineral., 57, 1315–1316 (abs. ref. 1).

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Kombatite $Pb_{14}O_9(VO_4)_2Cl_4$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Anhedral grains, to 0.2 mm.

Physical Properties: *Cleavage:* On {010}, perfect. *Tenacity:* Brittle. Hardness = [Very soft; 2–3] (by analogy to sahlinite). D(meas.) = > 4.3 D(calc.) = 7.979

Optical Properties: Semitransparent. *Color:* Bright yellow. *Streak:* Pale yellow.
Luster: Adamantine.
Optical Class: Biaxial (–). $n =$ > 1.90

Cell Data: *Space Group:* $C2/c$. $a = 12.682(2)$ $b = 22.566(2)$ $c = 11.279(2)$ $\beta = 118.11(1)^\circ$ Z = 4

X-ray Powder Pattern: Kombat mine, Namibia; pattern close to sahlinite.
3.006 (10), 2.958 (10), 2.812 (10), 2.253 (7), 1.756 (7), 1.590 (6), 1.989 (5)

Chemistry:

	(1)	(2)
V_2O_5	5.9	5.33
PbO	92.4	91.46
Cl	4.2	4.15
$-O = Cl_2$	0.9	0.94
Total	101.6	100.00

(1) Kombat mine, Namibia; by electron microprobe, corresponds to $Pb_{13.7}V_{2.10}O_{17.1}Cl_{3.9}$.
(2) $Pb_{14}O_9(VO_4)_2Cl_4$.

Occurrence: A rare component of layered manganese ores.

Association: Hematite, calcite, hausmannite, kentrolite, a mineral similar to harkerite.

Distribution: At the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia.

Name: For the Kombat mine, Namibia, in which it occurs.

Type Material: Canadian Geological Survey, Ottawa, Canada, 64563.

References: (1) Rouse, R.C., P.J. Dunn, and J. Innes (1986) Kombatite, the vanadium analogue of sahlinite, from the Kombat mine, South West Africa. Neues Jahrb. Mineral., Monatsh., 519–522. (2) (1988) Amer. Mineral., 73, 928 (abs. ref. 1). (3) Cooper, M. and F.C. Hawthorne (1994) The crystal structure of kombatite, $Pb_{14}(VO_4)_2O_9Cl_4$, a complex heteropolyhedral sheet mineral. Amer. Mineral., 79, 550–554.

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Komkovite $BaZrSi_3O_9 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* 32. As equant crystals terminated by trigonal pyramids, to 5 mm.

Physical Properties: *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 3.31(5) D(calc.) = 3.31 Light blue cathodoluminescence.

Optical Properties: Semitransparent. *Color:* Brown. *Streak:* Light brown. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.671(1)$ $\epsilon = 1.644(1)$

Cell Data: *Space Group: R*32. $a = 10.526(6)$ $c = 15.736(9)$ Z = 6

X-ray Powder Pattern: Vuoriyarvi complex, Russia.
5.23 (100), 2.96 (90), 3.59 (80), 3.02 (80), 2.57 (60), 2.106 (60)

Chemistry:

	(1)
SiO_2	34.44
ZrO_2	24.94
HfO_2	0.46
FeO	0.33
MnO	0.00
CaO	0.08
BaO	28.19
K_2O	0.13
H_2O	[11.43]
Total	[100.00]

(1) Vuoriyarvi complex, Russia; by electron microprobe, H_2O by difference (H_2O 10% to 11.5% by coulometric analysis); corresponds to $(Ba_{0.95}Fe_{0.02}Ca_{0.01}K_{0.01})_{\Sigma=0.99}(Zr_{1.04}Hf_{0.01})_{\Sigma=1.05}$ $Si_{2.95}O_9 \cdot 3.08H_2O$.

Occurrence: Apparently altering from catapleiite, in dolomitic veinlets cutting metasomatically altered pyroxenites, in a carbonatite.

Association: Dolomite, strontianite, phlogopite, barite, georgechaoite, pyrite.

Distribution: In the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia.

Name: To honor Russian mineralogist and crystallographer Aleksandr Ivanovich Komkov (1926–1987), Karpinskii All-Union Research Institute of Geology, St. Petersburg, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity; Mining Institute, St. Petersburg, 2037/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p462/1.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, Y.P. Men'shikov, Y.V. Sokolova, and Y.K. Yegorov-Tismenko (1990) Komkovite – a new hydrous barium zirconosilicate from the carbonatites of Vuoriyarvi (Kola Peninsula). Mineral. Zhurnal, 12(3), 69–73 (in Russian). (2) (1992) Amer. Mineral., 77, 207–208 (abs. ref. 1). (3) Sokolova, E.V., A.V. Araktscheeva, and A.V. Voloshin (1991) Crystal structure of komkovite. Doklady Acad. Nauk SSSR, 320, 1384–1388 (in Russian). (4) (1993) Amer. Mineral., 78, 454 (abs. ref. 3).

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Konderite $PbCu_3(Rh,Pt,Ir)_8S_{16}$

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Crystal Data: Hexagonal. *Point Group:* $6/m$, 6, $6/m$ $2/m$ $2/m$, 622, or $\overline{6}m2$. As inclusions in Pt–Fe alloy.

Physical Properties: *Cleavage:* In two directions, "average". *Tenacity:* Brittle. Hardness = n.d. VHN = 372–793, 592 average. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Steel-gray. *Luster:* Metallic.
R_1–R_2: (400) — , (420) 43.3–45.1, (440) 42.8–44.6, (460) 42.6–44.4, (480) 42.4–44.4, (500) 42.3–44.6, (520) 42.5–44.8, (540) 43.8–45.1, (560) 43.1–45.4, (580) 43.4–45.8, (600) 43.8–46.2, (620) 43.9–46.5, (640) 44.2–46.6, (660) 44.4–46.8, (680) 44.8–47.0, (700) 45.0–47.4

Cell Data: *Space Group:* $P6/m$, $P6$, $P6/mmm$, $P622$, or $P\overline{6}m2$. a = 7.024(20) c = 16.48(2) Z = n.d.

X-ray Powder Pattern: Konder massif, Russia.
2.98 (10), 1.763 (10), 2.459 (9), 2.85 (5), 1.715 (5), 1.291 (3), 5.10 (2)

Chemistry:

	(1)
Rh	14.2
Pt	25.2
Ir	19.2
Pb	9.53
Cu	8.25
Fe	0.28
Ni	0.38
S	23.7
Total	100.74

(1) Konder massif, Russia; by electron microprobe, average of 10 analyses; corresponding to $Pb_{1.00}(Cu_{2.81}Ni_{0.14}Fe_{0.11})_{\Sigma=3.06}(Rh_{2.99}Pt_{2.80}Ir_{2.16})_{\Sigma=7.95}S_{16.00}$.

Occurrence: As inclusions in a Pt–Fe alloy from an alkalic ultramafic massif.

Association: Pt–Fe alloy, erlichmanite.

Distribution: From the Konder massif, Aldan Shield, Sakha, Russia [TL].

Name: For the occurrence in the Konder massif, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1500/1.

References: (1) Rudashevskii, N.S., A.G. Mochalov, N.V. Trubkin, A.I. Gorshkov, Y.P. Men'shikov, and N.I. Shumskaya (1984) Konderite, $PbCu_3(Rh,Pt,Ir)_8S_{16}$, a new mineral. Zap. Vses. Mineral. Obshch., 113, 703–712 (in Russian). (2) (1986) Amer. Mineral., 71, 229 (abs. ref. 1).

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Koninckite $(Fe^{3+}, Al)PO_4 \cdot 3H_2O(?)$

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Crystal Data: Tetragonal. *Point Group:* n.d. Crystals, fibrous in spherical aggregates, to 0.8 mm.

Physical Properties: *Cleavage:* One, transverse to elongation. Hardness = 3.5
D(meas.) = 2.40(3) D(calc.) = [2.56]

Optical Properties: Transparent. *Color:* Yellow to white; pale yellow to colorless in transmitted light. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (+), may be biaxial to nearly isotropic. *Orientation:* X = elongation.
ω = 1.645–1.648 ϵ = 1.655–1.669 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. a = 11.95–11.977 c = 14.52–14.625 Z = 16

X-ray Powder Pattern: Richelle, Belgium.
8.42 (100), 3.77 (28), 2.98 (18), 3.85 (10), 2.83 (9), 5.99 (8), 4.48 (4)

Chemistry:

	(1)	(2)	(3)
P_2O_5	34.8	35.16	34.64
Al_2O_3	4.6	2.52	
Fe_2O_3	34.4	35.73	38.98
H_2O	[26.2]	[26.59]	26.38
Total	[100.0]	[100.00]	100.00

(1) Richelle, Belgium; average of two analyses, H_2O by difference; corresponds to $(Fe_{0.83}Al_{0.17})_{\Sigma=1.00}PO_4 \cdot 3H_2O$. (2) Suwa mine, Japan; by electron microprobe, H_2O by difference; corresponds to $(Fe_{0.90}Al_{0.10})_{\Sigma=1.00}P_{1.00}O_4 \cdot 2.98H_2O$. (3) $FePO_4 \cdot 3H_2O$.

Occurrence: Presumably as a secondary mineral in phosphatic sedimentary rocks (Richelle, Belgium); in a hydrothermally altered andesite enriched in Fe, SO_4, and PO_4 (Suwa mine, Japan).

Association: Richellite, halloysite, allophane (Richelle, Belgium); tinticite, strengite, jarosite, goethite (Suwa mine, Japan).

Distribution: From Richelle, near Visé, Belgium. In Japan, from a cave near Oni-Ana, Fukushima Prefecture, and at the Suwa mine, about seven km south-southwest of Mt. Tateshina, Nagano Prefecture, Japan. In the Kovdor massif, Kola Peninsula, Russia.

Name: Honors Laurent Guillaume de Koninck (1809–1887), Belgian geologist, University of Liège, Liège, Belgium.

Type Material: University of Liège, Liège, Belgium, 9251–9257.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 763. (2) Van Tassel, R. (1968) Données cristallographiques sur la koninckite. Bull. Soc. fr. Minéral., 91, 487–489 (in French with English abs.). (3) Sakurai, K., S. Matsubara, and A. Kato (1987) Koninckite from the Suwa mine, Chino City, Nagano Prefecture, Japan. Bull. Nat. Sci. Mus. Tokyo, Ser. C, 13, 149–156.

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Konyaite $Na_2Mg(SO_4)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As powdery aggregates of minute crystals.

Physical Properties: Hardness = 2.5 D(meas.) = 2.088(6) D(calc.) = 2.097 Readily soluble in H_2O; very unstable, commonly transforming to blödite in a matter of days.

Optical Properties: Transparent. *Color:* White, may be colorless.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 70(2)°$. $\alpha = 1.464(1)$ $\beta = 1.468(1)$ $\gamma = 1.474(1)$ 2V(meas.) = 74(2)° 2V(calc.) = 79°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.786(3)$ $b = 24.029(9)$ $c = 8.060(3)$ $\beta = 95.38°$ Z = 4

X-ray Powder Pattern: Synthetic.
4.541 (100), 4.017 (45), 3.960 (45), 2.597 (45), 12.01 (40), 4.202 (40), 2.659 (40)

Chemistry: (1) Identification depends on the identity of the X-ray pattern of the natural mineral with synthetic material, with the qualitative presence of Na, Mg, and SO_4.

Occurrence: Widespread in salt efflorescences on saline soils, formed between 30 °C and 50 °C by evaporation of ground and surface waters.

Association: Gypsum, hexahydrite, blödite, halite, starkeyite, löweite, mirabalite, thénardite, epsomite, burkeite, tychite.

Distribution: In Turkey, from near Çakmak, between Ereğli and Niğde, Great Konya Basin, Konya Province. In the Tăuçoare Cave, Rodna Mountains, Romania. In the USA, found at many places in North Dakota. In Canada, noted across central and southern Alberta.

Name: For its occurrence in the Great Konya Basin, Turkey.

Type Material: National Museum of Geology and Mineralogy, Leiden, The Netherlands.

References: (1) van Doesburg, J.D.J., L. Vergouwen, and L. van der Plas (1982) Konyaite, $Na_2Mg(SO_4)_2 \cdot 5H_2O$, a new mineral from the Great Konya Basin, Turkey. Amer. Mineral., 67, 1035–1038.

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Koritnigite $Zn(AsO_3OH)\cdot H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. As imperfect platy crystals, to 5 mm, in aggregates.

Physical Properties: *Cleavage:* {010}, perfect; cleavage traces ∥ [001] and ∥ [100], visible on {010}. *Tenacity:* Flexible. Hardness = 2 D(meas.) = 3.54 D(calc.) = 3.56

Optical Properties: Transparent. *Color:* Colorless, white, rose. *Luster:* Pearly on {010}. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y \wedge a \simeq 28°$; $Z \wedge c \simeq 22°$. $\alpha = 1.632(5)$ $\beta = 1.652(3)$ $\gamma = 1.693(3)$ 2V(meas.) = 70(5)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.948(2)$ $b = 15.829(5)$ $c = 6.668(2)$ $\alpha = 90.86(2)°$ $\beta = 96.56(2)°$ $\gamma = 90.05(2)°$ Z = 8

X-ray Powder Pattern: Tsumeb, Namibia; very close to cobaltkoritnigite.
7.90 (10), 3.16 (9), 3.83 (7), 2.461 (6), 2.186 (5), 3.95 (4), 2.926 (4)

Chemistry:

	(1)	(2)	(3)
As_2O_5	51.75	54.67	51.46
$FeO + Fe_2O_3$	trace	0.05	
CoO		4.54	
NiO		2.44	
ZnO	35.97	25.83	36.44
MgO	trace		
H_2O	[12.3]	[12.47]	12.10
Total	[100.0]	[100.00]	100.00

(1) Tsumeb, Namibia; by electron microprobe, $(AsO_3OH)^{2-}$ confirmed by IR, H_2O by difference. (2) Jáchymov, Czech Republic; H_2O by difference. (3) $Zn(AsO_3OH)\cdot H_2O$.

Occurrence: A secondary mineral of the lower oxidation zone in a dolostone-hosted polymetallic hydrothermal ore deposit (Tsumeb, Namibia).

Association: Tennantite, cuprian adamite, stranskiite, lavendulan, köttigite, tsumcorite, prosperite, o'danielite (Tsumeb, Namibia); erythrite, arsenolite, sphalerite (Jáchymov, Czech Republic).

Distribution: Found at Tsumeb, Namibia. From Jáchymov (Joachimsthal), Czech Republic. At Richelsdorf, Hesse, Germany.

Name: Honors Professor Sigmund Koritnig (1912–1984), petrologist, University of Göttingen, Göttingen, Germany.

Type Material: University of Stuttgart, Stuttgart, NM02; University of Göttingen, Göttingen, Germany; Harvard University, Cambridge, Massachusetts, 125338; National Museum of Natural History, Washington, D.C., USA, 143369.

References: (1) Keller, P., H. Hess, P. Süsse, G. Schnorrer, and P.J. Dunn (1979) Koritnigit, $Zn[H_2O|HOAsO_3]$, ein neues Mineral aus Tsumeb, Südwestafrika. Tschermaks Mineral. Petrog. Mitt., 26, 51–58 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 206 (abs. ref. 1). (3) Schmetzer, K., W. Horn, and W. Bartelke (1980) Kobalt- und Nickel-haltiger Koritnigit aus Jáchymov (Joachimsthal), ČSSR – ein zweiter Fundpunkt. Neues Jahrb. Mineral., Monatsh., 237–240 (in German with English abs.). (4) Keller, P., H. Hess, and H. Riffel (1980) Die Kristallstruktur von Koritnigit, $Zn[H_2O|HOAsO_3]$. Neues Jahrb. Mineral., Abh., 138, 316–332 (in German with English abs.).

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Kornelite $Fe_2^{3+}(SO_4)_3 \cdot 7{-}8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are lathlike, flattened on {010}, acicular, elongated along [001], to several mm, with about 15 forms reported; in radial fibrous, globular, or tufted aggregates; in crusts. *Twinning:* On {100}, polysynthetic.

Physical Properties: *Cleavage:* On {100}. Hardness = n.d. D(meas.) = 2.306 D(calc.) = [2.254] Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Pale rose-pink to violet under artificial light. *Luster:* Silky if fibrous.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 20(2)°$. *Dispersion:* $r > v$, perceptible. $\alpha = 1.567$ $\beta = 1.581$ $\gamma = 1.638$ 2V(meas.) = 49°–62°

Cell Data: *Space Group:* $P2_1/n$. a = 14.30(1) $b = 20.12(2)$ $c = 5.425(4)$ $\beta = 96.8(1)°$ Z = 4

X-ray Powder Pattern: Tintic Standard mine, Utah, USA.
10.0 (FFF), 6.64 (FF), 4.67 (FF), 4.30 (F), 3.14 (F), 4.39 (mF), 3.50 (mF)

Chemistry:

	(1)	(2)	(3)
SO_3	43.88	45.67	44.15
Fe_2O_3	29.72	30.36	29.36
H_2O	26.40	23.97	26.49
Total	[100.00]	100.00	100.00

(1) Tintic Standard mine, Utah, USA; recalculated to 100% from an original total of 99.82%, after deduction of 1.48% soluble and insoluble residue. (2) $Fe_2(SO_4)_3 \cdot 7H_2O$. (3) $Fe_2(SO_4)_3 \cdot 8H_2O$.

Occurrence: An uncommon secondary mineral formed by oxidation of pyrite.

Association: Voltaite, coquimbite (Smolník, Slovakia); coquimbite, römerite, copiapite, voltaite, rhomboclase (Copper Queen mine, Arizona, USA).

Distribution: From Smolník (Szomolnok), 16 km northeast of Rožňava, Slovakia. On Mt. Kozhokh, Bulgaria. From the Lanjarón mineral springs, Granada, Spain. In the USA, at the Tintic Standard mine, near Dividend, East Tintic district, Utah Co., Utah; in the Copper Queen mine, Bisbee, Cochise Co., Arizona; at the Island Mountain mine, Trinity Co., and from Coso Hot Springs, Inyo Co., California.

Name: To honor Kornel Hlavacsek (1835–1914), Hungarian mining engineer at the pyrite mines, Banská Štavnica, Slovakia.

Type Material: Natural History Museum, Budapest, Hungary, destroyed in 1956; topotypes remain.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 530–532. (2) Robinson, P.D. and J.H. Fang (1973) Crystal structures and mineral chemistry of hydrated ferric sulphates. III. The crystal structure of kornelite. Amer. Mineral., 58, 535–539. (3) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French).

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Kornerupine $(Mg, Fe^{2+})_4Al_6(Si, Al, B)_5O_{21}(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, to over 20 cm, showing principally {110}, {100}, and {010}, rarely terminated; as radiating aggregates.

Physical Properties: *Cleavage:* Good on {110}. Hardness = 6–7 D(meas.) = 3.29–3.35 D(calc.) = 3.288

Optical Properties: Transparent to translucent and opaque. *Color:* Colorless, white, blue, green, dark green, greenish yellow, yellow-brown, black. *Luster:* Vitreous. *Optical Class:* Biaxial (–); may be pseudouniaxial (–). *Pleochroism:* X = colorless to green; Y = colorless, pale brownish yellow, pale yellowish green; Z = pale brownish green, green, light amber. *Orientation:* X = c; Y = a; Z = b. *Dispersion:* $r < v$ or $r > v$. α = 1.660–1.671 β = 1.673–1.683 γ = 1.674–1.684 2V(meas.) = 3°–48°

Cell Data: *Space Group: Cmcm.* $a = 16.041(3)$ $b = 13.746(2)$ $c = 6.715(2)$ Z = 4

X-ray Powder Pattern: Mautia Hill, Tanzania.
2.639 (100), 3.03 (80), 3.37 (60), 2.118 (60), 1.503 (40), 2.096 (30), 1.685 (30)

Chemistry:

	(1)		(1)
SiO_2	29.80	MgO	18.96
TiO_2	0.06	CaO	0.07
B_2O_3	1.44	Li_2O	0.08
Al_2O_3	45.85	Na_2O	0.04
FeO	1.60	F	0.01
MnO	0.05	H_2O	[1.21]
		Total	[99.17]

(1) Fiskenæsset, Greenland; by electron microprobe, Li, B, F by ion microprobe, H_2O from stoichiometry; corresponds to $(Mg_{3.48}Fe_{0.16}Li_{0.04}Ca_{0.01}Na_{0.01})_{\Sigma=3.70}(Al_{5.64}Ti_{0.01})_{\Sigma=5.65}(Si_{3.67}Al_{1.02}B_{0.31})_{\Sigma=5.00}O_{21}[(OH)_{0.99}F_{0.01}]_{\Sigma=1.00}$.

Occurrence: In boron-rich volcanic and sedimentary rocks subjected to amphibolite to granulite facies metamorphism; in metamorphosed anorthosite complexes.

Association: Sapphirine, cordierite, spinel, corundum, tourmaline, grandidierite, dumortierite, kyanite, sillimanite, andalusite, biotite, phlogopite, magnetite, ilmenite, hematite, rutile.

Distribution: Some localities for well-studied material follow. In Greenland, at Fiskenæsset. At Bjordam, near Kragerö, Norway. In Germany, from Waldheim, Saxony. From Mautia Hill, Tanzania. On the Bok se Puts Farm, Namaqualand, Cape Province, South Africa. Gem crystals from Itrongahy, near Betroka, and elsewhere in Madagascar. From gem gravels of the Matale, Ratnapura, and Embilipitiya districts, Sri Lanka. In the Harts and Strangways Ranges, Northern Territory, Australia. At Lac Ste-Marie, Quebec, Canada.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1883.754.

Name: For the Danish geologist, Andreas Nikolaus Kornerup (1857–1883).

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 560–561. (2) McKie, D. (1965) The magnesium aluminium borosilicates: kornerupine and grandidierite. Mineral. Mag., 34, 346–357. (3) Grew, E.S., R.K. Herd, and N. Marquez (1987) Boron-bearing kornerupine from Fiskenæsset, West Greenland: a re-examination of specimens from the type locality. Mineral. Mag., 51, 695–708. (4) Moore, P.B., P.K. Sen Gupta, and E.O. Schlemper (1989) Kornerupine: chemical crystallography, comparative crystallography, and its cation relation to olivine and to Ni_2In intermetallic. Amer. Mineral., 74, 642–655. (5) Grew, E.S., J.V. Chernosky, G. Werding, K. Abraham, N. Marquez, and J.R. Hinthorne (1990) Chemistry of kornerupine and associated minerals, a wet chemical, ion microprobe, and X-ray study emphasizing Li, Be, B and F contents. J. Petrol., 31, 1025–1070.

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Kornite $KNa_2(Mg, Mn^{3+}, Fe^{3+}, Li)_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* [2/*m*.] In bundles of fibers, elongated along [001], commonly bent, to 200 μm; rimming hennomartinite.

Physical Properties: *Cleavage:* Parallel to [001]. *Tenacity:* Brittle. Hardness = [5–6] D(meas.) = n.d. D(calc.) = 3.15

Optical Properties: Transparent. *Color:* Dark red to brownish lilac. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = pink; Y = dark red; Z = red-orange. *Orientation:* $Z = b$; $Y \wedge c = 60°$–$65°$. $\alpha = 1.654(4)$ $\beta = [1.675]$ $\gamma = 1.696(4)$ 2V(meas.) = 88°–92°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1/a$. a = 9.94(1) b = 17.80(2) c = 5.302(4) $\beta = 105.5(2)°$ Z = 2

X-ray Powder Pattern: Wessels mine, South Africa; assembled from single crystal patterns. 3.257 (s), 3.132 (s), 2.812 (s), 2.553 (s), 8.890 (m), 8.427 (m), 5.077 (m)

Chemistry:

	(1)
SiO_2	56.06
Al_2O_3	0.00
Fe_2O_3	4.93
Mn_2O_3	13.17
MgO	10.03
CaO	0.00
Li_2O	1.96
Na_2O	7.61
K_2O	3.56
F	n.d.
H_2O	[2.68]
Total	[100.00]

(1) Wessels mine, South Africa; by electron microprobe, Li by ion microprobe, average of seven analyses, H_2O by difference; corresponds to $(K_{0.65}Na_{0.31})_{\Sigma=0.96}(Na_{1.79}Li_{0.21})_{\Sigma=2.00}(Mg_{2.12}Mn^{3+}_{1.43}Li_{0.91}Fe^{3+}_{0.52})_{\Sigma=4.98}Si_{8.00}O_{22}(OH)_2$.

Mineral Group: Amphibole (alkali) group: $Na_B \geq 1.34$; $Li_C \geq 0.5$; $Mn^{3+} > Fe^{3+}$.

Occurrence: From a hand specimen, in veinlets of sérandite-pectolite cutting sugilite, probably of hydrothermal origin in a bedded manganese deposit.

Association: Sérandite-pectolite, sugilite, braunite, taikanite, hennomartinite.

Distribution: From the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For Hermann Korn (?–1946), German geologist, professionally associated with Henno Martin, for whom an associated mineral is named.

Type Material: Natural History Museum, Bern, Switzerland, B5564.

References: (1) Armbruster, T., R. Oberhänsli, V. Bermanec, and R. Dixon (1993) Hennomartinite and kornite, two new Mn^{3+} rich silicates from the Wessels mine, Kalahari, South Africa. Schweiz. Mineral. Petrog. Mitt., 73, 349–355. (2) (1994) Amer. Mineral., 79, 763–764 (abs. ref. 1).

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$Mg_2Cl(OH)_3 \cdot 3.5–4.0H_2O$ Korshunovskite

Crystal Data: Triclinic. *Point Group:* n.d. As prismatic grains, elongated, to 2 mm, in thin veinlets.

Physical Properties: Hardness = ~2 D(meas.) = 1.798(2) D(calc.) = 1.787 Slowly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (-). *Orientation:* Extinction 6°–8° to elongation. $\alpha = 1.516(1)$ $\beta = 1.538(1)$ $\gamma = 1.547(1)$ 2V(meas.) = −62°

Cell Data: *Space Group:* n.d. $a = 8.64(3)$ $b = 6.25(1)$ $c = 7.42(1)$ $\alpha = 101.4(3)°$ $\beta = 103.9(1)°$ $\gamma = 72.7(6)°$ Z = 2

X-ray Powder Pattern: Korshunov deposit, Russia.
8.04 (100), 2.439 (95), 3.843 (75), 4.032 (70), 1.857 (70), 2.873 (60b), 2.703 (60)

Chemistry:

	(1)
SiO_2	0.09
Fe_2O_3	0.10
MgO	37.62
CaO	4.69
Cl	14.84
H_2O^+	27.06
H_2O^-	9.36
CO_2	8.78
$-O = Cl_2$	3.35
Total	99.19

(1) Korshunov deposit, Russia; (OH) and H_2O confirmed by IR; after deduction of magnesite and dolomite ~16%, minor magnetite, and antigorite, corresponds to $Mg_{2.00}Cl_{1.03}(OH)_3 \cdot 3.5H_2O$.

Occurrence: From a drill core taken at 770 m in an iron ore deposit, in low-temperature hydrothermal veinlets in dolomitic marble.

Association: Ekaterinite, shabynite, magnetite, antigorite, dolomite, magnesite.

Distribution: From the Korshunov iron deposit, Irkutsk region, Siberia, Russia.

Name: For the Korshunov deposit, Russia, where it was first discovered.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Malinko, S.V., A.E. Lisitsyn, S.P. Purusova, B.P. Fitsev, and T.A. Khruleva (1982) Korshunovskite $Mg_2Cl(OH)_3 \cdot nH_2O$, – a new hydrous magnesium chloride. Zap. Vses. Mineral. Obshch., 111, 324–329 (in Russian). (2) (1983) Amer. Mineral., 68, 643 (abs. ref. 1). (3) (1983) Mineral. Abs., 34, 184 (abs. ref. 1). (4) de Wolff, P.M. and L. Walter-Lévy (1953) The crystal structure of $Mg_2(OH)_3(Cl, Br) \cdot 4H_2O$. Acta Cryst., 6, 40–44.

Korzhinskite $CaB_2O_4 \cdot 0.5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Granular, prismatic, in lamellar aggregates. *Twinning:* Observed in some thin sections.

Physical Properties: *Cleavage:* One, parallel elongation. Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (+). *Orientation:* Parallel extinction; $X \perp$ cleavage, $Y = Z = \parallel$ cleavage.
$\alpha = 1.642(1)$ $\beta = 1.647(1)$ $\gamma = 1.672(1)$ 2V(meas.) = 43.6°

Cell Data: *Space Group:* $P2/m$. $a = 4.33$ $b = 6.47$ $c = 10.08$ $\beta = 85(2)°$ Z = n.d.

X-ray Powder Pattern: Novofrolovskoye deposit, Russia.
2.02 (10), 3.11 (7), 2.81 (7), 1.905 (5), 1.800 (5), 1.757 (4), 2.70 (3)

Chemistry:

	(1)	(2)
CO_3	18.41	
SiO_2	1.26	
B_2O_3	22.87	51.68
Al_2O_3	0.30	
Fe_2O_3	0.80	
FeO	trace	
MnO	0.15	
MgO	0.26	
CaO	50.12	41.63
H_2O^+	5.29	
H_2O^-	0.62	
H_2O		6.69
Total	100.08	100.00

(1) Novofrolovskoye deposit, Russia; analysis on material estimated 50% pure; after deduction of calcite, dolomite, garnet, major sibirskite, minor calciborite, then stated to correspond to $CaB_{2.10}O_{4.15} \cdot H_2O$; identification depends on correspondence of X-ray pattern with synthetic $CaB_2O_4 \cdot 0.5H_2O$. (2) $CaB_2O_4 \cdot 0.5H_2O$.

Occurrence: In boron-rich iron-ore skarn.

Association: Andradite–grossular, dolomite, calcite, sibirskite, calciborite.

Distribution: From the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains, Russia.

Name: Honoring Dmitrii Sergeevich Korzhinskii (1899–1985), Russian petrologist, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: Vernadsky Geological Museum, Moscow, 48612; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72025.

References: (1) Malinko, S.V. (1963) A new calcium borate, korzhinskite. Zap. Vses. Mineral. Obshch., 92, 555–559 (in Russian). (2) (1964) Amer. Mineral., 49, 441 (abs. ref. 1). (3) Malinko, S.V and V.T. Dubinchuk (1996) New data on calcium borates. Zap. Vses. Mineral. Obshch., 125(4), 60–71 (in Russian with English abs.).

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Kosmochlor $NaCr^{3+}Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Short prismatic crystals, to 2 mm; in fibrous and polycrystalline aggregates. *Twinning:* Simple, lamellar on {100}, {001}.

Physical Properties: *Cleavage:* Good on {110}, (110) ∧ $(1\bar{1}0)$ ∼87°; parting on {001}. Hardness = ∼6 D(meas.) = 3.51–3.60 D(calc.) = 3.60

Optical Properties: Semitransparent. *Color:* Emerald-green; green or yellow in thin section. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = yellowish green; Y = blue-green, grass-green; Z = emerald-green. *Orientation:* $Y = b$; $Z \wedge a = 8°$–$22°$. *Dispersion:* $r > v$, moderate to strong. $\alpha = 1.740$–1.766 $\beta = 1.756$–1.778 $\gamma = 1.745$–1.781 2V(meas.) = 6°–70°

Cell Data: *Space Group:* $C2/c$. $a = 9.550$ $b = 8.712$ $c = 5.273$ $\beta = 107.44°$ Z = 4

X-ray Powder Pattern: Synthetic.
2.956 (100), 2.867 (100), 2.5166 (90), 2.4476 (70), 2.0985 (70), 1.5957 (70), 1.3802 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	55.5	54.81	MgO	0.8	0.49
TiO_2		0.03	CaO	1.7	0.54
Al_2O_3		4.02	Na_2O	11.6	12.94
Fe_2O_3	0.2	3.61	K_2O		0.02
Cr_2O_3	30.6	23.67	P_2O_5		0.09
MnO		0.02	Total	100.4	[100.24]

(1) Coahuila meteorite; by electron microprobe, corresponds to $(Na_{0.83}Ca_{0.07})_{\Sigma=0.90}(Cr_{0.90}Mg_{0.04})_{\Sigma=0.94}Si_{2.06}O_6$. (2) Myanmar; by electron microprobe, average of seven analyses, average sum originally given as 100.19%; corresponds to $(Na_{0.93}Ca_{0.02})_{\Sigma=0.95}(Cr_{0.69}Al_{0.17}Fe_{0.10}Mg_{0.03})_{\Sigma=0.99}Si_{2.02}O_6$.

Mineral Group: Pyroxene group.

Occurrence: A major constituent of some jadeitites; an accessory constituent of some iron meteorites.

Association: "Cliftonite" [graphite], chromian diopside, troilite (Toluca); daubréelite (Coahuila); krinovite, roedderite, high albite, richterite, chromite (Canyon Diablo); jadeite, chromite, chlorite (Myanmar).

Distribution: In the Toluca, Coahuila, Hex River Mountains, and Canyon Diablo meteorites. Around Tawmaw and other towns, Myitkyina-Mogaung district, Kachin State, Myanmar (Burma). At Mocchie, Susa, Piedmont, Italy. From Williams Creek, Mendocino Co., California, USA.

Name: From the German *kosmisch*, for *cosmic*, in allusion to its meteoritic occurrence, and the Greek *chlor*, for *green*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 81869, 81870; The Natural History Museum, London, England, 81869–81870.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 20. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 520–525. (3) Frondel, C. and C. Klein, Jr. (1965) Ureyite [kosmochlor], $NaCr_2Si_2O_6$, a new meteoritic pyroxene. Science, 149, 742–744. (4) (1965) Amer. Mineral., 50, 2096 (abs. ref. 3). (5) Clark, J.R., D.E. Appleman, and J.J. Papike (1969) Crystal-chemical characterization of clinopyroxenes based on eight new structure refinements. MSA Spec. Paper 2, 31–50. (6) Yang, C.M.O. (1984) A terrestrial source of ureyite [kosmochlor]. Amer. Mineral., 69, 1180–1183. (7) Harlow, G.E. and E.P. Olds (1987) Observations on terrestrial ureyite [kosmochlor] and ureyitic pyroxene. Amer. Mineral., 72, 126–136.

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Kosnarite $KZr_2(PO_4)_3$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}\ 2/m$. As rhombohedral pseudocubic crystals, to 0.9 mm, with $\{10\overline{1}2\}$ and tiny $\{0001\}$.

Physical Properties: *Cleavage:* Perfect on $\{10\overline{1}2\}$. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.194(2) D(calc.) = 3.206

Optical Properties: Transparent to translucent. *Color:* Pale blue to blue-green, bluish gray, nearly colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.656(2)$ $\epsilon = 1.682(2)$

Cell Data: *Space Group:* $R\overline{3}c$. a = 8.687(2) c = 23.877(7) Z = 6

X-ray Powder Pattern: Mt. Mica, Maine, USA.
4.329 (100), 3.806 (90), 2.928 (90), 6.41 (50), 4.679 (50), 2.502 (50), 1.903 (45)

Chemistry:

	(1)	(2)	(3)
P_2O_5	43.3	42.2	42.04
ZrO_2	44.5	47.9	48.66
HfO_2	0.5	0.9	
FeO	0.2	< 0.1	
MnO	1.0	< 0.1	
Na_2O	1.4	< 0.1	
K_2O	8.7	9.25	9.30
Rb_2O	0.25	0.2	
F	0.20	0.2	
$-O = F_2$	0.08	0.08	
Total	99.97	100.57	100.00

(1) Mt. Mica, Maine, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(K_{0.93}Na_{0.08}Rb_{0.01})_{\Sigma=1.02}(Zr_{1.81}Na_{0.15}Mn_{0.07}Fe_{0.01}Hf_{0.01})_{\Sigma=2.05}[P_{1.02}(O_{3.98}F_{0.02})_{\Sigma=4.00}]_3$. (2) Black Mountain, Maine, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(K_{0.99}Rb_{0.01})_{\Sigma=1.00}(Zr_{1.96}Hf_{0.02})_{\Sigma=1.98}[P_{1.00}(O_{3.98}F_{0.02})_{\Sigma=4.00}]_3$. (3) $KZr_2(PO_4)_3$.

Occurrence: A very rare mineral, formed by late hydrothermal alteration, probably of beryl and zircon, in complex granite pegmatites.

Association: Eosphorite, fluorapatite, moraesite, siderite, zircon, quartz (Mt. Mica, Maine, USA); siderite, albite, quartz (Black Mountain quarry, Maine, USA); wycheproofite, eosphorite, selwynite, cyrilovite, schorl (Wycheproof, Australia).

Distribution: In the USA, at Mt. Mica, near Paris, and in the Black Mountain quarry, near Rumford, Oxford Co., Maine. From Wycheproof, Victoria, Australia.

Name: For Richard A. Kosnar (1946–), American mineral dealer of Black Hawk, Colorado, USA, long interested in pegmatite minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 170369, 170370.

References: (1) Brownfield, M.E., E.E. Foord, S.J. Sutley, and T. Botinelly (1993) Kosnarite, $KZr_2(PO_4)_3$, a new mineral from Mount Mica and Black Mountain, Oxford County, Maine. Amer. Mineral., 78, 653–656. (2) Birch, W.D., A. Pring, D.J.M. Bevan, and Kharisun (1994) Wycheproofite: a new hydrated sodium aluminum zirconium phosphate from Wycheproof, Victoria, Australia, and a new occurrence of kosnarite. Mineral. Mag., 58, 635–639. (3) Šljukić, M., B. Matković, B. Prodić, and D. Anderson (1969) The crystal structure of $KZr_2(PO_4)_3$. Zeits. Krist., 130, 148–161.

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Kostovite $(Cu, Ag)AuTe_4$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As equant to slightly elongated grains, to 50 μm. *Twinning:* Polysynthetic, fine lamellar, 0.1 to 20 μm thick.

Physical Properties: *Cleavage:* Distinct in one direction. *Tenacity:* Brittle.
Hardness = 2–2.5 VHN = 180–186 (25 g load). D(meas.) = 8.43 D(calc.) = [7.94]

Optical Properties: Opaque. *Color:* Grayish white; in polished section, pinkish creamy white. *Luster:* Metallic.
Optical Class: Biaxial (+). *Anisotropism:* Distinct; creamy white to creamy gray.
R_1–R_2: (400) 38.7–54.0, (420) 41.5–55.9, (440) 44.0–57.7, (460) 46.0–59.2, (480) 47.5–60.3, (500) 48.8–61.1, (520) 49.7–61.6, (540) 50.5–61.7, (560) 51.2–61.6, (580) 51.7–61.4, (600) 52.1–61.2, (620) 52.3–61.0, (640) 52.5–60.8, (660) 52.7–60.7, (680) 52.9–60.7, (700) 53.3–60.7

Cell Data: *Space Group:* n.d. $a = 16.50(5)$ $b = 8.84(2)$ $c = 4.42(2)$ Z = [4]

X-ray Powder Pattern: Chelopech, Bulgaria.
3.03 (10), 2.10 (9), 2.93 (6), 5.03 (5), 3.36 (5), 3.24 (5), 2.23 (4)

Chemistry:

	(1)	(2)	(3)	(4)
Au	25.2	27.2	27.37	25.55
Ag	0.4	0.5	4.03	
Cu	7.7	7.3	4.85	8.24
Fe		0.1		
Te	67.6	64.4	63.97	66.21
S		0.1		
Total	100.9	99.6	100.22	100.00

(1) Chelopech, Bulgaria; by electron microprobe, corresponding to $(Cu_{0.92}Ag_{0.03})_{\Sigma=0.95}Au_{0.97}Te_{4.00}$. (2) Bisbee, Arizona, USA; by electron microprobe; corresponding to $(Cu_{0.90}Ag_{0.04})_{\Sigma=0.94}Fe_{0.01}Au_{1.09}(Te_{3.98}S_{0.02})_{\Sigma=4.00}$. (3) Kochbulak deposit, Uzbekistan; by electron microprobe, corresponding to $(Cu_{0.61}Ag_{0.30})_{\Sigma=0.91}Au_{1.11}Te_{4.00}$. (4) $CuAuTe_4$.

Occurrence: From gold- and tellurium-bearing replacement copper deposits (Chelopech, Bulgaria; Campbell mine, Arizona, USA).

Association: Kesterite, tellurium, chalcopyrite, tennantite, barite (Chelopech, Bulgaria); tellurium, hessite, sylvanite (Buckeye Gulch, Colorado, USA); tellurium, altaite, calaverite, sylvanite, petzite, hessite, tellurantimony, melonite, chalcopyrite, tetrahedrite, sphalerite (Kochbulak deposit, Uzbekistan).

Distribution: From the Chelopech deposit, Sofia, Bulgaria [TL]. In the Campbell mine, Bisbee, Cochise Co., Arizona, and at Buckeye Gulch, near Leadville, Lake Co., Colorado, USA. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In the Guilaizhuang gold deposit, Shandong Province, China. At the Ashanti gold deposit, Obuasi, Ghana.

Name: To honor Professor Ivan Kostov (1913–), Bulgarian mineralogist, University of Sophia, Bulgaria.

Type Material: Geological Institute, Bulgarian Academy of Sciences; University of Sophia, Bulgaria; Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow, Russia.

References: (1) Terziev, G. (1966) Kostovite, a gold–copper telluride from Bulgaria. Amer. Mineral., 51, 29–36. (2) Kovalenker, V.A., N.V. Troneva, O.V. Kuz'mina, L.N. Vyal'sov, and P.M. Goloshchukov (1979) First occurrence of kostovite in the USSR. Doklady Acad. Nauk SSSR, 247, 1249–1252 (in Russian). (3) Van Tendeloo, G. and S. Amelinckx (1986) High-resolution electron-microscopic study of the modelated structure of kostovite ($Cu_{1-x}Au_{1+x}Te_4$). Acta Cryst., 42, 121–130.

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Kostylevite $K_2ZrSi_3O_9 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals elongated ‖ [001], showing {001}, {010}, {100}, and {011}. *Twinning:* On {100}.

Physical Properties: *Cleavage:* {110}, perfect. Hardness = ∼5 VHN = 428–435
D(meas.) = 2.74 D(calc.) = 2.79

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = 45°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.595(2)$ $\beta = 1.598(2)$ $\gamma = 1.610(2)$ 2V(meas.) = 48°

Cell Data: *Space Group:* $P2_1/a$. $a = 13.171(4)$ $b = 11.717(4)$ $c = 6.565(2)$ $\beta = 105.26°$
Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
3.087 (100), 5.60 (60), 3.336 (53), 2.802 (53), 6.42 (47), 5.86 (31), 5.24 (31)

Chemistry:

	(1)	(2)
SiO_2	42.01	43.37
TiO_2	2.06	
ZrO_2	23.90	29.64
HfO_2	0.61	
Fe_2O_3	0.02	
CaO	0.00	
Na_2O	0.00	
K_2O	22.14	22.66
H_2O		4.33
Total	90.74	100.00

(1) Khibiny massif, Russia; by electron microprobe. Presence of H_2O is shown by strong IR absorption bands; if 1.00 H_2O is assumed to satisfy structural requirements and measured density, note the analysis will then sum to only ∼95% however. (2)$K_2ZrSi_3O_9 \cdot H_2O$.

Polymorphism & Series: Dimorphous with umbite.

Occurrence: In alkalic pegmatite in a differentiated alkalic massif.

Association: Umbite, wadeite, eudialyte, potassian feldspar, aegirine.

Distribution: In the valley of the Vuonnemiok River, Khibiny massif, Kola Peninsula, Russia.

Name: For Ekaterina Evtikhievna Kostyleva-Labuntsova (1894–1974), Russian mineralogist, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity; Mining Institute, St. Petersburg, 1634/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82757.

References: (1) Khomyakov, A.P., A.A. Voronkov, L.I Polezhaeva, and N.N. Smol'yaninova (1983) Kostylevite, $K_4Zr_2Si_6O_{18} \cdot 2H_2O$, a new mineral. Zap. Vses. Mineral. Obshch., 112, 469–474 (in Russian). (2) Ilyushin, G.D., A.P. Khomyakov, N.V. Shumyatskaya, A.A. Voronkov, N.N. Nevskii, V.V. Ilyukhin, and N.V. Belov (1981) Crystal structure of a new natural zirconosilicate, $K_4Zr_2Si_6O_{18} \cdot 2H_2O$. Doklady Acad. Nauk SSSR, 256, 860–863 (in Russian). (3) (1984) Amer. Mineral., 69, 812 (abs. refs. 1 and 2).

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Kotoite $Mg_3(BO_3)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Granular massive. *Twinning:* On {101}, polysynthetic.

Physical Properties: *Cleavage:* On {110}, perfect; a parting on {101}. Hardness = 6.5 D(meas.) = 3.10 D(calc.) = 3.09

Optical Properties: Transparent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.652$ $\beta = 1.653$ $\gamma = 1.673$–1.674 2V(meas.) = 21°–22°

Cell Data: *Space Group:* $Pnmn$. $a = 5.401$ $b = 8.422$ $c = 4.507$ Z = 2

X-ray Powder Pattern: Synthetic.
2.67 (100), 2.23 (100), 2.18 (100), 1.73 (100), 1.67 (100), 1.51 (100), 3.47 (75)

Chemistry:

	(1)	(2)
SiO_2	1.32	
B_2O_3	35.20	36.54
Al_2O_3	0.26	
Fe_2O_3	0.20	
FeO	0.61	
MgO	62.78	63.46
CaO	0.18	
H_2O^+	0.05	
Total	100.60	100.00

(1) Hol Kol mine, North Korea; forsterite and spinel impurities. (2) $Mg_3(BO_3)_2$.

Occurrence: An uncommon mineral typically formed in the contact zone of magnesium-rich skarn borate deposits.

Association: Forsterite, clinohumite, ludwigite, spinel, fluoborite, szaibélyite (Hol Kol mine, North Korea); ludwigite, suanite, szaibélyite, warwickite (Neichi mine, Japan).

Distribution: From the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea. In the Neichi mine, Miyako, Iwate Prefecture, Japan. At Qiliping, Hunan Province, and near Dading, Guizhou Province, China. In Russia, in the Korotkov skarn deposit, central Transbaikal, and at the Titovskoye boron deposit, Tas-Khayakhtakh Mountains, Sakha. From Băiţa (Rézbánya), Romania. In the Brosso mine, northwest of Ivrea, Torino, Italy. In the USA, on Jumbo Mountain, south of Darrington, Snohomish Co., Washington, and near Brighton, Big Cottonwood district, Salt Lake Co., Utah.

Name: To honor Professor Bundjiro Koto (1856–1935), Japanese geologist and petrographer, University of Tokyo, Tokyo, Japan, who studied the ore deposits of Hol Kol, North Korea.

Type Material: The Natural History Museum, London, England, 1938,1286; Harvard University, Cambridge, Massachusetts, 94750; National Museum of Natural History, Washington, D.C., USA, 103502.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 328–329. (2) Effenberger, H. and F. Pertlik (1984) Verfeinerung der Kristallstrukturen der isotypen Verbindungen $M_3(BO_3)_2$ mit M=Mg, Co und Ni (Strukturtyp, Kotoit). Zeits. Krist., 166, 129–140 (in German with English abs.). (3) Berger, S.V. (1949) The crystal structure of the isomorphous orthoborates of cobalt and magnesium. Acta Chem. Scand., 3, 660–675.

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Kottenheimite $Ca_3Si(OH)_6(SO_4)_2 \cdot 12H_2O$

Crystal Data: Hexagonal. *Point Group*: 6/*m*. As radiated and sub-parallel clusters of curved and split hair-like crystals, to 0.2 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 2-2.5 D(meas.) = 1.92(2) D(calc.) = 1.93

Optical Properties: Translucent. *Color*: Snow-white, colorless in transmitted light. *Streak*: n.d. *Luster*: Vitreous to silky (aggregates).
Optical Class: Uniaxial (–). ω = 1.490(2) ε = 1.477(2)

Cell Data: *Space Group*: $P6_3/m$. a = 11.1548(3) c = 10.5702(3) Z = 2

X-ray Powder Pattern: Bellerberg, near Kottenheim, Eastern Eifel area, Germany.
9.72 (100), 5.590 (60), 3.840 (54), 2.751 (34), 2.185 (30), 2.536 (27), 4.645 (26)

Chemistry:

	(1)	(2)
CaO	26.04	25.54
MgO	0.20	
FeO	0.19	
Al_2O_3	0.25	
SiO_2	8.95	9.12
SO_3	24.26	24.31
CO_2	0.58	
H_2O	41.30	41.03
Total	101.77	100.00

(1) Bellerberg, near Kottenheim, Eastern Eifel area, Germany; average of 6 electron microprobe analyses, Fe^{+3} confirmed by Mössbauer spectroscopy, H_2O and CO_2 were determined by gas chromatography, OH, CO_3 and SO_4 confirmed by IR spectroscopy; corresponding to $Ca_{3.015}Mg_{0.03}Fe_{0.02}Al_{0.03}Si_{0.97}(OH)_{5.94}(SO_4)_{1.97}(CO_3)_{0.09} \cdot 11.91H_2O$. (2) $Ca_3Si(OH)_6(SO_4)_2 \cdot 12H_2O$.

Mineral Group: Ettringite group.

Occurrence: In miarolitic cavities in alkali basalt.

Association: Wollastonite, clinochlore, ellestadite, melilite, cuspidine, and earlier-formed sanidine, clinopyroxene, magnetite.

Distribution: At Bellerberg, near Kottenheim, Eastern Eifel area, Rhineland-Palatinate (Rheinland-Pfalz), Germany.

Name: For the town near the locality that produced the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (4102/1).

References: (1) Chukanov, N.V., S.N. Britvin, K.V. Van, S. Möckel, and A.E. Zadov (2012) Kottenheimite, $Ca_3Si(OH)_6(SO_4)_2 \cdot 12H_2O$, a new member of the ettringite group from the Eifel area, Germany. Can. Mineral., 50, 55-63. (2) (2014) Amer. Mineral., 99, 1515 (abs. ref. 1).

Köttigite $Zn_3(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are prismatic to acicular along [001], flattened on {010}, to 6 cm, prominent {010}, {201}, smaller {100}, {110}, {$\overline{2}$21}, in radiating sprays; as fibrous crusts, massive.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 2–3 D(meas.) = 3.33 D(calc.) = 3.24

Optical Properties: Translucent. *Color:* White, colorless; light carmine, peach-blossom-red (cobaltian); blue, grayish blue (ferroan); in transmitted light, colorless, may be pale rose. *Streak:* White to reddish white. *Luster:* Silky on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* Weak; $X = Y$ = colorless; Z = pale red. *Orientation:* $X = b$; $Z \wedge c = 32°–37°$. *Dispersion:* $r < v$. *Absorption:* $Z > X = Y$. $\alpha = 1.619–1.622$ $\beta = 1.638–1.645$ $\gamma = 1.671–1.681$ 2V(meas.) = 74°–85° 2V(calc.) = 72°–83°

Cell Data: *Space Group:* $C2/m$. $a = 10.241–10.259$ $b = 13.405–13.430$ $c = 4.757–4.762$ $\beta = 105.21°–105.38°$ Z = 2

X-ray Powder Pattern: Schneeberg, Germany.
6.66 (100), 2.994 (90), 7.87 (70), 2.734 (60), 3.220 (50), 3.006 (50), 2.462 (50)

Chemistry:

	(1)	(2)	(3)
As_2O_5	[37.17]	39.5	37.18
CoO	6.91	5.39	
NiO	2.00	1.78	
ZnO	30.52	33.6	39.50
CaO	trace		
H_2O	23.40	[19.73]	23.32
Total	[100.00]	[100.00]	100.00

(1) Schneeberg, Germany; As_2O_5 by difference. (2) Do.; by electron microprobe, H_2O by difference; corresponds to $(Zn_{2.44}Co_{0.42}Ni_{0.14})_{\Sigma=3.00}(AsO_4)_2 \cdot 8H_2O$. (3) $Zn_3(AsO_4)_2 \cdot 8H_2O$.

Polymorphism & Series: Forms a series with parasymplesite.

Mineral Group: Vivianite group.

Occurrence: A rare secondary mineral in the oxidation zone of some zinc deposits.

Association: Symplesite, parasymplesite, adamite, legrandite, metaköttigite, gypsum (Ojuela mine, Mexico); pharmacosiderite, legrandite, scorodite, adamite (Sterling Hill, New Jersey, USA); cuprian adamite (Tsumeb, Namibia).

Distribution: In Germany, from the Daniel mine, Schneeberg, Saxony; in the Richelsdorf Mountains, Hesse; at the Michael mine, Weiler, near Lahr, and the Clara mine, near Oberwolfach, Black Forest. At Jáchymov (Joachimsthal) and Příbram, Czech Republic. Large crystal groups from the Ojuela mine, Mapimí, Durango, Mexico. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and in the Clan Alpine Mountains, east side of Stingaree Valley, Churchill Co., Nevada, USA. From Tsumeb, Namibia. In the Ogibira mine, Osa, Okayama Prefecture, Japan. From the Puttapa zinc mine, near Beltana, South Australia.

Name: To honor Otto Köttig (1824–1892), chemist, of Schneeberg, Germany, who published the first description of the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 751–752. (2) Sturman, B.D. (1976) New data for köttigite and parasymplesite. Can. Mineral., 14, 437–441. (3) Cesbron, F., M.-C. Sichère, and H. Vachey (1977) Propriétés cristallographiques et comportment thermique des termes de la série kottigite-parasymplesite. Bull. Soc. fr. Minéral., 100, 310–314 (in French with English abs.). (4) Hill, R.J. (1979) The crystal structure of köttigite. Amer. Mineral., 64, 376–382.

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Kotulskite Pd(Te, Bi)

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Crystal Data: Hexagonal. *Point Group:* n.d. As minute grains included in other minerals.

Physical Properties: Hardness = n.d. VHN = 165–184; 277–322, 291 average (15 g load). D(meas.) = n.d. D(calc.) = 9.18

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, cream or pale yellow. *Luster:* Metallic. *Pleochroism:* Distinct, from pale cream to darker grayish cream. *Anisotropism:* Strong, from gray to dark bluish gray.
R_1–R_2: (400) — , (420) 46.3–46.5, (440) 50.5–52.1, (460) 54.2–57.1, (480) 57.1–61.1, (500) 59.7–64.2, (520) 61.4–66.3, (540) 62.7–67.9, (560) 64.0–69.4, (580) 64.6–70.2, (600) 65.8–71.2, (620) 66.3–72.7, (640) 67.0–72.9, (660) 67.5–73.4, (680) 67.3–73.5, (700) 68.6–74.6

Cell Data: *Space Group:* n.d. $a = 4.145(5)$ $c = 5.67(1)$ Z = [1]

X-ray Powder Pattern: Rustenburg mine, South Africa.
3.03 (100), 2.22 (90), 2.08 (70), 1.52 (30), 1.72 (20), 1.67 (20), 1.32 (10)

Chemistry:

	(1)	(2)	(3)	(4)
Pd	44.3	43.0	45.9	45.47
Pt	2.3			
Bi	1.8	7.0	17.2	
Te	53.5	49.4	38.0	54.53
Total	101.9	99.4	101.1	100.00

(1) Thierry mine, Canada; by electron microprobe, corresponds to $(Pd_{0.97}Pt_{0.03})_{\Sigma=1.00}(Te_{0.98}Bi_{0.02})_{\Sigma=1.00}$. (2) Messina, South Africa; by electron microprobe, corresponds to $Pd_{1.00}(Te_{0.96}Bi_{0.08})_{\Sigma=1.04}$. (3) Rustenburg mine, South Africa; by electron microprobe, corresponds to $Pd_{1.00}(Te_{0.69}Bi_{0.19})_{\Sigma=0.88}$. (4) PdTe.

Occurrence: A minor accessory mineral, of primary or secondary hydrothermal origin, in many Pt–Pd-bearing Cu–Ni deposits in ultramafic rocks.

Polymorphism & Series: Forms a series with sobolevskite.

Association: Sobolevskite, merenskyite, melonite, michenerite, moncheite, braggite, many other Pt–Pd minerals, chalcopyrite, bornite, pentlandite, pyrrhotite, pyrite.

Distribution: Some prominent localities include: in Russia, from the Monchegorsk Cu–Ni deposit, Kola Peninsula [TL]; in the Noril'sk region, western Siberia; from the Lukkulaisvaara layered intrusion, Karelia. In South Africa, at the Rustenburg platinum mine, in the Merensky Reef of the Bushveld complex; and in the Artonvilla mine, Messina, Transvaal. In Canada, in the Levak West and Creighton mines, Sudbury; the Lac des Iles complex; and from the Thierry mine, near Pickle Lake, Ontario. In the Stillwater complex, Montana; at the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming; in the Key West mine, east of Moapa, Bunkerville district, Clark Co., Nevada. In China, at Shiaonanshan, Inner Mongolia, and at Danba, Sichuan Province.

Name: To honor Vladimir Klement'evich Kotul'skii (1879–1949), Russian economic geologist and authority on Cu–Ni sulfide deposits, of the Mining Institute, St. Petersburg, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, Russia, 5966.

References: (1) Genkin, A.D., N.N. Zhuravlev, and E.M. Smirnova (1963) Moncheite and kotulskite – new minerals – and the composition of michenerite. Zap. Vses. Mineral. Obshch., 92, 33–50 (in Russian). (2) (1963) Amer. Mineral., 48, 1181 (abs. ref. 1). (3) Kingston, G.A. (1966) The occurrence of platinoid bismuthotellurides in the Merensky Reef at Rustenburg platinum mine in the western Bushveld. Mineral. Mag., 35, 815–834. (4) Patterson, G.C. and D.H. Watkinson (1984) Metamorphism and supergene alteration of Cu–Ni sulfides, Thierry mine, northwestern Ontario. Can. Mineral., 22, 13–21. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 297.

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Koutekite Cu_5As_2

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Crystal Data: Orthorhombic or hexagonal. *Point Group:* $2/m$ $2/m$ $2/m$ or n.d. In fine grains, to 1 mm, as an intergrowth.

Physical Properties: Hardness = ∼4 VHN = 136–157 (25 g load). D(meas.) = 8.48 D(calc.) = 8.437

Optical Properties: Opaque. *Color:* In polished section, bluish gray. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Strong.
R_1–R_2: (400) — , (420) — , (440) 45.9–46.4, (460) 44.6–43.4, (480) 43.0–41.4, (500) 41.5–39.2, (520) 40.0–37.6, (540) 38.9–36.0, (560) 38.0–34.5, (580) 37.6–33.4, (600) 37.2–32.2, (620) 37.4–31.4, (640) 37.6–30.7, (660) 38.0–30.3, (680) 38.5–29.9, (700) 39.2–29.8

Cell Data: *Space Group: Ibam* $a = 5.995$ $b = 11.58$ $c = 5.49$ Z = 4, or *Space Group:* n.d. $a = 11.54$ $c = 14.36$ Z = 18

X-ray Powder Pattern: Černý Důl mine, Czech Republic (orthorhombic).
2.078 (10), 2.024 (10), 1.994 (10), 1.147 (9), 1.324 (8), 1.197 (8), 1.178 (8)

X-ray Powder Pattern: Daluis, France (hexagonal-7C).
2.090 (FFF), 2.020 (FFF), 1.998 (FFF), 2.45 (mF), 2.16 (mf), 1.791 (f), 1.750 (f)

Chemistry:

	(1)	(2)	(3)
Cu	68.2	67.98	67.95
Fe		0.10	
As	32.5	31.69	32.05
Total	100.7	99.77	100.00

(1) Daluis, France; by electron microprobe. (2) Wasserfall, France; by electron microprobe. (3) Cu_5As_2.

Occurrence: In arsenical copper deposits.

Association: Paxite, arsenic, silver, skutterudite, nickeline, löllingite, chalcocite, algodonite, domeykite, allargentum, kutínaite, calcite.

Distribution: From the Černý Důl mine, Krkonoše (Giant Mountains), Czech Republic [TL]. In France, at Daluis, Alpes-Maritimes; Lautaret, Hautes-Alpes; and Wasserfall, about 20 km northwest of Belfort, Haute-Saône. From Långban, and at the Harstigen mine, near Persberg, Värmland, Sweden. From the Talmessi and Meskani deposits, Anarak district, Iran. In India, at Romehra, Himachal Pradesh. From Mohawk, Keeweenaw Co., Michigan, USA. Also noted from ill-defined localities in Israel and Kazakhstan.

Name: For Jaromir Koutek (1902–1983), Professor of Economic Geology, Charles University, Prague, Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 18269; National Museum of Natural History, Washington, D.C., USA, 162605.

References: (1) Johan, Z. (1958) Koutekite; a new mineral. Nature, 181, 1553–1554. (2) (1958) Amer. Mineral., 43, 794 (abs. ref. 1). (3) Johan, Z. (1960) Koutekite – Cu_2As, ein neues Mineral. Chem. Erde, 20, 217–226 (in German). (4) (1961) Amer. Mineral., 46, 467 (abs. ref. 3). (5) Picot, P. and J. Vernet (1967) Un nouveau gisement de koutekite: Le dôme du Barrot (Alpes Maritimes). Bull. Soc. fr. Minéral., 60, 82–89 (in French). (6) Picot, P. and F. Ruhlmann (1978) Présence d'arséniures de cuivre de haute température dan le granite des Ballons (Vosges méridionales). Bull. Minéral., 101, 563–569 (in French with English abs.). (7) Makovicky, M. and Z. Johan (1978) Reflectivity and microhardness of synthetic and natural koutekite, kutinaite and beta-domeykite. Neues Jahrb. Mineral., Monatsh., 421–432. (8) Liebisch, W. and K. Schubert (1971) Zur Struktur der Mischung Kupfer-Arsen. 23, 231–236 (in German).

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Kovdorskite $Mg_2(PO_4)(OH)\cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rough prismatic crystals, to 2 cm, with measurable {110}, {010}, {580}, {001}, {101}, {111}; granular.

Physical Properties: *Fracture:* Conchoidal to uneven. Hardness = 4 VHN = 420–450 D(meas.) = 2.28 D(calc.) = 2.30

Optical Properties: Transparent to opaque. *Color:* Colorless, pale rose, bright pink, pale blue, may be blue with pink terminations; colorless to pale rose in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $Z \wedge c = 1°$–$3°$. *Dispersion:* $r > v$, very weak.
$\alpha = 1.528(2)$ $\beta = 1.542$ $\gamma = 1.549$ 2V(meas.) = 80°–82°

Cell Data: *Space Group:* $P2_1/c$. $a = 4.74(2)$ $b = 12.90(4)$ $c = 10.35(4)$
$\beta = 102°00(30)'$ Z = 4

X-ray Powder Pattern: Kovdor massif, Russia.
7.96 (100), 2.258 (64), 2.821 (59), 5.44 (46), 4.32 (36), 1.884 (27), 2.658 (25)

Chemistry:

	(1)	(2)
P_2O_5	32.95	33.07
MgO	37.34	37.55
H_2O	29.47	29.38
Total	99.76	100.00

(1) Kovdor massif, Russia. (2) $Mg_2(PO_4)(OH)\cdot 3H_2O$.

Occurrence: A very rare mineral in an explosive breccia pipe cutting an iron ore deposit in a carbonatized ultramafic-alkalic intrusive.

Association: Collinsite, magnesite, dolomite, hydrotalcite, apatite, magnetite, forsterite.

Distribution: From the Kovdor massif, Kola Peninsula, Russia.

Name: For the Kovdor massif, Russia, in which it was first found to occur.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81408.

References: (1) Kapustin, Y.L., A.V. Bykova, and Z.V. Pudovkina (1980) Kovdorskite – a new mineral. Zap. Vses. Mineral. Obshch., 109, 341–347 (in Russian). (2) (1981) Amer. Mineral., 66, 437 (abs. ref. 1). (3) Ovchinnikov, V.E., L.P. Solov'eva, Z.V. Pudovkina, Y.L. Kapustin, and N.V. Belov (1980) The crystal structure of kovdorskite $Mg_2(PO_4)(OH)\cdot 3H_2O$. Doklady Acad. Nauk SSSR, 255, 351–354 (in Russian). (4) Ponomareva, E.V. and N.I. Krasnova (1990) New data on kovdorskite – $Mg_2(PO_4)(OH)\cdot 3H_2O$. Zap. Vses. Mineral. Obshch., 119(6), 92–100 (in Russian with English abs.).

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Kozoite-(La) $La(CO_3)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As rhombic dipyramidal crystals, to 10 μm, in aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.77

Optical Properties: Semitransparent. *Color:* Pale pinkish purple to white. *Luster:* Vitreous to dull.
Optical Class: Biaxial (–) [by analogy to ancylite-(Ce)]. $\alpha = 1.698(2)$ β = n.d. $\gamma = 1.780(5)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* [*Pmcn*] [by analogy to ancylite-(Ce)]. $a = 4.9829(1)$ $b = 8.5188(2)$ $c = 7.2570(2)$ Z = 4

X-ray Powder Pattern: Niikoba, Japan.
4.29 (100), 2.93 (89), 2.333 (78), 2.060 (78), 1.994 (75), 3.69 (72), 2.640 (59)

Chemistry:

	(1)		(1)
CO_2	21.10	Eu_2O_3	1.84
Y_2O_3	0.70	Gd_2O_3	2.99
La_2O_3	21.39	Tb_2O_3	0.11
Ce_2O_3	0.26	Dy_2O_3	0.24
Pr_2O_3	6.25	CaO	0.49
Nd_2O_3	30.66	H_2O	5.44
Sm_2O_3	5.39	Total	96.86

(1) Niikoba, Japan; by electron microprobe, average of six analyses, C and H by CHN analyzer, average of three analyses, $(CO_3)^{2-}$ and $(OH)^{1-}$ confirmed by IR; corresponds to $(Nd_{0.42}La_{0.30}Pr_{0.09}Sm_{0.07}Gd_{0.04}Eu_{0.02}Ca_{0.02}Y_{0.02})_{\Sigma=0.98}(CO_3)_{1.12}[(OH)_{0.68}(H_2O)_{0.23}]_{\Sigma=0.91}$.

Polymorphism & Series: Dimorphous with hydroxylbastnäsite-(Nd).

Occurrence: A rare secondary mineral in fractures in alkali olivine basalt, probably of hydrothermal origin.

Association: Lanthanite-(Nd), kimuraite-(Nd).

Distribution: From Niikoba, Saga Prefecture, Japan.

Name: To honor Kozo Nagashima (1925–1985), Japanese chemist, Tsukuba University, Tsukuba, Japan, pioneer in the study of rare-earth minerals in Japan.

Type Material: National Science Museum, Tokyo, Japan, M27940.

References: (1) Miyawaki, R., S. Matsubara, K. Yokoyama, K. Takeuchi, Y. Terada, and I. Nakai (2000) Kozoite-(Nd), $Nd(CO_3)(OH)$, a new mineral in an alkali olivine basalt from Hizen-cho, Saga Prefecture, Japan. Amer. Mineral., 85, 1076–1081. (2) Dexpert, H. and P. Caro (1974) Determination de la structure cristalline de la variété a des hydroxycarbonates de terres rare $LnOHCO_3$ (Ln=Nd). Materials Research Bull., 9, 1577–1585 (in French with English abs.).

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Kôzulite $\mathbf{NaNa_2[Mn_4^{2+}(Fe^{3+}, Al)]Si_8O_{22}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 3.5 mm, in banded aggregates.

Physical Properties: *Cleavage:* Perfect on {110}. *Tenacity:* [Brittle.] Hardness = 5 D(meas.) = 3.30 D(calc.) = 3.36

Optical Properties: Semitransparent. *Color:* Reddish black to black. *Streak:* Light purplish brown. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = yellow-brown; Y = reddish brown; Z = dark brown. *Orientation:* $Y = b$; $X \wedge c = 25°$. *Dispersion:* $r > v$, weak. *Absorption:* $Z > Y > X$. $\alpha = 1.685$ $\beta = 1.717$ $\gamma = 1.720$ 2V(meas.) = 34°–36°

Cell Data: *Space Group:* $C2/m$. $a = 9.914$ $b = 18.111$ $c = 5.308$ $\beta = 104.50°$ Z = 2

X-ray Powder Pattern: Tanohata mine, Japan.
8.51 (100), 3.15 (65), 2.827 (30), 3.30 (17), 4.53 (10), 3.40 (10), 2.722 (10)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	51.38	49.24	MgO	2.71	0.03
TiO_2		0.00	CaO	1.12	0.11
Al_2O_3	1.69	0.02	Na_2O	8.41	8.91
Fe_2O_3	2.85		K_2O	1.36	0.03
Cr_2O_3		0.03	F	0.08	
FeO		0.06	H_2O^+	2.10	
MnO	27.96	37.06	H_2O^-	0.06	
ZnO	0.03		$-O = F_2$	0.03	
			Total	99.72	95.48

(1) Tanohata mine, Japan; corresponding to $(Na_{2.54}K_{0.27}Ca_{0.19})_{\Sigma=3.00}(Mn_{3.69}Mg_{0.63}Fe^{3+}_{0.33}Al_{0.31})_{\Sigma=4.96}Si_{8.00}O_{21.78}[(OH), F]_{2.22}$. (2) Woods mine, Australia; by electron microprobe.

Mineral Group: Amphibole (alkali) group: $Mn^{2+}/(Mg + Fe^{2+} + Mn^{2+}) > 0.33$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) \geq 0.5$; $(Na + K)_A \geq 0.5$; $Na_B \geq 1.34$; $Mn_C \geq 2.5$.

Occurrence: In metamorphosed manganese-rich sediments along the contact of a granodiorite intrusion (Tanohata mine, Japan).

Association: Braunite, rhodonite, manganiferous alkalic pyroxene, quartz (Tanohata mine, Japan).

Distribution: In the Tanohata and Noda-Tamagawa mines, Iwate Prefecture, Japan. From the Woods mine, 30 km north-northeast of Tamworth, New South Wales, Australia.

Name: To honor Shukusuke Kôzu (1880–1955), Professor at Tohoku University, Sendai, Japan.

Type Material: Tohoku University, Sendai, Japan.

References: (1) Nambu, M., K. Tanida, and T. Kitamura (1969) Kôzulite, a new alkali amphibole from Tanohata mine, Iwate Prefecture, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 62, 311–328. (2) (1970) Amer. Mineral., 55, 1815 (abs. ref. 1). (3) Kitamura, M. and N. Morimoto (1972) Crystal structure of kôzulite and tetrahedral Al in amphiboles. Acta Cryst., A28, S71. (4) Kawachi, Y. and D.S. Coombs (1993) Namansilite, $NaMn^{3+}Si_2O_6$: a widespread clinopyroxene? Mineral. Mag., 57, 533–538.

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Kraisslite

$(Mn^{2+}, Mg)_{24}Zn_3Fe^{3+}(As^{3+}O_3)_2(As^{5+}O_4)_3(SiO_4)_6(OH)_{18}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As thin, curved, compact foliated scales and coarse plates, to 1 cm; in sprays; in veinlets and lenses.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Brittle. Hardness = 3–4
D(meas.) = 3.876 D(calc.) = 3.918

Optical Properties: Translucent. *Color:* Deep coppery brown; rich brown in thin section.
Streak: Golden brown. *Luster:* Submetallic.
Optical Class: Uniaxial (+). $\omega = 1.805(2)$ $\epsilon =$ n.d. ; weak birefringence.

Cell Data: *Space Group:* $P6_322$. $a = 8.22(1)$ $c = 43.88(5)$ Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
2.74 (100), 2.437 (55), 2.194 (55), 4.385 (45), 3.651 (35), 3.13 (20), 1.219 (7)

Chemistry:

	(1)	(2)
SiO_2	13.8	12.9
Al_2O_3	0.21	0.2
Fe_2O_3		2.0
As_2O_3	0.87	6.69
As_2O_5	17.7	10.35
FeO	1.92	
MnO	51.6	52.0
ZnO	8.47	8.6
MgO	2.53	2.6
H_2O	3.68	[3.68]
Total	100.78	[99.02]

(1) Sterling Hill, New Jersey, USA. (2) Do.; by electron microprobe and other chemical tests; average of five analyses, excepting As_2O_3 and As_2O_5 which are averages of three; H_2O from (1); corresponds to $(Mn_{21.96}Mg_{1.90})_{\Sigma=23.86}Zn_{3.16}Fe^{3+}_{0.74}(As^{3+}O_3)_{2.02}(As^{5+}O_4)_{2.70}(SiO_4)_{6.44}(OH)_{18}$.

Occurrence: In the zincite zone, as films and lenses in fractures, probably of secondary origin, in a metamorphosed stratiform zinc deposit.

Association: Zincite, willemite, franklinite, calcite, pyrochroite, barite, sphalerite, rhodochrosite, adelite, holdenite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For Frederick Kraissl, Jr. (1899–1986) and Alice L. Kraissl (1905–1986), of Hackensack, New Jersey, USA, American amateur mineralogists who specialized in Franklin and Sterling Hill minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137017, 137018.

References: (1) Moore, P.B. and J. Ito (1978) Kraisslite, a new platy arsenosilicate from Sterling Hill, New Jersey. Amer. Mineral., 63, 938–940. (2) Dunn, P.J. and J.A. Nelen (1980) Kraisslite and mcgovernite: new chemical data. Amer. Mineral., 65, 957–960.

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Krasnovite $Ba(Al,Mg)(PO_4,CO_3)(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Fibers, elongated along [010], in spherulites, to 3 mm.

Physical Properties: *Cleavage:* Two ∥ [010], perfect. *Fracture:* Fibrous. Hardness = 2 D(meas.) = 3.70(5) D(calc.) = 3.69

Optical Properties: Translucent. *Color:* Pale blue. *Streak:* White. *Luster:* Silky. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$. *Dispersion:* $r > v$, weak. $\alpha = 1.616(2)$ $\beta = 1.629(2)$ $\gamma = 1.640(2)$ 2V(meas.) = 70°–90° 2V(calc.) = 85°

Cell Data: *Space Group:* *Pnnn* or *Pnna*. $a = 8.939(2)$ $b = 5.669(3)$ $c = 11.073(3)$ Z = 4

X-ray Powder Pattern: Kovdor massif, Russia.
2.768 (100), 3.479 (82), 5.54 (79), 2.543 (61), 3.345 (59), 2.072 (41), 2.354 (32)

Chemistry:

	(1)
P_2O_5	19.8
CO_2	[3.55]
Al_2O_3	14.3
FeO	0.3
MgO	1.7
SrO	0.7
BaO	49.1
K_2O	0.05
H_2O	10.5
Total	[100.00]

(1) Kovdor massif, Russia; by electron microprobe, average of three analyses; total Fe as FeO, confirmed by microchemical tests, H_2O by the Penfield method, CO_2 by difference, confirmed by IR; corresponds to $(Ba_{1.00}Sr_{0.02})_{\Sigma=1.02}(Al_{0.88}Mg_{0.13}Fe_{0.01})_{\Sigma=1.02}[(PO_4)_{0.87}(CO_3)_{0.25}]_{\Sigma=1.12}(OH)_{1.85} \cdot 0.90H_2O$.

Occurrence: A very rare mineral from an iron ore deposit in a carbonatized ultramafic-alkalic intrusive.

Association: Dolomite, manasseite, carbonate-apatite, crandallite, barite.

Distribution: From the Iron mine, Kovdor massif, Kola Peninsula, Russia.

Name: Honoring Natal'ya Ivanovna Krasnova (1941–), mineralogist and specialist on the Kovdor massif, St. Petersburg University, St. Petersburg, Russia, in whose collection the first specimen was found.

Type Material: Mining Institute, St. Petersburg, Russia, 2044/1.

References: (1) Britvin, S.N., Y.A. Pakhomovskii, and A.N. Bogdanova (1996) Krasnovite $Ba(Al,Mg)(PO_4,CO_3)(OH)_2 \cdot H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 125(3), 110–112 (in Russian). (2) (1997) Amer. Mineral., 82, 621–622 (abs. ref. 1).

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Kratochvílite $C_{13}H_{10}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. [Crystalline massive.]

Physical Properties: Hardness = n.d. D(meas.) = 1.206 D(calc.) = 1.197 Fluoresces bright blue-violet under SW UV.

Optical Properties: Semitransparent. *Color:* [Colorless.]
Optical Class: Biaxial. $\alpha = 1.557$ $\beta = 1.725$ γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group: Pnam.* $a = 8.50$ $b = 5.71$ $c = 19.00$ $Z = 4$

X-ray Powder Pattern: Synthetic $C_{13}H_{10}$. (ICDD 28-2011).
4.68 (100b), 3.38 (90), 9.39 (70), 4.21 (70b), 2.54 (60), 3.79 (50), 2.45 (50)

Chemistry: (1) Identification depends on the identity of X-ray powder pattern and physical properties with synthetic material (fluorene).

Occurrence: Formed as a result of burning pyritic shale (Kladno, Czech Republic).

Association: n.d.

Distribution: In the Czech Republic, in the Kladno district, at the Nejedlý I coal mine, Libušín. Material from other localities may be the natural analog of fluorene; but the original material perhaps was not.

Name: To honor Professor Josef Kratochvíl (1878–1958), Czech petrographer, Charles University, Prague, Czech Republic.

Type Material: Lost.

References: (1) Rost, R. (1937) The minerals of the burning coal heaps in the vicinity of Kladno. Rozpravy Ceská Ákademie, Kl II, 47(11), 6 pp. (2) (1938) Amer. Mineral., 23, 667 (abs. ref. 1). (3) Witzke, T. (1995) Kratochvilit, $C_{13}H_{10}$ oder $C_{14}H_{10}$? Mineralien-Welt, 6(4), 25 (in German). (4) Brown, G.M. and M.H. Bortner (1954) On the crystal and molecular structure of fluorene. Acta Cryst., 7, 139.

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Krausite $KFe^{3+}(SO_4)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are equant, may be tabular on {001} or short prismatic along [001]. Small crystals may exhibit prominent {110}, with {$\overline{1}$01}, {$\overline{1}$02}, {$\overline{1}$12}, {001}, {100}, {210}, {$\overline{2}$11}; larger crystals, to 5 mm, are typically rough; forms massive crusts.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, good. Hardness = 2.5 D(meas.) = 2.840 D(calc.) = 2.839 Slowly decomposed by H_2O, leaving Fe_2O_3.

Optical Properties: Transparent to opaque. *Color:* Pale lemon-yellow, yellowish green, gray; pale yellow to colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to dull. *Optical Class:* Biaxial (+). *Pleochroism:* Distinct; X = colorless; $Y = Z$ = pale yellow. *Orientation:* $Z = b$; $X \wedge c = -35°$. $\alpha = 1.588$ $\beta = 1.650$ $\gamma = 1.722$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/m$. $a = 7.908$–7.920 $b = 5.152$–5.146 $c = 8.988$–9.014 $\beta = 102.75°$–$102.76°$ Z = 2

X-ray Powder Pattern: Borate, California, USA.
3.09 (100), 4.40 (74), 6.59 (66), 3.69 (64), 4.26 (45), 2.768 (40), 2.579 (38)

Chemistry:

	(1)	(2)	(3)
SO_3	51.05	53.02	52.49
SiO_2	2.19		
Fe_2O_3	24.94	25.90	26.17
FeO	0.24		
CaO	0.12		
Na_2O	0.64		
K_2O	14.71	15.28	15.44
H_2O	5.59	5.80	5.90
insol.	0.92		
Total	100.40	[100.00]	100.00

(1) Borate, California, USA; with estimated 1%–2% impurities including coquimbite, metavoltine, clay. (2) Analysis (1) recalculated to 100% after deduction of impurities; corresponds to $K_{0.98}Fe_{0.98}(SO_4)_{2.00} \cdot 0.98H_2O$. (3) $KFe(SO_4)_2 \cdot H_2O$.

Occurrence: An uncommon secondary mineral in sulfate-bearing cherts (Borate, California, USA); formed on a dump by post-mine oxidation of pyrite (Velardeña mine, Mexico).

Association: Alunite, coquimbite, römerite, voltaite, metavoltine (Borate, California, USA): copiapite, voltaite, halotrichite (Velardeña mine, Mexico).

Distribution: In the USA, in the Sulfur Hole prospect, near Borate, about 10 km northeast of Yermo, Calico Hills, San Bernardino Co., California, and in the Coral Reefs district, Wayne Co., Utah, USA. At the Santa Maria mine, Velardeña, Durango, Mexico. In the Santa Bárbara sulfur mine, El Palmar district, Jujuy Province, Argentina. From Campi Flegrei, near Naples, Campania, Italy.

Name: To honor Dr. Edward Henry Kraus (1875–1973), American mineralogist, Professor of Mineralogy and Crystallography, University of Michigan, Ann Arbor, Michigan, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 96094, R7652.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 462–463. (2) Effenberger, H., F. Pertlik, and J. Zemann (1986) Refinement of the crystal structure of krausite: a mineral with an interpolyhedral oxygen-oxygen contact shorter than the hydrogen bond. Amer. Mineral., 71, 202–205. (3) Graeber, E.J. and A. Rosenzweig (1965) The unit cell of krausite. Amer. Mineral., 50, 504–507. (4) Foshag, W.F. (1931) Krausite, a new sulfate from California. Amer. Mineral., 16, 352–360.

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Krauskopfite $BaSi_2O_4(OH)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As equant to short prismatic grains, subhedral to anhedral, to 6 mm.

Physical Properties: *Cleavage:* Perfect on {010} and {001} intersecting at 90°, with a third poor cleavage at a high angle to the other two. Hardness = ∼4 D(meas.) = 3.14(2) for impure material. D(calc.) = 3.10

Optical Properties: Transparent to translucent. *Color:* White to colorless; colorless in thin section. *Streak:* White. *Luster:* Subvitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y \wedge a = 6°$; $Z \wedge c = 10.5°$. *Dispersion:* $r > v$, distinct. $\alpha = 1.574(2)$ $\beta = 1.587(2)$ $\gamma = 1.599(2)$ 2V(meas.) = 88(5)° 2V(calc.) = 87°42′

Cell Data: *Space Group:* $P2_1/a$. $a = 8.460(5)$ $b = 10.622(6)$ $c = 7.837(4)$ $\beta = 94°32(8)'$ Z = 4

X-ray Powder Pattern: Rush Creek area, California, USA.
3.84 (100), 6.36 (45), 5.34 (45), 3.01 (40), 6.7 (30), 3.94 (30), 3.66 (30)

Chemistry:

	(1)
SiO_2	35.2
TiO_2	0.01
Al_2O_3	0.05
FeO	< 0.01
MnO	< 0.002
MgO	< 0.05
CaO	0.11
SrO	< 0.05
BaO	47.7
K_2O	< 0.1
LOI	16.7
Total	[100.0]

(1) Rush Creek area, California, USA; by D-C arc spectrography, loss on ignition taken as H_2O; stated to be recalculated to 100.0%; corresponds to $(Ba_{1.03}K_{0.01}Ca_{0.01})_{\Sigma=1.05}Si_{1.95}O_{3.95}(OH)_2 \cdot 2.08H_2O$.

Occurrence: In veins cutting sanbornite-quartz-bearing gneissic metamorphic rocks.

Association: Macdonaldite, "opal," witherite, sanbornite, quartz (Rush Creek area, California, USA).

Distribution: In the USA, in Calfornia, from the [Esquire No. 1 claim,] Rush Creek area, Fresno Co., in Chickencoop Canyon, Tulare Co., and on Trumbull Peak, near Incline, Mariposa Co.

Name: For Konrad Bates Krauskopf (1910–), Professor of Geochemistry, Stanford University, Palo Alto, California, USA.

Type Material: n.d.

References: (1) Alfors, J.T., M.C. Stinson, R.A. Matthews, and A. Pabst (1965) Seven new barium minerals from eastern Fresno County, California. Amer. Mineral., 50, 314–340. (2) Coda, A., A. Dal Negro, and G. Rossi (1967) The crystal structure of krauskopfite. Atti Rend. Accad. Lincei, 42(6), 859–873. (3) (1968) Chem. Abs., 69, 46894 (abs. ref. 2).

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Krautite $Mn^{2+}(AsO_3OH)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. As thin lamellae, to 2 mm; in fan-shaped aggregates.

Physical Properties: *Cleavage:* Perfect micaceous, on {010}; good on $\{\bar{1}01]\}$; distinct on {101}. *Tenacity:* Brittle. Hardness = < 4 D(meas.) = 3.30(2) D(calc.) = 3.274 Capable of absorbing organic compounds between structural layers.

Optical Properties: Translucent. *Color:* Pale rose. *Streak:* White with a faint rose tint. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z \wedge \{\bar{1}01\} = 16°$. $\alpha = 1.620(2)$ $\beta = 1.639(2)$ $\gamma = 1.686(2)$ 2V(meas.) = 65(5)°

Cell Data: *Space Group:* $P2_1$ (synthetic). $a = 8.012(2)$ $b = 15.956(4)$ $c = 6.801(2)$ $\beta = 96.60(3)°$ Z = 8

X-ray Powder Pattern: Săcărîmb, Romania.
7.96 (10), 3.84 (7), 3.17 (7), 3.27 (5), 2.480 (4), 3.96 (3), 2.730 (3)

Chemistry:

	(1)	(2)
As_2O_5	53.7	53.98
MnO	33.0	33.32
H_2O	12.8	12.70
Total	99.5	100.00

(1) Săcărîmb, Romania; corresponds to $Mn_{0.99}(AsO_3OH)_{1.00}\cdot 1.52H_2O$. (2) $Mn(AsO_3OH)\cdot H_2O$.

Occurrence: Found on museum mineral specimens.

Association: Rhodochrosite, nagyágite, quartz (Săcărîmb, Romania).

Distribution: From Săcărîmb (Nagyág) and Cavnic (Kapnikbánya), Romania. At Jáchymov (Joachimsthal), Czech Republic.

Name: Honors Dr. François Kraut, mineralogist, Natural History Museum, Paris, France.

Type Material: National School of Mines, Paris, France, 100329, 132295; Natural History Museum, Vienna, Austria, J8927; National Museum of Natural History, Washington, D.C., USA, R10961.

References: (1) Fontan, F., M. Orliac, and F. Permingeat (1975) La krautite $MnHAsO_4\cdot H_2O$, une nouvelle espèce minérale. Bull. Minéral., 98, 78–84 (in French with English abs.). (2) (1976) Amer. Mineral., 61, 503 (abs. ref. 1). (3) Catti, M. and M. Franchini-Angela (1979) Krautite, $Mn(H_2O)(AsO_3OH)$: crystal structure, hydrogen bonding and relations with haidingerite and pharmacolite. Amer. Mineral., 64, 1248–1254. (4) Beneke, K. and G. Lagaly (1981) Krautite, $MnHAsO_4\cdot H_2O$ – an intracrystalline reactive mineral. Amer. Mineral., 66, 432–435.

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Kremersite $(NH_4, K)_2Fe^{3+}Cl_5 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals pseudo-octahedral, with balanced {011} and {210}.

Physical Properties: *Cleavage:* Perfect on $\{21\overline{1}\}$ and {011}. Hardness = n.d. D(meas.) = 2.175 (synthetic). D(calc.) = [2.13] Easily soluble in H_2O; very deliquescent.

Optical Properties: Translucent. *Color:* Ruby-red to red, brownish red; red-brown or yellowish in transmitted light. *Luster:* Vitreous.
Optical Class: [Biaxial (+)] (by analogy to erythrosiderite). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = [1.733]$ $\beta = [1.763]$ $\gamma = [1.807]$ 2V(meas.) = [70°]

Cell Data: *Space Group: Pnma.* $a = 13.78$ $b = 9.85$ $c = 7.09$ $Z = 4$

X-ray Powder Pattern: Synthetic $(NH_4, K)_2FeCl_5 \cdot H_2O$ with NH_4:K ~1:1.
2.800 (100), 5.72 (80), 2.451 (65), 2.794 (60), 5.61 (55), 2.783 (55), 4.900 (40)

Chemistry:

	(1)	(2)
Na	0.16	
K	12.07	
NH_4	6.17	12.56
Fe	16.89	19.44
Cl	55.15	61.73
H_2O	[9.56]	6.27
Total	[100.00]	100.00

(1) Vesuvius, Italy. (2) $(NH_4, K)_2FeCl_5 \cdot H_2O$ with NH_4:K = 1:1.

Occurrence: As sublimates around fumaroles.

Association: Erythrosiderite, molysite, hematite (Vesuvius, Italy); erythrosiderite (Kliuchevsky volcano, Russia).

Distribution: On Vesuvius, Campania, Italy. From the Kliuchevsky volcano, Kamchatka Peninsula, and at Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia.

Name: Honors the German chemist, Peter Kremers (1827–?), who analyzed the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 101–103. (2) (1977) NBS Mono. 25, 14, 8. (3) Fleischer, M., R.E. Wilcox, and J.J. Matzko (1984) Microscopic determination of the nonopaque minerals. U.S. Geol. Sur. Bull. 1627, 187.

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Krennerite $(Au, Ag)Te_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals typically short prismatic and striated ‖ [001], to 1 cm.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 2–3 VHN = 138–192 (100 g load). D(meas.) = 8.62 D(calc.) = 8.86

Optical Properties: Opaque. *Color:* Silver-white to pale brass-yellow (tarnish ?); in polished section, creamy white. *Luster:* Very high metallic. *Pleochroism:* Weak. *Anisotropism:* Strong, to dark brown.
R_1–R_2: (400) 44.4–50.3, (420) 46.8–52.5, (440) 49.1–54.6, (460) 51.1–56.4, (480) 52.6–57.7, (500) 53.7–58.7, (520) 56.4–59.4, (540) 55.1–59.9, (560) 55.6–60.3, (580) 56.0–60.6, (600) 56.4–60.7, (620) 56.7–60.8, (640) 57.0–60.9, (660) 57.2–60.9, (680) 57.3–60.9, (700) 57.4–60.8

Cell Data: *Space Group:* $Pma2$. $a = 16.58(1)$ $b = 8.849(5)$ $c = 4.464(3)$ $Z = 8$

X-ray Powder Pattern: Cripple Creek, Colorado, USA.
3.03 (10), 2.11 (7), 2.94 (6), 2.23 (5), 2.07 (4), 1.78 (4), 1.69 (4)

Chemistry:

	(1)	(2)	(3)	(4)
Au	43.86	36.19	34.77	43.56
Ag	0.46	4.87	5.87	
Fe		0.05		
Te	55.68	58.50	58.60	56.44
insol.		0.09	1.58	
Total	100.00	99.70	100.82	100.00

(1) Cripple Creek, Colorado, USA; corresponds to $(Au_{1.02}Ag_{0.02})_{\Sigma=1.04}Te_{2.00}$. (2) Moose mine, Cripple Creek, Colorado, USA; Fe is from pyrite; corresponds to $(Au_{0.80}Ag_{0.20})_{\Sigma=1.00}Te_{2.00}$. (3) Săcărîmb, Romania; corresponds to $(Au_{0.77}Ag_{0.24})_{\Sigma=1.01}Te_{2.00}$. (4) $AuTe_2$.

Polymorphism & Series: Dimorphous with calaverite.

Occurrence: In hydrothermal veins with other tellurides.

Association: Calaverite, coloradoite, sylvanite, krennerite, petzite, hessite, tellurium, gold, pyrite, quartz.

Distribution: In Romania, from Săcărîmb (Nagyág) [TL] and Faţa Băii (Facebánya). In the Konstantin-Ovkoye gold deposit, Krasnoyarskii region, and the Bereznyakov gold deposit, Southern Ural Mountains, Russia. From the Zhana-Tyube Au–Te deposit, northern Kazakhstan. In the USA, in Colorado, at several mines in Cripple Creek, Teller Co.; the Smoky Hill mine, Boulder Co.; the Central City district, Gilpin Co., and several other minor localities; in the Campbell mine, Bisbee, and at Tombstone, Cochise Co., Arizona; from the Golden Sunlight mine, near Whitehall, Jefferson Co., Montana. In Canada, at the Bencourt mine, Louvricourt, Quebec. At Kalgoorlie and Mulgabbie, Western Australia. From the Emperor mine, Vatukoula, and in the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands. In the Date mine, Hokkaido, and at the Susaki mine, Shizuoka Prefecture, Japan.

Name: For József A. Krenner (1839–1920), Hungarian mineralogist who first noted the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 333–335. (2) Tunell, G. and K.J. Murata (1950) The atomic arrangement and chemical composition of krennerite. Amer. Mineral., 35, 959–984. (3) Pertlik, F. (1984) Crystal chemistry of natural tellurides. II: Redetermination of the crystal structure of krennerite, $(Au_{1-x}Ag_x)Te_2$ with x ∼0.2. Tschermaks Mineral. Petrog. Mitt., 33, 253–262. (4) Van Tendeloo, G., S. Amelinckx, and P. Gregoriades (1984) Electron microscopic studies of modulated structures in $(Au, Ag)Te_2$. III. Krennerite. J. Solid State Chem., 53, 281–289. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 427–428. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 301.

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Krettnichite $PbMn_2^{3+}(VO_4)_2(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Compact, with a felted lamellar to microscopically spherulitic texture.

Physical Properties: Hardness = n.d. D(meas.) = 1.92 D(calc.) = 1.95

Optical Properties: Translucent. *Color:* White. *Luster:* Dull.
Optical Class: Biaxial. $n = 1.484$; birefringence 0.002.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 18.126(25)$ $b = 13.519(225)$ $c = 7.500(13)$
$\alpha = 70°30(7)'$ $\beta = 117°52(7)'$ $\gamma = 136°35(7)'$ Z = 2

X-ray Powder Pattern: Kristineberg mine, Sweden.
11.57 (100), 5.02 (23), 6.62 (20), 2.863 (14), 5.37 (12), 5.72 (8), 2.930 (5)

Chemistry:

	(1)	(2)
SO_3	13.05	12.20
P_2O_5	31.27	32.46
Al_2O_3	38.45	38.86
MgO	0.02	
H_2O	17.22	16.48
Total	100.01	100.00

(1) Kristineberg mine, Sweden. (2) $Al_5(PO_4)_3(SO_4)(OH)_4 \bullet 4H_2O$.

Occurrence: Filling fractures in cupriferous pyrite.

Association: Pyrite.

Distribution: From the Kristineberg mine, Västerbotten, Sweden.

Name: A contraction of the type locality, the KRIstineBERG mine, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, RM450003.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1011. (2) de Abeledo, M.E.J., V. Angelelli, M.A.R. de Benyacar, and C. Gordillo (1968) Sanjuanite, a new hydrated basic sulfate-phosphate of aluminum. Amer. Mineral., 53, 1–8. (3) de Bruiyn, H., G.J. Beukes, W.A. van der Westhuizen, and E.A.W. Tordiffe (1989) Unit cell dimensions of the hydrated aluminium phosphate-sulphate minerals sanjuanite, kribergite, and hotsonite. Mineral. Mag., 53, 385–386.

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$ or 1. Compact, with a felted lamellar to microscopically spherulitic texture.

Physical Properties: Hardness = n.d. D(meas.) = 1.92 D(calc.) = 1.95

Optical Properties: Translucent. *Color:* White. *Luster:* Dull.
Optical Class: Biaxial. $n = 1.484$; birefringence 0.002.

Cell Data: *Space Group:* $P\bar{1}$ or $P1$. $a = 18.126(25)$ $b = 13.519(225)$ $c = 7.500(13)$
$\alpha = 70°30(7)'$ $\beta = 117°52(7)'$ $\gamma = 136°35(7)'$ Z = 2

X-ray Powder Pattern: Kristineberg mine, Sweden.
11.57 (100), 5.02 (23), 6.62 (20), 2.863 (14), 5.37 (12), 5.72 (8), 2.930 (5)

Chemistry:

	(1)	(2)
SO_3	13.05	12.20
P_2O_5	31.27	32.46
Al_2O_3	38.45	38.86
MgO	0.02	
H_2O	17.22	16.48
Total	100.01	100.00

(1) Kristineberg mine, Sweden. (2) $Al_5(PO_4)_3(SO_4)(OH)_4 \cdot 4H_2O$.

Occurrence: Filling fractures in cupriferous pyrite.

Association: Pyrite.

Distribution: From the Kristineberg mine, Västerbotten, Sweden.

Name: A contraction of the type locality, the KRIstineBERG mine, Sweden.

Type Material: Museum of Natural History, Stockholm, Sweden, RM450003.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1011. (2) de Abeledo, M.E.J., V. Angelelli, M.A.R. de Benyacar, and C. Gordillo (1968) Sanjuanite, a new hydrated basic sulfate-phosphate of aluminum. Amer. Mineral., 53, 1–8. (3) de Bruiyn, H., G.J. Beukes, W.A. van der Westhuizen, and E.A.W. Tordiffe (1989) Unit cell dimensions of the hydrated aluminium phosphate-sulphate minerals sanjuanite, kribergite, and hotsonite. Mineral. Mag., 53, 385–386.

Krinovite $Na_2Mg_4Cr_2^{3+}Si_6O_{20}$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\bar{1}$. As disseminated subhedral grains, to 200 μm. *Twinning:* Multiple twinning common.

Physical Properties: Hardness = 5.5–7 D(meas.) = 3.38 D(calc.) = 3.44

Optical Properties: Semitransparent. *Color:* Deep emerald-green. *Optical Class:* Biaxial (+). *Pleochroism:* Intense; X = yellow-green; Y = blue-green; Z = greenish black, may be an anomalous dark reddish brown. *Orientation:* $X = b$. $\alpha = 1.712(2)$ $\beta = 1.725(2)$ $\gamma = 1.760(5)$ 2V(meas.) = 61(2)° 2V(calc.) = 64°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.238(4)$ $b = 10.642(4)$ $c = 8.780(3)$ $\alpha = 105.15(3)°$ $\beta = 96.50(4)°$ $\gamma = 125.15(3)°$ Z = 2

X-ray Powder Pattern: Canyon Diablo meteorite.
2.501 (100), 2.655 (90), 2.893 (80), 2.080 (70), 7.92 (60), 3.639 (60), 3.104 (60)

Chemistry:

	(1)	(2)
SiO_2	48.1	49.00
TiO_2	0.5	
Al_2O_3	0.6	
Cr_2O_3	19.1	20.66
FeO	1.8	
MnO	0.1	
MgO	19.7	21.91
CaO	0.1	
Na_2O	9.1	8.43
K_2O	0.0	
Total	99.1	100.00

(1) Canyon Diablo meteorite; by electron microprobe. (2) $Na_2Mg_4Cr_2Si_6O_{20}$.

Mineral Group: Aenigmatite group.

Occurrence: Disseminated within graphite nodules in some octahedrite iron meteorites.

Association: Graphite, roedderite, high albite, richterite, forsterite, kosmochlor, chromite.

Distribution: In the Canyon Diablo, Wichita County, and Youndegin meteorites.

Name: For Evgeny Leonidovich Krinov, noted Russian investigator of meteorites.

Type Material: n.d.

References: (1) Olsen, E. and L. Fuchs (1968) Krinovite, $NaMg_2CrSi_3O_{10}$: a new meteorite mineral. Science, 161, 786–787. (2) (1969) Amer. Mineral., 54, 578 (abs. ref. 1). (3) Bonaccorsi, E., S. Merlino, and M. Pasero (1989) The crystal structure of the meteoritic mineral krinovite, $NaMg_2CrSi_3O_{10}$. Zeits. Krist., 187, 133–138.

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Krivovichevite $Pb_3[Al(OH)_6](SO_4)(OH)$

Crystal Data: Hexagonal. *Point Group*: 3*m*. Grains, to 1 cm, are equant.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 3 D(meas.) = n.d. D(calc.) = 5.37 Easily soluble in water.

Optical Properties: Transparent to translucent. *Color*: Pale gray to colorless. *Streak*: White. *Luster*: Vitreous.
Optical Class: Uniaxial (-). *n*(meas.) ≈ 1.9 *n*(calc.) = 1.85

Cell Data: *Space Group*: *R*3*c*. *a* = 7.742(9) *c* = 32.082(9) *Z* = 6

X-ray Powder Pattern: Mt. Lepkhe-Nelm, Lovozero alkaline massif, Kola Peninsula, Russia. 3.58 (100), 2.591 (90), 1.704 (80), 2.048 (70), 3.10 (60), 2.216 (50), 1.893 (50)

Chemistry:

	(1)	(2)
PbO	76.49	77.53
CaO	0.02	
Al_2O_3	5.38	5.90
SO_3	9.27	9.27
H_2O	7.20	7.30
Total	98.36	100.00

(1) Mt. Lepkhe-Nelm, Lovozero alkaline massif, Kola Peninsula, Russia; average of 5 electron microprobe analyses, H_2O by Penfield method, SO_4 and OH groups confirmed by IR spectroscopy; corresponding to $Pb_{3.04}Al_{0.94}(S_{1.03}O_{3.98})(OH)_{7.08}$. (2) $Pb_3Al(SO_4)(OH)_7$.

Occurrence: A low-temperature hydrothermal alteration product of galena and natrolite by oxidizing solutions in a zoned pegmatite vein within lujavrite. Possibly a metastable ephemeral phase that forms in the early stages of oxidation of galena prior to a transformation to stable plumbojarosite–hinsdalite-like phases.

Association: Galena, anglesite, cerrusite, hydrocerussite, lanarkite, leadhillite.

Distribution: From Mt. Lepkhe-Nelm, Lovozero alkaline massif, Kola Peninsula, Russia.

Name: Honors Sergey Vladimirovich Krivovichev (b. 1972), Professor of mineralogy and crystallography, St. Petersburg State University, Russia, for his contributions to the mineralogy of alkaline massifs and the structural mineralogy of sulfate and lead minerals.

Type Material: Mineralogical Museum, St. Petersburg State University and the Geological and Mineralogical Museum, Geological Institute of the Kola Science Center, Academy of Sciences, Apatity, Russia (no. 6281/1.07.2005).

References: (1) Yakovenchuk, V.N., Y.A. Pakhomovsky, Y.P. Men'shikov, J.A. Mikhailova, G.Yu. Ivanyuk, and O.A. Zalkind (2007) Krivovichevite, $Pb_3[Al(OH)_6](SO_4)(OH)$, a new mineral species from the Lovozero Alkaline Massif, Kola Peninsula, Russia. Can. Mineral., 45, 451-456. (2) (2007) Amer. Mineral., 92, 1777-1778 (abs. ref. 1). (3) Krivovichev, S. V., T. Armbruster and V. N. Yakovenchuk (2009) The crystal structure of krivovichevite, $Pb_3[Al(OH)_6](SO_4)(OH)$. Can. Mineral., 47, 153-158.

Kröhnkite $Na_2Cu(SO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are pseudo-octahedral, equant to short prismatic along [001] or [100], to 7 cm; typically they exhibit {110}, {011}, {010}, {021}, $\{\overline{1}11\}$, with over two dozen more forms recorded. In crusts and aggregates, granular, massive. *Twinning:* Common on {101}, may be heart-shaped.

Physical Properties: *Cleavage:* Perfect on {010}; poor on $\{\overline{1}01\}$. *Fracture:* Conchoidal. Hardness = 2.5–3 D(meas.) = 2.90 D(calc.) = 2.913 Easily soluble in H_2O.

Optical Properties: Transparent. *Color:* Sky-blue to pale blue or greenish blue, becoming green and opaque on exposure; pale blue to colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 48°$. *Dispersion:* $r < v$, weak, inclined. $\alpha = 1.544$ $\beta = 1.578$ $\gamma = 1.601$ 2V(meas.) = 78°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.807(1)$ $b = 12.656(2)$ $c = 5.517(1)$ $\beta = 108.32(1)°$ Z = 2

X-ray Powder Pattern: Chuquicamata, Chile. (ICDD 11-90).
6.33 (100), 3.278 (90), 2.757 (90), 2.925 (80), 3.715 (60), 4.145 (40), 3.099 (40)

Chemistry:

	(1)	(2)
SO_3	47.60	47.42
CuO	23.25	23.56
Na_2O	18.89	18.35
H_2O	10.72	10.67
Total	100.46	100.00

(1) Chuquicamata, Chile. (2) $Na_2Cu(SO_4)_2 \cdot 2H_2O$.

Occurrence: An uncommon secondary mineral formed in the oxidized zone of copper deposits, typically in very arid climates.

Association: Atacamite, blödite, chalcanthite, antlerite, natrochalcite (Chuquicamata, Chile).

Distribution: In Chile, abundantly and in large crystals from Chuquicamata, at Quetena, west of Calama, and at Collahuasi, Antofagasta; from El Cobre de Mejillones and in the Incahuasi district, Atacama. In Wheal Hazard, St. Just, Cornwall, England. From the Recsk copper deposit, Mátra Mountains, Hungary. At Capo Calamita, Elba, Italy. From Broken Hill, New South Wales, Australia.

Name: Honoring B. Kröhnke, who provided the first analysis of the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 444–446. (2) Hawthorne, F.C. and R.B. Ferguson (1975) Refinement of the crystal structure of kröhnkite. Acta Cryst., 31, 1753–1755.

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Krupkaite $PbCuBi_3S_6$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Typically as fibrous aggregates of parallel intergrowths with other bismuthinite–aikinite minerals.

Physical Properties: Hardness = n.d. VHN = 148–188 (100 g load). D(meas.) = n.d. D(calc.) = 6.98

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, grayish white. *Luster:* Metallic.
R_1–R_2: (400) 39.8–46.9, (420) 40.0–46.7, (440) 40.1–46.3, (460) 40.2–46.2, (480) 40.1–46.3, (500) 39.9–46.5, (520) 39.7–46.7, (540) 39.4–46.9, (560) 39.1–47.0, (580) 38.9–46.9, (600) 38.8–46.8, (620) 38.6–46.5, (640) 38.3–46.2, (660) 38.0–45.8, (680) 37.8–45.4, (700) 37.5–44.8

Cell Data: *Space Group:* $Pb2_1m$ $a = 11.200(9)$ $b = 11.560(9)$ $c = 4.003(3)$ $Z = 2$

X-ray Powder Pattern: Juno mine, Australia.
3.137 (100), 2.841 (37), 3.645 (30), 3.160 (27), 2.660 (26), 1.970 (26), 3.552 (24)

Chemistry:

	(1)	(2)	(3)
Pb	19.9	19.3	19.01
Cu	4.6	5.95	5.83
Bi	57.4	59.8	57.51
Se		0.95	
S	18.0	17.25	17.65
Total	[99.9]	103.25	100.00

(1) Krupka, Czech Republic; by electron microprobe, average of three analyses; corresponds to $Pb_{1.03}Cu_{0.77}Bi_{2.94}S_{6.00}$. (2) Juno mine, Australia; by electron microprobe, corresponds to $Pb_{1.02}Cu_{1.02}Bi_{3.12}(S_{5.87}Se_{0.13})_{\Sigma=6.00}$. (3) $PbCuBi_3S_6$.

Occurrence: Rare in hydrothermal veins.

Association: Gladite, bismuthinite, aikinite, bismuth, cassiterite, quartz.

Distribution: In the Czech Republic, from the Barbora gallery, Krupka, Krušné hory Mountains [TL] and at Bohutin, near Příbram. At Dobšiná (Dobschau), Slovakia. From Ocna de Fier (Morávicza; Vaskő); Baia Borşa, Baia Mare (Nagybánya); and Sasca Montană, Romania. At the Zidarovo copper deposit, Bulgaria. In Austria, in the Waschgang Au–Cu deposit, Goldberg Mountains, Upper Carinthia, and from the Felbertal tungsten mine, Salzburg. In the Loch Shin monzogranite, near Lairg, Scotland. From the Carrock mine, Caldbeck Fells, Cumbria, England. From Inkur, Transbaikal, Russia. At the Funiushan copper skarn, near Nanjing, Jiangsu Province, China. From Australia, in the Juno mine, Tennant Creek, Northern Territory. At Temiskaming, Quebec, Canada. In the USA, from Cucomungo Spring, Tule Canyon district, Esmeralda Co., Nevada; in Ball's mine, Little Cottonwood district, Salt Lake Co., Utah; and at the Alice mine, Alice district, Clear Creek Co., Colorado. At the Cordón do los Galeses, Andes Mountains, Chubut Province, Argentina.

Name: For the locality in the Czech Republic at Krupka.

Type Material: Charles University, Prague, Czech Republic, 14522.

References: (1) Žák, L., V. Syneček, and J. Hybler (1974) Krupkaite, $CuPbBi_3S_6$, a new mineral of the bismuthinite–aikinite group. Neues Jahrb. Mineral., Monatsh., 533–541. (2) Syneček, V. and J. Hybler (1974) The crystal structure of krupkaite, $CuPbBi_3S_6$, and of gladite, $CuPbBi_5S_9$, and the classification of superstructures in the bismuthinite–aikinite group. Neues Jahrb. Mineral., Monatsh., 541–560. (3) (1975) Amer. Mineral., 60, 737 (abs. refs. 1
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and 2). (4) Mumme, W.G. (1975) The crystal structure of krupkaite, $CuPbBi_3S_6$, from the Juno mine at Tennant Creek, Northern Territory, Australia. Amer. Mineral., 60, 300–308. (5) Topa, D., E. Makovicky, and W.H. Paar (2002) Composition ranges and exolution pairs for the members of the bismuthinite–aikinite series from Felbertal, Austria. Can. Mineral., 40, 849–869. (6) Topa, D., E. Makovicky, and T. Balić-Žunić (2002) The structural role of excess Cu and Pb in gladite and krupkaite based on new refinements of their structure. Can. Mineral., 40, 1147–1159. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 302.

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Kruťaite $(Cu, Co, Ni)Se_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As zoned crystals, to 1 cm, and as inclusions in clausthalite.

Physical Properties: Hardness = n.d. VHN = 248 (25 g load). D(meas.) = n.d. D(calc.) = 6.53

Optical Properties: Opaque. *Color:* Gray. *Luster:* Metallic. *Anisotropism:* Zones rich in Co and Ni are anisotropic in yellow-brown tints.
R: (400) 33.8, (420) 34.2, (440) 34.4, (460) 34.4, (480) 34.2, (500) 33.6, (520) 33.0, (540) 32.3, (560) 31.4, (580) 30.6, (600) 29.7, (620) 29.0, (640) 28.3, (660) 28.0, (680) 28.0, (700) 28.4
R: (400) 38.1, (420) 38.5, (440) 38.8, (460) 39.2, (480) 39.3, (500) 39.3, (520) 39.2, (540) 39.0, (560) 38.7, (580) 38.4, (600) 38.0, (620) 37.7, (640) 37.3, (660) 37.0, (680) 36.7, (700) 36.5

Cell Data: *Space Group: Pa*3. $a = 6.056$ $Z = 4$

X-ray Powder Pattern: Petrovice, Czech Republic.
2.712 (100), 3.023 (90), 2.477 (80), 1.827 (60), 1.678 (40), 1.166 (40), 1.618 (30)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	20.6	17.9	24.7	28.69
Co	4.8	2.2	2.4	
Ni	1.5	8.9	1.3	
Fe	0.6	0.1	0.2	
Hg	0.2			
Se	69.5	71.7	71.5	71.31
Total	97.2	100.8	100.1	100.00

(1) Petrovice, Czech Republic; by electron microprobe, corresponding to $(Cu_{0.74}Co_{0.18}Ni_{0.06}Fe_{0.02})_{\Sigma=1.00}Se_{2.00}$. (2) El Dragon mine, Bolivia; by electron microprobe, corresponding to $(Cu_{0.62}Ni_{0.33}Ni_{0.08})_{\Sigma=1.03}Se_{2.00}$. (3) Slavkovice, Czech Republic; by electron microprobe, corresponding to $(Cu_{0.86}Co_{0.09}Ni_{0.05}Fe_{0.01})_{\Sigma=1.01}Se_{2.00}$. (4) $CuSe_2$.

Mineral Group: Pyrite group.

Occurrence: Of hydrothermal origin.

Association: Clausthalite, eskebornite, uraninite, hematite, ferroselite, bukovite, umangite, berzelianite, chalcopyrite, goethite.

Distribution: In the Czech Republic, from the Petrovice uranium deposit, near Ždăr [TL] and at Slavkovice. In the El Dragón mine, Potosí, Bolivia. From Tuminico, Sierra de Cacho, and at Los Llantenes, La Rioja Province, Argentina.

Name: For Dr. Tomáš Kruťa (1906–), Director of the Mineralogy Laboratory, Moravian Museum, Brno, Czech Republic.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, R. Pierrot, and M. Kvaček (1972) La krutaïte, $CuSe_2$, un nouveau minéral du groupe de la pyrite. Bull. Soc. fr. Minéral., 95, 475–481 (in French with English abs.). (2) (1974) Amer. Mineral., 59, 210 (abs. ref. 1). (3) Grundmann, G., G. Lehrberger, and G. Schnorrer-Köhler (1990) The El Dragón mine, Potosí, Bolivia. Mineral. Record, 21, 133–146, esp. 137–138. (4) Yashunsky, Y.V., S.D. Rasulova, G.I. Necheljustov, E.G. Rjabeva, andS.A. Batulin (1996) New data on Krutaite, $CuSe_2$. Zap. Vses. Mineral. Obshch., 125.3, 60–66. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 303, 304.

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Krutovite $NiAs_2$

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Crystal Data: Cubic. *Point Group:* 23. As grains, to 0.1 mm, in close intergrowth with other sulfides.

Physical Properties: Hardness = 5.5 VHN = 624–633; 645–760, 719 average. D(meas.) = n.d. D(calc.) = [7.08–7.12]

Optical Properties: Opaque. *Color:* Pale gray, paler than associated nickel-skutterudite; in polished section, bright white with a rose tint. *Luster:* Metallic.
R: (400) — , (420) — , (440) 66.2, (460) 65.4, (480) — , (500) 64.0, (520) — , (540) 64.7, (560) — , (580) 65.7, (600) — , (620) 66.7, (640) — , (660) 66.8, (680) — , (700) 66.8

Cell Data: *Space Group:* $P2_13$. $a = 5.786–5.794$ $Z = 4$

X-ray Powder Pattern: Jáchymov, Czech Republic.
2.593 (10), 2.365 (8), 1.746 (8), 2.897 (6), 1.548 (6), 1.0242 (6), 2.051 (5)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	24.98	26.74	25.04	28.15
Co	0.22	0.30	1.65	
Fe	0.15	0.21	0.26	
Cu	0.86	0.85		
As	73.37	71.94	72.37	71.85
Sb			0.08	
S	0.19	0.15	0.02	
Total	99.65	100.19	99.42	100.00

(1) Jáchymov, Czech Republic; by electron microprobe, average of 32 analyses; corresponds to $(Ni_{0.87}Cu_{0.03}Co_{0.01})_{\Sigma=0.91}As_{2.00}$. (2) Do.; by electron microprobe, average of 31 analyses; corresponds to $(Ni_{0.94}Cu_{0.03}Co_{0.01}Fe_{0.01})_{\Sigma=0.99}(As_{1.99}S_{0.01})_{\Sigma=1.00}$. (3) Khovu-Aksy deposit, Russia; by electron microprobe, average of 10 analyses; corresponds to $(Ni_{0.88}Co_{0.03}Fe_{0.01})_{\Sigma=0.92}As_{2.00}$. (4) $NiAs_2$.

Polymorphism & Series: Trimorphous with rammelsbergite and pararammelsbergite.

Occurrence: In Co–Ni–As sulfide veins of hydrothermal origin.

Association: Nickel-skutterudite, tennantite (Jáchymov, Czech Republic); nickeline, breithauptite, löllingite, nickel-skutterudite, rammelsbergite, pararammelsbergite, silver (Khovu-Aksy deposit, Russia).

Distribution: From the Geshiber vein, Jáchymov (Joachimsthal), Czech Republic [TL]. At the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, Russia.

Name: For Georgi Alekseevich Krutov (1902–1989), Professor of Mineralogy, Moscow State University, Moscow, Russia.

Type Material: National Museum, Prague, Czech Republic, 61625; Mining Institute, St. Petersburg; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Vinogradova, R.A., N.S. Rudashevskii, I.A. Bud'ko, L.I. Bochek, P. Kaspar, and K. Padera (1976) Krutovite – a new cubic nickel diarsenide. Zap. Vses. Mineral. Obshch., 105, 59–71 (in Russian). (2) (1977) Amer. Mineral., 62, 173–174 (abs. ref. 1). (3) Vinogradova, R.A., N.S. Rudashevskii, L.I. Bochek, and I.A. Bud'ko (1976) First discovery of krutovite in the USSR. Doklady Acad. Nauk SSSR, 230, 938–941 (in Russian).

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Kryzhanovskite $Mn^{2+}Fe_2^{3+}(PO_4)_2(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are typically rough pseudo-octahedra, prismatic or as plates flattened on {010}, to 5 cm; may be granular.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven. Hardness = 3.5–4 D(meas.) = 3.31 D(calc.) = 3.35–3.46

Optical Properties: Translucent. *Color:* Deep red-brown, dark blackish brown to light golden-brown, bronze on cleavage surfaces. *Streak:* Yellowish brown. *Luster:* Vitreous to dull. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = wine-yellow; Y = orange-brown; Z = reddish brown. *Orientation:* OAP $\perp$ {001}. *Dispersion:* $r < v$ or $r > v$, strong. *Absorption:* $X > Y > Z$ or $Z{=}X > Y$. $\alpha = 1.79(5)$ $\beta = 1.80$ $\gamma = 1.82(1)$ 2V(meas.) = 40°–82°

Cell Data: *Space Group: Pbna.* $a = 9.450(2)$ $b = 10.013(2)$ $c = 8.179(2)$ Z = 4

X-ray Powder Pattern: Kalba Range, Kazakhstan.
3.156 (10), 4.996 (7), 4.701 (5), 4.253 (5), 2.723 (5), 2.534 (5), 2.207 (5)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	35.30	34.74	MgO	1.30		H_2O^+	8.75	8.82
Fe_2O_3	34.62	39.08	CaO	1.50		H_2O^-	0.95	
FeO	0.00		Na_2O	0.00		insol.	0.56	
MnO	16.39	17.36	K_2O	0.00		Total	99.37	100.00

(1) Kalba Range, Kazakhstan; $(OH)^{1-}$ calculated for charge balance, corresponding to $(Mn^{2+}_{0.95}Ca_{0.12}Mg_{0.10})_{\Sigma=1.17}Fe^{3+}_{1.82}(PO_4)_2(OH)_{1.82} \cdot 1.18H_2O$. (2) $Mn^{2+}Fe^{3+}_2(PO_4)_2(OH)_2 \cdot H_2O$.

Polymorphism & Series: Forms a series with garyansellite.

Occurrence: A rare low-temperature oxidation product of phosphate minerals in complex granite pegmatites and iron formations.

Association: Sicklerite, triphylite (Kalba Range, Kazakhstan); ferrisicklerite, triphylite (Clementine II pegmatite, Namibia); garyansellite, ludlamite, arrojadite, vivianite, metavivianite, souzalite, quartz (Rapid Creek, Canada).

Distribution: From [the Ak-Kezen' pegmatites,] near Belogorskii, Kalba Range, Kazakhstan. Abundant at the Clementine II pegmatite, Okatjimukuju farm, near Karibib, Namibia. Large crystals on the east side of Rapid Creek, one km north of Lake Creek, Yukon Territory, Canada. In the USA, in South Dakota, from the Bull Moose, Dan Patch, and Ferguson mines, near Keystone, and the Big Chief mine, one km south of Glendale, Pennington Co.; from the Tip Top mine, 8.5 km southwest of Custer, Custer Co.; in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire. At Hagendorf, Bavaria, Germany. From the Bendada pegmatite, near Guarda, and in the Mangualde pegmatite, near Mesquitela, Portugal. From the Pinilla de Fermoselle pegmatite, Zamora, Spain.

Name: Honors Vladimir Il'ich Kryzhanovskii (1881–1947), Russian mineralogist, Curator of the A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 50109–50115.

References: (1) Ginzburg, A.I. (1950) Kryzhanovskite – new mineral of the phosphate group. Doklady Acad. Nauk SSSR, 72, 763–766 (in Russian). (2) (1951) Amer. Mineral., 36, 382 (abs. ref. 1). (3) Moore, P.B. (1971) The $Fe^{2+}_3(H_2O)_n(PO_4)_2$ homologous series: crystal-chemical relationships and oxidized equivalents. Amer. Mineral., 56, 1–17. (4) Moore, P.B., T. Araki, and A.R. Kampf (1980) Nomenclature of the phosphoferrite structure type: refinements of landesite and kryzhanovskite. Mineral. Mag., 43, 789–795. (5) Sturman, B.D. and P.J. Dunn (1984) Garyansellite, a new mineral from Yukon Territory, Canada. Amer. Mineral., 69, 207–209. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 120.

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Ktenasite $(Cu, Zn)_5(SO_4)_2(OH)_6 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular crystals, to 1 mm, showing {011}, {100}, {013}, {201}, {401}.

Physical Properties: Hardness = 2–2.5 D(meas.) = 2.94–2.97 D(calc.) = 2.97

Optical Properties: Transparent. *Color:* Blue-green to emerald-green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; Y = bluish green; Z = pale green. *Orientation:* $Z = b$; $X \simeq c$. $\alpha = 1.574$ $\beta = 1.613$–1.615 $\gamma = 1.623$–1.628 2V(meas.) = 51°–59°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.595$–5.598 $b = 6.121$–6.123 $c = 23.762$–23.771 $\beta = 95.81°-99.5°$ Z = 2

X-ray Powder Pattern: Kamariza mine, Greece.
11.9 (10b), 2.74 (10), 5.87 (9), 4.85 (9), 3.53 (9), 1.704 (9), 2.95 (6)

Chemistry:

	(1)	(2)
SO_3	19.92	24.0
CuO	32.44	37.9
ZnO	[28.14]	16.6
H_2O	19.50	22.0
Total	[100.00]	100.5

(1) Kamariza mine, Greece; H_2O taken as loss on ignition, ZnO by difference. (2) Glomrudskollen mine, Norway; H_2O average of two analyses by elemental analyzer, H_2O and $(OH)^{1-}$ shown present by IR, $(OH)^{1-}$ calculated for charge balance; corresponds to $(Cu_{3.40}Zn_{1.46})_{\Sigma=4.86}(SO_4)_{2.14}(OH)_{5.44} \cdot 6.00H_2O$.

Occurrence: An uncommon secondary mineral formed by oxidation of chalcopyrite and sphalerite in Cu–Zn hydrothermal mineral deposits and in mine dumps.

Association: Glaucocerinite, serpierite, smithsonite, gypsum, namuwite, schulenbergite.

Distribution: In Greece, at Laurium, from the Kamariza mine, and in slag. In Italy, at the Trentini and Veneziana mine, near Torrebelvicino, Veneto. In the Glomrudskollen zinc mine, and at Skutterud, Modum, Norway. In England, in the Drakewalls mine, Gunnislake, Cornwall. At the Rammelsberg mine, near Goslar, and in slag at the Juliushütte, Astfeld, Harz Mountains, Germany. In the Komsomolsk deposit, Noril'sk, Siberia, Russia. From the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa. At Broken Hill, New South Wales, Australia. In the Tui mine, Te Aroha, New Zealand. In the USA, in Colorado, at the Commodore mine, Creede, Mineral Co., and in the Eagle mine, Gilman district, Eagle Co.; from the Lynchburg mine, nine km south of Magdalena, Socorro Co., New Mexico; in the 79 mine and on the Brick claims, Banner district, Gila Co., Arizona. Additional occurrences are known.

Name: Honoring Professor Konstantin Anton Ktenas (1884–1935), Greek mineralogist.

Type Material: University of Thessalonika, Thessalonika, Greece.

References: (1) Kokkoros, P. (1950) Ktenasit, ein Zink-Kupfersulfat aus Lavrion (Griechenland). Tschermaks Mineral. Petrog. Mitt., 1, 342–346 (in German). (2) (1951) Amer. Mineral., 36, 381–382 (abs. ref. 1). (3) Raade, G., C.J. Elliott, and E.E. Fejer (1977) New data on ktenasite. Mineral. Mag., 41, 65–70. (4) Mellini, M. and S. Merlino (1978) Ktenasite, another mineral with $^2_\infty[(Cu, Zn)_2(OH)_3O]^-$ octahedral sheets. Zeits. Krist., 147, 129–140.

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Kudriavite $CdBi_2S_4$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As slender platy or box-shaped skeletal crystals (usually striated along the elongation), to 400 μm, and as chaotic aggregates.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Very brittle. Hardness = n.d. VHN = 129 (10 g load). D(meas.) = n.d. D(calc.) = 6.578

Optical Properties: Opaque. *Color*: Dark gray with a reddish tint; white with a slight yellow hue in reflected light, without internal reflections. *Streak*: Black. *Luster*: Metallic. *Optical Class*: Uniaxial (+). *Bireflectance:* Weak to distinct. *Anisotropism:* Strong. R_1-R_2: (470) 29.6-36.4, (546) 32.4-38.8, (589) 31.8-38.2, (650) 31.4-37.7

Cell Data: *Space Group*: *C 2/m*. a = 13.095(1) b = 4.0032(3) c = 14.711(1) β = 115.59(1)° Z = 4

X-ray Powder Pattern: Kudriavy volcano, Iturup Island, Kurile arc, Russia. 2.809 (100), 3.715 (97), 3.632 (95), 3.520 (83), 2.948 (83), 1.914 (40), 2.346 (39)

Chemistry:

	(1)	(2)
Cd	8.25	17.07
Pb	13.10	
Fe	0.17	
Mn	0.26	
Bi	55.37	63.46
In	2.80	
Tl	0.02	
S	17.70	19.47
Se	2.23	
Cl	0.02	.
Total	99.71	100.00

(1) Kudriavy volcano, Iturup Island, Kurile arc, Russia; average of 9 electron microprobe analyses, corresponding to $(Cd_{0.51}Pb_{0.44}Fe_{0.02}Mn_{0.03})_{\Sigma=1.00}(Bi_{1.83}In_{0.17})_{\Sigma=2.00}(S_{3.81}Se_{0.19})_{\Sigma=4.00}$. (2) $CdBi_2S_4$.

Occurrence: As high-temperature (~ 400 °C) fumarole encrustations on the inner wall of an active andesitic stratovolcanic crater.

Association: Cannizzarite, greenockite, pyrite, sulfur.

Distribution: Kudriavy volcano, Iturup Island, Kurile arc, Russia.

Name: For the volcano from which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (3112/1).

References: (1) Chaplygin, I.V., N.N. Mozgova, L.O. Magazina, O.Yu. Kuznetsova, Y.G. Safonov, I.A. Bryzgalov, E. Makovicky, and T. Balić-Zunić (2005) Kudriavite, $(Cd,Pb)Bi_2S_4$, a new mineral species from Kudriavy volcano, Iturup Island, Kurile arc, Russia. Can. Mineral., 43, 695-701. (2) (2005) Amer. Mineral., 90, 1946-1947 (abs. ref. 1). (3) Balić-Žunić T. and E. Makovicky (2007) The crystal structure of kudriavite, $(Cd,Pb)Bi_2S_4$. Can. Mineral., 45, 437-443.

Kukharenkoite-(Ce) $Ba_2Ce(CO_3)_3F$

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Crystal Data: Monoclinic, pseudorhombohedral. *Point Group:* $2/m$. Crystals are platy or bladed prismatic, to 1 mm; typically in dendritic, reticulated, stellate, or fibrous aggregates; also fine granular massive. *Twinning:* Reticulated groups, not described as twins, are characteristic.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼4.5
VHN = 250–320, 280 average (25 g load). D(meas.) = 4.71 D(calc.) = 4.62–4.73

Optical Properties: Transparent to translucent, may be opaque from inclusions.
Color: Colorless, white, silvery gray, pale pink, yellow, greenish yellow, reddish brown.
Streak: White. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 26.5°$. *Dispersion:* $r > v$, medium.
$\alpha = 1.584–1.594$ $\beta = 1.710–1.730$ $\gamma = 1.715–1.730$ 2V(meas.) = 10°–20° 2V(calc.) = 18°–22°

Cell Data: *Space Group:* $P2_1/m$. $a = 13.360–13.418$ $b = 5.052–5.077$ $c = 6.681–6.714$
$\beta = 106.56°–106.58°$ Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
4.00 (100), 3.269 (100), 2.140 (40), 2.003 (40), 2.535 (20), 1.635 (10), 1.373 (10)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	[21.95]	21.10	CaO	0.39	2.33
Y_2O_3	0.15		SrO	1.55	1.79
$(La,Nd)_2O_3$		13.89	BaO	47.39	44.26
La_2O_3	6.61		F	3.18	3.21
Ce_2O_3	15.30	10.96	$-O = F_2$	1.34	1.35
Pr_2O_3	1.19		rem.		2.99
Nd_2O_3	4.26		Total	[100.63]	100.03
MgO		0.85			

(1) Khibiny massif, Russia; by electron microprobe, average of 12 analyses, F by microchemical methods, CO_3^{2-} calculated, corresponding to $(Ba_{1.86}Sr_{0.09}Ca_{0.04})_{\Sigma=1.99}(Ce_{0.56}La_{0.24}Nd_{0.15}Pr_{0.04}Y_{0.01})_{\Sigma=1.00}(CO_3)_{3.00}F_{1.01}$. (2) Bayan Obo deposit, China; remainder is ThO_2 0.41%, Al_2O_3 0.06%, Fe_2O_3 2.52%; corresponds to $(Ba_{1.56}Ca_{0.22}Mg_{0.11}Sr_{0.09})_{\Sigma=1.98}(Ce_{0.34}Ln_{0.46})_{\Sigma=0.80}(CO_3)_3F$.

Occurrence: In syenitic alkalic massifs and carbonatites.

Association: Belovite-(Ce), ancylite-(Ce), cebaite-(Ce), cordylite-(Ce), synchysite-(Ce), mckelveyite-(Y), ewaldite, rinkite, zakharovite, nenadkevichite, yofortierite, låvenite, burbankite, calcite, barite, fluorapatite, fluorite.

Distribution: In Russia, from Tuliylukht Bay and the Kirov apatite mine, Mt. Kukisvumchorr, Khibiny massif, and at the Vuoriyarvi carbonatite complex, Kola Peninsula. In the Bayan Obo Fe–Nb–Re deposit, 130 km north of Baotou, Inner Mongolia, China. At Mont Saint-Hilaire, and from near Saint-Amable, Quebec, Canada.

Name: To honor Professor Aleksandr Aleksandrovich Kukharenko (1914–1993), Russian mineralogist, St. Petersburg University, St. Petersburg, Russia, for his extensive work on the carbonatites of the Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 6097; Mineralogical Museum, St. Petersburg University, Russia, 1/18303; Canadian Museum of Nature, Ottawa, Canada, 81531–81533.

References: (1) Zaitsev, A.N., V.N. Yakovenchuk, G.Y. Chao, R.A. Gault, V.V. Subbotin, Y.A. Pakhomovskii, and A.N. Bogdanova (1996) Kukharenkoite-(Ce), $Ba_2Ce(CO_3)_3F$, a new mineral from Kola peninsula, Russia, and Québec, Canada. Eur. J. Mineral., 8, 1327–1336. (2) (1997) Amer. Mineral., 82, 1039 (abs. ref. 1). (3) Zhang Peishan and Tao Kejie (1981) Zhonghuacerite [= kukharenkoite-(Ce)] $Ba_2Ce(CO_3)_3F$ – a new mineral. Scientia Geologica Sinica, 195–196 (in Chinese with English abs.). (4) Mercier, N. and M. Leblanc (1993) Crystal growth and structures of rare earth fluorocarbonates: II. Structure of zhonghuacerite [= kukharenkoite-(Ce)] $Ba_2Ce(CO_3)_3F$. Eur. J. Solid State Inorg. Chem., 30, 207–216.

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Kukisvumite $Na_6ZnTi_4Si_8O_{28}\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic along [001], flattened on {100}, up to 7 mm, in fan-shaped aggregates replacing lamprophyllite.

Physical Properties: *Cleavage:* Parting on {010}. *Fracture:* Splintery, uneven. *Tenacity:* Elastic. Hardness = 5.5–6 VHN = 517–571, average 544 (20 g load). D(meas.) = 2.90 D(calc.) = 2.95 Yellow-green cathodoluminescence.

Optical Properties: Transparent. *Color:* White to colorless, rarely with a silver tint; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.676(3)$ $\beta = 1.746(3)$ $\gamma = 1.795(3)$ 2V(meas.) = n.d. 2V(calc.) = 77°

Cell Data: *Space Group: Pccn.* $a = 28.889(4)$ $b = 8.604(4)$ $c = 5.215(3)$ Z = 2

X-ray Powder Pattern: Korovskii mine, Russia.
3.009 (100), 14.49 (90), 4.815 (80), 3.722 (65), 6.42 (60)

Chemistry:

	(1)
SiO_2	42.66
TiO_2	27.03
Nb_2O_5	0.83
FeO	0.23
MnO	0.61
ZnO	5.99
Na_2O	16.27
F	0.20
H_2O	[6.26]
$-O = F_2$	[0.08]
Total	[100.00]

(1) Korovskii mine, Russia; by electron microprobe, contains F 0.20%, H_2O by difference; corresponding to $Na_{5.96}(Zn_{0.84}Mn_{0.10})_{\Sigma=0.94}(Ti_{3.85}Nb_{0.07}Fe_{0.04})_{\Sigma=3.96}Si_{8.08}O_{28}\cdot 4.03H_2O$.

Occurrence: In pegmatite veins cutting ijolite-urtite rocks in a differentiated alkalic massif.

Association: Lamprophyllite, arfvedsonite, microcline, nepheline, natrolite.

Distribution: At the Korovskii apatite mine, Mt. Kukisvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: For Mt. Kukisvumchorr, Kola Peninsula, Russia, on which it occurs.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5972; Mining Institute, St. Petersburg, 2020/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87091.

References: (1) Yakovenchuk, V.N., Y.A. Pakhomovskii, and A.N. Bogdanova (1991) Kukisvumite – a new mineral from the alkaline pegmatites of the Khibiny massif (Kola Peninsula). Mineral. Zhurnal, 13(2), 63–67 (in Russian). (2) (1992) Amer. Mineral., 77, 1116 (abs. ref. 1).

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Kuksite $\mathbf{Pb_3Zn_3Te^{6+}O_6(PO_4)_2}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, *or* 222. As thin tabular crystals, to 0.3 mm, with well-developed {100}.

Physical Properties: *Cleavage:* One, perfect. *Tenacity:* Brittle. Hardness = n.d. VHN = 325 (10 g load). D(meas.) = n.d. D(calc.) = 6.21 Fluoresces weakly under UV.

Optical Properties: Translucent, transparent in thin fragments. *Color:* Gray. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Orientation:* $Z = c$; positive elongation. *Dispersion:* $r > v$.
$\alpha = 1.971(5)$ β = n.d. $\gamma = 1.981(5)$ 2V(meas.) = 12°–20°

Cell Data: *Space Group:* $Cmmm$, $C222$, $Cmm2$, or $Cm2m$. $a = 8.50(3)$ $b = 14.72(5)$ $c = 5.19(3)$ Z = 2

X-ray Powder Pattern: Kuranakh deposit, Russia.
3.29 (10), 3.00 (8), 1.903 (5), 2.594 (4), 1.606 (3), 5.18 (2), 3.68 (2b)

Chemistry:

	(1)	(2)
TeO_3	14.30	14.26
P_2O_5	10.38	11.53
As_2O_5	0.07	
V_2O_5	1.81	
SiO_2	0.40	
ZnO	20.76	19.83
PbO	50.59	54.38
CaO	1.46	
Total	99.77	100.00

(1) Kuranakh deposit, Russia; by electron microprobe, average of nine analyses, corresponds to $(Pb_{2.68}Ca_{0.31})_{\Sigma=2.99}Zn_{3.01}Te_{0.96}O_{5.94}[(P_{0.86}V_{0.12}Si_{0.04})_{\Sigma=1.02}O_4]_2$. (2) $Pb_3Zn_3TeO_6(PO_4)_2$.

Occurrence: A late-stage mineral in the oxidized zone of a tellurium-bearing gold deposit.

Association: Cheremnykhite, Si-rich dugganite, yafsoanite, descloizite, calcite.

Distribution: In the Kuranakh gold deposit, near Aldan, Sakha, Russia.

Name: To honor A.I. Kuks (1906–), a discoverer of the Kuranakh deposit.

Type Material: Institute of Geosciences, Yakutsk Scientific Center, Academy of Sciences, Yakutsk, Russia, mk-112.

References: (1) Kim, A.A., N.V. Zayakina, and V.F. Makhotko (1990) Kuksite $Pb_3Zn_3TeO_6(PO_4)_2$ and cheremnykhite $Pb_3Zn_3TeO_6(VO_4)_2$ – new tellurates from the Kuranakh gold deposit (central Aldan, southern Yakutia [Sakha]). Zap. Vses. Mineral. Obshch., 119(5), 50–57 (in Russian). (2) (1992) Amer. Mineral., 77, 446 (abs. ref. 1).

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Kulanite $\mathbf{Ba(Fe^{2+},Mn,Mg)_2Al_2(PO_4)_3(OH)_3}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As plates, to 1.5 cm, tabular on $\{\bar{1}01\}$, with $\{10\bar{1}\}$, {100}, {001}, {011}, {161}, several others; aggregated in rosettes. Commonly in zoned intergrowth with penikisite.

Physical Properties: *Cleavage:* Fair to good on {010} and {100}. Hardness = ~4
D(meas.) = 3.91(3) D(calc.) = 3.92

Optical Properties: Transparent to translucent. *Color:* Green to blue. *Streak:* Very pale green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = brownish green; Y = green; Z = very pale brown. *Orientation:* $Y \simeq b$; $Z \wedge c = -8°$. *Dispersion:* $r \gg v$, very strong and asymmetrical, suggesting a triclinic structure. *Absorption:* $X \simeq Y \gg Z$. $\alpha = 1.703$ $\beta = 1.705$ $\gamma = 1.723$
2V(meas.) = 32° 2V(calc.) = 38°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.014(1)$ $b = 12.074(1)$ $c = 4.926(1)$
$\beta = 100.48(1)°$ Z = 2

X-ray Powder Pattern: Cross-cut Creek, Canada; almost identical to penikisite.
3.108 (100), 2.927 (80), 3.044 (70), 2.659 (70), 8.84 (60), 2.690 (60), 4.51 (50)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	33.28	33.80	MgO	3.08	3.89
SiO_2	0.19		CaO	0.77	0.42
Al_2O_3	14.30	15.06	BaO	23.66	24.99
Fe_2O_3	2.14	1.61	Na_2O	0.02	
FeO	10.50	13.47	H_2O^+	3.83	[4.27]
MnO	6.32	0.95	Total	98.09	[98.46]

(1) Cross-cut Creek, Canada; H_2O by DTA-TGA, corresponding to $Ba_{1.00}(Fe^{2+}_{0.94}Mn_{0.58}Mg_{0.50}Ca_{0.09})_{\Sigma=2.11}(Al_{1.81}Fe^{3+}_{0.18})_{\Sigma=1.99}(PO_4)_{3.02}(OH)_{2.74}$. (2) Do.; by electron microprobe, average of ten analyses, Fe^{2+}:Fe^{3+} ratio and H_2O from structure analysis; corresponding to $Ba_{1.03}(Fe^{2+}_{1.19}Mg_{0.61}Mn_{0.08})_{\Sigma=1.88}Al_{1.87}(PO_4)_{3.02}(OH)_3$.

Polymorphism & Series: Forms a series with penikisite.

Mineral Group: Bjarebyite group.

Occurrence: A weathering product in fractures in sideritic iron formation (Cross-cut Creek, Canada); as disseminations and veinlets in granite pegmatite (Xiyuantou, China).

Association: Penikisite, quartz, siderite, fluorapatite, rapidcreekite, brazilianite, arrojadite, anatase, goyazite (Cross-cut Creek, Canada); palermoite, montebrasite, triphylite (Palermo #1 mine, New Hampshire, USA).

Distribution: From Cross-cut Creek, 1.5 km upstream from the confluence with Rapid Creek, Big Fish-Blow River area, Yukon Territory, Canada. In the White Picacho district, Maricopa and Yavapai Cos., Arizona, and at the Palermo #1 mine, North Groton, Grafton Co., New Hampshire, USA. From the Xiyuantou pegmatite, Nanping, Fujian Province, China.

Name: Honors Mr. Alan Kulan, Ross River, Yukon Territory, Canada, a co-discoverer of the Rapid Creek phosphate occurrences.

Type Material: Royal Ontario Museum, Toronto, Canada, M34170; National Museum of Natural History, Washington, D.C., USA, 137304, 145737.

References: (1) Mandarino, J.A. and B.D. Sturman (1976) Kulanite, a new barium iron aluminum phosphate from the Yukon Territory, Canada. Can. Mineral., 14, 127–131. (2) (1977) Amer. Mineral., 62, 174 (abs. ref. 1). (3) Cooper, M. and F.C. Hawthorne (1994) Refinement of the crystal structure of kulanite. Can. Mineral., 32, 15–19. (4) Yeuqing Yang, Yunxiang Ni, Yongquan Guo, Yaping Zhang, and Jiapin Liu (1986) First discovery of kulanite in China. Yanshi Kuangwuxue Zashi, 5, 119–127 (in Chinese with English abstract). (5) (1990) Amer. Mineral., 75, 245–246 (abs. ref. 4).

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Kuliokite-(Y) $(Y,Yb)_4Al(SiO_4)_2(OH)_2F_5$

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Crystal Data: Triclinic. *Point Group:* 1. As platy crystals up to 0.5 mm.

Physical Properties: *Cleavage:* Poor on {010}. Hardness = 4–5 D(meas.) = 4.3(5) D(calc.) = 4.26 Yellow-green cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Orientation:* $Z = c$; $X \wedge a = 7°$; $Y \wedge b = 28°$. *Dispersion:* $r > v$. $\alpha = 1.656(1)$ $\beta = 1.700(1)$ $\gamma = 1.703(1)$ 2V(meas.) = 19(1)° 2V(calc.) = 29°

Cell Data: *Space Group:* $P1$. $a = 8.606(6)$ $b = 8.672(8)$ $c = 4.317(3)$ $\alpha = 102.79(6)°$ $\beta = 97.94(5)°$ $\gamma = 116.66(6)°$ Z = 1

X-ray Powder Pattern: Mt. Ploskaya, Russia.
2.793 (10b), 3.710 (9), 3.490 (9), 2.459 (8b), 1.702 (8b), 2.144 (7), 3.310 (6)

Chemistry:

	(1)
SiO_2	17.75
Al_2O_3	7.36
Y_2O_3	56.40
Gd_2O_3	0.39
Dy_2O_3	1.38
Ho_2O_3	0.19
Er_2O_3	2.24
Tm_2O_3	0.10
Yb_2O_3	2.71
Lu_2O_3	0.11
F	13.45
H_2O	[3.58]
$-O = F_2$	5.66
Total	[100.00]

(1) Mt. Ploskaya, Russia; by electron microprobe, H_2O by difference; corresponding to $(Y_{3.58}RE_{0.27})_{\Sigma=3.85}Al_{1.04}Si_{2.12}O_{7.60}(OH)_{2.88}F_{5.08}$.

Occurrence: As inclusions in fluorite or on fissures in microcline pegmatites.

Association: Thalenite, xenotime, kainosite, bastnäsite, keiviite-(Y), keiviite-(Yb), quartz, fluorite.

Distribution: From the Mt. Ploskaya, Keivy massif, Kola Peninsula, Russia.

Name: For the Kuliok River, Kola Peninsula, Russia, and *yttrium* in its composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5958/7; Mining Institute, St. Petersburg, 945/2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 85666, 85670.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, F.N. Tyusheva, Y.V. Sokolova, and Y.K. Yegorov-Tismenko (1986) Kuliokite-(Y) – a new yttrium–aluminum fluoride–silicate from amazonite pegmatites of the Kola Peninsula. Mineral. Zhurnal, 8(2), 94–99 (in Russian with English abs.). (2) (1988) Amer. Mineral., 73, 192 (abs. ref. 1).

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Kulkeite $\mathbf{Na_{0.35}Mg_8Al(AlSi_7)O_{20}(OH)_{10}}$

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Crystal Data: Monoclinic. *Point Group:* n.d. As platy to subhedral crystals, to 2 mm, and in aggregates.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 2.70

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Pearly on the cleavage.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$. $\alpha = 1.552$ $\beta = 1.5605$ $\gamma = 1.5610$ 2V(meas.) = 24(3)° 2V(calc.) = 27°

Cell Data: *Space Group:* n.d. $a = 5.319(1)$ $b = 9.195(2)$ $c = 23.897(10)$ $\beta = 97°1(2)'$ Z = 2

X-ray Powder Pattern: Derrag, Algeria.
7.90 (10), 11.9 (8), 3.38 (8), 4.74 (6), 2.55 (6), 2.96 (5), 2.46 (5)

Chemistry:

	(1)
SiO_2	40.53
Al_2O_3	12.64
MgO	33.19
CaO	0.06
Na_2O	1.20
K_2O	0.07
H_2O	[9.24]
Total	[96.93]

(1) Derrag, Algeria; by electron microprobe, H_2O from theoretical formula; corresponding to $(Na_{0.38}K_{0.01})_{\Sigma=0.39}Mg_{8.02}Al_{0.99}(Si_{6.57}Al_{1.43})_{\Sigma=8.00}O_{20}(OH)_{10}$.

Polymorphism & Series: A 1:1 regular interstratification of trioctahedral chlorite and talc.

Occurrence: In dolostone, metamorphosed below 400 °C, with evaporites.

Association: Talc, chlorite, phlogopite, tourmaline.

Distribution: From El Mourdur Hill, near Derrag, 35 km west of Ksar El Boukhari, Tell Atlas Mountains, Algeria.

Name: For Dr. Holger Kulke, geologist of Essen, Germany, who provided the original specimen.

Type Material: Ruhr University, Bochum, Germany; National Museum of Natural History, Washington, D.C., USA, 147361.

References: (1) Abraham, K., W. Schreyer, O. Medenbach, and W. Gebert (1980) Kulkeite, ein geordnetes 1:1 Mixed-Layer-Mineral zwischen Klinochlor und Talk. Fortschr. Mineral., Beiheft 1, 58, 4–5 (in German). (2) (1981) Amer. Mineral., 66, 218 (abs. ref. 1). (3) Schreyer, W., O. Medenbach, K. Abraham, W. Gebert, and W.F. Müller (1982) Kulkeite, a new metamorphic phyllosilicate mineral: ordered 1:1 chlorite/talc mixed layer. Contr. Mineral. Petrol., 80, 103–109.

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Kullerudite $NiSe_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Fine-grained, massive.

Physical Properties: Hardness = Soft. VHN = n.d. D(meas.) = n.d. D(calc.) = 6.72

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, creamy grayish white, paler than penroseite. *Pleochroism:* Distinct in oil, gray to pale gray. *Anisotropism:* Very strong, yellowish gray to gray to almost black.
R_1–R_2: n.d.

Cell Data: *Space Group: Pnnm* (probable). $a = 4.89$ $b = 5.96$ $c = 3.67$ Z = 2

X-ray Powder Pattern: Kuusamo, Finland.
2.64 (100), 2.545 (100), 2.935 (80), 1.925 (80), 1.84 (80), 1.648 (60), 2.095 (40)

Chemistry:

	(1)	(2)
Ni	23.1	27.10
Co	1.4	
Fe	1.91	
Cu	0.5	
Se	73.1	72.90
Total	100.01	100.00

(1) Kuusamo, Finland; by X-ray fluorescence. (2) $NiSe_2$.

Polymorphism & Series: Dimorphous with penroseite.

Mineral Group: Marcasite group.

Occurrence: In calcite veins in sills of albite diabase in schist, associated with low-grade uranium mineralization, almost exclusively as an alteration product of wilkmanite.

Association: Wilkmanite, sederholmite, penroseite, selenium, ferroselite.

Distribution: From Kuusamo, northeastern Finland [TL].

Name: In honor of Gunnar Kullerud (1921–1989), Norwegian-American mineralogist, Geophysical Laboratory, Washington, D.C., USA.

Type Material: n.d.

References: (1) Vuorelainen, Y., A. Huhma, and A. Häkli (1964) Sederholmite, wilkmanite, kullerudite, mäkinenite, and trüstedtite, five new nickel selenide minerals. Compt. Rendus Soc. Géol. Finlande, 36, 113–125. (2) (1965) Amer. Mineral., 50, 519–520 (abs. ref. 1).

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Kupčíkite $Cu_{3.4}Fe_{0.6}Bi_5S_{10}$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Cesium kupletskite

$(Cs,K,Na)_3(Mn^{2+},Fe^{2+})_7$
$(Ti,Nb)_2Si_8O_{24}(O,OH,F)_7$

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Crystal Data: Triclinic. *Point Group:* n.d. As rosettelike intergrowths of curved platy crystals, forming aggregates, to 3 cm.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = ∼4 VHN = 186
D(meas.) = 3.68 D(calc.) = [3.62]

Optical Properties: Semitransparent. *Color:* Golden brown. *Luster:* Dull.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow-green; Y = yellow to brown; Z = brown.
Orientation: $Z = a$; $Y \wedge b \simeq 10°$. α = n.d. $\beta = 1.726$ $\gamma = 1.758$ 2V(meas.) = 75°

Cell Data: *Space Group:* n.d. $a = 5.41(1)$ $b = 11.74(2)$ $c = 21.16(4)$ $\alpha = 89°$ $\beta = 90°$ $\gamma = 102°23'$ Z = 2

X-ray Powder Pattern: Alai Range, Tajikistan.
10.4 (100), 3.54 (80), 2.79 (80), 2.66 (80), 2.58 (60), 1.772 (40), 4.09 (30)

Chemistry:

	(1)		(1)
SiO_2	33.00	CaO	0.35
TiO_2	8.28	Li_2O	0.46
ZrO_2	1.01	Na_2O	2.46
Al_2O_3	0.52	K_2O	1.15
Fe_2O_3	3.05	Rb_2O	0.18
Nb_2O_5	4.95	Cs_2O	11.60
Ta_2O_5	0.06	F	1.26
FeO	10.00	H_2O^+	1.47
MnO	19.66	$-O = F_2$	0.54
MgO	trace	Total	98.92

(1) Alai Range, Tajikistan; corresponds to $(Cs_{1.22}Na_{1.14}K_{0.35}Ca_{0.09})_{\Sigma=2.80}(Mn_{3.99}Fe^{2+}_{2.00}Fe^{3+}_{0.55}Li_{0.44})_{\Sigma=6.98}(Ti_{1.49}Nb_{0.54}Zr_{0.12})_{\Sigma=2.15}(Si_{7.92}Al_{0.15})_{\Sigma=8.07}O_{24}[O_{3.69}(OH)_{2.35}F_{0.96}]_{\Sigma=7.00}$.

Polymorphism & Series: Forms a series with kupletskite.

Mineral Group: Astrophyllite group.

Occurrence: At the border of aegirine-microcline-quartz pegmatites, and in polylithionite-quartz replacement complexes in pegmatites.

Association: Pyrochlore, stillwellite, tienshanite, sogdianite, thorite.

Distribution: In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan.

Name: For the *cesium* in the composition and similarity to *kupletskite*.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, 16537; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74170.

References: (1) Efimov, A.F., V.D. Dusmatov, A.A. Ganzeev, and Z.T. Kataeva (1971) Cesium kupletskite, a new mineral. Doklady Acad. Nauk SSSR, 197, 1394–1397 (in Russian). (2) (1972) Amer. Mineral., 57, 328 (abs. ref. 1).

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Kupletskite $(K,Na)_3(Mn,Fe^{2+})_7(Ti,Nb)_2Si_8O_{24}(O,OH)_7$

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Crystal Data: Monoclinic, or triclinic, pseudomonoclinic. *Point Group:* n.d. In thin plates and lamellar masses, to 5 cm; as radial masses.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = 3–4 D(meas.) = 3.20–3.36 D(calc.) = [3.05]

Optical Properties: Semitransparent. *Color:* Bright straw-yellow when fresh, dark brown to black when altered to manganese oxides. *Streak:* Brown. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = yellow-orange; Z = cinnamon-brown. *Dispersion:* $r > v$, strong. α = [1.656]–1.660 β = 1.699–1.702 γ = 1.731–1.734 2V(meas.) = 79°–85°

Cell Data: *Space Group:* n.d. $a = 13.14$ $b = 12.82$ $c = 5.42$ $\alpha = 93°94'$ $\beta = 101°40'$ $\gamma = 113°38'$ Z = 1

X-ray Powder Pattern: Lovozero massif, Russia; nearly identical with astrophyllite. 3.505 (8), 2.642 (8), 2.573 (4), 2.099 (3), 1.732 (3), 3.249 (1), 2.998 (1)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	32.60	33.54	CaO	3.60	1.45
TiO_2	12.04	10.64	BaO		0.32
ZrO_2	1.19	0.00	Na_2O	2.14	2.14
Al_2O_3	1.68	1.00	K_2O	4.38	5.63
Fe_2O_3	5.44	5.35	F	1.22	
Nb_2O_5	0.66	2.48	H_2O^+	3.83	3.90
FeO		7.80	H_2O^-	1.08	0.80
MnO	27.65	23.60	$-O = F_2$	0.51	
MgO	2.98	1.63	Total	99.98	100.28

(1) Mt. Kuivchorr, Lovozero massif, Russia; total Fe as Fe_2O_3. (2) Mt. Lepkhe-Nelm, Lovozero massif, Russia.

Polymorphism & Series: Forms two series, with astrophyllite, and with cesium kupletskite.

Mineral Group: Astrophyllite group.

Occurrence: In the natrolite-rich central part and in the wall rocks of nepheline syenite pegmatites in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Manganoan pectolite, neptunite, microcline, eudialyte, nepheline, aegirine (Lovozero massif, Russia); aegirine, analcime, gonnardite, apophyllite, eggletonite, pyrophanite (Little Rock, Arkansas, USA).

Distribution: In Russia, on Mts. Kuivchorr and Lepkhe-Nelm, Lovozero massif, Kola Peninsula, and some other less-well-defined localities. From the Oktyabr massif, eastern Azov area, Ukraine. In the Ilímaussaq intrusion and the Werner Berge complex, Greenland. At Gjerdingen, north of Oslo, Norway. On Granite Mountain, near Little Rock, Pulaski Co., and the Diamond Jo quarry, Magnet Cove, Hot Spring Co., Arkansas, USA. At Mont Saint-Hilaire, Quebec, Canada.

Name: For Boris Mikhailovich Kupletskii (1894–1965), Russian geologist, Institute of Geosciences, Moscow, and El'za Maximilianovna Bohnshtedt-Kupletskaya (1898–1974), Russian mineralogist, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

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Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 1035; Vernadsky Geological Museum, Moscow, 47963; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 58869.

References: (1) Semenov, E.I. (1956) Kupletskite – a new mineral of the astrophyllite group. Doklady Acad. Nauk SSSR, 108, 933–936 (in Russian). (2) (1957) Amer. Mineral., 42, 118–119 (abs. ref. 1). (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 370–373 (in English). (4) Val'ter, A.A, G.K. Eremenko, and T.A. Lysenko (1965) Kupletskite from the Azov area alkaline rocks. Mineralog. Sb., L'vovsk. Gos. Univ., 19(2), 248–252 (in Russian). (5) (1966) Chem. Abs., 65, 495 (abs. ref. 4). (6) Chih-Chung P'eng and Che-Sheng Ma (1964) Crystal structure of triclinic manganastrophyllite. Sci. Sinica, 13(7), 1180–1183 (in Russian). (7) (1966) Chem. Abs., 64, 7460 (abs. ref. 6).

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Kuramite Cu_3SnS_4

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As minute inclusions, to 80 μm, aggregated with goldfieldite in round to elongated grains.

Physical Properties: Hardness = n.d. VHN = 322–373, 353 average (100 g load). D(meas.) = n.d. D(calc.) = 4.56

Optical Properties: Opaque. *Color:* In polished section, neutral gray. *Streak:* Metallic. *Anisotropism:* Distinct, in shades of brown.

R_1–R_2: (400) 21.0–21.6, (420) 21.4–22.1, (440) 21.9–22.9, (460) 22.5–23.8, (480) 23.0–24.5, (500) 23.5–25.1, (520) 23.9–25.5, (540) 24.4–25.9, (560) 24.9–26.2, (580) 25.4–26.6, (600) 25.8–26.8, (620) 26.2–27.0, (640) 26.5–27.2, (660) 26.9–27.3, (680) 27.3–27.5, (700) 27.7–27.7

Cell Data: *Space Group:* $I\bar{4}2m$. $a = 5.445(5)$ $c = 10.75(2)$ $Z = 2$

X-ray Powder Pattern: Kochbulak deposit, Uzbekistan.
3.13 (10), 1.914 (8), 1.640 (6), 1.108 (4), 1.244 (3), 2.70 (2), 1.044 (2)

Chemistry:

	(1)	(2)	(3)
Cu	37.27	38.3	43.56
Fe	2.36	5.6	
Zn	1.88	0.7	
Sn	30.12	26.7	27.13
In	0.32		
S	27.86	28.6	29.31
Total	99.81	99.9	100.00

(1) Kochbulak deposit, Uzbekistan; by electron microprobe, average of five analyses; corresponds to $(Cu_{2.70}Fe_{0.20}Zn_{0.13})_{\Sigma=3.03}(Sn_{1.17}In_{0.01})_{\Sigma=1.18}S_{4.00}$. (2) Gunheath china clay pit, England; by electron microprobe, corresponds to $(Cu_{2.70}Fe_{0.45}Zn_{0.05})_{\Sigma=3.20}Sn_{1.01}S_{4.00}$. (3) Cu_3SnS_4.

Mineral Group: Stannite group.

Occurrence: In gold–sulfide–quartz veins, as inclusions in goldfieldite (Kochbulak deposit, Uzbekistan).

Association: Goldfieldite, famatinite, hessite, petzite, sylvanite, altaite, gold, chalcostibite, emplectite, mohite, mawsonite, cassiterite (Kochbulak deposit, Uzbekistan).

Distribution: From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan [TL]. In the USA, at Bisbee, Cochise Co., Arizona; from the Zuni mine, near Silverton, San Juan Co., Colorado; in the Gold Crater district, Nye Co., Nevada. From the Gunheath china clay pit, St. Austell, Cornwall, England.

Name: For the occurrence in the Kuramin Mountains, Uzbekistan.

Type Material: Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80176.

References: (1) Kovalenker, V.A., T.L. Evstigneeva, N.V. Traneva, and L.N. Vyal'sov (1979) Kuramite, Cu_3SnS_4, a new mineral of the stannite group. Zap. Vses. Mineral. Obshch., 108, 564–569 (in Russian). (2) (1980) Amer. Mineral., 65, 1067 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 306.

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Kuranakhite $PbMn^{4+}Te^{6+}O_6$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* n.d. As tiny grains, to 0.25 mm, which may be in aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = 4–5 VHN = 228–441
D(meas.) = 6.72(2) D(calc.) = 6.66

Optical Properties: Translucent. *Color:* Pale brown to nearly black; pale gray with a bluish tint in reflected light. *Streak:* Brown. *Luster:* Vitreous.
Optical Class: Biaxial (–) or (+). $\alpha = 1.952–1.96$ $\beta = 1.98$ $\gamma = 2.002–2.01$ 2V(meas.) = n.d.
Anisotropism: Distinct; bright blue to brown. *Bireflectance:* Weak; in rose tints.
R: (460) 24.4, (540) 24.0, (580) 24.5, (660) 23.0

Cell Data: *Space Group:* *C* (possible). $a = 5.11(1)$ $b = 8.91(1)$ $c = 5.32(1)$ Z = 2

X-ray Powder Pattern: Kuranakh deposit, Russia.
3.40 (10), 2.558 (6), 2.050 (5), 1.851 (5), 1.596 (4), 2.322 (1), 1.668 (1)

Chemistry:

	(1)	(2)	(3)
TeO_3	38.2	38.10	36.15
MnO_2	15.4	16.41	17.90
PbO	45.4	45.40	45.95
Total	99.0	99.91	100.00

(1) Kuranakh deposit, Russia; by electron microprobe, average of three analyses, total Mn as MnO_2, total Te as TeO_3; corresponds to $Pb_{0.93}Mn_{0.81}Te_{1.00}O_6$. (2) Jialu deposit, China; by electron microprobe, average of six analyses, total Mn as MnO_2, total Te as TeO_3; corresponds to $Pb_{0.99}Mn_{0.92}Te_{1.06}O_6$. (3) $PbMnTeO_6$.

Occurrence: In the oxidized zone of a gold quartz deposit (Kuranakh deposit, Russia; Jialu deposit, China).

Association: Gold, "electrum", iron oxides (Kuranakh deposit, Russia); gold, calaverite, pyrite, galena, chalcopyrite, sphalerite, altaite, cerussite, anglesite, pyromorphite, quartz (Jialu deposit, China); gold (Ashley deposit, Canada); cuzticite, eztlite, emmonsite, schmitterite, pyrite (Moctezuma mine, Mexico).

Distribution: In the Kuranakh gold deposit, near Aldan, southern Sakha, Russia. At the Jialu gold deposit, Xiaoqinling district, Shaanxi Province, China. From the Ashley gold deposit, Bannockburn Township, Ontario, Canada. In Mexico, at the Oriental (Bambollita) mine, northeast of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora.

Name: For the Kuranakh deposit, Russia, where it was first found to occur.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76494.

References: (1) Yablokova, S.V., L.S. Dubakina, A.L. Dmitrik, and G.V. Sokolova (1975) Kuranakhite – a new supergene tellurium mineral. Zap. Vses. Mineral. Obshch., 104, 310–313 (in Russian). (2) (1976) Amer. Mineral., 61, 339 (abs. ref. 1). (3) Zhou Xinchun, Liu Liang, Wang Shizhong, Wang Yan, Yang Jiankun, Guo Nenglin, Li Guanghui, and Hu Jianmin (1998) Kuranakhite discovered in China for the first time. Chinese J. Geochem., 17(1), 77–80 (in English).

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Kurchatovite $Ca(Mg, Mn^{2+}, Fe^{2+})B_2O_5$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Granular, to 4 mm.

Physical Properties: *Cleavage:* One perfect, parallel elongation; two others, imperfect. Hardness = 4.5 D(meas.) = 3.02 D(calc.) = n.d. Fluoresces bright violet under LW UV.

Optical Properties: Semitransparent. *Color:* Pale gray. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, slight. $\alpha = 1.635(1)$ $\beta = 1.681(1)$ $\gamma = 1.698(1)$ 2V(meas.) = 66°

Cell Data: *Space Group:* n.d. $a = 11.15(2)$ $b = 36.4(1)$ $c = 5.55(1)$ Z = 24

X-ray Powder Pattern: Solongo deposit, Russia.
2.78 (10), 1.922 (9), 2.67 (8), 1.232 (8), 2.26 (7), 2.01 (7), 1.633 (6)

Chemistry:

	(1)	(2)		(1)	(2)
As_2O_5	0.31		FeO	1.48	
CO_2	1.60		MnO	6.84	
SiO_2	0.49		ZnO	0.28	
TiO_2	0.00		MgO	19.70	24.28
B_2O_3	38.22	41.94	CaO	30.23	33.78
Al_2O_3	0.65		H_2O^+	0.66	
Fe_2O_3	0.00		Total	100.46	100.00

(1) Solongo deposit, Russia; $(B_2O_5)^{4-}$ confirmed by IR; after deduction of calcite, szaibélyite, "chlorite", and svabite, corresponds to $Ca_{0.95}(Mg_{0.81}Mn_{0.18}Fe_{0.04})_{\Sigma=1.03}B_{1.98}O_5$. (2) $CaMgB_2O_5$.

Polymorphism & Series: Dimorphous with clinokurchatovite.

Occurrence: In an iron-bearing skarn (Solongo deposit, Russia).

Association: Clinokurchatovite, szaibélyite, solongoite, hexahydroborite, calcite, "chlorite", vesuvianite, garnet, svabite, magnetite, sphalerite (Solongo deposit, Russia).

Distribution: In Russia, from the Solongo boron deposit, Buryatia, and at the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains.

Name: To honor Igor Vasil'evich Kurchatov (1903–1960), Russian physicist, Institute of Nuclear Energy, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 998/2, 4; Vernadsky Geological Museum, Moscow, 49712; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 68717, 72769.

References: (1) Malinko, S.V., A.E. Lisitsyn, K.A. Dorofeeva, I.V. Ostrovskaya, and D.P. Shashkin (1966) Kurchatovite – a new mineral. Zap. Vses. Mineral. Obshch., 95, 203–209 (in Russian). (2) (1966) Amer. Mineral., 51, 1816 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 123.

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Kurgantaite $CaSr[B_5O_9]Cl \cdot H_2O$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Forms fine-grained nodules, to 4 cm; also as spherulites of crystals with wedge-shaped terminations, to 0.7 mm.

Physical Properties: *Cleavage*: Present in two directions. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 6-6.5 D(meas.) = 2.99(1) D(calc.) = 3.07(1)

Optical Properties: Transparent. *Color*: Colorless to white, light to dark yellow-orange to orange. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (+). α = 1.637(1) β = 1.638(1) γ = 1.675(1) 2V(meas.) < 10° 2V(calc.) = 19(19)°

Cell Data: *Space Group*: $P\bar{1}$. a = 6.573(1) b = 6.445(1) c = 6.369(1) α = 60.995(2)° β = 61.257(2)° γ = 77.191(2)° Z = 1

X-ray Powder Pattern: Chelkar, Kazakhstan.
2.92 (100), 3.22 (90), 2.84 (90), 5.69 (80), 2.79 (80), 3.13 (70), 2.14 (70)

Chemistry:

	(1)	(2)	(3)
CaO	14.69	15.06	16.19
SrO	26.43	26.34	25.51
B_2O_3	45.31	44.93	46.29
Cl	9.58	9.22	9.22
H_2O	[4.69]	[4.65]	[4.79]
-O = Cl	2.16	2.08	2.08
Total	98.54	98.12	99.92

(1) Kargan-tau, Kazakhstan; electron microprobe analysis, H_2O calculated from structure refinement; corresponding to $Ca_{1.01}Sr_{0.98}[B_{5.02}O_9]Cl_{1.04} \cdot H_2O$. (2) Nepskoye, Russia, electron microprobe analysis, H_2O calculated from structure refinement; corresponding to $Ca_{1.04}Sr_{0.98}[B_{4.99}O_9]Cl_{1.01} \cdot H_2O$. (3) Penobsquis deposit, New Brunswick, Canada; average of 3 electron microprobe analyses, H_2O calculated; corresponding to $Ca_{1.08}Sr_{0.93}[B_5O_9]Cl_{0.98} \cdot H_2O$.

Mineral Group: Hilgardite group.

Occurrence: In marine evaporite salt deposits and salt domes.

Association: Sylvite, halite, boracite, anhydrite, gypsum, magnesite, quartz (Kazakhstan); hydroboracite, boracite, walkerite, veatchite, szaibélyite, pringleite, congolite, a clay-group mineral (New Brunswick, Canada).

Distribution: In western Kargan-tau, Inder uplift and from Chelkar, Caspian region, Kazakhstan; in the Nepskoye potassium salt deposit, near Ust'-Kut, Irkutsk district, Siberia, Russia. In the Penobsquis evaporite deposits, 12 km NE of Sussex, New Brunswick, Canada.

Name: For the region, *Kargan-ta*u, Kazakhstan, that produced the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia.

References: (1) Pekov, I.V., E.V. Lovskaya, N.V. Chukanov, A.E. Zadov, V.N. Apollonov, D.Yu. Pushcharovsky, O. Ferro, S.A. Vino-gradova (2001) Kurgantaite, $CaSr[B_5O_9]Cl \cdot H_2O$, revalidation of the mineral species and new data. Zap. Vseross. Mineral. Obshch., 130(3), 71-79 (in Russian, with English abs.). (2) (2002) Amer. Mineral., 87, 1510-1511 (abs. ref. 1). (3) Grice, J.D., R.A. Gault and J. Van Velthuizen (2005) Borate minerals of the Penobsquis and Millstream deposits, Southern New Brunswick, Canada. Can. Mineral., 43, 1469-1487.

Kurilite Ag_8Te_3Se

Crystal Data: Hexagonal. *Point Group*: 3 or $\bar{3}$. As aggregates of micron-sized grains, to 2 mm, also as overgrowths.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 3 VHN = 99.9 (25 g load). D(meas.) = n.d. D(calc.) = 7.799

Optical Properties: Opaque. *Color*: Light gray to steel gray, white in reflected light.
Streak: Black. *Luster*: Metallic.
Optical Class: Isotropic.
R: (400) 42.3, (420) 42.6, (440) 43.0, (460) 43.0, (470) 43.0, (480) 43.0, (500) 42.8, (520) 42.6, (540) 42.4, (546) 42.3, (560) 42.0, (580) 41.6, (589) 41.4, (600) 41.3, (620) 40.8, (640) 40.6, (650) 40.4, (660) 30.90, (680) 39.6, (700) 39.2

Cell Data: *Space Group*: *R*3 or $R\bar{3}$. a = 15.80(1) c = 19.57(6) Z = 15

X-ray Powder Pattern: Prasolovskoe deposit, Kunashir Island, Kuril arc, Russia.
2.201 (100), 2.996 (50), 2.510 (30), 2.079 (30), 3.727 (20), 2.152 (20), 2.046 (20)

Chemistry:

	(1)	(2)
Ag	63.71	65.14
Au	0.29	
Te	29.48	28.90
Se	5.04	5.96
S	0.07	.
Total	98.71	100.00

(1) Prasolovskoe deposit, Kunashir Island, Kuril arc, Russia; average of 7 electron microprobe analyses, corresponding to $(Ag_{7.97}Au_{0.02})_{\Sigma=7.99}Te_{3.00}(Se_{0.86}Te_{0.12}S_{0.03})_{\Sigma=1.01}$. (2) Ag_8Te_3Se.

Occurrence: In hydrothermal Au-Ag quartz veins cutting calcalkaline volcanic rocks.

Association: Tetrahedrite, native gold, hessite, sylvanite, petzite.

Distribution: Prasolovskoe epithermal Au-Ag deposit, Kunashir Island, Kuril arc, Russia.

Name: For the islands (Kuril arc) on which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3717/1).

References: (1) Kovalenker, V.A., O.Yu. Plotinskaya, C.J. Stanley, A.C. Roberts, A.M. McDonald, and M.A. Cooper (2010) Kurilite - Ag_8Te_3Se - a new mineral from the Prasolovskoe deposit, Kuril islands, Russian Federation. Mineralogical Magazine, 74, 463-468. (2) (2014) Amer. Mineral., 99, 554 (abs. ref. 1).

Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Rough prismatic crystals, to 37 cm; typically in dense aggregates. *Twinning:* Infrequent, on an unknown law.

Physical Properties: *Cleavage:* On {010}. Hardness = 2.5–3 D(meas.) = 1.847–1.862 D(calc.) = 1.855

Optical Properties: Transparent to translucent. *Color:* White, greenish gray from included clay; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y \simeq b$; an optic axis nearly $\perp$ {001}.
Dispersion: $r > v$. $\alpha = 1.488–1.491$ $\beta = 1.508–1.510$ $\gamma = 1.515–1.525$ 2V(meas.) = 60°–80°

Cell Data: *Space Group:* $P\bar{1}$. $a = 8.3479(1)$ $b = 10.6068(1)$ $c = 6.4447(1)$
$\alpha = 98.846(1)°$ $\beta = 108.981(1)°$ $\gamma = 105.581(1)°$ Z = 2

X-ray Powder Pattern: [Inder deposit, Kazakhstan.]
7.224 (100), 4.895 (85), 4.205 (80), 5.007 (75), 2.677 (75), 2.477 (70), 3.479 (65)

Chemistry:

	(1)	(2)
SiO_2	0.10	
B_2O_3	37.58	37.32
R_2O_3	0.20	
MgO	15.46	14.40
CaO	0.16	
F	0.14	
H_2O	47.09	48.28
$-O = F_2$	0.06	
Total	100.67	100.00

(1) Inder deposit, Kazakhstan. (2) $MgB_3O_3(OH)_5 \cdot 5H_2O$.

Polymorphism & Series: Dimorphous with inderite.

Occurrence: An uncommon mineral, typically in lake-bed borate deposits.

Association: Szaibélyite (Lake Inder, Kazakhstan).

Distribution: From the Inder borate deposit, Kazakhstan. At the Zhacang-Caka brine lake, and others, Qinghai Province and Xizang, Tibet, China. In the Kirka borate deposit, Kütahya Province, Turkey. Very large crystals from the Kramer borate deposit, Boron, Kern Co., California, USA. At the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina.

Name: To honor Professor Nikolai Semenovich Kurnakov (1860–1941), Russian mineralogist and chemist, Institute of General and Inorganic Chemistry, Moscow, Russia.

Type Material: Karpinskii All-Union Research Institute of Geology, St. Petersburg; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 61590.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 360. (2) Corazza, E. (1974) The crystal structure of kurnakovite: a refinement. Acta Cryst., 30, 2194–2199. (3) Schmetzer, K. and H.R. Gärtner (1975) Über Kurnakovit und Inderit, zwei wasserhaltige Magnesiumborate gleicher chemischer Zusammensetzung ($2MgO \cdot 3B_2O_3 \cdot 15H_2O$). Zeit. Deut. Gemmol. Ges., 24, 130–137 (in German with English abs.).

Kurumsakite $(Zn, Ni, Cu)_8Al_8V_2^{5+}Si_5O_{35} \cdot 27H_2O(?)$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. As radiating to finely felted fibers.

Physical Properties: Hardness = n.d. D(meas.) = 4.03 D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Yellowish green to bright yellow.
Luster: Vitreous to silky.
Optical Class: Biaxial (+). $\alpha = 1.616$ $\beta =$ n.d. $\gamma = 1.622$–1.623 2V(meas.) = $\sim 35^\circ$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kurumsak, Kazakhstan. (ICDD 29-571, corrected lines).
1.53 (100), 3.91 (75), 2.61 (50), 2.28 (38), 4.91 (25), 1.42 (25), 2.42 (13)

Chemistry:

	(1)
SiO_2	13.82
Al_2O_3	20.51
Fe_2O_3	2.15
V_2O_5	8.50
NiO	7.33
CuO	3.05
ZnO	17.55
MgO	0.92
CaO	1.24
H_2O	23.25
SO_3	1.15
Total	99.47

(1) Kurumsak, Kazakhstan.

Occurrence: In bituminous schists in the walls of cavities and open fissures.

Association: n.d.

Distribution: From the Kurumsak vanadium deposit, near Dzhambul, Kara-Tau Mountains, Kazakhstan.

Name: For the locality at Kurumsak, Kazakhstan.

Type Material: Mining Institute, St. Petersburg, Russia, 1273/1.

References: (1) Ankinovich, E.A. (1954) [title unknown] Izv. Akad. Nauk Kazakhstan SSR, 134, Ser. Geol. 19, 116. (2) Bohnshtedt-Kupletskaya, E.N. (1955) Zap. Vses. Mineral. Obshch., 84, 343–344 (abs. ref. 1, in Russian). (3) (1957) Mineral. Abs., 13, 207 (abs. ref. 1). (4) (1957) Amer. Mineral., 42, 583–584 (abs. ref. 2).

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Kusachiite $CuBi_2O_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As short prismatic crystals, to 0.5 mm; in globular aggregates.

Physical Properties: *Cleavage:* {110}, perfect. Hardness = 4.5 VHN = 292–357 (25 g load). D(meas.) = 8.5(3) D(calc.) = 8.64

Optical Properties: Opaque. *Color:* Black; gray in reflected light, with deep red to dark brown internal reflections. *Streak:* Black. *Luster:* Metallic.
Optical Class: Uniaxial. *Pleochroism:* Gray, with faint bluish tint, and brownish gray. *Anisotropism:* Weak to distinct. *Bireflectance:* Weak.
R_1–R_2: (482) 19.0–21.1, (545) 18.0–20.2, (589) 17.6–19.7, (659) 17.3–19.5

Cell Data: *Space Group:* $P4/ncc$. $a = 8.511(2)$ $c = 5.823(2)$ $Z = 4$

X-ray Powder Pattern: Fuka, Japan.
3.191 (100), 2.695 (18), 1.947 (18), 4.26 (17), 2.913 (16), 2.404 (13), 1.728 (12)

Chemistry:

	(1)	(2)
Bi_2O_3	86.00	85.42
CuO	13.91	14.58
Total	99.91	100.00

(1) Fuka, Japan; by electron microprobe, average of six analyses; corresponding to $Cu_{0.96}Bi_{2.03}O_{4.00}$. (2) $CuBi_2O_4$.

Occurrence: On calcite crystals in a calcite vein between gehlenite-spurrite skarn and limestone; thought to be of low-temperature hydrothermal origin.

Association: Henmilite, sillénite, bakerite, tenorite, bultfonteinite, apophyllite, cuspidine, thaumasite.

Distribution: From Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: To honor Dr. Isao Kusachi (1942–), Professor of Mineralogy, Okayama University, Okayama, Japan, for his work on skarn minerals of the Fuka area.

Type Material: National Science Museum, Tokyo, Japan.

References: (1) Henmi, C. (1995) Kusachiite, $CuBi_2O_4$, a new mineral from Fuka, Okayama Prefecture, Japan. Mineral. Mag., 59, 545–548. (2) (1996) Amer. Mineral., 81, 517 (abs. ref. 1).

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Kutínaite $Cu_{14}Ag_6As_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Fine-grained, as intergrowths with novákite.

Physical Properties: *Tenacity:* Malleable. Hardness = ∼4.5 VHN = 237–270 (25 g load). D(meas.) = 8.38(7) (synthetic). D(calc.) = 8.400

Optical Properties: Opaque. *Color:* Silvery gray; in polished section, grayish white to pale blue-gray. *Luster:* Metallic.

R: (400) 49.6, (420) 48.8, (440) 48.0, (460) 46.8, (480) 45.6, (500) 44.5, (520) 43.5, (540) 42.6, (560) 42.0, (580) 41.4, (600) 41.1, (620) 40.8, (640) 40.5, (660) 40.4, (680) 40.5, (700) 40.9

Cell Data: *Space Group:* $Pm3m$. $a = 11.78079(2)$ (synthetic). $Z = 4$

X-ray Powder Pattern: Černý Důl mine, Czech Republic.
2.259 (100), 2.078 (100), 2.702 (90), 2.398 (80), 1.991 (70), 1.959 (70), 1.776 (70)

Chemistry:

	(1)	(2)	(3)
Cu	43.68	43.89	43.16
Ag	31.63	31.63	31.40
As	25.16	24.26	25.44
Total	100.47	99.78	100.00

(1) Černý Důl mine, Czech Republic; by electron microprobe. (2) Wasserfall, France; by electron microprobe. (3) $Cu_{14}Ag_6As_7$.

Occurrence: In carbonate-rich hydrothermal veins (Černý Důl mine, Czech Republic).

Association: Novákite, koutekite, paxite, arsenolamprite, löllingite (Černý Důl mine, Czech Republic); allargentum, koutekite, domeykite (Wasserfall, France); koutekite, domeykite (Meskani, Iran); paxite, lautite, arsenic, silver, löllingite, proustite (Niederbeerbach, Germany).

Distribution: From the Černý Důl mine, Krkonoše (Giant Mountains), Czech Republic [TL]. At Wasserfall, about 20 km northwest of Belfort, Haute-Saône, France. From Mühltal, Niederbeerbach, Odenwald, Hesse, Germany. At the Meskani mine, Anarak district, Iran. In the East Arm area, Great Slave Lake, Northwest Territories, Canada.

Name: For Dr. Jan Kutina (1924–), Lecturer at the Charles University, Prague, Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 14428; Yale University, New Haven, Connecticut, USA.

References: (1) Hak, J., Z. Johan, and B.J. Skinner (1970) Kutinaite, a new copper–silver arsenide mineral from Černý Důl, Czechoslovakia. Amer. Mineral., 55, 1083–1087. (2) Picot, P. and F. Ruhlmann (1978) Présence d'arséniures de cuivre de haute température dan le granite des Ballons (Vosges méridionales). Bull. Minéral., 101, 563–569 (in French with English abs.). (3) Makovicky, M. and Z. Johan (1978) Reflectivity and microhardness of synthetic and natural koutekite, kutinaite and beta-domeykite. Neues Jahrb. Mineral., Monatsh., 421–432. (4) Johan, Z. (1985) The Černy Důl deposit (Czechoslovakia): an example of Ni-, Fe-, Ag-, Cu-arsenide mineralization with extremely high activity of arsenic; new data on paxite, novakite and kutinaite. Tschermaks Mineral. Petrog. Mitt., 34, 167–182. (5) Karanović, L., D. Poleti, E. Mackovicky, T. Balić-Žunić, and M. Makovicky (2002) The crystal structure of synthetic kutinaite, $Cu_{14}Ag_6As_7$. Can. Mineral., 40, 1437–1449.

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Kutnohorite $Ca(Mn^{2+}, Mg, Fe^{2+})(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. In polycrystalline spherules, to 2 cm, aggregates, and cleavages.

Physical Properties: *Cleavage:* [On $\{10\overline{1}1\}$, perfect.] (by analogy to dolomite group). *Fracture:* [Subconchoidal.] *Tenacity:* [Brittle.] Hardness = [3.5–4] D(meas.) = 3.12 D(calc.) = 3.15

Optical Properties: Translucent. *Color:* White, pale pink to bright pink. *Optical Class:* Uniaxial (–). $\omega = 1.710$–1.727 $\epsilon = 1.519$–1.535

Cell Data: *Space Group:* $R\overline{3}$. $a = 4.8518(3)$ $c = 16.217(2)$ $Z = 3$

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.935 (100), 1.814 (31), 1.837 (27), 3.753 (20), 2.225 (19), 2.043 (19), 2.437 (14)

Chemistry:

	(1)	(2)	(3)
CO_2	42.62	41.80	40.93
FeO	4.27	0.50	
MnO	23.76	28.31	32.99
MgO	5.18	2.21	
CaO	24.66	27.44	26.08
Total	100.49	100.26	100.00

(1) Kutná Hora, Czech Republic. (2) Franklin, New Jersey, USA. (3) $CaMn(CO_3)_2$.

Polymorphism & Series: Forms two series, with dolomite, and with ankerite.

Mineral Group: Dolomite group; ordered Ca:Mn $\simeq$ 1:1, commonly with substitution by Mg and Fe^{2+}.

Occurrence: Typically in deposits associated with manganiferous sediments.

Association: Rhodochrosite, aragonite, calcite.

Distribution: Analyzed material, shown to have the dolomite structure type, occurs at: Kutná Hora and Chvaletice, Czech Republic. At Långban, Värmland, Sweden. From near Levane, Tuscany, Italy. In the USA, at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in the Sunnyside and Silver King mines, Silverton district, San Juan Co., Colorado; in the Longvale quarry, Laytonville, Mendocino Co., California; from Bald Knob, Alleghany Co., North Carolina. At Mont Saint-Hilaire, Quebec, Canada. In the Providencia district, Zacetecas, Mexico. Fine examples from the N'Chwaning mine, near Kuruman, South Africa. In Japan, in the Hoei tin mine, Oita Prefecture, from the Chichibu mine, Saitama Prefecture, and at the Ryujima mine, 15 km southwest of Matsumo, Nagano Prefecture. From Broken Hill, New South Wales, Australia.

Name: For its first described occurrence at Kutná Hora, Czech Republic [the original label translated as kutnohorite].

Type Material: Harvard University, Cambridge, Massachusetts, USA, 109033, 111690, 85670.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 217. (2) Frondel, C. and L.H. Bauer (1955) Kutnahorite [kutnohorite]: a manganese dolomite. Amer. Mineral., 40, 748–760. (3) Farkas, L., B.H. Bolzenius, W. Schäfer, and G. Will (1988) The crystal structure of kutnohorite $CaMn(CO_3)_2$. Neues Jahrb. Mineral., Monatsh., 539–546.

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Kuzelite $Ca_4Al_2(SO_4)(OH)_{12}\cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ or 3. Platy hexagonal to rhomboidal crystals, to 2 mm.

Physical Properties: *Cleavage:* On {0001}, perfect. *Fracture:* Uneven. Hardness = 1–2 D(meas.) = 1.99(5) D(calc.) = 2.014

Optical Properties: Transparent. *Color:* White. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.504(5)$ $\epsilon = 1.485(5)$

Cell Data: *Space Group:* $R\overline{3}$ or $R3$. $a = 5.76(1)$ $c = 53.66(2)$ Z = 3

X-ray Powder Pattern: Zeilberg quarry, Germany.
8.972 (100), 4.476 (70), 2.362 (40), 2.190 (40), 2.071 (35), 4.004 (30), 2.882 (30)

Chemistry:

	(1)	(2)
SO_3	12.9	12.86
Al_2O_3	19.6	16.38
CaO	34.5	36.03
Na_2O	0.0	
H_2O	33.45	34.73
Total	100.45	100.00

(1) Zeilberg quarry, Germany; by electron microprobe, H_2O by TGA; corresponding to $Ca_{3.83}Al_{2.40}(SO_4)(OH)_{12.86}\cdot 6H_2O$. (2) $Ca_4Al_2(SO_4)(OH)_{12}\cdot 6H_2O$.

Occurrence: A rare mineral in carbonaceous xenoliths in basalt, formed above 100 °C by decomposition of ettringite.

Association: Ettringite, afwillite, natrolite, calcite, torbermorite, gyrolite, portlandite, apophyllite (Zeilberg quarry, Germany); hydrocalumite, ettringite, tobermorite, strätlingite–vertumnite, portlandite, calcite, gypsum (Bellerberg volcano, Germany).

Distribution: In Germany, from the Zeilberg quarry, Maroldsweisach, Bavaria, and at the Bellerberg volcano, two km north of Mayen, Eifel district.

Name: Honoring Professor Hans Jürgen Kuzel (1932–1997), German mineralogist, Mineralogical Institute, Erlangen, Germany, who first synthesized the compound.

Type Material: Martin Luther University, Halle, Germany.

References: (1) Pöllmann, H., T. Witzke, and H. Kohler (1997) Kuzelite, $[Ca_4Al_2(OH)_{12}][(SO_4)\cdot 6H_2O]$, a new mineral from Maroldsweisach/Bavaria, Germany. Neues Jahrb. Mineral., Monatsh., 423–432. (2) (1998) Amer. Mineral., 83, 909 (abs. ref. 1). (3) Allmann, R. (1977) Refinement of the hybrid layer structure $Ca_2Al(OH)_6 + \frac{1}{2}SO_4\cdot 3H_2O$. Neues Jahrb. Mineral., Monatsh., 136–144. (4) Blass, G. and H.W. Graf (2001) Neue Mineralienfunde as der Vulkaneifel. Mineralien Welt, 12(1), 19–20 (in German).

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Kuzminite $Hg^{1+}(Br, Cl)$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2m$. As elongated grains, to 0.5 mm; in aggregates and powdery masses.

Physical Properties: *Cleavage:* {100}, good. *Fracture:* Uneven. Hardness = ≤ 2 VHN = 21–29, 25 average (25 g load). D(meas.) = n.d. D(calc.) = [7.36]

Optical Properties: Transparent. *Color:* Colorless, white, creamy white, pale yellow, pale brownish, bluish gray; gray to pale gray in reflected light, with colorless to pale yellow internal reflections. *Streak:* White to gray. *Luster:* Adamantine.
Optical Class: Uniaxial (+); high birefringence. *Pleochroism:* Weak; light yellow to very pale brown. $n = > 2.00$ *Anisotropism:* Yellowish gray, grayish brown, and bluish gray. *Bireflectance:* Strong.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I4/mmm$. $a = 4.597(5)$ $c = 11.034(8)$ $Z = 4$

X-ray Powder Pattern: Kadyrel deposit, Russia.
3.25 (100), 4.26 (55), 2.103 (50), 2.76 (40), 1.989 (35), 2.296 (25b), 1.768 (20)

Chemistry:

	(1)
Hg	77.00
Cl	5.66
Br	16.60
Total	99.26

(1) Kadyrel deposit, Russia; by electron microprobe, average of four analyses; corresponds to $Hg_{1.02}(Br_{0.56}Cl_{0.42})_{\Sigma=0.98}$.

Polymorphism & Series: Forms a series with calomel.

Occurrence: In vugs in mercury sulfides, in calcite veins in a mercury ore deposit (Kadyrel deposit, Russia).

Association: Eglestonite, lavrentievite, kadyrelite, calomel, mercury, corderoite, cinnabar, iron oxides (Kadyrel deposit, Russia).

Distribution: From the Kadyrel mercury deposit, Pii-Khem district, Tuva, Siberia, Russia. At Landsberg, near Obermoschel, Rhineland-Palatinate, Germany.

Name: Honors Aleksei Mikhailovich Kuzmin (1891–1980), Russian mineralogist of the Tomsk Polytechnic Institute, Tomsk, Russia.

Type Material: Central Siberian Geological Museum, Siberian Division, Academy of Sciences, Novosibirsk, VI-28/1; Mining Institute, St. Petersburg, Russia, 1908/1–2.

References: (1) Vasil'ev, V.I., Y.G. Lavrent'ev, and N.A. Pal'chik (1986) Kuzminite – $Hg_2(Br, Cl)_2$ – a new natural mercury halide. Zap. Vses. Mineral. Obshch., 115, 595–598 (in Russian). (2) (1988) Amer. Mineral., 73, 192 (abs. ref. 1). (3) (1988) Mineral. Abs., 39, 122 (abs. ref. 1).

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Kuznetsovite $Hg_2^{1+}Hg^{2+}(AsO_4)Cl$

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Crystal Data: Cubic. *Point Group:* 23. As grains, to 1 mm.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 8.64–8.82 D(calc.) = 8.691

Optical Properties: Semitransparent. *Color:* Pale brown to honey-yellow, darkening on exposure to light; in reflected light, pale brown internal reflections. *Streak:* Yellow-orange. *Luster:* Vitreous to adamantine.
Optical Class: Isotropic. n = High.
R: (460) 17.6, (546) 16.9, (590) 16.2

Cell Data: *Space Group:* $P2_13$. $a = 8.4013(2)$ Z = 4

X-ray Powder Pattern: Arzak deposit, Russia.
2.53 (10), 2.81 (7), 4.86 (6), 3.43 (6), 1.834 (6), 4.21 (5), 3.77 (5)

Chemistry:

	(1)	(2)	(3)
Hg	77.62	77.97	77.53
As	8.75	8.87	9.65
Cl	4.50	4.55	4.57
O	8.97	9.33	8.25
Total	99.84	100.72	100.00

(1) Arzak deposit, Russia; by electron microprobe, average of seven grains; corresponding to $Hg_{3.08}As_{0.93}O_{4.48}Cl_{1.02}$. (2) Khaydarkan deposit, Kyrgyzstan; by electron microprobe, average of three grains; corresponding to $Hg_{3.03}As_{0.92}O_{4.54}Cl_{1.00}$. (3) $Hg_2^{1+}Hg^{2+}(AsO_4)Cl$.

Occurrence: In the oxidation zone of hydrothermal mercury deposits.

Association: Cinnabar, calomel, eglestonite, corderoite, mercury (Arzak deposit, Russia); cinnabar, calomel, eglestonite, corderoite, mercury, livingstonite, montroydite, shakhovite, chursinite (Khaydarkan deposit, Kyrgyzstan).

Distribution: In the Arzak mercury deposit, Pii-Khem district, Tuva, and the Kelyan Sb–Hg deposit, Buryatia, Siberia, Russia. From the Khaydarkan mercury deposit, Fergana Valley, Alai Range, Kyrgyzstan.

Name: Honors Academician Valerii Alekseevich Kuznetsov (1906–1985), Institute of Geology and Geophysics, Novosibirsk, Russia, student of mercury deposits.

Type Material: Central Siberian Geological Museum, Novosibirsk, Russia, VI-18/1; Mining Institute, St. Petersburg, 1122/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81062.

References: (1) Vasil'ev, V.I. and Y.G. Lavrent'ev (1980) Kuznetsovite, $Hg_6As_2Cl_2O_9$, a new mercury mineral. Doklady Acad. Nauk SSSR, 255, 963–968 (in Russian). (2) (1981) Amer. Mineral., 66, 1100 (abs. ref. 1). (3) Solov'eva, L.P., S.V. Tsybulya, V.A. Zabolotnyi, and N.A. Pal'chik (1991) Determination and refinement of the structure of the mineral kuznetsovite from X-ray powder diffraction data. Kristallografiya (Sov. Phys. Crystal.), 36, 731–732.

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Kvanefjeldite $Na_4(Ca,Mn)Si_6O_{14}(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Anhedral plates, flattened on {010}; as aggregates, to 15 mm.

Physical Properties: *Cleavage:* Good on {010}; poor on {101}, intersecting at 83°. Hardness = 5.5–6 D(meas.) = 2.55 D(calc.) = 2.53

Optical Properties: Transparent. *Color:* Pink with a violet hue. *Luster:* Vitreous, pearly on {010} cleavage.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.522(1)$ $\beta = 1.522(1)$ $\gamma = 1.543(1)$ 2V(meas.) = 0°–9°

Cell Data: *Space Group: Pcab.* $a = 10.213(2)$ $b = 15.878(4)$ $c = 9.058(1)$ $Z = 4$

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
3.117 (10), 4.355 (7), 3.880 (7), 4.447 (6), 3.388 (6), 3.313 (5), 2.576 (5)

Chemistry:

	(1)
SiO_2	65.00
TiO_2	< 0.02
Al_2O_3	< 0.02
Y_2O_3	0.40
FeO	0.05
MnO	1.59
MgO	< 0.02
CaO	8.49
Na_2O	22.06
K_2O	< 0.02
Total	97.59

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, average of 16 analyses on two grains; TGA gave 4% weight loss at 600 °C; corresponds to $Na_{3.96}(Ca_{0.84}Mn_{0.12}Y_{0.02})_{\Sigma=0.98}Si_{6.01}O_{14}(OH)_2$.

Occurrence: As patches, streaks, and veinlets cutting arfvedsonite-bearing nepheline syenite; probably of late-stage hydrothermal origin.

Association: Villiaumite, analcime.

Distribution: On the Kvanefjeld Plateau, in the Ilímaussaq intrusion, southern Greenland.

Name: For the type locality, which is Danish for *the mountain where the* angelica *grows*.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1983.136, GGU 47887; Harvard University, Cambridge, Massachusetts, 127475; National Museum of Natural History, Washington, D.C., USA, 162234.

References: (1) Petersen, O.V. and O. Johnsen (1984) Kvanefjeldite, a new mineral species from the Ilímaussaq alkaline complex, southwest Greenland. Can. Mineral., 22, 465–467.
(2) Johnsen, O., E.S. Leonardsen, L. Fälth, and H. Annehed (1983) Crystal structure of kvanefjeldite: the introduction of $^2_\infty[Si_3O_7OH]$ layers with eight-membered rings. Neues Jahrb. Mineral., Monatsh., 505–512. (3) (1985) Amer. Mineral., 70, 873 (abs. refs. 1 and 2).

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Kyanite Al_2SiO_5

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals bladed and tabular on {100}, elongated ∥ to [001], to 0.5 m; typically bent or twisted. *Twinning:* Lamellar on {100}, twin axis ⊥ {100} or ∥ [010] or [001], common.

Physical Properties: *Cleavage:* Perfect on {100}, good on {010}, (100) ∧ (010) = 79°; parting on {001}. *Fracture:* Splintery. Hardness = 5.5 ∥ [001], 7 ∥ [100]. D(meas.) = 3.53–3.65 D(calc.) = [3.67]

Optical Properties: Transparent to translucent. *Color:* Blue, white, rarely green, gray, yellow, pink, black, can be zoned; colorless to pale blue in thin section. *Luster:* Vitreous to pearly. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; in thick sections, X = colorless; Y = violet-blue; Z = cobalt blue. *Orientation:* $X \simeq \perp$ {100} on {100}; $X' \wedge a = 0°$–$25°$ on {001}; $Z' \wedge c = 27°$–$32°$ on {100}; $Z' \wedge c = 5°$–$8°$ on {010}. *Dispersion:* $r > v$, weak. $\alpha = 1.710$–1.718 $\beta = 1.719$–1.724 $\gamma = 1.724$–1.734 2V(meas.) = 78°–83°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.1262(12)$ $b = 7.8520(10)$ $c = 5.5724(10)$ $\alpha = 89.99(2)°$ $\beta = 101.11(2)°$ $\gamma = 106.03(1)°$ Z = 4

X-ray Powder Pattern: Zillertal, Austria. (ICDD 11-46).
3.18 (100), 1.377 (75), 3.35 (65), 1.962 (55), 1.935 (50), 1.930 (50), 2.520 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	36.68	37.08	MnO	0.00	
TiO_2	0.00		MgO	0.02	
Al_2O_3	63.28	62.92	CaO	0.01	
Cr_2O_3	0.06		Na_2O	0.00	
FeO	0.37		K_2O	0.01	
			Total	100.43	100.00

(1) Elovyi, Karelia; by electron microprobe. (2) Al_2SiO_5.

Polymorphism & Series: Trimorphous with andalusite and sillimanite.

Occurrence: In gneisses, schists, included pegmatites, and quartz veins, from moderately high-pressure regional metamorphism of principally pelitic rocks; detrital in sedimentary rocks.

Association: Staurolite, andalusite, sillimanite, talc, "hornblende," gedrite, mullite, corundum.

Distribution: Widely distributed, even in good crystals. From Mt. Greiner, Zillertal, Tirol, Austria. At Alpe Sponda, Pizzo Forno, and at Alpe Campolungo, Tessin, Switzerland. In the Pfitschtal, Trentino-Alto Adige, Italy. From Röros, Norway. Around Yekaterinburg (Sverdlovsk), Ural Mountains, Russia. At Elovyi, Klavoloke, Karelia. From Sultan Hamud, Machakos district, Kenya. Large crystals from a number of localities in Minas Gerais, Brazil, as at Barro Prêto, São José do Jacuri. In the USA, at Lyme, Grafton Co., New Hampshire; at Judd's Bridge, Litchfield Co., Connecticut; at Darby, Delaware Co., Pennsylvania; from near Bakersville, Mitchell Co., and near Burnsville, Yancy Co., North Carolina; on Willis Mountain, Buckingham Co., Virginia.

Name: From the Greek for *blue*, in allusion to its common dark blue color.

Type Material: Mining Academy, Freiberg, Germany, 22491.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 500–501 [cyanite]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 780–800. (3) Parkin, K.M., B.M. Loeffler, and R.G. Burns (1977) Mössbauer spectra of kyanite, aquamarine, and cordierite showing intervalence charge transfer. Phys. Chem. Minerals, 1, 301–311. (4) Winter, J.K. and S. Ghose (1979) Thermal expansion and high-temperature crystal chemistry of the Al_2SiO_5 polymorphs. Amer. Mineral., 64, 573–586.

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Kyzylkumite $V_2^{3+}Ti_3O_9$

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Crystal Data: Monoclinic. *Point Group:* n.d. In grains, prismatic with pyramidal terminations, striated parallel elongation, to 0.2 mm.

Physical Properties: Hardness = n.d. VHN = 882–900 (100 g load). D(meas.) = 3.75(1) D(calc.) = 3.77

Optical Properties: Opaque. *Color:* Black. *Luster:* Vitreous to resinous.
Optical Class: Biaxial. *Anisotropism:* Distinct.
R_1–R_2: (440) 14.7–15.8, (460) 14.6–15.7, (480) 14.5–15.7, (500) 14.5–15.8, (520) 14.6–15.8, (540) 14.7–16.0, (560) 14.8–16.2, (580) 14.8–16.2, (600) 15.0–16.3, (620) 15.1–16.4, (640) 15.2–16.5, (660) 15.2–16.5

Cell Data: *Space Group:* n.d. $a = 33.80(5)$ $b = 4.578(5)$ $c = 19.99(3)$ $\beta = 93.40(5)^\circ$ $Z = 18$

X-ray Powder Pattern: Koscheka deposit, Uzbekistan.
2.92 (100), 3.70 (80), 1.682 (65), 1.650 (55), 2.60 (50), 1.692 (50), 2.192 (48)

Chemistry:

	(1)	(2)
TiO_2	61.7	61.52
Fe_2O_3	0.7	
V_2O_3	36.2	38.48
Cr_2O_3	1.2	
Total	99.8	100.00

(1) Koscheka deposit, Uzbekistan; by electron microprobe, average of ten grains, V^{3+} confirmed by titration, total Fe as Fe_2O_3; corresponds to $(V^{3+}_{1.90}Fe_{0.04}Cr_{0.01})_{\Sigma=1.95}Ti_{3.05}O_{9.09}$. (2) $V_2Ti_3O_9$.

Polymorphism & Series: Dimorphous with schreyerite.

Occurrence: In veins cutting siliceous schists.

Association: Chlorite, pyrite, rutile.

Distribution: From the Koscheka uranium deposit, Auminzatau Mountains, central Kyzylkum region, Uzbekistan.

Name: For the Kyzylkum Desert, Uzbekistan, where it was first found.

Type Material: Mineralogical Museum, St. Petersburg University, 17408; Mining Institute, St. Petersburg, Russia, 1197/1.

References: (1) Smyslova, I.G., A.I. Komkov, V.V. Pavshukov, and N.V. Kuznetsova (1981) Kyzylkumite $V_2Ti_3O_9$ – new mineral of vanadium and titanium of a group of complex oxides. Zap. Vses. Mineral. Obshch., 110, 607–612 (in Russian). (2) (1982) Amer. Mineral., 67, 855–856 (abs. ref. 1). (3) (1982) Mineral. Abs., 33, 309 (abs. ref. 1).

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Laachite $(Ca,Mn)_2Zr_2Nb_2TiFeO_{14}$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Forms isolated, imperfect, prismatic to acicular crystals elongated on [100], to 0.5 mm. *Twinning:* Twin plane is (130), with 65° between the *a* axes of the twin components.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.417

Optical Properties: Translucent. *Color*: Deep brownish red. *Streak*: Brownish red. *Luster*: Adamantine. *Pleochroism*: Medium, red-brown to brownish red. *Absorption*: X >Y ≈ Z. *Optical Class*: n.d. *n*(calc.) = 2.26

Cell Data: *Space Group*: *C*2/*c*. *a* = 7.3119(5) *b* = 14.1790(10) *c* = 10.1700(7) β = 90.072(2)° Z = 4

X-ray Powder Pattern: ''Zieglowski''quarry, Eifel region, Rheinland-Pfalz, Germany. 2.967 (100), 2.901 (59), 1.800 (34), 2.551 (32), 1.541 (24), 1.535 (23), 1.529 (23)

Chemistry:

	(1)
CaO	4.29
MnO	9.42
FeO	5.73
Y_2O_3	2.56
La_2O_3	2.00
Ce_2O_3	6.37
Nd_2O_3	2.22
Al_2O_3	0.99
ThO_2	7.75
TiO_2	10.98
ZrO_2	19.39
Nb_2O_5	27.82
Total	99.52

(1) ''Zieglowski''quarry, Eifel region, Rheinland-Pfalz, Germany; average of 5 electron microprobe analyses, absence of H_2O, OH^-, CO_3^{2-} confirmed by Raman spectroscopy; corresponding to $(Ca_{0.66}Mn_{0.37}Th_{0.25}Y_{0.20}La_{0.11}Ce_{0.34}Nd_{0.11})(Zr_{1.36}Mn_{0.64})(Nb_{1.81}Ti_{1.19})(Fe_{0.69}Al_{0.17}Mn_{0.14})O_{14.00}$.

Occurrence: In vesicular sanidinite volcanic ejectum.

Association: Sanidine, allanite-(Ce), baddeleyite, haüyne, hedenbergite, intermediate members of the jacobsite-magnetite series, phlogopite, rhodonite, spessartine, tephroite, thorite, zircon, a pyrochlore-group mineral.

Distribution: From the ''Zieglowski'' pumice quarry, 1.5 km NE of Mendig, near Laach Lake (Laacher See), Eifel volcanic region, Rheinland-Pfalz, Germany.

Name: For the locality that produced the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (4361/1).

References: (1) Chukanov, N.V., S.V. Krivovichev, A.S. Pakhomova, I.V. Pekov, C. Schäfer, M.F. Vigasina, and K.V. Van (2014) Laachite, $(Ca,Mn)_2Zr_2Nb_2TiFeO_{14}$, a new zirconolite-related mineral from the Eifel volcanic region, Germany. European Journal of Mineralogy, 26(1), 103-111. (2) (2014) Amer. Mineral., 99, 1809 (abs. ref. 1).

Labradorite $Na_{0.5-0.3}Ca_{0.5-0.7}Al_{1.5-1.7}Si_{2.5-2.3}O_8$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals typically thin, tabular along [010], and rhombic in section, to 4 cm. Cleavable, granular, or massive. *Twinning:* Common according to Albite, Pericline, Carlsbad, Baveno, or Manebach laws.

Physical Properties: *Cleavage:* Perfect on {001}, less perfect on {010}, intersecting at 90°; distinct on {110}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.68–2.72 D(calc.) = 2.685–2.710

Optical Properties: Translucent to transparent. *Color:* Gray, brown, greenish, blue, yellow, colorless; commonly exhibits iridescence, especially on {010}; colorless in thin section. *Streak:* White. *Luster:* Vitreous; pearly on cleavages.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, weak. $\alpha = 1.555–1.565$ $\beta = 1.558–1.569$ $\gamma = 1.563–1.573$ 2V(meas.) = 78°–87° (low); 80° to −81° (high).

Cell Data: *Space Group:* $C\bar{1}$ (low). $a = 8.1648$ $b = 12.8585$ $c = 7.0973$ $\alpha = 90°34'$ $\beta = 116°06'$ $\gamma = 89°47'$ Z = 4

X-ray Powder Pattern: Synthetic $Na_{0.40}Ca_{0.60}Al_{1.60}Si_{2.40}O_8$ (high).
3.20 (100), 4.03 (80), 3.75 (80), 3.17 (80), 3.63 (70), 2.94 (70), 2.51 (70)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	52.97	55.59	50.54	Na_2O	3.97	5.73	3.40
Al_2O_3	29.41	28.30	31.70	K_2O	0.26		
Fe_2O_3	0.76			H_2O	0.22		
CaO	12.59	10.38	14.36	Total	100.18	100.00	100.00

(1) San Marcos Mountains, California, USA. (2) $Na_{0.50}Ca_{0.50}Al_{1.50}Si_{2.50}O_8$.
(3) $Na_{0.30}Ca_{0.70}Al_{1.70}Si_{2.30}O_8$.

Polymorphism & Series: High- and low-temperature structural varieties are recognized.

Mineral Group: Feldspar group, plagioclase series.

Occurrence: In mafic igneous rocks and anorthosites. Rarer in metamorphic rocks, as amphibolites. As detrital grains in sedimentary rocks.

Association: Olivine, pyroxenes, amphiboles, magnetite.

Distribution: Widespread. From Ford Harbour, Pauls Island, Labrador, Newfoundland; at Lake St. John, Quebec; and elsewhere in Canada. In the USA, especially in northern New York, forming the Adirondack Mountains; crystals from Sagebrush Flat, about 37 km north of Plush, Lake Co., Oregon; atop the San Marcos Mountains, San Diego Co., and in the western San Gabriel Mountains, Los Angeles Co., California. Abundant gem crystals in the Pinacate volcanic field, Sonora, Mexico. At Vesuvius, Campania, and on Mt. Etna, Sicily, Italy. From Ylämaa, near Lappeenranta, Finland. In the Langesundsfjord- Larvik-Tvedalen area, Norway. On Surtsey Island, south of Iceland.

Name: For the type locality on Pauls Island, off the coast of Labrador, Canada.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 325–327, 334–337. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 94–165. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 352–360. (4) Goodyear, J. and W.J. Duffin (1954) The identification and determination of plagioclase feldspars by the X-ray powder method. Mineral. Mag., 30, 306–326. (5) Stewart, D.B, G.W. Walker, T.L. Wright, and J.J. Fahey (1966) Physical properties of calcic labradorite from Lake County, Oregon. Amer. Mineral., 51, 177–197. (6) Wenk, H.-R., W. Joswig, T. Tagai, M. Korekawa, and B.K. Smith (1980) The average structure of An 62-66 labradorite. Amer. Mineral., 65, 81–95.

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Labyrinthite $(Na, K, Sr)_{35}Ca_{12}Fe_3Zr_6TiSi_{51}O_{144}(O, OH, H_2O)_9Cl_3$

Crystal Data: Hexagonal. *Point Group*: 3. As rounded grains, to 1.0 cm.

Physical Properties: *Cleavage*: n.d. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 5-6 D(meas.) = 2.88(2) D(calc.) = 2.87

Optical Properties: Transparent. *Color*: Vivid pink. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (+). ω = 1.597(1) ε = 1.601(1)

Cell Data: *Space Group*: *R*3. a = 14.239(1) c = 60.733(7) Z = 3

X-ray Powder Pattern: Khibiny alkaline massif, Kola Peninsula, Russia.
2.977 (100), 2.853 (88), 4.324 (68), 3.230 (44), 3.550 (39), 2.685 (38), 3.049 (36)

Chemistry:

	(1)
Na_2O	16.77
K_2O	1.11
CaO	10.73
SrO	1.24
FeO	2.56
MnO	1.00
Ce_2O_3	0.27
SiO_2	50.04
ZrO_2	11.90
TiO_2	0.67
Cl	1.70
F	0.11
H_2O	1.58
-O = (Cl, F)	0.43
Total	99.25

(1) Khibiny alkaline massif, Kola Peninsula, Russia; average of 8 EDS electron microprobe analyses, OH and H_2O confirmed by IR, H_2O by Penfield method, corresponding to $(Na_{33.30}K_{1.45}Sr_{0.74})_{\Sigma=35.49}(Ca_{11.77}Ce_{0.10})_{\Sigma=11.87}(Fe_{2.19}Mn_{0.87})_{\Sigma=3.06}Zr_{5.94}(Ti_{0.52}Si_{0.26})_{\Sigma=0.78}Si_{51}O_{144.48}(OH)_{4.80}Cl_{2.95}F_{0.36}\cdot 3H_2O$.

Mineral Group: Eudialyte group.

Occurrence: A late-stage pegmatitic mineral in an alkaline igneous complex.

Association: K-feldspar, sodalite, alkali amphiboles, aegirine, pectolite, lamprophyllite, lomonosovite, villiaumite, lovozerite-group minerals.

Distribution: Eveslogchorr Mountain, Khibiny alkaline massif, Kola Peninsula, Russia.

Name: Alludes to its very complex (*labyrinthine*) crystal structure.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, 2624/2.

References: (1) Khomyakov, A.P., G.N. Nechelyustov, and R.K. Rastsvetaeva (2006) Labyrinthite $(Na, K, Sr)_{35}Ca_{12}Fe_3Zr_6TiSi_{51}O_{144}(O, OH, H_2O)_9Cl_3$, a new mineral with a modular eudialyte-like structure from Khibiny alkaline massif, Kola Peninsula, Russia. Zap. Ross. Mineral. Obshch., 135(2), 38–49 (in Russian, English abstract). (2) (2009) Amer. Mineral., 94, 400 (abs. ref. 1). (3) Rastsvetaeva, R.K., and A.P. Khomyakov (2001) Modular structure of a sodium-rich analogue of eudialyte with the doubled *c*-parameter and *R*3 symmetry. Crystallogr. Reports, 46, 752–757. (4) (2002) Amer. Mineral., 87, 767 (abs. ref. 3).

Lacroixite $NaAl(PO_4)F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rough crystals, to 1 cm; as druses, massive.

Physical Properties: *Cleavage:* Indistinct on {111} and $\{1\bar{1}1\}$. Hardness = 4.5
D(meas.) = 3.29 D(calc.) = 3.29

Optical Properties: Transparent. *Color:* Gray, pale yellow to pale green, almost white; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Dispersion:* $r < v$. $\alpha = 1.546(1)$ $\beta = 1.563(1)$ $\gamma = 1.580(1)$
2V(meas.) = 89(1)° 2V(calc.) = 89.1°

Cell Data: *Space Group:* $C2/c$. $a = 6.414$ $b = 8.207$ $c = 6.885$ $\beta = 115.47°$ Z = 4

X-ray Powder Pattern: Greifensteine, Germany.
3.155 (100), 2.895 (98), 2.476 (57), 4.73 (51), 2.166 (43), 4.627 (32), 1.578 (27)

Chemistry:

	(1)	(2)
P_2O_5	44.7	43.30
Al_2O_3	32.1	31.09
Na_2O	16.4	18.90
F	12.3	11.59
$-O = F_2$	5.17	4.88
Total	100.3	100.00

(1) Greifensteine, Germany; by electron microprobe; $(OH)^{1-}$ absent by IR and structure analysis.
(2) $NaAl(PO_4)F$.

Occurrence: In druses in granite (Greifensteine, Germany); an alteration product rimming natromontebrasite in a complex granite pegmatite (Rusororo, Rwanda).

Association: Morinite, viitaniemiite, apatite, childrenite, roscherite, feldspar, tourmaline, quartz (Greifensteine, Germany); montebrasite, scorzalite, berlinite (Rusororo pegmatite, Rwanda); apatite, augelite, brazilianite, natromontebrasite (Strickland quarry, Connecticut, USA).

Distribution: Large crystals [from the Koppar quarry,] on the Greifensteine, near Ehrenfriedersdorf, Saxony, Germany. At Lázně Kynzvart, near Mariánské Lázně (Königswart, near Marienbad), and Ječlov, near Jihlava, Czech Republic. From Montebras, Creuse, France. In the Rusororo and Buranga pegmatites, near Gatumba, Rwanda. At the Strickland quarry, Portland, Middlesex Co., Connecticut, and in the Mount Rubellite quarry, Hebron, Oxford Co., Maine, USA.

Name: Honors François Antoine Alfred Lacroix (1863–1948), French mineralogist, Natural History Museum, Paris, France.

Type Material: Charles University, Prague, Czech Republic, 7400; Harvard University, Cambridge, Massachusetts, USA, 86746.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 783. (2) Lahti, S.I. and A. Pajunen (1985) New data on lacroixite, $NaAlFPO_4$. Part I. Occurrence, physical properties and chemical composition. Part II. Crystal structure. Amer. Mineral., 70, 849–855. (3) Fransolet, A.-M. (1989) The problem of Na–Li substitution in primary Li-Al phosphates: new data on lacroixite, a relatively widespread mineral. Can. Mineral., 27, 211–217.

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Laffittite $AgHgAsS_3$

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Crystal Data: Monoclinic, pseudocubic. *Point Group:* $2/m$. As rough crystals, to 4 mm, spindlelike to prismatic, tabular on {100}; granular. *Twinning:* On {100}, twin axis $\perp$ {100}; also by an unknown law giving intergrowths at a 60° angle.

Physical Properties: *Cleavage:* Good to imperfect on {010}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 92–138 (25 g load). D(meas.) = 6.11 (synthetic). D(calc.) = 6.195

Optical Properties: Opaque; transparent in tiny crystals. *Color:* Dark red to cherry-red; in polished section, bluish white with numerous purple-red internal reflections. *Streak:* Pale cherry-red to brownish red. *Luster:* Metallic, adamantine. *Pleochroism:* Strong. *Anisotropism:* Strong to moderate, from pale gray-blue to dark gray.
R_1–R_2: (400) 34.5–38.4, (420) 34.6–37.7, (440) 34.7–37.0, (460) 34.4–36.1, (480) 33.8–35.2, (500) 32.9–34.3, (520) 31.8–33.4, (540) 30.7–32.5, (560) 29.5–31.7, (580) 28.6–30.8, (600) 28.0–30.1, (620) 27.4–29.7, (640) 27.1–29.4, (660) 26.8–29.4, (680) 26.6–29.2, (700) 26.3–28.9

Cell Data: *Space Group:* $A2/a$. $a = 7.732(3)$ $b = 11.285(7)$ $c = 6.643(4)$ $\beta = 115.16(3)°$ $Z = 4$

X-ray Powder Pattern: Jas Roux, France.
2.682 (100), 3.198 (80), 3.005 (80), 3.505 (70), 2.133 (60), 5.31 (50), 1.905 (50)

Chemistry:

	(1)	(2)	(3)
Ag	21.9	21.6	22.49
Hg	41.0	41.4	41.83
As	15.6	14.8	15.62
Sb		1.6	
S	20.3	19.8	20.06
Total	98.8	99.2	100.00

(1) Jas Roux, France; by electron microprobe, corresponding to $Ag_{0.97}Hg_{0.98}As_{1.01}S_{3.04}$. (2) Chauvai deposit, Kyrgyzstan; by electron microprobe, corresponding to $Ag_{0.97}Hg_{1.00}(As_{0.96}Sb_{0.06})_{\Sigma=1.02}S_{3.00}$. (3) $AgHgAsS_3$.

Occurrence: With other arsenic sulfides, in hydrothermal deposits.

Association: Smithite, stibnite, pierrotite, parapierrotite, aktashite, realgar, wakabayashilite, sphalerite, pyrite, routhiérite, chabournéite (Jas Roux, France); orpiment, realgar, stibnite, getchellite, sphalerite (Getchell mine, Nevada, USA); galkhaite, stibnite, cinnabar, metacinnabar, sphalerite, fluorite, calcite, quartz (Chauvai deposit, Kyrgyzstan).

Distribution: From the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France [TL]. In the USA, at the Getchell mine, Potosi district, Humboldt Co., Nevada. From the Chauvai Sb–Hg deposit, Fergana Valley, Alai Range, southern Kyrgyzstan.

Name: For Pierre Laffitte (1925–), Director, National School of Mines, Paris, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., J. Mantienne, and P. Picot (1974) La routhiérite, $TlHgAsS_3$, et la laffittite, $AgHgAsS_3$, deux nouvelles espèces minérales. Bull. Soc. fr. Minéral., 97, 48–53 (in French with English abs.). (2) (1975) Amer. Mineral., 60, 945–946 (abs. ref. 1). (3) Nakai, I. and D.E. Appleman (1983) Laffittite, $AgHgAsS_3$; crystal structure and second occurrence from the Getchell mine, Nevada. Amer. Mineral., 68, 235–244. (4) Stepanov, V.I., V.Y. Volgin, and N.I. Chistyakova (1986) Laffittite $AgHgAsS_3$ from the Chauvai mercury deposit, southern Kigizia, its first find in the USSR. Doklady Acad. Nauk SSSR, 288, 703–706 (in Russian).

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Laflammeite $Pd_3Pb_2S_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As euhedral to subhedral platelets, to 0.3 mm, and as intergrowths with vysotskite–braggite. *Twinning:* Finely twinned.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Brittle. Hardness = ∼3.5 VHN = 156–185, 171 average (50 g load). D(meas.) = n.d. D(calc.) = 9.41

Optical Properties: Opaque. *Color:* Cream with a brownish tint in reflected light. *Streak:* Dark gray. *Luster:* Metallic. *Anisotropism:* Weak; brownish gray to grayish brown. *Bireflectance:* Weak.

R_1–R_2: (400) 44.0–45.2, (420) 44.6–45.8, (440) 44.9–46.0, (460) 45.2–46.1, (480) 45.4–46.2, (500) 45.6–46.4, (520) 45.9–46.8, (540) 46.3–47.2, (560) 46.7–47.8, (580) 47.4–48.5, (600) 48.0–49.0, (620) 48.6–49.4, (640) 49.3–49.8, (660) 49.8–50.0, (680) 50.5–50.2, (700) 51.3–50.4

Cell Data: *Space Group:* $C2/m$ (by analogy to parkerite). $a = 11.521(11)$ $b = 8.294(10)$ $c = 8.321(6)$ $\beta = 134.38(5)^\circ$ $Z = 4$

X-ray Powder Pattern: Kirakkajuppura deposit, Finland.
4.144 (10), 2.917 (9), 2.413 (8), 2.365 (7), 5.953 (6), 2.082 (5), 3.379 (3)

Chemistry:

	(1)	(2)
Pd	39.46	40.02
Ir	1.08	
Pb	52.01	51.94
S	7.90	8.04
Total	100.15	100.00

(1) Kirakkajuppura deposit, Finland; by electron microprobe, average of 26 analyses on two grains; corresponds to $(Pd_{2.96}Ir_{0.05})_{\Sigma=3.01}Pb_{2.02}S_{1.98}$. (2) $Pd_3Pb_2S_2$.

Occurrence: In a platinum-group-element deposit in a layered ultramafic intrusive complex, formed under relatively high-Pb, low-S conditions.

Association: Vysotskite, zvyagintsevite, cuprorhodsite–malanite, laurite–erlichmanite, irarsite, keithconnite, gold, chalcopyrite, bornite, millerite.

Distribution: From the Kirakkajuppura deposit, Penikat layered complex, northeast of Kemi, Finland [TL].

Name: In honor of Joseph Hector Gilles Laflamme (1947–), Canada Centre for Mineral and Energy Technology (CANMET), Ottawa, Canada, for his work on platinum-group minerals.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 83195.

References: (1) Barkov, A.Y., R.F. Martin, T.A.A. Halkoaho, and A.J. Criddle (2002) Laflammeite $Pd_3Pb_2S_2$, a new platinum-group mineral species from the Penikat layered complex, Finland. Can. Mineral., 40, 671–678. (2) (??) Amer. Mineral., ??, ?? (abs. ref. 1).

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Laforêtite $AgInS_2$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. As anhedral inclusions, to 30 μm, in galena. *Twinning:* Polysynthetic lamellar twinning with stairsteplike offsets.

Physical Properties: Hardness = ∼3 VHN = 176–193, 183 average (100 g load) (synthetic). D(meas.) = n.d. D(calc.) = 4.93

Optical Properties: Opaque. *Color:* In reflected light, brownish gray with red internal reflections
Optical Class: Biaxial. *Pleochroism:* Weak; brown to brown-gray. *Anisotropism:* Strong; brick-red with orange tint, to bluish gray purplish.
R_1–R_2: (400) 30 , (420) 29 , (440) 28 , (460) 27 , (480) 26 , (500) 25.2, (520) 24.8, (540) 24.6, (560) 24.3, (580) 24.2, (600) 24.3, (620) 24.3, (640) 24.6, (660) 25.8, (680) 25.2, (700) 24.7

Cell Data: *Space Group:* $I\bar{4}2d$. $a = 5.880(2)$ $c = 11.21(1)$ Z = 4

X-ray Powder Pattern: Montgros mine, France (showing preferred orientation).
1.768 (vs), 2.072 (s), 1.702 (s), 2.024 (m), 1.471 (m), 1.403 (m), 1.346 (m)

Chemistry:

	(1)	(2)	(3)
Ag	37.68	37.48	37.61
Cu	0.04	0.52	
Zn		1.31	
Fe	0.02	0.18	
Se	0.01		
In	40.22	39.19	40.03
S	22.42	21.49	22.36
Total	100.39	100.17	100.00

(1) Montgros mine, France; by electron microprobe, average of eight analyses on two grains; corresponds to $Ag_{0.99}In_{1.00}S_{2.00}$. (2) Toyoha mine, Japan; by electron microprobe, corresponds to $Ag_{1.00}Zn_{0.06}Cu_{0.02}Fe_{0.01}In_{0.98}S_{1.93}$. (3) $AgInS_2$.

Mineral Group: Chalcopyrite group.

Occurrence: In a dump sample from a vein-type hydrothermal ore deposit (Montgros mine, France); in a vein-type hydrothermal ore deposit (Toyoha mine, Japan).

Association: Galena, sphalerite, barite, ankerite, quartz (Montgros mine, France); sphalerite, hocartite, pyrargyrite (Toyoha mine, Japan).

Distribution: From the Montgros Pb–Zn mine, near La Boriette, about 10 km southwest of Langeac, Haute-Loire, France [TL]. At the Toyoha Pb–Zn–Ag mine, 40 km southwest of Sapporo, Hokkaido, Japan.

Name: In honor of Claude P. Laforêt (1936–), French metallographer, Bureau de Recherches Géologiques et Minières, Orléans, France, who first observed the species.

Type Material: Geological Museum, Lausanne, Switzerland, MGL 58600; B.R.G.M., Orléans; Natural History Museum, Paris, France.

References: (1) Meisser, N., P. Thelin, P.-J. Chiappero, and C. Maurel (1999) Laforêtite, $AgInS_2$, a new mineral of the chalcopyrite group from the Montgros mine, Haute-Loire, France. Eur. J. Mineral., 11, 891–897. (2) (2000) Amer. Mineral., 85, 875 (abs. ref. 1).

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Lahnsteinite $Zn_4(SO_4)(OH)_6 \cdot 3H_2O$

Crystal Data: Triclinic (pseudo-orthorhombic). *Point Group*: 1. As hexagonal tabular crystals, to 0.7 mm, displaying {001}, {00$\bar{1}$}, {110}, {130}, {010}, {$\bar{1}$ $\bar{1}$ 0}, {$\bar{1}$ $\bar{3}$ 0}, and {0$\bar{1}$ 0}.

Physical Properties: *Cleavage*: Perfect on {001}, 2 more less-perfect sets perpendicular to (001). *Fracture*: n.d. *Tenacity*: Sectle. Hardness = 1.5 D(meas.) = 2.98(2) D(calc.) = 2.995

Optical Properties: Translucent. *Color*: Colorless. *Streak*: n.d. *Luster*: n.d.
Optical Class: Biaxial (–). α = 1.568(2) β = 1.612(2) γ = 1.613(2) 2V(meas.) = 18(3)° 2V(calc.) = 17° *Orientation*: $X \sim c$, $Y \sim b$, $Z \sim a$. *Dispersion*: None.

Cell Data: *Space Group*: $P1$. a = 8.312(1) b = 14.545(1) c = 18.504(2) α = 89.71(1)° β = 90 05(1)° γ = 90 13(1)° Z = 8

X-ray Powder Pattern: Friedrichssegen mine, near Lahnstein, Rhineland-Palatinate, Germany. 9.30 (100), 2.723 (57), 2.624 (36), 2.503 (35), 1.574 (23), 3.476 (19), 3.290 (19)

Chemistry:

	(1)
FeO	3.87
CuO	1.68
ZnO	57.85
SO_3	15.83
H_2O	22.3
Total	101.53

(1) Friedrichssegen mine, near Lahnstein, Rhineland-Palatinate, Germany; average of 6 electron microprobe analyses, H_2O by gas chromatography; corresponding to $(Zn_{3.53}Fe_{0.27}Cu_{0.11})_{\Sigma=3.91}(S_{0.98}O_4)(OH)_6 \cdot 3H_{2.10}O$.

Occurrence: In the oxidized zone of a hydrothermal polymetallic sulfide deposit.

Association: Hydrozincite, pyromorphite, native copper, goethite.

Distribution: From dumps at the Friedrichssegen mine, near Lahnstein, Ems District, Rhineland-Palatinate (Rheinland-Pfalz), Germany.

Name: For the city nearby the locality from which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (4352/1).

References: (1) Chukanov, N.V., R.K. Rastsvetaeva, S.M. Aksenov, I.V. Pekov, D.I. Belakovskiy, G. Blass, and G. Möhn (2013) Lahnsteinite, $Zn_4(SO_4)(OH)_6 \cdot 3H_2O$, a new mineral species from the Friederichssegen Mine, Germany. Zap. Ross. Mineral. Obshch., 142(1), 39-46 (in Russian, with English abstract). (2) Rastsvetaeva, R.K., S.M. Aksenov, N.V. Chukanov, and I.A. Verin (2012) Crystal structure of a new mineral lahnsteinite $Zn_4(SO_4)(OH)_6 \cdot 3H_2O$. Kristallografiya, 57, 5, 825-829 (in Russian). With English translation: Crystallography Reports (2012), 57(5) 737-741.
(3) (2014) Amer. Mineral., 99, 246 (abs. refs. 1 and 2).

Laihunite $Fe^{2+}Fe^{3+}_2(SiO_4)_2$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals subhedral, thick tabular to short prismatic, to 1 mm; as anhedral grains.

Physical Properties: *Cleavage:* Perfect on {100} and {010}, two less perfect $\sim\perp$ {100} and intersecting at 60°. Hardness = 5.5–6.5 VHN = 617–833 D(meas.) = 3.967 D(calc.) = 4.11 Moderately magnetic and electromagnetic.

Optical Properties: Opaque, translucent in very thin section. *Color:* Black; gray in reflected light. *Streak:* Pale brown, blackish brown. *Luster:* Submetallic to metallic. *Pleochroism:* Gray to grayish black. *Anisotropism:* Weak.

Cell Data: *Space Group:* $P2_1/b$. $a = 4.805(2)$ $b = 10.189(9)$ $c = 17.403(9)$ $\alpha = 91.0(2)°$ $Z = 12$

X-ray Powder Pattern: Little Lai-He Village, China.
3.488 (10b), 2.521 (10), 2.774 (9), 1.745 (8), 2.405 (7), 2.246 (7), 2.175 (6)

Chemistry:

	(1)
SiO_2	31.07
Fe_2O_3	44.24
FeO	23.64
MgO	0.87
CaO	0.21
Total	100.03

(1) Little Lai-He Village, China; corresponds to $(Fe^{2+}_{1.18}Mg_{0.08})_{\Sigma=1.26}Fe^{3+}_{2.00}(Si_{0.93}O_4)_2$.

Polymorphism & Series: 3M, 2M polytypes.

Occurrence: In a Precambrian metamorphic iron deposit, probably derived by oxidation of fayalite (Little Lai-He Village, China).

Association: Quartz, "hypersthene," magnetite, "hornblende," augite, plagioclase (Little Lai-He, China).

Distribution: At Little Lai-He village, Liaoning Province, China. From Kamitaga, Shizuoka Prefecture, and Yugawara, Kanagawa Prefecture, Japan. In the Cherkassk massif, Kuraminsk, Siberia, Russia. From the St. Peters Dome area, El Paso Co., Colorado, USA.

Name: For the occurrence at Little Lai-He Village, China.

Type Material: n.d.

References: (1) Laihunite Research Group, Guiyang Institute of Geochemistry, Academia Sinica and Geological Team 101, Liaoning Metallurgical and Geological Prospecting Company (1976) Laihunite, a new iron silicate mineral. Geochimica, 2, 95–103 (in Chinese with English abs.). (2) X-ray Laboratory, Guiyang Institute of Geochemistry, Academia Sinica (1976) The crystal structure of laihunite. Geochimica, 2, 104–105 (in Chinese with English abs.). (3) (1977) Amer. Mineral., 62, 1058 (abs. refs. 1 and 2). (4) Ferrifayalite Research Group, Department of Geology, Peking University and Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences (1976) Ferrifayalite and its crystal structure. Acta Geologica Sinica, 2, 161–175 (in Chinese with English abs.). (5) (1978) Amer. Mineral., 63, 424–425 (abs. ref. 4). (6) Shen, B., O. Tamada, M. Kitamura, and N. Morimoto (1986) Superstructure of laihunite-3M ($\square_{0.40}Fe^{2+}_{0.80}Fe^{3+}_{0.80}SiO_4$). Amer. Mineral., 71, 1455–1460.

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Laitakarite $Bi_4(Se,S)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As foliated plates and sheets, elongated along [001]; as grains, to 2 mm.

Physical Properties: *Cleavage:* {001}, excellent. Hardness = n.d. VHN = 54–78 (100 g load). D(meas.) = 8.12 D(calc.) = [8.28]

Optical Properties: Opaque. *Color:* In polished section, galena-white. *Luster:* Metallic. *Anisotropism:* Moderate, pale brown to dark gray.
R_1–R_2: (400) 50.6–53.8, (420) 50.4–54.0, (440) 50.2–54.2, (460) 50.1–54.5, (480) 49.9–54.6, (500) 49.8–54.6, (520) 49.4–54.6, (540) 49.1–54.6, (560) 48.8–54.6, (580) 48.5–54.6, (600) 48.2–54.5, (620) 47.9–54.4, (640) 47.6–54.0, (660) 47.2–53.5, (680) 46.5–52.9, (700) 45.9–52.3

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.2239(14)$ $c = 39.94(3)$ $Z = 3$

X-ray Powder Pattern: Orijärvi mine, Finland.
3.072 (100), 2.246 (80), 2.112 (80), 1.741 (70), 4.425 (60), 3.586 (60), 1.538 (60)

Chemistry:

	(1)	(2)		(1)	(2)
Bi	78.28	77.9	Zn	0.14	
Pb	0.78	3.4	Se	15.50	15.4
Ag	0.71		S	3.28	3.3
Cu	0.26		insol.	0.93	
			Total	99.88	100.0

(1) Orijärvi mine, Finland; after deducting 4% of galena, sphalerite, and chalcopyrite this yields $Bi_{3.95}(Se_{2.07}S_{0.93})_{\Sigma=3.00}$. (2) Falun, Sweden; by electron microprobe; corresponds to $(Bi_{3.75}Pb_{0.16})_{\Sigma=3.91}(Se_{1.96}S_{1.04})_{\Sigma=3.00}$.

Occurrence: In veinlets in quartz-anthophyllite-cordierite-biotite rocks (Orijärvi mine, Finland).

Association: Chalcopyrite, bismuth, sphalerite, molybdenite, silver, pyrite, galena (Orijärvi mine, Finland); tetrahedrite–tennantite, luzonite–famatinite, pyrite, mawsonite, nekrasovite, chalcopyrite, emplectite, bismuth, calcite, quartz, barite (Kuramin Mountains, Uzbekistan); nevskite, wolframite, natanite, wittite, selenian bismuthinite, selenian cosalite, cassiterite, guanajuatite (Nevskoye deposit, Russia).

Distribution: In southwestern Finland, from the Orijärvi mine, Orijärvi [TL]. At Falun, Kopparberg, and Boliden, Skellefte district, Sweden. From La Creusaz, Valais, Switzerland. In the Bonser vein, Coniston mines, Cumbria, England. At the Khayragatsch gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. From the Nevsky W–Sn deposit, 25 km northwest of Omsukchan, Magadan region, Russia. In the Akenobe mine, Hyogo Prefecture, Japan. From the Kidd Creek mine, near Timmins, Ontario, Canada. At the Lega Dembi gold deposit, Sidamo Province, Ethiopia.

Name: For Professor Aarne Laitakari (1890–1975), Director, Geological Survey of Finland, who collected the original material.

Type Material: n.d.

References: (1) Vorma, A. (1959) Laitakarite, a new Bi–Se mineral in Orijärvi. Geologi, 3, 11 (in Finnish). (2) (1959) Amer. Mineral., 44, 908 (abs. ref. 1). (3) Vorma, A. (1960) Laitakarite, a new Bi–Se mineral. Bull. Comm. Geol. Finlande, 188, 1–10 (in English). (4) (1962) Amer. Mineral., 47, 806 (abs. ref. 3). (5) Nenasheva, S.N., N.N. Mozgova, Y.S. Borodayev, A.V. Yefimov, and N.I. Organova (1988) Crystal structure of laitakarite as a function of its chemical composition. Doklady Acad. Nauk SSSR, 303, 1468–1472 (in Russian). (6) Bayliss, P. (1991) Crystal chemistry and crystallography of some minerals in the tetradymite group. Amer. Mineral., 76, 257–265. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 309.

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Lalondeite $(Na,Ca)_6Ca_3Si_{16}O_{38}(F,OH)_2 \cdot 3H_2O$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As roundish plates, to 3 mm, dominated by {001}; as densely packed, randomly oriented aggregates.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Splintery. *Tenacity*: Brittle, inelastic. Hardness = ~ 3 D(meas.) = 2.50(1) D(calc.) = 2.51

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Pearly. Medium to strong, violet-blue fluorescence in MW UV; weak under SW; none under LW. *Optical Class*: Biaxial (-). α = 1.522(1) β = 1.528(1) γ = 1.529(1) 2V(meas.) = 48(1)° 2V(calc.) = 44(1)° *Orientation*: X ≈ *c*.

Cell Data: *Space Group*: $P\bar{1}$. *a* = 9.589(2) *b* = 9.613(2) *c* = 12.115(2) α = 96.62(2)° β = 92.95(2)° γ = 119.81(2)° Z = 2

X-ray Powder Pattern: Poudrette Quarry, Mont Saint-Hilaire, Quebec, Canada.
2.888 (100), 11.987 (90), 5.968 (85), 2.967 (50), 3.972 (40), 2.981 (35), 4.142 (30)

Chemistry:

	(1)
Na_2O	11.28
K_2O	0.70
CaO	15.00
SiO_2	66.36
F	1.28
Cl	0.18
H_2O	4.27
-O = F+Cl	0.58
Total	98.49

(1) Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada; average of 18 electron microprobe analyses, IR and structure analysis confirms OH and H_2O, H_2O calculated, corresponding to $(Na_{5.33}Ca_{0.91}K_{0.22})_{\Sigma=6.46}Ca_3Si_{16.16}O_{38}(F_{0.99}OH_{0.94}Cl_{0.07})_{\Sigma=2} \cdot 3H_2O$.

Mineral Group: Reyerite-gyrolite group.

Occurrence: A late-stage low-temperature hydrothermal mineral.

Association: Microcline, clinoamphibole, narsarssukite.

Distribution: Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Professor Andre E. Lalonde, Department of Earth Sciences, University of Ottawa, Canada, for work on mica minerals and alkaline intrusions.

Type Material: Canadian Museum of Nature, Aylmer, Quebec, Canada (catalog no. CMNMC 83720).

References: (1) McDonald, A.M. and G.Y. Chao (2009) Lalondeite, a new hydrated Na–Ca fluorosilicate species from Mont Saint-Hilaire, Quebec: description and crystal structure. Can. Mineral., 47, 181–191. (2) (2009) Amer. Mineral., 94, 1497-1498 (abs. ref. 1).

Lammerite-β $Cu_3(AsO_4)_2$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As irregular prismatic grains, to 0.15 mm, with striations parallel to elongation.

Physical Properties: *Cleavage:* None observed. *Fracture:* n.d. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.06

Optical Properties: Transparent. *Color:* Light to dark green. *Streak:* n.d.
Luster: Vitreous.
Optical Class: Biaxial (+). α = 1.887(5) β = 1.936(5) γ = 2.01(1) 2V(calc) = 81°
Dispersion: $r < v$, strong. *Pleochroism:* None observed.

Cell Data: *Space Group: $P2_1/c$*. a = 6.306(1) b = 8.643(1) c = 11.310(1) β = 92.26(1)°
Z = 4

X-ray Powder Pattern: Great fissure Tolbachik eruption, Kamchatka peninsula, Russia.
2.83 (100), 6.50 (10), 5.65 (10), 4.32 (10), 4.03 (5), 2.90 (5), 2.86 (5)

Chemistry:	(1)
CuO	51.30
ZnO	0.32
As_2O_3	49.12
Total	100.74

(1) Great fissure Tolbachik eruption, Kamchatka peninsula, Russia; average of 5 electron microprobe analyses; corresponding to $Cu_{3.00}Zn_{0.02}As_{1.99}O_8$.

Polymorphism & Series: The polymorph of lammerite.

Occurrence: The product of post-eruption fumarolic reactions (400–650 °C) in an active volcano.

Association: Euchlorine, piypite, alumokluchevskite, alarsite, lammerite.

Distribution: Second Scoria cone of the Northern Branch of the Great fissure Tolbachik eruption (1975–1976), Kamchatka peninsula, Russia.

Name: Signifies the monoclinic polymorph of *lammerite*, named to honor Franz Lammer, mineral collector of Leoben, Austria, who provided the first specimen.

Type Material: Mineralogical Museum, Saint Petersburg University, Saint Petersburg, Russia.

References: (1) Starova, G.L., L.P. Vergasova, S.*K.* Filatov, S.N. Britvin, and V.V. Ananyev (2011) Lammerite-β, $Cu_3(AsO_4)_2$ - a new mineral from fumaroles of the Great fissure Tolbachic eruption (Kamchatka, Russia). Zap. Ross. Mineral. Obshch., 140(5), 46–51 (in Russian, English abstract).
(2) (2013) Amer. Mineral., 98, 1080 (abs. ref. 1).

Lammerite $Cu_3(AsO_4, PO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 2 mm, are prismatic along [001] to tabular on {100} and terminated by {011}; additional forms include {010} and striated {120}; in radial spheroidal aggregates.

Physical Properties: *Cleavage:* Perfect on {010}; good on {100}; imperfect on {001}. Hardness = 3.5–4 D(meas.) = 4.9–5.18 D(calc.) = 5.263

Optical Properties: Transparent. *Color:* Dark green. *Streak:* Pale green. *Luster:* Adamantine, vitreous on cleavage surfaces. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = pale blue; Y = sky-blue; Z = pale bluish green. *Orientation:* $X = b$; $Z \wedge c \simeq 40°$. *Dispersion:* $r \gg v$, very strong. $\alpha = \sim 1.89$ $\beta = 1.90$–2.06 $\gamma = 1.95$–2.14 2V(meas.) = 54(5)° 2V(calc.) = 50°

Cell Data: *Space Group:* $P2_1/a$. $a = 5.079(1)$ $b = 11.611(2)$ $c = 5.394(1)$ $\beta = 111.72(2)°$ Z = 2

X-ray Powder Pattern: Laurani, Bolivia.
2.89 (10), 2.52 (9), 3.06 (8), 3.00 (8), 2.62 (8), 2.59 (8), 2.84 (7)

Chemistry:

	(1)	(2)
As_2O_5	49.8	32.64
P_2O_5		12.40
FeO	0.2	0.06
CuO	49.9	54.64
ZnO	0.8	0.11
MgO	0.2	
Total	100.9	99.85

(1) Laurani, Bolivia; by electron microprobe, absence of $(OH)^{1-}$ and H_2O confirmed by IR; corresponding to $(Cu_{2.90}Zn_{0.05}Mg_{0.02}Fe_{0.01})_{\Sigma=2.98}(As_{1.00}O_4)_2$. (2) Tolbachik fissure volcano, Russia; by electron microprobe, corresponding to $(Cu_{2.96}Zn_{0.01})_{\Sigma=2.97}[(As_{0.62}P_{0.38})_{\Sigma=1.00}O_4]_2$.

Occurrence: On an old mineral specimen (Laurani, Bolivia); in an oxidized zone in a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia); in volcanic sublimates (Tolbachik fissure volcano, Russia).

Association: Olivenite (Laurani, Bolivia); chalcanthite, anhydrite, leightonite (Tsumeb, Namibia); euchlorine, melanothallite, dolerophanite, chalcocyanite, leningradite, tolbachite, anglesite, alarsite, fedotovite, klyuchevskite, nabokoite, atlasovite, langbeinite, hematite, tenorite (Tolbachik fissure volcano, Russia).

Distribution: From Laurani, Oruro, Bolivia. At Tsumeb, Namibia. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Franz Lammer, mineral collector of Leoben, Austria, who provided the first specimen.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany; The Natural History Museum, London, England, 1980,357; Harvard University, Cambridge, Massachusetts, 117006; National Museum of Natural History, Washington, D.C., USA, 146966, 148264.

References: (1) Keller, P., W.H. Paar, and P.J. Dunn (1981) Lammerit, $Cu_3[AsO_4]_2$, ein neues Mineral von Laurani, Bolivien. Tschermaks Mineral. Petrog. Mitt., 28, 157–164 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 415 (abs. ref. 1). (3) Hawthorne, F.C. (1986) Lammerite, $Cu_3(AsO_4)_2$, a modulated close-packed structure. Amer. Mineral., 71, 206–209. (4) Filatov, S.K., I.M. Gaykamako, S.F. Glavatskikh, G.L. Starova, and N.D. Sorokin (1984) Lammerite, $Cu_3[(As, P)O_4]_2$ from Kamchatka volcanic exhalations. Doklady Acad. Nauk SSSR, 279, 197–200 (in Russian).

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Lamprophyllite $(Na,Mn,K)_3(Sr,Ba)_2Ti_3O_2(Si_2O_7)_2(O,OH,F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals flattened on {100}, elongated along [001], rarely terminated, to 20 cm; as stellate clusters and sheaflike aggregates. *Twinning:* Common on {100}, rarely polysynthetic.

Physical Properties: *Cleavage:* Perfect micaceous on {100}; poor on {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 3.44–3.53 D(calc.) = [3.48]

Optical Properties: Opaque, transparent to translucent in thin section. *Color:* Dark brown, brownish yellow, straw-yellow, reddish brown with a golden tint. *Streak:* Pale yellow, may have an orange tint. *Luster:* Submetallic on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow; Y = straw-yellow; Z = orange or straw-yellow. *Orientation:* $X \perp b$; $Z \wedge c \simeq 4°$–$8°$. *Dispersion:* $r > v$, strong. $\alpha = 1.735$–1.749 $\beta = 1.747$–1.754 $\gamma = 1.770$–1.781 2V(meas.) = 21°–41°

Cell Data: *Space Group:* $C2/m$. $a = 19.431(3)$ $b = 7.086(1)$ $c = 5.392(1)$ $\beta = 96.75(5)°$ Z = 2

X-ray Powder Pattern: Kola Peninsula, Russia. (ICDD 17-751).
2.773 (100), 3.43 (55), 2.130 (45), 1.477 (45), 3.73 (40), 3.27 (40), 2.874 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	30.40	30.93	SrO	14.58	14.12
TiO_2	27.48	27.14	BaO	1.25	3.49
Al_2O_3		0.56	Na_2O	12.35	10.64
Fe_2O_3	3.87	1.36	K_2O	2.31	1.26
$(Nb,Ta)_2O_5$		0.16	F	1.82	1.10
FeO	1.97	2.31	H_2O^+		0.56
MnO	2.33	3.46	H_2O^-		0.16
MgO	0.25	0.40	LOI	0.60	
CaO	1.41	2.48	$-O = F_2$	0.77	0.46
			Total	99.85	99.67

(1) Kukisvumchorr apatite deposit, Khibiny massif, Russia. (2) Mt. Karnasurt, Lovozero massif, Russia.

Occurrence: In all rock types and most pegmatites of a differentiated alkalic massif (Lovozero massif, Russia).

Association: Microcline, nepheline, aegirine, lorenzenite, eudialyte, lomonosovite, murmanite, villiaumite (Lovozero massif, Russia); microcline, nepheline, catapleiite, aegirine, calcite, fluorite, analcime, pectolite (Pilansberg, South Africa).

Distribution: In Russia, in the Lovozero and Khibiny assifs, Kola Peninsula; in the Konder, Inagli, and Yllymakh massifs, Yakutia. In the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland. From the Langesundsfjord, Norway. At Pilansberg, Transvaal, South Africa. In the Rocky Boy stock, Bear Paw Mountains, Hill Co., Montana, USA. At Mont Saint-Hilaire, Quebec, Canada. From Pedro Balao, Poços de Caldas, Minas Gerais, and Serrote, Cascata, São Paulo, Brazil.

Name: From the Greek for *shining* and *leaf*, for its lustrous cleavage.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 40. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 207–209. (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 361–370 (in English). (4) Saf'yanov, Y.N., N.O. Vasil'eva, V.P. Golovachev, E.A. Kuz'min, and N.V. Belov (1983) Crystal structure of lamprophyllite. Doklady Acad. Nauk SSSR, 269, 117–120 (in Russian).

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Lanarkite $Pb_2O(SO_4)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 5 cm, are elongated along [010], showing {001}, {110}, with many {$h0l$} forms, may form radial aggregates; massive. *Twinning:* Rare, along the [010] zone.

Physical Properties: *Cleavage:* On {$\overline{2}01$}, perfect; on {$\overline{4}01$}, {201}, {010}, imperfect. *Tenacity:* Flexible in thin laminae. Hardness = 2–2.5 D(meas.) = 6.92 D(calc.) = 7.08 Fluoresces yellow under X-rays and LW UV.

Optical Properties: Transparent to translucent. *Color:* Gray, pale green, pale yellow; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine to resinous, pearly on cleavage surfaces.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 30°$. *Dispersion:* $r > v$, strong, inclined. $\alpha = 1.928(3)$ $\beta = 2.007(3)$ $\gamma = 2.036(3)$ 2V(meas.) = 60(2)°

Cell Data: *Space Group:* $C2/m$ (synthetic). $a = 13.769(5)$ $b = 5.698(3)$ $c = 7.079(2)$ $\beta = 115°56(10)'$ Z = 4

X-ray Powder Pattern: [Scotland?] (ICDD 18-702).
2.95 (100), 3.33 (80), 2.85 (30), 2.048 (20), 1.841 (20), 2.260 (16), 4.42 (10)

Chemistry:

	(1)	(2)
SO_3	15.37	15.21
PbO	84.63	84.79
Total	[100.00]	100.00

(1) Leadhills, Scotland; recalculated to 100% after deduction of ignition loss 0.83% from an original total of 98.66%. (2) $Pb_2O(SO_4)$.

Occurrence: A rare secondary mineral in the oxidized zone of lead sulfide deposits.

Association: Cerussite, leadhillite, susannite, hydrocerussite, caledonite.

Distribution: In Scotland, large crystals from the Susanna mine, Leadhills, Lanarkshire; at the Meadowfoot smelter, near Wanlockhead, Dumfriesshire, in slag. In England, from several mines in Caldbeck Fells, Cumbria; in the Gravel Hill mine, Perranzabuloe, Cornwall. At the Frongoch mine, Dyfed, Wales. In Germany, at Giepenbach, near Tanne, Harz Mountains; in the Herrensegen mine, Kinzigtal, and from near Badenweiler, Black Forest. From the Silberleiten mine, near Bieberwier, northwest of Innsbruck, Tirol, Austria. At the Laquorre mine, near Aulus, Ariège, France. At Laurium, Greece, in slag. In the Tchah Milleh mine, near Anarak, Iran. From the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa, in slag. In the Ediacara lead mine, 19 km west of Beltana, South Australia. In the USA, in the Leadville district, Lake Co., Colorado; at the C & B mine, Dripping Springs Mountains, Gila Co., Arizona. From the Buena Esperanza mine, Challacollo, Tarapacá, Chile.

Name: For the occurrence in the Susanna mine, Lanarkshire, Scotland.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 550–551. (2) Sahl, K. (1970) Zur Kristallstruktur von Lanarkit, $Pb_2O(SO_4)$. Zeits. Krist., 132, 99–117 (in German with English abs.).

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Landauite $\mathbf{NaMn^{2+}Zn_2(Ti, Fe^{3+})_6Ti_{12}O_{38}}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As prismatic crystals and irregular grains, to 1 mm, in aggregates. *Twinning:* Commonly as complex cyclic twins.

Physical Properties: *Fracture:* Conchoidal. Hardness = 7.5 D(meas.) = 4.42 D(calc.) = 4.46

Optical Properties: Opaque, translucent through thin edges. *Color:* Black; brownish green through thin edges. *Streak:* Gray. *Luster:* Submetallic.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X = Z$ = bottle-green; Y = green.
Dispersion: $r > v$, weak. *Absorption:* $Z > Y > X$. $\alpha = 2.373$ β = n.d. $\gamma = 2.388$
2V(meas.) = ∼60°

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.366(7)$ $c = 20.77(1)$ Z = 3

X-ray Powder Pattern: Burpala massif, Russia.
2.83 (10), 2.11 (9), 1.780 (8), 1.582 (8), 1.429 (8), 2.21 (7), 3.36 (6)

Chemistry:

	(1)
Nb_2O_5	0.29
TiO_2	72.59
ZrO_2	0.30
Fe_2O_3	6.77
FeO	1.26
MnO	4.12
ZnO	10.85
PbO	2.10
Na_2O	1.36
K_2O	0.45
Total	100.09

(1) Burpala massif, Russia; by electron microprobe, Fe^{2+}:Fe^{3+} ratio approximated from charge balance; corresponds to $(Na_{0.76}K_{0.16}Pb_{0.16})_{\Sigma=1.08}Mn_{1.00}Zn_{2.30}Ti_{15.70}Fe_{1.75}(Nb, Zr)_{0.08}O_{38}$.

Mineral Group: Crichtonite group.

Occurrence: An accessory mineral in albite veins cutting syenite pegmatite associated with an alkalic pluton.

Association: Albite, polylithionite, brookite, chabazite, monazite, bastnäsite, murataite.

Distribution: In the Burpala massif, 120 km north of Lake Baikal, eastern Siberia, Russia.

Name: Honors Lev Davidovich Landau (1908–1968), noted Russian physicist.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67187, vis5882, vis5883; National Museum of Natural History, Washington, D.C., USA, 144009.

References: (1) Portnov, A.M., L.Y. Nikolayeva, and T.I. Stolyarova (1966) A new titanium mineral, landauite. Doklady Acad. Nauk SSSR, 166, 1420–1421 (in Russian). (2) (1966) Amer. Mineral., 51, 1546 (abs. ref. 1). (3) Il'menev, E.S., A.M. Portnov, S.V. Bochkov, and S.I. Vostrova (1972) New type of baumhauer twins in landauite crystals. Doklady Acad. Nauk SSSR, 202, 1321–1323 (in Russian). (4) Grey, I.E. and B.M. Gatehouse (1978) The crystal structure of landauite, $Na[MnZn_2(Ti, Fe)_6Ti_{12}]O_{38}$. Can. Mineral., 16, 63–68.

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Landesite $(Mn^{2+},Mg)_9Fe_3^{3+}(PO_4)_8(OH)_3 \cdot 9H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Massive, replacing reddingite.

Physical Properties: *Cleavage:* Good on {100}; poor ⊥ {100}. Hardness = 3–3.5
D(meas.) = 3.026 D(calc.) = 3.210

Optical Properties: Translucent. *Color:* Yellowish brown; yellowish brown in transmitted light.
Optical Class: Biaxial (–). *Pleochroism:* X = dark brown; Y = light brown; Z = yellow.
Orientation: $Z \perp \{100\}$. $\alpha = 1.720$ $\beta = 1.728$ $\gamma = 1.735$ 2V(meas.) = Large.

Cell Data: *Space Group: Pbna.* $a = 9.458(3)$ $b = 10.185(2)$ $c = 8.543(2)$ Z = 4

X-ray Powder Pattern: Berry quarry, Maine, USA.
3.207 (100), 5.096 (54), 3.163 (35), 2.758 (29), 4.284 (27), 2.630 (24), 3.090 (23)

Chemistry:

	(1)
P_2O_5	31.94
$Fe_2O_3 + FeO$	13.91
Mn_2O_3	2.69
MnO	33.65
MgO	3.07
CaO	1.39
H_2O	13.60
insol.	0.13
Total	100.38

(1) Berry quarry, Maine, USA; corresponds to $(Mn^{2+}_{7.2}Mg_{1.2}Ca_{0.5})_{\Sigma=8.9}(Fe^{3+}_{2.7}Mn^{3+}_{0.5})_{\Sigma=3.2}(PO_4)_8(OH)_{3.2} \cdot 8.8H_2O$.

Occurrence: Replacing reddingite in a complex granite pegmatite (Berry quarry, Maine, USA).

Association: Reddingite, lithiophilite, rhodochrosite, eosphorite, fairfieldite, apatite (Berry quarry, Maine, USA).

Distribution: In the USA, in the Berry quarry, Poland, Androscoggin Co., and the Emmons quarry, Greenwood, Oxford Co., Maine; from Branchville, Fairfield Co., Connecticut. At Hagendorf, Bavaria, Germany.

Name: Honors Dr. Kenneth Knight Landes (1899–1984), Professor of Geology, University of Michigan, Ann Arbor, Michigan, USA, for his study of Maine pegmatites.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 91214.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 729–730. (2) Moore, P.B. (1964) Investigations of landesite. Amer. Mineral., 49, 1122–1125. (3) Moore, P.B., T. Araki, and A.R. Kampf (1980) Nomenclature of the phosphoferrite structure type: refinements of landesite and kryzhanovskite. Mineral. Mag., 43, 789–795.

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Långbanite $(Mn^{2+},Ca)_4(Mn^{3+},Fe^{3+})_9Sb^{5+}Si_2O_{24}$

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Crystal Data: Hexagonal or monoclinic. *Point Group:* $3m$ or $2/m$. As short to long prismatic crystals, to 1 cm, vertically striated ‖ $\{11\bar{2}0\}$.

Physical Properties: *Cleavage:* Good cleavage or parting on {0001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 4.92–4.94 D(calc.) = 4.97

Optical Properties: Opaque. *Color:* Iron-black. *Streak:* Dark reddish brown.
Luster: Metallic, brilliant.
Optical Class: Uniaxial (–). $\omega = 2.36$ (Li). $\epsilon = 2.31$

Cell Data: *Space Group:* $P31m$. a = 11.563(2) $c = 11.100(2)$ Z = 3, or *Space Group:* $C2/m$. a = 11.561(5) $b = 20.05(1)$ $c = 11.075(9)$ $\beta = 90.03(5)^\circ$ Z = 6

X-ray Powder Pattern: Långban, Sweden. (ICDD 14-195).
2.55 (100), 2.745 (90), 2.80 (80), 1.54 (80), 1.67 (70), 1.43 (50), 1.99 (40)

Chemistry:

	(1)	(2)
SiO_2	10.88	9.14
Fe_2O_3		8.56
Mn_2O_3		44.21
Y_2O_3		0.06
Sb_2O_5	15.42	14.36
FeO	10.32	
MnO	64.00	21.96
CaO		1.11
Total	100.62	99.40

(1) Långban, Sweden. (2) Do.; by electron microprobe, average of eight analyses; corresponding to $(Mn^{2+}_{3.73}Ca_{0.26}Y_{0.01})_{\Sigma=4.00}(Mn^{3+}_{7.23}Fe^{3+}_{1.38}Mn^{2+}_{0.27}Sb_{0.15})_{\Sigma=9.03}Sb_{1.00}Si_{1.97}O_{24}$.

Occurrence: In crystalline limestones and manganese-rich skarns in metamorphosed manganese deposits.

Association: Manganoan aegirine, richterite, braunite, magnetite, hausmannite, rhodonite, hedyphane.

Distribution: From Långban, Värmland, and the Sjö mine, near Grythyttan, Örebro, Sweden. In the Gozaisho mine, Fukushima Prefecture, Japan.

Name: For the place of its original discovery, Långban, Sweden.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 543–544, 1039–1040. (2) Giuseppetti, G., F. Mazzi, and C. Tadini (1991) The crystal structure of monoclinic langbanite: $(Mn,Ca,Fe,Mg)^{2+}_4(Mn,Fe)^{3+}_9Sb^{5+}[O_{16}(SiO_4)_2]$. Neues Jahrb. Mineral., Monatsh., 193–211. (3) Moore, P.B., P.K. Sen Gupta, and Y. Le Page (1991) The remarkable långbanite structure type: crystal structure, chemical crystallography, and relation to some other cation close-packed structures. Amer. Mineral., 76, 1408–1425.

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Langbeinite $K_2Mg_2(SO_4)_3$

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Crystal Data: Cubic. *Point Group:* 23. Crystals are rare, to 2 cm, equant {100}, {111}, {$\bar{1}$11}, many other modifying forms; in nodules, disseminated granular, typically bedded massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4
D(meas.) = 2.83 D(calc.) = 2.77 Slowly soluble in H_2O; piezoelectric.

Optical Properties: Transparent *Color:* Colorless, may be pale shades of yellow, pink, red, green, gray; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic. n = 1.5329–1.5347

Cell Data: *Space Group:* $P2_13$. a = 9.919(2) Z = 4

X-ray Powder Pattern: Synthetic.
3.137 (100), 2.651 (35), 4.051 (25), 2.992 (16), 2.753 (16), 2.405 (12), 1.609 (12)

Chemistry:

	(1)	(2)
SO_3	57.99	57.87
MgO	19.91	19.43
K_2O	22.72	22.70
Total	100.62	100.00

(1) Hall, Austria. (2) $K_2Mg_2(SO_4)_3$.

Occurrence: A principal ore of potash, mined from marine salt deposits.

Association: Carnallite, halite, sylvite.

Distribution: In Germany, from Wilhelmshall, near Halberstadt; at Solvayhall, near Bernberg; from Hattord, Hesse; and elsewhere. At Hall and Hallstatt, Austria. From Stebnyk, near Drogobych, Ukraine. At Sleights, Eskdale, Yorkshire, England. In the Mayo mine, Salt Range, Punjab, India. From the Qarhan salt lake, Qinghai Province, and the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China. In the USA, in New Mexico, in commercial quantities in the Carlsbad potash district, Eddy Co.

Name: To honor A. Langbein, of Leopoldshall [Stassfurt], Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 434–435. (2) Mereiter, K. (1979) Refinement of the crystal structure of langbeinite, $K_2Mg_2(SO_4)_3$. Neues Jahrb. Mineral., Monatsh., 182–188. (3) (1968) NBS Mono. 25, 40–41.

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Langisite $(Co, Ni)As$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As irregular grains and lamellae in safflorite.

Physical Properties: Hardness = n.d. VHN = 780–857 (50 g load). D(meas.) = n.d. D(calc.) = 8.174

Optical Properties: Opaque. *Color:* In reflected light, pinkish buff. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Moderate, in bluish gray and light brown. *Bireflectance:* Weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. a = 3.538 $c = 5.127$ Z = 2

X-ray Powder Pattern: Langis mine, Canada.
2.631 (10), 1.966 (9), 1.770 (8), 1.493 (4), 1.470 (3), 1.315 (3), 1.141 (3)

Chemistry:

	(1)
Co	35.5
Ni	7.0
As	56.0
Total	98.5

(1) Langis mine, Canada; by electron microprobe, corresponding to $(Co_{0.84}Ni_{0.16})_{\Sigma=1.00}As_{1.04}$.

Mineral Group: Nickeline group.

Occurrence: In pockets of ore minerals, mineralized fault gouge, and breccia cemented with calcite and quartz.

Association: Cobalt pentlandite, siegenite, parkerite, bravoite, safflorite, maucherite, pyrite, marcasite.

Distribution: From the Langis mine, Casey Township, Cobalt-Gowganda area, Ontario, Canada [TL].

Name: For the Langis mine in Canada, where it was discovered.

Type Material: Canadian Geological Survey, Ottawa, 12140; Royal Ontario Museum, Toronto, Canada.

References: (1) Petruk, W., D.C. Harris, and J.M. Stewart (1969) Langisite, a new mineral, and the rare minerals cobalt pentlandite, siegenite, parkerite and bravoite from the Langis mine, Cobalt–Gowganda area, Ontario. Can. Mineral., 9, 597–616. (2) (1972) Amer. Mineral., 57, 1910–1911 (abs. ref. 1).

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Langite $Cu_4(SO_4)(OH)_6 \cdot 2H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic or pseudohexagonal. *Point Group:* *m*. Crystals, showing {001}, {010}, {100}, {110}, {021}, to 7 mm, commonly skeletal; in wavy to flat crusts, earthy, massive. *Twinning:* On {110}, typically repeated to give snowflakelike or star-shaped groupings.

Physical Properties: *Cleavage:* On {001} and {010}. Hardness = 2.5–3
D(meas.) = 3.28–3.34 D(calc.) = 3.26–3.37

Optical Properties: Translucent. *Color:* Deep blue, greenish blue, blue-green.
Luster: Vitreous to silky.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellowish green; Y = blue-green; Z = sky-blue. *Orientation:* $Y = b$; $X \simeq c$; $Z \simeq a$. α = 1.641–1.654 β = 1.690–1.713 γ = 1.705–1.722 2V(meas.) = 56°–104°

Cell Data: *Space Group:* *Pc* [morphological orientation b > c > a]. a = 7.118–7.137 b = 6.031–6.034 c = 11.209–11.217 β = 90.00°–90.02° Z = 2

X-ray Powder Pattern: Lubietová, Slovakia.
7.063 (10), 3.567 (9), 2.134 (9), 2.493 (8), 2.662 (7), 2.616 (7), 1.773 (7)

Chemistry:

	(1)	(2)
SO_3	16.42	16.40
CuO	65.82	65.16
H_2O	18.32	18.44
Total	100.56	100.00

(1) Cornwall, England. (2) $Cu_4(SO_4)(OH)_6 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with wroewolfeite.

Occurrence: An uncommon but widespread secondary mineral in the oxidation zone of copper sulfide deposits; may be of post-mine formation.

Association: Wroewolfeite, posnjakite, serpierite, devilline, chalcophyllite, connellite, brochantite, malachite, gypsum.

Distribution: Some localities for rich or well-crystallized examples include: in England, in Cornwall, from a number of mines, as the Fowey Consols mine, Tywardreath; Botallack mine, St. Just; large crystals at the Bedford United mine, Tavistock, Devon; in the Engine Vein mine, Alderley Edge, Cheshire; at several mines in Caldbeck Fells, Cumbria. Found in the Dooneen mine, Allihies, Co. Cork, Ireland. In France, at Mazega, Aveyron; in the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, and elsewhere. At L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. In Germany, from the Clara mine, near Oberwolfach, Black Forest; Richelsdorfer Mountains, Hesse; in Saxony, at Schneeberg, Schwartzenberg, Freiberg; and others. At Klausen, Alto Adige, Italy. From Tsumeb, Namibia. At the Paddy's River mine, Australian Capital Territory, Australia. In the USA, from the Silver King mine, near Ely, White Pine Co., Nevada; at the Grandview mine, Grand Canyon, Coconino Co., and from Bisbee, Cochise Co., Arizona. In the El Teniente mine, 67 km west of Rancagua, O'Higgins Province, Chile. Many older localities require modern confirmation.

Name: Honoring Victor von Lang (1838–1921), physicist and crystallographer, Professor of Physics, University of Vienna, Vienna, Austria.

Type Material: Natural History Museum, Vienna, Austria, A.a.4353.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 583–585. (2) Galey, J., J. Jaud, R. Pulou, and R. Sempère (1984) Structure cristalline de la langite, $Cu_4[(SO_4)(OH)_6H_2O].H_2O$. Bull. Minéral., 107, 641–648 (in French with English abs.). (3) Gentsch, M. and K. Weber (1984) Structure of langite, $Cu_4[(OH)_6|SO_4].2H_2O$. Acta Cryst., C40, 1309–1311. (4) Řídkošil, T. and P. Povondra (1982) The relation between posnjakite and langite. Neues Jahrb. Mineral., Monatsh., 16–28.

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Lanmuchangite $TlAl(SO_4)_2 \cdot 12H_2O$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As anhedral grains, to 90 μm, columnar or in aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.1–3.4 VHN = 94–124
D(meas.) = 2.22 D(calc.) = [2.33] Soluble in H_2O.

Optical Properties: Transparent. *Color:* White to pale yellow. *Streak:* White.
Luster: Vitreous.
Optical Class: Isotropic. $n = 1.495$

Cell Data: *Space Group:* $Pa3$. $a = 12.212(5)$ $Z = 4$

X-ray Powder Pattern: Lanmuchang deposit, China.
4.314 (100), 2.801 (70), 7.03 (54), 2.731 (35), 6.11 (27), 3.524 (24), 3.676 (22)

Chemistry:

	(1)	(2)
SO_3	25.19	25.03
SiO_2	0.10	
Al_2O_3	8.07	7.97
FeO	0.04	
MgO	0.06	
CaO	0.08	
K_2O	0.35	
Tl_2O	33.25	33.20
H_2O	33.46	33.80
Total	100.60	100.00

(1) Lanmuchang deposit, China; by electron microprobe, average of six analyses, H_2O by TGA, $(SO_4)^{2-}$ and H_2O confirmed by IR; corresponds to $(Tl_{1.00}K_{0.05})_{\Sigma=1.05}(Al_{1.01}Si_{0.02}Ca_{0.01}Mg_{0.01}Fe_{0.01})_{\Sigma=1.06}(SO_4)_{2.02} \cdot 11.86H_2O$. (2) $TlAl(SO_4)_2 \cdot 12H_2O$.

Occurrence: In the oxidation zone of a Tl–Hg deposit.

Association: Melanterite, pickeringite, jarosite, gypsum, potassium alum, arsenolite, sulfur.

Distribution: From the Lanmuchang Tl–Hg deposit, Xinren Co., Guizhou Province, China [TL].

Name: For its occurrence in the Lanmuchang deposit, China.

Type Material: Geological Museum of China, Beijing, China.

References: (1) Chen Daiyan, Wang Guanxin, Zou Zhenxi, and Chen Yuming (2001) A new mineral – lanmuchangite. Acta Mineral. Sinica, 21(3), 271–277 (in Chinese with English abs.).
(2) (2002) Amer. Mineral., 87, 996–997 (abs. ref. 1).

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Lannonite $HCa_4Mg_2Al_4(SO_4)_8F_9 \cdot 32H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. Crystals are square platy, to 20 μm, in warty or nodular aggregates.

Physical Properties: Hardness = 2 D(meas.) = 2.22 D(calc.) = 2.32

Optical Properties: Semitransparent. *Color:* Chalky white.
Optical Class: Uniaxial (+). $\omega = 1.460$ $\epsilon = 1.478$

Cell Data: *Space Group:* n.d. $a = 6.84$ $c = 28.01$ Z = 1

X-ray Powder Pattern: Lone Pine mine, New Mexico, USA.
13.98 (10), 4.840 (8), 3,456 (7), 3.980 (5), 3.325 (5), 4.666 (4), 2.908 (4)

Chemistry:

	(1)	(2)
SO_3	34.40	34.93
Al_2O_3	11.06	11.12
MgO	4.46	4.40
CaO	12.06	12.23
F	9.44	9.32
H_2O	32.00	31.93
$-O = F_2$	3.97	3.93
Total	99.45	100.00

(1) Lone Pine mine, New Mexico, USA; by microanalysis, H_2O by the Penfield method.
(2) $HCa_4Mg_2Al_4(SO_4)_8F_9 \cdot 32H_2O$.

Occurrence: A rare post-mine mineral deposited from solutions derived from an oxidizing breccia zone.

Association: Fluorite, gypsum, khademite, wilcoxite, pyrite.

Distribution: From the Lone Pine mine, Wilcox district, near Silver City, Catron Co., New Mexico, USA.

Name: Honoring Dan Lannon, who early staked claims in the Wilcox district, New Mexico, USA.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,546; National Museum of Natural History, Washington, D.C., USA, 149526.

References: (1) Williams, S.A. and F.P. Cesbron (1983) Wilcoxite and lannonite, two new fluosulphates from Catron Co., New Mexico. Mineral. Mag., 47, 37–40. (2) (1984) Amer. Mineral., 69, 407 (abs. ref. 1).

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Lansfordite $MgCO_3 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals, elongated along [001], with principal forms {100}, {110}, {001}, a dozen additional forms, to 4 mm; as stalactites, which may be terminated by crystal faces; in parallel growths, and as efflorescences. *Twinning:* Observed.

Physical Properties: *Cleavage:* {001}, perfect; {100}, less perfect. Hardness = 2.5 D(meas.) = 1.692 D(calc.) = 1.693 Slowly effloresces at room temperature to produce nesquehonite.

Optical Properties: Transparent to translucent, becoming opaque on exposure. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous if fresh. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z = c$; $Y \perp \{100\}$. $\alpha = 1.456$–1.465 $\beta = 1.468$–1.469 $\gamma = 1.507$–1.508 2V(meas.) = 59°30′ 2V(calc.) = 59°20′

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 12.4758(7)$ $b = 7.6258(4)$ $c = 7.3463(6)$ $\beta = 101.762(6)°$ Z = 4

X-ray Powder Pattern: Synthetic.
2.839 (100), 4.583 (95), 3.237 (55), 1.710 (33), 5.239 (31), 5.110 (31), 7.178 (30)

Chemistry:

	(1)	(2)
CO_2	25.09	25.23
MgO	23.27	23.12
H_2O	51.75	51.65
Total	100.11	100.00

(1) Cogne, Italy. (2) $MgCO_3 \cdot 5H_2O$.

Occurrence: Stalactites pendant from the shale roof of an anthracite coal mine (Nesquehoning, Pennsylvania, USA); in a hydromagnesite deposit (Atlin, Canada); a weathering product of an ultramafic body (Sør-Trøndelag, Norway).

Association: Nesquehonite, hydromagnesite, dypingite.

Distribution: In the USA, from Nesquehoning, near Lansford, Carbon Co., Pennsylvania; near the Robinson Gulch pegmatite, Jefferson Co., Colorado. From Atlin, British Columbia, Canada. At Cogne, Val d'Aosta, Piedmont, Italy. From the Feragen ultramafic body, Sør-Trøndelag, Norway. Found in seafloor precipitates in the Japan Sea.

Name: For its occurrence near Lansford, Pennsylvania, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 228–230. (2) Hill, R.J., J.H. Canterford, and F.J. Moyle (1982) New data for lansfordite. Mineral. Mag., 46, 453–457. (3) Bai-Nian Liu, Xiang-Ting Zhou, Xiu-Shan Cui, and Ji-Gang Tang (1990) Synthesis of lansfordite $MgCO_3 \cdot 5H_2O$ and its crystal structure investigation. Science in China, Series B, 33(11), 1350–1356.

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Lanthanite-(Ce) $(Ce, La, Nd)_2(CO_3)_3 \cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are platy, flattened on {010}, with a rhombic outline, to 5 mm; commonly as a powdery crust. *Twinning:* On {101}, twin and composition plane.

Physical Properties: *Cleavage:* {010}, perfect, micaceous. *Tenacity:* Sectile. Hardness = ∼2.5 D(meas.) = 2.76 D(calc.) = 2.79

Optical Properties: Transparent. *Color:* Colorless, white, pink, yellow. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak.
$\alpha = 1.532(2)$ $\beta = 1.594(2)$ $\gamma = 1.616(2)$ 2V(meas.) = 60(2)° 2V(calc.) = 62°

Cell Data: *Space Group: Pbnb.* $a = 9.482(6)$ $b = 16.938(11)$ $c = 8.965(3)$ Z = 4

X-ray Powder Pattern: Britannia mine, Wales; close to lanthanite-(La) and lanthanite-(Nd).
8.47 (100), 3.255 (73), 4.746 (65), 3.028 (65), 4.462 (62), 4.125 (40), 3.943 (38)

Chemistry:

	(1)		(1)
CO_2	21.0	Sm_2O_3	2.50
Y_2O_3	0.74	Gd_2O_3	1.53
La_2O_3	14.44	H_2O	23.0
Ce_2O_3	20.61	Total	98.6
Nd_2O_3	14.78		

(1) Britannia mine, Wales; by electron microprobe, average of five analyses, CO_2 by CHN analyzer, H_2O by TGA, O^{2-} calculated for charge balance; corresponds to $(Ce_{0.78}La_{0.55}Nd_{0.55}Sm_{0.09}Gd_{0.05}Y_{0.04})_{\Sigma=2.06}C_{2.97}O_{9.03} \cdot 7.96H_2O$.

Occurrence: A rare secondary mineral typically formed by alteration or weathering from earlier rare-earth-element-bearing minerals.

Association: Allanite-(Ce), cerite-(Ce).

Distribution: From the Britannia mine, Snowdonia, Gwynedd, Wales. In Sweden, from the Bastnäs mine, near Riddarhyttan, Västmanland. At the Vuoriyarvi carbonatite massif, Kola Peninsula, Russia. In China, from Bayan Obo, Chengde and Chicheng, Hebei Province. The following lanthanite occurrences are listed here, but require a full analysis to establish the dominant rare-earth element. In the USA, from the Sanford mine, Moriah, Essex Co., New York; at the Medford quarry, 50 km west of Baltimore, Carroll Co., Maryland; from the Baringer Hill pegmatite, 26 km west of Burnet, Llano Co., Texas. from vermiculite prospects at the head of Big Sandy Creek, Rocky Boy's Indian Reservation, about 40 km east of Box Elder, Hill Co., Montana; At Mont Saint-Hilaire, Quebec, Canada. In the Qaqarssuk carbonatite, near Sukkertoppen, Greenland.

Name: For its relation to *lanthanite*-(La), and preponderance of *cerium* over other rare-earth elements.

Type Material: National Museum, Cardiff, Wales, 84.6G.M1; The Natural History Museum, London, England, 1984,614; National Museum of Natural History, Washington, D.C., USA, 162169.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 241–243. (2) Bevins, R.E., G. Rowbotham, F.S. Stevens, S.A. Turgoose, and P.A. Williams (1985) Lanthanite-(Ce), $(Ce, La, Nd)_2(CO_3)_3 \cdot 8H_2O$, a new mineral from Wales, U.K. Amer. Mineral., 70, 411–413. (3) Atencio, D., R.E. Bevins, M. Fleischer, C.T. Williams, and P.A. Williams (1989) Revision of the lanthanite group and new data for specimens from Bastnäs, Sweden and Bethlehem, USA. Mineral. Mag., 53, 639–642. (4) Dal Negro, A., G. Rossi, and V. Tazzoli (1977) The crystal structure of lanthanite. Amer. Mineral., 62, 142–146.

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Lanthanite-(La) $(La,Nd)_2(CO_3)_3 \cdot 8H_2O$

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Crystal Data: [Orthorhombic.] [by analogy to lanthanite-(Nd).] *Point Group:* [$2/m$ $2/m$ $2/m$.] [Crystals are platy, flattened on {010}, with a rhombic outline; may be a powdery crust.] *Twinning:* [On {101}, twin and composition plane.]

Physical Properties: *Cleavage:* [{010}, perfect, micaceous.] *Fracture:* [Uneven.] *Tenacity:* [Sectile.] Hardness = [~2.5] D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* [Bright pink, violet; colorless in transmitted light.] *Streak:* [White.] *Luster:* [Vitreous to pearly.]
Optical Class: [Biaxial (–).] *Orientation:* [$X = b$; $Y = c$; $Z =$ a.] *Dispersion:* [$r < v$, weak.] $\alpha =$ n.d. $\beta =$ n.d. $\gamma =$ n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* [*Pbnb*.] $a =$ n.d. $b =$ n.d. $c =$ n.d. Z = [4]

X-ray Powder Pattern: Curitiba, Brazil; here made identical to lanthanite-(Nd).
8.50 (100), 3.252 (63), 3.038 (58), 4.473 (56), 4.741 (52), 4.139 (34), 3.953 (32)

Chemistry: (1) Curitiba, Brazil; by electron microprobe, partial analysis of rare-earth elements only: La 41.8%, Ce 0.1%, Pr 9.1%, Nd 38.3%, Sm 6.6%, Eu 1.2%, Gd 1.8%, Tb 1.2%, Dy 0.7%, Ho 0.1%, Yb 0.1%.

Occurrence: A rare secondary mineral typically formed by alteration or weathering from earlier rare-earth-element-bearing minerals.

Association: Allanite-(Ce) (Saucon Township, Pennsylvania, USA).

Distribution: In Sweden, originally described from the Bastnäs mine, near Riddarhyttan, Västmanland; thought to be lanthanum-rich but a recent analysis, not on type material, shows Ce > La. From Curitiba, Paraná, and at Santa Isabel, São Paulo, Brazil. In the USA, found in lower Saucon Township, Northampton Co., Pennsylvania, and at the Scovill iron mine, Salisbury, Litchfield Co., Connecticut. From Niikoba, Saga Prefecture, Japan.

Name: For dominant *lanthanum* in its composition.

Type Material: Natural History Museum, Vienna, Austria, A.x.564.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 241–243. (2) Atencio, D., R.E. Bevins, M. Fleischer, C.T. Williams, and P.A. Williams (1989) Revision of the lanthanite group and new data for specimens from Bastnäs, Sweden and Bethlehem, USA. Mineral. Mag., 53, 639–642. (3) Dal Negro, A., G. Rossi, and V. Tazzoli (1977) The crystal structure of lanthanite. Amer. Mineral., 62, 142–146.

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Lanthanite-(Nd) $(Nd,La)_2(CO_3)_3 \cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Platy crystals, flattened on {010}, showing {001}, {010}, {100}, {101}, {121}, to 3 mm; commonly a powdery crust. *Twinning:* On {101}, common, twin and composition plane.

Physical Properties: *Cleavage:* Perfect on {010}; very good on {101}. *Fracture:* Uneven. *Tenacity:* [Sectile.] [by analogy to lanthanite-(Ce) and lanthanite-(Nd).] Hardness = 2.5–3 D(meas.) = 2.78–2.84 D(calc.) = 2.816

Optical Properties: Semitransparent *Color:* Bright pink, violet; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak. $\alpha = 1.529$–1.532 $\beta = 1.590$–1.595 $\gamma = 1.614$–1.617 2V(meas.) = 58°–61° 2V(calc.) = 60°–63.5°

Cell Data: *Space Group: Pbnb.* $a = 9.476(4)$ $b = 16.940(8)$ $c = 8.942(4)$ Z = 4

X-ray Powder Pattern: Curitiba, Brazil; almost identical to lanthanite-(La).
8.50 (100), 3.252 (63), 3.038 (58), 4.473 (56), 4.741 (52), 4.139 (34), 3.953 (32)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	22.15	21.43	Eu_2O_3	1.64	0.37
ThO_2	0.03		Gd_2O_3	1.69	2.20
Y_2O_3	0.22	0.94	Tb_2O_3		0.13
La_2O_3	19.44	22.28	Dy_2O_3	0.44	0.58
Ce_2O_3	0.03	0.29	Ho_2O_3		0.33
Pr_2O_3	5.18	3.89	Er_2O_3		0.20
Nd_2O_3	21.84	22.77	Yb_2O_3		< 0.02
Sm_2O_3	4.10	3.57	H_2O	22.75	21.00
			Total	99.51	

(1) Curitiba, Brazil; H_2O by the Penfield method; corresponds to $(Nd_{0.79}La_{0.73}Pr_{0.19}Sm_{0.14}Gd_{0.06}Eu_{0.06}Dy_{0.01}Y_{0.01})_{\Sigma=1.99}(CO_3)_3 \cdot 8H_2O$. (2) Santa Isabel, Brazil; by X-ray fluorescence spectrometry, Eu by polarography, CO_2 and H_2O by elemental analyzer.

Occurrence: A rare secondary mineral typically formed by alteration or weathering from earlier rare-earth-element-bearing minerals.

Association: n.d.

Distribution: In Brazil, from Curitiba, Paraná, at Santa Isabel, São Paulo, and near Morro do Ferro, Minas Gerais. At Kirigo and Niikoba, Saga Prefecture, Japan. From Pavlovsk, Primorskiy Kray, Russia. At South Mountain, Bethlehem, Lehigh Co., Pennsylvania, USA.

Name: For *lanthanum* in its composition, and preponderance of *neodymium* over other rare-earth elements.

Type Material: Pierre and Marie Curie University, Paris, France; Canadian Geological Survey, Ottawa, Canada, 12213; National Museum of Natural History, Washington, D.C., USA, 147003.

References: (1) Roberts, A.C., G.Y. Chao, and F. Cesbron (1980) Lanthanite-(Nd), a new mineral from Curitiba, Paraná, Brazil. Geol. Surv. Canada, Paper 80-1C, 141–142. (2) (1981) Amer. Mineral., 66, 637–638 (abs. ref. 1). (3) Dal Negro, A., G. Rossi, and V. Tazzoli (1977) The crystal structure of lanthanite. Amer. Mineral., 62, 142–146.

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Laphamite $As_2(Se,S)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to less than 5 mm, elongated along [100] and tabular (010). Crystals are commonly resorbed to give incomplete individuals.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Flexible but not elastic, extremely malleable. Hardness = Soft. VHN = n.d. D(meas.) = 4.5(1) D(calc.) = 4.60

Optical Properties: Nearly opaque. *Color:* Dark red; gray-white in reflected light, strong fiery red internal reflections, golden yellow internal reflections occur along scratches. *Streak:* Reddish orange. *Luster:* Resinous. *Pleochroism:* Moderate, from white to gray. *Anisotropism:* Moderate, in tints of gray.

R_1–R_2: (400) 34.4–42.1, (420) 33.9–41.0, (440) 33.8–39.9, (460) 33.8–38.8, (480) 33.2–37.4, (500) 32.3–36.3, (520) 30.9–35.1, (540) 29.5–34.0, (560) 28.4–33.1, (580) 27.6–32.3, (600) 26.9–31.6, (620) 26.4–31.1, (640) 26.4–30.9, (660) 26.3–30.6, (680) 26.1–30.4, (700) 25.9–30.1

Cell Data: *Space Group:* $P2_1/n$ (synthetic As_2Se_3). $a = 12.0774(4)$ $b = 9.9037(6)$ $c = 4.2835(6)$ $\beta = 90.458(9)^\circ$ Z = 4

X-ray Powder Pattern: Burnside, Pennsylvania, USA.
2.833 (100), 2.773 (80), 4.87 (70), 2.905 (60), 1.777(50), 1.709 (50), 3.72 (40)

Chemistry:

	(1)
As	47.0
Se	43.7
S	8.7
Total	99.4

(1) Burnside, Pennsylvania, USA; by electron microprobe, corresponding to $As_{2.00}(Se_{1.91}S_{0.93}As_{0.16})_{\Sigma=3.00}$.

Occurrence: As a secondary incrustation, probably by sublimation, on clinker adjacent to a surface vent on a burning pile of waste material from an anthracite coal mine.

Association: Arsenolite, orpiment.

Distribution: From Burnside, Northumberland Co., Pennsylvania, USA [TL].

Name: To honor Dr. Davis M. Lapham (1931–1974), former Chief Mineralogist of the Pennsylvania Geological Survey.

Type Material: The Natural History Museum, London, England, 1984,843 and E.1036; National Museum of Natural History, Washington, D.C., USA, 163039.

References: (1) Dunn, P.J., D.R. Peacor, A.J. Criddle, and R.B. Finkelman (1986) Laphamite, an arsenic selenide analogue of orpiment, from burning anthracite deposits in Pennsylvania. Mineral. Mag., 50, 279–282. (2) (1987) Amer. Mineral., 72, 1024–1025 (abs. ref. 1). (3) Stergiou, A.C. and P.J. Rentzeperis (1986) The crystal structue of arsenic selenide, As_2Se_3. Zeits. Krist., 173, 185–191.

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Lapieite $CuNiSbS_3$

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Crystal Data: Orthorhombic. *Point Group:* 222. As subhedral grains, to 150 μm.

Physical Properties: *Cleavage:* Fair on $\{0kl\}$. Hardness = 4.5–5 VHN = n.d. D(meas.) = n.d. D(calc.) = 4.966

Optical Properties: Opaque. *Color:* Gray, presumably. *Luster:* Metallic. *Pleochroism:* In shades of greenish gray to gray. *Anisotropism:* Strong, with very pale blue to intense yellowish pink tints.

R_1–R_2: (400) 33.4–32.1, (420) 34.0–32.2, (440) 34.6–32.5, (460) 34.9–33.3, (480) 34.8–34.5, (500) 34.5–35.8, (520) 34.1–36.5, (540) 33.9–36.8, (560) 34.1–36.7, (580) 34.3–36.7, (600) 34.3–36.8, (620) 34.4–37.0, (640) 34.8–37.3, (660) 35.6–37.8, (680) 36.6–38.6, (700) 37.8–39.5

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.422(2)$ $b = 12.508(3)$ $c = 4.900(1)$ $Z = 4$

X-ray Powder Pattern: Lapie River, Canada.
2.959 (100), 3.178 (90), 1.837 (90), 1.855 (60), 1.601 (30), 2.769 (20), 2.637 (20)

Chemistry:

	(1)	(2)	(3)
Cu	18.5	18.45	18.68
Ni	17.1	17.17	17.26
Fe	0.1	0.14	
Sb	35.0	35.23	35.79
As	0.1	0.15	
S	27.7	28.00	28.27
Total	98.5	99.14	100.00

(1) Lapie River, Canada; by electron microprobe, average of four grains; corresponding to $Cu_{1.01}(Ni_{1.01}Fe_{0.01})_{\Sigma=1.02}(Sb_{1.00}As_{0.01})_{\Sigma=1.01}S_{3.00}$. (3) Tyrnyauz deposit, Russia; by electron microprobe, corresponding to $Cu_{1.00}(Ni_{1.00}Fe_{0.01})_{\Sigma=1.01}(Sb_{0.99}As_{0.01})_{\Sigma=1.00}S_{3.00}$. (4) $CuNiSbS_3$.

Occurrence: In a highly altered and mineralized glacial erratic (Lapie River, Canada).

Association: Nickelian pyrite, gersdorffite, polydymite, millerite, marcasite, tetrahedrite, chalcopyrite, spinel, magnetite, mica, quartz (Lapie River, Canada); zinkenite, ullmannite, chalcostibite (Tyrnyauz deposit, Russia); mückeite, millerite, bismuthinite, sphalerite, aikinite, polydymite (Grüne Au mine, Germany).

Distribution: From near the confluence of Glacier Creek and the Lapie River, St. Cyr Ranges, Yukon Territory, Canada [TL]. In the Tyrnyauz deposit, left bank of the Baksan River Valley, northern Caucasus Mountains, Russia. At the Grüne gold mine, Schutzbach, 15 km southwest of Siegen, North-Rhine-Westphalia, Germany.

Name: For the Lapie River, Canada.

Type Material: Canadian Geological Survey, Ottawa, Canada, 63844, 63845, and 63846.

References: (1) Harris, D.C., A.C. Roberts, R.I. Thorp, I.R. Jonasson, and A.J. Criddle (1984) Lapieite $CuNiSbS_3$, a new mineral species from the Yukon Territory. Can. Mineral., 22, 561–564. (2) (1985) Amer. Mineral., 70, 1329–1330 (abs. ref. 1).

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Laplandite-(Ce) $Na_4CeTiPSi_7O_{22}\cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic plates, flattened $\perp \{001\}$, about 0.01 mm; also as radiating fibrous or fan-shaped platy aggregates, to 1 cm.

Physical Properties: *Fracture:* Splintery. Hardness = 2–3 D(meas.) = 2.83 D(calc.) = 2.71

Optical Properties: Transparent to translucent. *Color:* Light gray to yellowish, rarely bluish; colorless in thin section. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). $\alpha = 1.568$ $\beta = 1.584$ $\gamma = 1.585$ 2V(meas.) = n.d. 2V(calc.) = 28°

Cell Data: *Space Group: Pmmm.* $a = 7.27$ $b = 14.38$ $c = 22.25$ Z = 4

X-ray Powder Pattern: Mt. Karnasurt, Russia.
7.27 (100), 3.76 (100), 3.35 (100), 3.03 (100), 3.36 (80), 2.80 (80), 6.47 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.94	44.29	MgO	1.02	
TiO_2	4.08	8.41	CaO	0.56	
ThO_2	1.32		Na_2O	9.81	13.05
Al_2O_3	0.94		K_2O	1.88	
Ce_2O_3		17.28	H_2O^+	8.96	
RE_2O_3	16.79		H_2O^-	0.37	
Fe_2O_3	0.64		H_2O		9.49
Nb_2O_5	1.88		P_2O_5	9.62	7.48
MnO	0.20		Total	99.01	100.00

(1) Mt. Karnasurt, Russia; RE ratios La:Ce:Pr:Nd = 46.7:51.2:5.2:6.6 by X-ray spectrographic analysis. (2) $Na_4CeTiPSi_7O_{22}\cdot 5H_2O$.

Occurrence: In the natrolite zone of a pegmatite in a differentiated alkalic massif.

Association: Belovite, nordite, sérandite, thermonatrite, steenstrupine, leucosphenite, sphalerite, ilmajokite, raite, zorite.

Distribution: In the Jubilee pegmatite, on Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: For Lappland (Lapland), the region in which the Kola Peninsula lies.

Type Material: Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75512, 76312.

References: (1) Eskova, E.M., E.I. Semenov, A.P. Khomyakov, M.E. Kazakova, and O.V. Sidorenko (1974) Laplandite, a new mineral. Zap. Vses. Mineral. Obshch., 103, 571–575 (in Russian). (2) (1975) Amer. Mineral., 60, 487 (abs. ref. 1).

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Laptevite-(Ce) $NaFe^{2+}(REE_7Ca_5Y_3)(SiO_4)_4(Si_3B_2PO_{18})(BO_3)F_{11}$

Crystal Data: Hexagonal. *Point Group*: 3*m*. As crystals of irregular shape, to 1 cm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 4-4.5 VHN = 443-485 (50 g load). D(meas.) = 4.61(2) D(calc.) = 4.660

Optical Properties: Translucent. *Color*: Brown, with yellowish cores (metamict). *Streak*: n.d.
Luster: Vitreous to greasy.
Optical Class: Uniaxial (-). ω = 1.741(3) ε = 1.720(3)

Cell Data: *Space Group*: *R*3*m*. *a* = 10.804 (2) *c* = 27.726(6) Z = 3

X-ray Powder Pattern: Upper Darai-Pioz alkaline massif, Northern Tajikistan.
3.03 (100), 2.982 (85), 2.954 (60), 2.689 (40), 1.797 (31), 4.41 (29), 3.13 (26)

Chemistry:

	(1)		(1)		(1)
SiO_2	15.67	Y_2O_3	11.30	Dy_2O_3	1.37
TiO_2	0.28	La_2O_3	14.54	Tm_2O_3	0.17
ZrO_2	0.01	Ce_2O_3	16.93	Yb_2O_3	0.28
ThO_2	0.38	Pr_2O_3	2.76	B_2O_3	4.98
UO_2	0.65	Nd_2O_3	5.16	P_2O_5	1.51
FeO	1.48	Sm_2O_3	0.98	Na_2O	1.05
CaO	11.64	Eu_2O_3	0.10	F	8.53
MnO	1.02	Gd_2O_3	1.56	$-O=F_2$	3.59
SrO	0.95	Tb_2O_3	0.29	Total	100.00

(1) Upper Darai-Pioz alkaline massif, Northern Tajikistan; average of 42 electron microprobe analyses; corresponding to $(Na_{0.88}REE_{0.12})_{\Sigma=1.00}(Fe_{0.54}Mn_{0.37}Ti_{0.09})_{\Sigma=1.00}(REE_{6.79}Ca_{5.40}Y_{2.60}Sr_{0.24}U_{0.06}Th_{0.04})_{\Sigma=15.13}(SiO_4)_4(Si_{2.78}B_{2.68}P_{0.55}O_{17.33}F_{0.67})(B_{1.05}O_3)F_{11}$, with REE = $Ce_{2.68}La_{2.32}Nd_{0.80}Pr_{0.44}Gd_{0.22}Dy_{0.19}Sm_{0.15}Yb_{0.04}Tb_{0.04}Tm_{0.02}Eu_{0.01}$.

Mineral Group: Vicanite group.

Occurrence: A mineral of hydrothermal origin, discovered in a glacial moraine boulder of calcite-bafertisite-aegirine-microcline rock.

Association: Quartz, fluorite, polylithionite, albite, and intergrown with bafertisite, "calcy-beborosilite-(Y)", stillwellite-(Ce).

Distribution: Darai-Pioz glacier, at the junction of the Turkestan, Zeravshan, and Alay Mt. Ranges, Tien-Shan, Garmskii district, Northern Tajikistan.

Name: Honors Tatyana Mikhailovna Lapteva (1928-2011), a Russian geologist and petrologist who worked on the geology of Central Asia.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 4195/1).

References: (1) Agakhanov, A.A., L.A. Pautov, Yu.A. Uvarova, E.V. Sokolova, F.C. Hawthorne, and V.Yu. Karpenko (2013) Laptevite-(Ce) $NaFe^{2+}(REE_7Ca_5Y_3)(SiO_4)_4(Si_3B_2PO_{18})(BO_3)F_{11}$ - a new vicanite-group mineral from Darai-Pioz alkaline massif. Novye dannye o mineralakh (New data on minerals), 48, 5-11 (in Russian). (2) Uvarova, Y.A., E. Sokolova, F.C. Hawthorne, A.A. Agakhanov, V.Y. Karpenko, and L.A. Pautov (2013) The crystal structure of laptevite-(Ce), $NaFe^{2+}(REE_7Ca_5Y_3)(SiO_4)_4(Si_3B_2PO_{18})(BO_3)F_{11}$, a new mineral species from the Darai-Pioz alkaline massif, Northern Tajikistan. Zeitschrift für Kristallographie B, 228, 550-557. (3) (2014) Amer. Mineral., 99, 2154-2155 (abs. refs. 1 & 2).

Larderellite $(NH_4)B_5O_7(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are rhombic, flattened on {001}, to 0.1 mm; typically powdery.

Physical Properties: *Cleavage:* On {100}, {010}, perfect. Hardness = n.d.
D(meas.) = 1.905(4) D(calc.) = 1.887

Optical Properties: Semitransparent. *Color:* White, pale yellow if impure.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c \simeq 15°$. *Dispersion:* $r > v$ or $r < v$.
$\alpha = 1.493(1)$ $\beta = 1.509(1)$ $\gamma = 1.561(1)$ 2V(meas.) = 58°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.63$–11.65 $b = 7.615$–7.63 $c = 9.447$–9.47
$\beta = 96°45'$–$97°05'$ Z = 4

X-ray Powder Pattern: Larderello, Italy.
4.70 (100), 2.921 (100), 2.887 (100), 5.44 (71), 2.960 (71), 9.45 (50), 5.12 (50)

Chemistry:

	(1)	(2)
B_2O_3	71.64	68.49
$(NH_4)_2O$	9.93	10.24
H_2O	[18.43]	21.27
Total	[100.00]	100.00

(1) Larderello, Italy; average of four analyses, H_2O by difference. (2) $(NH_4)B_5O_7(OH)_2 \cdot H_2O$.

Occurrence: In boric-acid-rich fumarolic lagoons.

Association: Sassolite, ammonioborite, santite.

Distribution: From Larderello, Val di Cecina, Tuscany, Italy.

Name: Honoring Francesco de Larderel (1848–1925), principal operator of the Tuscan borax works.

Type Material: Natural History Museum, Paris, France, 100.1384, 100.1386, 100.1388.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 365–366. (2) Clark, J.R. (1960) X-ray crystallography of larderellite, $NH_4B_5O_6(OH)_4$. Amer. Mineral., 45, 1087–1093. (3) Merlino, S. and F. Sartori (1969) The crystal structure of larderellite, $NH_4B_5O_7(OH)_2.H_2O$. Acta Cryst., 25, 2264–2270.

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Larisaite $Na(H_3O)(UO_2)_3(SeO_3)_2O_2 \cdot 4H_2O$

Crystal Data: Monoclinic. *Point Group: m.* As rough, corrugated lamellar crystals to 1 mm, with {010} dominant, and as stellate radial aggregates to 2 mm.

Physical Properties: *Cleavage:* Perfect {010}. *Fracture:* Uneven. *Tenacity:* Sectile. Hardness = 1 D(meas.) = n.d. D(calc.) = 4.46

Optical Properties: Transparent to translucent. *Color:* Canary-yellow. *Streak:* Yellow. *Luster:* Vitreous; pearly on cleavage surfaces. Green fluorescence in UV. *Optical Class:* Biaxial (-). $\alpha = 1.597(2)$ $\beta = 1.770(5)$ $\gamma = 1.775(5)$ 2V(meas.) = 20° *Dispersion*: Strong; $r < v$. *Orientation*: $X = b$; Z parallel to the elongation. *Pleochroism*: $Y = Z$ = yellow; X = light greenish yellow. *Absorption:* $Y = Z > X$.

Cell Data: *Space Group: P11m.* $a = 6.9806(9)$ $b = 7.646(1)$ $c = 17.249(2)$ $\beta = 90.039(4)^o$ $Z = 2$

X-ray Powder Pattern: Repete mine, San Juan County, Utah, USA.
7.67 (100), 3.107 (77), 2.874 (53), 8.63 (43), 3.85 (40), 7.02 (33), 3.176 (33)

Chemistry:

	(1)	(2)
Na_2O	2.04	2.56
K_2O	0.69	
CaO	0.23	
UO_3	72.19	70.91
SeO_2	18.12	18.34
H_2O	7.64	8.19
Total	100.91	100.00

(1) Repete mine, San Juan County, Utah, USA; average of 3 electron microprobe analyses, H_2O by Penfield method; corresponding to $Na_{0.81}K_{0.18}Ca_{0.05}(H_3O)_{0.73}(UO_2)_{3.09}(SeO_3)_2O_2 \cdot 4.1H_2O$.
(2) $Na(H_3O)(UO_2)_3(SeO_3)_2O_2 \cdot 4H_2O$.

Occurrence: A secondary mineral in an oxidized 'roll-front' U deposit in sandstone.

Association: Montmorillonite, quartz, haynesite, wölsendorfite, andersonite, uranophane, gypsum, calcite.

Distribution: Repete mine, near Blanding, San Juan County, Utah, USA.

Name: Honors Russian mineralogist Larisa Nikolaevna Belova (1923-1998) for her studies of U minerals.

Type Material: Geoscientific Collections, Freiberg University of Mining and Technology, Freiberg, Germany; 80251.

References: (1) Chukanov, N.V., D.Yu. Pushcharovsky, M. Pasero, S. Merlino, A.V. Barinova, S. Möckel, I.V. Pekov, A.E. Zadov, and V.T. Dubinchuk (2004) Larisaite, $Na(H_3O)(UO_2)_3(SeO_3)_2O_2 \cdot 4H_2O$, a new uranyl selenite mineral from Repete mine, San Juan County, Utah, U.S.A. Eur. J. Mineral., 16, 367-374. (2) (2005) Amer. Mineral., 90, 519-520 (abs. ref. 1).

Larnite β–Ca_2SiO_4

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As anhedral grains flattened on {010}; subhedral interlocking grains; granular, massive. *Twinning:* Common, polysynthetic ∥ {100}; a second set may be ⊥ the first.

Physical Properties: *Cleavage:* {100}, good; {010}, imperfect. Hardness = n.d.
D(meas.) = 3.28–3.33 D(calc.) = 3.326

Optical Properties: Transparent to translucent. *Color:* White to gray; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 13°$–$14°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.700$–1.715 $\beta = 1.715$–1.723 $\gamma = 1.725$–1.740 2V(meas.) = 60°–63°

Cell Data: *Space Group:* $P2_1/n$. $a = 5.502(1)$ $b = 6.745(1)$ $c = 9.297(1)$ $\beta = 94.59(2)°$
Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 9-351).
2.795 (100), 2.744 (95), 2.780 (90), 2.608 (65), 2.188 (65), 2.731 (40), 2.716 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	31.00	33.89	34.88
Al_2O_3	1.12		
Fe_2O_3	trace		
FeO	0.64		
MgO	0.69		
CaO	64.98	65.56	65.12
Na_2O		0.36	
H_2O^+	0.61		
CO_2	0.82		
P_2O_5		0.32	
Total	99.86	100.13	100.00

(1) Scawt Hill, Ireland; minor spurrite impurity. (2) Do.; by electron microprobe, average of three analyses. (3) Ca_2SiO_4.

Occurrence: In contact metamorphic terranes involving sedimentary carbonate rocks.

Association: Spurrite, melilite, gehlenite, merwinite, perovskite, wollastonite (Scawt Hill, Ireland); rankinite, kilchoanite, scawtite, hydrogrossular (Tokatoka district, New Zealand); brownmillerite, mayenite, melilite, spurrite (Hatrurim Formation, Israel).

Distribution: At Scawt Hill and Ballycraigy, near Larne, Co. Antrim, Ireland. In Scotland, from Camas Mòr, Isle of Muck, and at Camphouse, Ardnamurchan, Argyllshire. From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. In the Hatrurim Formation, Israel. From near Rehia, and in Golden Gully, Tokatoka district, about 150 km north of Auckland, New Zealand. From near Gosse Pile, Tomkinson Ranges, and in the Deering Hills, South Australia. In the USA, at Marble Canyon, Culberson Co., Texas.

Name: For Larne, Ireland, in the vicinity of which the mineral was initially observed.

Type Material: n.d.

References: (1) Tilley, C.E. (1929) On larnite (calcium orthosilicate, a new mineral) and its associated minerals from the limestone contact-zone of Scawt Hill, Co. Antrim. Mineral. Mag., 22, 77–86. (2) (1929) Amer. Mineral., 14, 338 (abs. ref. 1). (3) Jost, K.H., B. Ziemer, and R. Seydel (1977) Redetermination of the structure of β-dicalcium silicate. Acta Cryst., 33, 1696–1700.
(4) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 248–255.

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Larosite $(Cu, Ag)_{21}(Pb, Bi)_2S_{13}$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As small acicular to flamelike crystals, the largest being about 300 μm long.

Physical Properties: Hardness = n.d. VHN = 87–124 (25 g load); 121–130, 124 average (100 g load). D(meas.) = n.d. D(calc.) = 6.19

Optical Properties: Opaque. *Color:* In polished section, pale buff. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Moderate, in gray and greenish buff.
R_1–R_2: (400) 35.4–36.9, (420) 34.9–36.1, (440) 34.4–35.4, (460) 33.8–34.8, (480) 33.2–33.9, (500) 32.7–33.3, (520) 32.2–32.8, (540) 32.0–32.7, (560) 31.9–32.6, (580) 31.9–32.6, (600) 31.8–32.5, (620) 31.9–32.5, (640) 32.0–32.3, (660) 32.2–32.2, (680) 32.3–32.0, (700) 32.5–31.9

Cell Data: *Space Group:* n.d. $a = 22.15$ $b = 24.03$ $c = 11.67$ Z = 10

X-ray Powder Pattern: Foster mine, Canada.
1.982 (100), 2.917 (90), 2.846 (60), 2.471 (60), 3.206 (50), 2.555 (40), 2.162 (40)

Chemistry:

	(1)	(2)
Cu	49.0	46.7
Ag	15.6	20.0
Pb	8.8	8.3
Bi	9.2	7.9
S	19.2	17.2
Total	101.8	100.1

(1) Foster mine, Canada; by electron microprobe, average of two analyses; corresponds to $(Cu_{16.74}Ag_{3.14})_{\Sigma=19.88}(Pb_{0.92}Bi_{0.96})_{\Sigma=1.88}S_{13.00}$. (2) Do.; by electron microprobe, corresponds to $(Cu_{17.81}Ag_{4.49})_{\Sigma=22.30}(Pb_{0.97}Bi_{0.92})_{\Sigma=1.89}S_{13.00}$.

Occurrence: In the central portion of a layered hydrothermal vein.

Association: Chalcocite, stromeyerite, arsenopyrite, galena, tetrahedrite, polybasite.

Distribution: From the Foster mine, Cobalt, Ontario, Canada [TL].

Name: To honor Frederick Alfred LaRose, Canadian blacksmith, one of the discoverers of silver ore at Cobalt.

Type Material: Canadian Geological Survey, Ottawa, Canada, 12126.

References: (1) Petruk, W. (1972) Larosite, a new copper–lead–bismuth sulfide. Can. Mineral., 11, 886–891. (2) (1974) Amer. Mineral., 59, 382 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 313.

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Larsenite $PbZnSiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals slender prismatic, striated || elongation; rarely tabular, flattened on {010}, equant, to 3 mm.

Physical Properties: *Cleavage:* {120}, distinct. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 5.90 D(calc.) = 6.141 Piezoelectric.

Optical Properties: Transparent. *Color:* White, colorless. *Luster:* Adamantine, pearly on platy surfaces.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, easily perceptible. *Absorption:* Strong. $\alpha = 1.92(1)$ $\beta = 1.95(1)$ $\gamma = 1.96(1)$ 2V(meas.) = 80°

Cell Data: *Space Group:* $Pna2_1$. $a = 8.244$ $b = 18.963$ $c = 5.06$ Z = 8

X-ray Powder Pattern: Synthetic.
3.19 (100), 2.854 (90), 4.88 (80), 3.04 (80), 4.19 (60), 4.11 (50), 4.03 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	16.87	17.2	16.48
FeO	0.10		
MnO	0.14		
ZnO	22.74	24.0	22.32
PbO	56.66	59.1	61.20
MgO	0.20		
CaO	2.42	0.1	
H_2O	0.76		
Total	99.89	100.4	100.00

(1) Franklin, New Jersey, USA; average of two analyses. (2) Do.; by electron microprobe. (3) $PbZnSiO_4$.

Occurrence: A very rare secondary mineral in veins cutting and replacing coarse, massive willemite-franklinite ore in a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA).

Association: Willemite, clinohedrite, esperite, hardystonite, hodgkinsonite, andradite, calcite, smithsonite, zincite, franklinite, roeblingite (Franklin, New Jersey, USA); queitite, alamosite (Tsumeb, Namibia).

Distribution: From Franklin, Sussex Co., New Jersey, USA. At Tsumeb, Namibia. In the Puttapa zinc mine, near Beltana, South Australia.

Name: For Esper Signius Larsen, Jr. (1879–1961), American petrologist, Harvard University, Cambridge, Massachusetts, USA.

Type Material: n.d.

References: (1) Palache, C., L.H. Bauer, and H. Berman (1928) Larsenite and calcium-larsenite, new members of the chrysolite group, from Franklin, New Jersey. Amer. Mineral., 13, 142–144. (2) Palache, C., L.H. Bauer, and H. Berman (1928) Larsenite, calcium-larsenite and the associated minerals at Franklin, New Jersey. Amer. Mineral., 13, 334–340. (3) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 80–82. (4) Prewitt, C.T., E. Kirchner, and A. Preisinger (1967) Crystal structure of larsenite $PbZnSiO_4$. Zeits. Krist., 124, 115–130. (5) Ito, J. and C. Frondel (1967) Synthesis of lead silicates: larsenite, barysilite and related phases. Amer. Mineral., 52, 1077–1084. (6) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727.

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Lasalite $Na_2Mg_2[V_{10}O_{28}]\cdot 20H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Typically as crusts of rounded crystals; as blocky prismatic crystals, elongated on [010] and exhibiting {100}, {010}, {001}, { $\bar{1}$ 11}, and {111}, to 2 mm.

Physical Properties: *Cleavage*: None. *Tenacity*: Very brittle. Hardness = 1
D(meas.) = 2.38(2) D(calc.) = 2.362 Crystals dehydrate to a yellow powder. Soluble in water.

Optical Properties: Transparent. *Color*: Yellow to yellow-orange. *Streak*: Yellow.
Luster: Adamantine.
Optical Class: Biaxial (–). α = 1.743(5) β = 1.773(5) γ = 1.780(5) 2V(meas.) = 43(1)°
Dispersion: $r > v$, strong. *Pleochroism*: *X* = light greenish yellow; *Y* = light yellow; *Z* = light brown.

Cell Data: *Space Group*: *C*2/*c*. a = 23.9019(7) b = 10.9993(3) c = 17.0504(5)
β = 118.284(1)° Z = 2

X-ray Powder Pattern: Vanadium Queen Mine, Utah.
9.72 (100), 6.67 (80), 7.42 (70), 9.09 (60), 8.19 (60), 2.882 (50), 2.706 (50)

Chemistry:

	(1)
Na_2O	4.06
MgO	5.42
CaO	1.75
K_2O	0.47
V_2O_5	61.87
SO_3	2.55
H_2O	23.88
Total	100.00

(1) Vanadium Queen Mine, Utah; average of 2 argon-plasma spectrometric analyses, H_2O by difference, corresponding to $(Na_{1.84}Ca_{0.44}K_{0.14})_{\Sigma=2.42}Mg_{1.89}(V_{9.55}S_{0.45})_{\Sigma=10.00}O_{28.55}\cdot 18.61H_2O$.

Occurrence: As efflorescences in oxidized portions of paleochannel uranium vanadium deposits of the Colorado Plateau type.

Association: Rossite, dickthomssenite, hewettite.

Distribution: Vanadium Queen Mine, La Sal district, and Firefly-Pigmay and Blue Cap mines, Utah, USA. Likely widespread in other similar deposits on the Colorado Plateau, e.g. Yellow Cat district, Grand County, Utah, USA.

Name: For the mining district that provided the first specimens.

Type Material: National Museum of Natural History, Washington, D.C., USA (174744).

References: (1) Hughes, J.M., W.S. Wise, M.E. Gunter, J.P. Morton, and J. Rakovan (2008) Lasalite, $Na_2Mg_2[V_{10}O_{28}]\cdot 20H_2O$, a new decavanadate mineral species from the Vanadium Queen mine, La Sal District, Utah: description, atomic arrangement, and relationship to the pascoite group of minerals. Can. Mineral., 46, 1365–1372; (2009) Addendum. Can Mineral., 47, 206. (2) (2009) Amer. Mineral., 94, 1078-1079 (abs. ref. 1).

Latiumite $(Ca,K)_8(Al,Mg,Fe)(Si,Al)_{10}O_{25}(SO_4)$

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Crystal Data: Monoclinic. *Point Group:* 2. Elongated tabular crystals, to 5 mm; also massive. *Twinning:* On {100} common, simple or multiple.

Physical Properties: *Cleavage:* {100}, perfect. Hardness = 5.5–6 D(meas.) = 2.93 D(calc.) = 2.92

Optical Properties: Transparent to translucent. *Color:* White, may be zoned or mottled. *Luster:* Vitreous.
Optical Class: Biaxial (+) or (–). *Orientation:* $Z = b$; $X \wedge c = 16°–28°$. *Dispersion:* $r > v$, marked. $\alpha = 1.600–1.603$ $\beta = 1.606–1.609$ $\gamma = 1.614–1.615$ 2V(meas.) = 83°–90°

Cell Data: *Space Group:* $P2_1$. $a = 12.06(1)$ $b = 5.08(2)$ $c = 10.81(1)$ $\beta = 106.0°$ Z = 2

X-ray Powder Pattern: Albano, Italy.
2.86 (s1), 3.06 (s2), 2.96 (s3), 2.54 (s), 4.6 (m), 4.5 (m), 3.83 (m)

Chemistry:

	(1)		(1)
SiO_2	28.33	K_2O	7.20
Al_2O_3	24.67	Cl	0.14
Fe_2O_3	0.50	H_2O^+	0.27
FeO	0.55	H_2O^-	0.00
MnO	0.02	CO_2	1.60
MgO	0.76	SO_3	5.42
CaO	29.41	$-O = Cl_2$	0.03
Na_2O	1.11	Total	99.95

(1) Albano, Italy; combination of two partial analyses, corresponding to $(Ca_{5.91}K_{1.73}Na_{0.40})_{\Sigma=8.04}(Al_{0.76}Mg_{0.21}Fe^{2+}_{0.09}Fe^{3+}_{0.07})_{\Sigma=1.03}(Si_{5.31}Al_{4.69})_{\Sigma=10.00}O_{25}[(SO_4)_{0.76}(CO_3)_{0.40}Cl_{0.02}]_{\Sigma=1.18}$.

Occurrence: In blocks of metamorphosed limestone ejected by volcanism.

Association: Hedenbergite, grossular-andradite, melilite, leucite, haüyne, kaliophilite.

Distribution: From Albano, in the Alban Hills, Lazio, and from Pitigliano, near Grosseto, Tuscany, Italy.

Name: For the Latin name of the district of origin, Latium, Italy.

Type Material: Cambridge University, Cambridge, England, 45482, 29799.

References: (1) Tilley, C.E. and N.F.M. Henry (1953) Latiumite (sulphatic potassium-calcium-aluminum silicate), a new mineral from Albano, Latium, Italy. Mineral. Mag., 30, 39–45. (2) (1954) Amer. Mineral., 39, 402–403 (abs. ref. 1). (3) Cannillo, E., A. Dal Negro, and G. Rossi (1973) The crystal structure of latiumite, a new type of sheet silicate. Amer. Mineral., 58, 466–470.

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Latrappite $(Ca, Na)(Nb, Ti, Fe)O_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As pseudocubic crystals, to 0.5 mm. *Twinning:* Commonly complexly twinned.

Physical Properties: Hardness = [5.5] (by analogy to the perovskite group).
D(meas.) = 4.40–4.42 D(calc.) = 4.457

Optical Properties: Opaque. *Color:* Black; dark grayish brown in transmitted light.
Luster: [Adamantine.]
Optical Class: Biaxial. *Anisotropism:* Moderate.
R_1–R_2: n.d.

Cell Data: *Space Group: Pcmn.* $a = 5.448$ $b = 7.777$ $c = 5.553$ Z = [4]

X-ray Powder Pattern: Oka complex, Canada.
2.744 (100), 3.887 (79), 1.942 (57), 2.773 (30), 1.579 (25), 1.595 (14), 1.737 (9)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8		< 0.005	MnO	0.77	0.07
Nb_2O_5	43.90	50.35	PbO		0.01
Ta_2O_5		0.55	MgO	2.20	
V_2O_5		0.11	CaO	25.95	20.0
SiO_2	0.45	0.17	SrO		0.29
TiO_2	10.05	15.16	BaO		0.03
ZrO_2		0.85	Na_2O	4.03	6.77
ThO_2		trace	K_2O	0.03	0.09
Al_2O_3		0.08	H_2O^+		0.22
RE_2O_3	2.03	0.64	S	0.90	
Fe_2O_3	8.74	4.92	LOI (less S)	0.65	
FeO		0.44	Total	99.70	[100.75]

(1) Oka complex, Canada; total Fe as Fe_2O_3, after deduction of diopside and pyrite, corresponds to $(Ca_{0.75}Na_{0.21}RE_{0.02})_{\Sigma=0.98}(Nb_{0.54}Ti_{0.21}Fe_{0.16}Mg_{0.08}Mn_{0.02})_{\Sigma=1.01}O_3$.
(2) Badloch quarry, Germany; original total given as 100.65%; corresponds to $[Ca_{0.55}Na_{0.34}Fe_{0.01}(RE, Sr, K, Mn)_{0.02}]_{\Sigma=0.92}[Nb_{0.59}Ti_{0.29}Fe_{0.10}Zr_{0.01}(Ta, Si, Al, V)_{0.01}]_{\Sigma=1.00}O_3(OH)_{0.02}$.

Mineral Group: Perovskite group; $Ca_A > 0.5$; $Nb_B > 0.5$.

Occurrence: In sövite zones of carbonatite complexes.

Association: Calcite, apatite, diopside, biotite, pyrochlore, magnetite, niocalite, dolomite, nepheline, monticellite (Oka complex, Canada); columbite (Badloch quarry, Germany).

Distribution: From the St. Lawrence Columbium and Metals Corporation mine, near La Trappe, Quebec, Canada. Found in the Badloch quarry, in the Kaiserstuhl, Baden-Württemberg, Germany.

Name: For the small community, La Trappe, Quebec, Canada, near the mine from which the first crystals were recovered.

Type Material: Royal Ontario Museum, Toronto, Canada, M26143.

References: (1) Nickel, E.H. (1964) Latrappite – a proposed new name for the perovskite-type calcium niobate mineral from the Oka area of Quebec. Can. Mineral., 8, 121–122. (2) (1965) Amer. Mineral., 50, 265 (abs. ref. 1). (3) Nickel, E.H. and R.C. McAdam (1963) Niobian perovskite from Oka, Quebec; a new classification for minerals of the perovskite group. Can. Mineral., 7, 683–697. (4) Van Wambeke, L. (1980) Latrappite and ceriopyrochlore, new minerals for the Federal Republic of Germany. Neues Jahrb. Mineral., Monatsh., 171–174.

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Laueite $Mn^{2+}Fe_2^{3+}(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As tabular prismatic crystals, composed of {100}, {010}, {001}, {110}, {$1\overline{1}0$}, {$0\overline{1}1$}, {011}, to 3 mm.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Very brittle. Hardness = 3 D(meas.) = 2.44–2.49 D(calc.) = 2.56

Optical Properties: Transparent to translucent. *Color:* Honey-brown, amber, yellow, dark yellow, yellow-orange, reddish orange. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r < v$, strong. $\alpha = 1.588$–1.603 $\beta = 1.654$–1.659 $\gamma = 1.680$–1.682 2V(meas.) = 63°–66° 2V(calc.) = 62°–63°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.28$ $b = 10.66$ $c = 7.14$ $\alpha = 107°55'$ $\beta = 110°59'$ $\gamma = 71°07'$ Z = 1

X-ray Powder Pattern: Hagendorf, Germany; close to ushkovite.
9.91 (100), 3.28 (9), 4.95 (8), 6.57 (7), 2.88 (6), 4.02 (5), 3.93 (5)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	26.47	26.55	MnO	11.06	13.27
Al_2O_3	1.76		MgO	0.52	
Fe_2O_3	27.54	29.86	CaO	0.23	
FeO	1.34		H_2O	30.84	30.22
			Total	99.76	100.00

(1) Hagendorf, Germany. (2) $Mn^{2+}Fe_2^{3+}(PO_4)_2(OH)_2 \cdot 8H_2O$.

Polymorphism & Series: Trimorphous with pseudolaueite and stewartite.

Mineral Group: Paravauxite group.

Occurrence: A common late-stage hydrothermal mineral in oxidized triphylite-bearing complex granite pegmatites.

Association: Rockbridgeite (Hagendorf, Germany); rockbridgeite, strunzite, stewartite, pseudolaueite, siderite, ludlamite (Palermo #1 mine, New Hampshire, USA).

Distribution: Well-crystallized from Hagendorf, Bavaria, Germany. At the Mangualde pegmatite, near Mesquitela, and in the Bendada pegmatite, near Guarda, Portugal. In the Norrö pegmatite, on Rånö Island, Sweden. On Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia. In the USA, at the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., and the Fitzgibbon mine, Alstead, Cheshire Co., New Hampshire; in the Emmons quarry, Greenwood, Oxford Co., Maine; in South Dakota, from the White Elephant and Etta mines, near Keystone, Pennington Co., at the Big Chief mine, near Glendale, and the Linwood, Hesnard, and Tip Top mines, near Custer, Custer Co.; at the Foote mine, Kings Mountain, Cleveland Co., North Carolina. From the Énio pegmatite mine, northeast of Galiléia, and the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. In the Wiperaminga Hill West quarry, near Olary, South Australia. From the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. Other minor occurrences are known.

Name: Honors Max Theodor Felix von Laue (1879–1960), German physicist, University of Munich, Munich, Germany, awarded the Nobel prize for his discovery of X-ray diffraction.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 119478.

References: (1) Strunz, H. (1954) Laueit, $MnFe_2^{\bullet\bullet\bullet}[OH|PO_4]_2 \cdot 8H_2O$, ein neues Mineral. Naturwissenschaften, 41, 256 (in German). (2) (1954) Amer. Mineral., 39, 1038 (abs. ref. 1). (3) Moore, P.B. (1965) The crystal structure of laueite, $Mn^{2+}Fe_2^{3+}(OH)_2(PO_4)_2(H_2O)_6 \cdot 2H_2O$. Amer. Mineral., 50, 1884–1892. (4) Plieth, K., G. Ruban, and H.-G. Smolczyk (1965) Zur Kristallstruktur des Laueits, $Fe_2Mn[PO_4/OH]_2 \cdot 8H_2O$. Acta Cryst., 19, 485 (in German). (5) Pitman, L.C. (1989) Laueite from Hagendorf-Süd and the Palermo mine. Mineral. Record, 20, 363–364. (6) Hurlbut, C.S., Jr. and R. Honea (1962) Sigloite, a new mineral from Llallagua, Bolivia. Amer. Mineral., 47, 1–8.

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Laumontite $CaAl_2Si_4O_{12}\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals square prisms with steep oblique terminations, stout, commonly elongated, to 20 cm. Radiating, columnar, fibrous; in interlocking aggregates, massive. *Twinning:* On {100}, typically with terminal re-entrants.

Physical Properties: *Cleavage:* {010}, {110}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.23–2.41 D(calc.) = 2.25 Undergoes a partial loss of H_2O on exposure to air.

Optical Properties: Transparent to translucent. *Color:* White to gray, pink, yellowish, brownish, golden brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous to pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge a = 10°–26°$; $Z \wedge c = 8°–33°$.
Dispersion: $r < v$, distinct, weakly inclined. $\alpha = 1.502–1.514$ $\beta = 1.512–1.522$
$\gamma = 1.514–1.525$ 2V(meas.) = 26°–47°

Cell Data: *Space Group:* $C2/m$. $a = 14.724(9)$ $b = 13.075(6)$ $c = 7.559(2)$
$\beta = 112.01(3)°$ Z = 4

X-ray Powder Pattern: Synthetic.
4.16 (100), 3.51 (80), 9.5 (60), 3.27 (55), 6.84 (40), 3.66 (35), 3.03 (35)

Chemistry:

	(1)
SiO_2	50.70
Al_2O_3	22.53
Fe_2O_3	0.04
CaO	11.54
Na_2O	0.40
K_2O	0.30
H_2O^+	12.00
H_2O^-	2.41
Total	99.92

(1) Halle, Germany; corresponds to $(Ca_{0.96}Na_{0.06}K_{0.03})_{\Sigma=1.05}Al_{2.07}Si_{3.94}O_{12}\cdot 3.12H_2O$.

Mineral Group: Zeolite group.

Occurrence: Of hydrothermal origin, lining cavities in igneous rocks. Thick sedimentary beds rich in laumontite may form by decomposition of analcime or metamorphism of plagioclase. May be authigenic, cementing sandstones.

Association: Zeolites, apophyllite, datolite, calcite, chlorite.

Distribution: Relatively common. Well-crystallized specimens: from Huelgoat, Finistère, France. From Săcărâmb (Nagyág), Romania. At St. Gotthard, Ticino, Switzerland. From Floitental, Zillertal, and other places in Tirol, Austria. In Italy, from Baveno, Piedmont. From Poona and in the Khandivali quarry, near Bombay, Maharashtra, India, large crystals. In the USA, exceptional crystals from the Pine Creek tungsten mine, Bishop, Inyo Co., California; from Drain, Douglas Co., Oregon; at Bergen Hill, Hudson Co., and Paterson, Passaic Co., New Jersey; in the Goose Creek quarry, Leesburg, Loudoun Co., Virginia; on the Keweenaw Peninsula, Houghton and Keweenaw Cos., Michigan.

Name: For François Pierre Nicolas Gillet de Laumont (1747–1834), who first found the mineral.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 587–588.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 401–407. (3) Liou, J.G. (1971) P-T stabilities of laumontite, wairakite, lawsonite, and related minerals in the system $CaAl_2Si_2O_8$–SiO_2–H_2O. J. Petrol. 12, 379–411.
(4) Yakubovich, O.V. and M.A. Simonov (1985) Refined crystal structure of the zeolite laumontite $Ca(H_2O)_{2.8}[Al_2Si_4O_{12}]0.5H_2O$. Kristallografiya (Sov. Phys. Crystal.), 30, 1072–1076 (in Russian).

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Launayite $Pb_{22}Sb_{26}S_{61}$

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Crystal Data: Monoclinic. *Point Group:* 2, m, or $2/m$. Material dug from polished surfaces tends to be somewhat fibrous by elongation ‖ [010], resulting from the two perfect cleavages.

Physical Properties: *Cleavage:* Perfect on {100} and {001}. Hardness = n.d. VHN = 179 D(meas.) = n.d. D(calc.) = 5.83

Optical Properties: Opaque. *Color:* Lead-gray. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Fairly strong, from white to gray. *Anisotropism:* Strong.
R_1–R_2: (470) 42.6–38.6, (546) 43.8–36.9, (589) 42.7–36.2, (650) 40.9–35.5

Cell Data: *Space Group:* $C2$, Cm, or $C2/m$ (pseudocell). $a = 42.6$ $b = 8.04$ $c = 32.3$ $\beta = 102°5(45)'$ Z = 2

X-ray Powder Pattern: Madoc, Canada.
3.45 (100), 4.17 (80), 2.92 (80), 2.010 (70), 3.40 (60), 2.836 (50), 3.97 (30)

Chemistry:

	(1)	(2)	(3)
Pb	48.5	44.95	47.09
Cu		1.35	
Sb	29.5	31.35	32.70
As	1.5	1.75	
S	21.25	20.85	20.21
Total	100.75	100.25	100.00

(1) Madoc, Canada; by electron microprobe, average of two analyses; corresponds to $Pb_{21.55}(Sb_{22.30}As_{1.84})_{\Sigma=24.14}S_{61.00}$. (2) Do.; by electron microprobe, average of two analyses; corresponds to $Pb_{20.35}Cu_{1.99}(Sb_{24.16}As_{2.19})_{\Sigma=26.35}S_{61.00}$. (3) $Pb_{22}Sb_{26}S_{61}$.

Occurrence: Of hydrothermal origin, in marbles.

Association: Veenite, boulangerite.

Distribution: From Madoc, Ontario, Canada [TL].

Name: For Professor Louis Alphonse Auguste de Launay (1860–1938), French student of mineral deposits, National School of Mines, Paris, France.

Type Material: Canadian Geological Survey, Ottawa, 12176; Canadian Museum of Nature, Ottawa, Canada.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Ontario. Part 2 – mineral descriptions. Can. Mineral., 9, 191–194. (2) (1968) Amer. Mineral., 53, 1423 (abs. ref. 1). (3) Jambor, J.L., J.H.G. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100, esp. 95.

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Laurelite $Pb_7F_{12}Cl_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}$. As acicular prismatic crystals, to 1 cm, with basal terminations. As jackstraw aggregates and parallel bundles. *Twinning:* By rotation around [0001], pervasive.

Physical Properties: *Cleavage:* {0001}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Brittle, needles are slightly flexible. Hardness = 2 D(meas.) = 7.65(5) D(calc.) = 7.77 Dissolves very slowly in cold H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Silky, subadamantine on broken surfaces.
Optical Class: Uniaxial (+). $\omega = 1.903(5)$ $\epsilon = 1.946(5)$

Cell Data: *Space Group:* $P\overline{6}$. $a = 10.267(1)$ $c = 3.9844(4)$ Z = 1

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
3.33 (100), 1.934 (60), 3.125 (40), 2.949 (40), 1.709 (40), 1.282 (40), 2.090 (35)

Chemistry:

	(1)	(2)
Pb	82.0	82.92
F	13.0	13.03
Cl	3.6	4.05
OH	0.9	
Total	99.5	100.00

(1) Grand Reef mine, Arizona, USA; by electron microprobe, H_2O by moisture titration; corresponding to $Pb_{0.97}[F_{1.68}Cl_{0.25}(H_2O)_{0.07}]_{\Sigma=2.00}$. (2) $Pb_7F_{12}Cl_2$.

Occurrence: In a vug isolated from acidic sulfate-rich solutions in the oxidized zone of a low-temperature Pb–Cu–Ag deposit.

Association: Grandreefite, pseudograndreefite, aravaipaite, galena, fluorite, anglesite, linarite, caledonite, quartz.

Distribution: From the Grand Reef mine, about six km northeast of Klondyke, Aravaipa district, Graham Co., Arizona, USA.

Name: For Laurel Canyon, Arizona, USA, where the Grand Reef mine is located.

Type Material: Natural History Museum, Los Angeles, California, 33608; National Museum of Natural History, Washington, D.C., USA, 166057.

References: (1) Kampf, A.R., P.J. Dunn, and E.E. Foord (1989) Grandreefite, pseudograndreefite, laurelite, and aravaipaite: four new minerals from the Grand Reef mine, Graham County, Arizona. Amer. Mineral., 74, 927–933. (2) Kampf, A.R. and E.E. Foord (1996) Calcioaravaipaite, a new mineral, and associated lead fluoride minerals from the Grand Reef mine, Graham County, Arizona. Mineral. Record, 27, 293–300. (3) Merlino, S., M. Pasero, N. Perchiazzi, and A.R. Kampf (1996) Laurelite: its crystal structure and relationship to $\alpha-PbF_2$. Amer. Mineral., 81, 1277–1281.

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Laurentianite $[NbO(H_2O)]_3(Si_2O_7)_2[Na(H_2O)_2]_3$

Crystal Data: Hexagonal. *Point Group*: 3. As acicular crystals elongate along [0001], to 0.15 mm, in randomly oriented groupings ('nests').

Physical Properties: *Cleavage*: None. *Fracture*: Splintery. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.464

Optical Properties: Translucent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous to satiny. *Optical Class*: Uniaxial (–). ω = 1.612(2) ε = 1.604(2)

Cell Data: *Space Group*: *P*3. *a* = 9.937(1) *c* = 7.004(1) Z = 1

X-ray Powder Pattern: Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada.
8.608 (100), 3.260 (31), 4.312 (25), 3.675 (25), 2.870 (20), 7.005 (19), 1.836 (14)

Chemistry:

	(1)	(2)
Na_2O	8.88	10.40
K_2O	0.26	
CaO	0.22	
TiO_2	0.58	
Nb_2O_5	43.64	44.59
SiO_2	26.87	26.88
H_2O	[17.93]	18.13
Total	98.38	100.00

(1) Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada; average of 12 electron microprobe analyses, H_2O inferred from Raman spectroscopy and crystal structure analysis; corresponding to $(Nb_{0.99}Ti_{0.01})_{\Sigma=1.00}O(H_2O)]_3(Si_{2.00}O_7)_2[(Na_{0.86}\square_{0.10}K_{0.02}Ca_{0.01})_{\Sigma=0.99}(H_2O)_2]_3$.
(2) $[NbO(H_2O)]_3(Si_2O_7)_2[Na(H_2O)_2]_3$.

Occurrence: From a highly oxidized waste-rock pile of siderite-dominant pods attributed to altered sodalite syenite. The mineral is likely a late-stage alteration product.

Association: Quartz, pyrite, franconite, rutile, lepidochrocite.

Distribution: At the Poudrette quarry, Mont Saint-Hilaire, Montérégie (formerly Rouville County), Quebec, Canada.

Name: For Laurentian University, Sudbury, Ontario, Canada, where the research characterizing this mineral as a new species was conducted.

Type Material: Royal Ontario Museum, Toronto, Canada (M55369).

References: (1) Haring, M.M.M., A.M. McDonald, M.A. Cooper, and G.A. Poirier (2012) Laurentianite, $[NbO(H_2O)]_3(Si_2O_7)_2[Na(H_2O)_2]_3$, a new mineral from Mont Saint-Hilaire, Quebec: description, crystal-structure determination and paragenesis. Can. Mineral., 50, 1265-1280.
(2) (2014) Amer. Mineral., 99, 1516 (abs. ref. 1).

Laurionite PbCl(OH)

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Pyramidally-terminated prismatic crystals, to 1 cm, tabular on {100} and elongated along [010]. May be striated along {100} ‖ {$0\overline{2}1$}, forming chevrons; 15 forms recorded.

Physical Properties: *Cleavage:* {101}, distinct. *Tenacity:* Flexible. Hardness = 3–3.5 D(meas.) = 6.241 D(calc.) = 6.212 Slightly soluble in cold H_2O, more so in hot H_2O.

Optical Properties: Transparent. *Color:* Colorless, white. *Luster:* Adamantine, pearly on {100}.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 2.08$ $\beta = 2.12$ $\gamma = 2.16$ 2V(meas.) = Large.

Cell Data: *Space Group: Pcmn.* $a = 9.6987$ $b = 4.0203$ $c = 7.1110$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 31-680).
4.01 (100), 3.30 (55), 2.30 (50), 3.56 (40), 3.33 (30), 5.7 (25), 2.87 (25)

Chemistry:

	(1)	(2)
Pb	79.38	79.80
O	3.17	3.08
Cl	13.77	13.65
H_2O	3.68	3.47
Total	100.00	100.00

(1) Laurium, Greece. (2) PbCl(OH).

Polymorphism & Series: Dimorphous with paralaurionite.

Occurrence: Produced by the action of saline water on lead-bearing slag. In the oxidized zone of lead-bearing mineral deposits.

Association: Paralaurionite, penfieldite, fiedlerite, phosgenite, cerussite, anglesite.

Distribution: Probably more widespread than the known localities indicate. An alteration product of slag from: Laurium, Greece. Along Baratti Beach, Tuscany, Italy. From Juliushütte, Astfeld, Harz Mountains, Germany. From the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa. In mineral deposits at: Wheal Rose, near Sithney, Cornwall, and the Wesley mine, near Higher Pitts, Somerset, England. From the Nant-y-Cagl (Eaglebrook) mine, Ceulanymaesmawr, Dyfed, Wales. In the Kara Elchi mercury deposit, Turkmenistan. Found at the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia, and in the Elura deposit, 43 km northeast of Cobar, New South Wales, Australia. From the Minnamax Cu–Ni sulfide deposit, Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota, USA.

Name: For the occurrence at Laurium, Greece.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 62–64. (2) Venetopoulos, C.C. and P.J. Rentzeperis (1975) The crystal structure of laurionite, Pb(OH)Cl. Zeits. Krist., 141, 246–259. (3) Merlino, S., M. Pasero, and N. Perchiazzi (1993) Crystal structure of paralaurionite and its OD relationships with laurionite. Mineral. Mag., 57, 323–328.

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Laurite RuS_2

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As octahedral, cubic, and pyritohedral crystals, to 1 mm, and as rounded grains and inclusions in other minerals.

Physical Properties: *Cleavage:* Perfect on {111}. *Fracture:* Subconchoidal. *Tenacity:* Very brittle. Hardness = 7.5 VHN = 2760–2898, 2870 average (25 g load). D(meas.) = 6.43 D(calc.) = 6.39

Optical Properties: Opaque. *Color:* Iron-black, in polished section, white to gray, bluish. *Streak:* Dark gray. *Luster:* Metallic.
R: (400) 51.2, (420) 49.8, (440) 48.5, (460) 47.0, (480) 45.7, (500) 44.6, (520) 43.7, (540) 42.8, (560) 42.0, (580) 41.3, (600) 40.6, (620) 40.1, (640) 39.5, (660) 39.0, (680) 38.5, (700) 38.1

Cell Data: *Space Group:* $Pa3$. $a = 5.6135$ $Z = 4$

X-ray Powder Pattern: Borneo.
2.81 (vs), 3.29 (vs), 3.24 (s), 1.982 (s), 1.082 (s), 1.287 (ms), 1.256 (ms)

Chemistry	(1)	(2)	(3)		(4)				
Ru	65.18	61.0	46.1		61.18				
Os	[3.03]		12.7						
Ir		1.0	5.3						
Cu			0.1	Compt. Rendus Acad. Sci. ParisS		31.79	38.0	35.4	38.82
Total	[100.00]	100.0	99.6		100.00				

(1) Borneo; placer material; Os by difference. (2) Goodnews Bay, Alaska, USA; by electron microprobe. (3) Rio Pilpe, Colombia; by electron microprobe. (4) RuS_2.

Polymorphism & Series: Forms a series with erlichmanite.

Mineral Group: Pyrite group.

Occurrence: In ultramafic complexes and in placer deposits.

Association: Cooperite, braggite, sperrylite, other minerals of the platinum-group elements, chromite.

Distribution: From placers in Borneo, as at Kalimantan (formerly Pontijn, Tanah Laut) [TL]. In South Africa, from the Merensky Reef of the Bushveld complex, at Potgietersrus; in the Rustenburg and Union mines; also the Driekop and Onverwacht mines. In the USA, in the Stillwater complex, Montana; on the Yuba River, Nevada Co., and from the Trinity River near Douglas City, Trinity Co., California; at Goodnews Bay, Alaska. In Canada, in the Tulameen area, British Columbia. In Sierra Leone, from placers at Guma Water, and the Senduma chrome mines. From the Konder massif, Aldan Shield, Sakha, Russia. In the Kapitanov chromite deposit, near Zvenyhorodka, Ukraine. At Maud Creek, Howard River, New Zealand. Known in small amounts from other localities.

Name: For Laura R. Joy, wife of Charles A. Joy, American chemist, Columbia University, New York City, USA.

Type Material: University of Göttingen, Göttingen, Germany, 24541.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 291–292. (2) Leonard, B.F. and G.A. Desborough (1969) Ore microscopy and chemical composition of some laurites. Amer. Mineral., 54, 1330–1346. (3) Bowles, J.F.W., D. Atkin, J.L.M. Lambert, T. Deans, and R. Phillips (1983) The chemistry, reflectance, and cell size of the erlichmanite (OsS_2) – laurite (RuS_2) series. Mineral. Mag., 47, 465–471. (4) Lutz, H.D., B. Müller, T. Schmidt, and T. Stingl (1990) Structure refinement of pyrite-type ruthenium disulfide, RuS_2, and ruthenium diselenide, $RuSe_2$. Acta Cryst., C46, 2003–2005. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 315.

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Lausenite $Fe_2^{3+}(SO_4)_3 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Fibrous, elongated along [001], to 0.5 mm; in fine-grained lumpy to chalky aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. May be partially soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White; colorless in transmitted light.
Luster: Silky.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = 27°$. α = 1.548–1.598 β = 1.628(5) γ = 1.600–1.654 2V(meas.) = Large to small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Velikomostov-2 mine, Ukraine.
3.52 (10), 3.38 (10), 2.065 (6), 3.03 (5), 2.85 (5), 5.555 (4), 4.82 (3)

Chemistry:

	(1)	(2)	(3)
SO_3	47.90	49.43	47.28
SiO_2		1.90	
Al_2O_3	1.40	7.72	
Fe_2O_3	28.07	12.63	31.44
FeO		0.17	
MgO		6.38	
CaO		0.52	
Na_2O	1.23	0.84	
K_2O	0.06	0.34	
H_2O	20.64	19.73	21.28
Total	99.30	99.66	100.00

(1) United Verde mine, Arizona, USA; corresponds to $(Fe_{1.76}Al_{0.14})_{\Sigma=1.90}(SO_4)_3 \cdot 6H_2O$.
(2) Velikomostov-2 mine, Ukraine; after deduction of kieserite, stated to correspond to $(Fe_{1.03}Al_{1.00})_{\Sigma=2.03}(SO_4)_3 \cdot 6H_2O$. (3) $Fe_2(SO_4)_3 \cdot 6H_2O$.

Occurrence: A very rare mineral, formed as the result of burning of a pyritic orebody (United Verde mine, Arizona, USA); on a burning waste heap formed by oxidation of pyrite reacting with clay (Velikomostov-2 mine, Ukraine).

Association: Copiapite (United Verde mine, Arizona, USA); kieserite (Velikomostov-2 mine, Ukraine).

Distribution: From the United Verde mine, Jerome, Yavapai Co., Arizona, USA. At the Velikomostov-2 coal mine, L'vov-Volyn' Basin, Ukraine.

Name: Honoring Carl B. Lausen, geologist, United Verde Mining Co., Jerome, Arizona, USA, who discovered the mineral.

Type Material: University of Arizona, Tucson, Arizona, M53; Harvard University, Cambridge, Massachusetts, USA, 90537.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 530. (2) Srebrodol'skii, B.I. (1974) Lausenite, first find in the USSR. Doklady Acad. Nauk SSSR, 219, 441–442 (in Russian).

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Lautarite $Ca(IO_3)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are small, short prismatic, elongated and striated along [001], showing {110}, {120}, {010}, {001}, small {011}, {101}, {$\bar{1}$01}; in radial aggregates.

Physical Properties: *Cleavage:* On {011}, good; {100}, {110}, interrupted. Hardness = 3.5–4 D(meas.) = 4.59 D(calc.) = 4.48 Slightly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, may be zoned in yellow with impurities. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 25°$. *Dispersion:* $r > v$, moderate. $\alpha = 1.792(3)$ $\beta = 1.840(3)$ $\gamma = 1.888(3)$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 7.1432(13)$ $b = 11.2969(31)$ $c = 7.2804(9)$ $\beta = 106.35(1)°$ Z = 4

X-ray Powder Pattern: Synthetic.
3.156 (100), 3.428 (85), 3.493 (65), 4.360 (50), 3.336 (40), 2.840 (35), 3.318 (30)

Chemistry:

	(1)	(2)
I_2O_5	85.04	85.62
CaO	14.95	14.38
Total	99.99	100.00

(1) Pampa del Pique III, Chile; I_2O_5 average of two analyses. (2) $Ca(IO_3)_2$.

Occurrence: Coating fractures or embedded in gypsum in the nitrate deposits.

Association: Gypsum, brüggenite, dietzeite, nitratine, anhydrite, hydroboracite, halite.

Distribution: From the Pampa del Pique III, about one km north of Oficina Lautaro, Taltal district, Antofagasta, Chile.

Name: For its occurrence at Oficina Lautaro, Chile.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 312–313. (2) Ghose, S., C. Wan, and O. Wittke (1978) The crystal structure of synthetic lautarite, $Ca(IO_3)_2$. Acta Cryst., 34, 84–88. (3) (1977) NBS Mono. 25, 14, 12.

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Lautenthalite $PbCu_4(SO_4)_2(OH)_6 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular crystals, to 0.7 mm, flattened on {100}, may be elongated along [010], with prominent {100}, {010}, {101}, also {102}, {110}, {$\bar{5}$14}; in sheaflike or irregular aggregates. *Twinning:* With {100} as twin plane, commonly polysynthetic.

Physical Properties: *Cleavage:* On {001} and {010}, good. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.84

Optical Properties: Transparent. *Color:* Bright blue. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Faint; X = pale blue; $Y = Z$ = blue. *Orientation:* $Z = b$; $Y \wedge c = 4(1)°$. *Dispersion:* $r > v$, distinct. $\alpha = 1.659(2)$ $\beta = 1.703(2)$ $\gamma = 1.732(2)$ 2V(meas.) = 79(1)° 2V(calc.) = 78°

Cell Data: *Space Group:* $P2_1/c$. $a = 21.642(8)$ $b = 6.040(2)$ $c = 22.544(8)$ $\beta = 108.2(1)°$ Z = 8

X-ray Powder Pattern: Lautenthal, Germany.
5.14 (100), 3.40 (80), 4.53 (60), 2.631 (50), 2.531 (40), 2.821 (30), 2.421 (30)

Chemistry:

	(1)	(2)
SO_3	19.7	19.78
CuO	39.3	39.30
PbO	27.2	27.57
H_2O	[13.8]	13.35
Total	[100.0]	100.00

(1) Lautenthal, Germany; by electron microprobe, average of determinations on three crystals, H_2O by difference, both $(OH)^{1-}$ and H_2O shown to be present by IR; corresponds to $Pb_{0.99}Cu_{4.01}(SO_4)_{2.00}(OH)_6 \cdot 3.10H_2O$. (2) $PbCu_4(SO_4)_2(OH)_6 \cdot 3H_2O$.

Occurrence: Formed in the oxidation zone of Pb–Cu sulfide deposits (Wales); an oxidation product in cavities in smelter slag (Germany, Austria, Scotland).

Association: Anglesite, devilline–serpierite, galena (Lautenthal, Germany); linarite, brochantite, schulenbergite, wroewolfeite (Penrhiw mine, Wales).

Distribution: From [the Trogtal quarry, near] Lautenthal, Harz Mountains, Germany. At Öblarn, Steiermark, Austria. Found at the Meadowfoot smelter, northwest of Wanlockhead, Dumfriesshire, Scotland. In Wales, from the Hendrefelen mine, Central Wales district; in Dyfed, at the Penrhiw mine, Ystumtuen, and the Frongoch mine.

Name: For its occurrence at Lautenthal, Germany.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany.

References: (1) Medenbach, O. and W. Gebert (1993) Lautenthalite, $PbCu_4[(OH)_6|(SO_4)_2] \cdot 3H_2O$, the Pb analogue of devillite – a new mineral from the Harz mountains, Germany. Neues Jahrb. Mineral., Monatsh., 401–407. (2) (1994) Amer. Mineral., 79, 571 (abs. ref. 1).

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Lautite CuAsS

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As crystals, short to long prismatic [100], to 2.3 cm, and tabular [001]; striated on {001} parallel to [100]. May also be massive, fine granular or radiating. *Twinning:* On {110}.

Physical Properties: *Cleavage:* {001}. *Tenacity:* Brittle. Hardness = 3–3.5 VHN = 239–259 (100 g load). D(meas.) = 4.91 D(calc.) = 4.878

Optical Properties: Opaque. *Color:* Black, steel-gray with reddish tone. *Streak:* Black. *Luster:* Metallic to semimetallic. *Pleochroism:* Very weak. *Anisotropism:* Weak.
R_1–R_2: (400) 34.2–36.6, (420) 33.6–35.8, (440) 33.0–35.0, (460) 32.1–33.9, (480) 31.5–33.1, (500) 30.9–32.5, (520) 30.6–31.9, (540) 30.5–31.4, (560) 30.6–31.0, (580) 30.6–30.8, (600) 30.8–30.8, (620) 31.0–31.1, (640) 31.5–31.4, (660) 31.8–31.4, (680) 31.9–31.2, (700) 31.6–31.0

Cell Data: *Space Group:* $Pna2_1$. $a = 11.350$ $b = 5.456$ $c = 3.749$ Z = 4

X-ray Powder Pattern: Lauta, Germany.
3.10 (100), 1.903 (80), 1.610 (60), 1.232 (50), 1.095 (50), 1.030 (50), 1.797 (40)

Chemistry:

	(1)	(2)	(3)
Cu	36.10	37.6	37.28
As	45.66	43.5	43.92
S	17.88	18.8	18.80
Total	99.64	99.9	100.00

(1) Lauta, Germany. (2) Do.; by electron microprobe. (3) CuAsS.

Occurrence: In hydrothermal veins formed at medium temperatures.

Association: Arsenic, tennantite, proustite, chalcopyrite, galena, barite (Lauta, Germany); kutínaite, paxite (Niederbeerbach, Germany); arsenic, bismuth, tennantite, löllingite, rammelsbergite, proustite, quartz (Gabe Gottes mine, France).

Distribution: In Germany, from Lauta, near Marienberg, Saxony [TL]; and at Mühltal, Niederbeerbach, Odenwald, Hesse. In the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, France. From Turţ, Romania. At the Laerma Au–Cu–U deposit, Sichuan Province, China.

Name: For the Lauta, Germany occurrence.

Type Material: Mining Academy, Freiberg, Germany, 44485.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 327–328. (2) Craig, D.C. and N.C. Stevenson (1965) The crystal structure of lautite, CuAsS. Acta Cryst., 19, 543–547. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 108–109. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 316.

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Lavendulan $NaCaCu_5(AsO_4)_4Cl \cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Rarely as crystals, to 3 mm; as radiating fibers or rosettes of plates, and as botyroidal crusts.

Physical Properties: *Cleavage:* Good on {010}; distinct on {100} and {001}.
Hardness = 2.5 D(meas.) = 3.54 D(calc.) = [3.59]

Optical Properties: Semitransparent. *Color:* Lavender, greenish blue. *Luster:* Vitreous, waxy, satiny in aggregates.
Optical Class: Biaxial (–), nearly uniaxial (–). *Pleochroism:* O = pale blue to pale greenish blue; E = blue to greenish blue. *Absorption:* $E > O$. $\omega = 1.748$ $\epsilon = 1.645$

Cell Data: *Space Group:* n.d. $a = 9.73$ $b = 41.0$ $c = 9.85$ Z = 8

X-ray Powder Pattern: San Juan, Chile.
9.77 (100), 3.11 (70), 4.87 (50), 7.01 (40), 4.41 (40), 2.90 (20), 2.76 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5		6.0		CaO	5.8	5.7	5.28
As_2O_5	44.8	36.4	43.28	Na_2O	3.1	3.3	2.92
CoO	0.0	0.03		Cl	3.5	5.5	3.34
CuO	36.3	38.2	37.45	H_2O	[7.3]	[6.0]	8.48
MgO		0.04		$-O = Cl_2$	[0.8]	1.2	0.75
				Total	[100.0]	[100.0]	100.00

(1) San Juan, Chile; H_2O by difference. (2) Dome Rock mine, Australia; by electron microprobe, H_2O by difference; corresponds to $Na_{1.07}(Ca_{1.01}Mg_{0.01})_{\Sigma=1.02}Cu_{4.80}[(As_{0.79}P_{0.21})_{\Sigma=1.00}O_4]_4Cl_{1.55} \cdot 5H_2O$. (3) $NaCaCu_5(AsO_4)_4Cl \cdot 5H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of some copper deposits.

Association: Erythrite, cuprite, malachite, cobaltian wad (San Juan, Chile); chalcophyllite, cyanotrichite, parnauite, mansfieldite, olivenite, tennantite, covellite, chalcanthite, antlerite, brochantite, geminite (Cap Garonne mine, France); cuprian adamite, conichalcite, o'danielite, tsumcorite, fahleite, quartz, calcite, gypsum (Tsumeb, Namibia).

Distribution: From Annaberg, Saxony, Germany. At Jáchymov (Joachimsthal), Czech Republic. In England, from the Littleham Cove area, Budleigh Salterton, Devon; in the Cligga mine, Perranzabuloe, and the Pentireglaze mine, Cornwall. From Bunmahon, Co. Waterford, Ireland. At Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland. In France, from the Cap Garonne mine, near le Pradet, Var, and at the Salsigne mine, 15 km north of Carcassone, Aude. Fine crystals from Pastrana Hill, Mazarrón area, Murcia Province, Spain. At Qued Mahisser, Tunisia. From the Talmessi and Meskani mines, Anarak district, Iran. At Tsumeb, Namibia. From the Arhbar (Aghbar) mine, Bou Azzer district, Morocco. In Chile, at the Blanca mine, San Juan, Freirina, and at several mines in the Sierra Gorda district, southwest of Calama, Antofagasta. In Australia, in the Dome Rock copper mine, about 40 km northwest of Mingary, and the Preamimma mine, near Callington, South Australia; from the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, at the Alice Mary copper mine, Kundip, and several other places in Western Australia. From Gold Hill, Tooele Co., Utah, USA.

Name: For its conspicuous *lavender* color.

Type Material: Mining Academy, Freiberg, Germany, 20944.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 750–751, 920–921 [freirinite = lavendulan]. (2) Guillemin, C. (1956) Contribution a la minéralogie des arséniates, phosphates et vanadates de cuivre. I. Arséniates de cuivre. Bull. Minéral., 79, 7–95, esp. 43–54 (in French). (3) Kleeman, A.W. and A.R. Milnes (1973) Phosphorian lavendulan from Dome Rock mine, South Australia. Royal Society of South Australia, Transactions, 97(2), 135–137.

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Låvenite $(Na,Ca)_2(Mn^{2+},Fe^{2+})(Zr,Ti,Nb)Si_2O_7(O,OH,F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic ‖ [100] or tabular with {100}, {110}, {111}, {101} dominant, to 2 cm. As acicular radial to stellate or matted fibrous aggregates, granular, massive. *Twinning:* Polysynthetic on {100}.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 VHN = 764–824 D(meas.) = 3.4–3.55 D(calc.) = 3.498

Optical Properties: Transparent to translucent. *Color:* Colorless, light to dark yellow, beige, yellow-orange, red-brown to brown-black; in thin section, colorless to shades of orange. *Streak:* Yellow. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless, pale yellow; Y = colorless, pale greenish yellow; Z = very pale yellow, orange to brownish yellow. *Orientation:* $Y = b$; $Z \wedge c = -20°$. *Dispersion:* $r < v$, perceptible. *Absorption:* $Z > Y > X$. α = 1.690–1.720 β = 1.707–1.746 γ = 1.720–1.760 2V(meas.) = 73°–85°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.83(1)$ $b = 9.98(1)$ $c = 7.174(5)$ $\beta = 108.1(1)°$ Z = 4

X-ray Powder Pattern: Langesundsfjord, Norway.
2.89 (100), 2.82 (90), 3.21 (70), 3.97 (50), 2.00 (50), 1.792 (50), 1.649 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	29.63	29.72	30.92	MgO		0.12	
TiO_2	2.35	3.22	11.30	CaO	9.70	8.32	10.92
ZrO_2	28.79	27.40	16.72	Na_2O	10.77	12.44	10.70
Fe_2O_3	4.73		0.12	K_2O			trace
Y_2O_3		0.23		F		4.68	1.55
$(Nb,Ta)_2O_5$	5.20	4.73	3.01	LOI	2.24		
FeO		3.86	4.89	$-O = F_2$		1.97	0.65
MnO	5.59	5.54	10.34	Total	99.00	98.29	99.82

(1) Lille Arø Island, Norway. (2) Låven Island, Norway; by electron microprobe, corresponds to $(Na_{1.62}Ca_{0.37}Y_{0.01})_{\Sigma=2.00}(Mn_{0.31}Ca_{0.23}Fe^{2+}_{0.22}Zr_{0.21}Mg_{0.01})_{\Sigma=0.98}(Zr_{0.70}Ti_{0.16}Nb_{0.14})_{\Sigma=1.00}(Si_2O_7)(F_{0.99}O_{0.95})_{\Sigma=1.94}$. (3) Lovozero massif, Russia.

Polymorphism & Series: Dimorphous with burpalite.

Occurrence: In alkalic rocks and related pegmatites.

Association: Feldspars, nepheline, titanite, ilmenite, apatite, zircon, amphibole, biotite, eudialyte, catapleiite, astrophyllite, rinkite, lorenzenite, aegirine.

Distribution: In Norway, on Låven and the Arø Islands, in the Langesundsfjord. In Italy, from the Isle of Ischia, near Naples, Campania. In Russia, in the Lovozero, Khibiny, and Kovdor massifs, Kola Peninsula; the Burpala massif, about 120 km north of Lake Baikal, and from Zaangar'ya, Yenisei Ridge, Siberia. At Kruft, Mendig, and other places in the Laacher Kessel, Eifel district, Germany. From the Kangerdlugssuaq Fjord, Greenland. On Tamara Isle, Los Islands, Guinea. On Boa Vista Island, Cape Verde Islands. From Tenerife, Canary Islands. At Mont Saint-Hilaire and in the Saint-Amable sill, near Varennes, Quebec, Canada. From Granite Mountain, near Little Rock, Pulaski Co., Arkansas, USA.

Name: For its occurrence on Låven Island, Langesundsfjord, Norway.

Type Material: Wroclaw University, Wroclaw, Poland, II–14583.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 375–376. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 335–342. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 381–384. (4) Mellini, M. (1981) Refinement of the crystal structure of låvenite. Tschermaks Mineral. Petrog. Mitt., 28, 99–112. (5) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 102.

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Lavoisierite $Mn_8^{2+}[Al_{10}(Mn^{3+}Mg)][Si_{11}P]O_{44}(OH)_{12}$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m.* As acicular to tabular prismatic crystals elongated on [010] and flattened on {001}, to a few millimeters.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.576

Optical Properties: Transparent. *Color*: Yellow-orange. *Streak*: White. *Luster*: Vitreous. *Optical Class*: n.d. n = 1.750 [calculated] *Pleochroism*: Pale yellow ∥ to [010], yellow-orange ⊥ to [010]. Parallel extinction; positive elongation on [010].

Cell Data: *Space Group*: *Pnmm*. a = 8.6891(10) b = 5.7755(3) c = 36.9504(20) Z = 2

X-ray Powder Pattern: Punta Gensane, Viù Valley, Piedmont, Italy.
2.931 (vs), 2.765 (s), 2.598 (s), 2.448 (ms), 4.62 (m), 4.23 (m), 3.747 (m)

Chemistry:

	(1)
P_2O_5	2.08
V_2O_5	0.37
SiO_2	34.81
TiO_2	0.13
Al_2O_3	22.92
Cr_2O_3	0.32
Fe_2O_3	0.86
MgO	5.73
MnO	[19.09]
Mn_2O_3	[6.92]
CaO	1.94
Na_2O	0.01
H_2O	[5.45]
Total	100.63

(1) Punta Gensane, Viù Valley, Piedmont, Italy; average of 3 electron microprobe analyses, H_2O calculated from structure, O/OH ratio adjusted for charge balance, MnO and Mn_2O_3 calculated from structure; corresponding to $(Mn^{2+}_{5.34}Mg_{1.81}Ca_{0.69}Na_{0.01})_{\Sigma=7.85}(Al_{8.92}Mn^{3+}_{1.74}Mg_{1.01}Fe^{3+}_{0.21}Cr_{0.08}Ti_{0.03})_{\Sigma=11.99}(Si_{11.50}P_{0.58}V_{0.08})_{\Sigma=12.16}O_{44.00}(OH)_{12.00}$.

Occurrence: In piemontite-bearing mica schists related to the Alpine tectono-metamorphism of (Mn, Al)-rich sediments.

Association: Quartz, "mica", sursassite, piemontite, spessartine, braunite, "tourmaline".

Distribution: From Punta Gensane, Viù Valley, Piedmont, Western Alps, Italy.

Name: Honors the French chemist and biologist Antoine-Laurent de Lavoisier (1743-1794), one of the fathers of modern chemistry.

Type Material: In Italy, at the Natural History Musuem, University of Pisa (# 19637), and in the mineralogical collections, Regional Museum of Natural Science, Torino (M/U 16359).

References: (1) Orlandi, P., C. Biagioni, M. Pasero, and M. Mellini (2013) Lavoisierite, $Mn^{2+}_8[Al_{10}(Mn^{3+}Mg)][Si_{11}P]O_{44}(OH)_{12}$, a new mineral from Piedmont, Italy: the link between "ardennite" and sursassite. Physics and Chemistry of Minerals, 40, 239-249. (2) (2014) Amer. Mineral., 99, 2155-2156 (abs. ref. 1).

Lavrentievite $Hg_3S_2(Cl,Br)_2$

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Crystal Data: Monoclinic, perhaps triclinic. *Point Group:* $2/m$, 2, or m. As complex intergrowths with arzakite, to 0.2 mm. *Twinning:* Noted.

Physical Properties: Hardness = 2.0–2.5 VHN = 82–103 D(meas.) = 7.46 D(calc.) = 7.26–7.5

Optical Properties: Transparent. *Color:* Colorless to yellow. *Luster:* Vitreous to adamantine.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. $a = 8.94(2)$ $b = 5.194(7)$ $c = 18.33(4)$ $\beta = 92.44(8)^\circ$ Z = 5

X-ray Powder Pattern: Arzak deposit, Russia; differs only by intensities from arzakite. 2.61 (100), 3.01 (55), 3.38 (50), 1.587 (45), 3.96 (40), 2.292 (40), 2.199 (40)

Chemistry:

	(1)	(2)	(3)	(4)
Hg	81.4	78.48	79.25	77.02
S	8.51	8.35	8.06	8.21
Br	1.29	6.94	7.73	10.23
Cl	9.13	6.04	5.20	4.54
Total	100.33	99.81	100.24	100.00

(1) Arzak deposit, Russia; by electron microprobe, average of ten analyses; corresponding to $Hg_{3.01}S_{1.96}(Cl_{1.91}Br_{0.12})_{\Sigma=2.03}$. (2) Do.; by electron microprobe, corresponding to $Hg_{3.01}S_{2.00}(Cl_{1.31}Br_{0.67})_{\Sigma=1.98}$. (3) Kadyrel deposit, Russia, by electron microprobe, average of eight grains; corresponding to $Hg_{3.11}S_{1.97}(Cl_{1.16}Br_{0.76})_{\Sigma=1.92}$. (4) $Hg_3S_2(Cl,Br)_2$ with Cl:Br = 1:1.

Polymorphism & Series: Dimorphous with corderoite; forms a series with arzakite.

Occurrence: In the oxidized zone of hydrothermal mercury-bearing deposits (Arzak and Kadyrel deposits, Russia).

Association: Arzakite, cinnabar, corderoite, quartz, kaolinite (Arzak deposit, Russia); bromian calomel, bromian corderoite, bromian eglestonite, kuzminite, mercury, cinnabar, iron oxides (Kadyrel deposit, Russia).

Distribution: In Russia, in the Pii-Khem district, Tuva, Siberia, from the Arzak mercury deposit, Uyuk Range [TL] and the Kadyrel mercury deposit, right bank of the Oorash-Khem River Valley.

Name: For Mikhail Alekseevich Lavrent'ev (1900–1980), Institute of Hydrodynamics, Novosibirsk, Russia, founder of the Siberian Academy of Science.

Type Material: Central Siberian Geological Museum, Novosibirsk, VI-24/3; Mining Institute, St. Petersburg, 1676/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84398.

References: (1) Vasil'ev, V.I., N.A. Pal'chik, and O.K. Grechishchev (1984) Lavrentievite and arzakite, new natural sulfohalogenides of mercury. Geol. i Geofiz., 7, 54–63 (in Russian). (2) (1985) Amer. Mineral., 70, 873–874 (abs. ref. 1). (3) (1984) Chem. Abs., 101, 174794 (abs. ref. 1). (4) Vasil'ev, V.I., Y.G. Lavrent'ev, and N.A. Pal'chik (1986) New data on arzakite and lavrentievite. Doklady Acad. Nauk SSSR, 290, 948–951 (in Russian).

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Lawrencite $(Fe^{2+}, Ni)Cl_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As massive efflorescences.

Physical Properties: *Cleavage:* {0001}, inferred from crystal structure. Hardness = Soft. D(meas.) = 3.16 (synthetic). D(calc.) = [3.26] Deliquescent.

Optical Properties: Translucent. *Color:* Green to brown; fresh synthetic material is white. *Optical Class:* Uniaxial (–); weak birefringence. $\omega = 1.567(5)$ $\epsilon =$ n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 3.58$ $c = 17.5$ Z = 3

X-ray Powder Pattern: Synthetic $FeCl_2$. (ICDD 1-1106).
2.54 (100), 5.9 (63), 1.800 (63), 3.07 (30), 1.467 (20), 1.138 (18), 1.953 (13)

Chemistry: Analyses of H_2O extracts of iron meteorites appear to agree with $FeCl_2$ with additional nickel; modern work does not support the species however, finding only akaganéite as the principal alteration product.

Occurrence: In iron meteorites, presumed to be a terrestrial alteration of meteoritic iron. Also as a volcanic sublimate.

Association: Iron, molysite.

Distribution: Noted in the Tazewell, Ovifak, Canyon Diablo, and other iron meteorites. At Vesuvius, Campania, Italy.

Name: Honors John Lawrence Smith (1818–1883), American chemist, mineralogist, and student of meteorites, who discovered the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 40. (2) Buchwald, V.F. and R.S. Clarke, Jr. (1989) Corrosion of Fe-Ni alloy by Cl-containing akaganéite (β-FeOOH): the Antarctic meteorite case. Amer. Mineral., 74, 656–667, esp. 663–664.

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Lawsonbauerite $(Mn^{2+},Mg)_9Zn_4(SO_4)_2(OH)_{22}\cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed prismatic crystals, elongated along [010], flattened on {001}, showing {001}, {100}, to 0.5 mm, typically in parallel growths.

Physical Properties: *Fracture:* Even. *Tenacity:* Moderately brittle. Hardness = ∼4.5
D(meas.) = 2.87(4) D(calc.) = 2.92

Optical Properties: Semitransparent. *Color:* Colorless to white, coated by black manganese oxides. *Luster:* Dull to vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 7°$. *Dispersion:* $r > v$, strong.
$\alpha = 1.590(2)$ $\beta = 1.608(2)$ $\gamma = 1.611(2)$ 2V(meas.) = 42(1)° 2V(calc.) = 45°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.50(5)$ $b = 9.64(5)$ $c = 16.41(8)$ $\beta = 95.21(10)°$
Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
10.5 (100), 5.24 (60), 3.90 (50), 1.587 (50), 2.772 (40), 6.24 (30), 3.33 (30)

Chemistry:

	(1)
SO_3	10.8
FeO	0.1
MnO	32.6
ZnO	23.1
MgO	8.4
H_2O	[25.0]
Total	[100.0]

(1) Sterling Hill, New Jersey, USA; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by difference; corresponds to $(Mn_{6.81}Mg_{3.09}Fe_{0.02})_{\Sigma=9.92}Zn_{4.21}(SO_4)_{2.00}(OH)_{24.26}\cdot 8.44H_2O$; later crystal-structure analysis established the formula as $(Mn,Mg)_9Zn_4(SO_4)_2(OH)_{22}\cdot 8H_2O$.

Occurrence: A rare secondary mineral formed in a metamorphosed stratiform zinc orebody.

Association: Sussexite, pyrochroite, zincite, franklinite, calcite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: Honors Lawson H. Bauer (1889–1954), American chemist, New Jersey Zinc Company, Franklin, New Jersey, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 143003.

References: (1) Dunn, P.J., D.R. Peacor, and B.D. Sturman (1979) Lawsonbauerite, a new mineral from Sterling Hill mine, New Jersey, and new data for torreyite, Amer. Mineral., 64, 949–952. (2) Treiman, A.H. and D.R. Peacor (1982) The crystal structure of lawsonbauerite, $(Mn,Mg)_9Zn_4(SO_4)_2(OH)_{22}\cdot 8H_2O$, and its relation to mooreite. Amer. Mineral., 67, 1029–1034.

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Lawsonite $CaAl_2Si_2O_7(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 2 2 2 Crystals commonly prismatic, tabular, to 5 cm; also granular, massive. *Twinning:* Common on {101}, may be lamellar.

Physical Properties: *Cleavage:* Perfect on {100} and {010}, imperfect on {101}. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.05–3.12 D(calc.) = 3.084–3.091

Optical Properties: Translucent. *Color:* Colorless, white, pale blue to grayish blue; colorless to bluish green in thin section. *Streak:* White. *Luster:* Vitreous, greasy. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; X = blue, pale brownish yellow; Y = deep bluish green, yellowish green; Z = colorless, yellowish. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* very strong. = 1.663–1.665 = 1.672–1.675 = 1.682–1.686 2V(meas.) = 76^{ffi}–87^{ffi}

Cell Data: *Space Group:* $a = 8.795(3)$ $b = 5.847(1)$ $c = 13.142(6)$ Z = 4

X-ray Powder Pattern: Tiburon Peninsula, California, USA.
2.624 (100), 1.550 (80), 2.726 (70), 4.84 (60), 3.66 (60), 2.433 (60), 2.129 (60)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	38.45	37.80	38.24	CaO	17.52	16.10	17.84
TiO_2	0.38	0.69		Na_2O	0.06	0.51	
Al_2O_3	31.35	32.56	32.45	K_2O	0.23	0.24	
Fe_2O_3	0.86	0.05		F		0.02	
FeO	0.10	0.34		H_2O^+	11.21	11.26	11.47
MnO	trace	trace		H_2O^-		0.04	
MgO	0.17	0.32		Total	100.33	99.93	100.00

(1) Tiburon Peninsula, California, USA; corresponds to $(Ca_{0.98}K_{0.02}Mg_{0.01}Na_{0.01})_{\Sigma=1.02}(Al_{1.94}Fe^{3+}_{0.03}Ti_{0.02})_{\Sigma=1.99}Si_{2.02}O_7(OH)_{1.92} \cdot H_2O$ (2) Santa Clara, Cuba; corresponds to $(Ca_{0.91}Na_{0.05}Mg_{0.02}Fe^{2+}_{0.02}K_{0.02})_{\Sigma=1.02}(Al_{2.00}Ti_{0.03})_{\Sigma=2.03}(Si_{1.98}Al_{0.02})_{\Sigma=2.00}O_7(OH)_{1.94} \cdot H_2O$ (3) $CaAl_2Si_2O_7(OH)_2 \cdot H_2O$

Polymorphism & Series: Dimorphous with parthéite.

Occurrence: Formed at high pressures and low temperatures, especially in low-grade regionally metamorphosed glaucophane schists; formed from plagioclase during saussuritization of gabbros and diabases; rarely in eclogites.

Association: Pumpellyite, epidote, garnet, crossite, muscovite, jadeite, glaucophane, quartz, calcite.

Distribution: In the USA, in California, numerous localities, as near Reed Station and elsewhere on the Tiburon Peninsula, Marin Co.; at Arroyo Mocho, Alameda Co.; on Porter Creek, Sonoma Co.; Panoche Pass, San Benito Co.; in the Pacheco Pass area, Santa Clara Co.; large crystals from Covelo, Mendocino Co., etc. At Darrington, Snohomish Co., Washington. Other localities for well-crystallized or studied materials include many in the French and Italian Alps. Near Tavşanlı, Turkey. At Ogose, Saitama Prefecture; Ubusan, Akita Prefecture; Kamba, Okayama Prefecture; and Kamuikotan, Hokkaido, Japan. From the Ouégoa district and elsewhere on New Caledonia. In the southeast part of Celebes Island.

Name: For Professor Andrew Cowper Lawson (1861–1952), Scottish-American geologist, University of California, Berkeley, California, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 83635; The Natural History Museum, London, England, 1933,239–240.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 41. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 180–200. (3) Davis, G.A. and A. Pabst (1960) Lawsonite and pumpellyite in glaucophane schist, north Berkeley Hills, California. Amer. J. Sci., 258, 689–704. (4) Baur, W.H. (1978) Crystal structure refinement of lawsonite. Amer. Mineral., 63, 311–315.

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Lazarenkoite $(Ca, Fe^{2+})Fe^{3+}As_3^{3+}O_7 \cdot 3H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* n.d. As fibrous crystals, in incrustations.

Physical Properties: Hardness = 1 D(meas.) = 3.450(5) D(calc.) = 3.59

Optical Properties: Semitransparent. *Color:* Bright orange. *Luster:* Resinous to silky. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = pale yellow; Y = pale brown; Z = rose-brown. $\alpha = 1.820(3)$ $\beta = 1.920(3)$ $\gamma = 1.955(3)$ 2V(meas.) = ∼30°

Cell Data: *Space Group:* n.d. $a = 21.80$ $b = 12.64$ $c = 8.40$ Z = 10

X-ray Powder Pattern: Khovu-Aksy deposit, Russia.
8.40 (10), 11.2 (9), 4.66 (9), 6.55 (8), 3.31 (4), 3.20 (4), 3.135 (4)

Chemistry:

	(1)
Fe_2O_3	16.7
As_2O_3	61.5
FeO	5.6
MgO	0.7
CaO	5.1
H_2O	12.2
Total	101.8

(1) Khovu-Aksy deposit, Russia; average of two analyses, absence of arsenate and arsenite and presence of H_2O shown by IR; corresponding to $(Ca_{0.44}Fe^{2+}_{0.38}Mg_{0.09})_{\Sigma=0.91}$ $Fe^{3+}_{1.02}As^{3+}_{3.04}O_7 \cdot 3.32H_2O$.

Occurrence: In the oxidation zone of a metallic ore deposit.

Association: Annabergite, skutterudite, löllingite.

Distribution: From the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, Russia.

Name: Honors Academician Evgenii Konstantinovich Lazarenko (1912–1979), mineralogist, Lvov University, Lvov, Ukraine.

Type Material: Mining Institute, St. Petersburg, 1263/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81172.

References: (1) Yakhontova, L.K. and I.I. Plosina (1981) The new mineral lazarenkoite. Mineral. Zhurnal, 3(3), 92–96 (in Russian with English abs.). (2) (1982) Amer. Mineral., 67, 415 (abs. ref. 1). (3) Yakhontova, L.K., I.A. Poroshina, and I.I. Plyunina (1983) Structural model of lazarenkoite according to refractometric analysis data. Probl. Kristallokhim. Genezisa Miner., 145–148 (in Russian). (4) (1984) Chem. Abs., 100, 163 (abs. ref. 3).

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Lazulite $MgAl_2(PO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, stubby to acute dipyramidal with forms {111}, {$\bar{1}$11}, {101}, to 15 cm, or tabular on {$\bar{1}$11} or {101}, with several other forms noted; granular, massive. *Twinning:* Common on {100} with composition plane {001} and marked re-entrant, occasionally producing lamellar or polysynthetic groups; rare on {223}; by reflection on {$\bar{2}$21} with composition plane {331}; several other twin laws reported.

Physical Properties: *Cleavage:* Poor to good on {110}; indistinct on {101}. *Fracture:* Uneven to splintery. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.122–3.240 D(calc.) = 3.144

Optical Properties: Transparent to translucent, may be nearly opaque. *Color:* Azure-blue, sky-blue, bluish white, yellow-green, blue-green, rarely green. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = colorless; Y = blue; Z = darker blue. *Orientation:* $Y = b$; $X \wedge c = 10°$. *Dispersion:* $r < v$, weak. *Absorption:* $Z > Y \gg X$. $\alpha = 1.604–1.626$ $\beta = 1.626–1.654$ $\gamma = 1.637–1.663$ 2V(meas.) = ∼70°

Cell Data: *Space Group:* $P2_1/c$. $a = 7.144(1)$ $b = 7.278(1)$ $c = 7.228(1)$ $\beta = 120.50(1)°$ Z = 2

X-ray Powder Pattern: Werfen, Austria; nearly identical to scorzalite.
3.23 (100), 3.20 (59), 3.14 (55), 3.077 (42), 4.73 (18), 2.548 (18), 1.571 (18)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	45.79	44.64	FeO	3.95	11.30
TiO_2	0.20		MgO	10.38	6.34
Al_2O_3	32.49	32.06	CaO	0.06	
Fe_2O_3	0.60		H_2O	6.48	5.66
			Total	99.95	100.00

(1) Graves Mountain, Georgia, USA. (2) $(Fe,Mg)Al_2(PO_4)_2(OH)_2$ with Fe:Mg = 1:1.

Polymorphism & Series: Forms a series with scorzalite.

Mineral Group: Lazulite group.

Occurrence: Disseminated in metamorphic quartzites, schists and quartz veins; in the border zones of complex granite pegmatites; in alluvium and colluvium.

Association: Quartz, andalusite, rutile, kyanite, corundum, muscovite, pyrophyllite, dumortierite, wagnerite, svanbergite, berlinite (metamorphic); albite, quartz, muscovite, tourmaline, beryl (pegmatites).

Distribution: Many minor localities. Well-crystallized or rich material from: Färbergraben and Höllgraben, near Werfen, Salzburg, Austria. In Sweden, very large crystals from Hålsjöberg, Värmland, and in the Västanå iron mine, Nasüm, Skåne. In the USA, large crystals from Graves Mountain, Lincoln Co., Georgia; from about 30 km southeast of Beatty, Nye Co., Nevada; at the Champion mine and the nearby Vulcanus claim, White Mountains, Mono Co., California. Fine crystals along Cross-cut Creek, Big Fish River–Rapid Creek area, Yukon Territory, Canada. From 15 km west of Dattas, Minas Gerais, Brazil. On Mt. Bity, Ranomainty, and near Jamalezo, Madagascar. Fine gemmy crystals from the Chilas area, near Nanga Parbat Peak, Pakistan.

Name: From the German *lazurstein*, for *blue stone*.

Type Material: The Natural History Museum, London, England, 83304.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 908–911. (2) Pecora, W.T. and J.J. Fahey (1950) The lazulite-scorzalite isomorphous series. Amer. Mineral., 35, 1–18. (3) Giuseppetti, G. and C. Tadini (1983) Lazulite, $(Mg,Fe)Al_2(OH)_2(PO_4)_2$: structure refinement and hydrogen bonding. Neues Jahrb. Mineral., Monatsh., 410–416. (4) Blanchard, F.N. and S.A. Abernathy (1980) X-ray powder diffraction data for the phosphate minerals: vauxite, scorzalite, and lazulite. Florida Scientist, 43, 257–265.

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Lazurite $Na_6Ca_2Al_6Si_6O_{24}[(SO_4), S, Cl, (OH)]_2$

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Crystal Data: Cubic; also monoclinic or triclinic. *Point Group:* $\bar{4}3m$. In dodecahedra, or more rarely cubes, up to 5 cm; granular, disseminated, or massive.

Physical Properties: *Cleavage:* {110}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.38–2.45 D(calc.) = 2.39–2.42

Optical Properties: Translucent to opaque. *Color:* Deep blue, azure, violet-blue, greenish blue; blue in thin section. *Streak:* Bright blue. *Luster:* Vitreous.
Optical Class: Isotropic; anomalously anisotropic. $n = 1.502–1.522$

Cell Data: *Space Group:* $P\bar{4}3n$. $a = 9.09$ Z = 1

X-ray Powder Pattern: Sar-e-Sang, Afghanistan. (ICDD 17-749).
3.71 (100), 2.622 (80), 2.872 (45), 6.43 (40), 2.141 (35), 1.782 (30), 2.272 (25)

Chemistry:

	(1)
SiO_2	31.34
Al_2O_3	26.27
Fe_2O_3	0.27
MgO	2.47
CaO	7.97
Na_2O	15.75
K_2O	1.02
Cl	0.78
H_2O	3.87
SO_3	8.71
S	1.84
$-O = S, Cl_2$	0.67
Total	99.62

(1) Sar-e-Sang, Afghanistan; corresponds to $(Na_{5.88}K_{0.25})_{\Sigma=6.13}(Ca_{1.65}Mg_{0.71}Fe_{0.04})_{\Sigma=2.40}Si_{6.04}Al_{5.96}O_{24}[(SO_4)_{1.26}S_{0.66}Cl_{0.26}]_{\Sigma=2.18}$.

Polymorphism & Series: Triclinic and monoclinic polymorphs are known.

Mineral Group: Sodalite group.

Occurrence: A contact metamorphic mineral in limestones.

Association: Calcite, pyrite, diopside, humite, forsterite, haüyne, muscovite.

Distribution: Exceptional crystals from Sar-e-Sang, Badakhshan Province, Afghanistan. Well-crystallized material from the basins of the Slyudyanka and Bystraya Rivers, Sayan Mountains, near Lake Baikal, Siberia, Russia. At Lyadzhuar-Darinsk, near Ishkashima, Pamir Mountains, Tajikistan. From Monte Somma, Campania, and in the Alban Hills, Lazio, Italy. In the USA, at Ontario Peak and Cascade Canyon, San Bernardino Co., California, and on North Italian Mountain, Gunnison Co., Colorado. In Canada, about 15 km north of Lake Harbour, Baffin Island, Northwest Territory. At Thabapin, near Mogok, Myanmar (Burma). From along the Cazadero River, near Ovalle, Chile.

Name: For its color resemblance to azurite, named from the Persian *lazhward*, for *blue*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 432–433. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 289–302. (3) Hogarth, D.D. and W.L. Griffin (1976) New data on lazurite. Lithos, 9, 39–54. (4) Hassan, I., R.C. Peterson, and H.D. Grundy (1985) The structure of lazurite, ideally $Na_6Ca_2(Al_6Si_6O_{24})S_2$, a member of the sodalite group. Acta Cryst., C41, 827–832. (5) Saposhnikov [Sapozhnikov], A.N. (1990) Indexing of additional reflections on the X-ray Debye diffraction patterns of lazurite concerning the study of modulation of its structure. Zap. Vses. Mineral. Obshch., 119(1), 110–116 (in Russian).

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Lead Pb

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals rare, to 6 cm; octahedral, cubic, and dodecahedral; commonly as rounded masses and plates, up to 60 kg in weight. Assumes wirelike and dendritic forms. *Twinning:* On {111}.

Physical Properties: *Tenacity:* Very malleable, moderately sectile. Hardness = 1.5 VHN = 5 (100 g load). D(meas.) = 11.37 D(calc.) = 11.341

Optical Properties: Opaque. *Color:* Gray-white, tarnishing to dull lead-gray; in polished section, gray-white, quickly tarnishing. *Streak:* Lead-gray. *Luster:* Metallic.
R: (400) 68.7, (420) 69.0, (440) 69.4, (460) 69.5, (480) 69.6, (500) 69.7, (520) 69.8, (540) 69.6, (560) 69.3, (580) 69.1, (600) 69.1, (620) 69.2, (640) 69.3, (660) 69.4, (680) 69.5, (700) 69.6

Cell Data: *Space Group: Fm3m.* $a = 4.9396(3)$ Z = 4

X-ray Powder Pattern: Synthetic.
2.855 (100), 2.475 (50), 1.493 (32), 1.750 (31), 1.1359 (10), 1.429 (9), 0.8369 (9)

Chemistry: Nearly pure lead, commonly with a little silver, copper, zinc, iron, tin, or antimony.

Occurrence: A rare mineral of hydrothermal origin, and found in placers; possibly also formed by authigenic processes and known to replace tree roots.

Association: Hydrocerussite, caryopilite, sarkinite, brandtite (Harstigen mine, Sweden); galena, minium, cerussite (Jay Gould mine, Idaho, USA; Red Cap mine, Australia); willemite, andradite, axinite (Franklin, New Jersey, USA).

Distribution: In the USA, in the Parker shaft at Franklin, Sussex Co., New Jersey; in Idaho, at the Jay Gould mine, Wood River district, and near Hailey, Mineral Hill district, Blaine Co.; in Arizona, from near Tubac, Santa Cruz Co., where it replaced tree roots; and in the Shafter district, Presidio Co., Texas. From El Dorado, Gran Sabana, Venezuela. At Keno Hill, Yukon Territory, Canada. From the Ilímaussaq intrusion, southern Greenland. In Sweden, in fine crystals and large masses from Långban, and at the Harstigen mine, near Persberg, Värmland. In the Zechstein copper district, near Legnica, Lower Silesia, Poland. From the Red Cap mine, near Chilliago, Queensland; and as minute balls in the Hawkesbury Sandstone, New South Wales, Australia. Reported from numerous other localities, but confirmation by modern methods is desirable.

Name: An Old English word for the metal; the chemical symbol from the Latin *plumbum*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 102–103. (2) Owen, E.A. and E.L. Yates (1933) XLI. Precision measurements of crystal parameters. Phil. Mag., 472–488. (3) (1953) NBS Circ. 539, 1, 141–143. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 317.

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Leadamalgam $HgPb_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Known only as a single grain of maximum dimension 50 μm.

Physical Properties: Hardness = 1.6 VHN = 12 (100 g load). D(meas.) = n.d. D(calc.) = 11.96

Optical Properties: Opaque. *Color:* Silver-white; yellowish white in reflected light. *Luster:* Strong metallic. *Pleochroism:* Weak, bluish gray to pale bluish gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I4/mmm$. $a = 3.545(16)$ $c = 4.525(20)$ Z = n.d.

X-ray Powder Pattern: Shiaonanshan, China.
1.49 (vs), 1.40 (vs), 2.49 (m), 2.25 (m), 1.78 (m), 1.68 (m), 2.78 (w)

Chemistry:

	(1)	(2)	(3)
Hg	33.03	31.48	32.62
Pb	66.96	68.42	67.38
Total	99.99	99.90	100.00

(1–2) Shiaonanshan, China; by electron microprobe. (3) $HgPb_2$.

Occurrence: In heavy concentrates of crushed ores from a platinum-bearing Cu–Ni sulfide deposit.

Association: Gersdorffite, pyrite, chalcopyrite, violarite, millerite, galena, stibnite, argentian gold, niggliite, sperrylite, iridosmine, platinum, merenskyite, kotulskite, chromite, ilmenite, magnetite.

Distribution: From Shiaonanshan, Inner Mongolia, China [TL].

Name: For the composition, by analogy to mercury–silver amalgam.

Type Material: n.d.

References: (1) Chen Keqiao, Yang Huifang, Ma Letian, and Peng Zhizhong (1981) The discovery of two new minerals– γ–goldamalgam and leadamalgam. Dizhi Pinglun [Geological Review (Peking)], 27, 107–115 (in Chinese with English abs.). (2) (1985) Amer. Mineral., 70, 215–216 (abs. ref. 1).

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Leadhillite $Pb_4(SO_4)(CO_3)_2(OH)_2$

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Crystal Data: Monoclinic, pseudorhombohedral. *Point Group:* $2/m$. Crystals, to 13 cm, are thick to thin tabular along [001], may be barrel-shaped, or pseudorhombohedral {101} and {$\bar{1}$42}, with over 40 forms noted; granular, massive. *Twinning:* On {140}, {340}, {1$\bar{4}$0}, very common, giving pseudohexagonal groupings.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Sectile. Hardness = 2.5–3 D(meas.) = 6.55 D(calc.) = 6.57 Decomposed by hot H_2O; may fluoresce pale yellow under UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, pale yellow, yellow, yellowish green, pale green, pale bluish green, pale blue, brown; colorless in transmitted light. *Luster:* Resinous to adamantine, pearly on {001}.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = -5.5°$. *Dispersion:* $r < v$, strong, horizontal. $\alpha = 1.87(1)$ $\beta = 2.00(1)$ $\gamma = 2.01(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/a$. $a = 9.11(2)$ $b = 11.59(3)$ $c = 20.82(4)$ $\beta = 90.46(2)°$ Z = 8

X-ray Powder Pattern: Leadhills, Scotland; nearly identical to susannite. (ICDD 18-705). 3.53 (100), 2.917 (60), 2.605 (50), 1.549 (35), 2.303 (30), 2.099 (30), 2.874 (25)

Chemistry:

	(1)	(2)
SO_3	7.33	7.42
CO_2	8.14	8.16
PbO	82.44	82.75
H_2O	1.68	1.67
Total	99.59	100.00

(1) Granby, Missouri, USA. (2) $Pb_4(SO_4)(CO_3)_2(OH)_2$.

Polymorphism & Series: Trimorphous with macphersonite and susannite.

Occurrence: An uncommon secondary mineral in the oxidation zone of lead deposits.

Association: Cerussite, anglesite, lanarkite, caledonite, linarite (Leadhills, Scotland); cerussite, caledonite, linarite, diaboleite, boleite, wherryite, paralaurionite, brochantite (Mammoth-St. Anthony mine, Arizona, USA).

Distribution: In Scotland, from Leadhills, Lanarkshire, and Wanlockhead, Dumfriesshire; in the Drumruck mine, Kirkcudbrightshire. In England, from Caldbeck Fells, Cumbria; at Penberthy Croft, St. Hilary, and in the Greystone quarry, Levant, Cornwall. From Bleiberg, Carinthia, Austria. In the USA, from the Beer Cellar mine, Granby, Newton Co., Missouri; in the Tintic district, Juab Co., Utah; in Arizona, fine crystals from the Mammoth-St. Anthony mine, Tiger, Pinal Co., in the Rowley mine, near Theba, Maricopa Co., at the Grand Reef mine, Gila Co., and from Bisbee, Cochise Co. In California, at the Blue Bell claims, near Baker, San Bernardino Co.; from the Searchlight district, Clark Co., and in the Chalk Mountain mine, Chalk Mountain district, Churchill Co., Nevada; from Leadville, Lake Co., Colorado. Very large crystals from Tsumeb, Namibia. At Dundas, Tasmania, Australia. A few other localities are known.

Name: For its initially-noted occurrence at Leadhills, Scotland.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 295–298. (2) Giuseppetti, G., F. Mazzi, and C. Tadini (1990) The crystal structure of leadhillite, $Pb_4(SO_4)(CO_3)_2(OH)_2$. Neues Jahrb. Mineral., Monatsh., 255–268.

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Leakeite $NaNa_2[Mg_2Fe^{3+}_2Li]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral crystals, prismatic along [001], to 1 mm, bounded by cleavage planes and terminated by irregular fracture surfaces.

Physical Properties: *Cleavage:* Perfect on {110} [intersecting at ∼56° and ∼124°.] *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.11 D(calc.) = 3.107

Optical Properties: Translucent. *Color:* Deep red. *Streak:* Very pale pink. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X \simeq Y$ = dark mauve-red; Z = light pinkish red. *Orientation:* $Z = b$; $X \wedge c = 10°$; $Y \wedge a = 4°$. *Dispersion:* $r \ll v$, strong. *Absorption:* $X \simeq Y > Z$. $\alpha = 1.667(1)$ $\beta = 1.675(1)$ $\gamma = 1.691(1)$ 2V(meas.) = 59°–71° 2V(calc.) = 72(10)°

Cell Data: *Space Group:* $C2/m$. $a = 9.822(3)$ $b = 17.836(6)$ $c = 5.286(2)$ $\beta = 104.37(3)°$ Z = 2

X-ray Powder Pattern: Kajlidongri mine, India.
3.122 (100), 8.399 (56), 2.798 (48), 3.254 (20), 3.383 (18), 2.696 (15), 4.461 (13)

Chemistry:

	(1)
SiO_2	55.80
TiO_2	0.03
Al_2O_3	1.27
Fe_2O_3	12.23
Mn_2O_3	3.86
MgO	10.96
CaO	0.50
Li_2O	[1.42]
Na_2O	9.69
K_2O	1.12
F	1.08
H_2O	[1.63]
$-O = F_2$	0.45
Total	[99.14]

(1) Kajlidongri mine, India; by electron microprobe, average of six analyses, Li and H_2O calculated from stoichiometry, original total given as 99.11%; corresponds to $(Na_{2.67}K_{0.20}Ca_{0.08})_{\Sigma=2.95}(Mg_{2.32}Fe^{3+}_{1.31}Li_{0.81}Mn^{3+}_{0.42}Al_{0.14})_{\Sigma=5.00}(Si_{7.98}Al_{0.07})_{\Sigma=8.00}O_{22}[(OH)_{1.49}F_{0.51}]_{\Sigma=2.00}$.

Mineral Group: Amphibole (alkali) group: $Na_B \geq 1.34$; $Li_C \geq 0.5$; $Fe^{3+} > Mn^{3+}$.

Occurrence: In a metasediment rich in manganese minerals, crosscut by epigenetic veins.

Association: Albite, braunite, bixbyite.

Distribution: In the Kajlidongri manganese mine, Jhabua district, Madhya Pradesh, India.

Name: To honor Bernard E. Leake, Professor of Geology, Glasgow University, Glasgow, Scotland, for his work on amphiboles.

Type Material: Canadian Museum of Nature, Ottawa, Canada.

References: (1) Hawthorne, F.C., R. Oberti, L. Ungaretti, and J. Grice (1992) Leakeite, $NaNa_2(Mg_2Fe^{3+}_2Li)Si_8O_{22}(OH)_2$, a new alkali amphibole from the Kajlidongri manganese mine, Jhabua district, Madhya Pradesh, India. Amer. Mineral., 77, 1112–1115.

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Lecontite $(NH_4,K)Na(SO_4)\cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. Small prismatic crystals, short along [001]; commonly very fine-grained.

Physical Properties: Hardness = 2–2.5 D(meas.) = 1.745 (synthetic). D(calc.) = 1.747 Soluble in H_2O, taste saline, bitter.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–) (synthetic). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, or $r < v$, strong. $\alpha = 1.440(3)$ $\beta = 1.452(3)$ $\gamma = 1.453(3)$ 2V(meas.) = 40°–43° 2V(calc.) = 29°44′

Cell Data: *Space Group:* $P2_12_12_1$ (synthetic). $a = 8.216(8)$ $b = 12.854(1)$ $c = 6.232(8)$ Z = 4

X-ray Powder Pattern: Las Piedras Cave, Honduras.
3.038 (100), 5.085 (83), 4.649 (83), 4.972 (67), 3.783 (56), 3.325 (56), 3.923 (50)

Chemistry:

	(1)
SO_3	44.97
P_2O_5	trace
Na_2O	17.56
K_2O	2.76
$(NH_4)_2O$	12.94
H_2O	19.45
insol.	2.41
Total	100.09

(1) Las Piedras Cave, Honduras; insoluble residue is organic 2.30%, inorganic 0.11%; corresponds to $[(NH_4)_{0.88}K_{0.10}]_{\Sigma=0.98}Na_{1.01}(SO_4)_{1.00}\cdot 1.92H_2O$.

Occurrence: An early product of the breakdown of bat guano.

Association: Thénardite, mascagnite, probable.

Distribution: From Las Piedras Cave, near Comayagua, 62 km northwest of Tegucigalpa, Honduras.

Name: Honoring John Lawrence LeConte (1825–1883), American entomologist, University of California, Berkeley, California, USA, who discovered the mineral.

Type Material: Philadelphia Academy of Natural Sciences, Philadelphia, Pennsylvania, Vaux 15337; Yale University, New Haven, Connecticut, USA, 1696.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 438–439. (2) Winchell, H. and R.J. Benoit (1951) Taylorite, mascagnite, aphthitalite, lecontite, and oxammite from guano. Amer. Mineral., 36, 590–602. (3) Faust, R.J. and F.D. Bloss (1963) X-ray study of lecontite. Amer. Mineral., 48, 180–188. (4) Corazza, E., C. Sabelli, and G. Giuseppetti (1967) The crystal structure of lecontite, $NaNH_4SO_4.2H_2O$. Acta Cryst., 22, 683–687.

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Lecoqite-(Y) $Na_3Y(CO_3)_3{\cdot}6H_2O$

Crystal Data: Hexagonal. *Point Group*: 6. As capillary to fibrous crystals, to 2.5 cm, with coarse striations along [001]; as compact spray-like masses, often matted, to 2.5 cm.

Physical Properties: *Cleavage*: None observed. *Fracture*: Splintery. *Tenacity*: Flexible, slightly elastic. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.358

Optical Properties: Transparent. *Color*: Colorless; white in aggregates. *Streak*: White. *Luster*: Silky.
Optical Class: Uniaxial (-). $\omega = 1.521(3)$ $\varepsilon = 1.497(3)$

Cell Data: *Space Group*: $P6_3$. $a = 11.316(4)$ $c = 5.931(2)$ $Z = 2$

X-ray Powder Pattern: Poudrette dike, Mont Saint-Hilaire, Quebec, Canada.
5.081 (100), 9.82 (57), 3.779 (39), 2.627 (39), 2.471 (37), 2.047 (30), 2.316 (29)

Chemistry:

	(1)	(2)
Na_2O	19.22	20.84
CaO	0.03	
Y_2O_3	17.95	25.31
Nd_2O_3	0.54	
Sm_2O_3	0.41	
Gd_2O_3	0.75	
Dy_2O_3	3.31	
Ho_2O_3	1.12	
Er_2O_3	3.20	
Yb_2O_3	1.48	
CO_2	27.0	29.61
H_2O	23.4	24.24
Total	98.41	100.00

(1) Poudrette dike, Mont Saint-Hilaire, Quebec, Canada; average of 7 electron microprobe analyses, H_2O by the Alimarin method, CO_2 by selective absorption, IR confirms OH, CO_3, and H_2O, corresponding to $Na_{2.94}(Y_{0.755}Dy_{0.085}Er_{0.08}Yb_{0.035}Ho_{0.03}Gd_{0.02}Nd_{0.015}Sm_{0.01})_{\Sigma=1.03}(CO_3)_{2.91}(OH)_{0.21}(H_2O)_{6.06}$. (2) $Na_3Y(CO_3)_3{\cdot}6H_2O$.

Occurrence: A late-stage hydrothermal mineral associated with a hyperagpaitic pegmatite.

Association: Microcline, albite, natrolite, gonnardite, aegirine, siderite, elpidite, gaidonnayite, zircon, franconite, dawsonite, rhodochrosite, cryolite, rutile, sphalerite.

Distribution: Poudrette pegmatite dike, Mont Saint-Hilaire, Quebec, Canada.

Name: Honors the French chemist P.É. Lecoq de Boisbaudran (1838–1912) and for the dominant rare earth element in its composition.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (catalog no. 3761/1); Canadian Museum of Nature, Ottawa, Ontario, Canada (catalog no. CMNMC 86065).

References: (1) Pekov, I.V., N.V. Chukanov, N.V. Zubkova, D.A. Ksenofontov, L. Horváth, A.E. Zadov, and D.Y. Pushcharovsky (2010) Lecoqite-(Y), $Na_3Y(CO_3)_3{\cdot}6H_2O$, A new mineral species from Mont Saint-Hilaire, Quebec, Canada. Can. Mineral., 48, 95–104. (2) (2010) Amer. Mineral., 95, 1599 (abs. ref. 1).

Legrandite $Zn_2(AsO_4)(OH)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, elongated along [001], to 28 cm, with dominant {110}, striated ‖ {001} and {$\bar{1}$11}, {100}, {001}; typically in sprays or sheaflike aggregates.

Physical Properties: *Cleavage:* Fair to poor on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.98–4.01 D(calc.) = 4.015

Optical Properties: Transparent to translucent. *Color:* Bright yellow, wax-yellow, colorless; pale yellow to colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = colorless to yellow; Z = yellow. *Orientation:* $X = b$; $Z \wedge c = 40°$. *Dispersion:* $r < v$, distinct. $\alpha = 1.702(2)$ $\beta = 1.709(2)$ $\gamma = 1.740(2)$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P2_1/c$. $a = 12.805(2)$ $b = 7.933(1)$ $c = 10.215(2)$ $\beta = 104°23.3(3)'$ Z = 8

X-ray Powder Pattern: Ojuela mine, Mexico.
4.08 (100), 6.68 (71), 5.93 (71), 3.09 (71), 4.19 (50), 12.36 (35), 3.03 (35)

Chemistry:

	(1)	(2)
As_2O_5	37.7	37.71
FeO	1.4	
MnO	1.7	
ZnO	50.1	53.42
H_2O^+	8.8	8.87
H_2O^-	0.1	
insol.	0.2	
Total	100.0	100.00

(1) Ojuela mine, Mexico; H_2O by the Penfield method. (2) $Zn_2(AsO_4)(OH)\cdot H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized zone of Zn–As-bearing deposits; rare in granite pegmatite.

Association: Adamite, paradamite, köttigite, scorodite, smithsonite (Ojuela mine, Mexico); leiteite, smithsonite, reniérite (Tsumeb, Namibia); köttigite, adamite, pharmacosiderite, scorodite (Sterling Hill, New Jersey, USA).

Distribution: In Mexico, from the Flor de Peña mine, Lampazos, Nuevo León; large crystals found in the Ojuela mine, Mapimí, Durango; at the Potosí mine, Santa Eulalia, Chihuahua. From Tsumeb, Namibia. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. In Japan, from the Ogibira mine, near Osa, Okayama Prefecture, and the Toroku mine, Miyazaki Prefecture. From Boa Vista, near Galiléia, Minas Gerais, Brazil.

Name: Honors a Mr. Legrand, Belgian mine manager, who collected the first specimen.

Type Material: The Natural History Museum, London, England, 1932,131; Harvard University, Cambridge, Massachusetts, 92567; National Museum of Natural History, Washington, D.C., USA, 114810.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 958–959. (2) Desautels, P.E. and R.S. Clarke, Jr. (1963) Re-examination of legrandite. Amer. Mineral., 48, 1258–1265. (3) McLean, W.J., J.W. Anthony, J.J. Finney, and R.B. Laughon (1971) The crystal structure of legrandite. Amer. Mineral., 56, 1147–1154.

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Lehnerite $Mn^{2+}(UO_2)_2(PO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. As thin pseudotetragonal crystals, tabular on {010} and modified by {101}, {$\bar{1}$01}, {100}, {001}, to 1 mm; as aggregates of parallel crystals stacked along [010].

Physical Properties: *Cleavage:* Perfect on {010}; good on {101}; less good on {$\bar{1}$01}; poor on {100}. Hardness = 2–3 D(meas.) = > 3.50 D(calc.) = 3.674 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Bronze-yellow, yellow, ocher-yellow. *Streak:* Pale yellow. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–), some parts uniaxial. *Pleochroism:* $X = Y$ = light yellow; Z = yellow. *Orientation:* $X = b$; $Y \wedge a \simeq 8°$; $Z \wedge c = \approx 8°$. *Dispersion:* $r \gg v$. $\alpha = 1.599(2)$ $\beta = 1.607(2)$ $\gamma = 1.607(2)$ 2V(meas.) = 45°

Cell Data: *Space Group:* $P2_1/n$. $a = 7.04(2)$ $b = 17.16(4)$ $c = 6.95(2)$ $\beta = 90°18'$ Z = 2

X-ray Powder Pattern: Hagendorf, Germany.
8.56 (10), 3.50 (8b), 2.23 (7), 4.96 (6), 1.375 (4b), 2.48 (3), 2.17 (3)

Chemistry:

	(1)	(2)
UO_3	63.0	61.58
P_2O_5	15.1	15.28
FeO	0.2	
MnO	7.5	7.63
H_2O	[14.2]	15.51
Total	[100.0]	100.00

(1) Hagendorf, Germany; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by difference; corresponding to $(Mn_{0.99}Fe_{0.03})_{\Sigma=1.02}(UO_2)_{2.07}(PO_4)_{2.00} \cdot 7.41H_2O$.
(2) $Mn(UO_2)_2(PO_4)_2 \cdot 8H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: A rare secondary mineral in the oxidized zone of a complex granite pegmatite.

Association: Zwieselite, rockbridgeite.

Distribution: From Hagendorf, Bavaria, Germany.

Name: Honors Ferdinand Lehner (1868–1943), Pleystein, Germany, an early collector of Hagendorf minerals.

Type Material: n.d.

References: (1) Mücke, A. (1988) Lehnerit $Mn[UO_2|PO_4]_2$ $8H_2O$, ein neues Mineral aus dem Pegmatit von Hagendorf/Oberpfalz. Aufschluss, 39, 209–217 (in German with English abs.).
(2) (1990) Amer. Mineral., 75, 1433 (abs. ref. 1).

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Leifite $\mathbf{Na_2(Si,Al,Be)_7(O,OH,F)_{14}}$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals hexagonal prisms, acicular and deeply striated, to 3 cm. In radiating fibrous masses and spherical aggregates.

Physical Properties: *Cleavage:* Distinct on $\{10\bar{1}0\}$. *Fracture:* Uneven to splintery. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 2.57 D(calc.) = 2.59

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Silky. *Optical Class:* Uniaxial (+). $\omega = 1.511$–1.518 $\epsilon = 1.519$–1.522

Cell Data: *Space Group:* $P3m1$. $a = 14.352(2)$ $c = 4.852(3)$ $Z = 3$

X-ray Powder Pattern: Narssârssuk, Greenland. (ICDD 18-710).
3.13 (100), 3.34 (70), 2.45 (70), 4.67 (60), 2.21 (60), 2.38 (50), 4.11 (40)

Chemistry:

	(1)	(2)
SiO_2	67.55	58.68
TiO_2		trace
Al_2O_3	12.69	16.40
Fe_2O_3		0.06
MnO	0.41	
ZnO		3.26
BeO		2.58
MgO		0.78
Na_2O	15.47	9.18
K_2O		1.55
F	4.93	
H_2O^+	0.77	5.00
H_2O^-		2.50
$-O = F_2$	2.08	
Total	99.74	99.99

(1) Narssârssuk, Greenland. (2) Mt. Karnasurt, Russia; apparently contaminated with zincian montmorillonite.

Occurrence: In pegmatite (Narssârssuk, Greenland); in a differentiated alkalic massif (Lovozero massif, Russia); associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Microcline, aegirine, zinnwaldite, calcite (Narssârssuk, Greenland); albite, natrolite (Lovozero massif, Russia); rhodochrosite, sérandite (Mont Saint-Hilaire, Canada).

Distribution: From Narssârssuk, Greenland. On Mt. Karnasurt, Lovozero massif, and in the Kukisvumchorr apatite deposit, Khibiny massif, Kola Peninsula, Russia. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada.

Name: For Leif Ericson, Norse adventurer and discoverer of Greenland in 982.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1915–1918; National Museum of Natural History, Washington, D.C., USA, 136173.

References: (1) Bøggild, O.B. (1915) Leifit, et nyt mineral fra Narsarsuk. Medd. Grønland, 51, 427–433 (in Danish). (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 141–143. (3) Micheelsen, H. and O.V. Petersen (1971) Leifite, revised, and karpinskyite, discredited. Proc. IMA, 7th Gen. Meet., Tokyo, 1970 [Mineral. Soc. Japan Spec. Paper 1, 264–265] (abs.). (4) (1972) Amer. Mineral., 57, 1006 (abs. ref. 3). (5) Coda, A., L. Ungaretti, and A. Della Giusta (1974) The crystal structure of leifite, $Na_6[Si_{16}Al_2(BeOH)_2O_{39}]\cdot 1.5H_2O$. Acta Cryst., 30, 396–401. (6) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 123.

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Leightonite $K_2Ca_2Cu(SO_4)_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Lathlike crystals, flattened on {100}, elongated along [010], or equant, showing {100}, {101}, {110}, {113}, several other forms, to 4 mm; commonly forms cross-fiber veinlets. *Twinning:* On $\{20\overline{1}\}$.

Physical Properties: Hardness = 3 D(meas.) = 2.95 D(calc.) = 2.95

Optical Properties: Transparent to translucent. *Color:* Pale watery blue to greenish blue; pale blue in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, moderately strong. $\alpha = 1.574$–1.578 $\beta = 1.587$ $\gamma = 1.595$ 2V(meas.) = ∼60° 2V(calc.) = 89°06′

Cell Data: *Space Group: Fmmm.* $a = 11.654(2)$ $b = 7.497(1)$ $c = 10.097(1)$
$\beta = 125.21(1)°$ Z = 2

X-ray Powder Pattern: Chuquicamata, Chile.
2.90 (100), 3.18 (60), 1.781 (30), 2.22 (20), 2.51 (10), 2.40 (10), 1.461 (10)

Chemistry:

	(1)	(2)
SO_3	49.33	49.87
CuO	11.97	12.39
CaO	18.41	17.46
Na_2O	0.56	
K_2O	13.93	14.67
H_2O	5.71	5.61
Total	99.91	100.00

(1) Chuquicamata, Chile; corresponds to $(K_{1.92}Na_{0.12})_{\Sigma=2.04}Ca_{2.13}Cu_{0.98}(SO_4)_{4.00} \cdot 2.06H_2O$.
(2) $K_2Ca_2Cu(SO_4)_4 \cdot 2H_2O$.

Occurrence: Of localized occurrence in the oxidized zone of a copper deposit, probably formed under conditions of low acidity (Chuquicamata, Chile).

Association: Natrochalcite, blödite, atacamite, bellingerite, kröhnkite, gypsum, quartz (Chuquicamata, Chile); chalcanthite, anhydrite, lammerite (Tsumeb, Namibia).

Distribution: From Chuquicamata, Antofagasta, Chile. At Tsumeb, Namibia.

Name: Honors Tomás Leighton Donoso (1896–1967), Chilean mining engineer and Professor of Mineralogy, University of Santiago, Santiago, Chile.

Type Material: The Natural History Museum, London, England, 1938,56; Harvard University, Cambridge, Massachusetts, 97540–97544; National Museum of Natural History, Washington, D.C., USA, C5536.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 461–462. (2) Van Loan, P.R. (1962) An X-ray study of leightonite. Can. Mineral., 7, 272–277. (3) Manchetti, S., L. Bindi, P. Bonazzi, and F. Olmi (2002) Disordered distribution of Cu in the crystal structure of leightonite, $K_2Ca_2Cu(SO_4)_4 \cdot 2H_2O$. Amer. Mineral., 87,721–725.

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Leisingite $(Cu, Mg, Zn)_2(Mg, Fe^{2+})Te^{6+}O_6 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Hexagonal plates, to 0.2 mm, prominent {0001} and $\{000\bar{1}\}$, with $\{10\bar{1}0\}$, $\{11\bar{2}0\}$; may be isolated or in clusters.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle to flexible. Hardness = 3–4 D(meas.) = n.d. D(calc.) = 3.41

Optical Properties: Transparent to translucent. *Color:* Pale yellow to pale yellow-orange. *Streak:* Pale yellow. *Luster:* Vitreous, may be satiny or frosted.
Optical Class: Uniaxial (–). $\omega = 1.803(3)$ $\epsilon = [1.581]$ calculated by Gladstone-Dale relation.

Cell Data: *Space Group:* $P\bar{3}1m$. $a = 5.316(1)$ $c = 9.719(2)$ $Z = 1$

X-ray Powder Pattern: Centennial Eureka mine, Utah, USA.
9.70 (100), 4.834 (80), 2.556 (70), 2.326 (70), 4.604 (60), 2.655 (60), 1.789 (40)

Chemistry:

	(1)
TeO_3	36.94
FeO	6.86
CuO	24.71
ZnO	0.45
MgO	6.19
H_2O	[21.55]
Total	[96.70]

(1) Centennial Eureka mine, Utah, USA; by electron microprobe, total Fe as Fe^{2+} [although the crystal-structure analysis indicates a probability of Fe^{3+}], H_2O confirmed as present by IR; corresponds to $(Cu^{2+}_{1.56}Mg_{0.25}Zn_{0.03})_{\Sigma=1.84}(Mg_{0.52}Fe_{0.48})_{\Sigma=1.00}Te^{6+}_{1.06}O_{6.02} \cdot 5.98H_2O$.

Occurrence: A very rare secondary mineral in dump material from the oxidized zone of a tellurium-bearing Cu–Au–Ag deposit.

Association: Quartz, jensenite, cesbronite, hematite.

Distribution: From the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: Honoring Joseph F. Leising (1949–), Reno, Nevada, USA, geologist and mineral collector, who helped collect the material.

Type Material: Canadian Geological Survey, Ottawa, Canada, 67882.

References: (1) Roberts, A.C., L.A. Groat, J.D. Grice, R.A. Gault, and M.C. Jensen (1996) Leisingite, $Cu(Mg, Cu, Fe, Zn)_2Te^{6+}O_6 \cdot 6H_2O$, a new mineral species from the Centennial Eureka mine, Juab County, Utah. Mineral. Mag., 60, 653–657. (2) (1997) Amer. Mineral., 82, 208 (abs. ref. 1). (3) Margison, S.M., J.D. Grice, and L.A. Groat (1997) The crystal structure of leisingite, $(Cu^{2+}, Mg, Zn)_2(Mg, Fe)Te^{6+}O_6 \cdot 6H_2O$.

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Leiteite $ZnAs_2^{3+}O_4$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Rare crystals, with pyramidal terminations, in parallel growths; more commonly as cleavable masses, to 17 cm.

Physical Properties: *Cleavage:* {100}, perfect. *Tenacity:* Cleavage lamellae are flexible, inelastic; somewhat sectile. Hardness = 1.5–2 D(meas.) = 4.3(1) D(calc.) = 4.619

Optical Properties: Transparent. *Color:* Colorless to pale brown. *Luster:* Pearly on the cleavage.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge a = 11°$; $Z \wedge c = 10°$. *Dispersion:* $r < v$, very strong. $\alpha = 1.87(1)$ $\beta = 1.880(5)$ $\gamma = 1.98(1)$ 2V(meas.) = 26.5(1.0)°

Cell Data: *Space Group:* $P2_1/c$. $a = 4.542(1)$ $b = 5.022(1)$ $c = 17.597(5)$ $\beta = 90.81(3)°$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia; strong preferred orientation.
2.940 (400), 4.405 (100), 8.808 (32), 1.761 (22), 3.133 (21), 2.884 (19), 3.163 (18)

Chemistry:

	(1)
As_2O_3	71.4
FeO	0.5
ZnO	28.5
Total	100.4

(1) Tsumeb, Namibia; corresponds to $(Zn_{0.97}Fe_{0.02})_{\Sigma=0.99}As_2^{3+}O_4$.

Occurrence: With other zinc- and arsenic-bearing minerals, apparently formed at low temperatures in an oxidized zone in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Chalcocite, tennantite, reinerite, schneiderhöhnite, zincian stottite, zincroselite, tsumcorite, stranskiite, legrandite, smithsonite.

Distribution: From Tsumeb, Namibia.

Name: For Luis Antonio Bravo Teixeira-Leite (1942–1999), Portuguese-South African amateur mineralogist of Pretoria, South Africa, who noted the first specimen.

Type Material: University of Pierre and Marie Curie, Paris, France; The Natural History Museum, London, England, 1976,432; Royal Ontario Museum, Toronto, Canada, M34727; National Museum of Natural History, Washington, D.C., USA, 137105.

References: (1) Cesbron, F.P., R.C. Erd, G.K. Czamanski, and H. Vachey (1977) Leiteite, a new mineral from Tsumeb. Mineral. Record, 8(3), 95–97. (2) (1977) Amer. Mineral., 62, 1259–1260 (abs. ref. 1). (3) Ghose, S., P.K. Sen Gupta. and E.O. Schlemper (1987) Leiteite, $ZnAs_2O_4$: a novel type of tetrahedral layer structure with arsenite chains. Amer. Mineral., 72, 629–632.

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Lemoynite **$(Na,K)_2CaZr_2Si_{10}O_{26}\cdot 5-6H_2O$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals bladed prismatic, elongated along [100], to about 0.05 mm. Commonly in subparallel, sheaflike arrangements and in spherules, to about 0.5 cm.

Physical Properties: *Cleavage:* Perfect on {100} and {010}; imperfect or parting on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 2.29 D(calc.) = 2.38

Optical Properties: Transparent to opaque. *Color:* White to slightly yellowish, colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge a = 5°$. $\alpha = 1.540$ $\beta = 1.553$ $\gamma = 1.570$ 2V(meas.) = 80° 2V(calc.) = 83°

Cell Data: *Space Group:* $C2/c$. $a = 10.384(3)$ $b = 15.947(7)$ $c = 18.601(6)$ $\beta = 104.59(3)°$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
8.01 (100), 3.562 (49), 2.807 (48), 9.0 (37), 3.034 (33), 3.482 (29), 4.39 (27)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	47.32	55.40	ZnO		0.19
TiO_2	0.43	0.49	MgO		0.16
ZrO_2	23.23	20.30	CaO	5.06	4.40
Al_2O_3		0.22	SrO		0.07
RE_2O_3	1.18	< 1.	Na_2O	4.75	3.02
Fe_2O_3	1.61	0.57	K_2O		3.70
Nb_2O_5	2.18	0.87	Rb_2O		0.03
MnO	0.10	0.04	H_2O	13.33	9.50
CuO		0.08	Total	99.19	99.04

(1) Mont Saint-Hilaire, Canada. (2) Do.; by XRF and AA, corresponding to $(Na_{1.05}K_{0.85})_{\Sigma=1.90}(Ca_{0.85}Fe_{0.08}Mg_{0.04}Zn_{0.02}Cu_{0.01})_{\Sigma=1.00}(Zr_{1.78}Nb_{0.07}Ti_{0.06})_{\Sigma=1.91}(Si_{9.95}Al_{0.05})_{\Sigma=10.00}O_{26}\cdot 5.69H_2O$.

Occurrence: An uncommon mineral, in pegmatite in an intrusive alkalic gabbro-syenite complex (Mpnt Saint-Hilaire, Canada); in miarolytic cavities in a nepheline syenite sill (near Saint-Amable, Canada).

Association: Sodalite, nepheline, eudialyte, catapleiite, elpidite, zircon, microcline (Mont Saint-Hilaire, Canada); albite, natrolite, zakharovite, aegirine, eudialyte, polylithionite (near Saint-Amable, Canada).

Distribution: From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada.

Name: For Charles Lemoyne (1625–1685), Lord of Longuevil, and his four sons, well-known personalities in French-Canadian history.

Type Material: Royal Ontario Museum, Toronto, Canada, M32124; National School of Mines, Paris, France.

References: (1) Perrault, G., E.I. Semenov, A.V. Bikova, and T.A. Capitonova (1969) La lemoynite, un nouveau silicate hydraté de zirconium et de sodium de St. Hilaire, Québec. Can. Mineral., 9, 585–596 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1913–1914 (abs. ref. 1). (3) Le Page, Y. and G. Perrault (1976) Structure crystalline de la lemoynite, $(Na,K)_2CaZr_2Si_{10}O_{26}$, $5-6H_2O$. Can. Mineral., 14, 132–138 (in French with English abs.). (4) Blinov, V.A., A.A. Voronkov, V.V. Ilyukhin, and N.V. Belov (1974) Crystal structure of lemoynite with a new type of mixed structure. Doklady Acad. Nauk SSSR, 217, 326–329 (in Russian). (5) (1974) Chem. Abs., 81, 142505 (abs. ref. 4). (6) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 124.

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Lenaite $AgFeS_2$

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Crystal Data: Tetragonal. *Point Group:* $4mm$ (possible). As equant grains, to 0.2 mm.

Physical Properties: Hardness = 4.5 VHN = 270–360, 310 average (10 g load). D(meas.) = n.d. D(calc.) = 4.63

Optical Properties: Opaque. *Color:* [Black]; cream with grayish tint in reflected light. *Luster:* Metallic.
Optical Class: Uniaxial. *Anisotropism:* Moderate.
R_1–R_2: (400) —, (420) 25.1–27.0, (440) 25.8–28.3, (460) 26.7–29.2, (480) 27.8–31.0, (500) 29.2–33.1, (520) 30.5–34.8, (540) 32.4–36.1, (560) 32.8–37.1, (580) 33.1–37.3, (600) 33.0–36.8, (620) 32.5–36.4, (640) 31.8–36.0, (660) 31.2–34.0, (680) 31.6–33.0, (700) —

Cell Data: *Space Group:* $P4_2mc$ (possible). $a = 5.64(1)$ $c = 10.34(3)$ $Z = 4$

X-ray Powder Pattern: Khachakchansky deposit, Russia.
3.15 (10), 1.910 (4), 2.445 (2), 1.692 (2), 2.340 (< 2), 3.43 (1), 2.824 (1)

Chemistry:

	(1)	(2)
Ag	46.58	47.34
Hg	0.3	
Fe	24.08	24.51
S	28.86	28.15
Total	99.8	100.00

(1) Khachakchansky deposit, Russia; by electron microprobe, average of 22 analyses; corresponds to $Ag_{0.98}Fe_{0.98}S_{2.04}$. (2) $AgFeS_2$.

Occurrence: In goethite pseudomorphs after magnesian siderite, in quartz-siderite veins.

Association: Acanthite, stephanite, Ag–Hg amalgam, chalcopyrite, tetrahedrite, galena, goethite.

Distribution: From the Khachakchansky Ag–Pb deposit, near the Lena River, eastern Sakha, Russia [TL].

Name: For its occurrence near the Lena River, Russia.

Type Material: Geological Museum, Yakutsk Scientific Center, Academy of Sciences, Yakutsk, Russia.

References: (1) Amuzinsky, V.A., Y.Y. Zhadov, N.V. Zayakina, and N.V. Leskova (1995) Lenaite $AgFeS_2$ – a new mineral species. Zap. Vses. Mineral. Obshch., 124(5), 85–91 (in Russian with English abs.). (2) (1996) Amer. Mineral., 81, 1283 (abs. ref. 1).

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Lengenbachite $Pb_6(Ag,Cu)_2As_4S_{13}$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. As thin, bladed crystals which are commonly bent or curled, to 4 cm; the large flat face {100} is striated parallel to its elongation direction. *Twinning:* On {100}; twin lamellae seen in polished section.

Physical Properties: *Cleavage:* Perfect on {100}; two others across the flat {100} face. *Tenacity:* Malleable, flexible, but not elastic. Hardness = 1.5–2 VHN = 35 D(meas.) = 5.80–5.85 D(calc.) = [5.78]

Optical Properties: Opaque. *Color:* Steel-gray, may tarnish to iridescence. *Streak:* Brown-black. *Luster:* Metallic. *Anisotropism:* Weak.
R_1–R_2: (400) 38.9–40.0, (420) 38.5–39.8, (440) 38.2–39.4, (460) 37.6–39.0, (480) 37.3–38.7, (500) 36.8–38.3, (520) 36.3–37.9, (540) 35.9–37.4, (560) 35.5–36.9, (580) 35.3–36.5, (600) 35.1–36.1, (620) 34.7–35.7, (640) 34.2–35.2, (660) 33.5–34.4, (680) 32.8–33.7, (700) 32.0–32.9

Cell Data: *Space Group:* Two subcells are recognized: the first (pseudotetragonal) has $a = 36.892(20)$ $b = 5.842(5)$ $c = 5.847(5)$ $\alpha = 90.00°$ $\beta = 92.00°$ $\gamma = 91.01(1)°$ Z = 6 and the second (pseudohexagonal) has $a = 36.892(20)$ $b = 3.895(4)$ $c = 6.378(7)$ $\alpha = 90.00°$ $\beta = 90.00°$ $\gamma = 91.01(1)°$ Z = 6

X-ray Powder Pattern: Binntal, Switzerland.
3.06 (100), 2.84 (90), 4.60 (30), 2.93 (20), 2.04 (20), 9.31 (10), 7.69 (10)

Chemistry:

	(1)	(2)	(3)
Pb	57.89	54.5	58.3
Ag	5.64	9.4	8.9
Cu	2.36	2.5	1.0
Fe	0.17		
Sb	0.77		0.2
As	13.46	13.5	12.5
S	19.33	20.8	18.2
Total	99.62	100.7	99.1

(1) Binntal, Switzerland; corresponds to $Pb_{6.02}(Ag_{1.13}Cu_{0.80})_{\Sigma=1.93}(As_{3.87}Sb_{0.14})_{\Sigma=4.01}S_{13.00}$. (2) Do.; by electron microprobe, corresponds to $Pb_{5.27}(Ag_{1.75}Cu_{0.79})_{\Sigma=2.54}As_{3.61}S_{13.00}$. (3) Do.; by electron microprobe, corresponds to $Pb_{6.44}(Ag_{1.89}Cu_{0.36})_{\Sigma=2.25}(As_{3.82}Sb_{0.04})_{\Sigma=3.86}S_{13.00}$.

Occurrence: Of hydrothermal origin.

Association: Pyrite, sphalerite, jordanite.

Distribution: In the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: For the locality at the Lengenbach quarry, Switzerland.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 398. (2) Nowacki, W. (1968) Über Hatchit, Lengenbachit und Vrbait. Neues Jahrb. Mineral., Monatsh., 69–75 (in German). (3) Williams, T.B. and A. Pring (1988) Structure of lengenbachite: a high-resolution transmission electron microscope study. Amer. Mineral., 73, 1426–1433. (4) Makovicky, E., E. Leonardson, and Y. Moëlo (1994) The crystallography of lengenbachite, a mineral with the non-commensurate layer structure. Neues Jahrb. Mineral., Abh., 166, 169–191. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 130. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 318.

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Leningradite $PbCu_3(VO_4)_2Cl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rough crystals and flakes, rhomboidal, flattened on {010}, to 0.3 mm; in radial spherical aggregates.

Physical Properties: *Cleavage:* On {010}, perfect. *Tenacity:* Brittle. Hardness = 4.25 VHN = 180–345, 247 average (10 g load). D(meas.) = 4.81 (thought low due to admixtures). D(calc.) = 4.97

Optical Properties: Opaque, transparent in very thin grains. *Color:* Bright red; golden red in transmitted light. *Streak:* Red-orange. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. α = n.d. $\beta = 2.29(1)$ $\gamma = 2.35(1)$ 2V(meas.) = Large.

Cell Data: *Space Group: Ibam.* $a = 8.988(2)$ $b = 11.083(2)$ $c = 9.360(6)$ Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia.
3.418 (100), 2.763 (95), 2.358 (73), 2.548 (66), 3.242 (62), 5.545 (49), 1.847 (49)

Chemistry:

	(1)	(2)
As_2O_5	0.49	
V_2O_5	26.22	26.03
CuO	32.84	34.16
ZnO	0.32	
PbO	32.13	31.95
Cl	9.60	10.15
$-O = Cl_2$	2.17	2.29
Total	99.43	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of ten analyses on five grains; corresponds to $Pb_{1.01}(Cu_{2.89}Zn_{0.05})_{\Sigma=2.94}[(V_{1.01}As_{0.01})_{\Sigma=1.02}O_4]_2(Cl_{1.90}O_{0.10})_{\Sigma=2.00}$.
(2) $PbCu_3(VO_4)_2Cl_2$.

Occurrence: In volcanic fumaroles, deposited at about 140° C.

Association: Tolbachite, lammerite, anglesite, hematite.

Distribution: At the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: For the city of Leningrad (once and again St. Petersburg), in the Universities of which this and related minerals have been studied.

Type Material: Mining Institute, St. Petersburg, Russia, 2003/1.

References: (1) Vergasova, L.P., S.K. Filatov, T.F. Semenova, and V.V. Anan'ev (1990) Leningradite $PbCu_3(VO_4)_2Cl_2$, a new mineral from volcanic exhalations. Doklady Acad. Nauk SSSR, 310, 1434–1437 (in Russian). (2) (1991) Amer. Mineral., 76, 1434–1435 (abs. ref. 1).

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Lennilenapeite

$K_{6-7}(Mg, Mn^{2+}, Fe^{2+}, Zn)_{48}(Si, Al)_{72}(O, OH)_{216} \cdot 16H_2O$

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Crystal Data: Triclinic. *Point Group:* n.d. As platy crystals forming dense aggregates, to 1 cm; as drusy coatings.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {*hk*0}. *Tenacity:* Brittle. Hardness = ~3 D(meas.) = 2.72 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* Dark brown, light green; black in aggregates. *Streak:* Brown. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–); pseudouniaxial (–). *Pleochroism:* Strong; X = light brown to colorless; $Y = Z$ = dark brown. *Absorption:* $Y = Z > X$. $\alpha = 1.553(2)$ $\beta = 1.594(4)$ $\gamma = 1.594(4)$ $2V(meas.) = 0°$

Cell Data: *Space Group:* n.d. $a = 21.9(1)$ b = n.d. c = n.d. α = n.d. β = n.d. γ = n.d. $Z = 1$

X-ray Powder Pattern: Franklin, New Jersey, USA.
12.11 (100), 2.582 (40), 2.734 (30), 2.365 (30), 1.593 (30), 1.578 (30), 4.07 (20)

Chemistry:

	(1)	(2)
SiO_2	44.5	45.11
Al_2O_3	5.4	4.79
Fe_2O_3	5.9	7.15
FeO	6.4	7.32
MnO	11.6	6.22
ZnO	6.3	4.92
MgO	7.0	11.39
CaO	trace	0.59
BaO	1.3	0.91
K_2O	3.0	2.76
Na_2O	0.2	0.38
H_2O	8.4	[8.46]
Total	100.0	[100.00]

(1) Franklin, New Jersey, USA; by electron microprobe, Fe^{2+}:Fe^{3+} and H_2O separately determined, total recalculated to 100.0% from 102.2%; corresponds to $(K_{5.36}Ba_{0.71}Na_{0.54})_{\Sigma=6.61}(Mg_{14.63}Mn_{13.78}Fe^{2+}_{7.50}Zn_{6.52}Fe^{3+}_{5.57})_{\Sigma=48.00}(Si_{62.42}Al_{8.93}Fe^{3+}_{0.65})_{\Sigma=72.00}[O_{171.29}(OH)_{44.71}]_{\Sigma=216.00} \cdot 16.94H_2O$. (2) Do.; H_2O by difference, corresponds to $(K_{4.79}Na_{1.01}Ca_{0.86}Ba_{0.48})_{\Sigma=7.14}(Mg_{23.12}Fe^{2+}_{8.33}Mn_{7.17}Zn_{4.95}Fe^{3+}_{4.43})_{\Sigma=48.00}(Si_{61.42}Al_{7.69}Fe^{3+}_{2.89})_{\Sigma=72.00}[O_{170.33}(OH)_{45.67}]_{\Sigma=216.00} \cdot 15.57H_2O$.

Polymorphism & Series: Forms a series with franklinphilite.

Occurrence: Apparently as both a primary and a late-stage low-temperature hydrothermal mineral in a metamorphosed stratiform zinc deposit.

Association: Nelenite, tirodite, franklinite, willemite, sphalerite, dolomite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: For the *Lenni Lenape* Indians (*original people* in the Algonquin Indian language) who inhabited the Franklin area.

Type Material: Harvard University, Cambridge, Massachusetts, 105542; National Museum of Natural History, Washington, D.C., USA, R582, 140297.

References: (1) Dunn, P.J., D.R. Peacor, and W.B. Simmons (1984) Lennilenapeite, the Mg-analogue of stilpnomelane, and chemical data on other stilpnomelane species from Franklin, New Jersey. Can. Mineral., 22, 259–263. (2) (1985) Amer. Mineral., 70, 216 (abs. ref. 1).

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Lenoblite $V_2^{4+}O_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Microcrystalline, in crusts, thin veinlets, and massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.14]

Optical Properties: Semitransparent. *Color:* Azure, darkens to greenish on exposure to air. *Optical Class:* Biaxial. *Orientation:* $X = a$; $Z = b$. $\alpha = 1.749$ $\beta =$ n.d. $\gamma = 1.848$ 2V(meas.) = 0°–10°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 2.995$ $b = 4.820$ $c = 14.800$ Z = [2]

X-ray Powder Pattern: Mounana mine, Gabon.
4.59 (FFF), 3.722 (FF), 2.528 (F), 7.46 (mF), 4.95 (f), 2.802 (f), 1.820 (f)

Chemistry:

	(1)	(2)	(3)
V_2O_5	10.27		
V_2O_4	69.45	76.44	82.16
Al_2O_3	1.16		
Fe_2O_3	0.35		
H_2O	17.93	19.20	17.84
insol.	0.50	3.20	
Total	99.66	98.84	100.00

(1) Mounana mine, Gabon; after correction for oxidation of vanadium and deduction of insoluble quartz, corresponds to $V^{4+}_{2.00}O_{4.12} \cdot 2.09H_2O$. (2) Kyzylkum Desert, Uzbekistan; after deduction of insoluble, corresponds to $V_{1.93}O_4 \cdot 2.22H_2O$. (3) $V_2O_4 \cdot 2H_2O$.

Occurrence: In a zone of reduction below the oxidized zone of a uranium deposit (Mounana mine, Gabon).

Association: Duttonite (Mounana mine, Gabon).

Distribution: From the Mounana uranium mine, Franceville, Gabon. From Kokpatas, in the Kyzylkum Desert, Uzbekistan.

Name: For André Lenoble (?–1968), formerly Head of the Laboratory of Mineralogy and Chief of Exploration, French Atomic Energy Commission.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1970,150; National Museum of Natural History, Washington, D.C., USA, 145134.

References: (1) Cesbron, F. and H. Vachey (1970) La lenoblite, nouvel oxyde hydraté de vanadium (IV). Bull. Soc. fr. Minéral., 93, 235–241 (in French with English abs.). (2) (1971) Amer. Mineral., 56, 635–636 (abs. ref. 1).

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Leogangite $Cu_{10}(AsO_4)_4(SO_4)(OH)_6 \cdot 8H_2O$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As aggregates of platelets, flattened on (100) and elongated on [010], to 0.1 mm.

Physical Properties: *Cleavage:* Perfect (100). *Fracture:* Partings parallel to (010) and (001). *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.55

Optical Properties: Transparent. *Color:* Green with a bluish tint. *Streak:* Light green. *Luster:* Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.590(2)$ $\beta = 1.740(2)$ $\gamma = 1.744(2)$ 2V(meas) = 18(2)° 2V(calc) = 17.3° *Dispersion:* Weak, $r > v$. *Pleochroism*: X = blue-green, Y=Z = pale green. Orientation: $X = a^*$; $Y = b$; $Z = c$.

Cell Data: *Space Group: C*2/*c*. $a = 21.770(7)$ $b = 12.327(4)$ $c = 10.720(3)$ $\beta = 92.85(1)°$ Z = 4

X-ray Powder Pattern: Danielstollen mining area, near Leogang, Salzburg Province, Austria. 10.85 (100), 2.630 (60), 5.44 (50), 3.625 (50), 3.090 (40), 2.672 (40), 4.9 (30)

Chemistry:

	(1)
CuO	51.1
As_2O_5	29.7
SO_3	5.1
SiO_2	0.2
H_2O	13.9
Total	100.0

(1) Danielstollen mining area, near Leogang, Salzburg Province, Austria.; average of 5 electron microprobe analyses, H_2O by difference, corresponding to $Cu_{9.94}(As_{0.99}Si_{0.01}O_4)_{\Sigma=4}(S_{0.99}O_4)(OH)_6 \cdot 8.89H_2O$.

Occurrence: A secondary mineral coating limonitic dolostone breccia and filling voids in the oxidized zone of a pyrite, galena, tennantite deposit.

Association: Olivenite, malachite, tyrolite, parnauite, strashimirite, euchroite, brochantite, langite, posnjakite, devilline.

Distribution: Found on one dump in both the Danielstollen and Inschlagalm mining areas, Schwarzleo Valley, about 10 km from Leogang, Salzburg Province, Austria.

Name: For the city (Leogang) in Austria near the first found specimens.

Type Material: Natural History Museum, Vienna, Austria; M8873.

References: (1) Lengauer, C.L., G. Giester, and E. Kirchner (2004) Leogangite, $Cu_{10}(AsO_4)_4(SO_4)(OH)_6 \cdot 8H_2O$, a new mineral from the Leogang mining district, Salzburg province, Austria. Mineral. Petrology, 81, 187–201. (2) (2005) Amer. Mineral., 90, 272 (abs. ref. 1).

Leonardsenite $MgAlF_5(H_2O)_2$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As earthy crusts of flattened prismatic crystals dominated by {011} and {101}, to 20 μm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 2.31

Optical Properties: Translucent. *Color*: White. *Streak*: White. *Luster*: Earthy (aggregates).
Optical Class: n.d. n = 1.38 [calculated]
R_1-R_2: (470) 15.3-16.8, (546) 14.1-15.9, (589) 13.8-15.3, (650) 13.4-14.8

Cell Data: *Space Group*: *Imma*. *a* = 7.055(1) *b* = 10.117(2) *c* = 6.813(1) Z = 4

X-ray Powder Pattern: Eldfell volcano, Heimaey island, Iceland.
5.66 (100), 3.00 (38), 3.03 (31), 4.92 (29), 3.53 (27), 1.76 (24), 1.77 (19)

Chemistry:

	(1)	(2)
Mg	14.66	13.33
Al	16.16	14.80
F	52.98	52.11
O	[15.88]	17.55
H	[1.78]	2.22
Total	101.46	100.00

(1) Eldfell volcano, Iceland; average of 6 electron microprobe analyses, O calculated from the OH^- required for charge neutrality plus remaining O as H_2O; corresponding to $Mg_{1.00}Al_{1.00}[F_{4.64}(OH)_{0.36}]_{\Sigma=5.00}(H_2O)_{1.29}$. (2) $MgAlF_5(H_2O)_2$.

Occurrence: A sublimated encrustations from fluorine-rich fumarolic gas.

Association: Jakobssonite, anhydrite, ralstonite, jarosite, anhydrous AlF_3, opal-A, oskarssonite (Heimaey); ralstonite, opal-A, jakobssonite, malladrite, fluorite (Heckla).

Distribution: From the northeast rim of the main crater, Eldfell volcano, Heimaey island, and from Heckla volcano, Iceland.

Name: Honors Erik Leonardsen (b. 1934), the former leader of the X-ray Diffraction Laboratory of the Geological Institute, University of Copenhagen, Denmark, for his work on the characterization of the fumarolic minerals from Icelandic volcanoes by X-ray diffraction.

Type Material: Mineral collection, Icelandic Institute of Natural History, Gardabaer, Iceland (NI 12256) and in the "C.L. Garavelli" Museum, Dipartimento di Scienze della Terra e Geoambientali, Università di Bari, Italy (14/nm-V28).

References: (1) Mitolo, D., A. Garavelli, T. Balić-Žunić, P. Acquafredda, and S.P. Jakobsson (2013) Leonardsenite, $MgAlF_5(H_2O)_2$, a new mineral species from Eldfell volcano, Heimaey island, Iceland. Can. Mineral., 51(3), 377-386. (2) (2015) Amer. Mineral., 100, 661 (abs. ref. 1).

Leonite $K_2Mg(SO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals elongated along [001] and flattened on {100}, with the prism zone well developed and complex terminations, to 7 cm; commonly granular.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5–3 D(meas.) = 2.20 D(calc.) = 2.20 Soluble in H_2O, taste slightly bitter.

Optical Properties: Transparent. *Color:* Colorless, pale yellow, honey-yellow; colorless in transmitted light. *Luster:* Waxy to vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge a$ = small. α = 1.479–1.480 β = 1.482–1.483 γ = 1.487–1.486 2V(meas.) = 90(2)°

Cell Data: *Space Group:* $C2/m$ (synthetic). $a = 11.769(3)$ $b = 9.539(3)$ $c = 9.889(3)$ $\beta = 95.31(2)°$ Z = 4

X-ray Powder Pattern: Carlsbad, New Mexico, USA.
3.42 (100), 3.04 (48), 2.38 (47), 3.49 (41), 3.31 (36), 2.88 (27), 5.88 (22)

Chemistry:

	(1)	(2)
SO_3	43.76	43.67
MgO	10.37	10.99
K_2O	25.62	25.69
KCl	0.50	
H_2O	19.57	19.65
Total	99.82	100.00

(1) Leopoldshall, Germany. (2) $K_2Mg(SO_4)_2 \cdot 4H_2O$.

Occurrence: An uncommon secondary mineral of metamorphic origin in marine salt deposits; may occur in volcanic fumaroles.

Association: Kainite, polyhalite, halite, sylvite (New Mexico, USA).

Distribution: In Germany, in the Stassfurt potash district, as at Westeregeln, Leopoldshall, Aschersleben, Vienenburg, Riedel-Hänigsen, Saxony-Anhalt; large crystals from the Sigmundshall mine, Bokeloh bei Wunstorf, Lower Saxony. At Vesuvius, Campania, Italy. From Stebnyk, Poland. In the Carlsbad potash district, Eddy Co., New Mexico, USA.

Name: To honor Leo Strippelmann, Director of the salt works at Westeregeln, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 450–451. (2) Madsen, B.M. (1966) Loeweite, vanthoffite, bloedite, and leonite from southeastern New Mexico. U.S. Geol. Surv. Prof. Paper 550-B, B125–B129. (3) Jarosch, D. (1985) Crystal structure of leonite. Zeits. Krist., 173, 75–79 (in German with English abs.).

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Lepersonnite-(Gd) $CaO \cdot (Gd,Dy)_2O_3 \cdot 24UO_3 \cdot 8CO_2 \cdot 4SiO_2 \cdot 60H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As mammilary crusts or spherules, to 5 mm in diameter, composed of radiating acicular crystals elongated along [001].

Physical Properties: Hardness = n.d. D(meas.) = 3.97(5) D(calc.) = 4.01 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Bright yellow.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; $Y = Z$ = bright yellow. *Orientation:* $Y = c$. $\alpha = 1.638(2)$ $\beta = 1.666(2)$ $\gamma = 1.682(2)$ 2V(meas.) = n.d. 2V(calc.) = 73°

Cell Data: *Space Group:* $Pnnm$ or $Pnn2$. $a = 16.23(3)$ $b = 38.74(9)$ $c = 11.73(3)$
Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
8.15 (100), 3.65 (70), 3.21 (50), 2.86 (40), 4.06 (15), 11.1 (10), 6.46 (10)

Chemistry:

	(1)
SiO_2	2.79
UO_3	76.14
Y_2O_3	0.41
Gd_2O_3	2.09
Tb_2O_3	0.09
Dy_2O_3	1.07
CaO	0.45
H_2O	12.12
CO_2	4.02
Total	99.18

(1) Shinkolobwe, Congo; by electron microprobe, CO_2 by chromatography, H_2O by TGA; corresponds to $Ca_{0.71}(Gd_{1.04}Dy_{0.52}Y_{0.32}Tb_{0.06})_{\Sigma=1.94}U_{23.95}C_{8.10}Si_{4.18}O_{100} \cdot 59.90H_2O$.

Occurrence: In the lower portion of the oxidation zone developed above uraninite-bearing dolomitic rocks.

Association: Bijvoetite, sklodowskite, curite, uranophane, becquerelite, rutherfordine, studtite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: For Jacques Lepersonne, honorary Head of the Department of Geology and Mineralogy, Royal Museum of Central Africa, Tervuren, Belgium, and for its *gadolinium* content.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM13781, RGM2696, RGM13250; National Museum of Natural History, Washington, D.C., USA, 150228.

References: (1) Deliens, M. and P. Piret (1982) Bijvoetite et lepersonnite, carbonates hydratés d'uranyle et de terres rares de Shinkolobwe, Zaïre. Can. Mineral., 20, 231–238 (in French with English abs.). (2) (1983) Amer. Mineral., 68, 1248 (abs. ref. 1).

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Lepidocrocite γ–$Fe^{3+}O(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals typically flattened on {010}, isolated, to 2 mm, or aggregated into plumose or rosettelike groups; bladed, micaceous, fibrous, massive.

Physical Properties: *Cleavage:* {010}, perfect; {100}, less perfect; {001}, good. *Fracture:* Brittle. Hardness = 5 VHN = 690–782 D(meas.) = 4.09(4) D(calc.) = 3.96

Optical Properties: Transparent. *Color:* Ruby-red to reddish brown; light reddish to red-orange in transmitted light; gray-white in reflected light. *Streak:* Dull orange. *Luster:* Submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = colorless to yellow; Y = orange, yellow, dark red-orange; Z = orange, yellow, darker red-orange. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* Slight. *Absorption:* $Z > Y > X$. $\alpha = 1.94$ $\beta = 2.20$ $\gamma = 2.51$ 2V(meas.) = 83° *Anisotropism:* Strong. *Bireflectance:* Strong.
R_1–R_2: (400) 13.0–21.4, (420) 12.7–20.3, (440) 12.4–19.2, (460) 12.0–18.6, (480) 11.7–18.1, (500) 11.4–17.8, (520) 11.2–17.4, (540) 11.0–17.0, (560) 10.8–16.5, (580) 10.7–16.0, (600) 10.6–15.7, (620) 10.5–15.4, (640) 10.4–15.2, (660) 10.4–15.1, (680) 10.4–15.0, (700) 10.4–14.9

Cell Data: *Space Group:* $Cmc2_1$ (synthetic). $a = 3.08(1)$ $b = 12.50(1)$ $c = 3.87(1)$
Z = 4

X-ray Powder Pattern: Locality unknown. (ICDD 8-98).
6.26 (100), 3.29 (90), 2.47 (80), 1.937 (70), 1.732 (40), 1.524 (40), 1.075 (40)

Chemistry:

	(1)	(2)
Fe_2O_3	89.90	89.86
H_2O	10.77	10.14
Total	100.67	100.00

(1) Eleonore mine, Mt. Dünsberg, Germany. (2) FeO(OH).

Polymorphism & Series: Trimorphous with feroxyhyte and goethite.

Occurrence: A weathering or oxidation product of other iron-bearing minerals, in soils and mineral deposits; a precipitate from ground water. In marine manganese nodules.

Association: Goethite, pyrite.

Distribution: Many minor localities; well-studied material from: in Germany, from Eiserfeld, Siegen, and at Herdorf and Müsen, North Rhine-Westphalia; on Mt. Dünsberg, near Giessen, Hesse; and elsewhere. In France, at Rancié-en-Sem, Ariège, and Chizeuil, Saône-et-Loire. From a cave at Dachstein-Mammuthöhle, Austria. At Příbram, Czech Republic. From Traversella, Piedmont, Italy. At the Great Retallack and Gravel Hill mines, Perranzabuloe, and the Trewethen mine, St. Kew, Cornwall, England. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In the USA, in Pennsylvania, at Easton, Northampton Co., Chestnut Hill, Lancaster Co., and other localities; from the Iron Mountain mine, Shasta Co., California; at Bisbee, Cochise Co., Arizona. At the Iron Monarch quarry, Iron Knob, South Australia. From Tsumeb, Namibia.

Name: From the Greek for *scale* and *thread*, for the occasionally feathery or scaly habit.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 642–645. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 122-124. (3) Christensen, H. and A.N. Christensen (1978) Hydrogen bonds of γ—FeOOH. Acta Chem. Scand., A32(1), 87–88.

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Lepidolite $K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m (1M). Tabular to prismatic pseudohexagonal crystals, commonly with rounded terminal faces, to 20 cm. In coarse to fine scaly aggregates and massive. *Twinning:* Rare, composition plane {001}, twin axis [310].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Flexible, elastic. Hardness = 2.5–4 D(meas.) = 2.8–2.9 D(calc.) = 2.693

Optical Properties: Transparent to translucent. *Color:* Pink, purple, rose-red, violet-gray, yellowish, white, colorless; colorless to pale pink in thin section. *Luster:* Pearly to vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = almost colorless; $Y = Z$ = pink, pale violet. *Orientation:* $Y = b$; $X \wedge a = 90°–87°$; $Z \wedge a = 0°–7°$. *Dispersion:* $r > v$, weak. *Absorption:* $Y \simeq Z > X$. $\alpha = 1.525–1.548$ $\beta = 1.551–1.585$ $\gamma = 1.554–1.587$ 2V(meas.) = 0°–58°

Cell Data: *Space Group:* $C2/m$ (1M). $a = 5.209(2)$ $b = 9.011(5)$ $c = 10.149(5)$ $\beta = 100.77(4)°$ Z = 2

X-ray Powder Pattern: Topsham, Sagadahoc Co., Maine, USA; 1M. (ICDD 10-485). 3.34 (100), 10.0 (75), 4.99 (75), 3.62 (75), 3.08 (75), 2.578 (75), 1.992 (60)

X-ray Powder Pattern: Gunnison Co., Colorado, USA; $2M_2$. (ICDD 14-11). 2.577 (100), 1.989 (80), 10.0 (60), 5.0 (50), 4.5 (50), 3.62 (50), 3.48 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.58	51.45	K_2O	10.02	9.09
Al_2O_3	28.93	22.62	Rb_2O	0.91	1.69
Fe_2O_3		0.16	Cs_2O	0.16	0.94
FeO	0.04	0.04	F	4.93	7.40
MnO	0.92	0.51	H_2O^+	2.56	2.36
MgO	0.00	0.53	H_2O^-	0.54	0.84
CaO	trace	0.20	$-O = F_2$	2.08	3.11
Li_2O	3.70	5.42	rem.		0.01
Na_2O	0.87	0.26	Total	100.08	100.41

(1) Stewart mine, Pala, California, USA; TiO_2 trace; corresponds to $(K_{0.85}Na_{0.11}Rb_{0.04})_{\Sigma=1.00}(Al_{1.50}Li_{0.99}Mn_{0.05})_{\Sigma=2.54}(Si_{3.23}Al_{0.77})_{\Sigma=4.00}O_{10}[(OH)_{1.14}F_{1.04}]_{\Sigma=2.18}$. (2) Radkovice, Czech Republic; remainder includes traces of Ga_2O_3, Cr_2O_3, and Tl_2O_3; corresponds to $(K_{0.79}Rb_{0.07}Na_{0.03}Cs_{0.03}Ca_{0.01})_{\Sigma=0.93}(Li_{1.48}Al_{1.30}Mg_{0.05}Mn_{0.03}Fe^{3+}_{0.01})_{\Sigma=2.87}(Si_{3.49}Al_{0.51})_{\Sigma=4.00}O_{10}(F,OH)_2$.

Polymorphism & Series: 1M, $2M_2$, 3A polytypes common; $2M_1$, $3M_2$ rare; a group name.

Mineral Group: Mica group.

Occurrence: In granite pegmatites, derived by metasomatic replacement of muscovite or biotite; in some high-temperature quartz veins, greisens, and granites.

Association: Spodumene, elbaite, amblygonite, columbite, cassiterite, topaz, beryl, micas.

Distribution: At Rožná, near Bystřice, Czech Republic. From Alabashka, Ural Mountains, Russia. In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. In the USA, at Mt. Mica, near Paris, Oxford Co., and Auburn, Androscoggin Co., Maine; in the Mesa Grande and Pala districts, San Diego Co., California; from the Brown Derby pegmatite, Gunnison Co., Colorado; in the Ingersoll mine, near Keystone, Pennington Co., South Dakota. From the Tanco mine, Bernic Lake, Manitoba, Canada. At Maharitra, Mt. Bity, Madagascar. From Bikita,

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Zimbabwe. In India, at Hazaribagh, Bihar. From the Virgem da Lapa pegmatite, Minas Gerais, Brazil.

Name: From the Greek *lepidos* for *scale*, in allusion to its micaceous structure.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 624–625. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 85–91. (3) Guggenheim, S. (1981) Cation ordering in lepidolite. Amer. Mineral., 66, 1221–1232.

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Lepkhenelmite-Zn $Ba_2Zn(Ti,Nb)_4[Si_4O_{12}]_2(O,OH)_4 \cdot 7H_2O$

Crystal Data: Monoclinic. *Point Group: m.* As length-striated, flattened prismatic crystals, elongated on [010], to 7 mm, displaying {100} and {001}. In sheaf-like aggregates.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ~5 D(meas.) = 2.96 D(calc.) = 3.07

Optical Properties: Transparent. *Color:* Light brown. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). α = 1.683(2) β = 1.692(2) γ = 1.795(4) 2V(obs.) = 30(10)° 2V(calc.) = 34.5° *Pleochroism:* Weak, *X* = *Z* = colorless; *Y* = pale yellowish-brown. *Orientation: Y = b*. *Dispersion:* None.

Cell Data: Space Group: *Cm*. *a* = 14.381(3) *b* =13.889(3) *c* = 7.793(2) β = 117.52(3)° *Z* =2

X-ray Powder Pattern: Pegmatite no. 45, Mount Lepkhe-Nel'm, Lovozero massif, Russia. 3.194 (100), 6.95 (37), 3.101 (22), 6.39 (10), 3.050 (8), 2.906 (6), 2.585 (6)

Chemistry:

	(1)		(1)
Na_2O	0.59	ZnO	3.66
K_2O	1.98	Al_2O_3	0.42
CaO	1.16	SiO_2	37.01
SrO	1.79	TiO_2	18.56
BaO	11.04	Nb_2O_5	10.60
MgO	0.02	H_2O	11.80
MnO	0.81	Total	99.65
FeO	0.21		

(1) Pegmatite no. 45, Mount Lepkhe-Nel'm, Lovozero massif, Russia; electron microprobe analyses, H_2O by TGA; corresponding to $(Ba_{0.92}K_{0.54}Ca_{0.26}Na_{0.24}Sr_{0.22})_{\Sigma=2.18}(Zn_{0.58}Mn_{0.15}Fe_{0.04}Mg_{0.01})_{\Sigma=0.78}(Ti_{2.97}Nb_{1.02})_{\Sigma=3.99}(Si_{7.89}Al_{0.11})_{\Sigma=8.00}O_{24}[O_{2.01}(OH)_{1.99}]_{\Sigma=4.00} \cdot 7.39H_2O$.

Polymorphism & Series: Forms a series with kuzmenkoite-Zn.

Mineral Group: Labuntsovite group.

Occurrence: A late-stage hydrothermal mineral in a complex granitic (eudialite, agerine, feldspar) pegmatite.

Association: Lamprophyllite, eudialyte, tsepinite-Na, kuzmenkoite-Zn, paratsepinite-Ba.

Distribution: From Pegmatite no. 45, north slope of Mount Lepkhe-Nel'm, Lovozero massif, Kola peninsula, Russia.

Name: For the locality that produced the first specimens and the dominant element in the D structural site, Zn.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia; 2709/1.

References: (1) Pekov, I.V., N.V., Chukanov, G.V., Shilov, N.N.,Kononkova, and A.E., Zadov, (2004) Lepkhenelmite-Zn, $Ba_2Zn(Ti,Nb)_4[Si_4O_{12}]_2(O,OH)_4 \cdot 7H_2O$, a new mineral of the labuntsovite group, and its crystal structure. Zapiski Vseross. Mineral. Obshch., 133(1), 49-58 (in Russian, English abstract). (2) (2005) Amer. Mineral., 90, 769-770 (abs. ref. 1).

Lermontovite $U^{4+}(PO_4)(OH)\cdot H_2O(?)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Fibrous, in veinlets, or radially fibrous botyroidal aggregates, to 1.5 mm.

Physical Properties: *Tenacity:* Very brittle. Hardness = n.d. D(meas.) = 4.00–4.50 D(calc.) = [4.08] Radioactive.

Optical Properties: Transparent. *Color:* Grayish green, green; grassy green in transmitted light. *Luster:* Dull, silky on fractures.
Optical Class: Biaxial (–). *Pleochroism:* In shades of green to greenish gray. *Orientation:* $Z = c \parallel$ elongation. $\alpha = 1.686$–1.690 $\beta = 1.707$ $\gamma = 1.724$–1.726 2V(meas.) = n.d. 2V(calc.) = 88(6)°

Cell Data: *Space Group:* *Ccca* (probable). $a = 9.74(1)$ $b = 19.00(1)$ $c = 10.10(1)$ Z = [12]

X-ray Powder Pattern: Beshtau deposit, Russia, by X-ray and electron diffraction; decomposes rapidly under the electron beam.
3.92 (100), 3.29 (95), 4.87 (80), 4.12 (80), 3.83 (80), 3.58 (80), 4.69 (70)

Chemistry:

	(1)	(2)
UO_2	65.63	73.38
P_2O_5	18.54	19.28
TlO_2	9.46	
CaO	0.27	
H_2O	[6.10]	7.34
Total	[100.00]	100.00

(1) Beshtau deposit, Russia; by electron microprobe, average of four analyses, H_2O by difference; corresponding to $(U_{0.93}Tl_{0.17}Ca_{0.02})_{\Sigma=1.12}(PO_4)(OH)_{0.93}\cdot 0.8H_2O$. (2) $U(PO_4)(OH)\cdot H_2O$.

Occurrence: In uranium-bearing veins in a granite porphyry stock.

Association: Halloysite, vrbaite, lorandite, evansite, uraninite, marcasite, molybdenum sulfate.

Distribution: From the Beshtau uranium deposit, near Pyatigorsk, northern Caucasus Mountains, Russia.

Name: Honors Mikhail Yur'evich Lermontov (1814–1841), Russian poet.

Type Material: n.d.

References: (1) Soboleva, M.V. and I.A. Pudovkina (1957) Uranium Minerals Handbook. Moscow, 404 pages, esp. 181–182 (in Russian). (2) Getseva, R.V. and K.T. Salev'eva (1956) Handbook for the determination of uranium minerals, Moscow, 260 pages, esp. 199–200 (in Russian). (3) (1958) Amer. Mineral., 43, 379–380 (abs. refs. 1 and 2). (4) Melkov, V.G., L.N. Belova, A.I. Gorshkov, O.A. Ivanova, A.V. Sivtsov, and V.A. Boronikhin (1983) New data on lermontovite. Mineral. Zhurnal, 5(1), 82–87 (in Russian with English abs.). (5) (1984) Amer. Mineral., 69, 214–215 (abs. ref. 3). (6) (1983) Mineral. Abs., 34, 475 (abs. ref. 3). (7) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 128.

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Letovicite $H(NH_4)_3(SO_4)_2$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $\overline{1}$ or 1. Crystals are platy, pseudohexagonal, flattened on {001}, corroded or skeletal, to 0.05 mm; typically granular. *Twinning:* Common, lamellar.

Physical Properties: *Cleavage:* {001}, distinct. *Fracture:* Uneven. Hardness = n.d. D(meas.) = 1.83 (synthetic). D(calc.) = 1.82 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, white.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 78°$. $\alpha = 1.501$ $\beta = 1.516$ $\gamma = 1.525$
2V(meas.) = 75°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$ (synthetic). $a = 5.87(1)$ $b = 10.17(3)$ $c = 8.27(1)$
$\alpha = 101.1(4)°$ $\beta = 111.1(1)°$ $\gamma = 89.9(2)°$ Z = 2

X-ray Powder Pattern: Synthetic.
4.95 (100), 4.98 (85), 3.77 (80), 3.39 (75), 2.932 (50), 3.36 (45), 4.65 (35)

Chemistry:

	(1)	(2)
SO_3	63.92	64.76
$(NH_4)_2O$	20.19	20.67
H_2O	[15.89]	14.57
Total	[100.00]	100.00

(1) Kladno, Czech Republic. (2) $H(NH_4)_3(SO_4)_2$.

Occurrence: A rare secondary mineral, formed from burning coal (Czech Republic); deposited from hot springs (The Geysers, California, USA).

Association: Sulfur (Letovice, Czech Republic); mascagnite, boussingaultite (The Geysers, California, USA).

Distribution: In the Czech Republic, from Písěcná, near Letovice; at Libušin, near Kladno; and from Radvanice. At Ormosbánya, Hungary. Found at The Geysers, Sonoma Co., California, USA.

Name: For Letovice, Czech Republic, the locality first noted for the mineral.

Type Material: Moravian Museum, Brno, Czech Republic, A6110.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 397. (2) Davis, B.L. and L.R. Johnson (1984) The true unit cell of ammonium hydrogen sulfate, $(NH_4)_3H(SO_4)_2$. J. Appl. Cryst., 17, 331–333.

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Leucite $KAlSi_2O_6$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m$. Commonly euhedral, pseudocubic crystals, showing {112}, with {100}, {110} may be present, to 9 cm, typically showing fine twin striae. As disseminated grains; rarely granular, massive. *Twinning:* Common and repeated on {110}, {101}, and other orientations, from two complex displacive phase transformations during cooling.

Physical Properties: *Cleavage:* Very poor on {110}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.45–2.50 D(calc.) = [2.46]

Optical Properties: Transparent to translucent. *Color:* White, gray; colorless in thin section. *Luster:* Vitreous.
Optical Class: Uniaxial (+); may be anomalously biaxial. *Dispersion:* Moderate. $\omega = 1.508$ $\epsilon = 1.509$ 2V(meas.) = Very small.

Cell Data: *Space Group:* $I4_1/a$. $a = 13.055$–13.057 $c = 13.749$–13.753 Z = 16

X-ray Powder Pattern: Villa Senni, Italy. (ICDD 15-47).
3.266 (100), 3.438 (85), 5.39 (80), 2.918 (70), 2.842 (70), 2.366 (65), 2.808 (55)

Chemistry:

	(1)	(2)	(3)
SiO_2	54.60	54.0	55.06
TiO_2	0.03	0.13	
Al_2O_3	21.97	22.3	23.36
Fe_2O_3	0.89		
FeO	0.14	0.63	
MgO		0.08	
CaO	0.10	0.09	
BaO		0.00	
Na_2O	0.23	0.42	
K_2O	21.45	21.6	21.58
Total	99.41	99.25	100.00

(1) Villa Senni, Italy. (2) Central Sierra Nevada, California, USA; by electron microprobe, average of nine analyses. (3) $KAlSi_2O_6$.

Occurrence: With potassium-rich mafic and ultramafic lavas and hypabyssal rocks, and may almost entirely compose them.

Association: Potassic feldspar, nepheline, analcime, natrolite, kalsilite.

Distribution: From numerous localities worldwide, typically in good crystals. Especially from Italy, as at Vesuvius, Monte Somma, and Roccamonfina, Campania; at Villa Senni, Frascati, and Ariccia, Lazio; and on Vulcano, Lipari Islands. Around the Laacher See, Eifel district, Germany. In the USA, from the Leucite Hills, Sweetwater Co., Wyoming; the Bear Paw Mountains, Hill Co., Montana; and at Magnet Cove, Hot Spring Co., Arkansas. In the West Kimberley district, Western Australia. In Tanzania, on Kilimanjaro. In Uganda, found around Ruwenzori and Kariya. From Mt. Nyiragongo, Kivu Province, Congo (Zaire).

Name: From the Greek *leucos* for *white*, in allusion to its color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 342–343. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 276–288. (3) Mazzi, F., E. Galli, and G. Gottardi (1976) The crystal structure of tetragonal leucite. Amer. Mineral., 61, 108–115. (4) Van Kooten, G.K. (1980) Mineralogy, petrology, and geochemistry of an ultrapotassic basaltic suite, Central Sierra Nevada, California, U.S.A. J. Petrol., 21, 651–684. (5) Palmer, D.C., A. Putnis, and E.K.H. Salje (1988) Twinning in tetragonal leucite. Phys. Chem. Minerals, 16, 298–303.

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Leucophanite $(Ca,Ce)CaNa_2Be_2Si_4O_{12}(F,OH)_2$

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Crystal Data: Orthorhombic or triclinic. *Point Group:* 222 or 1. Short prismatic to tabular pseudotetragonal crystals, to 3 cm. In radiating fibrous spherulites; massive. *Twinning:* Penetration fourlings; polysynthetic ∥ {110}.

Physical Properties: *Cleavage:* {001}, perfect; {100}, {010}, and {201}, distinct. *Fracture:* Conchoidal to uneven. *Tenacity:* Very brittle. Hardness = 3.5–4 D(meas.) = 2.96–3.07 D(calc.) = 2.961 May fluoresce pink or violet-blue in SW and LW UV; strongly phosphorescent; pyroelectric.

Optical Properties: Semitransparent. *Color:* Whitish green, greenish white, deep green with a yellow tinge, wine-yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, weak.
$\alpha = 1.565$–1.573 $\beta = 1.590$–1.595 $\gamma = 1.593$–1.598 2V(meas.) = 36°–50° 2V(calc.) = 38°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.401(2)$ $b = 7.412(2)$ $c = 9.990(2)$ Z = 2, or *Space Group:* $P1$. $a = 7.417(4)$ $b = 7.398(4)$ $c = 9.986(4)$ $\alpha = 90.00(2)°$ $\beta = 90.00(2)°$ $\gamma = 90.00(2)°$ Z = 2

X-ray Powder Pattern: Eikaholmen, Langesundsfjord, Norway. (ICDD 18-711).
2.75 (100), 3.60 (50), 2.97 (50), 1.69 (50), 2.31(40), 2.20 (40), 1.98 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.50	45.98	Na_2O	12.42	10.79
Al_2O_3	0.45	2.32	K_2O		0.70
FeO		0.22	F	5.94	7.04
BeO	10.03	11.52	H_2O^+	1.08	0.84
MgO	0.27	0.30	$-O = F_2$	[2.50]	2.96
CaO	22.94	23.65	Total	[99.13]	100.40

(1) Arø Island, Langesundsfjord, Norway; corresponds to $(Ca_{1.01}Mg_{0.02})_{\Sigma=1.03}Na_{0.99}Be_{0.98}(Si_{1.98}Al_{0.02})_{\Sigma=2.00}O_{5.96}[F_{0.77}(OH)_{0.30}]_{\Sigma=1.07}$. (2) Lovozero massif, Russia; corresponds to $(Ca_{1.04}Mg_{0.02})_{\Sigma=1.06}(Na_{0.86}K_{0.04})_{\Sigma=0.90}Be_{1.14}(Si_{1.89}Al_{0.11})_{\Sigma=2.00}O_6[F_{0.91}(OH)_{0.23}]_{\Sigma=1.14}$.

Occurrence: In pegmatites in augite syenite (Langesundsfjord, Norway); in albitization zones in pegmatites at the contact of alkalic massifs intruding Proterozoic carbonaceous quartz-sericite schists (Baikal massif, Russia).

Association: Albite, orthoclase, natrolite, analcime, sérandite, aegirine, polylithionite, ancylite, astrophyllite, catapleiite, epididymite, rhodochrosite, fluorite.

Distribution: In Norway, on Låven, Arø, Stokkø and other islands in the Langesundsfjord; at Morje, Telemark; and in the Vevja and Saga quarries, Tvedalen. In Russia, in the Lovozero massif, Kola Peninsula; in the Baikal massif, eastern Siberia; and in several other poorly specified localities. From Narssârssuk, Greenland. At Mont Saint-Hilaire, Quebec, Canada.

Name: From the Greek for *white* and *to appear*, its common color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 417–418. (2) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 432–433 (in English). (3) Portnov, A.M. (1964) The northern Baikal leucophanite. Trudy Mineral. Muzeya Akad. Nauk SSSR, 15, 229–231 (in Russian). (4) (1964) Chem. Abs., 14372 (abs. ref. 3). (5) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 126. (6) Grice, J.D. and F.C. Hawthorne (1989) Refinement of the crystal structure of leucophanite. Can. Mineral., 27, 193–197. (7) Cannillo, E., G. Giuseppetti, F. Mazzi, and V. Tazzoli (1992) The crystal structure of a rare earth bearing leucophanite: $(Ca,RE)CaNa_2Be_2Si_4O_{12}(F,O)_2$. Zeits. Krist., 202, 71–79.

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Leucophoenicite $Mn_7^{2+}(SiO_4)_3(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals rare, typically slender, prismatic, elongated and striated ‖ [010], to 8 mm; in isolated grains or granular massive. *Twinning:* On {001}, common, contact or interpenetrant twins, lamellar.

Physical Properties: *Cleavage:* {001}, imperfect. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 3.848 D(calc.) = [4.01]

Optical Properties: Transparent to translucent. *Color:* Brown to light purple-red, raspberry-red, deep pink to light pink; rose-red to colorless in thin section. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Faint; rose-red ‖ {001}; colorless ⊥ {001}. *Orientation:* $X \perp$ {001} cleavage. *Dispersion:* $r > v$, slight. $\alpha = 1.751(3)$ $\beta = 1.771(3)$ $\gamma = 1.782(3)$ 2V(meas.) = 74(5)°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.842(19)$ $b = 4.826(6)$ $c = 11.324(9)$ $\beta = 103.93(9)°$ Z = [2]

X-ray Powder Pattern: Franklin, New Jersey, USA.
1.8063 (10), 2.877 (9), 2.684 (8), 4.36 (5), 3.612 (5), 2.365 (5), 2.620 (4)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	26.36	26.7	26.7	CaO	5.67	2.4	2.8
FeO	trace	0.3	0.3	Na_2O	0.39		
MnO	60.63	62.8	64.7	K_2O	0.24		
ZnO	3.87	0.0	0.0	H_2O	2.64	[2.3]	[2.8]
MgO	0.21	5.5	2.7	Total	100.01	[100.0]	[100.0]

(1) Franklin, New Jersey, USA; composite of two analyses, corresponding to $(Mn_{5.89}Ca_{0.70}Zn_{0.32}Na_{0.04}Mg_{0.03}K_{0.01})_{\Sigma=6.99}(Si_{1.01}O_4)_3(OH)_2$. (2) Kombat mine, Namibia; by electron microprobe, H_2O by difference; corresponding to $(Mn_{5.98}Mg_{0.92}Ca_{0.29}Fe_{0.02})_{\Sigma=7.21}(SiO_4)_3(OH)_{1.72}$.
(3) Valsesia-Valtournanche area, Italy; by electron microprobe, H_2O by difference; corresponding to $(Mn_{6.16}Mg_{0.45}Ca_{0.34}Fe_{0.03})_{\Sigma=6.98}(SiO_4)_3(OH)_{2.10}$.

Mineral Group: Leucophoenicite group.

Occurrence: A late-stage hydrothermal or contact zone mineral in veins and skarns in a metamorphosed stratiform Zn-Mn orebody (Franklin, New Jersey, USA).

Association: Willemite, franklinite, calcite, vesuvianite, garnet, sussexite, rhodochrosite, pyrochroite, tephroite, sonolite, jerrygibbsite, glaucochroite, manganosite, copper, zincite (Franklin, New Jersey, USA); barysilite, spessartine, vesuvianite, barite, copper, hausmannite (Kombat mine, Namibia).

Distribution: At Franklin, Sussex Co., New Jersey, USA. From Pajsberg, Värmland, Sweden. In the Valsesia-Valtournanche area, Val d'Aosta, Italy. In the Kombat mine, 49 km south of Tsumeb, Namibia. From Hotazel, near Kuruman, Cape Province, South Africa.

Name: From the Greek for *pale* and *purplish red* in reference to its conspicuous color.

Type Material: Yale University, New Haven, Connecticut, 2.4830; Harvard University, Cambridge, Massachusetts, USA, 114565.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 63. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 103–105. (3) Moore, P.B. (1970) Edge-sharing silicate tetrahedra in the crystal structure of leucophoenicite. Amer. Mineral., 55, 1146–1166. (4) Dunn, P.J., C.A. Francis, and J. Innes (1988) A mcgovernite-like mineral and leucophoenicite from the Kombat mine, Namibia. Amer. Mineral., 73, 1182–1185.

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Leucophosphite $KFe_2^{3+}(PO_4)_2(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are diamond-shaped, to 1 cm, showing {100}, {210}, {111}, {$\overline{1}$11}; fine-grained, chalklike massive, amorphous in part.

Physical Properties: *Cleavage:* {100}, perfect. Hardness = n.d. D(meas.) = 2.948 D(calc.) = 2.911

Optical Properties: Semitransparent. *Color:* White, buff, yellow-brown, orange-brown, pink, greenish brown, brownish purple; may be grayish green in daylight, purplish gray in incandescent light. *Luster:* Vitreous to waxy, chalky.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 26°$. *Dispersion:* $r < v$, very strong. $\alpha = 1.707(2)$ $\beta = 1.721(2)$ $\gamma = 1.739(2)$ 2V(meas.) = n.d. 2V(calc.) = 84°

Cell Data: *Space Group:* $P2_1/n$. $a = 9.782(9)$ $b = 9.658(9)$ $c = 9.751(9)$ $\beta = 102.24(12)°$ Z = 4

X-ray Powder Pattern: Sapucaia mine, Brazil.
6.79 (10), 5.99(7), 3.06 (7), 2.916 (4), 2.829 (4), 7.60 (3), 4.76 (3)

Chemistry:

	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	34.99	36.05	Mn_2O_3	0.57		H_2O	11.29	11.44
Al_2O_3	0.25		Na_2O	0.53		Total	[100.00]	100.00
Fe_2O_3	41.35	40.55	K_2O	11.02	11.96			

(1) Sapucaia mine, Brazil; recalculated after deduction of insoluble 0.45% from an original total of 99.66%; corresponds to $(K_{0.93}Na_{0.04})_{\Sigma=0.97}(Fe_{2.05}Mn_{0.03}Al_{0.02})_{\Sigma=2.10}(PO_4)_{1.95}(OH)_{0.45}\cdot 2.01H_2O$.
(2) $KFe_2(PO_4)_2(OH)\cdot 2H_2O$.

Occurrence: Formed by reaction between bat or bird guano and earlier iron-bearing minerals; by hydrothermal alteration of iron-rich phosphates in complex granite pegmatites; crosscutting fluorapatite nodules in black shale; replacing fossil wood; in phosphate rock deposits.

Association: Variscite, "chalcedony", "opal" (Ninghanboun Hills, Australia); strengite, phosphosiderite (Liberia); cyrilovite, phosphosiderite, manganoan lipscombite, frondelite (Sapucaia mine, Brazil); vivianite, aluminian strengite, diadochite, ferrostrunzite, fluorapatite (Bethel Church, Indiana, USA); rockbridgeite, triphylite (Tip Top mine, South Dakota, USA).

Distribution: In Australia, from the Ninghanboun Hills, on the shore of Weelhamby Lake, Western Australia; in the Moculta phosphate quarry, northeast of Angaston, and at the Fairview quarry, near Robertstown, South Australia. In the Bomi Hill, Bambuta, and other caves, Liberia. In Namibia, from the Tsaobismund pegmatite, 60 km south of Karibib, and in the Sandamap pegmatite, west of Usakos. At Marivolanitra, Ambatofindrahana, Madagascar. From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, and in a cave at the west end of the Serra do Tamanduá, Minas Gerais, Brazil. In the USA, at the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from near Bethel Church, Pike Co., Indiana; large crystals in the Tip Top pegmatite, 8.5 km southwest of Custer, also at the Gap Lode, White Elephant, and Bull Moose mines, near Custer, Custer Co., South Dakota. In England, at Wheal Gorland, Gwennap, and the Gunheath china clay pit, St. Austell, Cornwall. From the Mangualde pegmatite, near Mesquitela, Portugal. On Rockall Island, North Atlantic. Several other minor localities are known.

Name: From the Greek for *white* and the *phosphate* in its composition.

Type Material: Western Australian Museum, Perth, Australia, M.69.1991, MDC6129; The Natural History Museum, London, England, 1932,1092; Harvard University, Cambridge, Massachusetts, 103879; National Museum of Natural History, Washington, D.C., USA, 96772.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 936. (2) Lindberg, M.L. (1957) Leucophosphite from the Sapucaia pegmatite mine, Minas Gerais, Brazil. Amer. Mineral., 42, 214–221. (3) Moore, P.B. (1972) Octahedral tetramer in the crystal structure of leucophosphite, $K_2[Fe_4^{3+}(OH)_2(H_2O)_2(PO_4)_4]\cdot 2H_2O$. Amer. Mineral., 57, 397–410.

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Leucosphenite $BaNa_4Ti_2B_2Si_{10}O_{30}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular and elongated ‖ [100], typically wedge-shaped, to 3 cm; as rosettes and laminated masses. *Twinning:* Common ⊥ {001}, contact plane {001}.

Physical Properties: *Cleavage:* {010}, {001}, distinct. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 3.04–3.09 D(calc.) = 3.103

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale to dark green, pale yellow, pale gray to blue; brown to black and sectored from inclusions. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $Y \wedge c \simeq 0°$. *Dispersion:* $r > v$, may be crossed. $\alpha = 1.644$–1.648 $\beta = 1.660$–1.664 $\gamma = 1.687$–1.691 2V(meas.) = 75°–78°

Cell Data: *Space Group:* $C2/m$. $a = 9.814(4)$ $b = 16.851(5)$ $c = 7.210(3)$ $\beta = 93.35(3)°$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
4.22 (100), 8.45 (90), 3.37 (70), 2.891 (60), 3.31 (50), 2.813 (40), 2.732 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	54.3	53.66	MnO	trace	0.00
TiO_2	13.92	14.52	MgO	0.15	0.00
ZrO_2	0.00	0.00	CaO	0.00	0.06
B_2O_3	6.36	6.6	SrO	0.03	
Al_2O_3	0.00	0.11	BaO	13.00	11.98
Fe_2O_3	0.28		Na_2O	10.70	11.61
Nb_2O_5	0.1	0.77	K_2O	0.79	0.51
FeO		0.04	H_2O	0.00	
			Total	99.63	99.86

(1) Inagli massif, Russia; corresponds to $(Ba_{0.94}Fe_{0.04}Mg_{0.04})_{\Sigma=1.02}(Na_{3.82}K_{0.18})_{\Sigma=4.00}$ $Ti_{1.92}B_{2.02}Si_{10}O_{29.95}$. (2) Mont Saint-Hilaire, Canada; by electron microprobe, corresponds to $(Ba_{0.94}Ca_{0.01})_{\Sigma=0.95}(Na_{4.10}K_{0.12})_{\Sigma=4.22}(Ti_{1.99}Nb_{0.06})_{\Sigma=2.05}B_{2.08}Si_{9.78}O_{29.90}$.

Occurrence: In pegmatite in syenite (Greenland, Russia, Canada); in aegirine-feldspar veins (Inagli massif, Russia); an authigenic mineral in shales (Utah and Wyoming, USA).

Association: Elpidite, aegirine, epididymite, albite, polylithionite (Narssârssuk, Greenland); arfvedsonite, eudialyte, neptunite, lamprophyllite, lorenzenite (Inagli massif, Russia); albite, aegirine, narsarsukite, molybdenite, calcite, fluorite (Mont Saint-Hilaire, Canada).

Distribution: From Narssârssuk, Greenland. In the USA, from the Green River Formation, in the Uinta basin, Utah and in the Bridger basin, Sweetwater Co., Wyoming. At Mont Saint-Hilaire, Quebec, Canada. From the Inagli massif, 30 km west of Aldan, Yakutia, and in the Lovozero massif, Kola Peninsula, Russia. From the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. At Ohmi, Niigata Prefecture, Japan.

Name: From the Greek for *white* and *wedge*, its color and crystal habit.

Type Material: University of Copenhagen, Copenhagen, Denmark; The Natural History Museum, London, England; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 135739, R3878.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 64. (2) Yefimov, A.F. and Z.T. Kataeava (1959) The first discovery of leucosphenite in

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the USSR. Doklady Acad. Nauk SSSR, 129, 896–899 (in Russian). (3) Chao, G.Y. and D.H. Watkinson (1972) Leucosphenite from Mont St. Hilaire, Quebec. Can. Mineral., 11, 851–860. (4) Pabst, A. and C. Milton (1972) Leucosphenite, and its occurrence in the Green River Formation of Utah and Wyoming. Amer. Mineral., 57, 1801–1822. (5) Malinovskii, Y.A., N.A. Yamnova, and N.V. Belov (1981) Refined crystal structure of leucosphenite. Doklady Acad. Nauk SSSR, 257, 1128–1132 (in Russian). (6) (1981) Chem. Abs., 95, 53078 (abs. ref. 5).

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Levinsonite-(Y) $(Y, Nd, Ce, Sm)Al(SO_4)_2(C_2O_4)\cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals are flattened on {101}, elongated along [101], showing {101}, {010}, and $\{10\bar{1}\}$, to 1 mm; in aggregates of crystals.

Physical Properties: *Cleavage:* On {101}, perfect. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.181 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \simeq c$; $Z \wedge c = 19°$. $\alpha = 1.48(1)$ $\beta = 1.49(1)$ $\gamma = 1.55(1)$ 2V(meas.) = 7(3)°

Cell Data: *Space Group:* $P2/n$. $a = 10.289(1)$ $b = 9.234(1)$ $c = 11.015(1)$ $\beta = 108.50(1)°$ $Z = 2$

X-ray Powder Pattern: Alum Cave Bluff, Tennessee, USA.
9.3 (100), 6.28 (90), 4.89 (60), 4.09 (50), 5.20 (40), 3.700 (30), 3.447 (30)

Chemistry:

	(1)		(1)
SO_3	24.58	Nd_2O_3	5.94
C_2O_3	[11.05]	Sm_2O_3	3.21
Al_2O_3	7.83	Eu_2O_3	0.54
Y_2O_3	5.72	Gd_2O_3	2.23
La_2O_3	0.50	Dy_2O_3	1.15
Ce_2O_3	3.02	Er_2O_3	0.29
Pr_2O_3	0.76	H_2O	[33.18]
		Total	[100.00]

(1) Alum Cave Bluff, Tennessee, USA; by electron microprobe, C_2O_3 and H_2O calculated from stoichiometry; corresponding to $(Y_{0.33}Nd_{0.23}Ce_{0.12}Sm_{0.12}Gd_{0.08}Dy_{0.04}Pr_{0.03}La_{0.02}Eu_{0.02}Er_{0.01})_{\Sigma=1.00}Al_{1.00}(SO_4)_{2.00}(C_{2.00}O_4)\cdot 12.00H_2O$.

Occurrence: Formed by evaporative precipitation during weathering of pyritiferous phyllite, the rare earths probably derived from monazite and xenotime.

Association: Zugshunstite-(Ce), epsomite, halotrichite.

Distribution: From Alum Cave Bluff, Great Smoky Mountains National Park, Tennessee, USA.

Name: To honor Dr. Alfred Abraham Levinson (1927–), mineralogist, University of Calgary, Calgary, Canada, who originated the nomenclature system in use for rare-earth-bearing minerals.

Type Material: University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA.

References: (1) Rouse, R.C., D.R. Peacor, E.J. Essene, T.D. Coskren, and R.J. Lauf (2001) The new minerals levinsonite-(Y) $[(Y, Nd, Ce)Al(SO_4)_2(C_2O_4)\cdot 12H_2O]$ and zugshunstite-(Ce) $[(Ce, Nd, La)Al(SO_4)_2(C_2O_4)\cdot 12H_2O]$: coexisting oxalates with different structures and differentiation of LREE and HREE. Geochim. Cosmochim. Acta, 65, 1101–1115. (2) (2001) Amer. Mineral., 86, 1535–1536 (abs. ref. 1).

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Lévyclaudite $Pb_8Sn_7Cu_3(Bi,Sb)_3S_{28}$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Levyne $(Ca, Na_2, K_2)Al_2Si_4O_{12}\cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Crystals are thin tabular $\perp$ {0001}, with faces typically striated and {0001} rounded, to 3 cm; in sheaflike or confused aggregates. *Twinning:* Penetration twins on {0001} ubiquitous.

Physical Properties: *Cleavage:* $\{10\bar{1}1\}$, indistinct. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 2.09–2.16 D(calc.) = 2.121

Optical Properties: Transparent to translucent. *Color:* Colorless, white; stained grayish, greenish, reddish, yellowish by impurities; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–); may be biaxial (–). ω = 1.496–1.505 ϵ = 1.491–1.500

Cell Data: *Space Group:* $R\bar{3}m$. a = 13.338(4) c = 23.014(9) Z = 3

X-ray Powder Pattern: Beech Creek, Oregon, USA.
4.084 (100), 2.805 (60), 6.69 (24), 8.15 (20), 3.854 (18), 3.156 (17), 3.338 (16)

Chemistry:

	(1)	(2)	(3)
SiO_2	46.76	43.88	49.76
Al_2O_3	21.91	22.73	19.09
CaO	11.12	10.57	8.88
Na_2O	1.34	2.01	1.71
K_2O	0.21	0.80	1.05
H_2O^+		14.87	
H_2O^-		5.67	
H_2O	18.65		19.51
Total	99.99	100.53	100.00

(1) Table Mountain, Colorado, USA. (2) Kuniga, Oki Islands, Japan; corresponds to $(Ca_{0.96}Na_{0.33}K_{0.09})_{\Sigma=1.38}Al_{2.27}Si_{3.72}O_{12}\cdot 5.8H_2O$. (3) Near Montresta, Sardinia, Italy; by electron microprobe, H_2O by TGA; corresponding to $(Ca_{0.79}Na_{0.27}K_{0.11})_{\Sigma=1.17}Al_{1.86}Si_{4.12}O_{12}\cdot 5.38H_2O$.

Mineral Group: Zeolite group.

Occurrence: Typically as a crystalline lining in cavities in basalts.

Association: Zeolites, especially offretite and erionite.

Distribution: Numerous localities, even for fine specimens. From near Dalsnipa, on Sandoy; Rossafelli and Nesvik, on Streymoy; and elsewhere on the Faeroe Islands. In Iceland, many localities, as at Mjöadalsá Canyon; Onundarfjord; Dyrafjord; around Berufjord, etc. In the USA, at Table Mountain, Jefferson Co., Colorado; from Spray, Wheeler Co., Beech Creek, Grant Co., and Goble, Colombia Co., Oregon. In Ireland, from Dungiven, Magilligan, and elsewhere in Co. Londonderry; and on Island Magee and in the Parkgate quarry, Templepatrick, Co. Antrim. From Cinchwad, Poona district, Maharashtra, India. Found at Flinders and on Victoria Island, Victoria, Australia.

Name: After Armand Lévy (1794–1841), French mineralogist and crystallographer.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 595.
(2) Sheppard, R.A., A.J. Gude 3d, G.A. Desborough, and J.S. White, Jr. (1974) Levyne-offretite intergrowths from basalt near Beech Creek, Grant County, Oregon. Amer. Mineral., 59, 837–842. (3) Passaglia, E. and E. Galli (1974) Levynes and erionites from Sardinia, Italy. Contr. Mineral. Petrol., 43, 253–259. (4) Merlino, S., E. Galli, and A. Alberti (1975) The crystal structure of levyne. Tschermaks Mineral. Petrog. Mitt., 22, 117–129. (5) Wise, W.S. and R.W. Tschernich (1976) The chemical compositions and origin of the zeolites offretite, erionite, and levyne. Amer. Mineral., 61, 853–863.

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Lewisite $(Ca, Fe^{2+}, Na)_2(Sb, Ti)_2O_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As minute octahedra, to 1 mm, and earthy masses. *Twinning:* On {111}, rare.

Physical Properties: *Cleavage:* {111}, nearly perfect. Hardness = 5.5 D(meas.) = 4.950 D(calc.) = 5.31

Optical Properties: Translucent. *Color:* Honey-yellow, amber-yellow, yellowish brown. *Streak:* Pale yellowish brown. *Luster:* Vitreous to resinous.
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group:* $Fd3m$ (ICDD 7-66). a = 10.264–10.306 Z = 8

X-ray Powder Pattern: Tripuhy, Brazil. (ICDD 7-66).
2.94 (100), 1.813 (100), 1.548 (100), 1.179 (50), 1.150 (50), 1.050 (50), 0.989 (50)

Chemistry:

	(1)	(2)
Sb_2O_5	67.52	65.52
TiO_2	11.35	11.70
FeO	4.55	6.79
MnO	0.38	
CaO	15.93	15.47
Na_2O	0.99	1.06
Total	100.72	100.54

(1–2) Tripuhy, Brazil.

Mineral Group: Stibiconite group.

Occurrence: In eluvial sands (Tripuhy, Brazil); an alteration of large tetrahedrite crystals (Johnny Lyon Hills, Arizona, USA).

Association: Mica, cinnabar, tripuhyite (Tripuhy, Brazil); tetrahedrite (Johnny Lyon Hills, Arizona, USA).

Distribution: At the Tripuhy cinnabar mine, Ouro Prêto, Minas Gerais, Brazil. Abundant from Tres Alamos Wash, in the Johnny Lyon Hills, Cochise Co., Arizona, USA. In the Miniera del Tafone, Grosseto, Tuscany, Italy.

Name: For William James Lewis (1847–1926), Professor of Mineralogy, Cambridge University, Cambridge, England.

Type Material: The Natural History Museum, London, England, 80141; National Museum of Natural History, Washington, D.C., USA, R5741.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 42–43. (2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1020–1022 [romeite, part]. (3) Hussak, E. and G.T. Prior (1895) Lewisite and zirkelite, two new Brazilian minerals. Mineral. Mag., 11, 80–83. (4) Machatschki, F. and O. Zedlitz (1932) Die Kristallstruktur des Lewisit. Zeits. Krist., 82, 72–76 (in German). (5) Baptista, A. (1981) Contribution to the study of lewisite and tripuhyite. Anais Acad. Brasileira Cienc., 53(2), 283–287 (in Portuguese). (6) (1981) Chem. Abs., 95, 207 (abs. ref. 5).

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Liandratite $U^{6+}(Nb,Ta)_2O_8$

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Crystal Data: Hexagonal; metamict. *Point Group:* $\overline{3}\ 2/m$. In crusts, to 2 mm thick, over petscheckite crystals.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3.5 D(meas.) = 7.0 (after heating). D(calc.) = 6.87 (for $U(Nb,Ta)_2O_8$ with Nb:Ta = 5:1). Radioactive.

Optical Properties: Translucent. *Color:* Yellow to yellow-brown. *Streak:* Pale yellow. *Luster:* Glassy.
Optical Class: Isotropic. $n = 1.83$

Cell Data: *Space Group:* $P\overline{3}1m$ after heating at 650 °C. $a = 6.36$ $c = 4.01$ Z = 1

X-ray Powder Pattern: Berere, Madagascar; after heating at 650 °C.
3.18 (10), 4.01 (8), 2.49 (4), 1.838 (3), 1.692 (2), 1.200 (2), 2.00 (1)

Chemistry:

	(1)	(2)
UO_3		49.22
UO_2	∼50.	
$(Nb,Ta)_2O_5$	∼50.	
Nb_2O_5		38.11
Ta_2O_5		12.67
H_2O	∼0.5	
Total		100.00

(1) Berere, Madagascar; by microchemical analysis. (2) $U(Nb,Ta)_2O_8$ with Nb:Ta = 5:1.

Occurrence: In a zoned pegmatite in amphibolite-grade gneiss, as an oxidized crust over petscheckite.

Association: Petscheckite, columbite, pyrochlore, strüverite, monazite, ilmenite, garnet, tourmaline, beryl, quartz, feldspar.

Distribution: From the Antsakoa I pegmatite, Fianavantsoa, near Berere, about 40 km northeast of Tsaratanana, Madagascar.

Name: Honors Professor George Liandrat, of Samoëns, France, who prospected in Madagascar.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145619.

References: (1) Mücke, A. and H. Strunz (1978) Petscheckite and liandratite, two new pegmatite minerals from Madagascar. Amer. Mineral., 63, 941–946.

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Liberite Li_2BeSiO_4

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Crystal Data: Monoclinic. *Point Group:* m. As aggregates of minute crystals, rarely showing pinacoidal faces.

Physical Properties: *Cleavage:* Perfect on {010}, distinct on {100} and {001}. *Tenacity:* Brittle. Hardness = ∼7 D(meas.) = 2.688(1) D(calc.) = [2.69]

Optical Properties: Transparent to translucent. *Color:* Pale yellow to brown; colorless in thin grains. *Luster:* Oily, vitreous on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z \wedge c = 41°$. $\alpha = 1.6220$ $\beta = 1.6332$ $\gamma = 1.6380$
2V(meas.) = 66°18′

Cell Data: *Space Group:* Pn. $a = 4.68$ $b = 4.95$ $c = 6.13$ $\beta = 90°30'$ Z = [2]

X-ray Powder Pattern: Synthetic.
3.84 (100), 3.72 (100), 2.596 (80), 2.349 (80), 2.471 (60), 2.273 (60), 3.41 (40)

Chemistry:

	(1)	(2)
SiO_2	48.39	52.26
Al_2O_3	0.26	
Fe_2O_3	0.11	
BeO	25.47	21.75
MgO	0.49	
CaO	0.29	
Li_2O	23.43	25.99
Na_2O	0.25	
K_2O	0.10	
H_2O^-	0.65	
Total	99.44	100.00

(1) "Nan Ling Ranges, south China." (2) Li_2BeSiO_4.

Occurrence: In veins cutting a lepidolite-fluorite-magnetite "ribbon rock" in tactite.

Association: Lepidolite, natrolite, eucryptite, hsianghualite, cassiterite, scheelite.

Distribution: At an undefined locality in the "Nan Ling Ranges, south China" [Hsianghua Ridge, Linwu Co., Hunan Province, China].

Name: Presumably for LIthium and BERyllium in the composition.

Type Material: Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 135815.

References: (1) Ch'un-Lin Chao (1964) Liberite (Li_2BeSiO_4), a new lithium-beryllium silicate mineral from the Nanling Ranges, south China. Ti Chih Hsueh Pao, 44, 334–342. (2) (1964) Chem. Abs., 61, 15841 (abs. ref. 1). (3) (1965) Amer. Mineral., 50, 519 (abs. ref. 1). (4) Han-Ching Chang (1966) Structural analysis of liberite. Ti Chih Hsueh Pao, 46, 76–86. (5) (1966) Chem. Abs., 65, 11457 (abs. ref. 4). (6) West, A. (1975) Crystal chemistry of liberite, Li_2BeSiO_4 and Li_2BeGeO_4. Bull. Soc. fr. Minéral., 98, 6–10.

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Libethenite $Cu_2(PO_4)(OH)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As wedge-topped prismatic crystals, elongated along [100] or [001], or equant to pseudo-octahedral, dominant forms include {110}, {011}, {111}, which may be striated, with a number of other forms noted, to 3 cm; in sprays of bladed to acicular crystals, and as druses; may be composite to compact fibrous.

Physical Properties: *Cleavage:* Imperfect on {100} and {010}. *Fracture:* Conchoidal to uneven. Hardness = 4 D(meas.) = 3.97 D(calc.) = 3.972

Optical Properties: Translucent. *Color:* Light to dark olive-green, dark green, blackish green, black; bluish green to pale green in transmitted light. *Luster:* Vitreous, greasy on fracture surfaces.
Optical Class: Biaxial (–). *Pleochroism:* May be faint; X = pale yellowish blue; Z = pale greenish blue. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, strong. $\alpha = 1.701$–1.704 $\beta = 1.743$–1.747 $\gamma = 1.787$–1.790 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/n$. $a = 8.062(5)$ $b = 8.384(4)$ $c = 5.881(2)$ $\beta =\sim 90°$ Z = 4

X-ray Powder Pattern: L'ubietová, Slovakia. (ICDD 36-404).
4.820 (100), 5.807 (80), 4.756 (70), 2.627 (60), 3.720 (50), 2.644 (40), 2.412 (30)

Chemistry:

	(1)	(2)	(3)
P_2O_5	29.31	26.46	29.69
As_2O_5		2.30	
CuO	66.42	66.29	66.54
H_2O	3.74	4.04	3.77
Total	99.47	99.09	100.00

(1) Mercedes mine, Coquimbo, Chile. (2) L'ubietová, Slovakia. (3) $Cu_2(PO_4)(OH)$.

Occurrence: An uncommon secondary mineral in the oxidized zone of copper deposits.

Association: Pseudomalachite, malachite, azurite, chrysocolla, iron oxides.

Distribution: Many minor localities, typically in small amounts. From L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. In England, good crystals at Wheal Phoenix, mines around Calstock, Illogan, and elsewhere in Cornwall. Around Nizhni Tagil, Ural Mountains, Russia. In Portugal, at the Miguel Vacas mine, near Vila Viçosa, and from near Alcoutim. Very large crystals from the Rokana mine, near Kitwe, and at Chingola, Zambia. At Kakanda, Mindouli, and Likasi, Katanga Province, Congo (Shaba Province, Zaire). From the Burra Burra mine, Mount Lofty Ranges, South Australia. In the USA, from the Empire-Nevada and Blue Jay mines, Yerington, Lyon Co., Nevada; at the Castle Dome mine, Globe-Miami, Gila Co., the Old Reliable mine, Copper Creek, Pinal Co., and elsewhere in Arizona; at the Santa Rita mine, Silver City, Grant Co., New Mexico. From Chuquicamata, Antofagasta, Chile.

Name: For the locality from which it was first described, L'ubietová, Slovakia (formerly Libethen, Hungary).

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 862–864. (2) Cordsen, A. (1978) A crystal-structure refinement of libethenite. Can. Mineral., 16, 153–157. (3) Keller, P., H. Hess, and F. Zettler (1979) Ladungsbilanzen an den verfeinerten Kristallstrukturen von Libethenit, Adamin und $Co_2[OH/AsO_4]$ und ihre Wasserstoffbrückenbindungen. Neues Jahrb. Mineral., Abh., 134, 147–156 (in German with English abs.). (4) Burns, P.C. and F.C. Hawthorne (1995) Rietveld refinement of the crystal structure of olivenite: a twinned monoclinic structure. Can. Mineral., 33, 885–888.

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Liddicoatite $Ca(Li,Al)_3Al_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$

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Crystal Data: Hexagonal. *Point Group:* 3*m*. Crystals stout prismatic, with curved convex trigonal outline, deeply striated ‖ [0001], to 25 cm.

Physical Properties: *Cleavage:* Poor on {0001}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 7.5 D(meas.) = 3.02 D(calc.) = 3.05

Optical Properties: Transparent to translucent. *Color:* Brown, green, pink, red, blue; commonly zoned parallel to pyramid faces. *Streak:* Very light brown. *Luster:* Vitreous on fractures.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; *O* = dark brown; *E* = light brown.
$\omega = 1.637$ $\epsilon = 1.621$

Cell Data: *Space Group: R3m.* $a = 15.875(3)$ $c = 7.126(2)$ $Z = 3$

X-ray Powder Pattern: Antsirabe, Madagascar. (ICDD 30-478).
2.933 (100), 2.559 (85), 3.962 (55), 4.197 (50), 3.445 (50), 2.025 (40), 1.9054 (35)

Chemistry:

	(1)
SiO_2	37.7
TiO_2	0.38
B_2O_3	10.89
Al_2O_3	37.9
FeO	0.83
MnO	0.27
MgO	0.11
CaO	4.21
Li_2O	2.48
Na_2O	0.88
F	1.72
H_2O^+	2.69
$-O = F_2$	0.72
Total	99.34

(1) Antsirabe, Madagascar; corresponds to $(Ca_{0.72}Na_{0.27})_{\Sigma=0.99}(Li_{1.59}Al_{1.13}Fe^{2+}_{0.11}Ti_{0.05}Mn_{0.04}Mg_{0.03})_{\Sigma=2.95}Al_6(BO_3)_3Si_{6.02}O_{18}[(OH)_{2.86}F_{0.87}O_{0.27}]_{\Sigma=4.00}$.

Mineral Group: Tourmaline group.

Occurrence: Detrital in soil, an apparent product of the local pegmatites.

Association: Quartz, elbaite, albite, micas.

Distribution: From Antsirabe, Tsilaizina, and Anjanabonoina, Madagascar. There are probably other localities but chemical analysis is required for distinction from other tourmaline group minerals.

Name: For Richard Thomas Liddicoat, Jr. (1918–), American gemologist.

Type Material: National Museum of Natural History, Washington, D.C., USA, 135815; The Natural History Museum, London, England, 1977,59.

References: (1) Dunn, P.J., D.E. Appleman, and J.E. Nelen (1977) Liddicoatite, a new calcium end-member of the tourmaline group. Amer. Mineral., 62, 1121–1124. (2) Nuber, B. and K. Schmetzer (1981) Strukturverfeinerung von Liddicoatit. Neues Jahrb. Mineral., Monatsh., 215–219 (in German with English abs.). (3) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 559–602.

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Liebauite $Ca_3Cu_5Si_9O_{26}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to < 0.03 mm.

Physical Properties: Hardness = 5–6 D(meas.) = n.d. D(calc.) = 3.62

Optical Properties: Transparent. *Color:* Bluish green. *Luster:* Vitreous.
Optical Class: Biaxial (+). $\alpha = 1.722(1)$ $\beta = 1.723(1)$ $\gamma = 1.734(1)$ 2V(meas.) = 72.8°

Cell Data: *Space Group:* $C2/c$. $a = 10.160(1)$ $b = 10.001(1)$ $c = 19.973(2)$
$\beta = 91.56(1)°$ Z = 4

X-ray Powder Pattern: Sattelberg volcano, Germany.
3.00 (100), 3.12 (90), 6.70 (70), 2.41 (70), 7.13 (60), 2.45 (60), 1.78 (50)

Chemistry:

	(1)
SiO_2	48.5
CuO	34.9
CaO	15.0
Total	98.4

(1) Sattelberg volcano, Germany; by electron microprobe, average of six analyses; corresponding to $Ca_{2.99}Cu_{4.91}Si_{9.05}O_{26}$.

Occurrence: In cavities in argillaceous sedimentary xenoliths subjected to very high-grade thermal metamorphism.

Association: Cuprorivaite, tenorite, volborthite, calciovolborthite.

Distribution: In Germany, at the Sattelberg and Nickenicher Sattel volcanos and the Emmelberg cone, near Kruft, Eifel district.

Name: For Dr. Friedrich Liebau, Kiel, Germany, prominent worker on silicate minerals.

Type Material: University of Würzburg, Würzburg; and University of Kiel, Kiel, Germany.

References: (1) Zöller, M.H., E. Tillmanns, and G. Hentschel (1992) Liebauite, $Ca_3Cu_5Si_9O_{26}$: a new silicate mineral with 14er single chain. Zeits. Krist., 200, 115–126. (2) (1993) Amer. Mineral., 78, 673 (abs. ref. 1).

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Liebenbergite $(Ni,Mg)_2SiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Grains, to 1 mm, filling interstices between trevorite grains.

Physical Properties: *Cleavage:* {010}, fair to poor; {100}, poor. Hardness = 6–6.5 D(meas.) = 4.60 D(calc.) = 4.60

Optical Properties: Transparent to translucent. *Color:* Yellowish green; colorless to pale green to greenish yellow in thin section.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = colorless to pale green; Z = greenish yellow. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.820(3)$ $\beta = [1.854]$ $\gamma = 1.888(3)$ 2V(meas.) = 88(2)°

Cell Data: *Space Group: Pbnm.* $a = 4.727(1)$ $b = 10.191(3)$ $c = 5.955(2)$ $Z = 4$

X-ray Powder Pattern: Bon Accord, South Africa.
2.442 (100), 2.759 (90), 1.738 (90), 2.503 (80), 3.47 (60), 5.09 (30), 2.252 (30)

Chemistry:

	(1)
SiO_2	29.39
FeO	4.37
CoO	1.80
NiO	56.32
MgO	6.50
Total	98.38

(1) Bon Accord, South Africa; by electron microprobe, average of eight grains; corresponds to $(Ni_{1.52}Mg_{0.33}Fe_{0.12}Co_{0.05})_{\Sigma=2.02}Si_{0.99}O_4$.

Mineral Group: Olivine group.

Occurrence: In a small tabular nickel deposit at the contact between quartzite and serpentinized ultramafics; it appears to have formed at ~730 °C and < 2 kbar during thermal metamorphism, possibly of a nickel-rich meteorite.

Association: Trevorite, nickeloan serpentine, nickeloan ludwigite, bunsenite, violarite, millerite, gaspéite, nimite, bonaccordite.

Distribution: From three km west of the Scotia Talc mine, Bon Accord, Barberton, Transvaal, South Africa.

Name: For W.R. Liebenberg, Deputy Director-General of the National Institute for Metallurgy of South Africa.

Type Material: Royal Ontario Museum, Toronto, Canada, M33443; Harvard University, Cambridge, Massachusetts, 133404; National Museum of Natural History, Washington, D.C., USA, 132463.

References: (1) De Waal, S.A. and L.C. Calk (1973) Nickel minerals from Barberton, South Africa: VI. Liebenbergite, a nickel olivine. Amer. Mineral., 58, 733–735. (2) Bish, D.L. (1981) Cation ordering in synthetic and natural Ni–Mg olivine. Amer. Mineral., 66, 770–776.

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Liebigite $Ca_2(UO_2)(CO_3)_3 \cdot 11H_2O$

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Crystal Data: Orthorhombic. *Point Group:* *mm*2. Crystals are rare, short prismatic along [001], or equant, rounded with convex or vicinal faces, to 5 mm; scaly or granular, in aggregates, crusts, and films.

Physical Properties: *Cleavage:* On {100}. Hardness = 2–3 D(meas.) = 2.41 D(calc.) = 2.41 Radioactive; strong green to blue-green fluorescence under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Apple-green, siskin-green, yellowish green. *Luster:* Vitreous to pearly on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* X = nearly colorless; $Y = Z$ = pale yellowish green. *Orientation:* X = a. *Dispersion:* $r > v$, moderate. α = 1.494–1.501 β = 1.498–1.505 γ = 1.535–1.542 2V(meas.) = 37°–42°

Cell Data: *Space Group:* *Bba*2. a = 16.699(3) b = 17.557(3) c = 13.697(2) Z = 8

X-ray Powder Pattern: Jáchymov, Czech Republic.
6.81 (10), 8.68 (9), 5.40 (9), 4.55 (6), 3.10 (6), 3.33 (5), 3.31 (5)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	23.87	18.12	CaO	15.56	15.40
UO_2	37.11		H_2O	23.35	27.21
UO_3		39.27	Total	99.89	100.00

(1) Jáchymov, Czech Republic. (2) $Ca_2(UO_2)(CO_3)_3 \cdot 11H_2O$.

Occurrence: An uncommon secondary mineral typically formed as an alteration product of uraninite in alkaline carbonate solutions.

Association: Uraninite, schröckingerite, uranophane-beta, tyuyamunite, autunite, uranophane, bayleyite, carnotite, gypsum, calcite.

Distribution: From Edirne (Adrianople) Province, Turkey. Abundant in a number of mines around Jáchymov (Joachimsthal), Czech Republic. In Germany, from Schneeberg, Saxony; at Eisleben and Hasserode, Saxony-Anhalt; and from Müllenbach, near Baden-Baden, Black Forest. At Schmiedeberg, Poland. From Wheal Basset, Redruth, Cornwall, England. At Tyndrum, Perthshire, Scotland. From the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, France. In the USA, at the Midnite mine, Wellpinit, Stevens Co., Washington; in the Schwartzwalder mine, near Golden, Jefferson Co., Colorado; in Wyoming, in the Pumpkin Buttes area, Powder River basin, and at the Silver Cliff mine, Lusk, Niobrara Co., and in the Lucky Mc mine, Wind River basin, Fremont Co.; from the Black Ape mine, Thompsons district, Grand Co., and in the Mi Vida mine, Big Indian district, San Juan Co., Utah; at Ambrosia Lake and Westwater Canyon, Grants district, McKinley Co., New Mexico; from Mt. Pisgah, Jim Thorpe, Carbon Co., Pennsylvania. At Rabbit Lake, Saskatchewan, Canada. In the Tono mine, Gifu Prefecture, Japan. From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Professor Justus von Liebig (1803–1873), German chemist, University of Munich, Munich, Germany.

Type Material: American Museum of Natural History, New York, New York, USA, 16847.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 240–241. (2) Evans, H.T., Jr., and C. Frondel (1950) Studies of uranium minerals (II): liebigite and uranothallite. Amer. Mineral., 35, 251–254. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 108–112. (4) Mereiter, K. (1982) The crystal structure of liebigite, $Ca_2UO_2(CO_3)_3 \cdot \sim 11H_2O$. Tschermaks Mineral. Petrog. Mitt., 30, 277-288.

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Likasite $Cu_3(NO_3)(OH)_5 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 1.5 mm, show a rectangular section, tabular on {001}, with {010}, {100}, {101}, {012}, {014}, {018}.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. D(meas.) = 2.96–2.98 D(calc.) = 2.97

Optical Properties: Transparent. *Color:* Sky-blue.
Optical Class: Biaxial. *Pleochroism:* X = pale greenish blue; Y = purplish blue. *Orientation:* $X = a$; $Z = b$. $\alpha = 1.61$–1.615 β = n.d. $\gamma = 1.685$–1.69 2V(meas.) = n.d.

Cell Data: *Space Group: Pcmn.* $a = 5.830(1)$ $b = 6.775(1)$ $c = 21.711(5)$ Z = 4

X-ray Powder Pattern: Likasi, Congo.
5.75 (FFF), 10.8 (FF), 2.722 (mF), 2.518 (mF), 2.168 (mF), 3.23 (m), 3.18 (m)

Chemistry: (1) Composition established by crystal-structure analysis.

Occurrence: A rare secondary mineral in the oxidized zone of copper deposits.

Association: Cuprite, brochantite, malachite, copper, silver, buttgenbachite, gerhardtite, miersite, iron oxides (Likasi mine, Congo).

Distribution: From Likasi, Katanga Province, Congo (Shaba Province, Zaire). At Dzhezkazgan, Kazakhstan. In the Hingston Down quarry, Calstock, Cornwall, England. From Huelgoat, Brittany, France. In the Copper Cities deposit, Gila Co., Arizona, USA. From the Spring Creek mine, near Wilmington, South Australia.

Name: For the locality where it was first found, Likasi, Congo.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM655; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 107463, 112521, 137714.

References: (1) Schoep, A., W. Borchert, and K. Kohler (1955) La likasite $Cu_{12}(OH)_{12}(NO_3)_4(PO_4)_2$, nouveau minéral. Bull. Minéral., 78, 84–88 (in French). (2) (1955) Amer. Mineral., 40, 942 (abs. ref. 1). (3) Deliens, M. (1973) La likasite de Likasi (République du Zaïre). Bull. Minéral., 96, 143–145 (in French). (4) Effenberger, H. (1986) Likasite, $Cu_3(OH)_5(NO_3) \cdot 2H_2O$: revision of the chemical formula and redetermination of the crystal structure. Neues Jahrb. Mineral., Monatsh., 101–110.

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Lileyite $Ba_2(Na,Fe,Ca)_3MgTi_2(Si_2O_7)_2O_2F_2$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. Crystals elongated platy, to 0.3 mm. Dominant form {100}.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3-4 D(meas.) = n.d. D(calc.) = 3.776

Optical Properties: Transparent. *Color:* Brown. *Streak:* White. *Luster:* n.d. *Optical Class:* Biaxial (+). α = 1.718(5) β = 1.735(5) γ = 1.755(5) 2V (meas.) = 75(15)° 2V (calc.) = 86° *Dispersion*: *r* > *v*, medium. *Orientation*: *X* = *a*; *Y* = elongation. *Pleochroism*: Medium, *Z* = greyish-brown; *Y* = light brown; *X* = colorless. *Absorption*: *Z* > *Y* > *X*.

Cell Data: *Space Group: C2/m*. *a* = 19.905(1) *b* = 7.098(1) *c* = 5.405(1) β = 96.349(5)° *Z* = 2

X-ray Powder Pattern: Löhley quarry, Germany.
2.792 (100), 3.464 (76), 2.672 (54), 2.140 (52), 3.749 (45), 2.624 (43), 3.045 (37)

Chemistry:

	(1)
SiO_2	28.05
BaO	26.39
TiO_2	18.53
Na_2O	6.75
MgO	4.58
FeO	4.48
CaO	2.3
SrO	2.23
MnO	1.44
K_2O	1.41
Nb_2O_5	0.95
F	3.88
$-O=F_2$	1.63
Total	99.36

(1) Löhley quarry, Germany; average of 5 SEM-EDX analyses; corresponding to $Ba_{1.50}Sr_{0.19}K_{0.26}Na_{1.89}Ca_{0.36}Mn_{0.18}Mg_{0.99}Fe_{0.54}Ti_{2.01}Nb_{0.06}Si_{4.06}O_{16.23}F_{1.77}$.

Mineral Group: Lamprophyllite group.

Occurrence: Occurs in miarolitic cavities in an alkaline basalt.

Association: Nepheline, leucite, augite, magnetite, fluorapatite, perovskite, götzenite.

Distribution: Löhley quarry, Üdersdorf, near Daun, Eifel Mountains, Rhineland-Palatinate (Rheinland-Pfalz), Germany.

Name: For the old name of the first known locality, Liley, Germany.

Type Material: A.E. Fersman Mineralogical Museum , Russian Academy of Sciences, Moscow, Russia, 4106/1.

References: (1) Chukanov, N.V., I.V. Pekov, R.K. Rastsvetaeva, S.M. Aksenov, A.E. Zadov, K.V. Van, G. Blass, W. Shüller, and B. Ternes (2012) Lileyite, $Ba_2(Na,Fe,Ca)_3MgTi_2(Si_2O_7)_2O_2F_2$, a new lamprophyllite-group mineral from the Eifel volcanic area, Germany. European Journal of Mineralogy, 24, 181-188. (2) (2013) Amer. Mineral., 98, 1080-1081 (abs. ref. 1).

Lillianite $Pb_3Bi_2S_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Elongated platy crystals, to 1 mm; also fibrous and granular massive.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–3 VHN = n.d.
D(meas.) = 7.02–7.16 D(calc.) = 7.09

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Distinct.
R: (400) 47.8, (420) 47.0, (440) 46.2, (460) 45.4, (480) 44.7, (500) 44.0, (520) 43.5, (540) 43.1, (560) 42.8, (580) 42.8, (600) 42.8, (620) 42.8, (640) 42.9, (660) 43.0, (680) 43.0, (700) 43.1

Cell Data: *Space Group: Bbmm.* $a = 13.535(3)$ $b = 20.451(5)$ $c = 4.104(1)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.52 (100), 2.913 (80), 3.42 (70), 1.777 (70), 3.01 (60), 2.778 (60), 2.070 (60)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Pb	49.61	45.33	50.45	Bi	31.31	33.97	33.93
Ag	2.17	2.68		Sb	0.57		
Cu	0.14	0.4		S	15.35	15.54	15.62
Fe		0.08		Total	99.15	98.0	100.00

(1) Spokoinoe deposit, Russia; corresponds to $(Pb_{3.00}Ag_{0.25}Cu_{0.03})_{\Sigma=3.28}(Bi_{1.88}Sb_{0.06})_{\Sigma=1.94}S_{6.00}$. (2) Baoshan mine, Hunan Province, China; by electron microprobe, corresponds to $(Pb_{2.71}Ag_{0.31}Cu_{0.08})_{\Sigma=3.10}Bi_{2.01}S_{6.00}$. (2) $Pb_3Bi_2S_6$.

Polymorphism & Series: Forms a series with gustavite.

Occurrence: In hydrothermal deposits of probable high-temperature origin.

Association: At a number of early reported occurrences the "lillianite" was shown to be mixtures, especially of galena and galenobismutite; cosalite, cannizzarite, sphalerite.

Distribution: In the USA, the "type locality" [Lillian mine, Leadville, Lake Co., Colorado] has been discredited; found at Twin Lakes, Fresno Co., California. At Yecora, five km west of Iglesia, Sonora, Mexico. From the Ivigtut cryolite deposit, southwestern Greenland. In Russia, at the Spokoinoe and Bukuka tungsten deposits, eastern Transbaikal. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In Finland, at Jilijärvi, near Orijärvi. From the Felbertal tungsten mine, Salzburg, Austria. Found near Narechenski Basni, southern Rhodope Mountains, Bulgaria. On Vulcano, in the Lipari Islands, Italy. From the Baoshan mine, Hunan Province, China. At the Tsubakihara mine, Gifu Prefecture, Japan. A few additional localities for mixed lillianite–gustavite are known.

Name: For the Lillian mine, Leadville, Colorado, USA, the discredited type locality.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 404–406. (2) Syritso, L.F. and V.M. Senderova (1964) The problem of the existence of lillianite. Zap. Vses. Mineral. Obshch., 93, 468–471 (in Russian). (3) Klyakhin, V.A. and M.T. Dmitrieva (1969) New data on synthetic and natural lillianite. Doklady Acad. Nauk SSSR, 178, 173–175 (in Russian). (4) Takagi, J. and Y. Takéuchi (1972) The crystal structure of lillianite. Acta Cryst., 28, 649–651. (5) Pring, A., M. Jercher, and E. Makovicky (1999) Disorder and compositional variation in the lillianite homologous series. Mineral. Mag., 63, 917–926. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 321.

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Lime CaO

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. [Massive.]

Physical Properties: *Cleavage:* {001}, perfect; parting on {011} (synthetic). Hardness = 3.5 D(meas.) = n.d. D(calc.) = 3.35

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Isotropic. $n = 1.837$

Cell Data: *Space Group:* $Fm3m$ (synthetic). $a = 4.81059(9)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.4059 (100), 1.7009 (54), 2.777 (34), 1.4505 (16), 1.3888 (16), 1.0758 (16), 0.8018 (16)

Chemistry: No analyses of natural material appear to be available.

Occurrence: In thermally metamorphosed calcareous ejecta (Vesuvius, Italy); in burning coal measures (Kopeysk, Russia).

Association: Calcite (Vesuvius, Italy); fluorellestadite, periclase, magnesioferrite, hematite, srebrodolskite, anhydrite (Kopeysk, Russia).

Distribution: On Vesuvius, Campania, Italy. From around Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia. In the Campbell mine, Bisbee, Cochise Co., Arizona, USA.

Name: From the Old English, *quicklime*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 503. (2) McMurdie, H. (1986) Powder Diff., 1, 266.

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Linarite $PbCu(SO_4)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [010], typically tabular on $\{\overline{1}01\}$ or {001}, with large {110} and well developed [*h*0*l*], with about another 40 forms known, to 8 cm; in crusts and aggregates. *Twinning:* On {100}, common; also on {001}.

Physical Properties: *Cleavage:* On {100}, perfect; on {001}, interrupted. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 5.35 D(calc.) = 5.33

Optical Properties: Transparent to translucent. *Color:* Bright to dark azure-blue; deep blue in transmitted light. *Streak:* Pale blue. *Luster:* Vitreous to subadamantine. *Optical Class:* Biaxial (–). *Pleochroism:* X = pale blue; Y = blue; Z = Prussian blue. *Orientation:* $Z = b$; $X \wedge c \simeq -24°$. *Dispersion:* $r < v$, strong. $\alpha = 1.809$ $\beta = 1.838$ $\gamma = 1.859$ 2V(meas.) = 80°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.701(2)$ $b = 5.650(2)$ $c = 4.690(2)$ $\beta = 102.65(2)°$ Z = 2

X-ray Powder Pattern: Red Gill mine, England.
3.12 (10), 3.53 (7), 1.719 (6b), 4.48 (4), 2.16 (4), 2.09 (4), 2.56 (3)

Chemistry:

	(1)	(2)
SO_3	19.95	19.97
CuO	19.63	19.85
PbO	55.97	55.69
H_2O	4.45	4.49
Total	[100.00]	100.00

(1) Arenas, Italy; recalculated to 100% after deduction of ZnO 0.04% and MgO 0.26%.
(2) $PbCu(SO_4)(OH)_2$.

Occurrence: An uncommon secondary mineral in the oxidized zone of Pb–Cu deposits.

Association: Brochantite, anglesite, caledonite, leadhillite, cerussite, malachite, hemimorphite.

Distribution: In small amounts from many localities, of which only a few are given here. From Linares, Jaén Province, Spain. At Arenas and San Giovanni, Sardinia, Italy. Fine crystals from the Red Gill and other mines, Caldbeck Fells, Cumbria, England. At Leadhills, Lanarkshire, Scotland. Large crystals in the Kisamori mine, Akita Prefecture, Japan. In Australia, from Broken Hill, New South Wales. In the USA, large crystals at the Mammoth-St. Anthony mine, Tiger, Pinal Co., and in the Grand Reef mine, Santa Teresa Mountains, Graham Co., Arizona; from the Blanchard and Mex-Tex mines, near Bingham, Hansonburg district, Socorro Co., New Mexico; in the Tintic district, Juab Co., Utah; at Cerro Gordo, Inyo Co., and on the Blue Bell claims, near Baker, San Bernardino Co., California. Large crystals from Tsumeb, Namibia.

Name: For its occurrence at Linares, Spain.

Type Material: Mining Academy, Freiberg, Germany, 46.527.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 553–555. (2) Effenberger, H. (1987) Crystal structure and chemical formula of schmiederite, $Pb_2Cu_2(OH)_4(SeO_3)(SeO_4)$, with a comparison to linarite, $PbCu(OH)_2(SO_4)$. Mineral. Petrol., 36, 2–12. (3) Berry, L.G. (1951) The unit cell of linarite. Amer. Mineral., 36, 511—512.

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Lindackerite $(Cu,Co)_5(AsO_4)_2(AsO_3OH)_2 \cdot 10H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals are lathlike, showing {010}, {001}, {101}, to 0.3 mm; in rosettes and crusts.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Conchoidal. Hardness = 2–2.5 D(meas.) = 3.35(2) D(calc.) = 3.37(1)

Optical Properties: Transparent. *Color:* Apple-green; pale green to colorless in transmitted light. *Streak:* Pale green to white. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; $X = Y$ = colorless; Z = green. *Orientation:* $Y \wedge a = 21.3°$ on {010} and 34.4° on {001}. *Dispersion:* $r < v$, strong. $\alpha = 1.626$–1.632 $\beta = 1.662$ $\gamma = 1.725$–1.728 2V(meas.) = 74° 2V(calc.) = 72°–73°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 8.035(2)$ $b = 10.368(4)$ $c = 6.453(2)$ $\alpha = 79.60(3)°$ $\beta = 84.83(3)°$ $\gamma = 86.17(3)°$ Z = 1

X-ray Powder Pattern: Jáchymov, Czech Republic.
10.2 (100), 8.02 (70), 3.668 (60), 3.154 (60), 2.665 (50), 4.001(40), 3.064 (40)

Chemistry:

	(1)	(2)	(3)
As_2O_5	44.2	44.64	43.71
CoO		3.39	1.24
NiO		0.00	0.50
CuO	39.4	33.04	36.47
H_2O	16.4	[18.93]	[18.08]
Total	100.0	[100.00]	[100.00]

(1) Jáchymov, Czech Republic. (2) Do.; by electron microprobe, H_2O by difference, corresponds to $(Cu_{4.36}Co_{0.47})_{\Sigma=4.83}(AsO_4)_{2.03}[(AsO_3)_{2.03}(OH)_{1.55}] \cdot 10.2H_2O$. (3) Cap Garonne mine, France; by electron microprobe, H_2O by difference; corresponds to $(Cu_{4.90}Co_{0.18}Ni_{0.07})_{\Sigma=5.15}(AsO_4)_{2.02}[(AsO_3)_{2.03}(OH)_{2.21}] \cdot 9.61H_2O$.

Occurrence: In the oxidized zone of some arsenic-rich copper deposits.

Association: Erythrite, pitticite, annabergite, lavendulan (Jáchymov, Czech Republic); olivenite, chalcanthite, antlerite, pushcharovskite, covellite, tennantite, quartz (Cap Garonne mine, France).

Distribution: From the Geister and Červená veins, Eliáš mine, Jáchymov (Joachimsthal), Czech Republic. At the Cap Garonne mine, near le Pradet, Var, and in the Salsigne mine, 15 km north of Carcassone, Aude, France. From the Carmenes copper mine, Villamanin, Léon Province, Spain. Found at the Talmessi mine, 35 km west of Anarak, Iran.

Name: To honor Joseph Lindacker, Austrian pharmacist-chemist, who made the first analyses.

Type Material: National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1007–1008. (2) Sarp, H. and B. Dominik (1995) Redefinition of lindackerite: new chemical formula and new crystallographic and optical data. Archs Sci. Genève, 48(3), 239–250 (in French with English abs.).

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Lindgrenite $Cu_3(MoO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tabular or platy on {010}, to 2 cm, showing {010}, may be striated ‖ [001], showing forms {100}, {021}, and a number of others; rarely acicular along [101] with square outline; as crusts, massive.

Physical Properties: *Cleavage:* {010}, perfect; {101} and {100}, very poor. Hardness = 4.5 D(meas.) = 4.20 D(calc.) = 4.29

Optical Properties: Transparent. *Color:* Green, yellowish green; pale green to yellow-green in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 9°$. *Dispersion:* $r > v$. $\alpha = 1.930(3)$ $\beta = 2.002(3)$ $\gamma = 2.020(3)$ 2V(meas.) = 71°

Cell Data: *Space Group:* $P2_1/n$. $a = 5.608(1)$ $b = 14.023(3)$ $c = 5.394(1)$ $\beta = 98.50(1)°$ Z = 2

X-ray Powder Pattern: Chuquicamata, Chile. (ICDD 36-405).
3.521 (100), 3.479 (65), 4.164 (50), 2.684 (40), 3.583 (30), 2.724 (25), 2.777 (20)

Chemistry:

	(1)	(2)	(3)
MoO_3	53.71	52.88	52.87
SiO_2		0.10	
FeO		0.08	
CuO	42.81	43.01	43.82
PbO		0.46	
H_2O	3.48	[3.30]	3.31
Total	[100.00]	[99.82]	100.00

(1) Chuquicamata, Chile; recalculated from an original total of 99.66% after deduction of Fe_2O_3 1.43% and SiO_2 3.34%; corresponds to $Cu_{2.88}(MoO_4)_{2.00}(OH)_{2.08}$. (2) Do.; by electron microprobe, average of ten analyses; total Fe as FeO, H_2O calculated from stoichiometry; corresponds to $Cu_{2.95}Si_{0.01}Fe_{0.01}Pb_{0.01}(MoO_4)_{2.01}(OH)_2$. (2) $Cu_3(MoO_4)_2(OH)_2$.

Occurrence: An uncommon secondary mineral in the oxidized zone of molybdenum-bearing copper deposits.

Association: Antlerite, molybdenite, powellite, brochantite, chrysocolla, iron oxides, quartz.

Distribution: In Chile, from Chuquicamata, Antofagasta; at the San Samuel mine, Carrara Pinto, and in the Jardinera No. 1 mine, five km east of Inca de Oro, Atacama. From the Brandy Gill mine, Caldbeck Fells, Cumbria, England. In the USA, at the Lodi No. 4 mine, Spring Creek district, Plumas Co., California; from Arizona, in the Live Oak pit, Inspiration mine, Globe-Miami district, Gila Co.; in the Cave Creek district, Maricopa Co.; at the Esperanza mine, Pima Co.; in the Childs-Aldwinkle mine, Copper Creek district, and on the Hull claims, south of Ray, Pinal Co.; from the Helena mine, Seven Devils district, Adams Co., Idaho.

Name: Honors Professor Waldemar Lindgren (1860–1939), Swedish–American economic geologist, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

Type Material: The Natural History Museum, London, England, 1936,102; Harvard University, Cambridge, Massachusetts, USA, 97527, 97528.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1094–1095. (2) Hawthorne, F.C. and R.K. Eby (1985) Refinement of the crystal structure of lindgrenite. Neues Jahrb. Mineral., Monatsh., 234–240. (3) Francis, C.A., L.C. Pitman, and D.E. Lange (1997) Szenicsite, a new copper molybdate from Inca de Oro, Atacama, Chile. Mineral. Record, 28, 387–394. (4) Palache, C. (1935) Lindgrenite, a new mineral. Amer. Mineral., 20, 484–491.

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Lindqvistite $\mathbf{Pb_2(Mn^{2+},Mg)Fe^{3+}_{16}O_{27}}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As subhedral crystals, tabular on {0001}, to 5 mm.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Brittle. Hardness = ∼6 VHN = 818–898, 857 average (100 g load). D(meas.) = n.d. D(calc.) = 5.76(1)

Optical Properties: Opaque. *Color:* Black; gray with a faint brownish tint in reflected light. *Streak:* Brownish black. *Luster:* Submetallic.
Optical Class: Uniaxial. *Anisotropism:* Moderate; in bluish gray to browns.
Bireflectance: Weak.
R_1–R_2: (470) 23.7–22.0, (546) 22.7–21.5, (589) 22.0–21.1, (650) 21.3–20.7

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.951(1)$ $c = 33.358(4)$ $Z = 2$

X-ray Powder Pattern: Jakobsberg, Sweden.
2.624 (100), 2.802 (95), 2.612 (90), 2.975 (70), 3.011 (60), 4.168 (55), 3.334 (40)

Chemistry:

	(1)
SiO_2	0.16
TiO_2	0.12
Al_2O_3	0.07
Fe_2O_3	67.49
MnO	5.13
ZnO	0.17
PbO	25.95
MgO	1.62
BaO	0.03
Cl	0.00
Total	100.74

(1) Jakobsberg, Sweden; by electron microprobe, average of six analyses, all Mn as Mn^{2+} from associated minerals, Fe^{2+} absent by Mössbauer spectroscopy; corresponds to $Pb_{2.04}Mn^{2+}_{1.27}Mg_{0.71}Zn_{0.04}Fe^{3+}_{14.84}Si_{0.05}Ti_{0.03}Al_{0.02}O_{27}$.

Occurrence: In a regionally metamorphosed lead-bearing Fe–Mn skarn deposit.

Association: Jacobsite, plumboferrite, hematite, phlogopite, andradite, calcite, hedyphane, barite, copper, cuprite, malachite, azurite.

Distribution: From Jakobsberg, Värmland, Sweden.

Name: For Dr. Bengt Lindqvist (1927–), formerly Senior Curator of the Swedish Museum of Natural History, Stockholm, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 38126; The Natural History Museum, London, England, 1992,375.

References: (1) Holtstam, D. and R. Norrestam (1993) Lindqvistite, $Pb_2MeFe_{16}O_{27}$, a novel hexagonal ferrite mineral from Jakobsberg, Filipstad, Sweden. Amer. Mineral., 78, 1304–1312.

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Lindsleyite $(Ba,Sr)(Ti,Cr,Fe,Mg,Zr)_{21}O_{38}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ or 3. Grains, to 5 mm, rimmed by and enclosed in other minerals.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = [1378–1714, 1505 average (100 g load)] ("comparable to mathiasite"). D(meas.) = n.d. D(calc.) = 4.63

Optical Properties: Opaque. *Color:* Black; tan in reflected light. *Luster:* Metallic. *Optical Class:* Uniaxial. *Pleochroism:* Weak; buff-white to tan. *Anisotropism:* Weak; pale tan to brown.
R_1–R_2: (400) 19.4–19.8, (420) 19.0–19.2, (440) 18.6–18.9, (460) 18.1–18.4, (480) 17.8–18.1, (500) 17.5–17.8, (520) 17.2–17.5, (540) 17.1–17.3, (560) 16.9–17.1, (580) 16.7–17.0, (600) 16.7–16.9, (620) 16.6–16.9, (640) 16.5–16.8, (660) 16.5–16.9, (680) 16.5–16.9, (700) 16.5–16.9

Cell Data: *Space Group:* $R\overline{3}$ or $R3$. $a = 10.37$ $c = 20.52$ $Z = 3$

X-ray Powder Pattern: South Africa.
2.13 (100), 1.80 (100), 1.59 (100), 1.44 (100), 2.87 (70), 2.83 (70), 1.50 (50)

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	0.02	2.04	V_2O_3		0.78
Ta_2O_5	0.03		FeO	11.20	8.92
V_2O_5	0.98		MnO	0.19	
SiO_2	0.00	0.17	PbO	0.07	
TiO_2	54.28	53.30	MgO	3.54	3.76
ZrO_2	4.02	4.39	CaO	0.42	0.38
Al_2O_3	0.09	0.27	SrO	1.69	0.93
La_2O_3		1.48	BaO	4.60	5.07
CeO_2		0.11	Na_2O	0.01	
RE_2O_3	2.21		K_2O	0.21	0.29
Cr_2O_3	16.22	17.19	Total	99.78	99.08

(1) De Beers mine, South Africa; by electron microprobe, all Fe as FeO, $RE_2O_3 = La_2O_3$ 0.05%, Ce_2O_3 1.36%, Nd_2O_3 0.01%, Eu_2O_3 0.08%, Tb_2O_3 0.04%, Ho_2O_3 0.03%, Er_2O_3 0.27%, Tm_2O_3 0.19%, Lu_2O_3 0.18%; corresponds to $(Ba_{0.55}Sr_{0.30}RE_{0.25}Ca_{0.14}Pb_{0.11}K_{0.08}Na_{0.01})_{\Sigma=1.44}(Ti_{12.36}Cr_{3.88}Fe_{2.84}Mg_{1.60}Zr_{0.59}V_{0.20}Mn_{0.05}Al_{0.03})_{\Sigma=21.55}O_{38}$. (2) Shandong Province, China; corresponds to $(Ba_{0.58}La_{0.16}Ca_{0.12}K_{0.11}Ce_{0.01})_{\Sigma=0.98}(Ti_{11.8}Cr_{4.00}Fe_{2.19}Mg_{1.65}Zr_{0.63}Nb_{0.27}V_{0.15}Al_{0.09}Si_{0.05})_{\Sigma=20.83}O_{38}$.

Mineral Group: Crichtonite group.

Occurrence: A mantle-derived phase in veinlets in metasomatized kimberlite (South Africa).

Association: Mathiasite, phlogopite, perovskite, chromian diopside, potassian richterite, Nb–Cr rutile, Mg–Cr–Nb ilmenite, chromian spinel (South Africa).

Distribution: From the De Beers and Bultfontein diamond mines, Kimberley, Cape Province, South Africa. At an undisclosed locality [Yimeng Mountain area] in Shandong Province, China.

Name: For Professor Donald Hale Lindsley (1934–), State University of New York, Stony Brook, New York, USA, for his work in high-pressure petrology.

Type Material: South African National Museum, Cape Town, South Africa; The Natural History Museum, London, England; National Museum of Natural History, Washington, D.C., USA.

References: (1) Haggerty, S.E., J.R. Smyth, A.J. Erlank, R.S. Rickard, and R.V. Danchin (1983) Lindsleyite (Ba) and mathiasite (K): two new chromium-titanates in the crichtonite series from the upper mantle. Amer. Mineral., 68, 494–505. (2) Zhang Jianhong, Ma Jianguo, and Li Liangjing (1988) The crystal structures and crystal chemistry of lindsleyite and mathiasite. Dizhi Lunp'ing [Geological Review], 34(2), 132–144 (in Chinese with English abs.).

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Lindströmite $Pb_3Cu_3Bi_7S_{15}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are prismatic, elongated and striated along [001], to 1 cm.

Physical Properties: *Cleavage:* Good on {100} and {010}; also on {230}. *Fracture:* Conchoidal to uneven. Hardness = 3–3.5 VHN = n.d. D(meas.) = 7.01 D(calc.) = 7.03

Optical Properties: Opaque. *Color:* Lead-gray. *Streak:* Black. *Luster:* Metallic. R_1–R_2: (400) 42.3–46.0, (420) 42.2–45.8, (440) 42.1–45.6, (460) 42.0–45.4, (480) 41.8–45.3, (500) 41.6–45.2, (520) 41.4–45.3, (540) 41.1–45.4, (560) 41.0–45.5, (580) 40.7–45.3, (600) 40.3–45.1, (620) 40.1–45.0, (640) 39.8–44.7, (660) 39.6–44.4, (680) 39.3–44.0, (700) 39.0–43.6

Cell Data: *Space Group: Pbnm.* $a = 55.99$–56.15 $b = 11.549$–11.570 $c = 3.99$–4.010 $Z = 4$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Pb	22.1	21.15	22.57
Cu	6.5	6.25	6.92
Fe	trace		
Bi	53.0	54.67	53.04
Sb		0.39	
S	[18.4]	17.51	17.47
Total	[100.0]	99.97	100.00

(1) Gladhammar, Sweden; S by difference, corresponds to $Pb_{2.79}Cu_{2.67}Bi_{6.63}S_{15.00}$. (2) Silver Miller mine, Canada; by electron microprobe, corresponds to $Pb_{2.80}Cu_{2.70}(Bi_{7.18}Sb_{0.09})_{\Sigma=7.27}S_{15.00}$. (3) $Pb_3Cu_3Bi_7S_{15}$.

Occurrence: Of hydrothermal origin.

Association: Krupkaite, other aikinite–bismuthinite series members, bismuth.

Distribution: From Gladhammar, Kalmar, Sweden [TL]. In the Beresovsk district, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, and at Inkur, Transbaikal, Russia. From Baia Borşa, Baia Mare (Nagybánya), Romania. At the Spissko-Gemerske Rudohorie Mountains, Slovakia. In the Loch Shin monzogranite, near Lairg, Scotland. From the Morro Potosi greisen, Rondonia, ??, Brazil. At Yecora, five km west of Iglesia, Sonora, Mexico. From the Beaver Mountains, near Milford, Beaver Co., Utah, and at Manhattan, Nye Co., Nevada, USA. In Canada, in the Drummond (Silver Miller) mine, three km south of Cobalt, Ontario.

Name: Honors Gustav Lindström (1838–1916), Swedish mineral chemist of the Swedish Museum of Natural History, Stockholm, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 459–460. (2) Mumme, W.G., E. Welin, and B.J. Wuensch (1976) Crystal chemistry and proposed nomenclature for sulfosalts intermediate in the system bismuthinite–aikinite (Bi_2S_3–$CuPbBiS_3$). Amer. Mineral., 61, 15–20. (3) Welin, E. (1966) Notes on the mineralogy of Sweden. 5. Bismuth-bearing sulphosalts from Gladhammar, a revision. Amer. Mineral., 53, 351. (4) Horiuchi, H. and B.J. Wuensch (1977) Lindströmite, $Cu_3Pb_3Bi_7S_{15}$: its space group and ordering scheme for metal atoms in the crystal structure. Can. Mineral., 15, 527–535. (5) Pring, A. and B.G. Hyde (1987) Structural disorder in lindströmite: a bismuthinite–aikinite derivative. Can. Mineral., 25, 393–399. (6) Pring, A., B.A. Grguric, and A.J. Criddle (1998) Lindströmite from Cobalt, Ontario. Can. Mineral., 36, 1139–1148. (7) Topa, D., E. Makovicky, and W.H. Paar (2002) Composition ranges and exolution pairs for the members of the bismuthinite–aikinite series from Felbertal, Austria. Can. Mineral., 40, 849–869.

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Linnaeite $Co^{2+}Co_2^{3+}S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Dominantly octahedral crystals, to 5 mm; commonly massive, granular and compact. *Twinning:* On {111}.

Physical Properties: *Cleavage:* Imperfect on {001}. *Fracture:* Uneven to subconchoidal. Hardness = 4.5–5.5 VHN = 435–558, average 492 (50 g load). D(meas.) = 4.5–4.8 D(calc.) = 4.85

Optical Properties: Opaque. *Color:* Pale gray to steel-gray. *Luster:* Metallic, easily tarnished.
R: (400) 41.5, (420) 41.8, (440) 42.2, (460) 43.0, (480) 44.0, (500) 45.0, (520) 46.0, (540) 47.0, (560) 48.0, (580) 49.0, (600) 49.9, (620) 50.7, (640) 51.6, (660) 52.4, (680) 53.1, (700) 53.7

Cell Data: *Space Group: Fd3m.* a = 9.43 Z = 8

X-ray Powder Pattern: Müsen, Germany.
2.83 (100), 1.670 (80), 2.36 (70), 1.815 (60), 0.988 (50), 3.34 (40), 1.090 (40)

Chemistry:

	(1)	(2)	(3)
Co	40.71	48.70	57.96
Ni	7.35	4.75	
Cu	8.79	2.40	
Fe	1.30	2.36	
S	41.43	41.70	42.04
insol.	0.14	0.40	
Total	99.72	100.31	100.00

(1) Gladhammar, Sweden; corresponds to $(Co_{2.14}Cu_{0.43}Ni_{0.39}Fe_{0.07})_{\Sigma=3.03}S_{4.00}$. (2) Carroll Co., Maryland, USA; corresponds to $(Co_{2.54}Ni_{0.25}Fe_{0.13}Cu_{0.12})_{\Sigma=3.04}S_{4.00}$. (3) $Co^{2+}Co_2^{3+}S_4$.

Polymorphism & Series: Forms a series with polydymite.

Mineral Group: Linnaeite group.

Occurrence: In hydrothermal veins with other cobalt and nickel sulfides.

Association: Chalcopyrite, pyrrhotite, millerite, bismuthinite, gersdorffite, carrollite, cattierite, ullmannite, marcasite, pyrite, galena, sphalerite.

Distribution: In Sweden, from the Bastnäs mine, near Riddarhyttan, Västmanland [TL], and at Gladhammar, Kalmar. At Outokumpu, Finland. In Germany, from Müsen, North Rhine-Westphalia; at Altenberg, Saxony; in the Grube Georg, near Horhausen, Westerwald. At Kladno, Czech Republic. In the USA, from the Springfield and Mineral Hill mines, Carroll Co., Maryland; and at the Mine La Motte, Madison Co., Missouri. In Congo (Zaire), in the Musonoi mine, near Kolwezi, Katanga (Shaba) Province. At the N'Kana mine, Kitwe, from the Chambishi Southeast prospect, and in the Rhokana mine, Zambia. In the Wonderland and Selukwe Peak mines, Selukwe, Zimbabwe. From Tsumeb, Namibia. Known from a number of other minor occurrences.

Name: In honor of Carl von Linné [Carolus Linnaeus] (1707–1778), Swedish taxonomist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 262–265. (2) De Jong, W.F. and H.W.V. Williams (1927) Die Verbindungen Fe_3S_4, Co_3S_4, Ni_3S_4 und ihre Struktur. Z. Anorg. Allg. Chem. 161, 311–315 (in German). (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 103. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 323.

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Lintisite **$Na_3LiTi_2(Si_2O_6)_2O_2 \cdot 2H_2O$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Needlelike crystals, elongated along [001], flattened on {100}, to 5 mm; in fibrous or columnar aggregates. *Twinning:* Twin axis [100].

Physical Properties: *Cleavage:* {100} and {010}, perfect. *Fracture:* Splintery. *Tenacity:* Elastic. Hardness = 5–6 D(meas.) = 2.77(5) D(calc.) = 2.825 Fluoresces weak yellow in UV.

Optical Properties: Transparent. *Color:* Colorless, white to pale yellow. *Luster:* Vitreous on fractures, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 2°$. *Dispersion:* $r < v$, strong.
$\alpha = 1.672(2)$ $\beta = 1.739(2)$ $\gamma = [1.802]$ 2V(meas.) = 85(1)°

Cell Data: *Space Group:* $C2/c$. $a = 28.583(4)$ $b = 8.600(1)$ $c = 5.219(1)$ $\beta = 91.03(2)°$ $Z = 4$

X-ray Powder Pattern: Lovozero massif, Russia.
14.29 (s), 2.996 (s), 6.39 (m), 4.77 (m), 3.69 (m), 2.744 (m), 2.709 (m)

Chemistry:

	(1)
SiO_2	44.03
TiO_2	27.68
Nb_2O_5	1.10
FeO	0.28
MnO	0.05
Li_2O	2.68
Na_2O	16.72
K_2O	0.03
LOI	6.55
Total	99.12

(1) Lovozero massif, Russia; by electron microprobe, average of four analyses; Li by flame photometry, loss on ignition taken as H_2O; corresponding to $Na_{2.97}Li_{0.99}(Ti_{1.91}Nb_{0.05}Fe_{0.02})_{\Sigma=1.98}Si_{4.03}O_{14} \cdot 2.00H_2O$.

Occurrence: Coating and replacing lorenzenite in ultra-agpaitic syenite pegmatites in a differentiated alkalic massif (Lovozero massif, Russia); in sodalite xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Lorenzenite, nepheline, sodalite, potassic feldspar, arfvedsonite, aegirine, eudialyte, ussingite, gmelinite (Lovozero massif, Russia); ussingite, natrolite, sérandite, aegirine, steenstrupine, sidorenkite, rasvumite, eudialyte, terskite, vuonnemite, vitusite (Mont Saint-Hilaire, Canada).

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia. From Mont Saint-Hilaire, Quebec, Canada.

Name: For LIthium, sodium (Natrium), TItanium, and SIlicon in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p503/3; The Natural History Museum, London, England, 1994,13.

References: (1) Khomyakov, A.P., L.I. Polezhaeva, S. Merlino, and M. Pasero (1990) Lintisite $Na_3LiTi_2Si_4O_{14} \cdot 2H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 119(3), 76–80 (in Russian). (2) (1991) Amer. Mineral., 76, 1730 (abs. ref. 1). (3) Merlino, S., M. Pasero, and A.P. Khomyakov (1990) The crystal structure of lintisite, $Na_3LiTi_2[Si_2O_6]_2O_2 \cdot 2H_2O$, a new titanosilicate from Lovozero (USSR). Zeits. Krist., 193, 137–148. (4) Chao, G.Y., R.P. Conlon, and J. Van Velthuizen (1990) Mont Saint-Hilaire unknowns. Mineral. Record, 21, 363–368 [UK74 = lintisite].

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Linzhiite $FeSi_2$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As irregular grains or tabular crystals to 0.5 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 6.5 D(meas.) = n.d. D(calc.) = 4.972

Optical Properties: Opaque. *Color*: Steel-gray. *Streak*: Grayish black. *Luster*: Metallic. *Optical Class*: n.d.
R: (470) 26.3, (546) 30.3, (589) 32.9, (650) 36.3

Cell Data: *Space Group*: *P*4/*mmm*. *a* = 2.696(1) *c* = 5.147(6) Z = 1

X-ray Powder Pattern: Luobusha mining district, Qusong County, Tibet, China.
2.374 (100), 5.163 (92), 1.851 (79), 1.899 (47), 1.087 (25) 1.774 (16), 1.708 (12)

Chemistry:

	(1)	(2)
Fe	49.09	49.85
Si	50.00	50.15
Al	0.64	
Mn	0.28	.
Total	100.01	100.00

(1) Luobusha mining district, Qusong County, Tibet, China; average of 12 electron microprobe analyses; corresponding to $(Fe_{0.98}Al_{0.03}Mn_{0.01})_{\Sigma=1.02}Si_{1.99}$. (2) $FeSi_2$.

Occurrence: In the heavy mineral fraction of a podiform chromitite deposit in the peridotite of an ophiolitic harzburgite. Likely the product of a strongly reducing environment and possibly are xenocrysts derived from a mantle source.

Association: Zangboite, native silicon.

Distribution: In a heavy mineral fraction from ore body 31, Group II of the Luobusha ("Luobusa") mining district, 200 km southeast of Lhasa, Qusong County, Shannan Prefecture, Tibet, People's Republic of China. From placers and drill-core samples from the Poltava series, Ukraine.

Name: For Linzhi Prefecture, near the locality that produced the first samples.

Type Material: Geological Museum of China, (M11799) and at the Institute of Geology, Academy of Geological Sciences (97-6), Beijing, People's Republic of China.

References: (1) Li, G., W. Bai, N. Shi, Q. Fang, M. Xiong, J. Yang, Z. Ma, and H. Rong (2012) Linzhiite, $FeSi_2$, a redefined and revalidated new mineral species from Luobusha, Tibet, China. European Jour. Mineral., 24, 1047-1052. (2) (2014) Amer. Mineral., 99, 1516 (abs. ref. 1).

Liottite $(Ca, Na, K)_8(Si, Al)_{12}O_{24}[(SO_4), Cl, (CO_3), OH]_4 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. As short prismatic crystals with pyramidal and pinacoidal terminations, up to 1 cm.

Physical Properties: Hardness = 5 D(meas.) = 2.56(2) D(calc.) = 2.61

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (–). $\omega = 1.530$ $\epsilon = 1.528$

Cell Data: *Space Group:* $P\bar{6}m2$. a = 12.842(3) c = 16.091(5) Z = 6

X-ray Powder Pattern: Pitigliano, Italy.
3.715 (100), 3.315 (75), 4.84 (36), 2.141 (24), 2.686 (10), 2.471 (10), 1.801 (10)

Chemistry:

	(1)
SiO_2	30.51
Al_2O_3	24.92
Fe_2O_3	0.36
CaO	16.71
Na_2O	7.97
K_2O	4.98
Cl	2.57
H_2O	1.8
CO_2	2.1
SO_3	8.66
$-O = Cl_2$	0.58
Total	100.00

(1) Pitigliano, Italy; by AA and XRF, corresponds to $(Ca_{3.59}Na_{3.10}K_{1.27}Fe^{3+}_{0.05})_{\Sigma=8.01}(Si_{6.11}Al_{5.89})_{\Sigma=12.00}O_{24}[(SO_4)_{1.30}Cl_{0.87}(CO_3)_{0.57}(OH)_{1.19}]_{\Sigma=3.93} \cdot 0.61H_2O$.

Mineral Group: Cancrinite group.

Occurrence: In cavities in ejecta blocks of metasomatized carbonate rocks in a pumice deposit.

Association: Melilite, latiumite, clintonite, anorthite, vesuvianite, grossular, andradite, pyroxene.

Distribution: At Pitigliano, near Grosseto, Tuscany, Italy.

Name: For mineral collector Luciano Liotti, who donated the specimen in which this mineral was first found.

Type Material: University of Pisa, Pisa, 3209; University of Modena, Modena, Italy.

References: (1) Merlino, S. and P. Orlandi (1977) Liottite, a new mineral in the cancrinite–davyne group. Amer. Mineral., 62, 321–326.

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Lipscombite $(Fe^{2+}, Mn^{2+})Fe_2^{3+}(PO_4)_2(OH)_2$

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Crystal Data: Tetragonal. *Point Group:* 422. As very small acicular crystals, in radial aggregates; massive.

Physical Properties: Hardness = n.d. D(meas.) = 3.66(1) D(calc.) = [3.68]

Optical Properties: Translucent to opaque. *Color:* Olive-green to black, yellowish brown.
Luster: Vitreous.
Optical Class: [Uniaxial.]
R_1–R_2: n.d.

Cell Data: *Space Group:* $P4_12_12$. $a = 7.40$ $c = 12.81$ $Z = 4$

X-ray Powder Pattern: Sapucaia mine, Brazil.
3.314 (10), 3.206 (6), 1.656 (4), 1.601 (4), 4.84 (3), 2.302 (3), 2.054 (3)

Chemistry:

	(1)	(2)	(3)
P_2O_5	33.37	33.76	36.26
Fe_2O_3	50.45	57.16	40.79
FeO	3.75	1.72	18.35
MnO	7.91		
H_2O	4.45	6.65	4.60
Total	99.93	99.29	100.00

(1) Sapucaia mine, Brazil; corresponds to $(Mn^{2+}_{0.44}Fe^{2+}_{0.21})_{\Sigma=0.65}Fe^{3+}_{2.49}(PO_4)_{1.85}O_{1.22}(OH)_{0.78}$.
(2) Anloua, Cameroon; corresponds to $Fe^{2+}_{0.09}Fe^{3+}_{2.82}(PO_4)_{1.87}O_{1.03}(OH)_{0.97}$. (3) $Fe^{2+}Fe^{3+}_2(PO_4)_2(OH)_2$.

Mineral Group: Dimorphous with barbosalite.

Occurrence: In a hydrothermally altered phosphate zone of a complex granite pegmatite (Sapucaia mine, Brazil).

Association: Cyrilovite, leucophosphite, phosphosiderite, frondelite (Sapucaia mine, Brazil); heterosite, strengite, cyrilovite, leucophosphite (Hagendorf, Germany).

Distribution: From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. At the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina. In the USA, on Fodderstack Mountain, Montgomery Co., Arkansas; at the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., and in the Rain mine, Carlin district, Elko Co., Nevada. From the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. At Anloua, near Ngaoundéré, Cameroon. From Hagendorf, Bavaria, Germany. In the Wolf Creek meteorite.

Name: To honor William Nunn Lipscomb (1909–), mineralogist, University of Minnesota, Minneapolis, Minnesota, USA, who determined the crystal structure of the synthetic compound.

Type Material: n.d.

References: (1) Lindberg, M.L. (1962) Manganoan lipscombite from the Sapucaia pegmatite mine, Minas Gerais, Brazil. Amer. Mineral., 47, 353–359. (2) Gheith, M.A, (1953) Lipscombite: a new synthetic "iron lazulite". Amer. Mineral., 38, 612–628. (3) Vencato, I., E. Mattievich, and Y.P. Mascarenhas (1989) Crystal structure of synthetic lipscombite: a redetermination. Amer. Mineral., 74, 456–460. (4) Vochten, R., P. van Acker, and E. De Grave (1983) Mössbauer, electrokinetic and refined lattice parameters study of synthetic manganoan lipscombite. Phys. Chem. Minerals, 9, 263–268.

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Liroconite $Cu_2Al(AsO_4)(OH)_4 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically as crystals with a flattened octahedral or lenticular aspect, dominated by {110} and {011} and striated parallel to their intersections, also {001}, {010}, {100}, to 3.6 cm, alone and in sub-parallel groups. May be granular, massive.

Physical Properties: *Cleavage:* On {110}, {011}, indistinct. *Fracture:* Uneven to conchoidal. Hardness = 2–2.5 D(meas.) = 2.94–3.01 D(calc.) = [3.03]

Optical Properties: Transparent to translucent. *Color:* Sky-blue, bluish green, verdigris-green, emerald-green; pale blue to pale bluish green in transmitted light. *Streak:* Pale blue to pale green. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = 25°$. *Dispersion:* $r < v$, moderate.
$\alpha = 1.612(3)$ $\beta = 1.652(3)$ $\gamma = 1.675(3)$ 2V(meas.) = n.d. 2V(calc.) = 72(5)°

Cell Data: *Space Group:* $I2/a$. $a = 12.664(2)$ $b = 7.563(2)$ $c = 9.914(3)$ $\beta = 91.32(2)°$
Z = 4

X-ray Powder Pattern: Cornwall, England.
6.46 (10), 3.01 (10), 5.95 (9), 2.69 (6), 3.92 (5), 2.79 (5), 2.21 (5)

Chemistry:

	(1)	(2)
P_2O_5	3.73	
As_2O_5	23.05	26.54
Al_2O_3	10.85	11.77
Fe_2O_3	0.98	
CuO	36.38	36.73
H_2O	25.01	24.96
Total	100.00	100.00

(1) Cornwall, England. (2) $Cu_2Al(AsO_4)(OH)_4 \cdot 4H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of some copper deposits.

Association: Olivenite, chalcophyllite, clinoclase, cornwallite, strashimirite, malachite, cuprite, "limonite".

Distribution: In England, in Cornwall, large crystals from Wheals Muttrell and Gorland, also Wheal Unity and the Ting Tang mine, near Gwennap; from Wheal Cock, St. Just. In Germany, in Saxony, from Schwarzenberg; at the Sadisdorf copper mine, near Schmiedeberg; in the Altväter samt Eschig mine, near Sayda; and from Ullersreuth, near Hirschberg, Thuringia. At Špania Dolina (Herrengrund), and at L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. In the Preobrazhensky mine, Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. In the USA, from Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and at Bisbee, Cochise Co., Arizona.

Name: From the Greek for *pale* and *powder*, for its pale blue to green streak.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 921–922. (2) Berry, L.G. (1951) Observations on conichalcite, cornwallite, euchroite liroconite and olivenite. Amer. Mineral., 36, 484–503. (3) Burns, P.C., R.K. Eby, and F.C. Hawthorne (1991) Refinement of the structure of liroconite, a heteropolyhedral framework oxysalt mineral. Acta Cryst., C47, 916–919.

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Lisetite $Na_2CaAl_4Si_4O_{16}$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. In lathlike clusters of ~100 μm-sized anhedral grains.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.73

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial. $\alpha = 1.56(2)$ β = n.d. $\gamma = 1.57(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pbc2_1$. $a = 8.260(1)$ $b = 17.086(1)$ $c = 9.654(1)$ Z = 4

X-ray Powder Pattern: Liset eclogite pod, Norway.
3.19 (100), 4.14 (44), 3.48 (36), 3.54 (31), 2.94 (31), 3.09 (21), 3.00 (15b)

Chemistry:

	(1)
SiO_2	43.09
TiO_2	0.02
Al_2O_3	36.33
Cr_2O_3	0.00
FeO	0.12
MnO	0.01
NiO	0.03
MgO	0.01
CaO	9.80
Na_2O	10.84
K_2O	0.01
Total	100.26

(1) Liset eclogite pod, Norway; by electron microprobe, average of 15 analyses; corresponds to $(Ca_{0.98}Fe_{0.01})_{\Sigma=0.99}Na_{1.96}Al_{3.99}Si_{4.02}O_{16}$.

Occurrence: Formed by retrograde metamorphism of a Na, Al-rich and K, Mg-poor eclogite pod in the highest pressure part of the greenschist, amphibolite, or granulite facies.

Association: Taramite, jadeite, hematite, ilmenite, högbomite, albite, quartz.

Distribution: In the Liset eclogite pod, Selje district, southwestern Norway.

Name: For the Liset eclogite pod, Norway.

Type Material: Natural History Museum, Paris, France, G201b7; University of Pavia, Pavia, Italy, G201b.

References: (1) Smith, D.C., S.-A. Kechid, and G. Rossi (1986) Occurrence and properties of lisetite, $CaNa_2Al_4Si_4O_{16}$, a new tectosilicate in the system Ca–Na–Al–Si–O. Amer. Mineral., 71, 1372–1377. (2) Rossi, G., R. Oberti, and D.C. Smith (1986) Crystal structure of lisetite, $CaNa_2Al_4Si_4O_{16}$. Amer. Mineral., 71, 1378–1383.

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Lishizhenite $ZnFe_2^{3+}(SO_4)_4 \cdot 14H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are tabular to prismatic, elongated along [100], to 8 mm, showing {010}, {100}, {001}, typically in aggregates.

Physical Properties: *Cleavage:* On {010}, nearly perfect; on {001}, poor. Hardness = 3.5 D(meas.) = 2.206 D(calc.) = 2.201 Soluble in H_2O; becomes dull and dark red or yellowish brown on exposure to air.

Optical Properties: Transparent if fresh. *Color:* Pale violet to yellowish brown; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* OAP $\wedge$ {010} = 86°. *Dispersion:* $r > v$, strong.
$\alpha = 1.522(2)$ $\beta = 1.568(1)$ $\gamma = 1.578(4)$ 2V(meas.) = 47°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.477(1)$ $b = 15.298(3)$ $c = 6.309(1)$ $\alpha = 90.20(1)°$ $\beta = 101.11(1)°$ $\gamma = 93.97(1)°$ Z = 1

X-ray Powder Pattern: Xitieshan mine, China.
4.79 (100), 3.61 (78), 5.07 (70), 4.06 (68), 3.98 (38), 2.859 (36), 4.11 (29)

Chemistry:

	(1)	(2)
SO_3	41.00	39.37
Al_2O_3	0.37	
Fe_2O_3	18.28	19.63
FeO	0.11	
MnO	0.76	
ZnO	8.17	10.00
CdO	0.01	
PbO	0.01	
MgO	0.05	
CaO	2.25	
Na_2O	0.02	
H_2O	29.20	31.00
Total	100.23	100.00

(1) Xitieshan mine, China; average of two analyses, Fe^{3+} confirmed by Mössbauer spectroscopy; neglecting CaO as anhydrite impurity, corresponds to $(Zn_{0.86}Mn_{0.09}Fe^{2+}_{0.01}Mg_{0.01})_{\Sigma=0.97}(Fe^{3+}_{1.96}Al_{0.06})_{\Sigma=2.02}S_{4.04}O_{16.13} \cdot 13.87H_2O$. (2) $ZnFe_2(SO_4)_4 \cdot 14H_2O$.

Occurrence: In cavities and veinlets in anhydrite in the oxidation zone of a Pb–Zn deposit.

Association: Anhydrite, römerite, copiapite, sulfur, gypsum, pyrite, quartz.

Distribution: From the Xitieshan Pb–Zn mine, south of Mt. Qilianshan, Chaidamu, Qinghai Province, China.

Name: To honor Li Shizhen (1518–1593), famous Chinese pharmacologist.

Type Material: Department of Geology, Lanzhou University, Lanzhou; Geology Museum, Beijing, China.

References: (1) Wanmao Li and Guoying Chen (1990) Lishizhenite – a new zinc sulfate mineral. Acta Mineral. Sinica, 10(4), 299–305 (in Chinese with English abs.). (2) (1991) Amer. Mineral., 76, 2022 (abs. ref. 1). (3) Wang Qiguang and Li Wanmao (1988) Crystal structure of a new ferric sulfate mineral. Kexue Tongbao, 33(21), 1783–1787 (in English).

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Lisiguangite $CuPtBiS_3$

Crystal Data: Orthorhombic. *Point Group*: 2 2 2. Crystals, tabular or lamellar on {010}, elongated along [100], to 2 mm.

Physical Properties: *Cleavage*: Perfect on {010}, distinct on {001}, visible on {100}. *Fracture*: Stepped. *Tenacity*: Brittle. Hardness = 2.5 VHN = 46.7–49.8 (25 g load). D(meas.) = n.d. D(calc.) = 7.42

Optical Properties: Opaque (?). *Color*: n.d.; in reflected light, bright white with a yellowish tint. *Streak*: n.d. *Anisotropism*: Weak to moderate; blue-green to brown. Parallel extinction. *Luster*: n.d.
Optical Class: n.d.
R_1-R_2: (470) 39.2-36.7, (546) 40.3-37.3, (589) 40.7-37.9, (650) 40.8-37.9

Cell Data: *Space Group*: $P2_12_12_1$. a = 7.7152(15) b = 12.838(3) c = 4.9248(10) Z = 4

X-ray Powder Pattern: Yanshan Mountains, Hebei Province, China.
3.03 (100), 3.24 (80), 1.865 (60), 2.14 (50), 2.27 (40), 6.40 (30), 1.423 (30)

Chemistry:

	(1)	(2)
Cu	12.98	11.27
Pd	2.69	
Pt	30.04	34.60
Bi	37.65	37.70
S	17.55	17.06
Total	100.91	100.00

(1) Yanshan Mountains, Hebei Province, China; average of 8 electron microprobe analyses, corresponding to $Cu_{1.10}(Pt_{0.83}Pd_{0.14})_{\Sigma=0.97}Bi_{0.97}S_{2.96}$. (2) $CuPtBiS_3$.

Mineral Group: Lapieite group.

Occurrence: Of contact metamorphic origin, along veins in an exoskarn associated with mafic igneous rocks (garnet pyroxenite).

Association: From a heavy mineral concentrate with chalcopyrite, bornite, galena, carrolite, molybdenite, pyrite, tenorite, daomanite, Co-bearing malanite, sperrylite, moncheite, cooperate, damiaoite, yixunite, malyshevite.

Distribution: Near Sandao Village, 250 km northeast of Beijing, Yanshan Mountains, Hebei Province, China.

Name: Honors Chinese geologist, Li Siguang (J.S. Lee) (1889–1971), Minister of Geology of China (1952–1971), Vice President of the Chinese Academy of Sciences, and Chairman of the China National Association of the Sciences.

Type Material: Geological Museum of China, Beijing (cat. no. M-11031).

References: (1) Yu, Z., F. Cheng, and H. Ma (2009) Lisiguangite, $CuPtBiS_3$, a new platinum-group mineral from the Yanshan Mountains, Hebei, China. Acta Geol. Sinica, 83, 238–244.
(2) (2009) Amer. Mineral., 94, 1498 (abs. ref. 1).

Liskeardite $(Al, Fe^{3+})_3(AsO_4)(OH)_6 \cdot 5H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Radially fibrous, in incrustations, to 6 mm thick.

Physical Properties: Hardness = Soft. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White, pale shades of green, blue, or brown; colorless in transmitted light.
Optical Class: Biaxial (+). *Orientation:* Z = elongation. $\alpha = 1.661$ $\beta = 1.675$ $\gamma = 1.689$
2V(meas.) = $\simeq 90°$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Type material gives a poor X-ray pattern.

Chemistry:

	(1)	(2)
SO_3	1.11	
As_2O_5	26.96	27.08
Al_2O_3	28.23	30.87
Fe_2O_3	7.64	8.09
CuO	1.03	
CaO	0.72	
H_2O^+	18.74	
H_2O^-	15.31	
H_2O		33.96
Total	99.74	100.00

(1) Liskeard, England. (2) $(Al, Fe)_3(AsO_4)(OH)_6 \cdot 5H_2O$ with Fe:Al = 1:6.

Occurrence: An oxidation product of arsenic-bearing sulfides.

Association: Scorodite, arsenopyrite, chalcopyrite, pyrite, quartz (Liskeard, England).

Distribution: In England, from the Marke Valley mine, Liskeard, and at the Penberthy Croft mine, St. Hilary, Cornwall. From the Cap Garonne mine, near le Pradet, Var, France. In the Tannenberg tin mine, Mühlleithen, Saxony, Germany.

Name: For its first-noted occurrence, near Liskeard, England.

Type Material: The Natural History Museum, London, England, 50821.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 924.

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Litharge **PbO**

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As alteration rims on other lead minerals, and as crusts.

Physical Properties: *Cleavage:* {110}. Hardness = 2 D(meas.) = 9.14 (synthetic). D(calc.) = [9.35]

Optical Properties: Transparent. *Color:* Red; red to red-orange in transmitted light. *Luster:* Greasy to dull.
Optical Class: Uniaxial (–). $\omega = 2.665$ (Li). $\epsilon = 2.535$ (Li).

Cell Data: *Space Group:* $P4/nmm$ (synthetic). $a = 3.9729$ $c = 5.0217$ Z = 2

X-ray Powder Pattern: Synthetic.
3.115 (100), 2.809 (62), 1.872 (37), 1.675 (24), 2.510 (18), 1.542 (11), 1.988 (8)

Chemistry: Analyses of natural material are not available.

Occurrence: As an alteration product of other lead-bearing minerals.

Association: Lead, galena, massicot, plattnerite, hydrocerussite.

Distribution: In the USA, from Cucamonga Peak, San Bernardino Co., California, and from near Hailey, Mineral Hill district, Blaine Co., Idaho. In the Ilímaussaq intrusion, Greenland. At Mežica (Mies), Slovenia. From Laurium, Greece, in slag. At Långban, Värmland, Sweden. In Germany, from Urberg, St. Blasien, and Badenweiler, Black Forest. Probably more common than indicated here.

Name: From the Greek word given by Dioscorides to the lead oxide obtained in parting lead from silver by fire metallurgy; a name long applied to the synthetic product.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 514–515. (2) Leciejewicz, J. (1961) On the crystal structure of tetragonal (red) PbO. Acta Cryst., 14, 1304. (3) (1953) NBS Circ. 539, 2, 30.

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Lithidionite $KNaCuSi_4O_{10}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As tiny plates lining cavities in the glassy crust of lapilli.

Physical Properties: Hardness = 5–6 D(meas.) = 2.75 D(calc.) = 2.85

Optical Properties: Semitransparent. *Color:* Blue.
Optical Class: Biaxial. $\alpha = 1.548$ $\beta = 1.574$ γ = n.d. 2V(meas.) = 56°

Cell Data: *Space Group:* $P\bar{1}$. $a = 9.80(1)$ $b = 8.01(1)$ $c = 6.97(1)$ $\alpha = 114.12(8)°$ $\beta = 99.52(6)°$ $\gamma = 105.59(8)°$ Z = 2

X-ray Powder Pattern: Vesuvius, Italy.
3.372 (100), 2.409 (85), 3.223 (75), 2.675 (37), 6.75 (35), 3.652 (18), 2.835 (18)

Chemistry:

	(1)	(2)	(3)
SiO_2	71.57	69.36	60.39
Fe_2O_3		0.94	
FeO	4.02		
CuO	6.49	13.29	19.99
PbO		0.73	
CaO		3.25	
Na_2O	6.78	5.10	7.79
K_2O	10.92	5.82	11.83
Total	99.78	99.49	100.00

(1) Vesuvius, Italy; average of two analyses of undoubtedly contaminated samples. (2) Do.; considered to contain tridymite ~40%. (3) $KNaCuSi_4O_{10}$.

Occurrence: In lapilli strongly modified by fumerolic action subsequent to the 1873 eruption of Vesuvius.

Association: Tridymite, wollastonite, glass.

Distribution: Found in the crater of Vesuvius, Campania, Italy.

Name: From the Greek for *pebble*, [Greek diminutive of *lithos*, for *stone*; *lithidion* in English, *litidion* in Italian] presumably for the size and shape of the lapilli on which the mineral occurs.

Type Material: Natural History Museum, Paris, France, 99.788.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1041 [lithidionite]. (2) Zambonini, F. (1935) Mineralogia Vesuviana, (2nd edition), Stab. Industrie Editoriali Meridionali, Naples, 435–439 [litidionite] (in Italian). (3) Pozas, J.M.M., G. Rossi, and V. Tazzoli (1975) Re-examination and crystal structure analysis of litidionite. Amer. Mineral., 60, 471–474. (4) Kawamura, K. and J.T. Iiyama (1981) Crystallochemistry and thermochemistry of sodipotassic copper silicate $Na_{2-2x}K_{2x}CuSi_4O_{10}$. Bull. Minéral., 104, 387–395.

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Lithiomarsturite $LiCa_2Mn_2^{2+}HSi_5O_{15}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As nearly equant rhombic to prismatic euhedral crystals, to 3 mm, with {100} prominent, {010} and {001}; divergent bundles of crystals.

Physical Properties: *Cleavage:* {100} and {001}, good. *Tenacity:* Brittle. Hardness = ~6
D(meas.) = 3.32 D(calc.) = 3.27

Optical Properties: Transparent. *Color:* Pale pinkish brown to light yellow. *Streak:* Very light brown. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X \wedge b = -7°$; $Y \wedge a = 28°$; $Z \wedge c = 6°$.
Dispersion: $r > v$, moderate. $\alpha = 1.645(1)$ $\beta = 1.660(1)$ $\gamma = 1.666(1)$ 2V(meas.) = 59.9(8)°
2V(calc.) = 64°

Cell Data: *Space Group:* $[P\bar{1}]$ (by analogy to rhodonite). $a = 7.652(3)$ $b = 12.119(3)$
$c = 6.805(2)$ $\alpha = 85.41(2)°$ $\beta = 94.42(3)°$ $\gamma = 111.51(2)°$ Z = 2

X-ray Powder Pattern: Foote mine, North Carolina, USA.
3.01 (100), 3.19 (90), 2.913 (90), 2.744 (60), 3.08 (50), 2.217 (50), 6.79 (20)

Chemistry:

	(1)
SiO_2	51.6
FeO	6.9
MnO	16.4
MgO	0.7
CaO	19.1
Li_2O	2.6
H_2O	[1.55]
Total	[98.9]

(1) Foote mine, North Carolina, USA; by electron microprobe, Li by ion microprobe, H_2O calculated from stoichiometry; corresponds to $Li_{1.01}Ca_{1.98}(Mn_{1.35}Fe_{0.56}Mg_{0.10})_{\Sigma=2.01}H_{1.00}Si_5O_{15}$.

Occurrence: In small vugs within a complex Li-Sn-rich pegmatite.

Association: Tetrawickmanite, brannockite, parsettensite, bavenite, fluorapatite, albite, pyrite.

Distribution: At the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA.

Name: As the *lithium* analogue of *marsturite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 165268, 165460.

References: (1) Peacor, D.R., P.J. Dunn, J.S. White, Jr., J.D. Grice, and P.H. Chi (1990) Lithiomarsturite, a new member of the pyroxenoid group, from North Carolina. Amer. Mineral., 75, 409–414.

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Lithiophilite $Li(Mn^{2+},Fe^{2+})PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Sharply terminated crystals may show {010}, {011}, {021}, {111}, with {100}, {110}, {130}, {140}; commonly as crudely anhedral crystals and cleavages, to 1 m. *Twinning:* Rare contact twins on {130}.

Physical Properties: *Cleavage:* On {100}, perfect; on {010}, good. *Fracture:* Uneven to subconchoidal. Hardness = 4–5 D(meas.) = 3.445–3.50 D(calc.) = 3.433

Optical Properties: Transparent to translucent. *Color:* Clove-brown, yellowish brown, honey-yellow, salmon-pink, blue-gray, gray, typically surficially black from alteration; colorless to pale yellow or pink in transmitted light. *Streak:* White to grayish white. *Luster:* Vitreous to subresinous.
Optical Class: Biaxial (+). *Pleochroism:* None to weak; X = deep pink; Y = pale greenish yellow; Z = pale pink. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, strong.
$\alpha = 1.663–1.696$ $\beta = 1.667–1.700$ $\gamma = 1.674–1.702$ 2V(meas.) = 48°–70°

Cell Data: *Space Group: Pmnb.* a = 6.094(5) b = 10.427(5) c = 4.743(1) Z = 4

X-ray Powder Pattern: Outpost mine, White Picacho district, Arizona, USA.
2.548 (100), 3.051 (89), 3.516 (71), 4.313 (56), 1.762 (29), 5.236 (28), 2.492 (28)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	44.95	44.5	45.11	CaO	trace		
SiO_2		0.09		Na_2O	0.24		
Al_2O_3		0.07		Li_2O	9.11	[8.8]	9.50
FeO	2.94	0.16	22.84	H_2O	0.65		
MnO	42.58	46.4	22.55	insol.	0.16		
				Total	100.63	[100.0]	100.00

(1) Buckfield, Maine, USA. (2) Foote mine, North Carolina, USA; by electron microprobe, total Fe as FeO, total Mn as MnO, Li_2O by difference. (3) $Li(Mn,Fe)PO_4$ with Mn:Fe = 1:1.

Mineral Group: Forms a series with triphylite.

Occurrence: A late-stage mineral in some complex granite pegmatites; usually primary but rarely secondary.

Association: Sicklerite, purpurite, huréaulite, numerous Fe–Mn phosphates and oxides.

Distribution: In the USA, from Branchville, Fairfield Co., and in the Strickland quarry, Portland, Middlesex Co., Connecticut; at several places in Maine, as Buckfield and Norway, Oxford Co., and Poland, Androscoggin Co.; in the Custer Mountain mine, and elsewhere in Custer Co., South Dakota; good crystals from the Foote mine, near Kings Mountain, Cleveland Co., North Carolina; in the Harding mine, Dixon, Taos Co., New Mexico; in the White Picacho district, Yavapai Co., Arizona; at several mines in the Pala district, San Diego Co., California. In Canada, from the Tanco mine, Bernic Lake, Manitoba. From the Mangualde pegmatite, near Mesquitela, and the Bendada pegmatite, near Guarda, Portugal. In the Viitaniemi pegmatite, near Eräjärvi, Finland. Large masses in the Blesberg mine, Noumas pegmatite, Northern Cape Province, South Africa. From Karibib, Namibia. In the Buranga pegmatite, near Gatumba, Rwanda. At Wodgina, Western Australia. Several other localities are known.

Name: For its *lithium* content and the Greek for *friend*.

Type Material: Yale University, New Haven, Connecticut, USA, 3.5641, 3.5645.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 665–669. (2) Geller, S. and J.L. Durand (1960) Refinement of the structure of $LiMnPO_4$. Acta Cryst., 13, 325–331. (3) Thomssen, R.W. and J.W. Anthony (1977) Lithiophilite crystals from the Foote mine. Mineral. Record, 8, 95–97. (4) Blanchard, F.N. (1981) X-ray powder diffraction data for lithiophilite. Florida Scientist, 44, 40–53.

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Lithiophorite $(Al,Li)Mn^{4+}O_2(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Very rarely in hexagonal crystals, to 1 cm; commonly scaly or very fine-grained, botryoidal, compact. *Twinning:* Sectoring observed on the basal plane of crystals may be due to twinning.

Physical Properties: *Cleavage:* {0001}, micaceous. *Tenacity:* Sectile, laminae somewhat flexible. Hardness = 2.5–3 D(meas.) = 3.14–3.37 D(calc.) = [3.30]

Optical Properties: Opaque. *Color:* Bluish black; light gray to dark brownish gray in reflected light. *Streak:* Blackish gray to greenish black. *Luster:* Dull to metallic.
Optical Class: Uniaxial. *Pleochroism:* Very strong. *Anisotropism:* Extreme; light gray to dark brown to bluish gray.
R_1–R_2: (400) 15.7–34.9, (420) 14.0–31.3, (440) 12.3–27.7, (460) 11.2–24.9, (480) 10.6–23.0, (500) 10.2–21.9, (520) 10.0–21.0, (540) 9.8–20.4, (560) 9.6–19.7, (580) 9.5–19.2, (600) 9.4–18.9, (620) 9.3–18.6, (640) 9.3–18.4, (660) 9.3–18.4, (680) 9.3–18.3, (700) 9.3–18.2

Cell Data: *Space Group:* $R\overline{3}m$. $a = 2.9247(4)$ $c = 28.169(6)$ Z = [3]

X-ray Powder Pattern: Krosnowice (Rengersdorf), Poland. (ICDD 41-1378).
4.714 (100), 9.428 (68), 2.371 (24), 1.880 (14), 3.143 (7), 1.453 (4), 1.447 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2		0.30	BaO	2.78	
Al_2O_3	10.54	23.84	K_2O	0.73	
Fe_2O_3	1.48	0.96	Li_2O	1.23	3.30
Bi_2O_3	trace		O	10.28	9.01
MnO	55.12	48.15	H_2O^+		13.15
(Co, Ni)O	2.42		H_2O^-		1.45
CuO	1.74		H_2O	12.64	
CaO	trace	trace	Total	98.96	100.16

(1) Schneeberg, Germany. (2) Gloucester Farm, Postmasburg, South Africa; Mn^{4+}:Mn^{3+} assumed; corresponds to $(Al_{0.69}Li_{0.32})_{\Sigma=1.01}(Mn^{4+}_{0.66}Mn^{3+}_{0.34})_{\Sigma=1.00}O_2(OH)_2$.

Occurrence: A relatively common constituent of "wad" in the oxidized zones of hydrothermal ore deposits and sedimentary manganese deposits; in banded iron formations; from lithium-rich granite pegmatites; in some lateritic soils and bauxites.

Association: Cryptomelane, hollandite, braunite, nsutite, pyrolusite, bixbyite, gibbsite, kaolinite, hematite.

Distribution: From Schneeberg and Eibenstock, Saxony; at St. Andreasberg, Harz Mountains; from Saalfeld, Thuringia; and elsewhere in Germany. At Krosnowice (Rengersdorf), Silesia, Poland. From Salmchâteau, Belgium. At the Lecht mines, Tomintoul, Baniffshire, Scotland. In the USA, from Charlottesville, Virginia; on White Oak Mountain, Bradley Co., Tennessee; in the Artillery Mountains, Mohave Co., Arizona. In Sima Menor cave, Mt. Sarisariñama, Venezuela. On Groote Eylandt, Northern Territory, Australia. In the Sundargarh district, Orissa, India. Large crystals from Gloucester Farm, Postmasburg district, Transvaal, South Africa. At Kobokobo, Kivu Province, Congo (Zaire). Other localities are known, but some require modern confirmation.

Name: For its content of LITHIum and the Greek for *to bear*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 566–572 [wad, part]. (2) De Villiers, J.E. (1945) Lithiophorite from the Postmasburg manganese deposits. Amer. Mineral., 30, 629–634. (3) Fleischer, M. and G.T. Faust (1963) Studies on manganese oxide minerals. VII. Lithiophorite. Schweiz. Mineral. Petrog. Mitt., 43, 197–216. (4) Mitchell, R.S. and R.E. Meintzer (1967) Lithiophorite from Charlottesville, Virginia. Amer. Mineral., 52, 1545–1549. (5) Post, J.E. and D.E. Appleman (1994) Crystal structure refinement of lithiophorite. Amer. Mineral., 79, 370–374.

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Lithiophosphate Li_3PO_4

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are elongated along [010], showing prominent {110}, {101}, with {010}, {013}, {001}, to 5 cm; typically as cleavages.

Physical Properties: *Cleavage:* Perfect on {010}; distinct on {110}, may be a parting. Hardness = 4 D(meas.) = 2.46–2.478 D(calc.) = 2.479 (synthetic). Turquoise-blue cathodoluminescence. Slightly soluble in hot H_2O.

Optical Properties: Transparent in thin flakes. *Color:* Colorless, white, may be pale rose or buff. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. α = 1.550–1.553 β = 1.557–1.558 γ = 1.566–1.567 2V(meas.) = 69°– ∼80°

Cell Data: *Space Group:* $Pmn2_1$ (synthetic). $a = 6.1155$ $b = 5.2340$ $c = 4.8452$ Z = 2

X-ray Powder Pattern: Mt. Okhmyl'k, Russia.
3.965 (10), 2.635 (10), 3.794 (9), 2.420 (9), 2.311 (9), 1.513 (9), 3.552 (8)

Chemistry:

	(1)	(2)
P_2O_5	59.92	61.29
SiO_2	1.14	
Al_2O_3	0.62	
Fe_2O_3	0.04	
MnO	0.01	
MgO	0.15	
CaO	0.88	
Na_2O	0.05	
Li_2O	37.07	38.71
F	trace	
H_2O^+	0.33	
H_2O^-	0.06	
Total	100.27	100.00

(1) Mt. Okhmyl'k, Russia; after deduction of 1.04% quartz, 1.38% montebrasite, 1.33% apatite, corresponds to $Li_{3.00}(PO_4)_{1.00}$. (2) Li_3PO_4.

Occurrence: Formed by hydrothermal replacement of montebrasite in the core of a granite pegmatite in amphibolite (Mt. Okhmyl'k, Russia); in a lithium-rich granite pegmatite (Foote mine, North Carolina, USA).

Association: Montebrasite, apatite, quartz, spodumene, lepidolite, beryl, elbaite, pollucite, tantalite, cassiterite, microcline (Mt. Okhmyl'k, Russia); leucophosphite, huréaulite, switzerite, jahnsite, rockbridgeite (Tip Top mine, South Dakota, USA).

Distribution: On Mt. Okhmyl'k, Voron'i massif, Kola Peninsula, Russia. In the USA, from the Foote mine, near Kings Mountain, Cleveland Co., North Carolina; at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota. Large crystals in the Tanco pegmatite, Bernic Lake, Manitoba, Canada.

Name: For its content of *lithium* and *phosphate*.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3347; Vernadsky Geological Museum, Moscow, 48601; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 58501.

References: (1) Matias, V.V. and A.M. Bondareva (1957) Lithiophosphate – a new mineral. Doklady Acad. Nauk SSSR, 112, 124–126 (in Russian). (2) (1957) Amer. Mineral., 42, 585 (abs. ref. 1). (3) White, J.S., Jr. (1969) A lithiophosphate occurrence in North Carolina. Amer. Mineral., 54, 1467–1469. (4) Bondareva, O.S., M.A. Simonov, and N.V. Belov (1978) Crystal structure of the synthetic analog of lithiophosphate, γ−$LiPO_4$. Kristallografiya (Sov. Phys. Crystal.), 23, 287–288. (5) (1966) NBS Mono. 25(4), 21.

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Lithiotantite $Li(Ta,Nb)_3O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In rough crystals, equant, to 0.4 mm.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 1200 (40 g load). D(meas.) = 7.0 D(calc.) = 7.08 Weak yellow-green cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless, creamy pink to brownish pink when included by cassiterite; grayish white under reflected light. *Luster:* Adamantine.
Optical Class: Biaxial; strong birefingence. *Dispersion:* Strong. $n = > 1.9$ 2V(meas.) = n.d. *Anisotropism:* Weak.
R_1–R_2: (486) 18.6–18.5, (553) 18.5–18.3, (589) 18.6–18.3, (656) 19.1–19.0

Cell Data: *Space Group:* $P2_1/c$. $a = 7.444$ $b = 5.044$ $c = 15.255$ $\beta = 107.18°$ Z = 4

X-ray Powder Pattern: "Eastern Kazakhstan".
2.96 (100), 1.722 (80), 1.451 (80), 1.772 (60b), 4.13 (5), 2.490 (5), 1.900 (5)

Chemistry:

	(1)
Nb_2O_5	24.96
Ta_2O_5	71.55
SnO_2	0.57
Li_2O	2.33
Total	99.41

(1) "Eastern Kazakhstan"; by electron microprobe, Li_2O by AA; corresponds to $Li_{0.92}(Ta_{1.90}Nb_{1.10}Sn_{0.02})_{\Sigma=3.02}O_8$.

Occurrence: In microcline-albite zones of granite pegmatites.

Association: Lepidolite, apatite, albite, thoreaulite, cassiterite, rankamaite, irtyshite ("Eastern Kazakhstan"); cassiterite, calciotantite, microlite, thoreaulite, cesplumtantite (Manono pegmatite, Congo).

Distribution: From the Ognevka tantalum deposit, Kalba Mountains, eastern Kazakhstan. In the Manono pegmatite, Katanga Province, Congo (Shaba Province, Zaire).

Name: For LITHIum and TANTalum in its composition.

Type Material: Mining Institute, St. Petersburg, 1655/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82543.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, V.I. Stepanov, and F.N. Tyusheva (1983) Lithiotantite $Li(Ta,Nb)_3O_8$ – a new mineral from granite pegmatites in Eastern Kazakhstan. Mineral. Zhurnal, 5(1), 91–95 (in Russian with English abs.). (2) (1984) Amer. Mineral., 69, 1191–1192 (abs. ref. 1).

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Lithiowodginite $LiTa_3O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As the central parts (to 5 mm) of wodginite crystals, to several cm. *Twinning:* Polysynthetic, characteristic.

Physical Properties: *Fracture:* Uneven. Hardness = 5–6 VHN = 1010–1080, 1050 average (40 g load). D(meas.) = 7.5(2) D(calc.) = 7.74(1)

Optical Properties: Translucent. *Color:* Dark pink to red; grayish white in reflected light. *Streak:* Pale pink. *Luster:* Adamantine.
Optical Class: Biaxial. *Anisotropism:* Strong. *Bireflectance:* Weak.
R_1–R_2: (486) 14.1–13.0, (553) 14.0–12.9, (589) 14.3–13.0, (656) 14.0–12.5

Cell Data: *Space Group:* $C2/c$. $a = 9.441(3)$ $b = 11.516(4)$ $c = 5.062(2)$ $\beta = 91.06(8)^\circ$
Z = [4]

X-ray Powder Pattern: "Eastern Kazakhstan".
2.978 (100), 3.65 (82), 2.940 (59), 2.502 (38), 1.709 (32), 1.724 (24), 1.777 (20)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	9.33	5.2	
Ta_2O_5	85.06	83.4	97.80
TiO_2	0.00		
SnO_2	1.66	4.6	
Fe_2O_3		0.1	
FeO	0.07	0.0	
MnO	2.02	4.6	
Li_2O	1.76	1.21	2.20
Total	99.90	[99.1]	100.00

(1) "Eastern Kazakhstan"; by electron microprobe, average of several analyses; corresponding to $(Li_{0.76}Mn_{0.18}Fe_{0.01})_{\Sigma=0.95}(Ta_{2.47}Nb_{0.45}Sn_{0.07})_{\Sigma=2.99}O_8$. (2) Tanco pegmatite, Canada; by electron microprobe, original total given as 99.3%; corresponds to $(Li_{0.53}Mn_{0.43}Fe^{3+}_{0.01})_{\Sigma=0.97}(Ta_{2.49}Nb_{0.26}Sn^{4+}_{0.20})_{\Sigma=2.95}O_8$. (3) $LiTa_3O_8$.

Mineral Group: Wodginite group: $Li_A > 0.5$; $Ta_B > 0.5$.

Occurrence: In the albite zone of granite pegmatites.

Association: Wodginite, ixiolite, irtyshite, simpsonite.

Distribution: From the Ognevka and Yubileinoye tantalum deposits, Kalba Mountains, eastern Kazakhstan. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada.

Name: For the dominant LITHium content and relation to *wodginite*.

Type Material: Mining Institute, St. Petersburg, 2052/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, and A.Y. Bakhchisaraytsev (1990) Lithiowodginite – a new mineral of the wodginite group from the granitic pegmatites of eastern Kazakhstan. Mineral. Zhurnal, 12(1), 94–100 (in Russian with English abs.). (2) (1991) Amer. Mineral., 76, 667 (abs. ref. 1). (3) Ercit, T.S., P. Černý, and F.C. Hawthorne (1992) The wodginite group. III. Classification and new species. Can. Mineral., 30, 633–638. (4) Ercit, T.S., F.C. Hawthorne and P. Černý (1992) The wodginite group. I. Structural crystallography. Can. Mineral., 30, 597–611.

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Lithosite $K_6Al_4Si_8O_{25}\cdot 2H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* n.d. As irregular, typically rounded grains, to 3 mm; as granular aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5.5 VHN = 412–824, 559 average (50–70 g load). D(meas.) = 2.51(1) D(calc.) = 2.54 Turns bright pink on irradiation with X-rays, which persists for at least 8 months.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = colorless; Z = bright rose. *Orientation:* $Z = b$; $Y \simeq a$; $X \simeq c$. $\alpha = 1.510(2)$ $\beta = 1.513(2)$ $\gamma = 1.527(2)$ 2V(meas.) = 47°

Cell Data: *Space Group:* n.d. $a = 15.197$ $b = 10.233$ $c = 8.435$ $\beta = 90.21°$ Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
3.07 (100), 3.46 (84), 3.26 (84), 3.16 (84), 2.10 (83), 2.82 (73), 2.05 (50)

Chemistry:

	(1)	(2)
SiO_2	50.0	49.6
Al_2O_3	20.7	20.4
K_2O	28.4	28.0
LOI	2.34	2.34
Total	101.44	100.34

(1–2) Khibiny massif, Russia; by electron microprobe, loss on ignition taken as H_2O; average corresponds to $K_{5.84}Al_{3.94}Si_{8.08}O_{25}\cdot 2.53H_2O$.

Occurrence: A secondary mineral from the weathering of ultraperalkalic pegmatite veins cutting nepheline syenites in a differentiated alkalic massif.

Association: Shafranovskite, lomonosovite, lamprophyllite, catapleiite, koashvite, zirsinalite, sodalite, aegirine, pectolite, molybdenite.

Distribution: In the Vuonnemiok River region, Khibiny massif, Kola Peninsula, Russia.

Name: From the Greek *lithos*, for *stone*, as the mineral is composed of the most abundant chemical elements of the crust of the earth.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity; Mineralogical Museum, St. Petersburg University, St. Petersburg, 17073; Mining Institute, St. Petersburg, 1633/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82751; The Natural History Museum, London, England, 1994,14.

References: (1) Khomyakov, A.P., N.M. Chernitsova, and N.I. Chistyakova (1983) Lithosite $K_6Al_4Si_8O_{25}\cdot 2H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 112, 218–222 (in Russian). (2) (1984) Amer. Mineral., 69, 210 (abs. ref. 1).

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Liveingite $Pb_9As_{13}S_{28}$

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Crystal Data: Monoclinic. *Point Group:* 2. As crystals, elongated and striated along [001], to 5 cm.

Physical Properties: Hardness = 3 VHN = 169–180 (100 g load). D(meas.) = 5.3 D(calc.) = [5.43]

Optical Properties: Opaque. *Color:* Lead-gray, with deep red internal reflections. *Streak:* Chocolate-brown. *Luster:* Metallic. *Anisotropism:* Distinct.

R_1–R_2: (400) 40.0–43.0, (420) 39.3–42.6, (440) 38.6–42.2, (460) 38.0–41.8, (480) 37.4–41.5, (500) 36.9–41.2, (520) 36.3–40.7, (540) 35.6–40.1, (560) 34.9–39.3, (580) 34.2–38.5, (600) 33.6–37.6, (620) 32.8–36.7, (640) 32.1–35.8, (660) 31.3–34.8, (680) 30.6–34.0, (700) 30.0–33.4

Cell Data: *Space Group:* $P2_1$. $a = 8.371(5)$ $b = 70.49(5)$ $c = 7.914(5)$ $\beta = 90°8(2)'$ $Z = 4$

X-ray Powder Pattern: Binntal, Switzerland. (ICDD 31-678).
2.990 (100), 4.11 (90), 3.423 (90), 2.350 (90), 2.093 (90), 1.931 (80), 1.917 (80)

Chemistry:

	(1)	(2)	(3)
Pb	47.58	49.1	49.90
As	26.93	26.5	26.07
S	24.91	24.0	24.03
Total	99.42	99.6	100.00

(1) Binntal, Switzerland. (2) Do.; by electron microprobe. (3) $Pb_9As_{13}S_{28}$.

Occurrence: Of hydrothermal origin.

Association: Pyrite, sphalerite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: In honor of George D. Liveing (1827–1924), Professor of Chemistry, Cambridge University, Cambridge, England.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 462. (2) Le Bihan, M.-T. (1962) Etude structurale de quelques sulfures de plomb et d'arsenic naturels du gisement de Binn. Bull. Soc. fr. Minéral., 85, 15–47 (in French). (3) Nowacki, W. (1967) Über die mögliche Identität von "liveingit" mit Rathite-II. Neues Jahrb. Mineral., Monatsh., 353–354 (in German). (4) (1969) Amer. Mineral., 54, 1498 (abs. refs. 2 and 3). (5) Engel, P. and W. Nowacki (1970) Die Kristallstruktur von Rathite II $[As_{25}S_{56}|Pb^{VII}_{6.5}Pb^{IX}_{12}]$. Zeits. Krist., 131, 356–375 (in German with English abs.). (6) Pring, A. (2001) The crystal chemistry of the sartorite group minerals from Lengenbach, Binntal, Switzerland – a HRTEM study. Schweiz. Mineral. Petrog. Mitt., 81, 69–87. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 324.

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Livingstonite $HgSb_4S_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As needles elongated [010], to 12 cm; also fibrous, massive, columnar, and in globular masses and interlaced needles. *Twinning:* Twin gliding postulated. Polysynthetic-twinninglike features noted in polished section.

Physical Properties: *Cleavage:* Perfect on {001}, poor on {010} and {100}. *Tenacity:* Flexible. Hardness = 2 VHN = 96–125 (100 g load). D(meas.) = 4.8(2); 4.88(2) (synthetic). D(calc.) = 4.98

Optical Properties: Opaque, translucent in thin fragments. *Color:* Blackish gray; in polished section, white; red in transmitted light, with deep red internal reflections. *Streak:* Red. *Luster:* Adamantine to metallic.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Orientation:* $Z = b$. $n = > 2.72$
Anisotropism: Strong.
R_1–R_2: (400) 35.0–44.3, (420) 34.2–44.3, (440) 33.2–44.4, (460) 32.8–44.9, (480) 32.6–44.9, (500) 32.3–43.8, (520) 31.8–42.3, (540) 31.2–41.0, (560) 30.7–40.0, (580) 30.4–39.2, (600) 29.9–38.1, (620) 29.1–36.8, (640) 28.4–35.7, (660) 27.8–34.9, (680) 27.4–34.2, (700) 26.9–33.6

Cell Data: *Space Group:* $A2/a$. $a = 30.567(6)$ $b = 4.015(1)$ $c = 21.465(3)$ $\beta = 103.39(1)^\circ$ Z = 8

X-ray Powder Pattern: Huitzuco, Mexico (may show preferred orientation).
3.00 (100), 3.74 (70), 3.48 (70), 2.28 (60), 1.734 (50), 5.16 (40), 2.67 (30)

Chemistry:

	(1)	(2)	(3)
Hg	22.52	21.0	21.25
Sb	53.75	51.6	51.58
S	23.73	28.6	27.17
Total	100.00	101.2	100.00

(1) Huitzuco, Mexico; recalculated after deduction of 13-16% impurities. (2) Do.; by electron microprobe. (3) $HgSb_4S_8$.

Occurrence: In low-temperature hydrothermal veins.

Association: Cinnabar, stibnite, sulfur, gypsum.

Distribution: In Mexico, from the La Cruz mine, Huitzuco, Guerrero [TL]; and at the Trinidad mine, Guadalcázar, San Luis Potosí. From the Matsuo mine, Iwate Prefecture, Japan. At Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan. From Pedrosa del Rey, León, Spain.

Name: Honors David Livingstone (1813–1873), Scottish explorer and missionary in Africa.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 485–486. (2) Srikrishnan, T. and W. Nowacki (1975) A redetermination of the crystal structure of livingstonite, $HgSb_4S_8$. Zeits. Krist., 141, 174–192. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 170. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 326.

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Lizardite $Mg_3Si_2O_5(OH)_4$

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Crystal Data: Hexagonal, pseudo-orthorhombic. *Point Group:* $3m$ (1A); $6mm$ ($2H_1$). Crystals rare, to 2 mm, as trigonal plates to truncated trigonal pyramids. Commonly as extremely fine-grained scales and massive aggregates.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Crystals are easily bent. Hardness = 2.5 D(meas.) = 2.55(3) D(calc.) = 2.57

Optical Properties: Translucent. *Color:* Green, light yellow to white; colorless to pale green in thin section. *Luster:* Waxy.
Optical Class: Uniaxial (–) to slightly biaxial (–). α = 1.538–1.554 β = 1.546–1.560 γ = 1.546–1.560 2V(meas.) = Small.

Cell Data: *Space Group:* $P31m$ (1A). $a = 5.325(5)$ $c = 7.259(7)$ Z = 2, or *Space Group:* $P6_3cm$ ($2H_1$). $a = 5.318(4)$ $c = 14.541(7)$ Z = [4]

X-ray Powder Pattern: Kennack Cove, England (1A).
7.4 (100), 2.505 (100), 4.6 (80), 3.67 (80), 2.156 (80), 1.538 (80), 1.505 (80)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	44.29	41.80	FeO		1.81
TiO_2	0.03		MgO	40.43	40.69
Al_2O_3	2.18	2.79	CaO	0.03	
Fe_2O_3	0.50		H_2O^+	12.42	[12.90]
			Total	99.88	[99.99]

(1) Kennack Cove, England; corresponds to $(Mg_{2.74}Al_{0.12}Fe^{3+}_{0.02})_{\Sigma=2.88}Si_{2.00}O_{5.13}(OH)_{3.87}$.
(2) Coli, Italy; by electron microprobe, $2H_2O$ assumed; corresponds to $(Mg_{2.82}Al_{0.09}Fe_{0.07})_{\Sigma=2.98}(Si_{1.94}Al_{0.06})_{\Sigma=2.00}O_5(OH)_4$.

Polymorphism & Series: 1A, 6A, $2H_1$ polytypes; polymorphous with antigorite, clinochrysotile, orthochrysotile, and parachrysotile; forms a series with népouite.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Typically a product of retrograde metamorphism, replacing olivine, orthopyroxene, or other minerals in ultramafic igneous rocks.

Association: Chrysotile, brucite, magnetite.

Distribution: Probably the most common serpentine mineral. A few prominent localities for well-studied material include: at Kennack Cove, The Lizard, Cornwall, England. On Unst, Shetland Islands, Scotland. From near Val Sissone, Lombardy, and Val Trebbia, Piacenza, Italy. In Japan, from Maruo Odori and Kodo, Yamaguchi Prefecture, and at Hamao, Fukuoka Prefecture. At Woodsreef, New South Wales, Australia. From the Jeffrey mine, Asbestos, Quebec, and the Cassiar mine, British Columbia, Canada. In the USA, in the Stillwater complex, Montana.

Name: For the type locality, the Lizard complex, Cornwall, England.

Type Material: The Natural History Museum, London, England, 1955,243; National Museum of Natural History, Washington, D.C., USA, 114569.

References: (1) Whittaker, E.J.W. and J. Zussman (1956) The characterization of serpentine minerals by X-ray diffraction. Mineral. Mag., 31, 107–126. (2) (1957) Amer. Mineral., 42, 585 (abs. ref. 1). (3) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals,

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v. 3, sheet silicates, 170–190. (4) Rucklidge, J.C and J. Zussman (1965) The crystal structure of the serpentine mineral, lizardite $Mg_3Si_2O_5(OH)_4$. Acta Cryst., 19, 381–389. (5) Wicks, F.J. and E.J.W. Whittaker (1975) A reappraisal of the structures of the serpentine minerals. Can. Mineral., 13, 227–243. (6) Mellini, M. and P.F. Zanazzi (1987) Crystal structures of lizardite-*1T* and lizardite-*2H1* from Coli, Italy. Amer. Mineral., 72, 943–948. (7) Wicks, F.J. and D.S. O'Hanley (1988) Serpentine minerals: structures and petrology. In: S.W. Bailey, Ed., Hydrous phyllosilicates. Rev. Mineral. 19, MSA, 91–167.

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Lokkaite-(Y) $CaY_4(CO_3)_7 \cdot 9H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Fibrous crystal bundles, to 0.5 mm, in isolated radial aggregates, and in powdery incrustations.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.92]

Optical Properties: Semitransparent. *Color:* White, may be discolored to pale yellow. *Optical Class:* Biaxial (–). *Orientation:* $Z = c$; positive elongation. $\alpha = 1.569$ $\beta = 1.592$ $\gamma = 1.620$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pbmm$, $Pb2m$, or $Pbm2$. $a = 39.07$–39.35 $b = 6.079$–6.104 $c = 9.19$–9.26 $Z = 8$

X-ray Powder Pattern: Pyörönmaa pegmatite, Finland.
3.808 (100), 4.594 (75), 3.902 (60), 6.509 (55), 9.77 (50), 5.792 (45), 2.931 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	32.4	28.09	31.51	Ho_2O_3	trace	1.12	
Y_2O_3	29.0	20.64	46.18	Er_2O_3	4.0	2.35	
La_2O_3	0.2	0.33		Tm_2O_3	0.9	0.28	
Ce_2O_3	0.7	0.43		Yb_2O_3	2.2	0.80	
Pr_2O_3	0.3	0.61		Lu_2O_3	trace	0.10	
Nd_2O_3	1.3	7.13		Fe_2O_3	0.4		
Sm_2O_3	1.8	3.84		CaO	3.2	5.25	5.73
Eu_2O_3		1.72		H_2O^+	1.6		
Gd_2O_3	4.6	7.47		H_2O^-	5.4		
Tb_2O_3	1.2	1.22		H_2O		14.13	16.58
Dy_2O_3	6.8	6.02		Total	96.0	101.53	100.00

(1) Pyörönmaa pegmatite, Finland; by electron microprobe, CO_2 and H_2O by "conventional procedures," corresponds to $Ca_{0.23}RE_{3.85}(C_{1.05}O_3)_7 \cdot 3.85H_2O$. (2) Kirigo, Japan; by ICP, corresponds to $Ca_{1.03}(Y_{2.00}Gd_{0.45}Nd_{0.40}Dy_{0.35}Sm_{0.24}Er_{0.14}Eu_{0.11}Tb_{0.07}Ho_{0.06}Yb_{0.04}Pr_{0.04}Ce_{0.03}Tm_{0.02}La_{0.02}Lu_{0.01})_{\Sigma=3.98}(CO_3)_{7.00} \cdot 8.60H_2O$. (3) $CaY_4(CO_3)_7 \cdot 9H_2O$.

Occurrence: A secondary mineral formed by alteration of primary rare-earth minerals.

Association: Tengerite-(Y) (Pyörönmaa pegmatite, Finland); lanthanite, kimuraite-(Y) (Kirigo, Japan).

Distribution: From the Pyörönmaa pegmatite, Kangasala, Finland. At Ytterby, on Resarö Island, near Vaxholm, and in the Åskagen pegmatite quarry, Värmland, Sweden. In Japan, from Kirigo and Yokatake, Higashi Matsuura district, Saga Prefecture, and at Lisaka, Date district, Fukushima Prefecture. In the Evans-Lou quarry, near Hull, Quebec, Canada.

Name: To honor Professor Lauri Lokka (1885–1966), Finnish mineralogist and Chief Chemist, Geological Survey of Finland, Helsinki, Finland.

Type Material: n.d.

References: (1) Perttunen, V. (1970) Lokkaite, a new hydrous RE-carbonate from Pyörönmaa pegmatite in Kangasala, SW-Finland. Bull. Geol. Soc. Finland, 43(1), 67–72. (2) (1971) Amer. Mineral., 56, 1838 (abs. ref. 1). (3) Nagashima, K., R. Miyawaki, J. Takase, I. Nakai, K. Sakurai, S. Matsubara, A. Kato, and S. Iwano (1986) Kimuraite, $CaY(CO_3)_4 \cdot 6H_2O$, a new mineral from fissures in an alkali olivine basalt from Saga Prefecture, Japan, and new data on lokkaite. Amer. Mineral., 71, 1028–1033.

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Löllingite $FeAs_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic ‖ [001], also pyramidal, commonly doubly terminated, to 4 cm; massive. *Twinning:* On {011}, may produce trillings; polysynthetic on {101}.

Physical Properties: *Cleavage:* Rarely distinct on {010}, {101}. Hardness = 5–5.5 VHN = 859–920 (100 g load). D(meas.) = 7.40 (synthetic). D(calc.) = 7.47

Optical Properties: Opaque. *Color:* Steel-gray to silver-white. *Streak:* Grayish black. *Luster:* Metallic. *Anisotropism:* Strong.
R_1–R_2: (400) 51.6–59.7, (420) 52.0–59.9, (440) 52.6–59.8, (460) 53.1–58.8, (480) 53.7–57.6, (500) 54.2–56.2, (520) 54.8–54.9, (540) 55.4–53.7, (560) 55.9–52.7, (580) 56.3–51.8, (600) 56.3–51.1, (620) 55.9–50.4, (640) 55.2–49.8, (660) 54.5–49.3, (680) 53.6–48.7, (700) 53.1–48.4

Cell Data: *Space Group: Pnnm* (synthetic). $a = 5.300$ $b = 5.983$ $c = 2.882$ Z = 2

X-ray Powder Pattern: Synthetic.
2.605 (100), 2.331 (65), 2.599 (60), 2.532 (60), 1.634 (35), 2.421 (30), 1.854 (30)

Chemistry:

	(1)	(2)	(3)
Fe	27.93	27.6	27.15
As	70.83	71.7	72.85
Bi			
S	0.77	0.5	
Total	99.53	99.8	100.00

(1) Drum's Farm, Alexander Co., North Carolina, USA. (2) Cligga Head, Cornwall, England; by electron microprobe. (3) $FeAs_2$.

Polymorphism & Series: Forms a series with safflorite.

Mineral Group: Löllingite group.

Occurrence: In mesothermal deposits associated with other sulfides and with calcite gangue; also in pegmatites.

Association: Skutterudite, bismuth, nickeline, nickel-skutterudite, siderite, calcite.

Distribution: In Austria, from Lölling, near Hüttenberg, Carinthia [TL]; and at Schladming, Styria. From Reichenstein, Silesia, Poland. At St. Andreasberg, in the Harz Mountains, Germany. From Guadalcanal, in the Sierra Morena, Seville Province, Spain. In Norway, in the Langesundfjord district. In the USA, from Mt. Mica, near Paris, Oxford Co., Maine; from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in Colorado, from several mines in Gunnison Co.; large masses were found in the Ingersoll mine, near Keystone, Pennington Co., South Dakota. In Canada, from a number of mines at Cobalt, Ontario. From Broken Hill, New South Wales, Australia. Also from numerous minor localities.

Name: For the Austrian locality at Lölling.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 303–307. (2) Radcliffe, D. and L.G. Berry (1968) The safflorite–loellingite solid solution series. Amer. Mineral., 53, 1856–1881. (3) Pearson, W.B. (1965) Compounds with the marcasite structure. Zeits. Krist., 121, 449–462. (4) (1960) NBS Circ. 539, 10, 34. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 327.

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Lomonosovite $Na_5Ti_2O_2(Si_2O_7)(PO_4)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Thin lamellar crystals, to 7 cm; also in scaly masses. *Twinning:* Around [100], composition plane {001}, simple contact to finely polysynthetic twinning.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.88–3.13 D(calc.) = [3.04]

Optical Properties: Transparent in thin plates. *Color:* Cinnamon-brown, rose-violet, light yellow, black; dark brown in thin section. *Streak:* Light rose-cinnamon. *Luster:* Vitreous to adamantine on cleavages, greasy on fractures.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = yellow, pale yellow, nearly colorless; Y = brownish, yellow-orange, lilac; Z = yellowish brown, dark brown, dark blackish brown. *Orientation:* $X \wedge$ cleavage = 61°–66°; $Y \wedge$ cleavage = 59°-65°; $Z \wedge$ cleavage = 37°–41°. *Absorption:* $Z > Y > X$. α = 1.654–1.670 β = 1.736–1.750 γ = 1.764–1.778 2V(meas.) = 56°–69°

Cell Data: *Space Group:* $P\bar{1}$. $a = 5.49$ $b = 7.11$ $c = 14.50$ $\alpha = 101°$ $\beta = 96°$ $\gamma = 90°$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
2.83 (10), 1.778 (9), 1.840 (8), 2.73 (7), 2.65 (7), 2.60 (7), 2.08 (7)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	24.07	23.94	23.76	MnO	3.17		
TiO_2	24.43	31.08	31.58	MgO	0.58		
ZrO_2	2.10			CaO	0.80	0.56	
Fe_2O_3	2.39			Na_2O	26.09	29.64	30.63
Nb_2O_5		0.54		Cl	trace		
Ta_2O_5	3.00			H_2O	0.26		
FeO		0.75		P_2O_5	12.84	14.23	14.03
				Total	99.73	100.74	100.00

(1) Lovozero massif, Russia. (2) Ilímaussaq intrusion, Greenland; by electron microprobe, average of six analyses; original analysis given as Si 11.19%, Ti 18.63%, Nb 0.38%, Fe 0.58%, Ca 0.40%, Na 21.99%, P 6.21%, here recalculated to oxides. (3) $Na_5Ti_2O_2(Si_2O_7)(PO_4)$.

Occurrence: In nepheline syenites and pegmatites cutting them (Lovozero massif, Russia); in lavas and gabbros near contacts with nepheline syenite (Ilímaussaq intrusion, Greenland).

Association: Nepheline, albite, pectolite, lorenzenite, ussingite, lamprophyllite, eudialyte, arfvedsonite, villiaumite, aegirine, and many other species.

Distribution: Widespread in the Lovozero massif, and on Mt. Rasvumchorr, Khibiny massif, Kola Penninsula, Russia. On the Kvanefjeld Plateau, in the Ilímaussaq intrusion, southern Greenland.

Name: For Mikhail Vasil'evich Lomonosov (1711–1765), Russian mineralogist and naturalist.

Type Material: n.d.

References: (1) Gerasimovskii, V.I. (1950) Lomonosovite, a new mineral. Doklady Acad. Nauk SSSR, 70, 83–86 (in Russian) (2) (1950) Amer. Mineral., 35, 1092–1093 (abs. ref. 1). (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 338–347 (in English). (4) Belov, N.V., G.S. Gavrilova, L.P. Solov'eva, and A.D. Khailov (1977) The refined structure of lomonosovite. Doklady Acad. Nauk SSSR, 235, 1064–1067 (in Russian). (5) Karup-Møller, S. (1983) Lomonosovite from the Ilímaussaq intrusion, South Greenland. Neues Jahrb. Mineral., Monatsh., 83–96.

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Londonite $(Cs, K, Rb)Al_4Be_4(B, Be)_{12}O_{28}$

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Crystal Data: Cubic. *Point Group:* $[\bar{4}3m]$ (by analogy to rhodizite). As portions of Cs-rich material heterogenously distributed throughout crystals, patchy, exsolutionlike, and in veinlets; crystals may show dominant {110}, modified by {111}, {221}, {211}, rare {100}, to 7 cm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 8
D(meas.) = 3.34 D(calc.) = 3.42 [Strongly piezoelectric and pyroelectric.]

Optical Properties: Transparent to translucent. *Color:* Colorless, white, sulfur-yellow, pale yellow, pale yellow-green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.693$

Cell Data: *Space Group:* $P\bar{4}3m$. $a = 7.3205(3)$ $Z = 1$

X-ray Powder Pattern: Antandrokomby, Madagascar (very similar to rhodizite).
2.9898 (100), 2.1132 (70), 2.4410 (50), 1.7759 (40), 3.276 (35), 1.9568 (35), 2.2076 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.07	0.45	Na_2O	0.11	0.12
B_2O_3	[47.39]	46.82	K_2O	2.21	1.79
Al_2O_3	25.10	24.41	Rb_2O	1.04	1.83
Fe_2O_3	0.06	0.12	Cs_2O	8.37	7.54
BeO	[15.49]	12.20	H_2O^+		4.10
MnO	0.05		H_2O^-		0.53
CaO	0.14		Total	[100.07]	[99.91]
Li_2O	0.04	0.00			

(1) Antandrokomby, Madagascar; by electron microprobe, average of five analyses, B_2O_3 and BeO calculated for stoichiometry; corresponds to $(Cs_{0.48}K_{0.38}Rb_{0.09}Na_{0.03}Ca_{0.02}Mn_{0.01})_{\Sigma=1.01}(Al_{3.98}Li_{0.02}Fe_{0.01})_{\Sigma=4.01}Be_{4.00}(B_{10.99}Si_{0.01}Be_{1.00})_{\Sigma=12.00}O_{28.00}$. (2) Manjaka, Madagascar; original total given as 99.92%, neglecting impurities and H_2O, corresponds to $(Cs_{0.45}K_{0.32}Rb_{0.16}Na_{0.03})_{\Sigma=0.96}Al_{4.08}Be_{4.00}(B_{11.48}Be_{0.15})_{\Sigma=11.63}O_{28.00}$.

Occurrence: An uncommon component of granite pegmatites, in the central zones and in miarolitic cavities.

Association: Rhodizite, danburite, elbaite–liddicoatite–schorl, Cs-rich beryl, spodumene, Mn-rich apatite, hambergite, microlite, manganocolumbite, manganotantalite, béhierite, hafnian zircon, albite, microcline, quartz.

Distribution: In Madagascar, from Antandrokomby, near Mt. Bity, Manandona Valley, Antsirabe district; at Antsongombato and Ampanivana, south of Mahaiza, and from Manjaka, Betafo region.

Name: To honor Dr. David London (1953–), Professor of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma, USA, for his contributions to the understanding of granite pegmatites.

Type Material: Museum of Natural History, Milan, Italy, M31115; Department of Geology and Geophysics, New Orleans, USA.

References: (1) Simmons, W.B., F. Pezzotta, A.U. Falster, and K.L. Webber (2001) Londonite, a new mineral species: the Cs-dominant analogue of rhodizite from the Antandrokomby granitic pegmatite, Madagascar. Can. Mineral., 39, 747–755. (2) Frondel, C. and J. Ito (1965) Composition of rhodizite. Tschermaks Mineral. Petrog. Mitt., 10, 409–412.

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Lonecreekite $(NH_4)(Fe^{3+}, Al)(SO_4)_2 \cdot 12H_2O$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Xenomorphic crystals, to 0.1 mm, aggregated in sugary crusts and efflorescences.

Physical Properties: Hardness = "Very soft". D(meas.) = 1.693 D(calc.) = 1.691
Soluble in H_2O, leaving brown $Fe(OH)_3$; dehydrates to sabieite.

Optical Properties: Transparent. *Color:* Colorless to white. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.483$

Cell Data: *Space Group:* $Pa3$. $a = 12.302$ $Z = 4$

X-ray Powder Pattern: Lone Creek Fall Cave, South Africa.
4.356 (100), 7.12 (70), 3.289 (65), 4.107 (60), 5.505 (50), 5.027 (25), 1.945 (20)

Chemistry:

	(1)
SO_3	33.49
Al_2O_3	1.69
Fe_2O_3	13.04
K_2O	0.02
$(NH_4)_2O$	5.34
H_2O	45.60
insol.	0.77
Total	99.95

(1) Lone Creek Fall Cave, South Africa; corresponds to $(NH_4)_{0.99}(Fe_{0.79}Al_{0.16})_{\Sigma=0.95}(S_{1.01}O_4)_2 \cdot 12.25H_2O$.

Occurrence: A rare secondary mineral probably formed by alteration of pyrite and reaction, at pH < 1, with ammonia fumes produced as the result of decay of organic matter (*Hyrax* excreta).

Association: Clairite, sabieite, tschermigite.

Distribution: On the ceiling of Lone Creek Fall Cave, near Sabie, Eastern Transvaal, South Africa.

Name: For Lone Creek Fall Cave, South Africa, its original occurrence.

Type Material: South African Geological Survey Museum, Pretoria, South Africa, LCH002.

References: (1) Martini, J.E.J. (1983) Lonecreekite, sabieite, and clairite, new secondary ammonium ferric-iron sulphates from Lone Creek Fall Cave, near Sabie, Eastern Transvaal. Ann. Geol. Surv. S. Africa, 17, 29–34. (2) (1986) Amer. Mineral., 71, 229 (abs. ref. 1).

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Lonsdaleite C

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Very fine-grained aggregates, forming cubes and cubo-octahedra, to 0.7 mm; in polycrystalline aggregates, mixed with diamond.

Physical Properties: Hardness = 3 VHN = n.d. D(meas.) = > 3.20 D(calc.) = 3.51

Optical Properties: Transparent. *Color:* Grayish in crystals; also pale yellowish or brown in broken fragments. *Luster:* Adamantine.
Optical Class: [Biaxial.] n = Slightly above 2.404. *Anisotropism:* Birefringence slight, probably due to strain.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.51$ $c = 4.12$ Z = 4

X-ray Powder Pattern: Cañon Diablo meteorite.
2.061 (100), 1.257 (60), 2.18 (40), 1.075 (30), 1.933 (20), 1.50 (10), 1.17 (10)

Chemistry:

	(1)
C	100.0
N	0.0
Total	100.0

(1) Cañon Diablo meteorite; by electron microprobe.

Polymorphism & Series: Polymorphous with diamond, graphite, and chaoite.

Occurrence: Discovered in the residue (ca. 200 mg) from the dissolution of 5 kg of Cañon Diablo meteorite. The mineral may be formed by impact shock, or be a product of direct crystallization in the parent body.

Association: Schreibersite, cohenite, taenite, graphite, chromite, kosmochlor, sphalerite, black diamond (Cañon Diablo); troilite, graphite, diamond, schreibersite, cohenite (Allan Hills 77283).

Distribution: In the Canyon Diablo [TL], Goalpara, and Allan Hills 77283 meteorites. From placers in northern Sakha; found in soil at the Tunguska explosion site, Federated SSR, Russia. At the Nördlinger Ries Crater, Bavaria, Germany. In the Sudbury impact structure, Ontario, Canada.

Name: To honor Professor Kathleen (Yardley) Lonsdale (1903–1971), distinguished British crystallographer, University of London, London, England.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 130245.

References: (1) Frondel, C. and U.B. Marvin (1967) Lonsdaleite, a hexagonal polymorph of diamond. Nature, 214, 587–589. (2) (1967) Amer. Mineral., 52, 1579 (abs. ref. 1). (3) Hanneman, R.E., H.M. Strong, and F.P. Bundy (1967) Hexagonal diamonds in meteorites: implications. Science, 155, 995–997. (4) Kaminskii, F.V., G.K. Blinova, E.M. Galimov, G.A. Gurkina, Y.A. Klyuev, L.A. Kodina, V.I. Koptil, V.F. Krivonos, L.N. Frolova, and A.Y. Khrenov (1985) Polycrystalline aggregates of diamond with lonsdaleite from Yakutian [Sakhan] placers. Mineral. Zhurnal, 7, 27–36 (in Russian). (5) Ownby, P.D., X. Yang, and J. Liu (1992) Calculated X-ray diffraction data for diamond polytypes. J. Amer. Ceram. Soc., 1876–1873.

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Loparite-(Ce) $(Ce, Na, Ca)(Ti, Nb)O_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As cubic or octahedral crystals, to 2 cm, which may be highly modified; overgrowing perovskite and massive. *Twinning:* Commonly as penetration twins on {111}.

Physical Properties: *Cleavage:* Imperfect on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–6 VHN = 734–893; 908–1422 (100 g load). D(meas.) = 4.60–4.89 D(calc.) = [4.75–4.94]

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black to grayish black; dark brown in thin section, may be zoned; light gray or white with a creamy tinge and brownish red internal reflections in reflected light. *Streak:* Cinnamon-brown to brown. *Luster:* Metallic to submetallic.
Optical Class: Isotropic, anomalously anisotropic. $n = 2.26–2.38$
R: (400) 18.8, (420) 18.2, (440) 17.8, (460) 17.3, (480) 17.0, (500) 16.8, (520) 16.6, (540) 16.4, (560) 16.3, (580) 16.1, (600) 16.1, (620) 16.0, (640) 15.9, (660) 15.9, (680) 15.9, (700) 15.8

Cell Data: *Space Group: Pm3m.* a = 3.85–3.90 Z = 1

X-ray Powder Pattern: Kola Peninsula, Russia.
2.749 (10), 1.583 (10), 1.226 (10), 1.936 (9), 1.373 (9), 1.120 (4), 2.244 (2)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_5	9.74	15.1	Al_2O_3	0.20		CaO	5.00	2.42
Ta_2O_5	0.75	1.01	La_2O_3		13.2	SrO	3.42	
SiO_2	0.38		CeO_2		17.7	Na_2O	8.32	10.7
TiO_2	39.65	35.8	Ce_2O_3	16.04		K_2O	0.13	
ZrO_2		0.20	Nd_2O_3		2.95	rem.	0.57	
ThO_2	0.76	0.80	RE_2O_3	14.76		Total	100.08	[100.07]
Fe_2O_3		0.19	FeO	0.36				

(1) Kola Peninsula, Russia. (2) Tenerife, Canary Islands; by electron microprobe, total Fe as Fe_2O_3, original total given as 100.10%; corresponding to $(Na_{0.58}Ce_{0.17}La_{0.14}Ca_{0.07}Nd_{0.03})_{\Sigma=0.99}(Ti_{0.76}Nb_{0.19}Ta_{0.01})_{\Sigma=0.96}O_3$.

Mineral Group: Perovskite group; $Ti_B > 0.5$.

Occurrence: A primary phase in differentiated nepheline syenite massifs and alkalic pegmatites; replacing perovskite in carbonatites.

Association: Nepheline, microcline, aegirine, rare-earth-bearing apatite, arfvedsonite, perovskite, ilmenite, eudialite–eucolite, titanite, lamprophyllite.

Distribution: Widespread in the Khibiny and Lovozero massifs, Kola Peninsula; in the Yllymakh massif, Aldan; large crystals from the Burpala massif, 120 km north of Lake Baikal, eastern Siberia, Russia. From Bratthagen, Lagendalen, near Larvik and Buer, Bjørkdalen, Norway. From the Gardiner complex, Kangerdlugssuaq Fjord, eastern Greenland. On Tenerife, Canary Islands. In the Schryburt Lake carbonatite, Ontario, Canada. At Sarambi and Chiriquelo, Paraguay. From the Salitre I alkaline complex, Minas Gerais, Brazil. On Boa Vista, Cape Verde Islands.

Name: From the Russian name for the Lapps, *Lopar*, inhabitants of the Kola Peninsula, Russia, first noted place of occurrence of the mineral, and for its *cerium* content.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 21043–21045.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 730–735 [perovskite, part]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 418–424. (3) Ferguson, A.K. (1978) The occurrence of ramsayite, titan-låvenite and a fluorine-rich eucolite in a nepheline-syenite inclusion from Tenerife, Canary Islands. Contr. Mineral. Petrol., 66, 15–20.

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Lopezite $K_2Cr_2O_7$

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Crystal Data: Triclinic (synthetic). *Point Group:* $\overline{1}$. As ball-like aggregates, to 1 mm.

Physical Properties: Hardness = 2.5 D(meas.) = 2.69 D(calc.) = 2.704 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Red-orange.
Optical Class: Biaxial (+). *Pleochroism:* X = reddish yellow; X = yellow; Z = greenish yellow.
Dispersion: $r > v$, medium. $\alpha = 1.714$ $\beta = 1.732$ $\gamma = 1.805$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P\overline{1}$ (synthetic). $a = 13.367(11)$ $b = 7.376(5)$ $c = 7.445(6)$
$\alpha = 90.75(5)°$ $\beta = 96.21(7)°$ $\gamma = 97.96(5)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 27-380).
3.298 (100), 3.472(90), 3.658 (85), 4.87 (45), 3.063 (30), 3.027 (30), 2.877 (30)

Chemistry: (1) Identification depends on microchemical tests for K and CrO_4, correspondence of optical properties, and X-ray powder pattern with the synthetic compound.

Occurrence: A rare secondary mineral in vugs in massive nitrate rock.

Association: Tarapacáite, dietzeite, ulexite (Oficina Maria Elena, Chile).

Distribution: In Chile, in Tarapacá, from Oficina Rosario, Huara, Pampa del Iquique; Oficina Maria Elena, near Tocopilla, Pampa del Tocopilla; and at Zapiga.

Name: Honoring Dr. Emiliano Lòpez Saa (1871–1959), Iquique, Chile, Chilean mining engineer and mineral collector long associated with the Chilean nitrate industry.

Type Material: National Museum of Natural History, Washington, D.C., USA, C5487.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 645–646. (2) Kuzmin, E.A., N.V. Belov, and V.V. Ilyukhin (1967) Crystal structure of the potassium dichromate K_2CrO_7 (lopezite). Doklady Acad. Nauk SSSR, 173, 1068–1071 (in Russian). (3) Brandon, J.K. and I.D. Brown (1968) An accurate determination of the crystal structure of triclinic potassium dichromate, $K_2Cr_2O_7$. Can. J. Chem., 46(6), 933–941. (4) Brunton, G. (1983) Refinement of the structure of $K_2Cr_2O_7$. Mat. Res. Bull. 8(3), 271–274. (5) Bandy, M.C. (1937) Lopezite, a new mineral. Amer. Mineral., 22, 929–930.

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Lorandite $TlAsS_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Short prisms or tabular on {201}, pyramidal, with many forms, striated parallel to [001]; needlelike to columnar, to 5 cm; granular.

Physical Properties: *Cleavage:* Excellent on {100}, very good on {201}, good on {001}. *Tenacity:* Flexible, forming cleavage lamellae and fibers, with plastic deformation. Hardness = 2–2.5 VHN = n.d. D(meas.) = 5.53 D(calc.) = 5.53

Optical Properties: Translucent to transparent. *Color:* Cochineal-red to carmine-red surface, commonly dark lead-gray, may be coated by an ocher-yellow powder. *Streak:* Cherry-red. *Luster:* Metallic, adamantine.
Optical Class: Biaxial (+) (?). *Pleochroism:* Weak; Y = purple-red; Z = orange-red.
Orientation: X, $Y \simeq \perp$ {100}; $Z = b$. *Dispersion:* $r > v$, strong. $n = > 2.72$ (Li).
2V(meas.) = Large. *Anisotropism:* Strong.
R_1–R_2: (400) 28.8–30.6, (420) 28.7–30.7, (440) 28.6–30.8, (460) 28.4–30.9, (480) 28.2–31.2, (500) 27.8–31.1, (520) 27.5–30.6, (540) 27.0–29.8, (560) 26.4–28.8, (580) 25.8–27.7, (600) 25.0–26.7, (620) 24.4–26.0, (640) 23.9–25.5, (660) 23.5–25.0, (680) 23.2–24.7, (700) 22.9–24.5

Cell Data: *Space Group:* $P2_1/a$. $a = 12.296(9)$ $b = 11.313(5)$ $c = 6.114(1)$ $\beta = 104.21(4)^\circ$ $Z = 8$

X-ray Powder Pattern: Alšar, Macedonia.
3.59 (10), 2.88 (8), 2.97 (7), 1.867 (5), 1.484(5), 5.28 (4), 2.64 (4)

Chemistry:

	(1)	(2)	(3)	(4)
Tl	59.76	58.75	59.5	59.46
As	22.30	21.65	21.6	21.87
S	18.99	19.26	18.8	18.67
rem.		0.08		
Total	101.05	99.74	99.9	100.00

(1–2) Alšar, Macedonia. (3) Carlin mine, Nevada, USA; by electron microprobe, average of five analyses. (4) $TlAsS_2$.

Occurrence: Although rare, the most widespread thallium mineral; of hydrothermal origin, typically formed at relatively low temperatures.

Association: Stibnite, realgar, orpiment, cinnabar, vrabite, greigite, marcasite, pyrite, tetrahedrite, antimonian sphalerite, arsenic, barite.

Distribution: From Alšar (Allchar), near Rošden, Macedonia [TL]. At the Dzhizhikrut Sb–Hg deposit, Tajikistan. From the Beshtau uranium deposit, near Pyatigorsk, northern Caucasus Mountains, Russia. An ore mineral in the Lanmuchang Hg–Tl deposit, Guizhou Province, China. At the Zarshuran gold deposit, near Takab, northestern Iran. From the Lengenbach quarry, Binntal, Valais, Switzerland. In the USA, at the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming; in Nevada, from the Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co., in the Jerritt Canyon mines, Independence Mountains district, Elko Co., and from the Getchell mine, Potosi district, Humboldt Co.; in the Mercur gold deposit, Tooele Co., Utah.

Name: For Eötvös Lorand (1848–1919), physicist of Budapest, Hungary.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 437–439. (2) Radtke, A.S., C.M. Taylor, R.C. Erd, and F.W. Dickson (1974) Occurrence of lorandite, $TlAsS_2$, at the Carlin gold deposit, Nevada. Econ. Geol., 69, 121–174. (3) Balić-Žunić, T., E. Makovicky, and Y. Moëlo (1995) Contributions to the crystal chemistry of thallium sulfosalts III. The crystal structure of lorandite ($TlAsS_2$) and its relation to weissbergite ($TlSbS_2$). Neues Jahrb. Mineral., Abh., 168, 213–235. (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 592–597. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 146–147.

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Loranskite-(Y) $(Y, Ca, Ce)(Ta, Zr)_2O_6(?)$

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Crystal Data: Metamict. *Point Group:* n.d. Massive; originally stated to occur in crystals resembling samarskite.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5
D(meas.) = 4.6 D(calc.) = n.d. Slightly radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black; greenish yellow in transmitted light. *Streak:* Greenish gray. *Luster:* Submetallic.
Optical Class: Isotropic. $n = 2.06$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
Ta_2O_5	47.0
ZrO_2	20.0
$(Y, Er)_2O_3$	10.0
$(Ce, La)_2O_3$	3.0
Fe_2O_3	4.0
CaO	3.3
LOI	8.15
Total	95.45

(1) Impilakhti, Russia; partial analysis, corresponds to $[(Y_{0.47}Ca_{0.31}Fe_{0.29}Ce_{0.10})_{\Sigma=1.17}(Ta_{1.13}Zr_{0.86})_{\Sigma=1.99}O_6]$.

Occurrence: In pegmatite.

Association: Intermixed with other oxides, monazite.

Distribution: From Impilakhti, Pitkäranta district, Lake Ladoga, Karelia, Russia.

Name: For Apollonie Mikhailovich Loranski (1847–?), Inspector of the Mining Institute, St. Petersburg, Russia.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 767. (2) Fauquier, D. (1960) Sur la "wiikite" et la "loranskite". Compt. Rendus Acad. Sci. Paris, 250, 3032–3034 (in French).

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Lorenzenite $Na_2Ti_2Si_2O_9$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals equant, bladed prismatic, to needlelike, to 6 cm; fibrous, felted, lamellar aggregates.

Physical Properties: *Cleavage:* Distinct on {010}. *Fracture:* Uneven. Hardness = 6 D(meas.) = 3.42–3.45 D(calc.) = 3.44 May fluoresce pale yellow to dull green under SW UV, with green cathodoluminescence.

Optical Properties: Transparent to opaque. *Color:* Pale purple-brown, pale pink to mauve, brown to black. *Luster:* Vitreous, adamantine to submetallic, or silky, dull. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; $X = Y =$ pale reddish yellow, yellowish brown to light brown; $Z =$ pale yellow, brownish to dark brown. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, distinct. $\alpha = 1.91$–1.95 $\beta = 2.01$–2.04 $\gamma = 2.03$–2.06 2V(meas.) = 38°–41°

Cell Data: *Space Group: Pbcn.* a = 8.7128(10) $b = 5.2327(5)$ $c = 14.487(2)$ Z = 4

X-ray Powder Pattern: Lovozero massif, Russia. (ICDD 18-1262).
2.74 (100), 3.33 (70), 1.60 (50), 5.56 (40), 2.45 (40), 1.64 (40), 3.12 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	35.40	35.3	35.15	FeO	0.34		
TiO_2	43.16	43.7	46.72	MnO	trace	0.12	
ZrO_2	0.07			CaO	0.19	0.14	
Al_2O_3	0.00	0.11		SrO	0.01		
Y_2O_3	0.02			Na_2O	16.23	17.4	18.13
La_2O_3	0.01			F	0.38		
Ce_2O_3	0.04			H_2O^+	0.42		
Fe_2O_3		0.99		H_2O^-	0.17		
Nb_2O_5	3.89	2.20		$-O = F_2$	0.16		
				Total	100.17	99.96	100.00

(1) Narssârssuk, Greenland; traces of V, Sc, Mn. (2) Tenerife, Canary Islands; by electron microprobe. (3) $Na_2Ti_2Si_2O_9$.

Occurrence: In nepheline syenites and their associated pegmatites.

Association: Aegirine, nepheline, microcline, arfvedsonite, elpidite, loparite, eudialyte, astrophyllite, mangan-neptunite, låvenite, rinkite, apatite, titanite, ilmenite.

Distribution: From Narssârssuk and in the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland. Near Mt. Karnasurt, Lovozero massif, in the Khibiny massif, and the Kondor massif, Kola Peninsula; in the Inagli, Konder, and Murun massifs, near Aldan, Yakutia, Russia. At Lågendalen, near Larvik, and on Låven Island, Langesundsfjord, Norway. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada. At Point of Rocks, Colfax Co., New Mexico, and in the Diamond Jo quarry, Magnet Cove, Hot Spring Co., Arkansas, USA. On Tenerife, Canary Islands.

Name: After Johannes Theodor Lorenzen (1855–1884), Danish mineralogist interested in Greenland minerals.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1967.382; Harvard University, Cambridge, Massachusetts, USA, 87917.

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References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 65. (2) Sahama, T.G. (1947) Analysis of ramsayite and lorenzenite. Amer. Mineral., 32, 59–63. (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 356–361 (in English). (4) Ferguson, A.K. (1978) The occurrence of ramsayite, titan-låvenite and a fluorine-rich eucolite [eudialyte] in a nepheline-syenite inclusion from Tenerife, Canary Islands. Contr. Mineral. Petrol., 66, 15–20. (5) Sundberg, M.R., M. Lehtinen, and R. Kivekäs (1987) Refinement of the crystal structure of ramsayite (lorenzenite). Amer. Mineral., 72, 173–177. (6) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 129.

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Loseyite $(Mn^{2+},Zn)_7(CO_3)_2(OH)_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are lathlike, elongated along [010], to 0.5 mm, in radiating bundles and subparallel aggregates.

Physical Properties: Hardness = ∼3 D(meas.) = 3.27 D(calc.) = 3.34

Optical Properties: Transparent. *Color:* Pale blue, pale brown; colorless in transmitted light. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$. *Dispersion:* $r > v$, weak. $\alpha = 1.637$ $\beta = 1.648$ $\gamma = 1.676$ 2V(meas.) = 64°

Cell Data: *Space Group:* $A2/a$. $a = 16.408(7)$ $b = 5.540(3)$ $c = 15.150(4)$ $\beta = 95.48(3)°$ Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
3.68 (100), 2.63 (100), 3.80 (90), 7.49 (80), 2.54 (70), 3.54 (60), 2.79 (60)

Chemistry:

	(1)
CO_2	12.59
Mn_2O_3	1.03
FeO	0.64
MnO	34.94
ZnO	32.77
MgO	3.42
H_2O	13.83
insol.	0.16
Total	99.38

(1) Franklin, New Jersey, USA; corresponds to $(Mn_{3.49}Zn_{2.85}Mg_{0.60}Fe_{0.06})_{\Sigma=7.00}(CO_3)_{2.02}(OH)_{10.86}$. (2) Do.; by electron microprobe, average of seven analyses, not given; stated to correspond to $(Mn_{3.48}Zn_{2.99}Mg_{0.53})_{\Sigma=7.00}(CO_3)_2(OH)_{10}$.

Occurrence: A very rare mineral occurring in veinlets in massive ore in a metamorphosed stratiform zinc orebody.

Association: Pyrochroite, sussexite, chlorophoenicite, calcite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: To honor Samuel R. Losey (1830–1904), mineral collector of Franklin, New Jersey, USA.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 89344; National Museum of Natural History, Washington, D.C., USA, 95984, 162599.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 214–215. (2) Hill, R.J. (1981) The structure of loseyite. Acta Cryst., 37, 1323–1328.

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Lotharmeyerite $\mathbf{Ca(Mn^{3+},Zn)_2(AsO_4)_2(OH,H_2O)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As equant to tapering bladelike crystals, elongated along [010], showing {001}, curved {10$\overline{1}$}, {20$\overline{1}$}, terminated by {110} and {111}, to 6 mm; in crystalline druses. *Twinning:* About [*h*0*l*], probable.

Physical Properties: *Cleavage:* On {001}, good. Hardness = ∼3 D(meas.) = 4.23(5) D(calc.) = 4.21–4.29

Optical Properties: Semitransparent. *Color:* Dark reddish orange. *Streak:* Pale orange to yellow-orange. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; $X = Z$ = yellow-orange; Y = red-brown. *Orientation:* $Y = b$; $Z \wedge c = -40°$. *Dispersion:* $r \gg v$, strong, inclined. *Absorption:* $Y \gg X > Z$. $\alpha = 1.797(5)$ $\beta = 1.804(5)$ $\gamma = 1.815(5)$ 2V(meas.) = ∼80°

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 9.066(4)$ $b = 6.276(2)$ $c = 7.408(2)$ $\beta = 116.16(3)°$ Z = 2

X-ray Powder Pattern: Ojuela mine, Mapimí, Mexico.
2.557 (100), 3.414 (90), 3.175 (90), 2.912 (90), 4.94 (80), 2.822 (80), 2.710 (80)

Chemistry:

	(1)	(2)
As_2O_5	45.7	47.0
Fe_2O_3	2.7	
Mn_2O_3	13.4	18.7
ZnO	18.3	14.2
CaO	11.3	11.4
H_2O	[8.6]	8.4
Total	[100.0]	99.7

(1) Ojuela mine, Mapimí, Mexico; by electron microprobe, total Fe as Fe_2O_3, total Mn as Mn_2O_3, H_2O by difference; corresponds to $Ca_{0.96}(Zn_{1.07}Mn_{0.81}Fe_{0.16})_{\Sigma=2.04}(AsO_4)_{1.89}(OH,H_2O)_2$.
(2) Do.; by electron microprobe, total Mn as Mn_2O_3, H_2O by moisture evolution analyzer.

Mineral Group: Tsumcorite group.

Occurrence: In the oxidized zone of an arsenic-rich polymetallic base-metal deposit.

Association: Adamite, cryptomelane, chalcophanite, goethite.

Distribution: From the Ojuela mine, Mapimí, Durango, Mexico.

Name: To honor Julius Lothar Meyer (1830–1895), German chemist and physician, Karlsruhe Polytechnic Institute and University of Tübingen, Germany, for his contributions to chemistry.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149482.

References: (1) Dunn, P.J. (1983) Lotharmeyerite, a new mineral from Mapimi, Durango, Mexico. Mineral. Record, 14, 35–36. (2) (1983) Amer. Mineral., 68, 849 (abs. ref. 1). (3) Kampf, A.R., J.E. Shigley, and G.R. Rossman (1984) New data on lotharmeyerite. Mineral. Record, 15, 223–226. (4) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Loudounite $NaCa_5Zr_4Si_{16}O_{40}(OH)_{11}\cdot 8H_2O$

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Crystal Data: n.d. *Point Group:* n.d. As radiating fibrous crystals, forming spherules, to 0.1 mm.

Physical Properties: Hardness = ~5 D(meas.) = 2.48(3) D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Light green to white in aggregates; in thin section, colorless. *Streak:* White.
Optical Class: Biaxial. $\alpha = 1.536(4)$ β = n.d. $\gamma = 1.550(4)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Goose Creek quarry, Virginia, USA.
2.931 (10b), 4.06 (7b), 7.37 (6), 5.81 (5), 3.527 (4), 2.694 (4), 4.56 (3)

Chemistry:

	(1)
SiO_2	45.8
ZrO_2	25.7
Al_2O_3	0.8
FeO	2.0
MnO	trace
MgO	0.3
CaO	12.1
Na_2O	1.3
K_2O	0.2
H_2O	[11.8]
Total	[100.0]

(1) Goose Creek quarry, Virginia, USA; by electron microprobe, H_2O by difference; corresponds to $(Na_{0.85}K_{0.09}Ca_{0.06})_{\Sigma=1.00}(Ca_{4.31}Fe_{0.56}Mg_{0.15})_{\Sigma=5.02}Zr_{4.22}(Si_{15.44}Al_{0.32})_{\Sigma=15.76}O_{40}(OH)_{10.70}\cdot 7.92H_2O$.

Occurrence: A late-stage mineral in the alteration of diabase.

Association: Ancylite, epidote, prehnite, chlorite, actinolite, stilbite, albite, zircon, apophyllite, apatite, titanite, quartz, calcite.

Distribution: In the Goose Creek quarry, Leesburg, Loudoun Co., and the Fairfax quarry, Centreville, Fairfax Co., Virginia, USA.

Name: For the occurrence in Loudoun Co., Virginia, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149397.

References: (1) Dunn, P.J. and D. Newbury (1983) Loudounite, a new zirconium silicate from Virginia. Can. Mineral., 21, 37–40. (2) (1983) Amer. Mineral., 68, 1039 (abs. ref. 1).

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Loughlinite $Na_2Mg_3Si_6O_{16}\cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Fibrous, to 1 cm; massive.

Physical Properties: Hardness = Soft. D(meas.) = 2.165 D(calc.) = [2.22]

Optical Properties: Translucent. *Color:* Pearly white. *Luster:* Silky.
Optical Class: Biaxial (+). $\alpha = 1.500$ $\beta = 1.505$ $\gamma = 1.525$ 2V(meas.) = n.d.
2V(calc.) = 60°

Cell Data: *Space Group: Pncn.* $a = 14.66$ $b = 26.71$ $c = 5.26$ Z = [4]

X-ray Powder Pattern: Sweetwater Co., Wyoming, USA.
12.9 (100), 4.34 (18), 4.51 (7b), 3.63 (7b), 2.55 (7), 3.83 (6b), 2.64 (6)

Chemistry:

	(1)	(2)
SiO_2	50.80	52.44
TiO_2	0.02	
Al_2O_3	0.66	
Fe_2O_3	1.85	
FeO	1.51	
MgO	16.01	17.59
CaO	0.00	
Na_2O	8.16	9.01
K_2O	0.00	
H_2O^+	6.82	
H_2O^-	13.68	
H_2O		20.96
CO_2	0.00	
Total	[99.51]	100.00

(1) John Hay, Jr. Well No. 1, Wyoming, USA; after deduction of dolomite 0.38% and magnesite 0.21% impurities. (2) $Na_2Mg_3Si_6O_{16}\cdot 8H_2O$.

Occurrence: As replacements in dolomitic medium- to low-grade oil shale of the Green River Formation (Sweetwater Co., Wyoming, USA).

Association: Shortite, northupite, searlesite (Sweetwater Co., Wyoming, USA); sepiolite, analcime, montmorillonite, dolomite (Killik, Turkey).

Distribution: In the USA, in core from the John Hay, Jr. Well No. 1 and the Union Pacific Well No. 4, and in the shaft of the Westvaco trona mine, Sweetwater Co., Wyoming. In Turkey, at Killik, near Mıhalıççik.

Name: For Dr. Gerald Francis Loughlin (1880–1946), Chief Geologist, U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 117717.

References: (1) Fahey, J.J., M. Ross, and J.M. Axelrod (1960) Loughlinite, a new hydrous sodium magnesium silicate. Amer. Mineral., 45, 270–281. (2) Biedl, A. and A. Preisinger (1962) Die Struktur des Loughlinit (Natrium-Sepiolith). Fortschr. Mineral., 40, 50–51 (in German). (3) Echle, W. (1967) Loughlinit (Na-Sepiolith) und Analcime in neogenen Sedimenten Anatoliens. Contr. Mineral. Petrol., 14, 86–101 (in German).

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Lourenswalsite $(K,Ba)_2Ti_4(Si,Al)_6O_{14}(OH)_{12}$

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Crystal Data: Pseudohexagonal. *Point Group:* n.d. As very thin hexagonal flakes, forming tiny rosettelike clusters, to 1 mm.

Physical Properties: *Cleavage:* {001}, good. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.17(2) D(calc.) = 3.199(5)

Optical Properties: Translucent. *Color:* Light brownish to silver-gray. *Luster:* Pearly to dull.
Optical Class: Biaxial (–). $\alpha = 1.815(2)$ $\beta = \sim 1.840$ $\gamma = 1.840(2)$ 2V(meas.) = $\sim 0°$

Cell Data: *Space Group:* n.d. $a = 5.244(2)$ $c = 20.49(3)$ $Z = 1$

X-ray Powder Pattern: Diamond Jo quarry, Arkansas, USA.
2.608 (100), 1.515 (80), 1.3111 (25), 10.22 (20), 3.93 (20), 2.249 (16), 4.08 (15)

Chemistry:

	(1)
SiO_2	28.20
TiO_2	28.73
Al_2O_3	5.37
Fe_2O_3	6.18
MgO	1.57
CaO	0.81
BaO	11.69
Na_2O	0.00
K_2O	5.82
H_2O	[11.63]
Total	[100.00]

(1) Diamond Jo quarry, Arkansas, USA; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponds to $(K_{1.16}Ba_{0.72})_{\Sigma=1.88}(Ti_{3.38}Mg_{0.37}Ca_{0.14}Fe_{0.13})_{\Sigma=4.02}(Si_{4.41}Al_{0.99}Fe_{0.60})_{\Sigma=6.00}[O_{19.94}(H_2O)_{6.06}]_{\Sigma=26.00}$.

Occurrence: A secondary mineral formed during weathering, in vugs and miarolitic cavities in a titaniferous nepheline syenite.

Association: Labuntsovite, delindeite, pectolite, barite, pyroxene, titanite, sphalerite, potassic feldspar.

Distribution: In the Diamond Jo quarry, Magnet Cove, Hot Spring Co., Arkansas, USA.

Name: In honor of Dr. Lourens Wals, mineral collector of Turnhout, Belgium.

Type Material: n.d.

References: (1) Appleman, D.E., H.T. Evans, Jr., G.L. Nord, E.J. Dwornik, and C. Milton (1987) Delindeite and lourenswalsite, two new titanosilicates from the Magnet Cove region, Arkansas. Mineral. Mag., 51, 417–425. (2) (1988) Amer. Mineral., 73, 1493–1494 (abs. ref. 1).

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Lovdarite $K_2Na_6(Be,Al)_4Si_{14}O_{36}\cdot 9H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals prismatic, to 2 mm; radial fibrous; compact, porcelaneous massive.

Physical Properties: *Cleavage:* Distinct on {100}, {010}, {001}; poor on {110}. *Tenacity:* Brittle. Hardness = 5–6 in aggregate. D(meas.) = 2.33(1) D(calc.) = 2.32 May fluoresce brilliant green under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to yellowish. *Luster:* Vitreous.
Optical Class: Biaxial (–) or (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$.
$\alpha = 1.513(2)$ $\beta = 1.516(2)$ $\gamma = 1.518(2)$ 2V(meas.) = 70°–90°

Cell Data: *Space Group:* $Pma2$. $a = 39.576(1)$ $b = 6.9308(2)$ $c = 7.1526(3)$ Z = 4

X-ray Powder Pattern: Mt. Karnasurt, Russia.
3.29 (100), 3.14 (100), 4.96 (90), 6.56 (60), 2.447 (60b), 2.288 (60), 1.785 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	56.13	57.00	Na_2O	14.95	14.51
TiO_2	0.15	0.02	K_2O	6.28	6.50
Al_2O_3	1.77	2.30	F	0.07	
Fe_2O_3	0.18	0.07	Cl	0.00	
MnO	0.003		H_2O^+	10.85	
BeO	6.90	6.70	H_2O^-	1.44	
MgO	0.06		H_2O		12.45
CaO	0.49		P_2O_5	0.05	
BaO	0.20		$-O = (F,Cl)_2$	0.02	
			Total	99.50	[99.55]

(1) Mt. Karnasurt, Russia; corresponds to $K_{1.98}(Na_{7.19}Ca_{0.13}Ba_{0.02})_{\Sigma=7.34}(Be_{4.11}Al_{0.47}Ti_{0.02}Fe_{0.02}Mg_{0.02})_{\Sigma=4.64}(Si_{13.93}Al_{0.05}P_{0.02})_{\Sigma=14.00}O_{37.66}\cdot 9.33H_2O$. (2) Do.; original total given as 99.75%, corresponds to $K_{2.0}Na_{6.9}(Be_{4.0}Al_{0.7})_{\Sigma=4.7}Si_{14}O_{37.4}\cdot 10H_2O$.

Occurrence: A late hydrothermal mineral in alkalic pegmatites in a differentiated alkalic massif.

Association: Chkalovite.

Distribution: From the Jubilee pegmatite, Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: From the Russian phrase *dar Lovozera*, for *a gift of Lovozero*.

Type Material: National School of Mines, Paris, France; Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3208; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Men'shikov, Y.P., A.P. Denisov, Y.I. Uspenskaya, and E.A. Lipatova (1973) Lovdarite, a new hydrous beryllosilicate of alkalies. Doklady Acad. Nauk SSSR, 213, 429–432 (in Russian). (2) (1974) Amer. Mineral., 59, 874 (abs. ref. 1). (3) Khomyakov, A.P., E.I. Semenov, A.V. Bikova, A.A. Voronkov, and N.N. Smol'yaninova (1975) New data on lovdarite. Doklady Acad. Nauk SSSR, 221, 699–702 (in Russian). (4) (1983) Amer. Mineral., 68, 474 (abs. ref. 3). (5) Merlino, S. (1990) Lovdarite, $K_4Na_{12}(Be_8Si_{28}O_{72})\cdot 18H_2O$, a zeolite-like mineral: structural features and OD character. Eur. J. Mineral., 2, 809–817.

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Loveringite $(Ca, Ce)(Ti, Fe^{3+}, Cr, Mg)_{21}O_{38}$

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Crystal Data: Hexagonal; metamict in part. *Point Group:* $\overline{3}$. Commonly anhedral, to 120 μm; may be acicular; as inclusions in other minerals.

Physical Properties: Hardness = n.d. VHN = 421–464; 870–933 (100 g load).
D(meas.) = n.d. D(calc.) = 4.42

Optical Properties: Opaque. *Color:* Black; white to grayish white in reflected light.
Streak: Iron-gray. *Luster:* Metallic to submetallic.
Optical Class: Uniaxial.
R: (400) — , (420) 18.2, (440) 17.7, (460) 17.4, (480) 17.0, (500) 16.8, (520) 16.5, (540) 16.4, (560) 16.4, (580) 16.5, (600) 16.5, (620) 16.5, (640) 16.5, (660) 16.5, (680) 16.6, (700) 16.5

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.337(6)$ $c = 20.677(12)$ $Z = 3$

X-ray Powder Pattern: Near Norseman, Western Australia; after heating in air at 800° C.
1.433 (100), 3.037 (93), 1.589 (92), 3.384 (87), 2.465 (72), 1.791 (71), 2.129 (68)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
V_2O_5	1.10		Y_2O_3	0.09		MnO	0.17	0.37
TiO_2	58.34	72.22	La_2O_3	1.22		NiO	0.08	
ZrO_2	4.18	0.14	CeO_2	1.28		PbO	0.22	
HfO_2	0.35		Nd_2O_3	0.24		MgO	2.18	1.77
ThO_2	0.09		RE_2O_3	0.26		CaO	2.37	3.90
UO_2	0.18		Fe_2O_3	15.77	15.81	Total	99.21	99.85
Al_2O_3	1.15	0.88	Cr_2O_3	9.94	4.76			

(1) Near Norseman, Western Australia; by electron microprobe, average of five analyses, total Fe as Fe_2O_3, total V as V_2O_5, RE_2O_3 estimated from chondrite-normalized rare earth patterns; corresponds to $[Ca_{0.72}RE_{0.33}(Y, Th, U, Pb)_{0.05}]_{\Sigma=1.10}(Ti_{12.48}Fe_{3.38}Cr_{2.24}Mg_{0.92}Zr_{0.58}Al_{0.39}V_{0.21}Mn_{0.04})_{\Sigma=20.24}O_{38}$. (2) Western Laouni massif, Algeria; by electron microprobe, total Fe as Fe_2O_3; corresponds to $[Ca_{1.13}(Ti_{14.66}Fe_{3.21}Cr_{1.02}Mg_{0.71}Al_{0.28}Mn_{0.08}Zr_{0.02})_{\Sigma=19.98}O_{38.04}]$.

Mineral Group: Crichtonite group.

Occurrence: A late-stage mineral from residual intercumulus magma in the pyroxene, olivine-chromite, or plagioclase-rich layers of mafic intrusions.

Association: Quartz, potassium feldspar, phlogopite, enstatite, baddeleyite, apatite, zircon, titanite, rutile, ilmenite, chromite (near Norseman, Australia); rutile, pseudobrookite, ilmenite, zirconolite, spinel, pargasite, phlogopite (Western Laouni massif, Algeria).

Distribution: In the Jimberlana intrusion, near Norseman, Western Australia. From St. Christophe and La Grave, near Bourg d'Oisans, Isère, France. In Austria, in the Lohning quarry, Rayris Valley. From the Koitelainen intrusion, Lappland, Finland. In the Western Laouni massif, Hoggar Mountains, Algeria.

Name: Honors Professor John Francis Lovering (1930–), Australian geochemist, University of Melbourne, Melbourne, Australia, for his work on fission-track methods in geochemistry.

Type Material: Museum Victoria, Melbourne, Australia, M34208; National Museum of Natural History, Washington, D.C., USA, 143350.

References: (1) Gatehouse, B.M., I.E. Grey, I.H. Campbell, and P. Kelly (1978) The crystal structure of loveringite – a new member of the crichtonite group. Amer. Mineral., 63, 28–36.
(2) Kelly, P.R., I.H. Campbell, I.E. Grey, and B.M. Gatehouse (1979) Additional data on loveringite $(Ca, REE)(Ti, Fe, Cr)_{21}O_{38}$ and mohsite discredited. Can. Mineral., 17, 635–638.
(3) Lorand, J.-P., J.-Y. Cottin, and G.C. Parodi (1987) Occurrence and petrological significance of loveringite in the Western Laouni layered complex, southern Hoggar, Algeria. Can. Mineral., 25, 683–693.

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Lovozerite $Na_2Ca(Zr,Ti)Si_6(O,OH)_{18}$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* 2. As pseudododecahedral crystals, to 3 mm, and spherical aggregates. In irregular but optically continuous grains, to 3 cm. *Twinning:* Polysynthetic and penetration, common.

Physical Properties: *Cleavage:* Two directions, imperfect. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.38–2.71 D(calc.) = 2.69

Optical Properties: Transparent to opaque. *Color:* Red-brown, dark brown, black; in thin section, yellowish pink, with altered regions dark brown. *Streak:* Brown. *Luster:* Vitreous, resinous to dull.
Optical Class: Uniaxial (–) to biaxial (–). *Pleochroism:* Weak, yellowish to pinkish. $\omega = 1.561$ $\epsilon = 1.549$ $\alpha = 1.545$ $\beta = 1.560$ $\gamma = 1.561$ 2V(meas.) = Small.

Cell Data: *Space Group:* $C2$. $a = 10.48$ $b = 10.20$ $c = 7.33$ $\beta = 92°30'$ Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
3.21 (100), 5.37 (80), 3.64 (70), 3.32 (70), 7.33 (50), 2.969 (50), 2.635 (50)

Chemistry:

	(1)		(1)
SiO_2	52.12	MgO	0.76
TiO_2	1.02	CaO	3.34
ZrO_2	16.54	SrO	0.06
Al_2O_3	0.40	Na_2O	3.74
Fe_2O_3	0.72	K_2O	1.90
Th_2O_3	0.56	H_2O^+	8.62
MnO	3.46	H_2O^-	6.41
		Total	99.65

(1) Lovozero massif, Russia; corresponds to $(Na_{0.87}Ca_{0.41}Mn_{0.33}K_{0.28}Mg_{0.13}Fe_{0.06})_{\Sigma=2.08}(Zr_{0.92}Ti_{0.09})_{\Sigma=1.01}(Si_{5.95}Al_{0.05})_{\Sigma=6.00}(O,OH)_{21.28}$.

Mineral Group: Lovozerite group.

Occurrence: In nepheline syenites and associated pegmatites.

Association: Potassic feldspar, nepheline, aegirine, lamprophyllite, eudialyte, murmanite (Kola Peninsula, Russia).

Distribution: In the Lovozero and Khibiny massifs, Kola Peninsula, Russia. From the Ilímaussaq southern intrusion, Greenland. At Mont Saint-Hilaire, Quebec, Canada.

Name: For the occurrence in the Lovozero massif, Kola Peninsula, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 42701.

References: (1) Gerasimovskii, V.I. (1939) Lovozerite – a new mineral. Doklady Acad. Nauk SSSR, 25, 753–756 (in Russian). (2) (1940) Amer. Mineral., 25, 504 (abs. ref. 1). (3) Ilyukhin, V.V. and N.V. Belov (1960) Derivation of the structure of lovozerite from sections of the three-dimensional Patterson function. Kristallografiya (Sov. Phys. Crystal.), 5, 200–214 (in Russian). (4) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 308–312 (in English). (5) Kapustin, Y.L., A.V. Bykova, and Z.V. Poduvkina (1973) Mineralogy of the lovozerite group. Izvest. Akad. Nauk SSSR, Ser. Geol., 8, 106–112 (in Russian). (6) (1974) Amer. Mineral., 59, 633 (abs. ref. 5). (7) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 130.

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Löweite $Na_{12}Mg_7(SO_4)_{13}\cdot 15H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Anhedral granular.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5–3 D(meas.) = 2.36–2.42 D(calc.) = 2.35 Soluble in H_2O, slightly bitter taste.

Optical Properties: Transparent. *Color:* Colorless, reddish yellow if included iron oxides; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.490$ $\epsilon = 1.471$

Cell Data: *Space Group:* $R\overline{3}$. $a = 18.866(2)$ $c = 13.434(2)$ Z = 3

X-ray Powder Pattern: Synthetic.
10.37 (100), 4.294 (65), 4.046 (60), 2.458 (50), 3.277 (45), 2.698 (45), 3.175 (40)

Chemistry:

	(1)	(2)
SO_3	52.53	52.97
MgO	14.31	14.36
Na_2O	18.58	18.92
H_2O	14.80	13.75
Total	100.22	100.00

(1) Ischl, Austria. (2) $Na_{12}Mg_7(SO_4)_{13}\cdot 15H_2O$.

Occurrence: An uncommon mineral in marine salt deposits; in efflorescences and crusts in saline playa deposits; a volcanic sublimation product.

Association: Anhydrite, gypsum, vanthoffite, blödite, langbeinite, aphthitalite, epsomite, pentahydrite, hexahydrite, kieserite, mirabilite, starkeyite, thénardite.

Distribution: From Ischl, Hallstatt, and Hall, Austria. In Germany, in the Stassfurt-Aschersleben-Bernburg potash district, Saxony-Anhalt; at Merkers, Thuringia; from Hattorf, near Philippsthal, and at Neuhof-Ellers, Hesse. In playas of the La Mancha region, Spain. Found on volcanoes on the Kamchatka Peninsula, Russia. In Turkey, from the Great Konya Basin, near Çakmak, Konya Province. In the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China. In the USA, in the Carlsbad potash district, Eddy Co., New Mexico; from northwest of Grand Junction, Mesa Co., Colorado.

Name: To honor Alexander Löwe (1808–1895), Austrian chemist, Chief Assayer at the Mint, Vienna, Austria.

Type Material: Natural History Museum, Vienna, Austria, A.x.583–A.x.585.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 446–447 (2) Fang, J.H. and P.D. Robinson (1970) Crystal structures and mineral chemistry of double-salt hydrates: II. The crystal structure of loeweite. Amer. Mineral., 55, 378–386. (3) (1977) NBS Mono. 25, 14.

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Luanheite Ag_3Hg

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Crystal Data: Hexagonal. *Point Group:* n.d. Granular to tabular grains, to 10 μm, in irregular spherical aggregates; intergrown with mercurian silver and silicates.

Physical Properties: *Tenacity:* Malleable. Hardness = ∼2.5 VHN = 44–75
D(meas.) = 12.5 D(calc.) = [12.6]

Optical Properties: Opaque. *Color:* Milky white in reflected light; tarnishes black. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Pinkish to milky white. *Anisotropism:* Very weak.
R_1–R_2: (546) 64.2–70.5, (589) 64.9–74.0

Cell Data: *Space Group:* n.d. $a = 6.61$ $c = 10.98$ $Z = 6$

X-ray Powder Pattern: Hebei Province, China.
1.495 (100), 1.204 (90), 2.830 (70), 1.134 (70), 2.000 (60), 1.105 (60), 1.010 (6)

Chemistry:

	(1)	(2)
Ag	62.4	61.73
Fe	0.0	
Co	0.05	
Ni	0.0	
Cu	0.01	
Hg	37.9	38.27
Te	0.10	
Total	100.46	100.00

(1) Hebei Province, China; by electron microprobe, average of five analyses, ranging from $Ag_{3.08}Hg_{0.92}$ to $Ag_{2.96}Hg_{1.04}$. (2) Ag_3Hg.

Occurrence: In a placer containing gold and other elements.

Association: Gold, lead, zinc, mercurian silver, silicates.

Distribution: From a poorly specified locality in the Luan River, Hebei Province, China [TL].

Name: For the Luan [Luan He in Mandarin Chinese] River, China, in which it is found.

Type Material: The National Geological Museum, Chinese Academy of Geological Sciences, Beijing, China.

References: (1) Shao Dianxin, Zhou Jianxiong, Zhang Jianhong, and Bao Daxi (1984) Luanheite – a new mineral. Acta Mineral. Sinica, 4, 97–101 (in Chinese with English abs.).
(2) (1988) Amer. Mineral., 73, 192–193 (abs. ref. 1).

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Luberoite Pt_5Se_4

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Granular fragments with angular edges due to cleavage, typically elongated, to 0.5 mm, or rounded due to alluvial transport; may be enclosed in platinum. *Twinning:* Commonly polysynthetic on {001}.

Physical Properties: *Cleavage:* Good on {001} Hardness = n.d. VHN = 322–620, 461 average (15 g load). D(meas.) = 10.68–12.78 D(calc.) = 13.02

Optical Properties: Opaque. *Color:* Dark bronze; white with a greenish yellow hue in reflected light. *Luster:* Metallic.
Optical Class: Biaxial. *Pleochroism:* Low. *Anisotropism:* Very high. *Bireflectance:* Very high. R_1–R_2: (400) 39.0–44.8, (420) 40.0–45.8, (440) 41.0–47.0, (460) 42.0–48.0, (480) 43.0–49.2, (500) 44.2–50.2, (520) 45.2–51.6, (540) 46.3–52.8, (560) 47.5–53.8, (580) 48.2–54.5, (600) 49.2–55.5, (620) 50.2–56.6, (640) 51.0–57.7, (660) 52.0–58.6, (680) 52.5–59.2, (700) 52.9–59.8

Cell Data: *Space Group:* $P2_1/c$. $a = 6.584(5)$ $b = 4.602(3)$ $c = 11.10(1)$ $\beta = 101.6(1)^\circ$ $Z = 2$

X-ray Powder Pattern: Mutushi, Congo.
1.875 (100B), 2.93 (80), 1.812 (70), 5.45 (60), 3.27 (60), 2.78 (60), 2.465 (60)

Chemistry:

	(1)	(2)	(3)
Pt	75.76	75.6	75.54
Pd		0.4	
Se	24.24	24.1	24.46
Total	100.00	100.1	100.00

(1) Mutushi, Congo; by electron microprobe, average of 12 analyses; corresponds to $Pt_{5.00}Se_{3.95}$. (2) Lubero, Congo; by electron microprobe, corresponds to $(Pt_{4.95}Pd_{0.05})_{\Sigma=5.00}Se_{3.90}$. (3) Pt_5Se_4.

Occurrence: In concentrates from placers derived from granodioritic source rocks.

Association: Platinum, anatase, florencite, gorceixite, kaolinite, chlorite, quartz.

Distribution: From Mutushi, Lubero district, Kivu Province, Congo (Zaire) [TL].

Name: For its occurrence in the Lubero district, Congo.

Type Material: Royal Institute of Natural Sciences, Brussels, Belgium, RC4.215.

References: (1) Jedwab, J., B. Cervelle, G. Gouet, X. Hubaut, and P. Piret (1992) The new platinum selenide luberoite Pt_5Se_4 from the Lubero region (Kivu Province, Zaire). Eur. J. Mineral., 4, 683–692. (2) (1993) Amer. Mineral., 78, 450–451 (abs. ref. 1). (3) Matković, P. and K. Schubert (1977) Krystall Struktur von Pt_5Se_4. J. Less-common Metals, 55, 185–190 (in German). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 332.

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Lucasite-(Ce) $(Ce, La)Ti_2(O, OH)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As discrete subhedral grains, rarely showing {001} and {101}, heavily striated ‖ [010], to 1 mm; as crystalline aggregates.

Physical Properties: *Cleavage:* Good on {001}, may be a parting. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = [6] VHN = 761–900, 824 average (10 g load). D(meas.) = n.d. D(calc.) = 5.00

Optical Properties: Translucent. *Color:* Light to dark brown, chocolate-brown, or shades of gray; brown in transmitted light; gray in reflected light, with brown internal reflections. *Streak:* White. *Luster:* Resinous.
Optical Class: Biaxial. $n = > 2.0$, with very high birefringence. 2V(meas.) = High.
Anisotropism: Weak.
R: (470) 16.6, (546) 15.6, (589) 15.3, (650) 15.0

Cell Data: *Space Group:* $C2/c$ or Cc; structure refined in $I2/a$. $a = 5.178(1)$ $b = 8.756(4)$ $c = 9.768(5)$ $\beta = 93.52(4)^\circ$ Z = 4

X-ray Powder Pattern: Argyle mine, Western Australia.
3.376 (10), 3.203 (8), 2.584 (7), 3.257 (6), 1.8306 (6), 2.225 (5), 2.541 (4)

Chemistry:

	(1)
SiO_2	0.25
TiO_2	47.93
Al_2O_3	0.04
La_2O_3	13.12
Ce_2O_3	24.99
Pr_2O_3	5.50
Nd_2O_3	5.90
MgO	0.03
CaO	0.62
Total	98.38

(1) Argyle mine, Western Australia; by electron microprobe; after neglecting Ca, Mg, and SiO_2, and assuming minor H_2O accounting for low total, corresponds to $(Ce_{0.51}La_{0.27}Pr_{0.11}Nd_{0.12})_{\Sigma=1.01}$ $Ti_{2.00}(O, OH)_6$.

Polymorphism & Series: Dimorphous with aeschynite-(Ce).

Occurrence: In heavy-media concentrates from non-sandy tuff in an olivine lamproite diatreme.

Association: Calcite, dolomite, talc, titanite, manganoan ilmenite, amphibole.

Distribution: In the Argyle AK1 diamond mine, east Kimberley area, Western Australia.

Name: For Hans Lucas, Australian geologist, CRA Exploration Pty. Ltd., who noted the mineral in concentrates.

Type Material: Western Australia Museum, Perth, M.75.1991; Museum Victoria, Melbourne, Australia, M38083; The Natural History Museum, London, England; National Museum of Natural History, Washington, D.C., USA, 163783.

References: (1) Nickel, E.H., I.E. Grey, and I.C. Madsen (1987) Lucasite-(Ce), $CeTi_2(O, OH)_6$, a new mineral from Western Australia: its description and structure. Amer. Mineral., 72, 1006–1010.

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Luddenite $Pb_2Cu_2Si_5O_{14}•14H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Rare crystals tend to a platy habit with wedge-shaped terminations; microcrystalline, with individual grains to 0.01 mm, forming rosettes and fan-shaped aggregates.

Physical Properties: *Cleavage:* Parallel and normal to the plane of flattening of the microcrystals. Hardness = 4 D(meas.) = 4.45 D(calc.) = [4.98]

Optical Properties: Semitransparent. *Color:* Nickel-green. *Streak:* Slightly paler nickel green.
Optical Class: Biaxial. *Pleochroism:* $X = Y$ = yellow-green; Z = rich emerald-green. $\alpha = 1.852$ β = n.d. $\gamma = 1.867$ 2V(meas.) = $\sim 40°$

Cell Data: *Space Group:* n.d. $a = 7.85$ $b = 20.06$ $c = 14.72$ $\beta = 90.78°$ Z = [6]

X-ray Powder Pattern: Artillery Peaks area, Arizona, USA.
7.361 (10), 3.173 (10), 2.918 (8), 5.218 (7), 4.226 (5), 3.515 (5), 3.411 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	25.7	27.2	25.94
TiO_2	4.7		
CuO	13.2	14.0	13.74
PbO	35.1	37.1	38.54
H_2O	20.5	21.7	21.78
Total	99.2	[100.0]	100.00

(1) Artillery Peaks area, Arizona, USA; microchemical analysis, H_2O by Penfield method; some H_2O may be nonessential. (2) Recalculated to 100.0% after removal of TiO_2 impurity. (3) $Pb_2Cu_2Si_5O_{14}•14H_2O$.

Occurrence: In thoroughly oxidized Pb–Cu sulfide ores.

Association: Galena, chalcopyrite, fluorite, quartz, alamosite, melanotekite, cerussite, chalcocite, shattuckite, chrysocolla, wickenburgite, altered Fe-Ti oxides.

Distribution: On the dumps of a Pb–Ag–Cu prospect in the Artillery Peaks area, Mohave Co., Arizona, USA.

Name: For Raymond W. Ludden, Chief Geologist for Western Exploration, Phelps Dodge Corporation.

Type Material: The Natural History Museum, London, England, 1984,473–474.

References: (1) Williams, S.A. (1982) Luddenite, a new copper-lead silicate from Arizona. Mineral. Mag., 46, 363–364. (2) (1983) Amer. Mineral., 68, 643 (abs. ref. 1).

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Ludjibaite $Cu_5(PO_4)_2(OH)_4$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As bladed crystals, flattened on {011}, or as crestlike crystalline aggregates, to 0.3 mm. *Twinning:* On {011}.

Physical Properties: *Fracture:* Uneven. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.36

Optical Properties: Translucent to opaque. *Color:* Blue-green. *Streak:* Pale blue to white. *Luster:* Vitreous.
Optical Class: Biaxial (+) or (–). *Pleochroism:* Weak; azure-blue to pale blue. $\alpha = 1.786$ (α') β = n.d. $\gamma = 1.840$ (γ') 2V(meas.) = Large.

Cell Data: *Space Group:* $P\overline{1}$. $a = 4.446(3)$ $b = 5.871(4)$ $c = 8.680(7)$ $\alpha = 103.9(2)°$ $\beta = 90.3(2)°$ $\gamma = 93.2(2)°$ Z = 1

X-ray Powder Pattern: Ludjiba mine, Congo.
4.46 (100), 2.462 (50), 2.353 (50), 3.02 (20), 2.408 (20), 2.017 (20), 1.572 (20)

Chemistry:

	(1)	(2)
P_2O_5	24.6	24.65
CuO	69.1	69.09
H_2O	6.3	6.26
Total	100.0	100.00

(1) Ludjiba mine, Congo; by electron microprobe, H_2O by difference. (2) $Cu_5(PO_4)_2(OH)_4$.

Polymorphism & Series: Trimorphous with pseudomalachite and reichenbachite.

Occurrence: A rare mineral in the oxidized zone of some copper deposits.

Association: Pseudomalachite, libethenite (Ludjiba mine, Congo); pseudomalachite (Lubietová, Slovakia).

Distribution: From the Ludjiba mine, about 12 km southeast of Kambove, Katanga Province, Congo (Shaba Province, Zaire). At Lubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. In the Käusersteimel mine, near Kausen, Siegerland, Germany.

Name: For its occurrence at Ludjiba, Congo.

Type Material: Royal Institute of Natural Sciences, Brussels, RC3514; Royal Museum of Central Africa, Tervuren, Belgium, RMG4445.

References: (1) Piret, P. and M. Deliens (1988) Description de la ludjibaïte, un polymorphe de la pseudomalachite, $Cu_5(PO_4)_2(OH)_4$. Bull. Minéral., 111, 167–171 (in French with English abs.). (2) (1988) Amer. Mineral., 73, 1495 (abs. ref. 1). (3) Shoemaker, G.L., J.B. Anderson, and E. Kostiner (1981) The crystal structure of a third polymorph of $Cu_5(PO_4)_2(OH)_4$. Amer. Mineral., 66, 169–175.

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Ludlamite $(Fe^{2+}, Mg, Mn^{2+})_3(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, usually tabular {001}, showing {100}, {110}, {001}, {$\bar{1}$11}, others, to 9 cm, may be in parallel groups; granular, massive.

Physical Properties: *Cleavage:* {001}, perfect; {100}, indistinct. Hardness = 3.5
D(meas.) = 3.12–3.19 D(calc.) = 3.176

Optical Properties: Translucent. *Color:* Apple-green to bright green; nearly colorless in transmitted light. *Streak:* Pale greenish white. *Luster:* Vitreous, pearly on {001} cleavage. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = -67°$. *Dispersion:* $r > v$, perceptible. $\alpha = 1.650–1.653$ $\beta = 1.669–1.675$ $\gamma = 1.688–1.697$ 2V(meas.) = 82°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.541(5)$ $b = 4.646(4)$ $c = 9.324(5)$
$\beta = 100°25.8(1.0)'$ Z = 2

X-ray Powder Pattern: Wheal Jane, England. (ICDD 17-468).
3.96 (100), 2.765 (100), 2.543 (100), 4.91 (75), 2.990 (60), 3.74 (50), 2.387 (40)

Chemistry:

	(1)	(2)
P_2O_5	32.95	33.04
FeO	49.22	50.18
MgO	0.96	
H_2O	16.12	16.78
insol.	0.57	
Total	99.82	100.00

(1) Palermo #1 mine, New Hampshire, USA. (2) $Fe_3(PO_4)_2 \cdot 4H_2O$.

Occurrence: In complex granite pegmatites, a common hydrothermal alteration product of earlier phosphates, formed under reducing conditions.

Association: Phosphoferrite, triploidite, triplite, triphylite, apatite (Hagendorf, Germany); fairfieldite, vivianite, siderite, whitlockite (Palermo #1 mine, New Hampshire, USA).

Distribution: Some localities for fine crystals or large masses include: from Wheal Jane, Kea, Cornwall, England. At Hagendorf, Bavaria, Germany. From the Stari Trg mine (Trepča), Kosovo, Serbia. In the USA, at the Palermo #1 mine, North Groton, Grafton Co., New Hampshire; large crystals from the Blackbird mine, Lemhi Co., Idaho; at the Dan Patch, Ferguson, Big Chief, and other pegmatites, near Keystone, Pennington Co., South Dakota. From the Rapid Creek district, Yukon Territory, Canada. Large crystals from the San Antonio mine, Santa Eulalia district, Chihuahua, Mexico. In the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. Fine crystals from Morococala and Huanuni, Oruro, Bolivia. In the Ashio mine, Tochigi Prefecture, Japan. A number of other localities are known.

Name: To honor Henry Ludlam (1824–1880), English mineral collector, London, England.

Type Material: The Natural History Museum, London, England, 44187.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 952–953. (2) Abrahams, S.C. and J.L. Bernstein (1966) Crystal structure of paramagnetic ludlamite, $Fe_3(PO_4)_2 \cdot 4H_2O$, at 298°K. J. Chemical Physics, 44(6), 2223–2229.

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Ludlockite $PbFe_4^{3+}As_{10}^{3+}O_{22}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Commonly as simply terminated laths, elongated along [100], and flattened on $\{0\overline{1}1\}$, less commonly prismatic with almost equant cross sections, to 4 cm; may be slightly twisted. In divergent bundles of such hairlike crystals. *Twinning:* Lamellar twinning on $\{0\overline{1}1\}$, common.

Physical Properties: *Cleavage:* Perfect micaceous on $\{0\overline{1}1\}$, perfect on {021}.
Tenacity: Very flexible and sectile. Hardness = 1.5–2 D(meas.) = 4.33–4.40 D(calc.) = 4.58

Optical Properties: Semitransparent. *Color:* Red, red-brown, orange-brown, yellow.
Streak: Pale brown. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow; Y = deep yellow; Z = yellow-orange.
Orientation: $Z \wedge a \simeq 3°$. *Absorption:* $Z > Y > X$. $\alpha = 1.96$ $\beta = 2.055$ $\gamma = > 2.11$
2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.426(4)$ $b = 11.972(5)$ $c = 9.894(4)$ $\alpha = 113.76(3)°$ $\beta = 99.83(3)°$ $\gamma = 82.50(3)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
8.81 (vvs), 2.935 (vs), 3.330 (ms), 3.160 (ms), 2.863 (ms), 10.90 (m), 4.74 (mb)

Chemistry:

	(1)	(2)	(3)
As_2O_5	70.82		
Fe_2O_3	21.63	19.96	20.85
As_2O_3		60.67	64.58
PbO	9.32	14.41	14.57
H_2O	0.00		
$-O$	1.69		
Total	100.08	95.04	100.00

(1) Tsumeb, Namibia; predominant Fe^{3+} confirmed by Mössbauer spectroscopy, total As as As_2O_5. (2) Do.; by electron microprobe, total Fe as Fe_2O_3, total As as As_2O_3, both confirmed by crystal-structure analysis; corresponding to $Pb_{1.04}Fe^{3+}_{4.04}As^{3+}_{9.93}O_{22}$. (3) $PbFe_4^{3+}As_{10}^{3+}O_{22}$.

Occurrence: In sulfide ore from a complex polymetallic hydrothermal ore deposit (Tsumeb, Namibia).

Association: Zincian siderite, tennantite, chalcocite, pyrite, bornite, germanite, quartz; leiteite, reniérite, stolzite, schneiderhöhnite (Tsumeb, Namibia).

Distribution: From Tsumeb, Namibia. At Laurium, Greece, in slag. From one km north of Campiglia, Tuscany, Italy, in slag. At Zarehehuran, near Takap, Takht-e-Suleiman massif, Azerbaijan.

Name: For Fredrick LUDlow Smith III, (1939–) and Charles LOCKe Key (1935–), American mineral dealers then resident in New Jersey, USA, who supplied the first specimens for study.

Type Material: The Natural History Museum, London, England, 1969,215 and 216; Harvard University, Cambridge, Massachusetts, USA, 127927.

References: (1) Embrey, P.G., M.H. Hey, and R.J. Davis (1977) Ludlockite: a new mineral from Tsumeb. Mineral. Record, 8(3), 91–94. (2) Cooper, M.A. and F.C. Hawthorne (1996) The crystal structure of ludlockite, $PbFe_4^{3+}As_{10}^{3+}O_{22}$, the mineral with pentameric arsenite groups and orange hair. Can. Mineral., 34, 79–89.

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Ludwigite $Mg_2Fe^{3+}BO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are unterminated, fibrous, curved, to 20 cm; commonly in fanlike to felted aggregates.

Physical Properties: *Tenacity:* Tough. Hardness = 5–5.5 D(meas.) = 3.80(3) D(calc.) = [3.78] Weakly ferromagnetic, probable.

Optical Properties: Opaque, translucent only in thin fragments and rims of crystals. *Color:* Pitch-black, olive-black. *Luster:* Submetallic. *Streak:* Black to greenish black. *Luster:* Silky.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = dark green; Z = dark reddish brown. *Orientation:* $Z = c$. *Dispersion:* $r \gg v$, extreme. α = 1.83–1.85 β = 1.83–1.90 γ = 1.97–2.03 2V(meas.) = Small. *Anisotropism:* Strong; yellowish brown to bluish violet gray. *Bireflectance:* Pinkish gray to dark greenish gray.
R_1–R_2: (400) 10.1–13.8, (420) 9.7–13.2, (440) 9.3–12.6, (460) 9.0–12.1, (480) 8.7–11.8, (500) 8.5–11.5, (520) 8.2–11.3, (540) 8.1–11.2, (560) 7.9–11.0, (580) 7.8–10.9, (600) 7.6–10.8, (620) 7.5–10.8, (640) 7.4–10.8, (660) 7.3–10.8, (680) 7.2–10.8, (700) 7.2–10.9

Cell Data: *Space Group: Pbam.* $a = 9.2411(6)$ $b = 12.2948(9)$ $c = 3.0213(3)$ Z = 4

X-ray Powder Pattern: Willis quadrangle, Montana, USA.
5.12 (100), 2.547 (70), 2.515 (70), 2.027 (50), 2.167 (35), 2.990 (25), 1.903 (25)

Chemistry:

	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	0.49		Fe_2O_3	39.00	40.89	CaO	0.11	
TiO_2	0.05		FeO	3.17		H_2O^+	0.15	
B_2O_3	17.43	17.83	MnO	0.33		Total	100.47	100.00
Al_2O_3	0.62		MgO	39.12	41.28			

(1) Ocna de Fier, Romania; B_2O_3 by ICP, H_2O by the Penfield method; corresponds to $(Mg_{1.91}Fe^{2+}_{0.09}Mn_{0.01})_{\Sigma=1.00}(Fe^{3+}_{0.98}Al_{0.02})_{\Sigma=1.00}B_{1.00}O_5$. (2) Mg_2FeBO_5.

Polymorphism & Series: Forms a series with vonsenite.

Mineral Group: Ludwigite group.

Occurrence: Typically formed in magnesian iron skarn and contact metamorphic deposits.

Association: Magnetite, forsterite, clinohumite, vonsenite, szaibélyite.

Distribution: Numerous localities, some with large amounts. From [the Iuliana mine,] Ocna de Fier (Morávicza; Vaskő), Romania. At the Brosso mine, northwest of Ivrea, Torino, Italy. From Broadford, Isle of Skye, Inverness-shire, Scotland. In the Nordmark district, Värmland, Sweden. In Russia, at the Tazheran massif, west of Lake Baikal; large crystals from Titovskoye, Sakha. In the Gole Gohar iron deposit, Bafq district, Iran. In the USA, from the Pomeroy mine, Anaconda, Deer Lodge Co., and at Philipsburg, Granite Co., Montana; from the Crestmore quarry, Riverside Co., California; at the Mountain Lake mine, Big Cottonwood district, Salt Lake Co., Utah. In Canada, in the York River tactite zone, Bancroft, Ontario; from the Cross quarry, near Wakefield, Quebec. In the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea.

Name: Honoring Ernst Ludwig (1842–1915), Austrian Professor of Chemistry, University of Vienna, Vienna, Austria, who analyzed the original material.

Type Material: Natural History Museum, Vienna, Austria, A.a.6315.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 321–324. (2) Marincea, S. (1999) Ludwigite from the type locality, Ocna de Fier, Romania: new data and review. Can. Mineral., 37, 1343–1362. (3) Irwin, M.B. and R.C. Peterson (1999) The crystal structure of ludwigite. Can. Mineral., 37, 939–943. (4) Appel, P.W.U. and M.F. Brigatti (1999) Ludwigite from central Sweden: new data and crystal structure refinement. Mineral. Mag., 63, 511–518. (5) Leonard, B.F., F.A. Hildebrand, and A.C. Vlisidis (1962) Members of the ludwigite–vonsenite series and their distinction from ilvaite. In: Petrologic studies. A volume to honor A.F. Buddington. Geol. Soc. Amer. Bull., 523–568.

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Lueshite $NaNbO_3$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals resemble cubes, to 1.5 cm, and irregular octahedra, with lightly striated, rough, or etched faces. *Twinning:* Complex penetration twins, common.

Physical Properties: *Cleavage:* {001}, imperfect. Hardness = 5–5.5 VHN = 446–572; 642–673 (100 g load). D(meas.) = 4.44 D(calc.) = [4.58]

Optical Properties: Opaque, translucent on thin edges. *Color:* Black, reddish brown on thin edges; violet-brown in thin section; light gray in reflected light. *Streak:* Gray. *Luster:* Submetallic.
Optical Class: Biaxial (–). n = 2.29–2.30 2V(meas.) = 46°–90° *Anisotropism:* Weak. *Bireflectance:* Weak; pale blue.

Cell Data: *Space Group: Pbma.* $a = 5.569(1)$ $b = 15.519(1)$ $c = 5.505(1)$ Z = 8

X-ray Powder Pattern: Lueshe, Congo.
3.91 (100), 2.77 (69), 1.955 (43), 1.96 (34), 1.596 (30), 1.748 (19), 1.382 (12)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_5	79.74	81.09	Fe_2O_3	1.27		K_2O	trace	
Ta_2O_5	trace		MgO	0.62		LOI	0.49	
SiO_2	[0.73]		CaO	0.76		Total	[99.46]	100.00
TiO_2	3.62		Na_2O	12.23	18.91			

(1) Lueshe, Congo; Fe_2O_3 and TiO_2 on a separate sample, SiO_2 then by difference, original total given as 100.46%; corresponding to $(Na_{0.66}Ca_{0.02})_{\Sigma=0.68}(Nb_{1.00}Ti_{0.08})_{\Sigma=1.08}O_3$. (2) $NaNbO_3$.

Polymorphism & Series: Dimorphous with isolueshite and natroniobite.

Mineral Group: Perovskite group: $Na_A > 0.5$; $Nb_B > 0.5$.

Occurrence: Incrusting a vermiculitelike mica, at the contact of cancrinite syenite with carbonatite (Lueshe, Congo); in sodalite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); a common accessory mineral formed during fenetization of pyroxenite and gabbro (Gem Park, Colorado, USA); in veins cutting nepheline syenites (Ilímaussaq intrusion, Greenland).

Association: Mica (Lueshe, Congo); sodalite, ussingite, villiaumite, steenstrupine, griceite, eudialyte, lovozerite (Mont Saint-Hilaire, Canada); vermiculite, ilmenite, pyrochlore, thorianite, perovskite, fersmite, dolomite (Gem Park, Colorado, USA).

Distribution: From the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire). At Gem Park, about six km east of Hillside, Fremont Co., Colorado, USA. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada. At Igdlunguaq, in the Ilímaussaq intrusion, Greenland. In Russia, from the Kovdor, Sallanlatvi, Lesnaya Varaka, and Lovozero massifs, Kola Peninsula, and unidentified carbonatites in Siberia.

Name: For the occurrence at Lueshe, Congo.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM8269; The Natural History Museum, London, England, 1960,440.

References: (1) Safiannikoff, A. (1959) Un nouveau minéral de niobium. Bull. Acad. Sci. d'Outre-mer (Bruxelles), 5, 1251–1255 (in French). (2) (1961) Amer. Mineral., 46, 1004 (abs. ref. 1). (3) Parker, R.L., J.W. Adams, and F.A. Hildebrand (1962) A rare sodium niobate mineral from Colorado. U.S. Geol. Surv. Prof. Paper 450C, 4–6. (4) Kummert, P. (1968) Propriétés optiques de la lueshite. Bull. Soc. Belg. Geol., 77, 269–273 (in French). (5) Seidel, P. and W. Hoffmann (1976) Verfeinerung der Kristallstruktur von $NaNbO_3$ *N.* Bestimmung der absoluten Konfiguration und des Zwillingsgesetzes. Zeits. Krist., 143, 444–459 (in German with English abs.). (6) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 321.

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Luetheite $Cu_2Al_2(AsO_4)_2(OH)_4 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As thin-bladed crystals showing prominent {100}, with {140}, {011}, to 0.2 mm; generally in spherulitic aggregates. *Twinning:* Observed during crystal structure refinement, at a very fine scale.

Physical Properties: *Cleavage:* On {100}, fair to good. *Tenacity:* Brittle, slightly flexible. Hardness = 3 D(meas.) = 4.28(5) D(calc.) = 4.40

Optical Properties: Semitransparent. *Color:* Blue, pale green on alteration, may be tan. *Streak:* White.
Optical Class: Biaxial (+). *Pleochroism:* Faint; in pale blues. *Orientation:* $X = b$; $Z \wedge c \simeq 10°$. *Dispersion:* $r < v$; moderate. *Absorption:* $Y = Z > X$. $\alpha = 1.752$ $\beta = 1.773$ $\gamma = 1.796$
2V(meas.) = n.d. 2V(calc.) = 88°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1/a$. $a = 14.743$ $b = 5.093$ $c = 5.598$
$\beta = 101°49'$ Z = 2

X-ray Powder Pattern: Patagonia district, Arizona, USA.
3.498 (10), 7.21 (7), 2.507 (5), 1.803 (5), 1.270 (4), 2.546 (3), 2.454 (3)

Chemistry:

	(1)	(2)
As_2O_5	41.7	42.18
Al_2O_3	18.9	18.71
CuO	29.8	29.19
H_2O	9.6	9.92
Total	[100.0]	100.00

(1) Patagonia district, Arizona, USA; by microchemical methods, Cu by AA, H_2O by the Penfield method, recalculated to 100% from a total of 97.1% averaged from several analyses; corresponds to $Cu_{1.98}Al_{1.95}(AsO_4)_{1.97}(OH)_{3.91} \cdot 0.87H_2O$. (2) $Cu_2Al_2(AsO_4)_2(OH)_4 \cdot H_2O$.

Mineral Group: Forms a series with chenevixite.

Occurrence: A rare mineral filling cavities in intensely altered volcanic rock (Patagonia district, Arizona, USA); in the oxidized zone of a copper deposit (Majuba Hill, Nevada, USA).

Association: Chenevixite, cornubite (Patagonia district, Arizona, USA); pharmacosiderite, arthurite, scorodite, chenevixite, zeunerite (Majuba Hill, Nevada, USA).

Distribution: In the USA, from a prospect about 2.7 km southeast of the Flux mine, Patagonia district, Santa Cruz Co., Arizona; at the Majuba Hill mine, Antelope district, Pershing Co., Nevada. From the Bali Lo copper prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia.

Name: Honors Ronald D. Luethe (1944–), geologist for Phelps Dodge Corporation, Douglas, Arizona, USA, who found the first material.

Type Material: The Natural History Museum, London, England, 1980,536; Harvard University, Cambridge, Massachusetts, 119098; National Museum of Natural History, Washington, D.C., USA, 135810.

References: (1) Williams, S.A. (1977) Luetheite, $Cu_2Al_2(AsO_4)_2(OH)_4 \cdot H_2O$, a new mineral from Arizona, compared with chenevixite. Mineral. Mag., 41, 27–32. (2) (1977) Amer. Mineral., 62, 1058 (abs. ref. 1). (3) Burns, P.C., J.V. Smith, and I.M. Steele (2000) Arizona porphyry copper/hydrothermal deposits. I. The structure of chenevixite and leutheite. Mineral. Mag., 64, 25–30.

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Lukechangite-(Ce) $Na_3Ce_2(CO_3)_4F$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Tabular to short prismatic, barrellike crystals, to 1 mm, showing {0001}, $\{11\bar{2}0\}$, $\{11\bar{2}1\}$, striated parallel {0001}.

Physical Properties: *Cleavage:* Perfect on {0001}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = ∼4.5 D(meas.) = > 3.3 D(calc.) = 4.02

Optical Properties: Semitransparent. *Color:* Colorless to pale beige. *Streak:* White. *Luster:* Vitreous to somewhat pearly on {0001}.
Optical Class: Uniaxial (–). $\omega = 1.728(3)$ $\epsilon = 1.542(1)$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.0612(8)$ $c = 22.820(9)$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
4.31 (100), 2.192 (90b), 3.169 (70), 2.534 (70), 1.978 (70), 2.877 (60), 5.71 (50)

Chemistry:

	(1)	(2)
CO_2	[28.40]	28.94
La_2O_3	16.36	
Ce_2O_3	29.48	53.97
Pr_2O_3	1.95	
Nd_2O_3	5.88	
CaO	0.10	
SrO	0.12	
Na_2O	14.94	15.29
F	3.58	3.12
$-O = F_2$	1.51	1.32
Total	[99.30]	100.00

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of five analyses on one grain, CO_2 calculated from crystal-structure analysis; corresponds to $(Na_{2.99}Ca_{0.01}Sr_{0.01})_{\Sigma=3.01}(Ce_{1.11}La_{0.62}Nd_{0.22}Pr_{0.07})_{\Sigma=2.02}(CO_3)_{4.00}F_{1.17}$. (2) $Na_3Ce_2(CO_3)_4F$.

Occurrence: A very rare mineral found in a pegmatite dike associated with an intrusive alkalic gabbro-syenite complex.

Association: Microcline, analcime, sodalite, aegirine, sérandite, eudialyte, catapleiite, fluorite, petersenite-(Ce), siderite, astrophyllite, albite.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Professor Luke L.Y. Chang (1934–), University of Maryland, College Park, Maryland, USA, for his studies of carbonate minerals.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81535.

References: (1) Grice, J.D. and G.Y. Chao (1997) Lukechangite-(Ce), a new rare-earth-fluorocarbonate mineral from Mont Saint-Hilaire, Quebec. Amer. Mineral., 82, 1255–1260.

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals pseudohexagonal tabular to blocky, to 3 mm; commonly flat nodular, spherulitic, fibrous to earthy, massive. *Twinning:* Common, by rotation about $[1\bar{1}0]$.

Physical Properties: *Cleavage:* On {010}, fair. Hardness = ~2 D(meas.) = 2.05 D(calc.) = 2.204

Optical Properties: Translucent. *Color:* White to brownish white, colorless.
Luster: Vitreous.
Optical Class: Biaxial (–). α = 1.520–1.522 β = 1.54–1.541 γ = 1.545–1.549
2V(meas.) = 63° 2V(calc.) = 62°

Cell Data: *Space Group:* $P\bar{1}$. a = 6.3475(6) b = 9.8027(11) c = 6.2976(5)
α = 84.456(9)° β = 106.402(8)° γ = 96.400(9)° Z = 1

X-ray Powder Pattern: Lüneburg, Germany. (ICDD 25-1155).
4.98 (100), 4.85 (70), 2.964 (60), 2.819 (45), 3.23 (40), 2.507 (35), 3.027 (30)

Chemistry:

	(1)	(2)	(3)
P_2O_5	29.61	29.96	28.70
B_2O_3	12.90	12.63	14.08
MgO	25.13	25.47	24.44
CaO	0.15	0.25	
H_2O	32.16	31.61	32.78
Total	99.95	99.92	100.00

(1) Lüneburg, Germany. (2) Bela Stena, Serbia; corresponds to $Mg_{3.2}B_{1.8}(PO_4)_{2.1}(OH)_{5.5} \cdot 6.1H_2O$. (3) $Mg_3B_2(PO_4)_2(OH)_6 \cdot 6H_2O$.

Occurrence: In marine evaporite sequences.

Association: Boracite, gypsum (Lüneburg, Germany); colemanite, howlite, searlesite, magnesite, dolomite (Bela Stena, Serbia); halite, sylvite, polyhalite (Permian Basin, USA).

Distribution: From Lüneburg, 40 km south-southeast of Hannover, Lower Saxony, Germany. At Bela Stena, Serbia. From Kerch, Crimean Peninsula, Ukraine. At Kara-Bogaz-Gol and Uzun-Su, Turkmenistan. In the Permian Basin, around Carlsbad, Eddy Co., New Mexico and into Culbertson Co., Texas, USA. At Mejillones, Tarapaca, Chile.

Name: For its first-noted occurrence at Lüneburg, Germany.

Type Material: Wroclaw University, Wroclaw, Poland, II–5734; National Museum of Natural History, Washington, D.C., USA, 162602.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 385. (2) Sen Gupta, P.K., G.H. Swihart, R. Dimitrijević, and M.B. Hossain (1991) The crystal structure of lüneburgite, $Mg_3(H_2O)_6[B_2(OH)_6(PO_4)_2]$. Amer. Mineral., 76, 1400–1407.

Lunijianlaite $[LiAl_4(Si_3Al)O_{10}(OH)_8]\cdot[Al_2Si_4O_{10}(OH)_2]$

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Crystal Data: n.d. *Point Group:* n.d. Crystals acicular, to 2 mm, in radiating aggregates.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 2 D(meas.) = 2.75 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Colorless to white. *Luster:* Vitreous to pearly, silky in aggregates.
Optical Class: Biaxial (–). *Orientation:* May show inclined extinction. $\alpha = 1.576(5)$ $\beta = 1.582(5)$ $\gamma = 1.587(5)$ 2V(meas.) = 60(5)°

Cell Data: *Space Group:* n.d. $a = 5.09$ $b = 8.97$ $c = 23.397$ [c•sin β]. $\beta =$ n.d. Z = n.d.

X-ray Powder Pattern: Qingtian, China; * = cookeite overlaps.
4.704 (100*), 3.343 (47), 3.539 (45*), 2.919 (40), 14.267 (22*), 7.802 (22), 2.832 (22)

Chemistry:

	(1)
SiO_2	41.61
Al_2O_3	44.80
Fe_2O_3	0.60
Li_2O	1.57
Na_2O	0.063
K_2O	0.012
H_2O^+	11.296
Total	99.951

(1) Qingtian, China; by electron microprobe, Li by AA, H_2O by TGA; corresponds to $Li_{0.73}Al_{4.19}(Si_3Al)O_{10}(OH)_8 \cdot Al_2Si_4O_{10}(OH)_2$.

Polymorphism & Series: Regular 1:1 interstratification of cookeite and pyrophyllite.

Occurrence: Within corundum, in a hydrothermal pyrophyllite deposit in rhyolite.

Association: Corundum, diaspore, chlorite, illite, halloysite, svanbergite, zeolites, hematite.

Distribution: From Qingtian, Chekiang Province, China.

Name: From the Chinese *luni*, for the chlorite group, representing cookeite; *jian*, a connective; and *lain* for pyrophyllite.

Type Material: n.d.

References: (1) Youhua Kong, Xiuwen Peng, and Dehui Tian (1990) Lunijianlaite – a new regular interstratified mineral. Acta Mineral. Sinica, 10(4), 289–298 (in Chinese with English abs.). (2) (1992) Amer. Mineral., 77, 447–448 (abs. ref. 1).

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Lun'okite $(Mn^{2+}, Ca)(Mg, Fe^{2+}, Mn^{2+})Al(PO_4)_2(OH)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic crystals in flattened radial aggregates, to 1 mm.

Physical Properties: *Cleavage:* Perfect on {010}; imperfect on {001}. Hardness = 3–4 VHN = 240 (40 g load). D(meas.) = 2.66 D(calc.) = 2.69

Optical Properties: Semitransparent. *Color:* Colorless to pale yellowish white. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$. $\alpha = 1.603$ $\beta = 1.608$ $\gamma = 1.616$ 2V(meas.) = 70°

Cell Data: *Space Group: Pbca.* $a = 14.95(5)$ $b = 18.71(2)$ $c = 6.96(3)$ Z = 8

X-ray Powder Pattern: Mt. Vasin-Myl'k, Russia.
2.809 (10b), 9.39 (9), 2.92 (7), 3.48 (6), 5.15 (5), 1.877 (5), 1.568 (5)

Chemistry:

	(1)
P_2O_5	35.42
Al_2O_3	13.42
FeO	5.55
MnO	18.97
MgO	3.59
CaO	3.21
H_2O	19.40
Total	99.56

(1) Mt. Vasin-Myl'k, Russia; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(Mn_{0.77}Ca_{0.23})_{\Sigma=1.00}(Mg_{0.35}Fe_{0.31}Mn_{0.30})_{\Sigma=0.96}Al_{1.05}(PO_4)_{1.99}(OH)_{1.10}\cdot 3.78H_2O$.

Mineral Group: Overite group.

Occurrence: In fractures and on crusts of mitridatite in granite pegmatites.

Association: Eosphorite, laueite, kingsmountite, fairfieldite, mitridatite.

Distribution: On Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia.

Name: For the Lun'ok River, nearby Mt. Vasin-Myl'k, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5771; Mining Institute, St. Petersburg, 1340/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82541, 82542.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, and F.N. Tyusheva (1983) Lun'okite, a new phosphate, the manganese analog of overite, from granitic pegmatites of the Kola Peninsula. Zap. Vses. Mineral. Obshch., 112, 232–237 (in Russian). (2) (1984) Amer. Mineral., 69, 210–211 (abs. ref. 1).

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Luobusaite $FeSi_2$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As irregular grains, to 0.2 mm.

Physical Properties: *Cleavage*: None. *Fracture:* Conchoidal. *Tenacity*: Brittle.
Hardness = 7 VHN = 1086 (100 g load). D(meas.) = n.d. D(calc.) = 4.55

Optical Properties: Opaque. *Color*: Steel gray. *Streak*: Black. *Luster*: Metallic.
Optical Class: n.d.
R: (400) 49.63, (470) 44.41, (540) 46.46, (580) 49.71, (650) 46.89, (700) 47.74

Cell Data: *Space Group*: *Cmca*. *a* = 9.784(14) *b* = 7.784(5) *c* = 7.829(7) Z = 16

X-ray Powder Pattern: Luobusha mine, Qusong county, Tibet, China.
1.844 (100), 3.06 (80), 1.889 (60), 1.977 (40), 1.865 (40), 2.402 (25), 2.849 (20)

Chemistry:

	(1)
Si	55.24
Fe	44.40
Al	0.63
Cr	0.06
Total	100.33

(1) Luobusha mine, Qusong county, Tibet, China; average of 8 electron microprobe analyses; corresponding to $Fe_{0.83}Si_2$.

Occurrence: In the heavy mineral fraction of a podiform chromitite deposit in the peridotite of an ophiolite.

Association: Diamond, moissanite, coesite, wustite, CrC, PGEM, naquite, base metal alloys, silicates, and various native elements.

Distribution: From the Luobusha ("Luobusa") mine, 200 km southeast of Lhasa, Qusong county, Shannan Prefecture, Tibet, China.

Name: For the "Luobusa" mine, the site from which the first specimens were collected.

Type Material: Geological Museum of China, Beijing, People's Republic of China.

References: (1) Bai, W., N. Shi, Q. Fang, G.Li, M. Xiong, J. , Yang, and H. Rong (2006) Luobusaite: a new mineral. Acta Geologica Sinica, 80(5), 656-659 (in Chinese with English abstract). (2) (2007) Amer. Mineral., 92, 1540-1541 (abs. ref. 1).

Luzonite Cu_3AsS_4

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Crystals rare, to 2 mm; commonly coarse-grained, fine-grained, massive, intimately intergrown with enargite. *Twinning:* Common on {112}, also polysynthetic in polished section.

Physical Properties: *Cleavage:* Good on {101}, distinct on {100}. Hardness = 3.5 VHN = n.d. D(meas.) = 4.38 D(calc.) = 4.53

Optical Properties: Opaque. *Color:* Deep pinkish brown, similar to bornite, although darker; in polished section, pale brownish pink. *Streak:* Black. *Luster:* Metallic, dull. *Pleochroism:* Weak. *Anisotropism:* Strong, in greenish yellow and purplish.
R_1–R_2: (400) 27.2–28.7, (420) 25.6–27.6, (440) 24.1–25.6, (460) 23.6–24.7, (480) 23.4–24.5, (500) 23.7–25.2, (520) 24.1–26.4, (540) 24.3–27.1, (560) 24.9–27.7, (580) 25.6–28.5, (600) 26.5–29.1, (620) 27.3–29.6, (640) 28.1–29.9, (660) 28.6–30.1, (680) 28.7–30.0, (700) 28.7–30.0

Cell Data: *Space Group:* $I\bar{4}2m$. $a = 5.332(5)$ $c = 10.57(1)$ $Z = 2$

X-ray Powder Pattern: Mankayan, Philippines.
3.046 (10), 1.855 (9), 1.592 (7), 1.578 (6), 1.204 (6), 1.078 (6), 1.321 (5)

Chemistry:

	(1)	(2)	(3)
Cu	48.32	48.4	48.42
As	17.35	17.4	19.02
Sb	1.48	1.0	
S	32.85	32.2	32.56
Total	[100.00]	99.0	100.00

(1) Mankayan, Philippines; recalculated to 100.00% after deduction of 0.97% insol. and 0.56% pyrite. (2) Huaron, Peru; by electron microprobe. (3) Cu_3AsS_4.

Polymorphism & Series: Dimorphous with enargite; forms a series with famatinite.

Mineral Group: Stannite group.

Occurrence: In hydrothermal Cu–As–Sb-rich vein and disseminated deposits, formed at low to medium temperatures.

Association: Enargite, tetrahedrite–tennantite, colusite, stannoidite, pyrite, chalcopyrite, covellite, sphalerite, bismuthinite, silver sulfosalts, silver, gold, marcasite, alunite, barite, quartz.

Distribution: From the Lepanto mine, Mankayan, Luzon, Philippines [TL], as an ore mineral. In the Chinkuashi mine, Keelung, Taiwan. In Japan, at the Teine, Morino, and Date mines, Hokkaido; the Kasuga and Akeshi mines, Kagoshima Prefecture; and other localities. From the Sierra Famatina, La Rioja Province, Argentina. In the Julcani district, at Cerro de Pasco, and at Huaron, Peru. In the USA, in Nevada, at Goldfield, Esmeralda Co., from the Golden Chariot mine, Jamestown district, Nye Co., and in the Burrus vein, Pyramid district, Washoe Co.; from Butte, Silver Bow Co., Montana; and at Summitville, Rio Grande Co., Colorado. At the Chelopech deposit, Sofia, Bulgaria. From Calabona, Sardinia, Italy. At the Kadzaharan deposit, Armenia. From Pîrîul lui Avram, Romania. In the Lahóca Hill mine, Recsk, Mátra Mountains, Hungary. Numerous additional localities are now known.

Name: For Luzon Island in the Philippines.

References: (1) Gaines, R.V. (1957) Luzonite, famatinite and some related minerals. Amer. Mineral., 42, 766–779. (2) Marumo, F. and W. Nowacki (1967) A refinement of the crystal structure of luzonite, Cu_3AsS_4. Zeits. Krist., 124, 1–8. (3) Pósfai, M. and M. Sundberg (1998) Stacking disorder and polytypism in enargite and luzonite. Amer. Mineral., 83, 365–372. (4) Pósfai, M. and P.R. Busek (1998) Relationships between microstructure and composition in enargite and luzonite. Amer. Mineral., 83, 373–382. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 334.

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Lyonsite $Cu_3Fe_4^{3+}(VO_4)_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As euhedral crystals, lathlike, flattened on {010}, to 230 μm.

Physical Properties: *Cleavage:* Good on {001}. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.215

Optical Properties: Opaque. *Color:* Black; in reflected light, creamy white. *Streak:* Dark gray. *Luster:* Metallic.
Optical Class: [Biaxial.] *Anisotropism:* Weak.
R_1–R_2: (481) 17.5–23.1, (547) 16.6–22.3, (591) 14.7–20.7, (644) 14.4–18.8

Cell Data: *Space Group: Pmcn.* $a = 10.296(1)$ $b = 17.207(2)$ $c = 4.910(1)$ $Z = 2$

X-ray Powder Pattern: Izalco volcano, El Salvador.
3.279 (100b), 2.526 (60), 4.423 (40), 2.779 (40), 2.722 (40), 1.591 (40), 1.550 (40)

Chemistry:

	(1)	(2)
V_2O_5	47.74	49.44
TiO_2	2.27	
Fe_2O_3	24.83	28.94
Mn_2O_3	3.41	
CuO	21.99	21.62
Total	100.24	100.00

(1) Izalco volcano, El Salvador; by electron microprobe, average of three analyses, total Fe as Fe_2O_3, total Mn as Mn_2O_3; corresponds to $Cu_{3.04}(Fe_{3.43}Mn_{0.48}Ti_{0.32})_{\Sigma=4.23}(V_{0.96}O_4)_6$.
(2) $Cu_3Fe_4(VO_4)_6$.

Occurrence: In summit crater fumaroles, as a sublimate formed at ≤800 °C.

Association: Thenardite, howardevansite.

Distribution: On the Izalco volcano, El Salvador.

Name: To honor Dr. John Bartholomew Lyons (1916–), Professor of Mineralogy, Dartmouth College, Hanover, New Hampshire, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 164470.

References: (1) Hughes, J.M., S.J. Starkey, M.L. Malinconico, and L.L. Malinconico (1987) Lyonsite, $Cu_3^{2+}Fe_4^{3+}(VO_4)_6^{3-}$, a new fumarolic sublimate from Izalco volcano, El Salvador: descriptive mineralogy and crystal structure. Amer. Mineral., 72, 1000–1005.

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Långbanshyttanite $Pb_2Mn_2Mg(AsO_4)_2(OH)_4 \cdot 6H_2O$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As felty to radial, hemispherical aggregates to 1 mm composed of acicular, lath-like crystals.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = "Exceedingly soft". D(meas.) = n.d. D(calc.) = 3.591

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Biaxial (+). $\alpha = 1.700(5)$ $\beta = 1.741(5)$, $\gamma = 1.792(5)$ 2V(meas.) ≈ 90° 2V(calc.) = 86° *Orientation*: $X \approx c$, $Z \wedge$ elongation = 16°. *Dispersion*: Strong, $r < v$.

Cell Data: *Space Group*: $P\bar{1}$. $a = 5.0528(10)$ $b = 5.7671(6)$ $c = 14.617(3)$ $\alpha = 85.656(14)°$ $\beta = 82.029(17)°$ $\gamma = 88.728(13)°$ Z = 1

X-ray Powder Pattern: Långban mine, Filipstad district, Värmland County, Sweden. 14.48 (100), 3.571 (54), 2.857 (45), 7.21 (43), 4.969 (34), 2.800 (34), 4.798 (28)

Chemistry:

	(1)	(2)
PbO	44.71	44.53
MgO	3.79	4.02
MnO	13.34	14.15
FeO	1.89	
P_2O_5	0.65	
As_2O_5	22.90	22.93
H_2O	14.4	14.38
Total	101.68	100.00

(1) Långban mine, Filipstad district, Värmland County, Sweden; average of 5 electron microprobe analyses, H_2O by gas chromatography, absence of CO_2 confirmed by IR spectroscopy; corresponding to $Pb_{1.97}Mn_{1.85}Mg_{0.93}Fe_{0.26}(AsO_4)_{1.96}(PO_4)_{0.09}(OH)_{3.87} \cdot 5.93H_2O$.
(2) $Pb_2Mn_2Mg(AsO_4)_2(OH)_4 \cdot 6H_2O$.

Occurrence: A last-stage hydrothermal mineral (likely below 70 ° C), in fractures and corrosion-veinlets that postdate regional metamorphism of the volcanic-hydrothermal ores and their host rocks.

Association: Calcite, antigorite, trigonite.

Distribution: From the Långban mine, Filipstad district, Värmland County, Bergslagen ore province, Sweden.

Name: From "Långbanshyttan", the old name for the mine that produced the first specimens, the mining village, and smelter that in more recent times have been known as "Långban". "Långbanshyttan" means "Långban's smelter" or "Långban's furnace."

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 4032/1) and at the Swedish Museum of Natural History, Stockholm, Sweden (NRM 20100076).

References: (1) Chukanov, N.V., I.V. Pekov, E. Jonsson, N.V. Zubkova, Y.E. Filinchuk, D.I. Belakovskiy, and D.Yu. Pushcharovsky (2011) Långbanshyttanite, a new low-temperature arsenate mineral with a novel structure from Långban, Sweden. Eur. J. Mineral, 23, 675-681.
(2) (2012) Amer. Mineral., 97, 759-760 (abs. ref. 1).

Macaulayite $(Fe^{3+}, Al)_{24}Si_4O_{43}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* n.d. As < 2 μm platy grains.

Physical Properties: *Cleavage:* {001}, strongly suspected. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 4.41

Optical Properties: Translucent. *Color:* Red; in transmitted light, pale red to yellowish.
Luster: Earthy.
Optical Class: Biaxial. $n = > 1.74$ 2V(meas.) = n.d.

Cell Data: *Space Group:* C-centered cell. $a = 5.038$ $b = 8.726$ $c = 36.342$ $\beta = 92°$
$Z = 2$

X-ray Powder Pattern: Bennachie, Scotland; strongest two lines from oriented sample. Basal planes expand after glycol treatment.
36.6 (vs), 18.16 (vs), 2.533 (100), 2.720 (35), 1.462 (35), 3.700 (25), 2.214 (20)

Chemistry:

	(1)
SiO_2	10.48
Al_2O_3	3.71
Fe_2O_3	78.41
H_2O	[7.4]
Total	[100.00]

(1) Bennachie, Scotland; by electron microprobe, average of 14 analyses, recalculated from anhydrous analyses; corresponds to $Fe^{3+}_{22.38}Al_{1.69}Si_{3.98}O_{43}(OH)_2$.

Occurrence: A secondary mineral formed in deeply weathered granite.

Association: Kaolinite, illite.

Distribution: From Bennachie, near Inverurie, Aberdeenshire, Scotland.

Name: For the Macaulay Institute for Soil Research, Aberdeen, Scotland.

Type Material: Royal Scottish Museum, Edinburgh, Scotland; The Natural History Museum, London, England.

References: (1) Wilson, M.J., J.D. Russell, J.M. Tait, D.R. Clark, A.R. Fraser, and I. Stephen (1981) A swelling hematite/layer-silicate complex in weathered granite. Clay Minerals, 16, 261–278. (2) Wilson, M.J., J.D. Russell, J.M. Tait, D.R. Clark, and A.R. Fraser (1984) Macaulayite, a new mineral from north-east Scotland. Mineral. Mag., 48, 127–129. (3) (1985) Amer. Mineral., 70, 1330 (abs. refs. 1 and 2).

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Macdonaldite $BaCa_4Si_{16}O_{36}(OH)_2 \cdot 10H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Needlelike crystals show {010}, {001}, and {100}, and are elongated along [100], to 6 mm; also fibrous, in radiating aggregates, and granular.

Physical Properties: *Cleavage:* Perfect on {010}, good on {001}, poor or a fracture on {100}. Hardness = 3.5–4 D(meas.) = 2.27(2) D(calc.) = 2.27

Optical Properties: Transparent to translucent. *Color:* White to colorless. *Streak:* White. *Luster:* Satiny to vitreous.
Optical Class: Biaxial (+) or (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.518(2)$ $\beta = 1.524(2)$ $\gamma = 1.530(2)$ 2V(meas.) = 90(5)° 2V(calc.) = 90°

Cell Data: *Space Group:* $Bmmb$, $B2mb$, or $Bm2_1b$. $a = 14.06(1)$ $b = 23.52(2)$ $c = 13.08(1)$ Z = 4

X-ray Powder Pattern: Fresno Co., California, USA.
6.5 (100), 4.36 (80), 6.3 (50), 3.36 (50), 3.02 (45), 2.74 (45), 8.9 (40)

Chemistry:

	(1)
SiO_2	61.1
TiO_2	0.01
Al_2O_3	0.06
FeO	< 0.01
MnO	0.004
MgO	< 6.05
CaO	14.8
SrO	< 0.05
BaO	10.2
LOI	13.7
Total	[100.00]

(1) Fresno Co., California, USA; by D-C arc spectrography, loss on ignition taken as H_2O, stated to be recalculated to 100.00%; corresponds to $(Ba_{0.98}Sr_{0.01})_{\Sigma=0.99}(Ca_{3.90}Mg_{0.02})_{\Sigma=3.92}(Si_{15.03}Al_{0.02})_{\Sigma=15.05}O_{35.01} \cdot 11.24H_2O$.

Occurrence: As veinlets, fracture coatings, and disseminated in a sanbornite-quartz-bearing metamorphic rock.

Association: Sanbornite, quartz.

Distribution: In the Big Creek-Rush Creek area, Fresno Co., and on Trumbull Peak, near Incline, Mariposa Co., California, USA.

Name: For Gordon Andrew MacDonald (1911–1978), American vulcanologist, University of Hawaii, Honolulu, Hawaii, USA.

Type Material: California Division of Mines & Geology, San Francisco, California, USA.

References: (1) Alfors, J.T., M.C. Stinson, R.A. Matthews, and A. Pabst (1965) Seven new barium minerals from eastern Fresno County, California. Amer. Mineral., 50, 314–340.
(2) Cannillo, E., G. Rossi, and L. Ungaretti (1968) The crystal structure of macdonaldite. Atti Rend. Accad. Lincei, 45, 399–414.

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Macedonite $PbTiO_3$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As equant to prismatic crystals, to 0.2 mm, showing {100}, {001}, {110}, {101}, and {111}; more commonly as irregular grains.

Physical Properties: *Tenacity:* Very brittle. Hardness = 5.5–6 VHN = 477–537, 606–681 (100 g load). D(meas.) = 7.82(6) D(calc.) = 8.09

Optical Properties: Opaque; transparent in extremely thin sections. *Color:* Black with a weak brownish tint; brownish yellow with a greenish tint in thin section; grayish white in reflected light, with yellow-brown to dark brownish green internal reflections. *Luster:* Vitreous.
Optical Class: Uniaxial, sensibly isotropic. *Anisotropism:* Very weak.
R: (470) 22.5, (490) 22.2, (510) 21.8, (530) 21.2, (546) 21.0, (570) 20.9, (589) 20.8, (610) 20.6, (630) 20.4, (650) 20.2

Cell Data: *Space Group:* $[P4/nmm]$ (by analogy to synthetic material). $a = 3.89$–3.91 $c = 4.16$–4.21 Z = [1]

X-ray Powder Pattern: Crni Kamen, Macedonia.
2.843 (10), 1.603 (9), 2.728 (8), 2.284 (7), 1.954 (7), 3.836 (6), 1.370 (5)

Chemistry:

	(1)	(2)	(3)
TiO_2	25.07	24.5	26.36
Bi_2O_3	2.20		
FeO	2.69	1.0	
PbO	70.55	74.5	73.64
Total	100.51	100.0	100.00

(1) Crni Kamen, Macedonia. (2) Långban, Sweden; by electron microprobe, average of 20 analyses; total Fe as FeO; corresponding to $(Pb_{1.04}Fe_{0.04})_{\Sigma=1.08}Ti_{0.96}O_3$. (3) $PbTiO_3$.

Occurrence: As a rare accessory mineral in microcline-quartz syenite pegmatite veins cutting pyroxene amphibole schist (Crni Kamen, Macedonia); as inclusions in hematite and magnetoplumbite in a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Microcline, quartz, aegirine, arfvedsonite, rutile, zircon (Crni Kamen, Macedonia); hematite, magnetoplumbite, manganoan phlogopite, calcian mimetite, manganoan kentrolite (Långban, Sweden); ganomalite, tephroite, lead, jacobsite, calcite, phlogopite, hancockite, melanotekite, hematite (Jakobsberg, Sweden).

Distribution: From Crni Kamen, near Prilep, Macedonia. At Långban and Jakobsberg, Värmland, Sweden.

Name: For Macedonia, where the mineral was discovered.

Type Material: Institute for Nuclear Raw Materials, Belgrade, Serbia (Yugoslavia); National Museum of Natural History, Washington, D.C., USA, 122391.

References: (1) Radusinović, D. and C. Markov (1971) Macedonite - lead titanate: a new mineral. Amer. Mineral., 56, 387–394. (2) Burke, E.A.J. and C. Kieft (1971) Second occurrence of makedonite [macedonite], $PbTiO_3$, Langban, Sweden. Lithos, 4, 101–104.

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Macfallite $Ca_2Mn^{3+}_3(SiO_4)(Si_2O_7)(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare single crystals, elongated, to 1 cm, invariably twinned; as radial and framboidal aggregates; in fine intergrowths with orientite; massive. *Twinning:* By reflection on {100}, commonly repeated.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 5–5.5 D(meas.) = 3.43(2) D(calc.) = 3.53

Optical Properties: Transparent to translucent. *Color:* Reddish brown, maroon, dull pink. *Streak:* Brown with a reddish tint. *Luster:* Silky to subadamantine. *Optical Class:* Biaxial (+) or (–). *Pleochroism:* X = colorless to yellow; Y = light brown; Z = dark brown to reddish brown. *Orientation:* $Y = b$. α = 1.773–1.775 β = 1.795 γ = 1.810–1.815 2V(meas.) = Very large.

Cell Data: *Space Group:* $P2_1/m$. a = 10.235(3) b = 6.086(6) c = 8.970(5) $\beta = 110.75(3)^\circ$ Z = 2

X-ray Powder Pattern: Manganese Lake, Michigan, USA.
2.70 (100), 4.76 (90), 1.588 (85), 3.904 (80), 3.40 (70), 2.97 (70), 2.18 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	32.04	33.88	MnO	0.69	
TiO_2	trace		CuO	1.13	
Al_2O_3	3.95	1.03	MgO	0.39	0.73
Fe_2O_3	0.18		CaO	19.75	20.40
Cr_2O_3	0.03		K_2O	0.12	
Mn_2O_3	35.96	41.47	Na_2O	0.03	
V_2O_5	0.28		H_2O	5.39	[2.49]
			Total	99.94	[100.00]

(1) Manganese Lake, Michigan, USA; corresponds to $(Ca_{1.93}Mn^{2+}_{0.05})_{\Sigma=1.98}(Mn^{3+}_{2.49}Al_{0.42}Cu_{0.08}Fe^{3+}_{0.01})_{\Sigma=3.00}(Si_{2.92}V_{0.02})_{\Sigma=2.94}O_{11}[(OH)_{2.66}(H_2O)_{0.34}]_{\Sigma=3.00}$. (2) Faggiona, Italy; by electron microprobe, average of eight analyses, H_2O by difference.

Occurrence: In abundance, replacing calcite in fissures and in lenses in basalt (Manganese Lake, Michigan, USA); replacing braunite under low-temperature metamorphic conditions (Faggiona, Italy).

Association: Manganite, braunite, orientite, pyrolusite (Manganese Lake, Michigan, USA); braunite, quartz, manganoan richterite, carbonates (Faggiona, Italy).

Distribution: From near Manganese Lake, Copper Harbor, Keweenaw Co., Michigan, USA. In Italy, in the Cerchiara mine, Faggiona, La Spezia, Liguria.

Name: For Russell P. MacFall, American amateur mineralogist.

Type Material: National Museum of Natural History, Washington, D.C., USA, 135923; The Natural History Museum, London, England, 1984,139.

References: (1) Moore, P.B., J. Ito, and I.M. Steele (1979) MacFallite and orientite: calcium manganese (III) silicates from upper Michigan. Mineral. Mag., 43, 325–331. (2) (1980) Amer. Mineral., 65, 406 (abs. ref. 1). (3) Moore, P.B., J. Shen, and T. Araki (1985) Crystal chemistry of the $^2_\infty[M^{3+}_2\Phi_2(TO_4)_2]$ sheet: structural principles and crystal structures of ruizite, macfallite and orientite. Amer. Mineral., 70, 171–181. (4) Basso, R., G. Lucchetti, and A. Palenzona (1989) Orientite and macfallite: new occurrence at the Cerchiara mine (eastern Liguria, Italy). Neues Jahrb. Mineral., Monatsh., 455–460.

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Machatschkiite $Ca_6(AsO_4)(AsO_3OH)_3(PO_4,SO_4)\cdot 15H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As crusts of subparallel pseudorhombohedral crystals, $\{10\bar{1}1\}$ with minor $\{10\bar{1}2\}$, to 2 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–3 D(meas.) = 2.5–2.6 D(calc.) = 2.594

Optical Properties: Transparent to translucent. *Color:* Colorless.
Optical Class: Uniaxial (–) or weakly biaxial (–). $\omega = 1.593(2)$ $\epsilon = 1.585(2)$

Cell Data: *Space Group: R3c.* $a = 15.127(2)$ $c = 22.471(3)$ Z = 6

X-ray Powder Pattern: Anton mine, Germany.
8.59 (10), 5.34 (8), 3.59 (8), 2.86 (8), 2.83 (8), 2.70 (8), 2.67 (8)

Chemistry:

	(1)
SO_3	2.6
P_2O_5	2.6
As_2O_5	41.0
CaO	28.7
H_2O	
Total	

(1) Anton mine, Germany; by electron microprobe, average of two partial analyses; H_2O 29.2% determined on a separate sample.

Occurrence: A very rare secondary mineral in crusts on granite.

Association: Picropharmacolite, pharmacolite, cobaltian sainfeldite, gypsum.

Distribution: From the Anton mine, Heubachtal, near Schiltach, Black Forest, Germany.

Name: Honors Felix Karl Ludwig Machatschki (1895–1970), Professor of Mineralogy, University of Vienna, Vienna, Austria.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137412.

References: (1) Walenta, K. (1977) Machatschkiit, ein neues Arsenatmineral aus der Grube Anton im Heubachtal bei Schiltach (Schwarzwald, Bundesrepublik Deutschland). Tschermaks Mineral. Petrog. Mitt., 24, 125–132 (in German with English abs.). (2) (1977) Amer. Mineral., 62, 1260 (abs. ref. 1). (3) Effenberger, H., K. Mereiter, M. Pimminger, and J. Zemann (1982) Machatschkiite: crystal structure and revision of the chemical formula. Tschermaks Mineral. Petrog. Mitt., 30, 145–155. (4) Walenta, K. (1982) Zum Chemismus von Admontit und Machatschkiit. Schweiz. Mineral. Petrog. Mitt., 62, 177–183 (in German with English abs.).

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Mackayite $Fe^{3+}Te_2^{4+}O_5(OH)(?)$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals, typically isolated, are short prismatic, pseudocubic or pseudododecahedral, to pyramidal, with prominent {112} and {010}, subsidiary {110}, and {012}, to 1 mm.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 4.5
D(meas.) = 4.86 D(calc.) = [5.32]

Optical Properties: Transparent. *Color:* Pale bottle-green, olive-green, brownish green, greenish black; greenish yellow to yellowish green in transmitted light. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* O = green; E = yellowish green. $\omega = 2.19(2)$ (Li) $\epsilon = 2.21(2)$

Cell Data: *Space Group:* $I4_1/acd$. $a = 11.704$ $c = 14.895$ $Z = 16$

X-ray Powder Pattern: Goldfield, Nevada, USA.
3.17 (10), 1.61 (9), 3.32 (8), 4.95 (7), 2.72 (7), 2.21 (7), 3.75 (6)

Chemistry:

	(1)	(2)	(3)	(4)
TeO_2	65.82	65.33	65.72	78.22
Fe_2O_3	22.04	21.67	21.92	19.57
H_2O	12.14	13.00	12.36	2.21
Total	[100.00]	[100.00]	100.00	100.00

(1) Near Moctezuma, Mexico; recalculated to 100% from an original total of 99.53% after deduction of insoluble 12.69%. (2) Do.; recalculated to 100% from an original total of 98.98% after deduction of Al_2O_3 1.00%, CaO 0.32%, and insoluble 4.68%. (3) $Fe_2^{3+}Te_3^{4+}O_9 \bullet 5H_2O$. (4) $Fe^{3+}Te_2^{4+}O_5(OH)$.

Occurrence: Of rare occurrence in the oxidized zone of Au–Te deposits, an alteration product of tellurium.

Association: Tellurium, tellurite, emmonsite, rodalquilarite, poughite, cliffordite, sonoraite, pyrite, alunite, barite, quartz.

Distribution: In the USA, at the Mohawk mine, and between the Jumbo and Clermont mines, Goldfield, Esmeralda Co., Nevada; in the Toughnut-Empire mine, Tombstone, Cochise Co., Arizona; at a prospect near the Lone Pine mine, Wilcox district, Catron Co., New Mexico; from the Klondike mine, Saguache Co., Colorado. In Mexico, at the Moctezuma (Bambolla) mine and the San Miguel and La Candelaria prospects, south of Moctezuma, and from Onovas, Sonora. In the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile.

Name: For John William Mackay (1831–1902), Irish–American Comstock Lode mining magnate, in honor of his endowment of the School of Mines, University of Nevada, Reno, Nevada, USA.

Type Material: American Museum of Natural History, New York City, New York, T24594; Harvard University, Cambridge, Massachusetts, USA, 97444, 97950.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 642–643. (2) Gaines, R.V. (1965) Nuevos datos sobre mackayita. Bol. Soc. Geol. Mexicana, 28(2), 75–82 (in Spanish). (3) Pertlik, F. and A. Gieren (1977) Verfeinerung der Kristallstruktur von Mackayit, $Fe(OH)[Te_2O_5]$. Neues Jahrb. Mineral., Monatsh., 145–154 (in German with English abs.).

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Mackinawite $(Fe, Ni)_{1+x}S$ (x = 0 to 0.11)

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As well-formed thin tabular crystals, to 1 mm; massive, fine-feathery.

Physical Properties: *Cleavage:* Very good on {001}. Hardness = Soft. VHN = 63–89 (15 g load). D(meas.) = n.d. D(calc.) = 4.30

Optical Properties: Opaque. *Color:* Bronzy. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Strong. *Anisotropism:* Extreme.
R_1–R_2: (400) 17.7–25.7, (420) 17.0–28.0, (440) 16.4–30.2, (460) 16.2–32.2, (480) 16.1–34.4, (500) 16.0–36.5, (520) 16.1–38.4, (540) 16.1–40.0, (560) 16.3–41.4, (580) 16.5–42.5, (600) 16.7–43.3, (620) 17.0–43.9, (640) 17.2–44.3, (660) 17.4–44.5, (680) 17.5–44.6, (700) 17.7–44.6

Cell Data: *Space Group:* $P4/nmm$. $a = 3.6735(4)$ $c = 5.0328(7)$ $Z = 2$

X-ray Powder Pattern: Mackinaw mine, Washington, USA.
5.03 (100), 2.31 (90), 1.809 (80), 2.96 (70), 1.838 (50), 1.729 (50), 1.055 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Fe	63.0	58.8	54.9	Ni	3.1	3.8	8.8
Cu		2.0	0.1	S	34.0	35.9	35.8
Co			0.4	Total	100.1	100.5	100.0

(1) Mackinaw mine, Washington, USA; by electron microprobe, corresponding to $(Fe_{1.06}Ni_{0.05})_{\Sigma=1.11}S_{1.00}$. (2) Talnakh area, Russia; by electron microprobe, corresponding to $(Fe_{0.94}Ni_{0.06}Cu_{0.03})_{\Sigma=1.03}S_{1.00}$. (3) Scotia deposit, Australia; by electron microprobe, corresponding to $(Fe_{0.88}Ni_{0.13}Co_{0.01})_{\Sigma=1.02}S_{1.00}$.

Occurrence: Formed by hydrothermal activity in mineral deposits, during serpentinization of peridotites, and in the reducing environment of river bottom muds; may be produced by magnetotactic and sulfate-reducing bacteria. Rarely in iron and carbonaceous chondrite meteorites.

Association: Chalcopyrite, cubanite, pentlandite, pyrrhotite, greigite, maucherite, troilite.

Distribution: Now known from a number of localities in addition to those listed here. In the USA, at the Mackinaw mine, Snohomish Co., Washington [TL]; in muds from the bottom of the Mystic River, Boston, Suffolk Co., Massachusetts; from the Howard Montgomery quarry, Howard Co., Maryland; in California, from the Kramer borate deposit, Boron, Kern Co. In Canada, in the Muskox intrusion, Northwest Territories, and at the Falconbridge mine, Sudbury, Ontario. From the Outokumpu mine and Hitura, Finland. At the Vena mines, near Askersund, Örebro, Sweden. In the Fiat mine, Piedmont, Italy. At Landsberg, near Obermoschel, Rhineland-Palatinate, Germany. From England, at The Rill, Kynance Cliff, The Lizard, Cornwall. On Cyprus, at Skouriotissa. In the Talnakh area, Noril'sk region, western Siberia, and at the Kovdor massif, Kola Peninsula, Russia. From Broken Hill, New South Wales, and the Scotia nickel deposit, Kalgoorlie, Western Australia.

Name: For the Mackinaw mine in Washington, USA.

Type Material: n.d.

References: (1) Evans, H.T., Jr., C. Milton, E.C.T. Chao, I. Adler, C. Mead, B. Ingram, and R.A. Berner (1964) Valleriite and the new iron sulfide, mackinawite. U.S. Geol. Sur. Prof. Paper 475-D, D64–D69. (2) (1964) Amer. Mineral., 49, 1497 (abs. ref. 1). (3) Kouvo, O. and Y. Vuorelainen (1963) A tetragonal iron sulfide. Amer. Mineral., 48, 511–524. (4) Buchwald, V.F. (1977) The mineralogy of iron meteorites. Phil. Trans. Royal Soc. London, A. 286, 453–491. (5) Ostwald, J. (1978) A note on the occurrences of nickeliferous and cupriferous mackinawite. Mineral. Mag., 42, 516–517. (6) Lennie, A.R., S.A.T. Redfern, P.F. Schofield, and D.J. Vaughan (1995) Synthesis and Rietveld crystal structure refinement of mackinawite, tetragonal FeS. Mineral. Mag., 59, 677–683. (7) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 673–679. (8) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 335.

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Macphersonite $Pb_4(SO_4)(CO_3)_2(OH)_2$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are commonly pseudohexagonal, thin to tabular on {010}, to 1 cm. *Twinning:* Common, lamellar and contact, composition plane {102}.

Physical Properties: *Cleavage:* On {010}, perfect. *Fracture:* Uneven. Hardness = 2.5–3 D(meas.) = 6.50–6.55 D(calc.) = 6.60–6.65 May exhibit a bright yellow fluorescence under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Colorless, white, very pale amber.
Luster: Adamantine to resinous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, moderate.
$\alpha = 1.87$ $\beta = 2.00$ $\gamma = 2.01$ 2V(meas.) = 35°–36°

Cell Data: *Space Group: Pcab.* $a = 10.383(2)$ $b = 23.050(5)$ $c = 9.242(2)$ $Z = 8$

X-ray Powder Pattern: Argentolle mine, France; may show preferred orientation.
3.234 (100), 2.654 (90), 3.274 (50), 2.598 (30), 2.310 (30), 2.182 (30), 2.033 (30)

Chemistry:

	(1)	(2)	(3)
SO_3	6.6	7.65	7.42
CO_2	8.8	8.47	8.16
CuO	0.1		
CdO	0.1		
PbO	83.4	83.59	82.75
H_2O^+	1.3	1.93	1.67
Total	100.3	101.64	100.00

(1) Leadhills, Scotland; by electron microprobe, average of ten analyses, CO_2 by evolved gas analysis, H_2O by TGA; corresponds to $(Pb_{4.08}Cu_{0.10}Cd_{0.07})_{\Sigma=4.25}(S_{0.90}O_4)(C_{1.09}O_3)_2(OH)_{1.58}$.
(2) Argentolle mine, France; corresponds to $Pb_{4.06}(S_{1.03}O_4)(C_{1.04}O_3)_2(OH)_{2.32}$.
(3) $Pb_4(SO_4)(CO_3)_2(OH)_2$.

Polymorphism & Series: Trimorphous with leadhillite and susannite.

Occurrence: An uncommon secondary mineral in the zone of oxidation of lead deposits.

Association: Leadhillite, susannite, cerussite, caledonite, pyromorphite, scotlandite, mattheddleite, galena, quartz

Distribution: From the Argentolle mine, near Saint-Prix, Saône-et-Loire, France. At Leadhills, Lanarkshire, Scotland. From the Red Gill mine, Caldbeck Fells, Cumbria, England. In the Churfürst Ernst mine, Bönkhausen, North Rhine-Westphalia, Germany. From Laurium, Greece, in slag. Large crystals from Tsumeb, Namibia. At the Moon Anchor mine, Maricopa Co., Arizona, USA.

Name: To honor Dr. Harry Gordon Macpherson (1925–), Keeper of Minerals, Royal Scottish Museum, Edinburgh, Scotland.

Type Material: Royal Scottish Museum, Edinburgh, Scotland, 721.34; Museum of Natural History, Geneva, Switzerland, 435/80.

References: (1) Livingstone, A. and H. Sarp (1984) Macphersonite, a new mineral from Leadhills, Scotland, and Saint-Prix, France – a polymorph of leadhillite and susannite. Mineral. Mag., 48, 277–282. (2) (1985) Amer. Mineral., 70, 874 (abs. ref. 1). (3) Steele, I.M., J.J. Pluth, and A. Livingstone (1998) Crystal structure of macphersonite ($Pb_4SO_4(CO_3)_2(OH)_2$): comparison with leadhillite. Mineral. Mag., 62, 451–459.

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Macquartite $Pb_3Cu(CrO_4)SiO_3(OH)_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ (probable). Euhedral crystals, elongated along [010], to 1 mm; commonly enclosed in quartz.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* Irregular. Hardness = 3.5 D(meas.) = 5.49(7) D(calc.) = 5.58

Optical Properties: Semitransparent. *Color:* Cadmium orange. *Streak:* Pale orange. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 36°$. $\alpha = 2.28$ $\beta = 2.31$ $\gamma = 2.34$ 2V(meas.) = 85°

Cell Data: *Space Group:* $C2/m$ (probable). $a = 20.81$ $b = 5.84$ $c = 9.26$ $\beta = 91°48'$ $Z = 4$

X-ray Powder Pattern: Tiger, Arizona, USA.
3.156 (10), 4.822 (9), 4.628 (9), 3.090 (6), 2.925 (5), 2.768 (5), 3.467 (3)

Chemistry:

	(1)	(2)
SiO_2	[4.9]	6.12
CrO_3	10.5	10.19
CuO	7.8	8.11
PbO	67.6	68.24
H_2O	7.3	7.34
Total	[98.1]	100.00

(1) Tiger, Arizona, USA; Si determined by UV spectrophotometry, Cu, Pb, Cr, Zn by AA, H_2O by the Penfield method; SiO_2 reduced in proportion to ZnO deducted as willemite 2.3%. (2) $Pb_3Cu(CrO_4)SiO_3(OH)_4 \cdot 2H_2O$.

Occurrence: On museum specimens from an oxidized Pb-Zn-Cu orebody.

Association: Dioptase, quartz, willemite, wulfenite, chrysocolla, hematite, fluorite, barite.

Distribution: From the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA.

Name: For the French chemist Louis Charles Henri Macquart (1745–1808), who brought to France the Russian crocoite specimens in which chromium was discovered.

Type Material: The Natural History Museum, London, England, 1980,542; University of Arizona, Tucson, Arizona; National Museum of Natural History, Washington, D.C., USA, R18726.

References: (1) Williams, S.A. and M. Duggan (1980) Macquartite, a new silicate-chromate from Tiger, Arizona. Bull. Minéral., 103, 530–532 (in French). (2) (1981) Amer. Mineral., 66, 638 (abs. ref. 1)

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Madocite $Pb_{18}(Sb, As)_{15}S_{41}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals are elongated and striated along [001], to 1.5 mm.

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Conchoidal. Hardness = n.d. VHN = 155 (50 g load). D(meas.) = n.d. D(calc.) = 5.98

Optical Properties: Opaque. *Color:* Gray-black. *Streak:* Gray-black, shining. *Luster:* Metallic. *Pleochroism:* Strong, from white to gray. *Anisotropism:* Strong. R_1–R_2: n.d.

Cell Data: *Space Group: Pbam* or *Pba*2. $a = 27.2$ $b = 34.1$ $c = 8.12$ $Z = 4$

X-ray Powder Pattern: Madoc, Canada.
3.396 (100), 3.355 (90), 2.720 (80), 3.67 (70), 2.925 (60), 3.87 (50), 3.110 (40)

Chemistry:

	(1)	(2)
Pb	55.0	54.5
Sb	22.8	23.1
As	3.1	2.2
S	19.9	19.3
Total	100.8	99.1

(1) Madoc, Canada; by electron microprobe, average of three analyses; corresponds to $Pb_{17.54}(Sb_{12.37}As_{2.73})_{\Sigma=15.10}S_{41.00}$. (2) Do.; by electron microprobe, corresponds to $Pb_{17.92}(Sb_{12.92}As_{2.00})_{\Sigma=14.92}S_{41.00}$.

Occurrence: In the marbles of the Precambrian Grenville Limestone, at the margin of an intrusive (Madoc, Canada); in a hydrothermal deposit in dolomitic limestones with other As–Tl minerals (Jas Roux, France).

Association: Jamesonite, boulangerite, arsnopyrite (Madoc, Canada); chabournéite, pierrotite, parapierrotite, stibnite, pyrite, sphalerite, twinnite, zinkenite, andorite, smithite, laffittite, routhierite, aktashite, wakabayashilite, realgar, orpiment (Jas Roux, France).

Distribution: From near Madoc, Huntington Township, Ontario, Canada [TL]. At the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France. From Novoye, Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan. At Boliden, Västerbotten, Sweden. From Colquiri, Bolivia.

Name: For the locality at Madoc, Canada.

Type Material: Canadian Geological Survey, Ottawa, Canada, 12146; National Museum of Natural History, Washington, D.C., USA, 160247.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Ontario—Part 1. Can. Mineral., 9, 7–24. (2) (1968) Amer. Mineral., 53, 1421 (abs. ref. 1). (3) Jambor, J.L., J.G.H. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100.

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Magadiite $NaSi_7O_{13}(OH)_3 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals minute, very thin, platy, with a near-orthogonal habit, may be equant, aggregating into spherulites composing thin laminae; less commonly powdery.

Physical Properties: *Tenacity:* Puttylike. Hardness = Soft. D(meas.) = n.d. D(calc.) = [2.25]

Optical Properties: Translucent to opaque. *Color:* White.
Optical Class: [Biaxial.] $n = 1.48$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 7.22(5)$ $b = 15.70(5)$ $c = 6.91(5)$ $\beta = 95°54(5)'$ Z = [2]

X-ray Powder Pattern: Lake Magadi, Kenya.
15.41 (100), 3.44 (80), 3.146 (50), 3.30 (35), 5.18 (19), 4.46 (18), 5.01 (16)

Chemistry:

	(1)	(2)	(3)
SiO_2	77.62	77.78	76.38
TiO_2	0.06	trace	
Al_2O_3	0.79	0.20	
Fe_2O_3	0.55	0.12	
MnO	0.01	< 0.01	
MgO	0.26	0.44	
CaO	0.14	0.12	
Na_2O	5.55	5.74	5.63
K_2O	0.35	0.10	
H_2O^+	5.28	5.96	
H_2O^-	9.32	9.46	
H_2O			17.99
Total	99.93	99.92	100.00

(1) Lake Magadi, Kenya. (2) Alkali Lake Playa, Oregon, USA. (3) $NaSi_7O_{13}(OH)_3 \cdot 4H_2O$.

Occurrence: In silts of upper Pleistocene to recent age, precipitated by evaporation of saline brines (Lake Magadi, Kenya); in veins cutting playa sediments and in muds associated with alkali salts and brines (Alkali Lake Playa, Oregon, USA); in altered volcanic rocks (Trinity Co., California, USA); in marble xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in miarolitic cavities in a nepheline syenite sill (near Saint-Amable, Canada).

Association: Kenyaite, calcite (Lake Magadi, Kenya); kanemite (Lake Chad, Chad); bavenite, pectolite, apophyllite, phlogopite, quartz, thaumasite (Mont Saint-Hilaire, Canada); varennesite, natroite, eudialyte, shkatulkalite, makatite, pectolite, sphalerite, monazite-(Ce), serandite, zakharovite, lorenzenite, aegirine, tuperssuatsiaite (near Saint-Amable, Canada).

Distribution: From Lake Magadi and Lake Bogoria, Rift Valley, Kenya. In the Kanem area, Lake Chad, Chad. In the USA, on Alkali Lake Playa, Lake Co., Oregon, and about five km north of Trinity Lake, Trinity Co., California. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada.

Name: For the Kenyan locality, Lake Magadi.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 121336.

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References: (1) Eugster, H.P. (1967) Hydrous sodium silicates from Lake Magadi, Kenya: precursors of bedded chert. Science, 157, 1177–1180. (2) (1968) Amer. Mineral., 53, 510 (abs. ref. 1). (3) McAtee, J.L., Jr., R. House, and H.P. Eugster (1968) Magadiite from Trinity County, California. Amer. Mineral., 53, 2061–2069. (4) Rooney, T.P., B.F. Jones, and J.T. Neal (1969) Magadiite from Alkali Lake, Oregon. Amer. Mineral., 54, 1034–1043. (5) Brindley, G.W. (1969) Unit cell of magadiite in air, in vacuo, and under other conditions. Amer. Mineral., 54, 1583–1591. (6) Eugster, H.P. (1969) Inorganic bedded cherts from the Magadi area, Kenya. Contr. Mineral. Petrol., 22, 1–31.

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Magbasite $\mathbf{KBa(Mg,Fe^{2+})_6(Al,Sc)Si_6O_{20}F_2}$

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Crystal Data: n.d. *Point Group:* n.d. As acicular crystals forming fibrous, fan-shaped aggregates, to 5 mm.

Physical Properties: Hardness = ∼5 D(meas.) = 3.41 D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Colorless or pinkish violet. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = colorless; Z = lilac. *Orientation:* $Z \wedge c = 10°$. $\alpha = 1.579$ $\beta = 1.609$ $\gamma = 1.615$ 2V(meas.) = 70°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: "Russia."
3.63 (100), 3.23 (100b) 3.16 (100b), 2.59 (80), 2.43 (80), 1.407 (70), 9.5 (50)

Chemistry:

	(1)
SiO_2	39.7
Al_2O_3	4.0
Sc_2O_3	2.1
FeO	8.9
MgO	21.4
CaO	1.7
BaO	14.8
K_2O	4.9
F	5.5
$-O = F_2$	2.3
Total	100.7

(1) "Russia;" corresponds to $K_{0.94}(Ba_{0.81}Ca_{0.27})_{\Sigma=1.08}(Mg_{4.81}Fe^{2+}_{1.12})_{\Sigma=5.93}(Al_{0.71}Sc_{0.28})_{\Sigma=0.99}Si_{6.00}O_{20}F_{2.62}$.

Occurrence: In hydrothermally altered dolostone invaded by alkalic ferro-hornblende-bearing granosyenite.

Association: Fluorite, barite, parisite.

Distribution: In "one of the [unspecified] Asiatic hydrothermal formations, Russia."

Name: For MAGnesium and BArium in its chemical composition.

Type Material: n.d.

References: (1) Semenov, E.I., A.P. Khomyakov, and A.V. Bykova (1965) Magbasite, a new mineral. Doklady Acad. Nauk SSSR, 163, 718–719 (in Russian). (2) (1966) Amer. Mineral., 51, 530–531 (abs. ref. 1).

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Maghagendorfite $NaMn^{2+}(Mg, Fe^{3+}, Fe^{2+})_2(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Granular, massive; as laths in hagendorfite.

Physical Properties: *Cleavage:* [Good on {001}; poor on {110}] (by analogy to hagendorfite). Hardness = [∼4.5] D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: [Translucent.] *Color:* [Greenish black.]
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	44.32	42.14	Na_2O	6.12	7.44
Al_2O_3	0.01	0.07	K_2O	0.00	
Fe_2O_3	9.89	6.77	Li_2O	0.06	
FeO	8.75	22.12	F		0.57
MnO	20.42	7.46	H_2O^+	3.06	n.d.
ZnO	0.23		$-O = F_2$		0.24
MgO	5.06	6.88	insol.	1.05	
CaO	0.86	2.38	Total	99.83	95.59

(1) Dyke Lode, Custer, South Dakota, USA; corresponding to $Na_{0.10}(Na_{0.83}Mn_{0.10}Ca_{0.07})_{\Sigma=1.00}Mn_{1.00}(Mg_{0.60}Fe^{3+}_{0.58}Fe^{2+}_{0.57}Mn_{0.24}Li_{0.01})_{\Sigma=2.00}(PO_4)_3$. (2) Rapid Creek, Canada; by electron microprobe, Fe^{3+}:Fe^{2+} from stoichiometry; corresponding to $Na_{0.82}(Na_{0.40}Fe^{2+}_{0.38}Ca_{0.22})_{\Sigma=1.00}(Mn_{0.53}Fe^{2+}_{0.47})_{\Sigma=1.00}(Mg_{0.87}Fe^{2+}_{0.70}Fe^{3+}_{0.43})_{\Sigma=2.00}(PO_4)_3$.

Mineral Group: Alluaudite group.

Occurrence: In a complex zoned granite pegmatite.

Association: Hagendorfite (Rapid Creek, Canada).

Distribution: From the Dyke Lode, near Custer, Custer Co., South Dakota, USA. At Rapid Creek, Yukon Territory, Canada.

Name: As the *magnesium* analog of *hagendorfite*.

Type Material: n.d.

References: (1) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (2) (1980) Amer. Mineral., 65, 810–811 (abs. ref. 1). (3) Robinson, G.W., J. Van Velthuizen, H.G. Ansell, and B.D. Sturman (1992) Mineralogy of the Rapid Creek and Big Fish River area, Yukon Territory. Mineral. Record, 23(4), 1–47, esp. 34–36.

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Maghemite γ–Fe_2O_3

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Crystal Data: Cubic, typically with a tetragonal supercell. *Point Group:* n.d. Rarely as minute octahedral crystals, or acicular overgrowths; commonly as coatings on or replacements of magnetite; massive.

Physical Properties: Hardness = 5 VHN = 920 D(meas.) = n.d. D(calc.) = 4.860 (synthetic). Strongly magnetic.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Brown, bluish black; brown to yellow in transmitted light; white to bluish gray in reflected light. *Streak:* Brown. *Optical Class:* Isotropic.
R: (400) 31.5, (420) 30.2, (440) 25.8, (460) 27.6, (480) 26.6, (500) 26.0, (520) 25.5, (540) 24.8, (560) 24.0, (580) 23.2, (600) 22.4, (620) 22.0, (640) 21.6, (660) 21.2, (680) 20.8, (700) 20.4

Cell Data: *Space Group:* $P4_132$ or $P4_332$ (synthetic), with $a = 8.3515(22)$ Z = 8 (for $Fe_{2.67}O_4$), or *Space Group:* $P4_1$ or $P4_3$ (synthetic), with $a = 8.35$ $c = 24.99$ Z = 32

X-ray Powder Pattern: Synthetic; cubic.
2.5177 (100), 2.953 (35), 1.4758 (34), 1.6073 (24), 2.0886 (16), 1.7045 (10), 1.0872 (7)

Chemistry:

	(1)
SiO_2	0.3
TiO_2	13.0
MnO_2	0.9
Al_2O_3	1.8
Fe_2O_3	74.6
MgO	8.4
Total	99.0

(1) Patos de Minas, Brazil; by electron microprobe, average of 28 analyses on 16 grains, total Fe as Fe_2O_3, total Mn as MnO_2; stated to correspond to $(Fe_{0.88}Mg_{0.11}Si_{0.01})_{\Sigma=1.00}(Fe_{0.96}Ti_{0.32}Mg_{0.30}Al_{0.07}[Cr_{0.03}]Mn_{0.02})_{\Sigma=1.70}O_4$.

Polymorphism & Series: Dimorphous with hematite.

Occurrence: Formed by weathering or low-temperature oxidation of spinels containing ferrous iron, commonly magnetite or titanian magnetite. A widespread yellow pigment in continental sediments, rocks, and soils.

Association: Magnetite, ilmenite, anatase, pyrite, marcasite, lepidocrocite, goethite.

Distribution: Studied material from: the Bushveld complex, Transvaal, South Africa. In the USA, at the Iron Mountain mine, near Redding, Shasta Co., California. In Canada, from the Wabush Iron Formation, Labrador City, Labrador, Newfoundland; in the Steep Rock Lake iron deposits, Ontario; at the Baffinland Iron Mines, northern Baffin Island; and elsewhere. From north of Patos de Minas, Minas Gerais, Brazil. In the Hatrurim Formation, Israel. On the Katzenbuckel, Odenwald, Baden-Württemberg, Germany. In Japan, from the Takanokura mine, Fukushima Prefecture; the Ohinata mine, Nagano Prefecture; and the Kumano mine, Yamaguchi Prefecture. Much more widespread than these localities indicate.

Name: From MAGnetite and HEMatite, in allusion to the mineral's magnetism and composition.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 708–709. (2) McLeod, C.R. (1970) Some Canadian occurrences of maghemite. Geol. Surv. Canada, Paper 70-7, 13 pp. (3) Collyer, S., N.W. Grimes, D.J. Vaughan, and G. Longworth (1988) Studies of the crystal structure and crystal chemistry of titanomaghemite. Amer. Mineral., 73, 153–160. (4) Schulz, D.L. and G.J. McCarthy (1988) X-ray powder data for an industrial maghemite (γ–Fe_2O_3). Powder Diffraction, 3, 104–105. (5) Fabris, J.D., J.M.D. Coey, Q. Qi, and W.N. Mussel (1995) Characterization of Mg-rich maghemite from tuffite. Amer. Mineral., 80, 664–669.

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Magnesio-arfvedsonite $NaNa_2[(Mg,Fe^{2+})_4Fe^{3+}]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, to 9 cm; in matted fibrous aggregates. *Twinning:* [Simple or lamellar twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°.] *Fracture:* [Uneven.] *Tenacity:* [Brittle.] Hardness = [6] D(meas.) = ∼3.1–3.3 D(calc.) = [3.25]

Optical Properties: Translucent to opaque. *Color:* Dark bluish green, color zoning common; yellowish, greenish, or bluish in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = blue-green; Y = green; Z = pale green. *Orientation:* $Z = b$; $X \wedge c = 20°–40°$. *Dispersion:* $r > v$, strong. *Absorption:* [$X > Y > Z$.] α = ∼1.64–1.67 β = ∼1.65–1.68 γ = ∼1.655–1.69 2V(meas.) = 0°– ∼50°

Cell Data: *Space Group:* $C2/m$. $a = 9.799$ (ICDD 23-495). $b = 17.833$ $c = 5.273$ $\beta = 104.18°$ Z = 2

X-ray Powder Pattern: Norra Kärr complex, Sweden. (ICDD 23-495).
3.11 (100), 8.38 (80), 3.24 (35), 2.694 (35), 4.45 (30), 3.38 (30), 5.03 (12)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	53.70	52.71	MnO	1.05	0.79	F	2.11	1.50
TiO_2	0.29	0.56	MgO	9.50	11.19	H_2O^+	1.02	1.16
ZrO_2	0.05		CaO	0.21	2.22	H_2O^-	0.36	0.01
Al_2O_3	1.85	3.13	Li_2O	0.24	0.02	$-O = F_2$	0.88	[0.63]
Fe_2O_3	15.27	9.50	Na_2O	10.40	8.35	Total	100.07	[99.89]
FeO	3.56	7.41	K_2O	1.34	1.97			

(1) Lovozero massif, Russia; corresponds to $(Na_{2.94}K_{0.25}Ca_{0.03})_{\Sigma=3.22}(Mg_{2.06}Fe^{3+}_{1.67}Fe^{2+}_{0.43}Al_{0.14}Mn_{0.13}Ti_{0.03}Li_{0.14})_{\Sigma=4.60}(Si_{7.82}Al_{0.18})_{\Sigma=8.00}O_{22}[(OH)_{0.99}F_{0.97}]_{\Sigma=1.96}$. (2) Oldonyo Dili, Tanzania; original total given as 99.69%, corresponding to $(Na_{2.37}K_{0.37}Ca_{0.35}Li_{0.01})_{\Sigma=3.10}(Mg_{2.44}Fe^{3+}_{1.05}Fe^{2+}_{0.91}Al_{0.22}Mn_{0.10}Ti_{0.06})_{\Sigma=4.78}(Si_{7.71}Al_{0.29})_{\Sigma=8.00}O_{22}[(OH)_{1.13}F_{0.70}O_{0.17}]_{\Sigma=2.00}$.

Polymorphism & Series: Forms a series with arfvedsonite.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) < 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) \geq 0.5$; $(Na + K)_A \geq 0.5$; $Na_B \geq 1.34$.

Occurrence: As exsolution lamellae in cummingtonite from metamorphosed iron formation; in felsic pegmatites; from sodium metasomatism (fenitization) around some carbonatites; as authigenic or diagenetic overgrowths on detrital igneous "hornblende."

Association: Aegirine, braunite, winchite, cummingtonite, albite, biotite.

Distribution: From the Norra Kärr complex, near Gränna, Sweden. In the Gardiner complex, beyond the head of the Kangerdlugssuaq Fjord, Greenland. From the Khibiny and Lovozero massifs, Kola Peninsula, Russia. In the Green River Formation, head of Avintagnia Canyon, Duchesne Co., Utah, USA. In the Wabush Iron Formation, southwestern Labrador, Newfoundland; near Perkins, and at Mont Saint-Hilaire, Quebec, Canada. From Oldonyo Dili, Tanzania. On Mbolwe Hill, Mkushi River area, Central Province, Zambia. From Ambatoharina, Madagascar. In the Kajlidongri and Tirodi mines, Madhya Pradesh, India. In the Modatamagawa mine, Noda, Iwate Prefecture, Japan. Other localities are known.

Name: For its high *magnesium* content and similarity to *arfvedsonite*.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 364–374. (2) McKie, D. (1966) Fenitization. In: O.F Tuttle and J. Gittins, Eds., Carbonatites. Interscience, New York, 261–294. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 243–245.

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Magnesioaubertite $(Mg,Cu)Al(SO_4)_2Cl{\cdot}14H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals, to 100 μm, in aggregates and crusts.

Physical Properties: *Cleavage:* On {010}, good. Hardness = 2–3 D(meas.) = 1.80(3) D(calc.) = 1.78 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Sky-blue. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = pale blue. *Orientation:* $X \wedge (010) = 17(1)°$. *Dispersion:* $r > v$. $\alpha = 1.466(1)$ $\beta = 1.481(1)$ $\gamma = 1.488(1)$ 2V(meas.) = 112° 2V(calc.) = 114°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.31(1)$ $b = 13.20(2)$ $c = 6.29(1)$ $\alpha = 91.74°$ $\beta = 94.55°$ $\gamma = 82.62°$ $Z = 1$

X-ray Powder Pattern: Vulcano, Italy.
4.50 (100), 3.97 (80), 5.61 (70), 4.25 (60), 3.68 (60), 6.26 (50), 4.81 (50)

Chemistry:

	(1)	(2)
SO_3	28.25	33.16
Al_2O_3	13.91	10.96
CuO	5.50	4.44
ZnO		0.01
MgO	3.38	3.08
F		0.14
Cl	7.6	3.90
H_2O	44.0	43.97
$-O = (F,Cl)_2$	1.7	0.94
Total	100.9	98.72

(1) Vulcano, Italy; corresponds to $(Mg_{0.44}Cu_{0.37}Al_{0.19})_{\Sigma=1.00}Al_{1.25}(S_{0.93}O_4)_2Cl_{1.13}{\cdot}12.92H_2O$.
(2) Do.; calculated from an elemental analysis, corresponds to $(Mg_{0.43}Cu_{0.32}Al_{0.20})_{\Sigma=0.95}Al_{1.00}(SO_4)_{2.31}(Cl_{0.61}F_{0.04})_{\Sigma=0.65}{\cdot}13.62H_2O$.

Occurrence: A rare secondary mineral formed by the reaction of volcanic gases and aluminum-bearing rocks.

Association: Alunogen, pickeringite, metasideronatrite, sulfur, tamarugite, aluminocopiapite, metavoltine.

Distribution: From the Grotta de Faraglione and along the Baia de Levante, Vulcano, Lipari Islands, Italy.

Name: For its content of *magnesium* greater than copper, and relation to *aubertite*.

Type Material: University of Bochum, Bochum, Germany; National Museum of Natural History, Washington, D.C., USA, 168433.

References: (1) Gebhard, G., O. Medenbach, and W. Gebert (1988) Magnesioaubertit, $(Mg,Cu)Al(SO_4)_2Cl{\cdot}14H_2O$, ein neues Chlorsulfat von Vulcano, Liparische Inseln. Aufschluss, 39, 97–102 (in German). (2) (1990) Amer. Mineral., 75, 1433 (abs. ref. 1). (3) Garavelli, A., M.F. Grasso, and F. Vurro (1996) Mineral occurrence and depositional processes at Baia di Levante area (Vulcano Island, Italy). Miner. Petrogr. Acta, 39, 251–261.

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Magnesioaxinite $Ca_2MgAl_2BSi_4O_{15}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As crystals, to 3 cm, with the axe-head-shaped morphology typical of axinites; originally found as a rough gemstone.

Physical Properties: *Cleavage:* [Good on {100}, poor on {001}, {110}, and {011}] (by analogy to the axinite group). *Fracture:* [Uneven to conchoidal.] *Tenacity:* [Brittle.] Hardness = ~6.5 D(meas.) = 3.178 D(calc.) = [3.18] Fluoresces red-orange in LW UV, duller red in SW UV.

Optical Properties: Transparent to translucent. *Color:* Pale blue to pale violet; light brown to light pink. *Streak:* White. *Luster:* [Vitreous.]
Optical Class: Biaxial (+) or (–). *Pleochroism:* Pale blue to pale violet and pale gray. *Dispersion:* $r > v$, strong. α = 1.656–1.667 β = 1.660–1.673 γ = 1.668–1.678
2V(meas.) = 82(2)°

Cell Data: *Space Group:* $P\bar{1}$. $a = 8.933$ $b = 9.155$ $c = 7.121$ $\alpha = 102.59°$ $\beta = 98.28°$ $\gamma = 88.09°$ Z = 2

X-ray Powder Pattern: Tanzania.
2.796 (100), 3.440 (65), 3.139 (65), 2.150 (32), 2.176 (28), 6.29 (25), 2.556 (25)

Chemistry:

	(1)	(2)
SiO_2	44.0	44.63
TiO_2	0.03	
B_2O_3	n.d.	6.46
Al_2O_3	17.9	18.93
V_2O_3	0.13	
MnO	0.4	
ZnO	0.06	
MgO	6.9	7.48
CaO	21.7	20.83
K_2O	0.01	
H_2O	n.d.	1.67
Total	91.13	100.00

(1) Tanzania; by electron microprobe, B confirmed qualitatively, Cr, Fe, Ni, Na not found.
(2) $Ca_2MgAl_2BSi_4O_{15}(OH)$.

Mineral Group: Axinite group.

Occurrence: [Typically a mineral formed during contact metamorphism and boron metasomatism.]

Association: Epidote, tremolite, calcite (London Bridge, Australia); prehnite, epidote, actinolite, vesuvianite (Luning, Nevada, USA).

Distribution: From an unrecorded locality in the Arusha district, Tanzania. At London Bridge, near Queanbeyan, New South Wales, Australia. Found near Luning, Santa Fe district, Mineral Co., Nevada, USA.

Name: For dominant *magnesium* in the composition, and its membership in the *axinite* group.

Type Material: Natural History Museum (Geological Museum), London, England, MI 34610.

References: (1) Jobbins, E.A., A.E. Tresham, and B.R. Young (1975) Magnesioaxinite, a new mineral found as a blue gemstone from Tanzania. J. Gemmol., 14, 368–375. (2) (1976) Amer. Mineral., 61, 503–504 (abs. ref. 1). (3) Dunn, P.J., P.B. Leavens, and C. Barnes (1980) Magnesioaxinite from Luning, Nevada, and some nomenclature designations for the axinite group. Mineral. Record, 11, 13–15.

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Magnesiocarpholite $MgAl_2Si_2O_6(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As small acicular to fibrous crystals elongated ‖ [001], to 5 cm; as crystal aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.84–2.92

Optical Properties: Transparent. *Color:* Light green to grayish; in transmitted light, colorless.
Optical Class: Biaxial. $n = 1.59–1.60$ 2V(meas.) = n.d.

Cell Data: *Space Group: Ccca.* $a = 13.714(2)$ $b = 20.079(2)$ $c = 5.105(1)$ Z = [8]

X-ray Powder Pattern: Vanoise massif, France.
5.66 (100), 5.02 (45), 2.59 (45), 3.42 (25), 2.99 (25), 2.73 (18), 1.89 (15)

Chemistry:

	(1)	(2)
SiO_2	38.66	39.9
TiO_2	1.03	0.15
Al_2O_3	28.95	33.1
Fe_2O_3	2.88	0.16
FeO	6.08	4.76
MnO	0.0	0.05
MgO	9.10	10.51
CaO	0.29	< 0.02
Na_2O	0.09	< 0.03
K_2O	0.18	< 0.01
H_2O	11.73	10.5
P_2O_5	0.30	< 0.02
Total	99.29	99.13

(1) Vanoise massif, France; corresponds to $(Mg_{0.7}Fe^{2+}_{0.3})_{\Sigma=1.0}(Al_{1.95}Fe^{3+}_{0.05})_{\Sigma=2.00}Si_2O_6(OH)_4$.
(2) Sfinari, Crete, Greece; by XRF and AA, Fe^{2+} by oxidimetry, H_2O by the Penfield method; corresponds to $(Mg_{0.80}Fe^{2+}_{0.20})_{\Sigma=1.00}(Al_{1.98}Fe^{3+}_{0.01}Ti_{0.01})_{\Sigma=2.00}Si_{2.00}O_6(OH)_4$.

Polymorphism & Series: Forms a series with ferrocarpholite.

Occurrence: In veins and in schist, quartzite, and metabauxite formed during high-pressure, low-temperature metamorphism (Vanoise, France).

Association: Chloritoid, pyrophyllite, paragonite, muscovite, diaspore, chlorite, hematite, quartz.

Distribution: From the Vanoise massif, Savoie, France. Found near Sfinari and Sisses, on Crete, Greece.

Name: As the *magnesium* analog of *carpholite*.

Type Material: n.d.

References: (1) Goffé, B., G. Goffé-Urbano, and P. Saliot (1973) Sur la présence d'une variété magnésienne de ferrocarpholite en Vanoise (Alpes françaises). Compt. Rendus Acad. Sci. Paris, 277, 1965–1968 (in French). (2) Viswanathan, K. and E. Seidel (1979) Crystal chemistry of Fe-Mg-carpholites. Contr. Mineral. Petrol., 70, 41–47. (3) (1980) Amer. Mineral., 65, 406 (abs. refs. 1 and 2). (4) Goffé, B. and P. Saliot (1977) Les associations minéralogiques des roches hyperalumineuses du Dogger de Vanoise. Leur signification dans le métamorphisme régional. Bull. Minéral., 100, 302–309 (in French with English abs.). (5) Viswanathan, K. (1981) The crystal structure of a Mg-rich carpholite. Amer. Mineral., 66, 1080–1085.

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Magnesiochloritoid $(Mg, Fe^{2+})Al_2SiO_5(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As irregular grains, to 4 mm. *Twinning:* Common on {001}, polysynthetic.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = [~6.5] (by analogy to chloritoid). D(meas.) = 3.25(2) D(calc.) = 3.343

Optical Properties: Transparent. *Color:* Pale blue-green to dark blue; in transmitted light, colorless.
Optical Class: Biaxial (+). *Pleochroism:* Very faint; light blue, gray-blue, yellowish.
$\alpha = 1.687(2)$ $\beta = 1.690(2)$ $\gamma = 1.702(2)$ 2V(meas.) = 40°–50° 2V(calc.) = 46°

Cell Data: *Space Group:* $C2/c$. $a = 9.460(1)$ $b = 5.471(1)$ $c = 18.182(2)$ $\beta = 101.4(1)°$
Z = 4

X-ray Powder Pattern: Monte Rosa massif, Italy.
4.46 (100), 2.964 (18), 2.306 (14), 1.574 (11), 2.356 (7), 2.459 (6), 1.482 (6)

Chemistry:

	(1)	(2)
SiO_2	25.73	27.27
TiO_2	0.00	
Al_2O_3	43.29	46.27
FeO	12.17	
MnO	0.05	
MgO	10.56	18.29
CaO	0.00	
Na_2O	0.00	
K_2O	0.01	
H_2O	[8.19]	8.17
Total	[100.00]	100.00

(1) Monte Rosa massif, Italy; by electron microprobe, H_2O by difference; corresponds to $(Mg_{0.61}Fe^{2+}_{0.40})_{\Sigma=1.01}Al_{1.99}Si_{1.00}O_5(OH)_2$. (2) $MgAl_2SiO_5(OH)_2$.

Polymorphism & Series: Monoclinic and triclinic polytypes are known.

Mineral Group: Chloritoid group.

Occurrence: In metapelites and related rocks within high-grade blueschist rocks; stable under metamorphic conditions of near 500 °C and 18 kbar.

Association: Talc, chlorite, muscovite, quartz, kyanite, garnet, omphacite, rutile, apatite.

Distribution: In Italy, from the Monte Rosa massif, near the Ghiacciaio di Verra; in the Val d'Ayas, near the border with Switzerland; and in the Praborna mine, near St. Marcel, Val d'Aosta. From Zermatt, Valais, Switzerland. In Austria, in the Hohe Tauern Mountains.

Name: For *magnesium* in its composition and its relation to *chloritoid*.

Type Material: National School of Mines, Paris, France; Museum of Natural Science, Torino, Italy.

References: (1) Chopin, C. (1983) Magnesiochloritoid, a key-mineral for the petrogenesis of high-grade pelitic blueschists. Bull. Minéral., 106, 715–717. (2) (1985) Amer. Mineral., 70, 216–217 (abs. ref. 1). (3) Chopin, C. and P. Monié (1984) A unique magnesiochloritoid-bearing, high-pressure assemblage from the Monte Rosa, Western Alps: petrologic and ^{40}Ar –^{39}Ar radiometric study. Contr. Mineral. Petrol., 87, 388–398. (4) Ivaldi, G., M. Catti, and G. Ferraris (1988) Crystal structure at 25 and 700 °C of magnesiochloritoid from a high-pressure assemblage (Monte Rosa). Amer. Mineral., 73, 358–364. (5) Chopin, C., E. Seidel, T. Theye, G. Ferraris, G. Ivaldi, and M. Catti (1992) Magnesiochloritoid, and the Fe–Mg series in the chloritoid group. Eur. J. Mineral., 4, 67–76.

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Magnesiochromite $MgCr_2^{3+}O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rarely as poorly formed octahedra, to 1.5 mm; commonly granular, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law, as contact twins.

Physical Properties: *Cleavage:* Parting on {111}, possible. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–7 D(meas.) = 4.39–4.67 D(calc.) = 4.414 Weakly magnetic.

Optical Properties: Opaque, transmits light through thin edges. *Color:* Black, deep red; gray in reflected light. *Streak:* Brown. *Luster:* Metallic.
Optical Class: Isotropic. $n = 1.96$

Cell Data: *Space Group:* $Fd3m$ (synthetic). $a = 8.3341(2)$ $Z = 8$

X-ray Powder Pattern: Synthetic.
2.512 (100), 4.813 (65), 2.083 (55), 1.4731 (55), 1.603 (40), 2.945 (14), 2.406 (14)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
TiO_2	0.17	0.11		FeO	11.90	13.77	
Al_2O_3	10.30	11.93		MnO		0.93	
V_2O_5	0.09			NiO	0.04		
Cr_2O_3	59.10	57.52	79.04	MgO	19.30	15.33	20.96
				Total	100.90	99.59	100.00

(1) Kalarangi mines, Orissa, India; by electron microprobe, total Fe as FeO; Fe^{2+}:Fe^{3+} recalculated for charge balance, then corresponding to $(Mg_{0.88}Fe^{2+}_{0.12})_{\Sigma=1.00}(Cr_{1.43}Al_{0.37}Fe^{3+}_{0.19})_{\Sigma=1.99}O_4$. (2) Leucite Hills, Wyoming, USA; by electron microprobe, total Fe as FeO. (3) $MgCr_2O_4$.

Polymorphism & Series: Forms two series, with chromite, and with spinel.

Mineral Group: Spinel group.

Occurrence: An accessory mineral in ultramafic rocks, as dunites, serpentinites, kimberlites, lamproites, and komatiites. More rarely as xenocrysts in lamprophyres and mid-ocean basalts. May be detrital.

Association: Olivine, augite, magnetite, plagioclase, pigeonite.

Distribution: Widespread. A few localities for analyzed material include: from near Tampadel and Groschau, Lower Silesia, Poland. From Dobřiš, and at Hamry, near Křemže, Czech Republic. At Ferdinandovo, Bulgaria. On Mt. Djeti, Togo. From Dun Mountain, New Zealand. In the Sukinda ultramafics, between Kansa to Mauabil, Orissa, India. In Canada, on Scottie Creek, about 32 km north of Ashcroft, British Columbia; from Black Lake and in the Caribou pit, Coleraine township, Quebec. In the Line Pit, Lancaster Co., Pennsylvania; from the Leucite Hills, Sweetwater Co., Wyoming, USA.

Name: For a MAGNESIum-rich *chromite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 709–712. (2) Sahoo, R.K. and G. van der Kaaden (1976) Chemistry of the Sukinda chromites, Orissa, India and its petrogenetic significance. Neues Jahrb. Mineral., Monatsh., 484–494. (3) Kuehner, S.M., A.D. Edgar, and M. Arima (1981) Petrogenesis of the ultrapotassic rocks from the Leucite Hills, Wyoming. Amer. Mineral., 66, 663–677. (4) O'Neill, H.St.C. and W.A. Dollase (1994) Crystal structures and cation distributions in simple spinels from powder XRD structural refinements: $MgCr_2O_4$, $ZnCr_2O_4$, Fe_3O_4 and the temperature dependence of the cation distribution in $ZnAl_2O_4$. Phys. Chem. Minerals, 20, 541–555. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 36–37. (6) (1960) NBS Circ. 539, 9, 34.

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Magnesiocopiapite $MgFe_4^{3+}(SO_4)_6(OH)_2 \cdot 20H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As scaly crystals, to several mm, commonly as efflorescences.

Physical Properties: *Cleavage:* [On {010}, perfect.] (by analogy to copiapite group members). Hardness = [2–3] D(meas.) = n.d. D(calc.) = 2.16

Optical Properties: Semitransparent. *Color:* Lemon-yellow, orange, greenish yellow. *Optical Class:* Biaxial (+). *Pleochroism:* Y = colorless; Z = greenish yellow. α = 1.507–1.510 β = 1.529–1.535 γ = 1.575–1.585 2V(meas.) = Moderate. 2V(calc.) = 67°

Cell Data: *Space Group:* $P\overline{1}$. a = 7.335–7.35 b = 18.782–18.84 c = 7.377–7.39 α = 91.23°−91.7° β = 102.17°−102.6° γ = 98.79°−99.0° Z = 1

X-ray Powder Pattern: Knoxville, California, USA.
9.29 (100), 18.57 (90), 5.600 (80), 3.588 (50), 6.192 (45), 4.208 (40), 3.506 (40)

Chemistry:

	(1)	(2)	(3)
SO_3	39.47	39.90	39.43
Al_2O_3		3.17	
Fe_2O_3	27.44	23.58	26.21
FeO	0.52	0.17	
CoO		0.16	
CuO		0.15	
MgO	3.26	1.97	3.31
H_2O	27.84	30.90	31.05
insol.	1.16		
Total	99.69	[100.00]	100.00

(1) Near Blythe, California, USA. (2) Forty Mile River, Alaska, USA; recalculated to 100% from an original total of 99.68% after deduction of remnant 1.40%; corresponds to $(Mg_{0.59}Al_{0.30}Fe^{2+}_{0.03}Co_{0.03}Cu_{0.02})_{\Sigma=0.97}(Fe^{3+}_{3.56}Al_{0.44})_{\Sigma=4.00}(SO_4)_6(OH)_2 \cdot 19.7H_2O$.
(3) $MgFe_4(SO_4)_6(OH)_2 \cdot 20H_2O$.

Mineral Group: Copiapite group.

Occurrence: An uncommon secondary mineral, typically formed by oxidation of pyrite.

Association: Pyrite, römerite, paracoquimbite, halotrichite, redingtonite.

Distribution: In the USA, from near Blythe, Riverside Co., and at the Redington mercury mine, Knoxville, Napa Co., California; from near Las Vegas, Tecolote district, San Miguel Co., New Mexico; at the Denver mine, Santa Cruz Co., and the United Verde mine, Jerome, Yavapai Co., Arizona; in Alaska, in a prospect pit along the Mosquito Fork, Forty Mile River, Eagle A-3 quadrangle. From the Prince mine, Cape Breton Island, Nova Scotia, Canada. At Falun, Kopparberg, Sweden. From the Ossling Berg, Lausitz, North Saxony, Germany.

Name: For its *magnesium* content and relation to *copiapite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 103543, 80696.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 623–627. (2) Bayliss, P. (1985) X-ray powder diffraction data and cell parameters for copiapite-group minerals. Can. Mineral., 23, 53–56. (3) Jolly, J.H. and H.L. Foster (1967) X-ray diffraction data of aluminocopiapite [= magnesiocopiapite]. Amer. Mineral., 52, 1220–1223. (4) Süsse, P. (1972) Crystal structure and hydrogen bonding of copiapite. Zeits. Krist., 135, 34–55.

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Magnesiocoulsonite $Mg(V,Cr)_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As grains, equant, may be crudely octahedral, to 0.3 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6.5
VHN = 873–1080, 969 average (100 g load). D(meas.) = n.d. D(calc.) = 4.31

Optical Properties: Opaque. *Color:* Black; light gray in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R: (400) 14.3, (420) 14.2, (440) 14.1, (460) 14.0, (480) 13.9, (500) 13.8, (520) 13.8, (540) 13.7, (560) 13.7, (580) 13.7, (600) 13.7, (620) 13.7, (640) 13.7, (660) 13.8, (680) 13.8, (700) 13.7

Cell Data: *Space Group:* $Fd3m$. $a = 8.385$ $Z = 8$

X-ray Powder Pattern: Pereval quarry, Russia.
2.52 (10), 4.84 (9), 1.482 (9), 2.093 (8), 1.612 (8), 1.092 (7), 1.048 (5)

Chemistry:

	(1)	(2)
TiO_2	0.14	
Al_2O_3	0.36	
V_2O_3	50.07	78.81
Cr_2O_3	28.09	
FeO	0.20	
MnO	0.18	
MgO	20.90	21.19
Total	99.94	100.00

(1) Pereval quarry, Russia; by electron microprobe, average of ten analyses, total Fe as FeO, total Mn as MnO; corresponds to $(Mg_{0.99}Fe_{0.01})_{\Sigma=1.00}(V_{1.28}Cr_{0.71}Al_{0.01})_{\Sigma=2.00}O_{4.00}$. (2) MgV_2O_4.

Mineral Group: Spinel group.

Occurrence: An accessory mineral in Cr–V-bearing metamorphic rocks.

Association: Cr–V-tremolite, Cr–V-diopside, goldmanite, Cr–V-chlorite, Cr–V-muscovite, vanadian magnesiochromite, karelianite, pyrite, calcite, quartz.

Distribution: From the Pereval marble quarry, near Slyudyanka, Sayan Mountains, near Lake Baikal, Siberia, Russia.

Name: For its dominant MAGNESIum content and relation to *coulsonite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 88235–88237.

References: (1) Reznitskii, L.Z., E.V. Sklyarov, and Z.F. Ushchapovskaya (1995) Magnesiocoulsonite MgV_2O_4 – a new mineral species in the spinel group. Zap. Vses. Mineral. Obshch., 124(4), 91–98 (in Russian). (2) (1996) Amer. Mineral., 81, 1283 (abs. ref. 1).

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Magnesio-cummingtonite $(Mg,Fe^{2+})_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prisms or needles. *Twinning:* Multiple twinning ‖ {100}.

Physical Properties: *Cleavage:* Good on {110}, intersecting at 54° and 126°. *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.13–3.22 D(calc.) = 3.18–3.24

Optical Properties: Semitransparent. *Color:* [Light green, beige; colorless to pale green in thin section.] *Luster:* [Vitreous.]
Optical Class: [Biaxial (–).] *Pleochroism:* [Weak, with increasing iron content; $X = Y$ = colorless; Z = pale green or yellow.] *Orientation:* [$Y = b$.] *Dispersion:* [$r < v$, weak.]
$\alpha = 1.621$ $\beta = 1.632$ $\gamma = 1.643$ 2V(meas.) = 66°–97°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.49$ $b = 18.00$ $c = 5.30$ $\beta = 102.0°$ Z = 2

X-ray Powder Pattern: Cooma, Australia.
3.044 (100), 3.425 (80), 3.230 (80), 2.963 (60), 3.838 (40), 2.724 (40), 2.495 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	58.1	55.97	NiO	0.11	
TiO_2	0.02	0.07	MgO	30.9	26.14
Al_2O_3	0.06	1.47	CaO	0.52	1.25
Fe_2O_3		0.01	Na_2O	0.00	0.32
Cr_2O_3	0.01		K_2O	0.00	0.01
FeO	7.06	10.5	H_2O	2.50	
MnO	0.37	0.37	P_2O_5		0.01
			Total	99.65	96.12

(1) Cima di Gagnone, Switzerland; by electron microprobe, corresponds to $(Mg_{6.26}Fe^{2+}_{0.80}Ca_{0.08}Mn_{0.04}Ni_{0.01})_{\Sigma=7.19}(Si_{7.89}Al_{0.01})_{\Sigma=7.90}O_{22}(OH)_2$. (2) Cooma, Australia; by electron microprobe, Fe^{2+}:Fe^{3+} confirmed by wet analysis; corresponds to $(Mg_{5.45}Fe^{2+}_{1.23}Ca_{0.19}Na_{0.09}Al_{0.07}Mn_{0.04}Ti_{0.01})_{\Sigma=7.08}(Si_{7.83}Al_{0.17})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with cummingtonite and grunerite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: $Mg/(Mg + Fe^{2+}) \geq 0.7$; $(Ca + Na)_B < 1.34$; $Li < 1.0$; $Mn < 0.5$.

Occurrence: In metamorphosed ultramafic rocks of the amphibolite facies; as exsolution lamellae in magnesio-arfvedsonite.

Association: Anthophyllite, tremolite, chlorite, magnesite, talc, enstatite (Cima di Gagnone, Switzerland).

Distribution: From near Cima di Gagnone, Ticino, Switzerland. At Cooma, New South Wales, Australia.

Name: For *magnesium* in its composition and similarity to *cummingtonite*.

Type Material: n.d.

References: (1) Tilley, C.E. (1939) Kyanite-gedrite parageneses. Geol. Mag. London, 76, 326–330. (2) Kisch, H.J. (1969) Magnesiocummingtonite-$P2_1/m$: a Ca- and Mn-poor clino-amphibole from New South Wales. Contr. Mineral. Petrol., 21, 319–331. (3) Rice, J.M. and B.W. Evans (1974) Widespread occurrence of magnesiocummingtonite in ultramafic schists, Cima di Gagnone, Ticino, Switzerland. Contr. Mineral. Petrol., 43, 245–251. (4) Klein, C. (1964) Cummingtonite-grunerite series: a chemical, optical and X-ray study. Amer. Mineral., 49, 963–982. (5) Ghose, S. (1961) The crystal structure of a cummingtonite. Acta Cryst., 14, 622–627. (6) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 225–258.

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Magnesioferrite $MgFe_2^{3+}O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals octahedral, to 5 mm; more commonly granular, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law, as contact twins.

Physical Properties: *Cleavage:* {111} parting likely. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 899–910 (100 g load). D(meas.) = 4.55–4.65 D(calc.) = 4.556 Strongly magnetic.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black to brownish black; reddish brown in transmitted light; gray in reflected light with red internal reflections. *Streak:* Black. *Luster:* Metallic to semimetallic, may be dull.
Optical Class: Isotropic. $n = 2.38$
R: (470) 18.9, (546) 18.5, (589) 18.3, (650) 17.5

Cell Data: *Space Group:* $Fd3m$. a = 8.37–8.39 Z = 8

X-ray Powder Pattern: Synthetic. (ICDD 17-464).
2.525 (100), 2.96 (40), 1.481 (35), 1.612 (30), 2.094 (25), 1.709 (14), 1.090 (12)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
TiO_2		23.4		FeO	1.79	27.9	
Al_2O_3		7.14		MnO	4.61	0.38	
Fe_2O_3	74.73	24.0	79.85	MgO	18.22	16.9	20.15
Cr_2O_3		1.24		Total	99.35	100.96	100.00

(1) Långban, Sweden. (2) Benfontein sill, South Africa; by electron microprobe, Fe^{2+}:Fe^{+3} calculated from stoichiometry; corresponds to $(Mg_{0.80}Fe^{2+}_{0.19}Mn_{0.01})_{\Sigma=1.00}(Fe^{3+}_{0.58}Ti_{0.56}Fe^{2+}_{0.56}Al_{0.27}Cr_{0.03})_{\Sigma=2.00}O_4$. (3) $MgFe_2O_4$.

Polymorphism & Series: Forms a series with magnetite.

Mineral Group: Spinel group.

Occurrence: Most commonly of fumarolic origin; also in high-grade (sanidinite facies) combustion-metamorphosed marls and burning coal heaps; in metamorphosed dolostones. An accessory mineral in some kimberlites, carbonatites, and alkali gabbros. As skeletal inclusions in glassy spherules in sediments attributed to bolide impact debris.

Association: Hematite, titanian magnetite, ferrian diopside.

Distribution: Numerous localities. In Italy, on Vesuvius and Monte Somma, Campania; on Etna, Sicily; from Stromboli and Vulcano, Lipari Islands. On Puy de la Tache, Mont Dore, Puy-de-Dôme, France. In the Hatrurim Formation, Israel. At Husereau Hill, Oka complex, Quebec, Canada. In the USA, from the Crestmore quarry, Riverside Co., California and at Magnet Cove, Hot Spring Co., Arkansas. Abundant at Långban, Värmland, Sweden. In Russia, from mines around Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains; in the Tazheran alkalic massif, west of Lake Baikal, Siberia; and in the Konder alkalic massif, Aldan Shield, Sakha. As a minor constituent of the widespread sediments marking some major geological period boundaries, as the Cretaceous-Tertiary.

Name: From the composition, with dominant MAGNESium and FERRic iron.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 698–707. (2) van de Pijpekamp, B., E.A.J. Burke, and P. Maaskant (1974) Magnesioferrite, a mineral new for Långban, Sweden. Arkiv Min. Geol., 5(1), 1–10. (3) O'Neill, H.St.C., H. Annersten, and D. Virgo (1992) The temperature dependence of the cation distribution in magnesioferrite ($MgFe_2O_4$) from powder XRD structural refinements and Mössbauer spectroscopy. Amer. Mineral., 77, 725–740.

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Magnesio-hastingsite $NaCa_2[(Mg,Fe^{2+})_4Fe^{3+}](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [Prismatic.] *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, with intersections at ∼56° and ∼124°; partings on {001}, {100}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.18–3.22 D(calc.) = 3.243

Optical Properties: Semitransparent. *Color:* Green. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* X = pale brown; Y = dark brown; Z = green-brown. *Orientation:* $Y = b$; $Z \wedge c \simeq 15°$–$19°$. $\alpha = 1.652$–1.676 $\beta = 1.664$–1.687 $\gamma = 1.672$–1.695 2V(meas.) = 80°–84°

Cell Data: *Space Group:* $C2/m$. $a = 9.880(2)$ $b = 18.012(4)$ $c = 5.324(2)$ $\beta = 105.26(2)°$ Z = 2

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.26	39.83	MgO	13.98	14.44
TiO_2	3.16	2.56	CaO	12.01	12.39
Al_2O_3	11.99	14.98	Na_2O	2.54	2.27
Fe_2O_3	7.78	7.66	K_2O	1.87	1.25
FeO	5.52	3.78	H_2O^+	1.63	0.58
MnO	0.12	0.00	Total	100.86	99.74

(1) Unteriefenbach, Austria; corresponds to $(Ca_{1.90}Na_{0.73}K_{0.35})_{\Sigma=2.98}(Mg_{3.07}Fe^{3+}_{0.86}Fe^{2+}_{0.68}Ti_{0.35}Mn_{0.02}Al_{0.02})_{\Sigma=5.00}(Si_{5.94}Al_{2.06})_{\Sigma=8.00}O_{22}(OH)_{1.60}$. (2) Březno nad Labem (Grosspriesen), Czech Republic; corresponds to $(Ca_{1.97}Na_{0.65}K_{0.24})_{\Sigma=2.86}(Mg_{3.20}Fe^{3+}_{0.86}Al_{0.54}Fe^{2+}_{0.47}Ti_{0.29})_{\Sigma=5.36}(Si_{5.92}Al_{2.08})_{\Sigma=8.00}O_{22}(OH)_{0.58}$.

Polymorphism & Series: Forms a series with hastingsite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.70$; $Fe^{3+} > Al^{vi}$; $(Na + K)_A \geq 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si < 6.25$; $Ti < 0.5$.

Occurrence: In alkalic basalts; in andesites, latites, tephrites, and their tuffs; in carbonatites.

Association: Olivine, plagioclase, pyroxenes.

Distribution: From Untertiefenbach, Austria. At Březno nad Labem (Grosspriesen), Czech Republic. In Germany, from the Radersberg, Eifel district. From Gillinge and Långban, Värmland, Sweden. In Russia, from the Khibiny massif, Kola Peninsula. At the Gardiner complex, beyond the head of the Kangerdlugssuaq Fjord, Greenland. From Lyndoch, Ontario, Canada. In the USA, at Iron Hill, Gunnison Co., Colorado. From the Marangudzi ring complex, Zimbabwe.

Name: For *magnesium* in its composition and relation to *hastingsite*.

Type Material: n.d.

References: (1) Billings, M.P. (1928) The chemistry, optics and genesis of the hastingsite group of amphiboles. Amer. Mineral., 13, 287 [hypothetical end member]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 263–314 [hornblende, in part], 315–320 [basaltic hornblende]. (3) Walitzi, E.M. and F. Walter (1981) Verfeinerung der Kristallstruktur eines basaltischen Magnesio-Hastingsites. Zeits. Krist., 156, 197–208 (in German).

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Högbomite $(Mg, Fe^{2+})_2(Al, Ti)_5O_{10}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}2/m$ or $6mm$. Rare crystals are tabular, thin to thick, on {0001}, to 5 mm; commonly granular, massive, intergrown and included with other species. *Twinning:* On {0001}, may be repeated; on $\{h0\overline{h}l\}$, probable.

Physical Properties: *Cleavage:* {0001}, another on $\{h0\overline{h}l\}$, may be partings. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6.5 VHN = 1064–1216 (100 g load). D(meas.) = n.d. D(calc.) = [3.85] Weakly magnetic.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black; brown in transmitted light; gray in reflected light. *Streak:* Gray. *Luster:* Metallic adamantine. *Optical Class:* Uniaxial (–). *Pleochroism:* Distinct; O = dark golden brown; E = light golden brown. *Absorption:* $O > E$. $\omega = 1.848$–1.853 $\epsilon = 1.803$–1.823 *Anisotropism:* Distinct.
R_1–R_2: (400) 9.74–10.2, (420) 9.28–9.79, (440) 8.91–9.37, (460) 8.55–9.08, (480) 8.40–8.91, (500) 8.31–8.88, (520) 8.27–8.80, (540) 8.21–8.75, (560) 8.16–8.70, (580) 8.15–8.70, (600) 8.17–8.70, (620) 8.20–8.71, (640) 8.24–8.73, (660) 8.31–8.74, (680) 8.30–8.75, (700) 8.37–8.77

Cell Data: *Space Group:* $R\overline{3}m$(4H), with $a = 5.718$ $c = 4.6$ Z = 3, or *Space Group:* $P6_3mc$(8H), with $a = 5.734(3)$ $c = 18.389(8)$ Z = 3

X-ray Powder Pattern: Mautia Hill, Tanzania (5H).
2.43 (vs), 1.426 (s), 2.49 (ms), 2.079 (ms), 1.978 (ms), 4.60 (m), 2.86 (m)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
TiO_2	6.26	4.74	MnO	0.15	0.19	Na_2O	0.15	
Al_2O_3	58.57	61.25	ZnO	3.86	4.12	H_2O		[1.45]
Fe_2O_3	9.04		GaO	0.16		Total	98.67	[100.09]
FeO	16.04	22.72	MgO	4.44	5.62			

(1) Strangways Range, Australia; by electron microprobe, original analysis elemental, here converted to oxides; Fe^{2+}:Fe^{3+} calculated from charge balance; corresponds to $[Fe^{2+}_{0.95}Fe^{3+}_{0.48}Mg_{0.47}Zn_{0.20}(Ga, Mn, Na)_{0.04}]_{\Sigma=2.14}(Al_{4.87}Ti_{0.33})_{\Sigma=5.20}O_{10}(OH)_{0.67}$. (2) Cape Ryugu, Antarctica; by electron microprobe, total Fe as FeO; corresponding to $(Fe_{1.31}Mg_{0.58}Zn_{0.21}Mn_{0.01})_{\Sigma=2.11}(Al_{4.98}Ti_{0.25})_{\Sigma=5.23}O_{10.07}(OH)_{0.67}$.

Polymorphism & Series: 4H, 5H, 6H, 8H, 15H, 15R, 18R, 24R polytypes, polytypoids.

Occurrence: A primary mineral, or replacing spinel or magnetite, in skarns, gabbros, gneisses, "emery" or other rocks formed during medium- to high-grade metamorphism; rarely detrital.

Association: Corundum, ferroan spinel, magnetite, ilmenite, rutile, nigerite, sapphirine, sillimanite, cordierite, kyanite, garnet, quartz, chlorite, gedrite, phlogopite.

Distribution: In the Ruoutevare Fe–Ti deposit, near Kvikkjokk, Norrbotten, Sweden. At Rödstrand, Norway. From the Shoriya Mountains, western Siberia, Russia. At Cashal, near Toombeola, Co. Galway, Ireland. On Mautia Hill, Tanzania. At the Linganga deposit, Njombe district, Tanzania. From Tsaobis, Namibia. In the USA, at Whittles, Pittsylvania Co., Virginia; Peekskill, Westchester Co., New York; and Franklin, Macon Co., North Carolina. In the Romay mine, San Juan, Catamarca Province, Argentina. From the Strangways Range, Northern Territory, Australia. On the Prince Olav Coast, eastern Antarctica. More localities are known.

Name: For Professor Arvid Gustaf Högbom (1857–1940), of the University of Uppsala, Uppsala, Sweden.

Type Material: The Natural History Museum, London, England, 1923,1019.

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;$hgbomite - 8H = magnesiohgbomite - 2N2Shgbomite - 10T = magnesiohgbomite - 2N3S; hgbomite - 24R = magnesiohgbomite - 6N6S; zinchgbomite - 8H = zinchgbomite - 2N2S; zinchgbomite - 16H = zinchgbomite - 2N6S; nigerite - 6T = ferronigerite - 2N1S; nigerite - 24R = ferronigerite - 6N6S; pengzhizhongite - 6T = magnesionigerite - 2N1S; pengzhizhongite - 24R = magnesionigerite - 6N8S; taaffeeite = magnesiotaaffeite - 2N'2S; musgravite = magnesiotaaffeite - 6N'3S; perhmanite = ferrotaaffeite - 6N'3S; Criddle, A.J. and C.J. Stanley, Eds.$ (1993) *Quantitative data file for ore minerals*, 3rd ed. Chapman & Hall, Londo

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Crystals short prismatic with flat pyramidal termination, to several cm; radial fibrous, massive. *Twinning:* Common on {101} or $\{10\overline{1}\}$.

Physical Properties: *Cleavage:* Prismatic, distinct. *Tenacity:* Brittle. Hardness = 6 VHN = 488–560 ∥ [001], 620–689 ⊥ [001] (100 g load). D(meas.) = 4.95 D(calc.) = [4.93]

Optical Properties: Opaque. *Color:* Black, grayish black to silvery gray; in reflected light, white. *Streak:* Black. *Luster:* Metallic, splendent.
Optical Class: Biaxial. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: (400) 31.3–37.7, (420) 31.2–37.4, (440) 31.1–37.1, (460) 30.5–36.5, (480) 29.7–35.9, (500) 29.1–35.0, (520) 28.5–34.2, (540) 27.8–33.1, (560) 27.1–32.2, (580) 26.6–31.5, (600) 26.3–30.9, (620) 26.1–30.4, (640) 25.8–30.0, (660) 25.6–29.5, (680) 25.3–29.0, (700) 25.0–28.4

Cell Data: *Space Group:* $I2/m$. $a = 10.013(1)$ $b = 2.8801(2)$ $c = 9.733(1)$ $\beta = 90.970(4)^\circ$ Z = 1

X-ray Powder Pattern: Langenberg, Germany; easily mistaken for coronadite.
3.13 (10), 2.40 (9), 3.47 (8), 2.15 (8), 1.55 (7), 1.83 (6), 6.98 (5)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2		0.58	MnO	5.12	
MnO_2	65.63	62.91	PbO		4.45
Al_2O_3	0.94	1.45	BaO	17.59	13.81
Fe_2O_3	10.56	12.63	Na_2O		0.58
Mn_2O_3		4.57	K_2O		0.23
			Total	99.84	[101.21]

(1) Kajlidongri, India; corresponds to $Ba_{0.95}[Mn^{4+}_{6.23}Mn^{2+}_{0.59}(Fe,Al)_{1.24}]_{\Sigma=8.06}O_{16}$. (2) Stuor Njvoskes, Sweden; by electron microprobe, average of several analyses, Mn^{4+}:Mn^{3+} calculated for charge balance; corresponds to $(Ba_{0.75}Pb_{0.16}Na_{0.10}K_{0.04})_{\Sigma=1.05}(Mn^{4+}_{6.08}Fe^{3+}_{1.32}Mn^{3+}_{0.50}Al_{0.23}Si_{0.08})_{\Sigma=8.21}O_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: A primary mineral in contact metamorphic manganese ores, and a secondary weathering product of earlier manganese-bearing minerals.

Association: Bixbyite, braunite, piemontite, other manganese oxides.

Distribution: In India, at Kajlidongri and Sitapar, Chhindwara district, Madhya Pradesh; in the Nagpur and Balaghat districts, Maharashtra; at Banswara, Rajasthan; and elsewhere. From Sörhårrås, Ultevis, Sweden. In Norway, from Tangen, Hurdal. At Langenberg, Saxony, Germany. From Inken, Tiovine region, Morocco. In the USA, in the Artillery Mountains, Mohave Co., and in the Apache mine, Sierra Ancha district, Gila Co., Arizona.

Name: For Dr. Thomas Henry Holland (1868–1947), Director of the Indian Geological Survey.

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Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 743–744. (2) Frondel, C. and E.W. Heinrich (1942) new data on hetaerolite, hydrohetaerolite, coronadite, and hollandite. Amer. Mineral., 27, 48–56. (3) Frondel, C., U.B. Marvin, and J. Ito (1960) New data on birnessite and hollandite. Amer. Mineral., 45, 871–875. (4) Post, J.E., R.B. Von Dreele, and P.R. Buseck (1982) Symmetry and cation displacements in hollandites: structure refinements of hollandite, cryptomelane, and priderite. Acta Cryst., 38, 1056–1065. (5) Miura, H. (1987) The crystal structure of hollandite. Mineral. J. (Japan), 13, 119–129, 397–398. (6) Post, J.E. and D.L. Bish (1989) Rietveld refinement of crystal structures using powder X-ray diffraction data. In: D.L. Bish and J.E. Post, Eds., Modern powder diffraction. Reviews in mineralogy, vol. 20, 277–308, esp. 296–300.

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Magnesio-hornblende $Ca_2[(Mg,Fe^{2+})_4Al](Si_7Al)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals; as reaction rims on pyroxenes. *Twinning:* Simple or lamellar twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; partings on {100}, {010}. *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.10–3.28 D(calc.) = 3.26

Optical Properties: Semitransparent. *Color:* Green, brown. *Luster:* [Vitreous to pearly.] *Optical Class:* Biaxial (–). *Pleochroism:* X = yellow; $Y = Z$ = green. *Orientation:* $Y = b$; $Z \wedge c = 15°–19°$. $\alpha = 1.675$ $\beta = 1.690$ $\gamma = 1.695$ 2V(meas.) = 56°

Cell Data: *Space Group:* $C2/m$. $a = 9.887(2)$ $b = 18.174(5)$ $c = 5.308(5)$ $\beta = 104°58(2)'$ Z = 2

X-ray Powder Pattern: Sierra Nevada batholith, California, USA.
3.136 (100), 8.51 (56), 2.720 (33), 3.291 (26), 2.818 (19), 2.172 (19), 1.656 (18)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.20	44.12	Na_2O	1.96	1.18
TiO_2	1.00	1.26	K_2O	0.41	0.88
Al_2O_3	10.00	8.82	F		0.14
Fe_2O_3	3.50	5.53	Cl		0.07
FeO	10.60	14.77	H_2O^+	2.22	1.80
MnO	0.17	0.50	H_2O^-	0.45	0.00
MgO	10.06	9.19	$-O = (F,Cl)_2$		0.08
CaO	10.59	11.74	Total	99.16	99.92

(1) Sibukawa district, central Japan; corresponds to $(Ca_{1.66}Na_{0.55}K_{0.08})_{\Sigma=2.29}(Mg_{2.18}Fe^{2+}_{1.29}Fe^{3+}_{0.39}Al_{0.76}Ti_{0.10}Mn_{0.02})_{\Sigma=4.74}(Si_{7.04}Al_{0.96})_{\Sigma=8.00}[O_{21.84}(OH)_{0.16}]_{\Sigma=22.00}(OH)_{2.00}$. (2) Sierra Nevada batholith, California, USA; corresponds to $(Ca_{1.90}Na_{0.35}K_{0.17})_{\Sigma=2.42}(Mg_{2.07}Fe^{2+}_{1.86}Fe^{3+}_{0.63}Al_{0.23}Ti_{0.14}Mn_{0.06})_{\Sigma=4.99}(Si_{6.66}Al_{1.34})_{\Sigma=8.00}O_{22}[(OH)_{1.87}F_{0.07}Cl_{0.02}]_{\Sigma=1.96}$.

Polymorphism & Series: Forms a series with ferrohornblende.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.50$; $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; 6.50 Si 7.24.

Occurrence: Common in amphibolites, schists, and pegmatitic alkalic gabbro. Also from welded tuffs, granodiorites, granites, and tonalites.

Association: Quartz, orthoclase, plagioclase, biotite, magnetite, apatite (granite).

Distribution: Very widespread. A few confirmed localities include: at Vesuvius and Monte Somma, Campania, Italy. In the granitic batholiths of the Scottish Highlands; Swiss and Italian Alps; Harz Mountains, Germany; Finland and Sweden. In the Southern California and Sierra Nevada batholiths, California, USA. Widespread in Japan.

Name: For its high *magnesium* content and from the German for *horn* and *to deceive*, in allusion to its similarity to valuable minerals in ores.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 385–398 [hornblende, in part]. (2) Dodge, F.C.W., J.J. Papike, and R.E. Mays (1968) Hornblendes from granitic rocks of the central Sierra Nevada batholith. J. Petrol., 9, 378–410. (3) Leake, B.E. (1968) A catalog of analyzed calciferous and subcalciferous amphiboles together with their nomenclature and associated minerals. Geol. Soc. Amer. Special Paper 98, 210 p. [analysis 216].

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Magnesiohulsite $(Mg, Fe^{2+})_2(Fe^{3+}, Sn^{4+}, Mg)BO_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As needlelike crystals, elongated along [010], to 0.4 mm, in tufted aggregates. *Twinning:* On {101}.

Physical Properties: *Tenacity:* Brittle. Hardness = [6] VHN = 689–825 (50 g load). D(meas.) = 4.18(2) D(calc.) = 4.15

Optical Properties: Opaque, transparent in thin section. *Color:* Black; bluish gray to grayish white in reflected light. *Streak:* Dark brown. *Luster:* Submetallic.
Optical Class: Biaxial. *Pleochroism:* Strong, X = dark brown; Y = dark green. $\alpha = 1.88$ β = n.d. $\gamma = 1.95$ 2V(meas.) = n.d. *Anisotropism:* Strong.

Cell Data: *Space Group:* $P2/m$. $a = 10.70(10)$ $b = 3.06(3)$ $c = 5.45(5)$ $\beta = 94.6(5)^\circ$ Z = 2

X-ray Powder Pattern: Qiliping, China.
2.665 (10), 2.563 (9), 2.467 (8), 2.018 (8), 5.32 (7), 2.129 (6), 1.9653 (6)

Chemistry:

	(1)
SiO_2	0.45
TiO_2	0.05
SnO_2	12.90
B_2O_3	16.59
Al_2O_3	0.05
Fe_2O_3	20.97
FeO	20.86
MnO	0.90
MgO	25.75
CaO	0.18
H_2O	0.00
Total	98.70

(1) Qiliping, China; corresponds to $(Mg_{1.25}Fe^{2+}_{0.66}Mn_{0.03}Ca_{0.01})_{\Sigma=1.95}(Fe^{3+}_{0.60}Sn_{0.19}Mg_{0.19}Al_{0.01}Ti_{0.01})_{\Sigma=1.00}B_{1.06}O_5$.

Occurrence: In a magnesium skarn borate deposit at the contact between granite and calcite–dolomite rocks.

Association: Szaibélyite, kotoite, fluoborite, stannian ludwigite, sakhaite, dolomite, calcite.

Distribution: From Daiy Mountain, Qiliping, Changning Co., Hunan Province, China.

Name: As the *magnesium* analog of *hulsite*.

Type Material: n.d.

References: (1) Yang Guangming, Peng Zhizhong, and Pan Zhaolu (1985) Magnesiohulsite – a new tin-rich borate mineral. Acta Mineral. Sinica, 5(2), 97–101 (in Chinese with English abs.). (2) (1988) Amer. Mineral., 73, 929 (abs. ref. 1). (3) Zhao Wenxia, Yang Guangming, and Pan Zhaolu (1991) Electron diffraction analysis of magnesiohulsite twin. Acta Petrologica et Mineralogica, 10(4), 339–344 (in Chinese with English abs.).

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Magnesiohögbomite-2*N*4*S* $Mg_{10}Al_{22}Ti_2O_{46}(OH)_2$

Crystal Data: Hexagonal. *Point Group*: 6*mm*. As hexagonal plates or prisms, to 4 mm.

Physical Properties: *Cleavage*: On {001}. *Fracture*: n.d. *Tenacity*: n.d.
Hardness = 6.5-7 VHN = 1032 (300 g load). D(meas.) = n.d. D(calc.) = 3.702(2)

Optical Properties: Transparent. *Color*: Orange-red. *Streak*: Light orange. *Luster*: n.d.
Optical Class: Uniaxial (-). *n(calc.)* = 1.85(3) *Pleochroism*: *O* = reddish brown, *E* = pale brown.

Cell Data: *Space Group*: $P6_3mc$. a = 5.71050(10) c = 27.6760(4) Z = 1

X-ray Powder Pattern: Koyubi Ridge area, Sør Rondane Mountains, East Antarctica.
2.42818 (100), 1.42785 (57), 2.01181 (50), 2.6120 (39), 2.4160 (39), 2.8561 (37), 1.54892 (35)

Chemistry:

	(1)		(1)
SiO_2	0.05	CaO	0.01
TiO_2	7.08	ZnO	0.96
SnO_2	0.15	NiO	0.01
Al_2O_3	66.03	CoO	0.02
Cr_2O_3	0.02	F	0.06
Fe_2O_3	0.50	Cl	0.01
FeO	4.87	H_2O	1.00
MnO	0.06	$-O = (Cl,F)_2$	0.02
MgO	18.71	Total	99.51

(1) Koyubi Ridge area, Sør Rondane Mountains, East Antarctica; average of 46 electron microprobe analyses, Raman spectroscopy confirms presence of OH; corresponding to $(Mg_{8.2}Fe_{1.2}Zn_{0.2})^{2+}(Al_{22.7}Fe_{0.1})^{3+}Ti^{4+}_{1.6}O_{46}(OH)_2$.

Polymorphism & Series: Part of a solid solution series between the two ideal end-members, $(Mg,Fe,Zn)^{2+}_{10}(Al,Fe)^{3+}_{22}Ti^{4+}_2O_{46}(OH)_2$ and $(Mg,Fe,Zn)^{2+}_8(Al,Fe)^{3+}_{26}O_{46}(OH)_2$.

Occurrence: The product of retrograde metamorphism in a Mg-Al-rich, Si-poor skarn developed in dolomitic impure marble.

Association: Corundum, spinel, phlogopite, clinochlore, rutile, zirconolite, polycrase-(Y).

Distribution: From the Koyubi Ridge area, Sør Rondane Mountains, Queen Maud Land, East Antarctica.

Name: Identifies a member in the *högbomit*e series with a structure based on spinel (*S*) and nolanite (*N*) modules and with $Mg^{2+} > Fe^{2+}$.

Type Material: At the National Museum of Nature and Science, Tokyo (NSM-MF15438), the Polar Science Museum, Tokyo (NIPR-0073), and the Science Museum of Niigata University, Niigata (NUMIN-NM02), Japan. Also at the Museum of Natural History, Bern, Switzerland (NMBE 41105).

References: (1) Shimura, T., J. Akai, B. Lazic, T. Armbruster, M. Shimizu, A. Kamei, K. Tsukada, M. Owada, and M. Yuhara (2012) Magnesiohögbomite-2*N*4*S*: A new polysome from the central Sør Rondane Mountains, East Antarctica. Amer. Mineral., 97, 268-280.

Magnesio-katophorite $Na[NaCa][(Mg,Fe^{2+})_4Al](Si_7Al)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic, granular, also as fibrous aggregates. *Twinning:* ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at ∼56° and ∼124°; parting on {010}. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.2–3.5 D(calc.) = [3.18]

Optical Properties: Transparent to translucent. *Color:* Black, dark green-black, red-brown; yellow to red-brown in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong in yellow and red-brown. *Orientation:* $Y = b$. *Dispersion:* $r < v$. *Absorption:* $Y > Z \simeq X$. $\alpha = 1.639$–1.681 $\beta = 1.658$–1.688 $\gamma = 1.600$–1.690
2V(meas.) = ∼0°–50°

Cell Data: *Space Group:* $C2/m$. $a = 10.019(2)$ $b = 18.036(7)$ $c = 5.286(3)$
$\beta = 104.98(3)°$ Z = 2

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.51	46.73	MgO	14.79	10.10
TiO_2	1.32	0.94	CaO	5.60	7.64
Al_2O_3	6.60	3.16	Na_2O	6.01	4.65
Fe_2O_3	4.09		K_2O	2.20	1.17
FeO	9.48	18.96	H_2O^+	1.47	
MnO	0.19	1.35	Total	100.26	94.70

(1) Shields River basin, Montana, USA; corresponds to $(Na_{1.71}Ca_{0.88}K_{0.41})_{\Sigma=3.00}(Mg_{3.24}Fe^{2+}_{1.16}Fe^{3+}_{0.45}Al_{0.26}Ti_{0.14}Mn_{0.02})_{\Sigma=5.27}(Si_{7.12}Al_{0.88})_{\Sigma=8.00}O_{22}(OH)_{1.44}$. (2) Rallier-du-Baty Peninsula, Kerguelen Island; by electron microprobe.

Polymorphism & Series: Forms a series with katophorite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.5$; $Fe^{3+} < 1.0$; $(Na + K)_A \geq 0.5$; 0.67 Na_B 1.33; $(Ca + Na)_B \geq 1.34$; 6.5 Si 7.49; $Al^{vi} < 1.0$.

Occurrence: In alkalic igneous rocks, including plutonic ring complexes and dikes, and carbonatites.

Association: Arfvedsonite, aegirine, nepheline, magnetite, calcite.

Distribution: On the Rallier-du-Baty Peninsula, Kerguelen Island, in the south Indian Ocean. From the Shields River basin, Park Co., Montana, USA. At Imeria, Madagascar. In the Khibiny massif, Kola Peninsula, Russia.

Name: For *magnesium* in its composition and its relation to *katophorite*.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 359–363. (2) Giret, A., B. Bonin, and J.-M. Leger (1980) Amphibole compositional trends in oversaturated and undersaturated alkaline plutonic ring complexes. Can. Mineral., 18, 481–495. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 241–242.

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Pengzhizhongite $(Mg, Zn, Al, Fe^{3+})_4(Sn^{4+}, Fe^{3+})_2Al_{10}O_{22}(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Tabular crystals, to 1 mm.

Physical Properties: Hardness = ∼8 D(meas.) = 4.22(3) D(calc.) = 4.16

Optical Properties: Transparent. *Color:* Light yellowish brown to light yellow, may be colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.802(2)$ $\epsilon = 1.814(2)$

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 5.692(5)$ $c = 13.78(2)$ Z = 1

X-ray Powder Pattern: Anhua area, China.
2.423 (100), 2.846 (90), 1.414 (50), 1.545 (40), 1.639 (30), 2.624 (20), 1.842 (20)

Chemistry:

	(1)
SiO_2	1.48
SnO_2	18.73
Al_2O_3	56.00
Fe_2O_3	8.38
MnO	0.40
ZnO	4.73
MgO	8.03
H_2O^+	1.88
Total	99.63

(1) Anhua area, China; by electron microprobe, total Fe as Fe_2O_3; corresponding to $(Mg_{1.93}Zn_{0.56}Al_{0.99}Si_{0.24}Fe_{0.22}Mn_{0.05})_{\Sigma=3.99}(Sn_{1.21}Fe_{0.79})_{\Sigma=2.00}Al_{9.71}O_{22}(OH)_2$.

Polymorphism & Series: 6H polymorph; 24M polymorph reported.

Occurrence: An accessory mineral in high-temperature tungsten ore.

Association: Quartz, scheelite, muscovite, magnetite, rutile, nigerite, cassiterite, zircon, taaffeite.

Distribution: From the Anhua area, Hunan Province, China.

Name: To honor Peng Zhizhong, Chinese mineralogist, Wuhan Geological College, Beijing, China, who determined the crystal structure.

Type Material: [China University of Geosciences, Wuhan, China].

; pengzhizhongite-6T = magnesionigerite-2N1S; pengzhizhongite-24R = magnesionigerite-6N8S; [full list given under högbohmite];

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Magnesiopascoite $Ca_2Mg(V_{10}O_{28}) \cdot 16H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As tabular to equant to prismatic crystals, to several mm, typically intergrown in parallel groups; displaying prominent {001} with numerous small faces that produce striations at 120° to one another.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Conchoidal, curved. *Tenacity*: Brittle. Hardness = 2.5 D(meas.) = 2.43(2) D(calc.) = 2.442

Optical Properties: Transparent. *Color*: Bright orange. *Streak*: Yellow. *Luster*: Adamantine. *Optical Class*: Biaxial (–). α = 1.769(3) β = 1.802(3) γ = 1.807(3) 2V(meas.) = 45(5)° 2V(calc.) = 42° *Pleochroism*: *Y* = Orange; *Z* = yellow. *Orientation:* *X* = *b*; *Z* $\wedge$ *a* = 20°.

Cell Data: *Space Group*: *C*2/*m*. *a* = 19.8442(15) *b* = 9.9353(8) *c* = 10.7149(8) β = 120.305(1)° *Z* = 2

X-ray Powder Pattern: Blue Cap mine, San Juan County, Utah, USA.
8.571 (100), 7.270 (40), 8.872 (30), 9.242 (20), 2.137 (20), 5.477 (15), 4.590 (15)

Chemistry:

	(1)	(2)
CaO	7.78	8.31
MgO	2.67	2.98
ZnO	0.23	
CoO	0.05	
V_2O_5	71.32	67.35
H_2O	21.94	21.35
Total	103.99	100.00

(1) Blue Cap mine, San Juan County, Utah, USA; average of 4 electron microprobe analyses, H_2O calculated from structure, corresponding to $Ca_{1.77}(Mg_{0.85}Zn_{0.04}Co_{0.01})(H_2O)_{15.34}(H_3O)_{0.66}(V_{10}O_{28})$.
(2) $Ca_2Mg(V_{10}O_{28}) \cdot 16H_2O$.

Mineral Group: Pascoite group.

Occurrence: Product of groundwater leaching and oxidation of vanadium oxides in a post-mining environment.

Association: Gypsum, rossite, pyrite, montroseite, martyite.

Distribution: Blue Cap and Vanadium Queen mines, near La Sal, San Juan County, Utah, USA.

Name: As the magnesium analog of *pascolite*.

Type Material: Natural History Museum of Los Angeles County, California, USA, 58610 and 58611.

References: (1) Kampf, A.R. and I.M. Steele (2008) Magnesiopascoite, a new member of the pascoite group: description and crystal structure. Can. Mineral., 46, 679–686. (2) (2009) Amer. Mineral., 94, 400 (abs. ref. 1).

Magnesio-riebeckite $Na_2[(Mg,Fe^{2+})_3Fe^{3+}_2]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [As prismatic crystals. Also columnar, fibrous, or granular aggregates.] *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼58° and ∼122°; partings on {010}, {001}.] *Fracture:* [Conchoidal to uneven.] *Tenacity:* [Brittle.] Hardness = [6] D(meas.) = 3.12–3.29 D(calc.) = [3.15]

Optical Properties: Semitransparent. *Color:* Blue, black; light blue in thin section. *Luster:* [Vitreous.]
Optical Class: Biaxial (+) or (–). *Pleochroism:* Strong; X = dark blue; Y = indigo; Z = yellow-green. *Orientation:* $Y = b$; $X \wedge c = 15°–32°$. $\alpha = 1.657–1.673$ $\beta = 1.660–1.677$ $\gamma = 1.657–1.675$ 2V(meas.) = 0°–80°

Cell Data: *Space Group:* $C2/m$. $a = 9.745$ $b = 17.912$ $c = 5.278$ $\beta = 103.49°$ Z = 2

X-ray Powder Pattern: Puolanka, Finland. (ICDD 29-1236).
3.09 (100), 8.35 (99), 4.23 (20), 3.25 (18), 4.49 (16), 2.692 (12), 3.40 (9)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	54.84	56.1	MgO	8.91	14.5
TiO_2	0.27		CaO	2.74	1.11
Al_2O_3	1.80	0.66	Na_2O	5.58	5.05
Fe_2O_3	11.69	15.6	K_2O	0.16	0.71
FeO	12.11	4.06	H_2O^+		[2.21]
MnO	0.43		H_2O^-		0.03
			Total	98.53	[100.03]

(1) Kodiak Islands, Alaska, USA; by electron microprobe, Fe^{2+}:Fe^{3+} calculated; corresponding to $(Na_{1.56}Ca_{0.43}K_{0.03})_{\Sigma=2.02}(Mg_{1.93}Fe^{2+}_{1.47}Fe^{3+}_{1.27}Al_{0.26}Mn_{0.05}Ti_{0.03})_{\Sigma=5.01}(Si_{7.95}Al_{0.05})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Cochabamba Province, Bolivia; H_2O calculated from stoichiometry, corresponding to $(Na_{1.38}Ca_{0.17}K_{0.13})_{\Sigma=1.68}(Mg_{3.06}Fe^{3+}_{1.66}Fe^{2+}_{0.48}Al_{0.05})_{\Sigma=5.25}(Si_{7.94}Al_{0.06})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with riebeckite.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) < 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) \geq 0.7$; $(Na + K)_A < 0.5$; $Na_B \geq 1.34$.

Occurrence: In granulites, ironstones, ferruginous metacherts, greenschist facies schists, and carbonatites.

Association: Stilpnomelane, epidote, quartz, muscovite, winchite.

Distribution: Many localities; may be in large deposits of asbestiform material. In the Ternovsk mine, Krivoy-Rog basin, Ukraine. From the Norra Kärr complex, near Gränna, Sweden. In Bolivia, around Chapare, Cochabamba Province. In South Africa, over a large area from Koegas, Cape Province, to Botswana, and to the east of Pietersburg, Transvaal. At Lusaka, Zambia. Through the Hamersley Ranges, Western Australia. At Bizan and Suberidani, Tokushima Prefecture, Japan. In the USA, at Franklin, Sussex Co., New Jersey.

Name: For its high *magnesium* content and similarity to *riebeckite*.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 333–351 [riebeckite, in part]. (2) Whittaker, E.J.W. (1949) The structure of Bolivian crocidolite. Acta Cryst., 2, 312–317. (3) Borg, I.Y. (1967) Optical properties and cell parameters in the glaucophane-riebeckite series. Contr. Mineral. Petrol., 15, 67–92. (4) Roeske, S.M. (1986) Field relations and metamorphism of the Raspberry Schist, Kodiak Islands, Alaska. In: B.W. Evans and E.H. Brown, Eds., Blueschists and eclogites, Geol. Soc. Amer. Memoir 164, 169–184. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 237–241.

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Magnesio-sadanagaite

$KCa_2[(Mg,Fe^{2+})_3(Al,Fe^{3+})_2](Si_5Al_3)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* m, 2, or $2/m$. As short prismatic or granular crystals, to a few hundred microns.

Physical Properties: *Cleavage:* Perfect on {110}. *Tenacity:* [Brittle.] Hardness = ~6 D(meas.) = n.d. D(calc.) = 3.27

Optical Properties: Semitransparent. *Color:* Dark brown to black; in thin section, paler with increasing silicon content. *Streak:* Very light brown. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X' = colorless; Z' = brownish yellow. *Orientation:* $Z \wedge c = 26°$. $\alpha = 1.674(2)$ $\beta = 1.686(2)$ $\gamma = 1.699(2)$ 2V(meas.) = 90° 2V(calc.) = 88°

Cell Data: *Space Group:* $C2$, Cm, or $C2/m$. $a = 9.964(2)$ $b = 18.008(3)$ $c = 5.354(2)$ $\beta = 105.55(2)°$ Z = 2

X-ray Powder Pattern: Myojin Island, Japan; identical to sadanagaite.
3.28 (100), 8.48 (80), 3.15 (70), 2.707 (60), 2.162 (55), 2.951 (50), 2.766 (45)

Chemistry:

	(1)
SiO_2	32.1
TiO_2	3.2
Al_2O_3	22.0
FeO	13.7
MnO	0.1
MgO	8.0
CaO	12.5
Na_2O	0.7
K_2O	3.8
Total	96.1

(1) Myojin Island, Japan; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry and charge balance; corresponding to $(K_{0.75}Na_{0.22})_{\Sigma=0.97}Ca_{2.07}(Mg_{1.84}Fe^{2+}_{1.37}Al_{0.94}Fe^{3+}_{0.39}Ti_{0.38}Mn_{0.01})_{\Sigma=4.93}(Si_{4.95}Al_{3.05})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with potassic-magnesiosadanagaite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg+Fe^{2+}) > 0.5$; $Fe^{3+}/(Fe^{3+}+Al^{vi})$ 0.50; $(Na+K)_A \geq 0.5$; $Na_B < 0.67$; $(Ca+Na)_B \geq 1.34$; $Si < 5.5$; $Ti < 0.5$.

Occurrence: In lenses and irregularly shaped nodules in crystalline limestone; metamorphism reached amphibolite facies in an Fe, Al, Ti-rich sedimentary protolith.

Association: Clinopyroxene, vesuvianite, spinel-hercynite, titanite, ilmenite, apatite, perovskite, pargasite.

Distribution: On Myojin Island, Ehime Prefecture, Japan.

Name: For *magnesium* in its composition and similarity to *sadanagaite*.

Type Material: University of Tokyo, Tokyo, Japan.

References: (1) Shimazaki, H., M. Bunno, and T. Ozawa (1984) Sadanagaite and magnesio-sadanagaite, new silica-poor members of calcic amphibole from Japan. Amer. Mineral., 69, 465–471. (2) Rock, N.M.S. and B.E. Leake (1984) The International Mineralogical Association amphibole nomenclature scheme: computerization and its consequences. Mineral. Mag., 48, 211–227.

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Musgravite $(Mg, Fe^{2+}, Zn)_2Al_6BeO_{12}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. Crystals platy on {0001}, to 0.5 mm; massive.

Physical Properties: *Cleavage:* Perfect, {0001}, or a parting; another, $\{10\overline{1}1\}$, less perfect. Hardness = [8–8.5] (by analogy to taaffeite). D(meas.) = 3.68(2) D(calc.) = 3.69

Optical Properties: Semitransparent. *Color:* Pale olive-green; in thin section, nearly colorless.
Optical Class: Uniaxial (–). $\omega = 1.739(2)$ $\epsilon = 1.735(2)$

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. $a = 5.682(1)$ $c = 41.13(1)$ $Z = 6$

X-ray Powder Pattern: Musgrave Ranges, Australia.
2.408 (100), 1.4189 (80), 2.052 (70), 2.658 (55), 4.57 (40), 1.4868 (40), 2.271 (35b)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.30		ZnO		5.18
TiO_2	0.02		BeO	5.50	[5.50]
Al_2O_3	71.44	68.45	MgO	15.76	10.64
Fe_2O_3	0.40		CaO	0.00	0.09
Cr_2O_3		0.01	K_2O		0.04
FeO	6.78	9.69	P_2O_5	0.02	
MnO	0.02	0.01	Total	100.24	[99.61]

(1) Musgrave Ranges, Australia; Be by colorimetric methods, corresponds to $(Mg_{1.66}Fe^{2+}_{0.40})_{\Sigma=2.06}(Al_{5.95}Si_{0.02}Fe^{3+}_{0.02})_{\Sigma=5.99}Be_{0.93}O_{12}$. (2) Enderby Land, Antarctica; by electron microprobe; Be assumed from (1), total Fe as FeO, original total given as 99.62%; corresponds to $(Mg_{1.17}Fe_{0.60}Zn_{0.28})_{\Sigma=2.05}Al_{5.97}Be_{0.98}O_{12}$.

Polymorphism & Series: 9R, 18R polytypoids.

Occurrence: In a nodule, perhaps formerly a corundum crystal, in high-grade metapyroxenite, associated with metaperidotites and granulites (Musgrave Ranges, Australia); in pegmatite cutting granulite (Enderby Land, Antarctica).

Association: Spinel, sapphirine, phlogopite (Musgrave Ranges, Australia); quartz, sillimanite, garnet, biotite, surinamite, sapphirine (Enderby Land, Antarctica).

Distribution: From 16 km north-northeast of Ernabella Mission, Musgrave Ranges, South Australia. Along Casey Bay, Enderby Land, Antarctica. Found at Dove Bugt, northeast Greenland.

Name: For the Musgrave Ranges, South Australia, from where it was first recognized.

Type Material: Western Australian Museum, Perth, M.70.1991; University of Queensland, Brisbane, Australia, V014820; National Museum of Natural History, Washington, D.C., USA, 147436.

; musgravite = magnesiotaaffeite-6N'3S; [full list given under högbohmite];

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Magnesiotantalite $(Mg,Fe)(Ta,Nb)_2O_6$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Typically octahedral, less commonly dodecahedral, striated ‖ $[0\bar{1}1]$ on {011}, to 25 cm, very rarely cubic; skeletal, granular, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law, as contact twins, flattened, lamellar.

Physical Properties: *Cleavage:* Parting on {111}, very good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–6.5 VHN = 681–792 (100 g load). D(meas.) = 5.175 D(calc.) = 5.20 Strongly magnetic.

Optical Properties: Opaque, translucent through very thin edges. *Color:* Black; gray with brownish tint in reflected light. *Streak:* Black. *Luster:* Metallic to submetallic, may be dull. *Optical Class:* Isotropic. $n = 2.42$
R: (400) 22.3, (420) 21.8, (440) 21.3, (460) 20.8, (480) 20.5, (500) 20.3, (520) 20.3, (540) 20.4, (560) 20.5, (580) 20.6, (600) 20.6, (620) 20.7, (640) 20.8, (660) 20.9, (680) 21.0, (700) 21.2

Cell Data: *Space Group:* $Fd3m$ (synthetic). $a = 8.3970(1)$ $Z = 8$

X-ray Powder Pattern: Synthetic.
2.532 (100), 1.485 (40), 2.967 (30), 1.616 (30), 2.099 (20), 1.093 (12), 1.715 (10)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.27	0.11		FeO	30.78	31.21	31.03
TiO_2	trace	0.29		MnO		0.09	
Al_2O_3	0.21	0.44		MgO	trace	0.02	
Fe_2O_3	68.85	67.16	68.97	CaO	trace		
Cr_2O_3		0.08		Total	100.11	99.40	100.00

(1) Lovers Pit, Mineville, Essex Co., New York, USA. (2) Meier's Find, Western Australia; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry. (3) $Fe^{2+}Fe^{3+}_2O_4$.

Polymorphism & Series: Forms two series, with jacobsite, and with magnesioferrite.

Mineral Group: Spinel group.

Occurrence: A common accessory mineral in igneous and metamorphic rocks, in which magmatic segregation or contact metamorphism may produce economic deposits. Extensive deposits in sedimentary banded iron formations; a biogenic product; important detrital deposits.

Association: Chromite, ilmenite, ulvöspinel, rutile, apatite, silicates (igneous); pyrrhotite, pyrite, chalcopyrite, pentlandite, sphalerite, hematite, silicates (hydrothermal, metamorphic); hematite, quartz (sedimentary).

Distribution: Many localities, even for fine crystals. In Sweden, at Falun, Kiruna, Västanfors, and elsewhere. At Arendal, Norway. From Zlatoust and Magnetigorsk, Ural Mountains, Russia. In the Zillertal, Tirol, Austria. From Traversella, Piedmont, Italy. In Switzerland, at Binntal and Rimpfischwäng, Valais, and elsewhere. In the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland. From Bancroft, Ontario, Canada. In the USA, around Lake Sanford, Essex Co., and in the Tilly Foster mine, Brewster, Putnam Co., New York; at Magnet Cove, Hot Spring Co., Arkansas; in the Iron Springs district, Iron Co., Utah. From the Cerro del Mercado, Durango, Mexico. At Itabira, Minas Gerais, Brazil.

Name: An ancient term, possibly an allusion to the locality, *Magnesia*, Greece.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 698–707. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 56–88. (3) Gole, M.J. and C. Klein (1981) High-grade metamorphic Archean banded iron-formations, Western Australia: assemblages with coexisting pyroxenes ± fayalite. Amer. Mineral., 66, 87–99. (4) O'Neill, H.St.C. and W.A. Dollase (1994) Crystal structures and cation distributions in simple spinels from powder XRD structural refinements: $MgCr_2O_4$, $ZnCr_2O_4$, Fe_3O_4 and the temperature dependence of the cation distribution in $ZnAl_2O_4$. Phys. Chem. Minerals, 20, 541–555. (5) (1967) NBS Mono. 25, 5, 31.

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Magnesiotaramite $Na[NaCa][(Mg,Fe^{2+})_3Al_2](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: [Monoclinic.] *Point Group:* [2/*m*.] [Prismatic.]

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = n.d. D(calc.) = [3.13]

Optical Properties: Semitransparent. *Color:* [Black to blue-green.] *Luster:* [Vitreous.] *Optical Class:* [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* [*C*2/*m*.] $a = 9.778(1)$ $b = 17.859(2)$ $c = 5.310(1)$ $\beta = 104.82(1)°$ Z = [2]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
SiO_2	43.57
TiO_2	0.36
Al_2O_3	17.66
FeO	8.27
MnO	0.13
NiO	0.04
MgO	12.65
CaO	6.92
Na_2O	7.07
K_2O	0.00
F	0.01
Cl	0.01
Total	96.69

(1) Nordfjord, Norway; by electron microprobe, Fe^{2+}:Fe^{3+} calculated; corresponding to $(Na_{1.94}Ca_{1.06})_{\Sigma=3.00}(Mg_{2.93}Al_{1.12}Fe^{3+}_{0.50}Fe^{2+}_{0.41}Ti_{0.04})_{\Sigma=5.00}(Si_{6.24}Al_{1.76})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with taramite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.5$; $(Na + K)_A \geq 0.5$; $0.67 \quad Na_B \quad 1.33$; $(Ca + Na)_B \geq 1.34$; $Si < 6.5$.

Occurrence: An unusual product of the retrograde metamorphism of eclogitic rocks.

Association: Plagioclase, clinopyroxene.

Distribution: In the Nybö eclogite pod, Nordfjord, Norway.

Name: For *magnesium* in its composition and similarity to *taramite*.

Type Material: n.d.

References: (1) Ungaretti, L., D.C. Smith, and G. Rossi (1981) Crystal-chemistry by X-ray structure refinement and electron microprobe analysis of a series of sodic-calcic to alkali-amphiboles from the Nybö eclogite pod, Norway. Bull. Minéral., 104, 400–412. (2) (1982) Amer. Mineral., 67, 858 (abs. ref. 1).

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Magnesite $MgCO_3$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Uncommon as crystals, to 30 cm, with large $\{10\bar{1}1\}$ or $\{01\bar{1}2\}$, modified by $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, or tabular on $\{0001\}$. Typically earthy, chalky, porcelaneous, fibrous, coarse to fine granular, compact massive.

Physical Properties: *Cleavage:* On $\{10\bar{1}1\}$, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4.5 D(meas.) = 3.00(2) D(calc.) = 3.010 May exhibit pale green to pale blue fluorescence and phosphorescence under UV; triboluminescent.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale yellow, pale brown, faintly pink, lilac-rose; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Dispersion:* Very strong. *Absorption:* $O > E$, if colored.
$\omega = 1.700$ $\epsilon = 1.509$

Cell Data: *Space Group:* $R\bar{3}c$. a = 4.6632 $c = 15.015$ Z = 6

X-ray Powder Pattern: Synthetic.
2.742 (100), 2.102 (45), 1.700 (35), 2.503 (18), 1.939 (12), 1.338 (8), 0.9134 (8)

Chemistry:

	(1)	(2)
CO_2	[51.74]	52.20
FeO	0.60	
MnO	0.67	
MgO	47.09	47.80
CaO	0.07	
Total	[100.17]	100.00

(1) Brumado, Brazil; CO_2 calculated for stoichiometry; corresponds to $(Mg_{0.98}Fe_{0.01}Mn_{0.01})_{\Sigma=1.00}CO_3$. (2) $MgCO_3$.

Polymorphism & Series: Forms two series, with gaspéite and with siderite.

Mineral Group: Calcite group.

Occurrence: A primary mineral in igneous or sedimentary rocks; formed by metamorphism or alteration of serpentine and peridotite; uncommon in marine evaporites and hydrothermal veins; rare in carbonatites.

Association: Talc, antigorite, "chlorite", dolomite, calcite.

Distribution: An ore of magnesium and used to prepare refractories, with world reserves estimated at about 10 billion t. Some well-studied localites include: from Magnesia, Greece. At Baldissero Canavese, Piedmont, Italy. Large crystals from Sunk, near Trieben, Styria, and Radenthein, Carinthia, Austria. At Snarum, Norway. Fine large crystals from several mines around Brumado, Bahia, Brazil. In Canada, at the Mt. Brussilof mine, near Radium, British Columbia, and in the Del Oro deposits, Timmins, Ontario. In the USA, in a large deposit near Gabbs, Gabbs district, Nye Co., Nevada; from a number of commercial deposits in California, as in the Red Mountain district, Stanislaus and Santa Clara Co.; from southwest of Chewelah, Stevens Co., Washington. Immense deposits in the Liaoning district, Liaoning Province, China. Numerous other occurrences are known.

Name: For *magnesium* in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 162–166. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 136–149. (3) Markgraf, S.A. and R.J. Reeder (1985) High-temperature structure refinements of calcite and magnesite. Amer. Mineral., 70, 590–600. (4) (1957) NBS Circ. 539, 7, 28.

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Magnesium astrophyllite

$(Na,K)_4Mg_2(Fe^{2+},Fe^{3+},Mn)_5Ti_2Si_8O_{24}(O,OH,F)_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Habit not described.

Physical Properties: *Cleavage:* Very perfect on {100}, perfect on {010}. Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.33]

Optical Properties: Semitransparent. *Color:* Straw-yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = bright yellow; Y = pale yellowish gray; Z = gray. *Orientation:* $Y = b$; $Z \wedge c = -5°$ to $-6°$. *Absorption:* $Z > Y > X$. $\alpha = 1.658$ $\beta = [1.687]$ $\gamma = 1.710$ 2V(meas.) = 81.5°–83°

Cell Data: *Space Group:* $A2/m$. $a = 10.56$ $b = 23.00$ $c = 5.35$ $\beta = 102°$ Z = [2]

X-ray Powder Pattern: Khibiny massif, Russia.
3.38 (10), 2.548 (9), 10.1 (8), 1.463 (7), 3.80 (6), 3.079 (5), 2.763 (5)

Chemistry:

	(1)
SiO_2	37.98
TiO_2	12.18
Al_2O_3	1.11
Fe_2O_3	2.95
FeO	17.91
MnO	4.00
MgO	6.39
CaO	1.15
Na_2O	5.38
K_2O	7.28
F	0.45
H_2O^+	3.44
P_2O_5	0.06
$-O = F_2$	0.19
Total	[100.09]

(1) Khibiny massif, Russia; original total given as 100.10%, corresponds to $(Na_{2.15}K_{1.96})_{\Sigma=4.11}Mg_{1.98}(Fe^{2+}_{3.08}Mn_{0.70}Fe^{3+}_{0.46}Ca_{0.25})_{\Sigma=4.49}Ti_{1.88}(Si_{7.81}Al_{0.27})_{\Sigma=8.08}O_{24}[(OH)_{4.72}O_{1.98}F_{0.30}]_{\Sigma=7.00}$.

Mineral Group: Astrophyllite group.

Occurrence: In a differentiated alkalic massif.

Association: n.d.

Distribution: From Mts. Kukisvumchorr and Yukspor, Khibiny massif, Kola Peninsula, Russia.

Name: For *magnesium* in the formula and relation to *astrophyllite*,

Type Material: Museum of Beijing University, Beijing, China.

References: (1) Peng Chi-Chung and Ma Cher-Sheng (1963) The discovery of a new type of Si–O chain radical-X-ray analysis of astrophyllite. Scientia Sinica, 12, 272–276 (in Russian). (2) X-ray Laboratory, Hubei (Hupei) Geologic College (1974) The crystal chemistry of astrophyllite group minerals. Scientia Geologia Sinica, 1, 18–33 (in Chinese). (3) (1975) Amer. Mineral., 60, 737 (abs. refs. 1 and 2). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 133–134.

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Magnesium-chlorophoenicite $(Mg,Mn)_3Zn_2(AsO_4)(OH,O)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, stout to acicular, usually in radial aggregates and rosettes, to 12 mm.

Physical Properties: *Cleavage:* One perfect, parallel to elongation. *Tenacity:* [Brittle] (by analogy to chlorophoenicite). Hardness = [Soft.] D(meas.) = 3.45 D(calc.) = [3.36]

Optical Properties: Translucent. *Color:* Colorless to white; colorless in thin section. *Luster:* [Vitreous.]
Optical Class: Biaxial (+). *Orientation:* Y = elongation. *Dispersion:* $r < v$, strong.
$\alpha = 1.669$ $\beta = 1.672$ $\gamma = 1.677$ 2V(meas.) = Small.

Cell Data: *Space Group:* $C2/m$. $a = 22.99(1)$ $b = 3.236(2)$ $c = 7.299(3)$ $\beta = 106.5(1)°$
Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA; nearly identical to chlorophoenicite.
2.607 (100), 3.706 (50), 3.092 (40), 2.977 (25), 6.98 (20), 6.87 (20), 1.7560 (20)

Chemistry:

	(1)
P_2O_5	0.1
As_2O_5	20.7
FeO	0.0
MnO	15.9
ZnO	37.5
MgO	10.6
CaO	0.0
H_2O	[15.2]
Total	[100.0]

(1) Franklin, New Jersey, USA; by electron microprobe, H_2O by difference; corresponding to $(Mg_{1.39}Mn_{1.18}Zn_{0.43})_{\Sigma=3.00}Zn_{2.00}(OH)_6[As_{0.42}H_{0.5}(OH,O)_3]_2$.

Occurrence: A very rare mineral, in open veinlets cutting a metamorphosed stratiform zinc orebody.

Association: Willemite, zincite, andradite, franklinite, hodgkinsonite, barite, calcite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: For its *magnesium* content and similarity to *chlorophoenicite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 92803.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 780. (2) Dunn, P.J. (1981) Magnesium-chlorophoenicite redefined and new data on chlorophoenicite. Can. Mineral., 19, 333–336. (3) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 671–672. (4) Bayliss, P. and S. St. J. Warne (1987) Powder X-ray diffraction data of magnesium-chlorophoenicite. Powder Diffraction, 2(4), 225–226.

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Magnesium-zippeite $Mg_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m$. As fine-grained efflorescences.

Physical Properties: Hardness = ∼2 D(meas.) = > 3.3 D(calc.) = n.d. Radioactive; fluoresces bright yellow under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Yellow-orange to orange-tan. *Optical Class:* Biaxial. *Pleochroism:* X = pale yellow; Y = yellow; Z = dark yellow. $\alpha = 1.72$ $\beta = 1.75$ $\gamma = 1.82$ 2V(meas.) = Moderate to large.

Cell Data: *Space Group:* $C2/c$ (by analogy to zippeite). $a = 8.649(1)$ $b = 14.241(2)$ $c = 17.696(2)$ $\beta = 104.11(5)°$ Z = 8

X-ray Powder Pattern: Lucky Strike No. 2 mine, Utah, USA. 3.58 (10), 7.2 (8), 3.48 (8), 3.11 (6), 2.74 (3), 2.88 (2), 2.52 (2)

Chemistry:

	(1)	(2)
SO_3	5.0	9.94
UO_3	74.6	71.06
CoO	1.4	
MgO	6.2	3.34
H_2O	10.9	15.66
Total	98.1	100.00

(1) Lucky Strike No. 2 mine, Utah, USA; by microchemical analysis; identification primarily established by correspondence of its X-ray powder pattern with that of synthetic material. (2) $Mg_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$.

Occurrence: A rare post-mine mineral on the walls of mine tunnels.

Association: Sodium-zippeite, gypsum, bieberite, cobaltocalcite, rabbittite (Lucky Strike No. 2 mine, Utah, USA); uranopilite, zippeite, sodium-zippeite, nickel-zippeite, johannite, cuprosklodowskite, sklodowskite, metaschoepite (Jáchymov, Czech Republic).

Distribution: From the Lucky Strike No. 2 mine, Emery Co., Utah, USA. In the Evangelista vein, Jáchymov (Joachimsthal), Czech Republic.

Name: For its content of *magnesium* and relation to *zippeite*.

Type Material: n.d.

References: (1) Frondel, C., J. Ito, R.M. Honea, and A.M. Weeks (1976) Mineralogy of the zippeite group. Can. Mineral., 14, 429–436. (2) Haacke, D.F. and P.A. Williams (1979) The aqueous chemistry of uranium minerals. Part I. Divalent cation zippeïte. Mineral. Mag., 43, 539–541. (3) Ondruš, P., F. Veselovský, J. Hloušek, R. Skála, I. Vavřín, J. Frýda, J. Čejka, and A. Gabašová (1997) Secondary minerals of the Jáchymov (Joachimsthal) ore district. J. Czech Geol. Soc., 42(4), 3–76, esp. 31–32.

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Typically octahedral, less commonly dodecahedral, striated || $[0\bar{1}1]$ on {011}, to 25 cm, very rarely cubic; skeletal, granular, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law, as contact twins, flattened, lamellar.

Physical Properties: *Cleavage:* Parting on {111}, very good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5–6.5 VHN = 681–792 (100 g load). D(meas.) = 5.175 D(calc.) = 5.20 Strongly magnetic.

Optical Properties: Opaque, translucent through very thin edges. *Color:* Black; gray with brownish tint in reflected light. *Streak:* Black. *Luster:* Metallic to submetallic, may be dull. *Optical Class:* Isotropic. $n = 2.42$
R: (400) 22.3, (420) 21.8, (440) 21.3, (460) 20.8, (480) 20.5, (500) 20.3, (520) 20.3, (540) 20.4, (560) 20.5, (580) 20.6, (600) 20.6, (620) 20.7, (640) 20.8, (660) 20.9, (680) 21.0, (700) 21.2

Cell Data: *Space Group: Fd3m* (synthetic). $a = 8.3970(1)$ $Z = 8$

X-ray Powder Pattern: Synthetic.
2.532 (100), 1.485 (40), 2.967 (30), 1.616 (30), 2.099 (20), 1.093 (12), 1.715 (10)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.27	0.11		FeO	30.78	31.21	31.03
TiO_2	trace	0.29		MnO		0.09	
Al_2O_3	0.21	0.44		MgO	trace	0.02	
Fe_2O_3	68.85	67.16	68.97	CaO	trace		
Cr_2O_3		0.08		Total	100.11	99.40	100.00

(1) Lovers Pit, Mineville, Essex Co., New York, USA. (2) Meier's Find, Western Australia; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry. (3) $Fe^{2+}Fe_2^{3+}O_4$.

Polymorphism & Series: Forms two series, with jacobsite, and with magnesioferrite.

Mineral Group: Spinel group.

Occurrence: A common accessory mineral in igneous and metamorphic rocks, in which magmatic segregation or contact metamorphism may produce economic deposits. Extensive deposits in sedimentary banded iron formations; a biogenic product; important detrital deposits.

Association: Chromite, ilmenite, ulvöspinel, rutile, apatite, silicates (igneous); pyrrhotite, pyrite, chalcopyrite, pentlandite, sphalerite, hematite, silicates (hydrothermal, metamorphic); hematite, quartz (sedimentary).

Distribution: Many localities, even for fine crystals. In Sweden, at Falun, Kiruna, Västanfors, and elsewhere. At Arendal, Norway. From Zlatoust and Magnetigorsk, Ural Mountains, Russia. In the Zillertal, Tirol, Austria. From Traversella, Piedmont, Italy. In Switzerland, at Binntal and Rimpfischwäng, Valais, and elsewhere. In the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland. From Bancroft, Ontario, Canada. In the USA, around Lake Sanford, Essex Co., and in the Tilly Foster mine, Brewster, Putnam Co., New York; at Magnet Cove, Hot Springs Co., Arkansas; in the Iron Springs district, Iron Co., Utah. From the Cerro del Mercado, Durango, Mexico. At Itabira, Minas Gerais, Brazil.

Name: An ancient term, possibly an allusion to the locality, *Magnesia*, Greece.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 698–707. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 56–88. (3) Gole, M.J. and C. Klein (1981) High-grade metamorphic Archean banded iron-formations, Western Australia: assemblages with coexisting pyroxenes ± fayalite. Amer. Mineral., 66, 87–99. (4) O'Neill, H.St.C. and W.A. Dollase (1994) Crystal structures and cation distributions in simple spinels from powder XRD structural refinements: $MgCr_2O_4$, $ZnCr_2O_4$, Fe_3O_4 and the temperature dependence of the cation distribution in $ZnAl_2O_4$. Phys. Chem. Minerals, 20, 541–555. (5) (1967) NBS Mono. 25, 5, 31.

Magnetoplumbite $Pb(Fe^{3+},Mn^{3+})_{12}O_{19}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals are steep dipyramids, to 6 mm; granular, massive.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = 6 VHN = 755–777 (Mn-rich, 100 g load); 841–868 (Fe-rich, 100 g load). D(meas.) = 5.517 D(calc.) = 5.57 (synthetic $PbFe^{3+}_{12}O_{19}$). Strongly magnetic.

Optical Properties: Opaque. *Color:* Gray-black; gray in reflected light. *Streak:* Dark brown. *Luster:* Metallic, brilliant.
Optical Class: Uniaxial. *Pleochroism:* Weak. *Anisotropism:* Distinct.
R_1–R_2: (400) 25.6–28.5, (420) 25.1–27.6, (440) 24.6–26.7, (460) 24.2–26.0, (480) 23.8–25.6, (500) 23.6–25.3, (520) 23.3–25.0, (540) 23.0–24.6, (560) 22.7–24.2, (580) 22.3–23.8, (600) 22.0–23.5, (620) 21.7–23.2, (640) 21.3–22.8, (660) 21.1–22.6, (680) 20.9–22.3, (700) 20.7–22.2

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.9015$-5.926 $c = 23.023$–23.230 $Z = 2$

X-ray Powder Pattern: Långban, Sweden.
2.766 (10), 2.953 (8), 2.427 (8), 2.235 (7), 1.476 (7), 4.99 (6), 1.667 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Sb_2O_5		0.01	1.87	ZnO		0.86	0.72
TiO_2	4.14	4.14	10.24	PbO	20.02	19.16	18.80
Al_2O_3	1.86	1.05	1.67	MgO	0.15	0.11	0.56
Fe_2O_3	52.22	52.89	50.44	CaO	0.28		
Mn_2O_3	17.27	18.91	5.90	BaO		0.09	0.37
Cr_2O_3	0.25	0.16	0.11	H_2O	0.08		
MnO	3.73	2.83	9.20	Total	100.00	100.21	99.88

(1) Långban, Sweden; corresponds to $Pb_{1.05}(Fe^{3+}_{7.66}Mn^{3+}_{2.56}Mn^{2+}_{0.62}Ti_{0.60}Al_{0.42}Ca_{0.06}Mg_{0.04}Cr_{0.04})_{\Sigma=12.00}O_{19}$. (2) Do.; by electron microprobe, Mn^{2+}:Mn^{3+} from charge balance; corresponds to $Pb_{1.00}(Fe^{3+}_{7.72}Mn^{3+}_{2.79}Ti_{0.60}Mn^{2+}_{0.47}Al_{0.24}Zn_{0.12}Mg_{0.03}Cr_{0.02}Ba_{0.01})_{\Sigma=12.00}O_{19}$. (3) Do.; by electron microprobe, Mn^{2+}:Mn^{3+} from charge balance; corresponds to $(Pb_{0.98}Ba_{0.02})_{\Sigma=1.00}(Fe^{3+}_{7.34}Mn^{2+}_{1.51}Ti_{1.49}Mn^{3+}_{0.87}Al_{0.38}Mg_{0.16}Sb_{0.13}Zn_{0.10}Cr_{0.02})_{\Sigma=12.00}O_{19}$.

Mineral Group: Magnetoplumbite group.

Occurrence: In skarns associated with metamorphosed Fe–Mn orebodies (Sweden).

Association: Melanotekite-kentrolite, hematite, jacobsite, hedyphane, braunite, pyrophanite, manganoan phlogopite, calcite, andradite, celsian (Sweden).

Distribution: In Sweden, from Långban; in the Harstigen mine, near Persberg; and at Jakobsberg, Värmland.

Name: For being a MAGNETic oxide of iron, manganese, and lead, *plumbum*.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 24639.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 728. (2) Burke, E.A.J. (1980) New data on magnetoplumbite from Långban, Sweden. Neues Jahrb. Mineral., Monatsh., 141–148. (3) Moore, P.B., P.K. Sen Gupta, and Y. Le Page (1989) Magnetoplumbite, $Pb^{2+}Fe^{3+}_{12}O_{19}$: refinement and lone-pair splitting. Amer. Mineral., 74, 1186–1194. (4) Holtstam, D. (1994) Mineral chemistry and parageneses of magnetoplumbite from the Filipstad district, Sweden. Eur. J. Mineral., 6, 711–724.
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Magniotriplite $(Mg, Fe^{2+}, Mn^{2+})_2(PO_4)(F, OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals and nodular masses, to 8 cm.

Physical Properties: *Cleavage:* One direction observed under the microscope.
Fracture: Uneven. Hardness = 4 D(meas.) = 3.57 D(calc.) = 3.68

Optical Properties: Translucent. *Color:* Reddish brown, yellow. *Streak:* Pale brown.
Luster: Vitreous to resinous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = light yellow to colorless; Y = light yellow; Z = wine-yellow. *Orientation:* $Z = b$; $X \wedge a = 18°$. *Dispersion:* $r > v; r < v$. $\alpha = 1.641$–1.648 $\beta = 1.649$–1.653 $\gamma = 1.661$–1.664 2V(meas.) = 60°

Cell Data: *Space Group:* $I2/a$. $a = 12.035(5)$ $b = 6.432(4)$ $c = 9.799(2)$ $\beta = 108.12(2)°$ Z = 8

X-ray Powder Pattern: Valmy, France; close to wagnerite.
2.864 (100), 3.015 (80), 3.162 (70), 2.794 (60), 3.587 (50), 3.324 (50), 2.576 (30)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	36.52	36.03	CaO	0.00	0.05
SiO_2	2.40		Na_2O	0.00	
TiO_2	0.92	0.30	K_2O	0.00	
Al_2O_3	0.70		F	6.00	6.50
FeO	25.90	31.68	H_2O^+	0.64	1.40
MnO	13.00	8.25	H_2O^-	0.10	
MgO	17.12	18.00	$-O = F_2$	2.52	2.74
			Total	100.78	99.47

(1) Karasu pegmatite, Kyrgyzstan; SiO_2 quartz impurity, corresponds to $(Mg_{0.88}Fe_{0.74}Mn_{0.38})_{\Sigma=2.00}(PO_4)_{1.06}[F_{0.66}(OH)_{0.14}]_{\Sigma=0.80}$. (2) Valmy, France; corresponding to $(Mg_{0.89}Fe_{0.87}Mn_{0.23}Ti_{0.01})_{\Sigma=2.00}(PO_4)[F_{0.68}(OH)_{0.31}]_{\Sigma=0.99}$.

Occurrence: In zoned complex granite pegmatites.

Association: Arrojadite, triphylite, muscovite, albite, quartz (Karasu pegmatite, Kyrgyzstan); vivianite, graftonite (Valmy, France).

Distribution: From the Karasu and Kyrk-Bulak pegmatites, Turkestan Range, Kyrgyzstan. At Hålsjöberget, Värmland, Sweden. From Valmy, Albères massif, Pyrénées-Orientales, France. In the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: As the *magnesium* dominant analog of *triplite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 50653–50658.

References: (1) Ginsburg, A.I., N.A. Kruglova, and V.A. Moleva (1951) Magniotriplite – a new mineral of the triplite group. Doklady Acad. Nauk SSSR, 77, 97–100 (in Russian). (2) (1952) Amer. Mineral., 37, 359–360 (abs. ref. 1). (3) Fontan, F. (1981) La magniotriplite ferrifère du massif des Albères (Pyrénées-Orientales, France). Une nouvelle variété. Bull. Minéral., 104, 672–676 (in French with English abs.). (4) Tadini, C. (1981) Magniotriplite: its crystal structure and relation to the triplite-triploidite group. Bull. Minéral., 104, 677–680. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 134.

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Magnocolumbite $(Mg, Fe^{2+}, Mn^{2+})(Nb, Ta)_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rough crystals, tabular to acicular, to 1.5 cm, with nine forms noted. *Twinning:* Common, with a 25° angle between extinction directions.

Physical Properties: *Cleavage:* {100} and {001}. *Fracture:* Uneven. Hardness = 6
D(meas.) = 5.17–5.25 D(calc.) = 5.23

Optical Properties: Opaque, translucent on thin edges. *Color:* Black to brownish black; brown, brownish red to reddish brown in transmitted light. *Streak:* Dark brown. *Luster:* Semimetallic.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = brownish yellow; Z = brownish red. *Orientation:* $X = b$; $Y = a$; $Z = c$. α = 2.33–2.36 β = n.d. γ = 2.39–2.44
2V(meas.) = ∼80°

Cell Data: *Space Group:* [*Pbcn*] (by analogy to ferrocolumbite). $a = 14.17$ $b = 5.65$ $c = 5.02$ Z = 4

X-ray Powder Pattern: Kukhi-Lal deposit, Tajikistan.
2.955 (10), 1.723 (9), 1.535 (9), 1.470 (9), 1.454 (9), 1.197 (9), 1.105 (9)

Chemistry:

	(1)	(2)
WO_3	0.86	
Nb_2O_5	70.59	68.27
Ta_2O_5	10.45	16.20
SiO_2	0.46	
TiO_2	4.61	1.40
Al_2O_3	1.12	
Fe_2O_3	0.30	
FeO	2.21	4.55
MnO	0.17	0.18
MgO	9.00	9.40
Total	99.77	100.00

(1) Kukhi-Lal deposit, Tajikistan; corresponds to $(Mg_{0.71}Fe^{2+}_{0.10}Mn^{2+}_{0.10}Al_{0.07}Fe^{3+}_{0.01})_{\Sigma=0.99}(Nb_{1.69}Ti_{0.18}Ta_{0.15}W_{0.01})_{\Sigma=2.03}O_6$. (2) "Eastern Siberia, Russia"; corresponds to $(Mg_{0.80}Fe^{2+}_{0.21})_{\Sigma=1.01}(Nb_{1.70}Ta_{0.24}Ti_{0.06})_{\Sigma=2.00}O_6$.

Occurrence: In a pegmatite in partially assimilated dolomitic marbles (Kukhi-Lal deposit, Tajikistan).

Association: Ilmenorutile, cordierite, dravite, spinel, andalusite, kyanite (Kukhi-Lal deposit, Tajikistan).

Distribution: In the Kukhi-Lal deposit, Pyandzh River valley, southwestern Pamir Mountains, Tajikistan. From an undisclosed locality in "eastern Siberia", Russia.

Name: For dominant MAGNesium in the composition, and its relation to *ferrocolumbite*.

Type Material: n.d.

References: (1) Mathias, V.V., L.N. Rossovskii, A.N. Shostatskii, and N.M. Kumskova (1963) Magnocolumbite, a new mineral. Doklady Acad. Nauk SSSR, 148, 420–423 (in Russian). (2) (1963) Amer. Mineral., 48, 1182–1183 (abs. ref. 1). (3) Nedashkovskii, P.G., N.A. Minaeva, K.P. Tolok, and I.F. Brovchuk (1967) A new occurrence of magnocolumbite. Zap. Vses. Mineral. Obshch., 96, 720–723 (in Russian). (4) Kornetova, V.A., M.E. Kazakova, and V.B. Aleksandrov (1971) Ilmenorutile from the pegmatites of Kukhi-Lal precious spinel deposits in the southwestern Pamirs and modifications in the formula of magnocolumbite. Trudy Mineral. Muzeya Akad. Nauk SSSR, 20, 107–113 (in Russian). (5) (1972) Chem. Abs., 76, 175 (abs. ref. 4).

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Magnolite $Hg_2^{1+}Te^{4+}O_3$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals bladed, showing {100} and {010}, striated on {001} ∥ [001], in parallel to subparallel groups, or acicular, elongated along [001], to 1 mm, in tufted aggregates.

Physical Properties: *Cleavage:* {001}, perfect; ⊥ {001}, good. *Tenacity:* Brittle. Hardness = "Soft". D(meas.) = n.d. D(calc.) = 8.12

Optical Properties: Transparent to opaque. *Color:* Colorless, creamy white, pale yellow-green; internally dark brown. *Streak:* Pale brown. *Luster:* Adamantine, silky in aggregates. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. $n = > 2$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = ≥45°

Cell Data: *Space Group:* $Pbm2$. $a = 5.958(1)$ $b = 10.576(2)$ $c = 3.749(1)$ $Z = 2$

X-ray Powder Pattern: Colorado, USA.
3.043 (100), 3.95 (70), 5.25 (50), 2.587 (50), 1.757 (50), 3.74 (40), 1.986 (40)

Chemistry:

	(1)	(2)
TeO_2	28.9	27.67
Hg_2O	72.3	72.33
Total	101.2	100.00

(1) Keystone mine, Colorado, USA; by electron microprobe, average of five analyses, valences from crystal-structure analysis; corresponds to $Hg_{1.94}Te_{1.01}O_3$. (2) Hg_2TeO_3.

Occurrence: A late alteration product of coloradoite, formed at low temperature and oxygen fugacity, in the oxidized zone of complex polymetallic hydrothermal mineral deposits.

Association: Mercury, coloradoite, tellurite, gold, tellurium, keystoneite, "limonite", manganese oxides, quartz.

Distribution: From the Keystone and Mountain Lion mines, Magnolia district, Boulder Co., Colorado, USA.

Name: For the Magnolia district, Colorado, USA, in which the species was first noted.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 65534; Harvard University, Cambridge, Massachusetts, 112683; National Museum of Natural History, Washington, D.C., USA, 165455.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 980. (2) Roberts, A.C., M. Bonardi, J.D. Grice, T.S. Ercit, and W.W. Pinch (1989) A restudy of magnolite, $Hg_2^{1+}Te^{4+}O_3$, from Colorado. Can. Mineral., 27, 129–131. (3) Grice, J.D. (1989) The crystal structure of magnolite, $Hg_2^{1+}Te^{4+}O_3$. Can. Mineral., 27, 133–136. (4) (1990) Amer. Mineral., 75, 437 (abs. refs. 2 and 3).

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Magnussonite $Mn_5^{2+}As_3^{3+}O_9(OH,Cl)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As fine-grained incrustations and fracture fillings; in granular aggregates, massive.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3.5–4 D(meas.) = 4.14–4.49 D(calc.) = 4.55–4.62

Optical Properties: Transparent to translucent. *Color:* Grass-green, emerald-green, blue-green, pale olive-green, brownish orange. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Isotropic; may be anomalously uniaxial (–). *Absorption:* $E > O$. $n = 1.980(5)$, birefringence 0.001.

Cell Data: *Space Group: Ia*3*d*. $a = 19.680(4)$ Z = 32

X-ray Powder Pattern: Långban, Sweden.
2.85 (10), 3.12 (3), 1.74 (2), 8.01 (1), 4.02 (1), 1.48 (1), 5.26 (< 1)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
As_2O_3	45.26	45.2	44.1	MgO	1.53	0.2	0.2
FeO		1.2	0.5	CaO		0.7	0.3
MnO	49.17	49.6	48.7	Cl	0.87	0.7	1.7
CuO	2.15	2.3	3.3	H_2O	1.21	1.5	n.d.
ZnO		0.0	2.4	$-O = Cl_2$	0.19	0.2	0.4
				Total	[100.00]	101.2	100.8

(1) Långban, Sweden; recalculated to 100% after deduction of insoluble 3.68% as barite. (2) Do.; by electron microprobe, total Mn as MnO, total Cu as CuO, H_2O by TGA; corresponds to $(Mn_{4.59}Cu_{0.19}Fe_{0.11}Ca_{0.08}Mg_{0.04})_{\Sigma=5.01}As_3O_{8.90}[(OH)_{1.10}Cl_{0.13}]_{\Sigma=1.23}$. (3) Sterling Hill, New Jersey, USA; by electron microprobe, total Mn as MnO, total Cu as CuO; with H_2O assumed for OH+Cl = 1, corresponds to $(Mn_{4.56}Cu_{0.29}Zn_{0.23}Fe_{0.04}Ca_{0.03}Mg_{0.03})_{\Sigma=5.18}$ $As_3O_{9.18}[(OH)_{0.66}Cl_{0.34}]_{\Sigma=1.00}$.

Occurrence: In a metamorphosed Fe–Mn orebody (Långban, Sweden); very rare in a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA).

Association: Dolomite, hausmannite, hematite, calcite, trigonite, dixenite, manganiferous serpentine (Långban, Sweden); katoptrite, sonolite, hausmannite, manganosite, magnetite (Brattfors mine, Sweden); zincite, willemite, franklinite, kraisslite (Sterling Hill, New Jersey, USA).

Distribution: From Långban, Värmland, and in the Brattfors mine, Nordmark, Värmland, Sweden. In the USA, from Sterling Hill, Ogdensburg, Sussex Co., New Jersey.

Name: For Nils Harald Magnusson (1890–1976), formerly Director, Geological Survey of Sweden, for his contributions to knowledge of the Långban mine.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; The Natural History Museum, London, England, 1963,233; Harvard University, Cambridge, Massachusetts, USA, 106140, 106337.

References: (1) Gabrielson, O. (1957) Magnussonite, a new arsenite mineral from the Långban mine in Sweden. Arkiv Mineral. Geol., 2(4), 133–135. (2) (1957) Amer. Mineral., 42, 581 (abs. ref. 1). (3) Moore, P.B. (1970) Stenhuggarite, a new mineral from Långban and new data on magnussonite. Arkiv Mineral. Geol., 5, 55–62. (4) Moore, P.B. and T. Araki (1979) Magnussonite, manganese arsenite, a fluorite derivative structure. Amer. Mineral., 64, 390–401. (5) Dunn, P.J. and R.A. Ramik (1984) Magnussonite: new chemical data, an occurrence at Sterling Hill, New Jersey, and new data on a related phase from the Brattfors mine, Sweden. Amer. Mineral., 69, 800–802. (6) Hålenius, U. and B. Lindqvist (1996) Chromophoric divalent iron in optically anisotropic magnussonite. Eur. J. Mineral., 8, 25–34.

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Mahlmoodite $Fe^{2+}Zr(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In spheroidal aggregates of radiating fibrous to lathlike crystals, to 0.15 mm.

Physical Properties: Hardness = ∼3 D(meas.) = n.d. D(calc.) = 2.877

Optical Properties: Translucent. *Color:* Cream-white.
Optical Class: Biaxial (–), sensibly uniaxial (–). *Orientation:* Positive elongation; parallel extinction. $\alpha = < 1.646$ $\beta = 1.652(2)$ $\gamma = 1.652(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 9.112(6)$ $b = 5.412(7)$ $c = 19.19(1)$ $\beta = 94.81(6)^\circ$ Z = 4

X-ray Powder Pattern: Wilson Springs mine, Arkansas, USA.
3.160 (100), 4.382 (80), 9.58 (75), 2.640 (70), 4.572 (65), 4.092 (60), 3.978 (40)

Chemistry:

	(1)	(2)
P_2O_5	36.2	34.70
SiO_2	0.3	
TiO_2	0.7	
ZrO_2	28.7	30.12
Al_2O_3	0.3	
FeO	16.1	17.56
MnO	0.8	
MgO	0.26	
CaO	1.3	
Na_2O	0.11	
F	0.5	
H_2O	[14.7]	17.62
Total	[100.0]	100.00

(1) Wilson Springs mine, Arkansas, USA; by electron microprobe, average of 25 analyses, total Fe as FeO, total Mn as MnO, H_2O by difference, probably reduced by loss under vacuum; excluding SiO_2 and F, corresponds to $(Fe_{0.88}Ca_{0.09}Mn_{0.04}Mg_{0.03}Na_{0.03})_{\Sigma=1.07}(Zr_{0.91}Ti_{0.03}Al_{0.02})_{\Sigma=0.96}(PO_4)_{2.01} \cdot 4H_2O$. (2) $FeZr(PO_4)_2 \cdot 4H_2O$.

Occurrence: A rare secondary mineral in vugs in alkaline igneous rock (Wilson Springs mine, Arkansas, USA); in a mineralized fissure vein (Kerriack Cove, Cornwall, England).

Association: Kolbeckite, sodic pyroxene (Wilson Springs mine, Arkansas, USA); sphalerite, pyrite, anatase (Kerriack Cove, Cornwall, England).

Distribution: In the USA, in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas. At Kerriack Cove, near Redruth, Cornwall, England.

Name: Honors Bertha K. Mahlmood, Analytical Assistant, U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 170394.

References: (1) Milton, C., J.J. McGee, and H.T. Evans, Jr. (1993) Mahlmoodite, $FeZr(PO_4)_2 \cdot 4H_2O$, a new iron zirconium phosphate mineral from Wilson Springs, Arkansas. Amer. Mineral., 78, 437–440. (2) Elton, N.J. and J.J. Hooper (1995) A second occurrence of mahlmoodite, from Cornwall, England. Mineral. Mag., 59, 166–168.

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Mahnertite $(Na,Ca)Cu_3(AsO_4)_2Cl•5H_2O$

Crystal Data: Tetragonal. *Point Group:* 4/*m* 2/*m* 2/*m*. Crystals, square in outline, to 0.1 mm, flattened on [001], showing {001}, {100}; in subparallel groups giving spherical aggregates.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Irregular. *Tenacity:* Fragile [*sic*]. Hardness = 2-3 D(meas.) = 3.33(2) D(calc.) = 3.14

Optical Properties: Translucent. *Color:* Bright blue to emerald-green. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Uniaxial (–). ω = 1.686(2) ε = 1.635(2) *Pleochroism:* Strong; *O* = blue to intense blue-green; *E* = blue to green.

Cell Data: *Space Group: I*4/*mmm.* *a* = 10.037(1) *c* = 23.739(1) Z = 8

X-ray Powder Pattern: Cap Garonne mine, France.
11.90 (100), 3.098 (80), 3.061 (70), 9.29 (60), 5.043 (60), 7.131 (50), 4.641 (40)

Chemistry:

	(1)
As_2O_5	39.07
CuO	36.37
CaO	2.14
Na_2O	4.58
K_2O	0.40
Cl	4.67
H_2O	14.5
$-O = Cl_2$	1.05
Total	100.68

(1) Cap Garonne mine, France; by electron microprobe; H_2O by loss on heating; corresponds to $(Na_{0.90}Ca_{0.23}K_{0.05})_{\Sigma=1.18}Cu_{2.79}(AsO_4)_{2.07}Cl_{0.81}•4.91H_2O$.

Occurrence: In the oxidized zone of an arsenic-rich copper deposit (Cap Garonne mine, France).

Association: Tennantite, covellite, geminite, pushcharovskite, quartz (Cap Garonne mine, France).

Distribution: From the Cap Garonne mine, near le Pradet, Var, and at the Salsigne mine, 15 km north of Carcassone, Aude, France. In the Falotta mine, Oberhalbstein, Graubünden, Switzerland.

Name: To honor Dr. Volker Mahnert (b. 1943), Director, Natural History Museum, Geneva, Switzerland.

Type Material: Natural History Museum, Geneva, Switzerland.

References: (1) Sarp, H. (1996) La mahnertite, $(Na,Ca)Cu_3(AsO_4)_2Cl•5H_2O$, un nouveau minéral de la mine de Cap Garonne, Var, France. Archs Sci. Genéve, 49(2), 119-126 (in French with English abs.). (2) (1997) Amer. Mineral., 82, 1262 (abs. ref. 1). (3) Pushcharovsky, D.Y., N. Zubkova, S.J. Teat, E.J. Maclean, and H. Sarp (2004) Crystal structure of mahnertite, Eur. J. Mineral. 16, 687-692. (4) (2005) Amer. Mineral., 90, 772 (abs. ref. 3).

Majakite PdNiAs

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Crystal Data: Hexagonal. *Point Group:* n.d. As rounded or oval inclusions, to 100 μm, in polarite and as intergrowths with stannopalladinite and isomertieite.

Physical Properties: Hardness = ∼5 VHN = 520 (50 g load). D(meas.) = 9.33 (synthetic). D(calc.) = 10.5

Optical Properties: Opaque. *Color:* Grayish white in reflected light. *Anisotropism:* Weak. R_1–R_2: (400) — , (420) — , (440) 47.4, (460) 49.0, (480) 50.5, (500) 51.2, (520) 52.3, (540) 52.8, (560) 54.4, (580) 55.2, (600) 55.8, (620) 56.1, (640) 56.7, (660) 58.0, (680) 57.9, (700) 58.5

Cell Data: *Space Group:* n.d. $a = 6.066$ $c = 7.20$ Z = 6

X-ray Powder Pattern: Majak mine, Russia.
2.65 (10), 1.988 (10), 2.19 (7), 2.30 (5), 3.04 (4), 2.40 (4), 1.800 (4b)

Chemistry:

	(1)	(2)	(3)
Pd	41.2	45.01	44.33
Pt		0.18	
Fe		0.06	
Ni	27.2	23.33	24.46
As	31.0	30.85	31.21
Sb		0.58	
Te		0.14	
Total	99.4	100.15	100.00

(1) Majak mine, Russia; by electron microprobe, average of two analyses; corresponding to $Pd_{0.94}Ni_{1.12}As_{1.00}$. (2) Konttijärvi intrusion, Finland; by electron microprobe, corresponding to $Pd_{1.02}Ni_{0.95}(As_{0.99}Sb_{0.01})_{\Sigma=1.00}$. (3) PdNiAs.

Occurrence: As intergrowths with other platinum-group minerals in chalcopyrite and talnakhite ores (Majak mine, Russia); in sulfide mineralization in a strongly metamorphosed layered intrusive (Konttijärvi intrusion, Finland).

Association: Chalcopyrite, talnakhite, polarite, stanopalladinite, silver, ferroplatinum, sperrylite, other platinum-group minerals (Majak mine, Russia); isomertieite, mertieite (Konttijärvi intrusion, Finland).

Distribution: In Russia, from the Majak mine, Talnakh area, Noril'sk region, western Siberia [TL]; also found at the Chiney layered intrusion, western Aldan shield, Siberia; near Nizhni Tagil, Ural Mountains; and in the Vostok deposit, Lukkulaisvaara layered intrusion, Karelia. From the Konttijärvi intrusion, northern Finland. At the Lubin and Polkovice copper mines, near Legnica, Zechstein copper district, Lower Silesia, Poland.

Name: For the Majak (Mayak) mine, Russia.

Type Material: Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Genkin, A.D., T.L. Evstigneeva, N.V. Troneva, and L.N. Vyal'sov (1976) Majakite, PdNiAs, a new mineral from copper-nickel sulfide ores. Zap. Vses. Mineral. Obshch., 105, 698–703 (in Russian). (2) (1977) Amer. Mineral., 62, 1260 (abs. ref. 1). (3) Vuorelainen, Y., T..A. Häkli, E. Hänninen, H. Papunen, J. Reino, and R. Törnroos (1982) Isomertieite and other platimum-group minerals from the Konttijärvi layered mafic intrusion, northern Finland. Econ. Geol., 77, 1511–1518.

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Majorite $Mg_3(Fe, Al, Si)_2(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Grains, to 10 μm, acicular to equant, within narrow veinlets.

Physical Properties: Hardness = 7–7.5 D(meas.) = ∼4 D(calc.) = 4.00

Optical Properties: Semitransparent. *Color:* Purple, pale yellowish brown, colorless; purple in thin section.
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group: Ia3d.* a = 11.524–11.543 Z = 8

X-ray Powder Pattern: Coorara meteorite; * = overlap with goethite impurity. (ICDD 25-843).
2.575 (100*), 2.881 (70), 1.540 (60), 2.454 (45*), 1.597 (40), 2.262 (35*), 2.352 (30)

Chemistry:

	(1)	(2)
SiO_2	52.0	54.89
TiO_2	0.0	
Al_2O_3	2.6	4.61
Cr_2O_3	0.68	
FeO	16.9	8.64
NiO	0.04	
MgO	27.5	30.99
CaO	0.0	1.63
Na_2O	0.7	
K_2O	0.0	
Total	100.42	[100.76]

(1) Coorara meteorite; by electron microprobe, average of five analyses; original analysis Si 24.3%, Al 1.4%, Cr 0.45%, Fe 13.1%, Mg 16.6%, Ni 0.03%, Na 0.5%, here recalculated to oxides; corresponds to $(Mg_{2.98}Na_{0.10})_{\Sigma=3.08}(Fe^{2+}_{1.02}Si_{0.78}Al_{0.23}Cr_{0.03})_{\Sigma=2.06}Si_{3.00}O_{12}$. (2) Pampa del Infierno meteorite; by electron microprobe, original total given as 100.77%; corresponds to $(Mg_{2.88}Ca_{0.12})_{\Sigma=3.00}(Si_{0.78}Fe^{2+}_{0.50}Al_{0.38}Mg_{0.32})_{\Sigma=1.98}Si_{3.00}O_{12}$.

Mineral Group: Garnet group.

Occurrence: Formed from low-calcium, high-aluminum pyroxene, olivine, and shock-induced glass, by high-pressure impact metamorphism in bolides.

Association: Pyroxene, ringwoodite, olivine, kamacite, goethite, troilite.

Distribution: In the Coorara, Catherwood, Pampa del Infierno, Tenham, and Peace River chondritic meteorites.

Name: For Alan Major, who assisted A.E. Ringwood in the high-pressure synthesis of garnet from pyroxene.

Type Material: National Museum of Natural History, Washington, D.C., USA, 122379.

References: (1) Smith, J.V. and B. Mason (1970) Pyroxene-garnet transformation in Coorara meteorite. Science, 168, 832–833. (2) (1970) Amer. Mineral., 55, 1815 (abs. ref. 1). (3) Coleman, L.C. (1977) Ringwoodite and majorite in the Catherwood meteorite. Can. Mineral., 15, 97–101. (4) Mao, H.K., P.M. Bell, and N.Z. Boktor (1982) The mineral chemistry of majorite in L6 chondrites. Carnegie Inst. Washington Yearbook 1981, 279–281.

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Makatite $Na_2Si_4O_8(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic (synthetic). *Point Group:* $2/m$. Crystals, thin striated prisms, to 1 cm; typically as spherulites or fibrous radiating acicular aggregates.

Physical Properties: *Cleavage:* One, parallel to longitudinal axis, excellent. Hardness = Soft. D(meas.) = 1.97–2.07 D(calc.) = [2.05]

Optical Properties: Translucent. *Color:* White. *Optical Class:* Biaxial (+). *Orientation:* Parallel extinction; length slow. $\alpha = 1.472–1.475$ $\beta = 1.480$ $\gamma = 1.487–1.490$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 7.3881(5)$ $b = 18.094(3)$ $c = 9.5234(5)$ $\beta = 90.64(1)°$ Z = 4

X-ray Powder Pattern: Lake Magadi, Kenya.
5.09 (100), 2.998 (57), 9.04 (53), 2.883 (42), 3.419 (36), 3.125 (35), 8.42 (29)

Chemistry:

	(1)	(2)	(3)
SiO_2	61.04	60.75	61.25
TiO_2	0.14		
Al_2O_3	0.15		
Fe_2O_3	0.11		
MgO	0.04		
CaO	0.28		
Na_2O	14.76	14.00	15.79
K_2O	0.09		
H_2O^+	12.71		
H_2O^-	8.12		
H_2O		25.00	22.96
Total	97.44	99.75	100.00

(1) Lake Magadi, Kenya. (2) Lovozero massif, Russia. (3) $Na_2Si_4O_8(OH)_2 \cdot 4H_2O$.

Occurrence: In cores from drill holes in a lacustrine evaporite series (Lake Magadi, Kenya); leached from natrosilite in an alkalic pegmatite in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Trona, erionite, magadiite, anorthoclase, gaylussite, organic material (Lake Magadi, Kenya); natrolite (Lovozero massif, Russia); vuonnemite, sodalite, ussingite, aegirine, steenstrupine, eudialyte, lovozerite (Mont Saint-Hilaire, Canada); varennesite, eudialyte, zakharovite,shkatulkalite, magdaiite (near Saint-Amable, Canada).

Distribution: From Lake Magadi, Rift Valley, Kenya. On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia. In the Höwenegg quarry, Hegau, Baden-Württemberg, Germany. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada. At Poços de Caldos, Minas Gerais, Brazil. From the Aris quarry, about 25 km south of Windhoek, Namibia.

Name: From the Masai word *emakut*, meaning *soda*, in allusion to the high sodium content of the mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA, 122170, 122171.

References: (1) Sheppard, R.A., A.J. Gude, III, and R.L. Hay (1970) Makatite, a new hydrous sodium silicate mineral from Lake Magadi, Kenya. Amer. Mineral., 55, 358–366. (2) Khomyakov, A.P., V.I. Stepanov, A.V. Bykova, and I.S. Naumova (1980) Makatite ($Na_2Si_4O_9 \cdot 5H_2O$) – the first discovery in the USSR. Doklady Acad. Nauk SSSR, 255, 971–976 (in Russian). (3) Annehed, H., L. Fälth, and F.J. Lincoln (1982) Crystal structure of synthetic makatite $Na_2Si_4O_8(OH)_2 \cdot 4H_2O$. Zeits. Krist., 159, 203–210. (4) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 321. (5) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 103–104.

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Mäkinenite γ–NiSe

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Crystal Data: Hexagonal. *Point Group:* $3m$. Massive.

Physical Properties: Hardness = 2.5–3 VHN = n.d. D(meas.) = n.d. D(calc.) = 7.22

Optical Properties: Opaque. *Color:* In polished section, yellow-orange, pure yellow in oil. *Pleochroism:* Strong, yellow to greenish yellow. *Anisotropism:* Strong, in oil pale green to pale orange-yellow, in air glowing cinder-red to blue-green or green.
R_1–R_2: (400) 24.0–25.0, (420) 27.5–30.0, (440) 31.0–35.0, (460) 35.3–38.7, (480) 39.4–41.6, (500) 43.0–43.8, (520) 46.0–45.8, (540) 48.8–47.4, (560) 51.1–48.6, (580) 53.2–49.6, (600) 54.9–50.5, (620) 56.3–51.2, (640) 57.4–51.9, (660) 58.5–52.4, (680) 59.4–52.9, (700) 60.2–53.4

Cell Data: *Space Group:* n.d. $a = 10.01$ $c = 3.28$ $Z = 9$

X-ray Powder Pattern: Kuusamo, Finland.
2.88 (100), 2.63 (100), 2.35 (100), 1.95 (100), 4.99 (60), 1.81 (40), 1.71 (40)

Chemistry:

	(1)	(2)
Ni	41.1	42.65
Co	1.0	
Cu	trace	
Se	57.9	57.35
Total	100.0	100.00

(1) Kuusamo, Finland; by X-ray fluorescence analysis. (2) NiSe.

Occurrence: In sills of albite diabase in schist, associated with low-grade uranium mineralization (Kuusamo, Finland).

Association: Clausthalite, selenian melonite (Kuusamo, Finland).

Distribution: In Finland, from Kuusamo [TL] and Hitura.

Name: Honors Eero Mäkinen (1886–1953), Finnish geologist, and former President of the Outokumpu Company.

Type Material: National School of Mines, Paris, France.

References: (1) Vuorelainen, Y., A. Huhma, and A. Häkli (1964) Sederholmite, wilkmanite, kullerudite, mäkinenite, and trüstedtite, five new nickel selenide minerals. Compt. Rendus Soc. Géol. Finlande, 36, 113–125. (2) (1965) Amer. Mineral., 50, 519–520 (abs. ref. 1).

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Makovickyite $Ag_3Bi_{11}S_{18}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As grains, composed of two exsolved phases, copper-rich and copper-poor, in almost parallel intergrowths; in aggregates, to 2 mm.

Physical Properties: Hardness = n.d. VHN = 210–221 (50–100 g load). D(meas.) = n.d. D(calc.) = 6.66–6.70

Optical Properties: Opaque. *Color:* Gray; in reflected light, pale gray. *Luster:* Metallic. *Optical Class:* Biaxial. *Anisotropism:* Pronounced, in shades of gray.
R_1–R_2: 43.2 (546)

Cell Data: *Space Group:* $C2/m$. $a = 13.35$–13.83 $b = 4.04$–4.05 $c = 14.71$–14.96 $\beta = 97.5°-100.5°$ Z = 4

X-ray Powder Pattern: Băiţa, Romania; composite intergrowth.
2.850 (100), 3.63 (50), 3.485 (50), 2.272 (40), 2.968 (30), 2.117 (30), 2.010 (30)

Chemistry:

	(1)	(2)	(3)
Ag	5.37	4.17	5.50
Pb	3.50	8.20	12.93
Cu	4.37	6.47	0.53
Te	0.69	0.50	
Se	0.40	0.48	0.17
Sb	0.09	0.12	
Bi	68.81	63.33	62.70
S	17.75	17.42	17.97
Total	100.98	100.69	99.80

(1) Băiţa, Romania; by electron microprobe, average of three analyses; copper-poor phase corresponding to $(Cu_{2.16}Ag_{1.56})_{\Sigma=3.72}(Bi_{10.38}Pb_{0.54}Sb_{0.20})_{\Sigma=11.12}(S_{17.44}Te_{0.18}Se_{0.16})_{\Sigma=17.78}$. (2) Do.; by electron microprobe, average of three analyses; copper-rich phase corresponding to $(Cu_{3.24}Ag_{1.24})_{\Sigma=4.48}(Bi_{9.64}Pb_{1.26}Sb_{0.04})_{\Sigma=10.94}(S_{17.28}Se_{0.20}Te_{0.12})_{\Sigma=17.60}$. (3) Felbertal mine, Austria; by electron microprobe, average of three analyses; copper-deficient phase corresponding to $(Ag_{1.70}Cu_{0.28})_{\Sigma=1.98}(Bi_{9.96}Pb_{2.08})_{\Sigma=12.04}(S_{18.62}Se_{0.08})_{\Sigma=18.70}$.

Mineral Group: Benjaminite group.

Occurrence: Among other bismuth-bearing sulfosalts in a dolomite skarn (Băiţa, Romania); in a hydrothermal tungsten deposit in amphibolites and felsic gneisses, in discordant quartz veins (Felbertal mine, Austria).

Association: Chalcopyrite, hammarite, bismuthinite, krupkaite–lindströmite, tetradymite, wittichenite, paděrite, miharaite, bismuth, gold, scheelite, molybdenite, galena, sphalerite, chalcocite, diopside, chondrodite, grossular–andradite (Băiţa, Romania); galenobismutite, bismuth, hammarite, lindströmite, gold, chalcopyrite, pyrrhotite (Felbertal mine, Austria).

Distribution: In Romania, from Băiţa (Rézbánya) [TL] and at Ocna de Fier (Morávicza; Vaskő). In the Felbertal tungsten mine, Salzburg, Austria.

Name: To honor Professor Emil Makovicky (1941–), Slovak–Danish mineralogist, University of Copenhagen, Copenhagen, Denmark.

Type Material: Charles University, Prague; National Museum, Prague, Czech Republic.

References: (1) Žak, L., J. Frýda, W.G. Mumme, and W.H. Paar (1994) Makovickyite, $Ag_{1.5}Bi_{5.5}S_9$. from Băiţa Bihorului, Romania: the ^{4}P natural mineral member of the pavonite series. Neues Jahrb. Mineral., Abh., 168, 147–169. (2) (1995) Amer. Mineral., 80, 1329 (abs. ref. 1).

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Malachite $Cu_2(CO_3)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are acicular to prismatic, thick tabular, equant, with {100}, {010}, {001}, {110}, {$\overline{2}$01}, several other forms, rounded, in sprays and crude composite aggregates, to 9 cm; typically stalactitic, mammillary, botryoidal, as such, radially fibrous internally. *Twinning:* On {100}, {201}, very common as contact or penetration twins, also polysynthetic.

Physical Properties: *Cleavage:* Perfect on {$\overline{2}$01}; fair on {010}. *Fracture:* Subconchoidal to uneven. Hardness = 3.5–4 D(meas.) = 4.05(2) D(calc.) = 3.983

Optical Properties: Translucent to opaque. *Color:* Bright green, dark green, blackish green, commonly banded in masses; green to yellowish green in transmitted light. *Streak:* Pale green. *Luster:* Adamantine to vitreous; silky if fibrous; dull to earthy if massive.
Optical Class: Biaxial (–). *Pleochroism:* X = nearly colorless; Y = yellowish green; Z = deep green. *Orientation:* $Y = b$; $X \wedge c = 23.5°$. *Dispersion:* $r < v$, moderately strong. $\alpha = 1.655(3)$ $\beta = 1.875(3)$ $\gamma = 1.909(3)$ 2V(meas.) = 43(2)°

Cell Data: *Space Group:* $P2_1/a$. $a = 9.502$ $b = 11.974$ $c = 3.240$ $\beta = 98°45'$ Z = 4

X-ray Powder Pattern: Synthetic.
2.857 (100), 3.693 (85), 5.055 (75), 5.993 (55), 2.520 (55), 2.778 (45), 2.464 (35)

Chemistry:

	(1)	(2)
CO_2	20.04	19.90
CuO	72.03	71.95
H_2O	8.09	8.15
Total	100.16	100.00

(1) Rio Marina, Elba, Italy. (2) $Cu_2(CO_3)(OH)_2$.

Occurrence: A common secondary mineral formed in the oxidation zone of copper deposits; locally may be an ore of copper.

Association: Azurite, cuprite, cerussite, chrysocolla, calcite. "limonite".

Distribution: Many localities; some for abundant and rich material include: from Chessy, near Lyon, Rhône, France. In Russia, large pure masses formerly from mines around Nizhni Tagil and Ekatarinburg, Ural Mountains. In Congo, in Katanga Province (Shaba Province, Zaire), from Lubumbashi, at the Musonoi mine, near Kolwezi, and elsewhere, with large crystals from the Mashamba West mine. In Namibia, from Tsumeb, and as large crystals at the Onganja mine, 60 km northeast of Windhoek. In Australia, from Broken Hill and Cobar, New South Wales, and Burra, South Australia. In the USA, from the Copper Queen, Czar, and other mines in the Warren district, Bisbee, Cochise Co. and at Morenci, Greenlee Co., Arizona; in the Fierro-Hanover district and at Santa Rita, Grant Co., New Mexico.

Name: From the Greek for *mallow*, in allusion to its green color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 252–256. (2) Süsse, P. (1967) Verfeinerung der Kristallstruktur des Malachites, $Cu_2(OH)_2CO_3$. Acta Cryst., 22, 146–151 (in German with English abs.). (3) Zigan, F., W. Joswig, H.D. Schuster, and S.A. Mason (1977) Verfeinerung der Struktur von Malachit, $Cu_2(OH)_2CO_3$, durch Neutronenbeugung. Zeits. Krist., 145, 412–426 (in German with English abs.). (4) (1960) NBS Circ. 539, 10, 31.

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Malanite $Cu(Pt,Ir,Co)_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are octahedral or dodecahedral, to 0.2 mm; massive, in veinlets and granular.

Physical Properties: *Cleavage:* On {111}, may be observed. *Tenacity:* Brittle. Hardness = 5 VHN = 445–479, 462–471 average (20 g load). D(meas.) = n.d. D(calc.) = 7.35–7.57

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, bright white with a faint brown to green tint. *Streak:* Black. *Luster:* Metallic.
R: (400) —, (420) —, (440) —, (460) 34.8, (480) 35.3, (500) 35.8, (520) 36.3, (540) 36.5, (560) 36.7, (580) 36.9, (600) 37.1, (620) 37.4, (640) 37.5, (660) 37.6, (680) 37.8, (700) 37.9

Cell Data: *Space Group: Fd3m.* a = 9.910–9.940 Z = 8

X-ray Powder Pattern: Malan Valley, China.
1.75 (10), 2.48 (8), 1.90 (8), 0.783 (8), 1.011 (7), 2.98 (6), 5.70 (5)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Cu	9.95	10.9	11.0	Ir	25.23	23.2	20.9
Ni	0.33	0.3		Pd	0.45	0.5	
Co	2.60	2.2		Rh		0.7	11.1
Fe	1.00	0.6	0.1	S	23.47	23.8	24.4
Pt	36.77	37.0	33.0	Total	99.80	99.2	100.5

(1) Malan Valley, China; by electron microprobe, corresponds to $(Cu_{0.85}Fe_{0.10}Ni_{0.03})_{\Sigma=0.98}(Pt_{1.02}Ir_{0.71}Co_{0.24}Pd_{0.02})_{\Sigma=1.99}S_{3.98}$. (2) Do.; by electron microprobe, corresponds to $(Cu_{0.93}Fe_{0.06})_{\Sigma=0.99}(Pt_{1.03}Ir_{0.66}Co_{0.20}Rh_{0.04}Ni_{0.03}Pd_{0.03})_{\Sigma=1.99}S_{4.03}$. (3) Konder massif, Russia; by electron microprobe, corresponds to $(Cu_{0.92}Fe_{0.01})_{\Sigma=0.93}(Pt_{0.90}Ir_{0.58}Rh_{0.57})_{\Sigma=2.05}S_{4.03}$.

Polymorphism & Series: Forms a series with cuproiridisite.

Mineral Group: Linnaeite group.

Occurrence: In peridotite-type platinum ores with Cu–Ni sulfides (Malan Valley, China).

Association: Pentlandite, pyrrhotite, bornite, magnetite, cooperite, sperrylite, moncheite, platinum, olivine, pyroxenes, serpentine, chlorite (Malan Valley, China); osmiridium, ferrian platinum (Shuangfeng village, China); osmium, laurite, isoferroplatinum (Konder massif, Russia).

Distribution: In China, in Hebei Province, from the Malan Valley, Zunhua Co., about 150 km east of Beijing [TL]; at Shuangfeng village, Yanshan Mountains, about 200 km northeast of Beijing; from near Damiao village and the Yixun River, about 270 km north of Beijing. In Russia, from the Konder massif, Aldan Shield, Sakha, and in the Mt. Bolshaya Varaka deposit, Imandra complex, Kola Peninsula. At the Kirakkajuppura deposit, Penikat layered complex, northeast of Kemi, Finland. In the Ojén lherzolite massif, Málaga Province, Spain. In the Baula complex, Orissa, India. From the Merensky Reef, Bushveld complex, Transvaal, South Africa.

Name: Apparently for the Malan Valley, China.

Type Material: Geological Institute, Academy of Geological Sciences of China, Beijing, China.

References: (1) Yu Zuxiang (1981) A restudy of malanite and cobalt-malanite (dayingite). Geol. Rev., 27, 55–71 (in Chinese with English abs.). (2) (1982) Amer. Mineral., 67, 1081–1082 (abs. ref. 1). (3) Rudashevskii, N.S., A.G. Mochalov, V.V. Shkurskii, N.I. Shumskaya, and Y.P. Men'shikov (1984) First discovery of malanite ($Cu(Pt,Ir,Rh)_2S_4$) in the USSR. Mineral. Zhurnal, 6, 93–97 (in Russian). (4) Rudashevskii, N.S., Y.P. Men'shikov, A.G. Mochalov, N.V. Trubkin, N.I. Shumskaya, and V.V. Zhdanov (1985) Cuprorhodsite $CuRh_2S_4$ and cuproiridsite $CuIr_2S_4$ – new natural thiospinels of platinum elements. Zap. Vses. Mineral. Obshch., 114, 187–195 (in Russian). (5) Yu Zuxiang (1996) Malanite – a new cupric platinum (Pt^{3+}) and iridium (Ir^{3+}) sulfide. Acta Geol. Sinica, 70(4), 309–314 (in Chinese).

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Malayaite $CaSnSiO_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals wedge-shaped, up to 3 cm; massive, as a coating on cassiterite.

Physical Properties: Hardness = 3.5–4 D(meas.) = 4.3(2) D(calc.) = [4.55] Fluoresces pale to bright yellow or yellow-green under UV.

Optical Properties: Translucent. *Color:* Very pale creamy yellow to deep yellow-orange, colorless. *Luster:* Resinous.
Optical Class: Biaxial (–). α = 1.764–1.765 β = 1.783–1.786 γ = 1.798–1.801
2V(meas.) = 84°–86°

Cell Data: *Space Group:* $A2/a$. $a = 7.156(6)$ $b = 8.895(9)$ $c = 6.668(4)$ $\beta = 113.4(1)°$
Z = 4

X-ray Powder Pattern: Synthetic.
3.28 (100), 5.05 (50), 2.639 (45), 3.06 (35), 2.665 (30), 2.412 (20), 2.099 (20)

Chemistry:

	(1)	(2)
SiO_2	21.26	22.49
SnO_2	58.48	56.38
FeO		0.15
CaO	19.14	20.94
LOI	0.50	
Total	99.38	99.96

(1) Sungei Lah Valley, Malaya; corresponds to $Ca_{0.95}Sn_{1.07}Si_{0.98}O_5$. (2) Gumble, Australia; by electron microprobe, corresponding to $Ca_{1.00}Sn_{1.00}Fe_{0.01}Si_{1.00}O_5$.

Occurrence: In tin-rich contact metamorphic skarn deposits, probably a hydrothermal alteration product of cassiterite or other tin-bearing minerals.

Association: Cassiterite, quartz, calcite, wollastonite, pyroxene, garnet.

Distribution: In the Sungei Lah Valley, Chenderiang, Perak State, and other locations in Malaya, Malaysia. From Piniok, Thailand. In the Toroku and Mitate mines, Miyazaki Prefecture; the Sampo mine, Okayama Prefecture; the Hoei mine, Oita Prefecture; and the Kuga mine, Yamaguchi Prefecture, Japan. In the Kan'onsk deposit, headwaters of the Seimchan River, Yakutia, Russia. From Alpe Rosso, Val Vigezzo, Piedmont, Italy. At the Red-a-Ven Brook mine, Meldon, Devon, England. From near Gumble and Bourke, New South Wales, Australia. From the JC claims, near Dorsey Lake, Cassiar Mountains, and near Ash Mountain, McDame, British Columbia, Canada. From the Mesa Grande district, San Diego Co., California, USA.

Name: For the localities in Malaya, Malaysia.

Type Material: n.d.

References: (1) Ingham, F.T. and E.F. Bradford (1960) The geology and mineral resources of the Kinta Valley, Perak Federation of Malaya. Geol. Sur. District Memoir No. 9, 1–347, esp. 105. (2) (1961) Amer. Mineral., 46, 768–769 (abs. ref. 1). (3) Takenouchi, S. (1971) Hydrothermal synthesis and consideration of the genesis of malayaite. Mineralium Deposita, 6, 335–347. (4) Higgins, J.B. and P.H. Ribbe (1977) The structure of malayaite, $CaSnOSiO_4$, a tin analog of titanite. Amer. Mineral., 62, 801–806. (5) Mulholland, I.R. (1984) Malayaite and tin-bearing garnet from a skarn at Gumble, NSW, Australia. Mineral. Mag., 48, 27–30.

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Maldonite Au_2Bi

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive granular, also in thin coatings; typically seen in polished section as "decomposed" into a predominantly coarse myrmekitic intergrowth of gold and bismuth in which are wedges of maldonite, or rimming gold grains.

Physical Properties: *Cleavage:* Distinct on {001} and {110}. *Fracture:* Conchoidal. *Tenacity:* Malleable and sectile. Hardness = 1.5–2 VHN = 147–264 (100 g load). D(meas.) = 15.46 D(calc.) = 15.70

Optical Properties: Opaque. *Color:* Silver-white with pinkish tinge on fresh surface, tarnishes copper-red to black. *Luster:* Metallic.
R: (400) 48.3, (420) 49.0, (440) 50.2, (460) 51.5, (480) 53.2, (500) 54.9, (520) 56.6, (540) 58.0, (560) 59.0, (580) 59.6, (600) 59.9, (620) 60.0, (640) 60.0, (660) 60.0, (680) 60.0, (700) 60.1

Cell Data: *Space Group:* $Fd3m$. $a = 7.971$ $Z = 8$

X-ray Powder Pattern: Nuggety Reef, Australia.
2.41 (100), 1.537 (60), 2.30 (50), 1.412 (50), 2.82 (40), 1.038 (40), 1.629 (30)

Chemistry:

	(1)	(2)	(3)	(4)
Au	65.12	63.80	65.92	65.36
Bi	34.88	36.80	34.07	34.64
Total	100.00	100.60	99.99	100.00

(1) Nuggety Reef, Australia; corresponds to $Au_{1.99}Bi_{0.99}$. (2) Salsigne mine, France; by electron microprobe, corresponds to $Au_{1.94}Bi_{1.06}$. (3) Tyrnyauz deposit, Russia; by electron microprobe, corresponds to $Au_{2.02}Bi_{0.98}$. (4) Au_2Bi.

Occurrence: Formed below 373 °C, under hydrothermal conditions in gold-quartz veins and stockworks, and calc-silicate skarns.

Association: Gold, bismuth, bismuthinite, joséite, arsenopyrite, löllingite, pyrite, pyrrhotite, chalcopyrite, cubanite, scheelite, apatite, siderite, calcite, quartz.

Distribution: In Australia, in Victoria, near Maldon, from Nuggety Reef [TL], and in the Eagle Hawk mine, Union Reef; at Kingsgate and from the Lucky Draw mine, New South Wales. In the Salsigne gold deposit, 15 km north of Carcassone, Aude, and from Scoufour, Cantal, France. At the Ortosa Au–Bi–Te deposit, Asturias, Spain. From Baita ??, Romania. In the Radzimowice deposit, Kaczawa Mountains, Poland. At the Orlik deposit, near Humpolec, Czech Republic. From the Tyrnyauz W–Mo deposit, left bank of the Baksan River Valley, northern Caucasus Mountains, Russia. At Syrymbet, Kazakhstan. From Ingram, Ontario, Canada. In the USA, in Alaska, in the Shotgun deposit, about 150 km north of Dillingham, and on the Pogo claims, 145 km southeast of Fairbanks. A number of other minor occurrences are known.

Name: For the locality at Maldon, Australia.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 95–96. (2) Boyer, F. and P. Picot (1963) Sur la présence de maldonite (Au_2Bi) à Salsigne (Aude). Bull. Soc. fr. Minéral., 86, 429 (in French). (3) Prokuronov, P.V., Y.I. Dryzhak, and V.I. Shkurskii (1976) First find of maldonite in the USSR. Zap. Vses. Mineral. Obshch., 105, 453–456 (in Russian). (4) Jurriaanse, T. (1935) The crystal structure of Au_2Bi. Zeits. Krist., 90, 322–329. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 15. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 348.

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Maleevite $BaB_2Si_2O_8$

Crystal Data: Orthorhombic. *Point Group:* 2/*m* 2/*m* 2/*m*. As equant grains to 2 mm, rarely tabular.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 7 VHN = 1018 (50 g load). D(meas.) = 3.78(1) D(calc.) = 3.79

Optical Properties: Transparent to translucent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous, slightly greasy. Bright blue fluorescence in short-wave UV. *Optical Class:* Biaxial (-). α = 1.649(2) β = 1.656(2) γ = 1.656(2) 2V(meas) = 5(3)° 2V(calc) = 0° *Dispersion:* None. *Pleochroism*: None.

Cell Data: *Space Group:Pnma*. *a* = 8.141(2) *b* = 8.176(2) *c* = 9.038(2) Z = 4

X-ray Powder Pattern: Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan. 3.62 (100), 2.021 (70), 6.07 (60), 3.39 (60), 2.83 (50), 2.481 (40), 4.86 (30)

Chemistry:

	(1)
BaO	43.64
PbO	0.42
B_2O_3	19.92
SiO_2	34.86
Total	98.84

(1) Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan; electron microprobe analysis, corresponding to $(Ba_{0.99}Pb_{0.01})_{\Sigma=1.00}B_{1.99}Si_{2.01}O_8$.

Occurrence: In a slightly rounded block of pegmatite in syenite within a boulder in the moraine of the Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan. The Dara-i-Pioz massif at the head of the glacier contains B-rich alkaline rocks and pegmatites.

Association: Quartz, microcline, aegirine, with subordinate arfvedsonite, polylithionite, reedmergnerite, cesium-kupletskite, hyalotekite, albite.

Distribution: Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan.

Name: Honors Bulgarian mineralogist Mikhael Naidenovich Maleev (b. 1940).

Type Material: A.E. Fersman Mineralogical Museum, Moscow, Russia.

References: (1) Pautov, L.A., A.A. Agakhanov, E. Sokolova, and F.C. Hawthorne (2004) Maleevite, $BaB_2Si_2O_8$, and pekovite, $SrB_2Si_2O_8$, new mineral species from the Dara-i-Pioz alkaline massif, northern Tajikistan: description and crystal structure. Can. Mineral., 42, 107–119. (2) (2005) Amer. Mineral., 90, 272-273 (abs. ref. 1).

Malladrite Na_2SiF_6

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Crystal Data: Hexagonal. *Point Group:* 32. As minute hexagonal prisms terminated by the base or a pyramid, in crusts.

Physical Properties: Hardness = n.d. D(meas.) = 2.755 D(calc.) = 2.74 Slightly soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Pale rose.
Optical Class: Uniaxial (–). $n = \sim 1.31$, birefringence weak.

Cell Data: *Space Group:* $P321$ (synthetic). $a = 8.859(2)$ $c = 5.038(2)$ Z = 3

X-ray Powder Pattern: Synthetic.
4.429 (100), 4.213 (95), 3.331 (90), 2.281 (90), 1.7962 (55), 3.056 (30), 1.6629 (20)

Chemistry: No analyses have been performed; the composition has been established through analogy to synthetic material.

Occurrence: As a volcanic sublimate.

Association: Avogadrite, hieratite, sal ammoniac, ferruccite, sassolite (Vesuvius, Italy); barberiite, sassolite (Vulcano, Italy).

Distribution: In Italy, from Vesuvius, Campania, and on Vulcano, Lipari Islands.

Name: Honors Professor Alessandro Malladra (1868–1945), Italian vulcanologist, Director, Vesuvius Observatory, Italy.

Type Material: University of Florence, Florence, Italy, 226/l.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 105–106. (2) Zalkin, A., J.D. Forrester, and D.H. Templeton (1964) The crystal structure of sodium fluosilicate. Acta Cryst., 17, 1408–1412. (3) (1979) NBS Mono. 25, 16, 68.

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Mallardite $Mn^{2+}SO_4 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As masses of fibers, to 12 mm, efflorescences, and crusts.

Physical Properties: *Cleavage:* On {001}, good; on {110}, probable. Hardness = ∼2 D(meas.) = 1.846 (synthetic). D(calc.) = 1.838 Soluble in H_2O; quickly dehydrates at room temperature.

Optical Properties: Transparent to translucent. *Color:* White to pale rose; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–), may be (+). *Orientation:* $Y = b$; $Z \wedge c = 43°–44°$. $\alpha = 1.462–1.513$ $\beta = 1.465–1.533$ $\gamma = 1.474–1.540$ 2V(meas.) = Moderate to large.

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy to melanterite and bieberite). $a = 14.15$ $b = 6.50$ $c = 11.06$ $\beta = 105°36'$ Z = 4

X-ray Powder Pattern: Jokoku mine, Japan.
4.92 (100), 5.49 (72), 4.88 (54), 3.79 (42), 2.758 (38), 3.26 (36), 3.13 (31)

Chemistry:

	(1)	(2)	(3)
SO_3	29.0	29.08	28.89
MnO	23.6	23.36	25.60
MgO	0.6	1.59	
CaO	0.7		
H_2O	44.5	44.89	45.51
insol.	1.6	1.39	
Total	100.0	100.31	100.00

(1) Lucky Boy mine, Utah, USA; corresponds to $(Mn_{0.92}Mg_{0.04}Ca_{0.04})_{\Sigma=1.00}SO_4 \cdot 6.83H_2O$.
(2) Jokoku mine, Japan; corresponds to $(Mn_{0.90}Mg_{0.11})_{\Sigma=1.01}SO_4 \cdot 6.83H_2O$. (3) $MnSO_4 \cdot 7H_2O$.

Mineral Group: Melanterite group.

Occurrence: A rare mineral formed by oxidation of Fe–Mn sulfides and carbonates under conditions of saturated relative humidity; typically post-mine, when it may be seasonal.

Association: Manganoan melanterite (Lucky Boy mine, Utah, USA); jokokuite, ilesite, rhodochrosite, manganoan calcite, kutnohorite (Jokoku mine, Japan); alabandite (Broken Hill, Australia); melanterite, chvaleticeite, epsomite, jokokuite, rozenite, ilesite, copiapite, gypsum (Chvaletice, Czech Republic).

Distribution: In the USA, from the Lucky Boy mine, Butterfield Canyon, Bingham district, Salt Lake Co., Utah; in New Mexico, in the Bayard area, Central (Bayard) district, Grant Co., and in the Lake Valley district, Sierra Co.; at the Moon Anchor mine, Cripple Creek district, Teller Co., Colorado. In the Jokoku mine, about 60 km southwest of Hakodate, Hokkaido, Japan. From Broken Hill, New South Wales, Australia. At Chvaletice, Czech Republic.

Name: To honor François Ernest Mallard (1833–1894), French crystallographer, National School of Mines, Paris, France.

Type Material: Natural History Museum, Paris, France, 96132.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 507–508. (2) Nambu, M., K. Tanida, and T. Kitamura (1979) Mallardite from the Jôkoku mine, Hokkaido, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 74, 406–412.

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Mallestigite $Pb_3Sb(SO_4)(AsO_4)(OH)_6 \cdot 3H_2O$

Crystal Data: Hexagonal. *Point Group: 6.* Crystals prismatic, elongated along [001], showing {100} and {101}, to 2 mm; also as radial aggregates to 3 mm.

Physical Properties: *Cleavage:* None observed. *Fracture:* Splintery. *Tenacity:* Brittle. VHN = 176 (10 g load). Hardness = 4 D(meas.) = n.d. D(calc.) = 4.91

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (+). $\omega = 1.760(4)$ $\varepsilon = 1.801(4)$

Cell Data: *Space Group: $P6_3$.* $a = 8.938$ $c = 11.098$ Z = 2

X-ray Powder Pattern: Mallisteger Mattagskogel, Austria.
3.655 (100), 3.48 (80), 2.675 (62), 6.35 (44), 2.235 (35), 3.175 (31), 7.74 (25)

Chemistry:

	(1)
SO_3	8.64
Sb_2O_5	14.68
As_2O_5	9.71
PbO	65.67
$H_2O_{(calc)}$	[10.38]
Total	109.08

(1) Mallisteger Mattagskogel, Corinthia, Austria; average of 14 electron microprobe analyses, H_2O calculated, corresponding to $Pb_{3.06}Sb_{0.95}[(SO_4)_{1.12}(AsO_4)_{0.88}]_{\sum=2.0}(OH)_{5.99} \cdot 3.01H_2O$.

Mineral Group: The Sb analog of fleischerite.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal polymetallic base-metal deposit containing galena and tetrahedrite (Austria); in weathered metallic slag (Hartz Mountains, Germany).

Association: Anglesite, brochantite, langite, linarite, and schultenite.

Distribution: From the dumps of an ancient Cu-Pb-Zn mine near Mallisteger Mattagskogel, Corinthia, Austria; in slag, Hartz Mountains, Germany.

Name: For the town near the dumps from where the mineral was first noted.

Type Material: Not mentioned.

References: (1) Sima, I. (1998) Mallestigite, $Pb_3Sb(SO_4)(AsO_4)(OH)_6 \cdot 3H_2O$, a new mineral from a dump of a former Cu-Pb-Zn mine northwest of the Mallisteger Mattagskogel in Westkarawanken, Corinthia, Austria. Mitteil. Österr. Mineral. Ges., 143, 225–227 (in German). (2) (2004) Amer. Mineral., 89, 1830 (abs. ref. 1). (3) (2003) Can. Mineral., 41, 1314 (abs. ref. 1).

Mammothite $Pb_6Cu_4AlSb^{5+}O_2(SO_4)_2Cl_4(OH)_{16}$

Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tabular or prismatic, elongated along [001], showing {010}, {110}, {001}, to 1 mm, commonly in parallel to radial aggregates.

Physical Properties: *Cleavage:* On {010}, distinct. *Fracture:* Even. *Tenacity:* Very brittle. Hardness = ~3 D(meas.) = > 4.2 D(calc.) = 5.21

Optical Properties: Transparent. *Color:* Cerulean blue, blue-green, pale blue. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Moderate; in pale blues. *Absorption:* $X \geq Y > Z$.
$\alpha = 1.868$ $\beta = 1.892$ $\gamma = 1.928$ 2V(meas.) = 80°

Cell Data: *Space Group:* $C2/m$. $a = 18.93(3)$ $b = 7.3(1)$ $c = 11.35(2)$ $\beta = 112.44(10)°$
$Z = 2$

X-ray Powder Pattern: Tiger, Arizona, USA.
2.896 (100), 6.67 (90), 3.05 (90), 4.72 (80), 10.43 (60), 6.08 (60), 5.24 (30)

Chemistry:

	(1)	(2)
SO_3	7.7	7.01
Sb_2O_5		7.08
Sb_2O_3	6.1	
Al_2O_3	2.3	2.23
CuO	14.9	13.93
PbO	57.6	58.63
Cl	5.7	6.21
H_2O	[7.0]	6.31
$-O = Cl_2$	1.3	1.40
Total	[100.0]	100.00

(1) Tiger, Arizona, USA; by electron microprobe, H_2O by difference; corresponds to $Pb_{5.81}Cu_{4.22}Al_{1.02}Sb_{0.94}O_2(S_{1.07}O_4)_2Cl_{3.62}(OH)_{15.58}$. (2)$Pb_6Cu_4AlSbO_2(SO_4)_2Cl_4(OH)_{16}$.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal polymetallic base-metal deposit (Tiger, Arizona, USA); in metallic slag, formed by reaction with ocean water (Laurium, Greece).

Association: Anglesite, leadhillite, caledonite, phosgenite, diaboleite, wulfenite (Tiger, Arizona, USA); cerussite, matlockite, laurionite, paralaurionite, phosgenite, fiedlerite, penfieldite, boleite, diaboleite (Laurium, Greece).

Distribution: From the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA. At Laurium, Greece, in slag.

Name: For the Mammoth vein at Tiger, Arizona, from where the mineral was first noted, and the town of Mammoth, Arizona, USA, named for the mine.

Type Material: Victor Goldschmidt University, Göttingen, Germany, M5632; National Museum of Natural History, Washington, D.C., USA, 141368, 161200.

References: (1) Peacor, D.R., P.J. Dunn, G. Schnorrer-Köhler, and R.A. Bideaux (1985) Mammothite , a new mineral from Tiger, Arizona and Laurium, Greece. Mineral. Record, 16, 117–120. (2) (1986) Amer. Mineral., 71, 229–230 (abs. ref. 1). (3) Effenberger, H. (1985) The crystal structure of mammothite, $Pb_6Cu_4AlSbO_2(OH)_{16}Cl_4(SO_4)_2$. Tschermaks Mineral. Petrog. Mitt., 34, 279–288.

Manaksite $KNaMn^{2+}Si_4O_{10}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As grains, to 3 mm, and aggregates, to 5 mm.

Physical Properties: *Cleavage:* {001}, perfect; {010}, less perfect. *Fracture:* Hackly to steplike. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.73(2) D(calc.) = 2.71

Optical Properties: Translucent to transparent. *Color:* Colorless, cream-white, pale rose. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, medium. $\alpha = 1.540(2)$ $\beta = 1.551(2)$ $\gamma = 1.557(2)$ 2V(meas.) = 73°

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.993(5)$ $b = 8.219(7)$ $c = 10.007(9)$ $\alpha = 105.11(7)°$ $\beta = 100.76(6)°$ $\gamma = 114.79(6)°$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
3.45 (100), 3.26 (90), 3.05 (80), 6.89 (70), 2.880 (70), 2.715 (70), 2.463 (70)

Chemistry:

	(1)
SiO_2	62.0
FeO	0.8
MnO	17.2
MgO	0.3
CaO	0.2
SrO	0.2
Na_2O	8.9
K_2O	10.8
Total	100.4

(1) Lovozero massif, Russia; by electron microprobe, average of three analyses; corresponds to $K_{0.89}Na_{1.11}Mg_{0.03}Ca_{0.01}Sr_{0.01}(Mn^{2+}_{0.94}Fe_{0.03})_{\Sigma=0.97}Si_{3.99}O_{10}$.

Occurrence: In ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Nepheline, sodalite, analcime, potassic feldspar, albite, cancrisilite, arfvedsonite, aegirine, ussingite, makatite, grumantite, lomonosovite, villiaumite, additional minor minerals.

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: For MAnganese; sodium, NAtrium; potassium, Kalium; and SIlicon in its composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p575/3.

References: (1) Khomyakov, A.P., T.A. Kurova, and G.N. Nechelyustov (1992) Manaksite $NaKMnSi_4O_{10}$ – a new mineral. Zap. Vses. Mineral. Obshch., 121(1), 112–115 (in Russian). (2) (1993) Amer. Mineral., 78, 1315–1316 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 238–239 (abs. ref. 1).

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Manandonite $Li_2Al_4(Si_2AlB)O_{10}(OH)_8$

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Crystal Data: Orthorhombic. *Point Group:* 222. As micaceous pseudohexagonal plates, fanlike lamellar aggregates, or as globules, to about 1 mm, forming crusts. *Twinning:* Commonly twinned around [001], producing six-fold sectors.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2.5 D(meas.) = 2.76–2.89 D(calc.) = 2.79

Optical Properties: Transparent to translucent. *Color:* White as crystals; dull yellow as globules. *Luster:* Pearly on cleavages.
Optical Class: Biaxial (+) to pseudouniaxial. *Orientation:* $Z \perp \{001\}$. $\alpha = 1.604(5)$ $\beta = 1.604(5)$ $\gamma =$ n.d. 2V(meas.) = 10°–15°

Cell Data: *Space Group:* $C222_1$. $a = 5.057(4)$ $b = 8.765(7)$ $c = 13.769(9)$ Z = 2

X-ray Powder Pattern: Antandrokomby, Madagascar.
6.92 (100), 3.447 (80), 2.376 (35), 4.362 (25), 2.489 (15), 1.863 (15), 4.158 (10)

Chemistry:

	(1)	(2)	(3)
SiO_2	25.20	23.12	23.48
B_2O_3	9.25	7.74	6.80
Al_2O_3	47.02	48.06	49.80
MnO		0.02	
MgO		0.03	
CaO		0.07	
Li_2O	3.97	5.40	5.84
Na_2O	0.48	0.13	
K_2O	0.20		
H_2O	14.10	15.43	14.08
Total	100.22	[100.00]	100.00

(1) Antandrokomby, Madagascar. (2) Do.; combined wet chemical analysis, plasma spectrometry, AA, and TGA, recalculated to 100.00% after deduction of FeO(OH) impurities. (3) $Li_2Al_4(Si_2AlB)O_{10}(OH)_8$.

Mineral Group: Kaolinite-serpentine group.

Occurrence: In miarolitic cavities developed in corroded differentiated quartz-microcline-tourmaline-bearing pegmatites.

Association: Elbaite, quartz, microcline, albite.

Distribution: At the Antandrokomby pegmatite, on the Manandona River, Sahatany Valley, Madagascar.

Name: For the Manandona River, nearby the type locality in Madagascar.

Type Material: n.d.

References: (1) Lacroix, M.A. (1912) Sur une nouvelle espèce minérale (manandonite) des pegmatites de Madagascar. Bull. Soc. fr. Minéral., 35, 223–226 (in French). (2) Ranorosoa, N., F. Fontan, and A.-M. Fransolet (1989) Rediscovery of manandonite in the Sahatany valley, Madagascar. Eur. J. Mineral., 1, 633–638.

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Manasseite $Mg_6Al_2(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. Hexagonal crystals, to 2 cm, prismatic with hexagonal dipyramidal forms, terminated by {0001}; commonly foliated massive, intermixed with hydrotalcite. *Twinning:* On {0001}, and on a pyramid at about 30° to [0001].

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = 2 D(meas.) = 2.05(5) D(calc.) = 2.00

Optical Properties: Transparent. *Color:* White, pale blue to sky-blue, pale gray, pale yellow, pale brown, pale orange to deep red-orange, may be zoned; colorless in transmitted light. *Luster:* Waxy to pearly on the cleavage.
Optical Class: Uniaxial (–); may be biaxial due to strain. $\omega = 1.524(3)$ $\epsilon = 1.510(3)$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 6.12$ $c = 15.34$ $Z = 1$

X-ray Powder Pattern: Dypingdal quarry, Snarum, Norway. (ICDD 14-525).
7.67 (100), 1.84 (60), 2.60 (50), 2.34 (40), 2.17 (40), 2.00 (40), 1.52 (30)

Chemistry:

	(1)	(2)
Al_2O_3	16.59	16.88
Fe_2O_3	0.21	
MgO	39.38	40.04
H_2O	36.34	35.79
CO_2	7.48	7.29
Total	100.00	100.00

(1) Snarum, Norway; estimated gibbsite 6.38%. (2) $Mg_6Al_2(CO_3)(OH)_{16}\cdot 4H_2O$.

Polymorphism & Series: Dimorphous with hydrotalcite.

Mineral Group: Manasseite group.

Occurrence: A secondary mineral in ultramafic rocks.

Association: Hydrotalcite, serpentine, dolomite.

Distribution: From Snarum, Norway. In Russia, found near Kusinsk, Southern Ural Mountains, at Asbest, Ural Mountains; on the Kola Peninsula, large crystals from the Kovdor massif, and at the Vuoriyarvi carbonatite complex. At Amity, Orange Co., New York, USA. From Mont St. Hilaire, Quebec, Canada. Fine crystals from the Jacupiranga mine, São Paulo, Brazil.

Name: Honors Ernesto Manasse (1875–1922), Italian chemist and mineralogist, Professor of Mineralogy, University of Florence, Florence, Italy, for work on pyroaurite-related minerals.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 87211.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 658–659. (2) Kapustin, Y.L. (1971) Mineralogy of carbonatites. Nauka Publishers, Moscow, 165 (in English). (3) Taylor, H.W.F. (1973) Crystal structures of some double hydroxide minerals. Mineral. Mag., 39, 377–389.

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Mandarinoite $Fe_2^{3+}(Se^{4+}O_3)_3 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are swordlike, elongated along [001], flattened on {100}, exhibiting {100}, {110}, {011}, rarely $\{\bar{1}01\}$, to 3 mm; typically in rosettes and subparallel aggregates. *Twinning:* Common as contact twins with {100}, twin and composition plane.

Physical Properties: *Cleavage:* Probable parting on {100}. Hardness = ∼2.5
D(meas.) = 2.93(3) D(calc.) = 3.04

Optical Properties: Transparent. *Color:* Pale yellowish green; nearly colorless in thin section. *Streak:* Very pale green. *Luster:* Vitreous to slightly greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = pale green. *Orientation:* $X = b$; $c \wedge Z = 2(1)°$. *Dispersion:* Strong, crossed. *Absorption:* $X < Y \leq Z$. $\alpha = 1.715$ $\beta = 1.797$–1.80 $\gamma = 1.86$–1.87 2V(meas.) = 80°–85°

Cell Data: *Space Group:* $P2_1/c$. $a = 16.810(4)$ $b = 7.880(2)$ $c = 10.019(2)$ $\beta = 98.26(2)°$ Z = 4

X-ray Powder Pattern: Pacajake mine, Bolivia.
7.10 (100), 2.977 (70), 3.55 (50), 3.43 (40), 2.804 (20), 1.521 (15), 1.482 (15)

Chemistry:

	(1)	(2)
SeO_2	59.53	55.42
Fe_2O_3	28.68	26.59
H_2O	[11.79]	17.99
Total	[100.00]	100.00

(1) Pacajake mine, Bolivia; by electron microprobe, average of two analyses, Fe^{3+} confirmed by microchemical tests, H_2O by difference, with about 1/3 apparently lost to heating in the electron beam; corresponds to $Fe_{2.01}Se_{2.99}O_9 \cdot 3.65H_2O$. (2) $Fe_2(SeO_3)_3 \cdot 6H_2O$ as determined by crystal-structure analysis.

Occurrence: Probably formed by the simultaneous oxidation of penroseite and pyrite in a selenium-rich ore deposit (Pacajake mine, Bolivia).

Association: Penroseite, siderite, goethite, quartz (Pacajake mine, Bolivia); chalcomenite, kruťaite (El Dragón mine, Bolivia); chlorargyrite (De Lamar mine, Idaho, USA); poughite (El Plomo mine, Honduras).

Distribution: In Bolivia, from the Pacajake mine, Hiaco, 30 km east-northeast of Colquechaca, and at the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí, Bolivia. In the USA, from the De Lamar mine, Silver City, Owyhee Co., Idaho; in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., and as large crystals from the Wind Mountain mine, San Emidio district, Washoe Co., Nevada; at Darwin, Inyo Co., California. From the El Plomo mine, Ojojona district, Tegucigalpa, Honduras. In the Skouriotissa mine, Cyprus. From the Baccu Locci mine, near Villaputzu, Sarrabus district, Sardinia, Italy.

Name: To honor Dr. Joseph Anthony Mandarino (1929–), American–Canadian mineralogist, Emeritus Curator of Mineralogy, Royal Ontario Museum, Toronto, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, 35273; Harvard University, Cambridge, Massachusetts, 111364, 111368D; National Museum of Natural History, Washington, D.C., USA, 142878.

References: (1) Dunn, P.J., D.R. Peacor, and B.D. Sturman (1978) Mandarinoite, a new ferric-iron selenite from Bolivia. Can. Mineral., 16, 605–609. (2) (1980) Amer. Mineral., 65, 206 (abs. ref. 1). (3) Lasmanis, R., J. Nagel, B.D. Sturman, and R.I. Gait (1981) Mandarinoite from the De Lamar mine, Owyhee County, Idaho, U.S.A. Can. Mineral., 19, 409–410. (4) Hawthorne, F.C. (1984) The crystal structure of mandarinoite, $Fe_2^{3+}Se_3O_9 \cdot 6H_2O$. Can. Mineral., 22, 475–480.

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Manganarsite $Mn_3^{2+}As_2^{3+}O_4(OH)_4$

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Crystal Data: Hexagonal or pseudohexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. As platy hexagonal crystals, imperfect, to 1 mm; fine-grained, massive. *Twinning:* Lamellar, two sets at ~60°, observed optically.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ~3 D(meas.) = 3.64 D(calc.) = 3.60

Optical Properties: Semitransparent. *Color:* Pale pinkish brown. *Streak:* Pale pink. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X \perp$ {0001} cleavage. *Dispersion:* $r > v$. $\alpha = 1.78$ $\beta = 1.81$ $\gamma = 1.81$ 2V(meas.) = 28°–43°

Cell Data: *Space Group:* $P\overline{3}1m$, $P31m$, $P3m1$, or $P312$. $a = 11.451(6)$ $c = 7.252(6)$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
2.662 (100), 1.845 (70), 1.652 (60), 3.62 (50), 1.531 (40), 5.74 (30), 4.49 (30)

Chemistry:

	(1)	(2)
As_2O_3	44.3	44.29
Sb_2O_3	1.3	
FeO	1.8	
MnO	43.1	47.64
MgO	1.7	
H_2O	7.7	8.07
Total	99.9	100.00

(1) Långban, Sweden; by electron microprobe, Fe^{2+} determined by microchemical tests, H_2O by TGA; corresponding to $(Mn_{2.74}Mg_{0.19}Fe_{0.11})_{\Sigma=3.04}(As_{2.02}Sb_{0.04})_{\Sigma=2.06}O_{4.21}(OH)_{3.85}$.
(2) $Mn_3As_2O_4(OH)_4$.

Occurrence: Coating armangite, and filling fractures, in a museum specimen from a metamorphosed Fe–Mn deposit.

Association: Calcite, barite, hematite, fluorite, armangite.

Distribution: From Långban, Värmland, Sweden.

Name: For MANGANese and ARSenic in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, R5795.

References: (1) Peacor, D.R., P.J. Dunn, W.B. Simmons, and F.J. Wicks (1986) Arsenites related to layer silicates: manganarsite, the arsenite analogue of manganpyrosmalite, and unnamed analogues of friedelite and schallerite from Långban, Sweden. Amer. Mineral., 71, 1517–1521.

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Manganaxinite $Ca_2Mn^{2+}Al_2BSi_4O_{15}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals typically flattened, axe-head-shaped, to 10 cm; granular, massive.

Physical Properties: *Cleavage:* {100}, good; {001}, {110}, and {011}, poor. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 3.314 D(calc.) = [3.31]

Optical Properties: Transparent to translucent. *Color:* Honey-yellow, clove-brown, brown, blue; colorless to pale brown or blue in thin section. *Luster:* Vitreous. *Optical Class:* Biaxial (–). $\alpha = 1.678(3)$ $\beta = 1.687(3)$ $\gamma = 1.692(3)$ 2V(meas.) = 75(5)°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.161(2)$ $b = 9.190(3)$ $c = 8.978(3)$ $\alpha = 88.26(3)°$ $\beta = 81.80(3)°$ $\gamma = 77.26(2)°$ Z = 2

X-ray Powder Pattern: Babbitt, Minnesota, USA. (ICDD 27-84).
3.16 (100), 3.47 (70), 2.810 (50), 6.31 (20), 2.891 (18), 2.189 (16), 3.44 (15)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	41.66	42.23	MgO	0.25	
TiO_2	0.01		CaO	18.08	19.70
B_2O_3	5.96	6.12	Na_2O	0.15	
Al_2O_3	18.00	17.91	K_2O	0.02	
Fe_2O_3	0.10		H_2O^+	1.26	1.58
FeO	3.27		H_2O^-	0.04	
MnO	11.66	12.46	Total	100.46	100.00

(1) Babbitt, Minnesota, USA; corresponds to $(Ca_{1.85}Mn^{2+}_{0.94}Fe^{2+}_{0.26}Mg_{0.04})_{\Sigma=3.09}(Al_{2.03}Fe^{3+}_{0.01})_{\Sigma=2.04}B_{0.99}Si_{3.98}O_{16}H_{0.83}$. (2) $Ca_2MnAl_2BSi_4O_{15}(OH)$.

Polymorphism & Series: Forms two series, with ferroaxinite, and with tinzenite.

Mineral Group: Axinite group; Ca > 1.5 per formula unit, Mn > Fe.

Occurrence: Typically a mineral formed by contact metamorphism and boron metasomatism; from a pegmatite vein cutting metamorphosed iron formation at a contact with gabbro (Minnesota, USA).

Association: Chlorite, quartz, potassic feldspar.

Distribution: A few verified localities include: in Germany, from St. Andreasberg, Harz Mountains. In Ireland, at Calliagh, eight km southwest of Monaghan, Co. Monaghan. On Monte Pu, Liguria, Italy. In the USA, from the Huachuca Mountains, Cochise Co., and at the Iron Cap Pb-Zn mine, near Aravaipa, Graham Co., Arizona; at the Consumnes Copper mine, Amador Co., and the Greystone claim, Genesee Valley, Plumas Co., California; from the Mesabi Range, St. Louis Co., Minnesota; in the McKinney mine, Mitchell Co., North Carolina. At Avondale, Delaware Co., and Cornog, Chester Co., Pennsylvania, and from Franklin, Sussex Co., New Jersey. In Canada, from Marmora Township, Ontario. At the Anawai mine, Kochi Prefecture, and the Obira mine, Bungo, Oita Prefecture, Japan.

Name: For dominant *manganese* in a mineral of the *axinite* group, named from the Greek for *axe* after their sharp crystal forms.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 527–529. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 603–623. (3) Sanero, E. and G. Gottardi (1968) Nomenclature and crystal-chemistry of axinites. Amer. Mineral., 53, 1407–1411. (4) French, B.M. and J.J. Fahey (1972) Manganaxinite from the Mesabi Range, Minnesota. Amer. Mineral., 57, 989–992. (5) Lumpkin, G.R. and P.H. Ribbe (1979) Chemistry and physical properties of axinites. Amer. Mineral., 64, 635–645.

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Manganbabingtonite $Ca_2(Mn^{2+},Fe^{2+})Fe^{3+}Si_5O_{14}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals short prismatic, to 5 mm.

Physical Properties: *Cleavage:* Perfect on {001}, less perfect on {010}, poor on {100}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 3.452 D(calc.) = [3.59]

Optical Properties: Translucent to opaque. *Color:* Dark greenish black to yellowish green. *Optical Class:* Biaxial (+). *Pleochroism:* X = emerald-green; Y = faint rose to nearly colorless; Z = purple-brown to rose-brown. *Orientation:* $Y \simeq c$; $Z = b$. *Dispersion:* $r > v$, strong. $\alpha = 1.716$ $\beta = 1.730$ $\gamma = 1.746$ 2V(meas.) = 78°–82° 2V(calc.) = 86°

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.88$ $b = 11.80$ $c = 6.77$ $\alpha = 90°30'$ $\beta = 93°30'$ $\gamma = 104°54'$ Z = 2

X-ray Powder Pattern: Rudnyi Kaskad deposit, Russia.
3.104 (10), 2.998 (10), 2.938 (10), 2.162 (10), 3.442 (8), 1.654 (7), 1.427 (6)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	51.85	52.45	K_2O	0.09	
TiO_2	0.15		F	0.12	
Al_2O_3	0.56		Cl	0.06	
Fe_2O_3	12.26	13.94	H_2O^+	1.95	
FeO	4.52	6.27	H_2O^-	0.26	
MnO	7.91	6.19	H_2O		1.57
MgO	0.60		CO_2	0.13	
CaO	19.00	19.58	$-O=(F,Cl)_2$	0.06	
Na_2O	0.25		Total	99.65	100.00

(1) Rudnyi Kaskad deposit, Russia. (2) $Ca_2(Mn^{2+},Fe^{2+})Fe^{3+}Si_5O_{14}(OH)$, calculated for Mn^{2+}:Fe^{2+} = 1:1.

Polymorphism & Series: Forms a series with babingtonite.

Occurrence: In thin stringers in amphibolized garnet-pyroxene-magnetite skarn associated with an iron deposit (Rudnyi Kaskad deposit, Russia); replacing hedenbergite-johannsenite skarn (Iron Cap mine, Arizona, USA).

Association: Epidote, calcite, quartz (Rudnyi Kaskad deposit, Russia); ilvaite, andradite, epidote, thaumasite, calcite, quartz, pyrite, galena, sphalerite (Iron Cap mine, Arizona, USA).

Distribution: From the Rudnyi Kaskad deposit, eastern Sayan Mountains, Siberia, Russia. In the Iron Cap Pb–Zn mine, near Aravaipa, Graham Co., Arizona, USA.

Name: For the *manganese* content and relation to *babingtonite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72039.

References: (1) Vinogradova, R.A., V.A. Sychkova, and Y.K. Kabalov (1966) Manganiferous babingtonite from the Rudnyi Kaskad deposit, Eastern Sayan. Doklady Acad. Nauk SSSR, 169, 434–437 (in Russian). (2) Vinogradova, R.A. and I.N. Plyusinna (1967) Composition, properties, and crystallochemical features of minerals of the isomorphous series ferrobabingtonite-manganbabingtonite. Vestn. Moskov. Univ. Ser. IV, Geol., 54–67 (in Russian). (3) (1968) Amer. Mineral., 53, 1064–1065 (abs. refs. 1 and 2). (4) Burt, D.M. and D. London (1978) Manganbabingtonite and ilvaite from a hedenbergite-johannsenite skarn, Aravaipa, Arizona. Geol. Soc. Amer., Abs. with Prog., 10, 98 (abs.).

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Manganbelyankinite $(Mn^{2+}, Ca)(Ti, Nb)_5O_{12}\cdot 9H_2O$

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Crystal Data: Amorphous. *Point Group:* n.d. Massive.

Physical Properties: Hardness = [2–3] (by analogy to belyankinite). D(meas.) = 2.54 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Brownish black. *Luster:* Resinous. *Optical Class:* Biaxial (–). *Pleochroism:* Noted. α = n.d. β = n.d. γ = n.d. 2V(meas.) = 29°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Lovozero massif, Russia; after heating at 900 °C. 1.692 (4), 2.48 (3), 3.21 (2), 2.89 (2), 2.17 (1), 1.880 (1)

Chemistry:

	(1)	(2)
Nb_2O_5	7.42	7.86
SiO_2	1.51	3.34
TiO_2	44.30	44.32
ZrO_2		3.06
MnO_2	14.03	6.45
Al_2O_3		0.60
Fe_2O_3	3.77	4.12
MgO		1.10
CaO	5.77	6.00
K_2O		0.90
H_2O^+	22.36	9.09
H_2O^-		13.61
P_2O_5		0.23
Total	99.16	100.68

(1) Lovozero massif, Russia; corresponds to $(Mn, Ca)_{1.9}(Ti, Nb)_5O_{12}\cdot 9H_2O$. (2) Do.

Polymorphism & Series: Forms two series, with belyankinite, and with gerasimovskite.

Occurrence: In pegmatite.

Association: n.d.

Distribution: On Mts. Kedykverpakhk and Punkaruaiv, Lovozero massif, Kola Peninsula, Russia.

Name: For its MANGANese content, and relation to *belyankinite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis6437.

References: (1) E.I. Semenov (1957) Oxides and hydroxides of titanium and niobium in the Lovozero alkalic massif. Inst. mineral., geokhim., and crystallokhim. redkikh elementov, Trudy, 1, 41–59 (in Russian). (2) (1958) Amer. Mineral., 43, 1220–1221 (abs. ref. 1). (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 390–392 (in English).

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Manganberzeliite $NaCa_2(Mn^{2+},Mg)_2(AsO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As rare trapezohedral crystals, {112}, modified by {011}, {012}, {001}, to 9 mm; typically granular or very fine-grained massive.

Physical Properties: *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 4.21–4.46 D(calc.) = 4.26

Optical Properties: Transparent to translucent. *Color:* Yellow, honey-yellow, yellowish red; colorless to orange in transmitted light. *Streak:* White to yellow-orange. *Luster:* Resinous. *Optical Class:* Isotropic. n = 1.770–1.777

Cell Data: *Space Group: Ia3d.* a = 12.500(5) Z = 8

X-ray Powder Pattern: Synthetic $NaCa_2Mn_2(AsO_4)_3$.
2.800 (100), 2.556 (90), 1.673 (80), 3.129 (50), 5.10 (40), 1.736 (40), 2.666 (35)

Chemistry:

	(1)	(2)	(3)
As_2O_5	52.90	54.52	57.54
V_2O_5	0.24		
SiO_2		0.35	
FeO	0.38	0.41	
MnO	21.41	19.64	11.84
ZnO		0.61	
MgO	0.72	1.01	6.73
CaO	18.34	18.43	18.72
Na_2O	5.05	4.68	5.17
K_2O	0.09		
H_2O	0.40	0.27	
Total	99.53	99.92	100.00

(1) Långban, Sweden. (2) Franklin, New Jersey, USA. (3) $NaCa_2(Mn,Mg)_2(AsO_4)_3$ with Mn:Mg = 1:1.

Polymorphism & Series: Forms a series with berzeliite.

Occurrence: In metamorphosed manganiferous skarns (Sweden); in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Hausmannite, rhodonite, tephroite, pyrochroite, bergslagite, caryinite, richterite, hedyphane, sarkinite, eveite, tilasite, barite, calcite (Långban, Sweden); sarkinite, hedyphane, schallerite, franklinite, willemite, calcite (Franklin, New Jersey, USA).

Distribution: In Sweden, from Långban, Värmland, at the Moss mine, near Nordmark, and the Sjö mine, near Grythyttan, Örebro. At Franklin, Sussex Co., New Jersey, USA. In the Gozaisho mine, Iwaki, Fukushima Prefecture, Japan.

Name: For the *manganese* dominant analogue of *berzeliite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 681–683. (2) Frondel, C. and J. Ito (1963) Manganberzeliite from Franklin, New Jersey. Amer. Mineral., 48, 663–664. (3) Ito, J. (1968) Synthesis of the berzeliite ($Ca_2NaMg_2As_3O_{22}$[*sic*])−manganese berzeliite ($Ca_2NaMn_2As_3O_{12}$) series (arsenate garnet). Amer. Mineral., 53, 316–319. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 673.

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Manganese-hörnesite $(Mn^{2+},Mg)_3(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals, flattened on {010}, in stellate radial aggregates, to 0.5 cm.

Physical Properties: *Cleavage:* Perfect on {010}; imperfect on {100}, {201}, {$\bar{2}$01}. Hardness = 1 D(meas.) = 2.64 (impure material). D(calc.) = 2.76

Optical Properties: Transparent to translucent. *Color:* White to colorless. *Streak:* White. *Luster:* Silky on cleavages.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 31°$. $\alpha = 1.579$ $\beta = 1.589$ $\gamma = 1.609$ 2V(meas.) = 65°–70°

Cell Data: *Space Group:* $P2_1/c$. a = 10.38(5) b = 28.09(5) c = 4.774(50) $\beta = 105°40'$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
7.01 (10), 8.19 (8), 3.02 (7), 2.41 (7), 3.25 (6), 3.09 (6), 2.88 (4)

Chemistry:

	(1)	(2)
As_2O_5	40.78	42.50
CO_2	1.35	
MnO	22.87	19.67
MgO	9.47	11.18
H_2O	25.64	26.65
Total	100.11	100.00

(1) Långban, Sweden; CO_2 and 2.17% MgO from rhodochrosite impurity; corresponds then to $(Mn_{1.65}Mg_{1.32})_{\Sigma=2.97}(AsO_4)_{2.00} \cdot 8.02H_2O$. (2) $(Mn,Mg)_3(AsO_4)_2 \cdot 8H_2O$ with Mn:Mg = 1:1.

Occurrence: In fissure veins in skarn in a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Rhodochrosite, synadelphite, quartz (Långban, Sweden); adelite, alleghanyite, kraisslite, willemite (Sterling Hill, New Jersey, USA).

Distribution: From Långban, Värmland, Sweden. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For the dominant *manganese* content and its relation to *hörnesite*.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Gabrielson, O. (1954) Manganiferous hoernesite and manganese-hoernesite from Långban, Sweden. Arkiv. Mineral. Geol., 1(11), 333–337. (2) (1954) Amer. Mineral., 39, 159 (abs. ref. 1).

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Manganese-shadlunite $(Mn, Pb, Cd)(Cu, Fe)_8S_8$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$ (probable). As irregular grains, to 0.4 mm, and as veinlets, mostly in cubanite. *Twinning:* Polysynthetic twinning seen in polished section.

Physical Properties: Hardness = n.d. VHN = 195 (20 g load). D(meas.) = n.d. D(calc.) = 4.44

Optical Properties: Opaque. *Color:* In polished section, grayish yellow, darker than cubanite. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak.
R: (400) — , (420) — , (440) 21.2, (460) 22.7, (480) 24.7, (500) 26.5, (520) 27.9, (540) 29.0, (560) 29.9, (580) 30.8, (600) 31.2, (620) 32.3, (640) 32.9, (660) 33.8, (680) 34.5, (700) 34.6

Cell Data: *Space Group:* $Fm3m$ (probable). $a = 10.73$ $Z = 4$

X-ray Powder Pattern: Oktyabr mine, Russia.
3.23 (100), 1.894 (90), 1.097 (40), 3.08 (30), 2.07 (30), 3.78 (20), 2.46 (20)

Chemistry:

	(1)	(2)
Mn	4.6	3.2
Pb	4.8	8.2
Cd	1.0	1.3
Cu	31.19	29.8
Fe	27.21	26.4
S	31.46	29.4
Total	100.26	98.3

(1) Oktyabr mine, Russia; by electron microprobe, corresponds to $(Mn_{0.68}Pb_{0.19}Cd_{0.07})_{\Sigma=0.94}(Cu_{4.00}Fe_{3.97})_{\Sigma=7.97}S_{8.00}$. (2) Majak mine, Russia; by electron microprobe, corresponds to $(Mn_{0.51}Pb_{0.34}Cd_{0.10})_{\Sigma=0.95}(Fe_{4.12}Cu_{4.09})_{\Sigma=8.21}S_{8.00}$.

Mineral Group: Pentlandite group.

Occurrence: In Cu–Ni sulfide ores (Noril'sk region, Russia).

Association: Cubanite.

Distribution: In Russia, from the Talnakh area, Noril'sk region, western Siberia, in the Oktyabr [TL] and Majak mines.

Name: For its manganese content and relation to shadlunite.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Evstigneeva, T.L., A.D. Genkin, N.V. Troneva, A.A. Filimonova, and A.I. Tsepin (1973) Shadlunite, a new sulfide of copper, iron, lead, manganese, and cadmium from copper–nickel ores. Zap. Vses. Mineral. Obshch., 102, 63–74 (in Russian). (2) (1973) Amer. Mineral., 58, 1114 (abs. ref. 1).

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Mangangordonite $(Mn^{2+},Fe^{2+})Al_2(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals nearly equant to tabular on {010}, slightly elongated along [001], to 2 mm; dominant forms include {010}, {100}, {001}, {$1\overline{1}0$}, {$0\overline{1}1$}; as fanlike to radial aggregates of bladed crystals.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 2.36(3) D(calc.) = [2.35]

Optical Properties: Transparent to translucent. *Color:* Colorless, white, may be stained yellow, tan, or brown; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z \simeq c$. *Dispersion:* $r < v$, distinct. $\alpha = 1.556(1)$ $\beta = 1.561(2)$ $\gamma = 1.571(2)$ 2V(meas.) = 70° 2V(calc.) = 71°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.257(3)$ $b = 10.363(4)$ $c = 7.040(3)$ $\alpha = 105.44(3)°$ $\beta = 113.07(3)°$ $\gamma = 78.69(4)°$ Z = 1

X-ray Powder Pattern: Kings Mountain, North Carolina, USA.
4.77 (10), 6.39 (8), 3.18 (7), 9.96 (6), 2.86 (5), 2.59 (4), 3.90 (3)

Chemistry:

	(1)	(2)
P_2O_5	33.96	29.57
Al_2O_3	25.38	22.09
FeO	3.88	3.44
MnO	12.43	10.79
MgO	0.4	0.34
H_2O		[33.77]
Total		[100.00]

(1) Kings Mountain, North Carolina, USA; by electron microprobe, average of three partial analyses, total Fe as FeO, total Mn as MnO, H_2O rapidly lost in the electron beam. (2) Analysis (1) recalculated to 100% with H_2O from structure analysis and by analogy to gordonite; then corresponding to $(Mn_{0.73}Fe_{0.23}Mg_{0.04})_{\Sigma=1.00}Al_{2.08}(PO_4)_{2.00}(OH)_2 \cdot 8H_2O$.

Polymorphism & Series: Dimorphous with kastningite.

Occurrence: A very rare secondary mineral in complex zoned granite pegmatites.

Association: Jahnsite, beraunite, strunzite, strengite, spodumene, quartz, muscovite, fluorapatite (Foote mine, North Carolina, USA); tourmaline, siderite, muscovite, quartz (Dunton quarry, Maine, USA).

Distribution: From the Foote mine, Kings Mountain, Cleveland Co., North Carolina and the Dunton quarry, Newry, Oxford Co., Maine, USA. On Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia. From Hagendorf, Bavaria, Germany.

Name: As the *manganese* analog of *gordonite*.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 54513; National Museum of Natural History, Washington, D.C., USA, 162695.

References: (1) Leavens, P.B., J.S. White, Jr., G.W. Robinson, and J.A. Nelen (1991) Mangangordonite, a new phosphate mineral from Kings Mountain, North Carolina and Newry, Maine, USA. Neues Jahrb. Mineral., Monatsh., 169–176. (2) (1991) Amer. Mineral., 76, 2022–2023 (abs. ref. 1). (3) Leavens, P.B. and A.L. Rheingold (1988) Crystal structures of gordonite, $MgAl_2(PO_4)_2(OH)_2(H_2O)_6 \cdot 2H_2O$, and its Mn analog. Neues Jahrb. Mineral., Monatsh., 265–270.

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Manganhumite $(Mn^{2+},Mg)_7(SiO_4)_3(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Anhedral grains, to about 1 cm.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 4 D(meas.) = 3.83(5) D(calc.) = 3.84

Optical Properties: Transparent. *Color:* Pale to deep brownish orange; very pale orange in thin section. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, perceptible. $\alpha = 1.707(3)$ $\beta = 1.712(3)$ $\gamma = 1.723(3)$ $2V(meas.) = 37(4)^\circ$

Cell Data: *Space Group: Pbnm.* $a = 4.815(1)$ $b = 10.580(2)$ $c = 21.448(5)$ $Z = 4$

X-ray Powder Pattern: Brattfors mine, Sweden.
1.777 (10), 2.500 (7), 3.371 (6), 2.628 (6), 1.525 (6), 2.752 (5), 2.813 (5b)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	29.8	26.21	CaO	0.34	0.13
TiO_2		0.17	F		1.46
Al_2O_3	trace	0.00	H_2O		[1.89]
FeO	0.98	0.94	P_2O_5	trace	
MnO	57.1	69.47	$-O = F_2$		[0.61]
MgO	14.2	0.73	Total	102.42	[100.39]

(1) Brattfors mine, Sweden; by electron microprobe, average of five grains; corresponds to $(Mn^{2+}_{4.76}Mg_{2.10}Fe_{0.07}Ca_{0.07})_{\Sigma=7.00}(SiO_4)_3(OH)_2$. (2) Bald Knob, North Carolina, USA; by electron microprobe, H_2O calculated from stoichiometry; corresponds to $(Mn^{2+}_{6.76}Mg_{0.12}Fe_{0.09}Ca_{0.02})_{\Sigma=6.99}Si_{3.01}O_{12}[(OH)_{1.45}F_{0.53}]_{\Sigma=1.98}$.

Mineral Group: Humite group.

Occurrence: A late-stage skarn mineral formed in recrystallized limestone banded between layers of manganese ore minerals (Brattfors mine, Sweden); in a manganese deposit metamorphosed to the amphibolite facies (Bald Knob, North Carolina, USA).

Association: Katoptrite, magnetite, manganostibite, magnussonite, tephroite, galaxite, manganosite (Brattfors mine, Sweden); sonolite, alleghanyite, rhodonite, kutnohorite, galaxite, jacobsite, kellyite, alabandite (Bald Knob, North Carolina, USA).

Distribution: In the Brattfors mine, Nordmark, and at Långban, Värmland, Sweden. In the USA, from Bald Knob, near Sparta, Alleghany Co., North Carolina, and Franklin, Sussex Co., New Jersey.

Name: For *manganese* in the composition and relation to *humite*.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; Harvard University, Cambridge, Massachusetts, 119819; National Museum of Natural History, Washington, D.C., USA, 137016, 162626.

References: (1) Moore, P.B. (1978) Manganhumite, a new species. Mineral. Mag., 42, 133–136. (2) (1979) Amer. Mineral., 64, 243 (abs. ref. 1). (3) Francis, C.A. and P.H. Ribbe (1978) Crystal structure of the humite minerals: V. Magnesian manganhumite. Amer. Mineral., 63, 874–877. (4) Winter, G.A., E.J. Essene, and D.R. Peacor (1983) Mn-humites from Bald Knob, North Carolina: mineralogy and phase equilibria. Amer. Mineral., 68, 951–959. (5) Dunn, P.J. (1985) Manganese humites and leucophoenicites from Franklin and Sterling Hill, New Jersey: parageneses, compositions, and implications for solid solution limits. Amer. Mineral., 70, 379–387.

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Manganiandrosite-(Ce) $Mn^{2+}CeMn^{3+}AlMn^{2+}Si_2O_7SiO_4O(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As elongated grains to 0.1 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.21-4.31

Optical Properties: Transparent. *Color*: Dark brown. *Streak*: Reddish brown.
Luster: Vitreous to adamantine.
Optical Class: Biaxial (+). α > 1.74 *n*(calc.) = 1.80 2V(meas.) = 80.6(1.5)° 2V(calc.) = n.d.
Orientation: *n.d.* *Pleochroism:* Strong, *X* = light yellow, *Y* = orange-brown, *Z* = red-brown.
Dispersion: None.

Cell Data: *Space Group*: $P2_1/m$. a = 8.901(2) b = 5.738(1) c = 10.068(2) β = 113.425(3)°
Z = 2

X-ray Powder Pattern: Praborna Mn deposit, Saint-Marcel, Val d'Aosta, Italy. [calculated pattern]
2.8964 (100), 2.6225 (53), 3.5141 (41), 2.7134 (39), 2.7069 (39), 2.8690 (35), 7.8639 (28)

Chemistry:

	(1)		(1)
SiO_2	29.04	CaO	3.82
Al_2O_3	8.20	Ce_2O_3	12.22
TiO_2	1.26	La_2O_3	6.08
Fe_2O_3	2.98	Nd_2O_3	3.24
MnO	15.01	Sm_2O_3	0.18
Mn_2O_3	11.62	F	0.07
MgO	0.28	H_2O	[1.45]
SrO	1.17	Total	96.59

(1) Praborna Mn deposit, Saint-Marcel, Val d'Aosta, Italy; average of 4 electron microprobe analyses, H_2O calculated from stoichiometry; corresponding to $[Mn^{2+}_{0.60}Ca_{0.40}]_{\Sigma=1.00}[(Ce_{0.46}La_{0.23}Nd_{0.12}Sm_{0.01})_{\Sigma REE\geq 0.82}Sr_{0.07}Ca_{0.02}]_{\Sigma\geq 0.91}[Mn^{3+}_{0.63}Fe^{3+}_{0.23}Ti_{0.10}Mg_{0.04}]_{\Sigma=1.00}Al_{1.00}[Mn^{2+}_{0.96}Mn^{3+}_{0.04}]_{\Sigma=1.00}Si_2O_7SiO_4O(OH)$.

Mineral Group: Epidote group, allanite subgroup.

Occurrence: In metamorphosed (eclogite facies) lenses near Mn deposits associated with ophiolite.

Association: Tephroite, Mn-pyroxenoid, hematite, calderite; or spessartine, calderite, hematite, pyrophanite.

Distribution: From the dumps of the Praborna Mn deposit, Saint-Marcel, Val d'Aosta, Italy,

Name: The Ce analogue of manganiandrosite-(La). An epidote-group mineral in which Mn^{2+} is dominant in A1, REE are dominant in A2, Mn^{3+} in M1, Al in M2, and in which Mn^{2+} is the dominant charge-compensating (*i.e*. divalent) cation in M3.

Type Material: Mineral Museum, School of Mines, Paris, France, (73951).

References: (1) Cenki-Tok, B., A. Ragu, T. Armbruster, C. Chopin, and O. Medenbach (2006) New Mn- and rare-earth rich epidote-group minerals in metacherts: manganiandrosite-(Ce) and vanadoandrosite-(Ce). Eur. J. Mineral., 18, 569-582. (2) (2007) Amer. Mineral., 92, 704-705 (abs. ref. 1).

Manganite $Mn^{3+}O(OH)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals prismatic and striated ‖ [001], short to long, to 7.5 cm; typically terminated by {001}, {$h0l$}, may be complex. In bundles, subparallel [001], fibrous; granular, massive. *Twinning:* Contact and penetration twins on {011}; lamellar on {100}.

Physical Properties: *Cleavage:* {010}, perfect; {110} and {001}, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4 VHN = 630–743 (100 g load). D(meas.) = 4.29–4.34 D(calc.) = 4.38

Optical Properties: Opaque, transparent on thin edges. *Color:* Dark steel-gray to iron-black; red-brown in transmitted light; in reflected light, gray-white with brownish tint, with blood-red internal reflections. *Streak:* Reddish brown to nearly black. *Luster:* Submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Faint; X = reddish brown; Z = red-brown.
Orientation: $X = a$; $Y = b$; $Z \wedge c = 0°$–$4°$. *Dispersion:* $r > v$, very strong.
Absorption: $Z > X = Y$. $\alpha = 2.25(2)$ $\beta = 2.25(2)$ $\gamma = 2.53(2)$ 2V(meas.) = Small.
Anisotropism: Weak. *Bireflectance:* Distinct; in grays.
R_1–R_2: (400) 18.0–25.1, (420) 18.0–24.8, (440) 18.0–24.5, (460) 17.9–24.1, (480) 17.8–23.7, (500) 17.6–23.2, (520) 17.3–22.7, (540) 17.0–22.2, (560) 16.8–21.6, (580) 16.5–21.2, (600) 16.3–20.8, (620) 16.1–20.6, (640) 16.0–20.3, (660) 15.8–20.1, (680) 15.7–19.9, (700) 15.7–19.7

Cell Data: *Space Group:* $B2_1/d$. $a = 8.94$ $b = 5.28$ $c = 5.74$ $\beta = 90°$ Z = 8

X-ray Powder Pattern: Ilfeld, Germany. (ICDD 8-99).
3.40 (100), 2.64 (60), 2.28 (50), 1.708 (40), 1.636 (40), 1.139 (40), 1.672 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Al_2O_3	0.30	0.3		BaO	0.15		
FeO		0.5		$(Na,K)_2O$	0.22		
MnO	79.55	79.3	80.66	OH	19.59	[19.9]	19.34
$(Cu,Pb)O$	0.10			gangue	0.28		
CaO	0.10			Total	100.29	[100.0]	100.00

(1) Ilfeld, Germany; average of three analyses. (2) Do.; by electron microprobe, OH by difference. (3) MnO(OH).

Polymorphism & Series: Trimorphous with feitknechtite and groutite.

Occurrence: Formed in low-temperature hydrothermal or hot-spring manganese deposits; replacing other manganese minerals in sedimentary deposits; a component in some clay deposits and laterites.

Association: Pyrolusite, braunite, hausmannite, barite, calcite, siderite, goethite.

Distribution: Many localities, but rarely well-crystallized. Fine crystals from Ilfeld, Harz Mountains, and Ilmenau, Thuringia, Germany. In the Botallack mine, St. Just, Cornwall; from Egremont, Cumbria; and at Upton Pyne, Exeter, Devonshire, England. From Granam, near Towie, Aberdeenshire, Scotland. At Bölet, near Karlsborg, Västergötland,Sweden. In the USA, good crystals from the Negaunee and Marquette districts, Marquette Co., Michigan; in the Powell's Fort mine, near Woodstock, Shenandoah Co., Virginia; and at Lake Valley, Sierra Co., New Mexico. From the Caland mine, Atikokan, Ontario, Canada. At Kuruman, Cape Province, South Africa.

Name: For MANGANese in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 646–650. (2) Dachs, H. (1963) Neutronen- und Röntgenuntersuchungen am Manganit, MnOOH. Zeits. Krist., 118, 303–326 (in German with English abs.). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 350.

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Manganlotharmeyerite $Ca(Mn^{3+}, \square, Mg)_2\{AsO_4, [AsO_2(OH)_2]\}_2(OH, H_2O)_2$

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Crystal Data: Cubic. *Point Group:* 23. Small tetrahedral crystals.

Physical Properties: Hardness = n.d. D(meas.) = 3.02–3.03 D(calc.) = 3.057

Optical Properties: Semitransparent. *Color:* Rose-red.
Optical Class: Isotropic. $n = 1.572$

Cell Data: *Space Group:* $P2_13$. $a = 10.014$ Z = 4

X-ray Powder Pattern: Synthetic.
3.198 (100), 2.702 (50), 3.047 (18), 1.6401 (16), 4.128 (14), 2.064 (14), 1.984 (14)

Chemistry: (1) Natural material has not been analyzed, but was determined to contain potassium and manganese; identification then depended additionally on the correspondence of the isotropic index of refraction with that of synthetic material.

Occurrence: In a cavern in lava, in thénardite and halite stalactites, formed by fumarolic action.

Association: Thénardite, halite, sylvite, aphthitalite.

Distribution: On Vesuvius, Campania, Italy.

Name: As a *manganese* compound analogous to *langbeinite*.

Type Material: University of Florence, Florence, Italy, 1975/I.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 435. (2) (1968) NBS Mono. 25, 6, 43.

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Mangan-neptunite $KNa_2Li(Mn^{2+},Fe^{2+})_2Ti_2Si_8O_{24}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Crystals prismatic, somewhat elongated along [001], to 7 cm, showing {110}, {001}, {100}, also {111}, {$\bar{1}$11}, rare {210}. Also as aggregates of small crystals, druses, rosettes, blooms, and earthy crusts. *Twinning:* As contact twins on {001}.

Physical Properties: *Cleavage:* Distinct in two directions, intersecting at ~80°. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.17–3.20 D(calc.) = 3.26

Optical Properties: Transparent to translucent to opaque. *Color:* Dark cherry-red, orange, or black in small crystals; cherry-red in thin fragments; in thin section, light yellow, orange, or red-orange. *Streak:* Brick-red to reddish brown. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (+). *Pleochroism:* Distinct; X = light yellow; Y = orange or yellow-orange; Z = red-orange. *Orientation:* $Y = b$; $Z \wedge c = 16°–20°$. *Dispersion:* $r < v$, very strong. *Absorption:* $Z > Y > X$. $\alpha = 1.691–1.697$ $\beta = 1.693–1.700$ $\gamma = 1.713–1.728$ 2V(meas.) = 31°–36°

Cell Data: *Space Group:* $C2/m$ or $C2/c$. $a = 16.38$ $b = 12.48$ $c = 10.01$ $\beta = 115°24'$ Z = 4

X-ray Powder Pattern: Lovozero massif, Russia.
2.485 (100), 1.506 (100), 1.483 (90), 2.170 (80), 1.924 (70), 2.841 (60), 2.948 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	52.65	52.68	52.98	CaO	0.37	0.43	
TiO_2	17.38	18.21	17.61	Li_2O	1.08		1.65
Al_2O_3	0.99			Na_2O	5.12	9.16	6.83
Fe_2O_3	1.07			K_2O	6.30	4.94	5.19
FeO	5.54	5.16	7.92	H_2O^+	0.06		
MnO	8.87	9.95	7.82	H_2O^-	0.10		
MgO	0.15	0.12		Total	99.68	100.65	100.00

(1) Mt. Karnasurt, Lovozero massif, Russia. (2) Kola Peninsula, Russia. (3) $KNa_2Li(Mn,Fe)_2Ti_2Si_8O_{24}$ with Mn:Fe = 1:1.

Polymorphism & Series: Forms a series with neptunite.

Occurrence: A late segregation mineral found in almost all rock types, including most of the pegmatites, in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Aegirine, natrolite, analcime, lamprophyllite, murmanite, lomonosovite, eudialyte, pectolite, villiaumite, sodalite (Lovozero massif, Russia); in miarolitic cavities in a nepheline syenite sill (Saint-Amable, Canada).

Distribution: On Mt. Malyi Mannepakhk, Khibiny massif, and in the Lovozero massif, Kola Peninsula, Russia. At Point of Rocks, Colfax Co., New Mexico, USA. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada. On Mt. Malosa, Zomba district, Malawi.

Name: For the preponderance of *manganese* in this chemical variant of the *neptunite* structure.

Type Material: n.d.

References: (1) A.E. Fersman (1923) Minerals of the Khibina and Lovozero Tundras. Trans. Northern Sci. Econ. Exped., 16, pp. 16, 69, 73. (2) (1927) Amer. Mineral., 12, 96–97 (abs. ref.

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1). (3) Bussen, I.V., A.P. Denisov, R.A. Kravchenko-Berezhnoi, and E.I. Uspenskaya (1965) Mineralogy of manganoneptunite [*sic*]. Zap. Vses. Mineral. Obshch., 94, 204–207 (in Russian). (4) (1965) Chem. Abs., 63, 2756–2757 (abs. ref. 3). (5) Mandarino, J.A., D.C. Harris, and J. Bradley (1965) Mangan-neptunite, epididymite, and new species from Mont St. Hilaire, Quebec. Can. Mineral., 8, 398. (6) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 373–376 (in English). (7) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 134. (8) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 104.

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Manganochromite $(Mn^{2+}, Fe^{2+})(Cr^{3+}, V^{3+})_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As six-sided grains, to 10 μm.

Physical Properties: Hardness = n.d. VHN = 1000(70) (100 g load). D(meas.) = n.d. D(calc.) = 4.86–4.90

Optical Properties: Semitransparent. *Color:* Brownish gray in reflected light. *Optical Class:* Isotropic.
R: (470) 16.8, (546) 16.5, (589) 16.5, (650) 16.3

Cell Data: *Space Group:* $Fd3m$. a = 8.47 Z = 8

X-ray Powder Pattern: Nairne deposit, South Australia.
2.55 (s), 1.63 (s), 1.50 (s), 4.89 (w), 2.99 (w), 2.44 (w), 1.73 (w)

Chemistry:

	(1)	(2)
TiO_2		0.2
V_2O_3	1.7	30.5
Cr_2O_3	62.3	35.9
FeO	9.4	5.3
MnO	24.0	26.3
ZnO	1.7	0.7
Total	[99.1]	98.9

(1) Nairne deposit, South Australia; original total given as 99.0%; corresponds to $(Mn_{0.77}Fe_{0.30}Zn_{0.05})_{\Sigma=1.12}(Cr_{1.88}V_{0.04})_{\Sigma=1.92}O_4$. (2) Sätra mine, Sweden; by electron microprobe, total Fe as FeO; corresponds to $(Mn_{0.83}Fe_{0.17}Zn_{0.02})_{\Sigma=1.02}(Cr_{1.06}V_{0.92}Ti_{0.01})_{\Sigma=1.99}O_4$.

Polymorphism & Series: Forms a series with vuorelainenite.

Mineral Group: Spinel group.

Occurrence: From an extension gash vein in a metamorphosed hydrothermal pyrite deposit (Nairne deposit, South Australia); in a metamorphosed iron sulfide deposit associated with submarine felsic volcanism (Sätra mine, Sweden); in sulfide nodules in an iron meteorite (Burkhala meteorite).

Association: Pyrrhotite, rutile, diopside (Nairne deposit, South Australia); vuorelainenite, sphalerite, alabandite (Sätra mine, Sweden); troilite, daubreelite, alabandite, zinc sulfides, olivine, pyroxene (Burkhala meteorite).

Distribution: From the Nairne deposit, near Brukunga, 47 km east of Adelaide, South Australia. In the Sätra mine, Doverstorp, Bergslagen metallic province, Sweden. Noted in the Burkhala meteorite.

Name: For MANGANese in its composition, and relation to *magnesiochromite*.

Type Material: Western Australian Museum, Perth, Australia, M.65.1991.

References: (1) Graham, J. (1978) Manganochromite, palladium antimonide, and some unusual mineral associations at the Nairne pyrite deposit, South Australia. Amer. Mineral., 63, 1166–1174. (2) Zakrzewski, M.A., E.A.J. Burke, and W.J. Lustenhouwer (1982) Vuorelainenite, a new spinel, and associated minerals from the Sätra (Doverstorp) pyrite deposit, central Sweden. Can. Mineral., 20, 281–290.

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Manganocolumbite $(Mn^{2+}, Fe^{2+})(Nb, Ta)_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. [Crystals short prismatic or equant, also tabular; in groups of parallel or subparallel crystals; massive] (by analogy to ferrocolumbite). *Twinning:* [on {021} and {023}, may produce pseudohexagonal trillings.]

Physical Properties: *Cleavage:* [Distinct on {100}, less distinct on {010}.] *Fracture:* [Subconchoidal to uneven.] *Tenacity:* [Brittle.] Hardness = [6] D(meas.) = 5.20–6.65 D(calc.) = [5.30]

Optical Properties: Opaque, translucent through thin edges. *Color:* Black to brownish black; reddish brown in transmitted light; in reflected light, grayish white with a brownish tint, with reddish brown internal reflections. *Streak:* Dark red to black. *Luster:* Submetallic to vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; red, red-brown, and orange. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$. *Absorption:* Strong; $Z > X$. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.
R_1–R_2: n.d.

Cell Data: *Space Group: Pbcn* (synthetic). $a = 14.433(2)$ $b = 5.7637(7)$ $c = 5.0832(8)$ $Z = 4$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	68.00	46.8	78.93
Ta_2O_5	9.88	31.2	
TiO_2	0.53	1.9	
$SnO_2 + WO_3$	0.88	0.4	
FeO	5.45	8.6	
MnO	14.79	9.4	21.07
Na_2O		0.02	
Total	99.53	98.32	100.00

(1) Old Mike mine, South Dakota, USA. (2) Herbb #2 pegmatite, Virginia, USA; by electron microprobe, total Fe as Fe^{2+}, total Mn as MnO; corresponding to $(Mn_{0.52}Fe_{0.47})_{\Sigma=0.99}(Nb_{1.37}Ta_{0.55}Ti_{0.09}Sn_{0.01})_{\Sigma=2.02}O_6$. (3) $MnNb_2O_6$.

Polymorphism & Series: Forms two series, with ferrocolumbite, and with manganotantalite.

Occurrence: As an accessory and primary constituent of granite pegmatites; detrital in placers.

Association: [Albite, microcline, beryl, lepidolite, muscovite, tourmaline, spodumene, lithiophilite, triphylite, amblygonite, triplite, apatite, samarskite, microlite, cassiterite.]

Distribution: Analyzed material from: in the USA, the Globe and Harding pegmatites, Taos Co., New Mexico; near Cañon City, Fremont Co., Colorado; at Elk Creek, Pennington Co., and the Old Mike mine, six km north-northwest of Custer, Custer Co., South Dakota; from Mineral Hill, Delaware Co., Pennsylvania; at the Herbb #2 pegmatite, six km northeast of Flat Rock, Powhatan Co., Virginia. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada. From the Varuträsk pegmatite, 15 km north of Skellefteå, Västerbotten, and from Utö, Stockholm, Skärgård, Sweden. Around Okehampton, Devon, England. Occurs at San Piero in Campo, Elba, Italy.

Name: For its dominant MANGANese content and its relation to ferroCOLUMBITE.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 780–787. (2) Wise, M.A. and P. Černý (1984) First U.S. occurrence of wodginite from Powhatan County, Virginia. Amer. Mineral., 69, 807–809. (3) Wise, M.A., A.C. Turnock, and P. Černý (1985) Improved unit cell dimensions for ordered columbite-tantalite end members. Neues Jahrb. Mineral., Monatsh., 372–378.

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Manganoeudialyte $Na_{14}Ca_6Mn_3Zr_3[Si_{26}O_{72}(OH)_2]Cl_2 \cdot 4H_2O$

Crystal Data: Hexagonal. *Point Group*: 3*m*. As cm-wide massive patches in igneous rock.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 5-6 D(meas.) = 2.890 D(calc.) = 2.935

Optical Properties: Transparent to translucent. *Color*: Pink to purple. *Streak*: White.
Luster: Vitreous.
Optical Class: Uniaxial (+). ω = 1.603(2) ε = 1.608(2)

Cell Data: *Space Group*: *R3m.* a = 14.2418(1) c = 30.1143(3) Z = 3

X-ray Powder Pattern: Poços de Caldas massif, Minas Gerais, Brazil.
3.218 (100), 1.609 (77), 3.526 (46), 1.605 (41), 6.421 (37), 4.329 (30), 3.023 (25)

Chemistry:

	(1)	(2)		(1)	(2)
Na_2O	12.01	14.18	SiO_2	48.70	51.05
K_2O	0.59		TiO_2	0.47	
CaO	10.70	11.00	ZrO_2	12.08	12.08
MnO	3.51	6.96	Nb_2O	1.21	
SrO	3.00		HfO_2	0.25	
FeO	2.72		F	0.08	
Al_2O_3	0.41		Cl	0.99	2.32
La_2O_3	0.15		H_2O	3.5	2.94
Ce_2O_3	0.12		$- O = (Cl,F)_2$	0.26	0.52
Nd_2O_3	0.00		Total	100.23	100.00

(1) Poços de Caldas massif, Minas Gerais, Brazil; average of 12 electron microprobe analyses, IR spectroscopy confirms absence of CO_2 and presence of OH and H_2O; corresponding to $[Na_{11.93}Sr_{0.81}(H_3O)_{0.70}K_{0.39}Ce_{0.07}]_{\Sigma=13.90}[Ca_6][^{VI}Mn_{1.56}{}^{V}Fe_{1.20}{}^{V}Na_{0.24}]_{\Sigma=3.00}[Zr_3][^{IV}(Si_{0.38}Al_{0.25})$ $^{VI}(Nb_{0.29}Zr_{0.08})]_{\Sigma=1.00}[^{IV}Si_{0.81}{}^{VI}Ti_{0.19}]_{\Sigma=1.00}[Si_{24}O_{72}][(OH)_2][(H_2O)_{3.55}Cl_{0.88}(OH)_{0.84}O_{0.40}F_{0.13}]_{\Sigma=5.80}$.
(2) $Na_{14}Ca_6Mn_3Zr_3[Si_{26}O_{72}(OH)_2]Cl_2 \cdot 4H_2O$.

Mineral Group: Eudialyte group.

Occurrence: An interstitial phase in nepheline syenite (khibinite).

Association: Eudialyte, K-feldspar, nepheline, aegirine, analcime, sodalite, rinkite, lamprophyllite, astrophyllite, titanite, fluorite, cancrinite.

Distribution: At the northern edge ("Anel Norte"), Poços de Caldas massif, Minas Gerais, Brazil.

Name: As a member of the *eudialyte* group with dominant manganese in the *M2* structural sites and silicon dominant in *M3* and *M4* sites.

Type Material: Museum of Geosciences, Institute of Geosciences, University of São Paulo, São Paulo, Brazil (DR704).

References: (1) Nomura, S.F., D. Atencio, N.V. Chukanov, R.K. Rastsvetaeva, J.M.V. Coutino, and T.K. Karipidis (2010) Manganoeudialyte - a new mineral from Poços De Caldas, Minas Gerais, Brazil. Zap. Ross. Mineral. Obshch., 139(4), 35-47 (in English with Russian abstract). (2) (2012) Amer. Mineral., 97, 1263-1264 (abs. ref. 1).

Dannemorite $Mn_2(Fe^{2+},Mg)_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, fibrous, to 1 cm; columnar or asbestiform.

Physical Properties: *Cleavage:* Perfect on {110}, with intersections at ∼55° and ∼125°. *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.50 D(calc.) = [3.35]

Optical Properties: Transparent to translucent. *Color:* Yellowish brown, greenish gray, colorless. *Luster:* Silky to vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = red-violet; Y = pale violet; Z = blue. *Orientation:* $Y = b$; $Z \wedge c = 15°$. *Dispersion:* $r < v$. $\alpha = 1.666$ $\beta = 1.682$ $\gamma = 1.698$ 2V(meas.) = 88°

Cell Data: *Space Group:* $C2/m$. a = 9.561 (ICDD 23-302). $b = 18.28$ $c = 5.348$ $\beta = 102.09°$ Z = 2

X-ray Powder Pattern: Väster Silfberg, Sweden. (ICDD 23-302).
8.40 (100), 3.08 (60), 3.28 (20), 2.764 (18), 4.70 (12), 2.637 (10), 2.201 (10)

Chemistry:

	(1)	(2)
SiO_2	50.74	51.6
TiO_2	0.06	0.13
Al_2O_3	0.88	0.65
Fe_2O_3	1.80	
FeO	24.13	23.9
MnO	7.38	8.1
MgO	10.57	11.1
CaO	2.00	0.83
Na_2O	0.22	1.1
K_2O	0.08	0.09
F	0.07	
H_2O^+	1.94	
Total	99.87	97.5

(1) Uttersvik, Sweden; corresponds to $(Fe^{2+}_{3.10}Mg_{2.42}Mn_{0.96}Ca_{0.33}Fe^{3+}_{0.21}Na_{0.07}Ti_{0.01}K_{0.01})_{\Sigma=7.11}(Si_{7.80}Al_{0.16})_{\Sigma=7.96}O_{22}[(OH)_{1.99}F_{0.03}]_{\Sigma=2.02}$. (2) Haute-Maurienne, France; by electron microprobe.

Polymorphism & Series: Forms a series with tirodite.

Mineral Group: Amphibole (Fe–Mn–Mg) group: $Mg/(Mg + Fe^{2+}) < 0.5$; $(Ca + Na)_B < 1.34$; $Li < 1.0$; $Mn \geq 0.5$.

Occurrence: An uncommon mineral in metamorphosed iron-poor manganiferous rocks.

Association: Calcite, quartz, garnet.

Distribution: From Dannemora, Uppland; Uttersvik and Nävekvarn, Södermanland; in the Brunsjö mine, near Grythyttan, Örebro; and at Väster Silfberg, Värmland, Sweden. At Haute-Maurienne, Isère, France. From Guarulhos, São Paulo, Brazil. At Paddy's River mine, Australian Capital Territory, and from Broken Hill, New South Wales, Australia.

Name: For the original locality, Dannemora, Sweden.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 386, 391, 395. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 239. (3) Mottana, A. (1986) Blueschist-facies metamorphism of manganiferous cherts: a review of the alpine occurrences. In: B.W. Evans and E.H. Brown, Eds., Blueschists and eclogites, Geol. Soc. Amer. Memoir 164, 267–299.

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Manganokaskasite $(Mo,Nb)S_2{\cdot}(Mn_{1-x}Al_x)(OH)_{2+x}$

Crystal Data: Hexagonal. *Point Group*: 3*m*, 32, or $\bar{3}$ 2/*m*. As lamellar or flaky, mica-like crystals flattened on [001], to 1 mm; also epitaxial and coplanar with {001} of pyrrhotite.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Laminated. *Tenacity*: Flexible, inelastic. Hardness = ~1 D(meas.) = n.d. D(calc.) = 4.09

Optical Properties: Opaque. *Color*: Iron black; light to dark gray in reflected light. *Streak*: Black. *Luster*: Metallic. *Anisotropism:* Strong. *Pleochroism*: Strong, light yellowish to blue-gray. *Optical Class*: n.d.
R_1-R_2: (470) 10.4-25.6, (546) 10.5-25.0, (589) 10.6-24.7, (650) 10.6-24.5

Cell Data: *Space Group*: $P\bar{3}\,m1$, $P3m1$, or $P321$. [a = 3.243(3) c = 11.71(1) sulfide sub-lattice] [a = 3.118(2) c = 11.62(1) hydroxide sub-lattice] One-layer polytypes. Z = 1

X-ray Powder Pattern: Mt. Kaskasnyunchorr, Khibiny alkaline complex, Kola Peninsula, Russia. 5.66 (100), 11.39 (85), 2.769 (43), 2.663 (25), 1.608 (23), 2.455 (18), 1.559 (13)

Chemistry:

	(1)		(1)
Mg	0.06	Nb	14.15
Al	3.00	Mo	20.08
Ca	0.00	W	9.12
V	0.15	S	24.84
Mn	11.44	O	13.36
Fe	2.06	H	[0.89]
		Total	99.15

(1) Mt. Kaskasnyunchorr, Russia; average of 5 electron microprobe analyses, H calculated so that all O are OH^-, OH^- confirmed by Raman spectroscopy; corresponding to $(Mo_{0.57}Nb_{0.34}W_{0.10}V_{0.01})_{\Sigma=1.02}S_2{\cdot}(Mg_{0.58}Al_{0.32}Fe_{0.06}Mn_{0.01})_{\Sigma=0.97}(OH)_{2.32}$.

Mineral Group: Valleriite group.

Polymorphism & Series: Forms a series with kaskasite.

Occurrence: Of hydrothermal origin in fenites formed by a peralkaline fluid, as a source of Nb, reacting with a xenolith of alumina-rich metamorphic rocks (metapelites) in agpaitic nepheline syenite.

Association: Orthoclase, anorthoclase, nepheline, fluorophlogopite, corundum, pyrrhotite, pyrite, rutile, monazite-(Ce), graphite, edgarite, molybdenite, tungstenite, alabandite, fluorite.

Distribution: From Mt. Kaskasnyunchorr, Khibiny alkaline complex, Kola Peninsula, Russia.

Name: As the manganese analog of *kaskaite*.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 94232).

References: (1) Pekov, I.V., V.O. Yapaskurt, Y.S. Polekhovsky, M.F. Vigasina, and O.I. Siidra (2014) Ekplexite $(Nb,Mo)S_2{\cdot}(Mg_{1-x}Al_x)(OH)_{2+x}$, kaskasite $(Mo,Nb)S_2{\cdot}(Mg_{1-x}Al_x)(OH)_{2+x}$ and manganokaskasite $(Mo,Nb)S_2{\cdot}(Mn_{1-x}Al_x)(OH)_{2+x}$, three new valleriite-group mineral species from the Khibiny alkaline complex, Kola peninsula, Russia. Mineral. Mag., 78(3), 663-679. (2) (2015) Amer. Mineral., 100, 658-659 (abs. ref. 1).

Manganokukisvumite $Na_6MnTi_4Si_8O_{28}•4H_2O$

Crystal Data: Orthorhombic. *Point Group:* 2/*m* 2/*m* 2/*m*. As sword-shaped crystals, flattened on {100}, elongate on [001] to 0.5 mm, showing {100}, {010}, and a prism; as fan-shaped to radial groups.

Physical Properties: *Cleavage:* None. *Fracture:* Splintery. *Tenacity:* Sectile and slightly flexible. Hardness = 5.5-6 D(meas.) = 2.86(1) D(calc.) = 2.88

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (-). α(calc.) = 1.657 β = 1.744(3) γ = 1.792(3) 2V(meas.) = 70° *Dispersion*: None. *Orientation: X = a*; *Y = b*; *Z = c*.

Cell Data: *Space Group: Pccn*. a = 29.05(2) b = 8.612(6) c = 5.220(4) Z = 2

X-ray Powder Pattern: Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada.
14.47 (100), 3.025 (40), 6.43 (20), 2.881 (20), 4.83 (10), 3.743 (10), 2.591 (10)

Chemistry:

	(1)		(1)
Na_2O	15.61	Al_2O_3	0.16
K_2O	0.21	Ce_2O_3	0.18
CaO	0.08	TiO_2	26.90
MgO	0.26	SiO_2	41.74
MnO	5.48	Nb_2O_5	0.68
FeO	0.57	H_2O	6.25
ZnO	0.00	Total	98.12

(1) Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada; average of 2 electron microprobe analyses, H_2O confirmed by IR and calculated; corresponding to $(Na_{5.81}K_{0.05}Ca_{0.02}Ce_{0.01})_{\Sigma=5.89}(Mn_{0.89}Fe_{0.09}Mg_{0.01}Al_{0.04})_{\Sigma=1.09}(Ti_{3.88}Nb_{0.06})_{\Sigma=3.94}Si_{8.01}O_{28}\cdot 4H_2O$.

Occurrence: A late mineral formed by hydrothermal dissolution of titanium-bearing minerals in an albite-rich syenite breccia in an intrusive alkaline complex.

Association: Aegirine, microcline, albite, annite, pyrite, pyrrhotite, natrolite, calcite (Canada); kukisvumite (Russia).

Distribution: Poudrette quarry, Mont Saint-Hilaire, Rouville County, Quebec, Canada; from Mount Kukisvumchorr, Khibiny massif, Russia.

Name: As the manganese-dominant analogue of kukisvumite.

Type Material: Canadian Museum of Nature, Ottawa, Ontario, Canada; CMNMC 83392 and CMNMC 83393.

References: (1) Gault, R.A., T.S. Ercit, J.D. Grice, and J. Van Velthuizen (2004) Manganokukisvumite, a new mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 42, 781-785. (2) (2005) Amer. Mineral., 90, 520 (abs. ref. 1).

Manganolangbeinite $K_2Mn_2^{2+}(SO_4)_3$

Crystal Data: Cubic. *Point Group:* 23. Small tetrahedral crystals.

Physical Properties: Hardness = n.d. D(meas.) = 3.02–3.03 D(calc.) = 3.057

Optical Properties: Semitransparent. *Color:* Rose-red.
Optical Class: Isotropic. $n = 1.572$

Cell Data: *Space Group:* $P2_13$. a = 10.014 Z = 4

X-ray Powder Pattern: Synthetic.
3.198 (100), 2.702 (50), 3.047 (18), 1.6401 (16), 4.128 (14), 2.064 (14), 1.984 (14)

Chemistry: (1) Natural material has not been analyzed, but was determined to contain potassium and manganese; identification then depended additionally on the correspondence of the isotropic index of refraction with that of synthetic material.

Occurrence: In a cavern in lava, in thénardite and halite stalactites, formed by fumarolic action.

Association: Thénardite, halite, sylvite, aphthitalite.

Distribution: On Vesuvius, Campania, Italy.

Name: As a *manganese* compound analogous to *langbeinite.*

Type Material: University of Florence, Florence, Italy, 1975/I.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 435. (2) (1968) NBS Mono. 25, 6, 43.

Manganosegelerite $(Mn^{2+},Ca)(Mn^{2+},Fe^{2+},Mg)Fe^{3+}(PO_4)_2(OH)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Subhedral prismatic crystals, to 0.05 mm, in granular aggregates.

Physical Properties: *Cleavage:* Imperfect on {001}. Hardness = 3–4 D(meas.) = 2.76(3) D(calc.) = 2.74

Optical Properties: Transparent to translucent. *Color:* Yellow to yellow-green. *Streak:* Yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* X = yellow; Z = pale yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, marked. $\alpha = 1.657(1)$ $\beta = 1.668(1)$ $\gamma = 1.691(2)$ 2V(meas.) = 75(5)° 2V(calc.) = 70°

Cell Data: *Space Group:* [*Pbca*] (by analogy to overite). $a = 14.89(1)$ $b = 18.79(1)$ $c = 7.408(5)$ Z = 8

X-ray Powder Pattern: Mt. Vasin-Myl'k, Kola Peninsula, Russia.
9.39 (10), 2.86 (9), 4.70 (5), 1.966 (5), 1.880 (5), 2.97 (4), 2.60 (4)

Chemistry:

	(1)
P_2O_5	33.21
Al_2O_3	1.48
Fe_2O_3	22.61
MnO	16.37
MgO	2.83
CaO	5.14
H_2O	[18.36]
Total	[100.00]

(1) Mt. Vasin-Myl'k, Kola Peninsula, Russia; by electron microprobe; total Fe as Fe_2O_3, total Mn as MnO, H_2O by difference, Fe^{2+}:Fe^{3+} for charge balance, $(OH)^{1-}$ and H_2O confirmed by IR; then corresponding to $(Mn_{0.61}Ca_{0.39})_{\Sigma=1.00}(Mn_{0.38}Fe^{2+}_{0.33}Mg_{0.30})_{\Sigma=1.01}(Fe^{3+}_{0.88}Al_{0.12})_{\Sigma=1.00}(PO_4)_{2.00}(OH)_{1.02}\cdot 4.04H_2O$.

Mineral Group: Overite group.

Occurrence: In fractures in granite pegmatite.

Association: Mitridatite, lun'okite, eosphorite, kingsmountite, manganoan gordonite.

Distribution: On Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia.

Name: As the *manganese* analog of *segelerite*.

Type Material: Mining Institute, St. Petersburg, 1592/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, and F.N. Tyusheva (1992) Manganosegelerite $(Mn,Ca)(Mn,Fe,Mg)Fe^{3+}(PO_4)_2(OH)\cdot 4H_2O$ – a new phosphate of the overite group from granitic pegmatites of the Kola Peninsula. Zap. Vses. Mineral. Obshch., 121(2), 95–103 (in Russian). (2) (1994) Amer. Mineral., 79, 185–186 (abs. ref. 1).

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Manganosite $Mn^{2+}O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Octahedral crystals with cube and dodecahedron; commonly granular, cleavable massive, to 10 cm.

Physical Properties: *Cleavage:* {001}, fair; {111}, parting. *Fracture:* Fibrous.
Hardness = 5.5 VHN = 317–328 (100 g load). D(meas.) = 5.364 D(calc.) = 5.365

Optical Properties: Transparent. *Color:* Emerald-green, becoming black on exposure; emerald-green in transmitted light; gray in reflected light, with emerald-green internal reflections. *Streak:* Brown. *Luster:* Vitreous to adamantine, dull on exposure.
Optical Class: Isotropic. n = 2.16–2.17
R: (400) 13.8, (420) 14.4, (440) 15.0, (460) 14.8, (480) 14.5, (500) 14.2, (520) 14.0, (540) 13.9, (560) 13.8, (580) 13.6, (600) 13.5, (620) 13.6, (640) 13.6, (660) 13.6, (680) 13.6, (700) 13.6

Cell Data: *Space Group:* $Fm3m$. a = 4.436(2) Z = 4

X-ray Powder Pattern: Synthetic.
2.223 (100), 2.568 (60), 1.571 (60), 1.340 (18), 0.9938 (18), 0.9074 (16), 1.283 (14)

Chemistry:

	(1)	(2)
$FeO + Fe_2O_3$	0.42	0.3
MnO	98.04	97.9
ZnO		0.4
MgO	1.71	1.2
CaO	0.16	
Total	100.33	99.8

(1) Långban, Sweden; average of two analyses. (2) Do.; by electron microprobe.

Mineral Group: Periclase group.

Occurrence: An alteration product of rhodochrosite or other manganese minerals, formed during oxygen-deficient metamorphism of manganese-bearing deposits; in marine manganese nodules.

Association: Pyrochroite, manganite, dolomite (Långban, Sweden); pyrochroite, hausmannite, garnet, dolomite (Nordmark, Sweden); franklinite, willemite, zincite (Franklin, New Jersey, USA).

Distribution: From Långban and Nordmark, Värmland, Sweden. From Roughton Gill, Caldbeck Fells, Cumbria, England. In the USA, at Franklin, Sussex Co., New Jersey. In Japan, an ore mineral in the Noda-Tamagawa mine, Iwate Prefecture, and the Hamayokokawa mine, Nagano Prefecture; in the Manako, Oashi, Kaso, and Hikoma mines, Tochigi Prefecture; the Taguchi mine, Aichi Prefecture; the Ioi mine, Shiga Prefecture; and elsewhere. On Inylchek Ridge, Tien Shan, Kyrgyzstan. From near Tambao, Burkina Faso.

Name: As an oxide of *manganese*.

Type Material: Wroclaw University, Wroclaw, Poland, II–1810.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 501–502. (2) Gavarri, J.-R., J. Arabski, S. Jasienska, J. Janowski, and C. Garel (1985) Structural evolution of manganosite: comparison of properties of nonstoichiometric manganese and iron monoxides. J. Solid State Chem., 58, 56–70. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 351. (4) (1955) NBS Circ. 539, 5, 45.

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Manganostibite $(Mn^{2+},Fe^{2+})_7Sb^{5+}As^{5+}O_{12}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As subhedral prismatic grains.

Physical Properties: *Fracture:* Uneven. Hardness = n.d. D(meas.) = 4.949 D(calc.) = 5.00

Optical Properties: Opaque to slightly translucent. *Color:* Coal-black; dark reddish brown in transmitted light. *Streak:* Chocolate-brown. *Luster:* Greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = reddish brown; Z = nearly opaque. *Orientation:* $X = b$; $Z \wedge c$ = very large. $\alpha = 1.92(2)$ $\beta = 1.95(2)$ $\gamma = 1.96(2)$ 2V(meas.) = Very small.

Cell Data: *Space Group: Ibmm.* $a = 8.727(5)$ $b = 18.847(6)$ $c = 6.062(4)$ Z = 4

X-ray Powder Pattern: Moss mine, Sweden.
2.651 (10), 4.965 (6), 4.38 (6), 1.5418 (5), 2.180 (5), 9.313 (4), 4.694 (4)

Chemistry:

	(1)	(2)
As_2O_5	7.44	11.7
Sb_2O_5	24.09	21.8
SiO_2		3.0
FeO	5.00	1.8
MnO	55.77	61.8
MgO	3.00	2.5
CaO	4.62	
Total	99.92	102.6

(1) Moss mine, Sweden. (2) Brattfors mine, Sweden; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(Mn_{6.34}Mg_{0.45}Fe_{0.19})_{\Sigma=6.98}Sb_{0.98}As_{0.74}Si_{0.36}O_{12}$.

Occurrence: In late-stage hydrothermal veins in manganese deposits in limestone.

Association: Hausmannite, sonolite, katoptrite, manganoan humite, garnet.

Distribution: In the Moss and Brattfors mines, near Nordmark, Värmland, Sweden.

Name: For MANGANese and antimony, STIBium, in the composition.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1027. (2) Moore, P.B. (1967) Contributions to Swedish mineralogy. II. Melanostibite and manganostibite, two unusual antimony minerals. The identity of ferrostibian with långbanite. Arkiv Mineral. Geol., 4(23), 449–458. (3) Moore, P.B. (1970) Manganostibite: a novel cubic close-packed structure type. Amer. Mineral., 55, 1489–1499. (4) Dunn, P.J. (1986) Manganostibite: new chemical data, and its relation to kolicite and holdenite. Geol. Fören. Förhandl. Stockholm, 109, 101–102.

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Manganotantalite $(Mn^{2+}, Fe^{2+})(Ta, Nb)_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. [Crystals short prismatic or equant, also tabular; in groups of parallel or subparallel crystals; massive] (by analogy to ferrocolumbite). *Twinning:* [On {021} and {023}, may produce pseudohexagonal trillings.]

Physical Properties: *Cleavage:* [{100}, distinct; {010}, less distinct.]
Fracture: [Subconchoidal to uneven.] *Tenacity:* [Brittle.] Hardness = [6] VHN = 488–681 (100 g load). D(meas.) = 6.65–8.00 D(calc.) = 8.01

Optical Properties: Opaque, transparent in thin edges. *Color:* Pink to nearly colorless, or reddish brown to black; colorless, reddish brown to red in transmitted light. *Streak:* Red, scarlet to black. *Luster:* Submetallic to vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; red, red-brown, and orange. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$. *Absorption:* Strong; $Z > X$. $\alpha = 2.14$ $\beta = 2.15$ $\gamma = 2.22$ 2V(meas.) = n.d.
R_1–R_2: (400) 15.5–16.4, (420) 15.1–16.0, (440) 14.8–15.7, (460) 14.6–15.4, (480) 14.3–15.2, (500) 14.1–15.0, (520) 13.9–14.8, (540) 13.8–14.7, (560) 13.6–14.5, (580) 13.6–14.4, (600) 13.5–14.4, (620) 13.5–14.3, (640) 13.4–14.3, (660) 13.4–14.3, (680) 13.3–14.2, (700) 13.3–14.2

Cell Data: *Space Group: Pbcn* (synthetic). $a = 14.440(2)$ $b = 5.7661(8)$ $c = 5.0930(9)$ Z = 4

X-ray Powder Pattern: Salinas, Brazil.
2.99 (10), 3.69 (9), 2.41 (7), 1.738 (7), 1.483 (7), 7.25 (5), 3.61 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5	4.47	0.29		MnO	13.88	13.8	13.83
Ta_2O_5	79.81	85.8	86.17	CaO	0.17		
$SnO_2 + WO_3$	0.67	0.03		LOI	0.16		
FeO	1.17	0.04		Total	100.33	99.96	100.00

(1) Sanarka, Russia. (2) Morrua mine, Zambesia, Mozambique; by electron microprobe, corresponds to $Mn_{1.00}(Ta_{1.99}Nb_{0.01})_{\Sigma=2.00}O_6$. (3) $MnTa_2O_6$.

Polymorphism & Series: Dimorphous with manganotapiolite; forms two series, with manganocolumbite, and with ferrotantalite.

Occurrence: As an accessory and primary constituent of granite pegmatites; detrital in placers.

Association: [Albite, microcline, beryl, lepidolite, muscovite, tourmaline, spodumene, lithiophilite, triphylite, amblygonite, triplite, samarskite, apatite, microlite, cassiterite.]

Distribution: Found on the Island of Utö, Sweden. At Glenbuchat, Aberdeenshire, Scotland. From Facciatoia, Elba, Italy. In the Zambesia, Tete, and Alto Ligonha districts, Mozambique. From Bikita, Zimbabwe. At the Steinkopf, Namaqualand, South Africa. In Brazil, from Salinas, Minas Gerais, and the Alto do Giz pegmatite, near Parelhas, Rio Grande do Norte. At Stak Nala, Gilgit district, Pakistan. From Wodgina, Greenbushes, and on Mt. Holland, Western Australia. In the USA, large crystals from Amelia, Amelia Co., Virginia; at Pala, San Diego Co., California. From the Tanco pegmatite, Bernic Lake, Manitoba, Canada. A few other less-well-defined localities are known.

Name: For its dominant MANGANese content, and the Greek mythical *Tantalus*, for the difficulty in bringing the mineral into solution.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 780–787. (2) Sahama, T.G. (1980) Minerals of the tantalite-niobite series from Mozambique. Bull. Minéral., 103, 190–197. (3) Wise, M.A., A.C. Turnock, and P. Černý (1985) Improved unit cell dimensions for ordered columbite-tantalite end members. Neues Jahrb. Mineral., Monatsh., 372–378.

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Manganotapiolite $(Mn^{2+}, Fe^{2+})(Ta, Nb)_2O_6$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Massive, in a zone, to 100 μ wide, in a poorly developed prismatic ferrotapiolite crystal, 1.5 mm long.

Physical Properties: Hardness = n.d. VHN = 665–752, 711 average (100 g load), probably low due to fractures. D(meas.) = n.d. D(calc.) = 7.72

Optical Properties: Opaque, translucent in very thin fragments. *Color:* Dark brown; gray in reflected light, with strong red-brown internal reflections. *Streak:* Dark brown. *Luster:* Adamantine to submetallic.
Optical Class: Uniaxial. *Pleochroism:* Strong; yellowish brown to reddish brown.
Bireflectance: Weak; light brownish gray to gray.
R_1–R_2: (470) 16.0–15.7, (546) 14.7–14.1, (589) 15.0–14.8, (650) 15.1–14.6

Cell Data: *Space Group:* $P4_2/mnm$. $a = 4.762(5)$ $c = 9.272(5)$ $Z = 2$

X-ray Powder Pattern: Eräjärvi area, Finland.
3.367 (100), 2.592 (90), 1.754 (90), 2.381 (60), 1.682 (60), 4.24 (40), 1.504 (40)

Chemistry:

	(1)
Nb_2O_5	8.5
Ta_2O_5	76.3
SnO_2	1.0
Sb_2O_3	0.1
FeO	3.2
MnO	10.2
MgO	0.0
CaO	0.4
Total	99.7

(1) Eräjärvi area, Finland; by electron microprobe, corresponds to $(Mn_{0.70}Fe_{0.22}Ca_{0.04})_{\Sigma=0.96}(Ta_{1.68}Nb_{0.31}Sn_{0.03})_{\Sigma=2.02}O_6$.

Polymorphism & Series: Dimorphous with manganotantalite; forms a series with ferrotapiolite.

Mineral Group: Ferrotapiolite group.

Occurrence: A rare accessory mineral in a lithium-rich granite pegmatite dike.

Association: Ferrotapiolite, antimony, cassiterite, microlite, albite, schorl, apatite.

Distribution: From the Viitaniemi pegmatite, Eräjärvi area, Orivesi, Finland.

Name: For its dominant MANGANese content and relation to ferroTAPIOLITE.

Type Material: Mineralogical Museum, Geological Survey of Finland, Espoo, Finland.

References: (1) Lahti, S.I., B. Johanson, and M. Virkkunen (1983) Contributions to the chemistry of tapiolite – manganotapiolite, a new mineral. Bull. Geol. Soc. Finland, 55, 101–109. (2) (1985) Amer. Mineral., 70, 217 (abs. ref. 1). (3) Wise, M.A. and P. Černý (1996) The crystal chemistry of the tapiolite series. Can. Mineral., 34, 631–647.

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Manganotychite $Na_6(Mn^{2+},Fe^{2+},Mg)_2(SO_4)(CO_3)_4$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As irregular grains, to 1 cm, and in massive aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4 D(meas.) = 2.70(5) D(calc.) = 2.79 Weakly magnetic; slightly soluble in H_2O, forming a brown coating.

Optical Properties: Semitransparent. *Color:* Pale pink, white. *Luster:* Vitreous to dull. *Optical Class:* Isotropic. $n = 1.544(2)$

Cell Data: *Space Group:* $Fd3$. $a = 13.9951(8)$ Z = 8

X-ray Powder Pattern: Mt. Alluaiv, Kola Peninsula, Russia.
2.695 (100), 4.22 (76), 2.474 (70), 1.959 (28), 1.616 (28), 2.366 (27), 1.605 (25)

Chemistry:

	(1)	(2)
SO_3	14.13	13.71
CO_2	30.68	30.15
FeO	6.00	
MnO	15.00	24.30
MgO	1.98	
Na_2O	32.21	31.84
Total	[100.00]	100.00

(1) Mt. Alluaiv, Kola Peninsula, Russia; $(CO_3)^{2-}$ and $(SO_4)^{2-}$ confirmed by IR, recalculated to 100% from an original total of 99.34%, after deduction of CO_2 1.65%, CaO 1.49%, Na_2O 0.77% as shortite $[Na_2Ca_2(CO_3)_3]$, corresponds to $Na_{5.99}(Mn^{2+}_{1.22}Fe^{2+}_{0.48}Mg_{0.28})_{\Sigma=1.98}(SO_4)_{1.04}(CO_3)_{4.02}$.
(2) $Na_6Mn_2(SO_4)(CO_3)_4$.

Occurrence: An uncommon mineral formed in pegmatite veins in a differentiated alkalic massif (Mt. Alluaiv, Kola Peninsula, Russia).

Association: Shortite, pirssonite, sidorenkite, kogarkoite, many other species (Mt. Alluaiv, Kola Peninsula, Russia); trona, shortite, petersenite-(Y), reederite-(Y), catapleiite, analcime (Mont Saint-Hilaire, Canada).

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: As the *manganese* analog of *tychite*.

Type Material: Mining Institute, St. Petersburg, 2023/1; Geology Museum, Kola Branch, Academy of Sciences, Apatity; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p545/2.

References: (1) Khomyakov, A.P., A.Y. Bakhchisaraitsev, A.V. Martynova, and T.M. Parashchenko (1990) Manganotychite $Na_6Mn_2(SO_4)(CO_3)_4$ – a new mineral. Zap. Vses. Mineral. Obshch., 119(5), 46–49 (in Russian). (2) (1992) Amer. Mineral., 77, 448 (abs. ref. 1).

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Mangazeite $Al_2(SO_4)(OH)_4 \cdot 3H_2O$

Crystal Data: Triclinic. *Point Group*: 1 or $\bar{1}$. As fine acicular crystals, to 0.04 mm; in radial aggregates.

Physical Properties: *Cleavage*: None observed. *Fracture*: n.d. *Tenacity*: n.d.
Hardness = 1-2 D(meas.) = n.d. D(calc.) = 2.15

Optical Properties: Transparent. *Color*: Colorless; aggregates white with pale yellow domains.
Streak: Colorless. *Luster*: Vitreous.
Optical Class: Biaxial. α = 1.525(9) β = n.d. γ = 1.545(9) 2V = n.d.

Cell Data: *Space Group*: *P*1 or $P\bar{1}$. a = 8.286(5) b = 9.385(5) c = 11.35(1)
α = 96.1(1)° β = 98.9(1)° γ = 96.6(1)° Z = 4

X-ray Powder Pattern: Mangazeya deposit, eastern Yakutia, Russia.
4.258 (100), 7.59 (49), 4.060 (48), 7.16 (46), 3.912 (43), 8.14 (19), 4.520 (13)

Chemistry:

	(1)	(2)
Al_2O_3	36.28	37.47
SO_3	28.81	29.42
H_2O^+	34.35	33.11
Total	99.44	100.00

(1) Mangazeya deposit, West Verkhoyansk, eastern Yakutia, Russia; average of 5 wet chemical analyses, IR confirms OH, SO_4 and H_2O, corresponding to $Al_{1.99}(SO_4)_{1.01}(OH)_{3.94} \cdot 3.37H_2O$.
(2) $Al_2(SO_4)(OH)_4 \cdot 3H_2O$.

Occurrence: A secondary mineral along the margins of quartz-arsenopyrite veins in the weathering zone of an intensively sericitized and pyritized granodiorite.

Association: Gypsum, chlorite.

Distribution: Mangazeya polymetallic-silver deposit, West Verkhoyansk, eastern Yakutia (Sakha Republic), Russia.

Name: For Mangazeya Creek, eastern Yakutsk (Sakha Republic), Russia, near the first described locality.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow (catalog no. 3291/1).

References: (1) Gamyanin, G.N., Yu.Ya. Zhdanov, N.V. Zayakina, V.V. Gamyanina, and V.S. Suknev (2006) Mangazeite, $Al_2(SO_4)(OH)_4 \cdot 3H_2O$, a new mineral. Zap. Ross. Mineral. Obshch., 135(4), 20–23 (in Russian, English abstract), Geol. Ore Deposits, 49, 514–517 (2007; in English)
(2) (2010) Amer. Mineral., 95, 1599 (abs. ref. 1).

Manjiroite $(Na,K)(Mn^{4+},Mn^{2+})_8O_{16}\cdot nH_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Compact, massive, to 10 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 181 average. D(meas.) = 4.29 D(calc.) = [4.45]

Optical Properties: Opaque. *Color:* Dark brownish gray; yellowish gray-white in reflected light. *Streak:* Brownish black. *Luster:* Dull.
Optical Class: Uniaxial. *Anisotropism:* Distinct; yellowish gray, gray, grayish black.
Bireflectance: Very weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I4/m$. $a = 9.916$ $c = 2.864$ Z = 1

X-ray Powder Pattern: Kohare mine, Japan.
2.406 (100), 7.017 (98), 3.136 (92), 4.941 (77), 2.160 (69), 1.839 (46), 1.548 (46)

Chemistry:

	(1)		(1)
SiO_2	0.12	MgO	0.18
MnO_2	85.79	CaO	0.22
Al_2O_3	0.62	BaO	0.16
Fe_2O_3	0.40	Na_2O	2.99
MnO	3.18	K_2O	1.39
CoO	0.00	H_2O^+	3.92
CuO	0.03	H_2O^-	0.68
ZnO	0.03	Total	99.71

(1) Kohare mine, Japan; corresponds to $(Na_{0.73}K_{0.22}Ca_{0.03}Ba_{0.01})_{\Sigma=0.99}(Mn^{4+}_{7.46}Mn^{2+}_{0.34}Al_{0.09}Fe_{0.04}Mg_{0.03})_{\Sigma=7.96}O_{16}\cdot 1.64H_2O$.

Mineral Group: Cryptomelane group.

Occurrence: In the oxidation zone of metamorphosed bedded manganese deposits.

Association: Pyrolusite, nsutite, birnessite, cryptomelane, goethite (Kohare mine, Japan); cryptomelane, pyrolusite, nsutite, romanèchite (Pilbara, Australia).

Distribution: In the Kohare, Tachikawa, Kotamagawa, Kawai, and Takinosawa mines, Iwate Prefecture, Japan. At Bollier, Mary Valley, Queensland, and the Pilbara manganese belt, Western Australia. From the Prompter mine, Tombstone, Cochise Co., Arizona, USA. Found in the Capillitas mine, Veta Balaza, Catamarca, Argentina. From Adams mine, near Kuruman, Cape Province, South Africa.

Name: Honors Dr. Manjiro Watanabe (1891–?), Emeritus Professor of Mineralogy, Tohoku University, Sendai, Japan.

Type Material: National Science Museum, Tokyo, Japan, M15748.

References: (1) Nambu, M. and K. Tanida (1967) Manjiroite, a new manganese dioxide mineral, from Kohare Mine, Iwate Prefecture, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 58, 39–54 (in Japanese with English abs.). (2) (1968) Amer. Mineral., 53, 2103 (abs. ref. 1). (3) Nambu, M., Ed. (1970) Introduction to Japanese minerals, Geol. Surv. Japan, 22, 82–83.

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Mannardite $BaTi_6(V^{3+},Cr^{3+})_2O_{16}\cdot H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals prismatic, bounded by {110} and {001}, may be doubly-terminated; elongated along [001], flattened on {100}, bent or twisted about [001], deeply striated ‖ elongation, to 5 mm; in fanlike aggregates.

Physical Properties: *Cleavage:* {100}, good. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–7 VHN = 609 D(meas.) = 4.12–4.43 D(calc.) = 4.28

Optical Properties: Opaque. *Color:* Jet-black; pale reddish brown in reflected light. *Streak:* White to grayish white. *Luster:* Adamantine.
Optical Class: Uniaxial (+). *Anisotropism:* Strong; light pinkish gray to dark brownish gray. *Bireflectance:* Distinct; light to dark brown.
R_1–R_2: (400) 16.5–18.0, (420) 16.3–17.6, (440) 16.0–17.2, (460) 15.7–17.0, (480) 15.5–16.9, (500) 15.4–17.0, (520) 15.2–17.2, (540) 15.1–17.4, (560) 15.0–17.7, (580) 15.0–17.9, (600) 15.0–18.1, (620) 15.0–18.3, (640) 15.0–18.4, (660) 15.0–18.5, (680) 15.1–18.6, (700) 15.1–18.6

Cell Data: *Space Group:* $I4_1/a$. $a = 14.357(2)$ $c = 5.908(1)$ $Z = 4$

X-ray Powder Pattern: Rough claims, Canada; close to redledgeite.
3.201 (100), 1.586 (80), 2.473 (70), 1.887 (70), 2.224 (50), 1.690 (50), 1.394 (40)

Chemistry:

	(1)	(2)		(1)	(2)
TiO_2	60.1	60.2	Cr_2O_3	1.9	1.9
Fe_2O_3		3.7	BaO	19.4	19.8
V_2O_3	16.3	12.2	H_2O	[2.2]	[2.2]
			Total	[99.9]	[100.0]

(1) Rough claims, Canada; by electron microprobe, H_2O calculated + Ba = 2; corresponds to $Ba_{1.02}(Ti_{6.03}V_{1.75}Cr_{0.20})_{\Sigma=7.98}O_{16}\cdot 0.98H_2O$. (2) Bathurst, Canada; by electron microprobe, H_2O calculated + Ba = 2; corresponds to $Ba_{1.04}(Ti_{6.07}V_{1.32}Fe_{0.38}Cr_{0.20})_{\Sigma=7.97}O_{16}\cdot 0.96H_2O$.

Mineral Group: Cryptomelane group.

Occurrence: In late-stage quartz-carbonate veins cutting shale and siltstone (Rough claims, Canada); in an orebody in faulted metasediments and iron formation (Bathurst, Canada); in a silver-bearing polymetallic deposit (Kantsi, China); in kimberlite (Star mine, South Africa).

Association: Barytocalcite, norsethite, sulvanite, barite, quartz (Rough claims, Canada); edingtonite, harmotome, barytocalcite, siderite, sphalerite, quartz (Bathurst, Canada).

Distribution: On the Rough claims, north of Sifton Pass, British Columbia, and in the Brunswick No. 12 orebody, Bathurst, New Brunswick, Canada. In China, from Kantsi, Sichuan Province. In the Star mine, Free State, South Africa.

Name: Honors Dr. George William Mannard (1932–1982), formerly President of Kidd Creek Mines, Ltd., Toronto, Canada, for his interest in the mineral deposits of British Columbia.

Type Material: Geological Survey of Canada, Ottawa, 64197; Royal Ontario Museum, Toronto, Canada, M40292, M40293; The Natural History Museum, London, England, 1983,68 and 1983,69; National Museum of Natural History, Washington, D.C., USA, 150275, 150337, 162567.

References: (1) Scott, J.D. and G.R. Peatfield (1986) Mannardite $[Ba\cdot H_2O](Ti_6V^{3+})_2O_{16}$, a new mineral species, and new data on redledgeite. Can. Mineral., 24, 55–66. (2) (1988) Amer. Mineral., 73, 193 (abs. ref. 1). (3) Szymański, J.T. (1986) The crystal structure of mannardite, a new hydrated cryptomelane-group (hollandite) mineral with a doubled short axis. Can. Mineral., 24, 67–78.

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Mansfieldite $AlAsO_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely in pseudo-octahedral crystals, to 2 mm; commonly as crusts, and porous to cellular masses with spherulitic structure.

Physical Properties: Hardness = 3.5 D(meas.) = 3.03 D(calc.) = [3.08]

Optical Properties: Semitransparent. *Color:* White to pale gray, light green to bluish green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$; strong.
$\alpha = 1.622$ $\beta = 1.624$ $\gamma = 1.642$ 2V(meas.) = $\sim 30^\circ$

Cell Data: *Space Group:* [*Pcab*] (by analogy to scorodite). $a = 10.08$ $b = 9.76$ $c = 8.72$
Z = 8

X-ray Powder Pattern: Hobart Butte, Oregon, USA.
5.45 (vvs), 4.36 (vvs), 3.09 (vs), 2.98 (s), 2.52 (s), 3.97 (ms), 1.627 (ms)

Chemistry:

	(1)	(2)
P_2O_5	0.59	
As_2O_5	56.43	56.91
Sb_2O_5	0.12	
TiO_2	0.91	
Al_2O_3	23.30	25.25
Fe_2O_3	0.88	
H_2O^+	17.77	17.84
Total	[100.00]	100.00

(1) Hobart Butte, Oregon, US; recalculated to 100% after removal of quartz, kaolinite impurities 30.68%. (2) $AlAsO_4 \cdot 2H_2O$.

Polymorphism & Series: Forms a series with scorodite.

Mineral Group: Variscite group.

Occurrence: A hydrothermal product in altered and mineralized andesitic pyroclastic rocks (Hobart Butte, Oregon, USA).

Association: Kaolinite, quartz, scorodite, realgar, stibnite (Hobart Butte, Oregon, USA).

Distribution: From Hobart Butte, about 22 km south of Cottage Grove, Lane Co., Oregon, USA. Found in the Sara Alicia mine, near Alamos, Sonora, Mexico. At Neubulach, Black Forest, and Puderbach, Westerwald, Germany. Crystallized from the Cap Garonne mine, near le Pradet, Var, France. In the Penberthy Croft mine, St. Hilary, Cornwall, England. At Djebel Debar, northeast of Hammam Meskhoutine, Qacentina (Constantine), Algeria. On Mt. Cobalt, 110 km south of Cloncurry, Queensland, Australia. In the Bota-Burum uranium deposit, 15 km southwest of Alakol Lake, Chu-Ili Mountains, southwestern Balkhash district, Kazakhstan.

Name: Honors Dr. George Rogers Mansfield (1875–1947), U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106565, 117722.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 763–767. (2) Walenta, K. (1963) Mansfieldit von Neubulach im württembergischen Schwarzwald. Neues Jahrb. Mineral., Monatsh., 79–87 (in German with English abs.). (3) Allen, V.T., J.J. Fahey, and J.M. Axelrod (1948) Mansfieldite, a new arsenate, the aluminum analogue of scorodite, and the mansfieldite-scorodite series. Amer. Mineral., 33, 122–134.

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Mantienneite $KMg_2Al_2Ti(PO_4)_4(OH)_3 \cdot 15H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As radially fibrous spherules, to 1 mm.

Physical Properties: *Cleavage:* Perfect on {001}; poor on {010}. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 2.31(1) D(calc.) = 2.25

Optical Properties: Translucent. *Color:* Caramel-brown to brownish honey-yellow. *Streak:* Pale brown with a rose tint. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = colorless; Z = very pale yellow.
Orientation: $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.564$ β = n.d. $\gamma = 1.598$
2V(meas.) = 50°–60°

Cell Data: *Space Group: Pbca.* $a = 10.409(2)$ $b = 20.330(4)$ $c = 12.312(2)$ Z = 4

X-ray Powder Pattern: Anloua, Cameroon.
6.158 (100), 3.076 (60), 10.18 (40), 7.41 (30), 3.104 (30), 2.949 (30), 2.839 (25)

Chemistry:

	(1)	(2)
P_2O_5	31.96	31.87
TiO_2	9.00	8.97
Al_2O_3	10.51	11.45
Fe_2O_3	5.63	
MnO	0.15	
MgO	6.51	9.05
CaO	0.30	
Na_2O	0.18	
K_2O	2.81	5.29
H_2O	32.95	33.37
Total	[100.00]	100.00

(1) Anloua, Cameroon; average of two analyses, H_2O by the Penfield method, recalculated after removal of quartz 5.42% and siderite 6.42% impurities; then corresponding to $(K_{0.53}Na_{0.05})_{\Sigma=0.58}(Mg_{1.43}Fe_{0.46}Ca_{0.05}Mn_{0.02})_{\Sigma=1.96}(Al_{1.83}Fe_{0.17})_{\Sigma=2.00}Ti_{1.00}(PO_4)_{4.00}(OH)_{2.96} \cdot 14.77H_2O$.
(2) $KMg_2Al_2Ti(PO_4)_4(OH)_3 \cdot 15H_2O$.

Occurrence: Replacing minerals in and forming the matrix of sandy layers in lacustrine shale.

Association: Kaolinite, siderite, quartz, vivianite, organic matter.

Distribution: From Anloua, near Ngaoundéré, Cameroon.

Name: Honors Dr. Joseph Mantienne (1929–), Bureau de Recherches Géologiques et Minières, Orlèans, France.

Type Material: National School of Mines, Paris, France.

References: (1) Fransolet, A.-M., P. Oustrière, F. Fontan, and F. Pillard (1984) La mantiennéite, une nouvelle espèce minérale du gisement de vivianite d'Anloua, Cameroun. Bull. Minéral., 107, 737–744 (in French with English abs.). (2) (1985) Amer. Mineral., 70, 1330 (abs. ref. 1).

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Mapimite $Zn_2Fe_3^{3+}(AsO_4)_3(OH)_4 \cdot 10H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. As rectangular tabular crystals dominated by {001}, {110}, {$\bar{1}$11}, to 4 mm. *Twinning:* Polysynthetic on {001} with [104] pseudoaxis.

Physical Properties: *Cleavage:* On {001} and {010}. Hardness = 3 D(meas.) = 2.95(3) D(calc.) = 3.02(4)

Optical Properties: Translucent. *Color:* Blue, blue-green, green; variable due to trichroism. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = pale yellow; Y = greenish yellow; Z = deep Prussian blue. *Orientation:* $Y = b$; $Z \wedge a = 13°$. *Dispersion:* $r < v$; strong. $\alpha = 1.672$ $\beta = 1.678$ $\gamma = 1.712$ 2V(meas.) = 50°

Cell Data: *Space Group:* Cm. $a = 11.415(5)$ $b = 11.259(5)$ $c = 8.661(3)$ $\beta = 107.74(4)°$ Z = 2

X-ray Powder Pattern: Ojuela mine, Mexico.
8.24 (100), 7.83 (94), 4.662 (61), 3.883 (46), 3.217 (41), 2.826 (37), 3.451 (36)

Chemistry:

	(1)	(2)
As_2O_5	35.6	35.79
Fe_2O_3	25.6	24.87
FeO	0.9	
ZnO	15.8	16.90
H_2O	21.6	22.44
Total	99.5	100.00

(1) Ojuela mine, Mexico; Zn and Fe^{3+} by AA, Fe^{2+} by colorimetry, As by spectrophotometry, H_2O by the Penfield method; corresponding to $(Zn_{1.88}Fe^{2+}_{0.12})_{\Sigma=2.00}Fe^{3+}_{3.10}O_{2.15}(AsO_4)_{3.00} \cdot 11.61H_2O$. (2) $Zn_2Fe_3(AsO_4)_3(OH)_4 \cdot 10H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of an arsenic-rich hydrothermal polymetallic ore deposit.

Association: Scorodite, adamite, smithsonite, "limonite".

Distribution: From the Ojuela mine, Mapimí, Durango, Mexico.

Name: For the Mapimí mining district in Mexico that produced the first specimens.

Type Material: University of Pierre and Marie Curie, Paris, France.

References: (1) Cesbron, F., M. Romero, and S.A. Williams (1981) La mapimite et l'ojuélaïte, deux nouveaux arséniates hydratés de zinc et de fer de la mine Ojuela, Mapimi, Mexique. Bull. Minéral., 104, 582–586 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 623–624 (abs. ref. 1). (3) Ginderow, D. and F. Cesbron (1981) Structure de la mapimite, $Zn_2Fe_3(AsO_4)_3(OH)_4 \cdot 10H_2O$. Acta Cryst., 37, 1040–1043 (in French with English abs.).

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Marcasite FeS_2

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals typically tabular on {010}, also pyramidal, prismatic, and, rarely, capillary; curved faces common. Stalactitic, reniform, fine-granular massive; cockscomb and spearhead shapes due to twinning on {101}. *Twinning:* Common and repeated on {101}; less common on {011}. Intense twin lamellae development observed in polished section.

Physical Properties: *Cleavage:* {101}, rather distinct; {110} in traces. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 915–1099 (200 g load). D(meas.) = 4.887 D(calc.) = 4.875

Optical Properties: Opaque. *Color:* Tin-white on fresh surface, pale bronze-yellow, darkening on exposure, iridescent tarnish. *Streak:* Grayish or brownish black. *Luster:* Metallic. *Pleochroism:* [100] creamy white; [010] light yellowish white; [001] white with rose-brown tint. *Anisotropism:* Very strong, yellow through pale green to dark green.
R_1–R_2: (400) 40.4–44.5, (420) 41.9–45.4, (440) 43.4–47.3, (460) 44.3–50.1, (480) 45.2–52.8, (500) 46.3–54.8, (520) 47.7–56.1, (540) 48.9–56.3, (560) 49.5–55.9, (580) 49.6–55.2, (600) 49.5–54.8, (620) 49.2–58.4, (640) 48.7–53.8, (660) 47.9–52.9, (680) 47.2–51.9, (700) 46.6–51.2

Cell Data: *Space Group: Pnnm.* $a = 4.436$ $b = 5.414$ $c = 3.381$ $Z = 2$

X-ray Powder Pattern: Webb City, Missouri, USA.
2.70 (100), 1.755 (90), 3.43 (60), 2.41 (60), 2.32 (60), 1.911 (50), 1.094 (50)

Chemistry:

	(1)	(2)	(3)
Fe	46.53	46.55	46.55
Cu	trace		
As		trace	
S	53.30	53.05	53.45
rem.	0.20		
Total	100.03	99.60	100.00

(1) Joplin, Missouri, USA; remainder is SiO_2. (2) Jasper, Wyoming, USA. (3) FeS_2.

Polymorphism & Series: Dimorphous with pyrite.

Mineral Group: Marcasite group.

Occurrence: Typically formed under low-temperature highly acidic conditions, both in sedimentary environments (shales, limestones, and low rank coals) and in hydrothermal veins formed by ascending solutions.

Association: Pyrite, pyrrhotite, galena, sphalerite, fluorite, dolomite, calcite.

Distribution: From numerous localities world-wide. In the USA, at Joplin, Jasper Co., Missouri; Picher and Cardin, Ottawa Co., Oklahoma; and Baxter Springs and Galena, Cherokee Co., Kansas; in Wisconsin, at Mineral Point, Iowa Co., and Racine, Racine Co. In the Czech Republic, from Vintířov, Litmice, Most, Osek, and other places. In Germany, at Clausthal, in the Harz Mountains, and Freiberg and Annaberg, Saxony. In France, at Cap Blanc-Nez, Pas-de-Calais. From England, in the chalk at Kent, and between Folkestone and Dover; at Tavistock, Devon. In Mexico, in the Santa Eulalia district, Chihuahua. From Llallagua, Bolivia. In the Oppu mine, Akita Prefecture, Japan.

Name: A word of Arabic or Moorish origin, early applied to pyrite and other substances.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 311–315. (2) Brostigen, G., A. Kjekshus, and C. Rømming (1973) Compounds with the marcasite type crystal structure VIII. Redetermination of the prototype. Acta Chem. Scand., 27, 2791–2796. (3) Dódony, I., M. Pósfai, and P.R. Buseck (1996) Structural relationship between pyrite and marcasite. Amer. Mineral., 81, 119–125. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 102. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 354.

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Marécottite $Mg_3(UO_2)_4(SO_4)_2O_3(OH)\cdot 28H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals, to 4 mm, are flattened on {100}, striated parallel [001], bound by large {010}, {011}, {$2\bar{3}0$}, modified by {230}, {101}, {201}, {301}, {211}, {210}.

Physical Properties: *Cleavage:* Perfect on {100}; imperfect on {010}. Hardness = n.d. D(meas.) = 4.4 D(calc.) = 4.37 Radioactive; dehydrates at ambient temperature.

Optical Properties: Semitransparent. *Color:* Yellowish green to greenish brown. *Optical Class:* Biaxial (–). *Pleochroism:* Y = yellowish green; Z = yellowish brown. *Orientation:* $X = a$; $Y = b$; $Z = c$. α = n.d. β = 1.780–1.785 γ = 1.795–1.800 2V(meas.) = 39° 2V(calc.) = n.d.

Cell Data: *Space Group:* $P2_1bn$. $a = 16.4537(10)$ $b = 17.2229(10)$ $c = 6.9879(4)$ Z = 4

X-ray Powder Pattern: Musonoi mine, Congo.
8.23 (FFF), 3.09 (FFF), 3.22 (FF), 2.900 (FF), 3.02 (F), 8.65 (mF), 4.44 (mF)

Chemistry:

	(1)	(2)
UO_3	60.5	65.82
SeO_2	23.7	17.02
CuO	4.3	6.10
H_2O	10.7	11.06
Total	99.2	100.00

(1) Musonoi Extension mine, Congo; H_2O by the Penfield method., partially dehydrated material approaching a probable composition $Cu(UO_2)_3O_2(SeO_3)_2\cdot 6H_2O$. (2) $Cu(UO_2)_3O_2(SeO_3)_2\cdot 8H_2O$.

Occurrence: A rare alteration product of selenian digenite in the oxidation zone of a uranium-bearing Cu–Co hydrothermal ore deposit.

Association: Digenite, demesmaekerite, denningite, guilleminite.

Distribution: From the Musonoi Co–Cu mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Aimé Marthoz (1894–1962), former Director of the Union Minière de Haut-Katanga, Congo.

Type Material: University of Pierre and Marie Curie, Paris, 12.252; Natural History Museum, Paris; National School of Mines, Paris, France.

References: (1) Cesbron, F., R. Oosterbosch, and R. Pierrot (1969) Une nouvelle espèce minérale: la marthozite. Uranyl-sélénite de cuivre hydraté. Bull. Soc. fr. Minéral., 92, 278–283 (in French with English abs.). (2) (1970) Amer. Mineral., 55, 533 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (2001) Structure topology and hydrogen bonding in marthozite, $Cu^{2+}[(UO_2)_3(SeO_3)_2O_2](H_2O)_8$, a comparison with guilleminite, $Ba[(UO_2)_3(SeO_3)_2O_2](H_2O)_3$. Can. Mineral., 39, 797–807.

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Margaritasite $(Cs,K,H_3O)_2(UO_2)_2(V_2O_8)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular crystals, to 3 μm, in amoeboid aggregates; typically massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.41 Radioactive.

Optical Properties: Translucent. *Color:* Yellow; gray in transmitted light.
Optical Class: Biaxial (–). $\alpha = [< 1.83]$ (synthetic). $\beta = 2.49(1)$ $\gamma = > 2.70$
2V(meas.) = 45.5°

Cell Data: *Space Group:* $P2_1/a$. a = 10.514(3) $b = 8.425(3)$ $c = 7.252(5)$ $\beta = 106.01°$
Z = 2

X-ray Powder Pattern: Margaritas deposit, Mexico.
6.965 (100), 3.600 (70), 3.344 (70), 3.489 (60), 3.231 (50), 3.164 (50), 3.129 (35)

Chemistry:

	(1)
UO_3	58.9
V_2O_5	18.1
Cs_2O	18.7
K_2O	1.73
H_2O	[2.5]
Total	[99.9]

(1) Margaritas deposit, Mexico; by electron microprobe, partial analysis, H_2O by CHN analyzer on a separate sample, recalculated assuming H_2O 2.5%; $(H_3O)^{1+}$ calculated for charge balance, then corresponding to $[Cs_{1.31}K_{0.36}(H_3O)_{0.15}]_{\Sigma=1.82}(UO_2)_{2.03}(V_2O_8)_{0.98}\cdot H_2O$.

Occurrence: As pore fillings and phenocryst casts in felsic volcanic tuffs, which have been altered by high-temperature hydrothermal fluids.

Association: Kaolinite, quartz.

Distribution: An ore at the Margaritas uranium deposit, Peña Blanca district, about 70 km north of Chihuahua City, Chihuahua, Mexico.

Name: For the Margaritas deposit, Mexico, that produced the first specimens.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149090.

References: (1) Wenrich, K.J., P.J. Modreski, R.A. Zielinski, and J.L. Seeley (1982) Margaritasite: a new mineral of hydrothermal origin from the Peña Blanca uranium district, Mexico. Amer. Mineral., 67, 1273–1289.

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Margarite $CaAl_2(Al_2Si_2)O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely forms distinct thin tabular crystals, with pseudohexagonal outline; commonly foliated micaceous aggregates, with lamellae to 3 cm; massive. *Twinning:* On composition plane {001}, with twin axis [310].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Laminae brittle.
Hardness = 3.5–4.5 D(meas.) = 2.99–3.08 D(calc.) = 3.077

Optical Properties: Translucent. *Color:* Grayish, pale pink, yellow, or green; colorless in thin section. *Streak:* White. *Luster:* Pearly on cleavage, vitreous on lateral faces.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 11°$–$13°$; $Y \wedge a = 6°$–$8°$.
Dispersion: $r < v$, distinct. $\alpha = 1.630$–1.638 $\beta = 1.642$–1.648 $\gamma = 1.644$–1.650
2V(meas.) = 40°–67°

Cell Data: *Space Group:* $C2/c$. $a = 5.10$ $b = 8.83$ $c = 19.15$ $\beta = 95.5°$ Z = 4

X-ray Powder Pattern: Shin-Kiura mine, Japan.
3.180 (100), 1.908 (35), 2.517 (25), 2.508 (18), 1.903 (18), 1.466 (16), 3.123 (14)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	31.98	32.59	CaO	10.64	9.79
Al_2O_3	49.21	50.33	Na_2O	1.53	1.96
FeO	0.79	0.24	K_2O	0.21	0.48
MgO	0.76		H_2O^+	4.95	[4.61]
			Total	100.07	[100.00]

(1) Unionville, Pennsylvania, USA; corresponds to $(Ca_{0.75}Na_{0.21}K_{0.02})_{\Sigma=0.98}(Al_{1.96}Mg_{0.07}Fe_{0.04})_{\Sigma=2.07}(Si_{2.10}Al_{1.90})_{\Sigma=4.00}O_{10}(OH)_{2.18}$. (2) Fettercairn, Scotland; by electron microprobe, H_2O by difference; corresponds to $(Ca_{0.69}Na_{0.25}K_{0.04})_{\Sigma=0.98}Al_{2.05}(Si_{2.15}Al_{1.85}Fe_{0.03})_{\Sigma=4.03}O_{10}(OH)_2$.

Polymorphism & Series: $2M_1$ polytype.

Mineral Group: Mica group.

Occurrence: From low- to medium-grade metamorphic rocks, as in emery deposits, chlorite and mica schists, and glaucophane-bearing rocks.

Association: Corundum, diaspore, tourmaline, staurolite, glaucophane, chlorite, magnetite, spinel, andalusite, calcite, quartz.

Distribution: On Mt. Greiner, in the Zillertal, Tirol, Austria. On Mákares and Naxos Islands, Greece. From Yekaterinburg (Sverdlovsk), Ural Mountains, Russia. In the USA, from Chester, Hampden Co., Massachusetts; Cruger's Point, Peekskill, Putnam Co., New York; Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; on Corundum Hill, Chester Co., and Village Green, Delaware Co., Pennsylvania; at Bull Mountain, Patrick Co., Virginia. In California, from Meadow Valley, Plumas Co., and Hilton Gulch, Oak Ridge, Santa Clara Co. At Glen Esk and Fettercairn, Scotland. In the Shin-Kiura mine, Oita Prefecture, Japan.

Name: From the Greek for *pearl*, for its pearly luster on cleavage.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 636–637.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 95–98. (3) Aoki, Y. and N. Shimada (1965) Margarite from the Shin-Kiura mine, Oita Prefecture. J. Mineral. Soc. Japan, 7, 87–93 (in Japanese). (4) Guggenheim, S. and S.W. Bailey (1975) Refinement of the margarite structure in subgroup symmetry. Amer. Mineral., 60, 1023–1029.
(5) Guggenheim, S. and S.W. Bailey (1978) Refinement of the margarite structure in subgroup symmetry: correction, further refinement, and comments. Amer. Mineral., 63, 186–187.
(6) Baltatzis, E. and C. Katagas (1981) Margarite pseudomorphs after kyanite in Glen Esk, Scotland. Amer. Mineral., 66, 213–216.

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Margarosanite $Pb(Ca,Mn^{2+})_2Si_3O_9$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As masses of thin plates, lamellar on {010}, closely packed together, to several cm, showing rhombic outlines resulting from the {100} and {001} cleavages.

Physical Properties: *Cleavage:* Perfect on {010}, good on {100}, fair on {001}. Hardness = 2.5–3 D(meas.) = 3.99–4.33 D(calc.) = 4.30 Blue, rarely pink to red UV fluorescence.

Optical Properties: Transparent. *Color:* Colorless to white; in thin section, colorless. *Streak:* White. *Luster:* Pearly on cleavage.
Optical Class: Biaxial (–). *Dispersion:* $r < v$, strong. $\alpha = 1.727$–1.730 $\beta = 1.771$ $\gamma = 1.795$–1.798 $2V(meas.) = 78°$

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.77(1)$ $b = 9.64(1)$ $c = 6.75(1)$ $\alpha = 110°35'$ $\beta = 102°0'$ $\gamma = 88°30'$ $Z = 2$

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.978 (100), 3.028 (50), 2.673 (40), 5.08 (30), 3.196 (30), 3.156 (30), 2.688 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	33.71	34.9	34.72
FeO		0.1	
MnO	1.14	0.6	2.17
ZnO		0.6	
PbO	43.50	44.9	41.74
MgO			0.20
CaO	21.73	20.5	20.28
BaO			0.69
H_2O	0.58		0.10
Total	100.66	101.6	99.90

(1) Franklin, New Jersey, USA; corresponds to $Pb_{1.00}(Ca_{1.99}Mn_{0.08})_{\Sigma=2.07}Si_{2.88}O_9$. (2) Do.; by electron microprobe, corresponding to $Pb_{1.04}(Ca_{1.88}Mn_{0.04}Zn_{0.04}Fe_{0.01})_{\Sigma=1.97}Si_{3.00}O_9$. (3) Långban, Sweden; corresponds to $Pb_{1.04}(Ca_{1.86}Mn_{0.16}Mg_{0.02}Ba_{0.02})_{\Sigma=2.06}Si_{2.97}O_9$.

Occurrence: In a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA).

Association: Nasonite, minehillite, almandine, hancockite, roeblingite, franklinite, willemite, rhodonite, manganaxinite, datolite, prehnite, manganoan biotite, johannsenite, barite (Franklin, New Jersey, USA).

Distribution: From Franklin, Sussex Co., New Jersey, USA. At Långban and Jakobsberg, Värmland, Sweden.

Name: From the Greek for *pearl* and *tablet*, in reference to its luster and lamellar habit.

Type Material: Yale University, New Haven, Connecticut, USa, 2.5943.

References: (1) Ford, W.E. and W.M. Bradley (1916) Margarosanite, a new lead-calcium silicate from Franklin, N.J. Amer. J. Sci., 42, 159–162. (2) (1916) Amer. Mineral., 1, 87–88 (abs. ref. 1). (3) Armstrong, R.L. (1963) New data on margarosanite. Amer. Mineral., 48, 698–703. (4) Glasser, F.P. and L.S.D. Glasser (1964) Additional notes on margarosanite. Amer. Mineral., 49, 781–782. (5) Freed, B. and D.R. Peacor (1969) Determination and refinement of the crystal structure of margarosanite, $PbCa_2Si_3O_9$. Zeits. Krist., 128, 213–228. (6) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727.

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Marialite $3NaAlSi_3O_8 \cdot NaCl$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals prismatic, typically with flat pyramidal terminations, striated ‖ [001], to 1.5 m; granular, massive.

Physical Properties: *Cleavage:* {100}, {110}, distinct. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.50–2.62 D(calc.) = [2.54] Commonly fluoresces orange to bright yellow or red under LW or SW UV or both.

Optical Properties: Transparent to opaque. *Color:* Colorless, white, grey; pink, violet, blue, yellow, brown, orange-brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly, resinous.
Optical Class: Uniaxial (–). $\omega = 1.539–1.550$ $\epsilon = 1.532–1.541$

Cell Data: *Space Group:* $I4/m$. $a = 12.060(3)$ $c = 7.572(3)$ $Z = 2$

X-ray Powder Pattern: Kenya (?).
3.45 (10), 3.05 (9), 3.80 (8), 2.68 (7), 1.907 (7), 1.363 (6), 2.29 (5)

Chemistry:

	(1)		(1)
SiO_2	60.64	Na_2O	12.29
Al_2O_3	19.56	K_2O	0.90
FeO	0.06	Cl	3.9
MgO	0.00	SO_3	0.18
CaO	2.66	$-O = Cl_2$	0.88
		Total	99.31

(1) Kenya (?); by electron microprobe, corresponding to $3[(Na_{0.80}Ca_{0.13}K_{0.05})_{\Sigma=0.98}Al_{1.07}Si_{2.83}O_8] \cdot (NaCl)_{0.92}$.

Polymorphism & Series: Forms a series with meionite; intermediate members are $P4_2/n$.

Mineral Group: Scapolite group.

Occurrence: Typically in regionally metamorphosed rocks, especially marbles, calcareous gneisses, granulites, and greenschists. Also in skarns, some pegmatites, pneumatolytically or hydrothermally altered mafic igneous rocks, and ejected volcanic blocks.

Association: Plagioclase, garnet, pyroxenes, amphiboles, apatite, titanite, zircon.

Distribution: Most specimens are intermediate in the series, see also meionite; some localities for highly sodic materials include: at Pianura, west of Naples, Campania, Italy. From Russia, in the Slyudyanka region, near Lake Baikal, Siberia. In the USA, at Hamburg and Franklin, Sussex Co., New Jersey; at Natural Bridge, Jefferson Co., Macomb, St. Lawrence Co., and Olmsteadville, Essex Co., New York; from French Creek, Chester Co., Pennsylvania. In Canada, at Bear Lake, Pontiac Co., Quebec, and Bancroft, Ontario. From the La Panchita mine, near Ayoquezco, Oaxaca, Mexico. From Serra da Chibita, Rio Pardo, Minas Gerais, Brazil. At Tsarasaotra and Betroka, Madagascar. From Mpwapwa, Morogoro region, Dodoma, Tanzania. In the Mogok district, Myanmar (Burma).

Name: For Maria Rosa vom Rath, wife of Gerhard vom Rath, German mineralogist, who named the species.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 468–473. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 321–337. (3) Papike, J.J., and T. Zoltai (1965) The crystal structure of a marialite scapolite. Amer. Mineral., 50, 641–655. (4) Lin, S.B. and B.J. Burley (1973) Crystal structure of a sodium and chlorine-rich scapolite. Acta Cryst., 29, 1272–1278. (5) Zwaan, P.C. (1979) More data on violet gem scapolite, probably from eastern Africa. J. Gemmol., 16, 448–451.

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Marianoite $Na_2Ca_4(Nb, Zr)_2(Si_2O_7)_2(O, F)_4$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As flattened prismatic crystals, to 0.3 mm, with resorbed faces. *Twinning*: Lamellar twinning on {100}.

Physical Properties: *Cleavage*: Distinct on {010}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 6 D(meas.) = > 3.32 D(calc.) = 3.45(2)

Optical Properties: Translucent. *Color*: Pale yellow; colorless in thin section. *Streak*: n.d. *Luster*: Vitreous on cleavage surfaces to greasy on resorbed surfaces.
Optical Class: Biaxial (-). $\alpha = 1.700$ $\beta = 1.715$ $\gamma = 1.725$ 2V(meas.) = 80° 2V(calc.) = 78°
Dispersion: Weak, $r < v$. *Orientation*: $Z = b$; $X \wedge c = 45°$.

Cell Data: *Space Group*: $P2_1$. $a = 10.8459(15)$ $b = 10.2260(14)$ $c = 7.2727(10)$ $\beta = 109.332(3)°$ $Z = 2$

X-ray Powder Pattern: Tantalum Pit, Prairie Lake intrusive complex, Ontario, Canada.
3.04 (S), 2.98 (S), 2.85 (S), 2.02 (S), 3.64 (M), 3.23 (M), 2.48(M)

Chemistry:

	(1)
Na_2O	7.45
CaO	27.92
MgO	0.14
MnO	0.37
FeO	0.72
TiO_2	0.94
ZrO_2	13.80
HfO_2	0.15
Nb_2O_5	16.01
Ta_2O_5	0.08
SiO_2	29.68
F	2.54
-O=F	1.07
Total	98.73

(1) Tantalum Pit, Prairie Lake intrusive complex, Ontario, Canada; average of 16 electron microprobe analyses, corresponding to $Na_{1.930}(Ca_{3.996}Mn_{0.042})_{\Sigma=4.038}(Nb_{0.967}Zr_{0.899}Ti_{0.094}Fe_{0.080}Mg_{0.028}Hf_{0.006}Ta_{0.003})_{\Sigma=2.077}(Si_{3.965}O_{14})O_{2.927}F_{1.073}$.

Occurrence: A primary mineral in phlogopite-calcite silicocarbonatite emplaced in ijolite.

Association: Calcite, phlogopite, U-rich pyrochlore, titanite.

Distribution: Tantalum Pit, south of Anomaly Lake, Prairie Lake intrusive complex, Thunder Bay district, Ontario, Canada.

Name: Honors Anthony Nicola Mariano (b. 1930) for contributions to the study of alkaline rocks and carbonatites.

Type Material: R.B. Ferguson Museum of Mineralogy, University of Manitoba, Winnipeg, Manitoba, Canada, M 7425.

References: (1) Chakhmouradian, A.R., R.H. Mitchell, P.C. Burns, Y. Mikhailova, and E.P. Reguir (2008) Marianoite, a new member of the cuspidine group from the Prairie Lake silicocarbonatite, Ontario. Can. Mineral., 46, 1023–1032. (2) (2009) Amer. Mineral., 94, 649 (abs. ref. 1).

Marićite $NaFe^{2+}PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely as crudely formed crystals, elongated along [100], usually radial to subparallel in nodules, to 15 cm; forms include {010}, {011}, {012}, {032}.

Physical Properties: Hardness = 4–4.5 D(meas.) = 3.66(2) D(calc.) = 3.69

Optical Properties: Transparent to translucent. *Color:* Colorless, pale gray, pale brown. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$. *Dispersion:* $r > v$; weak. $\alpha = 1.676(2)$ $\beta = 1.695(2)$ $\gamma = 1.698(2)$ 2V(meas.) = 43.5° 2V(calc.) = 43.0°

Cell Data: *Space Group: Pmnb.* $a = 6.861(1)$ $b = 8.987(1)$ $c = 5.045(1)$ Z = 4

X-ray Powder Pattern: Big Fish River area, Canada.
2.574 (100), 2.729 (90), 2.707 (80), 1.853 (60), 3.705 (40), 2.525 (30), 1.881 (30)

Chemistry:

	(1)	(2)
P_2O_5	42.5	40.83
FeO	37.4	41.34
MnO	3.1	
MgO	0.8	
CaO	0.0	
Na_2O	16.5	17.83
Total	100.3	100.00

(1) Big Fish River area, Canada; by electron microprobe, average of six analyses; corresponding to $Na_{0.91}(Fe_{0.89}Mn_{0.07}Mg_{0.03})_{\Sigma=0.99}P_{1.02}O_4$. (2) $NaFePO_4$.

Occurrence: In phosphatic nodules in sideritic ironstones.

Association: Ludlamite, vivianite, quartz, pyrite, wolfeite, apatite, wicksite, nahpoite, satterlyite.

Distribution: From the Big Fish River area, Yukon Territory, Canada.

Name: Honors Dr. Luka Marić (1899–?), Professor of Mineralogy and Petrology, University of Zagreb, Croatia.

Type Material: Mineralogical-Petrography Museum, University of Zagreb, Zagreb, Croatia; Royal Ontario Museum, Toronto, Canada, M34241; National Museum of Natural History, Washington, D.C., USA, 145745.

References: (1) Sturman, B.D., J.A. Mandarino, and M.I. Corlett (1977) Marićite, a sodium iron phosphate, from the Big Fish River area, Yukon Territory, Canada. Can. Mineral., 15, 396–398. (2) Le Page, Y. and G. Donnay (1977) The crystal structure of the new mineral marićite, $NaFePO_4$. Can. Mineral., 15, 518–521. (3) (1979) Amer. Mineral., 64, 655–656 (abs. refs. 1 and 2).

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Maricopaite $Pb_7Ca_2Al_{12}Si_{36}O_{100}\cdot 32H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. As thin bundles of crystals elongated along [001]; in radial sprays, to 1 mm.

Physical Properties: *Cleavage:* {010}, imperfect. *Tenacity:* Friable. Hardness = Extremely soft. D(meas.) = 2.94 D(calc.) = 2.90

Optical Properties: Translucent to transparent. *Color:* White, colorless. *Luster:* Silky to vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, strong.
$\alpha = 1.563(3)$ $\beta = 1.582(3)$ $\gamma = [1.592]$ 2V(meas.) = 70(10)°

Cell Data: *Space Group:* $Cmmm$, $Cm2m$, $Cmm2$, or $C222$. $a = 19.434(2)$ $b = 19.702(2)$ $c = 7.538(1)$ Z = 1

X-ray Powder Pattern: Moon Anchor mine, Arizona, USA.
13.7 (100), 3.216 (50), 9.86 (40), 3.357 (40), 2.978 (40), 2.845 (40), 4.35 (30)

Chemistry:

	(1)
SiO_2	42.0
Al_2O_3	11.4
PbO	30.8
CaO	2.4
H_2O	11.0
Hydrocarbons	0.5
Total	98.1

(1) Moon Anchor mine, Arizona, USA; by electron microprobe, H_2O by TGA; corresponds to $Pb_{7.2}Ca_{2.2}(Al_{11.6}Si_{36.4})_{\Sigma=48.0}O_{99.6}\cdot 31.8H_2O$.

Mineral Group: Zeolite group.

Occurrence: In a hydrothermal Pb-Cu ore vein, coating and filling fractures in quartz.

Association: Cerussite, mimetite, fornacite, phoenicochroite, duftite, chrysocolla, wickenburgite, calcite, fluorite, quartz.

Distribution: From the Moon Anchor mine, near Tonopah, Maricopa Co., Arizona, USA.

Name: For Maricopa Co., Arizona, USA, where it was discovered.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163247, 163248.

References: (1) Peacor, D.R., P.J. Dunn, W.B. Simmons, F.J. Wicks, and M. Raudsepp (1988) Maricopaite, a new hydrated Ca–Pb, zeolite-like silicate from Arizona. Can. Mineral., 26, 309–313. (2) (1989) Amer. Mineral., 74, 947 (abs. ref. 1). (3) Rouse, R.C. and D.R. Peacor (1994) Maricopaite, an unusual lead calcium zeolite with an interrupted mordenite-like framework and intrachannel Pb_4 tetrahedral clusters. Amer. Mineral., 79, 175–184.

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Mariinskite $(Cr,Al)_2BeO_4$

Crystal Data: Orthorhombic. *Point Group*: 222. As irregular grains to 0.3 mm. *Twinning*: As pseudohexagonal chrysoberyl-type twins.

Physical Properties: *Cleavage*: n.d. *Fracture*: Conchoidal. *Tenacity*: n.d. Hardness = 8.5 VHN = 1725 (150 g load). D(meas.) = 4.25(2) D(calc.) = 4.25

Optical Properties: Translucent. *Color*: Dark green, emerald green in transmitted light; in reflected light, gray with green reflections. *Streak*: Pale green. *Luster*: Vitreous. *Optical Class*: Biaxial (+). α = 2.05 (1) β = 2.09 (3) γ = 2.15 (1) 2V(meas.) = 80(10)° 2V(calc.) = 80.5° *Pleochroism*: Strong, *Z* = emerald-green, *Y* = yellow-green, *X* = greenish yellow. *Absorption*: *Z* > *Y* > *X*. *Bireflectance*: Very weak. *Anisotropism*: Weak. R_1-R_2: (589) 12.3-12.9

Cell Data: *Space Group*: $P2_12_12_1$. *a* = 4.487(1) *b* = 5.629(1) *c* = 9.732(2) Z = 4

X-ray Powder Pattern: Mariinskoye Be deposit, Ural Emerald Mines, Middle Urals, Russia. 1.651 (100), 3.31 (90), 2.139 (60), 2.629 (50), 2.434 (50), 4.08 (40), 2.381 (40)

Chemistry:

	(1)
BeO	16.3
Al_2O_3	23.89
Cr_2O_3	58.67
Fe_2O_3	0.26
V_2O_3	0.26
TiO2	0.61
Total	99.98

(1) Mariinskoye Be deposit, Ural Emerald Mines, Middle Urals, Russia; average of 92 electron microprobe analyses, BeO_4 confirmed by IR spectroscopy; corresponding to $(Cr_{1.22}Al_{0.74}Ti_{0.01}Fe_{0.01}V_{0.01})_{\Sigma=1.99}Be_{1.03}O_4$.

Occurrence: Replacing low-Al chromite of chromitite lens in serpentinite, probably of metasomatic origin.

Association: Fluorophlogopite, eskolaite, dravite-fluordravite, chromite.

Distribution: Mariinskoye (Malyshevskoe) Be deposit, Ural Emerald Mines, Middle Urals, Russia.

Name: For the locality from which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, and the Ural Geological Museum, Ekaterinburg, Russia.

References: (1) Pautov, L.A., M.P. Popov, Yu.V. Erokhin, V.V. Khiller, and V.Y. Karpenko (2012) Mariinskite, $BeCr_2O_4$, a new mineral, chromium analogue of chrysoberyl. Zap. Ross. Mineral. Obshch., 141(6), 43-62 (in Russian, with English abstract). (2) (2014) Amer. Mineral., 99, 246-247 (abs. ref. 1). (3) Yamnova, N.A., S.M. Aksenov, L.A. Pautov, M.P. Popov, and Yu.V. Erokhin (2014) Specific features of cation distribution in the crystal structure of mariinskite $BeCr_2O_4$ (Derivative of olivine-type structure). Crystallography Reports, 59(1), 30-35.

Marokite $CaMn_2^{3+}O_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals prismatic, to 5 cm, flattened on {010}, with {120}, {110}, {201}, and {011} prominent; may be fibrous, in dense groups.

Physical Properties: *Cleavage:* Perfect on {100}; good on {001}. Hardness = 6.5 VHN = 800 D(meas.) = 4.64(2) D(calc.) = 4.63(4)

Optical Properties: Opaque, translucent through thin edges. *Color:* Black; in reflected light, gray to brown, with carmine-red internal reflections. *Streak:* Reddish brown. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Very strong; X = safflower-red. *Orientation:* $X = c$. α = n.d. β = n.d. γ = n.d. 2V(meas.) = 20°–25° *Anisotropism:* Strong; yellowish green to greenish yellow. *Bireflectance:* Yellowish gray to gray-brown.
R_1–R_2: (400) 20.2–22.9, (420) 19.3–21.9, (440) 18.4–20.9, (460) 17.7–20.0, (480) 17.0–19.3, (500) 16.5–18.7, (520) 16.2–18.3, (540) 16.0–18.2, (560) 16.0–18.4, (580) 16.0–18.7, (600) 15.9–18.6, (620) 15.7–18.3, (640) 15.5–18.0, (660) 15.4–17.8, (680) 15.2–17.5, (700) 15.1–17.3

Cell Data: *Space Group:* $Pmab$ or $P2_1ab$. a = 9.71(2) b = 10.03(2) c = 3.162(5) Z = 4

X-ray Powder Pattern: Tachgagalt, Morocco.
2.71 (FF), 2.22 (FF), 2.29 (F), 2.07 (F), 2.87 (M), 2.56 (M), 1.63 (M)

Chemistry:

	(1)	(2)	(3)
SiO_2	0.62		
MnO_2	38.94	40.88	40.63
Fe_2O_3	1.60		
MnO	31.38	32.95	33.16
MgO	0.15		
CaO	25.60	26.17	26.21
Na_2O	0.30		
F	0.20		
H_2O^+	0.28		
H_2O^-	0.17		
CO_2	0.52		
Total	99.76	[100.00]	100.00

(1) Tachgagalt, Morocco. (2) Do.; recalculated to 100% after deduction of impurities.
(3) $CaMn^{4+}Mn^{2+}O_4$ (crystal-structure analysis of type material determined $CaMn_2^{3+}O_4$).

Occurrence: In hydrothermal manganese oxide deposits.

Association: Jouravskite, hausmannite, braunite, cryptomelane, pyrolusite, crednerite, dolomite, barite, calcite (Tachgagalt, Morocco); pyrolusite, cryptomelane, "opal" (Kuruman, South Africa).

Distribution: From Tachgagalt, 17 km south of Ouarzazate, Anti-Atlas Mountains, Morocco. In the Black Rock mine, near Kuruman, Cape Province, South Africa.

Name: For the first occurrence in Morocco, *Maroc* in French.

Type Material: Geological Survey, Rabat, Morocco; National School of Mines, Paris, France.

References: (1) Gaudefroy, C., G. Jouravsky, and F. Permingeat (1963) La marokite, $CaMn_2O_4$, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 86, 359–367 (in French). (2) (1964) Amer. Mineral., 49, 817 (abs. ref. 1). (3) Lepicard, G. and J. Protas (1966) Étude structurale de l'oxyde double de manganèse et de calcium orthorhombique $CaMn_2O_4$ (marokite). Bull. Soc. fr. Minéral., 89, 318–324 (in French). (4) De Villiers, P.R. and F.H. Herbstein (1968) Second occurrence of marokite. Amer. Mineral., 53, 495–496.

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Marrite $PbAgAsS_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals equant to tabular on {010}; striated parallel to [001]; nearly globular crystals, with over 40 forms, to 5 mm. *Twinning:* Partly bent twin lamellae seen in polished section, in two sets crossing at oblique angles.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = 168 D(meas.) = n.d. D(calc.) = 5.822

Optical Properties: Opaque. *Color:* Lead-gray to steel-gray, commonly tarnishes to iridescence; white in polished section, with red internal reflections. *Luster:* Metallic. *Anisotropism:* Distinct, strong in oil.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/a$. $a = 7.291(8)$ $b = 12.68(34)$ $c = 5.998(5)$ $\beta = 91°13(2)'$ Z = 4

X-ray Powder Pattern: Binntal, Switzerland.
3.45 (100), 2.75 (100), 3.00 (70), 2.05 (50), 2.91 (40), 2.01 (40), 0.996 (40)

Chemistry:

	(1)	(2)
Pb	41.0	42.62
Ag	23.7	22.19
As	17.9	15.41
S	18.8	19.78
Total	101.4	100.00

(1) Binntal, Switzerland; by electron microprobe, corresponding to $Pb_{1.01}Ag_{1.12}As_{1.22}S_{3.00}$.
(2) $PbAgAsS_3$.

Occurrence: Of hydrothermal origin, in dolostone.

Association: Lengenbachite, rathite, tennantite, sartorite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: In honor of Dr. John Edward Marr (1857–1933), Professor of Geology, Cambridge University, Cambridge, England.

Type Material: The Natural History Museum, London, England, 87130.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 487–488. (2) Wuensch, B.J. and W. Nowacki (1963) Zur Kristallchemie des Sulfosalzes Marrite. Chimia (Switzerland), 17, 381–382 (in German). (3) (1965) Amer. Mineral., 50, 812 (abs. ref. 2). (4) Wuensch, B.J. and W. Nowacki (1967) The crystal structure of marrite, $PbAgAsS_3$. Zeits. Krist., 125, 459–488.

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Marshite CuI

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As tetrahedra, rounded and striated by {100}, {113}, and {223}, flattened, to 5 mm; in crusts. *Twinning:* On {111}, may be repeated.

Physical Properties: *Cleavage:* {011}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 5.59–5.68 D(calc.) = 5.60 Fluoresces dark red under SW UV.

Optical Properties: Transparent. *Color:* Colorless, pale honey-yellow, turning salmon-red to brick-red on exposure to air; colorless in transmitted light. *Streak:* Bright to pale yellow. *Luster:* Adamantine.
Optical Class: Isotropic; may be anomalously anisotropic. $n = 2.346$ (Na).

Cell Data: *Space Group:* $F\bar{4}3m$ (synthetic). a = 6.0337(3) Z = 4

X-ray Powder Pattern: Synthetic.
3.493 (100), 2.139 (55), 1.824 (30), 3.025 (12), 1.3881 (12), 1.2351 (10), 1.5127 (8)

Chemistry:

	(1)	(2)	(3)
Ag	1.19		
Cu	32.35	33.01	33.37
Cl		0.33	
I	65.85	66.67	66.63
Total	99.39	100.01	100.00

(1) Broken Hill, Australia. (2) Chuquicamata, Chile. (3) CuI.

Occurrence: A rare mineral in the oxidized zone of a metamorphosed Pb–Zn–Ag deposit (Broken Hill, Australia); in the oxidized zone of a porphyry copper deposit (Chuquicamata, Chile); in tills over a copper anomaly, introduced by brackish seawater (Löytösuo, Finland).

Association: Copper, cuprite, cerussite, malachite, Fe–Mn oxides (Broken Hill, Australia); copper, atacamite, tenorite, gypsum (Chuquicamata, Chile).

Distribution: In Australia, from Broken Hill, New South Wales, and in the Poona mine, 5 km northeast of Moonta, South Australia. At Chuquicamata, Antofagasta, Chile. In the Löytösuo area, Ylikiiminki, Finland.

Name: For Charles W. Marsh, who first noted the mineral at Broken Hill, Australia.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 20–22. (2) Barclay, C.J. and J.B. Jones (1971) The Broken Hill silver halides. J. Geol. Soc. Austr., 18, 149–157. (3) Yude, Y., H. Boysen, and H. Schulz (1990) Neutron powder investigation of CuI. Zeits. Krist., 191, 79–91. (4) (1955) NBS Circ. 539, 4, 38–39.

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Marsturite $NaCaMn_3^{2+}Si_5O_{14}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$ or 1. As imperfectly terminated prismatic crystals, elongated along [010], with pinacoids {100} and {001}, to 2 mm, striated on {001} ∥ [100]; also as crusts.

Physical Properties: *Cleavage:* Imperfect on {100} and {001}. Hardness = ∼6
D(meas.) = 3.46 D(calc.) = 3.465

Optical Properties: Translucent. *Color:* Colorless, white to very light pink. *Luster:* Frosty, on the tips of crystals.
Optical Class: Biaxial (+). *Orientation:* $X \simeq c$; $Z' \wedge b = 4^\circ \perp \{001\}$; $Z' \wedge b = 15^\circ \perp \{100\}$. *Dispersion:* $r > v$, very weak. $\alpha = 1.686(2)$ $\beta = 1.691(1)$ $\gamma = 1.708(1)$ 2V(meas.) = 60(1)° 2V(calc.) = 57.4°

Cell Data: *Space Group:* n.d. $a = 7.70(1)$ $b = 12.03(3)$ $c = 6.78(1)$ $\alpha = 85.26(35)^\circ$ $\beta = 94.10(26)^\circ$ $\gamma = 111.04(12)^\circ$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.725 (100), 2.916 (90), 2.999 (80), 3.18 (40), 1.441 (40), 3.11 (30), 2.219 (30)

Chemistry:

	(1)
SiO_2	48.94
FeO	0.24
MnO	34.16
MgO	0.12
CaO	12.46
Na_2O	4.08
H_2O	n.d.
Total	100.00

(1) Franklin, New Jersey, USA; by electron microprobe, average of three analyses; corresponding to $Na_{0.81}Ca_{1.36}(Mn_{2.96}Fe_{0.02}Mg_{0.02})_{\Sigma=3.00}Si_5O_{15}$.

Occurrence: Implanted on manganaxinite and epitaxially overgrown on rhodonite in a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA).

Association: Rhodonite, manganaxinite, ganophyllite, willemite, franklinite (Franklin, New Jersey, USA); natronambulite, kôzulite (Tanohata mine, Japan).

Distribution: From Franklin, Sussex Co., New Jersey, USA. In the Tanohata mine, Iwate Prefecture, Japan. From the Molinello manganese mine, near Chiavari, Val Graveglia, Liguria, Italy.

Name: For MARion STUart, of Bellevue, Idaho, USA, benefactress of fossil and mineral collections in the USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 127923.

References: (1) Peacor, D.R., P.J. Dunn, and B.D. Sturman (1978) Marsturite, $Mn_3CaNaHSi_5O_{15}$, a new mineral of the nambulite group from Franklin, New Jersey. Amer. Mineral., 63, 1187–1189. (2) Dunn, P.J. and P.B. Leavens (1986) Marsturite epitaxial on rhodonite from Franklin, New Jersey. Mineral. Record, 17, 123–125.

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Marthozite $Cu(UO_2)_3O_2(Se^{4+}O_3)_2 \cdot 8H_2O$.

Crystal Data: Orthorhombic. *Point Group: mm*2. Crystals, to 4 mm, are flattened on {100}, striated parallel [001], bound by large {010}, {011}, {2$\bar{3}$0}, modified by {230}, {101}, {201}, {301}, {211}, {210}.

Physical Properties: *Cleavage:* Perfect on {100}; imperfect on {010}. Hardness = n.d. D(meas.) = 4.4 D(calc.) = 4.37 Radioactive; dehydrates at ambient temperature.

Optical Properties: Semitransparent. *Color:* Yellowish green to greenish brown. *Optical Class:* Biaxial (−). *Pleochroism:* Y = yellowish green; Z = yellowish brown. *Orientation:* $X = a$; $Y = b$; $Z = c$. α = n.d. β = 1.780–1.785 γ = 1.795–1.800 2V(meas.) = 39° 2V(calc.) = n.d.

Cell Data: *Space Group:* $P2_1bn$. a = 16.4537(10) b = 17.2229(10) c = 6.9879(4) Z = 4

X-ray Powder Pattern: Musonoi mine, Congo.
8.23 (FFF), 3.09 (FFF), 3.22 (FF), 2.900 (FF), 3.02 (F), 8.65 (mF), 4.44 (mF)

Chemistry:

	(1)	(2)
UO_3	60.5	65.82
SeO_2	23.7	17.02
CuO	4.3	6.10
H_2O	10.7	11.06
Total	99.2	100.00

(1) Musonoi Extension mine, Congo; H_2O by the Penfield method., partially dehydrated material approaching a probable composition $Cu(UO_2)_3O_2(SeO_3)_2 \cdot 6H_2O$. (2) $Cu(UO_2)_3O_2(SeO_3)_2 \cdot 8H_2O$.

Occurrence: A rare alteration product of selenian digenite in the oxidation zone of a uranium-bearing Cu–Co hydrothermal ore deposit.

Association: Digenite, demesmaekerite, denningite, guilleminite.

Distribution: From the Musonoi Co–Cu mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Aimé Marthoz (1894–1962), former Director of the Union Minière de Haut-Katanga, Congo.

Type Material: University of Pierre and Marie Curie, Paris, 12.252; Natural History Museum, Paris; National School of Mines, Paris, France.

References: (1) Cesbron, F., R. Oosterbosch, and R. Pierrot (1969) Une nouvelle espèce minérale: la marthozite. Uranyl-sélénite de cuivre hydraté. Bull. Soc. fr. Minéral., 92, 278–283 (in French with English abs.). (2) (1970) Amer. Mineral., 55, 533 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (2001) Structure topology and hydrogen bonding in marthozite, $Cu^{2+}[(UO_2)_3(SeO_3)_2O_2](H_2O)_8$, a comparison with guilleminite, $Ba[(UO_2)_3(SeO_3)_2O_2](H_2O)_3$. Can. Mineral., 39, 797–807.

Martyite $Zn_3(V_2O_7)(OH)_2 \cdot 2H_2O$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}\,2/m$. As thin plates and flakes with prominent {001}, to 1mm; in mats or rosette-like clusters.

Physical Properties: *Cleavage*: Perfect on {001}, good on {110}. *Fracture*: Curved. *Tenacity*: Brittle; thin flakes slightly flexible. Hardness = 3 D(meas.) = 3.37(3) D(calc.) = 3.375

Optical Properties: Transparent. *Color*: Bright yellow-orange to red-orange. *Streak*: Pale yellow-orange. *Luster*: Adamantine.
Optical Class: Uniaxial (+). ω = 1.797(3) ε = 1.806(3)
Pleochroism: *O* = Red-orange; *E* = yellow.

Cell Data: *Space Group*: $P\bar{3}\,m1$. a = 6.0818(4) c = 7.1793(10) Z = 1

X-ray Powder Pattern: Blue Cap mine, San Juan County, Utah, USA.
7.211 (100), 2.968 (50), 2.470 (40), 2.628 (35), 1.485 (25), 4.252 (20), 2.796 (20)

Chemistry:

	(1)	(2)
ZnO	46.93	50.85
CoO	2.39	
CaO	0.58	
MgO	0.03	
V_2O_5	39.47	37.89
H_2O	12.06	11.26
Total	101.46	100.00

(1) Blue Cap mine, San Juan County, Utah, USA; average of 4 electron microprobe analyses, H_2O calculated from structure, corresponding to $(Zn_{2.66}Co_{0.15}Ca_{0.05})_{\Sigma=2.86}(V_2O_7)(OH)_{1.72}\cdot 2.23H_2O$.
(2) $Zn_3(V_2O_7)(OH)_2 \cdot 2H_2O$.

Occurrence: Product of groundwater leaching and oxidation of vanadium oxides in a post-mining environment.

Association: Gypsum, rossite, pyrite, montroseite, magnesiopascoite.

Distribution: Blue Cap mine, near La Sal, San Juan County, Utah, USA.

Name: Honors Joe Marty (b. 1945) for his contributions to mineralogy.

Type Material: Natural History Museum of Los Angeles County, California, USA, 58610 and 58611.

References: (1) Kampf A.R., and I.M. Steele (2008) Martyite, a new mineral species related to volborthite: description and crystal structure. Can. Mineral., 46, 687–692. (2) (2009) Amer. Mineral., 94, 401 (abs. ref. 1).

Mascagnite $(NH_4)_2SO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rare in euhedral crystals; may be fibrous, to 5 mm; commonly in dendrites, stalactitic forms, and mealy crusts. *Twinning:* On {101}, common.

Physical Properties: *Cleavage:* {100}, good. *Fracture:* Uneven. *Tenacity:* Slightly sectile. Hardness = 2–2.5 D(meas.) = 1.768 D(calc.) = 1.769 Soluble in H_2O, taste sharp and bitter; slightly hygroscopic.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, may be tinged gray, yellowish gray, lemon-yellow; colorless in transmitted light. *Luster:* Vitreous to dull. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, weak. $\alpha = 1.521$ $\beta = 1.523$ $\gamma = 1.539$ 2V(meas.) = 52°

Cell Data: *Space Group: Pnma* (synthetic). $a = 7.782$ $b = 5.993$ $c = 10.636$ Z = 4

X-ray Powder Pattern: Synthetic.
4.33 (100), 4.39 (65), 3.055 (55), 3.890 (35), 5.22 (30), 3.139 (30), 3.122 (25)

Chemistry: (1) Natural material has never been analyzed; identification depends on correspondence of X-ray powder pattern and optical data with that of synthetic material.

Polymorphism & Series: Forms a series with arcanite.

Occurrence: A sublimation product in fumaroles and solfataras; formed by burning coal seams.

Association: Sal ammoniac, tschermigite, sylvite, halite, sassolite, boussingaultite, gypsum, sulfur, cinnabar.

Distribution: In Italy, on Vesuvius, Campania, and Etna, Sicily. In Russia, from volcanoes on the Kamchatka Peninsula. On Nyamuragira [Nyamlagira] volcano, Kivu Province, Congo. At The Geysers, Sonoma Co., California, USA. In Germany, from the Clara mine, near Oberwolfach, Black Forest, and on the dump of the Paul-Berndt mine, Freital, Saxony. From burning coal dumps at all of the following: Commentry, Allier, France. From Bradley, Staffordshire, England. At Arniston, Midlothian, Scotland. From Kladno and Radvanice, Czech Republic. Found near Ravat, Tien-Shan Mountains, Tajikistan. From near Chervonograd, Ukraine. In the USA, from Kehley's Run mine, near Shenandoah, Schuylkill Co., and Glen Lyon, Luzerne Co., Pennsylvania; at Bitter Creek, near Wamsutter, Sweetwater Co., Wyoming.

Name: Honoring Paolo Mascagni (1755–1815), Professor of Anatomy, University of Siena, Siena, Italy, who provided the original description.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 398–399. (2) (1960) NBS Circ. 539, 9, 8.

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Maslovite $(Pt, Pd)(Bi, Te)_2$

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Crystal Data: Cubic. *Point Group:* 23. As elongated grains, which may be rounded, to 200 μm.

Physical Properties: Hardness = n.d. VHN = 262–388 (20 g load), inversely proportional to Pd content. D(meas.) = n.d. D(calc.) = 11.51–11.74

Optical Properties: Opaque. *Color:* In polished section, pale gray with a lilac hue. *Luster:* Metallic.
R: (400) — , (420) — , (440) 55.9, (460) 55.2, (480) 55.0, (500) 55.5, (520) 56.0, (540) 56.1, (560) 55.9, (580) 55.9, (600) 56.1, (620) 56.3, (640) 56.8, (660) 57.1, (680) 57.5, (700) 58.4

Cell Data: *Space Group:* $P2_13$. $a = 6.689(7)$ $Z = 4$

X-ray Powder Pattern: Oktyabr mine, Russia.
3.01 (10), 2.71 (8), 2.02 (6), 1.788 (3), 2.36 (2), 1.852 (2), 1.286 (2)

Chemistry:

	(1)	(2)	(3)
Pt	26.6	21.0	36.69
Pd	5.6	10.6	
Pb	0.0	0.0	
Bi	53.0	49.0	39.31
Sb	1.6	1.2	
Te	15.7	19.05	24.00
Total	102.5	101.9	100.00

(1) Oktyabr mine, Russia; by electron microprobe, corresponding to $(Pt_{0.71}Pd_{0.27})_{\Sigma=0.98}(Bi_{1.31}Te_{0.64}Sb_{0.07})_{\Sigma=2.02}$. (2) Do.; corresponding to $(Pt_{0.53}Pd_{0.49})_{\Sigma=1.02}(Bi_{1.16}Te_{0.78}Sb_{0.05})_{\Sigma=1.99}$. (3) PtBiTe.

Mineral Group: Pyrite group.

Occurrence: In galena-rich portions of massive cubanite-chalcopyrite and mooihoekite ores.

Association: Altaite, sobolevskite, moncheite, michenerite, hessite, froodite, paolovite, tatyanaite, sperrylite, atokite–rustenbergite, galena, chalcopyrite, cubanite, mooihoekite.

Distribution: From the Oktyabr mine, Noril'sk region, western Siberia, Russia [TL]. At the Rustenburg mine, in the Merensky Reef, Bushveld complex, Transvaal, South Africa.

Name: Honors Georgii Dmitrievich Maslov (1915–1968), geologist, one of the discoverers of the Talnakh deposits.

Type Material: Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Kovalenker, V.A., V.D. Begizov, T.L. Evstigneeva, N.V. Troneva, and V.A. Ryabikin (1979) Maslovite, PtBiTe: a new mineral from the Oktyabr copper-nickel deposit. Geol. Rudn. Mestorozhd., 21, 94–104 (in Russian). (2) (1980) Amer. Mineral., 65, 406–407 (abs. ref. 1). (3) Bayliss, P. (1989) Crystal chemistry of pyrite-group minerals. Amer. Mineral., 74, 1168–1176.

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Massicot PbO

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Scaly, commonly earthy, as incrustations and massive.

Physical Properties: Hardness = 2 D(meas.) = n.d. D(calc.) = 9.640

Optical Properties: Translucent, transparent on thin edges. *Color:* Sulfur-yellow to orpiment-yellow, may have a reddish tint; in transmitted light, colorless to pale yellow. *Streak:* Yellow. *Luster:* Greasy to dull.
Optical Class: Biaxial (+). *Pleochroism:* Y = light sulfur-yellow; Z = deep yellow. *Dispersion:* Strong. $\alpha = 2.51$ $\beta = 2.61$ $\gamma = 2.71$ 2V(meas.) = $\sim 90°$

Cell Data: *Space Group: Pcam* (synthetic). $a = 5.4903(1)$ $b = 5.8920(1)$ $c = 4.7520(1)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.068 (100), 2.946 (24), 2.745 (23), 2.3767 (17), 1.7232 (16), 1.6401 (15), 2.0078 (13)

Chemistry: Analyses of natural material are not available; identification is through correspondence of other properties with synthetic material.

Occurrence: As an oxidation product of galena, bournonite, boulangerite, and other lead-bearing minerals.

Association: Cerussite, litharge, minium, wulfenite, antimony oxides, "limonite".

Distribution: Although widespread, typically only in minor amounts. Localities for representative material include: in Germany, from Freiberg, Saxony, at Greifenstein, Nassau, and elsewhere. In France, at Malmes, Gard; Ally, Haute-Loire; in the La Gardette mine, Bourg d'Oisans, Isère; and others. At Băiţa (Rézbánya), Romania. From Laurium, Greece, in slag. At Caracoles, Bolivia. On Popocatepetl volcano, Puebla; at Carachilas, Baja California; Tornacuxtla, Hidalgo; and many other places in Mexico. In the USA, in California, from the Cerro Gordo district, Inyo Co., and on Cucamonga Peak, San Bernardino Co.; in Arizona, from the Tonopah-Belmont mine, Osborne district, at the Moon Anchor mine, Potter-Cramer property, and the Rat Tail claim, Vulture district, Maricopa Co.; in the Flux mine, Patagonia Mountains, Santa Cruz Co.; and several other places. From Dundas, Tasmania, Australia.

Name: From early Arabic, through the Spanish *mazacote* and the French for *oxide of lead*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 516–517. (2) Hill, R.J. (1985) Refinement of the structure of orthorhombic PbO (massicot) by Rietveld analysis of neutron powder diffraction data. Acta Cryst., C41, 1281–1284. (3) McMurdie, H.F., M.C. Morris, E.H. Evans, B. Paretzkin, W. Wong-Ng, Y. Zhang, and C.R. Hubbard (1987) Standard X-ray diffraction powder patterns from the JCPDS research associateship. Powder Diffraction, 2(1), 41–56, esp. 46.

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Masutomilite $\mathbf{K(Li,Al,Mn^{2+})_3(Si,Al)_4O_{10}(F,OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* 2. As the core of a sharply zoned 10 cm mica crystal; as isolated flakes in a coating on garnet.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 2.5 D(meas.) = 2.90–2.94 D(calc.) = 2.96

Optical Properties: Transparent to translucent. *Color:* Pale purple-pink, purple; colorless to pink or purple in thin section.
Optical Class: Biaxial (–). *Pleochroism:* $X = Z$ = colorless, pale pink, pale purple; Y = purple. *Orientation:* $Y = b$; $Z \wedge a = 2°–4°$. *Dispersion:* $r > v$, very weak. *Absorption:* $Y > Z > X$. $\alpha = 1.534–1.536$ $\beta = 1.569–1.570$ $\gamma = 1.570–1.574$ 2V(meas.) = 28°–35°

Cell Data: *Space Group:* $C2$. $a = 5.262(2)$ $b = 9.102(3)$ $c = 10.094(3)$ $\beta = 100.83(2)°$ Z = [2]

X-ray Powder Pattern: Tanakamiyama, Japan.
3.32 (100), 10.10 (70), 3.35 (65), 3.09 (60), 3.64 (45), 2.589 (45), 1.989 (45)

Chemistry:

	(1)		(1)
SiO_2	46.85	Li_2O	4.45
TiO_2	0.13	Na_2O	0.54
Al_2O_3	19.81	K_2O	9.88
Fe_2O_3	0.38	Rb_2O	1.54
FeO	1.53	F	7.04
MnO	8.12	H_2O^+	1.27
MgO	0.00	H_2O^-	1.36
CaO	0.00	$-O = F_2$	2.96
		Total	99.94

(1) Tanakamiyama, Japan; corresponding to $(K_{0.89}Na_{0.07}Rb_{0.07})_{\Sigma=1.03}(Li_{1.27}Al_{0.98}Mn^{2+}_{0.49}Fe^{2+}_{0.09}Fe^{3+}_{0.03})_{\Sigma=2.86}(Si_{3.32}Al_{0.68})_{\Sigma=4.00}O_{9.82}[F_{1.58}(OH)_{0.60}]_{\Sigma=2.18}$.

Polymorphism & Series: 1M, $2M_1$ polytypes.

Mineral Group: Mica group.

Occurrence: In a druse in a granite pegmatite, as the core of a crystal zoned with manganoan zinnwaldite (Tanakamiyama, Japan); as reaction rims coating spessartine-rich garnets in manganese-rich parts of a lithium pegmatite (Ctidružice, Czech Republic).

Association: Zinnwaldite, topaz, tourmaline, albite, quartz, cassiterite (Tanakamiyama, Japan); manganoan garnet, manganoan elbaite (Ctidružice, Czech Republic).

Distribution: From Tanakamiyama, Otsu, Shiga Prefecture, and Tawara, Gifu Prefecture, Japan. At Washington Pass, Okanogan Co., Washington, USA. From Ctidružice, Czech Republic.

Name: For Dr. Kazunosuke Masutomi, Japanese amateur mineralogist.

Type Material: Kanazawa University, Kanazawa; Tohoku University, Kawauchi, Japan.

References: (1) Harada, K., M. Honda, K. Nagashima, and S. Kanisawa (1977) Masutomilite, manganese analog of zinnwaldite, with special reference to masutomilite-lepidolite-zinnwaldite series. Mineral. J. (Japan), 8, 95–109. (2) (1977) Amer. Mineral., 62, 594 (abs. ref. 1). (3) Němec, J. (1983) Masutomilite in lithium pegmatites of West-Moravia, Czechoslovakia. Neues Jahrb. Mineral., Monatsh., 537–540. (4) Mizota, T., T. Kato, and K. Harada (1986) The crystal structure of masutomilite, Mn analog of zinnwaldite. Mineral. J. (Japan), 13, 13–21.

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Masuyite $Pb_3U_8^{6+}O_{27}\cdot 10H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$ (probable). Crystals pseudohexagonal, tabular on {001}, to 3 mm, with {100}, {010}, {110}, and {150}; scaly, in rosettes. *Twinning:* Very common on {110} or $\{1\bar{3}0\}$ as twin and composition planes, contact and repeated, individuals with ∥ {001}.

Physical Properties: *Cleavage:* {001}, perfect; {010}, good. Hardness = n.d. D(meas.) = 5.08 D(calc.) = n.d. Radioactive. Some properties may be incorrectly ascribed to this species; the chemical formula used here is from J. Protas (1959) using synthetic material, the X-ray pattern of which matched natural material in the Sorbonne collection.

Optical Properties: Transparent. *Color:* Red-orange, orange, brownish orange. *Optical Class:* Biaxial (–). *Pleochroism:* X = pale yellow; $Y = Z$ = deep golden yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, moderate. $\alpha = 1.785$ $\beta = 1.895$–1.906 $\gamma = 1.915$–1.917 2V(meas.) = 40.5°–50°

Cell Data: *Space Group: Pcna*, probable, pseudocell. $a = 13.90$–14.09 $b = 12.04$–12.31 $c = 14.20$–14.92 Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
7.08 (100), 3.52 (70), 3.12 (50), 3.56 (35), 3.48 (21), 2.008 (18), 1.95 (17b)

Chemistry:

	(1)	(2)	(3)
UO_3	70.61	75.00	72.92
PbO	24.51	18.82	21.34
H_2O	[4.88]	[6.18]	5.74
Total	[100.00]	[100.00]	100.00

(1) Shinkolobwe, Congo [type I material]; by electron microprobe, average of 11 determinations on four grains, H_2O by difference; corresponds to $Pb_{4.01}U_{9.00}O_{31}\cdot 9.87H_2O$. (2) Do. [type II material]; by electron microprobe, average of five analyses on three grains, H_2O by difference; corresponds to $Pb_{0.97}U_{3.01}O_{10}\cdot 3.94H_2O$. (2) $Pb_3U_8O_{27}\cdot 10H_2O$.

Occurrence: A secondary mineral formed in the oxidized zone of uranium-bearing deposits.

Association: Uraninite, rutherfordine, becquerelite, fourmarierite, wyartite, wölsendorfite, kasolite, metastudtite.

Distribution: From Shinkolobwe, and the Kamoto mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). In the El Sharana mine, South Alligator Valley, Northern Territory, Australia. Found at the Rabéjac uranium deposit, seven km south-southwest of Lodève, Hérault, France.

Name: For Gustave Masuy (1905–1945), Belgian geologist, who studied Congolese (Zairian) minerals.

Type Material: Type material is lost; Royal Museum of Central Africa, Tervuren, Belgium has neotype material; Harvard University, Cambridge, Massachusetts, USA, 104455, although supplied as a type by Vaes, does not contain lead, found microchemically in original type material.

References: (1) Vaes, J.F. (1947) Six nouveaux minéraux d'urane provenant de Shinkolobwe (Katanga). Ann. Soc. Géol. Belg., 70, B212–B229, esp. B219 (in French). (2) (1947) Mineral. Abs., 10, 146 (abs. ref. 1). (3) (1948) Amer. Mineral., 33, 384 (abs. ref. 1). (4) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 78–81. (5) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates. Amer. Mineral., 45, 1026–1061. (6) Protas, J. (1959) Contribution á l'étude des oxydes d'uranium hydratés. Bull. Soc. fr. Minéral., 82, 239–272. (7) Deliens, M. and P. Piret (1996) Les masuyites de Shinkolobwe (Shaba, Zaïre) constituent un groupe formé de deux variétés distinctes par leur composition chimique et leurs propriétés radiocristallographiques. Bull. Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre, 66, 297–192 (in French with English abs.).

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Mathewrogersite $Pb_7(Fe^{2+},Cu)Al_3GeSi_{12}O_{36}(OH,H_2O)_6$

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Crystal Data: Hexagonal. *Point Group:* 3, $\overline{3}$, 32, $3m$, or $\overline{3}\,2/m$. As platy, six-sided crystals, to 0.3 mm, flattened on {0001}. Also as radiating groups, to < 1 mm, of intergrown blades and scales.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = ∼2 D(meas.) = 4.7 D(calc.) = 4.76

Optical Properties: Translucent. *Color:* Colorless, white, or pale greenish yellow. *Streak:* White. *Luster:* Vitreous, weakly pearly on cleavages. *Optical Class:* Uniaxial (–). $\omega = 1.810(4)$ $\epsilon = 1.745(3)$

Cell Data: *Space Group:* $R3$, $R\overline{3}$, $R32$, $R3m$, or $R\overline{3}\,2/m$. $a = 8.457(2)$ $c = 45.970(22)$ Z = 3

X-ray Powder Pattern: Tsumeb, Namibia.
3.257 (100), 15.30 (70), 2.030 (70), 7.68 (60), 2.766 (60), 1.762 (60), 4.08 (50)

Chemistry:

	(1)
SiO_2	26.2
GeO_2	3.9
Al_2O_3	5.9
FeO	1.7
CuO	0.8
PbO	57.5
MgO	0.1
H_2O	1.9
Total	98.0

(1) Tsumeb, Namibia; by electron microprobe, H_2O estimated by elemental analyzer; corresponds to $Pb_{7.08}(Fe_{0.65}Cu_{0.28}Mg_{0.07})_{\Sigma=1.00}Al_{3.18}Ge_{1.03}Si_{12}O_{41.81}H_{5.81}$.

Occurrence: In cavities of corroded Pb-Zn ores in the lower oxidation zone of a polymetallic mineral deposit.

Association: Queitite, alamosite, melanotekite, kegelite, larsenite, schaurteite, anglesite, willemite, leadhillite, mimetite.

Distribution: From Tsumeb, Namibia.

Name: To honor Mathew Rogers, the first European prospector at Tsumeb, Namibia.

Type Material: University of Stuttgart, Stuttgart, Germany, NM15; National Museum of Natural History, Washington, D.C., USA.

References: (1) Keller, P. and P.J. Dunn (1986) Mathewrogersit, ein neues Bleisilikatmineral von Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 203–208 (in German with English abs.). (2) (1987) Amer. Mineral., 72, 1025 (abs. ref. 1).

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Mathiasite $(K, Ca, Sr)(Ti, Cr, Fe, Mg)_{21}O_{38}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Grains, to 5 mm, may rim other minerals.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 1378–1714, 1505 average (100 g load). D(meas.) = n.d. D(calc.) = 4.39

Optical Properties: Opaque. *Color:* Black; tan in reflected light. *Luster:* Metallic. *Optical Class:* Uniaxial. *Pleochroism:* Weak; dark tan. *Anisotropism:* Moderate; brownish tan to dark brown.
R_1–R_2: (400) 20.1–20.8, (420) 19.5–20.2, (440) 19.0–19.7, (460) 18.5–19.2, (480) 18.1–18.6, (500) 17.7–18.4, (520) 17.4–18.2, (540) 17.2–17.9, (560) 16.9–17.7, (580) 16.8–17.6, (600) 16.6–17.4, (620) 16.5–17.4, (640) 16.5–17.3, (660) 16.5–17.3, (680) 16.4–17.3, (700) 16.4–17.3

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.361$ $c = 20.65$ $Z = 3$

X-ray Powder Pattern: South Africa.
2.14 (100), 1.44 (100), 2.25 (90), 2.99 (80), 2.88 (80), 1.79 (70), 3.39 (60)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
U_3O_8	0.01		Al_2O_3	0.62	0.51	CaO	1.09	0.39
Nb_2O_5	0.15		Cr_2O_3	16.71	17.70	SrO	0.66	0.79
Ta_2O_5	0.08		RE_2O_3	2.01	1.21	BaO	0.96	3.25
SiO_2	0.00		FeO	7.96	8.71	Na_2O	0.09	
TiO_2	59.32	56.86	MnO	0.14		K_2O	1.22	1.30
ZrO_2	5.35	5.22	PbO	0.02		Total	[100.52]	99.99
ThO_2	0.01		MgO	4.12	4.05			

(1) Jagersfontein, Bultfontein, and Kolonkwanen kimberlites, South Africa; by electron microprobe, average of six analyses, total Fe as FeO, original total given as 100.46%; RE_2O_3 = Y_2O_3 0.01%, La_2O_3 0.19%, Ce_2O_3 0.35%, Nd_2O_3 0.07%, Sm_2O_3 0.01%, Eu_2O_3 0.01%, Gd_2O_3 0.01%, Tb_2O_3 0.03%, Dy_2O_3 0.01%, Ho_2O_3 0.04%, Er_2O_3 0.21%, Tm_2O_3 0.39%, Yb_2O_3 0.01%, Lu_2O_3 0.67%; corresponds to $(K_{0.45}Ca_{0.34}RE_{0.18}Sr_{0.11}Ba_{0.11}Na_{0.05})_{\Sigma=1.24}$ $(Ti_{12.82}Cr_{3.89}Fe_{1.91}Mg_{1.76}Zr_{0.75}Al_{0.22}Ta_{0.07}Mn_{0.03}Nb_{0.02})_{\Sigma=21.47}O_{38}$. (2) Shandong Province, China; corresponds to $(K_{0.47}Ba_{0.36}Sr_{0.13}Ca_{0.12}RE_{0.12})_{\Sigma=1.20}(Ti_{12.10}Cr_{3.96}Fe_{2.06}Mg_{1.71}$ $Zr_{0.72}Al_{0.17})_{\Sigma=20.72}O_{38}$.

Mineral Group: Crichtonite group.

Occurrence: A primary mantle-derived phase found in heavy-mineral concentrates from metasomatized kimberlite (South Africa).

Association: Lindsleyite, olivine, diopside, phlogopite, Ce-bearing barite, Nb–Cr rutile, Mg–Cr spinel, ilmenite, perovskite, titanite (South Africa); yimengite (Shandong Province, China).

Distribution: From the Jagersfontein diamond mine, Free State, and the Bultfontein diamond mine and Kolonkwanen kimberlite prospect, Mackenzie's Post district, Cape Province, South Africa. From an undisclosed locality [Yimeng Mountains], Shandong Province, China.

Name: Honors Professor Frances Celia Morna Mathias (1913–), University of Cape Town, Cape Town, South Africa, for her contributions to studies of mantle-derived rocks.

Type Material: National Museum, Cape Town, South Africa; The Natural History Museum, London, England; National Museum of Natural History, Washington, D.C., USA.

References: (1) Haggerty, S.E., J.R. Smyth, A.J. Erlank, R.S. Rickard, and R.V. Danchin (1983) Lindsleyite (Ba) and mathiasite (K): two new chromium-titanates in the crichtonite series from the upper mantle. Amer. Mineral., 68, 494–505. (2) Gatehouse, B.M., I.E. Grey, and J.R. Smyth (1983) Structure refinement of mathiasite, $(K_{0.62}Na_{0.14}Ba_{0.14}Sr_{0.10})_{\Sigma=1.0}[Ti_{12.90}Cr_{3.10}$ $Mg_{1.53}Fe_{2.15}Zr_{0.67}Ca_{0.29}(V, Nb, Al)_{0.36}]_{\Sigma=21.0}O_{38}$. Acta Cryst., C39, 421–422. (3) Zhang Jianhong, Ma Jianguo, and Li Liangjing (1988) The crystal structures and crystal chemistry of lindsleyite and mathiasite. Dizhi Lunp'ing [Geological Review], 34(2), 132–144 (in Chinese with English abs.).

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Matildite $AgBiS_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Subhedral prismatic crystals rare; massive, granular; characteristically in intimate intergrowth with galena, which may form Widmanstättenlike textures.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5 VHN = 72–85 (100 g load). D(meas.) = 6.9 D(calc.) = 6.99

Optical Properties: Opaque. *Color:* Iron-black to gray; white in polished section. *Streak:* Pale gray. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak. R_1–R_2: (400) 41.4–47.2, (420) 41.9–47.8, (440) 42.2–48.3, (460) 43.1–48.8, (480) 43.4–49.3, (500) 43.4–49.3, (520) 43.0–49.0, (540) 42.8–48.4, (560) 42.5–47.8, (580) 42.2–47.3, (600) 41.7–46.9, (620) 41.3–46.7, (640) 40.8–46.7, (660) 40.3–46.7, (680) 39.9–46.3, (700) 39.3–46.1

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 4.0662(21)$ $c = 18.5958(17)$ $Z = 3$

X-ray Powder Pattern: Camsell River area, Canada.
2.827 (100), 3.302 (80), 1.966 (60), 2.029 (50), 6.311 (30), 1.709 (30), 3.453 (20)

Chemistry:

	(1)	(2)	(3)
Ag	28.76	27.3	28.33
Bi	54.50	56.0	54.84
S	17.24	16.9	16.83
Total	100.50	100.2	100.00

(1) Morococha, Peru; average of three analyses, after deduction of galena; corresponds to $Ag_{0.99}Bi_{0.97}S_{2.00}$. (2) Camsell River area, Canada; by electron microprobe, corresponds to $Ag_{0.96}Bi_{1.02}S_{2.00}$. (3) $AgBiS_2$.

Occurrence: Formed in hydrothermal deposits at medium to high temperatures and in pegmatites.

Association: Galena, pavonite, aikinite, bismuthinite, hessite, tetradymite, pyrite, chalcopyrite, sphalerite, arsenopyrite, tetrahedrite.

Distribution: From the Matilda mine, near Morococha, Peru [TL]. At Cerro Rico, Potosí, Bolivia. From the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. In the USA, at the Mayflower mine, Boise basin area, Ada Co., Idaho; in the Darwin mine, Inyo Co., California; in Colorado, near Lake City, Hinsdale Co., in the Revell #1 mine, north of Silver Cliff, Custer Co., at Leadville, Lake Co., and elsewhere; from the Campbell mine, Bisbee, Cochise Co., Arizona; at the Outlaw mine, Round Mountain district, Nye Co., Nevada. In Canada, in the O'Brien and other mines, Cobalt, Ontario; at Glacier Gulch, British Columbia; and along the Camsell River, about six km south of Great Bear Lake, Northwest Territories. In Germany, from Schapbach, Black Forest. At Baia Borşa, Baia Mare (Nagybánya), Romania. From Bustarviejo, near Madrid, Spain. At Panasqueira and in the Vale das Gatas tungsten mine, near Vila Real, Portugal. In southwestern Greenland, from the Ivigtut cryolite deposit. In the Kenya mine, Imtali, Zimbabwe. Also known from a few other occurrences with less-well-defined locality information.

Name: For its occurrence in the Matilda mine, Peru.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 429–430. (2) Harris, D.C. and R.I. Thorpe (1969) New observations on matildite. Can. Mineral., 9, 655–662. (3) Geller, S. and J.H. Wernick (1959) Ternary semiconducting compounds with sodium chloride-like structure: $AgSbSe_2$, $AgSbTe_2$, $AgBiS_2$, $AgBiSe_2$. Acta Cryst., 12, 46–54. (4) Bayliss, P. (1991) Crystal chemistry and crystallography of some minerals in the tetradymite group. Amer. Mineral., 76, 257–265. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 358.

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Matlockite PbFCl

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Tabular crystals, to 5 cm, flattened on {001}, with {110}, {011}, and {111} modifications, may be equant, rounded. In subparallel aggregates, rosettelike, radiating, hemispherical; lamellar, cleavable massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 7.12 D(calc.) = 7.16

Optical Properties: Transparent. *Color:* Colorless, pale yellow, amber-yellow, yellow-orange; colorless in transmitted light. *Luster:* Adamantine, pearly on {001}.
Optical Class: Uniaxial (–); rarely biaxial due to strain. $\omega = 2.145$ $\epsilon = 2.006$
2V(meas.) = Small.

Cell Data: *Space Group:* $P4/nmm$ (synthetic). $a = 4.1104(2)$ $c = 7.2325(5)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.574 (100), 2.906 (45), 3.617 (40), 2.265 (40), 2.715 (35), 1.781 (25), 2.055 (20)

Chemistry:

	(1)	(2)	(3)
Pb	79.55	78.92	79.19
F	7.11	7.25	7.26
Cl	13.44	13.57	13.55
Total	100.10	[99.74]	100.00

(1) Cromford, England. (2) Tiger, Arizona, USA; original total given as 99.67%. (3) PbFCl.

Occurrence: In the oxide zone of some lead-bearing mineral deposits.

Association: Phosgenite, anglesite, cerussite, galena, sphalerite, barite, fluorite (Cromford, England); diaboleite, boleite, caledonite, leadhillite (Tiger, Arizona, USA).

Distribution: Large crystals from the Bage and Wallclose mines, about 2.5 km south of Matlock, Derbyshire, England. In slag, at Laurium, Greece. In slag, along Baratti Beach and one km north of Campiglia, Tuscany, Italy. From the Christian-Levin mine, near Essen, North Rhine-Westphalia, Germany. Fine crystals from the Mammoth-St. Anthony mine, Tiger, Pinal Co.; in the Apache mine, Gila Co.; and the Mildren mine, Cabibi district, South Comobabi Mountains, Arizona, USA. At Chancay, Peru. From Challacollo, Tarapacá, Chile. At the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa, in slag.

Name: For the first occurrence near Matlock, England.

Type Material: The Natural History Museum, London, England, 89055.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 59–60. (2) Pasero, M. and N. Perchiazzi (1996) Crystal structure refinement of matlockite. Mineral. Mag., 60, 833–836. (3) (1976) NBS Mono. 25, 13, 25.

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Matraite ZnS

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Crystal Data: Hexagonal. *Point Group:* $3m$. In pyramidal crystal aggregates consisting of oriented sceptre-shaped overgrowths of matraite and sphalerite.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 4.13

Optical Properties: Transparent. *Color:* Brownish yellow. *Luster:* Vitreous.
Anisotropism: Pronounced in some crystals.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R3m$. $a = 3.8$ $c = 9.4$ $Z = 3$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Zn	61.70	67.10
Fe	5.10	
S	33.22	32.90
Total	100.02	100.00

(1) Matra Mountains, Hungary. (2) ZnS.

Polymorphism & Series: Trimorphous with sphalerite and wurtzite.

Occurrence: Of hydrothermal origin.

Association: Wurtzite, sphalerite, galena, chalcopyrite, pyrite.

Distribution: From an undefined locality in the Matra Mountains, Hungary. At Telluride, San Miguel Co., Colorado, USA.

Name: For the Matra Mountains locality in Hungary.

Type Material: n.d.

References: (1) Koch, S. (1958) The associated occurrence of three ZnS modifications in Gyöngyösoroszi. Acta mineralog. petrog. Univ. Szegediensis, 11, 11–12. (2) Sasvari, K. (1958) ZnS mineral with ZnS−3R crystal structure. Acta mineralog. petrog. Univ. Szegediensis, 11, 23–27. (3) (1960) Amer. Mineral., 45, 1131 (abs. refs. 1 and 2). (4) Buck, D.C. and L.W. Strock (1955) Trimorphism in zinc sulfide. Amer. Mineral., 40, 192–200.

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Mattagamite $CoTe_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As equidimensional and rarer bladelike grains isolated in altaite, and as irregular rims a few μm thick on pyrrhotite and chalcopyrite in contact with altaite. *Twinning:* In polished section twinning commonly observed perpendicular to elongation axis of the laths.

Physical Properties: Hardness = n.d. VHN = 383, 404 (25 g load). D(meas.) = n.d. D(calc.) = 8.00

Optical Properties: Opaque. *Color:* In polished section, violet. *Pleochroism:* Weak, colors from pink to cream. *Anisotropism:* Weak, pinkish violet to grayish violet.
R_1–R_2: (400) 50.2–62.2, (420) 51.0–60.3, (440) 51.8–58.4, (460) 51.0–56.6, (480) 49.9–55.6, (500) 48.7–54.7, (520) 48.2–54.2, (540) 47.9–53.9, (560) 47.8–53.9, (580) 47.7–54.0, (600) 47.8–54.3, (620) 48.0–54.7, (640) 48.3–55.2, (660) 48.6–55.6, (680) 48.9–56.3, (700) 49.1–56.9

Cell Data: *Space Group: Pnnm* (synthetic). $a = 5.3294(6)$ $b = 6.3223(8)$ $c = 3.9080(6)$ $Z = 2$

X-ray Powder Pattern: Mattagami Lake mine, Canada.
2.805 (10), 2.703 (8), 2.066 (6), 1.843 (4), 3.31 (3), 1.583 (3), 1.514 (2)

Chemistry:

	(1)	(2)
Co	10.3	18.76
Fe	6.7	
Te	82.4	81.24
Total	99.4	100.00

(1) Mattagami Lake mine, Canada; by electron microprobe, average of analyses of three grain sizes, corresponding to $(Co_{0.54}Fe_{0.37})_{\Sigma=0.91}Te_{2.00}$. (2) $CoTe_2$.

Polymorphism & Series: Forms a series with frohbergite.

Mineral Group: Marcasite group.

Occurrence: In a small telluride zone in a massive zinc-rich stratiform deposit in Archaen volcanics (Mattagami Lake mine, Canada).

Association: Frohbergite, altaite, pyrrhotite, chalcopyrite, magnetite, talc, chlorite (Mattagami Lake mine, Canada).

Distribution: From the Mattagami Lake mine, near Matagami, Quebec, Canada [TL]. At the Zhena-Tyube deposit, Kazakhstan. From Fe–Co–Au–U deposits in the the Kuusamo schist belt, northeastern Finland.

Name: For its occurrence at Mattagami Lake, Canada.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M31956.

References: $FeTe_2$, and $CoTe_2$.*ActaChem.Scand.*, 24, 1925 − −1940.

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Matteuccite $NaHSO_4 \cdot H_2O$

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Crystal Data: Monoclinic (synthetic). *Point Group:* m. A massive component of fumarolic stalactites.

Physical Properties: Hardness = n.d. D(meas.) = 2.118 (synthetic). D(calc.) = 2.124

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (–) (synthetic). $\alpha = 1.43$ $\beta = 1.46$ $\gamma = 1.48$ 2V(meas.) = Large.

Cell Data: *Space Group:* Aa (synthetic). $a = 8.213$ $b = 7.812$ $c = 7.805$ $\beta = 120.04°$
Z = 4

X-ray Powder Pattern: Synthetic.
3.557 (100), 3.462 (70), 3.422 (55), 5.110 (35), 3.633 (30), 2.759 (20), 3.378 (18)

Chemistry: (1) Identification depended on a single strong X-ray line at 3.47 which was interpreted as representing the two strongest lines of the synthetic compound.

Occurrence: In stalactites formed in a volcanic crater.

Association: Mercallite, ralstonite.

Distribution: From Vesuvius, Campania, Italy.

Name: Honors Vittorio Matteucci (1862–1909), Director of the Vesuvius Laboratory, Vesuvius, Italy.

Type Material: University of Florence, Florence, Italy, 1970/I.

References: (1) Carobbi, G. and C. Cipriani (1952) Ralstonite e bisolfato sodico (matteuccite) fra i prodotti della fumarole vesuviane. Atti Rend. Accad. Lincei, 12, 23–29 (in Italian).
(2) (1954) Amer. Mineral., 39, 848 (abs. ref. 1). (3) (1971) NBS Mono. 25, 9, 52.

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Mattheddleite $Pb_{20}(SiO_4)_7(SO_4)_4Cl_4$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As hexagonal prisms, up to 3 mm, forming radiating rosiform aggregates.

Physical Properties: *Cleavage:* On {0001}, or a parting. Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.96 Dull yellow fluorescence under SW UV.

Optical Properties: Transparent. *Color:* Creamy white to pinkish; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (–). $\omega = 2.017(5)$ $\epsilon = 1.999(5)$

Cell Data: *Space Group:* $P6_3/m$. $a = 9.963(5)$ $c = 7.464(5)$ Z = [0.5]

X-ray Powder Pattern: Leadhills, Scotland.
2.988 (100), 4.32 (40), 4.13 (40), 2.877 (40), 3.26 (30), 3.41 (20), 2.072 (20)

Chemistry:

	(1)	(2)
SiO_2	7.65	7.91
PbO	83.60	83.99
Cl	2.40	2.67
SO_3	6.00	6.03
$-O = Cl_2$	0.54	0.60
Total	99.11	100.00

(1) Leadhills, Scotland; by electron microprobe, average of two analyses; corresponds to $Pb_{20.28}Si_{6.90}S_{4.06}O_{44.34}Cl_{3.66}$. (2) $Pb_{20}(SiO_4)_7(SO_4)_4Cl_4$.

Occurrence: Lining cavities in quartz which contain other oxidized lead minerals.

Association: Lanarkite, cerussite, anglesite, pyromorphite, hydrocerussite, caledonite, leadhillite, susannite, macphersonite.

Distribution: From Leadhills, Lanarkshire, Scotland. In England, from the Brae Fells, Red Gill, and Roughton Gill mines, Caldbeck Fells, Cumbria. In Wales, from Dyfed, at the Esgair Hir mine, Bwlch-y-Esgair, Ceulanymaesmawr and the Darren mine, Penbont Rhydybeddau.

Name: For Matthew Forster Heddle (1828–1897), Scottish mineralogist.

Type Material: Royal Museum of Scotland, Edinburgh, Scotland, GY 721.34; The Natural History Museum, London, England, 1985,178.

References: (1) Livingstone, A., G. Ryback, E.E. Fejer, and C.J. Stanley (1987) Mattheddleite, a new mineral of the apatite group from Leadhills, Strathclyde region. Scottish J. Geol., 23, 1–8. (2) (1988) Amer. Mineral., 73, 929 (abs. ref. 1). (3) Cooper, M.P., D.I. Green, and R.S.W. Braithwaite (1988) The occurrence of mattheddleite in the Caldbeck Fells, Cumbria: a preliminary note. U.K. J. Mines and Minerals, 5, 21.

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Matulaite $CaAl_{18}(PO_4)_{12}(OH)_{20}\cdot 28H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As rosettes of pseudohexagonal thin tabular scaly crystals, to 1 mm; botyroidal and as spherules.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Slightly flexible but not elastic. Hardness = 1 D(meas.) = 2.330 D(calc.) = [2.33]

Optical Properties: Translucent. *Color:* Colorless, white, grayish white. *Luster:* Pearly. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 8°$. *Dispersion:* $r < v$, strong. $\alpha = [1.558]$ $\beta = 1.576(2)$ $\gamma = 1.582(2)$ 2V(meas.) = ∼60°

Cell Data: *Space Group:* $P2_1/c$. a = 20.4(1) $b = 16.7(1)$ $c = 10.6(1)$ $\beta = 98.2(5)°$ Z = 2

X-ray Powder Pattern: Hellertown, Pennsylvania, USA.
9.96 (10), 6.37 (4), 4.42 (4), 2.395 (4), 4.83 (3), 3.79 (3), 3.66 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	33.5	35.22	33.93	CaO	1.59	1.67	2.23
SiO_2	3.0			BaO	0.06		
TiO_2	0.12			Na_2O	0.06		
Al_2O_3	34.0	35.75	36.56	K_2O	0.04		
Fe_2O_3	1.05			H_2O^+	10.64	11.18	
MnO	0.07			H_2O^-	15.39	16.18	
CuO	0.09			H_2O			27.28
ZnO	0.14			Total	99.75	100.00	100.00

(1) Hellertown, Pennsylvania, USA. (2) Do.; analysis (1) recomputed to 100% after deduction of quartz and hematite impurities, and removal of minor oxides 0.58%.
(3) $CaAl_{18}(PO_4)_{12}(OH)_{20}\cdot 28H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized zone of phosphatic iron deposits.

Association: Beraunite, rockbridgeite, dufrénite, cacoxenite, strengite, wavellite, goethite, hematite.

Distribution: In the USA, from the Bachman iron mine, Hellertown, Northampton Co., and at General Trimble's mine, Chester Co., Pennsylvania; in the LCA pegmatite, Bessemer City, Gaston Co., North Carolina; at the Candelaria mine, Candelaria district, Mineral Co., Nevada. From the Rotläufchen iron mine, Waldgirmes, near Wetzlar, Hesse, and at Hagendorf, Bavaria, Germany.

Name: Honors Margaret Mary Matula (1925–), Allentown, Pennsylvania, USA, who supplied some of the first specimens.

Type Material: The Natural History Museum, London, England, 1984,138; National Museum of Natural History, Washington, D.C., USA, 137020.

References: (1) Moore, P.B. and J. Ito (1980) Jungit und Matulait: Zwei neue taflige Phosphat-Mineralien. Aufschluss, 31, 55–61 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 1067 (abs. ref. 1).

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Maucherite $Ni_{11}As_8$

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Crystal Data: Tetragonal. *Point Group:* 422. Commonly tabular {001}; also pyramidal with faces striated parallel to their intersections with {001}, to 1 mm. Massive, granular, and radiating fibrous. *Twinning:* On {203} and {106}.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 VHN = 623–724 (100 g load). D(meas.) = 8.00 D(calc.) = 8.02

Optical Properties: Opaque. *Color:* Platinum-gray with reddish tint, tarnishes coppery red; in polished section, pinkish gray. *Streak:* Blackish gray. *Luster:* Metallic. *Anisotropism:* Weak. R_1–R_2: (400) 44.2–44.8, (420) 45.1–45.4, (440) 46.0–45.9, (460) 46.9–46.4, (480) 47.6–46.8, (500) 48.1–47.1, (520) 48.7–47.6, (540) 49.4–48.2, (560) 50.2–49.1, (580) 51.4–50.2, (600) 52.7–51.5, (620) 53.9–52.9, (640) 55.1–54.1, (660) 56.1–55.4, (680) 57.0–56.4, (700) 57.8–57.4

Cell Data: *Space Group:* $P4_12_12$. $a = 6.872(4)$ $c = 21.821(1)$ $Z = 4$

X-ray Powder Pattern: Eisleben, Germany.
2.01 (100), 1.713 (100), 2.69 (90), 1.212 (60), 1.449 (50), 1.108 (50), 1.083 (50)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	49.96	50.03	51.7	51.85
Co	0.20	0.84	0.3	
Fe	0.84	trace		
Cu	0.69	0.13		
As	45.88	45.90	48.5	48.15
Sb			0.1	
S	0.97	0.18		
rem.	0.68	1.66		
Total	99.22	98.74	100.6	100.00

(1) Sudbury, Canada; remainder is H_2O 0.36%, gangue 0.32%. (2) Eisleben, Germany; remainder is gangue 1.66%. (3) Elk Lake, Canada; by electron microprobe. (4) $Ni_{11}As_8$.

Occurrence: In hydrothermal veins with other nickel arsenides and sulfides.

Association: Nickeline, nickel-skutterudite, chalcopyrite (Eisleben, Germany); millerite, uvarovite, pyroxene, calcite (Orford, Canada).

Distribution: In Germany, from Eisleben, Saxony-Anhalt [TL], at Mansfeld, Thuringia, and from Bieber, near Hanau, Hesse. From Schladming, Styria, Austria. In Romania, at Bădeanca, from Băiţa, and in the East Făgăraş Mountains. In Spain, from Los Jarales, Málaga Province; and at Vimbodi, Tarragona Province. At the Littleham Cove area, Budleigh Salterton, Devon, England. From Bou Azzer, Morocco. In the Talmessi mine, near Anarak, Iran. In Canada, at several mines in the Cobalt district, and at the Moose Horn mine, Elk Lake, Timiskaming district, Ontario; in Quebec, at the Orford nickel mine, Brompton Lake, and at the Jeffrey mine, Asbestos. In the USA, at the Gem mine, northwest of Silver Cliff, Fremont Co., Colorado; in the Mohawk mine, Keweenaw Co., Michigan; and in the Mackinaw mine, Monte Cristo, Snohomish Co., Washington. Now known from a few other minor localities.

Name: To honor Wilhelm Maucher (1879–1930), metallugical chemist and mineral dealer of Munich, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 192–194. (2) Fleet, M.E. (1973) The crystal structure of maucherite ($Ni_{11}As_8$). Amer. Mineral., 58, 203–210. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 400–402. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 42–43. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 359.

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Mavlyanovite Mn_5Si_3

Crystal Data: Hexagonal. *Point Group*: 6/*m* 2/*m* 2/*m*. Crystals prismatic, to 2 mm; in spherical to ovoid segregations, to 10 cm.

Physical Properties: *Cleavage*: Near perfect {0001}. *Fracture*: Conchoical. *Tenacity*: Brittle. Hardness = ~ 7 VHN = 1029-1098 (100 g load). D(meas.) = n.d. D(calc.) = 6.06

Optical Properties: Opaque. *Color*: Pale brownish-gray in reflected light. *Streak*: Dark gray. *Luster*: Metallic. *Anisotropism*: moderate; grayish-brown.
Optical Class: Uniaxial.
R_1-R_2: (470) 44.5-42.4, (546) 46.9-44.7, (589) 48.3-46.1, (650) 50.1-48.0

Cell Data: *Space Group*: *P6$_3$/mcm*. a = 6.8971(7) c = 4.8075(4) Z=2

X-ray Powder Pattern: Calculated.
2.044 (100), 1.972 (67), 2.258 (44), 1.991 (30), 2.230 (29), 1.307 (22), 1.401 (16)

Chemistry:

	(1)	(2)
Mn	70.84	76.52
Fe	6.12	
Si	22.57	23.48
Ti	0.15	
P	0.18	
Total	99.86	100.00

(1) Koshmansay river, Chatkal ridge, Uzbekistan; average of 19 electron microprobe analyses, corresponding to $(Mn_{4.66}Fe_{0.40})_{\Sigma=5.06}(Si_{2.91}Ti_{0.01}P_{0.02})_{\Sigma=2.94}$. (2) Mn_5Si_3.

Occurrence: In volcanic glass in a diamond-bearing lamproite diatreme, presumably of high temperature and pressure origin.

Association: Suessite, native iron, moissanite, diamond, an unnamed manganese silicicarbide, an unnamed manganese siliciphosphide; alabandite, khamrabaevite (as inclusions).

Distribution: Upper reaches of the Koshmansay river, Chatkal ridge, Uzbekistan.

Name: Honors Gani Arifkhanovich Mavlyanov (1910–1988) for his contributions to the geology of Uzbekistan.

Type Material: Geological Museum of the State Committee on Geology and Mineral Resources, Tashkent, Uzbekistan; Natural History Museum, London, England (catalog no. BM 2008, 31).

References: (1) Yusupov, R.G., C.J. Stanley, M.D. Welch, J. Spratt, G. Cressey, M.S. Rumsey, R. Seltmann, and E. Igamberdiev (2009) Mavlyanovite, Mn_5Si_3: a new mineral species from a lamproite diatreme, Chatkal Ridge, Uzbekistan. Mineral. Mag., 73, 43–50. (2) (2010) Amer. Mineral., 95, 205-206 (abs. ref. 1).

Mawbyite $PbFe_2^{3+}(AsO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 0.2 mm, show $\{\bar{1}01\}$, {110}, {001}, "dogtooth" to prismatic ‖ [001]; typically in hemispherical, cylindrical, and spongy sheaflike aggregates, druses, and crusts. *Twinning:* "V"-shaped, about {100}, common.

Physical Properties: *Cleavage:* On {001}, good. *Fracture:* Conchoidal. Hardness = ∼4
D(meas.) = n.d. D(calc.) = 5.365

Optical Properties: Transparent to translucent. *Color:* Pale orange, orange-brown to reddish brown. *Streak:* Yellow-orange. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Faint; brown to reddish brown. *Orientation:* $Y = b$; $X \simeq c$. $\alpha = 1.94(2)$ $\beta = 2.00(2)$ $\gamma = 2.04(2)$ 2V(meas.) = 80(5)°

Cell Data: *Space Group:* $C2/m$. $a = 9.066(4)$ $b = 6.286(3)$ $c = 7.564(3)$
$\beta = 114.857(5)°$ Z = 2

X-ray Powder Pattern: Broken Hill, Australia.
4.647 (100), 3.245 (100), 2.724 (70), 2.546 (50), 2.860 (40), 4.458 (30), 3.136 (30)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	0.23		ZnO	0.82	
As_2O_5	34.90	36.44	PbO	37.91	35.38
Al_2O_3	0.02		H_2O	[2.46]	2.85
Fe_2O_3	23.66	25.33	Total	[100.00]	100.00

(1) Broken Hill, Australia; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponds to $Pb_{1.11}(Fe_{1.94}Zn_{0.07})_{\Sigma=2.01}[(As_{0.99}P_{0.01})_{\Sigma=1.00}O_4]_2(OH)_{1.79}$.
(2) $PbFe_2(AsO_4)_2(OH)_2$.

Polymorphism & Series: Dimorphous with carminite.

Mineral Group: Tsumcorite group.

Occurrence: In an arsenic-rich reaction halo in fractures and cavities in a spessartine-quartz rock in the oxidization zone of a metamorphosed stratiform Pb–Zn orebody (Broken Hill, Australia); in the oxidization zone of Ag–Pb–Cu–Bi mineralization in fluorite–barite–quartz veins (Moldava, Czech Republic).

Association: Corkite–beudantite, adamite–olivenite, duftite, bayldonite, hidalgoite, pharmacosiderite, segnitite, Fe–Mn oxides (Broken Hill, Australia); mimetite, philipsbornite, thometzekite (Moldava, Czech Republic).

Distribution: In the Kintore open cut, Broken Hill, New South Wales, Australia. From Moldava, 20 km northwest of Teplice, Czech Republic. In Germany, from the Clara mine, near Oberwolfach, the Silberbrünnle mine, near Gengenbach, and in the St. Josef mine, Schuttertal, Black Forest; from Oberwiesenthal, Saxony.

Name: To honor Sir Maurice Alan Edgar Mawby (1904–1977), Chairman of CRA, Ltd., for his contribution to the Australian mining industry and preservation of Broken Hill minerals.

Type Material: South Australian Museum, Adelaide, G16062, G16066; Museum Victoria, Melbourne, Australia, M39065, M39068, M39173, M39178.

References: (1) Pring, A., E.M. McBriar, and W.D. Birch (1989) Mawbyite, a new arsenate of lead and iron related to tsumcorite and carminite, from Broken Hill, New South Wales. Amer. Mineral., 74, 1377-1381. (2) Kharisun, M.R. Taylor, D.J.M. Bevan, A.D. Rae, and A. Pring (1997) The crystal structure of mawbyite, $PbFe_2(AsO_4)_2(OH)_2$. Mineral. Mag., 61, 685–691. (3) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Mawsonite $Cu_6^{1+}Fe_2^{3+}Sn^{4+}S_8$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Typically as rounded to irregular inclusions, to 1.3 mm, exsolved from bornite.

Physical Properties: *Cleavage:* Two imperfect at right angles suggested by fractures during hardness tests. Hardness = 3.5–4 VHN = n.d. D(meas.) = n.d. D(calc.) = 4.65 Magnetic.

Optical Properties: Opaque. *Color:* In polished section, brownish orange.
Pleochroism: Strong, orange to brown with slight orange tint. *Anisotropism:* Very strong, from bright straw-yellow to bright royal blue to dark blue.
R_1–R_2: (400) 15.0–19.0, (420) 16.0–20.0, (440) 17.1–21.0, (460) 18.6–22.0, (480) 20.3–23.1, (500) 22.5–24.2, (520) 25.0–25.3, (540) 28.1–26.4, (560) 31.2–27.4, (580) 33.8–28.5, (600) 36.4–29.6, (620) 38.5–30.8, (640) 39.9–32.0, (660) 40.9–33.1, (680) 41.4–33.8, (700) 41.6–34.4

Cell Data: *Space Group:* $P\bar{4}m2$. $a = 7.603(2)$ $c = 5.358(1)$ $Z = 1$

X-ray Powder Pattern: Mt. Lyell, Tasmania, Australia.
3.09 (100), 1.895 (80), 1.618 (60), 2.680 (50), 1.063 (50), 1.232 (30), 5.37 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Cu	44.3	45.0	43.91	Sn	10.4	11.8	13.67
Fe	12.5	11.8	12.87	S	33.0	30.3	29.55
Zn		< 0.1		Total	100.2	98.9	100.00

(1) North Lyell mine, Australia; by electron microprobe, corresponds to $Cu_{5.42}Fe_{1.74}Sn_{0.68}S_{8.00}$.
(2) Tingha, Australia; by electron microscope, corresponds to $Cu_{6.00}Fe_{1.79}Sn_{0.84}S_{8.00}$.
(3) $Cu_6Fe_2SnS_8$.

Occurrence: In massive to disseminated hydrothermal copper ores within highly altered volcanic rocks; in skarns; disseminated in altered granites; rare in copper porphyry deposits.

Association: Bornite, pyrite, chalcopyrite, chalcocite, digenite, idaite, stannite, stannoidite, pyrrhotite, pentlandite, tetrahedrite–tennantite, enargite, luzonite–famatinite, kiddcreekite, mohite, bismuth, galena, sphalerite.

Distribution: In Australia, from the North Lyell [TL] and Crown Lyell mines, Mt. Lyell district, Queenstown, Tasmania; and in New South Wales, at the Royal George mine, near Tingha, New England district [TL]. In Bolivia, from Vila Apacheta. In Peru, at the Colquijirca mine, Junín. From the New Brunswick Tin Mines deposit, New Brunswick; the Maggie porphyry copper deposit, 15 km north of Ashcroft, British Columbia; and at the Kidd Creek mine, near Timmins, Ontario, Canada. From Bisbee, Cochise Co., Arizona, USA. At Neves-Corvo, Portugal. From Chizeuil, Saône-et-Loire, France. At Tsumeb, Namibia. In the Khayragatsch and Kochbulak gold deposits, Chatkal-Kuramin Mountains, eastern Uzbekistan. At the Akenobe, Tada, and Ikuno mines, Hyogo Prefecture; the Ashio mine, Tochigi Prefecture; the Fukoku mine, Kyoto Prefecture; and the Konjo mine, Okayama Prefecture, Japan. In the Ulsan mine, Kyongsang Province, South Korea. Now known from a number of other localities.

Name: Honoring Sir Douglas Mawson (1882–1958), noted English-Australian geologist and Antarctic explorer.

Type Material: The Australian Museum, Sydney, Australia, D48487; The Natural History Museum, London, England, 1965,347; Harvard University, Cambridge, Massachusetts, USA.

References: (1) Markham, N.L. and L.J. Lawrence (1965) Mawsonite, a new copper–iron–tin sulfide from Mt. Lyell, Tasmania and Tingha, New South Wales. Amer. Mineral., 50, 900–908. (2) Szymanski, J.T. (1976) The crystal structure of mawsonite, $Cu_6Fe_2SnS_8$. Can. Mineral., 14, 529–535. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 360.

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Maxwellite $NaFe^{3+}(AsO_4)F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As blocky to short prismatic crystals, dominated by {013}, {526}, {$\bar{5}$26}, {011}, to 1 mm.

Physical Properties: *Cleavage:* Good on {110}. *Fracture:* Irregular to conchoidal. Hardness = 5–5.5 D(meas.) = 3.90(2) D(calc.) = 3.95

Optical Properties: Transparent to translucent. *Color:* Medium to dark red. *Streak:* Medium to pale red-orange. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* $X = Y$ = medium yellow-orange; Z = dark orangish red. *Orientation:* $Y = b$; $X \wedge c = 11°$; $Z \wedge a = 35.5°$. *Dispersion:* $r > v$; strong. *Absorption:* $Z > X = Y$. $\alpha = 1.748(3)$ $\beta = 1.772(3)$ $\gamma = 1.798(3)$ 2V(meas.) = 86° 2V(calc.) = 89°

Cell Data: *Space Group:* $C2/c$. $a = 6.667(2)$ $b = 8.781(4)$ $c = 7.134(2)$ $\beta = 114.50(2)°$ Z = 4

X-ray Powder Pattern: Squaw Creek, New Mexico, USA.
3.290 (100), 2.614 (80), 3.039 (75), 4.844 (70), 2.637 (50), 3.642 (35), 3.437 (35)

Chemistry:

	(1)	(2)		(1)	(2)
As_2O_5	51.0	48.54	ZnO	0.1	
Nb_2O_5	0.2		MgO	3.5	
TiO_2	5.0		CaO	8.0	
SnO_2	0.6		Li_2O	0.1	
ZrO_2	0.3		Na_2O	8.0	13.09
Al_2O_3	5.0		F	6.0	8.02
Fe_2O_3	14.0	33.73	$-O = F_2$	2.5	3.38
Mn_2O_3	0.5		Total	99.8	100.00

(1) Squaw Creek, New Mexico, USA; by electron microprobe, average of 43 analyses, total Fe as Fe_2O_3, total Mn as Mn_2O_3, Li by ion microprobe; corresponding to $(Na_{0.59}Ca_{0.33}Li_{0.02})_{\Sigma=0.94}(Fe_{0.40}Al_{0.22}Mg_{0.20}Ti_{0.14}Mn_{0.01}Sn_{0.01}Zr_{0.01})_{\Sigma=0.99}(As_{1.01}O_4)(F_{0.72}O_{0.28})_{\Sigma=1.00}$. (2) $NaFe(AsO_4)F$.

Polymorphism & Series: Forms two series, with durangite, and with tilasite.

Occurrence: Rarely formed in miarolitic cavities in rhyolite adjacent to high-temperature veins in hydrothermal tin deposits.

Association: Squawcreekite, cassiterite, hematite, quartz, tridymite, pseudobrookite, sanidine, chernovite-(Y), gasparite-(Ce), tilasite, heulandite, stilbite, calcite.

Distribution: From the Squaw Creek tin prospect, Catron Co., and in Willow Spring Draw, Sierra Co., Taylor Creek district, New Mexico, USA.

Name: Honors Charles Henry Maxwell (1923–), geologist with the U.S. Geological Survey, who studied the Taylor Creek district.

Type Material: National Museum of Natural History, Washington, D.C., USA, 166613.

References: (1) Foord, E.E., P.F. Hlava, J.J. Fitzpatrick, R.C. Erd, and R.W. Hinton (1991) Maxwellite and squawcreekite, two new minerals from the Black Range tin district, Catron County, New Mexico, U.S.A. Neues Jahrb. Mineral., Monatsh., 363–384. (2) (1992) Amer. Mineral., 77, 449 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1995) The crystal structure of maxwellite. Neues Jahrb. Mineral., Monatsh., 97–104.

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Mayenite $Ca_{12}Al_{14}O_{33}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$ (synthetic). In rounded anhedral grains, to 60 μm.

Physical Properties: Hardness = n.d. D(meas.) = 2.85 D(calc.) = [2.67] Alters immediately to hydrated calcium aluminates on exposure to H_2O.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Isotropic. n = 1.614–1.643

Cell Data: *Space Group:* $I\bar{4}3d$ (synthetic). a = 11.97–12.02 Z = 2

X-ray Powder Pattern: Near Mayen, Germany.
2.69 (vs), 4.91 (s), 2.45 (ms), 3.00 (m), 2.19 (m), 1.95 (m), 1.66 (m)

Chemistry:

	(1)	(2)	(3)
SiO_2		0.4	
Al_2O_3	45.2	49.5	51.47
Fe_2O_3	2.0	1.5	
MnO		1.4	
CaO	45.7	47.0	48.53
LOI	2.2		
Total	95.1	99.8	100.00

(1) Near Mayen, Germany; by semiquantitative spectroscopy. (2) Hatrurim Formation, Israel; by electron microprobe, corresponding to $(Ca_{11.7}Mg_{0.5})_{\Sigma=12.2}(Al_{13.5}Fe_{0.25}Si_{0.10})_{\Sigma=13.85}O_{33}$. (3) $Ca_{12}Al_{14}O_{33}$.

Occurrence: In thermally metamorphosed limestone blocks included in volcanic rocks (near Mayen, Germany); common in high-temperature, thermally metamorphosed, impure limestones (Hatrurim Formation, Israel).

Association: Calcite, ettringite, wollastonite, larnite, brownmillerite, gehlenite, diopside, pyrrhotite, grossular, spinel, afwillite, jennite, portlandite, jasmundite (near Mayen, Germany); melilite, wollastonite, kalsilite, brownmillerite, corundum (Klöch, Austria); spurrite, larnite, grossite, brownmillerite (Hatrurim Formation, Israel).

Distribution: From the Ettringer-Bellerberg volcano, near Mayen, Eifel district, Germany. Found at Klöch, Styria, Austria. In the Hatrurim Formation, Israel. From Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia.

Name: For Mayen, Germany, near where the mineral was first described.

Type Material: Mineral Museum, University of Cologne, Cologne, Germany, M5026/86; National Museum of Natural History, Washington, D.C., USA, 120045.

References: (1) Hentschel, G. (1964) Mayenit, $12CaO \bullet 7Al_2O_3$, und Brownmillerit, $2CaO \bullet (Al,Fe)_2O_3$, zwei neue Minerale in den Kalksteineinschlüssen der Lava des Ettringer Bellerberges. Neues Jahrb. Mineral., Monatsh., 22–29 (in German with English abs.). (2) (1965) Amer. Mineral., 50, 2106–2107 (abs. ref. 1). (3) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 10–11.

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Mayingite IrBiTe

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Massive, in aggregates, to 0.2 mm, and in thin veinlets.

Physical Properties: *Tenacity:* Brittle. Hardness = 4 VHN = 158–241, 178 average (50 g load). D(meas.) = n.d. D(calc.) = 12.77

Optical Properties: Opaque. *Color:* Steel-black; in reflected light, bright white with a yellowish tint. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Moderate; anomalous bluish to yellowish tints.
R: (400) 47.6, (420) 49.3, (440) 49.5, (460) 49.7, (480) 49.9, (500) 50.2, (520) 50.4, (540) 50.7, (560) 51.0, (580) 51.4, (600) 51.7, (620) 51.9, (640) 52.1, (660) 52.4, (680) 52.3, (700) 52.3

Cell Data: *Space Group: Pa*3. $a = 6.502(4)$ $Z = 4$

X-ray Powder Pattern: Near Maying, China.
1.955 (100), 1.735 (80), 1.250 (80), 2.89 (70), 1.207 (70), 1.148 (70), 1.054 (70)

Chemistry:

	(1)	(2)
Ir	34.6	36.35
Pt	1.9	
Cu	0.1	
Te	24.6	24.13
Bi	38.5	39.52
Total	99.7	100.00

(1) Near Maying, China; by electron microprobe, average of 11 analyses; corresponding to $(Ir_{0.95}Pt_{0.05})_{\Sigma=1.00}Cu_{0.01}Bi_{0.97}Te_{1.02}$. (2) IrBiTe.

Occurrence: In chromite ore and placer concentrates.

Association: Platinum, iridisite, laurite, chromite, magnetite, gold, irarsite, shuanfengite.

Distribution: From near Maying, about 230 km north-northeast of Beijing, ??Hebei Province, China [TL]. [need check all Yu Zuxiang species for localities - 8 new from Yanshan Range?? including this, when done]

Name: For the locality.

Type Material: Geological Museum of China, Beijing, China.

References: (1) Yu Zuxiang (1995) Mayingite – a new iridium bismuth-telluride. Acta. Mineral. Sinica, 15(1), 5–8 (in Chinese with English abs.). (2) (1996) Amer. Mineral., 81, 251 (abs. ref. 1).

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Mazzettiite $Ag_3HgPbSbTe_5$

Crystal Data: Orthorhombic. *Point Group*: *mm*2 or 2/*m* 2/*m* 2/*m*. As irregular grains, to 200 μm, in sharp contact with altaite.

Physical Properties: *Cleavage:* None. *Tenacity:* Brittle. *Fracture:* n.d. Hardness = 3-3.5 VHN = 101 (25 g load). D(meas.) = n.d. D(calc.) = 9.04

Optical Properties: Opaque. *Color:* Light gray in reflected light. *Pleochroism*: Weak, greenish gray to a slightly darker bluish gray. *Anisotropism*: Moderate. *Streak:* Black. *Luster:* Metallic. *Optical Class:* n.d.
R_1-R_2: (400) 45.1-45.4, (420) 45.2-45.7, (440) 45.4-45.9, (460) 45.6-46.1, (480) 45.9-46.3, (500) 45.9-46.4, (520) 46.0-46.4, (540) 46.0-46.5, (560) 46.2-46.6, (580) 46.3-47.0, (600) 46.4-47.0, (620) 46.4-47.1, (640) 46.5-47.2, (660) 46.3-47.0, (680) 46.2-46.9, (700) 46.0-46.8

Cell Data: Space Group: $Pna2_1$ or *Pnam*. a = 16.495(6) b = 14.762(7) c = 4.506(2) Z = 4

X-ray Powder Pattern: Findley Gulch, Bonanza mining district, Saguache County, Colorado, USA. 3.01 (100), 3.65 (60), 3.17 (60), 2.754 (60), 1.806 (55), 3.26 (50), 2.137 (50), 2.316 (45)

Chemistry:

	(1)	(2)
Pb	14.12	13.90
Ag	21.60	21.70
Hg	13.58	13.45
Sb	8.07	8.16
Te	42.68	42.79
Total	100.05	100.00

(1) Findley Gulch, Saguache County, Colorado, USA; average of 20 electron microprobe analyses, corresponds to $Ag_{2.99}Hg_{1.01}Pb_{1.02}Sb_{0.99}Te_{4.99}$. (2) $Ag_3HgPbSbTe_5$.

Occurrence: A rare mineral in a hydrothermal telluride deposit.

Association: Altaite, galena, quartz.

Distribution: From Findley Gulch, Bonanza mining district, Saguache County, Colorado, USA.

Name: Honors Giuseppe Mazzetti (1942-2003), curator in chief of the Mineralogy Section, Museum of Natural History, University of Florence, Italy.

Type Material: Natural History Museum, University of Florence, Italy (2951/I) and the Mineralogical Collection, Royal Institute of Natural Sciences, Brussels, Belgium (V/876).

References: (1) Luca, B. and C. Cipriani, (2004) Mazzettiite, $Ag_3HgPbSbTe_5$, a new mineral species from Findley Gulch, Saguache county, Colorado, USA. Can. Mineral., 42(6), 1739-1743. (2) (2005) Amer. Mineral., 90, 1229 (abs. ref. 1).

Mazzite $K_2CaMg_2(Si,Al)_{36}O_{72}\cdot 28H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals are hexagonal prisms terminated by pinacoids. As radiating bundles of thin needles, up to 4 mm.

Physical Properties: Hardness = 4 D(meas.) = n.d. D(calc.) = 2.11

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White.
Optical Class: Uniaxial (–). $\omega = 1.506$ $\epsilon = 1.499$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 18.392$ $c = 7.646$ Z = [1]

X-ray Powder Pattern: Mont Sémiol, France.
3.185 (100), 2.941 (100), 3.824 (95), 3.531 (90), 9.20 (60), 6.02 (53), 4.729 (50)

Chemistry:

	(1)
SiO_2	58.10
Al_2O_3	18.14
MgO	2.92
CaO	2.75
Na_2O	0.03
K_2O	3.27
H_2O	18.42
Total	103.63

(1) Mont Sémiol, France; by electron microprobe, average of three analyses, H_2O by TGA; the high sum is thought due to loss of H_2O in the vacuum chamber during analysis; corresponds to $(K_{1.91}Na_{0.03})_{\Sigma=1.94}Ca_{1.35}Mg_{1.99}(Si_{26.53}Al_{9.77})_{\Sigma=36.30}O_{72}\cdot 28.06H_2O$.

Mineral Group: Zeolite group.

Occurrence: In cavities in a porphyritic olivine basalt.

Association: Phillipsite, offretite, chabazite, calcite, siderite.

Distribution: On Mont Sémiol (Mont Semiouse), near Montbrison, Loire, France.

Name: To honor Professor Fiorenzo Mazzi, mineralogist, University of Pavia, Pavia, Italy.

Type Material: University of Modena, Modena, Italy; National Museum of Natural History, Washington, D.C., USA, 128520.

References: (1) Galli, E., E. Passaglia, D. Pongiluppi, and R. Rinaldi (1974) Mazzite, a new mineral, the natural counterpart of the synthetic zeolite . Contr. Mineral. Petrol., 45, 99–105. (2) (1975) Amer. Mineral., 60, 340 (abs. ref. 1). (3) Galli, E. (1974) Mazzite, a zeolite. Cryst. Struct. Comm., 3, 339–344. (4) (1976) Mineral. Abs., 27, 300 (abs. ref. 3). (5) Gottardi, G. and E. Galli (1985) Natural zeolites. Springer, 160–163.

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Mbobomkulite $(Ni, Cu)Al_4[(NO_3)_2, SO_4]_2(OH)_{12}\cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Pseudohexagonal crystals, to 10 μm, stacked along [001] and as rosettes, forming very fine-grained powdery nodules.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = "Very soft". D(meas.) = 2.30 D(calc.) = 2.344

Optical Properties: Semitransparent. *Color:* Pale blue; colorless in transmitted light. *Optical Class:* Biaxial. *Orientation:* $X' \wedge c \simeq 10°$. $\alpha = 1.515$ β = n.d. $\gamma = 1.585$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1$ (by analogy to chalcoalumite). $a = 10.171$ $b = 8.865$ $c = 17.145$ $\beta = 95.37°$ Z = 4

X-ray Powder Pattern: Mbobo Mkulu Cave, South Africa.
8.550 (100), 4.271 (40), 7.87 (15), 4.549 (15), 3.179 (15), 3.054 (15), 2.512 (15)

Chemistry:

	(1)
SO_3	3.81
N_2O_5	15.23
SiO_2	1.91
Al_2O_3	39.42
NiO	7.98
CuO	4.28
C	0.26
F	0.07
H_2O	27.90
$-O = F_2$	0.03
Total	100.83

(1) Mbobo Mkulu Cave, South Africa; C, N, H by gas chromatography; about 5% additional H_2O is absorbed after removal from a dessicator; after deduction of SiO_2, Al_2O_3, H_2O as allophane, corresponds to $(Ni_{0.57}Cu_{0.29})_{\Sigma=0.86}Al_{3.93}[(NO_3)_{1.50}(SO_4)_{0.25}]_{\Sigma=1.75}[(OH)_{11.45}F_{0.02}]_{\Sigma=11.47}\cdot 1.59H_2O$.

Occurrence: A rare product of oxidation and leaching of Ni–Cu from sulfides in the cave roof, reacting with aluminum from phyllosilicates and nitrate from bat guano (Mbobo Mkulu Cave, South Africa); in a sedimentary U–V deposit (Jomac mine, Utah, USA).

Association: Allophane, chalcoalumite, hydrombobomkulite (Mbobo Mkulu Cave, South Africa); oswaldpeetersite, cuprite, antlerite, goethite, lepidocrocite, hydrombobomkulite, sklodowskite, gypsum (Jomac mine, Utah, USA).

Distribution: In the Mbobo Mkulu Cave, near Ngodwana, Eastern Transvaal, South Africa. From the Jomac mine, White Canyon district, San Juan Co., Utah, USA.

Name: For the Mbobo Mkulu Cave, South Africa, the mineral's first-noted occurrence.

Type Material: Museum of the Geological Survey, Pretoria, South Africa.

References: (1) Martini, J.E.J. (1980) Mbobomkulite, hydrombobomkulite and nickelalumite, new minerals from Mbobo Mkulu Cave, eastern Transvaal. Ann. Geol. Surv. South Africa, 14(2), 1–10. (2) (1982) Amer. Mineral., 67, 415–416 (abs. ref. 1).

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Mcallisterite $Mg_2B_{12}O_{14}(OH)_{12}\cdot 9H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Rhombohedral crystals, to 12 mm, showing {0001}, {01$\overline{1}$2}, {10$\overline{1}$4}, imbedded in other borates and as efflorescences.

Physical Properties: *Cleavage:* Good on {0001} and {01$\overline{1}$2}. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 1.867(5) D(calc.) = 1.866 Slowly soluble in H_2O; fluoresces pale yellow under UV.

Optical Properties: Transparent. *Color:* Snow-white, white, colorless, amber with impurities; colorless in thin section.
Optical Class: Uniaxial (–). $\omega = 1.505$–1.507 $\epsilon = 1.464$–1.465

Cell Data: *Space Group:* $R\overline{3}c$. $a = 11.546(1)$ $c = 35.562(5)$ $Z = 6$

X-ray Powder Pattern: Furnace Creek district, California, USA; exhibits preferred orientation.
8.715 (100), 5.772 (50), 4.063 (50), 3.351 (50), 3.261 (50), 2.805 (50), 6.645 (35)

Chemistry:

	(1)	(2)	(3)
B_2O_3	53.43	53.6	54.35
FeO		0.25	
MnO		0.04	
MgO	10.06	10.4	10.49
H_2O^+		34.9	
H_2O^-		0.76	
H_2O	36.51		35.16
Total	[100.00]	99.95	100.00

(1) Furnace Creek district, California, USA; recalculated to 100% after deduction of ginorite 15.85%, insoluble [clay] 7.32%, R_2O_3 1.32%, gypsum 0.51%, total impurities estimated 25%.
(2) Tincalayu deposit, Argentina; corresponds to $(Mg_{2.01}Fe^{2+}_{0.03})_{\Sigma=2.04}B_{12}O_{14}(OH)_{12}\cdot 9.10H_2O$.
(3) $Mg_2B_{12}O_{14}(OH)_{12}\cdot 9H_2O$.

Occurrence: A secondary mineral derived from colemanite and priceite veins in altered basalt (Furnace Creek district, California, USA); a primary mineral in a metamorphosed borate playa deposit (Tincalayu deposit, Argentina); at a saline lake (China).

Association: Sassolite, ginorite, gypsum (Furnace Creek district, California, USA); starkeyite, gypsum (Sterling Hill, New Jersey, USA); rivadavite (Tincalayu deposit, Argentina); hexahydrite, hydroboracite, hungchaoite (China).

Distribution: In the USA, from the Mott colemanite prospect, Twenty Mule Team Canyon, and at the Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., California; from Sterling Hill, Sussex Co., New Jersey. Found about 15 km northwest of Tubutama, Sonora, Mexico. From the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. On the Qinghai-Xizang Plateau, Tibet, China, not further located. From the Inder borate deposit, Kazakhstan.

Name: To honor James Franklin McAllister (1911–2000), geologist, U.S. Geological Survey, Menlo Park, California, USA, who collected the originally described material.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 109053; National Museum of Natural History, Washington, D.C., USA, 134613, 162598.

References: (1) Schaller, W.T., A.C. Vlisidis, and M.E. Mrose (1965) Macallisterite [mcallisterite], $2MgO\cdot 6B_2O_3\cdot 15H_2O$, a new hydrous magnesium borate mineral from the Death Valley region, Inyo County, California. Amer. Mineral., 50, 629–640. (2) Aristarain, L.F. and C.S. Hurlbut, Jr. (1967) Macallisterite [mcallisterite], $2MgO\cdot 6B_2O_3\cdot 15H_2O$, from Salta, Argentina. Amer. Mineral., 52, 1776–1784. (3) Dal Negro, A., C. Sabelli, and L. Ungaretti (1969) The crystal structure of macallisterite [mcallisterite], $Mg_2[B_6O_7(OH)_6]_2.9H_2O$. Atti Rend. Accad. Lincei, 47, 353–364.

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Mcalpineite $Cu_3Te^{6+}O_6 \cdot H_2O$

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Crystal Data: Cubic. *Point Group:* n.d. Sheaflike aggregates of fibrous to prismatic crystals, to 1 μm, in crusts.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.65

Optical Properties: Translucent to transparent. *Color:* Emerald-green, olive-green, dark green. *Streak:* Paler green. *Luster:* Adamantine.
Optical Class: Isotropic. $n = [2.01]$

Cell Data: *Space Group:* P^{***}. $a = 9.555(2)$ $Z = 8$

X-ray Powder Pattern: McAlpine mine, California, USA.
2.763 (100), 1.689 (80), 2.384 (70), 1.440 (60), 4.26 (40), 1.873 (40), 4.76 (30)

Chemistry:

	(1)	(2)	(3)
TeO_3	39.05	39.0	40.62
As_2O_5		0.8	
SiO_2	0.65	0.2	
NiO	0.17		
CuO	50.84	51.2	55.21
ZnO		3.1	
PbO	4.68		
H_2O	[4.61]	7.	4.17
Total	[100.00]	101.3	100.00

(1) McAlpine mine, California, USA; by electron microprobe, average of four analyses, H_2O by difference, presence confirmed by IR; corresponds to $(Cu_{2.79}Pb_{0.09}Ni_{0.01})_{\Sigma=2.89}(Te_{0.97}Si_{0.05})_{\Sigma=1.02}O_{5.90} \cdot 1.10H_2O$. (2) Centennial Eureka mine, Utah, USA; by electron microprobe, average of two analyses, H_2O by CHN analyzer; corresponds to $(Cu_{2.56}Zn_{0.15})_{\Sigma=2.71}(Te_{0.88}Si_{0.02}As_{0.02})_{\Sigma=0.92}O_{5.47} \cdot 1.53H_2O$. (3) $Cu_3TeO_6 \cdot H_2O$.

Occurrence: A very rare secondary mineral, formed by alteration of tellurides and tellurium-bearing sulfides.

Association: Quartz, chromian muscovite, choloalite, keystoneite, mimetite, malachite, azurite, annabergite, pyrite, acanthite, hessite, "electrum", altaite, silver, galena, pyrargyrite, sphalerite, owyheeite (McAlpine mine, California, USA); xocomecatlite, jensenite, additional uncharacterized tellurate-tellurites, hinsdalite–svanbergite, goethite (Centennial Eureka mine, Utah, USA).

Distribution: In the USA, from the McAlpine mine, Tuolumne Co., California, and at the Centennial Eureka mine, Tintic district, Juab Co., Utah.

Name: For the locality at which the mineral was originally found, the McAlpine mine, California, USA.

Type Material: The Natural History Museum, London, England, 1992,374; Canadian Geological Survey, Ottawa, Canada, 67163.

References: (1) Roberts, A.C., T.S. Ercit, A.J. Criddle, G.C. Jones, R.S. Williams, F.F. Cureton II, and M.C. Jensen (1994) Mcalpineite, $Cu_3TeO_6 \cdot H_2O$, a new mineral from the McAlpine mine, Tuolumne County, California, and from the Centennial Eureka mine, Juab Co., Utah. Mineral. Mag., 58, 417–424. (2) (1995) Amer. Mineral., 80, 630–631 (abs. ref. 1).

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Mcauslanite $HFe_3^{2+}Al_2(PO_4)_4F \cdot 18H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As clusters of radiating fibrous to bladed crystals, elongated along [001], to 1 mm; dominant forms include {010}, {100}, minor {001}. *Twinning:* By rotation about [100]*, creating suture lines on {010}.

Physical Properties: *Cleavage:* Good ‖ [001]. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.22(2) D(calc.) = 2.17

Optical Properties: Transparent to translucent. *Color:* Yellowish white. *Streak:* White. *Luster:* Vitreous to silky.
Optical Class: Biaxial (–). *Orientation:* $X \wedge b = 17°$ in β obtuse; $Y \wedge c = 18°$ in α obtuse; $Z \wedge a = 14°$ in γ obtuse. $\alpha = 1.522(1)$ $\beta = 1.531(1)$ $\gamma = 1.534(1)$ 2V(meas.) = 55(5)° 2V(calc.) = 59.7°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.055(5)$ $b = 11.568(5)$ $c = 6.888(5)$ $\alpha = 105.84(6)°$ $\beta = 93.66(6)°$ $\gamma = 106.47(5)°$ Z = 1

X-ray Powder Pattern: East Kemptville mine, Nova Scotia, Canada.
4.96 (100), 10.6 (90), 9.53 (85), 6.55 (70), 2.812 (55), 2.785 (45), 3.436 (35)

Chemistry:

	(1)	(2)
P_2O_5	30.5	30.02
Al_2O_3	11.1	10.78
FeO	18.1	22.79
MnO	5.0	
F	2.2	2.01
H_2O	34.0	35.25
$-O = F_2$	0.9	0.85
Total	[100.0]	100.00

(1) East Kemptville mine, Nova Scotia, Canada; by electron microprobe, total Fe as FeO, confirmed by microchemical test, original anhydrous total 84.8%, normalized to 100.0% with 34% H_2O by two separate TGA-EGA determinations; then corresponding to $H_{1.02}(Fe_{2.40}Mn_{0.67})_{\Sigma=3.07}Al_{2.08}(PO_4)_{4.10}F_{1.10} \cdot 17.49H_2O$. (2) $HFe_3Al_2(PO_4)_4F \cdot 18H_2O$.

Occurrence: A very rare non-oxidized secondary mineral along joints beneath the erosional surface of a greisen-hosted stockwork tin mine.

Association: Vivianite, phosphophyllite, childrenite–eosphorite.

Distribution: From the East Kemptville tin mine, Yarmouth Co., Nova Scotia, Canada.

Name: Honors Dr. David A. McAuslan (1943–), Exploration Manager for Shell Canada Resources Ltd., developers of the East Kemptville tin mine, Canada.

Type Material: Department of Earth Sciences, Carleton University, Canada, 4427; Canadian Museum of Nature, Ottawa, Canada, 64806; National Museum of Natural History, Washington, D.C., USA, 165484.

References: (1) Richardson, J.M., A.C. Roberts, J.D. Grice, and R.A. Ramik (1988) Mcauslanite, a supergene hydrated iron aluminum fluorophosphate from the East Kemptville tin mine, Yarmouth County, Nova Scotia. Can. Mineral., 26, 917–921. (2) (1990) Amer. Mineral., 75, 707–708 (abs. ref. 1).

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Mcbirneyite $Cu_3(VO_4)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As anhedral crystals, to 200 μm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.50

Optical Properties: Opaque. *Color:* Black; medium gray in reflected light.
Optical Class: [Biaxial.] *Luster:* Metallic.
R: (470) 18.5, (546) 17.5, (589) 18.7, (650) 20.6

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.3418(9)$ $b = 6.5100(8)$ $c = 5.1798(7)$ $\alpha = 88.61(1)°$ $\beta = 68.11(1)°$ $\gamma = 69.22(1)°$ Z = 1

X-ray Powder Pattern: Izalco Volcano, El Salvador.
3.12 (100), 2.82 (100), 4.01 (80), 2.641 (80), 2.428 (80), 4.25 (60), 2.572 (60)

Chemistry:

	(1)	(2)
V_2O_5	41.44	43.25
CuO	56.82	56.75
Total	98.26	100.00

(1) Izalco Volcano, El Salvador; by electron microprobe, average of six analyses of three crystals; corresponds to $Cu_{3.08}(VO_4)_{1.97}$. (2) $Cu_3(VO_4)_2$.

Occurrence: Very rare in the sulfate zone of sublimates around a fumarole in a composite volcano, likely formed between 100 °C–200 °C.

Association: Fingerite, thenardite, euchlorine.

Distribution: From fumarole "Y", Izalco Volcano, El Salvador.

Name: Honors Professor Alexander Robert McBirney (1924–), Volcanologist, University of Oregon, Corvallis, Oregon, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163183.

References: (1) Hughes, J.M., B.S. Christian, L.W. Finger, and L.L. Malinconico (1987) Mcbirneyite, $Cu_3(VO_4)_2$, a new sublimate mineral from the fumaroles of Izalco Volcano, El Salvador. J. Volcanology and Geothermal Research, 33, 183–190. (2) (1988) Amer. Mineral., 73, 1495 (abs. ref. 1).

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Mcconnellite $Cu^{1+}Cr^{3+}O_2$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As parallel intergrowths with grimaldiite in tabular rhombohedral crystals, to 1 mm; as granular aggregates of intergrown crystals.

Physical Properties: *Cleavage:* {0001}. Hardness = n.d. D(meas.) = 5.49 (synthetic). D(calc.) = 5.61

Optical Properties: Translucent in intergrowths with grimaldiite. *Color:* Deep red. *Optical Class:* Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R3m$. $a = 2.983(4)$ $c = 17.160(31)$ Z = 1

X-ray Powder Pattern: Merume River, Guyana; from a mixture with grimaldiite. 2.85 (ms), 2.462 (ms), 2.21 (vw), 1.420 (vw), 1.64 (vvw)

Chemistry:

	(1)	(2)
SiO_2	0.42	
Al_2O_3	4.3	
Fe_2O_3	0.85	
Cr_2O_3	77.3	51.51
CuO	5.5	
Cu_2O		48.49
LOI	11.5	
Total	99.9	100.00

(1) Merume River, Guyana; integrowth of 80%–86% grimaldiite, the balance mcconnellite and H_2O. (2) $CuCrO_2$.

Occurrence: In fine-grained intergrowth with other chromium oxide-hydroxide minerals in alluvial cobbles.

Association: Bracewellite, eskolaite, grimaldiite, guyanaite.

Distribution: In the basin of the Merume River, Guyana.

Name: For Dr. Richard Bradford McConnell, formerly Director, British Guyana Geological Survey.

Type Material: n.d.

References: (1) Milton, C., D.E. Appleman, M.H. Appleman, E.C.T. Chao, F. Cuttitta, J.I. Dinnin, E.J. Dwornik, B.L. Ingram, and H.J. Rose, Jr. (1976) Merumite – a complex assemblage of chromium minerals from Guyana. U.S. Geol. Surv. Prof. Paper 887, 1–29. (2) (1977) Amer. Mineral., 62, 593 (abs. ref. 1). (3) Dannhauser, W. and P.A. Vaughan (1955) The crystal structure of cuprous chromite. J. Amer. Chem. Soc., 77, 896–897.

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Mccrillisite $NaCs(Be,Li)Zr_2(PO_4)_4 \cdot 1-2H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As dipyramidal crystals, to 1.2 mm, dominated by {111}, minor {001}; crystal surfaces typically "crackled".

Physical Properties: *Fracture:* Conchoidal. Hardness = 4–4.5 D(meas.) = 3.125(5) D(calc.) = 3.30

Optical Properties: Translucent to transparent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+); some grains anomalously biaxial. $\omega = 1.634(2)$ $\epsilon = 1.645(2)$ 2V(meas.) = 5°

Cell Data: *Space Group:* $I4_1/amd$. $a = 6.573(2)$ $c = 17.28(2)$ Z = 2

X-ray Powder Pattern: Mt. Mica, Maine, USA; close to gainesite.
3.060 (100), 6.159 (90), 4.326 (80), 3.281 (80), 4.099 (40), 2.896 (30), 1.849 (30)

Chemistry:

	(1)		(1)
P_2O_5	38.3	CaO	< 0.1
SiO_2	0.1	SrO	0.2
Zr_2O	31.6	Li_2O	0.6
HfO_2	2.5	Na_2O	4.2
Al_2O_3	< 0.1	K_2O	0.3
FeO	< 0.1	Rb_2O	< 0.1
MnO	< 0.1	Cs_2O	15.3
ZnO	0.5	F	0.5
BeO	2.9	H_2O	3.0
MgO	0.1	$-O = F_2$	0.2
		Total	99.9

(1) Mt. Mica, Maine, USA; by electron and ion microprobe, average of five analyses; corresponding to $Na_{1.00}(Cs_{0.80}Li_{0.18}K_{0.05})_{\Sigma=1.03}(Be_{0.86}Li_{0.12}Mg_{0.02})_{\Sigma=1.00}(Zr_{1.90}Hf_{0.09}Zn_{0.05})_{\Sigma=2.04}P_{1.00}(O_{3.95}F_{0.05})_{\Sigma=4.00} \cdot 1.23H_2O$.

Occurrence: A rare product of late-stage hydrothermal alteration of primary zirconium-bearing minerals, in a complex granite pegmatite.

Association: Zircon, kosnarite, roscherite, moraesite, eosphorite, löllingite, uraninite, albite, quartz, manganoan almandine, muscovite, siderite, fluorapatite, elbaite, lepidolite, beryl, montebrasite, rhodochrosite, cassiterite, manganocolumbite.

Distribution: From Mt. Mica, near Paris, Oxford Co., Maine, USA.

Name: Honors the McCrillis family, principally Dean (1931–1989) and his son, Phillip, pegmatite miners from Oxford Co., Maine, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 170853.

References: (1) Foord, E.E., M.E. Brownfield, F.E. Lichte, A.M. Davis, and S.J. Sutley (1994) Mccrillisite, $NaCs(Be,Li)Zr_2(PO_4)_4 \cdot 1-2H_2O$, a new mineral species from Mount Mica, Oxford County, Maine, and new data for gainesite. Can. Mineral., 32, 839–842. (2) (1995) Amer. Mineral., 80, 1074 (abs. ref. 1).

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Mcgillite $(Mn^{2+},Fe^{2+})_8Si_6O_{15}Cl_2(OH)_8$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Massive.
Twinning: Universal, repeated about monoclinic [110] and $[\bar{1}10]$, composition plane {001}, giving pseudorhombohedral symmetry.

Physical Properties: *Cleavage:* Good on {0001}; fair on $\{10\bar{1}1\}$. Hardness = [4]
VHN = 278–330 (15 g load). D(meas.) = 2.98(4) D(calc.) = 3.071

Optical Properties: Transparent to translucent. *Color:* Light to dark pink. *Luster:* Pearly on cleavage surfaces.
Optical Class: Biaxial (–); nearly uniaxial. ϵ = 1.640–1.643 ω = 1.667–1.670
2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$. a = 23.312(16) b = 13.459(9) c = 7.423(7)
$\beta = 105.17(2)^\circ$ Z = [4]

X-ray Powder Pattern: Sullivan mine, Canada; nearly identical with friedelite.
2.560 (100), 7.16 (70), 2.888 (60), 3.570 (40), 2.112 (40), 1.683 (40), 11.67 (20)

Chemistry:

	(1)
SiO_2	34.54
As_2O_3	< 0.1
FeO	4.85
MnO	47.76
ZnO	< 0.1
MgO	1.62
CaO	< 0.05
Cl	6.36
H_2O	[7.16]
$-O = Cl_2$	1.44
Total	[100.85]

(1) Sullivan mine, Canada; by electron microprobe, Fe^{2+}:Fe3+ by charge balance; H_2O calculated from stoichiometry; corresponding to $(Mn^{2+}_{6.95}Fe^{2+}_{0.63}Mg_{0.42})_{\Sigma=8.00}(Si_{5.93}Fe^{3+}_{0.07})_{\Sigma=6.00}[O_{14.94}(OH)_{8.21}Cl_{1.85}]_{\Sigma=25.00}$.

Occurrence: As open-space fracture fillings in a manganese-rich section of quartzite and argillite in a metamorphosed Pb–Zn orebody (Sullivan mine, Canada).

Association: Sphalerite, boulangerite, galena, jamesonite, quartz (Sullivan mine, Canada).

Distribution: In the Sullivan mine, Kimberley, Kootenay district, British Columbia, Canada. From the Kyurazawa mine, Tochigi Prefecture, Japan.

Name: For McGill University, Montreal, Quebec, Canada.

Type Material: McGill University, Montreal, RMNS3100; Royal Ontario Museum, Toronto, Canada.

References: (1) Donnay, G., M. Bétournay, and G. Hamill (1980) McGillite, a new manganous hydroxychlorosilicate. Can. Mineral., 18, 31–36. (2) (1981) Amer. Mineral., 66, 1270. (3) Ozawa, T., Y. Takéuchi, T. Takahata, G. Donnay, and J.D.H. Donnay (1983) The pyrosmalite group of minerals. II. The layer structure of mcgillite and friedelite. Can. Mineral., 21, 7–17.

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Mcgovernite

$(Mn^{2+}, Mg, Zn, Fe^{3+})_{45}$
$(As^{3+}O_3)_2(As^{5+}O_4)_5(SiO_4)_7(OH)_{42}$

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Crystal Data: Hexagonal. *Point Group:* $3m$ or $\bar{3}\,2/m$. Coarse cleavable, granular, massive.

Physical Properties: *Cleavage:* Perfect micaceous on {0001}. *Tenacity:* Brittle.
Hardness = 3 D(meas.) = 3.719 D(calc.) = [3.71]

Optical Properties: Semitransparent. *Color:* Deep red-brown, somewhat bronzy; deep red-brown in thin section. *Luster:* Pearly.
Optical Class: Uniaxial (+). $n = 1.761(2)$ $\omega = 1.754$ $\epsilon =$ n.d.

Cell Data: *Space Group:* $R3c$ or $R\bar{3}2/c$. a = 8.22(2) c = 203.15(10) Z = [6]

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
2.257 (100), 2.418 (80), 5.630 (70), 2.604 (50), 4.228 (40), 11.205 (30), 2.819 (30)

Chemistry:

	(1)	(2)
SiO_2	8.92	9.2
Al_2O_3		0.0
Fe_2O_3		1.7
As_2O_3	4.45	4.6
As_2O_5	12.48	12.5
FeO	1.53	
MnO	42.72	42.2
ZnO	10.22	9.3
MgO	11.27	11.5
CaO		0.0
H_2O	8.49	[8.5]
Total	100.08	[99.5]

(1) Sterling Hill, New Jersey, USA. (2) Do.; by electron microprobe, total Fe as Fe_2O_3, H_2O from (1); corresponding to $(Mn_{26.6}Mg_{12.8}Zn_{5.1}Fe^{3+}_{0.9})_{\Sigma=45.4}(As^{3+}O_3)_{2.1}(As^{5+}O_4)_{4.9}Si_{6.9}O_{28}(OH)_{42.2}$.

Occurrence: As the principal filling of a vein in massive zinc ore in a metamorphosed stratiform Zn-Mn deposit.

Association: Franklinite, willemite, zincite, calcite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For J.J. McGovern (?–1915), of Franklin, New Jersey, USA, prominent collector of Franklin minerals.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 113888.

References: (1) Palache, C. and L.H. Bauer (1927) McGovernite, a new mineral from Sterling Hill, New Jersey. Amer. Mineral., 12, 373–374. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 91. (3) Wuensch, B.J. (1960) The crystallography of mcgovernite, a complex arsenosilicate. Amer. Mineral., 45, 937–945. (4) Moore, P.B. and T. Araki (1978) Hematolite: a complex dense-packed sheet structure. Amer. Mineral., 63, 150–159. (5) Moore, P.B. and J. Ito (1978) Kraisslite, a new platy arsenosilicate from Sterling Hill, New Jersey. Amer. Mineral., 63, 938–940. (6) Dunn, P.J., C.A. Francis, and J. Innes (1988) A mcgovernite-like mineral and leucophoenicite from the Kombat mine, Namibia. Amer. Mineral., 73, 1182–1185.

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Mcguinnessite $(Mg,Cu)_2(CO_3)(OH)_2$

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Crystal Data: Monoclinic, may be triclinic. *Point Group:* $2/m$. Crystals are fibrous, to 2 μm, aggregated into radially fibrous spherules, hemispherical or flattened.

Physical Properties: *Fracture:* Even. *Tenacity:* Brittle. Hardness = 2.5
D(meas.) = 3.02–3.22 D(calc.) = 3.076–3.234

Optical Properties: Translucent. *Color:* Pale blue-green, blue-green, white, typically color-banded. *Luster:* Vitreous to silky.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = very pale green; $Y = Z$ = pale bluish green. *Orientation:* Negative elongation; $X \wedge c = 11°$. *Absorption:* $X < Y = Z$. α = 1.596–1.607 β = 1.724–1.740 γ = 1.724–1.740 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2/a$ or $P2_1/a$. $a = 9.398(2)$ $b = 12.011(2)$ $c = 3.379(2)$ $\beta = 93.28(5)°$ Z = [4]

X-ray Powder Pattern: Red Mountain, California, USA.
6.015 (100), 3.694 (67), 2.530 (25), 2.139 (23), 5.054 (16), 2.326 (15), 3.002 (12)

Chemistry:

	(1)	(2)
CO_2	24.73	24.20
CuO	39.6	43.73
MgO	23.7	22.16
CaO	0.07	
H_2O	10.13	9.91
Total	98.23	100.00

(1) Red Mountain, California, USA; by electron microprobe, CO_2 and H_2O by TGA.
(2) $(Mg,Cu)_2(CO_3)(OH)_2$ with Mg:Cu = 1:1.

Mineral Group: Rosasite group.

Occurrence: A rare secondary mineral, typically formed in serpentinized peridotite.

Association: Vuagnatite, malachite, azurite, chrysocolla, iron oxides (Red Mountain, California, USA); coalingite, pokrovskite (Cedar Hill quarry, Pennsylvania, USA); glaukosphaerite, gaspéite, jamborite (Shinshiro, Japan).

Distribution: In the USA, from Red Mountain, 24 km southeast of Ukiah, Mendocino Co., California; occurs in the Rockville quarry, six km west of Rockville, Montgomery Co., Maryland; in the Cedar Hill quarry, Lancaster Co., Pennsylvania; at the Gabbs mine, Gabbs district, Nye Co., and from the Chalk Mountain mine and other claims in the Chalk Mountain district, Churchill Co., Nevada. In the Arroyo Puerto Nuevo, near San José de Castro, Baja California, Mexico. From the Kraubath serpentine massif, Styria, Austria. In the Arhbar (Aghbar) mine, Bou Azzer district, Morocco. Found at Shinshiro, Aichi Prefecture, Japan. In the Champion mine, Nelson, New Zealand.

Name: Honors Albert Leo McGuinness (1926–1990), amateur mineral collector and dealer, San Mateo, California, USA, for his contributions to scientific mineralogy.

Type Material: University of Pierre and Marie Curie, Paris, France; National Museum of Natural History, Washington, D.C., USA, 147169.

References: (1) Erd, R.C., F.P. Cesbron, F.E. Goff, and J.R. Clark (1981) Mcguinnessite, a new carbonate from California. Mineral. Record, 12, 143–147. (2) (1981) Amer. Mineral., 66, 1276 (abs. ref. 1).

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Mckelveyite-(Y) $Na(Ca,U)Ba_3Y(CO_3)_6 \cdot 3H_2O$

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Crystal Data: Triclinic, pseudorhombohedral. *Point Group:* 1. Crystals are tabular to pyramidal, with pseudorhombohedral $\{10\bar{1}2\}$, $\{10\bar{1}1\}$, $\{000\bar{1}\}$, small $\{0001\}$, may be rough, to 5 cm. *Twinning:* By three-fold rotation about pseudorhombohedral [0001] in 120° increments.

Physical Properties: Hardness = 3.5–4 D(meas.) = 3.25(5) D(calc.) = 3.37 Radioactive.

Optical Properties: Transparent to opaque. *Color:* Lime-yellow, greenish gray, reddish brown, black from contained organic material; transparent in thin section. *Luster:* Vitreous to dull. *Optical Class:* Uniaxial (–). *Pleochroism:* In greens. *Absorption:* $O > E$. $\omega = 1.644–1.66$ $\epsilon = 1.550–1.57$

Cell Data: *Space Group:* $P1$. $a = 9.170(3)$ $b = 9.169(3)$ $c = 7.075(2)$ $\alpha = 102.50(3)°$ $\beta = 115.63(3)°$ $\gamma = 59.99(3)°$ Z = 1

X-ray Powder Pattern: Sweetwater Co., Wyoming, USA.
2.942 (100), 4.47 (85), 2.648 (40), 6.40 (35), 3.32 (30), 2.040 (30), 4.15 (20)

Chemistry:

	(1)		(1)		(1)
CO_2	25.7	RE_2O_3	5.7	Na_2O	3.9
UO_2	4.6	CaO	4.0	K_2O	0.1
ThO_2	0.1	SrO	1.7	H_2O	6.1
Y_2O_3	7.7	BaO	40.6	Total	[100.2]

(1) Diamond Alkali No. 3 drillhole, Wyoming, USA; by a combination of gravimetric and spectrophotometric analyses, $RE_2O_3 = La_2O_3$ 0.09%, Ce_2O_3 0.16%, Pr_2O_3 0.05%, Nd_2O_3 0.26%, Sm_2O_3 0.34%, Eu_2O_3 0.19%, Gd_2O_3 1.18%, Tb_2O_3 0.38%, Dy_2O_3 1.00%, Ho_2O_3 0.28%, Er_2O_3 0.95%, Tm_2O_3 0.12%, Yb_2O_3 0.61%, Lu_2O_3 0.08%; recalculated to 100% mckelveyite after deduction of organic 3%, acmite 2.45%, "biotite" 9.40%, quartz 3.02%; then corresponds to $(Na_{1.26}K_{0.02})_{\Sigma=1.28}(Ca_{0.71}U_{0.17})_{\Sigma=0.88}(Ba_{2.64}Sr_{0.16})_{\Sigma=2.80}(Y_{0.68}RE_{0.31})_{\Sigma=0.99}(CO_3)_{5.98} \cdot 3.22H_2O$.

Occurrence: A rare mineral formed near trona beds in the Green River Formation (Wyoming, USA); in a differentiated alkalic massif (Khibiny massif, Kola Peninsula, Russia).

Association: Ewaldite, acmite, "biotite", quartz, labuntsovite, searlesite, leucosphenite (Wyoming, USA); ewaldite, belovite-(Ce), fluorite, nenadkevichite, ancylite-(Ce), synchysite-(Ce), kukharenkoite-(Y), burbankite, calcite, barite, orthoclase (Khibiny massif, Russia); dolomite, calkinsite-(Ce), carbocernaite, khanneshite, barite (Khanneshin complex, Afghanistan).

Distribution: In the USA, in the Westvaco trona mine, the John Hay, Jr. Well No. 1, the Diamond Alkali Daco No. 3 and Reid No. 2 drillholes, the Perkins Green River No. 3 drillhole, and the Texas Gulf Sulfur mine, all near Green River, Sweetwater Co., Wyoming. At Mont Saint-Hilaire, Quebec, Canada. In Russia, large crystals in the Khibiny and Sallanlatvi massifs, and the Vuoriyarvi carbonatite complex, Kola Peninsula. From the Khanneshin carbonatite complex, Afghanistan.

Name: To honor Vincent Ellis McKelvey (1916–1985), Director of the U.S. Geological Survey, Washington, D.C., USA, for his studies of the Phosphoria Formation of Wyoming and Idaho, USA.

Type Material: The Natural History Museum, London, England, 1971,138; National Museum of Natural History, Washington, D.C., USA, 121683, 162607.

References: (1) Milton, C., B. Ingram, J.R. Clark, and E.J. Dwornik (1965) Mckelveyite, a new hydrous sodium barium rare-earth uranium carbonate mineral from the Green River Formation, Wyoming. Amer. Mineral., 50, 593–612. (2) Donnay, G. and J.D.H. Donnay (1971) Ewaldite, a new barium calcium carbonate. Tschermaks Mineral. Petrog. Mitt., 15, 185–200. (3) Chao, G.Y., P.R. Mainwaring, and J. Baker (1978) Donnayite, $NaCaSr_3Y(CO_3)_6 \cdot 3H_2O$, a new mineral from Mont Saint-Hilaire, Québec. Can. Mineral., 16, 335–340. (4) Voloshin, A.V., V.V. Subbotin, V.N. Yakovenchuk, Y.A. Pakhomovskii, Y.P. Men'shikov, and A.N. Zaytsev (1990) Mckelveyite from carbonatites and hydrothermal metasomatites of Kola Peninsula alkaline rocks (first findings in the USSR). Zap. Vses. Mineral. Obshch., 119(6), 76–86 (in Russian with English abs.).

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Mckinstryite $(Ag, Cu)_2S$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As granular aggregates of interlocked crystals, to 3 mm.

Physical Properties: *Cleavage:* One, poorly developed. *Fracture:* Subconchoidal. Hardness = n.d. VHN = 43–45 (25 g load). D(meas.) = 6.61 D(calc.) = 6.57

Optical Properties: Opaque. *Color:* Steel-gray on fresh surface, becoming dark gray to black on long exposure; in polished section, pale grayish white. *Streak:* Dark steel-gray. *Anisotropism:* Strong, in gray, pale grayish blue, and pale tan.
R_1–R_2: (400) 34.0–40.1, (420) 34.0–39.5, (440) 33.9–39.8, (460) 33.7–37.8, (480) 32.9–36.6, (500) 31.9–35.3, (520) 31.0–34.2, (540) 30.2–33.3, (560) 29.6–32.4, (580) 29.1–31.7, (600) 28.7–31.1, (620) 28.5–30.5, (640) 28.2–30.1, (660) 27.9–29.4, (680) 27.6–28.8, (700) 27.4–28.4

Cell Data: *Space Group:* $Pnam$ or $Pna2_1$. $a = 14.043$ $b = 15.677$ $c = 7.803$ Z = 32

X-ray Powder Pattern: Foster mine, Cobalt, Canada.
2.606 (100), 2.070 (70), 3.51 (60), 3.06 (60), 2.862 (60), 1.948 (50), 2.567 (40)

Chemistry:

	(1)	(2)
Ag	60.0	60.7
Cu	24.9	24.8
S	15.1	14.8
Total	100.0	100.3

(1) Foster mine, Canada; by electron microprobe, corresponding to $(Ag_{1.18}Cu_{0.83})_{\Sigma=2.01}S_{1.00}$.
(2) Godejord, Norway; by electron microprobe, corresponding to $(Ag_{1.22}Cu_{0.84})_{\Sigma=2.06}S_{1.00}$.

Occurrence: Of hydrothermal or supergene origin; probably formed below 94.4 °C, the upper stability limit for mckinstryite.

Association: Silver, arsenopyrite, stromeyerite, actinolite, calcite (Foster mine, Canada); bornite, chalcocite, chalcopyrite, djurleite, digenite, tennantite, stromeyerite, wittichenite, bismuth, rammelsbergite, balkanite, mercurian silver, cinnabar, pyrite, calcite, barite, aragonite (Sedmochislenitsi mine, Bulgaria).

Distribution: In Canada, from the Foster mine, Coleman Township, about two km southeast of Cobalt, Ontario [TL], and from the Echo Bay mine, Great Bear Lake, Northwest Territories. In the USA, at the Colorado Central mine, Georgetown district, Clear Creek Co., and the Bulldog Mountain mine, Creede district, Mineral Co., Colorado; at Mogollon, Catron Co., New Mexico; and in the Homestake deposit, near Cooke City, Park Co., Montana. From Jalpa, Zacatecas, Mexico. At Godejord, Grong area, and in the Bleikvassli Zn–Pb–Cu deposit, Nordland, Norway. From the Vrancice deposit, near Příbram, Czech Republic. At the Sedmochislenitsi mine, Vratsa district, western part of the Stara Planina (Balkan Mountains), Bulgaria. From the Um Samiuki Zn–Cu–Pb–Ag volcanogenic deposits, Eastern Desert, Egypt. In the Tort Kudak Au–Ag deposit and the Sarbayskoye iron ore deposit, Kazakhstan. From Broken Hill, New South Wales, Australia. In the Sado mine, Niigata Prefecture; the Shakanai mine, Akita Prefecture; and the Koryu mine, Hokkaido, Japan.

Name: In honor of Hugh Exton McKinstry (1896–1961), Professor of Geology at Harvard University, Cambridge, Massachusetts, USA.

Type Material: Canadian Geological Survey, Ottawa, Canada, 12136; Harvard University, Cambridge, Massachusetts, 108804; National Museum of Natural History, Washington, D.C., USA, 120056.

References: (1) Skinner, B.J., J.L. Jambor, and M. Ross (1966) Mckinstryite, a new copper–silver sulfide. Econ. Geol., 61, 1383–1389. (2) (1967) Amer. Mineral., 52, 1253 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 361.

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Mcnearite $NaCa_5(AsO_4)(AsO_3OH)_4 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As bundles of fibers, to 2 mm, in radial aggregates. *Twinning:* Lamellar ‖ elongation.

Physical Properties: *Cleavage:* Perfect ‖ elongation. *Tenacity:* Very brittle. Hardness = n.d. D(meas.) = 2.60 (low due to porosity of fibrous aggregates). D(calc.) = 2.85 Fluoresces violet under LW UV.

Optical Properties: Translucent to transparent. *Color:* White; colorless in transmitted light. *Luster:* Pearly.
Optical Class: Biaxial (+). *Orientation:* $Y \wedge c = 6°–22°$; positive elongation. *Dispersion:* Moderately strong. $\alpha = 1.559$ $\beta = 1.562$ $\gamma = [1.572]$ 2V(meas.) = 60°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 13.50$ $b = 14.10$ $c = 6.95$ $\alpha = 90°$ $\beta = 92°$ $\gamma = 119°$ Z = 2

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France.
12.33 (100), 3.92 (60), 3.122 (60), 6.94 (50), 2.748 (40), 4.40 (30), 3.400 (25)

Chemistry:

	(1)	(2)
As_2O_5	59.19	57.80
CaO	25.71	28.21
Na_2O	3.40	3.12
H_2O	11.32	10.87
Total	[99.62]	100.00

(1) Sainte-Marie-aux-Mines, France; by AA, original total given as 100.62%, H_2O by TGA, average of two analyses; corresponding to $H_{3.91}Na_{1.09}Ca_{4.99}(AsO_4)_{5.00} \cdot 4.32H_2O$.
(2) $NaCa_5(AsO_4)(HAsO_3OH)_4 \cdot 4H_2O$.

Occurrence: A secondary mineral in the oxidized zone of an arsenic-bearing deposit.

Association: Picropharmacolite, pharmacolite, guérinite, haidingerite.

Distribution: From Sainte-Marie-aux-Mines, Haut-Rhin, France.

Name: Honors Elizabeth McNear, mineralogist and crystallographer, University of Geneva, Geneva, Switzerland.

Type Material: Natural History Museum, Geneva, Switzerland, 435/40.

References: (1) Sarp, H., J. Deferne, and B.W. Liebich (1981) La mcnearite, $NaCa_5H_4(AsO_4)_5 \cdot 4H_2O$, un nouvel arséniate hydraté de calcium et de sodium. Schweiz. Mineral. Petrog. Mitt., 61, 1–6 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 856 (abs. ref. 1).

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Medaite $(Mn^{2+}, Ca)_6(V^{5+}, As^{5+})Si_5O_{18}(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As elongated grains, to 1.5 mm, and as granular aggregates, to 1 cm; as oriented lamellae in tiragalloite. *Twinning:* Microscopic symmetrical twinning, the twin plane coincident with {100}.

Physical Properties: *Cleavage:* Good on {100}; a distinct parting ⊥ elongation. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.70(5) D(calc.) = 3.727

Optical Properties: Translucent in thin fragments; transparent in thin section. *Color:* Brownish red; dark orange to brownish in thin section. *Luster:* Subadamantine. *Optical Class:* Biaxial (+). *Pleochroism:* Faint, from dark to lighter orange. *Orientation:* $X = a$; $Y = b$; $Z = c$; $X \wedge \perp$ to cleavage = 3°. *Absorption:* Strong. $\alpha = 1.77(2)$ $\beta = 1.78(1)$ $\gamma = 1.80(2)$ 2V(meas.) = 71°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.712(1)$ $b = 28.948(8)$ $c = 7.578(2)$ $\beta = 95.4(2)°$ Z = 4

X-ray Powder Pattern: Molinello, Italy.
3.259 (100), 3.159 (83), 3.097 (70), 2.613 (69), 2.941 (68), 3.009(47), 2.785 (47)

Chemistry:

	(1)
SiO_2	38.09
As_2O_5	2.11
V_2O_5	7.44
FeO	0.31
MnO	49.94
CaO	1.30
H_2O	[1.09]
Total	[100.28]

(1) Molinello, Italy; by electron microprobe, H_2O calculated from crystal structure; corresponds to $(Mn^{2+}_{5.77}Ca_{0.19}Fe_{0.04})_{\Sigma=6.00}(V^{5+}_{0.82}As^{5+}_{0.18})_{\Sigma=1.00}Si_5O_{18}(OH)$.

Occurrence: Formed at low temperature and low H_2O fugacity in veinlets cutting manganese ores.

Association: Tiragalloite, braunite, quartz, manganoan calcite, parsettensite, albite (Molinello mine, Italy); palenzonaite, saneroite, pyrobelonite, fianelite, parsettensite, rhodochrosite, kutahorite, aegirine, quartz (Fianel mine, Switzerland).

Distribution: From the Molinello manganese mine, near Chiavari, Val Graveglia, Liguria, Italy. At the Fianel mine, Val Ferrera, Graubünden, Switzerland.

Name: Honors Dr. Francesco Meda (1926–1977), an amateur mineralogist from Turin, Italy.

Type Material: Milan University, Milan; University of Rome, Rome, Italy; University of Oslo, Oslo, Norway.

References: (1) Gramaccioli, C.M., W.L. Griffin, and A. Mottana (1982) Medaite, $Mn_6[VSi_5O_{18}(OH)]$, a new mineral and the first example of vanadatopentasilicate ion. Amer. Mineral., 67, 85–89. (2) Gramaccioli, C.M., G. Liborio, and T. Pilati (1981) Structure of medaite, $Mn_6[VSi_5O_{18}(OH)]$: the presence of a new kind of heteropolysilicate anion. Acta Cryst., 37, 1972–1978.

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Medenbachite $Bi_2Fe^{3+}(Cu, Fe^{2+})(O, OH)_2(AsO_4)_2(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As thin tabular crystals, to 2 mm, flattened on $\{\overline{1}01\}$ and elongated along [111]; forms include {001}, $\{\overline{1}01\}$, {101}, $\{\overline{1}10\}$, $\{0\overline{1}1\}$, $\{13\overline{1}\}$; typically aggregated in parallel $\{\overline{1}01\}$ growths.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 VHN = 420 (25 g load). D(meas.) = n.d. D(calc.) = 5.90

Optical Properties: Transparent to translucent. *Color:* Yellow to yellow-brown. *Luster:* Vitreous to adamantine. *Optical Class:* Biaxial (–). *Orientation:* X (−14°,74°); Y (−117°,52°); Z (95°,43°) [using (ϕ,ρ)]. *Dispersion:* $r > v$. $\alpha = 2.03(2)$ $\beta = [2.09]$ $\gamma = 2.10(2)$ 2V(meas.) = 43(3)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 4.570(1)$ $b = 6.162(1)$ $c = 8.993(1)$ $\alpha = 94.56(1)°$ $\beta = 99.69(1)°$ $\gamma = 94.28(1)°$ Z = 1

X-ray Powder Pattern: Reichenbach, Germany.
3.749 (100), 3.596 (77), 2.903 (69), 8.823 (62), 3.468 (58), 2.685 (48), 5.264 (44)

Chemistry:

	(1)
As_2O_5	25.32
Bi_2O_3	53.36
Fe_2O_3	8.99
FeO	1.00
CuO	7.85
H_2O	[3.07]
Total	[99.59]

(1) Reichenbach, Germany; by electron microprobe, average of 16 analyses, Fe^{2+}:Fe^{3+} estimated from microchemical test and requirements of site occupancy, $(OH)^{1-}$ and absence of H_2O confirmed by IR and apportioned for charge balance; corresponding to $Bi_{2.04}Fe^{3+}_{1.00}(Cu_{0.88}Fe^{2+}_{0.12})_{\Sigma=1.00}O_{1.11}(AsO_4)_{1.96}(OH)_{3.03}$.

Occurrence: A very rare secondary mineral in a weathered polymetallic sulfide vein.

Association: Mixite, preisingerite, alunite, goethite, reichenbachite, malachite, quartz.

Distribution: From [the Borstein quarry,] about one km east of Reichenbach, near Bensheim, Hesse, Germany.

Name: Honors Olaf Medenbach (1949–), mineralogist, Ruhr University, Bochum, Germany.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany, 8.0.137, 8.0.376.

References: (1) Krause, W., H.-J. Bernhardt, W. Gebert, H. Graetsch, K. Belendorff, and K. Petitjean (1996) Medenbachite, $Bi_2Fe(Cu, Fe)(O, OH)_2(OH)_2(AsO_4)_2$, a new mineral species: its description and crystal structure. Amer. Mineral., 81, 505–512.

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Megacyclite $Na_8KSi_9O_{18}(OH)_9 \cdot 19H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In irregular grains, to 3 mm.

Physical Properties: *Cleavage:* Perfect {100}; less perfect {001}. *Fracture:* Steplike. Hardness = 2 D(meas.) = 1.82(5) D(calc.) = 1.87 Turns white on exposure to air.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* [White.] *Luster:* Vitreous to subvitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 30°$. *Dispersion:* $r > v$, strong.
$\alpha = 1.460(2)$ $\beta = 1.478(2)$ $\gamma = 1.481(2)$ 2V(meas.) = 43(1)° 2V(calc.) = 44°

Cell Data: *Space Group:* $P2_1/c$. $a = 24.91(5)$ $b = 11.94(1)$ $c = 14.92(2)$ $\beta = 94.47(9)°$
$Z = 4$

X-ray Powder Pattern: Khibina massif, Russia.
3.08 (100), 2.938 (70b), 4.26 (60), 2.649 (60b), 2.400 (35), 2.289 (35), 7.42 (20)

Chemistry:

	(1)
SiO_2	43.42
Na_2O	19.75
K_2O	3.62
H_2O	[33.21]
Total	[100.00]

(1) Khibina massif, Russia; by electron microprobe, average of four analyses, H_2O by difference; corresponds to $Na_{7.96}K_{0.96}Si_{9.02}O_{18}(OH)_9 \cdot 18.51H_2O$.

Occurrence: In unweathered ultra-alkalic pegmatites in an alkalic massif.

Association: Orthoclase, fenaksite, revdite, delhayelite, many other minerals.

Distribution: On Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: From the Greek for *large* and *cyclical*, with reference to the large ringlike groups of silica tetrahedra in the structure.

Type Material: Mining Institute, St. Petersburg, 2066/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p733/2.

References: (1) Khomyakov, A.P., G.N. Nechelyustov, N.A. Yamnova, and D.Y. Pushcharovskii (1993) Megacyclite $Na_8KSi_9O_{18}(OH)_9 \cdot 19H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 122(1), 125–128 (in Russian). (2) (1994) Amer. Mineral., 79, 1011 (abs. ref. 1). (3) Yamnova, N.A., R.K. Rastsvetaeva, D.Y. Pushcharovskii, T. Mernaf, M.G. Mikheeva, and A.P. Khomyakov (1992) Crystal structure of the new annular Na, K silicate $Na_{16}K_2[Si_{18}O_{36}(OH)_{18}] \cdot 38H_2O$. Kristallografiya (Sov. Phys. Crystal.), 32, 167–174 (in Russian).

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Megawite $CaSnO_3$

Crystal Data: Orthorhombic. *Point Group:* 2/*m* 2/*m* 2/*m*. Crystals pseudo-cubic and pseudo-cuboctahedral, to 0.015 mm, as inclusions in spurrite or as rims on lakargiite. Twinning observed.

Physical Properties: *Cleavage:* Good on {110} and {001}. *Fracture:* n.d. *Tenacity:* n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.06

Optical Properties: Transparent. *Color:* Pale yellow or colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+) [Synthetic]. *n* = 1.89 *Orientation*: *X* = *b*; *Y* = *a*; *Z* = *c*.

Cell Data: *Space Group: Pbnm.* *a* = 5.555(3) *b* = 5.708(2) *c* = 7.939(5) *Z* = 4

X-ray Powder Pattern: Upper Chegem caldera, Kabardino-Balkaria, Northern Caucasus, Russia. 2.812 (100), 3.984 (52), 2.855 (43), 3.970 (19), 2.780 (19), 1.992 (13), 1.985 (13)

Chemistry:	(1)		(1)
UO_3	0.30	Cr_2O_3	0.39
Nb_2O_5	0.15	Fe_2O_3	0.85
SiO_2	0.22	La_2O_3	0.23
TiO_2	2.87	Ce_2O_3	0.21
ZrO_2	19.89	MgO	0.03
SnO_2	44.24	CaO	29.80
HfO_2	0.62	SrO	0.14
ThO_2	0.32	Total	100.58
Al_2O_3	0.04		
Sc_2O_3	0.28		

(1) Upper Chegem caldera, Kabardino-Balkaria, Northern Caucasus, Russia; average of 9 electron microprobe analyses; corresponding to molecular ratios $(CaSnO_3)_{56}(CaZnO_3)_{31}(CaTiO_3)_7$.

Polymorphism & Series: Forms series with perovskite, $CaTiO_3$, and lakargiite, $CaZrO_3$.

Mineral Group: Perovskite group.

Occurrence: Occurs as minute inclusions in rock-forming minerals in altered ignimbrite xenoliths in a caldera. Probably formed by contact metamorphism at low pressure and >800ºC.

Association: Spurrite, reinhardbraunsite, rondorfite, wadalite, srebrodolskite, lakargiite, perovskite, kerimasite, elbrusite-(Zr), periclase, hydroxylellestadite, hydrogrossular, ettringite-group minerals, afwillite, hydrocalumite, brucite.

Distribution: Upper Chegem caldera, Kabardino-Balkaria, Northern Caucasus, Russia.

Name: Honors British crystallographer Helen Dick Megaw (1907-2002) for significant contributions to our understanding of the perovskites.

Type Material: Mineralogical Museum of Wrocław University, Poland (MMUWr II16717), and in the A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (4021/1).

References: (1) Galuskin, E.V., I.O. Galuskina, V.M. Gazeev, P. Dzierżanowski, K. Prusik, N.N. Pertsev, A.E. Zadov, R. Bailau, and A.G. Gurbanov (2011) Megawite, $CaSnO_3$: a new perovskite-group mineral from skarns of the Upper Chegem caldera, Kabardino-Balkaria, Northern Caucasus, Russia. Mineral. Mag., 75(5), 2563-2572. (2) (2013) Amer. Mineral., 98, 1081 (abs. ref. 1).

Meionite $3CaAl_2Si_2O_8 \cdot CaCO_3$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals prismatic, typically with flat pyramidal terminations, striated ‖ [001], to 0.7 m; granular, massive.

Physical Properties: *Cleavage:* {100}, {110}, distinct. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.74–2.78 D(calc.) = [2.86] Commonly fluoresces orange to bright yellow or red under LW or SW UV or both.

Optical Properties: Transparent to opaque. *Color:* Colorless, white, grey; pink, violet, blue, yellow, orange-brown, brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous to pearly or resinous.
Optical Class: Uniaxial (–). $\omega = 1.590–1.600$ $\epsilon = 1.556–1.562$

Cell Data: *Space Group:* $I4/m$ (synthetic). $a = 12.179(1)$ $c = 7.571(1)$ $Z = 2$

X-ray Powder Pattern: Bolton, Massachusetts, USA. (ICDD 2-405).
3.47 (100), 3.08 (100), 2.07 (100), 2.73 (80), 1.91 (80), 1.37 (80), 3.87 (70)

Chemistry:

	(1)		(1)
SiO_2	41.38	Cl	0.18
Al_2O_3	31.59	H_2O^+	0.29
MgO	0.29	CO_2	4.35
CaO	20.72	SO_3	0.35
Na_2O	1.38	$-O = (F,Cl)_2$	0.04
K_2O	0.48	Total	100.97

(1) Vesuvius, Campania, Italy; corresponds to $(Ca_{3.39}Na_{0.41}K_{0.09}Mg_{0.07})_{\Sigma=3.96}(Si_{6.32}Al_{5.68})_{\Sigma=12.00}O_{24}[(CO_3)_{0.91}Cl_{0.05}(SO_4)_{0.04}]_{\Sigma=1.00}$.

Polymorphism & Series: Forms a series with marialite; intermediate members are $P4_2/n$.

Mineral Group: Scapolite group.

Occurrence: Typically in regionally metamorphosed rocks, especially marbles, calcareous gneisses, granulites, and greenschists. Also in skarns, some pegmatites, pneumatolytically or hydrothermally altered mafic igneous rocks, and ejected volcanic blocks.

Association: Plagioclase, garnet, pyroxenes, amphiboles, apatite, titanite, zircon.

Distribution: Most specimens are intermediate in the series, see also marialite; some localities for highly calcic material include: at Monte Somma and Vesuvius, Campania, Italy. Around the Laacher See, Eifel district, Germany. From Pargas and Pusunsaari, Finland. At Slyudyanka, near Lake Baikal, Siberia, Russia. From Gooderham, Ontario, and Grenville, Quebec, Canada. At Rossie, St. Lawrence Co., New York; Bolton, Worcester Co., Massachusetts; and Cutcane Creek, Fannin Co., Georgia, USA.

Name: From the Greek for *less*, referring to its less acute pyramidal form compared with vesuvianite.

Type Material: Natural History Museum, Paris, France, 3774.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 466–468. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 321–337. (3) Papike, J.J. and N.C. Stephenson (1966) The crystal structure of mizzonite, a calcium- and carbonate-rich scapolite. Amer. Mineral., 51, 1014–1027. (4) Aitken, B.G., H.T. Evans, Jr., and J.A. Konnert (1984) The crystal structure of a synthetic meionite. Neues Jahrb. Mineral., Abh., 149, 309–324. (5) Bayliss, P. (1987) Scapolite [meionite, part]. Mineral. Mag., 51, 176.

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Meixnerite $Mg_6Al_2(OH)_{18}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Tabular crystals, to 1 mm.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ∼2 D(meas.) = 1.9(1) D(calc.) = 1.95

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (–). $\omega = 1.517$ ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 3.0463(15)$ $c = 22.93(2)$ Z = 3/8

X-ray Powder Pattern: Ybbs-Persenberg, Austria; d's calculated. (ICDD 34-478).
1.94 (100), 1.52 (75), 3.82 (72), 2.287 (70), 2.57 (64), 1.494 (57), 7.64 (55)

Chemistry:

	(1)	(2)
Al_2O_3	15.0	17.64
Fe_2O_3	0.55	
MgO	36.5	41.84
H_2O	[47.95]	40.52
Total	[100.00]	100.00

(1) Ybbs-Persenberg, Austria; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference.
(2) $Mg_6Al_2(OH)_{18}\cdot 4H_2O$.

Occurrence: A secondary mineral in serpentinite.

Association: Talc, aragonite.

Distribution: From Ybbs-Persenberg, Ispertal, Austria.

Name: To honor Professor Heinrich Hermann Meixner (1908–1981), Austrian mineralogist, University of Salzburg, Salzburg, Austria.

Type Material: University of Salzburg, Salzburg, Austria; University of Göttingen, Göttingen, Germany; The Natural History Museum, London, England, 1980,687; Harvard University, Cambridge, Massachusetts, USA, 117008.

References: (1) Koritnig, S. and P. Süsse (1975) Meixnerite, $Mg_6Al_2(OH)_{18}\cdot 4H_2O$, ein neues Magnesium-Aluminium-Hydroxid-Mineral. Tschermaks Mineral. Petrog. Mitt., 22, 79–87 (in German with English abs.). (2) (1976) Amer. Mineral., 61, 176 (abs. ref. 1).

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Melanocerite-(Ce) $(Ce, Ca)_5(Si, B)_3O_{12}(OH, F)\cdot nH_2O(?)$

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Crystal Data: Hexagonal; commonly amorphous. *Point Group:* n.d. Crystals flat rhombohedral, to 2 cm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 4.13–4.29 D(calc.) = n.d.

Optical Properties: Translucent, transparent in thin fragments. *Color:* Brown, black; in thin section, bright wine-yellow. *Streak:* Light brown. *Luster:* Resinous to greasy. *Optical Class:* Uniaxial (–); commonly isotropic. $n = 1.70–1.76$; birefringence low.

Cell Data: *Space Group:* n.d. a = n.d. c = n.d. Z = n.d.

X-ray Powder Pattern: X-ray amorphous; when heated to 600 °C an apatitelike pattern results.

Chemistry:	(1)	(2)	(3)
SiO_2	13.07	12.97	15.68
ZrO_2	0.46	0.47	0.19
ThO_2	1.66	13.64	10.70
B_2O_3	[3.19]	4.70	3.23
Al_2O_3	0.83	0.87	0.91
Y_2O_3	9.17	2.21	
La_2O_3	41.37	35.92	51.44
Ce_2O_3	3.52	5.61	
Fe_2O_3	2.09	1.36	1.96
Mn_2O_3	1.22	0.66	
$(Nb, Ta)_2O_5$	3.65	3.11	0.01
MnO			0.75

	(1)	(2)	(3)
PbO			0.50
MgO	0.14	0.17	0.28
CaO	8.62	7.37	3.00
SrO			0.11
Na_2O	1.45	1.42	1.56
K_2O			0.15
F	5.78	5.63	1.92
H_2O	3.01	4.77	5.97
CO_2	1.75	0.35	
P_2O_5	1.29	0.86	2.62
$-O = F_2$	2.43	2.37	
Total	[99.84]	99.72	100.98

(1–2) Langesundsfjord, Norway. (3) Yenisei Ridge, Russia.

Occurrence: In nepheline syenite pegmatites (Langesundsfjord, Norway); in alkalic granite pegmatites (Russia).

Association: Astrophyllite, ferrian biotite, leucophanite, fluorite (Langesundsfjord, Norway); gadolinite, yttrialite, fergusonite (Russia).

Distribution: On Kjeø Island, near Barkevik, Langesundsfjord, Norway. In Russia, in Siberia, from the Burpala massif, about 120 km north of Lake Baikal, and on Yenisei Ridge.

Name: From the Greek for *black* or *dark* and *cerium* in its composition.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 414–415 [includes caryocerite]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 301–302. (3) Vasil'eva, Z.V. and E.V. Sveshnikova (1972) New data on melanocerite. Trudy Mineral. Muzeya Akad. Nauk SSSR, 21, 12–16 (in Russian). (4) (1972) Chem. Abs., 77, 167086 (abs. ref. 3).

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Melanophlogite $SiO_2 \cdot n(C, H, O, S)$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m\ 2/m\ 2/m$ supercells are statistically oriented along the pseudocubic axes. As well-formed cubes, modified by {210}, to 5 mm. Most commonly as thin crusts of complexly intergrown crystals and rounded, droplike aggregates. *Twinning:* Interpenetrant twinning on {201}, probable, giving sectored and depressed cube faces.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 VHN = 649–724, 680 average (100 g load). D(meas.) = 1.99–2.11 D(calc.) = 1.98–1.99 Impurities incorporated may include CH_4, CO_2, S.

Optical Properties: Transparent to translucent. *Color:* Colorless when pure; pale yellow to deep red-brown with impurities; turbid white when weathered. *Luster:* Adamantine. *Optical Class:* Isotropic; may be weakly anisotropic. $n = 1.425$–1.457

Cell Data: *Space Group:* $P4_232$. $a = 26.82(3)$ $c = 13.37(2)$ $Z = 184$

X-ray Powder Pattern: Chvaletice, Czech Republic.
5.99 (10), 3.580 (9), 5.471 (7), 3.862 (6), 3.248 (6), 3.716 (5), 3.158 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	92.4	94.6	96.18	O	3.40	2.6	2.24
C	1.2	0.9	0.84	S	2.3	0.1	< 0.01
H	0.81	0.6	0.79	Total	100.11	98.8	100.05

(1) Racalmuto, Sicily, Italy. (2) Chvaletice, Czech Republic; by electron microprobe and neutron activation, corresponding to $46SiO_2 \cdot (C_{2.17}H_{17.25}O_{5.42}S_{0.09})$. (3) Mt. Hamilton, California, USA; corresponding to $46SiO_2 \cdot (C_{2.01}H_{22.69}O_{4.02})$.

Polymorphism & Series: Becomes cubic above ~40 °C.

Occurrence: A late-stage, low-temperature mineral in sulfur deposits (Racalmuto, Sicily, Italy); in low-temperature hydrothermal veins associated with metamorphosed sedimentary manganese deposits (Chvaletice, Czech Republic); in carbonate-bearing serpentinites (Fortullino, Italy; Mt. Hamilton, California, USA).

Association: Sulfur, calcite, "opal," cristobalite, quartz, dolomite, celestite, pyrite, marcasite, rhodochrosite, magnesite.

Distribution: In Italy, at Solfatara Giona, Racalmuto, and at Caltanissetta, Sicily; and from Fortullino, near Quercianella, Tuscany. In the Chvaletice deposit, Czech Republic. In the USA, at Mt. Hamilton, Santa Clara Co., California.

Name: From the Greek for *black* and *to be burned*, in allusion to the fact that some specimens of the mineral turn black when heated.

Type Material: Natural History Museum, Paris, France, 135245; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, C1279, 93011.

References: (1) Frondel, C. (1962) Dana's system of mineralogy, (7th edition), v. III, silica minerals, 283–284. (2) Skinner, B.J. and D.E. Appleman (1963) Melanophlogite, a cubic polymorph of silica. Amer. Mineral., 48, 854–867. (3) Kamb, B. (1965) A clathrate crystalline form of silica. Science, 148, 232–234. (4) Appleman, D.E. (1966) The crystal structure of melanophlogite, a cubic polymorph of SiO_2. Amer. Mineral., 51, 258 (abs.). (5) Zák, L. (1972) A contribution to the crystal chemistry of melanophlogite. Amer. Mineral., 57, 779–796. (6) Cooper, J.F., Jr. and G.E. Dunning (1972) Melanophlogite from Mount Hamilton, Santa Clara County, California. Amer. Mineral., 57, 1494–1504. (7) Gallo, S. (1974) Melanophlogite, a new and interesting find. Mineral. Record, 5, 207–208. (8) Gies, H. and F. Liebau (1981) Melanophlogite: composition, thermal behavior and structure refinement. Acta Cryst., A37, C187–C188.

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Melanostibite $Mn^{2+}(Sb^{5+}, Fe^{3+})O_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Tiny rhombohedra, striated, in parallel growth, forming porous spongelike aggregates. *Twinning:* By rotation about [0001], common.

Physical Properties: *Cleavage:* {0001}, perfect, perhaps a parting. *Tenacity:* Brittle. Hardness = > 4 D(meas.) = 5.24, on porous fragments. D(calc.) = 5.63

Optical Properties: Opaque, transparent in thin fragments. *Color:* Coal-black; deep blood-red in transmitted light. *Streak:* Pale rouge-red to cherry-red. *Luster:* Brilliant.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}$. $a = 5.226$ $c = 14.325$ Z = 6

X-ray Powder Pattern: Sjö mine, Sweden.
2.806 (10), 2.613 (8), 1.766 (8), 3.819 (6), 4.775 (5), 1.915 (5), 4.313 (4)

Chemistry:

	(1)	(2)	(3)
Sb_2O_5	42.81	41.0	42.18
Fe_2O_3	28.93	19.4	20.82
MnO	28.26	33.8	37.00
Total	[100.00]	94.2	100.00

(1) Sjö mine, Sweden; recalculated to 100% after deduction of CaO 1.97%, MgO 1.03%, H_2O 1.06% as impurities. (2) Do.; partial analysis by electron microprobe. (3) $Mn(Sb_{0.50}Fe_{0.50})_{\Sigma=1.00}O_3$.

Occurrence: A very rare mineral in fissures in banded dolomite, in a small Fe–Mn orebody in manganoan dolomite.

Association: Dolomite.

Distribution: In the Sjö mine, near Grythyttan, Örebro, Sweden.

Name: From the Greek for *black*, for its color, and antimony, STIBium, in its composition.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; The Natural History Museum, London, England, 83307; National Museum of Natural History, Washington, D.C., USA, R5766.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1041 [melanostibian]. (2) Moore, P.B. (1967) Contributions to Swedish mineralogy. II. Melanostibite and manganostibite, two unusual antimony minerals. The identity of ferrostibian with långbanite. Arkiv Mineral. Geol., 4(23), 449–458. (3) (1968) Amer. Mineral., 53, 1779 (abs. ref. 2). (4) Moore, P.B. (1968) Substitutions of the type $(Sb^{5+}_{0.5}Fe^{3+}_{0.5}) \rightleftharpoons (Ti^{4+})$: the crystal structure of melanostibite. Amer. Mineral., 53, 1104–1109.

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Melanotekite $Pb_2Fe_2^{3+}O_2Si_2O_7$

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Crystal Data: Orthorhombic. *Point Group:* 222. As small spherules; commonly massive.

Physical Properties: *Cleavage:* In two directions, one more prominent. Hardness = 6.5 D(meas.) = 5.73–6.28 D(calc.) = [6.30]

Optical Properties: Nearly opaque; translucent in thin section. *Color:* Black to blackish gray or blackish green; dark green in thin section. *Streak:* Greenish gray. *Luster:* Metallic to greasy. *Optical Class:* Biaxial (+). *Pleochroism:* Bottle-green and red-brown. *Dispersion:* $r > v$, strong. $\alpha = 2.12$ $\beta = 2.17$ $\gamma = 2.31$ 2V(meas.) = 67°

Cell Data: *Space Group:* $C222_1$. $a = 6.93$ $b = 10.98$ $c = 10.06$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
2.90 (vs), 2.86 (vs), 2.735 (vs), 3.71 (s), 3.51 (s), 3.24 (s), 2.84 (s)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	17.32	16.59	16.55	PbO	55.26	62.38	61.46
TiO_2		0.90		MgO		0.10	
Al_2O_3		0.57		CaO		0.00	
Fe_2O_3	23.18	19.21	21.99	BaO		0.00	
Mn_2O_3	0.76			rem.	3.59		
MnO		0.39		Total	100.11	100.14	100.00

(1) Långban, Sweden; remainder FeO, CuO, MgO, CaO, BaO, Na_2O, K_2O, Cl, and P_2O_5. (2) Jakobsberg, Sweden; by electron microprobe, corresponds to $Pb_{2.03}(Fe^{3+}_{1.75}Al_{0.08}Ti_{0.08}Mn_{0.04}Mg_{0.02})_{\Sigma=1.97}Si_{2.00}O_9$. (3) $Pb_2Fe_2O_2Si_2O_7$.

Polymorphism & Series: Forms a series with kentrolite.

Occurrence: In a metamorphosed Fe–Mn deposit, from which over one ton was removed (Långban, Sweden); in oxidized Pb–Cu ores (Artillery Peaks, Arizona, USA).

Association: Lead, magnetite, garnet (Långban, Sweden); leadhillite, alamosite (Tsumeb, Namibia); diaboleite (Tiger, Arizona, USA); luddenite, alamosite, shattuckite, mimetite, wulfenite, cerussite, wickenburgite (Artillery Peaks, Arizona, USA).

Distribution: At Långban, Jakobsberg, and Pajsberg, Värmland, Sweden. In the Merehead quarry, Wesley mine, and at Higher Pitts Farm, Priddy, Somerset, and at Westbury-on-Trym, Avon, England. From Tsumeb, Namibia. In the USA, from Hillsboro, Sierra Co., New Mexico; in Arizona, at the Mammoth-St. Anthony mine, Tiger, Pinal Co., and from a Pb–Cu prospect near Artillery Peaks, Mohave Co.

Name: From the Greek *black* and *to melt* or *glass*, for the black bead formed under the blowpipe.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 545. (2) Gabrielson, O. (1963) The crystal structures of kentrolite and melanotekite. Arkiv Mineral. Geol. 3, 141–151. (3) Glasser, F.P. (1967) New data on kentrolite and melanotekite: ternary phase relations in the system $PbO - Fe_2O_3 - SiO_2$. Amer. Mineral., 52, 1085–1093. (4) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541. (5) Moore, P.B., P.K. Sen Gupta, J. Shen, and E.O. Schlemper (1991) The kentrolite-melanotekite series, $4Pb_2(Mn,Fe)_2^{3+}O_2[Si_2O_7]$: chemical crystallographic relations, lone-pair splitting, and cation relation to $8URe_2$. Amer. Mineral., 76, 1389–1399. (6) Holtstam, D. and J. Langhof (1994) Hancockite from Jakobsberg, Filipstad, Sweden: the second world occurrence. Mineral. Mag., 58, 172–174.

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Melanothallite Cu_2OCl_2

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Platy or scaly, to 1 cm.

Physical Properties: *Cleavage:* One direction, perfect, probably prismatic.
Tenacity: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.08 Alters rapidly to green minerals on exposure; partly dissolved in H_2O.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black to bluish black; deep brown in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group: Fddd.* $a = 9.595(3)$ $b = 9.693(3)$ $c = 7.461(3)$ Z = 8

X-ray Powder Pattern: Tolbachik volcano, Russia.
5.041 (100), 2.518 (77), 2.947 (44), 2.422 (20), 2.176 (19), 2.816 (17), 1.928 (16)

Chemistry:

	(1)	(2)
Na	0.04	
K	0.06	
Cu	59.41	59.39
Zn	0.07	
Pb	0.01	
Li	0.04	
O	[8.55]	7.48
Cl	28.33	33.13
H_2O^+	0.05	
H_2O^-	1.75	
SO_4	1.20	
Total	[99.51]	100.00

(1) Tolbachik volcano, Russia; after deduction of excess Cu 8.63%, probably present as tenorite, O calculated from stoichiometry. (2) Cu_2OCl_2.

Occurrence: Sublimed on crater walls formed in 1868 and 1906 (Vesuvius, Italy); in volcanic fissures (Tolbachik volcano, Russia).

Association: Eriochalcite, chalcocyanite, euchlorine, dolerophanite (Vesuvius, Italy); euchlorine, chalcocyanite, dolerophanite, tenorite (Tolbachik volcano, Russia).

Distribution: On Vesuvius, Campania, Italy. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: From the Greek for *black* and *a young shoot*, for the mineral's property of turning green on exposure.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 174.
(2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 44. (3) Bergasova, L.P. and S.K. Filatov (1982) The chemical formula and crystallochemical characteristics of melanothallite, Cu_2OCl_2. Zap. Vses. Mineral. Obshch., 111, 562–565 (in Russian). (4) (1983) Amer. Mineral., 68, 852 (abs. ref. 3). (5) (1983) Mineral. Abs., 34, 348 [questions identity] (abs. ref. 3).

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Melanovanadite $Ca(V^{5+},V^{4+})_4O_{10}\cdot 5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Prismatic crystals, to 2 mm, striated and elongated along [001], with prominent but rounded prism zone, complexly terminated; in radiating aggregates and rosettes, velvety.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Brittle. Hardness = 2.5
D(meas.) = 2.55 D(calc.) = 2.53

Optical Properties: Opaque, translucent in very thin flakes. *Color:* Black; dark reddish brown in transmitted light. *Streak:* Dark reddish brown. *Luster:* Submetallic.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = light reddish brown; $Y = Z$ = dark reddish brown. *Orientation:* $Z = b$; $Y \wedge c = 15°$. $\alpha = 1.73$ $\beta = 1.96$ $\gamma = 1.98$
2V(meas.) = Medium.

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.360(2)$ $b = 18.090(9)$ $c = 6.276(2)$ $\alpha = 110.18(4)°$ $\beta = 101.62(3)°$ $\gamma = 82.86(4)°$ Z = [2]

X-ray Powder Pattern: Minasragra, Peru.
8.40 (100), 4.208 (55), 2.974 (50), 2.473 (50), 3.109 (45), 4.120 (40), 3.182 (40)

Chemistry: Composition established by crystal-structure analysis; the mineral contains interlayer H_2O, easily displaced.

Occurrence: In altered black shale in a very rich vanadium deposit (Minasragra, Peru); in Colorado Plateau-type U–V deposits.

Association: Pascoite, pyrite, copper, gypsum, patrónite, sherwoodite (Minasragra, Peru); duttonite (Peanut mine, Colorado, USA).

Distribution: At Minasragra, 46 km from Cerro de Pasco, Peru. In the USA, in the Mesa No. 1, Mesa No. 5, and Kerr-McGee 4-1 mines, Lukachukai Mountains, Apache Co., Arizona; the Jackpile mine, Valencia Co., New Mexico; the Jo Dandy, Bitter Creek, and Peanut mines, Uravan district, Montrose Co., and the Garfield mines, Garfield Co., Colorado; and the Juniper mine, Thompsons district, Grand Co., Utah.

Name: From the Greek for *black*, for the color, and VANADium in the composition.

Type Material: Harvard University, Cambridge, Massachusetts, 90452; American Museum of Natural History, New York City, New York, 19310; National Museum of Natural History, Washington, D.C., USA, 138067, 160076.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1058–1060. (2) Bayliss, P. and J.M. Hughes (1985) X-ray diffraction data for melanovanadite. Amer. Mineral., 70, 644–645. (3) Konnert, J.A. and H.T. Evans, Jr. (1987) Crystal structure and crystal chemistry of melanovanadite, a natural vanadium bronze. Amer. Mineral., 72, 637-644. (4) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 519.

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Melanterite $Fe^{2+}SO_4 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are rare, equant, pseudo-octahedral, to short prismatic [001], showing {120}, {001}, may be thick tabular {010}, {$10\overline{2}$}, many smaller modifying forms, to 20 cm; commonly stalactitic, in concretions and crusts, massive, pulverulent, and as efflorescences.

Physical Properties: *Cleavage:* On {001}, perfect; on {120}, distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 1.895–1.898 D(calc.) = 1.897(4) Soluble in H_2O; taste sweetish, astringent, metallic.

Optical Properties: Transparent to translucent. *Color:* Green, pale green, greenish blue, bluish green, colorless; colorless to pale green in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+) (synthetic). *Orientation:* $Y = b$; $Z \wedge c = 61°$. *Dispersion:* $r > v$, weak, inclined. $\alpha = 1.471$ $\beta = 1.478$ $\gamma = 1.486$ 2V(meas.) = 85°27′

Cell Data: *Space Group:* $P2_1/c$. $a = 14.072(10)$ $b = 6.503(7)$ $c = 11.041(10)$ $\beta = 105°34(5)'$ Z = 4

X-ray Powder Pattern: Synthetic.
4.90 (100), 3.776 (60), 4.87 (50), 3.732 (20), 3.291 (16), 4.028 (14), 5.49 (12)

Chemistry:

	(1)	(2)
SO_3	29.19	28.80
FeO	22.27	25.84
MgO	1.87	
H_2O	45.79	45.36
Total	99.12	100.00

(1) Falun, Sweden. (2) $FeSO_4 \cdot 7H_2O$.

Mineral Group: Melanterite group.

Occurrence: A post-mine product of oxidation of pyrite and marcasite ores; rarely a volcanic sublimate.

Association: Pisanite, chalcanthite, epsomite, pickeringite, halotrichite, other sulfates.

Distribution: Occurs at many localities, a few with large crystals. In Germany, from the Rammelsberg mine, near Goslar, Harz Mountains. At Falun, Sweden. From Rio Tinto, Huelva Province, Spain. At Idria, Slovenia. Large crystals on the island of Cyprus. From Cantiere Conche, Elba, Italy. At Baia Sprie (Felsőbánya), Romania. From Damar, Murgul, northeast Anatolia, Turkey. In the USA, at the Alma mine, Leona Heights, Alameda Co., and the Island Mountain mine, Trinity Co., California; from Ducktown, Polk Co., Tennessee; at Butte, Silver Bow Co., Montana; in the Lucky Boy mine, Bingham district, Salt Lake Co., Utah. At volcanoes on the Kamchatka Peninsula, Russia. From Tierra Amarilla, southeast of Copiapó, Atacama, Chile.

Name: From the Greek for *a black metallic dye*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 499–504. (2) Baur, W.H. (1964) On the crystal chemistry of salt hydrates. III. The determination of the crystal structure of $FeSO_4.7H_2O$ (melanterite). Acta Cryst., 17, 1167–1174. (3) (1970) NBS Mono. 25, 8, 38.

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Meliphanite $(Ca,Na)_2Be(Si,Al)_2(O,OH,F)_7$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}$. As tablets, to 3 cm; platy, lamellar, massive.

Physical Properties: *Cleavage:* Distinct on {001}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 3.01–3.02 D(calc.) = 3.024 Strongly piezoelectric.

Optical Properties: Transparent to translucent. *Color:* Honey-yellow, citron-yellow, sulfur-yellow, flesh-red, brick-red. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.593$ $\epsilon = 1.613$

Cell Data: *Space Group:* $I\bar{4}$. $a = 10.516(2)$ $c = 9.887(2)$ Z = 8

X-ray Powder Pattern: Stokkø Island, Langesundsfjord, Norway. (ICDD 31-304).
2.75 (100), 2.96 (50), 3.59 (40), 2.346 (40), 2.342 (40), 2.316 (40), 1.978 (40)

Chemistry:

	(1)	(2)
SiO_2	43.66	43.60
Al_2O_3	1.57	4.61
BeO	11.74	9.80
MgO	0.11	0.16
CaO	26.74	29.56
Na_2O	8.55	7.98
K_2O	1.40	0.23
F	5.73	5.43
H_2O	0.30	
$-O = (F,Cl)_2$	[2.41]	[2.29]
Total	[97.39]	[99.08]

(1) Fredriksvärn, Norway; Al_2O_3 includes Fe_2O_3, Mn_2O_3, original total given as 99.80% before F correction. (2) Arø Island, Langesundsfjord, Norway; Al_2O_3 includes Fe_2O_3, original total given as 101.37% before F correction.

Occurrence: In augite syenite (Fredriksvärn, Norway).

Association: Natrolite, mica, fluorite (Fredriksvärn, Norway).

Distribution: From near Fredriksvärn; on several of the islands in the Langesundsfjord; and at Tvedalen, near Larvik, Norway. In Russia, from the Sakhariok massif, Kola Peninsula, and at other less-well-defined localities. In the USA, in the Iron Mountain No. 2 mine, near Brown City, Sierra Co., New Mexico.

Name: From the Greek for *honey-yellow* and *to appear*, in allusion to its color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 418–419.
(2) Dal Negro, A., G. Rossi, and L. Ungaretti (1967) The crystal structure of meliphanite. Acta Cryst., 23, 260–264. (3) (1970) NBS Mono. 25, 8, 135.

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Melkovite $H_6CaFe^{3+}(PO_4)(MoO_4)_4 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Crystals are pseudohexagonal, very thin, platy, to 2 μm, in powdery aggregates in veinlets.

Physical Properties: *Cleavage:* One, perfect. *Tenacity:* Brittle. Hardness = ∼3
D(meas.) = 2.969–2.973 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Lemon-yellow, brownish yellow. *Luster:* Dull to waxy.
Optical Class: Biaxial (?), anomalous blue interference color. *Pleochroism:* Weak; colorless to light green. *Orientation:* Extinction wavy to nearly parallel ⊥ to the cleavage. $n = 1.838$

Cell Data: *Space Group:* Aa. $a = 17.46$ $b = 18.48$ $c = 10.93$ $\beta = 94.5°$ Z = 6

X-ray Powder Pattern: Shunak Mountains, Kazakhstan.
2.916 (9), 3.537 (8), 8.42 (7), 3.036 (7), 1.789 (7), 1.992 (6), 2.415 (5)

Chemistry:

	(1)	(2)
MoO_3	57.17	60.94
P_2O_5	7.86	7.51
ZrO_2	0.97	
Fe_2O_3	10.90	8.45
CaO	5.15	5.94
Na_2O	1.12	
K_2O	0.28	
H_2O	16.59	17.16
Total	100.04	100.00

(1) Shunak Mountains, Kazakhstan; by electron microprobe, total Fe as Fe_2O_3, MoO_4 and PO_4 confirmed by IR; disregarding ZrO_2, corresponds to $H_6Na_{0.18}K_{0.03}Ca_{0.92}Fe^{3+}_{0.68}(MoO_4)_{3.96}(PO_4)_{0.56} \cdot 6.2H_2O$. (2) $H_6CaFe^{3+}(PO_4)(MoO_4)_4 \cdot 6H_2O$.

Occurrence: Localized along joints in sandstone, formed by alteration of molybdenite in the oxidized zone of small molybdenite–fluorite deposits.

Association: Fluorite, molybdenite, magnetite, powellite, ferrimolybdite, iriginite, jarosite.

Distribution: In the Shunak Mountains, 60 km west of the Mointy railroad station, Kazakhstan.

Name: To honor Professor Vyacheslav Gavrilovich Melkov (1911–1991), Russian mineralogist specializing in uranium minerals, of the All-Union Research Institute of Mineral Resources, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72716; National Museum of Natural History, Washington, D.C., USA, 160237.

References: (1) Yegorov, B.L., A.D. Dara, and V.M. Senderova (1969) Melkovite, a new phosphomolybdate from the oxidized zone. Zap. Vses. Mineral. Obshch., 98, 207–212 (in Russian). (2) (1970) Amer. Mineral., 55, 320 (abs. ref. 1).

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Mellite $Al_2[C_6(COO)_6]\cdot 16H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are dipyramidal {023}, also prismatic, elongated along [001], modified by {001}, {010}, {113}, to 7.5 cm; as nodules and coatings, fine-grained massive.

Physical Properties: *Cleavage:* {023}, indistinct. *Fracture:* Conchoidal. *Tenacity:* Slightly sectile. Hardness = 2–2.5 D(meas.) = 1.64 D(calc.) = 1.65 May fluoresce pale yellow to blue under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Honey-yellow, deep red, pale shades of red, brown, gray, white; colorless to pale yellow in transmitted light. *Streak:* White. *Luster:* Resinous to vitreous.
Optical Class: Uniaxial (–), may be anomalously biaxial. *Pleochroism:* Weak; O = yellowish brown; E = yellow. *Orientation:* $X = c$. $\omega = 1.539$ $\epsilon = 1.511$ 2V(meas.) = Small.

Cell Data: *Space Group:* $I4_1/acd$. $a = 15.53(1)$ $c = 23.19(1)$ Z = 8

X-ray Powder Pattern: Artern, Germany.
7.99 (100), 4.23 (70), 5.80 (55), 5.16 (40), 3.46 (30), 3.39 (30), 2.985 (25)

Chemistry:

	(1)	(2)
C_4O_3	42.6	42.48
Al_2O_3	15.1	15.03
H_2O	[42.3]	42.49
Total	[100.0]	100.00

(1) Artern, Germany; recalculated from a partial analysis C 8.01%, Al 21.3%, corresponding to $15.7H_2O$ by difference. (2) $Al_2[C_6(COO)_6]\cdot 16H_2O$.

Occurrence: An uncommon secondary mineral in brown coal and lignite deposits, aluminum typically derived from clay.

Association: n.d.

Distribution: In Germany, from Artern, Thuringia, and near Bitterfeld, Saxony-Anhalt. At Lušice, near Bílina, Valchov, and Boskovice, Czech Republic. Large crystals from the Csordakút mine, Tatabánya, Hungary. From Malevka, Bogoroditsk district, southeast of Tula, Russia.

Name: From the Greek for *honey*, in allusion to the color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1104–1105. (2) Giacovazzo, C., S. Menchetti, and F. Scordari (1973) The crystal structure of mellite. Acta Cryst., 29, 26–31. (3) Jobbins, E.A., G.A. Sergeant, and B.R. Young (1965) X-ray and other data for mellite. Mineral. Mag., 35, 542–544.

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Melonite $NiTe_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As hexagonal plates, to 1 cm, and small laminated particles.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 1–1.5 VHN = 46–59 (50 g load). D(meas.) = 7.72 D(calc.) = 7.73

Optical Properties: Opaque. *Color:* Reddish white, tarnished yellowish brown; in polished section white to faint pink. *Streak:* Dark gray. *Luster:* Metallic. *Pleochroism:* Very weak, cream-white to slightly more pinkish. *Anisotropism:* Moderate to strong.
R_1–R_2: (400) 51.1–57.3, (420) 52.8–56.5, (440) 54.1–55.7, (460) 55.3–54.8, (480) 56.6–54.4, (500) 58.2–54.6, (520) 59.8–55.4, (540) 61.5–56.8, (560) 63.1–58.4, (580) 64.7–60.0, (600) 66.2–61.7, (620) 67.6–63.0, (640) 68.6–64.0, (660) 69.4–64.8, (680) 69.9–65.1, (700) 70.5–65.6

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 3.843$ $c = 5.265$ $Z = 1$

X-ray Powder Pattern: Robb-Montbray mine, Canada.
2.82 (100), 1.549 (60), 2.06 (50), 1.918 (50), 2.64 (30), 1.590 (20), 1.227 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Ni	18.31	11.3	18.70	Ag	0.86		
Pd		7.4		Bi		14.4	
Pt		3.7		Te	80.75	65.2	81.30
				Total	99.92	102.0	100.00

(1) Stanislaus mine, California, USA; corresponding to $(Ni_{0.99}Ag_{0.02})_{\Sigma=1.01}Te_{2.00}$. (2) Strathcona mine, Canada; by electron microprobe, corresponding to $(Ni_{0.66}Pd_{0.24}Pt_{0.07})_{\Sigma=0.97}$ $(Te_{1.76}Bi_{0.24})_{\Sigma=2.00}$. (3) $NiTe_2$.

Polymorphism & Series: Forms a series with merenskyite.

Mineral Group: Melonite group.

Occurrence: With other tellurium minerals in the late stages of hydrothermal veins formed at medium to low temperatures. Also in high-temperature Ni–Cu–PGE magmatic sulfide deposits.

Association: Altaite, petzite, hessite, calaverite, coloradoite, krennerite, tellurobismuthite, montbrayite, gold, pyrite, chalcopyrite, pentlandite, pyrrhotite.

Distribution: In the USA, in California, from the Melones [TL] and Stanislaus mines, Carson Hill district, Calaveras Co., and the Jamestown mine, Tuolumne Co.; in Colorado, at the Cresson mine, Cripple Creek, Teller Co., and from a number of mines in the Magnolia district, Boulder Co.; in Arizona, from the Campbell mine, Bisbee, Cochise Co. In Ontario, Canada, from the Strathcona mine at Sudbury; in the Hemlo gold deposit, Thunder Bay district; and at the Wright-Hargreaves mine, Kirkland Lake; in Quebec, from the Robb-Montbray mine, Montbray Township. At Kalgoorlie and Kambalda, 56 km south of Kalgoorlie, Western Australia, and the Worturpa mine, Flinders Ranges, South Australia. From the Emperor mine, Vatukoula, Viti Levu, Fiji Islands. In South Africa, at Ookiep, Namaqualand. In the Omai gold deposit, Guiana. From Russia, in the Monchegorsk deposit, Kola Peninsula. At the Zhanatyube deposit, Kazakhstan. In the Yokozuru mine, north Kyushu, Japan. Many additional minor occurrences are known.

Name: For the Melones mine in California, USA, where it was discovered.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 341. (2) Peacock, M.A. and R.M. Thompson (1945) Melonite from Quebec and the crystal structure of $NiTe_2$. Univ. of Toronto Studies, Geol. Ser., 50, 63–73. (3) Rucklidge,

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J. (1968) Electron microprobe investigations of platinum metal minerals from Ontario. Can. Mineral., 9, 617–628. (4) Bensch, W., W. Heid, M. Muhler, S. Jobic, R. Brec, and J. Rouxel (1996) Anionic polymeric bonds in nickel ditelluride: crystal structure, and experimental and theoretical band structure. J. Solid State Chemistry, 121, 87–?94. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 145. (6) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 419–420. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 362.

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Mélonjosephite $CaFe^{2+}Fe^{3+}(PO_4)_2(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals tabular, showing {001}, {010}, and {100}; in fibrous masses, with fibers to 1 cm.

Physical Properties: *Cleavage:* One, longitudinal; another, transverse. *Tenacity:* Brittle. Hardness = < 5 D(meas.) = 3.65(2) D(calc.) = 3.61

Optical Properties: Semitransparent. *Color:* Dark green, nearly black. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–). *Pleochroism:* X = deep brown with greenish tint, dark blue-green; Y = greenish brown, dark olive-brown; Z = golden yellow with greenish tint, pale brown. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* Strong. α = 1.720–1.732 β = 1.763–1.770 γ = 1.787–1.800 2V(meas.) = 80°–85°

Cell Data: *Space Group: Pbam.* $a = 9.542(1)$ $b = 10.834(1)$ $c = 6.374(1)$ Z = 4

X-ray Powder Pattern: Angarf-Sud pegmatite, Morocco.
3.049 (100), 5.42 (90), 2.710 (90), 2.624 (60), 2.912 (40), 2.187 (35), 3.185 (30)

Chemistry:

	(1)	(2)
P_2O_5	39.96	39.57
Al_2O_3	0.17	
Fe_2O_3	21.81	22.26
FeO	17.39	20.03
MnO	0.44	
MgO	1.18	
CaO	14.99	15.63
Li_2O	0.07	
Na_2O	0.48	
H_2O	2.50	2.51
insol.	0.97	
Total	99.96	100.00

(1) Angarf-Sud pegmatite, Morocco; Ca and Mg by AA, Na and Li by flame photometry, H_2O by the Penfield method, insoluble is quartz; corresponds to $(Ca_{0.96}Mg_{0.11}Na_{0.06}Li_{0.02})_{\Sigma=1.15}(Fe^{2+}_{0.87}Mn^{2+}_{0.02})_{\Sigma=0.89}(Fe^{3+}_{0.98}Al_{0.02})_{\Sigma=1.00}(PO_4)_{2.01}(OH)_{0.99}$. (2) $CaFe^{2+}Fe^{3+}(PO_4)_2(OH)$.

Occurrence: Replacing an alluaudite group mineral in a complex granite pegmatite (Angarf-Sud pegmatite, Morocco).

Association: Triphylite.

Distribution: From the Angarf-Sud pegmatite, Tazenakht Plain, Anti-Atlas Mountains, Morocco. At the Sandamap pegmatite, west of Usakos, Namibia.

Name: To honor Professor Joseph Mélon (1898–1991), Institute of Mineralogy, University of Liège, Liège, Belgium.

Type Material: University of Liège, Liège, Belgium, 18587; National Museum of Natural History, Washington, D.C., USA, 128338.

References: (1) Fransolet, A.-M. (1973) La mélonjosephite, $CaFe^{2+}Fe^{3+}(PO_4)_2(OH)$, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 96, 135–142 (in French with English abs.). (2) (1975) Amer. Mineral., 60, 946 (abs. ref. 1). (3) Kampf, A.R. and P.B. Moore (1977) Melonjosephite, calcium iron hydroxy phosphate: its crystal structure. Amer. Mineral., 62, 60–66. (4) Keller, P. (1980) Giniit, $Fe^{2+}Fe^{3+}_4[(H_2O)_2|(OH)_2|(PO_4)_4$, ein neues Mineral aus dem Pegmatit von Sandamab [*sic*] bei Usakos, Namibia. Neues Jahrb. Mineral., Monatsh., 49–56 (in German with English abs.).

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Menchettiite $AgPb_{2.40}Mn_{1.60}Sb_3As_2S_{12}$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As irregular grains to 200 μm.
Twinning: Twinned on {100}.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 2.5-3 VHN = 128 (100 g load). D(meas.) = n.d. D(calc.) = 5.146

Optical Properties: Opaque. *Color*: Black. *Streak*: Black. *Luster*: Metallic.
Optical Class: Anisotropic. *Bireflectance*: Weak to moderate. *Pleochroism*: Weak, dark gray to dark green.
R_1-R_2: (471.1) 33.1-39.8, (548.3) 31.8-38.0, (586.6) 30.9-37.3, (652.3) 29.0-35.8

Cell Data: *Space Group*: $P2_1/n$. a = 19.233(2) b = 12.633(3) c = 8.476(2) β = 90.08(2)°
Z = 2

X-ray Powder Pattern: Calculated pattern.
3.2853 (100), 2.8535 (49), 2.8519 (47), 3.4066 (39), 3.4025 (39), 2.1190 (33), 2.8585 (26)

Chemistry:

	(1)	(2)
Pb	31.27	31.22
Ag	6.59	6.77
Cu	0.02	
Mn	5.52	5.52
Fe	0.03	
Zn	0.02	
Sb	23.26	22.93
As	9.27	9.41
Bi	0.03	
S	24.09	24.15
Se	0.02	.
Total	100.12	100.00

(1) Uchucchacua deposit, Catajambo, Peru; average of 12 electron microprobe analyses, corresponding to $Ag_{1.95}Cu_{0.01}Pb_{4.81}Mn_{3.20}Fe_{0.02}Zn_{0.01}Sb_{6.09}As_{3.94}Bi_{0.01}S_{23.95}Se_{0.01.}$
(2) $AgPb_{2.40}Mn_{1.60}Sb_3As_2S_{12}$.

Occurrence: In a polymetallic (Ag-Mn-Pb-Zn) vein, replacement, and contact metamorphic mineral district.

Association: Orpiment, tennantite/tetrahedrite, quartz, calcite.

Distribution: From Level 890, Uchucchacua polymetallic deposit, Oyon district, Catajambo, Lima Department, Peru.

Name: Honors Silvio Menchetti (b. 1937), Professor of Mineralogy and Crystallography, University of Florence, Italy, in recognition of his contributions to the systematics of sulfosalt minerals.

Type Material: Natural History Museum, University of Florence, Italy (3109/I).

References: (1) Bindi, L., F.N. Keutsch, and P. Bonazzi (2012) Menchettiite, $AgPb_{2.40}Mn_{1.60}Sb_3As_2S_{12}$, a new sulfosalt belonging to the lillianite series from the Uchucchacua polymetallic deposit, Lima Department, Peru. Amer. Mineral., 97, 440-446.

Mendeleevite-(Ce) $(Cs,\square)_6(\square,Cs)_6(\square,K)_6(REE,Ca,\square)_{30}(Si_{70}O_{175})(H_2O,OH,F,\square)_{35}$

Crystal Data: Cubic. *Point Group*: $2/m\,\bar{3}$. As well-formed cubic crystals to 30 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 5-5.5 VHN = 613 (50 g load). D(meas.) = 3.12(2) D(calc.) = 3.07

Optical Properties: Transparent. *Color*: Colorless to clear tea color. *Streak*: White. *Luster*: Vitreous.
Optical Class: Isotropic. n = 1.578(2)

Cell Data: *Space Group*: *Pm3*. a = 21.9148(4) Z = 2

X-ray Powder Pattern: Darai-Pioz alkaline massif, Tajikistan.
10.95 (100), 3.097 (50), 3.46 (40), 3.068 (40), 2.190 (30)

Chemistry:

	(1)		(1)
SiO_2	43.52	CaO	2.71
Ce_2O_3	19.24	SrO	1.07
La_2O_3	9.87	Cs_2O	8.64
Nd_2O_3	5.62	K_2O	1.08
Pr_2O_3	2.63	F	1.34
Sm_2O_3	0.58	H_2O	[4.25]
Gd_2O_3	0.38	-O=F	0.56
		Total	100.37

(1) Darai-Pioz alkaline massif, Tajikistan; average of 10 electron microprobe analyses, H_2O and OH calculated from structure analysis, corresponding to $Cs_{5.94}K_{2.22}[(Ce_{11.35}La_{5.86}Nd_{3.23}Pr_{1.54}Sm_{0.32}Gd_{0.20})_{\Sigma=22.50}(Ca_{4.68}Sr_{1.00})_{\Sigma=5.68}]_{\Sigma=28.18}Si_{70.12}O_{203.17}H_{45.67}F_{6.83}$.

Occurrence: In a massif composed of a variety of granitic, alkaline granitic and syenitic pegmatites, various hydrothermal rocks (albitites, fenites) and carbonatites.

Association: Pectolite, and subordinate amounts of quartz, aegirine, fluorite, sogdianite, stillwellite-(Ce), reedmergnerite, leucosphenite, aegirine, polylithionite, microcline, pyrochlore, turkestanite, hyalotecite, sokolovaite, kirchhoffite, pekovite, neptunite, zeravshanite.

Distribution: In glacial moraine, upper reaches of the Darai-Pioz River, near the junction of the Turkestan, Zeravshan, and Alai ridges, Darai-Pioz alkaline massif, Garm District, Tajikistan.

Name: Honors Dmitriy Ivanovich Mendeleev (1834-1907), the Russian chemist who among other accomplishments created the Periodic Table of Elements.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3921/1).

References: (1) Pautov, L.A., A.A. Agakhanov, V.Yu. Karpenko, E.V. Sokolova, and F.C. Hawthorne (2013) Mendeleevite-(Ce), $Cs_6(REE_{22}Ca_6)(Si_{70}O_{175})(OH,F)_{14}(H_2O)_{21}$, a new mineral from the Darai-Pioz massif, Tajikistan. Doklady Akademii Nauk, 452(4), 441-444 (in Russian). English translation: Doklady Earth Sciences, 452(2) 1023-1026. (2) Sokolova, E., F.C. Hawthorne, L.A. Pautov, A.A. Agakhanov, and V.Yu. Karpenko (2011) The crystal structure and crystal chemistry of mendeleevite-(Ce), $(Cs,\square)_6(\square,Cs)_6(\square,K)_6(REE,Ca,\square)_{30}(Si_{70}O_{175})(H_2O,OH,F,\square)_{35}$, a potential microporous material. Mineralogical Magazine, 75(5), 2583-2596. (3) (2014) Amer. Mineral., 99, 871-872 (abs. refs. 1 and 2).

Mendipite $Pb_3O_2Cl_2$

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Crystal Data: Orthorhombic. *Point Group:* 222. In columnar or fibrous aggregates, and cleavable masses, to 12 cm.

Physical Properties: *Cleavage:* {010}, perfect; {100} and {010}, less perfect. *Fracture:* Conchoidal to uneven. Hardness = 2.5 D(meas.) = 7.240 D(calc.) = 7.22

Optical Properties: Translucent, rarely transparent. *Color:* Colorless to white, brownish cream, gray, tinged yellow, pink, red, or blue; nearly colorless in transmitted light. *Streak:* White. *Luster:* Pearly to silky on cleavages; resinous to adamantine on fractures. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, very strong. $\alpha = 2.24(2)$ $\beta = 2.27(2)$ $\gamma = 2.31(2)$ 2V(meas.) = $\sim 90°$

Cell Data: *Space Group:* $P2_12_12_1$. $a = 9.52$ $b = 11.95$ $c = 5.87$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
2.78 (10), 2.64 (9), 3.04 (8), 3.51 (7), 7.40 (6), 3.78 (6), 3.08 (6)

Chemistry:

	(1)	(2)	(3)
Pb	85.87	85.69	85.79
O	4.53	[4.44]	4.42
Cl	9.35	9.87	9.79
Total	99.75	[100.00]	100.00

(1) Mendip Hills, England; corresponds to $Pb_{3.14}Cl_2O_{2.15}$. (2) Kunibert mine, near Brilon, Germany. (3) $Pb_3O_2Cl_2$.

Occurrence: In nodules in manganese oxide ores (Somerset, England).

Association: Hydrocerussite, cerussite, malachite, pyromorphite, calcite, chloroxiphite, diaboleite, parkinsonite (Somerset, England).

Distribution: In England, from the Higher Pitts Farm, the Priddy Hill Farm, the Wesley mine, and near Churchill, Mendip Hills, and in the Merehead quarry, near Shepton Mallet, Somerset. In the Kunibert mine, near Brilon, North Rhine-Westphalia, Germany. At Långban, Värmland, Sweden. From Tarnowitz, Silesia, Poland. From Laurium, Greece, in slag. Found in the Elura Zn–Pb–Ag deposit, 43 km northeast of Cobar, New South Wales, Australia.

Name: For the occurrence in the Mendip [Myne-deepes, Old English] Hills, England.

Type Material: Swedish Academy of Sciences, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 56–58. (2) Gabrielson, O. (1958) The crystal structure of mendipite, $Pb_3O_2Cl_2$. Arkiv Mineral. Geol., 2(16), 299–304. (3) Vincent, H. and G. Perrault (1971) Structure cristalline de l'oxychlorure de plomb synthétique $Pb_3O_2Cl_2$. Bull. Soc. fr. Minéral., 94, 323–331 (in French with English abs.). (4) Symes, R.F. and P.G. Embrey (1977) Mendipite and other rare oxychloride minerals from the Mendip Hills, Somerset, England. Mineral. Record, 8, 298–303. (5) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Mendozavilite

$$Na(Ca,Mg)_2Fe^{3+}_6(PO_4)_2(P^{5+}Mo^{6+}_{11}O_{39})(OH,Cl)_{10}\cdot 33H_2O$$

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Crystal Data: Monoclinic or triclinic. *Point Group:* n.d. As crystals, to 20 μm, in masses.

Physical Properties: Hardness = 1.5 D(meas.) = 3.85 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Empire yellow to orange. *Streak:* Bright yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* In pale yellows. *Dispersion:* $r > v$, very strong. *Absorption:* $Z > Y > X$. $\alpha = 1.762$ $\beta = 1.763$ $\gamma = 1.766$ 2V(meas.) = 5°–15°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Cumobabi deposit, Mexico.
8.77 (10), 9.46 (8), 3.676 (5), 1.820 (5), 3.118 (4), 1.552 (4), 11.56 (3)

Chemistry:

	(1)
MoO_3	50.47
P_2O_5	6.78
Al_2O_3	0.76
Fe_2O_3	14.31
MgO	0.35
CaO	2.48
Na_2O	1.25
Cl	0.26
H_2O	21.62
$-O = Cl_2$	0.06
Total	98.22

(1) Cumobabi deposit, Mexico; with $(OH)^{1-}$ calculated for charge balance, corresponds to $Na_{1.27}(Ca_{1.40}Mg_{0.27})_{\Sigma=1.67}Fe_{5.66}(PO_4)_2P_{1.02}Mo_{11.07}O_{39}[(OH)_{8.88}Cl_{0.23}]_{9.11}\cdot 33.44H_2O$.

Occurrence: In the oxidized zone of some molybdenum-bearing hydrothermal mineral deposits.

Association: Quartz, paramendozavilite (Cumobabi deposit, Mexico); molybdenite, schorl (Rustler mine, Utah, USA).

Distribution: From the Cumobabi molybdenum deposit, southwest of Cumpas, Sonora, Mexico. At the Rustler mine, Gold Hill, Tooele Co., Utah, USA. From Copaquiri, Antofagasta, Chile.

Name: To honor Heriberto Mendoza Avila (1924–), Phelps Dodge exploration geologist, who found the first specimen.

Type Material: The Natural History Museum, London, England, 1984,475.

References: (1) Williams, S. A. (1986) Mendozavilite and paramendozavilite, two new minerals from Cumobabi, Sonora. Boletín de Mineralogía, 2(1), 13–19. (2) (1988) Amer. Mineral., 73, 193 (abs. ref. 1).

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Mendozite $NaAl(SO_4)_2 \cdot 11H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As fibrous masses.

Physical Properties: Hardness = ∼3 D(meas.) = 1.730 D(calc.) = 1.781 Soluble in H_2O; on exposure dehydrates to tamarugite.

Optical Properties: Transparent. *Color:* Colorless, white; colorless in transmitted light. *Optical Class:* Biaxial (–) (synthetic). *Orientation:* $X = b$; $Y \wedge c = 30°$. *Dispersion:* Distinct, crossed. $\alpha = 1.449(1)$ $\beta = 1.461(3)$ $\gamma = 1.463(3)$ 2V(meas.) = 56(1)°

Cell Data: *Space Group:* $C2/c$. $a = 21.75(3)$ $b = 9.11(1)$ $c = 8.30(1)$ $\beta = 92°28(5)'$ Z = 4

X-ray Powder Pattern: Synthetic.
3.50 (100), 4.76 (85), 4.58 (65), 4.15 (50), 3.60 (35), 2.644 (35), 10.9 (30)

Chemistry:

	(1)	(2)
SO_3	37.70	36.37
Al_2O_3	12.00	11.58
Na_2O	7.96	7.04
H_2O	41.96	45.01
Total	99.62	100.00

(1) "San Juan", Argentina. (2) $NaAl(SO_4)_2 \cdot 11H_2O$.

Occurrence: Rarely formed by oxidation of pyrite in reaction with clays; may occur in volcanic fumaroles.

Association: Tamarugite.

Distribution: In Argentina, from "San Juan, near Mendoza" [probably meaning Mendoza Province; the original occurrence appears lost.] At the Lanjarón mineral springs, Granada, Spain. On volcanoes on the Kamchatka Peninsula, Russia. In the USA, from Eureka, St. Louis Co., and Fulton, Calloway Co., Missouri. Other localities may afford this species, but modern confirmation is lacking.

Name: For its originally described occurrence in Mendoza Province, Argentina.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 469–471. (2) Fang, J.H. and P.D. Robinson (1972) Crystal structures and mineral chemistry of double-salt hydrates: II. The crystal structure of mendozite, $NaAl(SO_4)_2 \cdot 11H_2O$. Amer. Mineral., 37, 1082–1088.

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Meneghinite $Pb_{13}CuSb_7S_{24}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are slender prismatic and striated ‖ [001], to 2 cm. Also massive, fibrous to compact.

Physical Properties: *Cleavage:* Perfect but interrupted on {010}; poor on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 VHN = n.d. D(meas.) = 6.36 D(calc.) = 6.35

Optical Properties: Opaque. *Color:* Blackish lead-gray; white in polished section. *Streak:* Shining black. *Luster:* Bright metallic. *Pleochroism:* Weak. *Anisotropism:* Strong. R_1–R_2: (400) 39.6–46.6, (420) 39.0–46.0, (440) 38.5–45.4, (460) 38.2–44.9, (480) 37.8–44.4, (500) 37.5–44.0, (520) 37.2–43.6, (540) 37.0–43.4, (560) 36.9–43.2, (580) 36.7–42.8, (600) 36.3–42.2, (620) 35.9–41.6, (640) 35.4–40.9, (660) 34.9–40.1, (680) 34.4–39.4, (700) 33.7–38.7

Cell Data: *Space Group: Pbnm.* $a = 11.343$–11.369 $b = 24.028$–24.080 $c = 4.126$–4.140 $Z = 4$

X-ray Powder Pattern: Bottino, Italy.
3.274 (10), 2.922 (9), 3.740 (8), 3.489 (6), 4.13 (5), 2.741 (4), 3.080 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb	61.52	62.44	61.51	Sb	19.53	19.47	19.46
Cu	1.20	1.52	1.45	S	17.59	17.49	17.58
				Total	99.84	100.92	100.00

(1) Bottino, Italy; by electron microprobe, corresponding to $Pb_{12.99}Cu_{0.83}Sb_{7.02}S_{24.00}$.
(2) Marmora, Canada; by electron microprobe. corresponding to $Pb_{13.26}Cu_{1.05}Sb_{7.04}S_{24.00}$.
(3) $Pb_{13}CuSb_7S_{24}$.

Occurrence: Uncommon, but widespread in hydrothermal veins, also contact metasomatic, volcanogenic sulfide, Cu–Mo porphyry, and rarely, Kuroko deposits.

Association: Galena, chalcopyrite, sphalerite, bournonite, cubanite, pyrite, pyrrhotite, boulangerite, jamesonite, franckeite, tetrahedrite, gudmundite.

Distribution: In Italy, from Bottino, about two km east of Seravezza, Tuscany [TL]. In England, at Shallowford Bridge, near South Molton, Devon, and in the Pengenna mine, St. Kew, the Pentire veins, St. Minver, and the Portquin veins, St. Endellion, Cornwall. From the Ochsenkopf, near Schwarzenberg, Saxony; at Goldkronach, in the Fichtelgebirge, Bavaria; and elsewhere in Germany. In the Maronia Cu–Mo deposit, 30 km southeast of Komotini, Greece. At Bournac, Montagne Noire, Finistère, France. From Hällefors, Sweden. At Aijala, Finland. In the Dodo mine, about 100 km west-northwest of Saranpaul, Subpolar Ural Mountains, Russia. At Pun-dung, North Korea. From Pingtoushan, Jiangxi Province, China. At Broken Hill, New South Wales, Australia. In Canada, in Ontario, at Marble Lake; in British Columbia, at the Bluebird-Mayflower mine, Trail Creek; and other localities. In the USA, at the Kalkar quarry, Santa Cruz, Santa Cruz Co., California. Many additional minor occurrences are known.

Name: Honors Professor Giuseppi Meneghini (1811–1889) of Pisa, Italy, who first observed the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 402–404. (2) Jambor, J.L. (1975) Synthetic copper-free meneghinite. Geol. Survey of Canada Paper 75-1B, 71–72. (3) Hicks, W.D. and E.W. Nuffield (1978) Natural and synthetic meneghinite. Can. Mineral., 16, 393–395. (4) Euler, R. and E. Hellner (1960) Über komplex zusammengesetzte sulfidische Erze. VI. Zur Kristallstruktur des Meneghinits, $CuPb_{13}Sb_7S_{24}$. Zeits. Krist., 113, 345–372 (in German with English abs.). (5) Moëlo, Y., A. Meerschaut, P. Palvadeau, and N. Meisser (2002) Structure cristalline d'une ménéghinite naturelle pauvre en cuivre, $Cu_{0,58}Pb_{12,72}(Sb_{7,04}Bi_{0,24})S_{24}$ (in French with English abs.). Compt. Rendus Acad. Sci. Paris-Geoscience, 334(8), 529–536. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 364.

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Menshikovite $Pd_3Ni_2As_3$

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Crystal Data: Hexagonal. *Point Group:* 622, $6/m$, or 6. Anhedral grains, to 0.2 mm, and intergrown with other species. *Twinning:* Very fine, mosaiclike, observed under reflected light and in single-crystal studies.

Physical Properties: *Tenacity:* Brittle. Hardness = ∼5 VHN = 517 average (40, 50, 65 g loads). D(meas.) = n.d. D(calc.) = 10.35

Optical Properties: Opaque. *Color:* In reflected light, pink with slight grayish tint. *Anisotropism:* Weak; pale gray to brownish gray.
R_1–R_2: (400) 45.3–47.1, (420) 46.2–48.2, (440) 46.7–49.0, (460) 47.8–49.8, (480) 48.9–50.7, (500) 49.8–51.8, (520) 50.2–52.4, (540) 51.0–53.0, (560) 51.6–53.8, (580) 52.6–54.8, (600) 53.9–56.0, (620) 55.0–57.1, (640) 56.2–58.3, (660) 56.9–59.0, (680) 57.2–59.4, (700) 57.4–59.7

Cell Data: *Space Group:* $P6_322$, $P6_3/m$, or $P6_3$. $a = 8.406(4)$ $c = 6.740(4)$ $Z = 4$

X-ray Powder Pattern: Lukkulaisvaara intrusion, Russia.
2.626 (10), 2.477 (10), 2.429 (8), 2.283 (7), 1.978 (7), 1.818 (7), 1,781 (7)

Chemistry:

	(1)	(2)	(3)
Pd	48.48	49.30	48.27
Ni	17.22	17.38	17.75
Co		0.12	
As	33.71	33.16	33.98
Total	99.41	99.96	100.00

(1) Lukkulaisvaara intrusion, Russia; by electron microprobe, average of 20 analyses; corresponds to $Pd_{3.04}Ni_{1.96}As_{3.00}$. (2) Chiney intrusion, Russia; by electron microprobe, average of 12 analyses; corresponds to $Pd_{3.08}(Ni_{1.97}Co_{0.01})_{\Sigma=1.98}As_{2.94}$. (3) $Pd_3Ni_2As_3$.

Occurrence: In a mineralized pod in altered gabbronorite (Lukkulaisvaara intrusion, Russia); in heavy-mineral concentrates from quartz-feldspar sandstones in contact with base-metal sulfides (Chiney intrusion, Russia).

Association: Chalcopyrite, pentlandite, merenskyite, sobolevskite, kotulskite, michenerite, hollingworthite, hessite (Lukkulaisvaara intrusion, Russia); cobaltite, paolovite, isomertieite, maucherite, sperrylite, chalcopyrite (Chiney intrusion, Russia).

Distribution: In Russia, from the Vostok deposit, Lukkulaisvaara layered intrusion, Karelia [TL]; at the Chiney layered intrusion, western Aldan shield, Siberia [TL]; in the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia.

Name: To honor Dr. Yurii Pavlovich Men'shikov (1934–), Geological Institute, Kola Science Center, Russian Academy of Sciences, Apatity, Russia, for his extensive work on descriptions of new minerals.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Barkov, A.Y., R.F. Martin, Y.A. Pakhomovsky, N.D. Tolstykh, and A.P. Krivenko (2002) Menshikovite, $Pd_3Ni_2As_3$, a new platinum-group mineral species from two layered complexes, Russia. Can. Mineral., 40, 679–692. (2) (??) Amer. Mineral., ??, ?? (abs. ref. 1).

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Menzerite-(Y) $\{(Y,REE)(Ca,Fe^{2+})_2\}[(Mg,Fe^{2+})(Fe^{3+},Al)](Si_3)O_{12}$

Crystal Data: Isometric. *Point Group:* 4/*m* $\bar{3}$ 2/*m*. As cores in composite crystals to 0.07 mm.

Physical Properties: *Cleavage:* None. *Fracture:* n.d. *Tenacity:* Brittle.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.31

Optical Properties: Transparent. *Color:* Dark reddish-brown in plane polarized light.
Streak: n.d. *Luster:* n.d.
R(air) = 8.83
Optical Class: Isotropic. *n* = 1.844(20)

Cell Data: *Space Group: Ia*3*d*. *a* = 11.9947(6) *Z* = 4

X-ray Powder Pattern: Bonnet Island, near Parry Sound, Ontario, Canada [calculated pattern].
2.6821 (100), 1.6029 (44), 2.9987 (36), 2.4484 (33), 1.6634 (30), 1.3087 (18), 2.1899 (17)

Chemistry:

	(1)		(1)
SiO_2	30.64	Y_2O_3	16.93
TiO_2	1.10	Sc_2O_3	0.17
CaO	13.92	V_2O_3	0.17
MgO	3.98	Cr_2O_3	0.04
MnO	0.85	RE_2O_3	8.39
FeO	11.82	Total	101.26
Fe_2O_3	8.38		
Al_2O_3	4.87		

(1) Bonnet Island, near Parry Sound, Ontario, Canada; average of 10 electron microprobe analyses, Fe^{3+} by stoichiometry; corresponding to
$\{Y_{0.83}Gd_{0.01}Dy_{0.05}Ho_{0.02}Er_{0.07}Tm_{0.01}Yb_{0.06}\ Lu_{0.02}Ca_{1.37}Fe^{2+}_{0.49}Mn_{0.07}\}_{\Sigma=3.00}$
$[Mg_{0.55}Fe^{2+}_{0.42}Fe^{3+}_{0.58}Al_{0.35}V_{0.01}Sc_{0.01}Ti_{0.08}]_{\Sigma=2.00}(Si_{2.82}Al_{0.18})O_{12}$.

Mineral Group: Garnet group; with Mg > Fe^{2+} and absence of Si in the *Y* structural site.

Occurrence: As cores and remnants in composite almandine crystals in a felsic granulite.

Association: Almandine.

Distribution: On the north shore of Bonnet Island, near Parry Sound, Ontario, Canada.

Name: Honors Gregor Menzer (1897-1989), German crystallographer who solved the garnet structure first and for the dominant rare earth component.

Type Material: Canadian Museum of Nature, Ottawa, Ontario, Canada; CMNMC 86088 and National Museum of Natural History, Washington, D.C., USA; NMNH 174896.

References: (1) Grew, E.S., J.H. Marsh, M.G. Yates, B. Lazic, T. Armbruster, A. Locock, S.W. Bell, M.D. Dyar, H-J. Bernhardt and O. Medenbach (2010) Menzerite-(Y), a new species, $\{(Y,REE)(Ca,Fe^{2+})_2\}[(Mg,Fe^{2+})(Fe^{3+},Al)](Si_3)O_{12}$, from a felsic granulite, Parry Sound, Ontario, and a new garnet end-member, $\{Y_2Ca\}[Mg_2](Si_3)O_{12}$. Canadian Mineralogist, 48, 1171-1193. (2) (2013) Amer. Mineral., 98, 812-813 (abs. ref. 1).

Mercallite $KHSO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Tabular crystals, to a few mm, aggregated in stalactites.

Physical Properties: Hardness = n.d. D(meas.) = 2.31 D(calc.) = 2.32 Soluble in H_2O, acid taste.

Optical Properties: Transparent. *Color:* Colorless, may be blue if impure; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak.
$\alpha = 1.445$ $\beta = [1.460]$ $\gamma = 1.491$ 2V(meas.) = 56°

Cell Data: *Space Group: Pbca.* $a = 8.429(3)$ $b = 18.976(6)$ $c = 9.807(3)$ Z = 16

X-ray Powder Pattern: Synthetic. (ICDD 11-649).
3.84 (100), 3.52 (85), 3.41 (85), 3.26 (85), 3.87 (65), 3.03 (65), 2.472 (30)

Chemistry:

	(1)	(2)	(3)
HSO_4	65.68	74.92	71.29
SO_4	4.25		
Al_2O_3	0.12		
Cu	0.77		
Ca	0.25		
Na	3.67		
K	21.99	25.08	28.71
H_2O^+	0.64		
H_2O^-	1.81		
insol.	0.57		
Total	99.75	[100.00]	100.00

(1) Vesuvius, Italy. (2) Do.; recalculated to 100% after deduction of misenite and thénardite estimated 6%–7% and other impurities. (3)$KHSO_4$.

Occurrence: In fumaroles.

Association: Halite, misenite, hieratite, carobbiite.

Distribution: On Vesuvius, Campania, Italy.

Name: To honor Giuseppe Mercalli (1850–1914), a Director of the Vesuvius Observatory, Italy.

Type Material: University of Florence, Florence, Italy, 1976/I.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 395. (2) Payan, F. and R. Haser (1976) On the hydrogen bonding in potassium hydrogen sulphate. Comparison with a previous crystal structure determination. Acta Cryst., 32, 1875–1879.

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Mercury Hg

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Commonly as liquid spheres or globules; crystallizes in rhombohedra.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = 13.596 (liquid). D(calc.) = 14.26 (solid) Liquid above −38.9 °C; volatile; vapor highly toxic.

Optical Properties: Opaque. *Color:* Tin-white. *Luster:* Metallic, brilliant.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 3.463$ $c = 6.706$ $Z = 3$

X-ray Powder Pattern: n.d.

Chemistry: Composition essentially mercury, rarely with a little silver or gold.

Occurrence: In hydrothermal deposits formed at low temperature and associated with hot springs.

Association: Cinnabar, metacinnabar, calomel, terlinguaite, eglestonite, mercurian silver, mercurian gold, pyrite, dolomite, barite, quartz.

Distribution: From a number of localities, but rarely in significant amounts. In the USA, in California, especially at New Almaden, Santa Clara Co., and Mt. Diablo, Contra Costa Co.; in Texas, at Terlingua, Brewster Co. A noted locality at Almadén, Ciudad Real Province, Spain. In Serbia, on Mount Avala, near Belgrade. From Idrija (Idria), Slovenia. In Germany, at Landsberg, near Obermoschel, Rhineland-Palatinate. From Brezina, Czech Republic. In Ukraine, at Nagolnii Krjasch, Donets Basin. From Sala, Västmanland, Sweden.

Name: From the Latin *Mercurius*, the mythological messenger of the gods, in allusion to its mobility in liquid form; the chemical symbol from the Latin *hydrargyrum*, *liquid silver*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 103. (2) Barrett, C.S. (1957) The structure of mercury at low temperatures. Acta Cryst., 58–60. (23) Black, P.J. and J.A. Cundall (1965) The structues of liquid mercuy and liquid aluminum. Acta Cryst., 19, 807–814.

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Mereheadite $Pb_2OCl(OH)$

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Crystal Data: n.d. *Point Group:* n.d. As dense, fine-grained aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 4.90 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Orange.
Optical Class: Biaxial (+). $\alpha = 1.897$ $\beta = 1.911$ $\gamma = 1.932$ 2V(meas.) = 81°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Oktyabr deposit, Russia.
3.089 (9), 1.676 (6), 1.283 (6), 3.425 (5), 1.986 (4), 1.944 (4), 1.915 (3)

Chemistry:

	(1)		(1)
UO_3	76.91	CaO	4.86
As_2O_5	0.48	BaO	4.84
SiO_2	1.0	Na_2O	2.47
ZrO_2	0.45	H_2O^+	3.78
Al_2O_3	0.25	H_2O^-	0.01
Fe_2O_3	0.44	CO_2	1.80
PbO	2.29	Total	99.58

(1) Oktyabr deposit, Russia; corresponds to $(Ca_{0.37}Na_{0.31}Ba_{0.24}Pb_{0.08})_{\Sigma=1.00}O \cdot 2.1UO_3 \cdot 1.7H_2O$.

Occurrence: In the oxidation zone of a U–Mo deposit, replacing "pitchblende", and being replaced by uranophane.

Association: Uraninite, uranophane, bauranoite, calciouranoite, protasite.

Distribution: From the Oktyabr U–Mo deposit, 12 km southeast of Krasnokamensk, Strel'tsovskoye district, eastern Transbaikal, Russia.

Name: As a lower hydrate of *calciouranoite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76549, 76550.

References: (1) Rogova, V.P., L.N. Belova, G.N. Kiziyarov, and N.N. Kuznetsova (1973) Bauranoite and metacaltsuranoite [metacalciouranoite] – new minerals of the group of hydrous uranium oxides. Zap. Vses. Mineral. Obshch., 102, 75–81 (in Russian). (2) (1973) Amer. Mineral., 58, 1111 (abs. ref. 1).

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Mereiterite $K_2Fe^{2+}(SO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are subhedral, strongly etched, to 1 cm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 2.5–3 D(meas.) = 2.36(1) D(calc.) = 2.358 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Pale yellow. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z \wedge c \simeq 20°$. *Dispersion:* $r > v$, very weak. $\alpha = 1.497(1)$ $\beta = 1.501(1)$ $\gamma = 1.509(1)$ 2V(meas.) = 71° 2V(calc.) = 73°

Cell Data: *Space Group:* $C2/m$. $a = 11.844(1)$ $b = 9.556(1)$ $c = 9.947(1)$ $\beta = 94.90(1)°$ Z = 4

X-ray Powder Pattern: Laurium, Greece.
3.440 (100), 3.505 (52), 3.490 (49), 3.331 (48), 4.778 (30), 2.405 (30), 3.051 (29)

Chemistry:

	(1)	(2)
SO_3	40.22	40.21
FeO	17.88	18.04
K_2O	22.7	23.65
H_2O	18.0	18.10
Total	98.8	100.00

(1) Laurium, Greece; by electron microprobe, average of three crystals, total Fe as Fe^{2+}, H_2O by TGA; corresponds to $K_{1.93}Fe_{1.00}(SO_4)_{2.00} \cdot 4H_2O$. (2) $K_2Fe(SO_4)_2 \cdot 4H_2O$.

Occurrence: A rare secondary mineral imbedded in gypsum, formed by decomposition of sulfides in a hydrothermal Pb–Zn–Cu ore deposit.

Association: Gypsum, smithsonite, goethite.

Distribution: From Laurium, Greece.

Name: Honoring Dr. Kurt Helmut Mereiter (1945–), Professor of Mineralogy, Technical University of Vienna, Vienna, Austria, in recognition of his work on iron sulfates.

Type Material: University of Vienna, Vienna, Austria, 6C/18-035#1; National Museum of Natural History, Washington, D.C., USA, 170971.

References: (1) Giester, G. and B. Rieck (1995) Mereiterite, $K_2Fe[SO_4]_2 \cdot 4H_2O$, a new leonite-type mineral from the Lavrion mining district, Greece. Eur. J. Mineral., 7, 559–566. (2) (1996) Amer. Mineral., 81, 251 (abs. ref. 1).

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Merenskyite $(Pd,Pt)(Te,Bi)_2$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As minute grains, intimately intergrown with other Pd–Pt minerals.

Physical Properties: Hardness = ∼3.5 VHN = 82–128 (10 g load). D(meas.) = n.d. D(calc.) = 8.547

Optical Properties: Opaque. *Color:* In polished section, white. *Pleochroism:* Weak, white to grayish white in air, more distinct in oil, from white to slightly creamy to light grayish white. *Anisotropism:* Distinct to strong, from dark brown to light greenish gray.
R_1–R_2: (400) – , (420) 63.6–65.0, (440) 63.5–65.2, (460) 62.5–64.7, (480) 62.3–64.6, (500) 62.3–64.8, (520) 62.4–65.4, (540) 62.8–66.0, (560) 63.3–66.7, (580) 63.1–67.2, (600) 63.5–68.0, (620) 64.8–69.1, (640) 65.2–69.7, (660) 65.7–71.0, (680) 67.7–73.0, (700) 66.8–73.0

Cell Data: *Space Group:* $P3m1$. $a = 3.978(1)$ $c = 5.125(2)$ $Z = 1$

X-ray Powder Pattern: Merensky Reef, South Africa.
2.92 (100), 2.10 (60), 3.07 (30), 2.02 (30), 1.67 (30), 1.54 (30), 2.51 (20)

Chemistry:	(1)	(2)	(4)		(1)	(2)	(4)
Pd	25.7	13.2	29.42	Sb		0.3	
Pt	2.0	24.0		Te	56.5	61.4	70.58
Bi	15.8			Total	[100.0]	98.9	100.00

(1) Rustenburg mine, South Africa; by electron microprobe, recalculated to 100.0%; corresponds to $(Pd_{0.93}Pt_{0.04})_{\Sigma=0.97}(Te_{1.71}Bi_{0.29})_{\Sigma=2.00}$. (2) Messina, South Africa; by electron microprobe, corresponds to $(Pd_{0.50}Pt_{0.50})_{\Sigma=1.00}(Te_{1.95}Sb_{0.01})_{\Sigma=1.96}$. (3) $PdTe_2$.

Polymorphism & Series: Forms a series with melonite.

Mineral Group: Melonite group.

Occurrence: A principal Pd–Pt-bearing mineral, associated with numerous other Pt–Pd species; typically in disseminated interstitial segregations of Cu–Fe–Ni sulfides and enclosing silicates.

Association: Moncheite, melonite, kotulskite, michenerite; sperrylite, laurite, cooperite; chalcopyrite, pyrrhotite, pentlandite, pyrite; chromite, magnetite.

Distribution: Some well-studied occurreences are: in South Africa, in Transvaal, from the Rustenburg mine, in the Merensky Reef, Bushveld complex [TL]; and at Messina. In the Great Dyke, Zimbabwe. From the Gabbro Akarem intrusion, Eastern Desert, Egypt. In Canada, in Ontario, at Werner Lake; Rathbun Lake; Temagami Island in Temagami Lake; the Lac des Iles complex; in the Thierry mine, near Pickle Lake; at the Sudbury district; from the Geordie Lake intrusion, Coldwell complex; in the Wellgreen Ni–Cu–PGE deposit, Yukon Territory; and elsewhere. In the USA, from the Stillwater complex, Montana; the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming; and in the Key West mine, east of Moapa, Bunkerville district, Clark Co., Nevada. From the Las Aguilas Ni–Cu deposit, San Luis Province, Argentina. In China, from Shiaonanshan, Inner Mongolia, and in the Jinchuan deposit, Gansu Province. At Kambalda, Western Australia. From the Noril'sk region, western Siberia, Russia. Numerous other localities are now known.

Name: To honor Dr. Hans Merensky (1871–1952), who was instrumental in the discovery of the "Reef" also named for him.

Type Material: n.d.

References: (1) Kingston, G.A. (1966) The occurrence of platinoid bismuthotellurides in the Merensky Reef at Rustenburg platinum mine in the western Bushveld. Mineral. Mag., 35, 815–834. (2) (1967) Amer. Mineral., 52, 926 (abs. ref. 1). (3) Pell, ?? ?? (1996) ??title?? Acta Cryst., 1331C–??. (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 118–119, 156. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 365.

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Merlinoite $(K, Ca, Na, Ba)_7Si_{23}Al_9O_{64}\cdot 23H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 4 mm, forming radiating fibrous spheroidal aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.14–2.27 D(calc.) = 2.19–2.23

Optical Properties: Transparent. *Color:* White.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.499$ $\beta = 1.500$ $\gamma = 1.501$ 2V(meas.) = 56°

Cell Data: *Space Group:* $Immm$; $I4/mmm$ pseudotetragonal. $a = 14.116(7)$ $b = 14.229(6)$ $c = 9.946(6)$ Z = [1]

X-ray Powder Pattern: Cupaello, Italy.
3.176 (100), 7.115 (90), 7.080 (88), 3.258 (44), 3.241 (41), 5.359 (40), 3.226 (38)

Chemistry:

	(1)
SiO_2	51.82
Al_2O_3	18.04
Fe_2O_3	0.72
CaO	3.18
BaO	2.49
Na_2O	0.65
K_2O	7.53
LOI	15.57
Total	[100.00]

(1) Cupaello, Italy; by electron microprobe, H_2O taken as loss on ignition, recalculated to 100.00%; corresponding to $(K_{4.21}Ca_{1.49}Na_{0.55}Ba_{0.43}Fe_{0.24})_{\Sigma=6.92}Si_{22.68}Al_{9.31}O_{64}\cdot 22.74H_2O$.

Mineral Group: Zeolite group.

Occurrence: A secondary mineral in veins and cavities of silica-undersaturated volcanic rocks (Cupaello, Italy); an alteration product of cataclastized pegmatitic rocks in a differentiated alkalic massif (Khibiny massif, Russia); in manganese nodules (Indian Ocean).

Association: Phillipsite, apophyllite, chabazite, calcite.

Distribution: In the Cupaello quarry, near Santa Rufina, and at Valle Beachella, Sacrofano, near Rome, Lazio, Italy. In the Höwenegg quarry, Hegau, Baden-Württemberg, and in the Ortenberg quarry, Vogelsberg, Hesse, Germany. In Russia, in the Khibiny massif, Kola Peninsula. From the Central Indian basin, Indian Ocean. In Searles Lake, San Bernardino Co., California, USA.

Name: In honor of Stefano Merlino (1938–), Professor of Crystallography, University of Pisa, Pisa, Italy.

Type Material: Municipal Museum of Natural History, Milan, 18078; University of Modena, Modena, Italy; Natural History Museum, Paris, France; National Museum of Natural History, Washington, D.C., USA, 137087.

References: (1) Passaglia, E., D. Pongiluppi, and R. Rinaldi (1977) Merlinoite, a new mineral of the zeolite group. Neues Jahrb. Mineral., Monatsh., 355–364. (2) (1978) Amer. Mineral., 63, 598 (abs. ref. 1). (3) Galli, E., G. Gottardi, and D. Pongiluppi (1979) The crystal structure of the zeolite merlinoite. Neues Jahrb. Mineral., Monatsh., 1–9. (4) Khomyakov, A.P., T.A. Kurova, and G.N. Muravitskaya (1981) Merlinoite, $(K, Ba)_2Al_3Si_5O_{16}\cdot 5H_2O$, first occurrence in the USSR. Doklady Acad. Nauk SSSR, 256, 172–174 (in Russian). (5) (1981) Chem. Abs., 94, 106675 (abs. ref. 4).

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Merrihueite $(K,Na)_2(Fe^{2+},Mg)_5Si_{12}O_{30}$

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Crystal Data: [Hexagonal] (by analogy to osumilite). *Point Group:* $6/m\ 2/m\ 2/m$. In aggregates, to 150 μm, of smaller individuals, as inclusions in enstatite.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.87

Optical Properties: Semitransparent. *Color:* Greenish blue; colorless to greenish blue in thin section, with anomalous blue to purple interference colors.
Optical Class: Uniaxial or anomalously biaxial. *Pleochroism:* Colorless to greenish blue.
n = 1.559–1.592; low to moderate birefringence. 2V(meas.) = 5°–10°

Cell Data: *Space Group:* [$P6/mcc$] (by analogy to osumilite). $a = 10.16(6)$ $c = 14.32(6)$
Z = 2

X-ray Powder Pattern: Mezö-Madaras meteorite; nearly identical to osumilite.
3.73 (100), 2.774 (100), 3.23 (90), 7.13 (80), 2.92 (60), 2.530 (50), 5.03 (30)

Chemistry:

	(1)
SiO_2	61.8
Al_2O_3	0.2
FeO	23.7
MnO	0.5
MgO	4.4
CaO	0.3
Na_2O	2.0
K_2O	3.8
Total	96.7

(1) Mezö-Madaras meteorite; by electron microprobe, corresponding to $(K_{0.94}Na_{0.76}Ca_{0.06})_{\Sigma=1.76}(Fe_{3.85}Mg_{1.27}Mn_{0.08})_{\Sigma=5.20}(Si_{12.00}Al_{0.02})_{\Sigma=12.02}O_{30}$.

Mineral Group: Milarite group; K > (Na+Ca); (Fe+Mn) > Mg; Al/(Al+Si) < 0.2.

Occurrence: Rare, in a few chondules of a chondrite, as inclusions in clinopyroxenes.

Association: Clinoenstatite, fayalitic olivine, nickel-iron.

Distribution: In the Mezö-Madaras chondritic meteorite.

Name: For Craig M. Merrihue (?–1965), meteoriticist, of the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, USA.

Type Material: n.d.

References: (1) Dodd, R.T., Jr., W.R. Van Schmus, and U.B. Marvin (1965) Merrihueite, a new alkali-ferromagnesian silicate from the Mezö-Madaras chondrite. Science, 149, 972–974. (2) (1965) Amer. Mineral., 50, 2096–2097 (abs. ref. 1). (3) Khan, A.A., W.H. Bauer, and W.C. Forbes (1972) Synthetic magnesian merrihueite, dipotassium pentamagnesium dodecasilicate: a tetrahedral magnesiosilicate framework crystal structure. Acta Cryst., 28, 267–272.

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Mertieite-I $Pd_{11}(Sb, As)_4$

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Crystal Data: Hexagonal; possibly monoclinic, pseudohexagonal. *Point Group:* n.d.
As small grains, to 0.5 mm.

Physical Properties: Hardness = n.d. VHN = 561–593, 578 average (50 g load).
D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* In polished section, brassy yellow. *Anisotropism:* Distinct.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 15.04$ $c = 22.41$ $Z = 18$

X-ray Powder Pattern: Goodnews Bay, Alaska, USA.
2.278 (vs), 2.171 (vs), 2.232 (m), 2.017 (m), 1.918 (m), 1.861 (m), 1.572 (m)

Chemistry:

	(1)
Pd	72.9
Cu	< 1.2
Sb	15.3
As	9.2
Total	< 98.6

(1) Goodnews Bay, Alaska, USA; by electron microprobe, average of four grains; corresponding to $(Pd_{11.03}Cu_{0.30})_{\Sigma=11.33}(Sb_{2.02}As_{1.98})_{\Sigma=4.00}$.

Polymorphism & Series: Dimorphous with isomertieite.

Occurrence: As fine grains in precious metal placer concentrates, apparently derived from ultramafic source rock.

Association: Gold, chromite, laurite, mertieite-II, Pt–Ir–Os alloys.

Distribution: In the USA, from the placer dredgings at Goodnews Bay, Alaska [TL].

Name: To honor John Beaver Mertie, Jr. (1888–1980), geologist, U.S. Geological Survey, who provided the original material; "I" to distinguish its unique composition and crystallography from that of mertieite-II and isomertieite.

Type Material: National Museum of Natural History, Washington, D.C., USA, 132499.

References: (1) Desborough, G.A., J.J. Finney, and B.F. Leonard (1973) Mertieite, a new palladium mineral from Goodnews Bay, Alaska. Amer. Mineral., 58, 1–10. (2) Cabri, L.J., J.H.G. Laflamme, J.M. Stewart, J.F. Rowland, and T.Z. Chen (1975) New data on some platinum arsenides and antimonides. Can. Mineral., 13, 321–335.

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Mertieite-II $Pd_8(Sb, As)_3$

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Crystal Data: Hexagonal. *Point Group:* n.d. Anhedral grains, to about 0.5 mm.

Physical Properties: Hardness = n.d. VHN = 561–593, 578 average (50 g load). D(meas.) = n.d. D(calc.) = 11.2 for Sb:As = 5:1.

Optical Properties: Opaque. *Color:* In polished section, brassy yellow. *Luster:* Metallic. *Anisotropism:* Distinct, dark blue-gray to dark brown.
R: (400) — , (420) 45.0, (440) 44.4, (460) 44.7, (480) 45.6, (500) 47.0, (520) 48.7, (540) 50.1, (560) 51.3, (580) 52.3, (600) 53.2, (620) 54.0, (640) 54.9, (660) 55.7, (680) 56.5, (700) 57.6

Cell Data: *Space Group:* n.d. $a = 7.546(2)$ $c = 43.18(1)$ $Z = 12$

X-ray Powder Pattern: Goodnews Bay, Alaska, USA.
2.286 (100), 2.177 (90), 1.226 (70), 1.200 (70), 0.9355 (60), 2.022 (50), 1.577 (40)

Chemistry:

	(1)	(2)	(3)
Pd	72.3	68.9	69.3
Cu	< 0.1	1.8	2.3
Sn		0.3	
Sb	24.7	27.4	28.0
As	3.3	1.9	2.2
Total	100.4	100.3	101.8

(1) Goodnews Bay, Alaska, USA; by electron microprobe, average of four grains and five areas; corresponding to $Pd_{8.26}(Sb_{2.46}As_{0.54})_{\Sigma=3.00}$. (2) Tweefontein Farm, South Africa; by electron microprobe, corresponding to $(Pd_{7.68}Cu_{0.34})_{\Sigma=8.02}(Sb_{2.67}As_{0.30}Sn_{0.03})_{\Sigma=3.00}$. (3) Oktyabr mine, Russia; by electron microprobe, corresponding to $(Pd_{7.53}Cu_{0.42})_{\Sigma=7.95}(Sb_{2.66}As_{0.34})_{\Sigma=3.00}$.

Occurrence: As fine grains in precious metal placer concentrates, apparently derived from an ultramafic source rock (Goodnews Bay, Alaska, USA); above massive cubanite–mooihoekite ore (Oktyabr mine, Russia).

Association: Gold, sperrylite, laurite, platarsite, ruthenarsenite, mertieite-I, genkinite, Pt–Ir–Os alloys, Pt–Fe alloy, stibiopalladinite, chalcocite, bornite, heazlewoodite, galena, chalcopyrite, pentlandite, valleriite, hauchecornite, parkerite, chromite.

Distribution: In the USA, from the placers at Goodnews Bay, Alaska [TL]; at the Stillwater complex, Montana. In the Wellgreen Ni–Cu–PGE deposit, Yukon Territory, Canada. From Tweefontein Farm, 26 km from Potgietersrus, and at the Onverwacht mine, in the Merensky Reef, Bushveld complex, Transvaal, South Africa. From the Oktyabr mine, Noril'sk area, western Siberia, and around Zlatoust, Ural Mountains, Russia. At Hope's Nose, Torquay, Devon, England. From the Konttijärvi intrusion, northern Finland. In Australia, at the Round Hill deposit, Moorkaie Hill, northeast of Broken Hill, New South Wales. From the Baula conplex, Orissa, India. There are additional localities known, with material close in composition, but not fully confirmed as this species.

Name: To honor John B. Mertie, Jr. (1888–1980), geologist, U.S. Geological Survey, who provided the original material; "II" to distinguish its unique composition and crystallography from that of mertieite-I and isomertieite.

Type Material: n.d.

References: (1) Desborough, G.A., J.J. Finney, and B.F. Leonard (1973) Mertieite, a new palladium mineral from Goodnews Bay, Alaska. Amer. Mineral., 58, 1–10. (2) Cabri, L.J., J.H.G. Laflamme, J.M. Stewart, J.F. Rowland, and T.Z. Chen (1975) New data on some platinum arsenides and antimonides. Can. Mineral., 13, 321–335. (3) Cabri, L.J. and T.Z. Chen (1976) Stibiopalladinite from the type locality. Amer. Mineral., 61, 1249–1254. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 119–120, 159. (5) Clark, A.M. and A.J. Criddle (1982) Palladium minerals from Hope's Nose, Torquay, Devon. Mineral. Mag., 46, 371–377.

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Merwinite $Ca_3Mg(SiO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are rare and inevitably pitted and rounded, to 3 mm; compact, massive. *Twinning:* Polysynthetic on {100}, twin axis [013], common.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = 6 D(meas.) = 3.15–3.32 D(calc.) = 3.33

Optical Properties: Transparent to translucent. *Color:* Colorless, white, very pale green; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 13°$. *Dispersion:* $r > v$, perceptible. $\alpha = 1.702–1.710$ $\beta = 1.710–1.714$ $\gamma = 1.718–1.728$ 2V(meas.) = 66°–76°

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 13.254(21)$ $b = 5.293(9)$ $c = 9.328(17)$ $\beta = 91.90(15)°$ Z = 4

X-ray Powder Pattern: Synthetic.
2.672 (100), 2.749 (40), 2.213 (40), 1.909 (40), 4.63 (30), 3.310 (30), 3.128 (30)

Chemistry:

	(1)
SiO_2	35.50
Al_2O_3	0.66
Fe_2O_3	0.00
FeO	1.22
MgO	11.62
CaO	49.96
Loss $< 110°$C	0.12
LOI	0.94
Total	100.02

(1) Crestmore, California, USA; corresponds to $Ca_{2.98}(Mg_{0.96}Fe_{0.06})_{\Sigma=1.02}(Si_{1.98}Al_{0.04})_{\Sigma=2.02}O_8$.

Occurrence: In siliceous dolomitic limestone in contact metamorphic zones, formed at relatively elevated temperatures, locally in substantial quantities.

Association: Gehlenite, spurrite, monticellite, vesuvianite (Crestmore, California, USA); spurrite, gehlenite, spinel (Scawt Hill, Ireland).

Distribution: In the USA, at Crestmore, Riverside Co., California; at Neihart, Cascade Co., Montana; and in the Christmas Mountains, Brewster Co., Texas. From Velardeña, Durango, Mexico. In Ireland, at Scawt Hill, near Larne, Co. Antrim. From near Kilchoan, Ardnamurchan, Argyllshire, and at Camas Mòr, Isle of Muck, Scotland. Found near Anakit Creek, at the mouth of the Lower Tunguska River, central Siberia, and in the Ozerskii massif, Lake Baikal, Russia. At Iglika, Elkhovsko district, Bulgaria. In the Hatrurim Formation, Israel.

Name: For Dr. Herbert Eugene Merwin (1878–1963), American mineralogist and petrologist, Carnegie Institute, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 94030; The Natural History Museum, London, England, 1923,1026.

References: (1) Larsen, E.S. and W.F. Foshag (1921) Merwinite, a new calcium magnesium orthosilicate from Crestmore, California. Amer. Mineral., 6, 143–148. (2) Moore, P.B. and T. Araki (1972) Atomic arrangement of merwinite, $Ca_3Mg[SiO_4]_2$, an unusual dense-packed structure of geophysical interest. Amer. Mineral., 57, 1355–1374. (3) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 256–262.

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Mesolite $Na_2Ca_2Al_6Si_9O_{30}\cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As prismatic crystals, elongated ‖ [001], to 20 cm; commonly in hairlike tufts and aggregates of fibers; divergent, radiating compact masses; in fibrous stalactites; porcelaneous, massive. *Twinning:* Characteristically twinned on {010} or {100}.

Physical Properties: *Cleavage:* {110}, $\{\bar{1}10\}$, perfect. *Fracture:* Uneven. *Tenacity:* Brittle, but compact masses are tough. Hardness = 5 D(meas.) = 2.26 D(calc.) = 2.27 May exhibit a small pyroelectric effect; piezoelectric.

Optical Properties: Transparent to translucent, opaque. *Color:* Colorless, white, gray, yellowish; in thin section, colorless. *Luster:* Vitreous, silky when fibrous.
Optical Class: Biaxial (+). *Orientation:* $X \wedge c \simeq 8°$; $Z = b$. *Dispersion:* $r > v$, strong.
$\alpha = 1.5048$ $\beta = 1.5050$ $\gamma = 1.5053$ 2V(meas.) = ∼80°

Cell Data: *Space Group:* $Fdd2$. $a = 18.4049(8)$ $b = 56.655(6)$ $c = 6.5443(4)$ Z = 8

X-ray Powder Pattern: Harbabkhandi, Iran.
6.585 (100), 2.857 (56), 2.885 (55), 4.715 (49), 5.858 (38), 4.196 (32), 4.600 (29)

Chemistry:

	(1)
SiO_2	46.98
Al_2O_3	26.43
CaO	10.06
Na_2O	4.57
K_2O	0.05
H_2O	11.94
Total	100.03

(1) Syhadree Mountains, Bombay, India; corresponds to $(Na_{1.70}K_{0.01})_{\Sigma=1.71}Ca_{2.07}Al_{5.99}Si_{9.04}O_{30}\cdot 7.66H_2O$.

Mineral Group: Zeolite group.

Occurrence: In cavities of volcanic rocks, typically basalt, also in andesites, porphyries, and hydrothermal veins.

Association: Natrolite, scolecite, other zeolites, calcite.

Distribution: Many localities, but only a few provide large crystals or rich masses. On North Mountain and Gates Mountain, and at Cape Blomiden, Nova Scotia, Canada. In the USA, on Table Mountain, Jefferson Co., Colorado; large crystals from Skookumchuck Dam, near Bucoda, Thurston Co., Washington. In Oregon, from Goble, Columbia Co.; near Dollar, and on Shotgun Creek, Linn Co.; Springfield, Lane Co.; Ritter Hot Springs, Grant Co., and elsewhere. From Puy de Marman, near Veyre, Puy-de-Dôme, France. In Iceland, from the Breiddalur-Berufjord area. On Naalsoy, Streymoy, and others of the Faeroe Islands. Exceptional crystals from the Pashan Hills and other localities around Poona, Maharashtra, India.

Name: From the Greek for *middle*, alluding to its composition intermediate between natrolite and scolecite.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 605–606. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 358–376. (3) Alberti, A., D. Pongiluppi, and G. Vezzalini (1982) The crystal chemistry of natrolite, mesolite and scolecite. Neues Jahrb. Mineral., Abh., 143, 231–248. (4) Artioli, G., J.V. Smith, and J.J. Pluth (1986) X-ray structure refinement of mesolite. Acta Cryst., C42, 937–942.

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Messelite $\mathbf{Ca_2(Fe^{2+},Mn^{2+})(PO_4)_2 \cdot 2H_2O}$

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Crystal Data: Triclinic. *Point Group:* $[\bar{1}]$ (by analogy to fairfieldite). As internally radial globular, hemispherical, or sheaflike aggregates of lamellar crystals, to 1.5 cm; may be granular.

Physical Properties: *Cleavage:* Perfect on {001}, producing curved irregular surfaces. Hardness = 3.5 D(meas.) = 3.16 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* White, pale greenish white, greenish gray, pink. *Luster:* Vitreous.
Optical Class: Biaxial (+). α = 1.644–1.654 β = 1.649–1.659 γ = 1.660–1.680
2V(meas.) = 5°–30°

Cell Data: *Space Group:* $[P\bar{1}]$ (by analogy to fairfieldite). Z = n.d.

X-ray Powder Pattern: Kings Mountain, North Carolina, USA.
6.36 (10), 3.17 (10), 3.02 (9), 2.67 (4), 3.58 (3), 2.80 (3), 2.63 (3)

Chemistry:

	(1)	(2)	(3)
P_2O_5	36.90	38.96	39.26
Fe_2O_3	0.83		
FeO	20.92	16.62	9.94
MnO	3.94	7.87	9.81
MgO	1.36	0.09	
CaO	23.19	25.64	31.02
H_2O	11.30	11.00	9.97
insol.	1.39		
Total	99.83	100.18	100.00

(1) Palermo #1 mine, New Hampshire, USA. (2) Kings Mountain, North Carolina, USA.
(3) $Ca_2(Fe,Mn)(PO_4)_2 \cdot 2H_2O$ with Fe:Mn = 1:1.

Mineral Group: Fairfieldite group.

Occurrence: Principally as a late stage hydrothermal alteration product in zoned complex granite pegmatites.

Association: Triphylite, anapaite, vivianite, ludlamite, siderite, goyazite, whitlockite, herderite, amblygonite, eosphorite, brazilianite, graftonite, fairfieldite, phosphoferrite, huréaulite.

Distribution: In Germany, from the Prinz Heinrich von Hessen and the Messel oil slate mines, Messel, Hesse; and from Hagendorf, Bavaria. In the Norrö pegmatite, on Rånö Island, Sweden. At Přibyslavice, Czech Republic. In the Salsigne mine, 15 km north of Carcassone, Aude, France. From Kustanai, Kazakhstan. In the USA, at the Foote mine, near Kings Mountain, Cleveland Co., North Carolina; from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; at the Tip Top, White Elephant, Linwood, and Bull Moose mines, near Custer, Custer Co., and the Big Chief, Ingersoll, and Dan Patch mines, near Keystone, Pennington Co., South Dakota. Large crystals from Rapid Creek, Yukon Territory, Canada. At the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil.

Name: For the locality that produced the first specimens, Messel, Germany.

References: (1) Frondel, C. (1955) Neomesselite [messelite] and beta-roselite: two new members of the fairfieldite group. Amer. Mineral., 40, 828–833. (2) Čech, F. and K. Paděra (1958) Messelit aus den Phosphatnestern im Granit bei Přibyslavice (Böhmen) und das Messelitproblem. Chem. Erde, 19, 436–449 (in German). (3) (1959) Amer. Mineral., 44, 469 (abs. ref. 2). (4) Privett, D.R. (1973) Messelite at Kings Mountain, North Carolina. Southeast Geology, 15, 71–75.

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Meta-aluminite $Al_2(SO_4)(OH)_4 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Microcrystalline, minute laths, aggregated into nodular to irregular masses.

Physical Properties: Hardness = "Soft". D(meas.) = 2.18 D(calc.) = 2.17

Optical Properties: Semitransparent. *Color:* White. *Luster:* Somewhat silky. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$, probable. $\alpha = 1.497(1)$ $\beta = 1.512(1)$ $\gamma = \sim 1.513$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P2_1/m$ or $P2/m$. $a = 7.930(3)$ $b = 16.879(4)$ $c = 7.353(5)$ $\beta = 106.74(7)^\circ$ Z = 4

X-ray Powder Pattern: Fuemrole mine, Utah, USA.
4.48 (100), 8.35 (79), 4.36 (67), 6.85 (53), 3.708 (35), 3.596 (34), 3.669 (30)

Chemistry:

	(1)	(2)
SO_3	26.26	25.98
Al_2O_3	33.59	33.09
H_2O	40.15	40.93
Total	[100.00]	100.00

(1) Fuemrole mine, Utah, USA; recalculated to 100% from an original total of 100.29% after deduction of Fe_2O_3 0.53% and SiO_2 0.77%; corresponds to $Al_{2.01}(SO_4)(OH)_{4.00} \cdot 5.00H_2O$.
(2) $Al_2(SO_4)(OH)_4 \cdot 5H_2O$.

Occurrence: A rare secondary mineral formed by reaction of acid sulfate solutions from oxidizing pyrite reacting with clay minerals (Fuemrole mine, Utah, USA).

Association: Gypsum, basaluminite (Fuemrole mine, Utah, USA).

Distribution: At the Fuemrole mine, Temple Mountain, Emery Co., Utah, USA. From Newhaven, Sussex, England.

Name: The prefix, from the Greek *meta*, indicates a lower hydrate than *aluminite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 109543.

References: (1) Frondel, C. (1968) Meta-aluminite, a new mineral from Temple Mountain, Utah. Amer. Mineral., 53, 717–721. (2) Farkas, L. and P.-E. Werner (1980) Powder diffraction studies on aluminite and meta-aluminite. Zeits. Krist., 151, 141–152.

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Meta-alunogen $Al_4(SO_4)_6 \cdot 27H_2O$

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Crystal Data: Orthorhombic (synthetic). *Point Group:* n.d. Typically in fibrous tangled masses and efflorescences, or crackled massive, altered from alunogen.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.85]

Optical Properties: Semitransparent. *Color:* White, pale yellow; colorless in transmitted light. *Luster:* Waxy to pearly.
Optical Class: Biaxial (+). *Orientation:* $X \perp b$. $\alpha = 1.469$ $\beta = 1.473$ $\gamma = 1.491$
2V(meas.) = Large.

Cell Data: *Space Group:* n.d. $a = 12.25$ $b = 13.95$ $c = 15.95$ Z = 4

X-ray Powder Pattern: Synthetic.
4.071 (100), 12.20 (26), 6.114 (11), 3.860 (9), 4.208 (7), 3.990 (5), 3.024 (4)

Chemistry:

	(1)	(2)
SO_3	41.04	41.03
Al_2O_3	17.33	17.42
H_2O	41.44	41.55
Total	99.81	100.00

(1) Francisco de Vergara, Chile. (2) $Al_4(SO_4)_6 \cdot 27H_2O$.

Occurrence: An uncommon mineral formed by dehydration of alunogen; found in sulfate-rich hydrothermal deposits and geothermal fields.

Association: Alunogen, pickeringite, halotrichite, mirabilite, kalinite, gypsum.

Distribution: From alum mines 3.5 km south of Francisco de Vergara, Antofagasta, Chile. In Ruatapu Cave and within the Te Kopia geothermal field, Taupo Volcanic Zone, New Zealand.

Name: For *meta*, indicating a lower hydrate, and *alunogen*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 539–540, 537–539 [alunogen, part]. (2) Náray-Szabó, I (1969) Über die hydrate des Aluminiumsulfats. Acta Chimica Academiae Scientiarum Hungaricae, 60(1–2), 27–36 (in German).

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Meta-ankoleite $K_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As tabular crystals with square outline, to 1 mm; in scaly aggregates.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {010}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.54(1) Radioactive; fluoresces yellow-green under SW and LW UV.

Optical Properties: Translucent. *Color:* Yellow.
Optical Class: Uniaxial (–). *Pleochroism:* Faint; yellow. $\omega = 1.580–1.583$ ϵ = n.d.

Cell Data: *Space Group:* $P4/nmm$. $a = 6.993(10)$ $c = 8.891(5)$ $Z = 1$

X-ray Powder Pattern: Mungenyi pegmatite, Uganda.
8.92 (100), 3.73 (65), 3.25 (55), 4.93 (50), 3.49 (50), 5.47 (45), 4.32 (40)

Chemistry:

	(1)	(2)
UO_3	60.8	62.43
P_2O_5	15.5	15.49
BaO	3.2	
K_2O	8.7	10.28
H_2O	11.8	11.80
Total	100.0	100.00

(1) Mungenyi pegmatite, Uganda; recalculated to 100% after removal of albite and quartz impurities; corresponds to $(K_{1.71}Ba_{0.20})_{\Sigma=1.91}(UO_2)_{1.97}(PO_4)_{2.02} \cdot 6.06H_2O$.
(2) $K_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: A rare secondary mineral in the weathered zone of a complex granite pegmatite (Mungenyi pegmatite, Uganda) and the sericitic matrix of a quartz sandstone (Sebungwe district, Zimbabwe).

Association: Muscovite, albite, quartz, phosphuranylite, grayite, zircon (Mungenyi pegmatite, Uganda).

Distribution: From the Mungenyi pegmatite, about 65 km southwest of Mbarara, Ankole district, Uganda. In the Sebungwe district, Zimbabwe. From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. At St. Yrieux, near Limoges, Haute-Vienne, France.

Name: For the Ankole district, Uganda, from which it was first characterized.

Type Material: Geological Survey Museum; The Natural History Museum, London, England, 1966,203 and 1966,204.

References: (1) Gallagher, M.J. and D. Atkin (1966) Meta-ankoleïte, hydrated potassium uranyl phosphate. Bull. Geol. Soc. Great Britain, 25, 49–54. (2) (1967) Amer. Mineral., 52, 560 (abs. ref. 1).

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Meta-autunite $Ca(UO_2)_2(PO_4)_2 \cdot 2{-}6H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$ or 422. As rectangular tabular crystals, exhibiting {001}, {111}, {110}, {011}, rarely pyramidal; as foliated or scaly aggregates.

Physical Properties: *Cleavage:* Perfect on {001}; indistinct on {010}. Hardness = 2–2.5 D(meas.) = 3.35–3.55 D(calc.) = 3.31 Radioactive. Fluoresces yellowish green under UV. Dehydrates irreversibly from autunite under ambient conditions.

Optical Properties: Translucent to opaque. *Color:* Lemon-yellow to greenish yellow, yellowish green, dark green. *Luster:* Pearly to dull.
Optical Class: Uniaxial (–), anomalously biaxial (–). *Pleochroism:* X = colorless to pale yellow; $Y = Z$ = dark yellow. *Orientation:* $Z = c$. *Dispersion:* $r > v$, strong. $\omega = 1.600$–1.611 $\epsilon = 1.594$–1.598 $\alpha = 1.596$–1.604 $\beta = 1.602$–1.622 $\gamma = 1.603$–1.630 2V(meas.) = 5–20°

Cell Data: *Space Group:* $P4/nmm$ or $P4_22$. $a = 6.99$ $c = 8.46$ Z = 1

X-ray Powder Pattern: Les Oudots mine, Saône-et-Loire, France. (ICDD 39-1351).
8.46 (100), 3.620 (60), 2.115 (35), 2.615 (30), 1.601 (25), 5.39 (20), 4.233 (20)

Chemistry: (1) The mineral usually analyzed as autunite; meta-autunite I contains $6H_2O$; meta-autunite II contains $2H_2O$ and probably does not occur in nature.

Mineral Group: Meta-autunite group.

Occurrence: A secondary mineral, formed as dehydration pseudomorphs after autunite.

Association: Autunite.

Distribution: Widespread. All autunite (q.v.) localities probably contain meta-autunite.

Name: The prefix *meta* indicates the dehydration product of *autunite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 984–987 [meta-autunite I]. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Survey Bulletin 1064, 205–207. (3) Leo, G.W. (1960) Autunite from Mt. Spokane, Washington. Amer. Mineral., 45, 99–128. (4) Makarov, E.S. and V.I. Ivanov (1960) Crystal structure of metaautunite. Doklady Acad. Nauk SSSR, 132, 673–676 (in Russian). (5) Takano, Y. (1961) X-ray study of autunite. Amer. Mineral., 46, 812–822. (6) Ross, M. (1963) The crystallography of meta-autunite (I). Amer. Mineral., 48, 1389–1393.

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Metaborite HBO_2

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals show combinations of {111}, {101}, {211}, to 1 cm, occurring typically in aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.47 D(calc.) = 2.489 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless to pale brown. *Luster:* Vitreous. *Optical Class:* Isotropic. $n = 1.618(2)$

Cell Data: *Space Group:* $P\bar{4}3n$. $a = 8.89(1)$ $Z = 24$

X-ray Powder Pattern: Ak-saĭ, Kazakhstan.
1.938 (10), 4.53 (5), 2.835 (4), 6.60 (3), 3.71 (3), 2.388 (3), 2.102 (3)

Chemistry:

	(1)	(2)
B_2O_3	77.60	79.44
MgO	2.15	
H_2O	20.00	20.56
Total	99.75	100.00

(1) Ak-saĭ, Kazakhstan. (2) HBO_2.

Occurrence: In fine-grained halite in a salt dome (Chalkar salt dome, Kazakhstan).

Association: Halite, anhydrite, kieserite, preobrazhenskite, boracite, aksaite, ginorite, hilgardite, strontioborite, halurgite (Chalkar salt dome, Kazakhstan).

Distribution: From the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, and at the Inder borate deposit, Kazakhstan.

Name: From the Greek *meta*, as a lesser hydrate than orthoboric acid.

Type Material: Mining Institute, St. Petersburg, 1015/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69825.

References: (1) Lobanova, V.V. and N.P. Avrova (1964) The new mineral metaborite – natural metaboric acid. Zap. Vses. Mineral. Obshch., 93, 329–334 (in Russian). (2) (1965) Amer. Mineral., 50, 261–262 (abs. ref. 1). (3) Zachariason, W.H. (1960) The crystal structure of cubic metaboric acid. Acta Cryst., 16, 380–384. (4) (1966) NBS Mono. 25, 4, 27.

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Crystal Data: n.d. *Point Group:* n.d. As dense, fine-grained aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 4.90 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Orange.
Optical Class: Biaxial (+). $\alpha = 1.897$ $\beta = 1.911$ $\gamma = 1.932$ 2V(meas.) = 81°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Russia.
3.089 (9), 1.676 (6), 1.283 (6), 3.425 (5), 1.986 (4), 1.944 (4), 1.915 (3)

Chemistry:

	(1)		(1)
UO_3	76.91	CaO	4.86
As_2O_5	0.48	BaO	4.84
SiO_2	1.0	Na_2O	2.47
ZrO_2	0.45	H_2O^+	3.78
Al_2O_3	0.25	H_2O^-	0.01
Fe_2O_3	0.44	CO_2	1.80
PbO	2.29	Total	99.58

(1) Russia; corresponds to $(Ca_{0.37}Na_{0.31}Ba_{0.24}Pb_{0.08})_{\Sigma=1.00}O \cdot 2.1UO_3 \cdot 1.7H_2O$.

Occurrence: In the oxidation zone of a U–Mo deposit, replacing "pitchblende", and being replaced by uranophane.

Association: Uraninite, uranophane, bauranoite, calciouranoite, protasite.

Distribution: From an undisclosed locality [Streltsovskoe U–Mo deposit, eastern Transbaikal] in Russia.

Name: As a lower hydrate of *calciouranoite.*

Type Material: n.d.

References: (1) Rogova, V.P., L.N. Belova, G.N. Kiziyarov, and N.N. Kuznetsova (1973) Bauranoite and metacaltsuranoite [metacalciouranoite] – new minerals of the group of hydrous uranium oxides. Zap. Vses. Mineral. Obshch., 102, 75–81 (in Russian). (2) (1973) Amer. Mineral., 58, 1111 (abs. ref. 1).

Metacinnabar HgS

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. Commonly massive; rarely as small (to 1 mm) tetrahedral crystals having rough faces. *Twinning:* Common on {111}, forming lamellae in polished section.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = n.d. D(meas.) = 7.65 D(calc.) = 7.63

Optical Properties: Opaque. *Color:* Grayish black; in polished section, grayish white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak, rarely. *Anisotropism:* Very weak, rarely. R: (400) 28.4, (420) 27.6, (440) 26.8, (460) 26.3, (480) 25.9, (500) 25.6, (520) 25.4, (540) 25.2, (560) 25.1, (580) 25.0, (600) 24.9, (620) 24.9, (640) 24.8, (660) 24.7, (680) 24.7, (700) 24.7

Cell Data: *Space Group:* $F\overline{4}3m$. a = 5.8717(5) Z = 4

X-ray Powder Pattern: Synthetic.
3.378 (100), 2.068 (55), 1.7644 (45), 2.926 (35), 1.3424 (12), 1.6891 (10), 1.3085 (10)

Chemistry:

	(1)	(2)	(3)	(4)
Hg	79.73	67.45	81.33	86.22
Zn	4.23	3.10		
Cd		11.72		
Fe	trace	0.2		
Se	1.08		6.49	
S	14.58	15.63	10.30	13.78
Total	99.62	98.10	98.12	100.00

(1) Guadalcázar, Mexico; corresponds to $(Hg_{0.85}Zn_{0.14})_{\Sigma=0.99}(S_{0.97}Se_{0.03})_{\Sigma=1.00}$. (2) Uland area, Russia; corresponds to $(Hg_{0.69}Cd_{0.21}Zn_{0.10}Fe_{0.01})_{\Sigma=1.01}S_{1.00}$. (3) San Onofre, Mexico; corresponds to $Hg_{1.00}(S_{0.80}Se_{0.20})_{\Sigma=1.00}$. (4) HgS.

Polymorphism & Series: Trimorphous with cinnabar and hypercinnabar.

Mineral Group: Sphalerite group.

Occurrence: In mercury deposits formed under low-temperature near-surface conditions.

Association: Cinnabar, mercury, wurtzite, stibnite, marcasite, realgar, calcite, barite, "chalcedony", hydrocarbons.

Distribution: Not uncommon in mercury deposits; may be a principal ore mineral. In the USA, in California, in the Redington mine [TL] and other properties, near Knoxville, Napa Co.; at the Ryne mine, Mt. Diablo, Contra Costa Co.; from New Almaden, Santa Clara Co.; at Skaggs Springs, Sonoma Co.; from New Idria, San Benito Co.; and many other places. At Terlingua, Brewster Co., Texas; from Marysvale, Ohio district, Piute Co., Utah; and in the Reward mines, Franklin, King Co., Washington. In Canada, from Read Island, Nanaimo mining division, British Columbia. In Mexico, at San Onofre, near Plateros, Zacatecas; also from Guadalcázar, San Luis Potosí. At Idrija (Idria), Slovenia. In Italy, from Levigliani, Tuscany. In Romania, at Baia Sprie (Felsőbánya). From Almadén, Ciudad Real Province, Spain. In the Uland area, Kurai ore zone, Altai Mountains, and other deposits in Russia. At Wen-Shan-Chang, Kweichow, and elsewhere in China.

Name: From the Greek for *with*, plus *cinnabar*, in allusion to its common association.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 215–217. (2) Aurivillius, K. (1964) An X-ray and neutron diffraction study of metacinnabarite. Acta Chem. Scand., 18, 1552–1553. (3) (1955) NBS Circ. 539, 4, 21–23. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 367.

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Metadelrioite $CaSrV_2^{5+}O_6(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Intimately intergrown in parallel orientation with delrioite, in radial fibrous aggregates of tiny acicular crystals.

Physical Properties: Hardness = ∼2 D(meas.) = 4.3 D(calc.) = 4.21 Readily soluble in H_2O.

Optical Properties: Translucent. *Color:* Light yellow-green to darker green on exposed surfaces, probably the result of photoreduction of some of the vanadium. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–); properties composite with delrioite. *Pleochroism:* X = colorless; Y = pale yellow; Z = deeper yellow. *Orientation:* Z = elongation; extinction parallel. $\alpha = 1.783(3)$ $\beta = 1.834(3)$ $\gamma = 1.866(3)$ 2V(meas.) = Medium to large.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 7.343(7)$ $b = 8.382(3)$ $c = 5.117(4)$ $\alpha = 111°39(2)'$ $\beta = 90°16(5)'$ $\gamma = 102°49(4)'$ Z = 2

X-ray Powder Pattern: Jo Dandy mine, Colorado, USA.
4.94 (s), 3.46 (s), 4.73 (ms), 2.683 (ms), 2.547 (m), 2.516 (m), 1.885 (m)

Chemistry:

	(1)	(2)
V_2O_5	46.6	50.58
CaO	13.5	15.59
SrO	24.8	28.82
H_2O^+	5.7	5.01
H_2O^-	9.4	
Total	[100.0]	100.00

(1) Jo Dandy mine, Colorado, USA; an estimated 1:5 mixture with delrioite, $CaSrV_2O_6(OH)_2 \cdot 3H_2O$, recalculated to 100% after deduction of quartz 1.30%.
(2) $CaSrV_2O_6(OH)_2$.

Occurrence: An efflorescence on sandstone of the Salt Wash member of the Jurassic Morrison Formation associated with a U–V deposit.

Association: Delrioite, rossite, metarossite, quartz.

Distribution: From a dump at the Hummer portal of the Jo Dandy mine, Bull Canyon district, Paradox Valley, Montrose Co., Colorado, USA.

Name: For its relation to *delrioite* and its lesser H_2O content.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128296.

References: (1) Smith, M.L. (1970) Delrioite and metadelrioite from Montrose County, Colorado. Amer. Mineral., 55, 185–200. (2) Thompson, M.E. and A.M. Sherwood (1959) Delrioite, a new calcium strontium vanadate from Colorado. Amer. Mineral., 44, 261–264.

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Metaheinrichite $Ba(UO_2)_2(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* 4, $4/m$, or 422. As tabular {001} crystals of square or rectangular outline, exhibiting {001}, {100}, and {110}, to 2 mm; as scaly aggregates.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {010}. *Fracture:* Irregular. Hardness = 2.5 D(meas.) = 4.04 D(calc.) = 4.09 Fluoresces bright green to greenish yellow under SW and LW UV. Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow to green. *Streak:* Pale yellow to white. *Luster:* Vitreous to pearly.
Optical Class: Uniaxial (–), may be anomalously biaxial (–). *Pleochroism:* O = pale yellow; E = colorless. $\omega = 1.637$–1.641 $\epsilon = 1.609(1)$ 2V(meas.) = 0°–18°

Cell Data: *Space Group:* $P4_2$, $P4_2/m$, or $P4_222$. $a = 7.07$ $c = 17.74$ Z = 2

X-ray Powder Pattern: White King mine, Oregon, USA.
8.90 (vs), 3.75 (s), 5.54 (ms), 4.42 (ms), 3.55 (ms), 3.28 (ms), 4.99 (m)

Chemistry:

	(1)	(2)
UO_3	52.5	52.03
P_2O_5	2.4	
As_2O_5	15.8	20.91
CO_2	0.6	
PbO	0.9	
CaO	0.1	
BaO	13.3	13.95
H_2O	12.2	13.11
insol.	2.4	
Total	100.2	100.00

(1) White King mine, Oregon, USA; insoluble is rhyolite tuff. (2) $Ba(UO_2)_2(AsO_4)_2 \cdot 8H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: A rare secondary mineral derived by the weathering of primary uranium minerals.

Association: Heinrichite, zeunerite, nováčekite, erythrite, arseniosiderite, pitticite.

Distribution: From the White King mine, about 22 km northwest of Lakeview, Lake Co., Oregon, USA. In Germany, in the Black Forest, from the Sophia mine and on the Schmiedestollen dump, near Wittichen; in the Anton mine, Heubachtal, near Schiltach; from Reinerzau and Menzenschwand; also at Sailauf, northeast of Aschaffenburg, Bavaria; in Saxony, from Schneeberg; in Rhineland-Palatinate, at Ellweiler.

Name: The prefix *meta* indicates the dehydration product of *heinrichite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 115884.

References: (1) Gross, E.B., A.S. Corey, R.S. Mitchell, and K. Walenta (1958) Heinrichite and metaheinrichite, hydrated barium uranyl arsenate minerals. Amer. Mineral., 43, 1134–1143. (2) de Abeledo, M.E.J., E.E. Galloni, and M.A.R. de Benyacar (1968) Electron diffraction data for some members of the metatorbernite group. Amer. Mineral., 53, 1028–1033.

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Metahewettite $CaV_6^{5+}O_{16}\cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As microscopic laths or tablets, flattened on {001}, in parallel or radial fibrous masses, pulverulent, and as coatings.

Physical Properties: Hardness = Soft. D(meas.) = 2.94 D(calc.) = 3.05 Reversibly hydrates to hewettite.

Optical Properties: Semitransparent. *Color:* Deep red; in transmitted light, red to orange. *Streak:* Maroon to brownish red. *Luster:* Dull to somewhat silky.
Optical Class: Biaxial (–). *Pleochroism:* X = light yellow-orange; Y = deep red; Z = deeper red. *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.70$ $\beta = 2.10$ $\gamma = \sim 2.23$ 2V(meas.) = n.d. 2V(calc.) = 52°

Cell Data: *Space Group:* $A2/m$. $a = 12.15(1)$ $b = 3.607(3)$ $c = 18.44(1)$ $\beta = 118°2(3)'$ Z = 2

X-ray Powder Pattern: Monument No. 2 mine, Arizona, USA.
8.19 (100), 3.578 (30), 2.812 (24), 2.206 (22), 3.062 (18), 2.295 (17), 5.36 (12)

Chemistry: No analyses appear to have been made. Existence of the trihydrate has been inferred from dehydration-rehydration studies of hewettite and unit cell volume calculations.

Occurrence: As an impregnation in sandstone (Colorado Plateau-type U–V deposits).

Association: Hewettite, gypsum, selenium.

Distribution: In the USA, in the Jo Dandy and Hummer mines, Paradox Valley, Montrose Co., Colorado; from the Cactus Rat mine group, Yellow Cat district, 24 km southeast of Thompson, Grand Co., Utah; in Arizona, at the Monument No. 2 mine, Monument Valley, Apache Co.; in the Ambrosia Lakes district, McKinley Co., New Mexico; from near Post, Crook Co., Oregon; and near Cockalorum Wash, Nye Co., Nevada. In several mines of the Kurumsak and Balasauskandyk districts, northwestern Kara-Tau Mountains, Kazakhstan.

Name: For its relation to *hewettite* and its lesser H_2O content.

Type Material: Harvard University, Cambridge, Massachusetts, 93306; National Museum of Natural History, Washington, D.C., USA, 93305–93308.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1061–1062. (2) Bayliss, P. (1979) X-ray powder data for metahewettite. Mineral. Mag., 43, 550. (3) Bayliss, P. (1982) X-ray powder data for hewettite. Mineral. Mag., 46, 503–504. (4) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 513–514.

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Metahohmannite $Fe_2^{3+}(SO_4)_2(OH)_2 \cdot 3H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Pulverulent massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Orange.
Optical Class: Biaxial (+). *Pleochroism:* X = pale yellow; Y = reddish yellow; Z = reddish brown. $\alpha = 1.709$ $\beta = 1.718$ $\gamma = 1.734$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Saghand, Iran; artificially dehydrated from hohmannite. (ICDD 39–379).
7.18 (100), 4.27 (71), 3.28 (71), 2.96 (71), 2.70 (71), 2.49 (71), 9.7 (57)

Chemistry:

	(1)	(2)
SO_3	39.61	40.86
Fe_2O_3	39.25	40.75
H_2O	20.29	18.39
Total	99.15	100.00

(1) Alcaparrosa, Chile. (2) $Fe_2(SO_4)_2(OH)_2 \cdot 3H_2O$.

Occurrence: Formed by the partial dehydration of hohmannite.

Association: Hohmannite.

Distribution: In Chile, in Antofagasta, from Chuquicamata, at Quetena, west of Calama, and Alcaparrosa, near Cerritos Bayos, southwest of Calama. From Saghand, Yazd, Iran. At the Redington mercury mine, Knoxville, Napa Co., California, USA.

Name: The prefix, from the Greek, *meta*, indicates a lower hydrate than *hohmannite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 99049, 99051.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 608.

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Metakahlerite $Fe^{2+}(UO_2)_2(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. As square tabular crystals, to 80 μm, and in scaly aggregates.

Physical Properties: *Cleavage:* Perfect on {001}; good on {010}. Hardness = n.d. D(meas.) = 3.73–3.77 (synthetic) D(calc.) = [3.83] Radioactive.

Optical Properties: Transparent. *Color:* Yellow to yellow-brown. *Luster:* Pearly on {001}. *Optical Class:* Uniaxial (–), anomalously biaxial (–). *Pleochroism:* Weak; O = pale yellow; E = colorless. $\omega = 1.642(2)$ $\epsilon = 1.608(2)$ 2V(meas.) = 0°–22°

Cell Data: *Space Group:* n.d. $a = 20.25(1)$ $c = 17.20(1)$ Z = 16

X-ray Powder Pattern: Sophia mine, Germany; indistinguishable from metakirchheimerite. 8.55 (10), 3.59 (9), 4.30 (6), 5.11 (5), 3.45 (4), 3.01 (4), 2.15 (4)

Chemistry: (1) Sophia mine, Germany; no quantitative analysis performed, the qualitatively dominant presence of Fe, As, U confirmed by microchemical analysis.

Mineral Group: Meta-autunite group.

Occurrence: A secondary mineral in the oxidized zone of U–As bearing deposits.

Association: Arseniosiderite, scorodite, löllingite, uraninite, siderite (Hüttenberg, Austria); kahlerite (Southwick Cliffs, Scotland).

Distribution: In Germany, in the Black Forest, from the Sophia and St. Joseph mines and at the Schmiedestollen, near Wittichen, and from Menzenschwand; at Ellweiler, Rhineland-Palatinate; and from Schneeberg, Saxony. From Hüttenberg, Carinthia, Austria. At Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland. From the Krantzberg mine, 20 km west of Karibib, Namibia.

Name: The prefix *meta* indicates the dehydration product of *kahlerite*.

Type Material: n.d.

References: (1) Walenta, K. (1958) Die sekundären Uranmineralien des Schwarzwaldes. Jahresheft geol. Landesamt Baden-Württemberg, 3, 17–51, esp. 33–34 (in German). (2) (1960) Amer. Mineral., 45, 254 (abs. ref. 1). (3) Walenta, K. (1964) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 1. Folge. Tschermaks Mineral. Petrog. Mitt., 9, 111–174, esp. 173 (in German). (4) Vochten, R., E. De Grave, and J. Pelsmaekers (1986) Synthesis, crystallographic and spectroscopic data, solubility, and electrokinetic properties of metakahlerite and its Mn analogue. Amer. Mineral., 71, 1037–1044.

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Metakirchheimerite $Co(UO_2)_2(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. As square tabular crystals, to 50 μm.

Physical Properties: *Cleavage:* Perfect on {001}; good on {010}. Hardness = 2–2.5 D(meas.) = > 3.33 D(calc.) = [4.11] Radioactive.

Optical Properties: Transparent to translucent. *Color:* Pale rose to flesh-pink; colorless in transmitted light. *Luster:* Pearly on {001}.
Optical Class: Uniaxial (–), anomalously biaxial (–). ω = 1.644(2) ϵ = 1.617(2)
2V(meas.) = 0°–20°

Cell Data: *Space Group:* n.d. $a = 6.98$ $c = 16.93$ Z = [2]

X-ray Powder Pattern: Sophia mine, Germany; indistinguishable from metakahlerite.
8.78 (10), 3.57 (10), 5.08 (6), 4.30 (6), 3.01 (6), 3.42 (5), 2.52 (5)

Chemistry: (1) Sophia mine, Germany; no quantitative analysis has been performed, qualitatively major Co, U, As and minor Fe, Ni were confirmed by microchemical analysis.

Mineral Group: Meta-autunite group.

Occurrence: A very rare secondary mineral formed in the oxidized zone of a U–As deposit.

Association: Metakahlerite, nováčekite, metaheinrichite, erythrite, uraninite.

Distribution: From the dump of the Sophia mine, near Wittichen, Black Forest, Germany.

Name: The prefix *meta* indicates membership of this species in the *meta-autunite* group; the name honors Professor Franz Waldemar Kirchheimer (1911–), former Director of the Geological Survey of Baden-Württemberg, Germany.

Type Material: n.d.

References: (1) Walenta, K. (1958) Die sekundären Uranmineralien des Schwarzwaldes. Jahresheft geol. Landesamt Baden-Württemberg, 3, 17–51, esp. 34–36 (in German).
(2) (1959) Amer. Mineral., 44, 466 (abs. ref. 1). (3) Vochten, R. and A. Goeminne (1984) Synthesis, crystallographic data, solubility, and electrokinetic properties of meta-zeunerite, meta-kirchheimerite and nickel-uranylarsenate. Phys. Chem. Minerals, 11, 95–100.

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Metaköttigite $(Zn, Fe^{3+}, Fe^{2+})_3(AsO_4)_2 \cdot 8(H_2O, OH)$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. Tabular crystals, very small, intergrown with köttigite. *Twinning:* Universal on $\{1\overline{1}0\}$.

Physical Properties: *Cleavage:* $\{1\overline{1}0\}$, perfect. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.03

Optical Properties: Semitransparent. *Color:* Bluish gray.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = deep blue; Y = yellow; Z = light yellow.
$\alpha = 1.648(3)$ $\beta = 1.680(1)$ $\gamma = 1.716(2)$ 2V(meas.) = 94(1)°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. a = 7.96(2) $b = 9.44(2)$ $c = 4.72(1)$ $\alpha = 95.6(2)°$ $\beta = 97.0(2)°$ $\gamma = 107.8(2)°$ Z = 1

X-ray Powder Pattern: Ojuela mine, Mexico; very similar to symplesite.
6.91 (100), 8.90 (40), 3.93 (30), 3.00 (30), 3.11 (25), 2.83 (25), 4.99 (20)

Chemistry:

	(1)
As_2O_5	37.36
FeO	14.70
CoO	0.09
ZnO	22.50
H_2O	[25.35]
Total	[100.00]

(1) Ojuela mine, Mexico; by electron microprobe, average of two analyses, total Fe as FeO, H_2O by difference; corresponds to $(Zn_{1.72}Fe_{1.27}Co_{0.01})_{\Sigma=3.00}(AsO_4)_{2.02} \cdot 8[H_2O, (OH)]$.

Polymorphism & Series: Dimorphous with köttigite.

Occurrence: A rare secondary mineral from the oxide zone of an arsenic-rich polymetallic mineral deposit, formed by oxidation and concomitant dehydrogenization of ferroan köttigite.

Association: Köttigite, smithsonite, adamite, goethite.

Distribution: In the Ojuela mine, Mapimí, Durango, Mexico.

Name: For its dimorphous relation to *köttigite*, and by analogy to *metavivianite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160541.

References: (1) Schmetzer, K., G. Amthauer, V. Stähle, and O. Medenbach (1982) Metaköttigite, $(Zn, Fe^{3+})(Zn, Fe^{3+}, Fe^{2+})_2(AsO_4)_2 \cdot 8(H_2O, OH)$, ein neues Mineral aus Mapimi, Mexiko. Neues Jahrb. Mineral., Monatsh., 506–518 (in German with English abs.). (2) (1983) Amer. Mineral., 68, 1039 (abs. ref. 1).

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Metalodèvite $Zn(UO_2)_2(AsO_4)_2 \cdot 10H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As lamellar crystals, elongated along [100] and flattened on {001}, to 2 mm; may be in divergent radial groups.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.00 Fluoresces faint yellow-green in SW UV. Radioactive.

Optical Properties: Transparent to translucent. *Color:* Pale to bright yellow, olive-green. *Luster:* Pearly.
Optical Class: Biaxial (–). *Pleochroism:* X = light brown; $Y = Z$ = pale yellow. $\alpha = 1.615(5)$ $\beta = 1.635(2)$ $\gamma = 1.638(2)$ 2V(meas.) = 27°–37°

Cell Data: *Space Group:* $P4_2/m$. $a = 7.16$ $c = 17.20$ Z = 2

X-ray Powder Pattern: Riviéral deposit, France.
3.59 (100), 8.66 (70), 2.98 (60), 5.09 (40), 3.50 (30), 2.545 (30), 2.288 (30)

Chemistry:

	(1)	(2)
UO_3	54.44	53.80
P_2O_5	0.76	
As_2O_5	20.64	21.61
FeO	0.63	
ZnO	6.47	7.65
H_2O	17.06	16.94
Total	[100.00]	100.00

(1) Riviéral deposit, France; recalculated from an original total of 99.43% after deduction of barite 7.40%; corresponds to $(Zn_{0.84}Fe_{0.09})_{\Sigma=0.93}(UO_2)_{2.00}[(AsO_4)_{1.88}(PO_4)_{0.12}]_{\Sigma=2.00} \cdot 9.96H_2O$.
(2) $Zn(UO_2)_2(AsO_4)_2 \cdot 10H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: A rare secondary mineral formed by alteration of arsenic-bearing minerals.

Association: Sphalerite, coffinite, uraninite, arsenopyrite (Riviéral deposit, France); adamite, legrandite, köttigite, scorodite, pharmacosiderite (Sterling Hill, New Jersey, USA).

Distribution: From the Riviéral uranium deposit, Saint-Martin-du-Bosc, five km southeast of Lodève, and in the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, France. From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: The prefix *meta* indicates membership in the *meta-autunite* group; the name is for Lodève, France, near which the first specimens were collected.

Type Material: Atomic Energy Commission, Fontenay-aux-Roses; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 165403.

References: (1) Agriner, H., F. Chantret, J. Geffroy, B. Héry, B. Bachet, and H. Vachey (1972) Une nouvelle espèce minérale: la méta-lodèvite (arséniate hydraté d'uranium et de zinc). Bull. Minéral., 95, 360–364 (in French with English abs.). (2) (1974) Amer. Mineral., 59, 210–211 (abs. ref. 1).

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Metamunirite β–$NaV^{5+}O_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are fibrous, needlelike, or flattened laths, with dominant {101}, unterminated, to 1 mm; in clusters of radiating needles.

Physical Properties: *Cleavage:* The fibrous character is probably due to one or more perfect cleavages. *Tenacity:* Friable. Hardness = Very soft. D(meas.) = 2.877 (synthetic). D(calc.) = 2.926 Readily soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.780(2)$ (synthetic). $\beta = 1.800(2)$ $\gamma =$ n.d. 2V(meas.) = 30°–40°

Cell Data: *Space Group: Pnma.* $a = 14.134(7)$ $b = 3.648(2)$ $c = 5.357(2)$ Z = 4

X-ray Powder Pattern: San Miguel Co., Colorado, USA; intensities from synthetic material. 5.05 (100), 2.957 (35), 3.530 (25), 3.241 (18), 3.016 (13), 2.685 (12), 7.07 (11)

Chemistry:

	(1)	(2)
V_2O_5	75.2	74.58
Na_2O	24.8	25.42
Total	[100.0]	100.00

(1) Deremo-Snyder mine, Colorado, USA; by electron microprobe, average of 31 determinations, recalculated to 100% to account for 8–10 wt% deficiency due to epoxy mounting medium between fibers. (2) $NaVO_3$.

Occurrence: Extremely rare, in cavities in vanadium-bearing sandstone.

Association: Rossite, metarossite, pascoite, clay minerals.

Distribution: From the Burro and Deremo-Snyder mines, near Slick Rock, San Miguel Co., Colorado, USA.

Name: For its relation to *munirite*, from which it may form by dehydration.

Type Material: National Museum of Natural History, Washington, D.C., USA, 168386.

References: (1) Evans, H.T., Jr. (1991) Metamunirite, a new anhydrous sodium metavanadate from San Miguel County, Colorado. Mineral. Mag., 55, 509–513. (2) (1992) Amer. Mineral., 77, 1116–1117 (abs. ref. 1). (3) Kato, K. and E. Takayama (1984) Das Entwässerungsverhalten des Natriummetavanadatdihydrats und die Kristallstruktur des β-Natriummetavanadats. Acta Cryst., 40, 102–105 (in German with English abs.). (4) Haynes, P.E. (1992) Metamunirite, haynesite, and other microminerals from the four-corners states. Thirteeenth annual New Mexico mineral symposium, Socorro, New Mexico, 9 (abs.).

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Metanováčekite $Mg(UO_2)_2(AsO_4)_2 \cdot 4-8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As rims on other minerals, to 0.5 mm; typically pseudomorphous after nováčekite crystals.

Physical Properties: *Cleavage:* Perfect on {001}; good on {010}. Hardness = 2–2.5 D(meas.) = 3.51 D(calc.) = 3.72 Radioactive. Fluoresces yellow or yellow-green under UV. Reversibly dehydrates from nováčekite under ambient conditions.

Optical Properties: Translucent. *Color:* Yellow.
Optical Class: Uniaxial (–). *Pleochroism:* O = pale yellow; E = colorless. *Absorption:* $E < O$.
$\omega = 1.632–1.637$ $\epsilon = 1.595–1.620$

Cell Data: *Space Group:* $P4/n$. $a = 7.16$ $c = 8.58$ $Z = 1$

X-ray Powder Pattern: Anton mine, Germany.
8.52 (10), 3.57 (9), 2.14 (6), 4.29 (5), 1.791 (5), 5.05 (4b), 3.02 (4)

Chemistry: (1) Anton mine, Germany; no chemical analysis has been performed; identification is from correspondence of properties with synthetic $Mg(UO_2)_2(AsO_4)_2 \cdot 8H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: Typically a dehydration product of nováčekite.

Association: Nováčekite (Germany, England); bassetite, saléeite (Sue mine, Arizona, USA).

Distribution: In Germany, in the Black Forest, from the Anton mine, Heubachtal, near Schiltach; at the Michael mine, Weiler, near Lahr; and the Clara mine, near Oberwolfach; in the Weisser Hirsch mine, Schneeberg, Saxony; from Ellweiler, Rhineland-Palatinate. In West Wheal Owles, St. Just, Cornwall, England. From the Sue mine, Cherry Creek area, Gila Co., Arizona, and on Twin Mountain, Comanche Co., Oklahoma, USA.

Name: The prefix *meta* indicates the dehydration product of *nováčekite*.

Type Material: n.d.

References: (1) Walenta, K. (1964) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 1. Folge. Tschermaks Mineral. Petrog. Mitt., 9, 111–174, esp. 136–160 (in German). (2) de Abeledo, M.E.J., E.E. Galloni, and M.A.R. de Benyacar (1968) Electron diffraction data for some members of the metatorbernite group. Amer. Mineral., 53, 1028–1033.

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Metarossite $CaV_2^{5+}O_6 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals to 0.1 mm, platy, flaky, massive; as alteration rims on and complete replacements of rossite. *Twinning:* On $\{10\overline{1}\}$ as twin plane.

Physical Properties: *Tenacity:* Friable. Hardness = Soft. D(meas.) = n.d. D(calc.) = [2.80] Soluble in H_2O; alters to rossite on exposure to dry air, which is reversible.

Optical Properties: Semitransparent. *Color:* Very light yellow to pale greenish yellow; colorless to pale yellow in transmitted light. *Luster:* Dull to pearly. *Optical Class:* Biaxial (+). *Dispersion:* Strong. $\alpha = 1.840$ $\beta = > 1.85$ $\gamma = > 1.85$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.215(5)$ $b = 7.065(5)$ $c = 7.769(5)$ $\alpha = 92°58(10)'$ $\beta = 96°39(10)'$ $\gamma = 105°47(10)'$ Z = 2

X-ray Powder Pattern: Locality unspecified [Bull Pen Canyon, Colorado, USA]. 5.9 (s), 5.1 (s), 3.05 (m)

Chemistry:

	(1)	(2)	(3)
V_2O_5	64.08	64.20	66.38
MgO	0.10	0.13	
CaO	20.04	19.60	20.47
H_2O	13.56	14.08	13.15
insol.	2.72	2.48	
Total	100.50	100.49	100.00

(1–2) Bull Pen Canyon, Colorado, USA. (3) $CaV_2O_6 \cdot 2H_2O$.

Occurrence: In veinlets in carnotite-bearing sandstone (Bull Pen Canyon, Colorado, USA).

Association: Rossite, carnotite, gypsum (Bull Pen Canyon, Colorado, USA).

Distribution: In the USA, on M.E. O'Neil's [Buckhorn] claim, Bull Pen Canyon, Slick Rock district, San Miguel Co., and in Paradox Valley, Montrose Co., Colorado; along Spring Creek, Brushy Basin, Monticello district, San Juan Co., and in the Thompsons district, Grand Co., Utah; from the Monument No. 2 mine, Apache Co., Arizona.

Name: For its relation to *rossite*, from which it may form by dehydration.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95331A, R5707A.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1054–1055. (2) Weeks, A.D. and M.E. Thompson (1954) Identification and occurrence of uranium and vanadium minerals from the Colorado Plateaus. U.S. Geol. Sur. Bull. 1009-B, 56–57. (3) Kelsey, C.H. and W.H. Barnes (1960) The crystal structure of metarossite. Can. Mineral., 6, 448–466, 697.

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Metaschoderite $Al_2(PO_4)(VO_4)\cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Pseudomorphous after bladed to scaly schoderite crystals or spherulitic aggregates; in microcrystalline coatings.

Physical Properties: Hardness = ∼2 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Yellowish orange. *Optical Class:* Biaxial (+). *Orientation:* $Y \wedge c = -20°$; $Z = b$. $\alpha = 1.598$ $\beta = 1.604$ $\gamma = 1.626$ 2V(meas.) = 56° 2V(calc.) = 59°

Cell Data: *Space Group:* $P2/m$ (probable). $a = 11.4$ $b = 14.9$ $c = 9.2$ $\beta = 79°$ Z = 4

X-ray Powder Pattern: Fish Creek Range, Nevada, USA.
7.5 (100), 14.9 (60), 11.1 (40), 3.02 (20), 9.6 (15), 4.92 (10), 5.68 (8)

Chemistry: (1) No chemical analysis has been performed, the hydration state determined by DTA of schoderite.

Occurrence: Typically a dehydration product of schoderite.

Association: Schoderite, wavellite, vashegyite (Fish Creek, Nevada, USA); metahewettite, schoderite, bokite, minyulite, leucophosphite (Cockalorum Wash, Nevada, USA); hewettite, duttonite, fervanite, schoderite, straczekite (Wilson Springs mine, Arkansas, USA).

Distribution: In the USA, from the Van-Nav-Sand claim group, Fish Creek Range, 48 km south of Eureka, Eureka Co., and near Cockalorum Wash, Nye Co., Nevada; at the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas.

Name: The prefix *meta* indicates the dehydration product of *schoderite*.

Type Material: n.d.

References: (1) Hausen, D.M. (1962) Schoderite, a new phosphovanadate mineral from Nevada. Amer. Mineral., 47, 637–648.

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Metaschoepite $UO_3 \cdot 1{-}2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As topotactically oriented alteration rims, threaded by minute tubes ‖ [001], on schoepite crystals.

Physical Properties: *Cleavage:* [{001}] (by analogy to schoepite and paraschoepite, with which this is an intermediate dehydration product). *Tenacity:* [Brittle.] Hardness = [∼2.5] D(meas.) = n.d. D(calc.) = [4.69–4.97] Radioactive.

Optical Properties: Semitransparent. *Color:* Bright yellow.
Optical Class: Biaxial (–) (indices given here are intermediate between schoepite and paraschoepite). *Pleochroism:* X = almost colorless; $Y = Z$ = lemon-yellow to golden yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$. α = 1.690–1.700 β = 1.714–1.750 γ = 1.735–1.770 2V(meas.) = Large.

Cell Data: *Space Group: Pbna.* $a = 13.99(4)$ $b = 16.72(5)$ $c = 14.73(4)$ Z = 32

X-ray Powder Pattern: Shinkolobwe, Congo; identical to paraschoepite.
5.09 (100), 3.45 (25), 3.39 (17), 2.890 (7), 2.48 (7b), 2.542 (6), 2.023 (5)

Chemistry: Composition intermediate between schoepite, $UO_3 \cdot 2H_2O$, and paraschoepite, $UO_3 \cdot 1{-}2H_2O$.

Occurrence: An irreversible alteration product of schoepite from the oxidized zone of uranium-bearing mineral deposits.

Association: Schoepite, paraschoepite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). Probably at many other schoepite occurrences.

Name: From the Greek *meta*, for a lower hydration state, and its relation to *schoepite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 94712.

References: (1) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates [schoepite II]. Amer. Mineral., 45, 1026–1061. (2) Christ, C.L. (1965) Phase transformations and crystal chemistry of schoepite. Amer. Mineral., 50, 235–239.

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Metasideronatrite $Na_2Fe^{3+}(SO_4)_2(OH)\cdot 1{-}2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rare crystals are prismatic, elongated along [001], showing {010}, {110}, {011}; typically in radiating aggregates, to 2.5 cm, and in flat mats and crusts.

Physical Properties: *Cleavage:* On {100}, {010}, perfect; on {001}, nearly perfect. *Fracture:* Fibrous. Hardness = 2.5 D(meas.) = 2.68 D(calc.) = 2.68 Reversibly alters from sideronatrite depending on relative humidity and exposure to sunlight; decomposes in boiling H_2O.

Optical Properties: Transparent. *Color:* Golden yellow, straw-yellow; yellow in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Y = pale yellow; Z = brownish yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, strong. $\alpha = 1.543$ $\beta = 1.575$ $\gamma = 1.634$ 2V(meas.) = 60°

Cell Data: *Space Group:* *Pbnm* or $Pbn2_1$. $a = 7.357(3)$ $b = 16.002(4)$ $c = 7.102(8)$ Z = 2

X-ray Powder Pattern: Chuquicamata, Chile.
3.680 (100), 8.05 (90), 6.682 (70), 2.749 (50), 2.665 (50), 3.485 (40), 3.994 (30)

Chemistry:

	(1)	(2)	(3)
SO_3	48.66	48.68	46.15
Fe_2O_3	22.90	24.27	23.01
Na_2O	17.56	18.84	17.86
K_2O	0.26		
H_2O	9.75	8.21	12.98
insol.	0.60		
Total	99.73	100.00	100.00

(1) Chuquicamata, Chile; $(OH)^{1-}$ calculated for charge balance, corresponding to $(Na_{2.02}K_{0.02})_{\Sigma=2.04}Fe_{1.02}(SO_4)_{2.17}(OH)_{0.76}\cdot 1.55H_2O$. (2) $Na_2Fe(SO_4)_2(OH)\cdot H_2O$. (3) $Na_2Fe(SO_4)_2(OH)\cdot 2H_2O$.

Occurrence: An uncommon alteration product of pyrite, typically formed in arid climates but stably formed in sea-shore environments.

Association: Sideronatrite, metavoltine, ungemachite, ferrinatrite, alunogen, natrojarosite, pickeringite, sulfur, tamarugite, aluminocopiapite, metavoltine, mendozite, kornelite, gypsum.

Distribution: From Chuquicamata and the Sierra Gorda district, southwest of Calama, Antofagasta, Chile. In the USA, in the Capitol Reef National Monument, Wayne Co., Utah; from the Yazzie No. 101 mine, near Cameron, Coconino Co., Arizona; large radiating crystals at the Hot Springs Point sulfur mine, eight km east-southeast of Crescent Valley, Eureka Co., Nevada. In the Sydney coalfield, Nova Scotia, Canada. From Trerubies Cove, near Delabole, Cornwall, and at Barton-on-Sea, Hampshire, England. From north of Ballybunion, Co. Kerry, Ireland. At the Lanjarón mineral springs, Granada, Spain. In the Grotto de Faraglione, Port di Levante, Vulcano, Lipari Islands, Italy.

Name: From the Greek *meta*, signifying a lower hydrate, and its relation to *sideronatrite*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 603–604. (2) Finney, J.J. (1973) Unit cell and X-ray powder data for metasideronatrite. Amer. Mineral., 58, 1080–1081. (3) Scordari, F. and G. Milella (1982) Metasideronatrite: a mixture of coexisting compounds. Neues Jahrb. Mineral., Monatsh., 255–264. (4) Scordari, F., F. Stasi, and G. Milella (1982) Concerning metasideronatrite. Neues Jahrb. Mineral., Monatsh., 341–347. (5) Bandy, M.C. (1938) Mineralogy of three sulphate deposits in northern Chile. Amer. Mineral., 23, 669–760, esp. 733–734.

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Metastibnite Sb_2S_3

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Crystal Data: Amorphous to X-rays. *Point Group:* n.d. Primarily as stains, mammilary and powdery coatings, and impregnations of siliceous sinter.

Physical Properties: Hardness = 2–3 VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Translucent, transparent in thin fragments. *Color:* Red, reddish brown, purplish; in polished section, bluish white, with intense red internal reflections in oil. *Streak:* Red. *Luster:* Submetallic. *Anisotropism:* Moderate in air.
R: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Sb	71.50	71.58	71.69
Pb		1.82	
S	26.56	27.57	28.31
Total	98.06	100.98	100.00

(1) Copiapó, Chile; by electron microprobe, corresponds to $Sb_{2.07}S_{2.93}$. (2) Rujevac deposit, Serbia; by electron microprobe, corresponds to $(Sb_{2.02}Pb_{0.03})_{\Sigma=2.05}S_{2.95}$. (3) Sb_2S_3.

Polymorphism & Series: Dimorphous with stibnite.

Occurrence: Appears to be of primary hydrothermal origin around fumarolic centers (The Geysers, California; Steamboat Springs, Nevada, USA); and the result of oxidation of stibnite (Copiapó, Chile).

Association: Cinnabar (The Geysers, California, USA); stibnite (Copiapó, Chile; Rujevac deposit, Serbia).

Distribution: In the USA, from Steamboat Springs, Washoe Co., Nevada [TL] and at The Geysers, Sonoma Co., California. From Canada, in the Lac Nicolet mine, South Ham, Quebec. In northern Chile, at the Alacrán Ag–As–Sb mine, Pampa Larga district, Copiapó. In Bolivia, at the San José mine, Oruro. From the Rujevac Sb–Zn–Pb deposit, western Serbia. In the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia.

Name: From the Greek for *with*, plus *stibnite*, in allusion to its composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 79185.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 275. (2) Brookins, D.G. (1970) Metastibnite from The Geysers, Sonoma County, California. Amer. Mineral., 55, 2103–2104. (3) Clark, A.H. (1970) Supergene metastibnite from Mina Alacrán, Pampa Larga, Copiapó, Chile. Amer. Mineral., 55, 2104–2106. (4) Mozgova, N.N., Y.S. Borodaev, A.I. Tsepin, and S. Jankovič (1977) New data on metastibnite. Doklady Acad. Nauk SSSR, 237, 937–940 (in Russian).

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Metastudtite $UO_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Fibrous, or as elongated tablets, to 3 mm; in nodules.

Physical Properties: *Tenacity:* Flexible. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.67 Radioactive.

Optical Properties: Semitransparent. *Color:* Pale yellow. *Streak:* Yellowish white. *Luster:* Silky.
Optical Class: Biaxial (+). *Orientation:* $Z = c$. $\alpha = 1.640(2)$ $\beta = 1.658(2)$ $\gamma = 1.760(2)$ 2V(meas.) = n.d. 2V(calc.) = 47.7°

Cell Data: *Space Group:* *Immm* (probable). $a = 6.51(1)$ $b = 8.78(2)$ $c = 4.21(1)$ Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
5.22 (100), 3.538 (80), 4.38 (50), 3.79 (50), 3.214 (50b), 2.756 (30), 2.669 (20)

Chemistry:

	(1)	(2)
UO_4	88.1	89.34
H_2O	∼10.	10.66
Total		100.00

(1) Shinkolobwe, Congo; by electron microprobe, H_2O by TGA, considered very approximate.
(2) $UO_4 \cdot 2H_2O$.

Occurrence: Extremely rare, on museum specimens of dolomite and uraninite, from the oxidized zone of a uranium deposit.

Association: Uraninite, uranophane, soddyite, uranopilite, fourmarierite, wölsendorfite, rutherfordine, becquerelite, masuyite, kasolite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: As a dehydration product of *studtite*.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM13748 and RGM13755.

References: (1) Deliens, M. and P. Piret (1983) Metastudtite, $UO_4 \cdot 2H_2O$, a new mineral from Shinkolobwe, Shaba, Zaire. Amer. Mineral., 68, 456–458. (2) Walenta, K. (1974) On studtite and its composition. Amer. Mineral., 59, 166–171.

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Metaswitzerite $Mn_3^{2+}(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular to bladed bent crystals, pseudomorphous after switzerite, to 5 mm.

Physical Properties: *Cleavage:* Perfect on {100}; fair on {010}. Hardness = ~2.5 D(meas.) = n.d. D(calc.) = 3.18 Topotactically transforms from switzerite.

Optical Properties: Translucent. *Color:* Pale golden brown. *Luster:* Adamantine to pearly. *Optical Class:* Biaxial (–). *Pleochroism:* Pale to dark red-brown. *Dispersion:* $r < v$, distinct. $\alpha = 1.602$ $\beta = 1.628$ $\gamma = 1.632$ 2V(meas.) = 42°

Cell Data: *Space Group:* $P2/a$. $a = 17.099$ $b = 12.694$ $c = 8.282$ $\beta = 95.91°$ Z = 8

X-ray Powder Pattern: Kings Mountain, North Carolina, USA.
8.55 (100), 2.585 (60), 7.128 (40), 6.775 (40), 3.175 (40), 2.934 (40), 2.842 (40)

Chemistry:

	(1)	(2)
P_2O_5	32.94	33.26
Al_2O_3	0.27	
SiO_2	0.06	
FeO	3.60	
MnO	46.05	49.86
MgO	0.15	
CaO	0.20	
H_2O	n.d.	16.88
Total	83.27	100.00

(1) Kings Mountain, North Carolina, USA; partial analysis by electron microprobe, average of six analyses, converted to metaswitzerite in the electron beam. (2) $Mn_3(PO_4)_2 \cdot 4H_2O$.

Occurrence: Forms by irreversible dehydration of switzerite on exposure to air.

Association: Switzerite, vivianite.

Distribution: From the Foote Mine, Kings Mountain, Cleveland Co., North Carolina, USA. On Reaphook Hill, near Blinman, from the Spring Creek mine, near Wilmington, Flinders Ranges, and in the Iron Monarch quarry, Iron Knob, South Australia.

Name: Emphasizes the close chemical and structural relations to *switzerite*.

Type Material: The Natural History Museum, London, England, 1967,407; National Museum of Natural History, Washington, D.C., USA, 120230.

References: (1) White, J.S., Jr., P.B. Leavens, and P.F. Zanazzi (1986) Switzerite redefined as $Mn_3(PO_4)_2 \cdot 7H_2O$, and metaswitzerite, $Mn_3(PO_4)_2 \cdot 4H_2O$. Amer. Mineral., 71, 1221–1223. (2) Zanazzi, P.F., P.B. Leavens, and J.S. White, Jr. (1986) Crystal structure of switzerite, $Mn_3(PO_4)_2 \cdot 7H_2O$, and its relationship to metaswitzerite, $Mn_3(PO_4)_2 \cdot 4H_2O$. Amer. Mineral., 71, 1224–1228. (3) Leavens, P.B. and J.S. White, Jr. (1967) Switzerite [metaswitzerite] $(Mn, Fe)_3(PO_4)2 \cdot 4H_2O$, a new mineral. Amer. Mineral., 52, 1595–1602.

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Metatorbernite $Cu(UO_2)_2(PO_4)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$ (with $4/m$ $2/m$ $2/m$ pseudosymmetry). Typically pseudomorphous after torbernite, as square tabular crystals, flattened on {001} and modified by {011}, in lamellar or subparallel to sheaflike aggregates, and as rosettes, to 2 cm.

Physical Properties: *Cleavage:* Perfect on {001}; indistinct on {010}. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 3.52–3.70 D(calc.) = 3.70–3.71 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Pale green to dark green.
Luster: Vitreous, subadamantine, pearly on {001}.
Optical Class: Uniaxial (+) or uniaxial (–); anomalously biaxial in sectors. *Pleochroism:* Weak; O = green; E = pale green to blue. *Dispersion:* $r > v$, extreme. *Absorption:* $O > E$.
ω = 1.618–1.631 ϵ = 1.622–1.628

Cell Data: *Space Group:* $P4/n$. $a = 6.969$–6.972 $c = 17.277$–17.306 Z = 2

X-ray Powder Pattern: Schneeberg, Germany.
8.71 (100), 3.678 (100), 3.480 (80), 3.232 (80), 5.44 (75), 4.93 (75), 2.931 (70)

Chemistry:

	(1)	(2)
UO_3	59.67	61.01
P_2O_5	14.00	15.14
SiO_2	0.40	
CuO	8.50	8.48
H_2O	15.00	15.37
Total	97.57	100.00

(1) Gunnislake mine, England. (2) $Cu(UO_2)_2(PO_4)_2 \cdot 8H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: Typically a secondary mineral, a dehydration product of torbernite formed during weathering; formed directly above 75 °C.

Association: Torbernite, meta-autunite.

Distribution: Widespread; probably occurs at all localities for torbernite (q.v.). First described from Schneeberg, Saxony, Germany. Material from the Gunnislake mine, Calstock, Cornwall, England, is thought to be primary.

Name: The prefix *meta* indicates the dehydration product of *torbernite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 991–992. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 208–211. (3) Ross, M., H.T. Evans, Jr., and D.E. Appleman (1964) Studies of the torbernite minerals (II): the crystal structure of meta-torbernite. Amer. Mineral., 49, 1603–1621. (4) Stergiou, A.C., P.J. Rentzeperis, and S. Sklavounos (1993) Refinement of the crystal structure of metatorbernite. Zeits. Krist., 205, 1–7.

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Metatyuyamunite $Ca(UO_2)_2(V_2O_8)\cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As bladed crystals, elongated along [010], to 3 mm; typically pulverulent, massive; always pseudomorphous after tyuyamunite.

Physical Properties: *Cleavage:* Perfect on {001}; indistinct on {010} and {100}. Hardness = ∼2 D(meas.) = 3.81–3.93 D(calc.) = 3.85 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Canary-yellow to greenish yellow, darkening on exposure to air; colorless to pale yellow in transmitted light. *Luster:* Adamantine, waxy if massive.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = colorless; Y = very pale canary-yellow; Z = pale canary-yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, weak.
α = [1.62–1.68] β = 1.835–1.842 γ = 1.865–1.899 2V(meas.) = 44°–48°

Cell Data: *Space Group: Pnam.* $a = 10.63$ $b = 8.36$ $c = 16.96$ Z = 4

X-ray Powder Pattern: Small Spot mine, Colorado, USA.
8.51 (vs), 4.22 (s), 3.26 (mb), 3.05 (mb), 5.22 (w), 3.77 (w), 2.58 (w)

Chemistry:

	(1)	(2)
UO_3	66.80	66.21
V_2O_5	18.27	21.05
V_2O_4	2.25	
CaO	6.22	6.49
H_2O	6.57	6.25
Total	100.11	100.00

(1) Small Spot mine, Colorado, USA. (2) $Ca(UO_2)_2(V_2O_8)\cdot 3H_2O$.

Occurrence: A common dehydration product of tyuyamunite in Colorado Plateau-type U–V deposits.

Association: Tyuyamunite, carnotite, volborthite, vésigniéite, autunite, malachite, gypsum.

Distribution: Occurs at all localities for tyuyamunite (q.v.). First fully characterized from the Jo Dandy mine, Montrose Co., and the Small Spot and May Day mines, Calamity Mesa, Mesa Co., Colorado, USA.

Name: The prefix *meta* indicates the dehydration product of *tyuyamunite*.

Type Material: n.d.

References: (1) Weeks, A.D. and M.E. Thompson (1954) Identification and occurrence of uranium and vanadium minerals from the Colorado Plateaus. U.S. Geol. Surv. Bull. 1009-B, 37–38. (2) (1954) Amer. Mineral., 39, 1037 (abs. ref. 1). (3) Stern, T.W., L.R. Stieff, M.N. Girhard, and R. Meyrowitz (1956) The occurrence and properties of metatyuyamunite, $Ca(UO_2)_2(VO_4)_2\cdot 3{-}5H_2O$. Amer. Mineral., 41, 187–201. (4) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 254–257.

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Metauranocircite $Ba(UO_2)_2(PO_4)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As rectangular tabular crystals flattened on {001}, and modified by {100} and {101}, to 2 cm; in subparallel growths and fanlike aggregates. *Twinning:* Lamellar twinning ∥ {100} and {010} observed optically.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {010}. *Tenacity:* Thin plates are flexible. Hardness = 2–2.5 D(meas.) = 3.94 D(calc.) = 3.95 Radioactive. Fluorescent green under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Yellow, yellow-green. *Luster:* Waxy, pearly on {001}.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = pale canary yellow.
Orientation: $X = c$. *Dispersion:* $r > v$. $\alpha = 1.610$ $\beta = 1.621$–1.623 $\gamma = 1.622$–1.623
2V(meas.) = 0°–45°

Cell Data: *Space Group:* $P4_2/n$. $a = 6.9526(5)$ $c = 17.6342(9)$ Z = 2

X-ray Powder Pattern: Streuberg, Bergen, Germany. (ICDD 36-407).
8.82 (100), 4.410 (55), 3.723 (50), 2.708 (20), 2.205 (18), 1.4621 (18), 5.46 (15)

Chemistry:

	(1)	(2)
UO_3	56.86	56.56
P_2O_5	15.06	14.03
BaO	14.57	15.16
H_2O	13.99	14.25
Total	100.48	100.00

(1) The Falkenstein, Germany. (2) $Ba(UO_2)_2(PO_4)_2 \cdot 8H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: Typically a secondary mineral in the oxidized zone of some uranium deposits; may be primary in low-temperature veins.

Association: Autunite, torbernite.

Distribution: In Germany, from Bergen, near the Falkenstein, Vogtland, and from Schwarzenberg and Aue, Saxony; at Wölsendorf, Bavaria; and from Menzenschwand, Black Forest. A uranium ore at Cayrou, Entraygues, Aveyron, France. From Vinaninkarena, near Antsirabe, Madagascar. At the Mounana mine, Franceville, Gabon. In the USA, in the Honeycomb Hills, Juab Co., Utah; the Wind River Basin, Fremont Co., Wyoming; and from Annie Creek, Lawrence Co., South Dakota; found near Cameron, Coconino Co., Arizona.

Name: The prefix *meta* indicates the dehydration product of *"uranocircite"*, named for its content of *uranium*, and from the Greek for *falcon*, for its occurrence at the Falkenstein, Germany.

Type Material: State Museum for Mineralogy and Geology, Dresden; Mining Academy, Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 987–988 [uranocircite = metauranocircite]. (2) Nuffield, E.W. and I.H. Milne (1953) Studies of radioactive compounds: VI – metauranocircite. Amer. Mineral., 38, 476–488. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 211–215. (4) Walenta, K. (1963) Über die Barium-Uranylphosphatmineralien Uranocircit I, Uranocircite II, Meta-uranocircit I und Meta-Uranocircite II von Menzenschwand im südlichen Schwarzwald. Jahresheft geol. Landesamt Baden-Württemberg, 6, 113–135 (in German).

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Meta-uranopilite $(UO_2)_6(SO_4)(OH)_{10}\cdot 5H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Needlelike to lathlike crystals.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Radioactive; fluoresces yellowish green under UV.

Optical Properties: Semitransparent. *Color:* Grayish yellow with a brownish tint. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.72$ $\beta = 1.76$ $\gamma = 1.76$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SO_3	4.17	4.05
UO_3	82.40	86.83
Fe_2O_3	2.03	
H_2O	9.40	9.12
Total	98.00	100.00

(1) Jáchymov, Czech Republic; Fe_2O_3 probably "limonite". (2) $(UO_2)_6(SO_4)(OH)_{10}\cdot 5H_2O$.

Occurrence: On a museum specimen from a uranium-bearing hydrothermal ore deposit [may = jáchymovite].

Association: Uranopilite.

Distribution: From Jáchymov (Joachimsthal), Czech Republic.

Name: From the Greek *meta*, for a lower hydrate, and its relation to *uranopilite*.

Type Material: National Museum, Prague, Czech Republic, listed but cannot be located.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 582–583. (2) Frondel, C. (1952) Studies of uranium minerals (X): uranopilite. Amer. Mineral., 37, 950–959. (3) Ondruš, P., F. Veselovský, J. Hloušek, R. Skála, I. Vavřín, J. Frýda, J. Čejka, and A. Gabašová (1997) Secondary minerals of the Jáchymov (Joachimsthal) ore district. J. Czech Geol. Soc., 42(4), 3–76, esp. 35–36.

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Metauranospinite $Ca(UO_2)_2(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. As small tabular crystals with square to rectangular outline.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2–3. D(meas.) = n.d. D(calc.) = 3.65 Radioactive.

Optical Properties: Translucent. *Color:* Yellow. *Luster:* Pearly on {010}. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = colorless; Z = pale yellow. α = n.d. β = n.d. $\gamma = 1.618$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 7.14$ $c = 17.00$ Z = 2

X-ray Powder Pattern: Clara mine, Germany.
8.65 (10), 3.57 (10), 3.31 (9), 5.53 (8), 3.00 (5), 5.08 (4), 4.36 (4b)

Chemistry: (1) Identity established by microchemical analysis yielding only Ca, U, As, and coincidence with the X-ray pattern of synthetic material.

Mineral Group: Meta-autunite group.

Occurrence: A secondary mineral of the oxide zone in a hydrothermal polymetallic barite–fluorite deposit.

Association: n.d.

Distribution: From the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: The prefix *meta* indicates the dehydration product of *uranospinite*.

Type Material: n.d.

References: (1) Walenta, K. (1958) Die sekundaren Uranmineralien des Schwarzwaldes. Jahresheft geol. Landesamt Baden-Württemberg, 3, 17–51, esp. 30–31 (in German). (2) (1960) Amer. Mineral., 45, 254 (abs. ref. 1). (3) Mrose, M.E. (1953) Studies of uranium minerals (XIII): synthetic uranospinites [metauranospinite]. Amer. Mineral., 38, 1159–1168. (4) Walenta, K (1965) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 2. Folge. Tschermaks Mineral. Petrog. Mitt., 9, 252–282, esp. 253–262 (in German).

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Metavandendriesscheite $PbU_7O_{22}\cdot nH_2O$ (n < 12)

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Crystal Data: Orthorhombic. *Point Group:* [$2/m$ $2/m$ $2/m$ or $mm2$] (by analogy to vandendriesscheite). A very fine-grained alteration product, intergrown in parallel and threaded with minute tubes, within vandendriesscheite crystals.

Physical Properties: Hardness = n.d. D(meas.) = 5.45 D(calc.) = [5.71–5.79] Alters from vandendriesscheite by dehydration.

Optical Properties: Transparent. *Color:* [Amber-yellow, yellowish orange to orange] (by analogy to vandendriesscheite).
Optical Class: Biaxial (–) (optics given here are for vandendriesscheite). *Pleochroism:* X = nearly colorless; $Y = Z$ = yellow-orange to golden yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong. $\alpha = 1.780(5)$ $\beta = 1.850(10)$ $\gamma = 1.860(10)$ 2V(meas.) = 60(2)°

Cell Data: *Space Group:* [$Pmma$, $P2_1ma$, or $Pm2a$] (by analogy to vandendriesscheite).
$a = 14.07(30)$ $b = 41.31(30)$ $c = 43.33(30)$ Z = [35]

X-ray Powder Pattern: Shinkolobwe, Congo; pattern here identical to vandendriesscheite with which it is inextricably intergrown.
7.24 (100), 3.61 (100), 3.17 (75), 1.985 (40), 3.53 (25b), 2.522 (25), 2.034 (15)

Chemistry: An analysis of pure metavandendriesscheite has not been made; its hydration is variable, less than vandendriesscheite, from which it alters by dehydration.

Occurrence: In the oxidized zone of a uranium-bearing mineral deposit.

Association: Vandendriesscheite, fourmarierite, becquerelite, metatorbernite, rutherfordine, uraninite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). Presumably other vandendriesscheite localites are likewise localities for metavandendriesscheite.

Name: As a dehydration product of *vandendriesscheite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 106523.

References: (1) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates [vandendriesscheite-II]. Amer. Mineral., 45, 1026–1061.

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Metavanmeersscheite $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tabular crystals, flattened on {010} and elongated along [001], modified by {101}, {$\bar{1}$01}, {100}, to 0.4 mm; usually in divergent groups.

Physical Properties: *Cleavage:* Good on {010}; fair on {100}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.49 Fluoresces bright green in SW and LW UV. Radioactive.

Optical Properties: Semitransparent. *Color:* Canary-yellow. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; yellow to pale yellow. $\alpha = \sim 1.67$ $\beta = \sim 1.68$ $\gamma = \sim 1.69$ 2V(meas.) = $\sim 83°$

Cell Data: *Space Group: Fddd.* $a = 34.18$ $b = 33.88$ $c = 14.074$ Z = 32

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
8.49 (100), 6.01 (90), 3.073 (70), 2.886 (60), 5.38 (50), 4.23 (50), 3.516 (50)

Chemistry:

	(1)	(2)
UO_3	83.24	83.14
P_2O_5	10.20	10.31
H_2O	[6.56]	6.55
Total	[100.00]	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, average of five analyses, H_2O by difference; corresponds to $U(UO_2)_{3.01}(PO_4)_{1.98}(OH)_6 \cdot 2.02H_2O$. (2) $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 2H_2O$.

Occurrence: A rare secondary mineral in the uraniferous zone of an altered granite pegmatite, formed by dehydration of vanmeersscheite.

Association: Vanmeersscheite, studtite.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: The prefix *meta* indicates the dehydration product of *vanmeersscheite*.

Type Material: University of Liège, Liège, F360; Royal Museum of Central Africa, Tervuren, Belgium, RMG13749.

References: (1) Piret, P. and M. Deliens (1982) La vanmeersscheite $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 4H_2O$, et la méta-vanmeersscheite $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 2H_2O$, nouveaux minéraux. Bull. Minéral., 105, 125–128 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 1077 (abs. ref. 1).

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Metavanuralite $Al(UO_2)_2(V_2O_8)(OH)\cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As multiply terminated prismatic crystals, dominated by {001} and {100}, pseudomorphous after vanuralite. *Twinning:* On {001}.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Radioactive.

Optical Properties: Semitransparent. *Color:* Yellow to greenish yellow. *Optical Class:* Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.46(3)$ $b = 8.44(3)$ $c = 10.43(3)$ $\alpha = 75°53(20)'$ $\beta = 102°50(20)'$ $\gamma = 90°0(20)'$ Z = 2

X-ray Powder Pattern: Mounana mine, Gabon.
9.92 (FFF), 4.174 (FF), 3.153 (FF), 4.086 (F), 3.240 (F), 3.073 (F), 5.10 (mF)

Chemistry:

	(1)	(2)
UO_3	59.63	59.71
V_2O_5	18.61	18.99
Al_2O_3	5.30	5.32
H_2O	16.20	15.98
Total	99.74	100.00

(1) Mounana mine, Gabon; by colorimetric analysis, H_2O by the Penfield method.
(2) $Al(UO_2)_2(V_2O_8)(OH)\cdot 8H_2O$.

Occurrence: In the oxidized zone of a lead-bearing U–V deposit, formed as a reversible dehydration product of vanuralite.

Association: Vanuralite.

Distribution: From the Mounana uranium mine, Franceville, Gabon.

Name: The prefix *meta* indicates the dehydration product of *vanuralite*.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 165404, R16486.

References: (1) Cesbron, F. (1970) Nouvelles données sur la vanuralite. Existence de la méta-vanuralite. Bull. Minéral., 93, 242–248 (in French with English abs.). (2) (1971) Amer. Mineral., 56, 637 (abs. ref. 1).

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Metavariscite $AlPO_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As pseudo-orthorhombic crystals, composed principally of {010}, {011}, {130}, {110}; tabular on {010} and either equant or bladed by elongation along [100] or [001]; in spheroidal aggregates, granular. *Twinning:* By contact on {102}.

Physical Properties: *Cleavage:* On {010}. Hardness = 3.5 D(meas.) = 2.51–2.54 D(calc.) = 2.535

Optical Properties: Transparent to translucent. *Color:* Pale green; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = colorless; $Y = Z$ = light green.
Orientation: $Y = b$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.551$ $\beta = 1.558$ $\gamma = 1.582$
2V(meas.) = 55°

Cell Data: *Space Group:* $P2_1/n$. $a = 5.178(2)$ $b = 9.514(2)$ $c = 8.454(2)$ $\beta = 90.35(2)°$
Z = 4

X-ray Powder Pattern: Lucin, Utah, USA. (ICDD 33-32).
4.758 (100), 2.705 (95), 4.552 (75), 4.227 (65), 3.503 (60), 6.325 (25), 2.290 (20)

Chemistry:

	(1)	(2)
P_2O_5	44.73	44.92
V_2O_3	0.32	
Al_2O_3	32.40	32.27
Fe_2O_3	0.06	
Cr_2O_3	0.18	
H_2O	22.68	22.81
Total	100.37	100.00

(1) Utahlite Hill, Utah, USA. (2) $AlPO_4 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with variscite.

Occurrence: Commonly a product of weathering phosphatic rocks; may form as concretions by the phosphatization of kaolin during weathering; probably a reaction product of phosphate fertilizer in acid soil.

Association: Variscite.

Distribution: In the USA, from the Edison-Bird mine, on Utahlite Hill, eight km northwest of Lucin, Box Elder Co., Utah; at Candelaria, Mineral Co., and the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada; from Twin Creek, Island Park, Fremont Co., Idaho; at the Mauldin Mountain quarry, near Mt. Ida, Montgomery Co., Arkansas. On Malpelo Island, west of Buenaventura, Colombia. From the Gunheath china clay pit, five km north-northwest of St. Austell, Cornwall, England. At Palazuelo de las Arribas, Zamora, Spain.

Name: For the dimorphous relation with *variscite*.

Type Material: The Natural History Museum, London, England, 1912,618; National Museum of Natural History, Washington, D.C., USA, 87484, 87485, 87495, 86933.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 767–769. (2) Kniep, R. and D. Mootz (1973) Metavariscite - a redetermination of its crystal structure. Acta Cryst., 29, 2292–2294.

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Metavauxite $Fe^{2+}Al_2(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic to acicular crystals, elongated along [001], showing {100}, {110}, {$\bar{1}$01}, {$\bar{1}$11}, {$\bar{2}$11}, to 2 cm; commonly in radiating aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.345 D(calc.) = [2.36]

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale green; colorless in thin section. *Luster:* Vitreous to silky in aggregates.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c \simeq -17°$. $\alpha = 1.550(1)$ $\beta = 1.561(1)$ $\gamma = 1.577(1)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/c$. $a = 10.22$ $b = 9.56$ $c = 6.94$ $\beta = 97.9°$ Z = 2

X-ray Powder Pattern: Llallagua, Bolivia.
4.687 (100), 4.337 (79), 2.764 (75), 10.12 (69), 3.985 (54), 5.095 (50), 2.749 (32)

Chemistry:

	(1)	(2)
P_2O_5	29.55	29.70
SiO_2	0.05	
Al_2O_3	21.01	21.34
Fe_2O_3	0.35	
FeO	14.57	15.03
MgO	0.55	
CaO	0.27	
H_2O^+	14.00	
H_2O^-	19.22	
H_2O		33.93
Total	99.57	100.00

(1) Llallagua, Bolivia. (2) $FeAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$.

Polymorphism & Series: Dimorphous with paravauxite.

Occurrence: An uncommon secondary mineral in the oxidized zone of tin mines.

Association: Vauxite, paravauxite, wavellite, quartz.

Distribution: From Llallagua and Tazna, Potosí, Bolivia.

Name: In allusion to the chemical relation to *vauxite*.

Type Material: The Natural History Museum, London, England, 1928,335; National Museum of Natural History, Washington, D.C., USA, 136009.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 971–972. (2) Baur, W.H. and B. Rama Rao (1967) The crystal structure of metavauxite. Naturwiss., 51, 561. (3) Blanchard, F.N. and S.A. Abernathy (1980) X-ray powder diffraction data for phosphate minerals: vauxite, metavauxite, vivianite, Mn-heterosite, scorzalite, and lazulite. Florida Scientist, 43, 257–265.

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Metavivianite $\mathbf{Fe^{2+}_{3-x}Fe^{3+}_{x}(PO_4)_2(OH)_x \cdot (8-x)H_2O}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As prismatic crystals, may be flattened, dominated by {110}, striated ‖ [001], to 9 cm; typically pseudomorphous after vivianite crystals. *Twinning:* Polysynthetic twinning on {110} on a microscopic scale.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.69

Optical Properties: Transparent to opaque. *Color:* Leek-green, khaki-green, brown. *Optical Class:* Biaxial (+). *Pleochroism:* X = light blue to blue-green; Y = yellow-green to light green; Z = yellow to light green. *Orientation:* $X \perp$ {110}; YZ plane ‖ {110}. *Absorption:* $X > Z > Y$. $\alpha = 1.579(6)$ $\beta = 1.603(2)$ $\gamma = 1.629(2)$ 2V(meas.) = 85(5)°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 7.81(2)$ $b = 9.08(2)$ $c = 4.65(1)$ $\alpha = 94.77(10)°$ $\beta = 97.15(10)°$ $\gamma = 107.37(10)°$ Z = 1

X-ray Powder Pattern: Big Chief mine, South Dakota, USA.
6.71 (100), 8.59 (40), 4.86 (40), 3.87 (30), 2.77 (30), 2.90 (20), 4.27 (10)

Chemistry:

	(1)	(2)
P_2O_5	28.4	28.4
Fe_2O_3		13.55
FeO	38.9	23.85
MnO	4.2	4.2
NiO	0.13	0.13
CaO	0.5	0.5
H_2O	[28.7]	
Total	[100.8]	

(1) Big Chief mine, South Dakota, USA; by electron microprobe, total Fe as FeO, H_2O from ideal formula with $8H_2O$. (2) Do.; analysis (1) with Fe^{2+}:Fe^{3+} = 1.14:1.86 from Mössbauer spectroscopy.

Occurrence: A secondary mineral typically formed from oxidizing vivianite, in complex granite pegmatites; authigenic, in bogs and soils.

Association: Kryzhanovskite, triphylite (Big Chief mine, South Dakota, USA); vivianite (many authigenic occurrences).

Distribution: Likely more widespread than reported here. Confirmed localities include: in the USA, from the Big Chief mine, one km south of Glendale, Pennington Co., South Dakota; Carroll, Carroll Co., Virginia. Large crystals from the Big Fish River area, Yukon Territory, Canada. From several localities in New Zealand, as at Hunua. Along the Wannon River, Victoria, Australia. At Wheal Jane, Truro, Cornwall, England. In the Norrö pegmatite, on Rånö Island, Sweden. From the Kamysh-Burun iron deposit, near Kerch, Crimean Peninsula, Ukraine.

Name: The prefix *meta* indicates the dehydration product of *vivianite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 127100.

References: (1) Ritz, C., E.J. Essene, and D.R. Peacor (1974) Metavivianite, $Fe_3(PO_4)_2 \cdot 8H_2O$, a new mineral. Amer. Mineral., 59, 896–899. (2) Dormann, J.-L., M. Gaspérin, and J.-F. Poullen (1980) Étude structurale de la séquence d'oxydation de la vivianite $Fe_3(PO_4)_2 \cdot 8H_2O$. Bull. Minéral., 105, 147–160 (in French with English abs.). (3) Sameshima, T., G.S. Henderson, P.M. Black, and K.A. Rodgers (1985) X-ray diffraction studies of vivianite, metavivianite, and baricite. Mineral. Mag., 49, 81–85. (4) Rodgers, K.A. and J.H. Johnston (1985) Type metavivianite: Mössbauer evidence for a revised composition. Neues Jahrb. Mineral., Monatsh., 539–542. (5) Rodgers, K.A. (1986) Metavivianite and kerchenite: a review. Mineral. Mag., 50, 687–691.

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Metavoltine $K_2Na_6Fe^{2+}Fe_6^{3+}O_2(SO_4)_{12}\cdot 18H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$ or 3. Crystals are thick hexagonal plates, to 1 mm, with large {0001}, {10$\bar{1}$0}, modified by a number of minor forms; commonly in granular to scaly aggregates and crusts.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 2.5 D(meas.) = 2.51; 2.396 (synthetic). D(calc.) = 2.435 Partly soluble in H_2O.

Optical Properties: Translucent. *Color:* Yellowish brown, orange-brown, greenish brown. *Luster:* Resinous.
Optical Class: Uniaxial (–). *Pleochroism:* O = dark brown, brown, dark yellow, dark yellow-orange; E = pale yellow, pale greenish yellow, very pale yellow. ω = 1.588–1.595 ϵ = 1.572–1.581

Cell Data: *Space Group:* $P\bar{3}$ or $P3$. $a = 9.575(5)$ $c = 18.17(1)$ Z = 1

X-ray Powder Pattern: Madeni Zakh, Iran.
9.12 (100), 3.300 (37), 2.002 (37), 18.28 (33), 2.899 (30), 3.087 (23), 2.375 (23)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	44.22	45.02	45.40	ZnO		0.23	
Fe_2O_3	22.55	22.45	22.64	Na_2O	8.89	8.75	8.79
FeO	2.83	2.22	3.40	K_2O	4.82	4.36	4.45
CuO		1.18		H_2O	17.23	15.30	15.32
				Total	100.54	99.51	100.00

(1) La Campania, Chile. (2) Sierra Gorda [district], Chile; corresponds to $K_{1.98}Na_{6.02}(Fe^{2+}_{0.66}Cu_{0.32}Zn_{0.06})_{\Sigma=1.04}Fe^{3+}_6O_{2.04}(SO_4)_{12}\cdot 18.12H_2O$. (3) $K_2Na_6Fe^{2+}Fe^{3+}_6O_2(SO_4)_{12}\cdot 18H_2O$.

Occurrence: Typically an alteration product of pyrite in arid climates; formed as a fumarolic sublimate and solfataric precipitate; may be a post-mining product.

Association: Voltaite, botryogen, ferrinatrite, coquimbite, copiapite, sideronatrite, metasideronatrite, jarosite, alunogen, pickeringite, sulfur, gypsum.

Distribution: From near Madeni Zakh, Iran. In Italy, on Vesuvius, at the Grotta dello Zolfo, Miseno, and from Solfatara di Pozzuoli, Campi Flegrei, near Naples, Campania; in the Cetine mine, 20 km southwest of Siena, Tuscany; from the Grotto de Faraglione, Port di Levante, Vulcano, Lipari Islands. At volcanoes on the Kamchatka Peninsula, Russia. In England, from Wheal Edward, St. Just, Cornwall, and in the Brigham quarries, Cockermouth, Cumbria. On Tristan da Cunha Island, South Atlantic Ocean. From Hainaut, Belgium. At Cervenica-Dubnik, Slovakia. From Jáchymov (Joachimsthal), Czech Republic. In the USA, in the Sulfur Hole prospect, near Borate, about 10 km northeast of Yermo, Calico Hills, San Bernardino Co., California; at Steamboat Hot Springs, Washoe Co., Nevada; from Bisbee, Cochise Co., Arizona. In Chile, in Antofagasta, at Quetena, west of Calama; Alcaparrosa, near Cerritos Bayos, and Sierra Gorda, both southwest of Calama, and at Chuquicamata. In Argentina, from the Santa Bárbara sulfur mine, El Palmar district, Jujuy Province, and in the Capillitas mine, Catamarca Province.

Name: From the Greek for *with* and *voltaite*, as originally associated with that species.

Type Material: Institute of Mineralogy and Crystallography, University of Vienna, Vienna, Austria; Natural History Museum, Paris, France, 100.154.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 619–621. (2) Scordari, F., F. Vurro, and S. Menchetti (1975) The metavoltine problem: relationships between metavoltine and Maus' salt. Tschermaks Mineral. Petrog. Mitt., 22, 88–97. (3) Scordari, F. (1977) The metavoltine problem: metavoltine from Madeni Zakh and Chuquicamata, and a related artificial compound. Mineral. Mag., 41, 371–374. (4) Giacovazzo, G., F. Scordari, A. Todisco, and S. Menchetti (1976) Crystal structure model for metavoltine from Sierra Gorda. Tschermaks Mineral. Petrog. Mitt., 23, 155–166. (5) Comunale, G., F. Scordari, P. Bonazzi, and S. Menchetti (1994) Metavoltine from Vesuvius: crystal structure and crystal chemistry. General Meeting of the Int. Mineral. Assoc., 16, 80–81 (abs.).

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Metazellerite $Ca(UO_2)(CO_3)_2 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ or $2/m\ 2/m\ 2/m$. A topotactic replacement of fibrous zellerite.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.414 Radioactive.

Optical Properties: Translucent. *Color:* Pale yellow. *Luster:* Chalky.
Optical Class: Biaxial (–). *Orientation:* $Z = c$. $n = 1.626$ α = n.d. β = n.d. γ = n.d.
2V(meas.) = n.d.

Cell Data: *Space Group:* $Pbn2_1$ or $Pbnm$. $a = 9.718(5)$ $b = 18.226(9)$ $c = 4.965(4)$
Z = 4

X-ray Powder Pattern: Lucky Mc mine, Wyoming, USA.
9.10 (100), 3.794 (50), 4.695 (36), 4.296 (36), 4.552 (18), 4.412 (18), 3.978 (18)

Chemistry: (1) No analysis could be performed; crystal chemical considerations indicate dehydration from $5H_2O$ in zellerite to $3H_2O$ in metazellerite.

Occurrence: A dehydration product of zellerite.

Association: Zellerite, gypsum, "limonite", iron sulfides, schoepite, meta-autunite, uranophane, voglite, "opal".

Distribution: In the USA, from the Lucky Mc mine, Wind River Basin, Fremont Co., Wyoming; in the White Canyon # 1 mine, Frey Point, San Juan Co., Colorado. At Jáchymov (Joachimsthal), Czech Republic. Other zellerite localities must also have this species.

Name: From the Greek *meta*, for a lower hydrate of *zellerite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 112827.

References: (1) Coleman, R.G., D.R. Ross, and R. Meyrowitz (1966) Zellerite and metazellerite, new uranyl carbonates. Amer. Mineral., 51, 1567–1578.

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Metazeunerite $Cu(UO_2)_2(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$ (with $4/m$ $2/m$ $2/m$ pseudosymmetry). As rectangular crystals, tabular on {001}, with {010}, to 3.5 cm, or dipyramidal, terminated by {001}; generally as foliated or micaceous aggregates.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 3.64 D(calc.) = [3.87] Fluoresces pale yellow-green under LW and SW UV. Radioactive.

Optical Properties: Transparent to translucent. *Color:* Grass-green to emerald-green. *Luster:* Vitreous, pearly on {001}.
Optical Class: Uniaxial (–). *Pleochroism:* O = green; E = pale green, bluish, colorless.
$\omega = 1.643–1.651$ $\epsilon = 1.623–1.635$

Cell Data: *Space Group:* $P4_2/n$. $a = 7.10$ $c = 17.42$ $Z = 2$

X-ray Powder Pattern: Anton mine, Germany.
8.86 (10), 3.73 (10), 5.57 (8), 3.30 (8), 3.57 (7), 5.10 (6), 1.561 (6)

Chemistry:

	(1)	(2)
UO_3	55.86	55.78
As_2O_5	20.94	22.41
CuO	7.49	7.76
H_2O	15.68	14.05
Total	99.97	100.00

(1) Schneeberg, Germany. (2) $Cu(UO_2)_2(AsO_4)_2 \cdot 8H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: An uncommon secondary mineral in the oxidized zone of arsenic-bearing hydrothermal uranium deposits.

Association: Torbernite, trögerite, walpurgite, uranospinite, erythrite, mimetite, pharmacosiderite, olivenite, chalcophyllite.

Distribution: Many minor localities, but few for good specimens. Well-studied material from: in Germany, at the Weisser Hirsch mine, Neustädtel-Schneeberg, Saxony; in the Anton mine, Heubachtal, near Schiltach, Black Forest. From Wheal Gorland, Gwennap, and at Wheals Owles and Edward and the Geevor mine, St. Just, Cornwall, England. From the Cap Garonne mine, near le Pradet, Var, France. In the USA, in the Centennial Eureka mine, Tintic district, Juab Co., Utah; from the Majuba Hill mine, Antelope district, Pershing Co., Nevada; large crystals at the Grandview mine, Grand Canyon, Coconino Co., Arizona. From Talmessi, Anarak, Iran. In the Bali Lo copper prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia; at the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia; and in the South Alligator Valley, Northern Territory, Australia. Large thick crystals from the Pedra Preta mine, Brumado, Bahia, Brazil.

Name: The prefix *meta* indicates the dehydration product of *zeunerite*.

Type Material: State Museum of Mineralogy and Geology, Dresden; Mining Academy, Freiberg, Germany, 21730.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 993–994. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 215–220. (3) Walenta, K. (1964) Beiträge zur Kenntnis seltener Arsenatmineralien unter besonderer Berücksichtigung von Vorkommen des Schwarzwaldes. 2. Folge. Tschermaks Mineral. Petrog. Mitt., 9, 111–174, esp. 115–135 (in German). (4) Ross, M., H.T. Evans, Jr., and D.E. Appleman (1964) Studies of the torbernite minerals (II): the crystal structure of meta-torbernite. Amer. Mineral., 49, 1603–1621. (5) de Abeledo, M.E.J., E.E. Galloni, and M.A.R. de Benyacar (1968) Electron diffraction data for some members of the metatorbernite group. Amer. Mineral., 53, 1028–1033.

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Meurigite $KFe_7^{3+}(PO_4)_5(OH)_7 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As tabular {001} to fibrous crystals elongated along [010], typically in hemispheres and globular aggregates of radiating crystals, to 2 mm; as fibrous rosettes or drusy coatings.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ∼3 D(meas.) = 2.96 D(calc.) = 2.86

Optical Properties: Translucent. *Color:* Yellowish brown, cream to white, canary-yellow, pale yellow to pale orange. *Streak:* Very pale yellow to cream. *Luster:* Vitreous, waxy to silky. *Optical Class:* Biaxial (+). $\alpha = 1.780(5)$ $\beta = 1.785(5)$ $\gamma = 1.800(5)$ 2V(meas.) = n.d. 2V(calc.) = 60°

Cell Data: *Space Group:* $C2$, Cm, or $C2/m$. $a = 29.52(4)$ $b = 5.249(6)$ $c = 18.26(1)$ $\beta = 109.27(7)°$ Z = 4

X-ray Powder Pattern: Santa Rita mine, New Mexico, USA.
3.216 (100), 4.84 (90), 3.116 (80), 4.32 (70), 9.41 (60), 3.470 (60), 4.25 (50)

Chemistry:

	(1)	(2)
P_2O_5	30.71	30.38
As_2O_5	0.03	
CO_2	0.73	
Al_2O_3	0.70	
Fe_2O_3	47.40	47.85
CuO	0.16	
Na_2O	0.07	
K_2O	3.37	4.03
H_2O	16.2	17.74
Total	99.37	100.00

(1) Santa Rita mine, New Mexico, USA; by electron microprobe, average of five analyses, total Fe as Fe_2O_3, H_2O and CO_2 by CHN analyzer; corresponding to $(K_{0.85}Na_{0.03})_{\Sigma=0.88}(Fe_{7.01}Al_{0.16}Cu_{0.02})_{\Sigma=7.19}(PO_4)_{5.11}(CO_3)_{0.20}(OH)_{6.7} \cdot 7.25H_2O$. (2) $KFe_7(PO_4)_5(OH)_7 \cdot 8H_2O$.

Occurrence: A late-stage mineral, rare at all localities. Along fault gouge in the oxidized zone of a copper sulfide deposit (Santa Rita mine, New Mexico, USA); by alteration of triphylite in granite pegmatite (Hagendorf, Germany); in the oxidized zone of a low-temperature sediment-hosted Carlin-type hydrothermal gold deposit (Gold Quarry mine, Nevada, USA).

Association: Dufrénite, beraunite, leucophosphite, hematite (Santa Rita mine, New Mexico, USA); nontronite, rockbridgeite, apatite, vivianite, strengite, beraunite, robertsite-mitridatite, cyrilovite, laueite, stewartite (Hagendorf, Germany); fluellite, kingite, tinticite, leucophosphite, strengite/variscite, hewettite, tyuyamunite, torbernite (Gold Quarry mine, Nevada, USA); rockbridgeite, cyrilovite, leucophosphite (Wycheproof, Australia).

Distribution: In the USA, from the Santa Rita copper mine, Silver City, Grant Co., New Mexico; in the Gold Quarry mine, near Carlin, Maggie Creek district, and at the Goldstrike mine, Lynn district, Eureka Co., and from the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada. At Hagendorf and Waidhaus, Bavaria, and from Rengersdorf, Saxony, Germany. At Wycheproof, Victoria, Australia.

Name: Honors Professor John Meurig Thomas (1932–), crystal chemist, University of Cambridge, Cambridge, England.

Type Material: n.d.

References: (1) Birch, W.D., A. Pring, P.G. Self, R.B. Gibbs, E. Keck, M.C. Jensen, and E.E. Foord (1996) Meurigite, a new fibrous iron phosphate resembling kidwellite. Mineral. Mag., 60, 787–793. (2) (1997) Amer. Mineral., 82, 622 (abs. ref. 1).

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Meyerhofferite $CaB_3O_3(OH)_5 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Rare as complex acicular to crude crystals, to ~4 cm, in fibrous divergent, radiating aggregates, commonly reticulated; may be nodular.

Physical Properties: *Cleavage:* On {010}, perfect; in traces on {100} and {1$\overline{1}$0}. Hardness = 2 D(meas.) = 2.120 D(calc.) = 2.125

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale yellow. *Luster:* Vitreous to silky.
Optical Class: Biaxial (–). *Orientation:* X (165°,62°); Y (45°30′,47°); Z (-83°,55°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. *Dispersion:* $r > v$. $\alpha = 1.500$ $\beta = 1.535$ $\gamma = 1.560$ 2V(meas.) = 78°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.632(1)$ $b = 8.337(1)$ $c = 6.4748(6)$ $\alpha = 90.81(1)°$ $\beta = 101.97(1)°$ $\gamma = 86.76(1)°$ Z = 2

X-ray Powder Pattern: Mt. Blanco, California, USA. (ICDD 12-411).
8.31 (100), 6.47 (100), 4.97 (25), 4.15 (20), 3.15 (20), 3.07 (20), 2.501 (20)

Chemistry:

	(1)	(2)
B_2O_3	46.40	46.71
CaO	25.45	25.08
H_2O^+	27.75	
H_2O^-	1.01	
H_2O		28.21
Total	100.61	100.00

(1) Mt. Blanco, California, USA. (2) $CaB_3O_3(OH)_5 \cdot H_2O$.

Occurrence: Typically a minor component of sedimentary or lake-bed borate deposits.

Association: Inyoite, colemanite, hydroboracite, ulexite.

Distribution: In the USA, from the Mt. Blanco deposit and along Gower Gulch, Furnace Creek district, Death Valley, Inyo Co., and in the Kramer borate deposit, Boron, Kern Co., California. At Mesa del Almo, 13 km southeast of Magdalena, Sonora, Mexico. In Argentina, at the Anita mine, Sijes district, and in the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province. In Turkey, from many deposits in the Bigadiç borate district, Balıkesir Province; in the Killik and Espey borate mines, near Emet, Kütahya Province. At the Inder borate deposit, Kazakhstan.

Name: Honoring Professor Wilhelm Meyerhoffer (1864–1906), German chemist, who first synthesized the compound.

Type Material: Harvard University, Cambridge, Massachusetts, 134572; National Museum of Natural History, Washington, D.C., USA, 87237, 93640.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 356–358. (2) Burns, P.C. and F.C. Hawthorne (1993) Hydrogen bonding in meyerhofferite: an X-ray and structure energy study. Can. Mineral., 31, 305–312.

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Meymacite $WO_3 \cdot 2H_2O$

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Crystal Data: Amorphous, or nearly so. *Point Group:* n.d. Powdery.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = 3.94–4.10 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Yellow-brown. *Luster:* Resinous to vitreous. *Optical Class:* Isotropic. $n = > 2$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Nzombe, Congo.
3.81, diffuse.

Chemistry:

	(1)	(2)
WO_3	84.1	86.55
CaO	2.0	
$H_2O^{575^\circ}$	6.5	
$H_2O^{110^\circ}$	6.6	
H_2O		13.45
Total	99.2	100.00

(1) Nzombe, Congo. (2) $WO_3 \cdot 2H_2O$.

Occurrence: An alteration product in tungsten deposits.

Association: n.d.

Distribution: From Nzombe, Kivu Province, Congo (Zaire). At Meymac, Corrèze, France. In Italy, at Genna Gureu, near Orroli, Sardinia. From the Clara Mine, near Oberwolfach, Black Forest, Germany.

Name: Originally applied to a mineral from Meymac, France, an alteration product of scheelite, later found to be ferritungstite. The name was, however, reinstated by the IMA CNMMN for this mineral, first described from Congo (Zaire), but which also occurs at Meymac, France.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 606 [ferritungstite]. (2) van Tassel, R. (1961) Ferritungstite et meymacite de Meymac, France, et d'Afrique central. Bull. Soc. Royal Belge Geol., 70, 376–399 (in French with English abs.). (3) Pierrot, R. and R. van Tassel (1965) Nouvelle définition de la meymacite et nomenclature des "acides tungstiques" naturels. Bull. Soc. fr. Minéral., 88, 613–617 (in French).

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Mgriite Cu_3AsSe_3

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, presumably.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 287–379 (20 g load). D(meas.) = n.d. D(calc.) = 4.9

Optical Properties: Opaque. *Color:* Gray with a brownish tint in reflected light. *Luster:* Metallic.
R: (420) 27.1, (460) 26.7, (500) 26.4, (540) 26.9, (580) 27.0, (620) 26.8, (660) 26.4, (700) 26.0

Cell Data: *Space Group:* $Fd3m$. $a = 5.530(5)$ $Z = 1$

X-ray Powder Pattern: Erzgebirge, Germany.
3.18 (100), 1.952 (100), 1.671 (50), 1.268 (40), 1.129 (40), 0.978 (40)

Chemistry:

	(1)	(2)
Cu	37.2	37.94
Fe	1.8	
As	14.7	14.91
Se	47.2	47.15
Total	100.9	100.00

(1) Erzgebirge, Germany; by electron microprobe, average of four samples; corresponding to $(Cu_{2.92}Fe_{0.16})_{\Sigma=3.08}As_{0.98}Se_{2.96}$. (2) Cu_3AsSe_3.

Occurrence: In hydrothermal veins.

Association: Clausthalite, berzelianite, umangite, ankerite, calcite.

Distribution: From an undefined locality in the southwestern part of the Erzgebirge, Saxony, Germany.

Name: From the first letters of Moscow Geological Exploration Institute [Moskovskogo Geologro Razvedounogo Instituta (MGRI)] the laboratory in which the mineral was discovered.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Dymkov, Y.M., T.I. Loseva, E.N. Zav'yalov, B.I. Ryzhov, and L.I. Bochek (1982) Mgriite, $(Cu, Fe)_3AsSe_3$, a new mineral. Zap. Vses. Mineral. Obshch., 111, 215–219 (in Russian). (2) (1983) Amer. Mineral., 68, 280–281 (abs. ref. 1).

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Miargyrite $AgSbS_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly as thick crystals, to 1 cm, tabular on {001}, {100}, or $\{\bar{1}01\}$; striations ‖ [010] and $[0\bar{1}1]$; massive. *Twinning:* Polysynthetic twinning observed in polished section.

Physical Properties: *Cleavage:* Imperfect on {010}; rare on {100} and {101}. *Fracture:* Subconchoidal. Hardness = 2.5 VHN = n.d. D(meas.) = 5.25 D(calc.) = 5.29

Optical Properties: Nearly opaque; translucent in thin fragments. *Color:* Iron-black to steel-gray; in polished section, white with raspberry-red internal reflections in oil, seldom seen in air; deep cherry-red in transmitted light. *Streak:* Cherry-red. *Luster:* Metallic adamantine. *Optical Class:* Biaxial (+). *Pleochroism:* In reflected light, distinct, in whites and pale grays. $\beta = > 2.72$ (Li). *Anisotropism:* Strong.

R_1–R_2: (400) 38.0–41.5, (420) 37.2–40.4, (440) 36.3–39.2, (460) 35.4–38.4, (480) 34.6–37.5, (500) 33.8–36.6, (520) 32.9–35.8, (540) 32.0–34.9, (560) 31.2–34.1 (580) 30.4–33.2, (600) 29.7–32.4, (620) 29.0–31.5, (640) 28.3–30.7, (660) 27.6–29.9, (680) 27.0–29.3, (700) 26.6–28.9

Cell Data: *Space Group:* $C2/c$. $a = 12.862(3)$ $b = 4.409(1)$ $c = 13.218(3)$ $\beta = 98.48(2)^\circ$ Z = 8

X-ray Powder Pattern: Synthetic.
2.892 (100), 3.440 (80), 2.748 (70), 2.013 (40), 3.186 (30), 3.101 (30), 1.791 (25)

Chemistry:

	(1)	(2)	(3)
Ag	37.06	36.71	36.72
Fe		trace	
Sb	41.13	41.15	41.45
As	0.79		
S	21.50	21.68	21.83
Total	100.48	99.54	100.00

(1) St. Andreasberg, Germany. (2) Příbram, Czech Republic. (3) $AgSbS_2$.

Polymorphism & Series: Trimorphous with cuboargyrite and baumstarkite.

Occurrence: In hydrothermal veins of low-temperature origin.

Association: Baumstarkite, proustite, pyrargyrite, polybasite, silver, galena, sphalerite, pyrite, quartz, calcite, barite.

Distribution: In small amounts in many mines, rarely a principal ore mineral. In Germany, from Braünsdorf, near Freiberg, Saxony [TL]; at St. Andreasberg and Clausthal, in the Harz Mountains; and many other localities. From Příbram and Třebsko, Czech Republic. At Baia Sprie, Romania (formerly Felsőbánya, Hungary). From Hiendelaencina, Guadalajara Province, Spain. In the Strezhen deposit, Altai Mountains, Russia. At the Rampura-Agucha deposits, Rajasthan, India. In the Ailaoshan metamorphic belt, Yunnan Province, China. From the Van Silver mine, Brandywine Creek, British Columbia, Canada. In the USA, in Idaho, from the Silver City and Flint districts, Owyhee Co.; at the Kelly, Coyote and Santa Fe mines, in the Randsburg district, San Bernardino Co., California. In Mexico, from Catorce, San Luis Potosí; and from Sombrerete and Veta Grande, Zacatecas. In Chile, from Tres Puntas, near Copiapó, and Huantajaya, Tarapacá. At Colquechaca and Cerro Rico, Potosí, and Pulcayo, Huanchaca, Bolivia. From Huancavalica and Julcani, Peru.

Name: From the Greek for *less* and *silver*, as it contains less silver than other red silver sulfosalt minerals.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 424–427. (2) Graham, A.R. (1951) Matildite, aramayoite, miargyrite. Amer. Mineral., 36, 436–449. (3) Effenberger, H., W.H. Paar, D. Topa, A.J. Criddle, and M. Fleck (2002) The new mineral baumstarkite and a structural reinvestigation of aramayoite and miargyrite. Amer. Mineral., 87, 753–764. (4) (1967) NBS Mono. 25, 5, 49–50. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 369.

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Micheelsenite $(Ca,Y)_3Al(PO_3OH,CO_3)(CO_3)(OH)_6 \cdot 12H_2O$

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Crystal Data: Tetragonal (?). *Point Group:* n.d. As spherules or crusts, composed of minute matted fibers.

Physical Properties: Hardness = 5.5 D(meas.) = 2.83 D(calc.) = [2.91]

Optical Properties: Translucent. *Color:* White, pale gray, greenish; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* Negative elongation. $\alpha = 1.584$ $\beta = 1.598$ $\gamma = 1.602$
2V(meas.) = Moderate.

Cell Data: *Space Group:* n.d. $a = 7.00$–7.04 $c = 18.99$–19.07 Z = [2]

X-ray Powder Pattern: Fairfield, Utah, USA.
4.84 (100b), 2.98 (80b), 2.81 (80b), 3.09 (60b), 6.6 (40), 3.93 (30), 3.48 (30)

Chemistry:

	(1)	(2)
P_2O_5	33.8	34.75
Al_2O_3	36.3	37.45
MgO	0.2	
CaO	7.1	6.87
Na_2O	2.8	2.66
K_2O	1.7	1.73
H_2O	18.0	16.54
Total	99.9	100.00

(1) Fairfield, Utah, USA; average of two analyses, corrected by removal of wardite 5% and "davisonite" [= apatite + crandallite] 1%. (2) $(Na,K)CaAl_6(PO_4)_4(OH)_9 \cdot 3H_2O$ with Na:K = 0.7:0.3.

Occurrence: As finely banded crusts on variscite nodules (Little Green Monster mine, Utah, USA); in phosphatic laterite (Taiba mine, Senegal); as cement in weathered phosphorite (Homeland mine, Florida, USA).

Association: Wardite, apatite, crandallite (Little Green Monster mine, Utah, USA); crandallite, augelite, wavellite, turquoise (Taiba mine, Senegal); crandallite, wavellite, goethite, kaolinite, quartz (Homeland mine, Florida, USA).

Distribution: In the USA, from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah, and between Bartow and Fort Meade, as in the Homeland mine, Peace Valley, Polk Co., Florida. At the Taiba mine, Thiès district, Senegal. In Australia, from the Iron Monarch quarry, Iron Knob, South Australia, and on Christmas Island, Indian Ocean. From Kiluli, Rwanda.

Name: Honors F.T. Millis, of Lehi, Utah, USA, who collected the first specimens.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 941–942. (2) Owens, J.P., Z.S. Altschuler, and R. Berman (1960) Millisite in phosphorite from Homeland, Florida. Amer. Mineral., 45, 547–561.

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Michenerite PdBiTe

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Crystal Data: Cubic. *Point Group:* 23. Typically as minute grains.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 VHN = 306–317 (25 g load). D(meas.) = ∼9.5 D(calc.) = ∼10.0

Optical Properties: Opaque. *Color:* Silver-white to grayish white; in polished section, cream-white with a tinge of gray. *Streak:* Black. *Luster:* Metallic.
R: (400) 52.6, (420) 53,6, (440) 54.4, (460) 55.3, (480) 55.8, (500) 56.1, (520) 56.4, (540) 56.5, (560) 56.7, (580) 56.9, (600) 57.1, (620) 57.1, (640) 57.9, (660) 58.4, (680) 58.8, (700) 59.3

Cell Data: *Space Group:* $P2_13$. $a = 6.646$ $Z = 4$

X-ray Powder Pattern: Synthetic PdBiTe.
2.974 (100), 2.000 (90), 2.715 (80), 1.773 (80), 1.451 (70), 1.234 (70), 0.8668 (70)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pd	24.0	24.1	24.02	Bi	46.5	36.6	47.18
Pt	n.d.	1.1		Sb	0.4	5.3	
Ag		0.2		Te	28.8	32.4	28.80
Ni		0.1		Total	99.7	99.8	100.00

(1) Vermilion mine, Sudbury, Canada; by electron microprobe, corresponding to $Pd_{1.00}(Bi_{0.99}Sb_{0.01})_{\Sigma=1.00}Te_{1.00}$. (2) Kambalda, Australia; by electron microprobe, corresponding to $(Pd_{0.96}Pt_{0.02})_{\Sigma=0.98}(Bi_{0.74}Sb_{0.18})_{\Sigma=0.92}Te_{1.08}$. (3) PdBiTe.

Mineral Group: Pyrite group.

Occurrence: A principal palladium mineral in Cu–Ni sulfide deposits.

Association: Testibiopalladite, froodite, merenskyite, moncheite, kotulskite, melonite, sobolevskite, hollingworthite, sperrylite, hessite, chalcopyrite, pentlandite, cubanite, pyrrhotite.

Distribution: In Canada, in Ontario, from the Frood [TL] and other mines in the Sudbury district; at the Pipe mine, Manitoba; in the Wellgreen deposit, Yukon Territory. In the USA, from the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming; and in the Stillwater complex, Montana. From the Las Aguilas deposit, San Luis Province, Argentina. In Russia, at the Oktyabr mine, Noril'sk region, western Siberia; from the Monchegorsk deposit, Kola Peninsula; in the Bissersk placers, Ural Mountains; at the Vostok deposit, Lukkulaisvaara layered intrusion, Karelia. From Hitura, Finland. At the Gabbro Akarem, Eastern Desert, Egypt. In the Ban Phuc deposit, northwest Vietnam. At Kambalda, 56 km south of Kalgoorlie, Western Australia. From the Rustenburg mine, in the Merensky Reef, Bushveld complex, Transvaal, South Africa. At Danba, Sichuan Province, China. Known in trace amounts from a few other localities.

Name: In honor of Dr. Charles Edward Michener (1907–), Canadian geologist for the Canadian Nickel Company, who discovered the mineral.

Type Material: All original material consumed by analysis; redefined, Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M31189 and M29438.

References: (1) Hawley, J.E. and L.G. Berry (1958) Michenerite and froodite, palladium bismuth minerals. Can. Mineral., 6, 200–209. (2) Cabri, L.J., D.C. Harris, and R.I. Gait (1973) Michenerite (PdBiTe) redefined and froodite ($PdBi_2$) confirmed from the Sudbury area. Can. Mineral., 11, 903–912. (3) Genkin, A.D., N.N. Zhuravlev, and E.M. Smirnova (1963) Moncheite and kotulskite—new minerals—and the composition of michenerite. Zap. Vses. Mineral. Obshch., 92, 33–50 (in Russian). (4) Childs, J.D. and S.R. Hall (1973) The crystal structure of michenerite, PdBiTe. Can. Mineral., 12, 61–65. (5) Hudson, D.R., B.W. Robinson, R.B.W. Vigers, and G.A. Travis (1978) Zoned michenerite–testibiopalladite from Kambalda, Western Australia. Can. Mineral., 16, 121–126. (6) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 120–121, 155. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 371.

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Microcline $KAlSi_3O_8$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Prismatic crystals elongated along [001] or [100], perhaps the largest of any species, to 50 m and 13,500 t. Cleavable to granular, massive. Commonly exhibits banded perthitic intergrowths from exsolution of albite. *Twinning:* Carlsbad, Baveno, and Manebach laws very common; polysynthetic twinning on the Albite and Pericline laws give an orthogonal grid pattern on (001).

Physical Properties: *Cleavage:* Perfect on {001} and {010}, intersecting at ∼90°; partings on {100}, {110}, {$\bar{1}$10}, and {$\bar{2}$01}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.54–2.57 D(calc.) = 2.56

Optical Properties: Transparent to translucent. *Color:* White, pale cream-yellow; red, green, blue; colorless in thin section. *Luster:* Vitreous, pearly on cleavage.
Optical Class: Biaxial (–). *Orientation:* $X \wedge \{001\} = 15°$. *Dispersion:* $r > v$, weak.
$\alpha = 1.514–1.529$ $\beta = 1.518–1.533$ $\gamma = 1.521–1.539$ 2V(meas.) = 66°–103°

Cell Data: *Space Group:* $C\bar{1}$. $a = 8.5784$ $b = 12.9600$ $c = 7.2112$ $\alpha = 90°18'$ $\beta = 115°58'$ $\gamma = 87°7.5'$ Z = 4

X-ray Powder Pattern: Vigo, Galacia, Spain. (ICDD 19-926).
4.22 (100), 3.26 (80), 3.25 (80), 3.29 (60), 3.70 (40), 3.37 (40), 3.24 (40)

Chemistry:

	(1)		(1)
SiO_2	64.46	Na_2O	0.49
Al_2O_3	18.55	K_2O	16.07
Fe_2O_3	0.14	H_2O^+	0.06
CaO	0.17	Total	99.94

(1) Norra Kärr complex, Sweden; corresponds to $(K_{0.95}Na_{0.04}Ca_{0.01})_{\Sigma=1.00}Al_{1.01}Si_{2.98}O_8$.

Polymorphism & Series: Dimorphous with orthoclase.

Mineral Group: Feldspar (alkali) group; (Si,Al) is completely ordered in low microcline.

Occurrence: Common in plutonic felsic rocks, as granites, granite pegmatites, syenites; in metamorphic rocks of the greenschist and amphibolite facies; in hydrothermal veins. A detrital component in sedimentary rocks and as authigenic overgrowths.

Association: Quartz, sodic plagioclase, muscovite, biotite, "hornblende."

Distribution: A widespread mineral. Notable occurrences include: at Fredriksvärn, Arendal, and Larvik, Norway. In the Ilmen Mountains, Ural Mountains, and on the Kola Peninsula, Russia. At St. Gotthard, Ticino, Switzerland. On Mt. Greiner, Zillertal, Tirol, Austria. At Baveno, Piedmont, Italy. In the USA, at Amelia, Amelia Co., Virginia; Haddam, Middlesex Co., Connecticut; and Magnet Cove, Hot Spring Co., Arkansas. In Colorado, in the Pikes Peak area, El Paso Co., Crystal Peak, Teller Co., with large crystals from the Devil's Hole beryl mine, Fremont Co.; in the Black Hills, Pennington and Custer Cos., South Dakota. At Bancroft, Ontario, Canada. From Klein Spitzkopje, Namibia. In Brazil, from Minas Gerais, at Fazenda do Bananal, Salinas, Urucum, and Capelinha. At Ambositra, Madagascar. From Kimpusan, Yamanshi Prefecture, and Tanakamiyama, Otsu, Shiga Prefecture, Japan. At Broken Hill, New South Wales, Australia.

Name: From the Greek for *little* and *inclined*, for the small deviation of the cleavage planes from 90°.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 322–324. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 6–93. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 348–351. (4) Mergoil-Daniel, J. and R. Chevalier (1984) Les feldspaths potassiques partiellement ordonnés: structure cristallographique et signification géologique. Bull. Minéral., 107, 401–410 (in French with English abs.). (5) Smith, J.V. and W.L. Brown (1988) Feldspar minerals, (2nd edition), v. I. Springer, 828 pp.

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Microlite $(Ca, Na)_2Ta_2O_6(O, OH, F)$

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Crystal Data: Cubic; metamict when uranoan. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly as euhedral to subhedral octahedra, modified by the dodecahedron, cube, and {113}, to 8 cm; also granular, massive. *Twinning:* Rare, according to the spinel law, twin plane {111}.

Physical Properties: *Cleavage:* {111}, poor. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 5.90–6.43 D(calc.) = 6.33 (for Ca:Na = 1:1). May be radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Pale yellow to brown, hyacinth-red, greenish yellow, grass-green, emerald-green; white, gray, black; colorless, yellow, brown in transmitted light, may be zoned. *Streak:* Pale yellow or brown. *Luster:* Vitreous to adamantine, resinous on fractures.
Optical Class: Isotropic. $n = 1.93$–2.02

Cell Data: *Space Group:* $Fd3m$. $a = 10.36$–10.46 $Z = 8$

X-ray Powder Pattern: Onça, Brazil.
1.568 (100), 1.838 (84), 3.00 (68), 1.193 (68), 1.000 (68), 1.354 (63), 1.163 (63)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_5		3.4	RE_2O_3	0.50		Na_2O	3.26	0.7
Ta_2O_5	73.72	77.9	FeO	2.77		K_2O	0.64	
TiO_2	1.58	1.1	MnO		0.2	H_2O	2.72	
SnO_2		1.1	MgO	0.34		Total	100.22	100.1
UO_2	4.21		CaO	10.48	15.7			

(1) Landås, Norway. (2) Wodgina, Australia; by electron microprobe, corresponds to $(Ca_{1.52}Na_{0.12}Sn_{0.04}Mn_{0.02})_{\Sigma=1.70}(Ta_{1.92}Nb_{0.14}Ti_{0.08})_{\Sigma=2.14}O_7$.

Polymorphism & Series: Forms a series with pyrochlore.

Mineral Group: Pyrochlore group, microlite subgroup; $(Na+Ca)_A > 20\%$; $(Nb+Ta)_B > 2Ti_B$; $Ta_B \geq Nb_B$.

Occurrence: A primary mineral in lithium-bearing granite pegmatites, or replacing tantalum minerals; in miarolitic cavities in granites.

Association: Albite, lepidolite, topaz, beryl, tourmaline, spessartine, tantalite, fluorite.

Distribution: Many localities, but only a few have large crystals. Well-studied material from: in the USA, at Chesterfield, Hampshire Co., Massachusetts; Haddam and Middletown, Middlesex Co., Connecticut; from Topsham, Sagadahoc Co., and Newry, Oxford Co., Maine; large crystals from Amelia, Amelia Co., Virginia. In the Harding mine, Taos Co., New Mexico; from the Brown Derby pegmatite, Gunnison Co., Colorado; in the Tin Mountain mine, near Custer, Custer Co., South Dakota. From the Iveland district, Norway. In the Muiâne and other pegmatites, Alto Ligonha district, Mozambique. At Antandranokomby, Madagascar. From Mapembe, Mumba, and Lueshe, Kivu Province, Congo (Zaire). In Brazil, at Onça, Picuí, Paraíba; large crystals from the Virgem da Lapa pegmatite, Minas Gerais. At Wodgina and Greenbushes, Western Australia.

Name: From the Greek for *small*, for the size of crystals at the original locality.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128730.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 748–757. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 326–333. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 519–525. (4) Kerr, P.F. and R.J. Holmes (1945) X-ray study of the tantalum mineral simpsonite. Bull. Geol. Soc. Amer., 56, 479–504. (5) Clark, A.M. (1972) Calciotantalite confirmed as a mixture. Mineral. Mag., 38, 765–767. (6) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (7) von Knorring, O. and A. Fadipe (1981) On the mineralogy and geochemistry of niobium and tantalum in some granite pegmatites and alkali granites of Africa. Bull. Minéral., 104, 496–507.

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Microsommite $(Na, Ca, K)_{7-8}(Si, Al)_{12}O_{24}(Cl, SO_4)_{2-3}$

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Crystal Data: Hexagonal. *Point Group:* 622. As groups of minute prismatic crystals, striated ‖ their length.

Physical Properties: *Cleavage:* $\{10\bar{1}0\}$, perfect; {0001}, less distinct. Hardness = 6 D(meas.) = 2.42–2.53. D(calc.) = [2.48]

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Silky to brilliant on $\{10\bar{1}0\}$, otherwise vitreous.
Optical Class: Uniaxial (+). $\omega = 1.521$ $\epsilon = 1.529$

Cell Data: *Space Group:* $P6_322$. a = 22.08(4) c = 5.33(2) Z = 3

X-ray Powder Pattern: Monte Somma, Italy.
4.81 (100), 3.69 (100), 3.29 (100), 2.670 (80), 2.660 (80), 2.765 (60), 2.455 (60)

Chemistry:

	(1)	(2)
SiO_2	31.70	30.74
Al_2O_3	32.07	31.57
CaO	14.72	10.77
Na_2O	12.45	8.46
K_2O	4.27	8.97
Cl	6.99	7.65
SO_3		5.17
$-O = Cl_2$	1.58	1.73
Total	[100.62]	101.60

(1) Monte Somma, Italy; original total given as 100.72%; corresponds to $(Na_{4.17}Ca_{2.72}K_{0.94})_{\Sigma=7.83}(Al_{6.53}Si_{5.47})_{\Sigma=12.00}O_{23}Cl_{2.04}$. (2) Do.; corresponds to $(Na_{2.90}Ca_{2.04}K_{2.02})_{\Sigma=6.96}(Al_{6.57}Si_{5.43})_{\Sigma=12.00}O_{23}[Cl_{2.29}(SO_4)_{0.68}]_{\Sigma=2.97}$.

Mineral Group: Cancrinite group.

Occurrence: In ejected volcanic masses and in leucitites.

Association: Nepheline.

Distribution: From Monte Somma, Campania, and at Pitigliano, near Grosseto, Tuscany, Italy.

Name: From the Greek for *small*, in allusion to crystal size, and for the original locality at Monte Somma, Italy.

Type Material: Natural History Museum, Paris, France, 97397.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 428.
(2) Bariand, P., F. Cesbron, and R. Giraud (1968) Une nouvelle espèce minérale: l'afghanite de Sar-e-Sang, Badakhshan, Afghanistan. Comparaison avec les minéraux du groupe de la cancrinite. Bull. Soc. fr. Minéral., 91, 34–42 (in French with English abs.).

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Middendorfite $K_3Na_2Mn_5Si_{12}(O, OH)_{36}\cdot 2H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m* or 2. As imperfect rhombic or octagonal plates, to 0.4 mm; as intergrown wormlike segregations, to 1 mm, or fan-shaped intergrowths.

Physical Properties: *Cleavage*: Perfect {001}. *Tenacity*: flexible but not elastic. *Fracture*: scaly. Hardness = 3-3.5 D(meas.) = 2.60(2) D(calc.) = 2.65

Optical Properties: Transparent. *Color*: Dark to bright orange. *Streak*: Yellowish. *Luster*: Vitreous.
Optical Class: Biaxial (–). α = 1.534(3) β = 1.562(2) γ = 1.563(2) 2V(meas.) = 10(5)° 2V(calc.) = 21° *Orientation: X* ~ *c*. *Pleochroism*: Strong, *X* = yellowish to colorless; *Y* = brown; *Z* = deep brown.

Cell Data: *Space Group*: $P2_1/m$ or $P2_1$. *a* = 12.55(1) *b* = 5.721(2) *c* = 26.86(2) β = 114.04(7)° *Z* = 2

X-ray Powder Pattern: Hilairite pegmatite, Khibiny pluton, Kola Peninsula, Russia.
12.28 (100), 2.840 (90), 2.634 (88), 4.31 (81), 2.366 (76), 1.669 (64), 3.555 (62)

Chemistry:

	(1)	(2)		(1)	(2)
Na_2O	4.55	4.44	Al_2O_3	0.20	
MgO	0.18		SiO_2	50.87	51.64
CaO	0.11		TiO_2	0.17	
MnO	24.88	25.41	F	0.23	
K_2O	10.16	10.12	H_2O	7.73	8.39
FeO	0.68		$-O = F_2$	0.10	
ZnO	0.15		Total	99.81	100.00

(1) Hilairite pegmatite, Khibiny pluton, Kola Peninsula, Russia; average of 19 electron microprobe analyses, H_2O by Penfield method, OH and H_2O confirmed by IR, corresponding to $K_{3.04}(Na_{2.07}Ca_{0.03})_{\Sigma=2.10}(Mn_{4.95}Fe_{0.13}Mg_{0.06}Ti_{0.03}Zn_{0.03})_{\Sigma=5.20}(Si_{11.94}Al_{0.06})_{\Sigma=12}[O_{27.57}(OH)_{8.26}F_{0.17}]\cdot 1.92H_2O$. (2) $K_3Na_2Mn_5Si_{12}(O,OH)_{36}\cdot 2H_2O$.

Occurrence: A late hydrothermal mineral in a hyperperalkaline pegmatite.

Association: Microcline, sodalite, cancrisilite, aegirine, calcite, natrolite, fluorite, narsarsukite, labuntsovite-Mn, mangan-neptunite, donnayite.

Distribution: Hilairite pegmatite, level +252 m, Kirovsky Mine, Mount Kukisvumchorr, Khibiny alkaline pluton, Kola Peninsula, Russia.

Name: Honors Aleksandr Fedorovich von Middendorf (1815–1894), Academician of the Imperial Russian Academy of Sciences, who carried out the first mineralogical study of the Khibiny Mountains.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, 3312/1.

References: (1) Pekov, I.V., N.V. Chukanov, V.T. Dubinchuk, and A.E. Zadov (2006) Middendorfite, $K_3Na_2Mn_5Si_{12}(O,OH)_{36}\cdot 2H_2O$, a new mineral from the Khibiny massif, Kola Peninsula. Zap. Ross. Mineral. Obshch., 135(3), 42–52 (in Russian, English abstract); (2007) Geology of Ore Deposits, 49, 522–529 (in English). (2) (2009) Amer. Mineral., 94, 1079 (abs. ref. 1).

Miersite $(Ag, Cu)I$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. As tetrahedra, (+) and (–) forms of which may be balanced to give pseudo-octahedra, or, with the cube, to give pseudocubo-octahedra, to 1 mm; cube faces striated ‖ tetrahedral faces. In crystalline crusts and aggregates. *Twinning:* On {111}, may be repeated.

Physical Properties: *Cleavage:* {011}, perfect. *Fracture:* Conchoidal. *Tenacity:* Somewhat brittle. Hardness = 2.5 D(meas.) = 5.64 D(calc.) = 5.67

Optical Properties: Transparent. *Color:* Canary-yellow; in transmitted light, pale yellow. *Streak:* Canary-yellow. *Luster:* Adamantine.
Optical Class: Isotropic; slight anomalous anisotropism. $n = 2.20(2)$

Cell Data: *Space Group:* $F\overline{4}3m$. a = 6.504 Z = 4

X-ray Powder Pattern: Locality not stated [Broken Hill, Australia].
3.23 (s), 2.28 (m), 1.948 (m), 3.72 (w), 1.489 (vw), 1.320 (vw), 1.290 (vw)

Chemistry:

	(1)	(2)
Ag	38.17	45.95
Cu	5.64	
I	56.58	54.05
Total	100.39	100.00

(1) Broken Hill, Australia. (2) AgI.

Occurrence: A rare mineral in the oxidized zone of some Pb–Zn–Cu–Ag deposits, especially in arid regions.

Association: Iodargyrite, chlorargyrite, malachite, cerussite, cuprite (Broken Hill, Australia); gerhardtite, likasite (Likasi, Congo).

Distribution: From Broken Hill, New South Wales, Australia. In the USA, at the Contention mine and Joe shaft, Tombstone; in the Southwest mine, Bisbee, Cochise Co.; and from the Mildren and Steppe claim, South Comobabi Mountains, Pima Co., Arizona. In the Likasi mine, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Henry Alexander Miers (1858–1942), Professor of Mineralogy, Oxford University, Oxford, England.

Type Material: Natural History Museum, Paris, France, 112.405; The Natural History Museum, London, England, 83822.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 19–20. (2) Barclay, C.J. and J.B. Jones (1971) The Broken Hill silver halides. J. Geol. Soc. Austr., 18, 149–157. (3) Waldo, A.W. (1935) Identification of the copper ore minerals by means of X-ray powder diffraction patterns. Amer. Mineral., 20, 575–597, esp. 585.

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Miharaite $PbCu_4FeBiS_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As grains, to 0.3 mm, or irregular masses; as intergrowths with other sulfides.

Physical Properties: Hardness = n.d. VHN = 190–230 (25 g load). D(meas.) = n.d. D(calc.) = 6.06

Optical Properties: Opaque. *Color:* Pale gray to grayish white in reflected light. *Luster:* Metallic. *Anisotropism:* Moderate, from grayish blue to pinkish brown or yellowish brown. *Bireflectance:* Very faint; pale gray to white.

R_1–R_2: (400) 29.2–30.8, (420) 29.7–30.8, (440) 30.6–31.4, (460) 31.2–32.0, (480) 31.3–32.0, (500) 32.1–32.8, (520) 32.2–32.9, (540) 32.2–33.0, (560) 32.1–33.0, (580) 32.2–33.5, (600) 32.2–33.9, (620) 32.3–34.3, (640) 32.4–34.9, (660) 32.4–35.1, (680) 32.8–35.7, (700) 32.8–35.8

Cell Data: *Space Group:* $Pbmn$, $Pb2m$, or $Pb2_1\ m$. $a = 10.854(4)$ $b = 11.985(4)$ $c = 3.871(1)$ $Z = 2$

X-ray Powder Pattern: Mihara mine, Japan.
3.03 (100), 3.00 (70), 1.935 (70), 2.18 (50), 3.25 (30), 3.11 (30), 2.70 (30)

Chemistry:

	(1)	(2)	(3)
Pb	22.72	23.10	22.56
Cu	28.24	27.62	27.67
Fe	6.05	6.05	6.08
Bi	22.75	23.54	22.75
S	20.60	20.66	20.94
Total	100.36	100.97	100.00

(1) Mihara mine, Japan; by electron microprobe, average of six analyses; corresponds to $Pb_{1.01}Cu_{4.09}Fe_{1.00}Bi_{1.00}S_{5.91}$. (2) Ulsan mine, Korea; by electron microprobe, average of 13 analyses on five gain; corresponds to $Pb_{1.03}Cu_{4.00}Fe_{1.00}Bi_{1.04}S_{5.94}$. (3) $PbCu_4FeBiS_6$.

Occurrence: As disseminations in a hedenbergite-garnet-epidote contact metamorphic deposit (Mihara mine, Japan); in a mineralized quartz vein through granite (Imooka mine, Japan); in a bornite vein in copper skarn ore (Ulsan mine, Korea).

Association: Wittichenite, bornite, chalcopyrite, galena.

Distribution: In Japan, in Okayama Prefecture, from the Honpi deposit, Mihara mine [TL], and the Imo-oka mine; in Hyogo Prefecture, in the Akenobe mine. In the Ulsan mine, Kyongsang Province, South Korea. At the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea. From Neves-Corvo, Portugal.

Name: For the type locality at the Mihara mine, Japan.

Type Material: The Institute of Mineralogy, Petrology, and Economic Geology, Faculty of Science, Tohoku University, Sendai, Japan.

References: (1) Sugaki, A., H. Shima, and A. Kitakaze (1980) Miharaite, $Cu_4FePbBiS_6$, a new mineral from the Mihara mine, Okayama, Japan. Amer. Mineral., 65, 784–788. (2) Choi, S.G. and N. Imai (1983) Miharaite in bornite-rich copper ore from the Ulsan mine, Republic of Korea. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 78, 350–360 (in English). (3) Petrova, ?? (1988) ??title-str?? Doklady Acad. Nauk SSSR, 157??.

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Mikasaite $(Fe^{3+}, Mn^{3+})_2(SO_4)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Typically in aggregates of porous spherical crystals, to 100 μm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.06] Deliquescent, dissolving in adsorbed H_2O.

Optical Properties: Semitransparent. *Color:* White to pale brown. *Streak:* White to pale brown.
Optical Class: Uniaxial (+). $\omega = 1.504(2)$ $\epsilon = 1.518(3)$

Cell Data: *Space Group:* $[R\overline{3}]$ (by analogy to synthetic $Fe_2(SO_4)_3$). $a = 8.14(1)$ $c = 21.99(8)$ Z = [6]

X-ray Powder Pattern: Ikushunbetsu, Japan.
3.56 (100), 5.99 (28), 4.35 (23), 2.97 (20), 2.72 (20), 2.64 (11), 2.35 (7)

Chemistry:

	(1)	(2)	(3)
SO_3	46.8	61.6	60.07
Al_2O_3	4.3	5.7	
Fe_2O_3	24.3	32.0	39.93
Mn_2O_3	0.5	0.7	
H_2O	23.0		
Total	98.9	100.0	100.00

(1) Ikushunbetsu, Japan; by electron microprobe, average of seven analyses, total Fe as Fe^{3+}, total Mn as Mn^{3+}, SO_3 by wet analysis, H_2O by moisture evolution analyzer, considered as adsorbed. (2) Analysis (1) recalculated to a H_2O−free basis, then corresponding to $(Fe_{1.56}Al_{0.44}Mn_{0.03})_{\Sigma=2.03}(SO_4)_{3.00}$. (2) $Fe_2(SO_4)_3$.

Occurrence: A sublimate around a burning coal-gas escape fracture, formed at > 300 °C.

Association: n.d.

Distribution: From Ikushunbetsu, near Mikasa, Hokkaido, Japan.

Name: For its occurrence near Mikasa, Japan.

Type Material: Hokkaido University, Sapporo, Japan.

References: (1) Miura, H., K. Niida, and T. Hirama (1994) Mikasaite, $(Fe^{3+}, Al)_2(SO_4)_3$, a new ferric sulphate mineral from Mikasa City, Hokkaido, Japan. Mineral. Mag., 58, 649–653. (2) (1995) Amer. Mineral., 80, 846 (abs. ref. 1).

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Milarite **$(K, Na)Ca_2AlBe_2Si_{12}O_{30}\cdot H_2O$**

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Typically as well-formed hexagonal prisms, to 4 cm; as radial-fibrous aggregates and intergrowths.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.46–2.61 D(calc.) = 2.524

Optical Properties: Transparent to translucent, opaque. *Color:* Colorless, grayish, tan, pale green, yellowish green, yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (–); anomalously biaxial, sectored, with a uniaxial core. $\omega = 1.532–1.551$ $\epsilon = 1.529–1.548$

Cell Data: *Space Group:* $P6/mcc$. $a = 10.340–10.410$ $c = 13.758–13.845$ Z = 2

X-ray Powder Pattern: Val Giuv, Switzerland. (ICDD 12-450).
3.307 (100), 2.880 (90), 4.160 (65), 5.21 (45), 2.743 (45), 4.495 (35), 3.776 (25)

Chemistry:

	(1)
SiO_2	71.66
Al_2O_3	4.68
BeO	5.24
CaO	11.70
Na_2O	0.46
K_2O	4.91
H_2O^+	1.02
H_2O^-	0.05
Total	99.72

(1) Val Giuv, Switzerland; corresponds to $(K_{1.04}Na_{0.15})_{\Sigma=1.19}Ca_{2.08}Al_{0.92}Be_{2.10}Si_{11.59}O_{30}\cdot 0.60H_2O$.

Mineral Group: Milarite group.

Occurrence: In alpine and low-temperature hydrothermal veins; in aplites, syenites, and granite pegmatites.

Association: Orthoclase, albite, fluorite, beryl, phenakite, bertrandite, bavenite, minasgeraisite-(Y), quartz, calcite, muscovite, chlorite.

Distribution: In the Val Giuv, Tavetsch, Graubünden, and many other localities in Switzerland. From Věžná, Maršíkov, and Radkovice, Czech Republic. In the Habachtal, at Gasteiner, Austria. From Henneberg, Thuringia, and Tittling, Bavaria, Germany. In the Cheesewring quarry, Linkinhorne, Cornwall, England. From Kent, Kazakhstan. At Yermakorskeye, Siberia, Russia. Fine crystals from Rössing, Namibia. In the USA, on Moat Mountain, North Conway, Carroll Co., New Hampshire, and in the Foote mine, Kings Mountain, Cleveland Co., North Carolina. In Canada, at Strange Lake, Quebec. From the Valencia mine, Guanajuato, Mexico. Large crystals in the José Pinto pegmatite, at Jaguaraçú, near Coronel Fabriciano, Minas Gerais, Brazil.

Name: After a spurious type locality, the Val Milà (Milar), Switzerland [originally from the nearby Val Giuv, but later found in Val Milà also].

Type Material: Federal Institute of Technology, Zurich, Switzerland, Wi8976.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 312–313. (2) Černý, P., F.C. Hawthorne, and E. Jarosewich (1980) Crystal chemistry of milarite. Can. Mineral., 18, 41–57. (3) Hawthorne, F.C., M. Kimata, P. Černý, N. Ball, G.R. Rossman, and J.D. Grice (1991) The crystal chemistry of the milarite-group minerals. Amer. Mineral., 76, 1836–1856.

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Millerite NiS

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Typically as slender to capillary crystals, to 7 cm, elongated ‖ [0001], in radiating groups of hairlike, interwoven masses; columnar tufted coatings. Single crystals may be helically twisted about [0001] or form rings. As cleavable masses up to several cm across. *Twinning:* By pressure on $\{01\bar{1}2\}$.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}1\}$ and $\{01\bar{1}2\}$. *Fracture:* Uneven. *Tenacity:* Brittle; capillary crystals elastic. Hardness = 3–3.5 VHN = 179 D(meas.) = 5.5 D(calc.) = 5.374

Optical Properties: Opaque. *Color:* Pale brass-yellow to bronze-yellow, tarnishes to iridescence. *Streak:* Greenish black. *Luster:* Metallic. *Pleochroism:* Weak in air, appreciably stronger in oil, pale yellow-brown to bright yellow. *Anisotropism:* Strong.
R_1–R_2: (400) 26.4–30.0, (420) 29.8–34.0, (440) 35.6–38.8, (460) 41.0–42.1, (480) 45.1–44.8, (500) 48.4–46.9, (520) 51.5–48.4, (540) 53.9–49.8, (560) 55.5–50.8, (580) 57.0–51.8, (600) 58.3–51.6, (620) 59.2–53.3, (640) 59.9–53.8, (660) 60.4–54.2, (680) 60.5–54.4, (700) 60.5–54.3

Cell Data: *Space Group:* $R\bar{3}m$. $a = 9.607$ $c = 3.143$ $Z = 9$

X-ray Powder Pattern: Canada.
2.777 (100), 1.8631 (95), 2.513 (65), 4.807 (60), 2.228 (55), 1.8178 (45), 2.946 (40)

Chemistry:

	(1)	(2)
Ni	63.68	64.67
Fe	1.03	
Co	0.21	
Cu	0.00	
S	35.47	35.33
Total	100.39	100.00

(1) Marbridge mine, Canada; by electron microprobe, corresponding to $(Ni_{0.98}Fe_{0.02})_{\Sigma=1.00}S_{1.00}$.
(2) NiS.

Occurrence: Most commonly as a low-temperature mineral, in cavities in limestones and carbonate veins and in barite; an alteration product of other nickel minerals; also in sedimentary rocks, associated with coal measures, and rarely in serpentines.

Association: Gersdorffite, polydymite, nickeline, galena, sphalerite, pyrite, chalcopyrite, pyrrhotite, pentlandite, cubanite, calcite, dolomite, siderite, barite, ankerite.

Distribution: Numerous localities world-wide. In Germany [TL], from Müsen and Wissen, and as large crystals at Ramsbeck, North Rhine-Westphalia; from Kamsdorf, Thuringia. At Kotalahti, Finland, large cleavages. From Kladno, Czech Republic. At Merthyr Tudful, Glamorgan, Wales. In the USA, from the Sterling mine, Antwerp, Jefferson Co., New York; at the Gap Nickel mine, Lancaster Co., Pennsylvania. In geodes from Keokuk, Lee Co., Iowa; St. Louis, St. Louis Co., Missouri; Esterbrook Park, Milwaukee, Waukesha Co., Wisconsin, and at Hall's Gap, Lincoln Co., Kentucky. In Canada, from Temagami, Ontario; at the Thompson mine, Thompson, Manitoba; in the Orford nickel mine, Brompton Lake, and as large cleavages from the Marbridge mine, Malartic, Quebec. At Kambalda, 56 km south of Kalgoorlie, and in the Agnew mine, Leinster, Western Australia. From the Trojan nickel mine, Bindura, Zimbabwe. On Mabilikwe Hill, Northern Transvaal, South Africa.

Name: Honors William Hallowes Miller (1801–1880), British mineralogist, Cambridge University, Cambridge, England, who first studied crystals of the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 239–241. (2) Grice, J.D. and R.B. Ferguson (1974) Crystal structure refinement of millerite (β–NiS). Can. Mineral., 12, 248–252. (3) Zhu Nai-jue, Liang Li, and Shi Ni-cheng (1991) Experimental electron density analysis of millerite. Scientia Sinica, 35(9), 1047–1055 (in English). (4) (1962) NBS Mono. 25, 1, 37. (5) Beran, A. and T. Mohsenzadeh (1982) A reflected light investigation of nickeline, breithauptite and millerite. Tschermaks Mineral. Petrog. Mitt., 30, 267–275.

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$(Na,K)CaAl_6(PO_4)_4(OH)_9 \cdot 3H_2O$ — Millisite

Crystal Data: Tetragonal (?). *Point Group:* n.d. As spherules or crusts, composed of minute matted fibers.

Physical Properties: Hardness = 5.5 D(meas.) = 2.83 D(calc.) = [2.91]

Optical Properties: Translucent. *Color:* White, pale gray, greenish; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* Negative elongation. $\alpha = 1.584$ $\beta = 1.598$ $\gamma = 1.602$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* n.d. $a = 7.00$–7.04 $c = 18.99$–19.07 Z = [2]

X-ray Powder Pattern: Fairfield, Utah, USA.
4.84 (100b), 2.98 (80b), 2.81 (80b), 3.09 (60b), 6.6 (40), 3.93 (30), 3.48 (30)

Chemistry:

	(1)	(2)
P_2O_5	33.8	34.75
Al_2O_3	36.3	37.45
MgO	0.2	
CaO	7.1	6.87
Na_2O	2.8	2.66
K_2O	1.7	1.73
H_2O	18.0	16.54
Total	99.9	100.00

(1) Fairfield, Utah, USA; average of two analyses, corrected by removal of wardite 5% and "davisonite" [= apatite + crandallite] 1%. (2) $(Na,K)CaAl_6(PO_4)_4(OH)_9 \cdot 3H_2O$ with Na:K = 0.7:0.3.

Occurrence: As finely banded crusts on variscite nodules (Little Green Monster mine, Utah, USA); in phosphatic laterite (Taiba mine, Senegal); as cement in weathered phosphorite (Homeland mine, Florida, USA).

Association: Wardite, apatite, crandallite (Little Green Monster mine, Utah, USA); crandallite, augelite, wavellite, turquoise (Taiba mine, Senegal); crandallite, wavellite, goethite, kaolinite, quartz (Homeland mine, Florida, USA).

Distribution: In the USA, from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah, and between Bartow and Fort Meade, as in the Homeland mine, Peace Valley, Polk Co., Florida. At the Taiba mine, Thiès district, Senegal. In Australia, from the Iron Monarch quarry, Iron Knob, South Australia, and on Christmas Island, Indian Ocean. From Kiluli, Rwanda.

Name: Honors F.T. Millis, of Lehi, Utah, USA, who collected the first specimens.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 941–942. (2) Owens, J.P., Z.S. Altschuler, and R. Berman (1960) Millisite in phosphorite from Homeland, Florida. Amer. Mineral., 45, 547–561.

Millosevichite $(Al, Fe^{3+})_2(SO_4)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ (by analogy to mikasite). Tiny crystals in granular aggregates; in stalactitic porous to pumiceous masses, to 3 cm.

Physical Properties: Hardness = 1.5 D(meas.) = 1.72 D(calc.) = 2.86 Hygroscopic.

Optical Properties: Semitransparent. *Color:* Indigo, bright red, brick-red, becoming gray with hydration. *Streak:* Red. *Luster:* Vitreous.
Optical Class: Isotropic, anomalous. $n = 1.573$

Cell Data: *Space Group:* $R\overline{3}$ (synthetic). $a = 8.055$ $c = 21.191$ $Z = 6$

X-ray Powder Pattern: L'vov-Volyn' Basin, Ukraine.
3.50 (10), 5.81 (5), 2.656 (4), 4.23 (3), 2.91 (3), 2.357 (2) 2.220 (2)

Chemistry:

	(1)
SO_3	54.35
Al_2O_3	20.9
Fe_2O_3	8.8
MgO	2.32
CaO	0.86
H_2O	2.55
insol.	9.96
Total	99.74

(1) L'vov-Volyn' Basin, Ukraine; average of two analyses, corresponding to $(Al_{1.85}Fe_{0.49})_{\Sigma=2.34}(SO_4)_3$.

Occurrence: Precipitated at high temperature from gasses originating from solfataric activity or burning coal measures.

Association: Sulfur, sal ammoniac, letovicite, alunogen, boussingaultite (Kladno, Czech Republic).

Distribution: From the Alum Grotto, Vulcano, Lipari Islands, Italy. At the Velikomostov-3 coal mine, L'vov-Volyn' Basin, Ukraine. In the Schoeller coal mine, Libušin, near Kladno, Czech Republic. From Miskolc-Lyukóbánya, Hungary. At Shamokin, near Burnside, Northumberland Co., Pennsylvania, USA.

Name: To honor Professor Federico Millosevich (1875–1942), Italian mineralogist, University of Rome, Rome, Italy.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 539. (2) Srebrodol'skii, B.I. (1974) A millosevichite find in the USSR. Doklady Acad. Nauk SSSR, 214, 429–430 (in Russian). (3) (1978) NBS Mono. 15, 8.

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Crystal Data: Cubic. *Point Group*: 23. As irregular gains, to 25 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 4.5 VHN = 465 (100 g load). D(meas.) = n.d. D(calc.) = 8.09

Optical Properties: Opaque. *Color*: Silvery gray; white in reflected light. *Streak*: Gray.
Luster: Metallic.
Optical Class: Isotropic. *Bireflectance:* Weak to distinct. *Anisotropism:* Strong.
R: (470) 48.6, (546) 47.5, (589) 47.7, (650) 49.0

Cell Data: *Space Group: P*2_13. a = 6.3181(5) Z = 4 (for synthetic PdSbSe)

X-ray Powder Pattern: (calculated from the structure of synthetic PdSbSe)
2.825 (100), 1.9047 (98), 2.579 (81), 3.159 (53), 2.234 (32), 1.7521 (27), 1.6883 (25)

Chemistry:

	(1)
Pd	34.17
Cu	0.78
Ag	0.35
Sb	38.03
Se	26.38
Total	99.71

(1) Předbořice, Czech Republic; average of 5 electron microprobe analyses, corresponding to $Pd_{0.98}Cu_{0.04}Ag_{0.01}Sb_{0.95}Se_{1.02}$.

Mineral Group: Ullmanite subgroup of the gersdorfite group.

Occurrence: A low-temperature mineral in fractures in selenium-rich uraninite in calcite veins.

Association: Embedded in eucairite and tiemannite, associated with bornite, selenian digenite, chrisstanleyite, fischesserite, gold, silver-rich hakite, tyrrellite, clausthalite, chaméanite, uraninite.

Distribution: In a polished section attributed to Předbořice, Czech Republic, purchased from a mineral dealer.

Name: Honors Milota Makovicky (b. 1941), Geological Institute, University of Copenhagen, for her outstanding investigations of sulfide and sulfarsenide systems with platinum-group elements.

Type Material: Department of Geography, Geology and Mineralogy, Division of Mineralogy and Material Sciences (Mineralogical Museum), Salzburg, Austria (14935).

References: (1) Paar, W.H., D. Topa, E. Makovicky, and F.J. Culetto (2005) Milotaite, PdSbSe, a new palladium mineral species from Předbořice, Czech Republic. Can. Min., 43, 689-694.
(2) (2005) Amer. Mineral., 90, 1947 (abs. ref. 1).

Mimetite $Pb_5(AsO_4)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals are usually prismatic to acicular ‖ [0001], to 12 cm, may be tabular, showing $\{10\bar{1}0\}$, $\{0001\}$, $\{10\bar{1}1\}$, rarely $\{11\bar{2}1\}$, $\{21\bar{3}1\}$, others; rounded, barrel-shaped, mammillary, stalactitic, granular. *Twinning:* On $\{11\bar{2}2\}$, very rare.

Physical Properties: *Cleavage:* On $\{10\bar{1}1\}$, interrupted. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 7.24 D(calc.) = 7.26 Piezoelectric; may fluoresce reddish yellow under LW or SW UV.

Optical Properties: Transparent to translucent. *Color:* Pale to bright yellow, yellowish brown, yellow-orange, white, may be colorless; colorless or pale yellow in transmitted light. *Streak:* White. *Luster:* Resinous to subadamantine.
Optical Class: Uniaxial (–), commonly anomalously biaxial (–), sectored. *Pleochroism:* Weak. *Absorption:* $O < E$. $\omega = 2.147$ $\epsilon = 2.128$

Cell Data: *Space Group:* $P6_3/m$ (synthetic). $a = 10.250(2)$ $c = 7.454(1)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.06 (100), 3.01 (90), 2.962 (66), 3.36 (38), 2.110 (30), 1.994 (22), 1.905 (20)

Chemistry:

	(1)	(2)
P_2O_5	0.14	
As_2O_5	23.17	23.17
PbO	74.58	74.99
Cl	2.39	2.38
$-O = Cl_2$	0.54	0.54
Total	99.74	100.00

(1) Phoenixville, Pennsylvania, USA. (2) $Pb_5(AsO_4)_3Cl$.

Polymorphism & Series: Dimorphous with clinomimetite.

Mineral Group: Apatite group.

Occurrence: A common secondary mineral in the oxidized zone of arsenic-bearing lead deposits.

Association: Cerussite, anglesite, smithsonite, willemite, pyromorphite, wulfenite.

Distribution: Many localities. A few for well-crystallized material include: Johanngeorgenstadt, Saxony, Germany. At Příbram, Czech Republic. In England, from a number of localities in Cornwall; fine examples from Dry Gill and other mines, Caldbeck Fells, Cumbria. From Leadhills, Lanarkshire, Scotland. Extraordinary crystals at Tsumeb, Namibia. From Gowde, Anarak district, Iran. In the USA, from Phoenixville, Chester Co., Pennsylvania; at the Mammoth-St. Anthony mine, Tiger, Pinal Co., and the Rowley mine, Maricopa Co., Arizona; from the Centennial Eureka mine, Tintic district, Juab Co., Utah. In Mexico, from Santa Eulalia and San Pedro Corallitos, Chihuahua; in the Ojuela mine, Mapimí, Durango. At Broken Hill, New South Wales; in the Mt. Bonnie mine, Grove Hill, Prices Station, Northern Territory, Australia. From Hat Yai, Thailand.

Name: From the Greek for *an imitator*, as it imitates pyromorphite.

Type Material: Mining Academy, Freiberg, Germany, 20225.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 889–895. (2) Dai, Y., J.M. Hughes, and P.B. Moore (1991) The crystal structures of mimetite and clinomimetite, $Pb_5(AsO_4)_3Cl$. Can. Mineral., 29, 369–376. (3) Calos, N.J. and C.H.L. Kennard (1990) Crystal structure of mimetite, $Pb_5(AsO_4)_3Cl$. Zeits. Krist., 191, 125–129. (4) Cockbain, A.G. (1968) Lead apatite solid-solution series. Mineral. Mag., 36, 1171–1173. (5) Baker, W.E. (1966) An X-ray diffraction study of synthetic members of the pyromorphite series. Amer. Mineral., 51, 1712–1721.

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Minamiite $(Na, Ca, K)Al_3(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Flat hexagonal plates, to 0.2 mm.

Physical Properties: Hardness = [3.5–4] (by analogy to the alunite group).
D(meas.) = n.d. D(calc.) = 2.81

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.981(2)$ $c = 33.490(14)$ Z = 6

X-ray Powder Pattern: Okumanza, Japan.
2.964 (100), 4.906 (80), 2.792 (80), 2.225 (65), 5.591 (60), 1.8968 (45), 1.8607 (40)

Chemistry:

	(1)
SO_3	38.09
Al_2O_3	37.74
CaO	1.94
Na_2O	3.37
K_2O	2.17
H_2O^+	12.22
rem.	4.28
Total	99.81

(1) Okumanza, Japan; remnant, all considered due to impurities, consists of P_2O_5 0.18%, V_2O_3 0.02%, SiO_2 3.58%, Fe_2O_3 0.03%, TiO_2 0.45%, H_2O^- 0.02%; corresponds then to $(Na_{0.46}Ca_{0.29}K_{0.19})_{\Sigma=0.94}Al_{3.11}(SO_4)_2(OH)_{5.70}$.

Mineral Group: Alunite group.

Occurrence: In a hydrothermally altered labradorite andesite (Okumanza, Japan); deposited from fumarolic gasses (Mt. Rainier, Washington, USA); in volcanic-hosted argillic alteration (Barton Peninsula, Antarctica).

Association: Alunite, natroalunite, huangite, quartz (Okumanza, Japan); natroalunite, woodhouseite (Mt. Rainier, Washington, USA); pyrophyllite, pyrite, sulfur, zunyite, rutile, chalcedonic silica (Barton Peninsula, Antarctica).

Distribution: From Okumanza, near the Kusatsu-Shirane volcano, Gumma Prefecture, Japan. On Mt. Rainier, Pierce Co., Washington, USA. In the Quechisla district, Bolivia. From the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. In the Fancel-Laƀuşna caldera, Gurghui Mountains, Romania. On Barton Peninsula, King George Island, Antarctica.

Name: In honor of Dr. A.E. Minami (1899–1977), who studied the hot springs around the Kusatsu-Shirane volcano, Japan.

Type Material: National Science Museum, Tokyo, Japan.

References: (1) Ossaka, J., J.-I. Hirabayashi, K. Okada, and R. Kobayashi (1982) Crystal structure of minamiite, a new mineral of the alunite group. Amer. Mineral., 67, 114–119. (2) Ossaka, J., N. Otsuka, J.-I. Hirabayashi, K. Okada, and H. Soga (1987) Synthesis of minamiite, $Ca_{0.5}Al_3(SO_4)_2(OH)_6$. Neues Jahrb. Mineral., Monatsh., 49–63. (3) Li, G., D.R. Peacor, E.J. Essene, D.R. Brosnahan, and R.E. Beane (1992) Walthierite, $Ba_{0.5}\square_{0.5}Al_3(SO_4)_2(OH)_6$, and huangite, $Ca_{0.5}\square_{0.5}Al_3(SO_4)_2(OH)_6$, two new minerals of the alunite group from the Coquimbo region, Chile. Amer. Mineral., 77, 1275–1284 [IMA definition of minamiite].

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Minasgeraisite-(Y) $Ca(Y,Bi)_2Be_2Si_2O_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As curved, sheaflike crystals, to < 5 μm, forming single and multiple rosettes, to 1 mm.

Physical Properties: *Cleavage:* Perfect on probable {100}; good on {001}. Hardness = 6–7 D(meas.) = > 4.25 D(calc.) = 4.90

Optical Properties: Translucent. *Color:* Lavender to lilac-purple, with individual rosettes having lighter-colored cores than rims; in transmitted light, colorless to pale yellow or purple. *Streak:* Light purple. *Luster:* Earthy to subvitreous.
Optical Class: Biaxial (+). *Pleochroism:* Moderate; X = colorless; Y = pale grayish yellow; Z = lavender-purple. *Dispersion:* $r > v$, very weak. $\alpha = 1.740(4)$ $\beta = 1.754(4)$ $\gamma = 1.786(4)$ 2V(meas.) = 50°–72°, average 68° 2V(calc.) = 68°

Cell Data: *Space Group:* $P2_1/a$. $a = 9.833(2)$ $b = 7.562(1)$ $c = 4.702(1)$ $\beta = 90.46(6)°$ Z = 2

X-ray Powder Pattern: José Pinto pegmatite, Brazil.
3.11 (100), 2.830 (100), 2.540 (90), 1.768 (35), 5.99 (30), 3.71 (30), 3.41 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	[26.37]	24.5	MnO	2.83	3.5
TiO_2	0.02	0.0	CuO	0.14	0.1
ZrO_2	< 0.02	0.0	ZnO	0.35	0.3
B_2O_3	1.45	1.5	BeO	7.8	7.8
Al_2O_3	0.00	0.0	MgO	0.61	0.6
Y_2O_3	16.38		CaO	11.47	8.1
RE_2O_3	15.78	23.1	Na_2O	< 0.1	< 0.1
Bi_2O_3	14.7	28.5	P_2O_5	1.21	1.2
FeO	0.69	0.7	Total	[99.8]	99.9

(1) José Pinto pegmatite, Brazil; by electron microprobe, ICP, and AA, after deduction of SiO_2 0.6% as mica; $RE_2O_3 = La_2O_3$ 0.25%, Ce_2O_3 0.20%, Pr_2O_3 0.13%, Nd_2O_3 0.50%, Sm_2O_3 0.26%, Eu_2O_3 0.00%, Gd_2O_3 0.32%, Tb_2O_3 0.23%, Dy_2O_3 1.26%, Ho_2O_3 0.37%, Er_2O_3 1.94%, Tm_2O_3 0.75%, Yb_2O_3 7.86%, Lu_2O_3 1.71%; corresponds to $(Ca_{0.45}Mn_{0.20}Mg_{0.08}Fe_{0.05}Zn_{0.02}Cu_{0.01})_{\Sigma=0.81}(Y_{0.72}Ca_{0.56}RE_{0.41}Bi_{0.31})_{\Sigma=2.00}(Be_{1.55}Si_{0.24}B_{0.21})_{\Sigma=2.00}(Si_{1.95}P_{0.08})_{\Sigma=2.03}O_{10}$. (2) Do.; Bi-richest portion, with $(RE_{0.86}Bi_{0.65}Ca_{0.49})_{\Sigma=2.00}$.

Mineral Group: Gadolinite group.

Occurrence: A late-stage accessory mineral in a zoned complex granite pegmatite.

Association: Milarite, muscovite, quartz, albite, orthoclase, hematite, garnet, magnetite, churchite, elbaite, anatase.

Distribution: In the José Pinto pegmatite, at Jaguaraçú, near Coronel Fabriciano, Minas Gerais, Brazil.

Name: For the state of Minas Gerais, Brazil, and *yttrium* in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 164209.

References: (1) Foord, E.E., R.V. Gaines, J.G. Crock, W.B. Simmons, Jr., and C.P. Barbosa (1986) Minasgeraisite, a new member of the gadolinite group from Minas Gerais, Brazil. Amer. Mineral., 71, 603–607.

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Minasragrite $V^{4+}O(SO_4)\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Minute equant crystals showing {001}, {110}, {011}, {$\bar{1}$01}, {$\bar{1}$11}; in spherulites and granular masses in delicate efflorescences.

Physical Properties: Hardness = n.d. D(meas.) = 2.03(10) D(calc.) = 2.06 Easily soluble in cold H_2O.

Optical Properties: Semitransparent. *Color:* Vivid cobalt-blue to pale aquamarine-blue; blue in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = deep blue; Y = blue; Z = colorless. *Orientation:* $X = b$; $Z \wedge c$ = small. *Absorption:* $X > Y > Z$. $\alpha = 1.513(2)$ $\beta = 1.536(2)$ $\gamma = 1.545(2)$ 2V(meas.) = Medium large.

Cell Data: *Space Group:* $P2_1/a$. $a = 12.902(4)$ $b = 9.716(5)$ $c = 6.976(2)$ $\beta = 110.90(3)^\circ$ Z = 4

X-ray Powder Pattern: Minasragra, Peru.
5.135 (100), 3.907 (70), 5.431 (60), 3.826 (35), 3.658 (24), 6.049 (20), 3.509 (17)

Chemistry:

	(1)	(2)
SO_3	32.0	31.64
V_2O_5	3.0	
V_2O_4	29.8	32.77
H_2O	34.5	35.59
insol.	0.6	
Total	99.9	100.00

(1) Minasragra, Peru; corresponding to $V_{1.00}O(SO_4)_{1.02}\cdot 4.89H_2O$. (2) $VO(SO_4)\cdot 5H_2O$.

Polymorphism & Series: Dimorphous with orthominasragrite.

Occurrence: An alteration product of patronite in a rich deposit of vanadian materials in fissures that cut red shales and that were probably filled by a remobilized asphaltite deposit (Minasragra, Peru); in a silicified tree, formed as an oxidation product of pyrite reacting with vanadium-rich organic material (Temple Mountain district, Utah, USA).

Association: Patronite, melanterite, morenosite, dwornikite, retgersite, szomolnokite, potassium alum, gypsum (Minasragra, Peru); orthominasragrite, pyrite, sulfur, iron sulfates (Temple Mountain district, Utah, USA).

Distribution: From Minasragra, 46 km from Cerro de Pasco, Peru. At the North Mesa mine group, Temple Mountain district, Emery County, Utah, USA.

Name: For its occurrence at Minasragra, Peru.

Type Material: National Museum of Natural History, Washington, D.C., USA, 87515.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 437–438. (2) Smith, M.L. and J. Marinenko (1973) A reexamination of minasragrite. Amer. Mineral., 58, 531–534. (3) Ballhausen, C.J., B.F. Djurinskij, and K.J. Watson (1968) The polarized absorption spectra of three crystalline polymorphs of $VOSO_4\cdot 5H_2O$. J. Amer. Chem. Soc. 90, 3305–3309. (4) Tachez, M., F. Théobald, K.J. Watson, and R. Mercier (1979) Redétermination de la structure du sulfate de vanadyle pentahydraté $VOSO_4.5H_2O$. Acta Cryst., 35, 1545–1550 (in French with English abs.).

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Mineevite-(Y) $Na_{25}Ba(Y,Gd,Dy)_2(CO_3)_{11}(HCO_3)_4(SO_4)_2F_2Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Anhedral grains, to 1 cm.

Physical Properties: *Cleavage:* On {0001}, perfect. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 2.85(2) D(calc.) = 2.84 Pale yellowish green fluorescence under UV.

Optical Properties: Transparent. *Color:* Pale green to yellowish green; nearly colorless in thin fragments. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Uniaxial (–). $\omega = 1.536(2)$ $\epsilon = 1.510(2)$

Cell Data: *Space Group:* $P6_3/m$. $a = 8.811(7)$ $c = 37.03(3)$ Z = 2

X-ray Powder Pattern: Mt. Alluaiv, Kola Peninsula, Russia.
2.829 (100), 2.270 (90), 2.531 (71b), 2.659 (51b), 1.660 (46), 3.32 (40), 7.61 (39)

Chemistry:

	(1)		(1)
SO_3	7.63	Ho_2O_3	0.15
CO_2	30.83	Er_2O_3	0.51
Y_2O_3	5.90	Yb_2O_3	0.06
La_2O_3	0.19	BaO	7.33
Ce_2O_3	0.58	Na_2O	36.87
Nd_2O_3	0.50	F	1.80
Sm_2O_3	0.95	Cl	1.70
Gd_2O_3	2.33	H_2O	[1.66]
Tb_2O_3	0.35	$-O = (F,Cl)_2$	1.14
Dy_2O_3	1.80	Total	[100.00]

(1) Mt. Alluaiv, Kola Peninsula, Russia; by electron microprobe, average of three analyses, CO_2 and F by wet methods, H_2O by difference; corresponds to $Na_{25.30}Ba_{1.02}(Y_{1.11}Gd_{0.27}Dy_{0.20}Sm_{0.11}Ce_{0.07}Nd_{0.06}Er_{0.06}Tb_{0.04}La_{0.03}Ho_{0.02}Yb_{0.01})_{\Sigma=1.98}(CO_3)_{10.98}(HCO_3)_{3.92}(SO_4)_{2.03}F_{2.01}Cl_{1.02}$.

Occurrence: Very rare in pegmatites in a differentiated alkalic massif.

Association: Nahcolite, trona, thermonatrite, sidorenkite, neighborite, aegirine, albite, sphalerite, manganotychite.

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: Honoring Professor Dmitry Andreevich Mineev (1935–1992), Russian geochemist and mineralogist, founder of the Russian Academy of Sciences.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p575/1.

References: (1) Khomyakov, A.P., L.I. Polezhaeva, N.A. Yamnova, and D.Y. Pushcharovskiy (1992) Mineevite-(Y) – $Na_{25}Ba(Y,Gd,Dy)_2(CO_3)_{11}(HCO_3)_4(SO_4)_2F_2Cl$ – a new mineral. Zap. Vses. Mineral. Obshch., 121(6), 138–143 (in Russian). (2) (1994) Amer. Mineral., 79, 764 (abs. ref. 1).

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Minehillite $(K,Na)_{2-3}Ca_{28}Zn_4Al_4Si_{40}O_{112}(OH)_{16}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\bar{6}m2$, or $6mm$. As plates, to 5 mm, forming bands and incrustations.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ∼4 D(meas.) = 2.93 D(calc.) = 2.94 Fluoresces medium dull violet in SW and duller violet in LW UV.

Optical Properties: Transparent. *Color:* Colorless; white in aggregates, gray to black with lead inclusions. *Luster:* Pearly on cleavage, vitreous on fractures.
Optical Class: Uniaxial (–). $\omega = 1.607(2)$ $\epsilon = 1.604(2)$

Cell Data: *Space Group:* $P6_3/mmc$, $P\bar{6}2c$, or $P6_3mc$. a = 9.77(2) $c = 33.01(7)$ Z = 1

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.764 (100), 3.35 (90), 1.847 (90), 16.1 (70), 3.07 (70), 3.14 (60), 2.965 (50)

Chemistry:

	(1)
SiO_2	49.8
Al_2O_3	4.6
FeO	0.2
MnO	0.2
ZnO	8.1
MgO	0.1
CaO	32.0
Na_2O	0.2
K_2O	1.9
H_2O	2.84
Total	99.9

(1) Franklin, New Jersey, USA; by electron microprobe, H_2O by the Penfield method; corresponds to $K_{1.9}Na_{0.3}Fe_{0.1}Mg_{0.1}Mn_{0.1}Ca_{27.5}Zn_{4.8}Al_{4.4}Si_{39.4}O_{112}(OH)_{15.2}$.

Occurrence: A secondary low-temperature hydrothermal mineral formed by replacement of associated minerals in a metamorphosed stratiform zinc deposit.

Association: Microcline, wollastonite, grossular, vesuvianite, margarosanite, calcite, diopside, lead, allanite.

Distribution: At Franklin, Sussex Co., New Jersey, USA.

Name: For Mine Hill, at Franklin, New Jersey, USA, where the Franklin deposit was exposed at the surface.

Type Material: National Museum of Natural History, Washington, D.C., USA, C6411, C6412, 150332.

References: (1) Dunn, P.J., D.R. Peacor, P.B. Leavens, and F.J. Wicks (1984) Minehillite, a new layer silicate from Franklin, New Jersey, related to reyerite and truscottite. Amer. Mineral., 69, 1150–1155.

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Minguzzite $K_3Fe^{3+}(C_2O_4)_3 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 0.1 mm, showing {010}, {11$\bar{1}$}, {111}, {110}.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = n.d. D(meas.) = 2.080 D(calc.) = 2.156 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Green to yellow-green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = yellow-green; Z = intense emerald-green. $\alpha = 1.498$ $\beta = 1.554$ $\gamma = 1.594$ 2V(meas.) = n.d. 2V(calc.) = 78°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 7.66(2)$ $b = 19.87(1)$ $c = 10.27(2)$ $\beta = 105°6'$ Z = 4

X-ray Powder Pattern: Synthetic.
6.9 (100), 3.61 (65), 2.18 (65), 2.67 (60), 10.2 (55), 4.96 (55), 3.16 (45)

Chemistry:

	(1)	(2)
C_2O_3	42.13	43.98
Al_2O_3	0.10	
Fe_2O_3	16.05	16.26
FeO	2.28	
MgO	0.10	
CaO	0.03	
K_2O	26.00	28.76
H_2O^+	11.35	
H_2O^-	1.60	
H_2O		11.00
insol.	0.10	
Total	99.74	100.00

(1) Capo Calamita, Elba, Italy; average of five partial analyses. (2) $K_3Fe(C_2O_4)_3 \cdot 3H_2O$.

Occurrence: Rare, in an oxidized gossan formed in a calcareous dolomite.

Association: Humboldtine, "limonite".

Distribution: From Capo Calamita, Elba, Italy.

Name: To honor Professor Carlo Minguzzi (1910–1953), Italian mineralogist, University of Pavia, Pavia, Italy.

Type Material: University of Florence, Florence, Italy, 1971/I.

References: (1) Garavelli, C.L. (1955) Un nuovo minerale tra i prodotti secondari del giacimento di Capo Calamita (Isola d'Elba). Atti Rend. Accad. Lincei, 18, 392–402 (in Italian). (2) (1956) Amer. Mineral., 41, 370 (abs. ref. 1). (3) Herpin, P. (1958) Structure cristalline des trioxalates complexes de potassium. Bull. Minéral., 81, 245–256 (in French).

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Minium $Pb_2^{2+}Pb^{4+}O_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Scaly; commonly earthy, pulverulent, massive.

Physical Properties: Hardness = 2.5 D(meas.) = 8.9–9.2 (synthetic). D(calc.) = [8.92]

Optical Properties: Semitransparent. *Color:* Scarlet to brownish red, may have a yellowish tint; red in transmitted light. *Streak:* Yellow-orange. *Luster:* Dull to slightly greasy. *Optical Class:* Uniaxial; may be weakly birefringent with anomalous green interference colors. *Pleochroism:* Strong; X = deep reddish brown; Z = nearly colorless. *Orientation:* Extinction parallel; elongation negative. $n = 2.42(2)$ (Li).

Cell Data: *Space Group:* $P4_2/mbc$ (synthetic). $a = 8.811(5)$ $c = 6.563(3)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.38 (100), 2.903 (50), 2.787 (45), 2.632 (30), 1.775 (30), 3.113 (20), 1.903 (20)

Chemistry:

	(1)	(2)
PbO_2		34.89
Pb_3O_4	97.02	
Fe_2O_3	2.70	
ZnO	0.26	
PbO		65.11
CaO	trace	
SiO_2	trace	
Total	99.98	100.00

(1) Santa Marta, Spain. (2) $Pb_2^{2+}Pb^{4+}O_4$.

Occurrence: A rare secondary mineral in some highly oxidized lead-bearing mineral deposits; may form during mine fires.

Association: Galena, cerussite, massicot, litharge, lead, wulfenite, mimetite.

Distribution: Many localities, but only in small amounts. In Germany, at Langhecke, Hesse; Badenweiler, Baden-Württemberg; Bleialf, Eifel district; Horhausen, Rhineland-Palatinate, and many other places. At Mies (Mežica), Slovenia. From Leadhills, Lanarkshire, Scotland. At Castelberg, near St. Avold, Moselle, France. From Långban, Värmland, Sweden. At Sarrabus, Sardinia, Italy. In the Tchah Khuni and Tchah Milleh mines, near Anarak, Iran. From Tsumeb, Namibia. In the USA, in the Jay Gould mine, Alturas Co., Idaho; an important ore in the Leadville district, Lake Co., Colorado; in the Tonopah-Belmont mine, Osborne district, Maricopa Co., Arizona. From Eschuchapa, Guerrero, and other places in Mexico.

Name: From the Latin, through Spanish, for *cinnabar*, which was once adulterated with red lead oxide, now applied exclusively to that compound.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 517–519. (2) Liso, M.J., J. Guixa, C. Galindo, and A. Lopez (1980) Study on minium of Santa Maria (Badajoz) [Spain]. Comun. Reun. Cient. Soc. Esp. Mineral., 2nd., 189–195 (in Spanish). (3) (1982) Chem. Abs., 97, 167–168 (abs. ref. 2). (4) Gavarri, J.-R. and D. Weigel (1975) Oxydes de plomb. I. Structure cristalline du minium Pb_3O_4, à température ambiant (293 K). J. Solid State Chem., 13, 252–257 (in French with English abs.). (5) (1959) NBS Circ. 539, 8, 32.

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Minnesotaite $(Fe^{2+},Mg)_3Si_4O_{10}(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. In microscopic plates or needles, the latter radiating or in sheaves; fibrous, rarely platy. *Twinning:* Inferred from single-crystal X-ray photographs.

Physical Properties: *Cleavage:* Perfect micaceous on {001}. Hardness = Soft.
D(meas.) = 3.01 D(calc.) = [2.97]

Optical Properties: Semitransparent. *Color:* Greenish gray to olive-green. *Luster:* Greasy to waxy, dull.
Optical Class: Biaxial. *Pleochroism:* X = pale green; Z = colorless to pale greenish yellow.
α = 1.580–1.592 β = n.d. γ = 1.615–1.632 2V(meas.) = Small.

Cell Data: *Space Group:* $P\bar{1}$. $a = 5.623(2)$ $b = 9.419(2)$ $c = 9.624(3)$ $\alpha = 85.21(3)^\circ$ $\beta = 95.64(3)^\circ$ $\gamma = 90.00(2)^\circ$ Z = 4

X-ray Powder Pattern: Cuyuna district, Minnesota, USA.
9.54 (100), 4.62 (58), 3.18 (50), 2.528 (45), 2.655 (35), 2.405 (32), 2.759 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	51.29	52.30	CaO	0.00	0.04
TiO_2	0.04		Na_2O	0.08	0.04
Al_2O_3	0.61	0.07	K_2O	0.03	
Fe_2O_3	2.00		H_2O^+	5.54	
FeO	33.66	35.85	H_2O^-	0.24	
MnO	0.12	1.31	H_2O		8.31
MgO	6.26	2.08	Total	99.87	100.00

(1) Mesabi district, Minnesota, USA; corresponding to $(Fe_{2.28}Mg_{0.72}Mn_{0.01})_{\Sigma=3.01}(Si_{3.95}Al_{0.05})_{\Sigma=4.00}O_{10}(OH)_2$. (2) Emilia-San Valentin deposit, Spain; by electron microprobe, corresponding to $(Fe_{2.62}Mg_{0.28}Mn_{0.10})_{\Sigma=3.00}Si_4O_{10}(OH)_2$.

Occurrence: In banded iron formations subjected to low-grade regional metamorphism.

Association: Quartz, siderite, stilpnomelane, greenalite (Mesabi Range, Minnesota, USA).

Distribution: In the USA, in the Mesabi and Cuyuna districts, St. Louis Co., Minnesota. From a number of places in the Sokoman Iron Formation, Howells River area, Labrador, Newfoundland; and in the Blue Bell mine, Riondel, British Columbia, Canada. In the Mamatwan mine, near Kuruman, Cape Province, South Africa. In the Emilia-San Valentin Pb–Zn deposit, Sierra de Cartagena, Murcia Province, Spain. From Tynagh, near Killimor, Co. Galway, Ireland. At The Lizard, Cornwall, England. From Hagendorf, Bavaria, Germany. In the Marra Mamba and Brockman Iron Formations, Hamersley basin, and in the Weld Range, Western Australia.

Name: For the State of Minnesota, USA, from which it was first described.

Type Material: n.d.

References: (1) Gruner, J.W. (1944) The composition and structure of minnesotaite, a common iron silicate in iron formations. Amer. Mineral., 29, 363–372. (2) Blake, R.L. (1965) Iron phyllosilicates of the Cuyuna district in Minnesota. Amer. Mineral., 50, 148–169. (3) Guggenheim, S. and S.W. Bailey (1982) The superlattice of minnesotaite. Can. Mineral., 20, 579–584. (4) Kager, P.C.A. and I.S. Oen (1983) Iron-rich talc-opal-minnesotaite spherulites and crystallochemical relations of talc and minnesotaite. Mineral. Mag., 47, 229–231. (5) Guggenheim, S. and R.A. Eggleton (1986) Structural modulations in iron-rich and magnesium-rich minnesotaite. Can. Mineral., 24, 479–497.

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Minrecordite $CaZn(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Mosaic rhombohedral crystals, showing only $\{10\overline{1}4\}$, to 0.5 mm, saddle-shaped and strongly twisted.

Physical Properties: *Cleavage:* On $\{10\overline{1}4\}$, prominent. Hardness = 3.5 D(meas.) = 3.45(2) D(calc.) = 3.445

Optical Properties: Semitransparent. *Color:* Milky white to colorless. *Luster:* Vitreous to pearly.
Optical Class: Uniaxial (–). $\omega = 1.734$–1.750 $\epsilon = 1.542$–1.550

Cell Data: *Space Group:* $R\overline{3}$. $a = 4.8183(4)$ $c = 16.0295(10)$ Z = n.d.

X-ray Powder Pattern: Tsumeb, Namibia; similar to dolomite.
2.890 (100), 1.789 (40), 1.806 (33), 2.410 (25), 3.701 (20), 2.196 (20), 2.019 (15)

Chemistry:

	(1)	(2)
CO_2	[39.50]	39.04
FeO	1.10	
MnO	0.10	
ZnO	33.46	36.09
MgO	1.20	
CaO	24.64	24.87
Total	[100.00]	100.00

(1) Tsumeb, Namibia; recalculated from an analysis presented as carbonates, CO_2 from stoichiometry; corresponds to $Ca_{0.98}(Zn_{0.92}Mg_{0.06}Fe_{0.03})_{\Sigma=1.01}(CO_3)_2$. (2) $CaZn(CO_3)_2$.

Mineral Group: Dolomite group.

Occurrence: In a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia); from the wallrock of a carbonate-hosted Pb–Zn orebody (Navan deposit, Ireland).

Association: Dioptase, duftite, malachite, cerussite, zincian dolomite, calcite (Tsumeb, Namibia); sphalerite, pyrite, melnikovite, magnesian calcite, dolomite, calcite, quartz (Navan deposit, Ireland).

Distribution: From Tsumeb, Namibia. In the Navan Pb–Zn orebody, Co. Meath, Ireland. At the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: For the MINeralogical RECORD magazine, in recognition of that journal's contributions to a beneficial interaction between professional and amateur mineralogists.

Type Material: Institute of Mineralogy, Bari University, Bari, Italy, HO-4/81.

References: (1) Garavelli, C.G., F. Vurro, and G.C. Fioravanti (1982) Minrecordite, a new mineral from Tsumeb. Mineral. Record, 13, 131–136. (2) (1983) Amer. Mineral., 68, 281 (abs. ref. 1).

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Minyulite $KAl_2(PO_4)_2(OH,F)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As radiating fibrous to prismatic crystals, elongated along [001] with {110} and {111} terminations; usually in subparallel growth or as spherules, to 15 cm.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.45 D(calc.) = 2.47

Optical Properties: Transparent. *Color:* Colorless to white, greenish yellow; colorless in transmitted light. *Luster:* Vitreous, silky in aggregates.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.531$ $\beta = 1.534$ $\gamma = 1.538$ 2V(meas.) = Large.

Cell Data: *Space Group:* $Pba2$. $a = 9.337(5)$ $b = 9.740(5)$ $c = 5.522(3)$ Z = 2

X-ray Powder Pattern: Dandarragan, Australia. (ICDD 37–467).
5.519 (100), 3.349 (55), 3.402 (45), 6.75 (35), 3.068 (35), 2.681 (25), 2.967 (23)

Chemistry:

	(1)	(2)
P_2O_5	35.58	38.00
Al_2O_3	29.98	27.79
Fe_2O_3	trace	0.80
MgO	0.00	0.08
CaO	0.00	0.76
Na_2O	0.45	0.24
K_2O	12.30	10.35
F	trace	2.7
H_2O^+	2.79	
H_2O^-	17.84	
H_2O		20.4
$-O = F_2$		1.1
Total	98.94	100.0

(1) Minyulo Well, Australia. (2) Wait's quarry, Noarlunga, Australia; corresponds to $(K_{0.82}Ca_{0.05}Na_{0.03})_{\Sigma=0.90}(Al_{2.04}Fe_{0.08})_{\Sigma=2.12}(PO_4)_{2.00}[F_{0.55}(OH)_{0.45}]_{\Sigma=1.00}\cdot 4.00H_2O$.

Occurrence: In weathered glauconitic phosphatic ironstone (Australia).

Association: Dufrénite, apatite, fluellite, wavellite, variscite, leucophosphite.

Distribution: In Australia, from near Minyulo Well, Dandarragan, Western Australia; in Wait's quarry and Oliver's quarry, near Noarlunga, 32 km south of Adelaide; in the Moculta phosphate quarry, northeast of Angaston, and from the St. John's quarry, seven km southeast of Kapunda, Mount Lofty Ranges, South Australia; at Wolfdene, near Beenleigh, Queensland. On Elephant Island, South Shetland Islands, about 800 km southeast of Cape Horn, British Antarctic Territory, Antarctica. From the Pereta mine, Scansano, Tuscany, Italy. In Belgium, at Richelle, near Visé, and at Blaton, Hainaut. Large crystal aggregates from Pannecé, Loire-Atlantique, France. In the USA, found near Cockalorum Wash, Nye Co., and at the Willard mine, Willard district, Pershing Co., Nevada; in the Ross Hannibal mine, Lawrence Co., South Dakota; on Utahlite Hill, eight km northwest of Lucin, Box Elder Co., Utah.

Name: For Minyulo Well, Western Australia, near the source of the first specimens.

Type Material: Western Australian Museum, Perth, Australia, M68.1991, CT S2034; The Natural History Museum, London, England, 1933,84; National Museum of Natural History, Washington, D.C., USA, 96769.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 970. (2) Spencer, L.J., F.A. Bannister, M.H. Hey, and H. Bennett (1943) Minyulite (hydrous K-Al fluophosphate) from South Australia. Mineral. Mag., 26, 309–314.
(3) Kampf, A.R. (1977) Minyulite: its atomic arrangement. Amer. Mineral., 62, 256–262.
(4) Menchetti, S. and C. Sabelli (1981) Minyulite, associated with fluellite, from Pereta, Tuscany, Italy. Neues Jahrb. Mineral., Monatsh., 505–510.

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Mirabilite $Na_2SO_4 \cdot 10H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals short to long prismatic, with complex form development, also crude, to 10 cm, in interlocking masses; crystalline, granular to compact massive, commonly as efflorescences. *Twinning:* Rare on {001} or {100}.

Physical Properties: *Cleavage:* On {100}, perfect; on {010} and {001}, good to fair. *Fracture:* Conchoidal. Hardness = 1.5–2.5 D(meas.) = 1.464 D(calc.) = 1.467 Quickly dehydrates to thénardite in dry air; very soluble in H_2O, taste cool, then saline and bitter.

Optical Properties: Transparent to opaque. *Color:* Colorless to white; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 31°$. *Dispersion:* $r < v$, strong, crossed. $\alpha = 1.391$–1.394 $\beta = 1.394$–1.396 $\gamma = 1.396$–1.398 2V(meas.) = 75°56′

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 11.512(3)$ $b = 10.370(3)$ $c = 12.847(2)$ $\beta = 107.789(10)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 11-647).
5.49 (100), 3.21 (75), 3.26 (60), 3.11 (60), 4.77 (45), 3.83 (40), 2.516 (35)

Chemistry:

	(1)	(2)
SO_3	25.16	24.85
Na_2O	18.67	19.24
H_2O	55.28	55.91
Total	99.11	100.00

(1) Kirkby Thore, Westmoreland, England. (2) $Na_2SO_4 \cdot 10H_2O$.

Occurrence: Typically in salt pans, playas, and saline lakes, where deposition may be seasonal, and bedded deposits formed therefrom; rarely in caves and lava tubes; in volcanic fumaroles; a product of hydrothermal sericitic alteration; a post-mining precipitate.

Association: Gypsum, thénardite, halite, trona, glauberite, aphthitalite, blödite, epsomite.

Distribution: Only a few prominent localities are represented here. In Austria, at Hallein, Hallstatt, and Ischl. In Italy, on Vesuvius, and at Campi Flegrei, near Naples, Campania; on Vulcano, Lipari Islands. In the Salar de Pintados, near La Guaica, Atacama Desert, Tarapacá, and at Chuquicamata, Antofagasta, Chile. In the USA, at Soda Lake, San Luis Obispo Co., and in Searles Lake, San Bernardino Co., California; along Great Salt Lake, Davis Co., Utah; at Lake Lucero, west of Valmont, Doña Ana Co., New Mexico; around Downey and Union Pacific Lakes, Albany Co., Wyoming; in Mammoth Cave, southwest central Kentucky.

Name: From the Latin *sal mirable*, for *miracle salt*, expressing Glauber's surprise on its synthesis.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 439–442. (2) Ericksen, G.E., M.E. Mrose, and J.J. Fahey (1970) Ice-clear mirabilite from Salar de Pintados, northern Chile. Mineral. Record, 1, 12–25. (3) Levy, H.A. and G.C. Lisensky (1978) Crystal structures of sodium sulfate decahydrate (Glauber's salt) and sodium tetraborate decahydrate (borax). Redetermination by neutron diffraction. Acta Cryst., 34, 3502–3510.

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Misenite $H_6K_8(SO_4)_7(?)$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals are needlelike or laths, elongated along [100] and flattened on {001}, to more than 3 mm, in fibrous masses and aggregates.

Physical Properties: *Cleavage:* On {010}, distinct. Hardness = n.d. D(meas.) = 2.32 D(calc.) = [2.37] Soluble in H_2O, taste bitter and acid.

Optical Properties: Transparent to translucent. *Color:* Grayish white; colorless in transmitted light. *Luster:* Pearly to silky.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 29°$. $\alpha = 1.475(3)$ $\beta = 1.480(3)$ $\gamma = 1.487(3)$ 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. $a = 23.00$ $b = 7.104$ $c = 8.710$ $\beta = 102.66°$ Z = [2]

X-ray Powder Pattern: Cape Miseno, Italy. (ICDD 41-1363).
4.24 (100), 3.648 (57), 4.92 (43), 4.83 (37), 3.592 (33), 3.490 (27), 2.892 (27)

Chemistry:

	(1)	(2)
SO_3	56.45	56.54
Al_2O_3		trace
K_2O	38.32	38.01
H_2O	5.23	5.45
Total	[100.00]	100.00

(1) Cape Miseno, Italy; recalculated to 100% after deduction of an unstated amount of hygroscopic H_2O. (2) $H_6K_8(SO_4)_7$.

Occurrence: Very rarely formed under fumarolic conditions.

Association: Potassium alum, alunogen, halotrichite, metavoltine, pickeringite, sulfur, tamarugite, voltaite (Cape Miseno, Italy).

Distribution: From the Grotto del Solfo fumarole, Cape Miseno, Campi Flegrei, near Naples, and on Vesuvius, Campania, Italy.

Name: For its occurrence on Cape Miseno, Italy.

Type Material: Natural History Museum, Paris, France, 100781; The Natural History Museum, London, England, 60393.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 396–397.

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Miserite $\mathbf{K(Ca,Ce)_6Si_8O_{22}(OH,F)_2}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals, unterminated, to 12 mm. Prismatic fragments are largely composed of fine fibers; in cleavable masses. *Twinning:* Lamellar.

Physical Properties: *Cleavage:* Perfect on {100}, imperfect on {010}.
Fracture: Subconchoidal to uneven. Hardness = 5.5–6 D(meas.) = 2.84–2.93
D(calc.) = 2.80

Optical Properties: Transparent to translucent. *Color:* Red-brown, raspberry-red, pink, with a lavender hue where weathered. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z \simeq a$ on {100}; $Y \wedge c \simeq 2°$ on {100}; $Y \wedge c = 11°$ on {010}. *Dispersion:* $r > v$, weak. $\alpha = 1.576$–1.587 $\beta = 1.583$–1.589 $\gamma = 1.591$–1.594
2V(meas.) = 65°–86° 2V(calc.) = 65°–87°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.100(5)$ $b = 16.014(7)$ $c = 7.377(5)$ $\alpha = 96°25(3)'$ $\beta = 111°9(3)'$ $\gamma = 76°34(2)'$ Z = 2

X-ray Powder Pattern: Kipawa Lake, Canada.
15.42 (100), 3.14 (90), 3.18 (80), 3.17 (80), 1.667 (66), 2.377 (65), 3.106 (64)

Chemistry:

	(1)		(1)
SiO_2	50.18	Yb_2O_3	0.47
Al_2O_3	0.60	Lu_2O_3	0.04
Y_2O_3	3.34	FeO	0.14
La_2O_3	0.59	MnO	0.45
CeO_2	1.00	MgO	0.37
Pr_6O_{11}	0.21	CaO	31.00
Nd_2O_3	0.86	Na_2O	0.81
EuO	0.04	K_2O	5.58
Dy_2O_3	0.58	F	2.04
Er_2O_3	0.31	H_2O	0.55
Tm_2O_3	0.03	Total	99.19

(1) Kipawa Lake, Canada; by electron microprobe, augmented by separate analyses for F, Cl, H_2O; corresponds to $K_{1.14}(Ca_{5.29}Y_{0.28}RE_{0.22})_{\Sigma=5.79}Si_{8.00}O_{22}[F_{1.03}(OH)_{0.28}]_{\Sigma=1.31}$.

Occurrence: In banded metamorphosed shales at the contact with a dike of nepheline syenite (Wilson Springs, Arkansas, USA); in a carbonatite vein (Kipawa Lake, Canada); in quartz-albite-aegirine veinlets and in albitites in syenites (Dara-i-Pioz massif, Tajikistan).

Association: Wollastonite, orthoclase, aegirine (Wilson Springs, Arkansas, USA); "hornblende," eudialyte, scapolite, fluorite, mosandrite (Kipawa Lake, Canada); baratovite, ekanite, titanite (Dara-i-Pioz massif, Tajikistan).

Distribution: In the USA, from the Wilson Springs (Potash Sulphur Springs) mine, between Hot Springs and Magnet Cove, Garland Co., Arkansas, and at Wausau, Marathon Co., Wisconsin. In Canada, from the [Sheffield Lake complex,] Kipawa River, Villedieu Township, and at Mont Saint-Hilaire, Quebec. From the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. In the Murun massif, southwest of Olekminsk, Yakutia, and other less-well-defined localities in Russia.

Name: For Dr. Hugh Dinsmore Miser (1884–1969), geologist with the U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA.

References: (1) Schaller, W.T. (1950) Miserite from Arkansas; a renaming of natroxonotlite. Amer. Mineral., 35, 911–921. (2) Berry, L.G., H.-C. Lin, and G.C. Davis (1972) A new occurrence of miserite from the Kipawa Lake area, Temiscamingue Co., Quebec. Can. Mineral., 11, 569 (abs.). (3) Scott, J.D. (1976) Crystal structure of miserite, a Zoltai type 5 structure. Can. Mineral., 14, 515–528. (4) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 141.

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Mitridatite $Ca_2Fe_3^{3+}O_2(PO_4)_3 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group: m.* Rarely as thin tabular pseudorhombohedral crystals, to 2 mm, comprised of {100}, {001}, {$\bar{4}$23}; more commonly massive, as nodules, veins, and crusts.

Physical Properties: *Cleavage:* Good on {100}. *Tenacity:* Typically pulverulent, friable, gumlike. Hardness = 2.5 if compact. D(meas.) = 3.24(2) D(calc.) = 3.249

Optical Properties: Translucent to opaque. *Color:* Olive-green, greenish yellow, brownish green, brownish black, red, bronzy-red. *Streak:* Olive-green. *Luster:* Dull, earthy to resinous. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = pale greenish yellow; $Y = Z$ = deep greenish brown, red. *Absorption:* $Y = Z > X$. α = 1.762–1.785 β = n.d. γ = 1.770–1.85 2V(meas.) = 5°–10°

Cell Data: *Space Group: Aa.* a = 17.553(2) b = 19.354(3) c = 11.248(2) β = 95.84(1)° Z = 12

X-ray Powder Pattern: White Elephant mine, South Dakota, USA.
8.64 (10), 2.721 (7), 5.55 (6), 3.20 (4), 2.881 (4), 2.562 (4), 2.169 (4)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	31.5	34.41	CaO	17.4	18.13
Fe_2O_3	35.6	38.72	H_2O	12.8	8.74
Mn_2O_3	2.7		Total	100.0	100.00

(1) White Elephant mine, South Dakota, USA. (2) $Ca_2Fe_3O_2(PO_4)_3 \cdot 3H_2O$.

Occurrence: A common stain or crust on minerals near oxidizing ferrous phosphate minerals, typically triphylite or vivianite in granite pegmatite; a component of cement or fossil replacements in some ferruginous oölitic sediments; in phosphatic soils.

Association: Triphylite, vivianite, rockbridgeite, heterosite, huréaulite, fairfieldite, cyrilovite, jahnsite, collinsite, apatite, iron hydroxides.

Distribution: Probably more widespread than the literature suggests. Well-studied material occurs at: the Kamysh-Burun iron deposit and numerous other localities near Kerch, Crimean Peninsula, Ukraine. On the Taman Peninsula, and at the Voron'i massif, Kola Peninsula, Russia. In South Africa, in the Boons and West Driefontein Caves, Transvaal. In the USA, from the Tip Top, White Elephant, Bull Moose, and Linwood mines, near Custer, Custer Co., and the Gap Lode pegmatite, Pennington Co., South Dakota; in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire. At Glen Chosaidh, Loch Quoich, Inverness-shire, Scotland. In the Gunheath china clay pit, St. Austell, Cornwall, England. From Hagendorf, Bavaria, Germany. In the Mangualde pegmatite, near Mesquitela, and in the Bendada pegmatite, near Guarda, Portugal. At the Spring Creek mine, near Wilmington, South Australia. From the Rubicon and Tsaobismund pegmatites, south of Karibib, Namibia.

Name: For Mt. Mithridat [named for King Mithridates], within the city of Kerch, Ukraine, near which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87594.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 955–956. (2) Moore, P.B. (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. II. Redefinition of overite, an isotype of segelerite. III. (with J. Ito) Isotypy of robertsite, mitridatite, and arseniosiderite. Amer. Mineral., 59, 48–59. (3) Moore, P.B. and T. Araki (1977) Mitridatite: a remarkable octahedral sheet structure. Mineral. Mag., 41, 527–528 and M8–M9. (4) Moore, P.B. and T. Araki (1977) Mitridatite, $Ca_6(H_2O)_6[Fe_9^{III}O_6(PO_4)_9] \cdot 3H_2O$. A noteworthy octahedral sheet structure. Inorg. Chem., 16, 1096–1106.

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Mitryaevaite $\mathbf{Al_{11}(PO_4,SO_3OH)_{10}F_3 \cdot 30H_2O}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As prismatic crystals, to 0.04 mm, rarely in globular nodules; massive, in veinlets and powdery coatings.

Physical Properties: *Cleavage:* On {001}, perfect; on {010}, {100}, good. Hardness = n.d. D(meas.) = 2.02 D(calc.) = 2.033

Optical Properties: Transparent in microcrystals. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous, dull in massive nodules.
Optical Class: Biaxial. *Orientation:* $Z \wedge b = 14°$; positive elongation. $\alpha = 1.504(1)$ $\beta =$ n.d. $\gamma = 1.515(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 6.92(1)$ $b = 10.09(1)$ $c = 22.46(1)$ $\alpha = 92.42(4)°$ $\beta = 96.43(7)°$ $\gamma = 104.3(2)°$ Z = 1

X-ray Powder Pattern: Kazakhstan.
9.75 (10), 6.35 (3), 9.24 (2), 3.333 (2), 3.222 (2), 2.923 (2), 7.54 (1)

Chemistry:

	(1)	(2)
SO_3	5.50	5.49
P_2O_5	32.40	32.50
SO_2	trace	
Al_2O_3	30.00	29.47
Fe_2O_3	0.30	2.40
MgO	trace	
CaO	0.90	0.74
F	3.00	
H_2O^+	27.80	
H_2O^-	1.90	
H_2O		[29.40]
$-O = F_2$	1.27	
Total	100.53	[100.00]

(1) Kazakhstan; H_2O by TGA, corresponds to $Al_{10.08}[(PO_4)_{8.71}(SO_3OH)_{1.29}]_{\Sigma=10.00}$ $Al_{1.00}[F_{2.97}(OH)_{0.03}]_{\Sigma=3.00} \cdot 29.63H_2O$. (2) Do.; by electron microprobe, average of four analyses, total Fe as Fe_2O_3, thought high due to a film of secondary goethite on the surface, H_2O by difference.

Occurrence: A secondary mineral in fractures and veinlets, in altered and oxidized vanadium-bearing phosphatic black shales.

Association: Minyulite, crandallite, gorceixite, wavellite, variscite, evansite, aluminite, meta-aluminite, kaolinite, hewettite, gypsum.

Distribution: In the Kurumsak Formation, from the Taldyk mining district, northwestern Kara-Tau Range to the Zhabagly Mountains, Tien-Shan, southern Kazakhstan.

Name: To honor Dr. Nonna Mikhailovna Mitryaeva (1920–), for her contributions to the mineralogy of Kazakhstan.

Type Material: Geological Museum, Satpaev Institute of Geological Sciences, Alma-Ata, Kazakhstan, GM IGS 24/1270.

References: (1) Ankinovich, E.A., G.K. Bekenova, T.A. Shabanova, I.S. Zazubina, and S.M. Sandomirskaya (1997) Mitryaevaite, $Al_{10}[(PO_4)_{8.7}(SO_3OH)_{1.3}]_{\Sigma 10}AlF_3 \cdot 30H_2O$, a new mineral species from a Cambrian carbonaceous chert formation, Karatau Range and Zhabagly Mountains, southern Kazakhstan. Can. Mineral., 35, 1415–1419. (2) (1999) Amer. Mineral., 84, 194–195 (abs. ref. 1).

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Mitscherlichite $K_2CuCl_4 \cdot 2H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$ (probable). Crystals, short prismatic along [001], or pyramidal {011}, minute; in stalactitic growths.

Physical Properties: Hardness = 2.5 D(meas.) = 2.418 D(calc.) = [2.39]

Optical Properties: Transparent. *Color:* Greenish blue; colorless in transmitted light.
Luster: Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = sky-blue; E = grass-green. *Absorption:* $O > E$.
$\omega = 1.6365$ $\epsilon = 1.6148$

Cell Data: *Space Group:* $P4_2/mnm$, probable, synthetic. a = 7.477(13) $c = 7.935(19)$
Z = 2

X-ray Powder Pattern: Synthetic.
2.635 (100), 2.711 (95), 5.42 (70), 3.164 (50), 3.072 (25), 1.977 (25), 1.5814 (25)

Chemistry: Natural samples were shown to contain only K, $CuCl_2$, and H_2O; no more complete analyses of natural material appear to have been made.

Occurrence: A volcanic sublimate (Vesuvius, Italy); an alteration product of ponomarevite (Tolbachik volcano, Russia).

Association: Sylvite, metavoltine, gypsum (Vesuvius, Italy); ponomarevite, tolbachite, dolerophanite, piypite, chalcocyanite, halite, sylvite, tenorite (Tolbachik volcano, Russia).

Distribution: In the crater of Vesuvius, Campania, Italy. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Eilhardt Mitscherlich (1794–1863), German crystallographer and chemist, who first synthesized the compound.

Type Material: University of Florence, Florence, Italy, 225/l; The Natural History Museum, London, England, 1928,239.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 100–101. (2) Chidambaram, R., Q.O. Navarro, A. Garcia, K. Linggoatmodjo, L. Shi-Chien, and I.-H. Suh (1970) Neutron diffraction refinement of the crystal structure of potassium copper chloride dihydrate, $K_2CuCl_4 \cdot 2H_2O$. Acta Cryst., 26, 827–830. (3) (1971) NBS Mono. 25, 9, 34.

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Mixite **$BiCu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$**

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As acicular crystals, elongated along [0001], commonly in mats, radial fibrous aggregates, or cross-fiber veinlets.

Physical Properties: Hardness = 3–4 D(meas.) = 3.79–3.83 D(calc.) = [4.04]

Optical Properties: Transparent to translucent. *Color:* Blue-green to emerald-green, pale green, white; pale green to colorless in transmitted light. *Streak:* Pale bluish green. *Luster:* Vitreous, silky in aggregates.
Optical Class: Uniaxial (+). *Pleochroism:* O = colorless; E = bright green.
Absorption: $E > O$. $\omega = 1.743–1.749$ $\epsilon = 1.810–1.830$

Cell Data: *Space Group:* $P6_3/m$. $a = 13.646(2)$ $c = 5.920(1)$ $Z = 2$

X-ray Powder Pattern: Anton mine, Germany.
12.03 (10), 2.46 (9), 3.57 (8), 2.95 (7), 2.86 (6), 2.70 (6), 2.57 (6)

Chemistry:

	(1)	(2)	(3)
P_2O_5	1.05	0.06	
As_2O_5	29.51	28.79	29.64
SiO_2		0.42	
Fe_2O_3		0.97	
Bi_2O_3	12.25	11.18	20.03
FeO	1.52		
CuO	44.23	43.89	41.04
ZnO		2.70	
CaO	0.83	0.26	
H_2O	11.06	11.04	9.29
Total	100.45	99.31	100.00

(1) Jáchymov, Czech Republic. (2) Tintic district, Utah, USA. (3) $BiCu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$.

Mineral Group: Mixite group.

Occurrence: An uncommon secondary mineral in the oxidized zone of copper deposits.

Association: Bismutite, smaltite, bismuth, atelestite, erythrite, malachite, barite.

Distribution: From the Geister vein, Werner mine, Jáchymov (Joachimsthal), Czech Republic. At Wheals Owles and Edwards, St. Just, and several other mines in Cornwall, England. In Germany, in the Black Forest, at the Anton mine, Heubachtal, near Schiltach; on the Schmiedestollen dump, near Wittichen; from the Clara mine, near Oberwolfach; from Neubulach; and in the Hechtsberg quarry, near Hausach; in Hesse, at Reichenbach, near Bensheim; in Saxony, from Schneeberg, Schwarzenberg, and in the Sadisdorf copper mine, near Schmiedeberg. At the Cap Garonne mine, near le Pradet, Var, France. From the Kamariza mine, Laurium, Greece. At Tsumeb, Namibia. In the Bonanza mine, Concepción del Oro, Zacatecas, Mexico. In the USA, from the Mammoth and other mines, Tintic district, Juab Co., and at the Gold Hill mine, Tooele Co., Utah; in the Majuba Hill mine, Antelope district, Pershing Co., Nevada; from the Mammoth-St. Anthony mine, Tiger, Pinal Co., and at the Joe Shaft, Tombstone, Cochise Co., Arizona; from Granite Gap, San Simon district, Hidalgo Co., New Mexico; at the Cerro Gordo mine, Inyo Co., California. A number of other localities are known.

Name: Honors Anton Mixa, a mining official from Příbram, who found the mineral at Jáchymov, Czech Republic.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 943–944. (2) Walenta, K. (1960) Chlorotil und Mixit. Neues Jahrb. Mineral., Monatsh., 223–236 (in German). (3) Mereiter, K., and A. Preisinger (1986) Kristallstrukturdaten der Wismutminerale Atelestit, Mixit, und Pucherit. Anzeiger der Österr. Akad. Wiss. math.-naturw. Kl., 123, 79–81 (in German).

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Miyahisaite $(Sr,Ca)_2Ba_3(PO_4)_3F$

Crystal Data: Hexagonal. *Point Group*: 6/*m*. As irregular grains to 10 μm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 5
D(meas.) = n.d. D(calc.) = 4.511

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous.
Optical Class: n.d.

Cell Data: *Space Group*: $P6_3/m$. a = 9.921(2) c = 7.469(3) Z = 2

X-ray Powder Pattern: Shimoharai mine, Oita Prefecture, Japan.
2.981 (100), 1.976 (23), 3.248 (22), 2.865 (21), 1.864 (17), 3.427 (16), 1.874 (16)

Chemistry:

	(1)	(2)
CaO	4.69	
SrO	16.51	23.25
BaO	52.05	51.62
P_2O_5	24.85	23.89
F	1.99	2.13
Cl	0.06	
-O = Cl+F	0.85	-0.90
H_2O	[0.09]	.
Total	99.39	100.00

(1) Shimoharai mine, Oita Prefecture, Japan; average of 4 electron microprobe analyses, H_2O calculated for charge balance; corresponding to $(Sr_{1.366}Ca_{0.717})_{\Sigma=2.083}Ba_{2.991}P_{3.002}O_{12}(F_{0.898}OH_{0.088}Cl_{0.014})_{\Sigma=1}$. (2) $Sr_2Ba_3(PO_4)_3F$.

Mineral Group: Hedyphane subgroup of the apatite group.

Occurrence: In a metamorphosed (low grade) bedded Mn and chert deposit.

Association: Fluorapatite, namansilite, quartz.

Distribution: From the Shimoharai mine, Yayoi Udoki area, Saiki City, Oita Prefecture, Japan.

Name: Honors Michitoshi Miyahisa (1928-1983) for his contribution to the study of ore deposits on Kyushu.

Type Material: National Museum of Nature and Science, Tokyo, Japan (NSMM-41299).

References: (1) Nishio-Hamane, D., Y. Ogoshi, and T. Minakawa (2012) Miyahisaite, $(Sr,Ca)_2Ba_3(PO_4)_3F$, a new mineral of the hedyphane group in the apatite supergroup from the Shimoharai mine, Oita Prefecture, Japan. Journal of Mineralogical and Petrological Sciences, 107, 121-126. (2) (2014) Amer. Mineral., 99, 1516-1517 (abs. ref. 1).

Moctezumite $Pb(UO_2)(Te^{4+}O_3)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are bladelike, elongated along [010] and flattened on {201}, commonly with curved faces, to 3 mm; in subparallel radiating groups and rosettes.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = ∼3 D(meas.) = 5.73 D(calc.) = 7.256 Radioactive.

Optical Properties: Semitransparent. *Color:* Bright orange, brownish orange to dark orange. *Luster:* Dull.
Optical Class: Biaxial (–). *Orientation:* Parallel extinction. $\alpha = > 2.11$ $\beta = > 2.11$ $\gamma = > 2.11$ 2V(meas.) = 5°–10°

Cell Data: *Space Group:* $P2_1/c$. $a = 7.813(5)$ $b = 7.061(2)$ $c = 13.775(4)$ $\beta = 93.71(2)°$ Z = 4

X-ray Powder Pattern: Moctezuma mine, Mexico.
3.156 (10), 3.492 (9), 2.997 (8), 3.088 (7), 3.385 (6), 2.012 (5), 1.949 (4)

Chemistry:

	(1)	(2)
UO_3	34.20	34.53
TeO_2	40.18	38.53
PbO	25.62	26.94
Total	[100.00]	100.00

(1) Moctezuma mine, Mexico; average of two analyses originally totalling 99.42%; recalculated to 100% after deduction of WO_3 8.63% and CaO 2.09% as scheelite contaminant introduced during separation, Fe_2O_3 0.29%, insoluble 3.26%, and loss on ignition 0.05%; then corresponding to $Pb_{0.94}(UO_2)_{0.98}(TeO_3)_{2.06}$. (2) $Pb(UO_2)(TeO_3)_2$.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal Au–Te deposit.

Association: Schmitterite, burckhardtite, zemannite, emmonsite, pyrite, barite, "limonite".

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: For its occurrence in the Moctezuma mine, Mexico.

Type Material: Natural History Museum, Paris, France, 175.84; Harvard University, Cambridge, Massachusetts, 119086; National Museum of Natural History, Washington, D.C., USA, 128392, 164345, 164346.

References: (1) Gaines, R.V. (1965) Moctezumite, a new lead uranyl tellurite. Amer. Mineral., 50, 1158–1163. (2) Swihart, G.H., P.K. Sen Gupta, E.O. Schlemper, M.E. Back, and R.V. Gaines (1993) The crystal structure of moctezumite $[PbUO_2](TeO_3)_2$. Amer. Mineral., 78, 835–839.

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Modderite (Co, Fe)As

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tiny grains, to 0.05 mm; massive.

Physical Properties: Hardness = ∼4 VHN = 26 D(meas.) = n.d. D(calc.) = 8.28 for CoAs.

Optical Properties: Opaque. *Color:* Bluish white.
R: (400) — , (420) — , (440) 37.1, (460) 38.0, (480) 38.3, (500) 39.1, (520) 39.2, (540) 39.8, (560) 39.7, (580) 39.6, (600) 39.2, (620) 39.0, (640) 38.2, (660) 37.4, (680) 37.1, (700) 35.5
R_1–R_2: n.d.

Cell Data: *Space Group: Pmcn.* $a = 3.458$ $b = 5.869$ $c = 5.292$ Z = 4.

X-ray Powder Pattern: Synthetic CoAs. (ICDD 9-94).
1.97 (100), 2.59 (90), 0.957 (70b), 2.55 (60), 1.047 (60), 0.999 (60), 0.927 (60)

Chemistry:

	(1)
Co	39.2
Fe	5.0
As	56.4
Total	100.6

(1) Dashkesan deposit, Azerbaijan; by electron microprobe, average of 11 grains; corresponding to $(Co_{0.88}Fe_{0.12})_{\Sigma=1.00}As_{1.00}$.

Occurrence: In heavy mineral concentrates (Witwatersrand, South Africa).

Association: Nickeline, alloclasite, safflorite, glaucodot, cobaltite, pentlandite, pyrrhotite, chalcopyrite (Witwatersrand, South Africa); alloclasite, glaucodot, cobaltite, pentlandite, pyrrhotite, chalcopyrite (Dashkesan deposit, Azerbaijan).

Distribution: From the "Far East" Witwatersrand, Transvaal, South Africa [TL]. In the Dashkesan deposit, Middle Caucasus Mountains, Azerbaijan.

Name: Derivation not given; presumably named for the Modderfontein mine, South Africa.

Type Material: National Museum of Natural History, Washington, D.C., USA, 161217.

References: (1) Cooper, R.A. (1923) Mineral constituents of Rand concentrates. J. Chem. Met. and Mining Soc. South Africa, 24, 90. (2) (1926) Amer. Mineral., 11, 77 (abs. ref. 1). (3) Cooper, R.A. (1924) Mineral constituents of Rand concentrates [discussion]. J. Chem. Met. and Mining Soc. South Africa, 24, 264–265. (4) Makhmudov, A.I. and I.P. Laputina (1977) First occurrence of modderite in the USSR. Zap. Vses. Mineral. Obshch., 106, 347–350 (in Russian). (5) Heyding, R.D. and L.D. Calvert (1957) Arsenides of transition metals: the arsenides of ion and cobalt. Can. J. Chem, 35, 449–457.

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Crystal Data: Hexagonal. *Point Group*: 3/*m*. As tabular crystals exhibiting $10\bar{1}\,1\}$, $\{01\bar{1}\,2\}$ and {0001}, to 2 cm.

Physical Properties: *Cleavage*: n.d. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 5.5 D(meas.) = 2.90(1) D(calc.) = 2.908

Optical Properties: Translucent. *Color*: Brown to reddish brown. *Streak*: White.
Luster: Vitreous.
Optical Class: Uniaxial (-). ω = 1.618(1) ε = 1.611(2) *Pleochroism*: Weak, colorless to yellow.

Cell Data: *Space Group*: *R3m*. *a* = 14.232(3) *c* = 30.210(3) Z = n.d.

X-ray Powder Pattern: Kovdor massif, Kola Peninsula, Russia.
3.213 (100), 2.977 (91), 2.859 (79), 3.027 (65), 4.31 (64), 2.703 (46), 2.595 (45)

Chemistry:

	(1)		(1)
Na_2O	9.78	SiO_2	47.49
K_2O	0.36	TiO_2	0.23
CaO	18.03	ZrO_2	11.90
MnO	0.68	Nb_2O_5	1.72
FeO	1.32	Cl	0.52
Fe_2O_3	3.78	H_2O	1.25
La_2O_3	0.15	CO_2	1.42
Ce_2O_3	0.28	-O = Cl	0.12
		Total	98.82

(1) Kovdor massif, Kola Peninsula, Russia; by electron microprobe analysis, IR and Mössbauer spectroscopy, and TGA; corresponding to $Na_9(Ca_{4.05}Na_{0.87}K_{0.24}Ce_{0.06}La_{0.03})_{\Sigma=5.25}Ca_{6.00}(Fe^{3+}_{1.48}Fe^{2+}_{0.58})_{\Sigma=2.06}Mn_{0.30}(Zr_{3.02}Ti_{0.09})_{\Sigma=3.11}(\square,Nb_{0.40})Si_{24.71}O_{72}(OH)_{2.86}(CO_3)_{1.03}Cl_{0.46}\bullet 0.74H_2O$.

Mineral Group: Eudialyte group, the CO_3-dominant analog of feklichevite with vacancies dominant in the *M3* structural site.

Occurrence: In a nepheline-pectolite vein within ijolite.

Association: Nepheline, pectolite, aegirine-augite, zircon, titanite, humite, andradite, scolecite, calcite.

Distribution: From the northern face of the iron-ore quarry at the 115 m horizon, Kovdor massif, Kola Peninsula, Russia.

Name: For the mountain, Mogo-Vid, near the locality from which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, (3221/1; 3290/1).

References: (1) Chukanov, N.V., M.M. Moiseyev, R.K. Rastsvetayeva, K.A. Rozenberg, and A.E. Zadov (2005) Golyshevite $(Na,Ca)_{10}Ca_9(Fe^{3+},Fe^{2+})_2Zr_3NbSi_{25}O_{72}(CO_3)(OH)_3\cdot H_2O$, and mogovidite, $Na_9(Ca,Na)_6Ca_6(Fe^{3+},Fe^{2+})_2Zr_3\square Si_{25}O_{72}(CO_3)(OH,H_2O)_4$, new eudialyte-group minerals from calcium-rich agpaitic pegmatites of the Kovdor massif, Kola Peninsula. Zap.Ross. Mineral. Obshch., 134(6), 36-47 (in Russian with English abstract). (2) (2007) Amer. Mineral., 92, 1541 (abs. ref. 1).

Mohite Cu_2SnS_3

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Crystal Data: Triclinic. *Point Group:* n.d. As grains, to 80 μm.

Physical Properties: Hardness = n.d. VHN = 151–203, 179 average (10 g load). D(meas.) = n.d. D(calc.) = [4.86]

Optical Properties: Opaque. *Color:* Gray with a greenish tint in reflected light. *Luster:* Metallic. *Anisotropism:* Distinct but without color effects.
R: (400) — , (420) — , (440) 24.6, (460) 24.7, (480) 25.3, (500) 25.6, (520) 25.4, (540) 25.5, (560) 25.6, (580) 25.7, (600) 25.6, (620) 25.7, (640) 26.0, (660) 25.9, (680) 26.2, (700) 26.4

Cell Data: *Space Group:* n.d. $a = 6.64$ $b = 11.51$ $c = 19.93$ $\alpha = 90°$ $\beta = 109°45'$ $\gamma = 90°$ $Z = 12$

X-ray Powder Pattern: Kochbulak deposit, Uzbekistan.
3.13 (100), 1.920 (70), 2.72 (20), 2.44 (20), 3.66 (10), 3.34 (10), 2.82 (10)

Chemistry:

	(1)	(2)
Cu	37.69	37.16
Sn	35.15	34.71
Sb	0.67	
S	27.91	28.13
Total	101.42	100.00

(1) Kochbulak deposit, Uzbekistan; by electron microprobe, average of analyses on seven grains; corresponds to $Cu_{2.04}Sn_{1.02}Sb_{0.02}S_{3.00}$. (2) Cu_2SnS_3.

Occurrence: Of hydrothermal origin.

Association: Tetrahedrite, famatinite, kuramite, mawsonite, emplectite (Kochbulak deposit, Uzbekistan).

Distribution: From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan [TL]. In the Barquilla deposit, Salamanca Province, Spain. At the April Fool mine, Delamar district, Lincoln Co., Nevada, USA.

Name: In honor of Professor Günter Harald Moh (1929–1994), University of Heidelberg, Heidelberg, Germany, who first synthesized the compound.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81594.

References: (1) Kovalenker, V.A., V.S. Malov, T.L. Evstigneeva, and L.N. Vyal'sov (1982) Mohite, Cu_2SnS_3, a new sulfide of tin and copper. Zap. Vses. Mineral. Obshch., 111, 110–114 (in Russian). (2) (1983) Amer. Mineral., 68, 281 (abs. ref. 1).

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Mohrite $(NH_4)_2Fe^{2+}(SO_4)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As subhedral crystals, to 0.2 mm, and irregular laminae.

Physical Properties: *Cleavage:* Perfect on $\{\bar{1}02\}$; distinct on {010}. Hardness = n.d. D(meas.) = 1.800–1.862 D(calc.) = 1.805–1.870 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Pale green to colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). α = 1.480–1.486 β = n.d. γ = 1.486–1.497 2V(meas.) = 65°–75°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). a = 6.24(1) b = 12.65(2) c = 9.32(2) β = 106.8(1)° Z = 2

X-ray Powder Pattern: Travale, Italy.
3.801 (100), 4.200 (65), 2.460 (28), 3.153 (25), 3.025 (20), 2.823 (20), 5.40 (18)

Chemistry:

	(1)	(2)
SO_3	41.05	42.69
FeO	17.49	9.86
MnO	0.11	0.34
MgO	0.56	5.08
$(NH_4)_2O$	13.13	13.40
H_2O	27.10	28.69
insol.	0.16	0.15
Total	99.60	100.21

(1) Travale, Italy; corresponds to $(NH_4)_{1.99}(Fe_{0.96}Mg_{0.06}Mn_{0.01})_{\Sigma=1.03}(SO_4)_{2.03} \cdot 5.95H_2O$.
(2) Do.; corresponds to $(NH_4)_{1.95}(Fe_{0.52}Mg_{0.48}Mn_{0.02})_{\Sigma=1.02}(SO_4)_{2.01} \cdot 6.01H_2O$.

Occurrence: In boriferous fumaroles and geysers.

Association: n.d.

Distribution: From Travale, near Montieri, Val di Cecina, Tuscany, Italy.

Name: To honor Karl Friedrich Mohr (1806–1879), German analytical chemist, for whom the synthetic compound has long been named.

Type Material: University of Florence, Florence, Italy, 16817/G.

References: (1) Garavelli, C.L. (1964) Mohrite: un nuovo minerale della zona borifera toscana. Atti Rend. Accad. Lincei, 36, 524–533 (in Italian). (2) (1965) Amer. Mineral., 50, 805 (abs. ref. 1). (3) Montgomery, H., R.V. Chastain, J.J. Natt, A.M. Witkowska, and E.C. Lingafelter (1967) The crystal structure of Tutton's salts. VI. Vanadium(II), iron(II) and cobalt(II) ammonium sulfate hexahydrates. Acta Cryst., 22, 775–780.

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Moissanite SiC

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Crystal Data: Hexagonal. *Point Group:* $6mm$. As hexagonal plates, to 5 mm, platy to elongated on $[10\bar{1}0]$, rounded; polytypes are commonly syntactically intergrown.

Physical Properties: *Cleavage:* {0001}, poor. *Fracture:* Conchoidal. Hardness = 9.5 D(meas.) = 3.1–3.29 D(calc.) = 3.21

Optical Properties: Transparent. *Color:* Green, emerald-green, blue-green, deep blue, blue-black, black; rarely pale green, yellow, or colorless; may be zoned. *Luster:* Metallic to adamantine.
Optical Class: Uniaxial (+). *Pleochroism:* Weak; O = light blue; E = deep indigo. $\omega = 2.654$ $\epsilon = 2.697$

Cell Data: *Space Group:* $P6_3mc$ (synthetic, 6H polytype). $a = 3.073$ $c = 15.08$ Z = 6

X-ray Powder Pattern: Synthetic (6H).
2.511 (100), 2.621 (40), 1.311 (40), 1.537 (35), 2.352 (20), 1.286 (15), 1.087 (15)

Chemistry:

	(1)	(2)	(3)
Si	68.54	70.01	70.05
C	31.00	29.99	29.95
Total	99.54	100.00	100.00

(1) Udachnaya kimberlite, Russia; by electron microprobe. (2) Metaxades, Greece; by electron microprobe. (3) SiC.

Polymorphism & Series: Polytypes 2H, 3C, 4H, 5H, 6H, 10R, 15R, 33R have been noted (of 74 known to exist).

Occurrence: A rare mineral: formed in an iron meteorite; as inclusions in diamond; in diamondiferous kimberlites and lamproites, and in eclogite; in volcanic breccias and rhyolite; in alluvium.

Association: Iron, diamond (Canyon Diablo); quartz, diamond (Fuxian, China); garnet, clinopyroxene, coesite, quartz, rutile, graphite, pyrrhotite, cobaltian pyrite (Udachnaya kimberlite, Russia).

Distribution: In the Canyon Diablo meteorite. From the Sevan-Amasii ophiolite, Dzoraget River, Armenia. Around Metaxades, Greece. In China, from near Fuxian, Liaoning Province, and in the Hong district, Tibet. From the Udachnaya, Mir, and Aikhal diamond mines, and elsewhere in Sakha, Russia. In the Argyle diamond mine, Kimberley district, Western Australia.

Name: For Ferdinand F. Henri Moissan (1852–1907), French chemist, who noted the species in the Canyon Diablo meteorite.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 123–124. (2) Gevorkyan, R.G., G.A. Gurkina, and F.V. Kaminskii (1974) New type of natural moissanite from Armenia. Zap. Vses. Mineral. Obshch., 7, 106–110 (in Russian). (3) Leung, I., W. Guo, I. Friedman, and J. Gleason (1990) Natural occurrence of silicon carbide in a diamondiferous kimberlite from Fuxian. Nature, 346, 352–354. (4) Marshintsev, V.K. (1990) Natural silicon carbide in kimberlitic rocks of Yakutia [Sakha]. Mineral. Zhurnal, 12(3), 17–26 (in Russian). (5) Filippidis, A. (1993) New find of moissanite in the Metaxades zeolite-bearing volcaniclastic rocks, Thrace county, Greece. Neues Jahrb. Mineral., Monatsh., 521–527. (6) Mathez, E.A., R.A. Fogel, I.D. Hutcheon, and V.K. Marshintsev (1995) Carbon isotopic composition and origin of SiC from kimberlites of Yakutia [Sakha], Russia. Geochim. Cosmochim. Acta, 59, 781–791. (7) Hannam, A.L. and P.T.B. Shaffer (1969) Revised X-ray diffraction line intensities for silicon carbide polytypes. J. Appl. Cryst., 2, 45–48.

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Moluranite $H_4U^{4+}(U^{6+}O_2)_3(MoO_4)_7 \cdot 18H_2O$

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Crystal Data: Amorphous. *Point Group:* n.d. As colloform aggregates in brannerite.

Physical Properties: *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = ∼4 D(calc.) = n.d. Radioactive.

Optical Properties: Translucent. *Color:* Black, brown in thin fragments; pale gray in reflected light. *Luster:* Resinous.
Optical Class: Isotropic. n = 1.97–1.98

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Aleksandrovskii Golets deposit, Russia; heated, near U_3O_8.
4.17 (10), 1.314 (6), 1.305 (6), 3.44 (5), 2.58 (5), 2.12 (5), 2.03 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	4.56	4.56	
MoO_3	37.5	38.50	40.37
UO_3		32.35	34.38
UO_2		10.30	10.82
U_3O_8	42.32		
H_2O	15.4	14.03	14.43
Total	99.78	99.74	100.00

(1) Aleksandrovskii Golets deposit, Russia. (2) Do.; H_2O taken as loss on ignition.
(3) $H_4U^{4+}(U^{6+}O_2)_3(MoO_4)_7 \cdot 18H_2O$.

Occurrence: In fine fissures in granulated albite, in part replacing brannerite.

Association: Brannerite, molybdenite, chalcopyrite, galena, irignite.

Distribution: From the Aleksandrovskii Golets Mo–U deposit, upper Chetkanda River, Udokan Range, Chara region, northern Transbaikal, Russia.

Name: For MOLybdenum and URANium in the composition.

Type Material: n.d.

References: (1) Getseva, R.V. and K.T. Salev'eva (1956) Handbook for the determination of uranium minerals. Moscow, 196 (in Russian). (2) Soboleva, M.V. and I.A. Pudovkina (1957) Uranium minerals handbook. Moscow, 252–253 (in Russian). (3) (1958) Amer. Mineral., 43, 378 and 380 (abs. refs. 1 and 2). (4) Epshtein, G.Y. (1959) On the molybdates of uranium – moluranite and iriginite. Zap. Vses. Mineral. Obshch., 88, 564–570 (in Russian). (5) (1960) Amer. Mineral., 45, 257–258 (abs. ref. 4).

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Molybdenite MoS_2

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$ ($2H_1$ polytype); or $3m$ (3R polytype). Crystals are commonly tabular, barrel shaped; also as slightly tapered prisms; face development poor; up to 15 cm across. Commonly shows trigonal markings on {0001} parallel to the trace of $\{10\bar{1}1\}$. Foliated, massive, or in scales.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Lamellae flexible, not elastic. Hardness = 1–1.5 VHN = n.d. D(meas.) = 4.62–4.73 D(calc.) = 4.998 Greasy feel.

Optical Properties: Nearly opaque; translucent in thin flakes; transparent in infrared light. *Color:* Lead-gray; very pale yellow to deep reddish brown in transmitted light. *Streak:* Bluish gray. *Luster:* Metallic. *Pleochroism:* Very strong. *Anisotropism:* Very strong.
R_1–R_2: (400) 21.0–55.0, (420) 22.2–54.8, (440) 23.4–54.6, (460) 24.1–53.8, (480) 23.8–52.3, (500) 22.7–49.7, (520) 21.9–47.1, (540) 21.3–45.5, (560) 20.9–44.4, (580) 20.6–44.0, (600) 20.4–44.6, (620) 20.2–45.3, (640) 20.0–45.7, (660) 20.0–45.6, (680) 19.9–45.4, (700) 19.7–44.2

Cell Data: *Space Group:* $P6_3/mmc$ ($2H_1$), with $a = 3.1604$ $c = 12.295$ Z = 2, or *Space Group:* $R3m$ (3R), with $a = 3.16$ $c = 18.33$ Z = 3

X-ray Powder Pattern: Synthetic ($2H_1$).
6.15 (100), 2.277 (45), 1.830 (25), 2.737 (16), 2.049 (14), 1.581 (12), 1.538 (12)

X-ray Powder Pattern: Con mine, Canada (3R).
6.09 (100), 2.71 (70), 1.581 (70), 1.529 (70), 2.63 (60), 2.344 (60), 2.194 (60)

Chemistry: Nearly pure MoS_2.

Polymorphism & Series: Dimorphous with jordisite; polytypes $2H_1$ and 3R are known.

Occurrence: In high-temperature hydrothermal veins. In disseminated deposits of the porphyry type, both with and without associated major copper mineralization. Also in contact metamorphic deposits in limestone with calcium silicate minerals as well as in pegmatites, granites, and aplites. Rarely in meteorites.

Association: Chalcopyrite, other copper sulfides.

Distribution: Of widespread occurrence; the most abundant molybdenum mineral. Fine crystals occur, in the USA, at the Crown Point mine, Lake Chelan, Chelan Co., Washington; and at the Frankford quarry, Philadelphia, Pennsylvania. In Canada, in the Temiskaming district, and in Aldfield Township, Quebec. In Norway, from Raade, near Moss, and at Vennesla, near Arendal. In Russia, in the Adun-Chilon Mountains, south of Nerchinsk, Transbaikal; at Miass, Ilmen Mountains, Southern Ural Mountains; and in the Slundyanogorsk deposit, Central Ural Mountains. In Germany, at Altenberg, Saxony. In Morocco, at Azegour, 80 km southwest of Marrakesh. From Kingsgate and Deepwater, New South Wales, Australia. At the Hirase mine, Gifu Prefecture, Japan. In the Wolak mine, Danyang, Chungchong Province, South Korea. The 3R polytype occurs in the Con mine, Yellowknife, Yukon Territory; and at Mont Saint-Hilaire, Quebec, Canada. From the Yamate mine, Okayama Prefecture, Japan.

Name: A word derived from the Greek *molybdos*, *lead*.

Type Material: 3R, Canadian Geological Survey, Ottawa, Canada, 12112.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 328–331. (2) (1955) NBS Circ. 539, 5, 47. (3) Traill, R.J. (1963) A rhombohedral polytype of molybdenite. Can. Mineral., 7, 524–526.

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Molybdite MoO_3

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Crystal Data: Orthorhombic. *Point Group:* n.d. Flat needles or thin plates, to 5 mm, elongated ‖ [001], flattened on {010}; in aggregates.

Physical Properties: *Cleavage:* {100}, perfect; {001}, distinct. *Tenacity:* Flexible. Hardness = n.d. D(meas.) = ∼4.5 (synthetic). D(calc.) = 4.72

Optical Properties: Transparent. *Color:* Light greenish yellow to nearly colorless. *Luster:* Adamantine.
Optical Class: Biaxial (+); very high birefringence. *Orientation:* $X = b$; $Y = a$; $Z = c$.
α = n.d. $\beta = > 2.0$ $\gamma = > 2.0$ 2V(meas.) = Very large.

Cell Data: *Space Group: Pbnm* (synthetic). $a = 3.954$ $b = 13.808$ $c = 3.690$ Z = 4

X-ray Powder Pattern: Krupka, Czech Republic.
3.25 (10+), 3.80 (10), 3.45 (9), 6.90 (6), 1.294 (5), 2.64 (4), 2.31 (4b)

Chemistry: (1) Krupka, Czech Republic; by semimicroanalysis, Mo = 66.2% [MoO_3 = 99.7%]; Si 0.X%; Ca 0.0X%; Al, Ag, Be, Bi, Cu, Fe, Mg, Mn, Pb, Zn traces.

Occurrence: In cavities and coating molybdenite in a weathered quartz vein near its contact with topaz-quartz greisen.

Association: Molybdenite, betpakdalite, quartz.

Distribution: Most material thought to be molybdite proves on examination to be ferrimolybdite. An authentic occurrence is at Krupka, Krušné hory Mountains, Czech Republic.

Name: As an oxide of *molybdenum*.

Type Material: Charles University, Prague, Czech Republic.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1095–1097 [molybdite = ferrimolybdite, part]. (2) Čech, F. and P. Povondra (1963) Natural occurrence of molybdenum trioxide, MoO_3, in Krupka (Molybdite, a new mineral). Acta Univ. Carolinae, Geologica, 1, 1–14 (in Czech with English abs.). (3) (1964) Amer. Mineral., 49, 1497–1498 (abs. ref. 2).

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Molybdofornacite $Pb_2Cu(AsO_4,PO_4)(MoO_4,CrO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic to lathlike crystals, elongated along [010], to 1 mm. *Twinning:* Rare "butterfly" contact twins, at 120°.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3–4 D(meas.) = n.d. D(calc.) = 6.6

Optical Properties: Transparent. *Color:* Light green to olive-green. *Streak:* Pale yellow. *Luster:* Adamantine.
Optical Class: Biaxial. *Pleochroism:* Distinct; $X = Y$ = pale yellow; Z = yellow-green. *Orientation:* $Z = b$. $\alpha = 2.05(2)$ β = n.d. $\gamma = 2.15(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 8.100(5)$ $b = 5.946(3)$ $c = 17.65(1)$ $\beta = 109.17(5)°$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
3.32 (100), 2.979 (60), 2.845 (60), 2.753 (60), 4.84 (50), 2.353 (50), 3.41 (40)

Chemistry:

	(1)
MoO_3	14.29
CrO_3	2.15
P_2O_5	2.13
As_2O_5	12.68
CuO	9.97
PbO	56.45
H_2O	[1.16]
Total	[98.83]

(1) Tsumeb, Namibia; by electron microprobe, original total given as 98.84%, H_2O calculated from stoichiometry; corresponds to $Pb_{1.97}Cu_{0.98}(As_{0.86}P_{0.23})_{\Sigma=1.09}O_4(Mo_{0.77}Cr_{0.17})_{\Sigma=0.94}O_4(OH)$.

Occurrence: In the deep oxidation zone of a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Dioptase, duftite, wulfenite, quartz, calcite, hematite (Tsumeb, Namibia); wulfenite, pyromorphite (Tonopah-Belmont mine, Arizona, USA); mimetite, descloizite, willemite, chrysocolla, hematite (Bullfrog #2 claim, New Mexico, USA).

Distribution: From Tsumeb, Namibia. In the USA, in Arizona, in the Tonopah-Belmont mine, Big Horn Mountains, Osborne district, Maricopa Co., and the Rawhide mine, Buckskin Mountains, Mohave Co.; at the Bullfrog #2 claim, near Silver Hill, three km northwest of Magdalena, Socorro Co., and in the Tres Hermanas Mountains, Mahoney district, Luna Co., New Mexico; at the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada. From La Cobradita, Sonora, Mexico.

Name: For its predominance of *molybdenum* and relation to *fornacite*.

Type Material: Mineralogical Institute, Ruhr-University, Bochum, Germany.

References: (1) Medenbach, O., K. Abraham, and W. Gebert (1983) Molybdofornacite, ein neues Blei-Kupfer-Arsenat-Molybdat-Hydroxid von Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 289–295 (in German with English abs.). (2) (1984) Amer. Mineral., 69, 567 (abs. ref. 1).

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Molybdomenite $PbSe^{4+}O_3$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are typically bladed, tabular on {010}, to 2 mm, thin scaly, less commonly in needles, may be as crusts.

Physical Properties: *Cleavage:* On {001} and {$h0l$}, good. Hardness = 3.5
D(meas.) = 7.07 (synthetic). D(calc.) = 7.12

Optical Properties: Transparent to translucent. *Color:* Colorless to white, yellowish white.
Luster: Pearly, adamantine, to greasy.
Optical Class: Biaxial (–), may be (+). *Orientation:* Positive elongation, parallel extinction,
$\alpha = 2.12$ $\beta = 2.14$ $\gamma =$ n.d. 2V(meas.) = $\sim 80°$

Cell Data: *Space Group:* $P2_1/m$. $a = 6.91$ $b = 5.48$ $c = 4.51$ $\beta = 112°50'$ Z = 2

X-ray Powder Pattern: Cerro de Cacheuta, Argentina.
2.756 (10), 3.32 (9), 3.43 (7), 3.17 (7), 4.15 (6), 2.090 (6b), 2.99 (5)

Chemistry: (1) No chemical analysis has been performed; identity depends on correspondence of X-ray patterns between natural and synthetic material.

Occurrence: A rare species in the oxidized zone of selenium-bearing hydrothermal base metal deposits.

Association: Chalcomenite (Cerro de Cacheuta, Argentina); clausthalite, uraninite, calcite (Ranwick mine, Canada); chalcomenite, cobaltomenite, schmiederite, kruťaite (El Dragón mine, Bolivia).

Distribution: From Cerro de Cacheuta, Mendoza Province, Argentina. At the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, and the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí, Bolivia. In the Trogtal quarry, near Lautenthal, Harz Mountains, Germany. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. At the Ranwick uranium mine, north of Sault Sainte Marie, Ontario, Canada. In the Bozo #1 mine, Skull Creek, Moffat Co., Colorado, USA.

Name: From the Greek for *lead* and *moon*, for its composition, selenium being named for the moon.

Type Material: Natural History Museum, Paris, France, 98293.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 640. (2) Mandarino, J. (1965) Molybdomenite from the Ranwick uranium mine, Montreal River area, Ontario. Can. Mineral., 8, 149–158. (3) Fischer, R. (1972) Die Kristallstruktur von Molybdomenit, $PbSeO_3$. Tschermaks Mineral. Petrog. Mitt., 17, 196 –207 (in German with English abs.).

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Molybdophyllite $Pb_2Mg_2Si_2O_7(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* Rhombohedral. In foliated aggregates of platy crystals.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Somewhat flexible in thin foliae. Hardness = 3–4 D(meas.) = 4.717 D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Pale green; colorless in thin section. *Luster:* Vitreous; pearly on {001}.
Optical Class: Uniaxial (–). $\omega = 1.815$ $\epsilon = 1.761$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Långban, Sweden.
13.8 (100), 4.60 (90), 2.67 (70), 3.80 (60), 3.04 (60), 2.95 (60), 1.762 (60)

Chemistry:

	(1)	(2)
SiO_2	18.15	18.06
Al_2O_3	0.46	
PbO	61.09	67.11
MgO	11.71	12.12
Na_2O	0.82	
K_2O	0.69	
H_2O	6.32	2.71
Total	99.24	100.00

(1) Långban, Sweden. (2) $Pb_2Mg_2Si_2O_7(OH)_2$.

Occurrence: In skarns in granular limestone or dolostone.

Association: Hausmannite, calcite, rhodonite, garnet.

Distribution: From Långban, Värmland, Sweden.

Name: From the Greek *molybdos*, for *lead*, and *phyllos*, for *leaf*, in allusion to its lead content and foliated habit.

Type Material: n.d.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 70. (2) Aminoff, G. (1918) Röntgenographische Ermittelung der Symmetrie und des Elementes p_0 des Molybdophyllits. Geol. Fören. Förhandl. Stockholm, 40, 923–938 (in German). (3) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Molysite $Fe^{3+}Cl_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As coatings, massive.

Physical Properties: Hardness = Soft. D(meas.) = 2.90 (synthetic). D(calc.) = [2.91] Very deliquescent; hydrolyzed by H_2O to hydrous iron oxide.

Optical Properties: Semitransparent. *Color:* Brownish red or yellowish.
Optical Class: Uniaxial (–); very strong birefringence. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}$ (synthetic). $a = 6.065$ $c = 17.42$ Z = [6]

X-ray Powder Pattern: Synthetic.
2.68 (100), 2.08 (40), 5.9 (32), 1.75 (32), 1.63 (16), 1.67 (6), 4.79 (< 6)

Chemistry: Natural material has not been analyzed.

Occurrence: A volcanic sublimate.

Association: Tridymite, hematite, anhydrite, halite (Augustine volcano, Alaska, USA).

Distribution: In Italy, from Vesuvius, Campania; at Larderello, Val di Cecina, Tuscany; and on Vulcano, Lipari Islands. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. Found on the Augustine volcano, Augustine Island, near the Kenai Peninsula, Alaska, USA.

Name: From the Greek for *a stain*, as it stains the host rock.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 47–48. (2) Hashimoto, S., K. Forster, and S.C. Moss (1989) Structure refinement of an $FeCl_3$ crystal using a thin plate sample. J. Applied Cryst., 22, 173–180.

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Momoiite $(Mn^{2+},Ca)_3(V^{3+},Al)_2Si_6O_3$

Crystal Data: Cubic. *Point Group*: $4/m\,\bar{3}\,2/m$. As granular aggregates, to 1 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: n.d.
Hardness = 6.5. D(meas.) = n.d. D(calc.) = 4.01

Optical Properties: Translucent. *Color*: Greenish yellow to emerald-green (less green with < V).
Streak: Dull green. *Luster*: Vitreous.
Optical Class: Isotropic. n = 1.86(1)

Cell Data: *Space Group*: $Ia\bar{3}\,d$. a = 11.9242(7) Z = 1

X-ray Powder Pattern: Kurase mine, Ehime Prefecture, Japan.
2.668 (100), 2.980 (78), 2.435 (42), 1.594 (30), 1.935 (21), 2.178 (20), 1.654 (20)

Chemistry:

	(1)	(2)
CaO	12.24	
MnO	24.74	44.04
MgO	0.28	
FeO	0.05	
Al_2O_3	5.12	
V_2O_3	21.96	18.60
SiO_2	35.02	37.35
Total	99.41	100.00

(1) Kurase mine, Ehime Prefecture, Japan; average of 10 electron microprobe analyses, corresponding to $(Mn_{1.80}Ca_{1.12}Mg_{0.12})_{\Sigma=2.96}(V_{1.51}Al_{0.52})_{\Sigma=2.03}Si_{3.00}O_{12}$. (2) $(Mn^{2+})_3(V^{3+})_2Si_6O_3$.

Mineral Group: Garnet group.

Polymorhism & Series: Solid solution with spessartine, grossular, and goldmanite.

Occurrence: Product of the metamorphism of siliceous manganese-bearing rocks.

Association: Rhodonite, calcite, tephroite, goldmanite, spessartine, vuorelainenite (Kurase mine); rhodonite, tephroite, celsian, rhodochrosite, pyrophanite (Hokkejino mine); in quartz-free assemblages with rhodonite, tephroite, rhodochrosite, spessartine, nickeline, or in quartz-bearing assemblages with rhodonite, molybdenite, rhodochrosite, spessartine, Mn-rich vanadoallanite-(La) (Fujii mine).

Distribution: In Japan, at the Kurase mine, Ehime Prefecture, the Hokkejino mine, Kyoto Prefecture, the Fujii mine, Fukui Prefecture and from the Tanohata mine, Iwate Prefecture.

Name: Honors Hitoshi Momoi (1930-2002), who first recognized $Mn_3V_2Si_3O_{12}$ molecules in garnet.

Type Material: Hokkaido University Museum, Sapporo, Japan (#Mineral-07401).

References: (1) Tanaka, H., S. Endo, T. Minakawa, M. Enami, D. Nishio-Hamane, H. Miura, and A. Hagiwara (2010) Momoiite, $(Mn^{2+},Ca)_3(V^{3+},Al)_2Si_6O_3$, a new manganese vanadium garnet from Japan. Journal of Mineralogical and Petrological Sciences, 105, 92-96. (2) (2014) Amer. Mineral., 99, 554-555 (abs. ref. 1). (3) Matsubara, S., R. Miyawaki, K. Yokoyama, M. Shigeoka, H. Miyajima, Y. Suzuki, O. Murakami and T. Ishibashi (2010) Momoiite and nagashimalite from the Tanohata mine, Iwate Prefecture, Japan. Bull. Natl. Mus. Nat. Sci., Ser. C, 36, 1-6.

Monazite-(Ce) $(Ce, La, Nd, Th)PO_4$

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Crystal Data: Monoclinic; metamict if thorium-rich. *Point Group:* $2/m$. Crystals typically tabular on {100}, may be prismatic, equant or wedge-shaped, to 27 cm; granular, massive. *Twinning:* Common, {100} as twin and composition plane, as contact twins.

Physical Properties: *Cleavage:* {100}, distinct; {010}, poor; parting on {001} or $\{\bar{1}11\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 4.98–5.43 D(calc.) = 5.26 Radioactive if thorium-rich. Dull brown cathodoluminescence. Paramagnetic.

Optical Properties: Translucent to opaque. *Color:* Reddish brown, brown, pale yellow, pink, gray; yellowish brown to yellow in transmitted light. *Luster:* Resinous, waxy, vitreous to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* Weak; in pale yellows. *Orientation:* $X = b$; $Z \wedge c$ = 2°–6°. *Dispersion:* $r < v, r > v$, weak, horizontal. *Absorption:* Distinct; $Y > X = Z$.
α = 1.770–1.793 β = 1.778–1.800 γ = 1.823–1.860 2V(meas.) = 10°–26°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.7902(10)$ $b = 7.0203(6)$ $c = 6.4674(7)$ $\beta = 103.38(1)°$ Z = 4

X-ray Powder Pattern: Sri Lanka.
2.862 (100), 3.078 (80), 1.963 (50), 2.151 (40), 1.738 (40b), 3.285 (35), 1.876 (30)

Chemistry:

	(1)		(1)		(1)
P_2O_5	27.4	ThO_2	11.6	Pb_3O_4	0.1
U_3O_8	0.4	Al_2O_3	0.02	CaO	1.0
SiO_2	0.4	RE_2O_3	59.24	Total	100.16

(1) Sri Lanka; by electron microprobe, RE_2O_3 = La_2O_3 21.7%, Ce_2O_3 28.7%, Pr_6O_{11} 1.9%, Nd_2O_3 6.0%, Sm_2O_3 0.6%, Gd_2O_3 0.09%, Dy_2O_3 0.2%, Ho_2O_3 0.05%; corresponding to $(Ce_{0.43}La_{0.33}Th_{0.11}Nd_{0.09}Ca_{0.04}Pr_{0.03}Sm_{0.01})_{\Sigma=1.04}(P_{0.94}Si_{0.02})_{\Sigma=0.96}O_4$.

Mineral Group: Monazite group.

Occurrence: An accessory mineral in granites, syenites, and their pegmatites; in carbonatites and volcanoclastic rocks; in fissure veins and high-grade metamorphic rocks; commonly detrital in river and beach sands; rarely authigenic in shales and intense weathering zones.

Association: Zircon, xenotime, titanite, thorite, allanite, columbite, wolframite (pegmatites and Alpine fissures); rhabdophane, cerianite, florencite, churchite (Mt. Weld, Australia).

Distribution: Widespread, but uncommon in fine crystals. In the Ilmen Mountains, Southern Ural Mountains, Russia, at Miass. At Arendal and many other places in Norway. In Madagascar, at Ambatofotsikely, Ampangabe, and Ampatakala. From the Kangankunde Hill carbonatite, 30 km west of Lalaka, Malawi. In the USA, large crystals from Mars Hill, Madison Co., near Double Shoals, Cleveland Co., and elsewhere in North Carolina. Fine twins from the Joaquim Felicio mine, near Buenopolis, and large crystals in the José Pinto pegmatite, at Jaguaraçú, near Coronel Fabriciano, Minas Gerais, Brazil. Good crystals from the Ishikawa district, Fukushima Prefecture, Japan. In the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China, 35 million tons estimated. At the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia, 15 million tons estimated. The principal source of Ce, RE, Th, from heavy mineral sands in North and South Carolina and Florida, USA; also Australia, Sri Lanka, India, Brazil.

Name: From the Greek for *solitary*, for its initial apparent rarity, and dominant *cerium*.

Type Material: Mining Academy, Freiberg, Germany, 19539.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 691–696. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 335–352. (3) Jobbins, E.A., A.E. Tresham, and B.R. Young (1977) Gem monazite from Sri Lanka. J. Gemmol., 15, 295–299. (4) Y. Ni, J.M. Hughes, and A.N. Mariano (1995) Crystal chemistry of the monazite and xenotime structures. Amer. Mineral., 80, 21–26.

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Monazite-(La) $(La, Ce, Nd)PO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [Crystals typically tabular on {100}, may be prismatic, equant or wedge-shaped; granular, massive] [by analogy to monazite-(Ce)].

Physical Properties: *Cleavage:* [{100}, distinct; {010}, poor.] *Fracture:* [Conchoidal to uneven.] *Tenacity:* [Brittle.] Hardness = [5–5.5] D(meas.) = 5.17–5.27 D(calc.) = 5.13 Radioactive if thorium-rich.

Optical Properties: [Translucent.] *Color:* [Yellowish to dark brown, pale red, yellow.] *Luster:* [Resinous, waxy, vitreous to adamantine.]
Optical Class: Biaxial (+). α = 1.785–1.791 β = 1.787–1.791 γ = 1.840–1.844
2V(meas.) = 10°–14°

Cell Data: *Space Group:* $P2_1/n$ (ICDD 35-731). $a = 6.84$ $b = 7.07$ $c = 6.45$ $\beta = 103.85°$ Z = 4

X-ray Powder Pattern: Synthetic $LaPO_4$.
3.12 (100), 3.31 (85), 2.15 (40), 2.88 (35), 3.53 (20), 3.01 (20), 2.21 (20)

Chemistry:

	(1)
P_2O_5	26.81
U_3O_8	0.21
SiO_2	2.24
ThO_2	4.51
Al_2O_3	0.36
Fe_2O_3	0.48
Ce_2O_3	24.58
La_2O_3	38.51
PbO	0.03
CaO	0.86
H_2O	0.91
Total	99.50

(1) Ebisie mine, Japan. (2) Near Kokšín, Czech Republic; by electron microprobe, analysis not given; corresponds to $(La_{0.35}Ce_{0.30}Nd_{0.21}Pr_{0.05}Gd_{0.03}Ca_{0.02}Sm_{0.02}Tb_{0.01}Tm_{0.01})_{\Sigma=1.00}PO_4$.

Mineral Group: Monazite group.

Occurrence: In fissure veins, granite and gneissic metamorphic rocks.

Association: n.d.

Distribution: From the Kounrad Massif, northern Balkhash region, Kazakhstan. At Kokšín, near Mítov, Czech Republic. From Poiana Marului, Muntele Mic Mountains, Romania. In the Gasteiner Tal, Austria. At the Ebisie mine, Wada, Gifu Prefecture, Japan. From Ratnapura, Sri Lanka. Along the Grey River, Westland, New Zealand. In Dickens Township, Nipissing district, Ontario, Canada. From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: For the member of the *monazite* group with dominant *lanthanum*.

Type Material: n.d.

References: (1) Borovskii, I.B. and V.I. Gerasimovskii (1945) Rare earths in minerals. Doklady Acad. Nauk SSSR, 49, 353–356 (in Russian). (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 335–352. (3) Johan, Z., V. Johan, B. Scharm and Z. Pouba (1995) Minéralogie et géochimie des terres rares et du chrome dans les cherts protérozoïques de Kokšín, République tchèque. Compt. Rendus Acad. Sci. Paris, 321, 1127–1138 (in French with English abs.). (4) Carron, M.K., F.A. Hildebrand, C.R. Naeser, and H.J. Rose, Jr. (1958) Fractional precipitation of rare earths with phosphoric acid. U.S. Geol. Survey Bull. 1036N, 253–275.

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Monazite-(Nd) $(Nd, La, Ce)PO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As long prismatic crystals, or grains, to 15 μm.

Physical Properties: *Cleavage:* [{100}, distinct; {010}, poor] [by analogy to monazite-(Ce)]. *Tenacity:* [Brittle.] Hardness = [5–5.5] D(meas.) = n.d. D(calc.) = 5.43

Optical Properties: Translucent. *Color:* Bright rose-red.
Optical Class: Biaxial (+). $\alpha = 1.793(2)$ $\beta = 1.795(2)$ $\gamma = 1.860(5)$ 2V(meas.) = 18°–20°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.745(4)$ $b = 6.964(4)$ $c = 6.435(4)$ $\beta = 103.65(4)°$ Z = 4

X-ray Powder Pattern: Pta. Glogstafel, Italy.
3.080 (100), 3.280 (60), 2.846 (50), 2.425 (40), 4.15 (30), 2.590 (30), 2.177 (30)

Chemistry:

	(1)
P_2O_5	28.65
SiO_2	0.22
ZrO_2	0.77
Ce_2O_3	19.85
La_2O_3	2.48
Pr_2O_3	6.47
Nd_2O_3	30.32
Sm_2O_3	8.81
Gd_2O_3	2.26
Total	99.83

(1) Pta. Glogstafel, Italy; by electron microprobe, average of three analyses; corresponding to $(Nd_{0.44}Ce_{0.29}Sm_{0.12}Pr_{0.09}La_{0.04}Gd_{0.03}Zr_{0.02})_{\Sigma=1.03}(P_{0.97}Si_{0.01})_{\Sigma=0.98}O_4$.

Mineral Group: Monazite group.

Occurrence: In fissures in aplitic veins through white-mica gneiss (Pta. Glogstafel, Italy); replacing brindleyite in bauxite (Marmara deposit, Greece); in volcanic-associated marine cherts (Kokšín, Czech Republic).

Association: Rutile, xenotime, gadolinite, bastnäsite, allanite, monazite-(Ce) (Pta. Glogstafel, Italy).

Distribution: From Pta. Glogstafel, Val Formazza, on the southeastern slope of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont, Italy. In the Marmara bauxite deposit, Megora, Greece. At Kokšín, near Mítov, Czech Republic.

Name: For the member of the *monazite* group with dominant *neodymium*.

Type Material: Mineralogical Institute, University of Basel, Basel; Natural History Museum, Basel, Switzerland, 30803.

References: (1) Graeser, S. and H. Schwander (1987) Gasparite-(Ce) and monazite-(Nd): two new minerals to the monazite group from the Alps. Schweiz. Mineral. Petrog. Mitt., 67, 103–113. (2) (1988) Amer. Mineral., 73, 1494–1495 (abs. ref. 1).

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Moncheite $(Pt, Pd)(Te, Bi)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Euhedral to subhedral crystals, to 1 mm, and as minute grains.

Physical Properties: *Cleavage:* On {0001}. Hardness = n.d. VHN = 73–111, 92 average; 124–168; 128–153 (10 g load). D(meas.) = n.d. D(calc.) = 9.88

Optical Properties: Opaque. *Color:* Steel-gray; in polished section, white. *Luster:* Metallic. *Pleochroism:* Weak in air, distinct in oil. *Anisotropism:* Strong, except close to ⊥ {0001}. R_1–R_2: (400) 50.3–51.6, (420) 51.5–52.6, (440) 52.4–53.5, (460) 53.4–54.4, (480) 54.2–55.1, (500) 54.9–55.8, (520) 55.5–56.4, (540) 56.0–56.9, (560) 56.4–57.3, (580) 56.7–57.6, (600) 57.1–58.0, (620) 57.4–58.4, (640) 57.7–58.7, (660) 58.0–59.0, (680) 58.3–59.2, (700) 58.4–59.4

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 4.049$ $c = 5.288$ $Z = 1$

X-ray Powder Pattern: Monchegorsk deposit, Russia.
2.93 (100), 2.11 (80), 2.02 (70), 1.462 (70), 1.282 (70), 5.32 (60), 1.664 (7)

Chemistry:

	(1)	(2)	(3)
Pt	26.6	38.3	42.1
Pd	6.93		0.0
Bi	20.93	13.0	1.2
Te	45.55	49.1	56.7
Total	100.0	100.4	100.0

(1) Monchegorsk deposit, Russia; average of microspectrographic analyses of four samples, corresponding to $(Pt_{0.60}Pd_{0.28})_{\Sigma=0.88}(Te_{1.56}Bi_{0.44})_{\Sigma=2.00}$. (2) Impala mine, Transvaal, South Africa; by electron microprobe, corresponding to $(Pt_{0.88}(Te_{1,72}Bi_{0.28})_{\Sigma=2.00}$. (3) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $Pt_{0.06}(Te_{1.97}Bi_{0.03})_{\Sigma=2.00}$.

Mineral Group: Melonite group.

Occurrence: Typically in small amounts in Pt–Pd-bearing massive Cu–Ni sulfide deposits.

Association: Merenskyite, melonite, sobolevskite, michenerite, kotulskite, froodite, sperrylite, cooperite, laurite, braggite, insizwaite, gold, pyrrhotite, pentlandite, chalcopyrite, pyrite.

Distribution: In Russia, from the Monchegorsk deposit, Monche Tundra, Kola Peninsula [TL]; and at the Oktyabr mine, Noril'sk region, western Siberia. In South Africa, from several mines along the Merensky Reef, Bushveld complex, Transvaal. In the USA, at the Stillwater complex, Montana; from the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming; at the Key West mine, east of Moapa, Bunkerville district, Clark Co., Nevada; and in gravels of the San Joaquin River, at Friant, Fresno Co., California. In Canada, at Sudbury, in the Strathcona and Thierry mines, near Pickle Lake, and the Lac des Iles complex, Ontario; from the Wellgreen Ni–Cu–PGE deposit, Yukon Territory. At Kambalda, 56 km south of Kalgoorlie, Western Australia. A number of additional localities are now known.

Name: For the locality at Monche Tundra in Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5966; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64852.

References: (1) Genkin, A.D., N.N. Zhuravlev, and E.M. Smirnova (1963) Moncheite and kotulskite—new minerals—and the composition of michenerite. Zap. Vses. Mineral. Obshch., 92, 33–50 (in Russian). (2) (1963) Amer. Mineral., 48, 1181 (abs. ref. 1). (3) X-Ray Laboratory, Guiyang Institute of Geochemistry, Academia Sinica (1975) The crystal structures of biteplapalladite and biteplatinite. Geochimica, 184–185 (in Chinese). (4) (1976) Mineral. Abs., 27, 214 (abs. ref. 3). (5) Volborth, A., M. Tarkian, E.F. Stumpfl, and R.M. Housley (1986) A survey of the Pd–Pt mineralization along the 35-km strike of the J-M reef, Stillwater Complex, Montana. Can. Mineral., 24, 329–346. (6) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 121. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 379–381.

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Monetite $CaHPO_4$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Euhedral crystals uncommon, to 7 cm, typically aggregated into crusts, stalactitic, massive. *Twinning:* Multiple, twin plane parallel to elongation.

Physical Properties: *Cleavage:* Indistinct in three directions. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.93 (synthetic). D(calc.) = 2.92

Optical Properties: Translucent. *Color:* Pale yellowish white; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* ∼30° to twin plane. *Dispersion:* $r > v$, weak.
α = 1.587–1.60 β = ∼1.615 γ = 1.640–1.65 2V(meas.) = Large.

Cell Data: *Space Group:* $P\overline{1}$ (synthetic). $a = 6.910(1)$ $b = 6.627(2)$ $c = 6.998(2)$
$\alpha = 96.34(2)°$ $\beta = 103.82(2)°$ $\gamma = 88.33(2)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 9-80).
2.958 (100), 3.35 (75), 3.37 (70), 2.937 (35), 2.721 (35b), 3.13 (20), 2.754 (20)

Chemistry:

	(1)	(2)
P_2O_5	50.3	52.16
FeO	0.2	
MnO	0.6	
CaO	39.6	41.22
H_2O	n.d.	6.62
Total		100.00

(1) Boqueirão pegmatite, Brazil; by electron microprobe, partial analysis. (2) $CaHPO_4$.

Occurrence: As coatings and cements resulting from guano-induced phosphatization of sedimentary rocks; a coating on phosphate minerals in granite pegmatite.

Association: Newberyite, gypsum, whitlockite, aphthitalite, syngenite (guano-related), apatite, lithiophilite, jahnsite, huréaulite, barbosalite, whitlockite (pegmatites).

Distribution: On Monito (Moneta), Mona, Los Monges, and Aruba Islands, West Indies, Caribbean Sea. From Ascension Island, South Atlantic Ocean. On Paoha Island, Mono Lake, Mono Co., California, USA. From the Boqueirão pegmatite, Parelhas, Rio Grande do Norte, Brazil. In Murra-el-elevyn Cave, Cocklebiddy, Western Australia. From the Gunong Keriang Cave and the Niah Great Cave, Sarawak, Malaysia. At the Sandamap pegmatite, west of Usakos, Namibia.

Name: For Moneta (now Monito) Island, which contains a notable occurrence.

Type Material: The Natural History Museum, London, England, 54779; National Museum of Natural History, Washington, D.C., USA, 123822, 128714.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 660–661. (2) Murdoch, J. (1958) Phosphate minerals of the Borborema pegmatites: II – Boqueirão. Amer. Mineral., 43, 1148–1156. (3) Kampf, A.R. and P.J. Dunn (1994) Chavesite discredited. Amer. Mineral., 79, 385–386. (4) Catti, M., G. Ferraris, and A. Filhol (1977) Hydrogen bonding in the crystalline state. $CaHPO_4$ (monetite), $P\overline{1}$ or $P1$? A novel neutron diffraction study. Acta Cryst., 33, 1223–1229.

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Mongolite $Ca_4Nb_6Si_5O_{24}(OH)_{10}\cdot 5-6H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. As a micalike aggregate of fine scales.

Physical Properties: *Cleavage:* One direction, good. Hardness = 2 D(meas.) = 3.147, possibly lowered by admixed quartz. D(calc.) = [3.53]

Optical Properties: Translucent. *Color:* Pale lilac or grayish lilac. *Luster:* Silky. *Optical Class:* Uniaxial (–). $\omega = 1.80$ $\epsilon = 1.74$

Cell Data: *Space Group:* n.d. $a = 7.00(5)$ $c = 29.0(1)$ $Z = 2$

X-ray Powder Pattern: Khan-Bogdinskii massif, Mongolia.
3.163 (100), 2.974 (70), 3.087 (65), 9.67 (45), 5.82 (45), 2.664 (40), 2.901 (35)

Chemistry:

	(1)	(2)
SiO_2	22.05	22.34
TiO_2	0.02	0.07
Al_2O_3	0.81	0.86
Nb_2O_5	53.13	51.77
MnO	1.15	0.86
ZnO	0.41	0.90
MgO	0.07	0.12
CaO	12.38	11.97
SrO	2.11	1.83
BaO	0.71	0.73
Na_2O	0.72	0.26
K_2O	0.49	0.38
H_2O	6.70	8.74
Total	[100.75]	[100.83]

(1) Khan-Bogdinskii massif, Mongolia; by electron microprobe, original total given as 100.76%; corresponds to $(Ca_{3.01}Na_{0.31}Sr_{0.28}K_{0.14}Ba_{0.06})_{\Sigma=3.80}(Nb_{5.45}Al_{0.22}Mn_{0.22}Zn_{0.07}Mg_{0.03})_{\Sigma=5.99}Si_5O_{27.84}\cdot 5.07H_2O$. (2) Do.; original total given as 100.82%; corresponds to $(Ca_{2.87}Sr_{0.24}Na_{0.11}K_{0.11}Ba_{0.06})_{\Sigma=3.39}(Nb_{5.24}Al_{0.23}Mn_{0.16}Zn_{0.15}Mg_{0.04})_{\Sigma=5.82}Si_5O_{27.07}\cdot 6.53H_2O$.

Occurrence: In the quartz-rich core zone of an alkalic pegmatite, as a late-stage alteration product of a niobium silicate.

Association: Polylithionite, zincian montmorillonite, niobium and rare-earth silicates.

Distribution: At the Dorozhny site, northern Khan-Bogdinskii granitic massif, Gobi, Mongolia.

Name: For Mongolia, the country where the mineral was discovered.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Vladykin, N.V., V.A. Drits, V.I. Kovalenko, M.D. Dorfman, V.S. Malov, and A.I. Gorshkov (1985) A new silicate of niobium, mongolite $Ca_4Nb_6[Si_5O_{20}]O_4(OH_{10})\cdot nH_2O$. Zap. Vses. Mineral. Obshch., 114, 374–377 (in Russian). (2) (1986) Amer. Mineral., 71, 1279 (abs. ref. 1).

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Monimolite $(Pb, Ca)_3Sb_2O_8(?)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$ (probable). As octahedra with {113}, or less commonly, cube dominant, with {111} and {011}.

Physical Properties: *Cleavage:* Indistinct on {111}. *Fracture:* Small conchoidal to splintery. Hardness = 4.5–6 D(meas.) = 5.94–7.29 D(calc.) = n.d.

Optical Properties: Opaque, translucent on thin edges. *Color:* Yellow, gray-green, dark brown. *Streak:* Straw-yellow to cinnamon-brown. *Luster:* Greasy to adamantine. *Optical Class:* Isotropic; may show weak anisotropism. $n = > 2.06$

Cell Data: *Space Group:* n.d. $a = 10.47$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Sb_2O_5	40.51	38.18
FeO	5.38	5.57
MnO	0.41	1.16
PbO	42.74	55.33
MgO	0.56	
CaO	9.70	
Na_2O	0.54	
Total	99.84	100.24

(1) Harstigen mine, Sweden. (2) Do.; corresponds to $(Pb_{2.12}Fe_{0.66}Mn_{0.14})_{\Sigma=2.92}Sb_2O_{7.92}$.

Occurrence: In calcite veins in an iron and manganese deposit.

Association: Tephroite, calcite.

Distribution: In the Harstigen mine, near Persberg, Värmland, Sweden.

Name: From the Greek for *stable*, as it is decomposed chemically only with great difficulty.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1023. (2) Mason, B. and C.J. Vitaliano (1953) The mineralogy of the antimony oxides and antimonates. Mineral. Mag., 30, 100–112.

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Monipite MoNiP

Crystal Data: Hexagonal. *Point Group*: $\bar{6}\,m2$. As an irregular 0.002 mm grain.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d.. *Tenacity*: n.d.. Hardness = n.d. D(meas.) = n.d. D(calc.) = 8.27

Optical Properties: Opaque. *Color*: n.d. *Streak*: n.d.
Luster: n.d.
Optical Class: n.d..

Cell Data: *Space Group*: $P\bar{6}\,2m$. a = 5.861 c = 3.704 Z = 3

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Mo		51.69
Ni		31.62
P		16.69
Total		100.00

(1) Electron microprobe analyses, not given, corresponding to $(Mo_{0.84}Fe_{0.06}Co_{0.04}Rh_{0.03})_{\Sigma=0.97}(Ni_{0.89}Ru_{0.09})_{\Sigma=0.98}P$. (2) MoNiP.

Occurrence: As a single grain in the Allende meteorite, probably a secondary product of the oxidation of Mo-phosphides and/or P-rich alloys.

Association: Apatite, tugarovinite, a Ru-Mo-Ni metal grain.

Distribution: In a melilite-rich mantle of a B1 CAI (calcium aluminum rich inclusion) from the Allende meteorite.

Name: An acronym composed of the chemical symbols of the three essential components.

Type Material: National Museum of Natural History, Washington, D.C., USA, USNM 7554.

References: (1) Ma, C., J.R. Beckett, and G.R. Rossman (2009) Discovery of a new phosphide mineral, monipite (MoNiP), in an Allende type B1 CAI. 72nd Annual Meeting of the Meteoritical Society Abstracts. (2) (2010) Amer. Mineral., 95, 206 (abs. ref. 1).

Monohydrocalcite $CaCO_3 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 32. Rare as aggregates of rhombohedral crystals, to 2 mm; most commonly as spheroids and crusts.

Physical Properties: Hardness = n.d. D(meas.) = 2.38 (synthetic). D(calc.) = 2.48

Optical Properties: Transparent to opaque. *Color:* Colorless to white.
Optical Class: Uniaxial (–). $\omega = 1.590–1.591$ $\epsilon = 1.545–1.546$

Cell Data: *Space Group:* $P3_121$ or $P3_221$. $a = 6.084(4)$ $c = 7.542(7)$ $Z = 3$

X-ray Powder Pattern: Lake Issyk-Kol, Kyrgyzstan.
2.17 (10), 1.926 (10), 4.49 (9), 3.15 (9), 2.90 (8), 1.770 (7), 1.746 (7)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	38.96	33.6	37.27	K_2O		0.07	
FeO		0.13		H_2O^-		2.1	
MgO		2.49		H_2O^+	11.61	15.9	15.25
CaO	49.30	42.5	47.48	insol.	0.79	5.0	
SrO		0.40		Total	100.66	102.88	100.00
Na_2O		0.69					

(1) Lake Issyk-Kol, Kyrgyzstan; corresponds to $CaCO_3 \cdot 0.65H_2O$. (2) Lake Fellmongery, Australia; corresponds to $(Ca_{0.91}Mg_{0.07})_{\Sigma=0.98}CO_3 \cdot 1.15H_2O$. (3) $CaCO_3 \cdot H_2O$.

Occurrence: In lake-bed sediments and as tuffaceous deposits on lake margins, formed by precipitation at pH > 8.0 and high Mg:Ca or by biological activity; in caves, in speleothems, crusts, and "moonmilk," probably formed from an aerosol, possibly in the presence of organic matter; rarely in hydrothermal mineral deposits.

Association: Calcite, aragonite, hydromagnesite, nesquehonite.

Distribution: From Lake Issyk-Kol, Kyrgyzstan. At Lakes Maibalyk and Teke, Kazakhstan. From Lake Kivu, on the Congo (Zaire)–Rwanda border. In the Sarfartôq carbonatite complex, near Kangerdlugssuaq, Greenland. In Castleguard Cave, Columbia Icefields, Alberta, Canada. In the USA, from the Gunsight, Cottonwood, and Hidden Caves, Guadalupe Mountains, Eddy Co., New Mexico; at Sterling Hill, Ogdensburg, Sussex Co., New Jersey. From the Muckross mine, Co. Kerry, Ireland. In the Gerstenegg-Sommerloch cable tunnel, north of the Grimsel Pass, Bern, Switzerland. At the Vrančice deposit, near Příbram, and at Jáchymov (Joachimsthal), Czech Republic. From the Sedmochislenitsi deposit, western Stara Planina Mountains, Bulgaria. In the Feengrotten Cave, Thuringia, and at Ramsbeck, North Rhine-Westphalia, Germany. At Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, France. Around and in Lakes Fellmongery and Butler, near Robe, South Australia.

Name: For having the composition of *calcite* and the Greek for *one*, as with an additional H_2O.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72027.

References: (1) Semenov, E.I. (1964) Hydrous carbonates of calcium and sodium. Kristallografiya (Sov. Phys. Crystal.), 9, 109–110 (in Russian). (2) (1964) Amer. Mineral., 49, 1151 (abs. ref. 1). (3) Řídkošil, T., J. Sejkora, and P. Ondruš (1991) Monohydrocalcite from polymetallic vein of the Vrančice deposit, near Příbram, Czechoslovakia. Neues Jahrb. Mineral., Monatsh., 289–295. (4) Effenberger, H. (1980) The crystal structure of calcium carbonate monohydrate, $CaCO_3 \cdot H_2O$. 6th European Crystallographic Meeting, Barcelona, Spain.

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Montanite $Bi_2Te^{6+}O_6 \cdot 2H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Fibrous, earthy to compact, massive.

Physical Properties: Hardness = "Soft". D(meas.) = 3.7(1) D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Pale yellow, pale green, white. *Luster:* Dull to waxy. *Optical Class:* Biaxial (–), birefringence 0.01, exhibiting anomalous green interference colors. *Dispersion:* $r < v$, extreme. $n = 2.09(3)$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Highland, Montana, USA. (ICDD 38-418).
3.49 (100), 1.896 (100), 2.576 (75), 1.503 (50), 3.187 (40), 2.027 (40), 1.255 (35)

Chemistry:

	(1)	(2)	(3)
TeO_3	26.83	26.46	25.91
Bi_2O_3	66.78	53.70	68.77
Fe_2O_3	0.56		
PbO	0.39	11.89	
CaO		0.77	
H_2O	[5.44]	[7.18]	5.32
Total	[100.00]	[100.00]	100.00

(1) Highland, Montana, USA; H_2O by difference. (2) Nizhni Priamur'ya, Russia; H_2O by difference; corresponds to $(Bi_{1.16}Pb_{0.50}Ca_{0.30})_{\Sigma=1.96}Te_{1.87}O_6 \cdot nH_2O$. (3) $Bi_2TeO_6 \cdot 2H_2O$.

Occurrence: An alteration product of tetradymite.

Association: Tetradymite, bismuthinite.

Distribution: In the USA, from Highland, Silver Bow Co., and in German Gulch, Deer Lodge Co., Montana; at the Little Joe mine, Tombstone, Cochise Co., Arizona; from near Hatchita, Hidalgo Co., New Mexico. In Russia, from Nizhni Priamur'ya, otherwise not located. At Norongo, Captain's Flat, New South Wales, Australia. From Nyirjes, near Gyöngyösslymos, Mátra Mountains, Hungary.

Name: For its occurrence in Montana, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 636–637. (2) Kazachenko, V.T., I.I. Fat'yanov, and V.M. Chubanov (1980) Discovery of a lead-containing variety of montanite. Doklady Acad. Nauk SSSR, 255, 968–971. (3) (1981) Chem. Abs., 94, 203 (abs. ref. 2).

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Montbrayite Au_2Te_3

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Crystal Data: Triclinic. *Point Group:* 1. Generally rounded to irregular grains, to 1 cm; may be aggregated into larger equidimensional masses.

Physical Properties: *Cleavage:* $\{1\bar{1}0\}$, $\{0\bar{1}1\}$, $\{1\bar{1}1\}$. *Fracture:* Flat, conchoidal. *Tenacity:* Brittle. Hardness = 2.5 VHN = 223–253, 238 average (100 g load) D(meas.) = 9.94 D(calc.) = [9.91]

Optical Properties: Opaque. *Color:* Yellowish white. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Weak to moderate, pale gray, yellow-brown, and blue-gray.
R_1–R_2: (400) 46.1–49.9, (420) 47.6–51.3, (440) 49.0–52.8, (460) 50.5–54.5, (480) 52.1–55.9, (500) 53.6–57.1, (520) 54.9–58.2, (540) 56.1–59.0, (560) 57.1–59.7, (580) 57.9–60.3, (600) 58.7–60.8, (620) 59.3–61.2, (640) 59.8–61.5, (660) 60.2–61.9, (680) 60.6–62.1, (700) 61.0–62.4

Cell Data: *Space Group:* $P1$. $a = 12.11$ $b = 13.44$ $c = 10.80$ $\alpha = 104°23'$ $\beta = 97°30'$ $\gamma = 107°56'$ Z = 12

X-ray Powder Pattern: Robb-Montbray mine, Canada.
2.087 (100), 2.983 (80), 2.922 (60), 4.425 (40), 2.119 (40), 7.363 (20), 11.2 (10)

Chemistry:

	(1)	(2)	(3)
Au	44.32	46.66	50.72
Ag	0.55	0.37	
Pb	1.61	1.02	
Sb	0.90	1.12	
Bi	2.81	3.23	
Te	49.80	46.66	49.28
Total	99.99	99.76	100.00

(1) Robb-Montbray deposit, Canada; corresponds to $(Au_{1.73}Bi_{0.10}Sb_{0.06}Pb_{0.06}Ag_{0.04})_{\Sigma=1.99}Te_{3.00}$.
(2) Do.; by electron microprobe, corresponds to $(Au_{1.97}Bi_{0.13}Sb_{0.08}Pb_{0.04}Ag_{0.03})_{\Sigma=2.25}Te_{3.00}$.
(3) Au_2Te_3.

Occurrence: With other tellurides, sulfides, and gold in coarsely crystalline masses almost free from gangue (Robb-Montbray mine, Canada).

Association: Calaverite, gold, tellurobismuthite, altaite, petzite, melonite, frohbergite, chalcopyrite, pyrite, sphalerite, chalcocite, covellite, marcasite (Robb-Montbray mine, Canada).

Distribution: From the Robb-Montbray mine, Montbray Township, Quebec, Canada [TL]. At the April Fool mine, Delamar district, Lincoln Co., Nevada, USA. From the Voronezhskiy massif, 50 km south of Orel, Russia. At Enasen, Sweden. From Musariu, Romania. At Kalgoorlie, Western Australia. In the Donping gold deposit, Hebei Province, China. Several undefined localities are known.

Name: For the Robb-Montbray mine, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M15815, M19883; Harvard University, Cambridge, Massachusetts, USA, 97681, 102067.

References: (1) Peacock M.A. and R.M. Thompson (1946) Montbrayite, a new gold telluride. Amer. Mineral., 31, 515–526. (2) Rucklidge, J. (1969) Frohbergite, montbrayite, and a new Pb–Bi telluride. Can. Mineral., 9, 709–716. (3) Bachechi, F. (1971) Crystal structure of montbrayite. Nature, Phys. Sci., 231, 67–68. (4) Bachechi, F. (1972) Synthesis and stability of montbrayite, Au_2Te_3. Amer. Mineral., 57, 146–154. (5) Criddle, A.J., C.J. Stanley, and W.H. Paar (1991) The optical properties of montbrayite, Au_2Te_3, from Robb Montbray, Quebec, compared with those of the other gold tellurides. Can. Mineral., 29, 223–229.

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Montebrasite $LiAl(PO_4)(OH, F)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals typically equant, may be short to long prismatic, to 10 cm; as coarse cleavable or blocky to rounded nodular masses. *Twinning:* Common on $\{\overline{1}\overline{1}1\}$, producing tabular composite crystals; microscopic polysynthetic twinning on {111}.

Physical Properties: *Cleavage:* Perfect on {100}; good on {110}; distinct on $\{0\overline{1}1\}$ [morphological orientation of ref. (1)]. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.98–3.04 D(calc.) = [3.03]

Optical Properties: Translucent to transparent. *Color:* Pale brown, pink, pale yellow, gray, white, colorless; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (+), may be biaxial (–). *Dispersion:* $r < v$. α = 1.594–1.615 β = 1.608–1.624 γ = 1.616–1.646 2V(meas.) = 66°–101°

Cell Data: *Space Group:* $C\overline{1}$. $a = 6.713(1)$ $b = 7.708(1)$ $c = 7.0194(7)$ $\alpha = 91.31(1)°$ $\beta = 117.93(1)°$ $\gamma = 91.77(1)°$ Z = 4

X-ray Powder Pattern: Varuträsk, Sweden. (ICDD 12-448).
2.968 (100), 3.164 (90), 4.672 (70), 3.200 (60), 3.327 (45), 3.271 (45), 3.229 (45)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	49.11	48.31	Na_2O	0.14		H_2O^-	0.07	
Al_2O_3	35.10	34.70	K_2O	0.01		$-O = F_2$	0.59	2.72
CaO	0.08		F	1.40	6.47	Total	100.09	100.00
Li_2O	9.52	10.17	H_2O^+	5.25	3.07			

(1) Tanco pegmatite, Canada; corresponds to $Li_{0.93}Na_{0.01}Al_{1.01}(PO_4)_{1.01}(OH)_{0.85}F_{0.11}$.
(2) $LiAl(PO_4)(OH, F)$ with OH:F = 1:1.

Polymorphism & Series: Forms a series with amblygonite.

Mineral Group: Amblygonite group.

Occurrence: A late primary and secondary mineral in zoned granite pegmatites; may be an ore of lithium.

Association: Hydroxylapatite, spodumene, lepidolite, petalite, pollucite, tourmaline, triplite, lithiophilite, lacroixite, crandallite, muscovite, albite.

Distribution: A few localities for well-studied material include: from Montebras, Creuse, France. In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. From the Tanco pegmatite, Bernic Lake, Manitoba, Canada. In the USA, at the Nevel quarry and Bell Pit, Newry, Oxford Co., and elsewhere in Maine; in the Midnight Owl pegmatite, White Picacho district, Maricopa Co., Arizona; in South Dakota, from the Peerless and Hugo mines, near Keystone, Pennington Co.; around Custer, Custer Co., at the Tip Top and Tin Mountain mines, with large masses from the Beecher lode, eight km southeast of Custer; at the Nesbit mine, Gunnison Co., Colorado; in the Stewart mine, Pala, San Diego Co., California. In Brazil, gemmy crystals from Linópolis, Galiléia; at Araçuaí, Itinga, Governador Valadares, and other places in Minas Gerais. In the Buranga pegmatite, near Gatumba, Rwanda.

Name: For the locality, Montebras, France, from which it was first described.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 823–827. (2) Černá, I., P. Černý, and R.B. Ferguson (1973) The fluorine content and some physical properties of the amblygonite-montebrasite minerals. Amer. Mineral., 58, 291–301. (3) Greiner, D.J. and F.D. Bloss (1987) Amblygonite-montebrasite optics: response to $(OH)^-$ orientation and rapid estimation of F from 2*V*. Amer. Mineral., 72, 617–624. (4) Groat, L.A., M. Raudsepp, F.C. Hawthorne, T.S. Ercit, B.L. Sherriff, and J.S. Hartman (1990) The amblygonite-montebrasite series: characterization by single-crystal structure refinement, infrared spectroscopy, and multinuclear MAS–NMR spectroscopy. Amer. Mineral., 75, 992–1008.

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Monteponite CdO

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, with cube modification, in a druse of fine crystals, to 0.05 mm; pulverulent, massive. *Twinning:* Penetration twins, law unknown.

Physical Properties: Hardness = 3 D(meas.) = 8.1–8.2 (synthetic). D(calc.) = 8.238

Optical Properties: Transparent. *Color:* Black; red to orange-brown in transmitted light. *Luster:* Brilliant.
Optical Class: Isotropic. $n = 2.49$ (Li).

Cell Data: *Space Group:* $Fm3m$ (synthetic). a = 4.6953 Z = 4

X-ray Powder Pattern: Synthetic.
2.712 (100), 2.349 (88), 1.661 (43), 1.416 (28), 1.355 (13), 1.0499 (13), 0.9584 (11)

Chemistry:

	(1)	(2)
Cd	87.5	87.54
O	[12.5]	12.46
Total	[100.0]	100.00

(1) Genarutta mine, Sardinia, Italy; O by difference. (2) CdO.

Mineral Group: Periclase group.

Occurrence: As a coating over "calamine" (Genarutta mine, Sardinia, Italy); in sulfide ore (Verkhoyan'ya, Russia).

Association: "Calamine" [smithsonite or hemimorphite] (Genarutta mine, Sardinia, Italy); cadmium, otavite (Verkhoyan'ya, Russia).

Distribution: From the Genarutta mine, Monteponi, near Iglesias, Sardinia, Italy. At Welrath, Belgium. From southern Verkhoyan'ya, Russia.

Name: For Monteponi, near the locality on Sardinia, Italy.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 502–503 [cadmium oxide]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 575–576. (3) Fairbanks, E.E. (1946) The punched card identification of ore minerals [cadmium oxide=monteponite]. Econ. Geol., 41, 761–768, esp. 767. (4) (1947) Amer. Mineral., 32, 484 (abs. ref. 3). (5) (1953) NBS Circ. 539, 2, 27.

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Monteregianite-(Y) $K_2Na_4(Y,Ca)_2Si_{16}O_{38}\cdot 10H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals needlelike, elongated and flattened, to 2.5 cm; may be tabular; as irregular micaceous masses, radiating clusters, and parallel groups.

Physical Properties: *Cleavage:* Perfect on $\{1\bar{1}0\}$, very good on {010}, good to fair on {110}. Hardness = ~3.5 D(meas.) = 2.42(2) D(calc.) = 2.41 Fluoresces green under SW UV.

Optical Properties: Transparent to opaque. *Color:* Colorless, white, gray; pale rose or violet, rarely mauve or pale green; may be color zoned. *Streak:* White. *Luster:* Vitreous to silky. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.510(1)$ $\beta = 1.513(1)$ $\gamma = 1.517(1)$ 2V(meas.) = 87(1)° 2V(calc.) = 82°

Cell Data: *Space Group:* $P2_1/n$. $a = 9.512(2)$ $b = 23.956(4)$ $c = 9.617(2)$ $\beta = 93.85(1)°$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
12.00 (100), 7.03 (100), 4.42 (100), 2.873 (80), 6.02 (50), 3.405 (50), 3.026 (50)

Chemistry:

	(1)
SiO_2	60.30
Al_2O_3	0.50
Y_2O_3	11.97
MgO	0.15
CaO	0.65
BaO	0.35
Na_2O	9.14
K_2O	5.36
H_2O	11.40
Total	99.82

(1) Mont Saint-Hilaire, Canada; Y by electron microprobe, H_2O by DTA; corresponds to $K_{1.80}Na_{4.66}(Y_{1.68}Ca_{0.18}Mg_{0.06}Ba_{0.04})_{\Sigma=1.96}(Si_{15.87}Al_{0.16})_{\Sigma=16.03}O_{38}\cdot 10.02H_2O$.

Occurrence: In miarolitic cavities, metamorphosed inclusions, and rheomorphic breccias in nepheline syenite in an intrusive alkalic gabbro-syenite complex.

Association: Calcite, pectolite, microcline, albite, aegirine, arfvedsonite, phlogopite, fluorite, quartz, ekanite, sepiolite, ashcroftine, lorenzenite, narsarsukite, natrolite, harmotome, apophyllite, molybdenite, pyrite.

Distribution: At Mont Saint-Hilaire, Quebec, Canada.

Name: For the Monteregian Hills, of which Mont Saint-Hilaire is one, and *yttrium* in the composition.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 37130; National Museum of Natural History, Washington, D.C., USA, 145548.

References: (1) Chao, G.Y. (1978) Monteregianite, a new hydrous sodium potassium yttrium silicate mineral from Mont St-Hilaire, Québec. Can. Mineral., 16, 561–565. (2) (1980) Amer. Mineral., 65, 207 (abs. ref. 1). (3) Ghose, S., P.K. Sen Gupta, and C.F. Campana (1987) Symmetry and crystal structure of montregianite [*sic*], $Na_4K_2Y_2Si_{16}O_{38}\cdot 10H_2O$, a double-sheet silicate with zeolitic properties. Amer. Mineral., 72, 365–374. (4) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 144–145.

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Montesommaite $(K,Na)_9Al_9Si_{23}O_{64}\cdot 10H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $mm2$. Dipyramidal crystals, truncated by pedions, to 0.1 mm.

Physical Properties: Hardness = n.d. D(meas.) = 2.34(4) D(calc.) = 2.30

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = a$ or b, $Z = a$ or b. $\alpha = 1.498(1)$ $\beta = 1.506(1)$ $\gamma = 1.507(1)$ 2V(meas.) = 35(5)° 2V(calc.) = 39°

Cell Data: *Space Group:* $Fdd2$. $a = 10.099(1)$ $b = 10.099(1)$ $c = 17.307(3)$ Z = 1

X-ray Powder Pattern: Pollena, Italy.
3.299 (100), 3.130 (100), 6.589 (75), 4.334 (43), 2.797 (30), 2.347 (22), 1.784 (22)

Chemistry:

	(1)
SiO_2	55.7
Al_2O_3	19.8
Na_2O	0.2
K_2O	16.7
H_2O	[7.6]
Total	[100.0]

(1) Pollena, Italy; by electron microprobe, H_2O by difference; corresponding to $(K_{8.6}Na_{0.2})_{\Sigma=8.8}(Si_{22.6}Al_{9.4})_{\Sigma=32.00}O_{73.9}H_{20.5}$.

Mineral Group: Zeolite group.

Occurrence: In volcanic scoria.

Association: Dolomite, calcite, chabazite, natrolite.

Distribution: From Pollena, Monte Somma, Campania, Italy.

Name: For Monte Somma, the volcano ancestral to Vesuvius, Italy, in the remnants of which the mineral occurs.

Type Material: National Museum of Natural History, Washington, D.C., USA, 165440.

References: (1) Rouse, R.C., P.J. Dunn, J.D. Grice, J.L. Schlenker, and J.B. Higgins (1990) Montesommaite, $(K,Na)_9Al_9Si_{23}O_{64}\cdot 10H_2O$, a new zeolite related to merlinoite and the gismondine group. Amer. Mineral., 75, 1415–1420.

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Montetrisaite $Cu_6(SO_4)(OH)_{10}\cdot 2H_2O$

Crystal Data: Orthorhombic. *Point Group*: *mm*2. Crystals, acicular along [100], to 0.2 mm, tabular on {001} and striated on {010}.

Physical Properties: *Cleavage*: Distinct on {001}. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 2-3 D(meas.) = n.d. D(calc.) = 3.023

Optical Properties: Transparent. *Color*: Blue. *Streak*: n.d. *Luster*: Vitreous. *Optical Class*: Biaxial. $\alpha = 1.584$ $\gamma = 1.65$ *Orientation: X = a*; *Z = b*. *Pleochroism*: *X* = blue; *Y* = very pale blue.

Cell Data: *Space Group*: $Cmc2_1$. $a = 2.989(2)$ $b = 16.970(5)$ $c = 14.812(4)$ Z = 2

X-ray Powder Pattern: Monte Trisa, Torrebelvicino, Vicenza, Italy.
7.45 (100), 3.73 (35), 1.595 (20), 2.788 (18), 2.503 (14), 2.341 (9), 2.166 (9)

Chemistry:

	(1)
CuO	71.66
ZnO	0.33
PbO	0.11
SO_3	11.17
H_2O	19.00
Total	102.27

(1) Monte Trisa, Torrebelvicino, Vicenza, Italy; average of 5 electron microprobe analyses, H_2O calculated from structure analysis, corresponding to $Cu_{5.97}Zn_{0.03}(SO_4)_{0.93}(OH)_{10.00}\cdot 2H_2O$.

Occurrence: A secondary mineral formed near oxidizing sulfide minerals.

Association: Kaolinite, galena, sphalerite, chalcopyrite, cerussite, anglesite, goethite, langite, posnjakite, linarite, redgillite.

Distribution: Mining concesson Lombardo, near the Veneziana mine, Monte Trisa, Torrebelvicino, Vicenza, Italy.

Name: For the first described locality, Monte Trisa, Italy.

Type Material: Museo di Storia Naturale e del Territorio of the University of Pisa at Calci, Pisa, Italy (catalog no. 18900).

References: (1) Orlandi P., and E. Bonaccorsi (2009) Montetrisaite, a new hydroxy-hydrated copper sulfate species from Monte Trisa, Vicenza, Italy. Can. Mineral., 47, 143–151.
(2) (2009) Amer. Mineral., 94, 1498-1499 (abs. ref. 1).

Montgomeryite $Ca_4MgAl_4(PO_4)_6(OH)_4 \cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. As laths, flattened on {010} and elongated and striated along [001], terminated by pyramids, to 5 mm; {010} dominant, with many {*hk*0} forms.

Physical Properties: *Cleavage:* {010}, perfect; {100}, poor. Hardness = 4
D(meas.) = 2.53(5) D(calc.) = 2.523

Optical Properties: Translucent. *Color:* Dark green to pale green, colorless, red, yellow, may be zoned. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless to pale green; $Y = Z$ = colorless. May be X = light orange brown; Y = pale magenta-pink; Z = light orange-brown. *Orientation:* $Z = b$; $X \wedge c = 60°$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.572(2)$ $\beta = 1.578(2)$ $\gamma = 1.582(2)$
2V(meas.) = 75(10)°

Cell Data: *Space Group:* $C2$. $a = 10.004$–10.023 $b = 24.083$–24.121 $c = 6.235$–6.243
$\beta = 91.55$–$91.60°$ Z = 2

X-ray Powder Pattern: Tip Top mine, South Dakota, USA. (ICDD 35-624).
12.0 (100), 5.11 (65), 2.895 (45), 2.580 (30), 2.874 (25), 2.615 (25), 6.03 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	37.70	36.6	37.14	MgO		3.5	3.52
Al_2O_3	21.32	17.1	17.78	CaO	19.07	19.1	19.56
MnO		0.5		H_2O	21.65	[23.2]	22.00
				Total	99.74	[100.0]	100.00

(1) Fairfield, Utah, USA. (2) Tip Top mine, South Dakota, USA; by electron microprobe, total Mn as MnO, H_2O by difference; corresponding to $(Ca_{3.97}Mn_{0.08})_{\Sigma=4.05}Mg_{1.01}Al_{3.89}(PO_4)_6(OH)_{4.06} \cdot 12.94H_2O$. (3) $Ca_4MgAl_4(PO_4)_6(OH)_4 \cdot 12H_2O$.

Mineral Group: Montgomeryite group.

Occurrence: In sedimentary phosphatic nodules (Fairfield, Utah, USA); a late mineral in highly oxidized phosphate nodules in granite pegmatite (South Dakota, USA).

Association: Variscite, englishite, wardite, gordonite, crandallite (Fairfield, Utah, USA); mitridatite, triphylite, rockbridgeite–frondelite, whitlockite, carbonate-apatite, robertsite, fairfieldite, englishite (South Dakota, USA).

Distribution: In the USA, from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah; in South Dakota, in the Etta mine, near Keystone, Pennington Co., and at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; in the Redhouse Barite mine, Golconda district, Humboldt Co., Nevada. From the Lavra da Ilha pegmatite, in the Jequitinhonha River, three km north of Taquaral, Minas Gerais, Brazil. About 15 km northwest of Milgun Station, Western Australia; in the Iron Monarch quarry, Iron Knob, and the Moculta phosphate quarry, northeast of Angaston, South Australia. At the Mangualde pegmatite, near Mesquitela, and the Bendada pegmatite, near Guarda, Portugal. In Spain, from Montcada and Bruguers, Barcelona Province. At the Sandamap pegmatite, west of Usakos, Namibia.

Name: To honor Dr. Arthur Montgomery (1909–1999), American mineralogist, Professor of Geology, Lafayette College, Easton, Pennsylvania, USA, who collected the first specimens.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 95481.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 978–979. (2) Moore, P.B. and T. Araki (1974) Montgomeryite, $Ca_4Mg(H_2O)_{12}[Al_4(OH)_4(PO_4)_6]$: its crystal structure and relation to vauxite, $Fe_2^{2+}(H_2O)_4[Al_4(OH)_4(H_2O)_4(PO_4)_4] \cdot 4H_2O$. Amer. Mineral., 59, 843–850. (3) Fanfani, L., A. Nunzi, P.F. Zanazzi, and A.R. Zanzari (1976) Additional data on the crystal structure of montgomeryite. Amer. Mineral., 61, 12–14. (4) Dunn, P.J., W.L. Roberts, T.J. Campbell, and P.B. Leavens (1983) Red montgomeryite and associated minerals from the Tip Top pegmatite with notes on kingsmountite and calcioferrite. Mineral. Record, 14, 195–197.

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Monticellite $CaMgSiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As well-formed prismatic crystals, to 5 cm; massive, granular. *Twinning:* On {031}, producing six-pointed star-shaped forms.

Physical Properties: *Cleavage:* Poor on {010}. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 3.03–3.27 D(calc.) = 3.058

Optical Properties: Transparent to translucent. *Color:* Colorless, whitish, pale greenish gray, yellowish gray; colorless in thin section. *Streak:* White. *Luster:* Vitreous, slightly resinous when massive.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, distinct.
$\alpha = 1.638$–1.654 $\beta = 1.646$–1.664 $\gamma = 1.650$–1.674 2V(meas.) = 72°–82°

Cell Data: *Space Group: Pbnm.* a = 4.815 b = 11.08 c = 6.37 Z = 4

X-ray Powder Pattern: San Bernardino Co., California, USA.
2.666 (100), 3.637 (40), 2.586 (40), 4.185 (35), 2.935 (35), 2.543 (30), 1.818 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	37.46	37.13	38.40	MnO	0.52	0.45	
TiO_2		< 0.05		ZnO		0.10	
Al_2O_3		< 0.05		MgO	22.78	23.61	25.76
Fe_2O_3		0.00		CaO	35.20	35.15	35.84
FeO	3.98	3.99		H_2O	0.15		
				Total	100.09	100.43	100.00

(1) Crestmore, California, USA. (2) Cascade Lake, New York, USA; by electron microprobe. (3) $CaMgSiO_4$.

Polymorphism & Series: Forms a series with kirschsteinite.

Occurrence: Formed during metamorphism of siliceous dolostones; in contact metamorphic deposits between limestones and olivine gabbros; in skarns at granite-dolomitic limestone contacts; rarely in kimberlites.

Association: Gehlenite, spinel, calcite, merwinite, åkermanite, vesuvianite, apatite, cuspidine.

Distribution: Some localities for crystals or studied material follow. From Monte Somma and Vesuvius, Campania, Italy. At Camas Mòr, Isle of Muck, Scotland. From Scawt Hill, near Larne, Co. Antrim, Ireland. In the USA, at Crestmore, Riverside Co., California; on Cascade Mountain, Essex Co., New York; at Magnet Cove, Hot Spring Co., Arkansas. In Canada, at Isle Cadieux and Oka, Quebec; on Somerset Island, Northwest Territories. From Congo (Zaire), at Mt. Shaheru, Kivu Province. On Dupezeh Mountain, near Hero Town, Qala-Diza region, Iraq. In Russia, in the Kovdor massif, Kola Peninsula, and numerous other localities.

Name: For the Italian mineralogist Teodoro Monticelli (1759–1845).

Type Material: University of Naples, Naples, Italy, 22111.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 449–450. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 352–375. (3) Moehlman, R.S. and F.A. Gonyer (1934) Monticellite from Crestmore, California. Amer. Mineral., 19, 474–475. (4) Onken, H. (1965) Verfeinerung der Kristallstruktur von Monticellit. Tschermaks Mineral. Petrog. Mitt., 10, 34–44 (in German). (5) Valley, J.W. and E.J. Essene (1980) Åkermanite in the Cascade Slide xenolith and its significance for regional metamorphism in the Adirondacks. Contr. Mineral. Petrol., 74, 143–152.

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Montmorillonite $(Na, Ca)_{0.3}(Al, Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tiny scaly crystals, tabular on {001}; as lamellar or globular microcrystalline aggregates; clayey, compact, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven. Hardness = 1–2 D(meas.) = 2–3 D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* White, pale pink, buff, yellow, red, green.
Luster: Dull, earthy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless to pale brown, yellow-green; Y = dark brown to yellow-green, olive-green, pale yellow; Z = brown to olive-green, pale yellow.
Orientation: $X \simeq c$; $Y = b$; $Z \simeq a$. α = 1.492–1.503 β = 1.513–1.534 γ = 1.513–1.534
2V(meas.) = 10°–25°

Cell Data: *Space Group:* $C2/m$. $a = 5.17(2)$ $b = 8.94(2)$ $c = 9.95(6)$ β = n.d. Z = 1

X-ray Powder Pattern: Chambers, Arizona, USA; Na and glycerol saturated.
17.6 (10), 4.49 (8), 1.50 (6), 9.00 (5), 3.58 (4), 2.57 (4b), 2.99 (3)

Chemistry:

	(1)
SiO_2	51.14
Al_2O_3	19.76
Fe_2O_3	0.83
MgO	3.22
CaO	1.62
Na_2O	0.11
K_2O	0.04
H_2O^+	7.99
H_2O^-	14.81
Total	99.52

(1) Montmorillon, France; corresponds to $(Ca_{0.14}Na_{0.02})_{\Sigma=0.16}(Al_{1.68}Mg_{0.36}Fe_{0.04})_{\Sigma=2.08}(Si_{3.90}Al_{0.10})_{\Sigma=4.00}O_{10}(OH)_2 \cdot 1.02H_2O$.

Polymorphism & Series: Interstratifies with chlorite, muscovite, illite, cookeite, kaolinite.

Mineral Group: Smectite group.

Occurrence: An alteration product of volcanic tuff and ash, forming bentonite beds, and of pegmatite dikes and wall rocks bordering hydrothermal mineral deposits. Forms under alkaline conditions of poor drainage, with Mg, Ca, Na, and K remaining in the soil.

Association: Cristobalite, zeolites, biotite, quartz, orthoclase, dolomite, amphiboles, pyroxenes, olivine, calcite, gypsum, pyrite, "limonite".

Distribution: A common clay mineral, with numerous localities worldwide. From Montmorillon, Vienne, France. In the USA, material considered as standards from Bayard and Santa Rita, Grant Co., New Mexico; near Chambers, Apache Co., Arizona; at Belle Fourche, Butte Co., South Dakota; in Wyoming, on the John C. Lane tract, Upton, Weston Co., at Clay Spur, near Newcastle, Crook Co., and elsewhere. In the Itawamba mine, Itawamba Co., and in mines around Polkville, Simpson Co., Mississippi; at Strasburg, Shenandoah Co., Virginia.

Name: After the occurrence at Montmorillon, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 690–691, 695–697. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 226–245. (3) Early, J.W., B.B. Osthaus, and I.H. Milne (1953) Purification and properties of montmorillonite. Amer. Mineral., 38, 707–724.

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Montroseite $(V^{3+}, Fe^{2+}, V^{4+})O(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As microscopic bladed crystals, to 0.5 mm, flattened on {010}, with {110}, and terminated by {0.10.1}(?) and {121}; in very fine-grained aggregates.

Physical Properties: *Cleavage:* {010} and {110}, good. *Tenacity:* Brittle. Hardness = Soft. D(meas.) = 4.0 D(calc.) = 4.11 Rapidly transforms topotactically to paramontroseite in air.

Optical Properties: Opaque. *Color:* Black to grayish black. *Streak:* Black.
Luster: Submetallic.
Optical Class: Biaxial.
R_1–R_2: (400) 16.6–18.7, (420) 15.8–18.0, (440) 15.0–17.3, (460) 14.6–17.0, (480) 14.4–16.8, (500) 14.3–16.6, (520) 14.4–16.7, (540) 14.6–16.8, (560) 14.9–16.9, (580) 15.1–17.1, (600) 15.5–17.4, (620) 15.8–17.8, (640) 16.2–18.2, (660) 16.6–18.7, (680) 17.0–19.2, (700) 17.5–19.8

Cell Data: *Space Group: Pbnm.* $a = 4.54$ $b = 9.97$ $c = 3.03$ Z = 4

X-ray Powder Pattern: Unspecified locality, USA.
4.31 (s), 2.644 (s), 3.38 (m), 2.495 (m), 2.217 (m), 1.512 (m), 2.423 (w)

Chemistry:

	(1)	(2)	(3)
V_2O_4	72.5	66.90	
V_2O_3	10.5	11.10	89.27
SiO_2		6.12	
Al_2O_3		3.00	
FeO	8.8	8.26	
H_2O	5.0	4.82	10.73
Total	[96.8]	100.20	100.00

(1) Bitter Creek mine, Colorado, USA; partial analysis. (2) Matchless mine, Colorado, USA. (3) VO(OH).

Occurrence: In relatively unoxidized Colorado Plateau-type U–V ores in sandstones; thought to be a primary mineral (Colorado, Utah, and Arizona, USA); in vanadiferous anthraxolite bitumen (Guangxi, China).

Association: Paramontroseite, uraninite, corvusite, hewettite, melanovanadite, pascoite, hummerite, pyrite, galena, barite, quartz.

Distribution: In the USA, at the Bitter Creek, Jo Dandy, Whitney, and Virgin mines, Uravan district, Montrose Co., and the Matchless mine, Gateway district, Mesa Co., Colorado; in the Juniper mine, near Thompson, Grand Co., the Rex No. 2 mine, Temple Mountain, and Mi Vida mine, Monticello district, Emery Co., Utah. In the Martin, Mesa 4-1/2, and Cove mines, Carrizo Mountains, and the Monument No. 2 mine, Monument Valley, Apache Co., Arizona; in the Grants district, McKinley Co., New Mexico; and in the Runge mine, Edgemont, Fall River Co., South Dakota. At Příbram, and in the Novoveska Huta deposit, Czech Republic. In the Urcal deposit, La Rioja, and in the Huemul mine, Malargüe district, Mendoza Province, Argentina. From the Mounana uranium mine, Franceville, Gabon. In the Shanglin and Hechi bitumens, Guangxi, Zhuang Autonomous Region, China.

Name: For Montrose Co., Colorado, USA, where it was first found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106897, 106898.

References: (1) Weeks, A.D., E.A. Cisney, and A.N. Sherwood (1953) Montroseite, a new vanadium oxide from the Colorado Plateaus. Amer. Mineral., 38, 1235–1241. (2) Evans, H.T., Jr. and S. Block (1953) The crystal structure of montroseite, a new vanadium member of the diaspore group. Amer. Mineral., 38, 1242–1250. (3) Weeks, A.D. and M.E. Thompson (1954) Identification and occurrence of uranium and vanadium minerals from the Colorado Plateaus. U.S. Geol. Sur. Bull. 1009-B, 52–53. (4) Evans, H.T., Jr. and M.E. Mrose (1955) A crystal chemical study of montroseite and paramontroseite. Amer. Mineral., 40, 861–875.

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Montroyalite $Sr_4Al_8(CO_3)_3(OH,F)_{26}\cdot 10-11H_2O$

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Crystal Data: Triclinic (probable). *Point Group:* n.d. As flattened or elongated polycrystalline hemispheres, composed of a waxy interior and radial fibers forming a rough exterior, to 1 mm; as aggregates of hemispheres. *Twinning:* Complex, polysynthetic, with multiple crystallites.

Physical Properties: *Fracture:* Uneven to splintery. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.677(3) D(calc.) = n.d. Fluoresces white under SW and LW UV.

Optical Properties: Translucent. *Color:* White, pale blue or gray from inclusions. *Streak:* White. *Luster:* Dull.
Optical Class: Biaxial (–). *Orientation:* $Y \simeq$ elongation; X and Z at about 45° to plane of flattening of laths. $\alpha = 1.515(5)$ $\beta = 1.530(5)$ $\gamma = 1.545(5)$ 2V(meas.) = 80(10)° 2V(calc.) = 89°

Cell Data: *Space Group:* n.d. a = 7.14 b = 6.55 c = n.d. $\alpha =\sim 77.5°$ β = n.d. γ = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

6.57 (100), 3.283 (55), 4.00 (50), 3.190 (50), 2.365 (45b), 2.862 (40), 2.551 (40b)

Chemistry:

	(1)
CO_2	9.2
Al_2O_3	28.8
CaO	1.1
SrO	27.7
F	11.5
H_2O	24.6
$-O = F_2$	4.8
Total	98.1

(1) Francon quarry, Canada; by electron microprobe, CO_2 and H_2O by TGA-EGA, $(CO_3)^{2-}$, $(OH)^{1-}$, and H_2O confirmed by IR; corresponds to $(Sr_{3.78}Ca_{0.28})_{\Sigma=4.06}Al_8(CO_3)_{2.96}[(OH_{17.63}F_{8.57}]_{\Sigma=26.20}\cdot 10.52H_2O$.

Occurrence: In cavities in a silicocarbonate sill.

Association: Albite, strontiodresserite, calcite, quartz, dawsonite, ankerite, fluorite, barite, strontianite, smythite, marcasite, pyrite, halloysite, doyleite.

Distribution: From the Francon quarry, Montreal Island, Montreal, Quebec, Canada.

Name: For the Monteregian Hill, Mont Royal, prominent landmark in Montreal, Canada, from which the city's name was derived.

Type Material: Canadian Geological Survey, Ottawa, Canada, 64261–64265.

References: (1) Roberts, A.C., A.P. Sabina, M. Bonardi, J.L. Jambor, R.A. Ramik, B.D. Sturman, and M.J. Carr (1986) Montroyalite, a new hydrated Sr–Al hydroxylcarbonate from the Francon quarry, Montreal, Quebec. Can. Mineral., 24, 455–459. (2) (1987) Amer. Mineral., 72, 1025 (abs. ref. 1).

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Montroydite HgO

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, elongated ‖ [100], to 4 cm, or equant, with prominent {140} and a multiplicity of other forms; may have several sets of striations, bent or twisted. In aggregates, vermiform, tubular, or spherical; powdery, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Sectile; flexible but not elastic, brittle if bent on [001]. Hardness = 2.5 D(meas.) = 11.23 D(calc.) = 11.22

Optical Properties: Opaque, transparent on thin edges. *Color:* Deep red, brownish red to brown; red-orange to pale yellow in transmitted light. *Streak:* Yellow-brown. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* In thick sections, deep red-orange to yellowish brown. *Orientation:* X = a or b; Y = b or a; Z = c. $\alpha = 2.37(2)$ $\beta = 2.5$ $\gamma = 2.65(2)$ 2V(meas.) = Large.

Cell Data: *Space Group: Pnma* (synthetic). $a = 6.608$ $b = 5.518$ $c = 3.519$ Z = 4

X-ray Powder Pattern: Synthetic.
2.972 (100), 2.836 (70), 2.4090 (55), 2.762 (52), 1.8159 (38), 1.4956 (20), 1.4435 (12)

Chemistry:

	(1)	(2)	(3)
Hg	92.87	92.74	92.61
O	7.13	7.49	7.39
Total	100.00	100.23	100.00

(1) Terlingua, Texas, USA; O by loss on heating. (2) Do.; O by volumetric analysis. (3) HgO.

Occurrence: In hydrothermal mercury deposits.

Association: Mercury, cinnabar, metacinnabar, calomel, eglestonite, terlinguaite, mosesite, kleinite, edgarbaileyite, gypsum, calcite, dolomite.

Distribution: In the USA, large crystals from Terlingua, Brewster Co., Texas; in California, in the Challenge deposit, near Emerald Lake, southwest of Redwood City, San Mateo Co., in the Socrates and Esperanza mines, Sonoma Co., the Kings and White mines, Parkfield district, Kings Co., the Red Elephant mine, near Lower Lake, Lake Co., and the Alpine and Clear Creek mines, New Idria district, San Benito Co.; and from the McDermitt mine, Opalite district, Humboldt Co., Nevada. Large crystals from Huahuaxtla, Guerrero, and at El Doktor, Queretaro, Mexico. From Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan.

Name: Honors Montroyd Sharp, an owner of the mercury deposit at Terlingua, Texas, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 82936; National Museum of Natural History, Washington, D.C., USA, 86637, 86638, 87483.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 511–514. (2) Roth, W.L. (1956) The structure of mercuric oxide. Acta Cryst., 9, 277–280. (3) Aurivillius, K. (1956) The structure of mercury(II) oxide. Acta Cryst., 9, 685–686. (4) McMurdie, H.F., M.C. Morris, E.H. Evans, B. Paretzkin, W. Wong-Ng, Y. Zhang, and C.R. Hubbard (1986) Standard X-ray diffraction powder patterns from the JCPDS Research Associateship. Powder Diffraction, 1(4), 334–345, esp. 341.

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Mooihoekite $Cu_9Fe_9S_{16}$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Grains, to 1 mm, in massive sulfides, and as intergrowths with haycockite.

Physical Properties: Hardness = n.d. VHN = 240–246 (100 g load). D(meas.) = 4.36 D(calc.) = 4.37

Optical Properties: Opaque. *Color:* Pale yellow in reflected light, tarnishes to pinkish brown and purple. *Luster:* Metallic.

R: (400) 14.3, (420) 16.7, (440) 20.0, (460) 23.9, (480) 27.5, (500) 30.6, (520) 33.2, (540) 35.2, (560) 36.7, (580) 37.8, (600) 38.8, (620) 39.4, (640) 40.0, (660) 40.2, (680) 40.3, (700) 40.4

Cell Data: *Space Group:* $P\bar{4}2m$. $a = 10.585(5)$ $c = 5.383(5)$ $Z = 1$

X-ray Powder Pattern: Mooihoek mine, South Africa.
3.06 (10), 1.881 (8), 1.593 (6), 1.081 (6), 1.219 (5), 1.870 (5), 1.321 (4)

Chemistry:

	(1)	(2)	(3)
Cu	35.91	34.08	36.02
Fe	31.88	32.47	31.66
Ni	0.26	0.24	
S	32.44	32.84	32.32
Total	100.49	99.65	100.00

(1) Bushveld complex, South Africa; by electron microprobe, average of 13 analyses; corresponding to $(Cu_{8.94}Ni_{0.07})_{\Sigma=9.01}Fe_{9.03}S_{16.00}$. (2) Minnesota, USA; by electron microprobe, average of four analyses; corresponding to $(Cu_{9.04}Ni_{0.06})_{\Sigma=9.10}Fe_{9.08}S_{16.00}$. (3) $Cu_9Fe_9S_{16}$.

Occurrence: In massive sulfide from a pipe-shaped dunite pegmatite in the Norite Zone of the Bushveld complex (Mooihoek mine, South Africa); in troctolite from the basal Duluth Gabbro complex (Minnesota, USA).

Association: Haycockite, magnetite, troilite, cuprian pentlandite, mackinawite, sphalerite, moncheite (Mooihoek Farm, South Africa); haycockite, copper, troilite, pentlandite, cubanite, magnetite (Minnesota, USA).

Distribution: In South Africa, from Transvaal, in the Mooihoek mine, Lydenburg district [TL], and from the Townlands pipe, Rustenburg. At the Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota, USA. From the Talnakh area, Noril'sk region, western Siberia, Russia. At Krzemianka, Poland. In the Malanjkhand Cu–Mo deposit, Madhya-Pradesh, India.

Name: For the locality on Mooihoek Farm, South Africa.

Type Material: Princeton University, Princeton, New Jersey; National Museum of Natural History, Washington, D.C., USA, 124965; Canadian Museum of Nature, Ottawa, 10309; Royal Ontario Museum, Toronto, Canada, M30992; Heidelberg University, Heidelberg, Germany, 2313a.

References: (1) Cabri, L.J. and S.R. Hall (1972) Mooihoekite and haycockite, two new copper–iron sulfides, and their relationship to chalcopyrite and talnakhite. Amer. Mineral., 57, 689–708. (2) Hall, S.R. and J.F. Rowland (1973) The crystal structure of synthetic mooihoekite, $Cu_9Fe_9S_{16}$. Acta Cryst., 29, 2365–2372. (3) Putnis, A. (1978) Talnakhite and mooihoekite: the accessibility of ordered structures in the metal-rich region around chalcopyrite. Can. Mineral., 16, 23–30. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 384.

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Moolooite $Cu(C_2O_4)\cdot 0.4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystallites are lathlike or prismatic, to 4 μm, in microconcretions.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.43

Optical Properties: Semitransparent. *Color:* Turquoise green, green, blue. *Luster:* Dull to waxy.
Optical Class: Biaxial. *Orientation:* $X \parallel$ elongation; $Z \perp$ elongation. $\alpha = 1.57$ $\beta = [1.77]$ $\gamma = 1.95$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 5.35$ (by analogy to synthetic $Cu(C_2O_4)\cdot 0.1H_2O$. $b = 5.63$ $c = 2.56$ Z = 1

X-ray Powder Pattern: Mooloo Station, Australia.
3.88 (100), 2.50 (30), 1.753 (30), 2.31 (25), 1.787 (25), 2.14 (20), 2.33 (18)

Chemistry:

	(1)
SiO_2	[6.35]
CuO	[46.7]
C_2O_3	42.3
H_2O	4.65
Total	[100.0]

(1) Mooloo Station, Australia; CHN analyzer gave C 14.10% and H 0.52% and a positive test for oxalate was obtained; calculating CuO for stoichiometry and assuming SiO_2 by difference, corresponds to $Cu(C_2O_4)\cdot 0.44H_2O$.

Occurrence: On an outcrop of quartz, thought to have formed by reaction between bird guano and soluble secondary copper minerals (Mooloo Station, Australia); in a mine shaft near tree roots (Sainte-Marie-aux-Mines, France).

Association: Opaline silica, sampleite, libethenite, brochantite, antlerite, atacamite, whewellite, chalcopyrite, digenite, covellite, gypsum, barite, jarosite (Mooloo Station, Australia).

Distribution: From Mooloo Station, 12 km east of the homestead, Murchison, Western Australia. At Sainte-Marie-aux-Mines, Haut-Rhin, France.

Name: For the original locality on Mooloo Station, Australia.

Type Material: Western Australian Museum, Perth, Australia, MDC6738.

References: (1) Clarke, R.M. and I.R. Williams (1986) Moolooite, a naturally occurring hydrated copper oxalate from Western Australia. Mineral. Mag., 50, 295–298. (2) (1987) Amer. Mineral., 72, 1025–1026 (abs. ref. 1).

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Mooreite $Mg_9Zn_4Mn_2^{2+}(SO_4)_2(OH)_{26}\cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are flat tabular to platy $\perp$ [010], with large {010}, the edges modified by ten other forms, commonly distorted and etched, in subparallel aggregates, to 10 cm.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 3 D(meas.) = 2.47(2) D(calc.) = 2.444

Optical Properties: Transparent. *Color:* Pale yellowish brown; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 44°$. *Dispersion:* $r > v$, perceptible. $\alpha = 1.533$ $\beta = 1.545$ $\gamma = 1.547$ 2V(meas.) = ∼50°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.147(3)$ $b = 20.350(6)$ $c = 8.202(3)$ $\beta = 92.69(4)°$ Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
5.079 (100), 10.089 (78), 2.379 (78), 1.619 (58), 3.452 (51), 1.832 (47), 2.667 (40)

Chemistry:

	(1)	(2)
SO_3	10.99	11.60
MnO	11.93	9.76
ZnO	24.58	23.99
MgO	25.38	26.75
H_2O	27.12	[27.90]
Total	[100.00]	[100.00]

(1) Sterling Hill, New Jersey, USA; average of two analyses, totalling 99.77%, recalculated to 100% after deduction of SiO_2 0.06% and $CaCO_3$ 0.89%; corresponds to $Mg_{8.61}Zn_{4.11}Mn_{2.28}(SO_4)_{1.86}(OH)_{26.28}\cdot 7.47H_2O$. (2) Do.; by electron microprobe, total Mn as MnO, H_2O by difference, $(OH)^{1-}$ calculated for charge balance, SO_3^{2-} and H_2O confirmed by IR; corresponds to $Mg_{9.10}Zn_{4.04}Mn_{1.89}(SO_4)_{1.99}(OH)_{26.08}\cdot 8.21H_2O$.

Occurrence: Rarely in cavities and veinlets in franklinite–willemite–calcite ore from a metamorphosed stratiform zinc orebody.

Association: Pyrochroite, rhodochrosite, zincite, torreyite, fluoborite, franklinite, willemite, calcite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: Honoring Dr. Gideon Emmet Moore (1842–1895), University of California, Berkeley, California, USA, American chemist, an early investigator of Franklin and Sterling Hill minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95985.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 574–575. (2) Hill, R.J. (1979) Crystal data for mooreite. Australian Mineralogist, no. 26, 126–128. (3) Hill, R.J. (1980) The structure of mooreite. Acta Cryst., 36, 1304–1311.

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Moorhouseite $(Co, Ni, Mn^{2+})SO_4 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Granular to fine-grained columnar, in crusts and efflorescences.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 1.97–2.02 D(calc.) = 2.006 (synthetic). Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Pink; pale pink in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Pale pink. *Orientation:* $Y = b$ (synthetic). *Absorption:* $X \gg Z$. $\alpha = 1.470$ $\beta = [1.496]$ $\gamma = 1.496$ 2V(meas.) = 20(10)°

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 10.032(4)$ $b = 7.233(3)$ $c = 24.261(10)$ $\beta = 98.37(3)°$ Z = 8

X-ray Powder Pattern: Magnet Cove mine, Canada.
4.39 (10), 4.01 (6), 2.91 (5), 4.13 (4), 5.45 (3), 3.58 (3), 5.84 (2)

Chemistry: (1) Magnet Cove mine, Canada; identity depends on correspondence of the X-ray powder pattern with synthetic material; analysis of an aqueous solution by X-ray spectroscopy gave Co:Ni:Mn:Cu:Fe:Zn = 100:45:21:9:6:1 or $(Co_{0.55}Ni_{0.25}Mn_{0.12}Cu_{0.05}Fe_{0.03})_{\Sigma=1.00}SO_4 \cdot 6H_2O$.

Mineral Group: Hexahydrite group.

Occurrence: As efflorescences with sulfides (probably cobaltian and nickelian pyrite) on siderite–barite matrix from a hydrothermal Pb–Zn–Cu orebody associated with a large barite deposit (Magnet Cove mine, Canada); as crusts on sandstone (near Cameron, Arizona, USA).

Association: Aplowite, siderite, barite (Magnet Cove mine, Canada); koritnignite, köttigite, picropharmacolite (Jáchymov, Czech Republic).

Distribution: From the Magnet Cove barite mine, four km southwest of Walton, Nova Scotia, Canada. In a prospect 13 km east-southeast of Gray Mountain, Cameron district, Coconino Co., Arizona, USA. From the Geschieber and Evangelista veins, Jáchymov (Joachimsthal), Czech Republic. At Fontana Rosa, Corsica, France. In Germany, on the dump of the Schmiedestollen, near Wittichen, in the Rötenback quarry, near Alpirsbach, Black Forest; at the Daniel mine, Schneeberg, Saxony.

Name: To honor Dr. Walter Wilson Moorhouse (1913–1969), Canadian Professor of Geology, University of Toronto, Toronto, Canada.

Type Material: National School of Mines, Paris, France; Canadian Geological Survey, Ottawa, Canada, 12145.

References: (1) Jambor, J.L. and R.W. Boyle (1965) Moorhouseite and aplowite, new cobalt minerals from Walton, Nova Scotia. Can. Mineral., 8, 166–171. (2) (1965) Amer. Mineral., 50, 808 (abs. ref. 1). (3) Zalkin, A., H. Ruben, and D.H. Templeton (1962) The crystal structure of cobalt sulphate hexahydrate. Acta Cryst., 15, 1219–1224.

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Mopungite $NaSb^{5+}(OH)_6$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Pseudocubic crystals, to 0.3 mm, showing {001}, {110}, and {101}; rarely acicular; as incrustations.

Physical Properties: Hardness = 3 D(meas.) = 3.21 D(calc.) = 3.264 Soluble in hot H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless to milky white.
Luster: Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.614$ $\epsilon = 1.605$

Cell Data: *Space Group:* $P4_2/n$. $a = 7.994$ $c = 7.859$ Z = [4]

X-ray Powder Pattern: Mopung Hills, Nevada, USA.
4.581 (10), 3.985 (8), 1.205 (7), 1.629 (5), 1.325 (5), 1.265 (5), 1.192 (5)

Chemistry:

	(1)	(2)
Sb_2O_5	65.2	65.54
Na_2O	12.8	12.56
H_2O	[22.0]	21.90
Total	[100.0]	100.00

(1) Mopung Hills, Nevada, USA; by X-ray fluorescence, H_2O from analysis of synthetic material; recalculated to 100% after deduction of sulfur 11.1%. (2) $NaSb(OH)_6$.

Mineral Group: Stottite group.

Occurrence: An oxidation product of stibnite.

Association: Selenium, sulfur, stibiconite, sénarmontite, roméite, tripuhyite (Mopung Hills, Nevada, USA); cetineite, sénarmontite, brizziite, other antimony oxides (Cetine mine, Italy).

Distribution: At the Green prospect, Mopung Hills, Lake district, Churchill Co., Nevada, USA. From the Cetine mine, 20 km southwest of Siena, Tuscany, Italy.

Name: For the Mopung Hills, Nevada, USA, where it was first found.

Type Material: The Natural History Museum, London, England, 1984,477; National Museum of Natural History, Washington, D.C., USA, 161224.

References: (1) Williams, S.A. (1985) Mopungite, a new mineral from Nevada. Mineral. Record, 16, 73–74. (2) (1985) Amer. Mineral., 70, 1330 (abs. ref. 1).

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Moraesite $Be_2(PO_4)(OH)\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group: m.* As radiating tabular acicular crystals, elongated along [001], to 5 mm; dominant forms include {100}, {1$\bar{3}$0}, {130}, {1$\bar{3}$1}, {131}; aggregates may resemble cotton-balls, or in matted coatings and crusts.

Physical Properties: *Cleavage:* Perfect, two directions yielding traces parallel [100] and [001] on {100}. Hardness = n.d. D(meas.) = 1.805 D(calc.) = 1.806

Optical Properties: Translucent. *Color:* White. *Streak:* White. *Luster:* Silky. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $Y \wedge c = 11°$. $\alpha = 1.462$ $\beta = 1.482$ $\gamma = 1.490$ 2V(meas.) = 65°

Cell Data: *Space Group: Cc.* $a = 8.553(6)$ $b = 36.957(18)$ $c = 7.155(8)$ $\beta = 97.93(9)°$ Z = 12

X-ray Powder Pattern: Sapucaia mine, Brazil; nearly identical to bearsite.
7.00 (10), 3.278 (9), 4.24 (6), 3.023 (6), 2.819 (6), 6.15 (4), 2.325 (4)

Chemistry:

	(1)	(2)
P_2O_5	34.76	35.12
Al_2O_3	0.00	
Fe_2O_3	0.11	
BeO	25.28	24.76
H_2O	39.80	40.12
insol.	0.30	
Total	100.25	100.00

(1) Sapucaia mine, Brazil; iron impurity as hematite; corresponds to $Be_{2.04}(P_{0.99}O_4)(OH)\cdot 3.98H_2O$. (2) $Be_2(PO_4)(OH)\cdot 4H_2O$.

Occurrence: A rare late-stage hydrothermal mineral in complex zoned granite pegmatites.

Association: Beryl, beryllonite, hydroxylherderite, frondelite, triphylite, apatite, muscovite.

Distribution: In Brazil, from the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares; at the Mulundu and Humaita pegmatites, along the Jequitinhonha River, Itinga, and from the Almerindo pegmatite, Linópolis, Minas Gerais. At the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from Greenwood, in the Dunton quarry, Newry, and at Mt. Mica, near Paris, Oxford Co., Maine, USA. In the Viitaniemi pegmatite, near Eräjärvi, Finland. At Arnac-la-Poste, Haute-Vienne, France. From Bojeveskoje, Middle Ural Mountains, Russia. In the Londonderry quarry, 19 km south of Coolgardie, Western Australia.

Name: Honors Dr. Luciano Jacques de Moraes (1896–1968), Brazilian mineralogist and geologist.

Type Material: National Musuem, Rio de Janeiro, Brazil; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 106577.

References: (1) Lindberg, M.L., W.T. Pecora, and A.L. de M. Barbosa (1953) Moraesite, a new hydrous beryllium phosphate from Minas Gerais, Brazil. Amer. Mineral., 38, 1126–1133. (2) Merlino, S. and M. Pasero (1992) Crystal chemistry of beryllophosphates: the crystal structure of moraesite, $Be_2(PO_4)(OH)\cdot 4H_2O$. Zeits. Krist., 201, 253–262.

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Mordenite $(Ca, Na_2, K_2)Al_2Si_{10}O_{24}\cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ or $2/m\ 2/m\ 2/m$. Prismatic crystals, striated || elongation; acicular to fine fibrous, to 2.5 cm. In radiating groups or cottony aggregates; compact, porcelaneous.

Physical Properties: *Cleavage:* Perfect on {100}, distinct on {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.12–2.15 D(calc.) = 2.125

Optical Properties: Transparent to translucent. *Color:* Colorless, white, yellowish, pinkish; in thin section, colorless. *Luster:* Vitreous, pearly on {010}, silky if fibrous.
Optical Class: Biaxial (+) or (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. α = 1.472–1.483 β = 1.475–1.485 γ = 1.477–1.487 2V(meas.) = 76°–90°

Cell Data: *Space Group:* $Cmc2_1$ or $Cmcm$. a = 18.052–18.168 b = 20.404–20.527 c = 7.501–7.537 Z = [4]

X-ray Powder Pattern: Aros, Isle of Mull, Scotland.
3.483 (10), 3.222 (10), 9.10 (9), 6.61 (9), 3.999 (9), 3.393 (9), 4.525 (8)

Chemistry:

	(1)	(2)
SiO_2	66.06	67.35
Al_2O_3	12.32	11.49
MgO	0.36	
CaO	3.02	3.87
Na_2O	3.86	2.63
K_2O	0.50	0.11
H_2O^+	9.19	8.82
H_2O^-	4.68	5.13
Total	99.99	99.40

(1) Challis, Idaho, USA; average of four analyses, corresponding to $(Na_{1.11}Ca_{0.48}K_{0.10}Mg_{0.08})_{\Sigma=1.77}Al_{2.16}Si_{9.80}O_{24}\cdot 5.86H_2O$. (2) Coyote, Garfield Co., Utah, USA; corresponds to $(Ca_{1.24}Na_{0.76}K_{0.02})_{\Sigma=2.02}Al_{2.02}Si_{10.04}O_{24}\cdot 6.94H_2O$.

Mineral Group: Zeolite group.

Occurrence: In veins and amygdules in various igneous rocks; a hydration product of volcanic glasses; an authigenic mineral in sediments.

Association: Zeolites, calcite, kaolinite, glauconite.

Distribution: Many localities for abundant and well-crystallized material. At Morden and along the Bay of Fundy, Nova Scotia, Canada. In the USA, from near Stevenson, Skamania Co., Washington; at Challis, Custer Co., Idaho; in Oregon, along Crooked Creek, Rome, Malheur Co., at Goble, Columbia Co., and at Cape Lookout, Tillamook Co. In Colorado, on Table Mountain, Jefferson Co. and in Wolf Creek Pass, Mineral Co.; from Crestmore, Riverside Co., California; and in Union Pass, Mohave Co., Arizona. At San Piero in Campo, Elba, Italy. In the Berufjord area, Iceland. From Cinchwad and elsewhere in the Poona district, Maharashtra, India.

Name: For the locality at Morden, Nova Scotia, Canada.

Type Material: National Museum of Natural History, Washington, D.C., USA, R4062; The Natural History Museum, London, England, 52574.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 572–573 [ptilolite, part]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 401–407. (3) Schaller, W.T. (1932) Ptilolite [mordenite] from Utah. Amer. Mineral., 17, 125–127. (4) Harris, P.G. and G.W. Brindley (1954) Mordenite as an alteration product of pitchstone glass. Amer. Mineral., 39, 819–824. (5) Passaglia, E. (1975) The crystal chemistry of mordenites. Contr. Mineral. Petrol., 50, 65–77. (6) Alberti, A., P. Davoli, and G. Vezzalini (1986) The crystal structure refinement of a natural mordenite. Zeits. Krist., 175, 249–256.

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Moreauite $Al_3(UO_2)(PO_4)_3(OH)_2 \cdot 13H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular crystals flattened on {100}, may be elongated along [010], to 0.2 mm; as nodules or subparallel aggregates of tablets resembling "open books."

Physical Properties: *Cleavage:* Good on {100}, micaceous. Hardness = n.d. D(meas.) = 2.64(5) D(calc.) = 2.61 Radioactive; bright green fluorescence under SW and LW UV.

Optical Properties: Translucent to opaque. *Color:* Greenish yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \simeq c$; $X \approx a^*$. $\alpha = 1.540(3)$ $\beta = 1.552(2)$ $\gamma = 1.558(2)$ 2V(meas.) = n.d. 2V(calc.) = 70°

Cell Data: *Space Group:* $P2_1/c$. $a = 23.41(6)$ $b = 21.44(4)$ $c = 18.34(3)$ $\beta = 92.0(1)°$ Z = 16

X-ray Powder Pattern: Kobokobo pegmatite, Congo (fully hydrated). 10.80 (100), 11.69 (80), 9.13 (70), 2.931 (70), 14.02 (60), 3.043 (60), 5.43 (40)

Chemistry:

	(1)	(2)	(3)
UO_3	38.9	32.8	31.63
P_2O_5	27.2	23.0	23.55
Al_2O_3	20.4	17.2	16.92
H_2O	[13.5]	[27.0]	27.90
Total	[100.0]	[100.0]	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, average of five grains, partially dehydrated, H_2O by difference, corresponding to $Al_{3.05}(U_{1.04}O_2)(P_{0.97}O_4)_3(OH)_{1.94} \cdot 13H_2O$. (2) Do.; H_2O calculated from density, supported by TGA. (3) $Al_3(UO_2)(PO_4)_3(OH)_2 \cdot 13H_2O$.

Occurrence: A rare secondary mineral in the oxidized uraniferous zone of a complex granite pegmatite.

Association: Furongite, ranunculite, phosphosiderite.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: Honors Professor Jules Moreau (1931–), Belgian mineralogist, Catholic University of Louvain, Louvain, Belgium.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG6601, RMG6197, RMG6203.

References: (1) Deliens, M. and P. Piret (1985) Les phosphates d'uranyle et d'aluminium de Kobokobo. VII. La moreauïte, $Al_3UO_2(PO_4)_3(OH)_2 \cdot 13H_2O$, nouveau minéral. Bull. Minéral., 108, 9–13 (in French with English abstract). (2) (1985) Amer. Mineral., 70, 1330–1331 (abs. ref. 1).

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Morelandite $(Ba, Ca, Pb)_5(AsO_4, PO_4)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6. As irregular segregations, to 2.5 cm, in calcite.

Physical Properties: *Cleavage:* Poor on {0001}. Hardness = 4.5 D(meas.) = 5.33 D(calc.) = 5.30

Optical Properties: Translucent. *Color:* Light yellow to gray. *Streak:* White. *Luster:* Greasy to vitreous.
Optical Class: Uniaxial (+). $\omega = 1.880(4)$ $\epsilon = 1.884(4)$

Cell Data: *Space Group:* $P6_3/m$ or $P6_3$. a = 10.169(2) c = 7.315(2) Z = 2

X-ray Powder Pattern: Jakobsberg, Sweden.
3.030 (10), 2.969 (7), 2.935 (6), 3.658 (5), 5.089 (3), 4.175 (3), 1.965 (3)

Chemistry:

	(1)
P_2O_5	2.05
As_2O_5	28.11
FeO	0.41
MnO	0.39
PbO	24.85
CaO	8.85
BaO	33.00
F	0.00
Cl	3.69
H_2O	trace
$-O = Cl_2$	0.83
Total	100.52

(1) Jakobsberg, Sweden; by electron microprobe, corresponds to $(Ba_{2.25}Ca_{1.65}Pb_{1.16}Fe_{0.06}Mn_{0.06})_{\Sigma=5.18}[(AsO_4)_{2.56}(PO_4)_{0.30}]_{\Sigma=2.86}Cl_{1.09}$.

Mineral Group: Apatite group.

Occurrence: On a museum specimen from a metamorphosed manganese deposit.

Association: Hausmannite, calcite.

Distribution: From Jakobsberg, Värmland, Sweden.

Name: Honors Grover C. Moreland (1912–1978), Supervisor of sample preparation, Smithsonian Institution, Washington, D.C., USA.

Type Material: Royal Ontario Museum, Toronto, Canada, M35176; Harvard University, Cambridge, Massachusetts, 126607; National Museum of Natural History, Washington, D.C., USA, C4147.

References: (1) Dunn, P.J. and R.C. Rouse (1978) Morelandite, a new barium arsenate chloride member of the apatite group. Can. Mineral., 16, 601–604. (2) (1980) Amer. Mineral., 65, 207 (abs. ref. 1).

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Morenosite $NiSO_4 \cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. As indistinct crystals and fibers, in stalactites and efflorescent crusts.

Physical Properties: *Cleavage:* On {010}, distinct. *Fracture:* Conchoidal. Hardness = 2–2.5 D(meas.) = 1.953 D(calc.) = 1.959 Soluble in H_2O, metallic astringent taste; rapidly dehydrates to retgersite; weakly paramagnetic.

Optical Properties: Transparent. *Color:* Apple-green to greenish white; green in transmitted light. *Streak:* Pale green to white. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, weak.
$\alpha = 1.470$ $\beta = 1.493$ $\gamma = 1.500$ 2V(meas.) = 41°54′

Cell Data: *Space Group:* $P2_12_12_1$ (synthetic). $a = 11.746(7)$ $b = 12.003(8)$ $c = 6.751(4)$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 1-403).
4.20 (100), 5.3 (60), 2.85 (25), 3.75 (16), 3.45 (16), 2.65 (16), 4.45 (12)

Chemistry:

	(1)	(2)
SO_3	28.54	28.51
As_2O_5	0.27	
NiO	26.76	26.59
H_2O	44.43	44.90
Total	100.00	100.00

(1) Richelsdorf, Germany. (2) $NiSO_4 \cdot 7H_2O$.

Polymorphism & Series: Forms a series with epsomite.

Occurrence: An uncommon secondary mineral in the oxidized zone of nickel-bearing hydrothermal mineral deposits, formed from H_2O solution below 31.5 °C.

Association: Retgersite, nickelhexahydrite, annabergite, millerite.

Distribution: Not all listed localities are certainly of this species. From Cabo Ortegal, Galicia, Spain. At Jáchymov (Joachimsthal), Czech Republic. From near Plattelen, and on Mt. Pollux, both near Zermatt, Valais, Switzerland. At Sasso Moro, Val Malenco, Lombardy, Italy. In Germany, from Richelsdorf, Hesse-Nassau; in the Rammelsberg mine, near Goslar, Harz Mountains; at Ramsbeck, Sauerland, and elsewhere. In the St. Patrick's copper mine, Avoca, Co. Wicklow, Ireland. In Australia, from Kambalda, 56 km south of Kalgoorlie, and at the Mount Keith nickel deposit, 400 km north-northwest of Kalgoorlie, Western Australia. At Minasragra, 46 km from Cerro de Pasco, Peru. From a number of mines in the Sudbury district, Ontario, Canada. In the USA, from the Gap Nickel mine, Lancaster Co., Pennsylvania; in California, at the Coyote Mountain nickel prospect, Imperial Co., at the Friday Ni–Co–Cu mine, San Diego Co., and in the Island Mountain copper mine, Trinity Co.; from the Lovelock and Nickel mines, Table Mountain district, Churchill Co., Nevada.

Name: To honor Señor Antonio Moreno Ruiz (1796–1852), Spanish pharmacist and chemist, Academy of Natural Sciences, Madrid, Spain.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 516–519. (2) Ptasiewicz-Bak, H., I. Olovsson, and G.J. McIntyre (1997) Charge density in orthorhombic $NiSO_4 \cdot 7H_2O$ at room temperature and 25 K. Acta Cryst., 53, 325–336.

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Morinite $NaCa_2Al_2(PO_4)_2(F,OH)_5 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular to blocky, prismatic crystals, to 1 cm; flattened on {100}, elongated along [010]; {hk0} faces striated ‖ [001]; subparallel aggregates of crystals terminated by {$\bar{1}$11}, {110} yield groups with serrated upper edges; as botryoidal crusts and radial fibrous aggregates.

Physical Properties: *Cleavage:* Perfect on {100}; imperfect on {001}. Hardness = 4–4.5 D(meas.) = 2.94–2.96 D(calc.) = 2.98

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale pink, wine-red. *Streak:* White. *Luster:* Vitreous to pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge a = 45°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.553$ $\beta = 1.565$ $\gamma = 1.567$ 2V(meas.) = 40°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.454(3)$ $b = 10.692(4)$ $c = 5.444(2)$ $\beta = 105.46(2)°$ Z = 2

X-ray Powder Pattern: Hugo mine, South Dakota, USA.
2.94 (10), 3.47 (8), 1.783 (8), 4.70 (7), 2.63 (7), 9.11 (6), 3.73 (6)

Chemistry:

	(1)	(2)
P_2O_5	29.31	30.04
SiO_2	2.40	
Al_2O_3	22.46	22.33
MnO	0.02	
CaO	22.49	23.60
Na_2O	5.85	6.62
F	14.58	13.31
H_2O	9.80	9.98
insol.	0.14	
$-O = F_2$	6.12	5.60
Total	100.93	100.28

(1) Montebras, France. (2) Hugo mine, South Dakota, USA; corresponds to $Na_{1.00}Ca_{1.97}Al_{2.05}(P_{0.99}O_4)_2[F_{3.52}(OH)_{1.22}]_{\Sigma=4.74} \cdot 2H_2O$.

Occurrence: An uncommon late-stage mineral in complex granite pegmatites.

Association: Montebrasite, apatite, augelite, wardite, wavellite, cassiterite.

Distribution: From Montebras, Creuse, France. On the Greifensteine, near Ehrenfriedersdorf, Saxony, and at Hagendorf, Bavaria, Germany. In the Gunheath china clay pit, St. Austell, Cornwall, England. From the Viitaniemi pegmatite, near Eräjärvi, Finland. In the USA, in the Hugo mine, 1.5 km south of Keystone, Pennington Co., South Dakota; at the Stewart mine, Pala, San Diego Co., California; from the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada. In a pegmatite nearby Broken Hill, New South Wales, and at the Mt. Cleveland tin mine, 14 km southwest of Waratah, Tasmania, Australia.

Name: Honors Mr. E.A. Morineau, Director of the tin mine, Montebras, France, who supplied the first specimens.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 783–784, 784–785 [ježekite = morinite]. (2) Fisher, D.J. and J.J. Runner (1958) Morinite from the Black Hills. Amer. Mineral., 43, 585–594. (3) Hawthorne, F.C. (1979) The crystal structure of morinite. Can. Mineral., 17, 93–102. (4) Čech, F. and P. Povondra (1985) Identity of ježekite with morinite. Bull. Minéral., 108, 533–539.

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Morozeviczite $(Pb, Fe)_3Ge_{1-x}S_4$ (x = 0.18 to 0.69)

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Crystal Data: Cubic. *Point Group:* n.d. Massive, with other sulfides.

Physical Properties: Hardness = n.d. VHN = 119–124 (50 g load). D(meas.) = n.d. D(calc.) = 6.62

Optical Properties: Opaque. *Color:* Brownish gray; in reflected light, white with cream-red tint. *Streak:* Dark gray. *Anisotropism:* Distinct.
R_1–R_2: (470) 43.5–44.5, (535) 43.0–44.0, (591) 44.0–45.0, (658) 45.5–46.5

Cell Data: *Space Group:* n.d. a = 10.61 Z = 8

X-ray Powder Pattern: Lower Silesia, Poland.
3.08 (10), 2.15 (9), 2.80 (6), 2.047 (6), 1.791 (5), 1.565 (5), 1.467 (5)

Chemistry:

	(1)
Pb	58.6
Fe	8.6
Cu	1.2
Ge	9.0
As	0.8
S	21.0
Total	99.2

(1) Lower Silesia, Poland; by electron microprobe, corresponding to $(Pb_{1.73}Fe_{0.94}Cu_{0.12})_{\Sigma=2.79}(Ge_{0.76}As_{0.06})_{\Sigma=0.82}S_{4.00}$.

Polymorphism & Series: Forms a series with polkovicite.

Occurrence: In epigenetic veinlets and metasomatic replacement zones replacing sandstone and older sulfides, in brecciated sandstones underlying copper-bearing shales.

Association: Marcasite, chalcopyrite, bornite, chalcocite, tennantite, sphalerite, galena.

Distribution: From the Polkovice mine, near Legnica, Zechstein copper district, Lower Silesia, Poland [TL].

Name: To honor Josef Morozewicz (1865–1941), Professor of Mineralogy, Jagellonian University, Kraków, Poland.

Type Material: Jagellonian University, Kraków, Poland.

References: (1) Harańczyk, C. (1975) Morozeviczite and polkovicite, typochemical minerals of Mesozoic mineralization of the Fore-Sudenten monocline. Rudy i Metalle, 20, 288–293 (in Polish). (2) (1981) Amer. Mineral., 66, 437 (abs. ref. 1).

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Moschelite $Hg^{1+}I$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Tabular to short prismatic crystals, irregular platy, to 0.1 mm; crystalline, in crusts.

Physical Properties: *Cleavage:* Imperfect. *Fracture:* Conchoidal. *Tenacity:* Sectile. Hardness = 1–2 D(meas.) = n.d. D(calc.) = 7.75

Optical Properties: Opaque, translucent on thin edges. *Color:* Citrus-yellow, changing immediately to dark olive-green on exposure to light. *Streak:* Brown. *Luster:* Adamantine. *Optical Class:* Uniaxial. ω = high. ϵ = high.

Cell Data: *Space Group:* $I4/mmm$. a = 4.920(3) c = 11.600(9) Z = [4]

X-ray Powder Pattern: Landsberg, Germany.
3.483 (10), 2.231 (9), 2.896 (6), 2.099 (6), 4.537 (2), 1.881 (2), 1.242 (2)

Chemistry:

	(1)	(2)
Hg	61.02	61.25
I	38.55	38.75
Total	99.57	100.00

(1) Landsberg, Germany; by electron microprobe. (2) HgI.

Occurrence: In a sandstone-hosted mercury deposit, the iodine thought to be provided from underlying coal beds.

Association: Mercury, cinnabar, metacinnabar, calomel, terlinguaite, eglestonite, tetrahedrite, malachite, azurite, gypsum, aragonite, lepidocrocite, iron oxides, quartz.

Distribution: From Landsberg, near Obermoschel, Rhineland-Palatinate, Germany.

Name: For its occurrence in the Moschel-Landsberg mines, Germany.

Type Material: n.d.

References: (1) Krupp, E.R., G. Nottes, and U. Heidtke (1989) Moschelite (Hg_2J_2): a new mercury mineral from Landsberg-Obermoschel. Neues Jahrb. Mineral., Monatsh., 524–526.
(2) (1990) Amer. Mineral., 75, 1211 (abs. ref. 1).

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Moschellandsbergite Ag_2Hg_3

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As dodecahedral crystals commonly modified by the cube, octahedron, and trapezohedron, to 1 cm; also massive, granular.

Physical Properties: *Cleavage:* {011} and {001}, distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5 VHN = 147–159, 153 average (100 g load). D(meas.) = 13.48 D(calc.) = 13.5

Optical Properties: Opaque. *Color:* Silver-white. *Luster:* Bright metallic.
R: (400) 73.5, (420) 74.6, (440) 75.7, (460) 76.9, (480) 78.2, (500) 79.5, (520) 80.7, (540) 81.7, (560) 82.6, (580) 83.3, (600) 83.7, (620) 84.0, (640) 84.2, (660) 84.4, (680) 84.5, (700) 84.7

Cell Data: *Space Group:* $Im3m$. $a = 10.04$ $Z = 10$

X-ray Powder Pattern: Landsberg, Germany.
2.36 (100), 1.365 (70), 1.236 (60), 1.275 (50), 0.941 (50), 0.799 (50), 2.67 (40)

Chemistry:

	(1)	(2)	(3)
Ag	27.04	26.48	26.39
Hg	72.94	73.44	73.61
Total	99.98	99.92	100.00

(1) Landsberg, Germany. (2) Sala, Sweden. (3) Ag_2Hg_3.

Occurrence: Probably of low-temperature hydrothermal origin.

Association: Metacinnabar, cinnabar, mercurian silver, tetrahedrite–tennantite, pyrite, sphalerite, chalcopyrite.

Distribution: From Landsberg, near Obermoschel, Rhineland-Palatinate, Germany [TL]. At Sala, Västmanland, Sweden. In the Chalanches mine, near Allemont, Isère, France. From the Gould-Curry mine, Comstock Lode, Virginia City, Storey Co., Nevada, USA.

Name: For the locality at Landsberg, near Obermoschel, Germany.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 103–104. (2) Fairhurst, C.W. and J.B. Cohen (1972) The crystal structure of two compounds found in dental amalgam: Ag_2Hg_3 and Ag_3Sn. Acta Cryst., 28, 371–378. (3) Cipriani, C., G.P. Bernardini, M. Corazza, G. Mazzetti, and V. Moggi (1993) Reinvestigation of natural and synthetic silver amalgams. Eur. J. Mineral., 5, 903–914. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 16–17. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 385.

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Mosesite $Hg_2N(Cl, SO_4, MoO_4, CO_3)\cdot H_2O$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. Crystals pseudo-octahedra, less commonly dodecahedra, cubo-octahedra, cubes, rarely isolated, to 2 mm, several other forms have been noted; typically in nearly spherical aggregates of crystals. *Twinning:* On {111}, common, may be repeated.

Physical Properties: *Cleavage:* {111}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 7.72 D(calc.) = 7.53

Optical Properties: Semitransparent. *Color:* Lemon-yellow, canary-yellow, sulfur-yellow, becoming light olive-green on long exposure to light; amber-orange to nearly black, rarely zoned. *Streak:* Very pale yellow. *Luster:* Adamantine.
Optical Class: Isotropic; may be weakly anisotropic. $n = 2.065(10)$

Cell Data: *Space Group:* $F\overline{4}3m$. $a = 9.524$ $Z = 8$

X-ray Powder Pattern: Huahuaxtla, Mexico.
2.74 (10), 2.86 (8), 1.68 (7), 1.44 (7), 2.18 (6), 1.61 (6), 2.38 (5)

Chemistry:

	(1)	(2)
Hg^{2+}	79.4	85.60
Hg^{1+}	3.6	
Cl	3.3	7.57
H_2O	3.2	3.84
CO_3	0.8	
SO_4	5.4	
MoO_4	2.0	
N	2.4	2.99
Total	100.1	100.00

(1) Huahuaxtla, Mexico; H_2O by the Penfield method; corresponds to $Hg_{2.20}N_{0.93}(Cl, SO_4, MoO_4, CO_3)_{0.93}\cdot 0.95H_2O$. (2) $Hg_2NCl\cdot H_2O$.

Occurrence: A rare secondary mineral formed at low temperature in hydrothermal mercury deposits.

Association: Calcite, cinnabar, metacinnabar, mercury, eglestonite, kleinite, terlinguaite, montroydite, calomel, gypsum.

Distribution: In the USA, from Terlingua, Brewster Co., Texas; in the T.S. Clack Quicksilver mine, about 37 km northeast of Lovelock, Fitting district, Mineral Co., and the McDermitt mine, Humboldt Co., Nevada; from near the Clear Creek mercury mine, New Idria district, San Benito Co., California. In Mexico, at Huahuaxtla, Guerrero, and El Doktor, Querétaro.

Name: Honors Alfred J. Moses (1859–1920), American mineralogist, Professor of Mineralogy, Columbia University, New York City, New York, USA, who described several other mercury minerals from Terlingua.

Type Material: National Museum of Natural History, Washington, D.C., USA, C87, 93292.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 89–90. (2) Switzer, G., K.J. Murata, and J.J. Fahey (1953) Re-examination of mosesite. Amer. Mineral., 38, 1225–1234.

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Mottramite $PbCu(VO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, equant or dipyramidal {111}, prismatic [001] or [100], with {101}, {201}, many others, to 3 mm, in drusy crusts, botryoidal, usually granular to compact, massive.

Physical Properties: *Fracture:* Small conchoidal to uneven. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = ∼5.9 D(calc.) = 6.187

Optical Properties: Transparent to nearly opaque. *Color:* Grass-green, olive-green, yellow-green, siskin-green, blackish brown, nearly black. *Streak:* Yellowish green. *Luster:* Greasy. *Optical Class:* Biaxial (–), rarely biaxial (+). *Pleochroism:* Weak to strong; $X = Y =$ canary-yellow to greenish yellow; $Z =$ brownish yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong; rarely $r < v$. $\alpha = 2.17(2)$ $\beta = 2.26(2)$ $\gamma = 2.32(2)$ 2V(meas.) = ∼73°

Cell Data: *Space Group: Pnma.* $a = 7.667$–7.730 $b = 6.034$–6.067 $c = 9.278$–9.332 Z = 4

X-ray Powder Pattern: Mottram St. Andrew, England; close to descloizite. 3.24 (vvs), 5.07 (vs), 2.87 (vs), 2.68 (vs), 2.66 (vs), 2.59 (vs), 1.648 (vs)

Chemistry:

	(1)	(2)		(1)	(2)
CrO_3	0.50		ZnO	0.31	10.08
P_2O_5	0.24		PbO	55.64	55.30
As_2O_5	1.33		H_2O	3.57	2.23
V_2O_5	21.21	22.53	insol.	0.17	
CuO	17.05	9.86	Total	100.02	100.00

(1) Bisbee, Arizona, USA; average of three analyses. (2) $Pb(Cu, Zn)(VO_4)(OH)$ with Zn:Cu = 1:1.

Polymorphism & Series: Forms a series with descloizite.

Mineral Group: Descloizite group.

Occurrence: A secondary mineral in the oxidized zone of vanadium-bearing base metal deposits.

Association: Descloizite, duftite, mimetite, wulfenite, cerussite, azurite, dioptase.

Distribution: Many localities. From Mottram St. Andrew, Cheshire, England. In the USA, at the Mammoth-St. Anthony mine, Tiger, Pinal Co., from Bisbee, Cochise Co., at the Total Wreck mine, Pinal Co., in the Apache mine, near Globe, and from the 79 mine, near Hayden, Gila Co., Arizona; at the Mayflower mine, Socorro Peak district, Socorro Co., New Mexico; from the Whale mine, Goodsprings district, Clark Co., Nevada. At Mina Grande, Arqueros, Coquimbo, Chile. Abundant at Tsumeb and elsewhere in the Otavi district, Namibia. At Kabwe (Broken Hill), Zambia.

Name: For an occurrence in England, ore stockpiled at Mottram St. Andrew, Cheshire; likely mined from the nearby Pim Hill mine, Shrewsbury, Shropshire.

Type Material: The Natural History Museum, London, England, 52314–52315.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 811–815. (2) Kingsbury, A.W.G. and J. Hartley (1956) New occurrences of vanadium minerals (mottramite, descloizite, and vanadinite) in the Caldbeck area of Cumberland. Mineral. Mag., 31, 289–295. (3) van der Westhuizen, W.A., H. de Bruiyn, E.A.W. Tordiffe, and B.J.V. Botha (1986) The descloizite–mottramite series of vanadates from the Otavi Mountain Land, South West Africa: an X-ray study. Mineral. Mag., 50, 137–140. (4) Cooper, M.A. and F.C. Hawthorne (1995) The crystal structure of mottramite, and the nature of Cu ⇌ Zn solid solution in the mottramite-descloizite series. Can. Mineral., 33, 1119–1124.

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Motukoreaite $Na_2Mg_{38}Al_{24}(SO_4)_8(CO_3)_{13}(OH)_{108}\cdot 56H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As tabular hexagonal crystals, showing rounded {0001} and possible {$11\overline{2}0$}, {$10\overline{1}1$}, {$10\overline{1}4$}, to 0.2 mm, forming rosettes, boxworks, and subparallel aggregates, and as a claylike cement.

Physical Properties: *Cleavage:* Good on {0001}, perhaps a parting. *Tenacity:* Sectile, flexible. Hardness = 1–1.5 D(meas.) = 1.43–1.53 D(calc.) = 1.478 Partial dehydration readily occurs.

Optical Properties: Semitransparent. *Color:* Colorless, white, pale yellow, pale yellow-green. *Luster:* Dull.
Optical Class: Uniaxial (+), nearly isotropic. n = ∼1.51, birefringence ∼0.012. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 9.172(2)$ $c = 33.51(1)$ Z = 3

X-ray Powder Pattern: Brown's Island, New Zealand; may exhibit preferred orientation. 11.32 (vvs), 5.58 (s), 4.59 (s), 3.72 (s), 2.578 (s), 2.386 (s), 2.158 (s)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	10.00	10.65	CaO	0.92	
SiO_2	5.55		Na_2O	0.71	1.03
CO_2	9.32	9.52	K_2O	0.10	
Al_2O_3	17.87	20.35	H_2O^+	19.62	
Fe_2O_3	0.73		H_2O^-	10.35	
MnO	0.70		H_2O		32.97
ZnO	0.56		Total	99.41	100.00
MgO	22.98	25.48			

(1) Brown's Island, New Zealand; contains estimated quartz 5%, traces of calcite and goethite; after removal of probable impurities, and with $(OH)^{1-}$ calculated for charge balance, corresponds to $(Na_{1.50}K_{0.14})_{\Sigma=1.64}Mg_{37.36}Al_{22.97}(SO_4)_{8.18}(CO_3)_{13.81}(OH)_{101.29}\cdot 58.36H_2O$. (2) $Na_2Mg_{38}Al_{24}(SO_4)_8(CO_3)_{13}(OH)_{108}\cdot 56H_2O$.

Occurrence: Relatively common in assemblages formed by reaction of basalt volcanoclastics with sea-water; in cavities in a haüyne-nephelinite.

Association: Olivine, pyroxene, calcic feldspar, magnetite, calcite, gypsum, barite, hisingerite, zeolites, "limonite", quartz (Brown's Island, New Zealand); hydrotalcite, nordstrandite, montmorillonite, phillipsite, gismondine, chabazite, calcite, apatite (Stradner Hill, Austria).

Distribution: From Brown's Island (Motukorea), Waitemata Harbour, Auckland, New Zealand. On the Island of Surtsey, and the Great Meteor and Josephine seamounts, North Atlantic, and along the mid-Atlantic Ridge. Northwest of the Emile Baudot Bank, western Mediterranean. Along the Axial Rift, Red Sea. On Stradner Kogel, south of Gleichenberg, Austria.

Name: From Motukorea, *island of cormorants*, the Maori name for Brown's Island, New Zealand.

Type Material: University of Auckland, Auckland, New Zealand; The Natural History Museum, London, England, 1977,422; National Museum of Natural History, Washington, D.C., USA, 142971.

References: (1) Rodgers, K.A., J.E. Chisholm, R.J. Davis, and C.S. Nelson (1977) Motukoreaite, a new hydrated carbonate, sulphate, and hydroxide of Mg and Al from Auckland, New Zealand. Mineral. Mag., 41, 389–390. (2) (1978) Amer. Mineral., 63, 598 (abs. ref. 1). (3) Rius, J. and F. Plana (1986) Contribution to the superstructure resolution of the double layer mineral motukoreaite. Neues Jahrb. Mineral., Monatsh., 263–272. (4) Zamarreño, I., F. Plana, A. Vazquez, and D.A. Clague (1989) Motukoreaite: a common alteration product in submarine basalts. Amer. Mineral., 74, 1054–1058. (5) Bryner, V., K.A. Rodgers, S.F. Courtney, and W. Postl (1991) Motukoreaite from Brown's Island, New Zealand, and Stradner Kogel, Austria: a scanning electron microscope study. Neues Jahrb. Mineral., Abh., 163, 291–304.

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Mounanaite $PbFe_2^{3+}(VO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals elongated along [001], flattened on {010}, to 0.3 mm; equant crystals appear pseudohexagonal; crystals are dominated by {010}, with {100}, {110}, {011}, {11$\overline{1}$}, {12$\overline{1}$}, {$\overline{1}$2$\overline{1}$}, {02$\overline{1}$}, {01$\overline{1}$}, {021}; as microcrystalline crusts. *Twinning:* Common as simple twins of two types, by rotation around [001] or on {1$\overline{1}$1}.

Physical Properties: *Cleavage:* On {001}, good. Hardness = 4.5 D(meas.) = 4.85 D(calc.) = 4.88–4.89

Optical Properties: Translucent to transparent. *Color:* Reddish brown. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; $X = Z$ = pale yellow; Y = brown. *Orientation:* $Y = b$; $X \wedge c = \sim 20°$. *Dispersion:* $r > v$, strong. α = [2.19] β = 2.25(2) γ = [2.27] 2V(meas.) = 50(10)°

Cell Data: *Space Group:* $C2/m$. a = 9.294 b = 6.164–6.166 c = 7.703–7.713 β = 115.54°−115.57° Z = 2

X-ray Powder Pattern: Mounana mine, Gabon.
4.64 (100), 3.055 (96), 3.264 (92), 7.766 (72), 2.816 (60), 2.320 (59), 4.562 (49)

Chemistry:

	(1)	(2)
P_2O_5	0.81	
As_2O_5	0.18	
V_2O_5	29.28	31.21
Al_2O_3	0.32	
Fe_2O_3	26.01	27.40
CuO	0.87	
PbO	38.47	38.30
H_2O	[3.21]	3.09
Total	[99.15]	100.00

(1) Mounana mine, Gabon; by electron microprobe, total Fe as Fe_2O_3, confirmed by IR and Mössbauer spectroscopy, $(OH)^{1-}$ calculated for charge balance; corresponds to $Pb_{1.02}(Fe_{1.92}Al_{0.04}Cu_{0.06})_{\Sigma=2.02}[(VO_4)_{1.92}(PO_4)_{0.07}(AsO_4)_{0.01}]_{\Sigma=2.00}(OH)_{2.04}$. (2) $PbFe_2(VO_4)_2(OH)_2$.

Mineral Group: Tsumcorite group.

Occurrence: A rare mineral in the oxidized zone of a sediment-hosted U–V deposit.

Association: Francevillite, curienite, vanuralite, goethite.

Distribution: From the Mounana uranium mine, Franceville, Gabon.

Name: For the Mounana mine, Gabon, the locality that produced the first specimens.

Type Material: University of Pierre and Marie Curie, Paris, 11647; National School of Mines, Paris, France.

References: (1) Cesbron, F. and J. Fritsche (1969) La mounanaïte, nouveau vanadate der fer et de plomb hydraté. Bull. Minéral., 92, 196–202 (in French with English abs.). (2) (1969) Amer. Mineral., 54, 1738–1739 (abs. ref. 1). (3) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Mountainite $(Ca, Na_2, K_2)_2Si_4O_{10} \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As matted laths and fibers, elongated along [010], forming small rosettes, to 2 mm.

Physical Properties: *Cleavage:* {001} (?). Hardness = 3 D(meas.) = 2.36 D(calc.) = 2.47

Optical Properties: Transparent to translucent. *Color:* White. *Luster:* Silky. *Optical Class:* Biaxial (+) (probable). *Orientation:* $Y = b$; $Z \wedge c = 18°$. $\alpha = 1.500–1.504$ $\beta = 1.505–1.510$ $\gamma = 1.513–1.519$ 2V(meas.) = Moderate to large. 2V(calc.) = 76°

Cell Data: *Space Group:* n.d. $a = 13.51$ $b = 6.55$ $c = 13.51$ $\beta = 104°$ Z = 8

X-ray Powder Pattern: Kimberley, South Africa.
2.94 (vvs), 6.6 (vs), 13.1 (s), 4.67 (s), 2.80 (ms), 1.967 (ms), 4.18 (m)

Chemistry:

	(1)	(2)
SiO_2	58.5	51.57
Al_2O_3	0.0	2.31
CaO	13.4	10.07
MgO	0.2	0.00
Na_2O	7.9	10.15
K_2O	6.0	4.43
H_2O^+		9.74
H_2O^-		8.02
H_2O	13.4	
CO_2		0.87
LOI		2.47
Total	99.4	99.63

(1) Kimberley, South Africa; corresponds to $(Na_{1.04}Ca_{0.99}K_{0.54}Mg_{0.02})_{\Sigma=2.59}$ $Si_{4.02}O_{9.99} \cdot 3.09H_2O$. (2) Lovozero massif, Russia; corresponds to $(Na_{1.28}Ca_{0.80}K_{0.42})_{\Sigma=2.50}$ $(Si_{3.80}Al_{0.20})_{\Sigma=4.00}O_{9.99} \cdot 2.75H_2O$.

Occurrence: In a kimberlite pipe (Kimberley, South Africa); in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Rhodesite (Kimberley, South Africa); natrolite, steenstrupine, chkalovite, neptunite, sérandite, aegirine, leucosphenite, zorite, raite, polylithionite, halite (Lovozero Massif, Russia).

Distribution: In the Bultfontein diamond mine, Kimberley, Cape Province, South Africa. On Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. In the Höwenegg quarry, Hegau, Baden-Württemberg, Germany.

Name: For Edgar Donald Mountain, Professor of Geology, Rhodes University, Grahamstown, South Africa.

Type Material: The Natural History Museum, London, England, 1957,369; National Museum of Natural History, Washington, D.C., USA, 114792.

References: (1) Gard, J.A., H.F.W. Taylor, and R.A. Chalmers (1957) An investigation of two new minerals: rhodesite and mountainite. Mineral. Mag., 31, 611–623. (2) (1958) Amer. Mineral., 43, 624–625 (abs. ref. 1). (3) Bussen, I.V., L.G. Latysheva, Y.P. Men'shikov, A.N. Mer'kov, T.S. Romanova, and A.S. Sakharov (1973) First find of mountainite in the Soviet Union. Doklady Acad. Nauk SSSR, 210, 674–677 (in Russian).

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Mountkeithite $(Mg,Ni)_{11}(Fe^{3+},Cr,Al)_3(SO_4,CO_3)_{3.5}(OH)_{24}\cdot 11H_2O$

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Crystal Data: Hexagonal (by analogy to pyroaurite). *Point Group:* n.d. Scaly crystals, to 1 mm, in rosettes and whorllike aggregates.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Friable. Hardness = "Soft". D(meas.) = 2.12 D(calc.) = 1.95

Optical Properties: Translucent. *Color:* White, pale pink. *Luster:* Pearly. *Optical Class:* Uniaxial (–) or biaxial (–). *Pleochroism:* Weak; white to very pale pink. *Orientation:* Length-slow. $\omega = 1.52$ $\epsilon = 1.51$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 10.698$ $c = 22.545$ Z = 2

X-ray Powder Pattern: Mount Keith, Australia.
11.30 (10), 5.63 (8), 3.765 (6), 1.554 (5), 2.645 (4), 2.545 (4), 1.505 (3)

Chemistry:

	(1)
SO_3	14.7
CO_2	3.9
Al_2O_3	2.6
Fe_2O_3	8.3
Cr_2O_3	6.1
NiO	6.1
CuO	0.1
MgO	31.7
H_2O	30.6
Total	104.1

(1) Mount Keith deposit, Australia; by electron microprobe, average of 20 analyses, total Fe as Fe_2O_3, CO_2 and H_2O by microchemical techniques; with $(OH)^{1-}$:H_2O calculated for charge balance, then corresponds to $(Mg_{10.76}Ni_{1.12}Cu_{0.02})_{\Sigma=11.90}(Fe_{1.42}Cr_{1.10}Al_{0.71})_{\Sigma=3.23}[(SO_4)_{2.52}(CO_3)_{1.21}]_{\Sigma=3.73}(OH)_{26.07}\cdot 10.20H_2O$.

Occurrence: Rare in a vein in serpentinite in a disseminated nickel sulfide deposit, formed by low-temperature alteration of stichtite by sulfate-rich solutions.

Association: Stichtite, morenosite, hexahydrite, pyroaurite, pyrite, magnetite, magnesite.

Distribution: From the Mount Keith nickel deposit, 400 km north-northwest of Kalgoorlie, Western Australia.

Name: For the Mount Keith deposit, Australia, in which it occurs.

Type Material: Western Australian Museum, Perth, Australia, M72.1991; The Natural History Museum, London, England.

References: (1) Hudson, D.R. and M. Bussell (1981) Mountkeithite, a new pyroaurite-related mineral with an expanded interlayer containing exchangeable $MgSO_4$. Mineral. Mag., 44, 345–350. (2) (1982) Amer. Mineral., 67, 624 (abs. ref. 1).

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Mourite $U^{4+}Mo_5^{6+}O_{17}\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* m or $2/m$. As plates with rectangular outlines, elongated ‖ [010], flattened on {100}, to 0.5 mm, in fanlike, spherulitic, or vermiform aggregates; as nodules and crusts.

Physical Properties: *Cleavage:* {100}, pronounced. Hardness = ∼3 VHN = 75 D(meas.) = 3.78–4.12 D(calc.) = [4.22] Radioactive.

Optical Properties: Opaque to translucent. *Color:* Violet. *Streak:* Blue-violet. *Luster:* Adamantine.
Optical Class: Biaxial. *Pleochroism:* Distinct; $X = Y$ = pale blue-violet with greenish tint; Z = pale blue-violet. *Orientation:* Positive elongation, extinction ‖ fiber axis, inclined to cleavage ∼10°. $n = > 1.780$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d. *Anisotropism:* Strong; X = rose; Y = green; Z = blue.

Cell Data: *Space Group:* Pa or $P2/a$. $a = 24.420$ $b = 7.183$ $c = 9.893$ $\beta = 102.00°$ Z = 4

X-ray Powder Pattern: Kyzylsai deposit, Kazakhstan.
5.897 (10), 12.77 (9), 2.871 (8), 1.728 (8), 3.285 (7), 3.193 (7), 3.148 (7)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3	2.40	2.27		MgO	0.49		
MoO_3	63.67	64.47	66.65	CaO	2.09		
SiO_2	1.72	0.82		Na_2O	0.54	0.13	
TiO_2		0.06		K_2O	0.58	0.46	
UO_2	19.38	21.65	25.01	H_2O^+	6.07	7.73	
Al_2O_3	1.36	0.21		H_2O^-	1.67	1.12	
Fe_2O_3	0.57	0.05		H_2O			8.34
Tl_2O_3		0.23		Total	[100.54]	99.29	100.00
PbO		0.09					

(1) Kyzylsai deposit, Kazakhstan; original total given as 100.52%. (2) Do. (3) $UMo_5O_{17}\cdot 5H_2O$.

Occurrence: In the oxidized zone of a U–Mo deposit (Kyzylsai deposit, Kazakhstan); in a sandstone-hosted uranium deposit (Boso-Hackney prospect, Texas, USA).

Association: Uraninite, molybdenite, jordisite, ilsemannite, pyrite, umohoite, sedovite, iriginite, powellite, sodium uranospinite, uranophane, tyuyamunite, goethite, jarosite, kaolinite (Kyzylsai deposit, Kazakhstan); pyrite, marcasite, "opal," chalcedony (Boso-Hackney prospect, Texas, USA).

Distribution: From the Kyzylsai Mo–U deposit, Chu-Ili Mountains, southwestern Balkhash region, Kazakhstan. At the Boso-Hackney prospect, about 19 km southwest of Falls City, Karnes Co., Texas, USA.

Name: For MOlybdenum and URanium in the composition.

Type Material: Mining Institute, St. Petersburg, 999/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 65196, 67299; National Museum of Natural History, Washington, D.C., USA, 127972.

References: (1) Kopchenova, E.V., K.V. Skvortsova, N.I. Silantieva, G.A. Sidorenko, and L.V. Mikhailova (1962) Mourite – a new supergene uranium-molybdenum mineral. Zap. Vses. Mineral. Obshch., 91, 67–71 (in Russian). (2) (1962) Amer. Mineral., 47, 1217 (abs. ref. 1). (3) Smith, M.L. and J. Marinenko (1971) Comparison of mourite from Karnes County, Texas with mourite from the U.S.S.R. Amer. Mineral., 56, 163–173. (4) Serezhkin, V.N., B.S. Osipov, and V.F. Chuvaev (1980) Structure and some physicochemical properties of mourite (1980) Geokhimiya, 10, 1557–1562 (in Russian). (5) (1980) Chem. Abs., 93, 570 (abs. ref. 4).

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Moydite-(Y) $YB(CO_3)(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Platy crystals, to 1 mm, with dominant {010}, {111}, minor {100}, {001}, in subparallel aggregates.

Physical Properties: *Cleavage:* Good on {010}; poor on {101}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = "Soft". D(meas.) = 3.13(3) D(calc.) = 3.01(8)

Optical Properties: Transparent. *Color:* Yellow, pale yellow, colorless in thin crystals. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, weak.
$\alpha = 1.588(2)$ $\beta = 1.681(1)$ $\gamma = 1.690(1)$ 2V(meas.) = 32(3)° 2V(calc.) = 34°

Cell Data: *Space Group: Pbca.* $a = 9.089(1)$ $b = 12.244(1)$ $c = 8.926(1)$ Z = 8

X-ray Powder Pattern: Evans-Lou quarry, Quebec, Canada.
6.106 (10), 4.501 (9), 3.179 (7), 2.818 (5), 2.525 (4), 2.749 (3), 2.203 (3)

Chemistry:

	(1)
CO_2	17.7
B_2O_3	14.4
Y_2O_3	35.0
Ce_2O_3	0.8
Nd_2O_3	1.3
Sm_2O_3	1.2
Gd_2O_3	3.4
Dy_2O_3	3.8
Ho_2O_3	1.9
CaO	0.5
H_2O	[20.0]
Total	[100.0]

(1) Evans-Lou quarry, Quebec, Canada; by electron microprobe, average of two analyses, H_2O by difference, $(CO_3)^{2-}$, $(OH)^{1-}$ confirmed by IR; corresponds to $(Y_{0.68}Gd_{0.04}Dy_{0.04}Ca_{0.02}Nd_{0.02}Sm_{0.02}Ho_{0.02}Ce_{0.01})_{\Sigma=0.85}B_{0.84}(C_{0.84}O_3)(OH_{1.24})_4$.

Occurrence: A rare secondary mineral in quartz in a zoned granite pegmatite.

Association: Hellandite, kainosite, lokkaite, caysichite, xenotime, titanite, yttrian fluorapatite, yttrian spessartine, fergusonite, metatyuyamunite, metatorbernite, quartz.

Distribution: In the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada.

Name: To honor Louis Moyd (1916–), Canadian mineralogist, Emeritus Curator, National Museum of Natural Sciences, Ottawa, Canada, for his contributions to mineralogy.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 50771, 50772; National Museum of Natural History, Washington, D.C., USA, 162936.

References: (1) Grice, J.D., J. Van Velthuizen, P.J. Dunn, D.E. Newbury, E.S. Etz, and C.H. Nielsen (1986) Moydite $(Y, REE)[B(OH)_4](CO_3)$, a new mineral species from the Evans-Lou pegmatite, Quebec. Can. Mineral., 24, 665–673. (2) (1988) Amer. Mineral., 73, 193–194 (abs. ref. 1). (3) Grice, J.D. and T.S. Ercit (1986) The crystal structure of moydite. Can. Mineral., 24, 675–678.

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Mozartite $CaMnSiO_4(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. As subhedral crystals, short prismatic, elongated ‖ [100], terminated by a bisphenoid, to 4.4 cm; commonly granular, in aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d.
D(meas.) = 3.63(4) D(calc.) = 3.68

Optical Properties: Transparent. *Color:* Reddish brown to deep red. *Streak:* Red.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = yellow-brown; Y = yellow; Z = red-orange. *Orientation:* Z = a. $\alpha = 1.840(5)$ $\beta = 1.855(5)$ $\gamma = 1.920(5)$ 2V(meas.) = 50(2)° 2V(calc.) = 52.8°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 5.838(1)$ $b = 7.224(1)$ $c = 8.690(1)$ Z = 4

X-ray Powder Pattern: Cerchiara mine, Italy.
2.584 (VS), 5.558 (S), 3.070 (S), 2.687 (S), 4.025 (W), 3.613 (W), 2.509 (W)

Chemistry:

	(1)
SiO_2	29.25
Al_2O_3	0.49
Mn_2O_3	38.72
MgO	0.05
CaO	27.08
F	0.00
H_2O	[4.41]
Total	[100.00]

(1) Cerchiara mine, Italy; by electron microprobe, average of 16 analyses, H_2O by difference; corresponds to $Ca_{0.98}(Mn_{1.00}Al_{0.02})_{\Sigma=1.02}Si_{0.99}O_4(OH)$.

Occurrence: In veins cutting massive braunite in ophiolitic metacherts.

Association: Pectolite, hausmannite, calcite, quartz.

Distribution: In the Cerchiara manganese mine, near Faggiona, Val di Vara, Liguria, Italy. Large crystals from the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For Wolfgang Amadeus Mozart (1756–1791), discovered in the 200th year after his death.

Type Material: University of Genoa, Genoa, Italy.

References: (1) Palenzona, A. and A. Pozzi (1993) Mozartite, a new mineral species from Cerchiara, La Spezia. Revista Mineral. Ital., no. 2, 79–82 (in Italian with English abs.).
(2) Basso, R., G. Lucchetti, L. Zefiro, and A. Palenzona (1993) Mozartite, $CaMn(OH)SiO_4$, a new mineral species from the Cerchiara mine, northern Apennines, Italy. Can. Mineral., 31, 331–336.
(3) (1994) Amer. Mineral., 79, 388 (abs. refs. 1 and 2).

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Mozgovaite $PbBi_4(S,Se)_7$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Acicular crystals, to 600 μm, in sprays.

Physical Properties: Hardness = n.d. VHN = 116 (10 g load). D(meas.) = n.d. D(calc.) = 6.26(6)

Optical Properties: Opaque. *Color:* Silvery gray; white in reflected light. *Luster:* Metallic. *Optical Class:* Biaxial. *Anisotropism:* Strong, without color effects. *Bireflectance:* Very weak. R_1–R_2: (400) —, (420) 36.4–40.3, (440) 36.0–40.1, (460) 35.8–40.2, (480) 35.7–40.3, (500) 35.7–40.3, (520) 35.4–40.6, (540) 35.3–40.6, (560) 35.1–40.6, (580) 35.0–40.6, (600) 35.0–40.3, (620) 34.9–40.1, (640) 34.8–40.1, (660) 34.9–40.1, (680) 34.8–39.8, (700) 34.7–39.6

Cell Data: *Space Group:* *Bbmm* (by analogy to synthetic $PbBi_4S_7$). $a = 13.18(6)$ $b = 37.4(2)$ $c = 4.05(3)$ Z = 6

X-ray Powder Pattern: Vulcano, Italy.
3.80 (10), 2.95 (4B), 2.34 (4B), 3.58 (3), 3.30 (3), 3.40 (2), 3.11 (2)

Chemistry:

	(1)	(2)
Pb	13.90	16.35
Cu	0.01	
Cd	0.26	
Fe	0.02	
Bi	64.79	65.94
As	0.05	
S	16.91	17.71
Total	97.57	100.00

(1) Vulcano, Italy; by electron microprobe, average of four analyses; corresponding to $(Pb_{0.87}Cd_{0.03})_{\Sigma=0.90}(Bi_{4.01}As_{0.01})_{\Sigma=4.02}(S_{6.82}Se_{0.27})_{\Sigma=7.09}$. (2) $PbBi_4S_7$.

Occurrence: Very rare, as a sublimate in a volcanic fumarole, deposited at about 600 °C.

Association: Bismuthinite, cannizzarite, lillianite, galenobismutite.

Distribution: From the Fossa crater, Vulcano, Lipari Islands, Italy [TL].

Name: In honor of Dr. Nadezhda Nikolaevna Mozgova (1931–), Russian mineralogist, Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Moscow, Russia, who has contributed especially to the knowledge of sulfosalt minerals.

Type Material: University of Bari, Bari, Italy, 5/nm.

References: (1) Vurro, F., A. Garavelli, C. Garbarino, Y. Moëlo, and Y.S. Borodaev (1999) Rare sulfosalts from Vulcano, Aeolian Islands, Italy. II. Mozgovaite, $PbBi_4(S,Se)_7$, a new mineral species. Can. Mineral., 37, 1499–1506. (2) (2000) Amer. Mineral., 85, 1562–1563.

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Mpororoite $WAlO_3(OH)_3 \cdot 2H_2O$

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Crystal Data: Triclinic (?). *Point Group:* n.d. Platy, very fine grained, powdery.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Greenish yellow.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. a = 9.40 b = 11.46 c = 8.20 $\alpha = 94°20'$ $\beta = 89°45'$ $\gamma = 95°10'$ Z = n.d.

X-ray Powder Pattern: Mpororo deposit, Uganda.
8.21 (100), 3.084 (90b), 4.09 (19), 5.69 (18), 4.20 (17), 6.18 (16), 2.357 (15)

Chemistry:

	(1)	(2)
WO_3	66.90	67.03
Al_2O_3	8.22	14.74
Fe_2O_3	9.78	
CaO	0.27	
H_2O^+	7.97	
H_2O^-	6.89	
H_2O		18.23
Total	100.03	100.00

(1) Mpororo deposit, Uganda; corresponding to $W_{1.00}(Al_{0.57}Fe^{3+}_{0.43})_{\Sigma=1.00}O_3(OH)_3 \cdot 2H_2O$.
(2) $WAlO_3(OH)_3 \cdot 2H_2O$.

Occurrence: An alteration product of primary tungsten minerals.

Association: Scheelite, ferberite, ferritungstite (Mpororo deposit, Uganda); anthoinite (Kara mine, Tasmania); scheelite, ferberite, ferritungstite, russellite, anthoinite (Kalzas Mountain, Canada).

Distribution: In the Mpororo tungsten deposit, 20 km north of Kisoro, Kigezi district, Uganda. At the Kara tungsten mine, southwest of Burnie, Tasmania, Australia. From the Flo property, Kalzas Mountain, 67 km southeast of Mayo, Yukon Territory, Canada. In the Hingston Down quarry, Calstock, Cornwall, England.

Name: For the Mpororo deposit, Uganda, where it was first found.

Type Material: n.d.

References: (1) von Knorring, O., T.G. Sahama, and M. Lehtinen (1972) Mpororoite, a new secondary tungsten mineral from Uganda. Bull. Geol. Soc. Finland, 44, 107–110. (2) (1973) Amer. Mineral., 58, 1112 (abs. ref. 1). (3) Sahama, T.G. (1981) The secondary tungsten minerals, a review. Mineral. Record, 12, 81–87. (4) Matsubara, S., A. Kato, and K. Nagashima (1984) Mpororoite and anthoinite from the Kara mine, Tasmania. Mineral. Mag., 48, 397–400.

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Mrázekite $Bi_2Cu_3O_2(PO_4)_2(OH)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular to slender bladed crystals, tabular on {101}, elongated along [010] or $[20\overline{1}]$, with wedgelike terminations, to 2 mm; in rosettes or spherules of radial acicular crystals, and as crusts.

Physical Properties: *Cleavage:* On $\{20\overline{1}\}$. Hardness = 2–3 D(meas.) = 4.90(2) D(calc.) = 5.00

Optical Properties: Translucent to transparent. *Color:* Cerulean blue. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Very faint; in ink-blue tints. *Orientation:* $X = b$; $Y \simeq a$; $Z \wedge c = 16°$; or $Z =$ b; $X \wedge c = 27°$; $Y \wedge a = 15°$. *Dispersion:* $r < v$, strong. *Absorption:* $X < Y < Z$. $n = 1.865(5)$ or 1.89(5) 2V(meas.) = 66(5)°–68(2)°

Cell Data: *Space Group:* $P2_1/n$. $a = 9.065(1)$ $b = 6.340(1)$ $c = 21.239(3)$ $\beta = 101.57(1)°$ Z = 4

X-ray Powder Pattern: Lubietová, Slovakia.
3.040 (100), 2.924 (83), 7.625 (78), 3.014 (63), 5.200 (52), 5.145 (45), 5.410 (43)

Chemistry:

	(1)	(2)	(3)
P_2O_5	15.89	15.16	15.76
As_2O_5	0.11	0.26	
V_2O_5		0.25	
Bi_2O_3	51.97	50.09	51.74
CuO	26.14	25.44	26.50
PbO		0.10	
H_2O	[5.90]	[6.00]	6.00
Total	[100.01]	[97.30]	100.00

(1) Lubietová, Slovakia; by electron microprobe, original total given as 100.00%, H_2O calculated from stoichiometry, IR confirms $(OH)^{1-}$, H_2O, $(PO_4)^{3+}$; corresponds to $Bi_{2.01}Cu_{2.96}O_{2.00}[(P_{1.01}As_{0.01})_{\Sigma=1.02}O_4]_2(OH)_2 \cdot 1.95H_2O$. (2) Reichenbach, Germany; by electron microprobe, average of 14 analyses, H_2O calculated, presence of $(OH)^{1-}$ and molecular H_2O confirmed by FTIR spectroscopy; corresponds to $Bi_{2.05}Cu_{2.99}O_{2.00}[(PO_4)_{1.95}(AsO_4)_{0.02}(VO_4)_{0.02}]_{\Sigma=1.99}(OH)_{1.98} \cdot 1.88H_2O$. (3) $Bi_2Cu_3O_2(PO_4)_2(OH)_2 \cdot 2H_2O$.

Occurrence: A rare secondary mineral formed by oxidization of polymetallic sulfides.

Association: Chalcopyrite, tetrahedrite, chalcocite, malachite, pyromorphite, pseudomalachite, libethenite, reichenbachite, beudantite, bismutite, mixite, chrysocolla.

Distribution: From L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. At Gadernheim and Reichenbach, near Bensheim, Hesse, Germany. From Sainte-Marie-aux-Mines, Haut-Rhin, France. In the Morass Creek Gorge, 15 km north of Benambra, Victoria, Australia.

Name: Honors Zdenek Mrázek (1952–1984), who collected the first specimens and recognized their unusual characteristics.

Type Material: Charles University, Prague; National Museum, Prague, Czech Republic, P1N 88529.

References: (1) Řídkošil, T., V. Šrein, J. Fábry, J. Hybler, and B.A. Maximov (1992) Mrázekite, $Bi_2Cu_3(OH)_2O_2(PO_4)_2 \cdot 2H_2O$, a new mineral species and its crystal structure. Can. Mineral., 30, 215–224. (2) (1992) Amer. Mineral., 77, 1306 (abs. ref. 1). (3) Effenberger, H., W. Krause, K. Belendorff, H.-J. Bernhardt, O. Medenbach, J. Hybler, and V. Petříček (1994) Revision of the crystal structure of mrázekite, $Bi_2Cu_3(OH)_2O_2(PO_4)_2 \cdot 2H_2O$. Can. Mineral., 32, 365–372. (4) Birch, W.D., D.A. Henry, and A. Pring (1995) A new occurrence of mrazekite [*sic*] from Benambra, Victoria, Australia. Mineral. Record, 26, 107–113.

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Mroseite $CaTe^{4+}O_2(CO_3)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals may show poorly developed {100}, with elongation parallel [001], very small, commonly with a crude radiating structure; typically massive.

Physical Properties: Hardness = ∼4 D(meas.) = 4.35 D(calc.) = 4.171

Optical Properties: Semitransparent. *Color:* Colorless to white. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r \ll v$. $\alpha = 1.79$ $\beta = 1.85$ $\gamma = 1.89$ 2V(meas.) = 74°

Cell Data: *Space Group: Pbca.* $a = 6.988(15)$ $b = 11.201(10)$ $c = 10.566(10)$ Z = 8

X-ray Powder Pattern: Moctezuma mine, Mexico.
3.14 (10), 5.14 (9), 4.20 (8), 1.97 (8), 3.35 (7), 3.02 (7), 2.39 (7)

Chemistry:

	(1)	(2)
TeO_2	61.3	61.46
CO_2	16.8	16.95
CaO	22.4	21.59
Total	100.5	100.00

(1) Moctezuma mine, Mexico; by neutron activation, CO_2 by TGA; corresponds to $Ca_{1.03}Te_{0.99}O_{2.00}(C_{0.99}O_3)$. (2) $CaTeO_2(CO_3)$.

Occurrence: Very rare in a hydrothermal Au–Te deposit (Moctezuma mine, Mexico).

Association: Spiroffite, tellurium, tellurite, denningite, zemannite, quartz (Moctezuma mine, Mexico); oboyerite, choloalite, gold (Tombstone, Arizona, USA).

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the Tombstone Exploration open pit, Tombstone, Cochise Co., Arizona, USA.

Name: To honor Mary Emma Mrose (1910–2003), American mineralogist, U.S. Geological Survey, Washington, D.C.

Type Material: Royal Ontario Museum, Toronto, Canada, M33757.

References: (1) Mandarino, J.A., R.S. Mitchell, and R.G.V. Hancock (1975) Mroseite, a calcium tellurite-carbonate from Moctezuma, Sonora, Mexico. Can. Mineral., 13, 286–288. (2) (1976) Amer. Mineral., 61, 339 (abs. ref. 1). (3) Fischer, R., F. Pertlik, and J. Zemann (1975) The crystal structure of mroseite, $CaTeO_2(CO_3)$. Can. Mineral., 13, 383–387.

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Mückeite $CuNiBiS_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As euhedral to subhedral crystals, to 1 mm, tabular on {010}, elongated along [001], exhibiting {100}, {010}, {001}, {101}, and an {*hk*0} form.

Physical Properties: *Cleavage:* Very good on {010}, good on {001}. Hardness = 3.5 VHN = 136–165, 152 average (100 g load). D(meas.) = 5.88 D(calc.) = 6.04

Optical Properties: Opaque. *Color:* Pale gray with an orange tint; creamy gray to pale gray with a yellow-brown tint in reflected light *Streak:* Grayish black. *Luster:* Metallic. *Optical Class:* Biaxial. *Pleochroism:* Distinct. *Anisotropism:* Weak; gray with shades of blue and yellow-orange to red-brown. *Bireflectance:* Low.
R_1–R_2: 35.7–36.4 (470), 34.1–39.0 (546), 39.8–40.2 (589), 40.9–42.2 (650

Cell Data: *Space Group:* $P2_12_12_1$. a = 7.509(2) 7.514(3) b = 12.551(2) 12.557(6) c = 4.877(1) 4.8880(2) Z = 4

X-ray Powder Pattern: Grüne Au mine, Germany.
2.975 (100), 3.177 (80), 1.837 (70), 2.087 (60) 1.863 (50), 2.895 (40), 2.232

Chemistry:

	(1)	(2)
Cu	15.1	14.87
Ni	14.0	13.73
Sb	2.1	
Bi	45.6	48.89
S	22.9	22.51
Total	99.7	100.00

(1) Grüne Au mine, Germany; by electron microprobe, average of seven analyses; corresponds to $Cu_{1.00}Ni_{1.01}(Bi_{0.92}Sb_{0.07})_{\Sigma=0.99}S_{3.01}$. (2) $CuNiBiS_3$.

Occurrence: In dump material at a polymetallic hydrothermal deposit, topotactically relacing lapieite.

Association: Lapieite, millerite, bismuthinite, sphalerite, aikinite, polydymite.

Distribution: From the Grüne Au mine, Schutzbach, 15 km southwest of Siegen, North Rhine-Westphalia, Germany [TL].

Name: Honors Dr. Arno Mücke (1937–), German mineralogist, Mineralogical-Petrological Institute, Göttingen University, Göttingen, Germany, for his work in systematic and ore mineralogy.

Type Material: Göttingen University, Göttingen; Tübingen University, Tübingen, Germany.

References: (1) Schnorrer-Köhler, G., U. Neumann, and T. Doering (1989) Mückeite, $CuNiBiS_3$, a new ore mineral from the Grüne Au mine, Schutzbach/Siegerland. Neues Jahrb. Mineral., Monatsh., 193–200. (2) (1990) Amer. Mineral., 75, 708 (abs. ref. 1). (3) Bente, K., T. Doering, A. Edenharter, V. Kupcik, M. Steins, and M. Wendschuh-Josties (1990) Structure of the new mineral mückeite, $BiCuNiS_3$. Acta Cryst., C46, 127–128.

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Muirite $\mathbf{Ba_{10}Ca_2Mn^{2+}TiSi_{10}O_{30}(OH,Cl,F)_{10}}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Subhedral to euhedral crystals not uncommon, bounded principally by {100} and {001}, also {110} and {$h0l$} forms; in grains and aggregates, to 3 mm.

Physical Properties: *Cleavage:* Indistinct on {001} and {100}. Hardness = ~2.5
D(meas.) = 3.86(2) D(calc.) = 3.88

Optical Properties: Transparent to translucent. *Color:* Orange; anomalous purple-brown interference color. *Streak:* Pale orange. *Luster:* Subvitreous.
Optical Class: Uniaxial (+). *Pleochroism:* O = orange; E = colorless. $\omega = 1.697(1)$
$\epsilon = 1.704(2)$

Cell Data: *Space Group:* $P4/mmm$. $a = 14.000(3)$ $c = 5.625(2)$ Z = 1

X-ray Powder Pattern: Fresno Co., California, USA.
2.91 (100), 4.42 (75), 3.73 (60), 3.51 (60), 3.31 (60), 3.60 (50), 2.814 (40)

Chemistry:

	(1)		(1)
SiO_2	22.15	SrO	0.13
TiO_2	4.17	BaO	59.6
Al_2O_3	0.53	K_2O	0.1
FeO	0.4	F	1.4
MnO	2.04	Cl	4.5
MgO	0.11	H_2O	1.8
CaO	4.67	$-O = (F,Cl)_2$	1.6
		Total	[100.0]

(1) Fresno Co., California, USA; by D-C emission arc spectrography, K and Cl by X-ray spectroscopy, stated to be recalculated to 100.0%; corresponds to $(Ba_{9.82}K_{0.05}Sr_{0.03})_{\Sigma=9.90}Ca_{2.10}(Mn_{0.73}Fe_{0.14}Mg_{0.07})_{\Sigma=0.94}Ti_{1.32}(Si_{9.31}Al_{0.26})_{\Sigma=9.57}O_{29.52}[(OH)_{5.05}Cl_{3.21}F_{1.86}]_{\Sigma=10.12}$.

Occurrence: In sanbornite-quartz-bearing metamorphic rock (Fresno Co., California, USA).

Association: Sanbornite, verplanckite (Fresno Co., California, USA); gillespite, sanbornite, taramellite, fresnoite, pellyite, barite (Itsy Mountains, Yukon, Canada).

Distribution: On Big Creek and Rush Creek, Fresno Co., California, USA. From the Gunn claim, near Macmillan Pass, Itsy Mountains, Yukon Territory, Canada.

Name: For John Muir (1834–1914), American mountaineer, conservationist, and naturalist, whose name is intimately associated with the California Sierra Nevada.

Type Material: California Division of Mines & Geology, San Francisco, California, USA.

References: (1) Alfors, J.T., M.C. Stinson, R.A. Matthews, and A. Pabst (1965) Seven new barium minerals from eastern Fresno County, California. Amer. Mineral., 50, 314–340. (2) Alfors, J.T. and G. Putman (1965) Revised chemical analyses of traskite, verplanckite and muirite from Fresno County, California. Amer. Mineral., 50, 1500–1503. (3) Malinovskii, Y.A., E.A. Pobedimskaya, and N.V. Belov (1975) Crystal structure of muirite $Ba_9(Ca,Ba)(Ca,Ti)_4(OH)_8Si_8O_{24}(Cl,OH)_8$. Doklady Acad. Nauk SSSR, 221, 343–345 (in Russian). (4) (1981) Mineral. Abs., 32, 247 (abs. ref. 3).

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Mukhinite $Ca_2Al_2V^{3+}(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic. *Point Group:* n.d. Irregular, short prismatic crystals, to 2.5 mm; as grains and vuggy accumulations and segregations. *Twinning:* Simple twins on {100}.

Physical Properties: *Cleavage:* {001}, perfect; {100}, less so; (001) ∧ (100) = 64°. *Tenacity:* Brittle. Hardness = 8 VHN = 1375 average. D(meas.) = n.d. D(calc.) = [3.47]

Optical Properties: Translucent. *Color:* Black with brownish tints, reddish brown to brown; in thin section, reddish brown to olive-green. *Streak:* Light brownish gray. *Luster:* Vitreous. *Optical Class:* Biaxial (+) or (–). *Pleochroism:* Strong; X = pale olive-green; Y = pale reddish brown; Z = reddish brown. *Orientation:* $Y = b$; $Z \wedge a = 32°$. $\alpha = 1.723(2)$ $\beta = 1.733(2)$ $\gamma = 1.755(2)$ 2V(meas.) = 88°

Cell Data: *Space Group:* n.d. $a = 8.90$ $b = 5.61$ $c = 10.15$ $\beta = 115°30'$ Z = 2

X-ray Powder Pattern: Tashelginskoye deposit, Russia.
2.892 (10), 2.682 (8), 2.600 (8), 2.398 (8), 1.405 (8), 1.394 (8), 2.530 (7)

Chemistry:

	(1)
SiO_2	36.50
Al_2O_3	21.81
Fe_2O_3	1.31
V_2O_3	11.29
Cr_2O_3	0.28
MgO	trace
CaO	22.23
H_2O	1.76
S	0.98
Total	96.16

(1) Tashelginskoye deposit, Russia; corresponds to $Ca_{2.0}(Al_{2.1}V_{0.8}Fe_{0.1})_{\Sigma=3.0}Si_{3.1}O_{12}(OH)$.

Mineral Group: Epidote group.

Occurrence: In marble associated with an iron deposit (Tashelginskoye deposit, Russia); a late-stage mineral in garnet-bearing metamorphic rocks (Kuznetsk, Kazakhstan).

Association: Goldmanite, muscovite, pyrite, pyrrhotite, sphalerite, chalcopyrite (Tashelginskoye deposit, Russia); garnet, diopside, titanite, quartz, clinozoisite, galena, molybdenite (Kuznetsk, Kazakhstan).

Distribution: From the Tashelginskoye iron deposit, Shoriya Mountains, about 400 km southeast of Novosibirsk, southwestern Siberia, Russia. At Kuznetsk, Ala-Tau Range, Tien Shan, Kazakhstan. From Lewiston, Fergus Co., Montana, USA.

Name: In honor of Aleksei Stepanovich Mukhin (1910–1974), geologist with the West Siberian Geological Survey.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 71421.

References: (1) Shepel, A.V. and M.V. Karpenko (1969) Mukhinite, a new vanadium species of epidote. Doklady Acad. Nauk SSSR, 185, 1342–1345 (in Russian). (2) (1970) Amer. Mineral., 55, 321–322 (abs. ref. 1). (3) Karev, M.E. (1974) New finds of vanadium-containing minerals in metamorphic rocks of the Kuznetsk Alatau. Geol. Geofiz., 11, 141–143. (4) (1975) Chem. Abs., 83, 45824 (abs. ref. 3).

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Mullite $Al_6Si_2O_{13}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic to acicular, elongated ‖ [001].

Physical Properties: *Cleavage:* Distinct on {010}. Hardness = 6–7 D(meas.) = 3.11–3.26 D(calc.) = 3.170 Insoluble in acids, including HF.

Optical Properties: Transparent to translucent. *Color:* Colorless to pale pink, gray; colorless to pink in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = colorless; Z = rose-pink. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. α = 1.630–1.670 β = 1.636–1.675 γ = 1.640–1.691 2V(meas.) = 45°–61°

Cell Data: *Space Group: Pbam* (synthetic). a = 7.5785(6) b = 7.6817(7) c = 2.8864(3) Z = 1

X-ray Powder Pattern: Synthetic.
3.390 (100), 3.428 (95), 2.206 (60), 5.39 (50), 2.542 (50), 2.694 (40), 1.5242 (35)

Chemistry:

	(1)	(2)
SiO_2	29.04	28.20
TiO_2	0.79	
Al_2O_3	69.63	71.80
Fe_2O_3	0.50	
Na_2O	0.18	
K_2O	0.06	
Total	100.20	100.00

(1) Isle of Mull, Scotland. (2) $Al_6Si_2O_{13}$.

Occurrence: In fused argillaceous inclusions in Tertiary eruptive rocks (Isle of Mull, Scotland); as microscopic inclusions in sillimanite in pelitic inclusions in a tonalite (Val Sissone, Italy); in a complex assemblage of emerylike rocks (Sithean Sluaigh, Scotland).

Association: Corundum (Isle of Mull, Scotland); sillimanite, kyanite (Val Sissone, Italy); corundum, magnetite, spinel, pseudobrookite, sanidine, cordierite (Sithean Sluaigh, Scotland).

Distribution: From Nuns Pass, Carsaig, and a number of other places on the Isle of Mull, also at Sithean Sluaigh, Strachur, Argyllshire, Scotland. At Tievebulliagh, Co. Antrim, Ireland. In the Bergell massif, at Val Sissone, Lombardy, Italy. At the Bellerberg, Nickenicher Sattel, and other volcanoes, Eifel district, Germany. From the Bushveld complex, at Maandagshoek, Transvaal, and in the Roberts Victor diamond mine, near Kimberley, Cape Province, South Africa. In Russia, on Buguchan Mountain and near Arkhara Station, Amur region.

Name: For its type locality on the Isle of Mull, Scotland.

Type Material: The Natural History Museum, London, England, 1925,432–437.

References: (1) Bowen, N.L., J.W. Greig, and E.G. Zeiss (1924) Mullite, a new silicate of alumina. J. Wash. Acad. Sci., 14, 183–191. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 742–758. (3) Angel, R.J., R.K. McMullan, and C.T. Prewitt (1991) Substructure and superstructure of mullite by neutron diffraction. Amer. Mineral., 76, 332–342. (4) (1940) NBS Mono. 25, 3, 3.

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Mummeite $Ag_2PbCuBi_6S_{13}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As intergrowths of short columnar crystals, to 1 mm, exsolved to alternating lamellae of mummeite and plumbocuprian mummeite. *Twinning:* Along a straight composition plane parallel to elongation.

Physical Properties: Hardness = n.d. VHN = 186–220, average 203 D(meas.) = n.d. D(calc.) = 6.79–6.80

Optical Properties: Opaque. *Color:* Gray. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Pronounced, in shades of gray to brownish yellow to dark indigo. *Bireflectance:* Perceptible.
R_1–R_2: 43.3–47.5 (470), 42.8–47.0 (546), 42.5–46.4 (589), 42.2–45.7 (650)

Cell Data: *Space Group:* $C2/m$ (mummeite), with $a = 13.47(1)$ $b = 4.06(1)$ $c = 21.63(1)$ $\beta = 92.9(1)°$ Z = 2, or *Space Group:* $C2/m$ (plumbocuprian mummeite), with $a = 13.48(1)$ $b = 4.06(1)$ $c = 21.72(1)$ $\beta = 93.9(1)°$ Z = 2

X-ray Powder Pattern: Alaska mine, Colorado, USA.
2.863 (10), 2.023 (10), 3.53 (5), 3.43 (5), 1.652 (4), 1.285 (4), 5.55 (3)

Chemistry:

	(1)	(2)	(3)
Ag	11.69	10.81	10.00
Pb	12.10	14.40	9.60
Cu	2.22	4.32	2.95
Bi	56.04	52.34	58.13
S	17.30	16.99	19.32
Total	99.35	99.84	100.00

(1) Alaska mine, Colorado, USA; by electron microprobe, mummeite; corresponds to $Ag_{2.61}Pb_{1.41}Cu_{0.84}Bi_{6.46}S_{13.00}$. (2) Do.; by electron microprobe, plumbocuprian mummeite; corresponds to $Ag_{2.46}Pb_{1.71}Cu_{1.67}Bi_{6.14}S_{13.00}$. (3) $Ag_2PbCuBi_6S_{13}$.

Mineral Group: Benjaminite group.

Occurrence: In hydrothermal base-metal sulfide vein deposits.

Association: Chalcopyrite, sphalerite, pyrite, ourayite, schapbachite, heyrovskyite, quartz (Alaska mine, Colorado, USA).

Distribution: In the USA, from the Alaska mine, Poughkeepsie Gulch, near Ouray [TL] and at the Mike mine, Silverton district, San Juan Co., Colorado.

Name: To honor Dr. William Gustav Mumme (1936–), Australian mineralogist, C.S.I.R.O., Melbourne, Australia, who first studied the mineral, for his work with sulfosalts.

Type Material: University of Copenhagen, Copenhagen, Denmark; Museum of Natural History, Denver, Colorado, USA.

References: (1) Karup-Møller, S. and E. Makovicky (1992) Mummeite – a new member of the pavonite homologousseries from the Alaska mine, Colorado. Neues Jahrb. Mineral., Monatsh., 555–576. (2) (1993) Amer. Mineral., 78, 847 (abs. ref. 1). (3) Mumme, ?? (1990) ??title?? Neues Jahrb. Mineral., Monatsh., 193–204.

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Munakataite $Pb_2Cu_2(Se^{4+}O_3)(SO_4)(OH)_4$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As fibrous aggregates, to 0.03 mm.

Physical Properties: *Cleavage*: Perfect {010}. *Tenacity*: Brittle. *Fracture*: None.
Hardness = < 2 D(meas.) = n.d. D(calc.) = 5.526

Optical Properties: Transparent. *Color*: Light blue. *Streak*: Bluish white.
Luster: Vitreous, pearly on cleavage surfaces. Easily mistaken visually for linarite.
Optical Class: n.d. n = 1.891 (calculated). *Pleochroism*: Weak, colorless to pale blue.

Cell Data: *Space Group*: $P2_1/m$. a = 9.766(8) b = 5.666(5) c = 9.291(10) β = 102.40(8)°
Z = 2

X-ray Powder Pattern: Kato mine, Fukuoka Prefecture, Japan.
3.18 (100), 3.14 (68), 4.77 (57), 4.86 (44), 3.53 (39), 2.72 (22), 1.813 (19)

Chemistry:

	(1)	(2)
PbO	53.71	53.62
CuO	18.33	19.11
CaO	0.04	
SO_3	9.73	9.62
SeO_2	13.19	13.32
H_2O	4.19	4.33
Total	99.19	100.00

(1) Kato mine, Fukuoka Prefecture, Japan; average of 7 EDS analyses, H_2O calculated, complex anions and OH confirmed by FT-IR, corresponding to $Pb_{2.03}(Cu_{1.94}Ca_{0.01})_{\Sigma=1.95}(Se^{4+}O_3)_{1.00}(SO_4)_{1.02}(OH)_{3.92}$. (2) $Pb_2Cu_2(Se^{4+}O_3)(SO_4)(OH)_4$.

Occurrence: A secondary mineral in the weathering zone of a polymetallic sulfide deposit.

Association: Malachite.

Distribution: Dumps of the Kato mine, Fukuoka Prefecture and at the Kisamori mine, Akita Prefecture, Japan.

Name: For the city of Munakata, where the Kato mine, source of the first specimens, is located.

Type Material: National Museum of Nature and Science, Tokyo, Japan (NSM-M28982).

References: (1) Matsubara, S., T. Mouri, R. Miyawaki, K. Yokoyama, and M. Nakahara (2008) Munakataite, a new mineral from the Kato mine, Fukuoka, Japan. J. Mineral. Petrol. Sci., 103, 327–332. (2) (2009) Amer. Mineral., 94, 1079-1080 (abs. ref. 1).

Mundite $Al(UO_2)_3(PO_4)_2(OH)_3 \cdot 5.5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As tabular rectangular crystals, flattened on {010} and elongated along [001], to 0.5 mm.

Physical Properties: *Cleavage:* Perfect on {010}, {100}, {001}. Hardness = n.d. D(meas.) = > 4.05 D(calc.) = 4.295 Radioactive; fluoresces pale green in LW and SW UV.

Optical Properties: Transparent. *Color:* Golden yellow; pale yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Orientation:* $X = b$; $Y = c$; $Z = a$. α = [1.62] $\beta = 1.682(2)$ $\gamma = 1.688(2)$ 2V(meas.) = 33°

Cell Data: *Space Group:* $Pmcn$ or $P2_1cn$. $a = 17.08(3)$ $b = 30.98(5)$ $c = 13.76$ Z = 16

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
7.80 (100), 3.37 (70), 3.87 (60), 3.06 (50), 5.74 (40), 3.00 (40), 4.23 (30)

Chemistry:

	(1)	(2)
UO_3	72.20	72.90
P_2O_5	12.55	12.06
Al_2O_3	4.45	4.33
H_2O	[10.80]	10.71
Total	[100.00]	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, average of four analyses, H_2O by difference. (2) $Al(UO_2)_3(PO_4)_2(OH)_3 \cdot 5.5H_2O$.

Occurrence: A rare mineral in the oxidized uraniferous zone of a complex granite pegmatite.

Association: Phuralumite, upalite, ranunculite, threadgoldite, eylettersite.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: Honors Professor Walter Mund (1892–1956), radiochemist, Catholic University of Louvain, Louvain, Belgium.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG11888.

References: (1) Deliens, M. and P. Piret (1981) Les phosphates d'uranyle et d'aluminium de Kobokobo. V. La mundite, nouveau minéral. Bull. Minéral., 104, 669–671 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 624 (abs. ref. 1).

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Mundrabillaite $(NH_4)_2Ca(PO_3OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. In aggregates of tiny crystals.

Physical Properties: *Tenacity:* Fragile [*sic*]. Hardness = Very soft. D(meas.) = n.d. D(calc.) = 2.09 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless. *Streak:* White. *Luster:* Dull. *Optical Class:* Biaxial (–). *Orientation:* Extinction angle +26(1)°. $\alpha = 1.522(2)$ $\beta = 1.544(2)$ $\gamma = 1.552(2)$ 2V(meas.) = n.d. 2V(calc.) = 61°

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. $a = 8.643$ $b = 8.184$ $c = 6.411$ $\beta = 98.0°$ Z = 2

X-ray Powder Pattern: Petrogale Cave, Australia.
4.279 (100), 3.106 (60), 8.60 (30), 3.687 (30), 2.873 (30), 2.728 (20), 2.116 (15)

Chemistry:

	(1)	(2)
SO_3	0.04	
P_2O_5	48.6	49.61
Fe_2O_3	0.05	
MgO	0.04	
CaO	20.4	19.60
K_2O	0.85	
$(NH_4)_2O$		18.20
H_2O		12.59
Total		100.00

(1) Petrogale Cave, Australia; by electron microprobe, average of nine partial analyses, presence of NH_4 and H_2O confirmed; formula derived by correspondence of X-ray and optical data with synthetic material. (2) $(NH_4)_2Ca(PO_3OH)_2 \cdot H_2O$.

Polymorphism & Series: Dimorphous with swaknoite.

Occurrence: Derived from bat guano and urine in caves.

Association: Biphosphammite, archerite, aphthitalite, halite, syngenite, stercorite, oxammite, weddellite, whitlockite, guanine, newberyite, calcite (Petrogale Cave, Australia); swaknoite, dittmarite, arcanite (Arnhem Cave, Namibia).

Distribution: In Petrogale Cave, near Madura, Western Australia. In Arnhem Cave, 150 km east of Windhoek, Namibia.

Name: For Mundrabilla Station, nearby the Petrogale Cave, Western Australia.

Type Material: Western Australian Museum, Perth, MDC5902.

References: (1) Bridge, P.J. and R.M. Clarke (1983) Mundrabillaite – a new cave mineral from Western Australia. Mineral. Mag., 47, 80–81. (2) (1984) Amer. Mineral., 69, 407 (abs. ref. 1).

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Munirite $\mathbf{NaV^{5+}O_3 \cdot (2-x)H_2O}$ (x = 0 to 0.2)

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 3 mm, in radiating to spherical fibrous aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.43 D(calc.) = [2.44] Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White, tinged apple-green; colorless in transmitted light. *Luster:* Pearly.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.692$ $\beta = 1.757$ $\gamma = 1.800$ 2V(meas.) = 75°

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 16.72(2)$ $b = 3.636(3)$ $c = 8.015(6)$ $\beta = 111.0(1)°$ Z = 4

X-ray Powder Pattern: Bhimber area, Pakistan.
7.85 (100), 3.297 (90), 2.685 (80), 4.134 (70), 2.984 (70), 6.74 (50), 1.820 (50)

Chemistry:

	(1)	(2)
V_2O_5	67.46	58.24
Na_2O	22.91	19.84
H_2O	10.26	21.92
Total	100.63	100.00

(1) Bhimber area, Pakistan; by AA, H_2O by the Penfield method, yielding Na:V = 1:1.
(2) $NaVO_3 \cdot 1.9H_2O$.

Occurrence: On sandstone, presumably formed from oxidation of vanadium-bearing primary uranium minerals.

Association: n.d.

Distribution: From the Bhimber area, Azad Kashmir, Pakistan.

Name: Honors Munir Ahmad Khan, Chairman, Pakistan Atomic Energy Commission.

Type Material: Atomic Energy Minerals Centre, Peshawar, Pakistan; The Natural History Museum, London, England, 1983,196.

References: (1) Butt, K.A. and K. Mahmood (1983) Munirite, naturally occurring sodium vanadium oxide hydrate, a new mineral. Mineral. Mag., 47, 391–392. (2) (1984) Amer. Mineral., 69, 812 (abs. ref. 1). (3) Björnberg, A. and B. Hedman (1977) The crystal structure of $NaVO_3 \cdot 1.89H_2O$. Acta Chem. Scand., A31, 579–584. (4) Evans, H.T., Jr. (1988) The crystallography of munirite, $NaVO_3 \cdot (2\text{-}x)H_2O$. Mineral. Mag., 52, 716–717.

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Murataite $(Y,Na)_6(Zn,Fe^{3+})_5(Ti,Nb)_{12}O_{29}(O,F)_{14}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As subhedral crystals, to 5 mm; granular.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–6.5 VHN = 782–870, 827 average (100 g load). D(meas.) = 4.50–4.69 D(calc.) = 4.64

Optical Properties: Opaque to translucent on thin edges. *Color:* Black; brown or yellow in transmitted light; gray in reflected light, with faint orange internal reflections. *Luster:* Submetallic.
Optical Class: Isotropic; slight anisotropism due to strain. n = 2.11–2.13 *Anisotropism:* Weak. *Bireflectance:* Slight.
R: (546) 13.7–13.3, (589) 13.1–12.7, (630) 12.7–12.3

Cell Data: *Space Group:* $F\overline{4}3m$. a = 14.886(2) Z = 4

X-ray Powder Pattern: St. Peters Dome, Colorado, USA.
2.858 (10), 1.746 (8), 1.489 (8), 2.468 (6), 1.432 (5), 1.138 (5), 8.51 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.64	0.34		Nb_2O_5	10.01	10.10	0.0
TiO_2	37.87	38.07	48.2	Fe_2O_3		3.99	
SnO_2	0.17	0.27		FeO	4.37		2.3
Y_2O_3	12.06	12.53	20.5	MnO	0.61	0.75	
Gd_2O_3	0.17	0.27		PbO	0.11		
Tb_2O_3		[0.16]		ZnO	12.45	11.32	16.2
Dy_2O_3	2.18	2.59		CaO	0.90	0.91	6.7
Ho_2O_3	0.57	0.95		Na_2O	5.80	6.10	5.9
Er_2O_3	3.09	2.83		F	6.55	7.11	0.0
Tm_2O_3	0.34	0.45		H_2O	0.55	[0.55]	
Yb_2O_3	2.96	3.11	0.7	$-O = F_2$	2.76	2.99	
Lu_2O_3	0.34	0.47		Total	[98.98]	[99.88]	100.5

(1) St. Peters Dome, Colorado, USA; by XRF, flame photometry, electron microprobe, semiquantitative spectrographic analysis, volumetric and microcoulumetric methods; after rejection of Ba 0.008%. (2) Do.; by electron microprobe, total Fe as Fe_2O_3, Tb_2O_3 interpolated, H_2O from (1); corresponds to $(Na_{3.97}Y_{2.24}RE_{1.15}Zn_{2.81}Fe^{3+}_{1.01}Ca_{0.33}Mn_{0.21})_{\Sigma=11.72}(Ti_{9.60}Nb_{1.53}Si_{0.11}Sn_{0.04})_{\Sigma=11.28}O_{32.11}F_{7.55}(OH)_{1.23}$. (3) Burpala massif, Russia.

Occurrence: A rare accessory mineral in samples from the dump of a prospect in a pegmatite subjected to alkali metasomatism (St. Peters Dome, Colorado, USA); in pegmatite in a differentiated alkalic massif (Burpala massif, Russia).

Association: Quartz, astrophyllite, microcline, albite, riebeckite, chlorite, zircon, aegirine, anatase, rutile, thorite, pyrochlore, xenotime, genthelvite, zincian davidite (St. Peters Dome, Colorado, USA); landauite, rutile, monazite, bastnäsite, brookite (Burpala massif, Russia).

Distribution: From the St. Peters Dome area, near Pikes Peak, El Paso Co., Colorado, USA. In the Burpala massif, 120 km north of Lake Baikal, eastern Siberia.

Name: To honor Kiguma Jack Murata (1909–), geochemist, U.S. Geological Survey, Menlo Park, California, USA, for his work on rare-earth chemistry.

Type Material: National Museum of Natural History, Washington, D.C., USA, 133319–133321.

References: (1) Adams, J.W., T. Botinelly, W.N. Sharp, and K. Robinson (1974) Murataite, a new complex oxide from El Paso County, Colorado. Amer. Mineral., 59, 172–176. (2) Portnov, A.M., L.S. Dubakina, and G.K. Krivokoneva (1981) Murataite in predicted association with landauite. Doklady Acad. Nauk SSSR, 261, 741–744 (in Russian). (3) Ercit, T.S. and F.C. Hawthorne (1995) Murataite, a UB_{12} derivative structure with condensed Keggin molecules. Can. Mineral., 33, 1223–1229.

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Murdochite $PbCu_6O_{8-x}(Cl,Br)_{2x}$ ($x \leq 0.5$)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra and cubo-octahedra, to 2 mm. *Twinning:* Common, law not stated.

Physical Properties: *Cleavage:* {111}. *Tenacity:* Brittle. Hardness = 4 VHN = 519–567 (100 g load). D(meas.) = 5.9–6.7 D(calc.) = 6.06

Optical Properties: Opaque. *Color:* Black; gray in reflected light, with yellowish brown tint, may be very finely zoned. *Streak:* Black. *Luster:* Adamantine.
Optical Class: Isotropic.
R: (470) 16.3, (490) 16.4, (510) 16.7, (530) 16.9, (570) 17.2, (610) 17.5, (630) 17.5, (650) 17.6

Cell Data: *Space Group:* $Fm3m$. a = 9.210–9.224 Z = 4

X-ray Powder Pattern: Tiger, Arizona, USA.
5.30 (10), 2.659 (10), 1.629 (10), 2.303 (9), 2.109 (9), 3.25 (8), 2.776 (8)

Chemistry:

	(1)	(2)	(3)
SiO_2	0.05		
PbO_2	30.53	31.0	32.4
Fe_2O_3	0.17		
CuO	67.24	64.4	61.6
Cl		3.0	4.6
Br		1.5	1.5
insol.	1.11		
Total	99.10	99.9	100.1

(1) Tiger, Arizona, USA; corresponds to $Pb_{0.9}Cu_{6.1}O_8$. (2) Hansonburg district, New Mexico, USA; by electron microprobe, average of two analyses. (3) Tchah Khuni mine, Iran; by electron microprobe, average of two analyses.

Occurrence: In oxidized Pb–Cu deposits.

Association: Wulfenite, fluorite, hemimorphite, willemite, descloizite, dioptase, chrysocolla, creaseyite, quartz (Tiger, Arizona, USA); plattnerite, malachite, "limonite" (Mapimí, Mexico); embolite, chrysocolla, dioptase, plattnerite, hemimorphite, iranite, boleite, diaboleite, "limonite" (Tchah Khuni mine, Iran).

Distribution: In the USA, in Arizona, from the Mammoth-St. Anthony mine, Tiger, Pinal Co., in the Higgins mine, Bisbee, Cochise Co., from the Silver Hill mine, Pima Co., the 79 mine, Gila Co., the Tonopah-Belmont mine, Osborne district, Maricopa Co., and at the Eagle Eye mine, New Water Mountains, La Paz Co.; in the Blanchard and Mex-Tex mines, near Bingham, Hansonburg district, Socorro Co., New Mexico; and at the Blue Bell claims, near Baker, San Bernardino Co., California. From the Ojuela mine, Mapimí, Durango, and at Santa Eulalia, Chihuahua, Mexico. In the Tchah Khuni mine, near Anarak, Iran. From the Whim Creek copper mine, Pilbara district, Western Australia.

Name: In honor of Professor Joseph Murdoch (1890–1973), American mineralogist, University of California, Los Angeles, California, USA.

Type Material: n.d.

References: (1) Fahey, J.J. (1955) Murdochite, a new copper lead oxide mineral. Amer. Mineral., 40, 905–906. (2) Christ, C.L. and J.R. Clark (1955) The crystal structure of murdochite. Amer. Mineral., 40, 907–916. (3) Burke, E.A.J. and P. Maaskant (1970) New data on murdochite. Neues Jahrb. Mineral., Monatsh., 558–565. (4) Dubler, E., A. Vedani, and H.R. Oswald (1983) New structure determination of murdochite, Cu_6PbO_8. Acta Cryst., C39, 1143–1146.

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Murmanite $Na_2(Ti, Nb)_2Si_2O_9 \cdot nH_2O$

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Crystal Data: Triclinic. *Point Group:* 1. Rarely in well-formed crystals, to 2 cm. As flaky and lamellar segregations and radial and fine-grained aggregations.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 2.76–2.84 D(calc.) = 3.00

Optical Properties: Translucent to opaque. *Color:* Lilac to bright pink when fresh; yellow, brown, cinnamon-brown to black when altered; in thin section, light pink, brownish, or dull gray. *Luster:* Vitreous on cleavages, greasy on fractures.
Optical Class: Biaxial (–). *Pleochroism:* X = light pink; Y = light brown; Z = pinkish brown to dark brown. *Orientation:* $X \perp (100)$; $Z = b$. *Dispersion:* $r > v$, distinct. *Absorption:* $Z > X > Y$. $\alpha = 1.682–1.735$ $\beta = 1.765–1.770$ $\gamma = 1.807–1.839$ 2V(meas.) = 57°–64°

Cell Data: *Space Group:* $P1$. $a = 10.535(5)$ $b = 13.884(4)$ $c = 11.688(14)$ $\alpha = 94.31(6)°$ $\beta = 98.62(8)°$ $\gamma = 89.81(3)°$ Z = [4]

X-ray Powder Pattern: Lovozero massif, Russia.
4.220 (10), 2.867 (10), 11.56 (9), 5.810 (9), 3.762 (6), 2.640 (4), 2.485 (4)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	30.06	31.24	30.83	MgO	0.35	0.64	0.33
TiO_2	38.24	30.40	33.48	CaO	2.56	3.16	5.40
ZrO_2	2.08	1.62		Na_2O	10.38	8.64	10.58
Fe_2O_3	2.33	2.96	0.48	K_2O	0.83	0.62	0.19
Nb_2O_5		6.56	4.78	H_2O^+	4.17	5.37	[8.62]
Ta_2O_5		0.56		H_2O^-	6.03	6.13	
FeO	0.30		1.73	P_2O_5			2.66
MnO	2.30	2.38	0.75	Total	99.63	100.28	[99.83]

(1) Chinglusuai Valley, Russia. (2) Sengischorr cirque, Lovozero massif, Russia. (3) Ilímaussaq intrusion, Greenland; by electron microprobe, XRF, and DTA, here recalculated to oxides, $Fe^2 + :Fe^{3+} = 4:1$, H_2O estimated from oxygen difference; corresponds to $(Na_{0.88}Ca_{0.38}Fe^{2+}_{0.09}Mg_{0.03}K_{0.02})_{\Sigma=1.40}(Ti_{1.63}Nb_{0.14}Mn_{0.04}Fe^{3+}_{0.03})_{\Sigma=1.84}Si_2O_{8.63} \cdot 0.15Na_3PO_4 \cdot 1.87H_2O$.

Occurrence: In pegmatites and associated igneous rocks of alkalic complexes, as a primary magmatic mineral or altered from lomonosovite.

Association: Lomonosovite, aegirine, arfvedsonite, neptunite, microcline, albite, natrolite, analcime, nepheline, sodalite, eudialyte, lorenzenite, lamprophyllite, rinkite, ussingite.

Distribution: In Russia, from the Chinglusuai Valley, on Mts. Flora, Punkaruaiv, and Angvundaschorr, Lovozero massif, and on Mts. Rasvumchorr and Koashva, Khibiny massif, Kola Peninsula. In the Ilímaussaq intrusion, at Kvanefjeld, Steenstrups Fjeld, and Skovfjord, southern Greenland.

Name: For the Murman coast on the northern side of the Kola Peninsula, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 25852–25854, 25862, 25863.

References: (1) Gutkowa, N. (1930) Sur un nouveau titanosilicate – la murmanite – de Lujawrurt (Halbinsel Kola). Compt. Rendu Acad. Sci. URSS, 731 (in French). (2) (1936) Fortschr. Mineral., 20, 129–130 (abs. ref. 1, in German). (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 347–351 (in English). (4) Karup-Møller, S. (1986) Murmanite from the Ilímaussaq alkaline complex, South Greenland. Neues Jahrb. Mineral., Abh., 155, 67–88. (5) Rastsvetaeva, R.K. and V.I. Andrianov (1986) New data on the crystal structure of murmanite. Kristallografiya (Sov. Phys. Crystal.), 31, 82–87 (in Russian).

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Murunskite $K_2Cu_3FeS_4$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$, $4mm$, 422, or $4/m\ 2/m\ 2/m$. As very tiny grains, to 1 μm, and in aggregates.

Physical Properties: *Cleavage:* Imperfect. *Tenacity:* Brittle. Hardness = Soft. VHN = 92–123, 109 average (10 g load). D(meas.) = n.d. D(calc.) = [3.86]

Optical Properties: Opaque. *Color:* Copper-red to pinchbeck-brown, iridescent; grayish orange-cream in reflected light; a fresh surface oxidizes to a sooty black film. *Luster:* Metallic. *Anisotropism:* Moderate, gray to brownish gray with a bluish tint.
R: (400) — , (420) — , (440) 15.0, (460) 15.6, (480) 16.6, (500) 17.4, (520) 18.2, (540) 19.2, (560) 20.0, (580) 21.0, (600) 21.8, (620) 22.6, (640) 23.3, (660) 24.0, (680) 24.6, (700) 25.4

Cell Data: *Space Group:* $I\bar{4}m2$, $I\bar{4}2m$, $I4mm$, $I422$, or $I4/mmm$. $a = 3.88(1)$ $c = 13.10(5)$ $Z = 1$

X-ray Powder Pattern: Murun massif, Russia.
6.52 (10), 2.53 (8), 2.90 (6), 1.940 (5), 1.715 (4), 2.10 (3), 3.29 (2)

Chemistry:

	(1)	(2)
K	14.57	17.27
Cu	44.38	42.09
Fe	12.07	12.33
S	28.14	28.31
Total	99.16	100.00

(1) Murun massif, Russia; by electron microprobe, corresponding to $K_{1.72}Cu_{3.23}Fe_{1.09}S_{4.05}$.
(2) $K_2Cu_3FeS_4$.

Occurrence: In rocks that have undergone intensive potassium metasomatism.

Association: Charoite, acmite, potassium feldspar.

Distribution: From the Murun alkalic massif, near Olekminsk, Sakha, Russia.

Name: For the locality in the Murun massif, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81604.

References: (1) Dobrovolskaya, M.G., A.I. Tsepin, T.L. Evstigneeva, L.N. Vyal'sov, and A.O. Zaozerina (1981) Murunskite, $K_2Cu_3FeS_4$, a new sulfide of potassium, copper, and iron. Zap. Vses. Mineral. Obshch., 110, 468–473 (in Russian). (2) (1982) Amer. Mineral., 67, 624 (abs. ref. 1).

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Muscovite **$KAl_2(Si_3Al)O_{10}(OH,F)_2$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular to columnar ∥ [001], striated ∥ {001}, pseudohexagonal or diamond-shaped, to 4.5 m and 77 t. As stellate aggregates, plumose, globular; scaly, granular, compact massive. *Twinning:* Composition plane {001}, twin axis [310], forming six-pointed stars.

Physical Properties: *Cleavage:* {001} perfect; partings on {110}, {010}. *Tenacity:* Laminae flexible and elastic; tough. Hardness = 2.5 ∥ [001]; 4 ⊥ [001]. D(meas.) = 2.77–2.88 D(calc.) = 2.83

Optical Properties: Transparent to translucent. *Color:* Colorless, gray, brown, green, yellow, rose-red; commonly colorless in thin section, but may be pale yellow, green, red-brown. *Streak:* White. *Luster:* Vitreous to pearly or silky.
Optical Class: Biaxial (–). *Pleochroism:* Weak when colored. *Orientation:* $Z = b$; $X \wedge c$ = 0°–5°; $Y \wedge a$ = 1°–3°. *Dispersion:* $r > v$, weak. *Absorption:* Faint; $Y \simeq Z > X$.
α = 1.552–1.576 β = 1.582–1.615 γ = 1.587–1.618 2V(meas.) = 30°–47°

Cell Data: *Space Group:* $C2/c$ ($2M_1$). $a = 5.19$ $b = 9.04$ $c = 20.08$ $\beta = 95°30'$ Z = 4

X-ray Powder Pattern: Synthetic; $2M_1$.
10.0 (> 100), 3.351 (> 100), 2.562 (90), 2.010 (75), 4.46 (65), 5.02 (55), 4.48 (55)

Chemistry:

	(1)	(2)
SiO_2	45.87	45.26
Al_2O_3	38.69	38.40
MgO	0.10	
Na_2O	0.64	
K_2O	10.08	11.82
H_2O	4.67	4.52
Total	100.05	100.00

(1) Blue Mountain, Methuen Township, Canada. (2) $KAl_2(Si_3Al)O_{10}(OH)_2$.

Polymorphism & Series: $2M_1$, 1M, 3A polytypes; interstratifies with vermiculite, paragonite, montmorillonite.

Mineral Group: Mica group.

Occurrence: A common rock-forming mineral, in phyllites, schists, and gneisses; in granites, granite pegmatites, and aplites. Formed from other minerals under hydrothermal conditions; may be detrital or authigenic.

Association: Quartz, plagioclase, potassic feldspar, biotite, tourmaline, topaz.

Distribution: Uncommon in euhedral crystals. From Slyudyanka, near Lake Baikal, Siberia, and at Mursinka, Ural Mountains, Russia. At Kammerfors, Kragerö, and Bamble, Norway. In the USA, at Mt. Mica, near Paris, Oxford Co., and elsewhere in Maine; large crystals from Pennsbury, Chester Co., Pennsylvania; at Amelia, Amelia Co., Virginia; fine crystals from near Shelby, Cleveland Co., North Carolina; in the Black Hills, in Pennington, Lawrence, and Custer Cos., South Dakota; and from the Harding mine, Dixon, Taos Co., New Mexico. In Methuen and Calvin Townships, Ontario, Canada. In Brazil, in Minas Gerais, at Urucum, from the Taquaral mine, Itinga, and in the José Pinto pegmatite, at Jaguaraçú, near Coronel Fabriciano. Around Nellore, Andhra Pradesh, India, in commercial deposits which may contain huge crystals.

Name: From "Muscovy glass," for an occurrence in the old province of Muscovy, Russia.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 614–621. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 11–30. (3) Yoder, H.S. and H.P. Eugster (1955) Synthetic and natural muscovites. Geochim. Cosmochim. Acta, 8, 225–280.

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Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystal fragments, to 300 μm, exhibit a platy to flaky morphology, dominated by {001}.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. *Fracture:* Hackly. Hardness = 1-1.5 VHN = 42 (15 g load). D(meas.) = n.d. D(calc.) = 9.04

Optical Properties: Opaque. *Color:* Dark silver-gray, in reflected light grayish white with a slightly greenish tint. *Streak:* Gray-black. *Luster:* Metallic. *Bireflectance:* Very low. *Pleochroism*: Weak. *Anisotropism*: Distinct.
Optical Class: n.d.
R_{min}–R_{max}: (471.1) 38.4-40.3, (548.3) 38.1-40.1, (586.6) 37.5-39.4, and (652.3) 35.9-38.0

Cell Data: Space Group: $P2_1$ or $P2_1/m$. a = 4.361(2) b = 6.618(3) c = 20.858(9) β = 92.71(5)° Z = n.d.

X-ray Powder Pattern: Sacarîmb deposit, Metaliferi Mountains, western Romania.
3.56 (100), 3.47 (58), 4.80 (52), 2.99 (50), 2.56 (41), 4.10 (40), 3.31 (40), 6.93 (38)

Chemistry:

	(1)
Pb	52.00
Au	10.68
Sb	6.16
Te	11.71
S	19.43
Total	99.98

(1) Sacarîmb deposit, Metaliferi Mountains, western Romania; average of 25 electron microprobe analyses, corresponds to $Pb_{5.00}Au_{1.08}Sb_{1.01}Te_{1.83}S_{12.08}$.

Occurrence: Fills cavities and vugs in nagyágite with which its contacts are sharp with evidence of replacement. Found on a museum specimen from a hydrothermal gold-telluride deposit.

Association: Nagyágite, hessite, sylvanite, petzite, coloradoite, calcite, quartz.

Distribution: From the Sacarîmb (the former Nagyág) gold-telluride deposit, southeastern part of the Metaliferi Mountains, western Romania.

Name: Honors all *museum*s in the world that preserve their old samples with care and accuracy.

Type Material: Natural History Museum, University of Florence, Italy (899/G).

References: (1) Bindi, L. and C. Cipriani (2004) Museumite, $Pb_5AuSbTe_2S_{12}$, a new mineral from the gold-telluride deposit of Sacarîmb, Metaliferi Mountains, western Romania. Eur. J. Mineral., 16, 835-838. (2) (2005) Amer. Mineral., 90, 1229 (abs. ref. 1).

Mushistonite $(Cu, Zn, Fe^{2+})Sn^{4+}(OH)_6$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. In fine-grained earthy aggregates.

Physical Properties: Hardness = 4–4.4 VHN = 240–254 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Brownish green to malachite-green, yellow-brown; colorless in thin section; gray in reflected light. *Luster:* Vitreous. *Optical Class:* Isotropic. n = n.d.

Cell Data: *Space Group: Pn3m.* a = 7.705–7.735 Z = 4

X-ray Powder Pattern: Mushiston deposit, Tajikistan.
3.880 (100), 2.740 (50), 1.729 (35), 1.578 (23), 2.230 (20), 1.932 (16), 2.330 (13)

Chemistry:

	(1)	(2)
SnO_2	52.2	47.2
FeO	3.3	10.6
CuO	13.5	11.4
ZnO	11.1	7.0
Ag_2O	0.1	
H_2O	[19.1]	[23.6]
Total	[99.3]	[99.8]

(1) Mushiston deposit, Tajikistan; by electron microprobe, original analysis elemental, here converted to oxides, H_2O calculated from excess O given, $(OH)^{1-}$ confirmed by IR; corresponds to $(Cu_{0.48}Zn_{0.39}Fe_{0.13})_{\Sigma=1.00}Sn_{0.98}(OH)_{6.02}$. (2) Do.; corresponds to $(Cu_{0.48}Zn_{0.39}Fe_{0.17})_{\Sigma=1.04}Sn_{1.00}(OH)_{5.95}$.

Mineral Group: Schoenfliesite group.

Occurrence: In the oxidized zone of a tin deposit, replacing stannite (Mushiston deposit, Tajikistan); from a zoned pegmatite (Etta mine, South Dakota, USA).

Association: Stannite, chalcopyrite, sphalerite, galena (Mushiston deposit, Tajikistan); cassiterite, pseudomalachite, quartz (Etta mine, South Dakota, USA).

Distribution: In the Mushiston tin deposit, Kaznok Valley, Zeravshan Mountains, Tajikistan. From the Etta mine, near Keystone, Pennington Co., South Dakota, USA.

Name: For its occurrence in the Mushiston deposit, Tajikistan.

Type Material: Mining Institute, St. Petersburg, 1999/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81069.

References: (1) Marshukova, N.K., A.B. Pavlovskii, and G.A. Sidorenko (1984) Mushistonite $(Cu, Zn, Fe)Sn(OH)_6$ – a new tin mineral. Zap. Vses. Mineral. Obshch., 113, 612–617 (in Russian). (2) (1985) Amer. Mineral., 70, 1331 (abs. ref. 1). (3) (1986) Mineral. Abs., 37, 98 (abs. ref. 1). (4) Marshukova, N.K., G.A. Sidorenko, and N.I. Chistyakova (1978) On natural hydrostannates. New data on minerals of the U.S.S.R., 27, 89–95 (in Russian). (5) (1980) Amer. Mineral., 65, 1069–1070 (abs. ref. 4). (6) Dunn, P.J. and W.L. Roberts (1986) Cuprocassiterite discredited as mushistonite; and an unnamed tin mineral from the Etta Mine. Mineral. Record, 17, 383.

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Muskoxite $Mg_7Fe_4^{3+}O_{13}\cdot 10H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ (probable). As hexagonal crystals, to 0.25 mm, very thin on {0001}, in reticular to divergent aggregates, some intergrown to simulate larger trigonal crystals. In cross-fiber veinlets, anhedral grains; fine-grained powdery.

Physical Properties: *Cleavage:* Perfect on {0001}, micaceous. *Tenacity:* Brittle, flexible. Hardness = ∼3 D(meas.) = 3.10–3.20 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* Dark reddish brown; amber-orange to deep red in transmitted light. *Streak:* Pale orange-brown. *Luster:* Vitreous.
Optical Class: Biaxial (–). n = 1.80–1.81 2V(meas.) = 10°–40°

Cell Data: *Space Group:* $R\overline{3}m$ pseudocell. a = 3.07 c = 4.6 Z = n.d.

X-ray Powder Pattern: Muskox intrusion, Canada; preferred orientation evident.
2.308 (10), 4.61 (8), 1.746 (6), 1.543 (4), 4.12 (3), 2.660 (3), 4.44 (2)

Chemistry:

	(1)	(2)
Fe_2O_3	41.1	40.86
FeO	0.0	
MgO	35.4	36.09
H_2O	23.8	23.05
CO_2	< 1.	
Total	100.3	100.00

(1) Muskox intrusion, Canada; corresponds to $Mg_{6.82}Fe^{3+}_{4.00}O_{12.82}\cdot 10.2H_2O$.
(2) $Mg_7Fe^{3+}_4O_{13}\cdot 10H_2O$.

Occurrence: In thin veinlets in serpentinite from a layered ultramafic complex.

Association: Lizardite, coalingite, Mg–Fe–Mn oxides.

Distribution: In the Muskox intrusion, Coppermine River area, Northwest Territories, Canada.

Name: For its occurrence in the Muskox intrusion, Canada.

Type Material: Canadian Geological Survey, Ottawa, 12123; Royal Ontario Museum, Toronto, Canada, M36526.

References: (1) Jambor, J.L. (1969) Muskoxite, a new hydrous magnesium-ferric iron oxide from the Muskox intrusion, Northwest Territories, Canada. Amer. Mineral., 54, 684–696.

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Muthmannite (Ag, Au)Te

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular crystals, typically elongated in one direction; as rims and aggregates, to 0.2 mm; in anhedral grains.

Physical Properties: *Cleavage:* One perfect, in zone of elongation. *Fracture:* Uneven. Hardness = 2.5 VHN = 172–207, 194 average (10 to 20 g load). D(meas.) = n.d. D(calc.) = 11.04

Optical Properties: Opaque. *Color:* Brassy yellow to pale bronze, pale gray on fresh fracture surface; pale gray in reflected light. *Streak:* Black to gray-black. *Luster:* Bright metallic. *Pleochroism:* Very low. *Bireflectance:* Very low.
R_1–R_2: (400) — , (420) 42.3, (440) 41.3, (460) 40.4, (480) 39.7, (500) 39.2, (520) 38.7, (540) 38.4, (560) 38.2, (580) 38.1, (600) 38.0, (620) 38.0, (640) 38.0, (660) 38.1, (680) 38.2, (700) 38.4

Cell Data: *Space Group:* $P2/m$. a = 7.211(9) 5.124(2) b = 4.425(5) 4.419(1) c = 5.100(6) 7.437(2) $\beta = 89.96(1)^\circ$ Z = 2

X-ray Powder Pattern: Baia-de-Arieş, Romania.
3.03 (10), 2.113 (8), 2.94 (5), 1.954 (3), 1.322 (3), 1.038 (3), 5.09 (2)

Chemistry:

	(1)	(2)	(3)
Ag	16.69	18.63	19.25
Au	30.03	33.51	35.20
Fe		0.06	
Cu		0.27	
Hg		0.47	
Sb	[9.75]		
Te	39.14	46.39	45.55
S	4.39		
Total	[100.00]	99.33	100.00

(1) Săcărîmb, Romania; neglecting Sb, calculated by difference, and S from stibnite impurity, then corresponds to $Ag_{1.01}Au_{0.99}Te_{2.00}$. (2) Baia-de-Arieş, Romania; by electron microprobe, corresponds to $Ag_{0.97}Au_{0.98}Cu_{0.02}Fe_{0.01}Hg_{0.01}Te_{2.04}$. (3) $AgAuTe_2$.

Occurrence: In close intergrowths with other tellurides, especially krennerite, in epithermal hydrothermal veins, and in ores enriched by secondary processes (Săcărîmb, Romania); replacing calaverite (Baia-de-Arieş, Romania).

Association: Krennerite, stibnite, hessite, nagyágite, petzite, pyrargyrite, sylvanite, calaverite, pyrite, sphalerite, altaite, tetrahedrite–tennantite, alabandite, (Săcărîmb, Romania); calaverite (Baia-de-Arieş, Romania).

Distribution: In Romania, from Săcărîmb (Nagyág) [TL] and Baia-de-Arieş (Offenbánya).

Name: To honor the chemist and crystallographer, Professor Friedrich Wilhelm Muthmann (1861–1913), Technische Hochschule, Munich, Germany.

Type Material: University of Naples Museum, Naples, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 260–261. (2) Spiridonov, E.M. and T.N. Chvileva (1985) New data on muthmannite, $AuAgTe_2$. Doklady Acad. Nauk SSSR, 280, 994–997 (in Russian). (3) Bayliss, P. (1991) ICDD 42-1377. ??ck if superceded?? (4) Bindi, L. and C. Cipriani (2004) Ordered distribution of Au and Ag in the crystal structure of muthmannite, $AuAgTe_2$, a rare telluride from Sacarîmb, western Romania. Amer. Mineral., 89, 15-5–1509. [from abs - ck entire article??]

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Nabalamprophyllite $Ba(Na,Ba)\{Na_3Ti[Ti_2O_2Si_4O_{14}](OH,F)_2\}$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals lamellar prismatic with dominant {100} and minor {010} and {130}. Forms radial sheaf-like and random aggregates, to 10 cm.

Physical Properties: *Cleavage:* Perfect on (100). *Tenacity:* Brittle. *Fracture:* n.d.
Hardness = 3 D(meas.) = 3.62(2) D(calc.) = 3.58 (for empirical Formula)

Optical Properties: Transparent to translucent. *Color:* Brown to bright yellow. *Streak:* n.d.
Luster: Vitreous.
Optical Class: Biaxial (+). α = 1.750(12) γ = 1.799(15) 2V(meas.) = 40.5°
Dispersion: Strong, *r* >*v*. *Orientation:* $a \wedge \gamma = 10°$, Y = *a*. *Pleochroism:* Weak, green-brown.

Cell Data: Space Group: *P*2/*m*. *a* = 19.741(5) *b* = 7.105(4) *c* = 5.408(2) β = 96.67(1)° Z = 2

X-ray Powder Pattern: Inagli massif, south Yukutsk, Russia.
2.797 (100), 9.87 (96), 3.45 (90), 3.275 (78), 3.75 (65), 2.610 (43), 3.040 (41), 2.143 (40)

Chemistry:	(1)	(2)		(1)	(2)
Na_2O	11.14	11.99	Fe_2O_3	0.78	1.81
K_2O	0.94	1.03	Al_2O_3	0.44	0.16
CaO	0.36	0.10	TiO_2	27.80	27.31
SrO	0.65	n.d.	Nb_2O_5	n.d.	0.64
BaO	24.12	25.32	SiO_2	28.75	29.08
MgO	0.34	0.83	F	1.18	n.d.
MnO	1.10	1.09	H_2O	1.83	n.d.
			$-O=F_2$	[0.50]	n.d.
			Total	98.93	99.36

(1) Inagli massif, south Yukutsk, Russia; average of 20 electron microprobe analyses, H_2O by TGA; corresponds to $Na_{2.95}K_{0.17}Ca_{0.05}Sr_{0.05}Ba_{1.29}Mn_{0.13}(Ti_{2.86}Fe_{0.08}Mg_{0.07})_{\Sigma=3.01}[(Si_{3.93}Al_{0.07})_{\Sigma=4.00}O_{14.00}]\ O_{1.94}(OH)_{1.67}F_{0.51}$. (2) Kovdor massif, Russia; average of 20 electron microprobe analyses, H_2O by TGA.

Occurrence: In peralkaline pegmatite dikes cutting alkaline ultramafic rocks.

Association: Aegirine, albite, ancylite, batisite, diopside, eckermannite, innelite, leucosphenite, lorenzenite, natrolite, neptunite, strontium apatite (Inagli); apatite, cancrinite, eudialyte-group minerals, lorenzenite, lueshite, nepheline, pectolite, pyrrhotite, thomsonite-Ca, titanite, diopside, hedenbergite, aegirine (Kovdor). In cancrinite-bearing pegmatite (Kovdor), it forms aggregates with pectolite and cancrinite, often intergrown with lorenzenite. In nepheline-bearing pegmatite (Kovdor), it forms radial aggregates of lamellar crystals with lorenzenite, titanite and eudialyte group minerals.

Distribution: From the Inagli massif, south Yukutsk and the Kovdor massif, Kola Peninsula, Russia.

Name: For its composition and relation to other *lamprophyllite*-group minerals.

Type Material: Geological Museum, Institute of Geology and Geophysics, Russian Academy of Science, Novosibirsk, Russia (XIII-274/1) and the A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia (90837 and 90843).

References: (1) Chukanov, N.V., M.M. Moiseev, I.V. Pekov, K.A. Lazebnik, R.K. Rastsvetaeva, N.V. Zayakina, G. Ferraris, and G. Ivaldi (2004) Nabalamprophyllite $Ba(Na,Ba)\{Na_3Ti[Ti_2O_2Si_4O_{14}](OH,F)_2\}$, a new layer titanosilicate of the lamprophyllite group from the Inagli and Kovdor alkaline-ultrabasic massifs, Russia. Zapiski Vseross. Mineral. Obshch., 133(1), 59-72 (in Russian, English abstract). (2) (2005) Amer. Mineral., 90, 1230 (abs. ref. 1).

Nabaphite $NaBaPO_4 \cdot 9H_2O$

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Crystal Data: Cubic. *Point Group:* 23. As irregular grains, to 5 mm.

Physical Properties: *Cleavage:* On {100}, distinct. *Fracture:* Semiconchoidal. *Tenacity:* Brittle. Hardness = ∼2 D(meas.) = 2.3 D(calc.) = 2.26 Readily dehydrates in air; partly decomposed in H_2O. Fluoresces pale violet under UV.

Optical Properties: Transparent, turbid with alteration. *Color:* Colorless, snow-white with alteration. *Luster:* Dull vitreous [*sic*].
Optical Class: Isotropic. $n = 1.504(1)$

Cell Data: *Space Group:* $P2_13$. $a = 10.711(9)$ $Z = 4$

X-ray Powder Pattern: Mt. Yukspor, Kola Peninsula, Russia.
2.598 (10), 2.866 (9), 5.36 (8), 4.81 (8), 2.102 (8), 3.575 (7), 3.794 (6)

Chemistry:

	(1)	(2)
P_2O_5	18.86	17.00
CaO	0.04	
SrO	0.86	
BaO	37.00	36.74
Na_2O	6.31	7.42
H_2O	36.94	38.84
Total	[100.01]	100.00

(1) Mt. Yukspor, Kola Peninsula, Russia; by electron microprobe, average of three analyses, recalculated to 100%, H_2O by TGA; corresponding to $Na_{0.80}(Ba_{0.95}Sr_{0.03})_{\Sigma=0.98}P_{1.05}O_4 \cdot 8.07H_2O$.
(2) $NaBaPO_4 \cdot 9H_2O$.

Occurrence: A rare late-stage hydrothermal mineral in cavities in ijolite-urtite pegmatite in a differentiated alkalic massif.

Association: Natrolite, pectolite, shcherbakovite, wadeite, eudialyte, lamprophyllite, ferrian biotite, aegirine, microcline.

Distribution: On Mt. Yukspor, Khibiny massif, Kola Peninsula, Russia.

Name: For sodium, NAtrium, BArium, and PHosphorus in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5713/2; Mining Institute, St. Petersburg, 1635/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80819.

References: (1) Khomyakov, A.P., M.F. Korobitsyn, Y.P. Men'shikov, and L.I. Polezhaeva (1982) Nabaphite, $NaBaPO_4 \cdot 9H_2O$, a new mineral. Doklady Acad. Nauk SSSR, 266, 707–710 (in Russian). (2) Baturin, S.V., Y.A. Malinovskii, and N.V. Belov (1982) Crystal structure of nabaphite, $NaBaPO_4 \cdot 9H_2O$. Doklady Acad. Nauk SSSR, 266, 624–627 (in Russian). (3) (1983) Amer. Mineral., 68, 643–644 (abs. refs. 1 and 2). (4) (1983) Mineral. Abs., 34, 348 and (1987) Mineral. Abs., 38, 531 (abs. ref. 1).

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Nabiasite $BaMn_(VO_4, AsO_4)_6(OH)_2$

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Crystal Data: Triclinic. *Point Group:* 1. As rounded pseudohexagonal inclusions, to 7 mm, in thermonatrite.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3 D(meas.) = 2.85 D(calc.) = 2.88 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Dispersion:* $r > v$, weak. $\alpha = 1.508(2)$ $\beta = 1.515(2)$ $\gamma = 1.520(2)$ 2V(meas.) = 80°

Cell Data: *Space Group:* $P1$. $a = 13.387(7)$ $b = 13.383(5)$ $c = 7.072(3)$ $\alpha = 90.25(3)°$ $\beta = 89.73(4)°$ $\gamma = 133.12(3)°$ Z = [8]

X-ray Powder Pattern: Mt. Rasvumchorr, Kola Peninsula, Russia. 2.649 (100), 3.054 (45), 3.049 (40), 2.005 (40), 1.762 (33), 3.51 (24), 1.470 (21)

Chemistry:

	(1)	(2)
P_2O_5	36.00	35.48
MnO	0.39	
CaO	26.66	28.04
SrO	0.55	
Na_2O	31.44	30.98
K_2O	0.10	
F	9.32	9.50
$-O = F_2$	3.92	4.00
Total	100.54	100.00

(1) Mt. Rasvumchorr, Kola Peninsula, Russia; corresponding to $Na_{1.99}(Ca_{0.94}Sr_{0.01}Mn_{0.01})_{\Sigma=0.96}P_{1.00}O_{3.97}F_{0.97}$. (2) $Na_2Ca(PO_4)F$.

Occurrence: A rare late-stage mineral in ijolite-urtite pegmatite.

Association: Thermonatrite, villiaumite, aegirine, apatite, barytolamprophyllite.

Distribution: On Mts. Rasvumchorr, Yukspor, and Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: For sodium, NAtrium, CAlcium, and PHosphorus in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5534; Mining Institute, St. Petersburg, 1116/2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79854; The Natural History Museum, London, England, 1994,15.

References: (1) Khomyakov, A.P., M.Y. Kazakova, and D.Y. Pushcharovskiy (1980) Nacaphite ($Na_2Ca(PO_4)F$) – a new mineral. Zap. Vses. Mineral. Obshch., 109, 50–52 (in Russian). (2) (1981) Amer. Mineral., 66, 218 (abs. ref. 1). (3) Sokolova, E.V., Y.K. Yegorov-Tismenko, and A.P. Khomyakov (1989) The crystal structure of nacaphite. Doklady Acad. Nauk SSSR, 304, 610–615 (in Russian).

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Nabokoite $Cu_7(Te^{4+}O_4)(SO_4)_5 \cdot KCl$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are thin tabular on {001}, to 1 mm, showing {001}, {110}, {102}, {014}, in banded intergrowth with atlasovite.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2–2.5 D(meas.) = 4.18(5) D(calc.) = 3.974

Optical Properties: Transparent. *Color:* Pale yellow-brown, yellow-brown. *Streak:* Yellow-brown. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.778(3)$ $\epsilon = 1.773(3)$

Cell Data: *Space Group:* $P4/ncc$. a = 9.833(1) c = 20.591(2) Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia.
10.35 (10), 2.439 (7), 3.421 (6), 2.881 (5), 4.57 (4), 3.56 (4), 1.972 (4)

Chemistry:

	(1)	(2)
SO_3	33.66	33.60
TeO_2	13.78	13.40
V_2O_3	0.07	
Bi_2O_3	0.49	
Fe_2O_3	0.09	
CuO	45.25	46.74
ZnO	1.26	
PbO	0.28	
K_2O	3.94	3.95
Cs_2O	0.11	
Cl	2.92	2.98
$-O = Cl_2$	0.66	0.67
Total	101.19	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, corresponds to $(Cu_{6.74}Zn_{0.18})_{\Sigma=6.92}(Te_{1.02}Bi_{0.02}Pb_{0.01}Fe_{0.01}V_{0.01})_{\Sigma=1.07}O_{4.10}(SO_4)_{4.98}Cl_{0.98}$. (2) $KCu_7(TeO_4)(SO_4)_5Cl$.

Polymorphism & Series: Forms a series with atlasovite.

Occurrence: A rare sublimate formed in a volcanic fumarole.

Association: Atlasovite, chalcocyanite, dolerophanite, chloroxiphite, euchlorine, piypite, atacamite, alarsite, fedotovite, lammerite, klyuchevskite, anglesite, langbeinite, hematite, tenorite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honoring Sof'ya Ivanovna Naboko (1909–), Institute of Volcanology, Petropavlovsk-Kamchatskii, Russia, Russian volcanologist who first collected the mineral.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87577.

References: (1) Popova, V.I., V.A. Popov, N.S. Rudashevskiy, S.F. Glavatskikh, V.O. Polyakov, and A.F. Bushmakin (1987) Nabokoite $Cu_7TeO_4(SO_4)_5 \cdot KCl$ and atlasovite $Cu_6Fe^{3+}Bi^{3+}O_4(SO_4)_5 \cdot KCl$ – new minerals of volcanic exhalations. Zap. Vses. Mineral. Obshch., 116, 358–367 (in Russian with English abs.). (2) (1988) Amer. Mineral., 73, 929 (abs. ref. 1). (3) Pertlik, F. and J. Zemann (1988) The crystal structure of nabokoite, $Cu_7TeO_4(SO_4)_5 \cdot KCl$: the first example of a $Te(IV)O_4$ pyramid with exactly tetragonal symmetry. Mineral. Petrol., 38, 291–298.

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Nacaphite $Na_2Ca(PO_4)F$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As rounded pseudohexagonal inclusions, to 7 mm, in thermonatrite; as elongate, untwinned, pseudohexagonal prisms, to 2 cm. Polysynthetic pseudorhombohedral twinning observed.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3
D(meas.) = 2.85 D(calc.) = 2.880 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (-). *Dispersion: r > v*, weak. α = 1.508(2) β = 1.515(2) γ = 1.520(2)
2V(meas.) = 80°

Cell Data: *Space Group: $P2_1/c$.* a = 13.3185(14) b = 7.0964(8) c = 10.6490(11)
β = 113.5260(10)° Z = 8

X-ray Powder Pattern: Mt. Rasvumchorr, Kola Peninsula, Russia.
2.649 (100), 3.054 (45), 3.049 (40), 2.005 (40), 1.762 (33), 3.51 (24), 1.470 (21)

Chemistry:

	(1)	(2)
P_2O_5	36.00	35.48
MnO	0.39	
CaO	26.66	28.04
SrO	0.55	
Na_2O	31.44	30.98
K_2O	0.10	
F	9.32	9.50
$-O = F_2$	3.92	4.00
Total	100.54	100.00

(1) Mt. Rasvumchorr, Kola Peninsula, Russia; corresponding to $Na_{1.99}(Ca_{0.94}Sr_{0.01}Mn_{0.01})_{\Sigma=0.96}P_{1.00}O_{3.97}F_{0.97}$. (2) $Na_2Ca(PO_4)F$.

Occurrence: A rare late-stage hydrothermal mineral in ijolite-urtite pegmatite.

Association: Thermonatrite, villiaumite, aegirine, apatite, barytolamprophyllite (Khibiny massif); interstial with nepheline, potassic arfvedsonite, microcline, eudialyte and associated with sodalite, kalsilite, pectolite, lamprophyllite, lomonosovite, ershovite, loparite-(Ce), djerfisherite. (Mt. Rasvumchorr).

Distribution: On Mts. Rasvumchorr, Yukspor, and Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: For sodium, NAtrium, CAlcium, and PHosphorus in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5534; Mining Institute, St. Petersburg, 1116/2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79854; The Natural History Museum, London, England, 1994,15.

References: (1) Khomyakov, A.P., M.Y. Kazakova, and D.Y. Pushcharovskiy (1980) Nacaphite ($N_2Ca(PO_4)F$) - a new mineral. Zap. Vses. Mineral. Obshch., 109, 50-52 (in Russian).
(2) (1981) Amer. Mineral., 66, 218 (abs. ref. 1). (3) Sokolova, E.V., Y.K. Egorov-Tismenko, and A.P. Khomyakov (1989) The crystal structure of nacaphite. Doklady Acad. Nauk SSSR, 304, 610-615 (in Russian). (4) Krivovichev, S.V., V.N. Yakovenchuk, G.Y. Ivanyuk, Y.A. Pakhomovsky, T. Armbruster, and E.A. Selivanova (2007) The crystal structure of nacaphite, $Na_2Ca(PO_4)F$: a re-investigation. Can. Mineral., 45, 915–920.

Nacareniobsite-(Ce) $Na_3Ca_3(Ce,La)(Nb,Ti)(Si_2O_7)_2OF_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As lath-shaped crystals elongated ‖ [001], with prominent {100}, {410}, and {310}, to 3 mm; in subparallel crystal aggregates.

Physical Properties: *Cleavage:* {011}, good. *Fracture:* Uneven. Hardness = 5
D(meas.) = 3.45 D(calc.) = 3.43

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \simeq c$; $Z \wedge a = 11°$. $\alpha = 1.662$ $\beta = 1.671$ $\gamma = [1.692]$ 2V(meas.) = 66(1)°

Cell Data: *Space Group:* $P2_1/a$. $a = 18.901(5)$ $b = 5.683(3)$ $c = 7.462(2)$ $\beta = 101.29(4)°$ Z = 2

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
3.077 (10), 3.089 (5), 2.955 (5), 2.031 (5), 1.5518 (5), 1.8652 (4), 1.6879 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	29.63	29.18	Sm_2O_3	0.81	
TiO_2	2.79	2.55	Dy_2O_3	0.05	
ZrO_2	< 0.10		Nb_2O_5	11.61	11.75
Al_2O_3	< 0.05		Ta_2O_5	0.34	
Y_2O_3	0.78	0.68	CaO	19.92	20.22
La_2O_3	4.09	4.79	SrO	0.27	
Ce_2O_3	10.32	10.35	Na_2O	10.01	10.75
Pr_2O_3	1.42	1.10	F	6.87	n.d.
Nd_2O_3	4.19	3.70	$-O = (F)_2$	2.89	
			Total	100.21	95.07

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, average of 10 analyses; corresponds to $(Nb_{0.71}Ti_{0.28}Ta_{0.01})_{\Sigma=1.00}Na_{2.62}(Ca_{2.88}RE_{1.08}Sr_{0.02})_{\Sigma=3.98}Si_{4.00}O_{14}(F_{2.93}O_{0.70})_{\Sigma=3.63}$. (2) Do.

Occurrence: In the groundmass and as a secondary mineral in dissolution cavities within arfvedsonite-nepheline syenite.

Association: Arfvedsonite, sodalite, eudialyte, villiaumite, microcline, albite.

Distribution: Found in the Kvanefjeld tunnel and at another unspecified locality in the Ilímaussaq intrusion, southern Greenland.

Name: For sodium, NAtrium, CAlcium, Rare Earths, NIOBium, and Silicon in its chemical composition.

Type Material: University of Copenhagen, Copenhagen, Denmark; National Museum of Natural History, Washington, D.C., USA, 160684.

References: (1) Petersen, O.V., J.G. Rønsbo, and E.S. Leonardsen (1989) Nacareniobsite-(Ce), a new mineral species from the Ilímaussaq alkaline complex, South Greenland, and its relation to mosandrite and the rinkite series. Neues Jahrb. Mineral., Monatsh., 84–96. (2) (1990) Amer. Mineral., 75, 708 (abs. ref. 1).

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Nacrite $Al_2Si_2O_5(OH)_4$

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Crystal Data: Monoclinic. *Point Group: m.* As irregular pseudohexagonal plates, to 8 mm, and aggregates of plates; commonly massive.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible but inelastic. Hardness = 2–2.5 D(meas.) = 2.5–2.7 D(calc.) = 2.582

Optical Properties: Transparent, quite or nearly. *Color:* White. *Luster:* Pearly. *Optical Class:* Biaxial (–) or (+). *Orientation:* $Z = b$; $X \wedge c = 7°–12°$. *Dispersion:* $r > v$, weak. $\alpha = 1.557–1.560$ $\beta = 1.562–1.563$ $\gamma = 1.563–1.566$ 2V(meas.) = 40°–90°

Cell Data: *Space Group: Cc.* $a = 8.909(2)$ $b = 5.146(1)$ $c = 15.697(2)$ $\beta = 113°42(5)'$ Z = 4

X-ray Powder Pattern: Tracy mine, Michigan, USA.
7.18 (100), 4.361 (80), 3.588 (80), 4.130 (70), 2.432 (60), 2.404 (40), 1.486 (40)

Chemistry:

	(1)	(2)
SiO_2	46.22	46.55
Al_2O_3	39.92	39.50
H_2O	13.96	13.95
Total	100.10	100.00

(1) St. Peters Dome, Colorado, USA. (2) $Al_2Si_2O_5(OH)_4$.

Polymorphism & Series: Dickite, halloysite, and kaolinite are polymorphs.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Of hydrothermal origin.

Association: Kaolinite, dickite, mica, quartz.

Distribution: Probably at many localities, but careful characterization is required for confirmation. A few verified localities include: in Germany, from Brand-Erbisdorf, near Freiberg, and Erdmannsdorf, Saxony, with large crystals from St. Andreasberg, Harz Mountains. At Lodève, Haute-Vienne, France. From Groby, Leicestershire, England. At Sidi-Amour-ben-Salem, Tunisia. From near Saint-Amable and at St. Eustache, Quebec, Canada. In the USA, at the Tracy mine, south of Negaunee, Marquette Co., Michigan; from near Texas, Cecil Co., Maryland; at St. Peters Dome, near Pikes Peak, El Paso Co., Colorado. From San Juanito, Chihuahua, Mexico. In Japan, at Yaita, Tochigi Prefecture; in the Kobayashi, Kanekura, and Yonago mines, Nagano Prefecture; and the Kasuga mine, Kagoshima Prefecture.

Name: From the French *nacre*, for *mother of pearl*, in allusion to its appearance.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 685. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 194–212. (3) Bailey, S.W. (1963) Polymorphism of the kaolin minerals. Amer. Mineral., 48, 1196–1209. (4) Blount, A.M., I.M. Threadgold, and S.W. Bailey (1969) Refinement of the crystal structure of nacrite. Clays and Clay Minerals, 17, 185–194. (5) Zvyagin, B.B., S.V. Soboleva, and A.F. Fedotov (1972) Refinement of the structure of nacrite by high-voltage electron diffraction. Kristallografiya (Sov. Phys. Crystal.), 17, 514–520, 1972 (in Russian).

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Nadorite $PbSb^{3+}O_2Cl$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals tabular {010}, with square or octagonal outline, or elongated along [100], to 1 cm; may be in subparallel or divergent platy groups. *Twinning:* On {101}, nearly perpendicular, common.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 3.5–4 D(meas.) = 7.02 D(calc.) = 7.06

Optical Properties: Translucent. *Color:* Smoky brown, brownish yellow to yellow. *Streak:* Yellow to yellowish white. *Luster:* Resinous to adamantine. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, strong. $\alpha = 2.30$ $\beta = 2.34$–2.35 $\gamma = 2.36$–2.40 2V(meas.) = Very large.

Cell Data: *Space Group: Cmcm.* $a = 5.603(5)$ $b = 12.245(8)$ $c = 5.448(7)$ Z = 4

X-ray Powder Pattern: Djebel Nador, Algeria. (ICDD 17-469).
2.800 (100), 3.71 (30), 1.945 (30), 1.615 (30), 1.587 (30), 2.703 (25), 2.057 (25)

Chemistry:

	(1)	(2)	(3)
Pb	51.60	51.88	52.27
Sb	31.55	31.17	30.71
O	8.00	8.22	8.07
Cl	8.85	9.00	8.95
Total	100.00	100.27	100.00

(1–2) Djebel Nador, Algeria. (3) $PbSbO_2Cl$.

Occurrence: As an alteration product of other antimony-bearing minerals in hydrothermal mineral deposits.

Association: Jamesonite, galena, sphalerite, bindheimite, sénarmontite, valentinite, anglesite, cerussite, smithsonite, mimetite.

Distribution: Large crystals at Djebel Nador, Qacentina (Constantine), Algeria. Fine groups in the Touissit mine, near Oujda, Morocco. In England, from the Bodannon mine and at Portquin Beach, St. Endellion; in the Trevinnick mine, St. Kew; at the Treore mine, St. Teath; and from Wheal Leigh, Pillaton, Cornwall. At Långban, Jakobsberg, and in the Harstigen mine, near Persberg, Värmland, Sweden. At the Reichensteinerberg mine, near Reichenstein, Westerwald, Germany. At the Madzharov deposit, Rhodope Mountains, Bulgaria. In the Kara Elcha mercury deposit, Turkmenistan. From the Kara-Oba Mo–W deposit, Bet-Pak-Dal Desert, central Kazakhstan. At Tsumeb, Namibia.

Name: For its original occurrence at Djebel Nador, Algeria.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 863.
(2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1039–1041. (3) Giuseppetti, G. and C. Tadini (1973) Riesame della struttura cristallina della nadorite: $PbSbO_2Cl$. Period. Mineral., 42, 335–345 (in Italian with English abs.).

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Nagashimalite $Ba_4(V^{3+},Ti)_4(B_2Si_8O_{27})Cl(O,OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals tabular on {001}, elongated along [010], to 15 mm, forming subparallel aggregates; striated on {001} ∥ [010].

Physical Properties: Hardness = ∼6 VHN = 606–681 (100 g load). D(meas.) = 4.08 D(calc.) = 4.14

Optical Properties: Opaque to transparent. *Color:* Greenish black. *Streak:* Green. *Luster:* Submetallic to vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = greenish yellow; Y = green; Z = greenish brown. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > Y > X$. $\alpha = 1.750$ $\beta = 1.753$ $\gamma = 1.780$ 2V(meas.) = ∼30°

Cell Data: *Space Group: Pmmn.* a = 13.937(3) b = 12.122((3) c = 7.116(2) Z = 2

X-ray Powder Pattern: Mogurazawa mine, Japan.
3.020 (100), 3.030 (60), 2.592 (28), 3.854 (25), 2.791 (20), 3.319 (15), 3.273 (15)

Chemistry:

	(1)
SiO_2	32.37
TiO_2	2.75
B_2O_3	4.0
V_2O_3	16.65
MnO	0.48
BaO	41.36
Cl	1.73
H_2O	[0.77]
$-O = Cl_2$	0.39
Total	[99.72]

(1) Mogurazawa mine, Japan; by electron microprobe, B by wet chemical analysis, H_2O calculated to give Cl+(OH)=2; corresponds to $Ba_{4.00}(V^{3+}_{3.30}Ti_{0.51}Mn_{0.10})_{\Sigma=3.91}B_{1.71}Si_8O_{27.64}Cl_{0.72}(OH)_{1.28}$.

Occurrence: In fissures cutting massive rhodonite ore in a bedded manganese deposit.

Association: Rhodochrosite, rhodonite, barite, barian roscoelite, alabandite, digenite, bornite, tetrahedrite.

Distribution: In the Mogurazawa mine, Kiryu, Gumma Prefecture, Japan.

Name: For pioneer Japanese amateur mineralogist, Otokichi Nagashima (1890–1969).

Type Material: National Science Museum, Tokyo, Japan, M21727; National Museum of Natural History, Washington, D.C., USA, 142987.

References: (1) Matsubara, S. and A. Kato (1980) Nagashimalite, $Ba_4(V^{3+},Ti)_4[(O,OH)_2|Cl|Si_8B_2O_{27}]$, a new mineral from the Mogurazawa mine, Gumma Prefecture, Japan. Mineral. J. (Japan), 10, 122–130. (2) Matsubara, S. (1980) The crystal structure of nagashimalite, $Ba_4(V^{3+},Ti)_4[(O,OH)_2|Cl|Si_8B_2O_{27}]$. Mineral. J. (Japan), 10, 131–142. (3) (1981) Amer. Mineral., 66, 638 (abs. refs. 1 and 2).

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Nagelschmidtite $Ca_3(PO_4)_2 \cdot 2(\alpha\text{–}Ca_2SiO_4)$

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Crystal Data: n.d. *Point Group:* n.d. As elongated anhedral grains, to 150 μm. *Twinning:* Complexly twinned to produce lamellae intersecting at ~60°.

Physical Properties: Hardness = n.d. D(meas.) = 3.065 (synthetic). D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Colorless to yellowish or brownish. *Optical Class:* Uniaxial (–); rarely biaxial (+). α = 1.638–1.680 (synthetic). β = 1.642–1.675 γ = 1.652–1.698 2V(meas.) = ~0°–20°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Hatrurim Formation, Israel.
2.66 (vs), 2.80 (s), 1.94 (s), 3.80 (m), 3.42 (m), 2.20 (m), 1.34 (m)

Chemistry:

	(1)
SiO_2	27.88
Al_2O_3	0.03
Fe_2O_3	0.02
Cr_2O_3	0.03
[MnO]	0.05
MgO	0.03
CaO	62.06
Na_2O	0.82
K_2O	0.84
P_2O_5	8.27
SO_3	0.12
Total	100.15

(1) Hatrurim Formation, Israel; by electron microprobe, some MgO probably a misprint for MnO; corresponding to $(Ca_{3.78}Na_{0.06}K_{0.06})_{\Sigma=3.90}(Si_{1.58}P_{0.40})_{\Sigma=1.98}O_8$.

Polymorphism & Series: α and β polymorphic phases appear to be intergrown in the natural material.

Occurrence: In a complex assemblage of high-temperature contact metamorphosed sedimentary rocks.

Association: Gehlenite, rankinite, perovskite, titanian andradite, magnetite.

Distribution: In the Hatrurim Formation, Israel.

Name: For Guenther Nagelschmidt, chemist who first reported the synthetic compound in slags.

Type Material: n.d.

References: (1) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 31. (2) (1978) Amer. Mineral., 63, 425–426 (abs. ref. 1). (3) Barrett, R.L. and W.J. McCaughey (1942) The system $CaO - SiO_2 - P_2O_5$. Amer. Mineral., 27, 680–695. (4) Segnit, E.R. (1950) New data on the slag minerals nagelschmidtite and steadite. Mineral. Mag., 29, 173–190.

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Nagyágite $(Te, Au)Pb(Pb, Sb)S_2$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Thin tabular crystals, to 1 cm, platy on {010}, commonly bent, with striations on (001) ‖ [100] and [010]; also granular massive. *Twinning:* Crossed twin lamellae exhibited on (001) sections.

Physical Properties: *Cleavage:* Perfect on {010}, excellent on {101}. *Tenacity:* Flexible, slightly malleable. Hardness = 1.5 VHN = 60–94 (100 g load). D(meas.) = 7.35–7.49 D(calc.) = 7.29

Optical Properties: Opaque. *Color:* Blackish lead-gray; pale gray in polished section. *Streak:* Blackish lead-gray. *Luster:* Metallic, bright on fresh cleavage. *Pleochroism:* Weak in air and oil. *Anisotropism:* Weak but distinct.
R_1–R_2: (400) 46.4–48.4, (420) 45,4–47.4, (440) 44.5–46.7, (460) 43.6–45.9, (480) 42.9–45.1, (500) 42,1–44.2, (520) 31.3–43.3, (540) 40.5–42.4, (560) 39.8–41.6, (580) 39.2–40.9, (600) 38.7–40.3, (620) 38.3–39.8, (640) 37.8–39.2, (660) 37.2–38.6, (680) 36.6–37.8, (700) 36.0–37.2

Cell Data: *Space Group:* $P2_1/m$ (synthetic). $a = 4.220(1)$ $b = 4.176(1)$ $c = 15.119(3)$ $\beta = 95.42(3)^\circ$ Z = 2

X-ray Powder Pattern: Săcărîmb, Romania.
3.023 (100), 2.829 (80), 2.081 (50), 2.431 (40), 1.511 (40), 1.823 (30), 1.710 (30)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Pb	56.81	56.76	58.8	Sb	7.39	7.68	7.8
Au	7.51	7.47	9.0	Te	17.72	16.97	15.1
Ag		0.10	0.17	S	10.76	10.83	10.1
Fe	0.41	0.02		Total	100.60	99.85	101.0
Cu		0.02					

(1) Săcărîmb, Romania; corresponding to $(Te_{0.81}Au_{0.22})_{\Sigma=1.03}Pb_{1.00}(Pb_{0.60}Sb_{0.36}Fe_{0.04})_{\Sigma=1.00}S_{2.00}$. (2) Do.; by electron microprobe, average of 61 analyses on one specimen; corresponding to $(Te_{0.78}Au_{0.22})_{\Sigma=1.00}Pb_{1.00}(Pb_{0.62}Sb_{0.37})_{\Sigma=0.99}S_{2.00}$. (3) Cripple Creek, Colorado, USA; by electron microprobe, corresponding to $(Te_{0.71}Au_{0.28}Ag_{0.01})_{\Sigma=1.00}Pb_{1.00}(Pb_{0.71}Sb_{0.39})_{\Sigma=0.99}S_{2.00}$.

Occurrence: In Au–Te-bearing epithermal hydrothermal veins.

Association: Altaite, petzite, stutzite, sylvanite, tellurantimony, coloradoite, krennerite, arsenic, gold, proustite, rhodochrosite, arsenopyrite, sphalerite, tetrahedrite (Săcărîmb, Romania); calaverite, gold, tellurobismuthite, altaite, galena, pyrite (Bohuliby mine, Czech Republic).

Distribution: In Romania, from Săcărîmb (Nagyág) [TL] and Baia-de-Arieş (Offenbánya). In the Bohuliby mine, Jílové gold deposit, Czech Republic. From the Chelopech deposit, Sofia, Bulgaria. At Schellgaden, Austria. From Manka, Kazakhstan. At Zod, Armenia. In the Glen Rosa mine, Selukwe, Zimbabwe. In the USA, from Gold Hill, Boulder Co., and Cripple Creek, Teller Co., Colorado; in the Dorleska mine, Coffee Creek district, Trinity Co., California; from the Mayflower mine, Tobacco Root Mountains, Madison Co., Montana; and at the Foote mine, Kings Mountain, Cleveland Co., North Carolina. In Canada, in the Huronian mine, Moss Township, Ontario; and from the Olive Mabel claim, Gainer Creek, British Columbia. At Farallon Negro, Catamarca Province, Argentina. In the Kalgoorlie district, at Oroya, and in the Golden Mile deposit, Western Australia. From the Sylvia mine, Tararu Creek, New Zealand. In the Rendaiji mine, Shizuoka Prefecture, Japan. From the Tarua gold field, Vitu Levu, Fiji Islands.

Name: For the Săcărîmb (Nagyág), Romania locality.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 168–169. (2) Stumpfel, E.F. (1970) New electron probe and optical data on gold tellurides. Amer. Mineral., 55, 808–814. (3) Stanley, C.J., A.C. Roberts, and D.C. Harris (1994) New data for nagyagite. Mineral. Mag., 58, 479–482. (4) Effenberger, H., W. H. Paar, D. Topa, F.J. Culetto, and G. Giester (1999) Towards the crystal structure of nagyagite, $[Pb(Pb, Sb)S_2][(Au, Te)]$. Amer. Mineral., 669–676. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 388.

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Nahcolite $NaHCO_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are typically elongated along [001], to about 1 cm, with large {110}, {010}, {101}, smaller {120}, {$\bar{1}$01}, {111}; as fibrous masses, oriented perpendicular to bedding planes; in friable porous aggregates. *Twinning:* Common on {101} as twin and composition plane, interpenetration and contact, may be in reticulated groups.

Physical Properties: *Cleavage:* Perfect on {101}; good on {111}; fair on {100}. *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 2.21–2.238 D(calc.) = 2.16 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, white, yellow, may be gray, reddish brown, to black from impurities; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, resinous on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 27°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.375(2)$ $\beta = 1.498$–1.503 $\gamma = 1.583$ 2V(meas.) = ∼75° 2V(calc.) = 74°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 7.525(4)$ $b = 9.72(4)$ $c = 3.53(3)$ $\beta = 93°19'$ Z = 4

X-ray Powder Pattern: Anvil Points, ten miles west of Rifle, Garfield Co., Colorado, USA. 2.97 (100), 2.60 (90), 3.08 (25), 2.217 (18), 2.032 (18), 3.48 (15), 1.900 (15)

Chemistry:

	(1)	(2)
CO_2	51.15	52.39
$(Al,Fe)_2O_3$	0.16	
CaO	0.20	
Na_2O	36.74	36.89
H_2O	10.76	10.72
insol.	0.82	
Total	99.83	100.00

(1) Searles Lake, California, USA. (2) $NaHCO_3$.

Occurrence: A precipitate from hot springs; as efflorescences around saline lakes and in brines; formed at a late stage in differentiated alkalic massifs; as a solid in liquid inclusions in a variety of other mineral species.

Association: Trona, thermonatrite, thénardite, halite, gaylussite, burkeite, northupite, borax.

Distribution: In a Roman conduit at Stufe de Nerone, Campi Flegrei, near Naples, and on Vesuvius, Campania, Italy. In the USA, from Searles Lake, San Bernardino Co., California; abundant in the Green River Formation, Colorado and Utah, northwestern Colorado having estimated reserves of over 30 billion tons. In the Tincalayu deposit, Salar del Hombre Muerto, Salta Province, Argentina. Along the Ilmajok River and on Mt. Alluaiv, Lovozero massif, and at Tuliylukht Bay and on Mt. Kukisvumchorr, Khibiny massif, Kola Peninsula, Russia. Around Mt. Erebus, Victoria Land, Antarctica.

Name: From the composition, NaHCO-lite.

Type Material: National School of Mines, Paris, France, 17912.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 134–136. (2) Fahey, J.J. (1962) Saline minerals of the Green River Formation. U.S. Geol. Surv. Prof. Paper 405, 30–31, 47. (3) Sass, R.L. and R.F. Scheuerman (1962) The crystal structure of sodium bicarbonate. Acta Cryst., 15, 77–81.

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Nahpoite Na_2HPO_4

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As elongate grains, to 4 μm; in powdery, earthy to compact porcelaneous masses.

Physical Properties: Hardness = Very soft; 1–3 if porcelaneous. D(meas.) = n.d. D(calc.) = 2.60 Extremely soluble in H_2O.

Optical Properties: Translucent. *Color:* White; colorless in transmitted light. *Luster:* Dull. *Optical Class:* [Biaxial.] *Orientation:* Length-fast, nearly parallel extinction. *Dispersion:* $r < v$, (synthetic). $\alpha = 1.490$ $\beta =$ n.d. $\gamma = 1.505$ 2V(meas.) = 80° (synthetic).

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 5.47(1)$ $b = 6.84(1)$ $c = 5.45(1)$ $\beta = 116.33(8)°$ Z = 2

X-ray Powder Pattern: Big Fish River area, Canada.
2.803 (100), 2.720 (70), 3.84 (55), 3.97 (45), 2.868 (30), 3.41 (25), 2.650 (15)

Chemistry:

	(1)	(2)
P_2O_5	49.54	49.99
Na_2O	43.67	43.66
H_2O	[6.32]	6.35
Total	[99.53]	100.00

(1) Big Fish River area, Canada; colorimetric and AA analysis, H^{1+} calculated for charge balance.
(2) Na_2HPO_4.

Occurrence: An alteration product of marićite in nodules in phosphatic ironstone (Yukon Territory, Canada); in sodalite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in differentiated alkalic massifs (Kola Peninsula, Russia).

Association: Marićite (Yukon Territory, Canada); natrophosphate, villiaumite (Kola Peninsula, Russia).

Distribution: From the Big Fish River area, Yukon Territory, and at Mont Saint-Hilaire, Quebec, Canada. On Mt. Karnasurt, Lovozero massif and on Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: For the principal chemical components, sodium, NAtrium, Hydrogen, Phosphorus, and Oxygen.

Type Material: University of Saskatchewan, Saskatoon, Canada, 12504.

References: (1) Coleman, L.C. and B.T. Robertson (1981) Nahpoite Na_2HPO_4, a new mineral from the Big Fish River area, Yukon, Territory. Can. Mineral., 19, 373–376. (2) (1982) Amer. Mineral., 67, 856–857 (abs. ref. 1). (3) Khomyakov, A.P., Y.P. Men'shikov, and M.D. Dorfman (1982) New natural sodium phosphate, nahpoite (Na_2HPO_4), from the Lovozero and the Khibiny plutons. Doklady Acad. Nauk SSSR, 264, 191–194 (in Russian).

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Nakauriite $Cu_8(SO_4)_4(CO_3)(OH)_6 \cdot 48H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystals are fibers, to 3 mm, in sprays and aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.39(2) D(calc.) = 2.35

Optical Properties: Semitransparent. *Color:* Sky-blue.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale greenish blue; Z = pale sky-blue to very pale blue. *Orientation:* Positive elongation, parallel extinction. *Dispersion:* $r < v$. α = 1.585–1.597 β = 1.604–1.612 γ = 1.612–1.618 2V(meas.) = 60°–70° 2V(calc.) = 65.3°

Cell Data: *Space Group:* n.d. $a = 14.585$ $b = 11.47$ $c = 16.22$ Z = 2

X-ray Powder Pattern: Nakauri, Japan.
7.31 (100), 3.652 (20), 2.367 (16), 1.9148 (16), 4.840 (14), 3.936 (14), 2.397 (14)

Chemistry:

	(1)
SO_3	16.23
CO_2	2.28
Fe_2O_3	0.06
MnO	0.09
NiO	0.88
CuO	32.12
ZnO	0.03
H_2O^+	45.31
H_2O^-	3.01
Total	[100.01]

(1) Nakauri, Japan; by AA, CO_2 by volumetric analysis; after deduction of estimated 67% chrysotile, corresponds to $(Cu_{7.77}Ni_{0.23}Mn_{0.02})_{\Sigma=8.01}(SO_4)_{3.90}(CO_3)_{1.00}(OH)_{6.23} \cdot 48.4H_2O$.
(2) Material from Gabbs, Nevada and the Cedar Hill quarry, Pennsylvania, USA, and the Hagdale quarry, Scotland, contains only traces to no detectable SO_4.

Occurrence: As fracture fillings in serpentinite (Nakauri, Japan); on chromatite from serpentinite (Hagdale quarry, Scotland).

Association: Chrysotile, magnetite, artinite, pyroaurite, brochantite, malachite (Nakauri, Japan); callaghanite, hydromagnesite (Gabbs, Nevada, USA); antigorite, magnesite, talc, quartz (Cedar Hill quarry, Pennsylvania, USA); chrysotile, theophrastite, pentlandite, heazlewoodite (Hagdale quarry, Scotland).

Distribution: From an abandoned mine at Nakauri, about 6 km southeast of Shinshiro, Aichi Prefecture, Japan. In the USA, good crystals at the Gabbs mine, Gabbs district, Nye Co., Nevada; from the Cedar Hill quarry, Lancaster Co., Pennsylvania. In the Hagdale quarry, Unst, Shetland Islands, Scotland.

Name: For the original material found at Nakauri, Japan.

Type Material: National Science Museum, Tokyo, Japan, M-24586; National Museum of Natural History, Washington, D.C., USA, 136584.

References: (1) Suzuki, J., M. Ito, and T. Sugiura (1976) A new copper sulfate-carbonate hydroxide hydrate mineral, $(Mn, Ni, Cu)_8(SO_4)_4(CO_3)(OH)_6 \cdot 48H_2O$, from Nakauri, Aichi Prefecture, Japan. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 71(7), 183–192 (in English). (2) (1977) Amer. Mineral., 62, 594 (abs. ref. 1). (3) Braithwaite, R.S.W. and P. Pritchard (1983) Nakauriite from Unst, Shetland. Mineral. Mag., 47, 84-85. (4) Foord, E.E., R.B. Finkelman, A.H. Feinberg, I. O'Neill, A.V. Heyl, D.K. Smith, and B. Brookmyer (1985) Nakauriite from Cedar Hill quarry, Lancaster County: a new mineral for Pennsylvania. Friends of Mineralogy, Pennsylvania Chapter, Newsletter 13(4), 4–12.

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Naldrettite Pd_2Sb

Crystal Data: Orthorhombic. *Point Group*: *mm*2. As irregular grains, to 239 μm. *Twinning*: Strain-induced polysynthetic twinning observed.

Physical Properties: *Cleavage:* None. *Tenacity:* Ductile (flexibly inelastic). *Fracture:* Irregular. Hardness = 4-5 VHN =393 (50 g load). D(meas.) = n.d. D(calc.) = 10.694

Optical Properties: Opaque. *Color:* Bright creamy white in plane-polarized reflected light, no internal reflections. *Birefringence:* Weak. *Pleochroism*: None. *Anisotropism*: Distinct in shades of deep bright blue, lemon-buff, and mauve to pale pink. *Streak:* n.d. *Luster:* Metallic.
Optical Class: n.d.
R_1-R_2: (470) 49.0-50.9 $(35.9\text{-}37.6)_{oil}$, (546) 53.2-55.1 $(40.3\text{-}42.1)_{oil}$, (589) 55.4-57.5 $(42.5\text{-}44.3)_{oil}$, (650) 58.5-60.1 $(45.4\text{-}47.2)_{oil}$

Cell Data: Space Group: $Cmc2_1$. a = 3.906(1) b = 17.5551(5) c = 6.957(2) Z = 8

X-ray Powder Pattern: Mesamax Northwest deposit, Ungava region, Québec, Canada.
2.2454 (100), 0.8584 (56), 2.0567 (52), 1.2122 (50), 1.2842 (42), 2.0009 (40), 2.3029 (35)

Chemistry:

	(1)	(2)
S	0.02	
Fe	0.11	
As	0.31	
Sb	35.75	36.39
Pd	63.49	63.61
Total	99.68	100.00

(1) Mesamax Northwest deposit, Ungava region, Québec, Canada; average of 69 electron microprobe analyses, corresponds to $(Pd_{1.995}Fe_{0.007})_{\Sigma=2.002}(Sb_{0.982}As_{0.014}S_{0.002})_{\Sigma=0.998}$. (2) Pd_2Sb.

Occurrence: In drill core through the contact zone between massive and disseminated sulfide mineralization hosted by amphibolite and serpentinite replacing pyroxenite and peridotite.

Association: Clinochlore monoclinic pyrrhotite, pentlandite, chalcopyrite, galena, sphalerite, cobaltite, magnetite, sudburyite, electrum, altaite, and more rarely ungavaite, sperrylite, michenerite, petzite, hessite.

Distribution: From the Mesamax Northwest deposit, Cape Smith Fold belt, Ungava region, Québec, Canada.

Name: Honors Professor Anthony J. Naldrett (b. 1933), University of Toronto and past President of both the Mineralogical Association of Canada and the International Mineralogical Association for significant contributions to our understanding of platinum-group element (PGE) deposits.

Type Material: Natural History Museum, London, England (BM 2004,34) and the Canadian Museum of Nature, Ottawa, Canada (CNMMN 84397).

References: (1) Cabri, L.J., A.M. McDonald, C.J. Stanley, N.S. Rudashevsky, G. Poirier, B.R. Durham, J.E. Mungall, and V.N. Rudashevsky (2005) Naldrettite, Pd_2Sb, a new intermetallic mineral from the Mesamax Northwest deposit, Ungava region, Québec, Canada. Mineral. Mag., 69, 89-97. (2) (2005) Amer. Mineral., 90, 1466-1467 (abs. ref. 1).

Nalipoite $NaLi_2PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As anhedral to subhedral blocky grains, to 2 mm.

Physical Properties: *Cleavage:* Good on {100}, {010}, {001}, {110}; distinct on probable {101}. *Fracture:* Uneven. *Tenacity:* Very brittle. Hardness = ∼4 D(meas.) = 2.58(1) D(calc.) = 2.587

Optical Properties: Transparent to translucent. *Color:* White, pale blue, pale yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.533(1)$ $\beta = 1.540(1)$ $\gamma = 1.541(1)$ 2V(meas.) = 49(1)° 2V(calc.) = 41°

Cell Data: *Space Group: Pmnb.* $a = 6.884(2)$ $b = 9.976(4)$ $c = 4.927(2)$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
4.02 (100), 3.507 (100), 3.441 (100), 2.493 (90), 2.462 (90), 2.833 (40), 2.712 (40)

Chemistry:

	(1)	(2)
P_2O_5	51.76	53.83
Al_2O_3	0.06	
Na_2O	24.54	23.51
Li_2O	22.12	22.66
Total	98.48	100.00

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of six analyses, Li_2O calculated from stoichiometry and confirmed by crystal-structure analysis; corresponding then to $Na_{1.07}Li_{2.00}P_{0.99}O_4$. (2) $NaLi_2PO_4$.

Occurrence: Very rare in sodalite syenite xenoliths associated with an intrusive alkalic gabbro-syenite complex.

Association: Silinaite, revdite, serandite, lovozerite, villiaumite, ussingite, eudialyte, sodalite, analcime, microcline, aegirine.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: For the principal chemical components in the composition, sodium NAtrium, LIthium, Phosphorus, and Oxygen.

Type Material: Canadian Museum of Nature, Ottawa, 56467, 56468; Royal Ontario Museum, Toronto, Canada, 44516, 44517.

References: (1) Chao, G.Y. and T.S. Ercit (1991) Nalipoite, sodium dilithium phosphate, a new mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 29, 565–568. (2) Ercit, T.S. (1991) The crystal structure of nalipoite. Can. Mineral., 29, 569–573. (3) (1992) Amer. Mineral., 77, 449 (abs. refs. 1 and 2).

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Namansilite $NaMn^{3+}Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As stout prismatic crystals, to 2 mm, forming irregular pods and aggregates. *Twinning:* On {100}, simple; polysynthetic.

Physical Properties: *Cleavage:* Perfect on {110}; (110) ∧ $(1\bar{1}0)$ ~87°. *Tenacity:* Brittle. Hardness = ~6 D(meas.) = 3.51 D(calc.) = [3.61]

Optical Properties: Transparent. *Color:* Red-violet. *Streak:* Brownish violet.
Luster: Adamantine; vitreous to pearly.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = lemon-yellow to pale yellow-orange; Y = raspberry-red to brownish red; Z = blood-red to reddish purple. *Orientation:* $Y = b$; $X \wedge c$ = 19°–25°. *Dispersion:* Very weak. *Absorption:* $Z > Y > X$. α = 1.734–1.750 β = 1.769–1.85 γ = 1.835–1.87 2V(meas.) = 15°–85°

Cell Data: *Space Group:* $C2/c$. a = 9.500–9.513 b = 8.610–8.615 c = 5.353–5.356 β = 105.00°–105.12° Z = [4]

X-ray Powder Pattern: Woods mine, Australia.
2.925 (100), 2.883 (100), 6.29 (66), 2.499 (50), 2.495 (50), 4.305 (45), 1.579 (24)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	52.64	51.69	CaO	0.07	0.01
TiO_2	0.19	0.05	SrO	0.42	
Al_2O_3	0.20	0.08	BaO	0.05	
Fe_2O_3	1.65	1.11	Na_2O	13.81	13.10
Mn_2O_3	32.36	33.72	K_2O	0.05	
MgO	0.32	0.01	Total	[101.76]	99.77

(1) Irnimi deposit, Russia; by electron microprobe, average of six analyses, original total given as 101.16%; corresponds to $(Na_{1.01}Ca_{0.02}Sr_{0.01})_{\Sigma=1.04}(Mn_{0.93}Fe_{0.05}Mg_{0.02})_{\Sigma=1.00}(Si_{1.99}Al_{0.01}Ti_{0.01})_{\Sigma=2.01}O_6$. (2) Woods mine, Australia; by electron microprobe, average of five analyses; corresponds to $Na_{0.99}(Mn_{0.99}Fe_{0.03})_{\Sigma=1.02}Si_{1.99}O_6$.

Mineral Group: Pyroxene group.

Occurrence: In low-grade metamorphosed and highly oxidized Mn, Na-rich sediments.

Association: Taikanite, pectolite, manganoan amphiboles, manganoan orthoclase, manganoan vermiculite (Irnimi deposit, Russia); pectolite, potassic feldspar, braunite, quartz (Cerchiara mine, Italy); quartz, sérandite, aegirine, kôzulite (Woods mine, Australia).

Distribution: From the Irnimi deposit, Taikan Mountains, Khabarovsk Territory, Russia. In the Cerchiara mine, near Faggiona, Val di Vara, Liguria, Italy. From Australia, in the Hoskins mine, near Grenfell, and the Woods mine, 30 km north-northeast of Tamworth, New South Wales.

Name: For sodium, NAtrium; MANganese; and SILicon in the formula.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Kalinin, V.V., I.M. Marsiy, Y.P. Dikov, N.V. Troneva, and N.V. Trubkin (1992) Namansilite $NaMn^{3+}Si_2O_6$ – a new silicate. Zap. Vses. Mineral. Obshch., 121(1) 89–94 (in Russian). (2) (1993) Amer. Mineral., 78, 1316 (abs. ref. 1). (3) Basso, R., G. Lucchetti, and A. Palenzona (1989) Crystallographic and chemical study on a natural C2/c ordered Na–Mn–clinopyroxene from Val di Vara (Northern Apennines, Italy). Neues Jahrb. Mineral., Monatsh., 59–68. (4) Ohashi, H., T. Osawa, and K. Tsukimura (1987) Refinement of the structure of manganese sodium dimetasilicate. Acta Cryst., C43, 605–607. (5) Kawachi, Y. and D.S. Coombs (1993) Namansilite, $NaMn^{3+}Si_2O_6$: a widespread clinopyroxene? Mineral. Mag., 57, 533–538.

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Nambulite $(Li,Na)Mn_4^{2+}Si_5O_{14}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As prismatic to tabular crystals, to 8 mm; massive in veinlets.

Physical Properties: *Cleavage:* Perfect on {001}, distinct on {010} and {100}.
Hardness = 6.5 D(meas.) = 3.53(1) D(calc.) = 3.55

Optical Properties: Transparent. *Color:* Reddish brown with an orange tint. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Slight. *Orientation:* $X' \wedge c = 19°$ on {010}.
Dispersion: $r > v$, weak. $\alpha = 1.707(2)$ $\beta = 1.710(2)$ $\gamma = 1.730(2)$ 2V(meas.) = 30(2)°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.621(5)$ $b = 11.761(8)$ $c = 6.731(5)$ $\alpha = 92°46(3)'$ $\beta = 95°5(3)'$ $\gamma = 106°52(5)'$ Z = 2

X-ray Powder Pattern: Funakozawa mine, Japan.
2.96 (100), 2.97 (80), 2.92 (70), 3.17 (65), 3.07 (60), 3.09 (55), 3.14 (45)

Chemistry:

	(1)		(1)
SiO_2	49.23	Na_2O	2.49
TiO_2	0.01	K_2O	0.04
Al_2O_3	0.37	Cl	0.00
Fe_2O_3	0.40	H_2O^+	1.63
MnO	40.67	H_2O^-	0.26
MgO	1.32	CO_2	0.19
CaO	0.81	P_2O_5	0.02
Li_2O	1.55	SO_3	0.00
		Total	98.99

(1) Funakozawa mine, Japan; corresponding to $(Li_{0.50}Na_{0.49}K_{0.01})_{\Sigma=1.00}(Mn_{3.48}Mg_{0.20}Li_{0.14}Ca_{0.09}Al_{0.04}Fe_{0.03})_{\Sigma=3.98}Si_5O_{13.90}(OH)_{1.10}$.

Polymorphism & Series: Forms a series with natronambulite.

Occurrence: In veinlets cutting braunite ores in chert (Funakozawa mine, Japan).

Association: Braunite, albite, neotocite, rhodochrosite (Funakozawa mine, Japan).

Distribution: In the Funakozawa and Ohtaniyama mines, Ohno, Iwate Prefecture, and the Gozaisho mine, Iwaki, Fukushima Prefecture, Japan.

Name: For Professor Matsuo Nambu, Tohoku University, Sendai, Japan.

Type Material: National Science Museum, Tokyo, Japan, M18829.

References: (1) Yoshii, M., Y. Aoki, and K. Maeda (1972) Nambulite, a new lithium- and sodium-bearing manganese silicate from the Funakozawa mine, northeastern Japan. Mineral. J. (Japan), 7, 29–44. (2) (1973) Amer. Mineral., 58, 1112 (abs. ref. 1). (3) Narita, H., K. Koto, and N. Morimoto (1975) The crystal structure of nambulite $(Li,Na)Mn_4Si_5O_{14}(OH)$. Acta Cryst., 31, 2422–2426.

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Namibite $Cu(BiO)_2(VO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. Rarely as platy crystals, flattened on {100}, with {101} and {111}, to 2 mm, in "bowtie" or parallel aggregates; as radiating dendritic veinlets, spheres, and as rounded masses. *Twinning:* Common on {011}, interpenetrating and polysynthetic.

Physical Properties: *Cleavage:* On {001}, good. Hardness = 4.5–5 VHN = 473 (100 and 200 g loads). D(meas.) = 6.86(3) D(calc.) = 6.91

Optical Properties: Semitransparent. *Color:* Dark olive-green to greenish black.
Streak: Pistachio-green.
Optical Class: Biaxial (–). *Pleochroism:* Slight; X = pale yellowish green; Y = pistachio-green; Z = dark green. *Orientation:* $Z = b$; $X \wedge a \simeq 12°$. *Absorption:* $Z > Y > X$. $\alpha = > 2.10$ $\beta = > 2.10$ $\gamma = > 2.10$ 2V(meas.) = Moderate for red, very small for blue.

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 11.864(8)$ $b = 3.696(4)$ $c = 7.491(5)$ $\beta = 109°42(6)'$ Z = 2

X-ray Powder Pattern: Khorixas, Namibia.
3.018 (100), 3.574 (75), 5.58 (70), 2.672 (60), 3.284 (50), 3.525 (40), 2.611 (35)

Chemistry:

	(1)	(2)	(3)
V_2O_5	14.5	13.77	14.09
Bi_2O_3	74.1	72.24	72.19
CuO		12.03	12.32
Cu_2O	11.5		
H_2O		1.51	1.40
Total	100.1	99.55	100.00

(1) Khorixas, Namibia; by electron microprobe, average of three analyses. (2) Jáchymov, Czech Republic; $(OH)^{1-}$ and $(VO_4)^{3-}$ demonstrated present by IR; corresponds to $Cu_{0.98}(BiO)_{2.01}(VO_4)_{0.98}(OH)_{1.03} \bullet 0.03H_2O$. (3) $Cu(BiO)_2(VO_4)(OH)$.

Occurrence: A secondary mineral in bismuth-bearing hydrothermal polymetallic mineral deposits and granite pegmatites.

Association: Bismuth, bismutite, wittichenite, bismite, bismutostibiconite, bismutoferrite, clinobisvanite, pucherite, beyerite, schumacherite, mixite, eulytite, chrysocolla.

Distribution: From an undefined locality [Copper Valley,] near Khorixas, Namibia. In the USA, at the Stewart and White Queen mines, Pala district, San Diego Co., in the Lodi #4 mine, Spring Creek district, Plumas Co., and at Amboy, San Bernardino Co., California; from the Mica Lode mine, Eight Mile Park, Fremont Co., Colorado. In the Evans Lou quarry, near Wakefield Lake Quebec, Canada. From Morass Creek, north of Benambra, Victoria, and at the Iron Monarch quarry, Iron Knob, South Australia. At the Eliáš mine, Jáchymov (Joachimsthal), Czech Republic. From the Hechtsberg quarry, near Hausach, Black Forest, and in the Wolfgang Maassen mine, Schneeberg, Saxony, Germany. At Buckbarrow Beck, Cumbria, England.

Name: For the Namib Desert, along the coast of Namibia.

Type Material: The University, Leeds, England; University of Helsinki, Helsinki, Finland.

References: (1) von Knorring, O. and T.G. Sahama (1981) Namibite, a new copper-bismuth-vanadium mineral from Namibia. Schweiz. Mineral. Petrog. Mitt., 61, 7–12. (2) (1982) Amer. Mineral., 67, 857 (abs. ref. 1). (3) Mrázek, Z., F. Veselovský, J. Hloušek, H. Moravcová, and P. Ondruš (1994) Redefinition of namibite, $Cu(BiO)_2VO_4OH$. Neues Jahrb. Mineral., Monatsh., 481–488. (4) Dunning, G.E. and J.F. Cooper, Jr. (1998) Namibite: a summary of world occurrences. Mineral. Record, 29, 163–166.

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Namuwite $(Zn, Cu)_4(SO_4)(OH)_6 \cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. In flat platy hexagonal crystals, to 60 μm, or elongated trangular needles; typically aggregated into incrustations.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 2 D(meas.) = 2.77 D(calc.) = 2.81

Optical Properties: Semitransparent. *Color:* Pale sea-green. *Streak:* Very pale green. *Luster:* Pearly.
Optical Class: Uniaxial, very low birefringence. $n = 1.577(5)$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P\overline{3}$. $a = 8.330(1)$ $c = 10.540(2)$ $Z = 2$

X-ray Powder Pattern: Aberllyn mine, Wales.
10.59 (100), 2.71 (42), 2.63 (41), 4.15 (25), 1.57 (23), 2.41 (22), 1.55 (20)

Chemistry:

	(1)	(2)	(3)
SO_3	14.9	13.73	14.04
CuO	22.0	23.48	13.16
ZnO	37.8	32.28	53.02
H_2O^+	13.4		
H_2O^-	11.1		
H_2O		[21.77]	[25.03]
Total	99.2	[91.26]	[105.25]

(1) Aberllyn mine, Wales; by AA, SO_3 and H_2O by TGA; corresponds to $(Zn_{2.50}Cu_{1.49})_{\Sigma=3.99}(SO_4)(OH)_6 \cdot 4.34H_2O$. (2) Smallcleugh mine, England; by electron microprobe, H_2O calculated for stoichiometry; corresponds to $(Zn_{2.30}Cu_{1.71})_{\Sigma=4.01}(SO_4)_{0.99}(OH)_{6.04} \cdot 4H_2O$. (3) Granetal, Germany; by electron microprobe, H_2O calculated for stoichiometry; corresponds to $(Zn_{3.28}Cu_{0.83})_{\Sigma=4.11}(SO_4)_{0.88}(OH)_{6.46} \cdot 4H_2O$.

Occurrence: An uncommon secondary mineral formed in the oxidized zone of hydrothermal Cu–Zn bearing mineral deposits; may be derived from metallic slags.

Association: Hydrozincite, schulenbergite, serpierite, ktenasite, devilline, gypsum.

Distribution: In Wales, from the Aberllyn lead mine, about two km from Bettws-y-coed, Llanrwst district, Gwynedd, and at the Frongoch mine, Dyfed. In England, from the Smallcleugh mine, Nenthead, Cumbria, and in the Waterbank mine, Ecton Hill, Staffordshire. In Germany, in the Harz Mountains, from Granetal, at the Glücksrad mine, near Oberschulenberg, and in slag at the Juliushütte, Astfeld; from the Friedrichssegen mine, near Bad Ems, and at Virneberg, near Rheinbreitbach, Rhineland-Palatinate; at Stolberg, near Aachen, North Rhineland-Westphalia. In the Veneziana mine, near Torrebelvicino, Vicenta, Italy. From the Kamariza mine, and in slag, at Laurium, Greece. At Tsumeb, Namibia. From the ZCA#4 mine, Balmat, St. Lawrence Co., New York, USA.

Name: For the NAtional MUseum of Wales, Cardiff, Wales, in the collection of which the type specimen was noted.

Type Material: National Museum of Wales, Cardiff, Wales, 27.111.GR414; The Natural History Museum, London, England, 1983,341; National Museum of Natural History, Washington, D.C., USA, 150334.

References: (1) Bevins, R.E., S. Turgoose, and P.A. Williams (1981) Namuwite, $(Zn, Cu)_4SO_4(OH)_6.4H_2O$, a new mineral from Wales. Mineral. Mag., 46, 51–54. (2) (1983) Amer. Mineral., 68, 281 (abs. ref. 1). (3) Groat, L.A. (1996) The crystal structure of namuwite, a mineral with Zn in tetrahedral and octahedral coordination, and its relationship to the synthetic basic zinc sulfates. Amer. Mineral., 81, 238–243.

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Nanlingite $CaMg_4(As^{3+}O_3)_2F_4$

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Crystal Data: Hexagonal. *Point Group:* $3m$ or $\bar{3}\ 2/m$. Crystals rarely well-formed, tabular, with {0001} and {$h0\bar{h}l$}; commonly granular, to 0.2 mm, in dendritic aggregates.

Physical Properties: *Cleavage:* One, imperfect. Hardness = 2.3 VHN = 107
D(meas.) = 3.927 D(calc.) = 3.925

Optical Properties: Transparent. *Color:* Brownish red to dark brown when oxidized; deep red in transmitted light, with anomalous red interference colors. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.82$ $\epsilon = 1.78$

Cell Data: *Space Group:* $R3m$ or $R\bar{3}m$. $a = 10.24(5)$ $c = 25.76(5)$ Z = 15

X-ray Powder Pattern: Nan Ling area, China.
2.78 (10), 8.35 (9), 1.730 (8), 1.699 (8), 2.425 (7), 1.460 (7), 1.104 (6)

Chemistry:

	(1)	(2)
Al_2O_3	0.98	
Fe_2O_3	7.09	
As_2O_3	44.11	43.09
MnO	0.21	
MgO	25.04	35.11
CaO	11.74	12.21
Na_2O	1.81	
Li_2O	1.22	
F	13.64	16.56
H_2O	0.60	
$-O = F_2$	5.74	6.97
Total	100.70	100.00

(1) Nan Ling area, China; by wet chemistry supplemented by spectrographic and semiquantitative electron microprobe; when recalculated to 100%, corresponds to $(Ca_{0.96}Na_{0.27})_{\Sigma=1.23}(Mg_{2.83}Fe^{3+}_{0.41}Li_{0.37}Al_{0.09}Mn_{0.01})_{\Sigma=3.71}(AsO_3)_{2.04}F_{3.28}(OH)_{0.30}O_{0.02}$. (2) $CaMg_4(AsO_3)_2F_4$.

Occurrence: Along a contact between greisenized granite and dolomitic limestone.

Association: Fluorite, fluoborite, zinnwaldite, magnesian dolomite, arsenopyrite, pyrrhotite, gahnite, nigerite.

Distribution: From an undisclosed locality [Shizhuyuan, Guangxi Province] in the Nan Ling area, southern China.

Name: For the locality, Nan Ling area, China.

Type Material: n.d.

References: (1) Gu Xiongfei, Ding Kuishou, and Xu Yingnian (1976) A new arsenite mineral from southern China. Geochemica, 2, 107–112 (in Chinese with English abs.). (2) (1977) Amer. Mineral., 62, 1058–1059 (abs. ref. 1). (3) (1977) Mineral. Abs., 28, 80–81 (abs. ref. 1).

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Nanpingite $\mathbf{Cs(Al,Mg,Fe^{2+},Li)_2(Si_3Al)O_{10}(OH,F)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely as pseudohexagonal crystals; as radiating and comb aggregates, and scales and plates, to 1 cm.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle, with some elasticity. Hardness = 2–3 D(meas.) = 3.11(2) D(calc.) = 3.19

Optical Properties: Transparent in flakes. *Color:* White to silver-white. *Streak:* White. *Luster:* Vitreous, pearly on sheets.
Optical Class: Biaxial (–). *Orientation:* $Z = b$. *Dispersion:* $r > v$, weak. $\alpha = 1.551(5)$ $\beta = 1.584(2)$ $\gamma = 1.588(2)$ 2V(meas.) = 46(2)°

Cell Data: *Space Group:* $C2/c$. $a = 5.362(3)$ $b = 8.86(1)$ $c = 21.42(1)$ $\beta = 95.77(2)°$ Z = 4

X-ray Powder Pattern: Nanping area, China.
2.664 (100), 2.129 (85), 2.122 (16), 2.654 (14), 1.328 (14), 3.329 (6), 3.622 (5)

Chemistry:

	(1)
SiO_2	38.54
Al_2O_3	25.61
FeO	2.44
MnO	0.07
MgO	1.78
Li_2O	0.44
Na_2O	0.00
K_2O	0.54
Rb_2O	0.25
Cs_2O	25.29
F	1.00
H_2O	3.27
$-O = F_2$	0.42
Total	98.81

(1) Nanping area, China; by combined wet chemical analysis and electron microprobe, TiO_2 0.002%, CaO 0.007%; corresponds to $(Cs_{0.88}K_{0.06}Rb_{0.01})_{\Sigma=0.95}(Al_{1.64}Mg_{0.22}Fe_{0.17}Li_{0.15})_{\Sigma=2.18}(Si_{3.16}Al_{0.84})_{\Sigma=4.00}O_{9.95}[(OH)_{1.79}F_{0.26}]_{\Sigma=2.05}$.

Polymorphism & Series: $2M_1$ polytype.

Mineral Group: Mica group.

Occurrence: In veinlets in the pollucite-rich middle zone of a muscovite-albite-spodumene pegmatite.

Association: Montebrasite, quartz, apatite.

Distribution: At an undefined locality in the Nanping area, Fukien Province, China.

Name: For its occurrence in the Nanping area, China.

Type Material: Institute of Mineral Deposits, Chinese Academy of Geological Sciences; National Museum of Geology, Beijing, China.

References: (1) Yueqing Yang, Yunxiang Ni, Liben Wang, Wenying Wang, Yaping Zhang, and Chenghu Chen (1988) Nanpingite–a new cesium mineral. Yanshi Kuangwuxue Zashi, 7, 49–58 (in Chinese with English abs.). (2) (1990) Amer. Mineral., 75, 708–709 (abs. ref. 1).

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Nantokite CuCl

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. Granular, massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Sectile. Hardness = 2.5
D(meas.) = 3.93–4.3; 4.136 (synthetic). D(calc.) = 4.22 Alters to paratacamite on exposure.

Optical Properties: Transparent to translucent. *Color:* Colorless, white; grayish to greenish on exposure; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine.
Optical Class: Isotropic; may be anomalously anisotropic. $n = 1.930(5)$ (synthetic).

Cell Data: *Space Group:* $F\overline{4}3m$. $a = 5.407$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.127 (100), 1.915 (55), 1.633 (30), 1.243 (10), 2.710 (8), 1.1054 (8), 1.354 (6)

Chemistry:

	(1)	(2)	(3)
Cu	64.17	64.28	64.19
Cl	35.52	35.82	35.81
Total	99.69	100.10	100.00

(1) Nantoko, Chile. (2) Broken Hill, Australia. (3) CuCl.

Occurrence: A secondary mineral in hydrothermal copper-bearing deposits; rarely in volcanic sublimates.

Association: Cuprite, copper, atacamite, paratacamite, claringbullite, cerussite, hematite.

Distribution: In the Carmen Bajo mine, Pintada Mountain, near Nantoko, Copiapó district, Atacama, Chile. From Broken Hill, New South Wales, and at the Wewak, Magpie, and Great Australia mines, Cloncurrie, Queensland, Australia. In the Malanjkhand copper deposit, north of Durg, Madhya Pradesh, India. From the Tolbachik volcano, Kamchatka Peninsula, Russia. At Dzhezkazgan, Kazakhstan. From the Levant mine, St. Just, Cornwall, England. Along Baratti Beach, Tuscany, Italy, in slag. In the USA, at Bisbee, Cochise County, Arizona, and in the Steeple Rock district, Grant Co., New Mexico. From the Ojuela mine, Mapimí, Durango, Mexico.

Name: For its occurrence near Nantoko, Chile.

Type Material: Mining Academy, Freiberg, Germany, 12012.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 18–19. (2) (1955) NBS Circ. 539, 4, 35–36.

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Naquite FeSi

Crystal Data: Cubic. *Point Group*: 23. As irregular grains to 0.1 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 6.5
D(meas.) = n.d. D(calc.) = 6.186

Optical Properties: Opaque. *Color*: Steel-gray. *Streak*: Grayish black. *Luster*: Metallic.
Optical Class: n.d.
R: (470) 40.6, (546) 42.23, (589) 41.6, (650) 42.5

Cell Data: *Space Group*: $P2_13$. a = 4.486(4) Z = 4

X-ray Powder Pattern: Luobusha mining district, Qusong County, Tibet, China.
2.374 (100), 5.163 (92), 1.851 (79), 1.899 (47), 1.087 (25) 1.774 (16), 1.708 (12)

Chemistry:

	(1)	(2)
Fe	65.65	66.54
Si	32.57	33.46
Al	1.78	.
Total	100.00	100.00

(1) Luobusha mining district, Qusong County, Tibet, China; average of 4 electron microprobe analyses; corresponding to $(Fe_{0.994}Al_{0.054})_{\Sigma=1.02}Si_{0.952}$. (2) FeSi.

Occurrence: In the heavy mineral fraction of a podiform chromitite deposit in the peridotite of an ophiolitic harzburgite. Likely the product of a strongly reducing environment and possibly are xenocrysts derived from a mantle source.

Association: Luobusaite.

Distribution: In a heavy mineral fraction from ore body 31, Group II of the Luobusha ("Luobusa") mining district, 200 km southeast of Lhasa, Qusong County, Shannan Prefecture, Tibet, People's Republic of China. From placers and drill-core samples from the Poltava series, Ukraine.

Name: For Naqu (Nagchu) Prefecture, Tibet, near the locality that produced the first samples.

Type Material: Geological Museum of China, Beijing, People's Republic of China (M11798).

References: (1) Li, G., N. Shi, M. Xiong, Z. Ma, W. Bai, and Q. Fang (2012) Naquite, FeSi, a new mineral species from Luobusha, Tibet, western China. Acta Geologica Sinica, 86(3), 553-538.
(2) (2014) Amer. Mineral., 99, 1517 (abs. ref. 1).

Narsarsukite $Na_2(Ti,Fe^{3+})Si_4(O,F)_{11}$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals, commonly flat tabular to equant, rarely prismatic, striated ‖ [001], to 3 cm. In divergent, radiating groups; as fine-grained segregations, massive.

Physical Properties: *Cleavage:* {100} and {110}, good. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–7 D(meas.) = 2.64–2.83 D(calc.) = 2.78–2.84

Optical Properties: Transparent to translucent. *Color:* Honey-yellow to lemon-yellow, reddish brown, brownish gray, tan, pink, may be zoned; green from inclusions. *Streak:* White. *Luster:* Vitreous, pearly on {110}.
Optical Class: Uniaxial (+). *Pleochroism:* Weak; O = colorless to yellow; E = colorless to honey-yellow. $\omega = 1.601–1.614$ $\epsilon = 1.632–1.655$

Cell Data: *Space Group:* $I4/m$. $a = 10.61–10.76$ $c = 7.89–7.99$ $Z = 4$

X-ray Powder Pattern: Sweetgrass Hills, Montana, USA.
5.365 (100), 3.394 (80), 3.260 (80), 2.579 (60), 2.524 (60), 3.976 (50), 7.609 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	61.63	63.74	MgO	0.24	
TiO_2	14.00	13.74	Na_2O	16.12	15.48
ZrO_2		0.64	K_2O		0.13
Al_2O_3	0.28	0.53	F	0.71	1.38
Fe_2O_3	6.30	5.55	H_2O	0.29	
MnO	0.47	0.20	$-O = F_2$	0.30	0.58
			Total	99.74	100.81

(1) Narssârssuk, Greenland. (2) Do.; by electron microprobe, total Fe as Fe_2O_3; corresponds to $(Na_{1.92}K_{0.01})_{\Sigma=1.93}(Ti_{0.66}Fe^{3+}_{0.27}Zr_{0.02}Mn_{0.01})_{\Sigma=0.96}(Si_{4.07}Al_{0.04})_{\Sigma=4.11}(O_{10.72}F_{0.28})_{\Sigma=11.00}$.

Occurrence: In pegmatite (Narssârssuk, Greenland); in quartz veins in syenite intruding limestone (Sweetgrass Hills, Montana, USA); in hornfels, igneous breccia, and marble xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Aegirine, microcline, albite, elpidite, epididymite, taeniolite, quartz (Narssârssuk, Greenland); aegirine, pectolite, calcite, feldspar, galena, quartz (Sweetgrass Hills, Montana, USA).

Distribution: From Narssârssuk; on the Island of Igdlutalik, in the Ilímaussaq intrusion; and in the Werner Berge complex, Greenland. On Mt. Flora, Lovozero massif, Kola Peninsula; in the Murun massif, southwest of Olekminsk, Yakutia; and other less-well-defined localities in Russia. In the Oslofjord, Norway. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. From near Whitlash, Sweetgrass Hills, Sweetgrass Co., Montana; in the Diamond Jo quarry, Magnet Cove, Hot Spring Co., and from Granite Mountain, near Little Rock, Pulaski Co., Arkansas, USA. At Mont Saint-Hilaire, Quebec, Canada. From Gouré, Damagaram, Niger. In the Sirwa massif, north of Ouarzazate, Morocco.

Name: For the Greenland locality at Narssârssuk (Narsarsuk).

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 73. (2) Stewart, D.B. (1959) Narsarsukite from Sage Creek, Sweetgrass Hills, Montana. Amer. Mineral., 44, 265–273. (3) Peacor, D.R. and M.J. Buerger (1962) The determination and refinement of the structure of narsarsukite, $Na_2TiOSi_4O_{10}$. Amer. Mineral., 47, 539–556. (4) Mandarino, J.A. and V. Anderson (1989) Monteregian treasures. Cambridge Univ. Press, 149. (5) Wagner, C., G.C. Parodi, M. Semet, J.-L. Robert, M. Berrahma, and D. Velde (1991) Crystal chemistry of narsarsukite. Eur. J. Mineral., 3, 575–585.

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Nasinite $Na_2B_5O_8(OH)\cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Tiny crystals and microcrystalline clusters, in earthy masses.

Physical Properties: Hardness = n.d. D(meas.) = 2.2 D(calc.) = 2.134

Optical Properties: Semitransparent. *Color:* White to yellow, yellow-orange. *Optical Class:* Biaxial (–) (synthetic). *Orientation:* $Y = b$; $Z \wedge a = 6.8(1)°$ [*sic*]. $\alpha = 1.494$ $\beta = 1.512$ $\gamma = 1.524$ 2V(meas.) = 66.8(7)° 2V(calc.) = 77.4°

Cell Data: *Space Group:* $Pna2_1$ (synthetic). $a = 12.015(2)$ $b = 6.518(1)$ $c = 11.173(1)$ Z = 4

X-ray Powder Pattern: Synthetic.
6.00 (100), 5.29 (92), 2.897 (65), 2.999 (45), 2.648 (26), 2.531 (18), 2.207 (18)

Chemistry: (1) Larderello, Italy; identity depends on the chemical analysis of a mixture with biringuccite, and the correspondence of lines in the mixture's X-ray powder pattern with those of synthetic material.

Occurrence: As scales on piping in a geothermal field.

Association: Biringuccite, thénardite, orpiment, quartz.

Distribution: From Larderello, Val di Cecina, Tuscany, Italy.

Name: To honor Rafaello Nasini (1854–1931), Italian chemist.

Type Material: University of Florence, Florence, Italy, 16803/G; National Museum of Natural History, Washington, D.C., USA, 163785.

References: (1) Cipriani, C. and P. Vannuccini (1961) Hoeferite [= biringuccite] e nasinite: due nuori borati fra i prodotti di Lardarello. Pt. I. Atti Rend. Accad. Lincei, 30, 74–83; Pt. II. 235–245 (in Italian). (2) (1963) Amer. Mineral., 48, 709–711 (abs. ref. 1). (3) Corazza, E., Menchetti, S., C. Sabelli, and A. Stoppioni (1977) Hydrothermal synthesis at 150 °C and X-ray study of resulting products in the $NaOH-B_2O_3-H_2O$ system. Neues Jahrb. Mineral., Abh., 131, 208–223. (4) Corazza, E., S. Menchetti, and C. Sabelli (1975) The crystal structure of nasinite, $Na_2[B_5O_8(OH)]\cdot 2H_2O$. Acta Cryst., 31, 2405–2410.

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Nasledovite $PbMn_3^{2+}Al_4O_5(CO_3)_4(SO_4)\cdot 5H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Radial fibrous, forming oölites, to 3 mm.

Physical Properties: Hardness = 2 D(meas.) = 3.069 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Snow-white, commonly covered by dark brown to reddish material. *Luster:* Silky.
Optical Class: Biaxial (?). *Orientation:* $Z \wedge c = 2°–23°$, wavy extinction. α = n.d. β = n.d. $\gamma = 1.591$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Sardob deposit, Tajikistan.
3.261 (10), 2.028 (6), 2.019 (6), 1.462 (6), 2.853 (5), 2.983 (4), 1.749 (4)

Chemistry:

	(1)	(2)
SO_3	4.76	8.12
CO_2	19.08	17.85
Al_2O_3	20.40	20.68
Fe_2O_3	1.39	
MnO	15.46	21.58
ZnO	0.76	
PbO	24.35	22.64
MgO	3.68	
H_2O	10.12	9.13
Total	[100.00]	100.00

(1) Sardob deposit, Tajikistan; recalculated to 100% after deduction of SiO_2 1.58%, MnO_2 2.04%, and H_2O^- 0.60 % from an original total of 100.84%; then corresponds to $Pb_{1.03}(Mn_{2.05}Mg_{0.87}Zn_{0.08})_{\Sigma=3.00}(Al_{3.77}Fe_{0.17})_{\Sigma=3.94}(CO_3)_{4.08}(SO_4)_{0.56}O_{5.30}\cdot 5.27H_2O$. (2) $PbMn_3Al_4O_5(CO_3)_4(SO_4)\cdot 5H_2O$.

Occurrence: A rare fracture filling in oxidized granodiorite porphyry which also hosts polymetallic ores.

Association: Pyrolusite, iron oxide, cerussite.

Distribution: From the Sardob deposit, eastern Altyn-Topkan district, Kuramin Mountains, northern Tajikistan. [??ck not Chatkal-Kuramin Mountains, Uzbekistan??]

Name: To honor Professor Boris Nikolaevich Nasledov (1885–1942), geologist, for his investigations of the mineral resources of the Chatkal-Kuramin region, Kyrgyzstan-Uzbekistan.

Type Material: n.d.

References: (1) Enikeev, M.R. (1958) A new mineral, nasledovite, from the Altyn-Topkansk ore field. Doklady Akad. Nauk Uzbek. S.S.R., 5, 13–16 (in Russian). (2) (1959) Amer. Mineral., 44, 1325 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 146.

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Nasonite $Pb_6Ca_4Si_6O_{21}Cl_2$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Rare crystals are prismatic with $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, terminated by $\{10\bar{1}1\}$; commonly granular, massive.

Physical Properties: *Cleavage:* Good on {0001}; indistinct prismatic. Hardness = 4
D(meas.) = 5.42–5.55 D(calc.) = 5.63

Optical Properties: Transparent to translucent. *Color:* White, rarely yellow or blue-green, probably as the result of impurities. *Luster:* Greasy to adamantine.
Optical Class: Uniaxial (+). $\omega = 1.913$–1.946 $\epsilon = 1.923$–1.963

Cell Data: *Space Group:* $P6_3/m$. $a = 10.08$ $c = 13.27$ $Z = 2$

X-ray Powder Pattern: Långban, Sweden. (ICDD 14-328).
3.27 (100), 1.81 (100), 3.16 (90), 2.61 (90), 2.88 (60), 2.16 (60), 2.73 (50)

Chemistry:

	(1)	(2)
SiO_2	18.32	18.9
FeO		trace
MnO	2.37	trace
ZnO	0.03	
PbO	65.96	66.0
MgO	0.00	
CaO	10.98	13.0
Cl	3.07	3.5
H_2O^+	0.25	
$-O = Cl_2$	0.69	0.8
Total	100.29	[100.6]

(1) Franklin, New Jersey, USA. (2) Do.; by electron microprobe, original total given as 99.9%; corresponding to $Pb_{6.00}Ca_{4.42}Si_{5.64}O_{21}Cl_2$.

Occurrence: A rare mineral, formed under hydrothermal conditions, cutting franklinite-willemite ore in a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA); in calcite-filled veins in a metamorphosed Fe–Mn deposit (Långban, Sweden).

Association: Clinohedrite, barysilite, datolite, prehnite, willemite, axinite, hancockite, garnet, manganophyllite (Franklin, New Jersey, USA); manganoan diopside, manganoan aegirine, lead, apophyllite, margarosanite, thaumasite (Långban, Sweden).

Distribution: In the USA, at Franklin, Sussex Co., New Jersey, and at Crestmore, Riverside Co., California. From Långban and Jakobsberg, Värmland, Sweden.

Name: For Frank Lewis Nason (1856–1928), American geologist, Geological Survey of New Jersey, USA.

Type Material: Yale University, New Haven, Connecticut, USA, 2.4192, 2.4193.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 48. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 92–93. (3) Frondel, C. and L. H. Bauer (1951) Nasonite and its relation to pyromorphite. Amer. Mineral., 36, 534–537. (4) Guiseppetti, G., G. Rossi, and C. Tadini (1971) The crystal structure of nasonite. Amer. Mineral., 56, 1174–1179. (5) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727. (6) Brès, E.F., W.G. Waddington, J.L. Hutchinson, S. Cohen, I. Mayer, and J.-C. Vogel (1987) Detection of non-hexagonal symmetry in an apatite-structure-related mineral (nasonite). Acta Cryst., 43, 171–174.

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Nastrophite $Na(Sr,Ba)PO_4 \cdot 9H_2O$

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Crystal Data: Cubic. *Point Group:* 23. As cubic crystals, to 1 cm; in irregular aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼2 D(meas.) = 2.05 D(calc.) = 2.03 Partially dehydrates under ambient conditions; partially dissolves in hot H_2O.

Optical Properties: Semitransparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Isotropic. $n = 1.502(1)$

Cell Data: *Space Group:* $P2_13$. $a = 10.559(1)$ $Z = 4$

X-ray Powder Pattern: Lovozero massif, Kola Peninsula, Russia. 2.54 (10), 4.67 (9), 5.21 (8), 3.49 (5), 1.953 (5), 3.69 (4), 1.918 (4)

Chemistry:

	(1)
P_2O_5	19.04
CaO	0.41
SrO	22.19
BaO	8.17
Na_2O	8.21
K_2O	0.05
H_2O	40.52
insol.	1.64
Total	100.23

(1) Mt. Alluaiv, Kola Peninsula, Russia; K, Na, Ca by flame photometry, insoluble = aegirine, PO_4 and H_2O confirmed by IR; separate determination of H_2O on fully hydrated material gives 43.5%, then corresponding to $Na_{0.98}(Sr_{0.79}Ba_{0.20}Ca_{0.03})_{\Sigma=1.02}P_{1.00}O_4 \cdot 8.96H_2O$.

Occurrence: In pegmatitic veinlets in cancrinite and nepheline syenites.

Association: Vuonnemite, steenstrupine-(Ce), ilmajokite, mountainite (Mt. Karnasurt, Kola Peninsula, Russia); K-feldspar, sodalite, analcime, natrolite, davyne, aegirine (Mt. Alluaiv, Kola Peninsula, Russia).

Distribution: On Mts. Karnasurt and Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: For sodium, NAtrium, STROntium, and PHosphorus in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5529; Mining Institute, St. Petersburg, 1194/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81405; The Natural History Museum, London, England, 1994,16.

References: (1) Khomyakov, A.P., M.E. Kazakova, G.N. Popova, and Y.A. Malinovskii (1981) Nastrophite $Na(Sr,Ba)PO_4 \cdot 9H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 110, 604–607 (in Russian). (2) (1982) Amer. Mineral., 67, 857 (abs. ref. 1). (3) Baturin, S.V., Y.A. Malinovskii, and N.V. Belov (1981) Crystal structure of nastrophite $Na(Sr,Ba)PO_4 \cdot 9H_2O$. Kristallografiya (Sov. Phys. Crystal.), 26, 1023–1026. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 146–147.

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Natalyite $Na(V^{3+},Cr^{3+})Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As grains, to 1 mm, commonly acicular to asbestiform ‖ [001], showing {110}, and {100} or {010}.

Physical Properties: *Cleavage:* {110}, distinct; parting on {001}. Hardness = ~7 VHN = 1013–1079 (50 g load). D(meas.) = n.d. D(calc.) = 3.55

Optical Properties: Translucent. *Color:* Bright green with a tinge of yellow; in transmitted light, emerald-green to yellow. *Streak:* Green. *Luster:* Vitreous to silky. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = greenish yellow to yellow; $Y = Z$ = emerald-green. $\alpha = 1.741(2)$ $\beta = 1.762(3)$ $\gamma = 1.762(3)$ 2V(meas.) = 8°–12°

Cell Data: *Space Group:* $C2/c$. $a = 9.58(1)$ $b = 8.72(1)$ $c = 5.27(1)$ $\beta = 107.16°$ Z = 4

X-ray Powder Pattern: Slyudyanka complex, Russia.
2.96 (10), 2.52 (10), 2.87 (8), 1.391 (8b), 2.46 (7), 6.24 (6), 4.36 (6)

Chemistry:

	(1)
SiO_2	53.15
TiO_2	0.11
Al_2O_3	0.75
V_2O_3	17.97
Cr_2O_3	12.23
MgO	1.28
CaO	1.78
Na_2O	12.65
Total	99.92

(1) Slyudyanka complex, Russia; by electron microprobe, average of five analyses; corresponds to $(Na_{0.92}Ca_{0.07})_{\Sigma=0.99}(V_{0.54}Cr_{0.36}Mg_{0.07}Al_{0.03})_{\Sigma=1.00}Si_{1.99}O_6$.

Mineral Group: Pyroxene group.

Occurrence: In Cr, V-rich diopside-quartz rocks that are part of a Precambrian metamorphic complex (Slyudyanka complex, Russia).

Association: Eskolaite–karelianite, uvarovite–goldmanite, chromian vanadian tourmaline, pyrite, apatite, diopside (Slyudyanka complex, Russia).

Distribution: From the Pereval marble quarry, near Slyudyanka, Lake Baikal, Siberia, Russia. On the Zaonezhki Peninsula, southern Karelia.

Name: In honor of the geologist Nataliya Vasil'evna Frolova (1907–1960), geologist, Irkutsk University, Irkutsk, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Reznitskii, L.Z., E.V. Skliarov, and Z.F. Ushchapovskaya (1985) Natalyite $Na(V,Cr)Si_2O_6$ – a new chromium-vanadium pyroxene from Slyudyanka. Zap. Vses. Mineral. Obshch., 114, 630–635 (in Russian). (2) (1987) Amer. Mineral., 72, 223–224 (abs. ref. 1).

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Natanite $Fe^{2+}Sn^{4+}(OH)_6$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals, to 3 mm, in irregular aggregates; massive.

Physical Properties: Hardness = 4.7 VHN = 315 D(meas.) = n.d. D(calc.) = 4.035

Optical Properties: Semitransparent. *Color:* Greenish brown; dark gray in reflected light.
Luster: Vitreous.
Optical Class: Isotropic. $n = 1.755$

Cell Data: *Space Group:* $Pn3m$. a = 7.69(1) Z = 4

X-ray Powder Pattern: Mushiston deposit, Tajikistan.
1.710 (10), 3.729 (9), 1.563 (7.5), 2.709 (7), 2.221 (5), 1.031 (4), 1.920 (3)

Chemistry:

	(1)	(2)
Sn	43.6	42.92
Fe	19.8	20.19
OH	36.3	36.89
Total	99.7	100.00

(1) Mushiston deposit, Tajikistan; by electron microprobe, average of three analyses; corresponding to $Fe_{0.99}Sn_{1.03}(OH)_{5.98}$. (2) $FeSn(OH)_6$.

Mineral Group: Schoenfliesite group.

Occurrence: Formed by oxidation of earlier tin sulfides in tin deposits.

Association: Stannite, vismirnovite, malachite, azurite, goethite (Mushiston deposit, Tajikistan); hocartite (Chat-Karagai deposit, Russia); nevskite, wolframite, cassiterite, laitakarite, guanajuatite (Nevskoye deposit, Russia); ilvaite, fluorite, jeanbandyite, pyrrhotite, siderite, quartz (Santa Eulalia, Mexico).

Distribution: In the Trudov tin deposit, Sarydzhaz Range, near Inyl'chek, and in the Chat-Karagai tin deposit, Tallas Alatan, Kyrgyzstan. From the Mushiston tin deposit, Kaznok Valley, Zeravshan Range, Tajikistan. In the Nevskoye W–Sn deposit, 25 km northwest of Omsukchan, Magadan region, Russia. In the El Potosi and San Antonio mines, Santa Eulalia, Chihuahua, Mexico. From Llallagua, Bolivia.

Name: Honors Professor Natan (Antolii) Il'ich Ginzburg (1917–1984), mineralogist and geologist, All-Union Research Institute of Mineral Resources, Moscow, Russia, student of oxidized tin deposits.

Type Material: Mining Institute, St. Petersburg, 1988/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81651.

References: (1) Marshukova, N.K., A.B. Palovskii, G.A. Sidorenko, and N.I. Chistyakova (1981) Vismirnovite, $ZnSn(OH)_6$, and natanite, $FeSn(OH)_6$, new tin minerals. Zap. Vses. Mineral. Obshch., 110, 492–500 (in Russian). (2) (1982) Amer. Mineral., 67, 1077 (abs. ref. 1). (3) (1982) Mineral. Abs., 33, 170 (abs. ref. 1).

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Natisite $Na_2TiO(SiO_4)$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As rosettelike intergrowths and grains.

Physical Properties: *Cleavage:* Perfect on {001}, distinct on {100}. Hardness = 3–4
D(meas.) = n.d. D(calc.) = 3.15

Optical Properties: Transparent to translucent. *Color:* Yellow-green to greenish gray.
Luster: Vitreous to adamantine.
Optical Class: Uniaxial (–). $\omega = 1.756(2)$ $\epsilon = 1.680(2)$

Cell Data: *Space Group:* $P4/nmm$. $a = 6.50(1)$ $c = 5.07(1)$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
2.709 (100), 5.05 (80), 1.689 (70), 2.349 (60), 1.1001 (60), 3.96 (50), 1.611 (50)

Chemistry:

	(1)	(2)
SiO_2	29.77	29.14
TiO_2	38.93	39.62
Nb_2O_5	0.72	0.18
Ta_2O_5	0.12	
FeO	0.52	1.35
MnO	0.31	0.37
Na_2O	30.32	29.47
Total	100.69	100.13

(1) Lovozero massif, Russia; by electron microprobe, average of analyses of four grains; corresponding to $Na_{1.99}(Ti_{0.99}Mn_{0.01}Fe_{0.01}Nb_{0.01})_{\Sigma=1.02}Si_{1.01}O_5$. (2) Do.; by electron microprobe.

Polymorphism & Series: Dimorphous with paranatisite.

Occurrence: In natrolite-ussingite veins cutting alkalic rocks in a differentiated alkalic massif.

Association: Chkalovite, aegirine, vuonnemite.

Distribution: On Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: For sodium, NAtrium, TItanium, and SIlicon in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3393; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; The Natural History Museum, London, England, 1994,16.

References: (1) Men'shikov, Y.P, Y.A. Pakhomovskii, E.A. Goiko, I.V. Bussen, and A.N. Mer'kov (1975) A natural tetragonal titanosilicate of sodium, natisite. Zap. Vses. Mineral. Obshch., 104, 314–317 (in Russian). (2) (1976) Amer. Mineral., 61, 339 (abs. ref. 1). (3) Khomyakov, A.P., L.I. Polezhaeva, and E.V. Sokolova (1992) Paranatisite Na_2TiSiO_5 – a new mineral. Zap. Vses. Mineral. Obshch., 121(6), 133–136 (in Russian).

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Natrite Na_2CO_3

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Crystals, to 1 cm; in veinlets, lenses, and dense granular masses. *Twinning:* Finely polysynthetic, probably due to a phase change.

Physical Properties: *Cleavage:* Perfect on {001}, good on {100}, {110}. Hardness = 3.5 D(meas.) = 2.54 D(calc.) = 2.55 Soluble in H_2O, yielding a strongly alkaline solution; surficially alters rapidly in air to thermonatrite.

Optical Properties: Transparent. *Color:* Colorless to pale yellow or pale rose if fresh, becoming grayish white on exposure. *Luster:* Vitreous to dull on exposure.
Optical Class: Biaxial (–). *Orientation:* $Y \simeq b$. $\alpha = 1.410(2)$ $\beta = 1.535(2)$ $\gamma = 1.543(2)$
2V(meas.) = 28°

Cell Data: *Space Group:* $C2/m$. $a = 8.905(4)$ $b = 5.237(3)$ $c = 6.045(2)$
$\beta = 101.32(1)°$ Z = 4

X-ray Powder Pattern: Mt. Karnasurt, Kola Peninsula, Russia.
2.962 (100), 2.366 (70), 2.545 (60), 2.602 (40), 2.254 (35), 2.175 (35), 2.621 (30)

Chemistry:

	(1)	(2)
CO_2	42.92	41.52
Na_2O	57.08	58.48
Total	[100.00]	100.00

(1) Mt. Karnasurt, Kola Peninsula, Russia; CO_2 by gravimetry, Na_2O by flame photometry; H_2O proven absent by IR, recalculated to 100% after deduction of H_2O 3.7% from admixed thermonatrite; corresponds then to $Na_{1.92}C_{1.02}O_3$. (2) Na_2CO_3.

Occurrence: Locally abundant in deep drillholes in pegmatites occurring in differentiated alkaline massifs (Kola Peninsula, Russia); in sodalite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Thermonatrite, vinogradovite, shortite, pirssonite, gaylussite, nacaphite, natrosilite, villiaumite, neighborite, rasvumite, lomonosovite, pectolite, sodalite, fluorcaphite, many other minerals.

Distribution: In Russia, on the Kola Peninsula, on Mt. Karnasurt, Lovozero massif; in the Khibiny massif, on Mt. Rasvumchorr; near the Olenii stream; on Mt. Koashva; and on Mt. Restin'yun. At Mont Saint-Hilaire, Quebec, Canada.

Name: For sodium, *natrium*, the sole cation in the chemical formula of the mineral.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5710/1; Mining Institute, St. Petersburg, 1200/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82761.

References: (1) Khomyakov, A.P. (1982) Natrite, Na_2CO_3 – a new mineral. Zap. Vses. Mineral. Obshch., 111, 220–225 (in Russian). (2) (1983) Amer. Mineral., 68, 281–282 (abs. ref. 1). (3) Zubkova, N.V., D.Y. Pushcharovskiy, G. Ivaldi, G. Ferraris, I.V. Pekov, and N.V. Chukanov (2002) Crystal structure of natrite, γ–Na_2CO_3. Neues Jahrb. Mineral., Monatsh., 85–96.

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Natroalunite $NaAl_3(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals are rhombohedral, pseudocubic, $\{01\overline{1}2\}$, with small {0001}, several other forms, to 1 mm; fibrous, columnar, typically massive.

Physical Properties: *Cleavage:* Distinct on {0001}; traces on $\{01\overline{1}2\}$. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.75–2.83 D(calc.) = 2.819

Optical Properties: Transparent to translucent. *Color:* White; less commonly gray, yellow, green, brown; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to pearly on {0001}.
Optical Class: Uniaxial (+). $\omega = 1.574$ $\epsilon = 1.590$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.982$–6.992 $c = 16.725$–16.905 $Z = 3$

X-ray Powder Pattern: Koenabib, South Africa.
2.96 (100), 4.90 (70), 2.98 (70), 2.22 (40), 1.895 (35), 3.49 (25), 1.745 (25)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	38.93	37.75	39.42	K_2O	4.26	0.39	5.80
Al_2O_3	39.03	35.66	37.66	H_2O	13.35	n.d.	13.31
Fe_2O_3		1.10		rem.		0.27	
Na_2O	4.41	6.12	3.81	insol.	0.50		
				Total	100.48		100.00

(1) National Belle mine, Colorado, USA. (2) Matanumad, India; remnant SiO_2 0.09%, TiO_2 0.10%, MnO 0.01%, CaO 0.06%, MgO 0.01%; stated to correspond to $(Na_{0.96}K_{0.04})_{\Sigma=1.00}(Al_{2.98}Fe^{3+}_{0.02})_{\Sigma=3.00}(SO_4)_2(OH)_6$. (3) $(Na,K)Al_3(SO_4)_2(OH)_6$ with Na:K = 1:1.

Polymorphism & Series: Forms a series with alunite.

Mineral Group: Alunite group.

Occurrence: Less common than alunite, formed by solfataric or hydrothermal sulfate-bearing solutions reacting with clays, rarely with sillimanite; may be in laterites and as an authigenic sedimentary mineral.

Association: Alunite, kaolinite, halloysite, sillimanite, quartz.

Distribution: In the USA, from the National Belle mine, Red Mountain district, Ouray Co., and in the Rosita Hills, Custer Co., Colorado; at Sugarloaf Butte, near Quartzsite, La Paz Co., Arizona; in Carlsbad Cavern and Lechuguilla Cave, Eddy Co., New Mexico; on Desert Strip, Molokai, Hawaiian Islands. In the Ugusu mine and at Shirakawa, Shizuoka Prefecture, and from Sonomi, Makurazaki, Kagoshima Prefecture, Japan. In the Tatum copper deposit and Chinkuashi Cu–Au deposit, Taiwan. At Kalgoorlie and Kanowna, Western Australia; from Coober Pedy, South Australia. On Ruapahu volcano and Mount Taranaki, New Zealand. From Matanumad, 110 km northwest of Bhuj, Gujarath State, India. On the Gemsa Peninsula, Egypt. At Šaca, Košice district, Slovakia. In the Blyava deposit, Southern Ural Mountains, Russia. Found in the Hotson 6 quarry, Koenabib, west of Pofadder, Cape Province, South Africa.

Name: As the sodium, *natrium*, analog of *alunite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 556–560. (2) Okada, K., J. Hirabayashi, and J. Ossaka (1982) Crystal structure of natroalunite and crystal chemistry of the alunite group. Neues Jahrb. Mineral., Monatsh., 534–540. (3) Chitale, D.V. and N. Guven (1987) Natroalunite in a lateritic profile over Deccan Trap basalts at Matanumad, Kutch, India. Clays and Clay Minerals, 35(3), 196–202. (4) Schoch, A.E., G.J. Beukes, W.A. van der Westhuizen, and H. de Bruiyn (1989) Natroalunite from Koenabib, Pofadder district, South Africa. South African J. Geol., 92(1), 20–28.

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Natroapophyllite $NaCa_4Si_8O_{20}F \cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As composite crystals, euhedral to subhedral, to 1 mm, with prismatic {100} and truncated by {111}, striated $\perp$ [001].

Physical Properties: *Cleavage:* Perfect on {001}, poor on {110}. Hardness = 4–5
D(meas.) = 2.50, including contaminants. D(calc.) = 2.30

Optical Properties: Transparent to translucent. *Color:* Colorless to white, brownish yellow to yellowish brown; colorless in thin section. *Streak:* Light gray. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+). *Dispersion:* $r < v$. $\alpha = 1.536(2)$ $\beta = 1.538(2)$ $\gamma = 1.544(2)$
2V(meas.) = 32(1)°

Cell Data: *Space Group:* $Pnnm$ or $Pnn2$. a = 8.875(4) $b = 8.881(6)$ $c = 15.79(1)$
Z = 2

X-ray Powder Pattern: Sampo mine, Japan.
3.96 (100), 2.98 (63), 2.48 (24), 7.83 (20), 4.54 (19), 7.77 (18), 2.50 (18)

Chemistry:

	(1)
SiO_2	52.79
Al_2O_3	0.00
CaO	25.41
Na_2O	3.05
K_2O	0.33
F	2.27
H_2O	[17.11]
$-O = F_2$	0.96
Total	[100.00]

(1) Sampo mine, Japan; by electron microprobe, H_2O by difference; corresponds to $(Na_{0.90}K_{0.06})_{\Sigma=0.96}Ca_{4.13}Si_8O_{20.07}F_{1.09} \cdot 8.6H_2O$.

Occurrence: In skarns, banded between granite and marble, of a contact metamorphic mineral deposit.

Association: Zeophyllite, cuspidine, apophyllite, calcite, andradite, xonotlite, wollastonite, clinopyroxene, magnetite, quartz, bismuth.

Distribution: At the Sampo mine, 10 km west of Takahashi, Okayama Prefecture, Japan.

Name: For sodium, *natrium*, in the composition, and its relation to other *apophyllite* species.

Type Material: National Science Museum, Tokyo, M21067; Institute of Mining Geology, Akita University, Akita, Japan; National Museum of Natural History, Washington, D.C., USA, 136398.

References: (1) Matsueda, H., Y. Miura, and J. Rucklidge (1981) Natroapophyllite, a new orthorhombic sodium analog of apophyllite: I. Description, occurrence, and nomenclature. Amer. Mineral., 66, 410–415. (2) Miura, Y., T. Kato, J. Rucklidge, and H. Matsueda (1981) Natroapophyllite, a new orthorhombic sodium analog of apophyllite II. Crystal structure. Amer. Mineral., 66, 416–423.

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Natrobistantite $(Na, Cs)Bi(Ta, Nb, Sb)_4O_{12}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As aggregates of octahedral crystals, to 5 mm.

Physical Properties: Hardness = n.d. VHN = 750 (40 g load). D(meas.) = 6.1–6.2 D(calc.) = 6.32 Colorless material fluoresces strong red-orange under UV.

Optical Properties: Transparent. *Color:* Yellow-green, blue-green; colorless in thin grains. *Luster:* Adamantine.
Optical Class: Isotropic. n = n.d.
R: (486) 16.7, (553) 16.5, (589) 17.0, (656) 15.7

Cell Data: *Space Group: Fd3m.* a = 10.502(3) Z = 4

X-ray Powder Pattern: Koktokay, China.
3.03 (10), 1.858 (9), 1.584 (9), 2.628 (8), 6.07 (6), 3.17 (5), 1.205 (5)

Chemistry:

	(1)
Nb_2O_5	11.21
Ta_2O_5	56.46
Sb_2O_5	2.24
TiO_2	0.09
Bi_2O_3	23.16
CaO	0.10
Na_2O	2.04
Cs_2O	4.10
Total	99.40

(1) Koktokay, China; by electron microprobe, corresponds to $(Na_{0.73}Cs_{0.32}Ca_{0.02})_{\Sigma=1.07}Bi_{1.09}(Ta_{2.83}Nb_{0.93}Sb_{0.15}Ti_{0.02})_{\Sigma=3.93}O_{12}$.

Mineral Group: Pyrochlore group.

Occurrence: Replacing bismutotantalite in museum samples from a granite pegmatite.

Association: Bismutotantalite, microlite, pucherite, clinobisvanite, bismuth oxides.

Distribution: From near Koktokay, Sinkiang-Uighur Autonomous Province [Kyokfogoi, Xinjiang Uygur Autonomous Region], China.

Name: For sodium, NATRium, BISmuth, and TANTalum in the composition [deviant from IMA pyrochlore nomenclature].

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, V.I. Stepanov, and F.N. Tyusheva (1983) Natrobistantite, $(Na, Cs)Bi(Ta, Nb, Sb)_4O_{12}$ – a new mineral from granitic pegmatite. Mineral. Zhurnal, 5(2), 82–86 (in Russian with English abs.). (2) (1984) Amer. Mineral., 69, 407–408 (abs. ref. 1).

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Natrochalcite $NaCu_2(SO_4)_2(OH)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Steep pyramidal crystals, with large {111}, truncated by {001}, {110}, many smaller forms, to 1 cm; commonly cross-vein fibrous.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 4.5 D(meas.) = 3.49(2) D(calc.) = 3.54 Slightly soluble in H_2O.

Optical Properties: Transparent to translucent. *Color:* Bright emerald-green. *Streak:* Pale greenish. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = -12°$. *Dispersion:* $r < v$, strong, slightly inclined. $\alpha = 1.649$ $\beta = 1.655$ $\gamma = 1.714$ 2V(meas.) = 36°48′

Cell Data: *Space Group:* $C2/m$ (synthetic). $a = 8.809(1)$ $b = 6.187(1)$ $c = 7.509(1)$ $\beta = 118.74(1)°$ Z = 2

X-ray Powder Pattern: Chuquicamata, Chile. (ICDD 19-1189).
2.797 (10), 6.57 (8), 3.44 (8), 2.522 (8), 3.20 (7), 4.82 (6), 2.302 (6)

Chemistry:

	(1)	(2)
SO_3	42.42	43.01
CuO	42.01	42.74
Na_2O	7.98	6.99
H_2O	7.71	7.26
Total	100.12	100.00

(1) Chuquicamata, Chile. (2) $NaCu_2(SO_4)_2(OH)\cdot H_2O$.

Mineral Group: Tsumcorite group.

Occurrence: A rare mineral typically formed in an arid climate in the oxidized zone of copper deposits.

Association: Kröhnkite, antlerite, brochantite, chalcanthite, blödite, atacamite, gypsum (Chuquicamata, Chile); kröhnkite, brochantite (Capo Calamita, Italy).

Distribution: In Chile, from Chuquicamata, at the Fortuna mine, east of Baquedano, and from the Santiagina mine, Sierra Gorda, southwest of Calama, Antofagasta. At Capo Calamita, Elba, Italy.

Name: From the Latin for sodium, *natrium*, and the Greek for copper, *chalkos*, in the composition.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 97537, 97538.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 602–603. (2) Rumanova, I.M. and G.F. Volodina (1958) The crystal structure of natrochalcite, $NaCu_2OH(SO_4)_2\cdot H_2O = Na(SO_4)_2(Cu_2OH\cdot H_2O)$. Doklady Acad. Nauk SSSR, 123, 78–81 (in Russian). (3) Giester, G. (1989) The crystal structures of $Ag^+Cu_2(OH)(SO_4)_2\cdot H_2O$ and $Me^+Cu_2(OH)(SeO_4)_2\cdot H_2O$ [Me^+=Ag, Tl, NH_4], four new representatives of the natrochalcite type, with a note on natural natrochalcite. Zeits. Krist., 187, 239–247. (4) Beran, A., G. Giester, and E. Libowitzky (1997) The hydrogen bond system in natrochalcite-type compounds – an FTIR spectroscopic study of the $H_3O_2^-$ unit. Mineral. Petrol., 61, 223–235.

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Natrodufrénite $Na(Fe^{3+},Fe^{2+})(Fe^{3+},Al)_5(PO_4)_4(OH)_6 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $[2/m]$ (by analogy to dufrénite). As radially fibrous spherulites, to 5 mm, may be in warty nodules.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.20(5) D(calc.) = 3.23

Optical Properties: Translucent. *Color:* Greenish brown. *Streak:* Green. *Optical Class:* Biaxial (+). *Pleochroism:* X = pale yellow; Z = dark green. *Orientation:* Positive elongation. $\alpha = 1.765(5)$ (α') β = n.d. $\gamma = 1.775(5)$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* $[C2/c]$ (by analogy to dufrénite). $a = 25.83(2)$ $b = 5.150(3)$ $c = 13.772(9)$ $\beta = 111°32'$ Z = 4

X-ray Powder Pattern: Rochefort-en-Terre, France; close to dufrénite. 3.152 (100), 12.04 (80), 3.400 (80), 3.204 (80), 5.040 (60), 4.124 (50), 2.989 (50)

Chemistry:

	(1)
P_2O_5	32.67
Al_2O_3	5.51
Fe_2O_3	46.21
FeO	0.42
CaO	0.14
Na_2O	2.36
H_2O^+	13.04
Total	100.35

(1) Rochefort-en-Terre, France; Na, Al, Ca by AA, P, Fe by colorimetry, H_2O by the Penfield method; thought to correspond to $[Na_{0.63}(H_2O)_{0.35}Ca_{0.02}]_{\Sigma=1.00}(Fe^{3+}_{0.67}Fe^{2+}_{0.05})_{\Sigma=0.72}(Fe^{3+}_{4.11}Al_{0.89})_{\Sigma=5.00}[(PO_4)_{3.80}(H_4O_4)_{0.20}]_{\Sigma=4.00}[(OH)_{5.56}(H_2O)_{0.44}]_{\Sigma=6.00} \cdot 2H_2O$.

Occurrence: A low-temperature secondary mineral.

Association: Cyrilovite, goethite.

Distribution: From Rochefort-en-Terre, Morbihan, France. At the Pinilla de Fermoselle pegmatite, Zamora, Spain. In Australia, at the Mt. Oxide mine, Mt. Isa district, Queensland; in the Lake Boga granite quarry, near Swan Hill, Victoria; and at Broken Hill, New South Wales. From the Lone Star copper deposit, Safford district, Graham Co., Arizona, USA.

Name: For essential sodium, *natrium*, and its relation to *dufrénite*.

Type Material: Natural History Museum, Paris, 106384, 106385; National School of Mines, Paris, France, 18329.

References: (1) Fontan, F., F. Pillard, and F. Permingeat (1982) La natrodufrénite (Na, □) $(Fe^{+++},Fe^{++})(Fe^{+++},Al)_5(PO_4)_4(OH)_6 \cdot 2H_2O$, une nouvelle espèce minérale du groupe de la dufrénite. Bull. Minéral., 105, 321–326 (in French with English abs.). (2) (1983) Amer. Mineral., 68, 1039 (abs. ref. 1).

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Natrofairchildite $Na_2Ca(CO_3)_2$

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Crystal Data: Hexagonal (by analogy to fairchildite). *Point Group:* $6/m\ 2/m\ 2/m$. Crystals are flattened, to 2 mm, and as fan-shaped aggregates. *Twinning:* Polysynthetic, observed along {0001} cleavage.

Physical Properties: *Cleavage:* On {0001}. Hardness = 2.5 D(meas.) = n.d. D(calc.) = 2.14 Weak orange fluorescence.

Optical Properties: Semitransparent. *Color:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–), may be weakly birefringent. $\omega = 1.525$ $\epsilon = 1.459$

Cell Data: *Space Group:* $P6_3/mmc$ (ICDD 25-804). $a = 5.291$ $c = 13.218$ Z = 2

X-ray Powder Pattern: Vuoriyarvi complex, Kola Peninsula, Russia. 3.18 (10), 2.64 (9), 6.71 (6), 2.20 (6), 1.891 (6), 2.67 (4), 4.50 (3)

Chemistry:

	(1)	(2)
CO_2	41.93	42.71
CaO	25.61	27.21
SrO	0.85	
BaO	0.44	
Na_2O	29.46	30.08
K_2O	1.35	
Total	99.64	100.00

(1) Vuoriyarvi complex, Kola Peninsula, Russia; corresponds to $(Na_{1.99}K_{0.06})_{\Sigma=2.05}(Ca_{0.96}Sr_{0.02}Ba_{0.01})_{\Sigma=0.99}(CO_3)_{2.00}$. (2) $Na_2Ca(CO_3)_2$.

Polymorphism & Series: Trimorphous with nyerereite and zemkorite.

Occurrence: In a carbonatite complex, at depths below 70 m.

Association: Calcite, burbankite.

Distribution: From the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia.

Name: As the sodium, *natrium*, analog of *fairchildite*.

Type Material: n.d.

References: (1) Kapustin, Y.L. (1971) Mineralogy of carbonatites [sodium-fairchildite]. Izdat. "Nauka", Moscow, 181–183 (in Russian). (2) (1975) Amer. Mineral., 60, 488 (abs. ref. 1).

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Natrojarosite $NaFe_3^{3+}(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals, to 1 mm, are typically pseudocubic, $\{01\bar{1}2\}$, may be flattened on {0001} to give a hexagonal shape; typically in earthy crusts, pulverulent masses, and as a powder.

Physical Properties: *Cleavage:* Perfect on {0001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 3.11–3.18 D(calc.) = 3.29

Optical Properties: Transparent to translucent. *Color:* Bright yellow, golden brown, cinnamon-brown. *Luster:* Vitreous.
Optical Class: Uniaxial (–); may exhibit sectored anomalous birefringence. *Pleochroism:* O = pale yellowish; E = nearly colorless. $\omega = 1.832(5)$ $\epsilon = 1.750(5)$

Cell Data: *Space Group: R*3*m*. $a = 7.327$–7.34 $c = 16.634$–16.72 $Z = 3$

X-ray Powder Pattern: Gypsum Spring anticline, Carbon Co., Montana, USA.
5.06 (vs), 3.06 (s), 3.12 (ms), 2.24 (m), 1.98 (m), 5.57 (mw), 1.83 (mw)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	32.30	33.2	33.04	Na_2O	6.32	7.0	6.39
P_2O_5	0.20			K_2O	0.68	0.0	
Fe_2O_3	49.86	48.9	49.42	H_2O	10.93	[10.9]	11.15
FeO	0.16			Total	100.45	[100.0]	100.00

(1) Kundip, Western Australia; corresponding to $(Na_{0.94}K_{0.06})_{\Sigma=1.00}Fe_3(SO_4)_2(OH)_6$. (2) Tintic Standard mine, Dividend, Utah Co., Utah, USA; by electron microprobe, H_2O by difference; corresponds to $Na_{1.09}Fe_{2.95}(SO_4)_{2.00}(OH)_{5.88}$. (3) $NaFe_3(SO_4)_2(OH)_6$.

Polymorphism & Series: Forms a series with jarosite.

Mineral Group: Alunite group.

Occurrence: Formed typically in the oxidized zone of mineral deposits by alteration of pyrite in the presence of sodium; rarely as a volcanic sublimate.

Association: Gypsum, alunite, jarosite, plumbojarosite.

Distribution: In small amounts at many localities. In the USA, on the east side of Soda Springs Valley, Mineral Co., and at Gilbert, 40 km east of Mina, Esmeralda Co., Nevada; at Cook's Peak, Luna Co., New Mexico; on the Georgia Sunset claim, about 6 km south of Kingman, Mohave Co., Arizona; in the Tintic district, Juab Co., Utah; from Palos Verdes, Los Angeles Co., California; at the Buxton mine, Lawrence Co., Kansas. Along Rapid Creek, Yukon Territory, Canada. In the San Toy mine, Santa Eulalia, Chihuahua, Mexico. From Chuquicamata, Antofagasta, Chile. In Spain, at the Rio Tinto mine, Huelva Province. From the Wanthwaite mine, St. John-in-the-Vale, Cumbria, England. On Valachov Hill, near Skřivaň, and at Jáchymov (Joachimsthal), Czech Republic. From Modum, Norway. At Pavlodar, Kazakhstan. On volcanos along the Kamchatka Peninsula, Russia. In South Australia, at Boolcoomatta, and from Kundip, Philips River goldfield, Western Australia.

Name: As the sodium, *natrium*, analog of *jarosite*.

Type Material: Yale University, New Haven, Connecticut, USA, 3.3160; National Museum of Natural History, Washington, D.C., USA, 86932, R6307.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 563–565. (2) Brophy, G.P. and M.F. Sheridan (1965) Sulfate studies IV: the jarosite-natrojarosite-hydronium jarosite solid solution series. Amer. Mineral., 50, 1595–1607. (3) Menchetti, S. and C. Sabelli (1976) Crystal chemistry of the alunite series: crystal structure refinement of alunite and synthetic jarosite. Neues Jahrb. Mineral., Monatsh., 406–417. (4) Jambor, J.L. and J.E. Dutrizac (1983) Beaverite-plumbojarosite solid solutions. Can. Mineral., 21, 101–113. (5) Mitchell, R.S. and W.F. Giannini (1958) Natrojarosite from near the Montana-Wyoming line. Amer. Mineral., 43, 1205–1210.

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Natrolite $Na_2Al_2Si_3O_{10}\cdot 2H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $mm2$. Crystals short to long prismatic, to 1 m, commonly with {110} terminated by {111}, striated ‖ elongation. In stellate or interlacing groups; also radiating fibrous, granular, or compact, massive. *Twinning:* On {110}, {011}, {031}.

Physical Properties: *Cleavage:* {110}, perfect; parting on {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.20–2.26 D(calc.) = 2.25 Pyroelectric, piezoelectric; commonly fluoresces orange to yellow under UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, bluish, yellowish, pink; colorless in thin section. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, weak.
$\alpha = 1.473$–1.483 $\beta = 1.476$–1.486 $\gamma = 1.485$–1.496 2V(meas.) = 58°–64°

Cell Data: *Space Group:* $Fdd2$. $a = 18.272(6)$ $b = 18.613(6)$ $c = 6.593(2)$ Z = 8

X-ray Powder Pattern: Wingendorf, Lauban, Poland; may be confused with gonnardite. (ICDD 20-759).
2.85 (100), 5.89 (85), 2.87 (80), 4.35 (70), 6.55 (60), 3.16 (50), 3.19 (45)

Chemistry:

	(1)
SiO_2	47.60
Al_2O_3	27.40
CaO	0.13
Na_2O	15.36
K_2O	0.23
H_2O	9.47
Total	100.19

(1) Puy de Marman, France; corresponds to $(Na_{1.88}K_{0.02}Ca_{0.01})_{\Sigma=1.91}Al_{2.03}Si_{3.00}O_{10}\cdot 1.99H_2O$.

Polymorphism & Series: Dimorphous with tetranatrolite.

Mineral Group: Zeolite group.

Occurrence: In cavities in amygdaloidal basalts and related igneous rocks, one of the last minerals to form; fills seams in granite, gneiss, and syenite.

Association: Zeolites, calcite, nepheline, sodalite, quartz.

Distribution: Many localities, even for fine crystals. From the Höwenegg quarry, Hegau, Baden-Württemberg, Germany. At Puy de Marman, near Veyre, Puy-de-Dôme, France. In the Dean quarry, St. Keverne, Lizard Peninsula, Cornwall, England. At White Head, Co. Antrim, Ireland. From the Langesundsfjord and Tvedalen areas, Norway. In the Khibiny and Lovozero massifs, Kola Peninsula, Russia, large crystals. In the USA, at Bergen Hill, Hudson Co., at Prospect Park, Passaic Co., and in the Chimney Rock quarry, Bound Brook, Passaic Co., New Jersey; from north of Livingstone, Park Co., Montana; around Springfield, Lane Co., Oregon; and at the Gem mine, San Benito Co., California, USA. In Canada, huge crystals from the Johnston asbestos mine, near Thetford, and from Mont Saint-Hilaire, Quebec; in the Bay of Fundy district, Nova Scotia; and along the Ice River, British Columbia.

Name: From the Latin *natron*, for the sodium content.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 600–604. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 358–376. (3) Artioli, G., J.V. Smith, and Å Kvick (1984) Neutron diffraction study of natrolite, $Na_2Al_2Si_3O_{10}\cdot 2H_2O$, at 20 K. Acta Cryst., C40, 1658–1662.

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Natromontebrasite $(Na, Li)Al(PO_4)(OH, F)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Anhedral to rough crystals, showing {001}, {010}, {100}, {$1\overline{2}0$}, {$0\overline{2}1$}, {$\overline{1}01$}, to 15 cm; usually in cleavable masses. *Twinning:* Polysynthetic, in two directions.

Physical Properties: *Cleavage:* {001}, good; {100}, fair. *Fracture:* [Uneven to subconchoidal] (by analogy to amblygonite). *Tenacity:* [Brittle.] Hardness = 5.5 D(meas.) = 3.01–3.06 D(calc.) = n.d. Fluoresces greenish yellow-orange under SW UV, cream-white under LW UV.

Optical Properties: Translucent to opaque. *Color:* Grayish to white. *Luster:* Vitreous to greasy, chalky on weathering.
Optical Class: Biaxial (+). $\alpha = 1.594$ $\beta = 1.603$ $\gamma = 1.615$ 2V(meas.) = Very large.

Cell Data: *Space Group:* $P\overline{1}$. a = n.d. b = n.d. c = n.d. α = n.d. β = n.d. γ = n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
P_2O_5	44.35	45.81
Al_2O_3	33.59	32.90
Na_2O	11.23	10.02
K_2O	0.14	
Li_2O	3.21	4.82
F	5.63	6.13
H_2O	4.78	2.90
$-O = F_2$	2.37	2.58
Total	100.56	100.00

(1) Eight Mile Park, Colorado, USA. (2) $(Na, Li)Al(PO_4)(OH, F)$ with Na:Li = 1:1 and OH:F = 1:1.

Mineral Group: Amblygonite group.

Occurrence: In granite pegmatites.

Association: Lepidolite, quartz, elbaite, mica (Eight Mile Park, Colorado, USA).

Distribution: In the USA, from Eight Mile Park, about six km northwest of Cañon City, Fremont Co., Colorado; in the Strickland quarry, Portland, Middlesex Co., Connecticut. At Jeclov, near Jihlava, Czech Republic. From the Tremearne pegmatite, Breage, Cornwall. In Brazil, large crystals from Presidente Bueno, Rio Doce Valley, Minas Gerais. At the Rusororo pegmatite, Gatumba district, Rwanda.

Name: For its content of sodium, *natrium*, and relation to *montebrasite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 86843, 87490.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 823–827. (2) Heinrich, E.W. (1948) Pegmatites of Eight Mile Park, Fremont County, Colorado. Amer. Mineral., 33, 550–587, esp. 561–562.

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Natron $Na_2CO_3 \cdot 10H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Granular to fine crystalline, as crusts, efflorescences, and coatings. *Twinning:* On {001}.

Physical Properties: *Cleavage:* Distinct on {001}; imperfect on {010}; in traces on {110}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1–1.5 D(meas.) = 1.478 D(calc.) = 1.458 Soluble in H_2O, alkaline taste; dehydrates rapidly in air forming thermonatrite.

Optical Properties: Semitransparent. *Color:* Colorless to white, may be yellow or gray due to impurities; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c \simeq 41°$. *Dispersion:* $r > v$, perceptible, crossed. $\alpha = 1.405(3)$ $\beta = 1.425(3)$ $\gamma = 1.440(3)$ 2V(meas.) = Large.

Cell Data: *Space Group:* Cc (synthetic). $a = 12.83(2)$ $b = 9.026(9)$ $c = 13.44(5)$ $\beta = 123.0(5)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 15-800).
3.04 (100), 3.02 (70), 2.894 (60), 5.37 (45), 3.94 (30), 3.45 (25), 4.50 (20)

Chemistry:

	(1)	(2)
SO_3	0.83	
CO_2	15.66	15.38
MgO	0.15	
CaO	0.18	
Na_2O	21.50	21.66
Cl	0.41	
H_2O	61.69	62.96
Total	100.42	100.00

(1) Hall, Austria. (2) $Na_2CO_3 \cdot 10H_2O$.

Occurrence: Formed on the margins around soda-rich lakes, or as a precipitate on lake bottoms during cold weather; as an efflorescence on lavas; rare in differentiated alkaline massifs.

Association: Thermonatrite, trona, mirabilite, gaylussite, gypsum, calcite.

Distribution: Many reported occurrences may be of thermonatrite, an easily-obtained alteration product. Confirmed occurrences include: from the Debrecen and Szeged districts, Hungary. In Austria, in the Salzburger Schacht, Untersberg; at Hall, Tirol, from Dürrnberg, near Hallein, and at Hallstatt. On Vesuvius, Campania, and Etna, Sicily, Italy. On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia. In the USA, noted in the Mt. Pisgah lava tubes, Mohave Desert, San Bernardino Co., California, and in Colorado, formed around artesian wells in the San Luis Valley, Costilla Co. In Goodenough Lake, near Clinton, British Columbia, and at Mont Saint-Hilaire, Quebec, Canada. Around Lake Fellmongery, Robe, South Australia.

Name: From *nitrum*, a name from antiquity.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 230–231. (2) Hintze, C. (1916–1929) Handbuch der Mineralogie, Gruyter & Co., Berlin, I(3.1), 2778–2787 [soda], esp. 2786 (in German). (3) Taga, T. (1969) Crystal structure of $Na_2CO_3 \cdot 10H_2O$. Acta Cryst., 25, 2656–2658.

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Natronambulite $(Na,Li)Mn_4^{2+}Si_5O_{14}(OH)$

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Crystal Data: Triclinic. *Point Group:* 1 or $\bar{1}$. Tabular prismatic crystals, to 6 cm; also as coarse-grained mosaic aggregates.

Physical Properties: *Cleavage:* Perfect on {100} and {001}, distinct on {010}. Hardness = 5.5–6 D(meas.) = 3.51 D(calc.) = 3.50

Optical Properties: Transparent. *Color:* Pinkish orange to pink, deep red; in thin section, very pale yellow. *Streak:* White, with slight orange tint. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Dispersion:* $r > v$, distinct. *Absorption:* $Z > Y = X$. $\alpha = 1.703$–1.706 $\beta = 1.710$–1.712 $\gamma = 1.726$–1.730 2V(meas.) = 45°–48°

Cell Data: *Space Group:* $P1$ or $P\bar{1}$. $a = 7.620$ $b = 11.762$ $c = 6.737$ $\alpha = 92.81°$ $\beta = 94.55°$ $\gamma = 106.87°$ Z = [2]

X-ray Powder Pattern: Tanohata mine, Japan.
3.559 (100), 7.13 (47), 3.078 (45), 6.70 (44), 3.348 (40), 2.506 (38), 2.972 (34)

Chemistry:

	(1)	(2)
SiO_2	49.20	48.97
FeO	0.11	0.15
MnO	39.46	40.30
MgO	1.11	2.16
CaO	3.42	2.87
Li_2O	0.44	0.98
Na_2O	4.14	3.12
H_2O^+	1.48	1.50
H_2O^-		0.20
Total	99.36	100.25

(1) Tanohata mine, Japan; by electron microprobe, Li and H_2O by wet chemical analysis; corresponds to $(Na_{0.82}Li_{0.18})_{\Sigma=1.00}(Mn_{3.41}Ca_{0.37}Mg_{0.17}Fe_{0.01})_{\Sigma=3.96}Si_{5.02}O_{14.00}(OH)_{1.00}$.
(2) Kombat mine, Namibia; corresponds to $(Na_{0.61}Li_{0.40})_{\Sigma=1.01}(Mn_{3.45}Mg_{0.33}Ca_{0.31}Fe_{0.01})_{\Sigma=4.10}Si_{4.95}O_{13.99}(OH)_{1.01}$.

Polymorphism & Series: Forms a series with nambulite.

Occurrence: In banded ore of a contact metamorphosed bedded manganese deposit, and as an accessory mineral in an albite-microcline-quartz pegmatite cutting the ore (Tanohata mine, Japan).

Association: Aegirine, manganoan arfvedsonite, rhodonite, kôzulite, marsturite, sérandite, quartz, albite, microcline (Tanohata mine, Japan); gypsum, brushite, cahnite, chlorite, kentrolite, barite, calcite (Kombat mine, Namibia).

Distribution: From the Tanohata mine, Iwate Prefecture, Japan. At the Kombat mine, 49 km south of Tsumeb, Namibia.

Name: For sodium, *natrium*, in its composition, and its relation to *nambulite*.

Type Material: National Science Museum, Tokyo, Japan, M23817.

References: (1) Matsubara, S., A. Kato, and T. Tiba (1985) Natronambulite, (Na, Li)(Mn, Ca)$_4$Si$_5$O$_{14}$OH, a new mineral from the Tanohata mine, Iwate Prefecture, Japan. Mineral. J. (Japan), 12, 332–340. (2) (1987) Amer. Mineral., 72, 224 (abs. ref. 1). (3) von Knorring, O., T.G. Sahama, and R. Törnroos (1978) Second find of nambulite. Neues Jahrb. Mineral., Monatsh., 346–348.

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Natroniobite $NaNbO_3$

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Crystal Data: Monoclinic, probable. *Point Group:* n.d. As irregular grains and in fine-grained aggregates.

Physical Properties: Hardness = 5.5–6 D(meas.) = 4.40 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Pale yellowish, pale brown, pale black. *Optical Class:* Biaxial (–). *Orientation:* $X \wedge c' = 10°–15°$. *Dispersion:* $r < v$, strong. $\alpha = 2.10–2.13$ $\beta = 2.19–2.21$ $\gamma = 2.21–2.24$ 2V(meas.) = 10°–30°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kola Peninsula, Russia.
2.97 (10), 3.06 (9), 1.60 (8), 1.72 (6), 1.89 (5), 3.79 (4), 1.59 (4)

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	74.06	81.09	Fe_2O_3	1.35	
Ta_2O_5	0.83		MnO	0.05	
SiO_2	0.97		MgO	0.35	
TiO_2	5.56		CaO	2.80	
ThO_2	0.56		Na_2O	9.08	18.91
Al_2O_3	0.20		F	0.00	
RE_2O_3	3.25		H_2O	0.67	
			Total	99.73	100.00

(1) Kola Peninsula, Russia. (2) $NaNbO_3$.

Polymorphism & Series: Dimorphous with isolueshite and lueshite.

Occurrence: Replacing perovskite and pyrochlore in dolomite carbonatites.

Association: Dolomite, apatite, phlogopite, perovskite, pyrochlore.

Distribution: From the Lesnaya Varaka massif, Kola Peninsula, Russia. In the Sallanlatvi massif, northern Karelia, Russia. At Gem Park, about six km east of Hillside, Fremont Co., Colorado, USA.

Name: For sodium, NATRium, and NIOBium in the composition.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, Russia, 17401.

References: (1) Bulakh, A.G., A.A. Kukharenko, Y.N. Knipovich, V.V. Kondrat'eva, K.A. Baklanova, and E.N. Baranova (1960) Some new minerals in carbonatites of the Kola Peninsula. Mat. Vses. Nauk Geol. Inst. 1960, 114–116. (2) (1962) Amer. Mineral., 47, 1483 (abs. ref. 1).

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Natrophilite $NaMn^{2+}PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely as crystals; granular, cleavable massive.

Physical Properties: *Cleavage:* {001}, good; {100}, indistinct; {210}, interrupted. *Fracture:* Conchoidal. Hardness = 4.5–5 D(meas.) = 3.41 D(calc.) = 3.47

Optical Properties: Transparent to translucent. *Color:* Deep wine-yellow. *Luster:* Bright resinous to nearly adamantine, somewhat pearly on the {001} cleavage.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, strong.
$\alpha = 1.671(3)$ $\beta = 1.674(3)$ $\gamma = 1.684(3)$ 2V(meas.) = 75(5)°

Cell Data: *Space Group: Pnam.* $a = 10.523(5)$ $b = 4.987(2)$ $c = 6.312(3)$ Z = 4

X-ray Powder Pattern: Branchville, Connecticut, USA.
2.604 (10), 2.583 (10), 2.863 (8), 1.831 (7), 4.498 (6), 4.045 (6), 3.656 (5)

Chemistry:

	(1)	(2)
P_2O_5	41.03	41.05
FeO	3.06	
MnO	38.19	41.03
Li_2O	0.19	
Na_2O	16.79	17.92
H_2O	0.43	
insol.	0.81	
Total	100.50	100.00

(1) Branchville, Connecticut, USA. (2) $NaMnPO_4$.

Occurrence: A rare mineral, replacing lithiophilite, in a complex granite pegmatite.

Association: Lithiophilite, triploidite, eosphorite, huréaulite, fairfieldite, dickinsonite.

Distribution: From Branchville, Fairfield Co., Connecticut, USA.

Name: For its content of sodium, *natrium*, and from the Greek for *a friend*.

Type Material: Yale University, New Haven, Connecticut, 3.2362–3.2364; Harvard University, Cambridge, Massachusetts, USA, 95263.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 670–671. (2) Moore, P.B. (1972) Natrophilite, $NaMn(PO_4)$, has ordered cations. Amer. Mineral., 57, 1333–1344.

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Natrophosphate $Na_7(PO_4)_2(F,Cl)\cdot 19H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rare as octahedra, dodecahedra, or tetrahedra, to 1 cm, typically rounded; in monomineralic aggregates and veinlets.

Physical Properties: *Cleavage:* On {111}, imperfect, in slightly altered specimens. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1–2.5 D(meas.) = 1.71–1.72 D(calc.) = n.d. Fluoresces pale orange under UV, with a stronger orange cathodoluminescence; partially decomposes to a white powder on exposure to air, dissolves in H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous to greasy, waxy to frosty on exposure.
Optical Class: Isotropic. n = 1.450–1.462

Cell Data: *Space Group: Fd3c.* a = 27.79–27.93 Z = 56

X-ray Powder Pattern: Mt. Yukspor, Kola Peninsula, Russia.
2.67 (10), 2.42 (9), 8.18 (7), 3.05 (6), 4.93 (5), 4.06 (5), 2.90 (5)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3		0.97	F	3.20	3.30
P_2O_5	21.51	18.00	Cl		1.86
CO_2	2.60		H_2O	41.30	47.04
Na_2O	32.60	29.53	$-O = (F,Cl)$	1.34	1.81
			Total	99.87	98.89

(1) Mt. Karnasurt, Kola Peninsula, Russia; with a separate DTA determination of H_2O 47.0%, and after deduction of CO_2 attributed to atmospheric contamination, then corresponds to $Na_{6.94}(PO_4)_2F_{1.11}\cdot 18.2H_2O$. (2) Aris quarry, Namibia; Na by AA, P, S, F, Cl by ion chromatograph, H_2O by Karl-Fischer titration; corresponds to $Na_{7.04}[(PO_4)_{1.87}(SO_4)_{0.09}]_{\Sigma=1.96}(F_{1.28}Cl_{0.39})_{\Sigma=1.67}\cdot 19.29H_2O$.

Occurrence: A rare mineral in ijolite-urtite pegmatite in a differentiated alkaline massif (Kola Peninsula, Russia); in sodalite xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in miarolitic cavities in phonolite (Aris quarry, Namibia).

Association: Villiaumite, aegirine, delhayelite, strontian apatite, natrolite, pectolite, albite (Mt. Yukspor, Kola Peninsula, Russia); villiaumite, nahpoite, dorfmanite, kogarkoite, sidorenkite, thermonatrite, analcime, aegirine (Mts. Alluaiv and Karnasurt, Kola Peninsula, Russia); villiaumite, ussingite, vuonnemite, lovozerite, eudialyte, steenstrupine, chkalovite, lueshite, serandite, griceite, kogarkoite (Mont Saint-Hilaire, Canada); villiaumite, aegirine, albite, eudialyte (Aris quarry, Namibia).

Distribution: On Mts. Yukspor and Koashva, Khibiny massif, and Mts. Karnasurt and Alluaiv, Lovozero massif, Kola Peninsula, Russia. From Mont Saint-Hilaire, Quebec, Canada. In the Aris quarry, about 25 km south of Windhoek, Namibia.

Name: For sodium, *natrium*, and *phosphate* in the composition.

Type Material: Vernadsky Geological Museum, Moscow, 51117; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74383.

References: (1) Kapustin, Y.L., A.V. Bykova, and V.I. Bukin (1972) Natrophosphate – a new mineral. Zap. Vses. Mineral. Obshch., 101, 80–86 (in Russian). (2) (1973) Amer. Mineral., 58, 139 (abs. ref. 1). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 325. (4) Genkina, E.A. and A.P. Khomyakov (1992) Refinement of the crystal structure of natural natrophosphate. Kristallografiya (Sov. Phys. Crystal.), 37, 1559–1560. (5) Khomyakov, A.P. (1995) Mineralogy of hyperagpaitic alkaline rocks, 162–164. (6) Petersen, O.V., T. Fockenberg, P.C. Toft, and M. Rattay (1997) Natrophosphate from the Aris phonolites, Windhoek, Namibia. Neues Jahrb. Mineral., Monatsh., 511–517.

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Natrosilite $Na_2Si_2O_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Thick tabular pseudohexagonal crystals, to 6 cm; granular.

Physical Properties: *Cleavage:* {100}, perfect micaceous; {001}, distinct; {011}, poor. Hardness = n.d. D(meas.) = 2.48 D(calc.) = 2.51 Soluble in water.

Optical Properties: Transparent. *Color:* Colorless; anomalous blue interference colors in thin section. *Luster:* Pearly.
Optical Class: Biaxial (–). *Orientation:* $Y \wedge c = -12°$ to 2°. *Dispersion:* $r < v$. $\alpha = 1.507$. $\beta = 1.517$ $\gamma = 1.521$ 2V(meas.) = 49°–64°

Cell Data: *Space Group:* $P2_1/a$. a = 12.30(2) $b = 4.88(1)$ $c = 8.27(3)$ $\beta = 104°14'$ Z = 4

X-ray Powder Pattern: Lovozero massif, Russia.
6.06 (10), 2.98 (9), 3.97 (8), 2.435 (8), 3.64 (7), 4.17 (6), 4.28 (5)

Chemistry:

	(1)	(2)
SiO_2	66.03	65.97
Na_2O	33.96	34.03
K_2O	0.01	
H_2O^-	0.06	
Total	100.06	100.00

(1) Lovozero massif, Russia; by electron microprobe and wet chemical analysis; organic matter 0.4%. (2) $Na_2Si_2O_5$.

Occurrence: In pegmatites in nepheline syenites in differentiated alkalic massifs (Kola Peninsula, Russia); in sodalite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Microcline, analcime, natrolite, lomonosovite, ussingite, vuonnemite (Lovozero massif, Russia); aenigmatite, aegirine, sodalite, cancrinite, eudialyte (Khibiny massif, Russia); revdite (Mont Saint-Hilaire, Canada).

Distribution: On Mt. Karnasurt, Lovozero massif, and in the Khibiny massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For sodium, NATRium, and SILicon in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3394; Mining Institute, St. Petersburg, 1087/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis5123, vis5147.

References: (1) Timoshenkov, I.M., Y.P. Men'shikov, L.F. Gannibal, and I.V. Bussen (1975) A natural sodium silicate, natrosilite, from the Lovozero massif. Zap. Vses. Mineral. Obshch., 104, 317–321 (in Russian). (2) (1976) Amer. Mineral., 61, 339–340 (abs. ref. 1). (3) Khomyakov, A.P. (1982) First discovery of Lovozero natrosilite in the Khibina massif and Khibina zirsinalite and rasvumite in the Lovozero massif. Nov. Dannye Miner., 30, 168–173 (in Russian). (4) (1983) Chem. Abs., 53, 219073 (abs. ref. 3).

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Natrotantite $Na_2Ta_4O_{11}$

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Crystal Data: Hexagonal, pseudomonoclinic. *Point Group:* $\overline{3}$ $2/m$. Rimming crystals of simpsonite, in turn rimmed by alumotantite; intergrown with microlite.

Physical Properties: *Fracture:* Uneven. Hardness = n.d. VHN = 1270 (40 g load). D(meas.) = n.d. D(calc.) = n.d. Strong yellow-green cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless, with slight yellowish tint.
Luster: Adamantine.
Optical Class: Uniaxial. *Anisotropism:* Strong.
R_1–R_2: (486) 15.0–13.6, (589) 12.4–11.8, (656) 12.0–12.0

Cell Data: *Space Group:* $R\overline{3}c$. $a = 6.2092(1)$ $c = 36.619(1)$ Z = 6

X-ray Powder Pattern: Kola Peninsula, Russia.
3.02 (10b), 2.778 (9b), 1.556 (8), 1.548 (8), 3.06 (7), 2.474 (6b), 1.799 (6b)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	2.71	1.0	
Ta_2O_5	91.26	94.3	93.45
PbO	0.87	0.6	
CaO	0.08	0.3	
Na_2O	4.69	3.1	6.55
K_2O		0.06	
Total	99.61	99.4	100.00

(1) Kola Peninsula, Russia; by electron microprobe, corresponding to $(Na_{1.40}Pb_{0.04}Ca_{0.01})_{\Sigma=1.45}(Ta_{3.81}Nb_{0.19})_{\Sigma=4.00}O_{10.75}$. (2) Alto do Giz pegmatite, Brazil; by electron microprobe, corresponding to $(Na_{0.93}Ca_{0.04}Pb_{0.03}K_{0.01})_{\Sigma=1.01}(Ta_{3.93}Nb_{0.07})_{\Sigma=4.00}O_{10.54}$. (3) $Na_2Ta_4O_{11}$.

Occurrence: In albite units of granite pegmatites.

Association: Simpsonite, alumotantite, microlite, sosedkoite.

Distribution: From Mt. Vasin-Myl'k, Voroni massif, Kola Peninsula, Russia. At the Alto do Giz pegmatite, near Parelhas, Rio Grande do Norte, Brazil.

Name: For sodium, NATRium, and TANTalum in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, Russia, 5518.

References: (1) Voloshin, A.V., Y.P. Men'shikov, and Y.A. Pakhomovskii (1981) Alumotantite and natrotantite, new tantalum minerals in granitic pegmatites. Zap. Vses. Mineral. Obshch., 110, 338–345 (in Russian). (2) (1982) Amer. Mineral., 67, 413 (abs. ref. 1). (3) Ercit, T.S., F.C. Hawthorne, and P. Černý (1985) The crystal structure of synthetic natrotantite. Bull. Minéral., 108, 541–549.

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Natrotitanite $(Na_{0.5}Y_{0.5})Ti(SiO_4)O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As chemically and optically distinct thin rims on prismatic crystals of (Na,Y,REE)-bearing titanite.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.833

Optical Properties: Transparent to translucent. *Color*: Milky white to yellowish grey. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (n.d.). α = 1.904(2) β = n.d. γ = 2.030(2) 2V = n.d.

Cell Data: *Space Group*: *C*2/*m*. *a* = 6.5691(2) *b* = 8.6869(3) *c* = 7.0924(2) β = 114.1269(4)° Z = 4

X-ray Powder Pattern: Verkhnee Espe REE deposit, Kazakhstan.
2.597 (100), 3.248 (80), 2.994 (60), 3.253 (40), 1.641 (40), 4.941 (30), 1.498 (30)

Chemistry:

	(1)		(2)
Nb_2O_5	1.28	Ho_2O_3	0.16
SiO_2	27.83	Er_2O_3	2.24
TiO_2	35.00	Tm_2O_3	0.50
SnO_2	0.57	Yb_2O_3	2.53
V_2O_3	0.36	Nd_2O_3	0.35
Fe_2O_3	0.23	Lu_2O_3	0.28
Y_2O_3	7.87	MnO	0.33
Ce_2O_3	0.83	CaO	8.16
Sm_2O_3	0.26	Na_2O	5.55
Gd_2O_3	0.46	F	1.52
Tb_2O_3	0.17	-O=F	0.64
Dy_2O_3	2.45	Total	98.71

(1) Verkhnee Espe REE deposit, Kazakhstan; average electron microprobe analysis; corresponds to $(Na_{0.39}Ca_{0.32}Y_{0.15}Dy_{0.03}Yb_{0.03}\ Er_{0.03}Ce_{0.01}Ho_{0.01}Tm_{0.01}Gd_{0.01}Nd_{0.01})_{\Sigma=1.00}\ (Ti_{0.95}Nb_{0.02}Sn_{0.01}Fe^{3+}{}_{0.01}\ Mn_{0.01}V_{0.01})_{\Sigma=1.01}\ Si_{1.01}O_{4.00}(O_{0.83}F_{0.17})$.

Occurrence: In the wall rock zone of an alkaline granite associated with a granitic massif.

Association: Yttrium-bearing fluorite, microcline, albite, quartz, riebeckite, aegirine, biotite, astrophyllite, rutile, zircon, elpidite.

Distribution: From the Verkhnee Espe REE deposit, northern margin of the Akjailyautuas granite massif, Kazakhstan.

Name: For a *titanite* structure with Na(Y,REE)-dominant in the *Ca* site.

Type Material: Geological Scientific Museum, K.I. Satpaev Institute of Geological Sciences, Almaty, Kazakstan (3010).

References: (1) Stepanov, A.V., G.K. Bekenova, V.L. Levin, and F.C. Hawthorne (2012) Natrotitanite, ideally $(Na_{0.5}Y_{0.5})Ti(SiO_4)O$, a new mineral from the Verkhnee Espe deposit, Akjailyautas mountains, Eastern Kazakhstan district, Kazakhstan: description and crystal structure. Mineral. Mag., 76, 37-44. (2) (2012) Amer. Mineral., 97, 1529 (abs. ref. 1).

Natroxalate $Na_2(C_2O_4)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [001], to 5 mm, showing {110}, {001}, {010}, {100}, {221}, in radiating aggregates; typically fine-grained, forming veins and nodules. *Twinning:* On {110}.

Physical Properties: *Cleavage:* On {100}, perfect; on {001} and {221}, distinct. *Fracture:* Interrupted. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.32(3) D(calc.) = 2.338 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Cream to pale yellow, with pinkish or greenish tint. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 20°$. *Dispersion:* $r < v$, moderate. $\alpha = 1.415(2)$ $\beta = 1.524(2)$ $\gamma = 1.592(2)$ 2V(meas.) = 72(1)° 2V(calc.) = 72°

Cell Data: *Space Group:* $P2_1/a$ (by analogy to synthetic). $a = 10.426(9)$ $b = 5.255(5)$ $c = 3.479(3)$ $\beta = 93.14(8)°$ Z = 2

X-ray Powder Pattern: Mt. Alluaiv, Kola Peninsula, Russia.
2.826 (100), 2.602 (56), 2.334 (33), 2.898 (27), 2.041 (14), 5.203 (13), 2.117 (13)

Chemistry:

	(1)	(2)
C_2O_3	53.70	53.75
Na_2O	46.24	46.25
Total	99.94	100.00

(1) Mt. Alluaiv, Kola Peninsula, Russia. (2) $Na_2(C_2O_4)$.

Occurrence: In a hydrothermally altered pegmatite in a differentiated alkalic massif.

Association: Aegirine, albite, elpidite, natron, nenadkevichite, taeniolite, sphalerite, pyrite, galena.

Distribution: From Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: For sodium, *natrium*, in the composition, and as a naturally occurring *oxalate*.

Type Material: Mining Institute, St. Petersburg, 2080/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 1522.

References: (1) Khomyakov, A.P. (1996) Natroxalate – $Na_2C_2O_4$ – a new mineral. Zap. Vses. Mineral. Obshch., 125(1), 126–132 (in Russian with English abs.). (2) (1997) Amer. Mineral., 82, 432 (abs. ref. 1). (3) Reed, D.A. and M.M. Olmstead (1981) Sodium oxalate structure refinement. Acta Cryst., 37, 938–939.

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Naujakasite $Na_6(Fe^{2+},Mn^{2+})Al_4Si_8O_{26}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As aggregates of pseudohexagonal plates, to 2 cm.

Physical Properties: *Cleavage:* Perfect micaceous on {001}; {$\bar{4}$01} and {010}, distinct. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 2.615–2.622 D(calc.) = 2.661

Optical Properties: Semitransparent. *Color:* Gray to silver-white; colorless in thin section. *Luster:* Pearly on {001}.
Optical Class: Biaxial (–). α = 1.536–1.538 β = 1.548–1.551 γ = 1.555–1.557
2V(meas.) = 52°–71° 2V(calc.) = 62°–75°

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. a = 15.025(1) b = 7.991(2) c = 10.486(1) $\beta = 113°40(5)'$ Z = 2

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
3.99 (100), 3.56 (70), 2.26 (70), 3.69 (60), 3.44 (60), 3.06 (60), 2.79 (60)

Chemistry:

	(1)	(2)
SiO_2	50.95	50.65
TiO_2		0.03
Al_2O_3	20.63	20.64
Fe_2O_3	2.76	2.18
FeO	5.25	4.46
MnO	0.57	1.09
MgO	0.10	
CaO	0.55	0.3
Na_2O	14.51	18.37
K_2O	0.80	0.49
H_2O^+	2.60	1.71
H_2O^-	1.02	
P_2O_5		0.07
Total	99.74	[100.00]

(1) Ilímaussaq intrusion, Greenland. (2) Tuperssuatsiait, Greenland; CaO 0.2%–0.4%, Fe^{2+}:Fe^{3+} and H_2O by TGA, recalculated to 100.00%; corresponds to $(Na_{5.67}K_{0.10})_{\Sigma=5.77}(Fe^{2+}_{0.60}Mn_{0.14}Ca_{0.06})_{\Sigma=0.80}(Al_{3.87}Fe^{3+}_{0.27})_{\Sigma=4.14}Si_{8.08}O_{26}\bullet 1.83H_2O$.

Occurrence: In an alkalic intrusion.

Association: Arfvedsonite, sodalite, steenstrupine, analcime.

Distribution: In southern Greenland, in the Ilímaussaq intrusion, at Naujakasik, at Tuperssuatsiait Bay, and on the Kvanefjeld Plateau, all around the Tunugdliarfik Fjord.

Name: For the locality of original discovery, Naujakasik, Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1933.31; National Museum of Natural History, Washington, D.C., USA, 97479.

References: (1) Bøggild, O.B. (1933) Igalikite and naujakasite, two new minerals from South Greenland. Medd. Grønland, 92(9), 1–12. (2) (1935) Amer. Mineral., 20, 138 (abs. ref. 1). (3) Peterson, O.V. (1967) The mineralogy of naujakasite. Medd. Grønland, 181(6), 1–18. (4) (1968) Amer. Mineral., 53, 1780 (abs. ref. 3). (5) Petersen, O.V. and S. Andersen (1975) The crystal habit of naujakasite. Geol. Sur. Greenland, Rep. 116, 5–9. (6) Basso, R., A. Dal Negro, A. Della Guista, and L. Ungaretti (1975) The crystal structure of naujakasite. Geol. Sur. Greenland, Rep. 116, 11-24. (7) (1976) Chem. Abs., 84, 129188 (abs. ref. 6). (8) Khalilov, A.D., N.K. Dzhafarov, and K.S. Mamedov (1977) Crystal structure of naujakasite – $Na_6\{Fe^{2+}[(Si,Al)_8Si_4O_{26}]\}$. Dokl. Acad. Nauk Az. SSR, 33(7), 35–40 (in Russian). (9) (1978) Chem. Abs., 88, 113658 (abs. ref. 8).

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Naumannite Ag_2Se

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* 222. Granular massive; rarely as pseudocubes and plates, to 1 cm.

Physical Properties: *Fracture:* Hackly, poor. *Tenacity:* Somewhat sectile. Hardness = 2.5 VHN = 33–84 (25 g load). D(meas.) = 7.0–8.0 D(calc.) = 8.24

Optical Properties: Opaque. *Color:* Grayish iron-black, tarnishes to iridescent brownish. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Distinct but weak, pale gray to dark gray. R_1–R_2: (400) 37.2–41.8, (420) 37.0–41.2, (440) 37.4–40.5, (460) 38.0–39.9, (480) 38.2–39.3, (500) 37.9–38.5, (520) 37.1–37.6, (540) 35.9–36.7, (560) 34.8–36.0, (580) 33.9–35.5, (600) 33.2–35.2, (620) 32.8–34.9, (640) 32.4–34.5, (660) 32.0–34.1, (680) 31.6–33.7, (700) 31.2–33.3

Cell Data: *Space Group:* $P2_12_12_1$. $a = 4.333$ $b = 7.062$ $c = 7.764$ $Z = 4$

X-ray Powder Pattern: Tilkerode, Germany.
2.67 (100), 2.57 (100), 2.24 (60), 2.006 (40), 4.15 (20), 2.42 (20), 2.11 (20)

Chemistry:

	(1)	(2)	(3)
Ag	72.3	74.8	73.21
Cu	0.1		
Se	28.0	25.0	26.79
Te	0.3		
S		1.3	
Total	100.7	101.1	100.00

(1) Tilkerode, Germany; by electron microprobe, corresponds to $(Ag_{1.95}Cu_{0.01})_{\Sigma=1.96}(Se_{1.03}Te_{0.01})_{\Sigma=1.04}$. (2) Silver City, Idaho, USA; corresponds to $Ag_{1.98}(Se_{0.90}S_{0.12})_{\Sigma=1.02}$. (3) Ag_2Se.

Occurrence: In hydrothermal veins deficient in sulfur, associated with other selenides, quartz, and carbonates.

Association: Clausthalite, aguilarite, acanthite, tiemannite, umangite, eucairite, argentian tetrahedrite, argentian gold, pyrite, chalcopyrite.

Distribution: In Germany, in the Harz Mountains, at Tilkerode [TL] and St. Andreasberg. From Săcărîmb (Nagyág), Romania. In the Předbořice deposit, Czech Republic. At Kongsberg, Norway. In the USA, from Republic, Ferry Co., and in the L-D mine, Wenatchee, Chelan Co., Washington; at the De Lamar mine, Silver City district, Owyhee Co., and from the 4th of July mine, Yankee Fork, Custer Co., Idaho; in Nevada, large crystals in the Ken Snyder mine, Gold Circle district, Elko Co., and at the Rex Grande deposit, Midas, Elko Co. From the Betty claim group, north of Divide Lake, British Columbia; and in the Kidd Creek mine, near Timmins, Ontario, Canada. At Guanajuato, Mexico. From the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, Potosí, Bolivia. At Tuminico, Sierra de Cacho, La Rioja Province, Argentina. From the Wolumia goldfield, New South Wales, Australia. In the Emperor mine, Vatukoula, and the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands. From the Hishikari and Kushikino Au–Ag deposits, Kagoshima Prefecture, and in the Sanru mine, Hokkaido, Japan. At the Axi gold deposit, Ili, Xinjiang Uygur Autonomous Region, China. A number of additional minor occurrences are known.

Name: For German mineralogist and crystallographer Carl Friedrich Naumann (1797–1873).

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 179–180. (2) Wiegers, G.A. (1971) The crystal structure of the low temperature form of silver selenide. Amer. Mineral., 56, 1882–1888. (3) Petruk, W., D.R. Owens, J.M. Stewart, and E.J. Murray (1974) Observations on acanthite, aguilarite and naumannite. Can. Mineral., 12, 365–369. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 34–35. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 474–475. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 389.

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Navajoite $(V^{5+},Fe^{3+})_{10}O_{24}\cdot 12H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As fibrous cross-vein fillings, to 3 mm; as coatings around pebbles and impregnations of sandstone and shale.

Physical Properties: *Tenacity:* Sectile. Hardness = < 2 D(meas.) = 2.56 D(calc.) = 2.53

Optical Properties: Semitransparent. *Color:* Dark brown. *Streak:* Brown.
Luster: Adamantine to silky.
Optical Class: Biaxial (–) (probable). *Pleochroism:* $X = Y$ = yellowish brown; Z = dark brown.
Orientation: $Z = b$. $\alpha = 1.905(3)$ $\beta = \sim 2.02$ $\gamma = > 2.02$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$. a = 34.94(2) $b = 3.597(2)$ $c = 11.79(1)$ $\beta = 95.98(6)°$
Z = [2]

X-ray Powder Pattern: Monument No. 2 mine, Arizona, USA; exhibits preferred orientation.
11.79 (100), 3.41 (20), 3.18 (8), 17.38 (7), 5.79 (6), 1.992 (4), 10.54 (3)

Chemistry:

	(1)
V_2O_5	71.68
V_2O_4	3.08
SiO_2	1.20
Fe_2O_3	3.58
CaO	0.22
H_2O	20.30
Total	100.06

(1) Monument No. 2 mine, Arizona, USA; corresponds to $(V_{9.48}Fe_{0.52})_{\Sigma=10.00}Ca_{0.05}O_{24}\cdot 12H_2O$.

Occurrence: In the highly oxidized portion of a Colorado Plateau-type U–V deposit, in a stream channel filled with conglomeratic and silty sandstone; thought to be an oxidation product of corvusite.

Association: Corvusite, tyuyamunite, rauvite, hewettite, steigerite, "limonite".

Distribution: In the Monument No. 2 mine, Monument Valley, Apache Co., Arizona, USA.

Name: For the Navajo Indians, on whose reservation the mineral was first found.

Type Material: Harvard University, Cambridge, Massachusetts, 105102; National Museum of Natural History, Washington, D.C., USA, 106900.

References: (1) Weeks, A.D., M.E. Thompson, and A.M. Sherwood (1955) Navajoite, a new vanadium oxide from Arizona. Amer. Mineral., 40, 207–212. (2) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 517–519.

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Nefedovite $Na_5Ca_4(PO_4)_4F$

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Crystal Data: Triclinic, pseudotetragonal. *Point Group:* $\overline{1}$ or 1; pseudo $\overline{4}$. As irregular rounded grains, to 1 mm, in aggregates, typically replacing apatite.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼4.5 D(meas.) = 3.01(1) D(calc.) = 3.05

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+); sensibly uniaxial (+). $\alpha = 1.571(2)$ $\beta = 1.571(2)$ $\gamma = 1.590(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.401(6)$ $b = 11.647(8)$ $c = 16.484(7)$ $\alpha = 134.99(3)°$ $\beta = 90.04(6)°$ $\gamma = 89.96(7)°$ Z = 2, or, for the pseudotetragonal cell: *Space Group:* $I\overline{4}$. $a = 11.644(2)$ $c = 5.396(1)$ Z = 2

X-ray Powder Pattern: Khibiny massif, Kola Peninsula, Russia. 2.772 (100), 3.73 (80b), 2.508 (80), 2.290 (80), 2.703 (70), 1.877 (60), 5.83 (40)

Chemistry:

	(1)	(2)
P_2O_5	42.1	42.11
CaO	33.7	33.27
Na_2O	22.7	22.99
K_2O	0.8	
F	2.5	2.82
$-O = F_2$	1.0	1.19
Total	100.8	100.00

(1) Khibiny massif, Kola Peninsula, Russia; by electron microprobe, average of three analyses; corresponds to $(Na_{4.90}K_{0.11})_{\Sigma=5.01}Ca_{4.02}(P_{0.99}O_4)_4F_{0.88}$. (2) $Na_5Ca_4(PO_4)_4F$.

Occurrence: In pegmatitic segregations in nepheline syenite in a differentiated alkalic massif.

Association: Apatite, nacaphite, eudialyte, delhayelite, canasite, djerfisherite, rasvumite, orthoclase, alkalic amphibole, titanite.

Distribution: On Mt. Yukspor and from a drillcore in the Kuniok River valley, Khibiny massif, Kola Peninsula, Russia.

Name: To honor Dr. Yevgeny I. Nefedov (1910–1976), Russian mineralogist, St. Petersburg, Russia, involved in the discovery of a number of Kola minerals.

Type Material: Mining Institute, St. Petersburg, 1302/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82759.

References: (1) Khomyakov, A.P., G.N. Nechelyustov, and G.I. Dorokhova (1983) Nefedovite $Na_5Ca_4(PO_4)_4F$ – a new mineral. Zap. Vses. Mineral. Obshch., 112, 479–483 (in Russian). (2) (1983) Mineral. Abs., 35, 193–194 (abs. ref. 1). (3) (1984) Amer. Mineral., 69, 812–813 (abs. ref. 1). (4) Sebais, M., G.I. Dorokhova, E.A. Pobedimskaya, and A.P. Khomyakov (1984) Crystal structure and typomorphism of nefedovite. Sov. Phys. Doklady Acad. Nauk SSSR, 29, 700–703 (in Russian).

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$. As pseudo-octahedral or pseudocubic crystals, to 3 mm, and as oblong to rounded grains. *Twinning:* Polysynthetic and interpenetrant, complex but poorly defined.

Physical Properties: *Fracture:* Uneven. Hardness = 4.5 D(meas.) = 3.03(3) D(calc.) = 3.06

Optical Properties: Transparent to opaque. *Color:* Colorless, cream, pink, red, brown, may be zoned. *Luster:* Vitreous to dull, greasy.
Optical Class: Isotropic, but with birefringence about 0.003. $n = 1.364(2)$

Cell Data: *Space Group: Pcmn.* $a = 5.363(1)$ $b = 7.676(1)$ $c = 5.503(1)$ Z = 4

X-ray Powder Pattern: South Ouray, Utah, USA.
1.918 (100), 2.71 (50), 3.83 (35), 2.30 (25), 1.556 (25), 2.23 (18), 2.20 (13)

Chemistry:

	(1)	(2)
Fe_2O_3	0.17	
MgO	39.36	38.65
CaO	1.10	
Na_2O	27.02	29.71
K_2O	0.77	
F	54.76	54.65
H_2O	0.25	
$-O = F_2$	[23.06]	23.01
Total	[100.37]	100.00

(1) Ural Mountains, Russia; original total given as 100.49%; corresponds to $(Na_{0.87}K_{0.02})_{\Sigma=0.89}(Mg_{0.98}Ca_{0.02})_{\Sigma=1.00}F_{2.97}$. (2) $NaMgF_3$.

Occurrence: An authigenic mineral, formed under aluminum-deficient conditions in dolomitic oil shale (South Ouray, Utah, USA); in metamorphosed tuff and clayey carbonate sediments (Ural Mountains, Russia); in miarolitic cavities in an alkalic granite (Lake Gjerdingen, Norway); in cavities in pegmatite and in hornfels in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Burbankite, nahcolite, wurtzite, barytocalcite, garrelsite, pyrite, calcite, quartz (South Ouray, Utah, USA).

Distribution: From the South Ouray and Sun Havenstrite wells, about 8 km south-southeast of South Ouray, Uintah Co., Utah, USA. At Mont Saint-Hilaire, Quebec, Canada. From near Lake Gjerdingen, Nordmarka, Norway. In the Lovozero, Khibiny, and Kovdor massifs, Kola Peninsula, the Ural Mountains, and other poorly defined localities in Russia.

Name: Honors Frank Neighbor, district geologist of Sun Oil Co., Salt Lake City, Utah, USA, for his assistance in providing samples.

Type Material: National Museum of Natural History, Washington, D.C., USA, 115216, 162603.

References: (1) Chao, E.C.T., H.T. Evans, Jr., B.J. Skinner, and C. Milton (1961) Neighborite, $NaMgF_3$, a new mineral from the Green River Formation, South Ouray, Utah. Amer. Mineral., 46, 379–393. (2) Efimov, A.F., E.M. Eskova and S.T. Kataeva (1967) On the first discovery of neighborite in the U.S.S.R. Doklady Acad. Nauk SSSR, 174, 5, 1182–1184 (in Russian). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 325–326.

Nekoite $Ca_3Si_6O_{15}\cdot 7H_2O$

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Crystal Data: Triclinic. *Point Group:* 1. Crystals fine, slender needles, to 5 mm, elongated ‖ [001]. *Twinning:* Repeated, lamellae ‖ {010} cleavage.

Physical Properties: *Cleavage:* Distinct on {010}. Hardness = n.d. D(meas.) = 2.21–2.24 D(calc.) = 2.21

Optical Properties: Transparent to translucent. *Color:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). $n = 1.535(2)$, very low birefringence. 2V(meas.) = ∼70°

Cell Data: *Space Group:* $P1$. $a = 7.558(3)$ $b = 9.793(5)$ $c = 7.339(5)$ $\alpha = 111.77(7)°$ $\beta = 103.50(5)°$ $\gamma = 86.53(3)°$ Z = 1

X-ray Powder Pattern: Crestmore, California, USA.
9.25 (vs), 3.36 (vsb), 2.82 (vs), 2.47 (ms), 1.83 (ms), 1.90 (mw), 1.79 (mw)

Chemistry:

	(1)	(2)	(3)
SiO_2	55.	56.17	55.05
CaO	24.	26.10	25.69
H_2O	19.6	16.83	19.26
Total	99.	99.10	100.00

(1) Crestmore, California, USA. (2) Do.; probably slightly dehydrated. (3) $Ca_3Si_6O_{15}\cdot 7H_2O$.

Occurrence: In a contact metamorphosed limestone deposit (Crestmore, California, USA).

Association: Apophyllite (Crestmore, California, USA); heulandite, apophyllite (Caxias do Sul, Brazil).

Distribution: In the USA, from Crestmore, Riverside Co., California, and at Landsman's Camp, Aravaipa district, Graham Co., Arizona. At Caxias do Sul, Rio Grande do Sul, Brazil. In the Kochbulak deposit, eastern Uzbekistan.

Name: An anagram of OKENite, for which it was originally mistaken.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95637.

References: (1) Gard, J.A. and H.F.W. Taylor (1956) Okenite and nekoite (a new mineral). Mineral. Mag., 31, 5–20. (2) Chalmers, R.A., A.W. Nicol, and H.F.W. Taylor. (1962) The composition of nekoite. Mineral. Mag., 33, 70–71. (3) Alberti, A. and E. Galli (1980) The structure of nekoite, $Ca_3Si_6O_{15}\cdot 7H_2O$, a new type of sheet silicate. Amer. Mineral., 65, 1270–1276.

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Nekrasovite $Cu_{26}V_2(Sn, As, Sb)_6S_{32}$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. As small rounded grains, to less than 1 μm.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 286–338 (20 g load). D(meas.) = n.d. D(calc.) = 4.62

Optical Properties: Opaque. *Color:* Pale brown with a pink shadow.
R: (400) — , (420) — , (440) 22.6, (460) 23.8, (480) 25.0, (500) 25.6, (520) 26.0, (540) 26.4, (560) 26.9, (580) 27.4, (600) 28.0, (620) 28.6, (640) 29.3, (660) 29.6, (680) 29.9, (700) 30.0

Cell Data: *Space Group:* $P\overline{4}3n$. $a = 10.73(5)$ $Z = 1$

X-ray Powder Pattern: Khayragatsch deposit, Uzbekistan.
3.09 (10), 1.894 (8), 1.617 (6), 1.230 (5), 1.096 (3), 1.033 (3), 2.68 (2)

Chemistry:

	(1)	(2)
Cu	44.18	39.9
Fe	4.11	0.2
Zn	0.10	7.4
V	1.93	3.1
Sn	11.40	21.2
As	3.03	
Sb	4.20	
Se	0.32	
S	29.86	29.1
Total	99.13	100.9

(1) Khayragatsch deposit, Uzbekistan; by electron microprobe, corresponding to $(Cu_{23.97}Fe_{1.98}Zn_{0.05})_{\Sigma=26.00}(V_{1.31}Fe_{0.58})_{\Sigma=1.89}(Sn_{3.31}As_{1.39}Sb_{1.19}Se_{0.11})_{\Sigma=6.00}S_{32.11}$. (2) Bisbee, Arizona, USA; by electron microprobe, corresponding to $(Cu_{21.91}Zn_{3.95}Fe_{0.12})_{\Sigma=25.98}V_{2.12}Sn_{6.23}S_{31.66}$.

Mineral Group: Colusite group.

Occurrence: In ore aggregates within propylitic andesites and dacites (Khayragatsch deposit, Uzbekistan).

Association: Tetrahedrite–tennantite, luzonite–famatinite, pyrite, mawsonite, chalcopyrite, emplectite, laitakarite, bismuth, calcite, quartz, barite (Khayragatsch deposit, Uzbekistan).

Distribution: From the Khayragatsch gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan [TL]. In the USA, in the Campbell mine, Bisbee, Cochise Co., Arizona. At Neves-Corvo, Portugal. From the Persenk district, Rhodopes Mountains, Bulgaria.

Name: To honor Ivan Yakovlevich Nekrasov (1929–), Russian mineralogist, Institute of Experimental Mineralogy, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84283.

References: (1) Kolavalenker, V.A., T.L. Evstigneeva, V.S. Malov, N.V. Trubkin, A.I. Gorshkov, and V.R. Geinke (1984) Nekrasovite, $Cu_{26}V_2Sn_6S_{32}$, a new mineral of the colusite group. Mineral. Zhurnal, 6(2), 88–97 (in Russian). (2) (1985) Amer. Mineral., 70, 437 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 390.

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Nelenite $(Mn^{2+},Fe^{2+})_{16}As_3^{3+}Si_{12}O_{36}(OH)_{17}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\,2/m$. Coarse granular, to 4.5 cm; massive.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ~5 D(meas.) = 3.46 D(calc.) = 3.44–3.45

Optical Properties: Transparent. *Color:* Light to medium brown; in transmitted light, colorless to light brown. *Streak:* Light brown. *Luster:* Vitreous on cleavages, resinous and duller on fractures.
Optical Class: Uniaxial (–); may appear biaxial. *Pleochroism:* O = light brown; E = colorless. $\omega = 1.718(4)$ $\epsilon = 1.700(4)$ 2V(meas.) = 0°

Cell Data: *Space Group:* $R\bar{3}m$. $a = 13.418(5)$ $c = 85.48(8)$ Z = [2]

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.552 (100), 2.878 (70), 3.55 (60), 1.677 (60), 1.723 (50), 7.10 (40), 2.402 (40)

Chemistry:

	(1)	(2)
SiO_2	31.12	30.8
As_2O_3	12.46	13.2
FeO	17.12	17.8
MnO	29.22	28.1
ZnO	3.63	2.6
MgO	0.12	0.5
CaO		0.4
H_2O	6.42	[6.6]
Total	100.00	[100.0]

(1) Franklin, New Jersey, USA; corresponds to $(Mn_{9.54}Fe_{5.51}Zn_{1.04}Mg_{0.07})_{\Sigma=16.16}$ $As_{2.92}Si_{12}O_{36.28}(OH)_{16.52}$. (2) Do.; by electron microprobe, H_2O by difference; corresponds to $(Mn_{9.27}Fe_{5.80}Zn_{0.75}Mg_{0.29}Ca_{0.17})_{\Sigma=16.28}As_{3.12}Si_{12}O_{36.39}(OH)_{17.14}$.

Polymorphism & Series: Dimorphous with schallerite.

Occurrence: In a metamorphosed stratiform zinc deposit, within pegmatitic textured masses, and as calcite-cemented fragments in a breccia probably derived from the pegmatitic material.

Association: Actinolite, calcite, willemite, tirodite, rhodonite, apatite, lennilenapeite, stilpnomelane, microcline, talc.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: In honor of Joseph A. Nelen, chemist at the Smithsonian Institution, Washington, D.C., USA.

Type Material: Harvard University, Cambridge, Massachusetts, 92791; National Museum of Natural History, Washington, D.C., USA, R7824, C6219, 145972; The Natural History Museum, London, England, 1983,237.

References: (1) Dunn, P.J. and D.R. Peacor (1984) Nelenite, a manganese arsenosilicate of the friedelite group, polymorphous with schallerite, from Franklin, New Jersey. Mineral. Mag., 48, 271–275. (2) (1985) Amer. Mineral., 70, 874–875 (abs. ref. 1).

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Neltnerite $CaMn_6^{3+}SiO_{12}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Rarely as dipyramidal crystals, to 1 mm; as small grains.

Physical Properties: *Fracture:* Subconchoidal. Hardness = 6 VHN = 1200–1220 (100 g load). D(meas.) = 4.63(5) D(calc.) = 4.65

Optical Properties: Opaque. *Color:* Black; in reflected light, gray to brownish gray. *Luster:* Submetallic. *Anisotropism:* Weak.
R_1–R_2: (470) 21.3–22.3, (546) 19.2–20.2, (589) 18.5–19.5, (650) 17.65–18.65

Cell Data: *Space Group:* $I4_1/acd$. $a = 9.464$ $c = 18.854$ $Z = 8$

X-ray Powder Pattern: Tachgagalt, Morocco.
2.728 (10), 1.672 (8.5), 1.427 (6), 1.085 (5), 1.0595 (4.5), 1.056 (4.5), 2.364 (3)

Chemistry:

	(1)
SiO_2	10.16
Fe_2O_3	1.29
Mn_2O_3	78.94
CaO	8.94
Total	99.33

(1) Tachgagalt, Morocco; by electron microprobe, average of 14 analyses; corresponds to $(Ca_{0.95}Mn^{2+}_{0.06})_{\Sigma=1.01}(Mn^{3+}_{5.89}Fe^{3+}_{0.10})_{\Sigma=5.99}Si_{1.01}O_{12}$.

Occurrence: In a vein with minerals containing manganese and calcium (Tachgagalt, Morocco).

Association: Braunite, marokite, crednerite (Tachgagalt, Morocco).

Distribution: At Tachgagalt, Anti-Atlas Mountains, Morocco. From Manganese Creek Falls, Keeweenaw Co., Michigan, USA.

Name: For Louis Neltner, pioneer student of mineral deposits of the High Atlas Mountains, Morocco.

Type Material: National School of Mines, Paris, France.

References: (1) Baudracco-Gritti, C., R. Caye, F. Permingeat, and J. Protas (1982) La neltnérite $CaMn_6SiO_{12}$, une nouvelle espèce minérale du groupe de la braunite. Bull. Minéral., 105, 161–165 (in French). (2) (1983) Amer. Mineral., 68, 282 (abs. ref. 1).

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Nenadkevichite $(Na, Ca, K)(Nb, Ti)Si_2O_6(O, OH) \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As equant or bladed pseudohexagonal prisms, to 8 mm; in foliated segregations and lamellar masses.

Physical Properties: *Cleavage:* Poor on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.78–2.885 D(calc.) = 2.70–2.81

Optical Properties: Opaque to translucent, transparent in very small fragments. *Color:* Rose, very pale pink, pale yellow, brown; dark brown due to manganese oxides. *Streak:* White to very pale rose. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+). *Pleochroism:* Slight; X = colorless; Y = pale yellow; Z = pale rose. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Absorption:* $Z > Y > X$. $\alpha = 1.633–1.659$ $\beta = 1.642–1.686$ $\gamma = 1.738–1.785$ $2V(meas.) = 31°–45°$

Cell Data: *Space Group: Pbam*. $a = 7.408(2)$ $b = 14.198(3)$ $c = 7.148(2)$ $Z = 4$

X-ray Powder Pattern: Lovozero massif, Russia.
3.20 (100), 3.10 (100), 1.427 (100), 1.289 (90), 2.49 (80), 2.58 (70), 1.705 (70)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	37.15	37.7	CaO	1.75	0.57
TiO_2	12.12	7.45	BaO	1.39	
Al_2O_3	1.15	trace	Na_2O	4.16	11.3
RE_2O_3	0.30		K_2O	2.24	1.10
Fe_2O_3	0.80	0.51	H_2O^+	8.84	
Nb_2O_5	24.61	29.9	H_2O^-	2.00	
MnO	2.90	0.25	H_2O		11.7
MgO	0.52		Total	99.93	100.48

(1) Kola Peninsula, Russia. (2) Mont Saint-Hilaire, Canada; corresponds to $(Na_{0.94}K_{0.06}Ca_{0.03}Mn_{0.01})_{\Sigma=1.04}(Nb_{0.69}Ti_{0.30})_{\Sigma=0.99}Si_{2.00}O_6[O_{0.70}(OH)_{0.30}]_{\Sigma=1.00} \cdot 2H_2O$.

Occurrence: Between crystals of microcline in a natrolite-albite-rich pegmatite in nepheline syenite in a differentiated alkalic massif (Lovozero massif, Russia); in pegmatites, cavities in igneous breccia, hornfels, and marble xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Microcline (Lovozero massif, Russia); microcline, aegirine, catapleiite, ancylite, epididymite, eudialyte, sérandite, pectolite, apophyllite, monteregianite, vesuvianite, many other species (Mont Saint-Hilaire, Canada).

Distribution: On Mts. Karnasurt and Flora, in the Lovozero massif, and in the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. From Gjerdingen, near Oslo, Norway. At Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada. From the Ilímaussaq intrusion and at Narssârssuk, Greenland.

Name: For Konstantin Avtonomovich Nenadkevich (1880–1963), Russian mineralogist and geochemist, A.E. Fersman Mineralogical Museum, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 183a/4; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 57260, 59411, vis4521.

References: (1) Kuz'menko, M.V. and M.E. Kazakova (1955) Nenadkevichite – a new mineral. Doklady Acad. Nauk SSSR, 100, 1159–1160 (in Russian). (2) (1955) Amer. Mineral., 40, 1154 (abs. ref. 1). (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 547–549. (4) Perrault, G., C. Boucher, and J. Vicat (1973) Structure cristalline du nenadkevichite $(Na, K)_{2-x}(Nb, Ti)(O, OH)Si_2O_6 \cdot 2H_2O$. Acta Cryst., 29, 1432–1438 (in French with English abs.). (5) Mandarino, J.A. and V. Anderson (1989) Monteregian treasures. Cambridge Univ. Press, 155.

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Neotocite $(Mn^{2+},Fe^{2+})SiO_3 \cdot H_2O(?)$

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Crystal Data: Amorphous to poorly crystalline. *Point Group:* n.d. Massive, compact.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–4
D(meas.) = 2.1–2.7 D(calc.) = n.d.

Optical Properties: Opaque, translucent in thin fragments. *Color:* Black, dark brown to dark olive-green. *Streak:* Dark brown to black. *Luster:* Dull to resinous or vitreous, may be feebly metallic.
Optical Class: Isotropic essentially. n = 1.50–1.65

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Montreal mine, Wisconsin, USA; indistinguishable from hisingerite.
4.36 (w), 3.59 (w), 1.54 (w), 2.59 (vw)

Chemistry:

	(1)	(2)
SiO_2	40.1	40.19
Al_2O_3	1.3	
Fe_2O_3	0.3	
Mn_2O_3	7.7	
FeO		24.03
MnO	33.7	23.73
MgO	1.5	
CaO	1.3	
Na_2O	0.1	
K_2O	0.1	
H_2O^+	11.6	12.05
CO_2	2.2	
Total	99.9	100.00

(1) Geevor mine, England. (2) $(Mn,Fe)SiO_3 \cdot H_2O$ with Fe:Mn = 1:1.

Occurrence: An alteration product of manganese-bearing silicate minerals.

Association: Rhodonite, calcite, quartz.

Distribution: In Sweden, from Gestrikland; at Långban, Jakobsberg, and the Harstigen mine, near Persberg, Värmland; and in the Brunsjö mine, near Grythyttan, Örebro. In Wheal Owles, Penwith, and the Geevor mine, St. Just, Cornwall, England. In the USA, from the Aravaipa district, Graham Co., Arizona; in California, in the Charles Mountain deposit, Humboldt Co., in the Elsinor area, Riverside Co., and at the Johe Ranch mine, San Louis Obispo Co.; from the Montreal mine, Gogebic Range, Iron Co., Wisconsin; and at the Foote mine, Kings Mountain, Cleveland Co., North Carolina. From Bueycito, Oriente Province, Cuba. In Japan, from Shidara, Aichi Prefecture; in the Kawazu mine, Shidzuoka Prefecture; and at Tamaga, Iwate Prefecture. Probably additional localities are not yet recognized.

Name: From the Greek, meaning *of recent origin*, as it is an alteration product.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 704–705.
(2) Whelan, J.A. and S.S. Goldich (1961) New data for hisingerite and neotocite. Amer. Mineral., 46, 1412–1423. (3) Clark, A.M., A.J. Easton, and M. Mount (1978) A study of the neotocite group. Mineral. Mag., 42, 279–280, M26–M27. (4) Eggleton, R.A., J.H. Pennington, R.S. Freeman, and I.M. Threadgold (1983) Structural aspects of the hisingerite-neotocite series. Clay Minerals, 18, 21–31.

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Nepheline $(Na,K)AlSiO_4$

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Crystal Data: Hexagonal. *Point Group:* 6. As stout six- or twelve-sided prisms, terminated by dominant {0001}, typically poorly formed, to 10 cm. Also granular, compact, massive. *Twinning:* On $\{10\bar{1}0\}$, $\{33\bar{6}5\}$, and $\{11\bar{2}2\}$.

Physical Properties: *Cleavage:* Poor on $\{10\bar{1}0\}$, {0001}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.55–2.66 D(calc.) = [2.64]

Optical Properties: Transparent to nearly opaque, from inclusions or alteration. *Color:* Colorless, white, gray, yellowish; variously colored by impurities; colorless in thin section. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (–). $\omega = 1.529–1.546$ $\epsilon = 1.526–1.542$

Cell Data: *Space Group:* $P6_3$. $a = 9.993(2)$ $c = 8.374(3)$ $Z = 8$

X-ray Powder Pattern: Synthetic $(Na_{0.67}K_{0.33})_{\Sigma=1.00}AlSiO_4$.
3.027 (100), 3.870 (60), 3.294 (40), 4.21 (35), 2.905 (35), 2.359 (30), 2.593 (20)

Chemistry:

	(1)
SiO_2	43.55
Al_2O_3	34.66
MgO	0.05
CaO	4.44
Na_2O	12.09
K_2O	4.87
H_2O^+	0.25
H_2O^-	0.25
Total	100.16

(1) Monte Somma, Italy; corresponds to $(Na_{0.56}K_{0.15}Ca_{0.11})_{\Sigma=0.82}Al_{0.97}Si_{1.04}O_4$.

Occurrence: Characteristic of alkalic rocks as nepheline syenites and gneisses, alkalic gabbros; in sodium-rich hypabyssal rocks, tuffs and lavas, and pegmatites; as a product of sodium metasomatism.

Association: Potassic feldspar, plagioclase, sodic pyroxenes, sodic amphiboles, leucite, olivine, augite, diopside.

Distribution: Wide-spread; only a few prominent localities can be mentioned. In Italy, at Vesuvius and Monte Somma, Campania. On the Katzenbuckel, Odenwald, Baden-Württemberg, Germany. In the Langesundsfjord area, Norway. In Portugal, from the Sierra de Monchique. Around the Tunugdliarfik Fjord and on the Kangerdluarssuk Plateau, in the Ilímaussaq intrusion, southern Greenland. In the Lovozero massif, Kola Peninsula, Russia. From the Nyiragongo volcano, Kivu Province, Congo (Zaire). In the USA, at Litchfield, Kennebec Co., Maine; near Magnet Cove, Hot Spring Co., and on Granite Mountain, near Little Rock, Pulaski Co., Arkansas; from Iron Hill, Gunnison Co., Colorado; at Point of Rocks, Colfax Co., New Mexico. In Canada, in the Bancroft district, Ontario, especially large crystals from Davis Hill; from Mont Saint-Hilaire, Quebec.

Name: From the Greek for *cloud*, as it becomes cloudy when treated with strong acid.

Type Material: Natural History Museum, Paris, France, Haüy collection.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 423–426, 1042. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 231–270. (3) Smith, J.V. and F. Tuttle (1957) The nepheline-kalsilite system: I. X-ray data for the crystalline phases. Amer. J. Sci., 255, 282–305. (4) Foreman, N. and D.R. Peacor (1970) Refinement of the nepheline structure at several temperatures. Zeits. Krist., 132, 45–70. (5) Gregorkiewitz, M. (1984) Crystal structure and Al/Si ordering of a synthetic nepheline. Bull. Minéral., 107, 499–507.

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Népouite $Ni_3Si_2O_5(OH)_4$

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Crystal Data: Orthorhombic, probable. *Point Group:* n.d. As crude pseudohexagonal vermiform crystals, to 1 cm; massive.

Physical Properties: Hardness = 2.5 D(meas.) = 3.24 D(calc.) = [3.07–3.40]

Optical Properties: Semitransparent. *Color:* Intense dark green to dull green. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = dark green; Z = yellow-green. $\alpha = 1.622$ $\beta = 1.576$–1.579 $\gamma = 1.645$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 5.27$–5.31 $b = 9.14$–9.20 $c = 7.24$–7.28 Z = [2]

X-ray Powder Pattern: Letovice, Czech Republic.
7.31 (100), 3.63 (90), 2.501 (70), 2.894 (60), 1.530 (60), 4.55 (50b), 2.321 (40)

Chemistry:

	(1)	(2)	(3)
SiO_2	32.84	37.0	31.60
Al_2O_3	0.97	0.21	
Fe_2O_3		0.22	
FeO	1.90		
NiO	49.05	44.9	58.92
MgO	3.64	5.95	
CaO	0.50	0.22	
Na_2O		0.10	
K_2O		0.07	
H_2O^+	9.64	11.9	9.48
Total	98.54	100.6	100.00

(1) Népoui, New Caledonia. (2) Nakety, New Caledonia. (3) $Ni_3Si_2O_5(OH)_4$.

Polymorphism & Series: Dimorphous with pecoraite; forms a series with lizardite.

Mineral Group: Kaolinite-serpentine group.

Occurrence: An alteration product of nickel-rich ultramafic rocks.

Association: Serpentine, chlorite, hydrous nickel silicates, iron oxides.

Distribution: From the Reis II mine, Népoui; near Nakety, and at Thio, New Caledonia. In the 132 North nickel mine, Widgiemooltha district, Western Australia. From Pavlos, Greece. In the Tyulenevsk Formation, Ural Mountains, Russia. At Letovice, Czech Republic. In the Kalkar quarry, Santa Cruz Co., California, USA.

Name: After the locality, Népoui, New Caledonia.

Type Material: n.d.

References: (1) Glasser, M.E. (1907) Sur une espèce minéral nouvelle, la népouite, silicate hydraté de nickel et de magnésie. Bull. Soc. fr. Minéral., 30, 17–28 (in French). (2) Maksimovic, Z. (1973) Lizardite–nepouite isomorphous series. Zap. Vses. Mineral. Obshch., 102, 143–149 (in Russian). (3) (1973) Chem. Abs., 79, 33542 (abs. ref. 2). (4) Brindley, G.W. and H.-M. Wan (1975) Compositions, structures, and thermal behavior of nickel-containing minerals in the lizardite–nepouite series. Amer. Mineral., 60, 863–871. (5) Bayliss, P. (1981) Unit cell data of serpentine group minerals. Mineral. Mag., 44, 153–156. (6) Milton, C., E.J. Dwornik, and R.B. Finkelman (1983) Pecoraite, the nickel analogue of chrysotile, $Ni_3Si_2O_5(OH)_4$ from Missouri. Neues Jahrb. Mineral., Monatsh., 513–523.

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Neptunite $KNa_2Li(Fe^{2+},Mn^{2+},Mg)_2Ti_2Si_8O_{24}$

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Crystal Data: Monoclinic. *Point Group:* *m*. As prismatic crystals, to 7.5 cm, with {110} prominent, typically with square cross sections, may be curved or twisted. *Twinning:* Interpenetrant on {301}.

Physical Properties: *Cleavage:* Perfect on {110}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.19–3.23 D(calc.) = [3.24] Piezoelectric.

Optical Properties: Nearly opaque. *Color:* Black; deep red-brown in thin fragments. *Streak:* Cinnamon-brown. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = pale yellow; Y = yellow-orange; Z = red-orange to red-brown. *Orientation:* $Y = b$; $Z \wedge c = 16°–20°$. *Dispersion:* $r < v$, extreme. $\alpha = 1.692(1)$ $\beta = 1.702(1)$ $\gamma = 1.734(2)$ 2V(meas.) = ∼40°

Cell Data: *Space Group:* *Cc*. $a = 16.427(2)$ $b = 12.478(2)$ $c = 9.975(1)$ $\beta = 115.56(1)°$ Z = 4

X-ray Powder Pattern: San Benito Co., California, USA.
3.186 (100), 9.6 (60), 3.517 (45), 3.308 (35), 2.942 (32), 2.837 (32), 2.480 (32)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	52.29	54.06	CaO	0.62	
TiO_2	17.35	17.30	Li_2O	1.63	1.54
FeO	11.92	12.45	Na_2O	6.81	6.33
MnO	2.27	1.75	K_2O	5.58	4.92
MgO	1.55	1.65	Total	100.02	100.00

(1) San Benito Co., California, USA. (2) Do.; by electron microprobe, Li by wet chemical analysis; corresponds to $K_{0.95}Na_{1.85}Li_{0.92}(Fe_{1.51}Mg_{0.35}Mn_{0.20})_{\Sigma=2.06}Ti_{1.94}Si_{8.10}O_{24}$.

Polymorphism & Series: Forms a series with mangan-neptunite.

Occurrence: In natrolite veins cutting a glaucophane schist inclusion in a serpentinite body (San Benito Co., California, USA).

Association: Eudialyte, arfvedsonite, aegirine (Narssârssuk, Greenland); natrolite, benitoite, joaquinite-(Ce) (San Benito Co., California, USA); nordite-(La), lomonosovite, sodalite, ussingite (Kola Peninsula, Russia).

Distribution: From Narssârssuk, Iglunguak, and the Ilímaussaq intrusion, Greenland. In the Inagli massif, 30 km west of Aldan, Yakutia, and in the Khibiny and Lovozero massifs, Kola Peninsula, Russia. From the Khan-Bogdinskii granitic massif, Gobi, Mongolia. In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. From Barnavave, near Carlingford, Co. Louth, Ireland. At Mont Saint-Hilaire, Quebec, and Seal Lake, Labrador, Newfoundland, Canada. In the USA, splendid crystals from the Gem mine and Mina Numero Uno, San Benito Co., California, and at Point of Rocks, Colfax Co., New Mexico. From near Woodsreef, New South Wales, Australia.

Name: For *Neptune*, sea-god of Roman mythology; so named because of its close association at the type occurrence with aegirine, the name of which derives from *Ægir*, the Scandinavian sea-god.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 49. (2) Berry, L.G. (1963) Neptunite: unit cell and X-ray powder data. Can. Mineral., 7, 679–681. (3) Laird, J. and A.L. Albee (1972) Chemical composition and physical, optical, and structural properties of benitoite, neptunite, and joaquinite. Amer. Mineral., 57, 85–102. (4) Kunz, M., T. Armbruster, G.A. Lager, A.J. Schultz, R.J. Goyette, W. Lottermoser, and G. Amthauer (1991) Fe, Ti ordering and octahedral distortions in acentric neptunite: temperature dependent X-ray and neutron structure refinements and Mössbauer spectroscopy. Phys. Chem. Minerals, 18, 199–213.

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Neskevaaraite-Fe $NaK_3Fe(Ti,Nb)_4(Si_4O_{12})_2(O,OH)_4 \cdot 6H_2O$

Crystal Data: Monoclinic. *Point Group: m.* As prismatic crystals, to 1.8 cm, some showing longitudinally striations on {$\bar{2}$ 01}, also showing {100}, {$\bar{1}$ 01}, and less commonly {010} and {021}. Microtwinned on (001) and ($\bar{4}$ 01).

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5
D(meas.) = 2.88(3) D(calc.) = 2.90

Optical Properties: Translucent, almost opaque. *Color:* Brownish to yellowish brown.
Streak: White. *Luster:* Vitreous.
Optical Class: Biaxial (+). α = 1.677(1) β = 1.684(2) γ = 1.790(5) 2V(meas.) = 25(10)°
Orientation: Y = b. "Practically" nonpleochroic.

Cell Data: *Space Group: Cm.* a = 14.450(6) b = 13.910(6) c = 7.836(4) β = 117.42(1)°
Z = 2

X-ray Powder Pattern: Neskevaara Hill, Vuoriyarvi complex, Northern Karelia, Russia.
6.93 (100), 3.21 (100), 3.11 (90), 4.93 (80), 2.62 (60), 2.49 (50), 1.687 (40)

Chemistry:

	(1)
Na_2O	3.10
K_2O	88.3
BaO	3.37
MgO	0.75
MnO	0.50
FeO	1.82
SiO_2	39.29
TiO_2	15.08
Nb_2O_5	17.96
H_2O	9.26
Total	99.96

(1) Neskevaara Hill, Vuoriyarvi complex, Northern Karelia, Russia; electron microprobe analysis, H_2O by TGA; corresponding to $Na_{1.22}K_{2.29}Ba_{0.26}(Fe_{0.31}Mg_{0.23}Mn_{0.09})_{\Sigma=0.63}(Ti_{2.31}Nb_{1.65})_{\Sigma=3.96}(Si_8O_{24})[O_{2.78}(OH)_{1.22}]_{\Sigma=4} \cdot 5.68H_2O$.

Mineral Group: Labuntsovite group.

Occurrence: In alkaline igneous rocks sometimes intergrown with labuntsovite-Fe or in hydrothermally altered carbonatite veins.

Association: Dolomite, calcite, phlogopite, fluorapatite, pyrite, pyrrhotite, chalcopyrite, serpentine, nenadkevichite (Neskevaara Hill); calcite, labuntsovite-Fe, donnayite-(Y), bitumen (Kirovskii mine).

Name: For the locality (Neskevaara Hill) and Fe-dominant composition of the D structural site.

Distribution: Neskevaara Hill, central part of the Vuoriyarvi alkaline complex, Northern Karelia, and the Kirovskii apatite mine, Mount Kukisvumchorr, Khibiny alkaline massif, Kola Peninsula, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia; 2814/1.

References: (1) Chukanov, N.V., V.V. Subbotin, I.V. Pekov, A.E. Zadov, A.I. Tsepin, K.A. Rozenberg, R.K. Rastsvetaeva, and G. Ferraris (2003) Neskevaaraite-Fe - $NaK_3Fe(Ti,Nb)_4(Si_4O_{12})_2(O,OH)_4 \cdot 6H_2O$, a new labuntsovite group mineral. New Data on Minerals, 38, 9-14. (2) (2005) Amer. Mineral., 90, 520 (abs. ref. 1).

Nesquehonite $Mg(HCO_3)(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are prismatic, elongated along [010], {001}, {010}, {011}, {101} striated ‖ [010], to 3 cm; radial sprays and flat radial coatings, botryoidal. *Twinning:* Synthetic material is universally twinned on {001}.

Physical Properties: *Cleavage:* Perfect on {101}; good on {010}. *Fracture:* Splintery to fibrous. Hardness = 2.5 D(meas.) = 1.824–1.854 D(calc.) = 1.856 Very slightly soluble in H_2O; may fluoresce green under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous to slightly greasy.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z \simeq c$. *Dispersion:* $r < v$, weak.
$\alpha = [1.417]$ $\beta = 1.503(1)$ $\gamma = 1.527(1)$ 2V(meas.) = 53°

Cell Data: *Space Group:* $P2_1/m$ (synthetic). $a = 7.7053(11)$ $b = 5.3673(6)$
$c = 12.1212(11)$ $\beta = 90.451(13)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 20-669).
6.48 (100), 3.85 (75), 2.617 (55), 3.03 (30), 3.23 (20), 2.337 (20), 1.925 (16)

Chemistry:

	(1)	(2)
CO_2	30.22	31.81
MgO	29.22	29.13
H_2O	40.32	39.06
Total	99.76	100.00

(1) Lansford, Pennsylvania, USA; average of four analyses. (2) $Mg(HCO_3)(OH)\cdot 2H_2O$, supported by proton magnetic resonance spectroscopy, TGA, and IR.

Occurrence: Typically recently formed under near-surface conditions, as efflorescences in coal mines; in fractures in serpentinites; deposits around springs; in caves due to loss of CO_2 in waters.

Association: Lansfordite, dypingite, calcite, aragonite, artinite, hydromagnesite, brucite, pyroaurite, monohydrocalcite.

Distribution: In the USA, from Nesquehoning, near Lansford, Carbon Co., Pennsylvania; near the Robinson Gulch pegmatite, Jefferson Co., Colorado. Along Rapid Creek, Yukon Territory, Canada. In France, large crystals at a coal mine at Lamure, Isère, and from Restivalgues, near Salers, Cantal. In Austria, at Kraubath, Styria. In Italy, from near Rain, Taufers, Tirol; on Monte Ramazzo, north of Borzoli, Liguria; in the Franscia asbestos mine, Val Lanterna, Val Malenco, Lombardy; from Cogne, Val d'Aosta, Piedmont; and at Viu, near Fubina, Val di Lanzo. From the Feragen ultramafic body, Sør-Trøndelag, Norway. In Australia, from Paddy's River mine, Australian Capital Territory, and under Rainbow Falls, Sempill Creek, Barrington Tops, New South Wales. Around Mt. Erebus, Victoria Land, Antarctica. In Japan, from Yoshikawa, Aichi Prefecture, and at Shiraki, Mie Prefecture. A few other minor localities are known.

Name: For its first-noted occurrence at Nesquehoning, Pennsylvania, USA.

Type Material: Yale University, New Haven, Connecticut, USA, 3.1550, 3.1566, 3.1567.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 225–227. (2) Kinsolving, M.R., C. MacGillavry, and R. Pepinsky (1950) Twinning in nesquehonite, $MgCO_3\cdot 3H_2O$. Amer. Mineral., 35, 127. (3) Stephan, G.W. and C.H. MacGillavry (1972) The crystal structure of nesquehonite, $MgCO_3\cdot 3H_2O$. Acta Cryst., 28, 1031–1033. (4) Gasiunas, K., A. Kaminskas, I. Kapacauskas, B. Valuziene, and P. Kicas (1973) Nature of water in nesquehonite. Zh. Neorg. Khim. 18(9), 2332–2335 (in Russian). (5) (1974) Chem. Abs., 80, 154 (abs. ref. 4).

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Neustädtelite $Bi_2Fe^{3+}Fe^{3+}O_2(OH)_2(AsO_4)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are usually tabular on {100}, or equant, showing {001}, {010}, {100}, {021}, {102}, {111}, many other forms, to 2.5 cm; powdery, compact.

Physical Properties: *Cleavage:* {010}, perfect; {001}, imperfect. Hardness = 3–3.5 D(meas.) = 2.10 D(calc.) = [2.13] Slightly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to gray. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.514(3)$ $\beta = 1.517(3)$ $\gamma = 1.533(3)$ 2V(meas.) = 44°46′

Cell Data: *Space Group: Pbca.* $a = 10.203$–10.24 $b = 10.679$–10.74 $c = 9.99$–10.018 Z = [8]

X-ray Powder Pattern: Paoha Island, California, USA and Skipton lava tube caves, Australia.
5.34 (100), 4.71 (60), 3.460 (40), 3.083 (40), 2.580 (40), 5.94 (30), 3.039 (30)

Chemistry:

	(1)	(2)
P_2O_5	40.73	40.71
Fe_2O_3	0.85	
Mn_2O_3	0.21	
MgO	22.37	23.12
H_2O	[35.84]	36.17
Total	[100.00]	100.00

(1) Skipton lava tube caves, Australia; H_2O by difference. (2) $Mg(PO_3OH)\bullet 3H_2O$.

Occurrence: In caves, formed directly from bat guano.

Association: Hannayite, struvite (Skipton lava tube caves, Australia); biphosphammite (Petrogale Cave, Australia); monetite, struvite (Paoha Island, California, USA).

Distribution: In the Skipton lava tube caves, 40 km southwest of Ballarat, Victoria, and the Petrogale Cave, near Madura, Western Australia. At the Niah Great Cave, Sarawak, Malaysia. Around Mt. Erebus, Victoria Land, Antarctica. On Réunion Island, Indian Ocean. From Ascension Island, south Atlantic. In the USA, on Paoha Island, Mono Lake, Mono Co., California. From near Mejillones, Antofagasta, Chile. From Ficus and Boon's Caves, Transvaal, South Africa.

Name: To honor James Cosmo Newbery (1843–1895), geologist, Melbourne, Australia, who initially found the mineral.

Type Material: Natural History Museum, Paris, France, 99.504.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 709–711. (2) Cohen, L.H. and P.H. Ribbe (1966) Magnesium phosphate mineral replacement at Mono Lake, California. Amer. Mineral., 51, 1755–1765. (3) Bartl, H., M. Catti, W. Joswig, and G. Ferraris (1983) Investigation of the crystal structure of newberyite, $MgHPO_4\bullet 3H_2O$, by single crystal neutron diffraction. Tschermaks Mineral. Petrog. Mitt., 32, 187–194.

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Nevadaite $(Cu^{2+},\square,Al,V^{3+})_6[Al_8(PO_4)_8F_8](OH)_2(H_2O)_{22}$

Crystal Data: Orthorhombic. *Point Group: mm*2. Crystals prismatic on [001] in radiating clusters to 1 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.54 D(calc.) = 2.55

Optical Properties: Translucent. *Color:* Turquoise-blue, pale green. *Streak:* Pale powder-blue. *Luster:* Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.540$ $\beta = 1.548$ $\gamma = 1.553$ 2V(meas.) = 76° 2V(calc.) = 76°
Orientation: $X = c$; $Y = a$; $Z = b$. *Pleochroism:* Moderate, X = pale greenish blue; Y = very pale greenish blue; Z= blue. *Absorption:* $Z >> X > Y$.

Cell Data: *Space Group:* $P2_1mn$, $a = 12.123(2)$ $b = 18.999(2)$ $c = 4.961(1)$ $Z = 1$

X-ray Powder Pattern: Gold Quarry mine, Carlin, Nevada, USA.
6.077 (100), 5.618 (90), 9.535 (80), 2.983 (60), 3.430 (40), 2.661 (40), 1.844 (40)

Chemistry:

	(1)
CuO	9.24
ZnO	0.11
Al_2O_3	27.07
Fe_2O_3	0.07
V_2O_3	4.24
P_2O_5	32.54
H_2O	23.48
F	9.22
-O = F	3.88
Total	102.09

(1) Gold Quarry mine, Carlin, Nevada, USA; electron microprobe analysis, H_2O calculated from structure, H_2O and OH^- confirmed by IR and structure analysis; corresponding to $(Cu^{2+}_{2.00}Zn_{0.02}V^{3+}_{0.98}Fe^{3+}_{0.01}Al_{1.15})_{\Sigma=4.16}Al_8P_{7.90}O_{32}[F_{8.37}(OH)_{1.63}]_{\Sigma=10}(H_2O)_{21.65}$.

Occurrence: A weathering-derived mineral above a low grade, disseminated gold deposit in hydrothermally altered sedimentary rocks.

Association: Intermediate members of the strengite-variscite series, fluellite, hewettite, and more rarely anatase, kazakhstanite, leucophosphite, tinticite, torbernite, tyuyamunite, wavellite.

Name: For the US state from which the first specimens were collected.

Distribution: From the open-pit Gold Quarry mine, near Carlin, Eureka County, Nevada, USA.

Type Material: Systematic Reference Series, National Mineral Collection of Canada, Geological Survey of Canada, Ottawa, Ontario, Canada; NMCC68091.

References: (1) Cooper, M.A., F.C. Hawthorne, A.C. Roberts, E.E. Foord, R.C. Erd, H.T. Evans Jr., and M.C. Jensen (2004) Nevadaite, $(Cu^{2+},\square,Al, V^{3+})_6[Al_8(PO_4)_8F_8](OH)_2(H_2O)_{22}$, a new phosphate mineral species from the Gold Quarry mine, Carlin, Eureka County, Nevada: description and crystal structure. Can. Mineral., 42, 741-752. (2) (2005) Amer. Mineral., 90, 521 (abs. ref. 1).

Nevskite **Bi(Se, S)**

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$, $3m$, or 32. Irregular grains, to 2 mm in diameter.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = n.d. VHN = 60–114, 90 average (15 g load). D(meas.) = n.d. D(calc.) = 7.85

Optical Properties: Opaque. *Color:* Lead-gray; in reflected light, white with creamy tinge. *Luster:* Metallic. *Anisotropism:* Isotropic on basal sections, distinctly anisotropic in perpendicular sections, with weak color effects from brown to pale gray.
R_1–R_2: (400) — , (420) — , (440) 52.5–58.0, (460) 52.1–57.3, (480) 51.7–56.8, (500) 51.3–56.3, (520) 50.8–55.9, (540) 50.5–55.5, (560) 50.1–55.0, (580) 49.8–54.5, (600) 49.6–54.1, (620) 49.4–53.7, (640) 49.1–53.2, (660) 48.9–52.8, (680) 48.8–52.5, (700) 48.6–52.2

Cell Data: *Space Group:* $P\overline{3}m1$, $P3m1$, $P31m$, or $P321$. $a = 4.197$ $c = 22.80$ $Z = 6$

X-ray Powder Pattern: Nevskoye deposit, Russia.
3.06 (10), 3.59 (4), 2.24 (4), 2.10 (4), 1.903 (3), 1.734 (3), 1.534 (3)

Chemistry:

	(1)
Bi	69.8
Pb	3.0
Ag	0.6
Se	24.6
S	1.6
Total	99.6

(1) Nevskoye deposit, Russia; by electron microprobe, average of four analyses; corresponding to $(Bi_{0.92}Pb_{0.04}Ag_{0.02})_{\Sigma=0.98}(Se_{0.86}S_{0.14})_{\Sigma=1.00}$.

Occurrence: In quartz-cassiterite veins.

Association: Wolframite, cassiterite, natanite, laitakarite, guanajuatite.

Distribution: From the Nevskoye W–Sn deposit, 25 km northwest of Omsukchan, Magadan region, Russia [TL].

Name: For the Nevskoye deposit in Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82673.

References: (1) Nechelyustov, G.N., N.I. Christyakova, and E.N. Zav'yalov (1984) Nevskite Bio(Se, S) – a new bismuth selenide. Zap. Vses. Mineral. Obshch., 113, 351–355 (in Russian). (2) (1985) Amer. Mineral., 70, 875 (abs. ref. 1).

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are usually tabular on {100}, or equant, showing {001}, {010}, {100}, {021}, {102}, {111}, many other forms, to 2.5 cm; powdery, compact.

Physical Properties: *Cleavage:* {010}, perfect; {001}, imperfect. Hardness = 3–3.5 D(meas.) = 2.10 D(calc.) = [2.13] Slightly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to gray. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.514(3)$ $\beta = 1.517(3)$ $\gamma = 1.533(3)$ 2V(meas.) = 44°46′

Cell Data: *Space Group: Pbca.* $a = 10.203$–10.24 $b = 10.679$–10.74 $c = 9.99$–10.018 Z = [8]

X-ray Powder Pattern: Paoha Island, California, USA and Skipton lava tube caves, Australia.
5.34 (100), 4.71 (60), 3.460 (40), 3.083 (40), 2.580 (40), 5.94 (30), 3.039 (30)

Chemistry:

	(1)	(2)
P_2O_5	40.73	40.71
Fe_2O_3	0.85	
Mn_2O_3	0.21	
MgO	22.37	23.12
H_2O	[35.84]	36.17
Total	[100.00]	100.00

(1) Skipton lava tube caves, Australia; H_2O by difference. (2) $Mg(PO_3OH)\cdot 3H_2O$.

Occurrence: In caves, formed directly from bat guano.

Association: Hannayite, struvite (Skipton lava tube caves, Australia); biphosphammite (Petrogale Cave, Australia); monetite, struvite (Paoha Island, California, USA).

Distribution: In the Skipton lava tube caves, 40 km southwest of Ballarat, Victoria, and the Petrogale Cave, near Madura, Western Australia. At the Niah Great Cave, Sarawak, Malaysia. Around Mt. Erebus, Victoria Land, Antarctica. On Réunion Island, Indian Ocean. From Ascension Island, south Atlantic. In the USA, on Paoha Island, Mono Lake, Mono Co., California. From near Mejillones, Antofagasta, Chile. From Ficus and Boon's Caves, Transvaal, South Africa.

Name: To honor James Cosmo Newbery (1843–1895), geologist, Melbourne, Australia, who initially found the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 709–711. (2) Cohen, L.H. and P.H. Ribbe (1966) Magnesium phosphate mineral replacement at Mono Lake, California. Amer. Mineral., 51, 1755–1765. (3) Bartl, H., M. Catti, W. Joswig, and G. Ferraris (1983) Investigation of the crystal structure of newberyite, $MgHPO_4\cdot 3H_2O$, by single crystal neutron diffraction. Tschermaks Mineral. Petrog. Mitt., 32, 187–194.

Neyite $Ag_2Cu_6Pb_{25}Bi_{26}S_{68}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As masses of small intergrown crystals and grains; also as aggregates of prismatic to bladed crystals with stepped surfaces on the broad faces, to 3 mm; some prismatic aggregates are twisted and curved.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 2.5 VHN = n.d. D(meas.) = 7.02 D(calc.) = 7.037

Optical Properties: Opaque. *Color:* Lead-gray, tarnishes yellow then Prussian blue; galena-white in reflected light. *Luster:* Bright metallic. *Anisotropism:* Moderate, pale gray, yellow-green, and pale reddish brown to gray-black.
R_1–R_2: (400) 41.3–44.5, (420) 41.6–44.8, (440) 41.8–45.0, (460) 42.1–45.2, (480) 42.3–45.3, (500) 42.4–45.0, (520) 42.2–45.1, (540) 41.9–44.8, (560) 41.6–44.5, (580) 41.4–44.4, (600) 41.2–44.5, (620) 41.0–44.6, (640) 40.7–44.6, (660) 40.4–44.5, (680) 40.2–44.3, (700) 39.9–44.1

Cell Data: *Space Group:* $C2/m$. $a = 37.527(6)$ $b = 4.0705(6)$ $c = 43.701(7)$ $\beta = 108.801(2)^\circ$ Z = 4

X-ray Powder Pattern: Lime Creek deposit, Canada.
3.72 (10), 3.51 (10), 2.92 (10), 2.04 (6), 2.27 (5), 2.08 (4), 1.461 (4)

Chemistry:

	(1)	(2)	(3)
Pb	41.76	37.9	38.68
Cu	2.84	2.90	2.85
Cd		0.30	
Ag	1.52	1.58	1.61
Bi	36.62	40.4	40.58
Sb		0.10	
S	15.65	16.2	16.28
Total	98.39	99.4	100.00

(1) Lime Creek deposit, Canada; corresponding to $Ag_{1.96}Cu_{6.23}Pb_{28.08}Bi_{24.42}S_{68.00}$. (2) Do.; by electron microprobe, corresponding to $Ag_{1.97}Cu_{6.14}Cd_{0.36}Pb_{24.62}Bi_{26.02}Sb_{0.11}S_{68.00}$. (3) $Ag_2Cu_6Pb_{25}Bi_{26}S_{68}$.

Occurrence: In late-forming crosscutting hydrothermal quartz veins in a quartz-molybdenite stockwork (Lime Creek deposit, Canada); in mesozonal synmetamorphic quartz veins (Johnny Lyon Hills, Arizona, USA).

Association: Pyrite, galena, sphalerite, chalcopyrite, aikinite, cosalite, tetrahedrite, nuffieldite, molybdenite (Lime Creek deposit, Canada); gold, chalcopyrite, nordströmite, quartz (Johnny Lyon Hills, Arizona, USA).

Distribution: From Patsy Creek, immediately south of the Lime Creek molybdenum deposit, Kitsault, near Alice Arm, British Columbia, Canada [TL]. In the USA, from the Johnny Lyon Hills, north of Benson, Cochise Co., Arizona; at the Alaska mine, Poughkeepsie Gulch, San Juan Co., Colorado; from the Whiskey Canyon prospect, Lewis district, Lander Co., Nevada. In the Golconda prospect, Chishawasha, near Harare, Zimbabwe. From the Vale das Gatas tungsten mine, near Vila Real, Portugal. At the Felbertal tungsten mine, Salzburg, Austria.

Name: To honor Charles Stuart Ney (1918–1975), geologist in charge of early exploration at the Lime Creek deposit.

Type Material: Canadian Geological Survey, Ottawa, Canada, 68067; National Museum of Natural History, Washington, D.C., USA, 142527.

References: (1) Drummond, A.D., J. Trotter, R.M. Thompson, and J.A. Gower (1969) Neyite, a new sulphosalt from Alice Arm, British Columbia. Can. Mineral., 10, 90–96. (2) (1970) Amer. Mineral., 55, 1444 (abs. ref. 1). (3) Makovicky, E., T. Balić-Žunić, and D. Topa (2001) The crystal structure of neyite, $Ag_2Cu_6Pb_{25}Bi_{26}S_{68}$. Can. Mineral., 39, 1365–1376. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 392.

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Niahite $(NH_4)(Mn^{2+},Mg)PO_4 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Rarely as individual crystals; in radiating and subparallel aggregates of crystals, to 0.5 mm.

Physical Properties: Hardness = n.d. D(meas.) = 2.39 D(calc.) = 2.437

Optical Properties: Semitransparent. *Color:* Pale orange; colorless in thin section.
Streak: White.
Optical Class: Biaxial (–). $\alpha = 1.582(2)$ $\beta = 1.604(2)$ $\gamma = 1.609(2)$ 2V(meas.) = 54°
2V(calc.) = 50°

Cell Data: *Space Group:* $Pmn2_1$. $a = 5.68$ $b = 8.78$ $c = 4.88$ Z = 2

X-ray Powder Pattern: Niah Great Cave, Sarawak, Malaysia.
8.82 (10), 2.832 (9), 2.845 (8), 4.267 (6), 4.79 (5), 3.412 (4), 2.300 (4)

Chemistry:

	(1)
P_2O_5	37.83
MnO	27.21
MgO	4.19
CaO	1.99
$(NH_4)_2O$	12.9
H_2O	11.88
Total	96.00

(1) Niah Great Cave, Sarawak, Malaysia; by electron microprobe, total Mn as MnO, N, H, and P by microchemical methods; corresponding to $(NH_4)_{0.93}(Mn_{0.72}Mg_{0.20}Ca_{0.06})_{\Sigma=0.98}P_{1.00}O_{3.95} \cdot 1.23H_2O$.

Occurrence: A rare mineral, derived from the breakdown of bat guano (Niah Great Cave, Sarawak, Malaysia).

Association: Newberyite, collophane, hannayite, struvite, variscite (Niah Great Cave, Sarawak, Malaysia); newberyite, sussexite, pyrochroite (Sterling Hill, New Jersey, USA).

Distribution: From the Niah Great Cave, Sarawak, Malaysia. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. In the Taguchi mine, Shidara, Aichi Prefecture, Japan.

Name: For the place of its first-noted occurrence, the Niah Great Cave, Malaysia.

Type Material: Malaysian Geological Survey, Kuching (Sarawak), Sarawak, Malaysia; Bureau of Mineral Resources, Canberra; Government Chemical Laboratories, Perth, Australia, MDC5089.

References: (1) Bridge, P.J. and B.W. Robinson (1983) Niahite – a new mineral from Malaysia. Mineral. Mag., 47, 79–80. (2) (1984) Amer. Mineral., 69, 408 (abs. ref. 1). (3) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 674.

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Nickel Ni

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As euhedral cubic grains or intergrown cubes, to 0.1 mm, enclosed in heazlewoodite; also as anhedral "spiderlike" irregular masses between heazlewoodite grains; as flakes, to 0.75 mm, in a placer. *Twinning:* On {111}.

Physical Properties: *Tenacity:* Malleable. Hardness = 4.5 VHN = 172–184 (50 g load). D(meas.) = 8.90 (synthetic). D(calc.) = 8.91

Optical Properties: Opaque. *Color:* Bright silver; white in reflected light, more bluish white than heazlewoodite. *Luster:* Metallic.
R: n.d.

Cell Data: *Space Group:* $Fm3m$. a = 3.5238 Z = 4

X-ray Powder Pattern: Synthetic.
2.034 (100), 1.762 (42), 1.246 (21), 1.0624 (20), 0.7880 (15), 0.8084 (14), 1.0172 (7)

Chemistry:

	(1)	(2)
Ni	> 98	96.30
Fe	trace	1.77
Co	trace	0.69
Total	> 98	98.76

(1) Bogota, New Caledonia; by electron microprobe. (2) Jerry River, New Zealand; by electron microprobe.

Occurrence: In serpentinized ultramafic rocks as a result of low-temperature hydrothermal activity.

Association: Heazlewoodite, pyrite, pyrrhotite, pentlandite, godlevskite, orcelite, millerite, nickel, copper, chalcopyrite, chalcocite, galena.

Distribution: From Bogota, near Canala, New Caledonia [TL]. In the Jerry River, in placers derived from the Red Hills Range, southern Westland, New Zealand. From Mount Clifford and Cutmore, near Agnew, Western Australia, and the Nairne pyrite deposit, South Australia. At Kaltenberg, Turtmauntal, Valais, Switzerland. In the Kauniinvaara ultramafic lens, near Lake Kauniinlampi, eastern Finland. On Grasshopper Mountain, Tulameen, British Columbia, Canada.

Name: From the German *nickel*, *demon*, from a contraction of *kupfernickel*, or *Devil's copper*, as the mineral was believed to contain copper but yielded none.

Type Material: n.d.

References: (1) Ramdohr, P. (1968) The wide-spread paragenesis of ore minerals originating during serpentinization (with some data on new and insufficiently described minerals). Geol. Rudn. Mestorozhd., 2, 32–43 (in Russian). (2) (1968) Amer. Mineral., 53, 348 (abs. ref. 1). (3) Challis, G.A. (1975) Native nickel from the Jerry River, south Westland, New Zealand; an example of natural refining. Mineral. Mag., 40, 247–251. (4) Hudson, D.R. and G.A. Travis (1981) A native nickel-heazlewoodite-ferroan trevorite assemblage from Mount Clifford, Western Australia. Econ. Geol., 76, 1686–1697. (5) (1953) NBS Circ. 539, 1, 13.

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Nickelaustinite $Ca(Ni,Zn)(AsO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals are flattened on {110}, elongated along [001], commonly fibrous, to 0.3 mm, in radial aggregates.

Physical Properties: *Cleavage:* On {110}, good. Hardness = 4 D(meas.) = n.d. D(calc.) = 4.27

Optical Properties: Transparent. *Color:* Yellowish green to grass-green. *Streak:* White. *Luster:* Silky to subadamantine.
Optical Class: Biaxial (+). *Orientation:* $X = c$. $\alpha = 1.770(2)$ β = n.d. $\gamma = 1.778(3)$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.455(3)$ $b = 8.955(3)$ $c = 5.916(2)$ Z = 4

X-ray Powder Pattern: Bou Azzer, Morocco.
2.626 (10), 3.151 (9), 2.769 (9), 1.605 (9), 2.577 (8), 2.508 (8), 2.058 (7)

Chemistry:

	(1)
As_2O_5	43.70
FeO	0.10
CoO	1.22
NiO	20.40
CuO	0.06
ZnO	6.88
MgO	1.00
CaO	23.32
H_2O	[3.32]
Total	[100.00]

(1) Bou Azzer, Morocco; by electron microprobe, H_2O by difference; corresponds to $Ca_{1.01}(Ni_{0.67}Zn_{0.21}Mg_{0.06}Co_{0.04}Cu_{0.01})_{\Sigma=0.99}(As_{0.93}O_4)(OH)$.

Mineral Group: Adelite group.

Occurrence: On dolomite.

Association: Roselite, calcite, dolomite, chalcopyrite, skutterudite.

Distribution: At Bou Azzer, Anti-Atlas Mountains, Morocco.

Name: For the predominance of *nickel* in the composition and relation to *austinite*.

Type Material: National School of Mines, Paris, France.

References: (1) Cesbron, F.P., D. Ginderow, R. Giraud, P. Pelisson, and F. Pillard (1987) La nickelaustinite $Ca(Ni,Zn)(AsO_4)(OH)$: nouvelle espèce minérale du district cobalto-nickelifère de Bou-Azzer, Maroc. Can. Mineral., 25, 401–407 (in French with English abs.). (2) (1988) Amer. Mineral., 73, 930 (abs. ref. 1).

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Nickelbischofite $NiCl_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As a 2 mm patch of crystalline material on the surface of drill core; a minor component of powdery sublimates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.932 Deliquescent; soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Green.
Optical Class: Biaxial (+) (synthetic). *Pleochroism:* Weak; X = greenish yellow; Z = green. *Orientation:* $Y = b$; $X \wedge c = 8°$. *Absorption:* $Z > X$. $\alpha = 1.590$ $\beta = 1.620$ $\gamma = 1.648$ 2V(meas.) = Very large.

Cell Data: *Space Group:* $I2/m$ (synthetic). $a = 8.786(2)$ $b = 7.076(2)$ $c = 6.625(2)$ $\beta = 97.27(1)°$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 25-1044).
5.59 (100), 5.50 (40), 4.82 (35), 2.926 (35), 2.747 (30), 2.689 (20), 2.178 (20)

Chemistry: Natural material shown to contain nickel and chlorine, and to be identical with synthetic material by X-ray diffraction.

Occurrence: As an alteration product on the surface of drill core from an ultramafic intrusion containing low-grade nickel mineralization, formed after storage (Amos, Canada); as a volcanic sublimate (Mt. Shirane, Japan).

Association: Coalingite, paratacamite, pentlandite, awaruite, heazlewoodite (Amos, Canada); alunogen (Mt. Shirane, Japan).

Distribution: From the Dumont ultramafic intrusive, 27 km west of Amos, Quebec, Canada. On Mt. Shirane, Gumma Prefecture, Japan.

Name: As the compositional *nickel* analog of *bischofite*, with which it is, however, not isostructural.

Type Material: Canadian Geological Survey, Ottawa, Canada, 17980.

References: (1) Jambor, J.L. (1975) Secondary minerals in an ultramafic intrusion, Amos area, Quebec. Geol. Surv. Canada Paper 75-1A, 261–263. (2) Crook, W.W., III and J.L. Jambor (1979) Nickelbischofite, a new nickel chloride hydrate. Can. Mineral., 17, 107–109. (3) (1980) Amer. Mineral., 65, 207–208 (abs. ref. 2). (4) Peacor, D.R., W.B. Simmons, Jr., E.J. Essene, and E.W. Heinrich (1982) New data on and discreditation of "texasite," "albrittonite," "cuproartinite," "cuprohydromagnesite," and "yttromicrolite," with corrected data on nickelbischofite, rowlandite, and yttrocrasite. Amer. Mineral., 67, 156–169. (5) (1974) NBS Mono. 25, 11, 42.

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Nickelblödite $Na_2Ni(SO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As flat crystallites, to 150 μm; with smooth forms, perhaps rounded by solution, in efflorescences.

Physical Properties: Hardness = n.d. VHN = 104–139 (5 gm load). D(meas.) = 2.43 D(calc.) = 2.432–2.455

Optical Properties: Translucent. *Color:* Pale yellowish green to pale green; in transmitted light, colorless to pale green.
Optical Class: Biaxial (–). α = 1.504–1.513 β = [1.507–1.518] γ = 1.509–1.520
2V(meas.) = 60°–70°

Cell Data: *Space Group:* $P2_1/a$ (by analogy to blödite). $a = 10.87$ $b = 8.07$ $c = 5.46$ $\beta = 100°43'$ Z = 2

X-ray Powder Pattern: Kambalda, Western Australia.
3.223 (10), 4.466 (9), 3.190 (8), 4.193 (7), 3.720 (6), 2.589 (6), 3.920 (5)

Chemistry:

	(1)	(2)
SO_3	49.00	43.41
FeO	1.03	
NiO	15.41	20.25
CuO	0.04	
MgO	1.53	
Na_2O	16.35	16.80
H_2O	[16.64]	19.54
Total	[100.00]	100.00

(1) Kambalda, Western Australia; by electron microprobe, recalculated to 100% from an elemental analysis, H_2O by difference; corresponding to $Na_{2.02}(Ni_{0.79}Mg_{0.14}Fe_{0.06})_{\Sigma=0.99}(SO_4)_{2.00} \cdot 3.17H_2O$. (2) $Na_2Ni(SO_4)_2 \cdot 4H_2O$.

Occurrence: By evaporation of fluids containing Na, Ni, and SO_4.

Association: Violarite, pyrite, siderite, halite (Kambalda, Western Australia); morenosite (Carr Boyd Rocks mine, Western Australia).

Distribution: From the Durkin nickel mine, Kambalda, 56 km south of Kalgoorlie, and in the Carr Boyd Rocks mine, Goongarrie, Western Australia.

Name: For its relation to *blödite*, with Ni > Mg.

Type Material: Western Australian Museum, Perth, Australia, M.63.1991, M.64.1991, MDC5657; The Natural History Museum, London, England, 1976,378; National Museum of Natural History, Washington, D.C., USA, 136207.

References: (1) Nickel, E.H. and P.J. Bridge (1977) Nickelblödite, $Na_2Ni(SO_4)_2 \cdot 4H_2O$, a new mineral from Western Australia. Mineral. Mag., 41, 37–41. (2) (1977) Amer. Mineral., 62, 1059 (abs. ref. 1).

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Nickel-boussingaultite $(NH_4)_2(Ni,Mg)(SO_4)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic grains, to < 0.01 mm, in thin films.

Physical Properties: *Cleavage:* Imperfect. Hardness = 2.5 D(meas.) = n.d. D(calc.) = 1.85 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Greenish blue to emerald-green; green in transmitted light.
Optical Class: Biaxial (+). *Pleochroism:* X = pale blue; Z = yellow. *Orientation:* $X \wedge c = 0°$–$4°$. $\alpha = 1.490$ $\beta = 1.494$ $\gamma = 1.501$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/b$ (by analogy to synthetic $(NH_4)_2Ni(SO_4)_2 \cdot 6H_2O$).
$a = 9.241(2)$ $b = 12.544(15)$ $c = 6.243(5)$ $\beta = 106°58(6)'$ Z = 2

X-ray Powder Pattern: Noril'sk, Russia.
4.153 (10), 3.759 (8), 11.7 (7), 2.119 (7), 3.022 (6), 2.793 (6), 1.806 (6)

Chemistry:

	(1)
SO_3	40.20
FeO	0.37
NiO	16.84
CuO	2.74
MgO	2.30
Na_2O	0.52
$(NH_4)_2O$	[10.40]
H_2O	27.42
Total	[100.79]

(1) Noril'sk, Russia; original total given as 100.89%, $(NH_4)^{1+}$ calculated for charge balance, found present by IR; corresponds to $[(NH_4)_{1.59}Na_{0.07}]_{\Sigma=1.66}(Ni_{0.90}Mg_{0.23}Cu_{0.14}Fe_{0.02})_{\Sigma=1.29}(SO_4)_2 \cdot 6H_2O$.

Mineral Group: Picromerite group.

Occurrence: In an underground nickel ore stockpile, around and on a wooden timber, and on "limonite" (Noril'sk, Russia).

Association: Pentlandite, chalcopyrite, "limonite" (Noril'sk, Russia); wupatkiite, hydrohonessite, pickeringite (Cameron, Arizona, USA).

Distribution: From the Talnakh area, Noril'sk, western Siberia, Russia. At the Heimberg quarry, Wolfshagen, Harz Mountains, Germany. In the USA, from a prospect 13 km east-southeast of Gray Mountain, Cameron district, Coconino Co., Arizona.

Name: As the *nickel*-bearing analog of *boussingaultite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 83553.

References: (1) Yakhontova, L.K., G.A. Siderenko, T.I. Stolyarova, I.I. Plyusnina, and T.L. Ivanova (1976) Nickel-containing sulfates from the oxidation zone of the Norilskiye deposits. Zap. Vses. Mineral. Obshch., 105, 710–720 (in Russian). (2) (1986) Amer. Mineral., 71, 1545 (abs. ref. 1). (3) Montgomery, H. and E.C. Lingafelter (1964) The crystal structure of Tutton's salts. II. Magnesium ammonium sulfate hexahydrate and nickel ammonium sulfate hexahydrate. Acta Cryst., 17, 1478–1479. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 152.

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Nickelhexahydrite $(Ni, Mg, Fe^{2+})SO_4 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In crystalline crusts and coatings, which may be formed only during relatively dry seasons.

Physical Properties: *Cleavage:* On {010}, probable, perfect; on {100}, less perfect. Hardness = n.d. D(meas.) = 2.036 D(calc.) = 2.05 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Bluish green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z \wedge c = 45°$. α = 1.469–1.470 β = n.d. γ = 1.493–1.494 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 9.880(3)$ $b = 7.288(2)$ $c = 24.130(3)$ $\beta = 98.32(2)°$ Z = 8

X-ray Powder Pattern: Noril'sk, Russia.
4.35 (10), 2.89 (9), 3.98 (8), 1.994 (8), 1.856 (7), 5.41 (6), 5.07 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	30.82	30.67	30.46	CuO	0.26		
Fe_2O_3	0.18			ZnO	0.00		
FeO	2.63			MgO	2.43	4.07	
MnO	0.07			CaO	0.00		
CoO	0.03	0.21		H_2O	41.05	41.96	41.12
NiO	22.57	22.69	28.42	Total	100.04	99.60	100.00

(1) Noril'sk, Russia; corresponds to $(Ni_{0.77}Mg_{0.16}Fe_{0.10})_{\Sigma=1.03}(SO_4)_{0.99} \cdot 5.84H_2O$. (2) Jáchymov, Czech Republic; corresponds to $(Ni_{0.78}Mg_{0.26}Co_{0.01})_{\Sigma=1.05}(SO_4)_{0.99} \cdot 5.99H_2O$. (3) $NiSO_4 \cdot 6H_2O$.

Polymorphism & Series: Dimorphous with retgersite.

Mineral Group: Hexahydrite group.

Occurrence: Precipitated from mine waters in the bottom of an open-pit nickel mine, and on nickel-bearing gabbro-dolerite rocks in the oxidation zone (Noril'sk region, Russia); in shear zones in talc overlying ultramafic rocks (Lahnaslampi deposit, Finland); formed from H_2O solution below 31.5 °C.

Association: Morenosite.

Distribution: From the Severnaya mine, Noril'sk, western Siberia, and in the Izumrudnye Kopi emerald mines, Asbest district, Ural Mountains, Russia. At the Lahnaslampi talc deposit, Finland. From the Riffelalp and Pollux, near Zermatt, Valais, Switzerland. At Droskovac, near Vares, Bosnia-Herzegovina. From Jáchymov (Joachimsthal), Czech Republic. At the Bauhaus mine, Richelsdorfer Mountains, Hesse, Germany. In Australia, from Noddy's Creek, Tasmania, and from Kambalda, 56 km south of Kalgoorlie, Western Australia.

Name: As the *nickel*-dominant analog of *hexahydrite*.

Type Material: Mineralogical Institute, Tomsk Polytechnical Institute, Tomsk, Russia.

References: (1) Oleinikov, B.V., S.L. Shvartsev, N.T. Mandrikova, and N.N. Oleinikova (1965) Nickelhexahydrite – a new mineral. Zap. Vses. Mineral. Obshch., 93, 534–547 (in Russian). (2) (1966) Amer. Mineral., 51, 259 (abs. ref. 1). (3) Angel, R.J. and L.W. Finger (1988) Polymorphism of nickel sulfate hexahydrate. Acta Cryst., C44, 1869–1873. (4) Ondruš, P., F. Veselovský, J. Hloušek, R. Skála, I. Vavřín, J. Frýda, J. Čejka, and A. Gabašová (1997) Secondary minerals of the Jáchymov (Joachimsthal) ore district. J. Czech Geol. Soc., 42(4), 3–76, esp. 39–40.

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Nickeline NiAs

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Commonly in granular aggregates, reniform masses with radial structure, and reticulated and arborescent growths. Rarely as distorted, horizontally striated, $\{10\bar{1}1\}$ terminated crystals, to 1.5 cm. *Twinning:* On $\{10\bar{1}1\}$ producing fourlings; possibly on $\{31\bar{4}1\}$.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–5.5 VHN = n.d. D(meas.) = 7.784 D(calc.) = 7.834

Optical Properties: Opaque. *Color:* Pale copper-red, tarnishes gray to blackish; white with strong yellowish pink hue in reflected light. *Streak:* Pale brownish black. *Luster:* Metallic. *Pleochroism:* Strong; whitish, yellow-pink to pale brownish pink. *Anisotropism:* Very strong, pale greenish yellow to slate-gray in air.
R_1–R_2: (400) 39.2–45.4, (420) 38.0–44.2, (440) 36.8–43.5, (460) 36.2–43.2, (480) 37.2–44.3, (500) 39.6–46.4, (520) 42.3–48.6, (540) 45.3–50.7, (560) 48.2–52.8, (580) 51.0–54.8, (600) 53.7–56.7, (620) 55.9–58.4, (640) 57.8–59.9, (660) 59.4–61.3, (680) 61.0–62.5, (700) 62.2–63.6

Cell Data: *Space Group:* $P6_3/mmc$. $a = 3.621(1)$ $c = 5.042(1)$ $Z = 2$

X-ray Powder Pattern: Unknown locality.
2.66 (100), 1.961 (90), 1.811 (80), 1.071 (40), 1.328 (30), 1.033 (30), 0.821 (30)

Chemistry:

	(1)	(2)
Ni	43.2	43.93
Co	0.4	
Fe	0.2	
As	55.9	56.07
Sb	0.1	
S	0.1	
Total	99.9	100.00

(1) Jáchymov, Czech Republic; by electron microprobe, corresponds to $(Ni_{0.98}Co_{0.01}Fe_{0.01})_{\Sigma=1.00}As_{1.00}$. (2) NiAs.

Mineral Group: Nickeline group.

Occurrence: A minor component of Ni–Cu ores in high-temperature hydrothermal veins; massive and in disseminations in peridotite and norite.

Association: Skutterudite–nickel-skutterudite, safflorite, rammelsbergite, gersdorffite, maucherite, breithauptite, michenerite, bismuth, bismuthinite.

Distribution: In Germany, from Eisleben and Mansfeld, Saxony-Anhalt; at St. Andreasberg, Harz Mountains; from Schneeberg, Saxony; crystallized at Richelsdorf, Hesse-Nassau. From Schladming, Austria. At Jáchymov (Joachimsthal), Czech Republic. From the Chalanches mine, near Allemont, Isère, France. In the USA, at Silver Cliff, Custer Co., and in the Gem mine, Fremont Co., Colorado. In Ontario, Canada, from the Cobalt–Gowganda and Sudbury districts, and at Silver Islet, Thunder Bay district. At Cochabamba, Bolivia. From the Aït Ahmane mine, 10 km east of Bou Azzer, Morocco. In the Talmessi mine, 35 km west of Anarak, Iran. At the Ban Phuc Ni–Cu deposit, northwestern Vietnam. Many additional occurrences have been noted.

Name: From the German *kupfernickel*, or *Devil's copper*, as the mineral was believed to contain copper but yielded none.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 236–238. (2) Faber, ?? (1933) ??title??Zeits. Krist., 84, 408 str??. (3) Beran, A. and T. Mohsenzadeh (1982) A reflected light investigation of nickeline, breithauptite and millerite. Tschermaks Mineral. Petrog. Mitt., 30, 267–275. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 62.

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Nickelphosphide $(Ni, Fe)_3P$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As lathlike crystals, elongated along [0001], to 2 μm, found in perchloric acid-resistant residues.

Physical Properties: Hardness = ∼9 VHN = 2600–3500 (100 g load) (synthetic). D(meas.) = 3.167–3.171 (synthetic). D(calc.) = 3.11

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (–) (synthetic). $\omega = 2.03$ $\epsilon = 2.02$

Cell Data: *Space Group:* $P31c$ (synthetic). $a = 7.74(2)$ $c = 5.61(2)$ Z = 4

X-ray Powder Pattern: Source material not stated.
4.31 (32), 2.15 (32), 2.87 (28), 2.59 (28), 6.70 (17), 3.35 (17), 2.81 (17)

Chemistry:

	(1)	(2)
Si	57.2	60.06
N	42.8	39.94
Total	100.0	100.00

(1) Indarch meteorite; by scanning transmission electron microscope, average of eight analyses; corresponding to $Si_{2.79}N_{4.21}$. (2) Si_3N_4.

Occurrence: A very rare component of enstatite chondrite and chondrite meteorites, probably formed by exsolution during metamorphism.

Association: Diamond, kamacite, perryite, schreibersite, troilite, spinel, chromite, hibonite, rutile.

Distribution: In the Indarch enstatite chondrite meteorite, and the Inman, Adrar, and Tieschitz chondrite meteorites.

Name: Honors Alfred Otto Carl Nier (1912–1994), Professor of Chemistry at the University of Minnesota, Minneapolis, Minnesota, USA, a founder of mass spectroscopy.

Type Material: The Natural History Museum, London, England.

References: (1) Lee, M.R., S.S. Russell, J.W. Arden, and C.T. Pillinger (1995) Nierite (Si_3N_4), a new mineral from ordinary and enstatite chondrites. Meteoritics, 30, 387–398. (2) (1996) Amer. Mineral., 81, 251 (abs. ref. 1). (3) Kohatsu, I. and J.W. McCauley (1974) Re-examination of the crystal structure of α-Si_3N_4. Mat. Res. Bull., 9, 917–920.

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Nickelschneebergite $BiNi_2(AsO_4)_2[(H_2O)(OH)]$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic grains, elongated along $[10\overline{1}]$, fibrous, radial or lamellar ∥ {010}, may show {010}, {100}, $\{10\overline{1}\}$, to 0.2 mm.

Physical Properties: *Cleavage:* {010}, perfect; {100}, $\{10\overline{1}\}$, good. Hardness = ∼3
D(meas.) = n.d. D(calc.) = 4.06

Optical Properties: Semitransparent. *Color:* Bright blue. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Light blue to blue. *Orientation:* $Y = b$; $Z \wedge a = 28°$.
$\alpha = 1.714(5)$ $\beta = 1.744(5)$ $\gamma = 1.783(5)$ 2V(meas.) = 60(6)° 2V(calc.) = 84°

Cell Data: *Space Group:* $C2/c$. $a = 11.882(4)$ $b = 12.760(4)$ $c = 6.647(2)$
$\beta = 112.81(2)°$ Z = 4

X-ray Powder Pattern: Nickenicher Sattel volcano, Germany.
2.744 (10), 3.195 (4), 4.06 (3), 4.35 (3), 3.56 (3), 3.066 (3), 2.605 (3b)

Chemistry:

	(1)
P_2O_5	0.9
As_2O_5	64.3
V_2O_5	0.06
Al_2O_3	1.1
Fe_2O_3	5.5
MnO	0.5
CuO	4.7
MgO	17.9
CaO	2.8
Na_2O	4.6
K_2O	0.1
Total	102.5

(1) Nickenicher Sattel volcano, Germany; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO; corresponds to $(Na_{0.81}K_{0.01})_{\Sigma=0.82}Ca_{0.27}Cu_{0.32}(Mg_{2.42}Fe_{0.38}Al_{0.12}Mn_{0.03})_{\Sigma=2.95}[(As_{1.02}P_{0.02})_{\Sigma=1.04}O_4]_3$; crystal-structure analysis gives $Na_{0.76}Ca_{0.41}Cu_{0.39}(Mg_{2.33}Fe_{0.52}Al_{0.12}Mn_{0.03})_{\Sigma=3.00}[(As_{0.98}P_{0.02})_{\Sigma=1.00}O_4]_3$.

Occurrence: In a cavity in volcanic scoria.

Association: Vanadinite, duhamelite.

Distribution: From the Nickenicher Sattel volcano, Eifel district, Germany.

Name: For the village of Nickenich, Germany, nearby the Nickenicher Sattel volcano.

Type Material: University of Vienna, Vienna, Austria.

References: (1) Auernhammer, M., H. Effenberger, G. Hentschel, T. Reinecke, and E. Tillmanns (1993) Nickenichite, a new arsenate from the Eifel, Germany. Mineral. Petrol., 48, 153–166. (2) (1994) Amer. Mineral., 79, 571 (abs. ref. 1).

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Nickel-skutterudite $(Ni, Co)As_{2-3}$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Rare as euhedral crystals with combinations of {001}, {111}, and rarely {011}, to 2 mm; also as reticular skeletal growths, distorted aggregates and granular; {001} typically warped. *Twinning:* On {112} as sixlings; commonly complex and distorted.

Physical Properties: *Cleavage:* Distinct on {001} and {111}, in traces on {011}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 5.5–6 VHN = 642–740 (100 g load). D(meas.) = 6.5 D(calc.) = [5.07–6.90]

Optical Properties: Opaque. *Color:* Tin-white to silver-gray, may tarnish gray or iridescent; in reflected light, yellowish white, but anisotropic zones may be somewhat reddish. *Streak:* Black. *Luster:* Bright metallic on fresh surface. *Anisotropism:* Weak to distinct in some zones.

R: (400) 52.0, (420) 52.5, (440) 53.3, (460) 53.8, (480) 54.5, (500) 55.0, (520) 55.3, (540) 55.4, (560) 55.3, (580) 55.1, (600) 54.7, (620) 54.3, (640) 53.9, (660) 53.4, (680) 52.8, (700) 52.5

Cell Data: *Space Group:* $Im3$. $a = 8.17$ $Z = 8$

X-ray Powder Pattern: Timiskaming mine, Cobalt, Canada.
2.61 (100), 1.841 (90), 1.616 (90), 2.20 (80), 1.681 (70), 1.410 (70), 1.213 (70)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	12.89	15.2	28.15	20.71
Co	5.95	4.5		
Cu		0.7		
Fe	3.06	3.5		
As	78,10	75.3	71.85	79.29
Total	[100.00]	99.3	100.00	100.00

(1) Bullard Peak, New Mexico, USA; recalculated to 100.00% after deduction of SiO_2 4.56% and Ag 8.38%; then corresponds to $(Ni_{0.58}Co_{0.27}Fe_{0.15})_{\Sigma=1.00}As_{2.78}$. (2) Schneeberg, Germany; corresponds to $(Ni_{0.63}Co_{0.19}Fe_{0.15}Cu_{0.03})_{\Sigma=1.00}As_{2.46}$. (3) $NiAs_2$. (4) $NiAs_3$.

Polymorphism & Series: Forms a series with skutterudite.

Occurrence: In hydrothermal veins deposited at medium temperature.

Association: Arsenopyrite, silver, bismuth, calcite, siderite, barite, quartz.

Distribution: In the USA, in the Black Hawk district, on Bullard Peak, 24 km southwest of Silver City, Grant Co., from the Rose [TL] and Alhambra mines. In Canada, at the O'Brien mine and elsewhere, Cobalt, Ontario. In Germany, at Bieber and Riechelsdorf, Hesse; St. Andreasberg, Harz Mountains; and Annaberg and Schneeberg, Saxony. From Horní Slavkov (Schlaggenwald) and Jáchymov (Joachimsthal), Czech Republic. At Dobšiná (Dobschau), Slovakia. From Saint-Marie-aux-Mines, Haut-Rhin, France. In the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, Russia.

Name: Nickel, as the nickel member of the series; skutterudite from its locality at Skutterud, Norway.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 342–346. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 117–118. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 867–873. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 393.

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Nickel-zippeite $Ni_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Very fine grained, in crusts and coatings. *Twinning:* Common on $\{h0l\}$ with symmetrical extinction $Z \wedge Z' \simeq 28°$; may be polysynthetic or as fourlings, with extinction $Y \wedge Y' \simeq 74°$.

Physical Properties: *Cleavage:* Perfect to {010}; perhaps another, inclined (synthetic). Hardness = ∼2 (synthetic). D(meas.) = > 3.3 D(calc.) = n.d. Radioactive; fluoresces bright yellow under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Tan to brownish yellow, yellow-orange. *Optical Class:* Biaxial (+) (synthetic). *Pleochroism:* X = colorless to pale yellow; Y = yellow; Z = dark yellow to golden yellow. *Orientation:* $Z = c$. α = 1.73–1.74 β = 1.76–1.77 γ = 1.82–1.83 2V(meas.) = Moderate to large.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Happy Jack mine, Utah, USA; nearly identical to cobalt-zippeite. 3.45 (100), 7.10 (93), 3.10 (67), 3.56 (42), 9.63 (37), 2.481 (31), 2.644 (30)

Chemistry:

	(1)	(2)
SO_3	10.56	9.67
UO_3	66.1	69.09
FeO	0.70	
MnO	0.33	
CoO	1.33	
NiO	2.14	6.01
MgO	0.54	
H_2O	18.1	15.23
Total	[99.8]	100.00

(1) Happy Jack mine, Utah, USA; recalculated after deduction of SiO_2 1.23%, Al_2O_3 0.5%, TiO_2 0.08%, $(Ce,Y)_2O_3$ 0.41%; corresponds to $(Ni_{0.78}Co_{0.48}Mg_{0.36}Fe_{0.26}Mn_{0.12})_{\Sigma=2.00}$ $(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$. (2) $Ni_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$.

Occurrence: Typically as secondary coatings on mine walls, derived from oxidation of uranium-bearing primary Ni–Co sulfides.

Association: Cobalt-zippeite, sodium-zippeite, zippeite, johannite, uranopilite, zeunerite, schröckingerite, bayleyite, chalcanthite, antlerite, siderotil, bieberite, erythrite, epsomite, gypsum, uraninite.

Distribution: In the USA, from the Happy Jack mine, White Canyon, San Juan Co., and at Castleton, La Sal Mountains, Grand Co., Utah; in the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co., Arizona. From Great Bear Lake, Northwest Territories, Canada. At Jáchymov (Joachimsthal), Czech Republic.

Name: For its dominant content of *nickel* and relation to other *zippeite* group species.

Type Material: n.d.

References: (1) Frondel, C., J. Ito, R.M. Honea, and A.M. Weeks (1976) Mineralogy of the zippeite group. Can. Mineral., 14, 429–436. (2) Haacke, D.F. and P.A. Williams (1979) The aqueous chemistry of uranium minerals. Part I. Divalent cation zippeïte. Mineral. Mag., 43, 539–541.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic grains, elongated along $[10\bar{1}]$, fibrous, radial or lamellar $\parallel$ {010}, may show {010}, {100}, $\{10\bar{1}\}$, to 0.2 mm.

Physical Properties: *Cleavage:* {010}, perfect; {100}, $\{10\bar{1}\}$, good. Hardness = ~3 D(meas.) = n.d. D(calc.) = 4.06

Optical Properties: Semitransparent. *Color:* Bright blue. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* Light blue to blue. *Orientation:* $Y = b$; $Z \wedge a = 28°$. $\alpha = 1.714(5)$ $\beta = 1.744(5)$ $\gamma = 1.783(5)$ 2V(meas.) = 60(6)° 2V(calc.) = 84°

Cell Data: *Space Group:* $C2/c$. $a = 11.882(4)$ $b = 12.760(4)$ $c = 6.647(2)$ $\beta = 112.81(2)°$ $Z = 4$

X-ray Powder Pattern: Nickenicher Sattel volcano, Germany.
2.744 (10), 3.195 (4), 4.06 (3), 4.35 (3), 3.56 (3), 3.066 (3), 2.605 (3b)

Chemistry:

	(1)
P_2O_5	0.9
As_2O_5	64.3
V_2O_5	0.06
Al_2O_3	1.1
Fe_2O_3	5.5
MnO	0.5
CuO	4.7
MgO	17.9
CaO	2.8
Na_2O	4.6
K_2O	0.1
Total	102.5

(1) Nickenicher Sattel volcano, Germany; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO; corresponds to $(Na_{0.81}K_{0.01})_{\Sigma=0.82}Ca_{0.27}Cu_{0.32}(Mg_{2.42}Fe_{0.38}Al_{0.12}Mn_{0.03})_{\Sigma=2.95}[(As_{1.02}P_{0.02})_{\Sigma=1.04}O_4]_3$; crystal structure determination gives $Na_{0.76}Ca_{0.41}Cu_{0.39}(Mg_{2.33}Fe_{0.52}Al_{0.12}Mn_{0.03})_{\Sigma=3.00}[(As_{0.98}P_{0.02})_{\Sigma=1.00}O_4]_3$.

Occurrence: In a cavity in volcanic scoria.

Association: Vanadinite, duhamelite.

Distribution: From the Nickenicher Sattel volcano, Eifel district, Germany.

Name: For the village of Nickenich, Germany, nearby the Nickenicher Sattel volcano.

Type Material: University of Vienna, Vienna, Austria.

References: (1) Auernhammer, M., H. Effenberger, G. Hentschel, T. Reinecke, and E. Tillmanns (1993) Nickenichite, a new arsenate from the Eifel, Germany. Mineral. Petrol., 48, 153–166. (2) (1994) Amer. Mineral., 79, 571 (abs. ref. 1).

Niedermayrite $Cu_4Cd(SO_4)_2(OH)_6 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 50 μm, flattened ∥ {010}, with {100}, {001}, {hk0}, in crusts.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.29

Optical Properties: Semitransparent. *Color:* Bluish green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$. *Dispersion:* $r > v$, strong. α = [1.599–1.619] $\beta = 1.642(2)$ $\gamma = 1.661(2)$ 2V(meas.) = 66°–84°

Cell Data: *Space Group:* $P2_1/m$. $a = 5.543(1)$ $b = 21.995(4)$ $c = 6.079(1)$ $\beta = 92.04(1)°$ Z = 2

X-ray Powder Pattern: Laurium, Greece.
5.496 (100), 11.02 (90), 4.079 (50), 3.243 (40), 3.437 (30), 2.470 (30), 5.322 (25)

Chemistry:

	(1)	(2)
SO_3	21.6	21.85
MnO	< 0.1	
CuO	45.7	43.42
CdO	16.5	17.52
ZnO	< 0.1	
H_2O	[16.2]	17.21
Total	[100.0]	100.00

(1) Laurium, Greece; by electron microprobe, average of seven analyses, H_2O by difference, 18.9% by TGA; corresponds to $Cu_{4.29}Cd_{0.96}(SO_4)_{2.01}(OH)_{6.50} \cdot 3.46H_2O$. (2) $Cu_4Cd(SO_4)_2(OH)_6 \cdot 4H_2O$.

Occurrence: Very rare in the oxidation zone of a zinc-rich hydrothermal orebody in brecciated marble, formed as an alteration product of chalcopyrite and greenockite.

Association: Gypsum, malachite, chalcanthite, brochantite, hemimorphite, hydrozincite, aurichalcite, monteponite, otavite, sphalerite, greenockite, hawleyite, pyrite, galena.

Distribution: From Laurium, Greece.

Name: To honor Dr. Gerhard Niedermayr (1941–), Curator, Natural History Museum, Vienna, Austria.

Type Material: Natural History Museum, Vienna; Institute for Mineralogy and Crystallography, Vienna University, Vienna, Austria.

References: (1) Giester, G., B. Rieck, and F. Brandstätter (1998) Niedermayrite, $Cu_4Cd(SO_4)_2(OH)_6 \cdot 4H_2O$, a new mineral from the Lavrion mining district, Greece. Mineral. Petrol., 63, 19–34. (2) (1999) Amer. Mineral., 84, 686 (abs. ref. 1).

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Nielsbohrite $K(UO_2)_3(AsO_4)(OH)_4 \cdot H_2O$

Crystal Data: Orthorhombic. *Point Group*: *mm*2. Crystals, rhombohedron-like, showing forms {001}, {100} or {010}, {210} or {120}, to 0.15 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = ~ 2 D(meas.) = n.d. D(calc.) = 5.45 (structure); 5.65 (chemical data)

Optical Properties: Transparent. *Color*: Yellow. *Streak*: Yellow. *Luster*: Vitreous to dull. *Optical Class*: Biaxial (-). $\alpha = 1.756(2)$ $\beta = 1.764(2)$ $\gamma = 1.765(2)$ 2V(meas.) = 35(5)° 2V(calc.) = 39° *Orientation*: $Y = c$. *Dispersion*: $r > v$, strong. Anomalous blue-green and reddish brown interference colors.

Cell Data: *Space Group*: *Cccm.* $a = 8.193(3)$ $b = 11.430(4)$ $c = 13.500(5)$ $Z = 4$

X-ray Powder Pattern: Menzenschwand, Baden-Württemberg, Germany. 6.03 (100), 6.71 (80), 3.33 (80), 3.78 (70), 2.96 (60), 2.63 (50), 1.942 (50)

Chemistry:

	(1)	(2)
K_2O	1.90	4.38
UO_3	83.34	79.89
As_2O_5	10.64	10.70
H_2O	5.07	5.03
Total	100.95	100.00

(1) Menzenschwand, Baden-Württemberg, Germany; average of 2 electron microprobe analyses, H_2O calculated from structure analysis, anionic groups confirmed by IR, corresponding to $(K_{0.430}\square_{0.570})(AsO_4)_{0.987}(UO_2)_{3.106}(OH)_4 \cdot 1.00H_2O$. (2) $K(UO_2)_3(AsO_4)(OH)_4 \cdot H_2O$.

Occurrence: A secondary mineral formed near oxidizing uraninite.

Association: Hematite, pyrite, schoepite, metazeunerite.

Distribution: From mine dumps near the village of Menzenschwand, Krunkelbach valley, southern Black Forest, Baden-Württemberg, Germany.

Name: Honors Niels Hendrik David Bohr (1885-1962), Danish physicist.

Type Material: Staatliches Museum für Naturkunde, Stuttgart, Germany; Laboratory of Mineralogy, University of Liège, Belgium (no. 20355).

References: (1) Walenta, K., F. Hatert, T. Theye, F. Lissner, and K. Röller (2009) Nielsbohrite, a new potassium uranyl arsenate from the uranium deposit of Menzenschwand, southern Black Forest, Germany. Eur. J. Mineral., 21, 515–520. (2) (2009) Amer. Mineral., 94, 1499 (abs. ref. 1).

Nielsenite $PdCu_3$

Crystal Data: Tetragonal. *Point Group*: 4*mm*. As droplet shaped or irregular grains, to 0.05 mm.

Physical Properties: *Cleavage*: None. *Fracture*: None. *Tenacity*: Sectile. Hardness = n.d. D(meas.) = n.d. D(calc.) = 9.53

Optical Properties: Opaque. *Color*: Steel gray; bright creamy white in reflected light.
Streak: Black. *Luster*: Metallic.
Optical Class: n.d.
R_1-R_2: (470) 57.6-47.5, (546) 60.85-50.8, (589) 62.8-53.0, (650) 66.7-57.5

Cell Data: *Space Group*: *P*4*mm* (synthetic). a = 3.7125(8) c = 25.62(1) Z = 4

X-ray Powder Pattern: Skaergaard intrusion, Kangerdlunssuaq area, East Greenland.
2.137 (100), 1.8596 (70), 1.3042 (60), 1.1181 (55), 1.8337 (40), 1.0663 (30), 0.8459 (25)

Chemistry:

	(1)	(2)
Pd	29.86	35.82
Pt	3.08	
Au	3.70	
Cu	61.96	64.18
Fe	0.59	
Pb	0.17	
Total	99.36	100.00

(1) Skaergaard intrusion, East Greenland; average of 11 EDS analyses, corresponding to $(Pd_{0.862}Au_{0.058}Pt_{0.049}Fe_{0.028}Pb_{0.003})(Cu_{2.996}Fe_{0.004})_{\Sigma=3}$.
(2) $PdCu_3$.

Occurrence: As the crystallized products of immiscible melts in thoelitic gabbro and that formed at temperatures at of below 508° C, in a highly differentiated layered intrusion.

Association: Bornite-chalcocite, bornite with trace Ni-Co and Zn sulfides, skaergaardite, keithconnite, vasilite, zvyagintsevite, (Cu,Pd,Au), (Pd,Cu,Sn), (Pt,Fe,Cu,Pd) alloys, and unnamed phases Au_3Cu and PdAuCu.

Distribution: Platinova Reef, Skaergaard intrusion, Kangerdlunssuaq area, East Greenland.

Name: Honors Troels F.D. Nielsen (b. 1950), a geologist with the Geological Survey of Denmark and Greenland.

Type Material: Geologisk Museum, Copenhagen K, Denmark, 2008.1.

References: (1) Macdonald, A.M., L.J. Cabri, N.S. Rudashevsky, C.J. Stanley, V.N. Rudashevsky, and K.C. Ross (2008) Nielsenite, $PdCu_3$, a new platinum-group intermetallic mineral species from the Skaergaard intrusion, Greenland. Can. Mineral., 46, 709–716. (2) (2009) Amer. Mineral., 94, 401 (abs. ref. 1).

Crystal Data: Hexagonal. *Point Group:* $3m$. As lathlike crystals, elongated along [0001], to 2 μm, found in perchloric acid-resistant residues.

Physical Properties: Hardness = ~9 VHN = 2600–3500 (100 g load) (synthetic). D(meas.) = 3.167–3.171 (synthetic). D(calc.) = 3.11

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (–) (synthetic). $\omega = 2.03$ $\epsilon = 2.02$

Cell Data: *Space Group:* $P31c$ (synthetic). $a = 7.74(2)$ $c = 5.61(2)$ $Z = 4$

X-ray Powder Pattern: Source material not stated.
4.31 (32), 2.15 (32), 2.87 (28), 2.59 (28), 6.70 (17), 3.35 (17), 2.81 (17)

Chemistry:

	(1)	(2)
Si	57.2	60.06
N	42.8	39.94
Total	100.0	100.00

(1) Indarch meteorite; by scanning transmission electron microscope, average of eight analyses; corresponding to $Si_{2.79}N_{4.21}$. (2) Si_3N_4.

Occurrence: A very rare component of enstatite chondrite and chondrite meteorites, probably formed by exsolution during metamorphism.

Association: Diamond, kamacite, perryite, schreibersite, troilite, spinel, chromite, hibonite, rutile.

Distribution: In the Indarch enstatite chondrite meteorite, and the Inman, Adrar, and Tieschitz chondrite meteorites.

Name: Honors Alfred Otto Carl Nier (1912–1994), Professor of Chemistry at the University of Minnesota, Minneapolis, Minnesota, USA, a founder of mass spectroscopy.

Type Material: The Natural History Museum, London, England.

References: (1) Lee, M.R., S.S. Russell, J.W. Arden, and C.T. Pillinger (1995) Nierite (Si_3N_4), a new mineral from ordinary and enstatite chondrites. Meteoritics, 30, 387–398. (2) (1996) Amer. Mineral., 81, 251 (abs. ref. 1). (3) Kohatsu, I. and J.W. McCauley (1974) Re-examination of the crystal structure of α-Si_3N_4. Mat. Res. Bull., 9, 917–920.

Nifontovite $Ca_3B_6O_6(OH)_{12}\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular crystals, to 6 cm; granular.

Physical Properties: *Cleavage:* One, ‖ elongation, poor. Hardness = 3.5–5
D(meas.) = 2.35–2.36 D(calc.) = n.d. Fluoresces violet under LW UV.

Optical Properties: Semitransparent. *Color:* Colorless to gray; colorless in thin section.
Luster: Vitreous.
Optical Class: Biaxial (+), showing anomalous interference colors. *Orientation:* Positive elongation, inclined extinction. *Dispersion:* $r > v$, strong. α = 1.573–1.575 β = 1.577–1.578 γ = 1.585–1.584 2V(meas.) = 66°–76°

Cell Data: *Space Group:* $C2/c$. a = 13.119–13.12 b = 9.500–9.526 c = 13.445–13.56 β = 118.40°−119.62° Z = 4

X-ray Powder Pattern: Novofrolovskoye deposit, Russia.
2.41 (10), 7.04 (8), 2.21 (8), 3.79 (7), 3.66 (7), 3.02 (7), 2.05 (7)

Chemistry:

	(1)	(2)	(3)
SiO_2	2.09		
B_2O_3	39.58	39.37	40.07
Al_2O_3	0.72		
Fe_2O_3	1.23		
FeO	0.00		
MnO	0.00		
MgO	0.47		
CaO	33.00	32.31	32.28
H_2O^+	23.35	27.08	
H_2O^-	0.00	0.83	
H_2O			27.65
Total	100.44	99.59	100.00

(1) Novofrolovskoye deposit, Russia. (2) Fuka, Japan; corresponds to $Ca_{3.05}B_{5.99}O_{6.04}(OH)_{12}\cdot 1.96H_2O$. (3) $Ca_3B_6O_6(OH)_{12}\cdot 2H_2O$.

Occurrence: In a skarn formed by quartz diorite intruding limestone (Novofrolovskoye deposit, Russia); near gehlenite-spurrite skarn (Fuka, Japan).

Association: Grossular–andradite, szaibélyite, sibirskite, calciborite, dolomite, calcite (Novofrolovskoye deposit, Russia); olshanskyite, pentahydroborite, sibirskite, calcite (Fuka, Japan).

Distribution: From the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains, Russia. At Fuka, near Bicchu, Okayama Prefecture, Japan. Very large crystals from Charcas, San Luis Potosi, Mexico.

Name: Honors Roman Vladimirovich Nifontov (1901–1960), Russian geologist who studied sedimentary and placer deposits.

Type Material: Vernadsky Geological Museum, Moscow, 48611; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64942.

References: (1) Malinko, S.V. and A.E. Lisitsyn (1961) A new boron mineral – nifontovite. Doklady Acad. Nauk SSSR, 139, 188–190 (in Russian). (2) (1962) Amer. Mineral., 47, 172 (abs. ref. 1). (3) Yegorov-Tismenko, Y.K., M.A. Simonov, and N.V. Belov (1973) Crystal structure of nifontovite, $Ca_3[B_3O_3(OH)_6]_2.2H_2O$, a natural calcium metaborate. Doklady Acad. Nauk SSSR, 210, 678–681 (in Russian). (4) Kusachi, I. and C. Henmi (1994) Nifontovite and olshanskyite from Fuka, Okayama Prefecture, Japan. Mineral. Mag., 58, 279–284. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 152–153.

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Niggliite PtSn

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As rounded to anhedral inclusions, to 75 μm.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 572–612, average 595; 642–673, average 663 (25 g load). D(meas.) = n.d. D(calc.) = 13.4

Optical Properties: Opaque. *Color:* Silver-white; in reflected light, pinkish to blue. *Luster:* Metallic. *Bireflectance:* Strong, from pinkish cream to pale cobalt-blue. *Anisotropism:* Very high, bright pinkish cream to very dark blue or black.
R_1–R_2: (400) 42.6–46.4, (420) 43.9–50.0, (440) 44.7–52.9, (460) 45.6–55.7, (480) 45.9–58.2, (500) 46.0–60.0, (520) 45.9–61.7, (540) 45.6–63.0, (560) 45.3–64.1, (580) 45.0–65.0, (600) 44.8–66.0, (620) 44.6–66.6, (640) 44.6–67.1, (660) 44.6–67.6, (680) 44.7–68.2, (700) 45.0–68.5

Cell Data: *Space Group:* $P6_3/mmc$ (synthetic). $a = 4.100(1)$ $c = 5.432(2)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.157 (100), 0.781 (100), 1.203 (90), 2.050 (80), 1.485 (80), 0.7758 (80), 2.971 (70)

Chemistry:

	(1)	(2)	(3)
Pt	61.0	61.1	62.17
Pd		0.38	
Sn	31.4	36.7	37.83
Sb	4.7	1.05	
Bi	2.2	0.35	
Te		0.08	
Total	99.3	99.66	100.00

(1) Insizwa deposit, South Africa; by electron microprobe, corresponding to $Pt_{1.00}(Sn_{0.85}Sb_{0.12}Bi_{0.04})_{\Sigma=1.01}$. (2) Sudbury, Canada; by electron microprobe, corresponding to $(Pt_{0.98}Pd_{0.01})_{\Sigma=0.99}(Sn_{0.97}Sb_{0.03}Bi_{0.01})_{\Sigma=1.01}$. (3) PtSn.

Mineral Group: Nickeline group.

Occurrence: In late-forming hydrothermal veins.

Association: Pentlandite, chalcopyrite, bornite, parkerite, insizwaite, cubanite, pyrrhotite (Insizwa deposit, South Africa); stannopalladinite, hessite, platinum and palladium tellurides (Monchegorsk, Russia); froodite (Sudbury, Canada); leadamalgam, chromite, ilmenite, magnetite, gersdorffite, pyrite, chalcopyrite, violarite, millerite, galena, stibnite, argentian gold, sperrylite, iridosmine, platinum, merenskyite, kotulskite (Shiaonanshan, China).

Distribution: From the Insizwa Cu–Ni deposit, Waterfall Gorge, Eastern Cape, South Africa [TL]. At Monchegorsk, Kola Peninsula, and the Talnakh area, Noril'sk region, western Siberia, Russia. In China, From Shiaonanshan, Inner Mongolia. At the Szklary serpentinite massif, Poland. In the Strathcona mine, Sudbury, Ontario, Canada. From Fox Gulch, Goodnews Bay, Alaska, USA.

Name: In honor of Professor Paul Niggli (1888–1953), Swiss mineralogist, University of Zurich, Zurich, Switzerland.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162610.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 347. (2) Cabri, L.J. and D.C. Harris (1972) The new mineral insizwaite ($PtBi_2$) and new data on niggliite (PtSn). Mineral. Mag., 38, 794–800. (3) Yushko-Zakharova, O.E. and A. Chernaev (1966) The composition and properties of niggliite from copper-nickel ores of the Monchegorsk deposit. Doklady Acad. Nauk SSSR, 170, 148–150 (in English). (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 121–122, 164. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 395.

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Nimite $(Ni, Mg, Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As irregular grains, to 0.5 mm, in veins.

Physical Properties: *Cleavage:* {001}, pronounced. Hardness = 3 D(meas.) = 3.123(2) D(calc.) = 3.20

Optical Properties: Translucent. *Color:* Yellowish green.
Optical Class: Biaxial (–). *Pleochroism:* Faint; X = yellow-green; Z = apple-green.
$\alpha = 1.637(2)$ $\beta = 1.647(2)$ $\gamma = \sim 1.647(2)$ 2V(meas.) = 15(2)°

Cell Data: *Space Group:* $C2/m$. $a = 5.320(1)$ $b = 9.214(3)$ $c = 14.302(3)$ $\beta = 97.10(2)°$ Z = 2

X-ray Powder Pattern: Bon Accord, South Africa.
7.10 (100), 3.55 (45), 14.2 (25), 4.74 (16), 2.841 (7), 2.582 (3), 2.003 (3)

Chemistry:

	(1)
SiO_2	27.27
Al_2O_3	15.21
Fe_2O_3	4.35
Cr_2O_3	< 0.01
FeO	2.78
MnO	0.06
CoO	0.38
NiO	29.49
MgO	10.13
CaO	0.38
H_2O^+	10.48
H_2O^-	0.27
Total	100.80

(1) Bon Accord, South Africa; corresponds to $(Ni_{2.62}Mg_{1.66}Al_{0.98}Fe^{3+}_{0.36}Fe^{2+}_{0.26}Ca_{0.04}Co_{0.04})_{\Sigma=5.96}(Si_{3.01}Al_{0.99})_{\Sigma=4.00}O_{10.29}(OH)_{7.71}$.

Mineral Group: Chlorite group.

Occurrence: In a small tabular body of nickeliferous serpentinite, probably a contact deposit, along the junction of quartzite and an ultramafic intrusive; it appears to have formed at ~730 °C and < 2 kbar during thermal metamorphism, possibly of a nickel-rich meteorite.

Association: Willemseite, nickeloan talc, ferroan trevorite, bonaccordite, violarite, millerite, reevesite, goethite.

Distribution: From three km west of the Scotia talc mine, Bon Accord area, Barberton, Transvaal, South Africa.

Name: An acronym for the National Institute of Metallurgy of South Africa.

Type Material: National Museum of Natural History, Washington, D.C., USA, 132463–132465.

References: (1) Hiemstra, S.A. and S.A. De Waal (1968) Nickel minerals from Barberton. II. Nimite, a nickelian chlorite. Nat. Inst. Met. (South Africa) Res. Rep. 344, 1–10. (2) (1969) Amer. Mineral., 54, 1739–1740 (abs. ref. 1). (3) De Waal, S.A. (1970) Nickel minerals from Barberton, South Africa: II. Nimite, a nickel-rich chlorite. Amer. Mineral., 55, 18–30.

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Ningyoite $(U, Ca, Ce)_2(PO_4)_2 \cdot 1{-}2H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* 222 (probable). Acicular to elongated lozenge-shaped crystals, to 5 μm; may form star-shaped aggregates.

Physical Properties: *Tenacity:* Friable. Hardness = n.d. D(meas.) = > 3.30 D(calc.) = [4.70] Radioactive.

Optical Properties: Semitransparent. *Color:* Brownish green to brown. *Optical Class:* Biaxial; low birefringence. *Pleochroism:* Slight; X = pale brown. *Orientation:* Parallel extinction; positive elongation. $n = 1.60$–1.70

Cell Data: *Space Group:* $P222$ (probable). $a = 6.78(3)$ $b = 12.10(5)$ $c = 6.38(3)$ $Z = 3$

X-ray Powder Pattern: Ningyo-Toge mine, Japan.
3.02 (vsb), 2.81 (s), 2.13 (s), 4.33 (m), 3.38 (mb), 5.99 (wb), 3.45 (w)

Chemistry:

	(1)
UO_3	n.d.
P_2O_5	16.8
UO_2	23.3
FeO	4.8
CaO	6.1
H_2O^+	7.4
H_2O^-	1.9
H_2O	
C	2.3
insol.	30.9
Total	93.5

(1) Ningyo-Toge mine, Japan; RE $\approx$ a few %, which may be in included apatite, corresponds to $Ca_{0.92}U_{0.73}Fe_{0.56}(PO_4)_2 \cdot 3.47H_2O$.

Mineral Group: Rhabdophane group.

Occurrence: The principal uranium mineral, as coatings and filling cavities in carbonaceous conglomerate (Ningyo mine, Japan); in uranium deposits in organic-rich conglomerate-sandstone-mudstone (British Columbia, Canada).

Association: Pyrite, marcasite, sphalerite, apatite, chlorite, gypsum, quartz, hypersthene, feldspar, clay minerals (Ningyo mine, Japan); saléeite, autunite, uraninite (Okanagan district, Canada).

Distribution: From the Ningyo-Toge uranium mine, Tottori Prefecture, Japan. In the Tyee and Blizzard uranium deposits, 60 and 30 km southeast of Kelowna, Okanagan district, British Columbia, Canada. From the Dzhantuar and Rudnoye uranium deposits, Auminzatau Mountains, central Kyzylkum region, Uzbekistan. At an undefined locality in the Czech Republic.

Name: For Ningyo Pass, Japan, where the mine in which the mineral was first found is located.

Type Material: The Natural History Museum, London, England, 1960,92; National Museum of Natural History, Washington, D.C., USA, 113822, 115885.

References: (1) Muto, T., R. Meyrowitz, A.M. Pommer, and T. Murano (1959) Ningyoite, a new uranous phosphate mineral from Japan. Amer. Mineral., 44, 633–650. (2) Boyle, D.R., A.L. Littlejohn, A.C. Roberts, and D.M. Watson (1981) Ningyoite in uranium deposits of south-central British Columbia: first North American occurrence. Can. Mineral., 19, 325–331.

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Niningerite $(Mg, Fe^{2+}, Mn)S$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As grains intimately intergrown with kamacite and troilite; grains may contain oriented exsolution lamellae of troilite and minute grains of kamacite.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 3.21–3.59

Optical Properties: Opaque. *Color:* Gray in reflected light. *Luster:* Metallic.
R: n.d.

Cell Data: *Space Group:* $Fm3m$ (by analogy to synthetic). a = 5.17(2) Z = 4

X-ray Powder Pattern: Synthetic MgS.
2.601 (100), 1.8388 (60), 1.5010 (16), 1.1630 (14), 1.0617 (10), 3.004 (8), 1.3001 (8)

Chemistry:

	(1)	(2)	(3)
Mg	18.3	23.5	16.84
Fe	27.0	15.6	38.72
Mn	6.5	11.6	
Ca	1.28	0.39	
Cr	1.66	0.14	
S	43.4	46.9	44.45
Total	98.14	98.13	100.00

(1) Indarch meteorite; by electron microprobe, corresponds to $(Mg_{0.56}Fe_{0.36}Mn_{0.09}Ca_{0.02}Cr_{0.02})_{\Sigma=1.05}S_{1.00}$. (2) Kota-Kota meteorite; by electron microprobe, corresponds to $(Mg_{0.66}Fe_{0.19}Mn_{0.14}Ca_{0.01})_{\Sigma=1.00}S_{1.00}$. (3) (Mg, Fe)S with Mg:Fe = 1:1.

Mineral Group: Galena group.

Occurrence: In less extensively metamorphosed enstatite chondrite meteorites.

Association: "Nickel-iron" (kamacite), troilite.

Distribution: In the Indarch [TL], St. Marks [TL], Kota-Kota [TL], Qingzhen, Yamoto 691, Yamoto 74370, South Oman, Kaidun, etc. enstatite chondrite meteorites.

Name: In honor of Harvey Harlow Nininger (1887–1986), of Sedona, Arizona, USA, for his contributions to meteoritics.

Type Material: n.d.

References: (1) Klaus, K. and K.G. Snetsinger (1967) Niningerite: a new meteoric sulfide. Science, 155, 451–453. (2) (1967) Amer. Mineral., 52, 925 (abs. ref. 1). (3) Leitch, C.A. and J.V. Smith (1982) Petrography, mineral chemistry and origin of type I enstatite chondrites. Geochim. Cosmochim. Acta, 46, 2083–2097. (4) Ehlers, K. and A. El Goresy (1988) Normal and reverse zoning in niningerite: a novel key parameter to the thermal histories of EH-chondrites. Geochim. Cosmochim. Acta, 52, 877–887. (5) (1957) NBS Circ. 539, 7, 31.

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Nioboaeschynite-(Ce) $(Ce, Ca, Th)(Nb, Ti)_2(O, OH)_6$

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Crystal Data: Orthorhombic; commonly metamict. *Point Group:* $2/m\ 2/m\ 2/m$. In prismatic crystals, may be tabular, striated; as grains, to 1.5 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4.5–5.5 VHN = 593–683 D(meas.) = 4.97–5.13 D(calc.) = [5.16]

Optical Properties: Translucent to opaque. *Color:* Black, red-brown to dark brown; red to red-brown in thin fragments. *Streak:* Orange to reddish brown. *Luster:* Resinous. *Optical Class:* Isotropic when metamict. *Pleochroism:* Weak; X = red, reddish brown, yellowish brown; Y = reddish brown to brown; Z = reddish brown to dark brown. $n = 2.26$ when metamict. $\alpha = 2.27$–2.28 $\beta = 2.32$–2.38 $\gamma = 2.36$–2.50 2V(meas.) = 75°–97°

Cell Data: *Space Group: Pmnb.* $a = 7.50$–7.86 $b = 10.97$–11.09 $c = 5.32$–5.38 Z = [4]

X-ray Powder Pattern: Tofty tin belt, Alaska, USA (non-metamict); commonly amorphous to X-rays.
2.983 (10), 3.048 (7), 3.132 (4), 5.539 (2), 3.445 (2), 2.827 (2), 2.699 (2)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8		0.01	Fe_2O_3	2.75	
Nb_2O_5	41.41	47.0	FeO		1.09
Ta_2O_5	0.00	< 0.1	MnO	trace	
SiO_2	0.35	3.51	MgO	trace	
TiO_2	18.73	20.2	CaO	4.82	4.52
ThO_2	2.52	1.33	H_2O^+	0.41	
Al_2O_3	0.35	n.d.	H_2O^-	0.04	
RE_2O_3	28.17	28.38	Total	99.55	106.

(1) Vishnevy Mountains, Russia; Nb:Ti = 1.05:0.79; RE = La 14%, Ce 42%, Pr 9%, Nd 25%, Sm 3.1%, Eu 0.4%, Gd 1.3%, Tb 0.2%, Dy 1.2%, Ho 0.2%, Er 0.3%, Yb 0.2%, Y ∼3%. (2) Tofty tin belt, Alaska, USA; by emission spectroscopy, RE = La_2O_3 4.9%, Ce_2O_3 15.8%, Pr_2O_3 1.9%, Nd_2O_3 5.6%, Y_2O_3 0.18%; corresponds to $(Ce_{0.32}Ca_{0.27}Nd_{0.11}La_{0.10}Fe_{0.05}Pr_{0.04}Th_{0.02}Y_{0.01})_{\Sigma=0.92}(Nb_{1.17}Ti_{0.83})_{\Sigma=2.00}(O, OH)_{5.78}$.

Occurrence: In quartz-arfvedsonite veinlets cutting fenites (Vishnevy Mountains, Russia); in heavy-mineral concentrates (Tofty tin belt, Alaska, USA).

Association: Quartz, arfvedsonite (Vishnevy Mountains, Russia).

Distribution: In the Vishnevy Mountains, Southern Ural Mountains, Russia. At undisclosed localities in China. From the Tofty tin belt, Manley Hot Springs district, Alaska, USA. At Manjaka, Madagascar.

Name: For similarity to *aeschynite* but with NIOBium greater than titanium, with cerium as the dominant rare-earth element.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis6310.

References: (1) Zhabin, A.G., G.N. Mukhitdinov, and M.Y. Kazakova (1960) Paragenetic associations of accessory rare-earth minerals in exocontact fenitized rocks of miaskite intrusives of the Vishnevy Mountains [nioboaeschynite]. Inst. mineral., geokhim., krystallokhim. redkikh elementov, Trudy, 4, 51–73 (in Russian). (2) (1962) Amer. Mineral., 47, 417 (abs. ref. 1). (3) Rosenblum, S. and E.L. Mosier (1975) Nonmetamict nioboeschynite-(Ce) [nioboaeschynite-(Ce)] from Alaska. Amer. Mineral., 60, 309–315.

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Nioboaeschynite-(Y) $[(Y, Ln), Ca, Th](Nb, Ta, Ti, Fe^{3+})_2 (O, OH)_6$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As subhedral crystals, to 10 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle.
Hardness = 5-6 VHN = 922 (100 g load). D(meas.) = 5.34 D(calc.) = 5.33 Metamict.

Optical Properties: Translucent. *Color*: Deep brownish-red to black. *Streak*: Grayish-brown.
Luster: Vitreous.
Optical Class: Isotropic.
R_1-R_2: (470) 3.4-14.6, (546) 3.3-14.1, (589) 3.2-13.8, (650) 3.2-13.7

Cell Data: *Space Group*: *Pbnm*. *a* = 5.279(3) *b* = 10.966 (5) *c* = 7.443(3) *Z* = 4

X-ray Powder Pattern: Bear Lake Diggings, Haliburton County, Ontario, Canada (after heating).
3.009 (100), 2.931 (69), 3.079 (20), 1.580 (16), 1.863 (14), 2.783 (12), 2.636 (12)

Chemistry:

	(1)		(1)
CaO	4.34	ThO_2	12.10
MnO	0.11	UO_2	0.59
Fe_2O_3	2.16	TiO_2	18.41
Y_2O_3	5.34	Nb_2O_5	31.46
La_2O_3	0.84	Ta_2O_5	3.97
Ce_2O_3	4.50	H_2O	2.61
Pr_2O_3	0.65	Total	95.41
Nd_2O_3	4.47		
Sm_2O_3	1.21		
Eu_2O_3	0.10		
Gd_2O_3	0.91		
Dy_2O_3	0.60		
Er_2O_3	0.42		
Tm_2O_3	0.05		
Yb_2O_3	0.57		

(1) Bear Lake Diggings, Haliburton County, Ontario, Canada; average of 10 EDS analyses, H_2O by TGA and not used to derive the empirical formula, corresponding to $[(Y_{0.19}RE_{0.34})Ca_{0.31}Th_{0.18}U_{0.009}Mn_{0.006}]_{\Sigma=1.04}(Nb_{0.94}Ti_{0.92}Ta_{0.07}Fe^{3+}_{0.11})_{\Sigma=2.04}O_6$.

Mineral Group: Aeschynite group.

Occurrence: In calcite veins in regionally metamorphosed metasedimentary rocks that may have undergone fenitization-like metasomatism.

Association: Apatite-(CaF), amphibole, titanite, anorthite, microcline, annite, calcite, quartz, monazite, pyrite, uranian thorite.

Distribution: Bear Lake Diggings, Lot 9, concession X, Monmouth Township, Haliburton County, near Gooderham, Ontario, Canada.

Name: For the dominant *B*-site cation (Nb) and principal rare earth element (Y) in a member of the aeschynite group.

Type Material: Croatian Natural History Museum, Zagreb, Croatia, no. 600:ZAG; 9613MP1.

References: (1) Bermanec, V., N. Tomašić, G. Kniewald, M.E. Back, and G. Zagler (2008) Nioboaeschynite-(Y), a new member of the aeschynite group from the Bear Lake diggings, Haliburton County, Ontario, Canada. Can. Mineral., 46, 395–402. (2) (2008) Amer. Mineral., 93, 1943-1944 (abs. ref. 1).

Niobocarbide $(Nb, Ta)C$

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Crystal Data: Hexagonal. *Point Group:* $6mm$. As euhedral hexagonal plates, to 1 mm, exhibiting {0001}, $\{10\overline{1}0\}$, and $\{10\overline{1}1\}$; as exsolution lamellae in vanadian magnetite; commonly aggregated into crusts and massive vein fillings.

Physical Properties: Hardness = ∼5 VHN = 710–760, 734 average (20 g load).
D(meas.) = 4.65 D(calc.) = 4.60

Optical Properties: Opaque, slightly translucent in thin fragments. *Color:* Black; dark gray to dark grayish violet in reflected light. *Streak:* Brownish black. *Luster:* Submetallic.
Optical Class: Uniaxial. *Pleochroism:* Dark brown to deep blue. *Anisotropism:* Moderate; light to dark gray.
R_1–R_2: (470) 11.0–12.7, (546) 11.8–13.5, (589) 12.3–14.0

Cell Data: *Space Group:* $P6_3mc$. $a = 5.846$–5.897 $c = 9.254$–9.295 $Z = 1$

X-ray Powder Pattern: Saskatchewan, Canada.
3.44 (100), 2.66 (90), 2.49 (90), 1.495 (60), 4.66 (55), 2.23 (50), 2.46 (40)

Chemistry:

	(1)	(2)
Ti	3.7	6.7
V	45.0	33.5
Al	0.9	0.8
Fe	15.9	24.0
Mn	< 0.1	0.1
Mg	< 0.1	0.1
Na	0.1	0.2
Total		

(1–2) Kalgoorlie, Western Australia; by electron microprobe; V and Fe valences and $(OH)^{1-}$ from crystal-structure analysis, corresponding respectively to $(V^{3+}_{6.9}Fe^{3+}_{1.6}Fe^{2+}_{0.6}Ti_{0.6}Al_{0.3})_{\Sigma=10.0}O_{14}(OH)_2$ and $(V^{3+}_{5.2}Fe^{3+}_{2.4}Fe^{2+}_{1.1}Ti_{1.1}Al_{0.2})_{\Sigma=10.0}O_{14}(OH)_2$.

Occurrence: In hydrothermal uranium deposits (Saskatchewan, Canada); in gold deposits in metamorphosed greenstones (Kalgoorlie, Western Australia).

Association: Dolomite, calcite, quartz, uraninite, pyrite, chalcopyrite, galena, ilmenite, hematite, carnotite (Saskatchewan, Canada); gold, gold tellurides, vanadian muscovite, tourmaline, tivanite, vanadian hematite, vanadian magnetite (Kalgoorlie, Western Australia).

Distribution: From Fish-Hook Bay, Lake Athabaska, and at the Ace mine, the Consolidated Nicholson Mine No. 2, and the Pitche claims, Beaverlodge Lake, Saskatchewan, Canada. From Wild Steer Canyon, Paradox Valley, Montrose Co., Colorado, and in the Campbell mine, Bisbee, Cochise Co., Arizona, USA. In several mines at Kalgoorlie, Western Australia. From the Mounana uranium mine, Franceville, Gabon.

Name: To honor Dr. Thomas Brennan Nolan (1901–1992), formerly Director of the U.S. Geological Survey, Washington, D.C., USA.

Type Material: The Natural History Museum, London, England, 1965,206; National Museum of Natural History, Washington, D.C., USA, 112965.

References: (1) Robinson, S.C., H.T. Evans, Jr., W.T. Schaller, and J.J. Fahey (1957) Nolanite, a new iron-vanadium mineral from Beaverlodge, Saskatchewan. Amer. Mineral., 42, 619–628. (2) Gatehouse, B.M., I.E. Gray, and E.H. Nickel (1983) The crystal chemistry of nolanite, $(V, Fe, Ti, Al)_{10}O_{14}(OH)_2$, from Kalgoorlie, Western Australia. Amer. Mineral., 68, 833–839.

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Niobophyllite $(K,Na)_3(Fe^{2+},Mn^{2+})_6(Nb,Ti)_2Si_8O_{24}(O,OH,F)_7$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. In polycrystalline aggregates of small flakes. *Twinning:* By reflection on (001), common.

Physical Properties: *Cleavage:* Perfect on {001}, poor on {0*kl*}. Hardness = n.d.
D(meas.) = 3.42 D(calc.) = 3.406

Optical Properties: Translucent. *Color:* Chocolate-brown; in transmitted light, brownish yellow to red-orange.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X = Y$ = brownish yellow; Z = red-orange.
Orientation: $Y = a$; $X \wedge b = 13°$; $Z \perp \{001\}$. $\alpha = 1.724$ $\beta = 1.760$ $\gamma = [1.772]$
2V(meas.) = 60°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 5.391$ $b = 11.88$ $c = 11.66$ $\alpha = 113.1°$
$\beta = 94.5°$ $\gamma = 103.1°$ Z = 1

X-ray Powder Pattern: Seal Lake, Canada.
3.506 (10b), 10.52 (9), 2.778 (8), 2.574 (7), 3.019 (6), 3.258 (5), 3.741 (4b)

Chemistry:

	(1)		(1)
SiO_2	33.40	MgO	0.16
TiO_2	2.94	CaO	0.72
Al_2O_3	0.89	Na_2O	2.49
RE_2O_3	1.50	K_2O	5.51
Nb_2O_5	14.76	F	0.46
Ta_2O_5	0.52	H_2O^+	3.64
FeO	23.74	H_2O^-	0.08
MnO	9.83	$-O = F_2$	0.19
		Total	100.45

(1) Seal Lake, Canada; corresponds to $(Na_{1.57}K_{1.08}Ca_{0.17}RE_{0.12})_{\Sigma=2.94}(Fe_{4.44}Mn_{1.86}Mg_{0.05})_{\Sigma=6.35}(Nb_{1.49}Ti_{0.49}Ta_{0.03})_{\Sigma=2.01}(Si_{7.47}Al_{0.24})_{\Sigma=7.71}[O_{25.25}(OH)_{5.43}F_{0.32}]_{\Sigma=31.00}$.

Mineral Group: Astrophyllite group.

Occurrence: As discontinuous seams and polycrystalline aggregates within a paragneiss intruded by an alkalic syenite (Seal Lake, Canada).

Association: Albite, arfvedsonite, "aegirine-augite," barylite, eudidymite, neptunite, manganoan pectolite, pyrochlore, joaquinite, sphalerite, galena (Seal Lake, Canada).

Distribution: From Seal Lake, Labrador, Newfoundland, Canada. In the Ilímaussaq intrusion, southern Greenland.

Name: For its *niobium* content and the Greek word *phyllite*, meaning *leaf*, in allusion to its micaceous habit.

Type Material: Royal Ontario Museum, Toronto, Canada, M26148.

References: (1) Nickel, E.H., J.F. Rowland, and D.J. Charette (1964) Niobophyllite–the niobium analogue of astrophyllite; a new mineral from Seal Lake, Labrador. Can. Mineral., 8, 40–52. (2) (1965) Amer. Mineral., 50, 263–264 (abs. ref. 1).

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Niocalite $Ca_7Nb(Si_2O_7)_2O_3F$

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Crystal Data: Monoclinic. *Point Group:* m. Crystals prismatic, to 1 cm, with square cross sections and curved faces; larger crystals are tapered at both ends. *Twinning:* Finely twinned with {001} as composition plane.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6
D(meas.) = 3.32 D(calc.) = 3.29

Optical Properties: Transparent. *Color:* Lemon-yellow; colorless in thin section.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 12°$. $\alpha = 1.701$ $\beta = 1.714$ $\gamma = 1.720$
2V(meas.) = 56°

Cell Data: *Space Group:* Pa. $a = 10.863(3)$ $b = 10.431(3)$ $c = 7.370(2)$ $\beta = 110.1(1)°$
Z = 2

X-ray Powder Pattern: Oka, Canada.
3.012 (10), 2.891 (6), 2.852 (6), 3.240 (5), 1.844 (4), 7.31 (3), 2.557 (3)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	29.70	29.48	MgO	0.28	0.32
TiO_2	0.22	0.11	CaO	47.50	46.58
ZrO_2		0.27	Na_2O	0.78	0.57
Al_2O_3	1.31		K_2O	0.02	
Y_2O_3		0.00	F	1.7	2.14
Fe_2O_3	0.54	0.48	H_2O	0.16	
Nb_2O_5	16.56	15.19	P_2O_5	0.60	
Ta_2O_5		[3.5]	$-O = F_2$	0.71	0.90
MnO	1.28	0.93	Total	99.94	[98.67]

(1) Oka, Canada; CaO includes some SrO, Nb_2O_5 includes some Ta_2O_5, Al_2O_3 includes some RE and Zr; corresponds to $(Ca_{6.54}Na_{0.16})_{\Sigma=6.70}(Nb_{1.06}Mg_{0.12}Mn_{0.12}Fe_{0.06}Ti_{0.02})_{\Sigma=1.38}(Si_{3.88}Al_{0.08})_{\Sigma=3.96}O_{14}[O_{3.16}F_{0.70}(OH)_{0.08}]_{\Sigma=3.94}$. (2) Do.; by electron microprobe, partial analysis; corresponds to $(Ca_{6.77}Na_{0.15})_{\Sigma=6.92}(Nb_{0.93}Mn_{0.10}Mg_{0.06}Fe_{0.05}Zr_{0.02}Ti_{0.01})_{\Sigma=1.17}Si_4O_{14}[O_{3.02}F_{0.92}]_{\Sigma=3.94}$.

Occurrence: In coarse-grained strontian carbonatite.

Association: Calcite, magnetite, apatite, diopside, biotite, pyrochlore, niobian perovskite.

Distribution: At Oka, Quebec, Canada.

Name: For NIObium and CALcium in the composition.

Type Material: n.d.

References: (1) Nickel, E.H. (1956) Niocalite–a new calcium niobium silicate mineral. Amer. Mineral., 41, 785–786. (2) Nickel, E.H., J.F. Rowland, and J.A. Maxwell (1958) The composition and crystallography of niocalite. Can. Mineral., 6, 264–272. (3) Mellini, M. (1982) Niocalite revised: twinning and crystal structure. Tschermaks Mineral. Petrog. Mitt., 30, 249–266.

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Nisbite $NiSb_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As irregular grains, to 20 μm.

Physical Properties: Hardness = n.d. VHN = 420–513, 479 average (5 g load).
D(meas.) = n.d. D(calc.) = 8.0

Optical Properties: Opaque. *Color:* White in reflected light. *Luster:* Metallic.
Pleochroism: Weak. *Anisotropism:* Weak. *Bireflectance:* Very weak.
R_1–R_2: n.d.

Cell Data: *Space Group: Pnnm* (synthetic). $a = 5.178(3)$ $b = 6.319(3)$ $c = 3.832(3)$
Z = 2

X-ray Powder Pattern: Synthetic.
2.761 (10), 2.689 (9), 2.0301 (8), 1.8427 (7), 0.9045 (7), 1.5611 (6), 1.1683 (6)

Chemistry:

	(1)	(2)
Ni	19.15	19.43
Sb	80.43	80.57
Total	99.58	100.00

(1) Trout Bay, Canada; by electron microprobe, average of four grains. (2) $NiSb_2$.

Mineral Group: Löllingite group.

Occurrence: Very rare in a high-grade base-metal sulfide deposit in altered mafic rock (Trout Bay, Canada); in Pb–Zn–Cu–Ag ore deposits remobilized by hydrothermal solutions from younger granite emplacement (Bergslagen, Sweden).

Association: Chalcopyrite, breithauptite, pyrargyrite, galena, pyrrhotite, tetrahedrite (Trout Bay, Canada); costibite, paracostibite, oenite, allargentum, bismuth, breithauptite, gudmundite, chalcopyrite, bornite, tetrahedrite, pyrrhotite, galena, sphalerite, gersdorffite, ullmannite (Bergslagen, Sweden).

Distribution: From Trout Bay, 32 km west of Red Lake, Kenora district, Ontario, Canada [TL]. At the Festivalnoe Cu–Sn mine, Magadan region, Sakha, and from Zolotaya Gora, Ural Mountains, Russia. In the Gruvåsen and Getön deposits, and at Tunaberg, Bergslagen metallic province, Sweden. From Sulitjelma, northern Norway.

Name: For the composition, NIckel and SB, from the chemical symbol for antimony, *stibium*.

Type Material: Canadian Geological Survey, Ottawa, 12162; Canadian Museum of Nature, Ottawa, Canada.

References: (1) Cabri, L.J., D.C. Harris and J.M. Stewart (1970) Paracostibite (CoSbS) and nisbite ($NiSb_2$), new minerals from the Red Lake area, Ontario, Canada. Can. Mineral., 10, 232–246. (2) (1971) Amer. Mineral., 56, 631–632 (abs. ref. 1). (3) Zakrzewski, M.A., E.A.J. Burke, and H.W. Nugteren (1980) Cobalt minerals in the Hallëfors area, Bergslagen, Sweden: new occurrences of costibite, paracostibite, nisbite and cobaltian ullmannite. Can. Mineral., 18, 165–171.

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Nissonite $Cu_2Mg_2(PO_4)_2(OH)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals are tabular on {100}, elongated along [001], diamond-shaped, to 2 mm, showing {001}, {100}, {$\overline{1}$11}; more commonly in aggregates and thin crusts.

Physical Properties: *Cleavage:* {100}, fair. Hardness = 2.5 D(meas.) = 2.73(1) D(calc.) = 2.782

Optical Properties: Semitransparent. *Color:* Bluish green to deep blue, turquoise-blue. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = turquoise-blue. *Orientation:* $Z = b$; $X \wedge a = 15°$; $Y \wedge c = 6°$. *Dispersion:* $r > v$, very strong. $\alpha = 1.584(2)$ $\beta = 1.620(2)$ $\gamma = 1.621(2)$ 2V(meas.) = n.d. 2V(calc.) = 19°

Cell Data: *Space Group:* $C2/c$. $a = 22.523(5)$ $b = 5.015(2)$ $c = 10.506(3)$ $\beta = 99.62(2)°$ Z = 4

X-ray Powder Pattern: Panoche Valley, California, USA.
10.8 (100), 2.768 (100), 4.36 (70), 2.218 (65), 2.679 (60), 3.72 (55), 2.531 (55)

Chemistry:

	(1)	(2)
P_2O_5	27.1	28.98
V_2O_5	0.2	
FeO	0.04	
CuO	32.2	32.49
MgO	15.8	16.46
H_2O^+	16.8	
H_2O^-	5.6	
H_2O		22.07
insol.	1.4	
Total	99.14	100.00

(1) Panoche Valley, California, USA; insoluble is barite. (2) $Cu_2Mg_2(PO_4)_2(OH)_2 \cdot 5H_2O$.

Occurrence: A very rare mineral in a copper prospect (Panoche Valley, California, USA); in a Precambrian sedimentary iron deposit (Iron Monarch quarry, Australia).

Association: Malachite, azurite, libethenite, turquoise, chrysocolla, cuprite, barite, calcite, gypsum, riebeckite (Panoche Valley, California, USA); malachite, calcite, hematite, quartz (Iron Monarch quarry, Australia); turquoise, libethenite (Mt. Oxide, Australia).

Distribution: From a small copper prospect [Llanada copper mine, 6.5 km north-northeast of Llanada] in the Panoche Valley, San Benito Co., California, USA. At the Mt. Oxide copper mine, 150 km north of Mt. Isa, Queensland, and as fine crystals from the Iron Monarch quarry, Iron Knob, South Australia.

Name: To honor William H. Nisson (1912–1965), amateur mineralogist, mineral collector and dealer, of Petaluma, California, USA, who first noted the mineral.

Type Material: n.d.

References: (1) Mrose, M.E., R. Meyrowitz, J.T. Alfors, and C.W. Chesterman (1966) Nissonite, $CuMg(PO_4)(OH) \cdot 2.5H_2O$, a new hydrous copper magnesium phosphate mineral from the Panoche Valley, California. Geol. Soc. Amer. Annual Meeting Abs. with Prog., 145–146 (abs.). (2) (1967) Amer. Mineral., 52, 927 (abs. ref. 1). (3) Groat, L.A. and F.C. Hawthorne (1990) The crystal structure of nissonite. Amer. Mineral., 75, 1170–1175. (4) Bayliss, P. (1986) X-ray powder diffraction for nissonite and waylandite. Powder Diffraction, 1(4), 331–333.

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Niter KNO_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Acicular crystals, in silky tufted to branching aggregates, may be flowerlike, to 2 cm; commonly in thin crusts, granular, earthy, mealy, massive. *Twinning:* Common on {110}, forming pseudohexagonal trillings.

Physical Properties: *Cleavage:* {011}, nearly perfect; {010}, good; {110}, imperfect. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 2.109(2) D(calc.) = 2.104 Soluble in H_2O, taste saline and cooling.

Optical Properties: Transparent. *Color:* Colorless to white, may be gray from impurities. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, weak.
$\alpha = 1.332$ $\beta = 1.504$ $\gamma = 1.504$ 2V(meas.) = 7°

Cell Data: *Space Group: Pmcn.* $a = 5.414$ $b = 9.164$ $c = 6.431$ Z = 4

X-ray Powder Pattern: Synthetic.
3.78 (100), 3.73 (56), 3.033 (55), 2.647 (55), 2.661 (41), 2.192 (41), 2.763 (28)

Chemistry: (1) Identified by correspondence of optical data and X-ray powder pattern with that of synthetic material.

Occurrence: In some caves, typically formed by bacterial action on animal matter, as bat guano, or from vegetable matter, such as humus, exposed to seeping groundwater; an efflorescence on soils or cliff faces in arid regions.

Association: Nitratine, nitrocalcite, nitromagnesite, epsomite, gypsum, calcite.

Distribution: Usually in minor amounts, but may form substantial masses, into the thousands of tons, especially in some cave deposits. Typical large-scale occurrences are represented by: Pulo di Molfetta Cave, Apulia, Italy. In lava tubes 16 km east of Lava Station, Socorro Co., New Mexico, USA. In the Rusensky Lom Cave, Bulgaria. Small amounts occur in many other caves worldwide.

Name: A name from antiquity, used to distinguish potassium nitrate from sodium nitrate.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 303–305. (2) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, esp. 160. (3) Kennedy, S.W. and M. Odlyha (1977) Orientations and twinning in the structural transformation aragonite-type to calcite-like in potassium nitrate crystals. Acta Cryst., 33, 168–171. (4) (1954) NBS Circ. 539, 3, 58.

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Nitratine $NaNO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Rare as rhombohedral crystals, $\{10\overline{1}1\}$, to 3 mm; stalactitic, cottonlike, typically granular or in massive incrustations.

Physical Properties: *Cleavage:* Perfect on $\{10\overline{1}1\}$; imperfect on $\{01\overline{1}2\}$, $\{0001\}$. *Fracture:* Conchoidal. *Tenacity:* Sectile to some degree. Hardness = 1.5–2 D(meas.) = 2.24–2.29 D(calc.) = 2.25 Soluble in H_2O, taste bitter, pungent, cooling; deliquescent above ∼80% humidity.

Optical Properties: Transparent. *Color:* Colorless to white, tinged reddish brown, lemon-yellow, gray with impurities; colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.587$ $\epsilon = 1.336$

Cell Data: *Space Group:* $R\overline{3}c$. $a = 5.070$ $c = 16.829$ Z = 6

X-ray Powder Pattern: Synthetic.
3.03 (100), 2.311 (25), 2.81 (16), 1.898 (16), 2.53 (10), 2.125 (10), 1.880 (8)

Chemistry: (1) Identified by correspondence of optical data and X-ray powder pattern with that of synthetic material.

Occurrence: Principally in bedded deposits formed in playas; in caves, deposited from seeping groundwater leaching nitrates from overlying rocks, especially in very dry and cold climates.

Association: Niter, nitrocalcite, epsomite, mirabilite, halite, gypsum.

Distribution: In Chile, in the Tarapacá district, and elsewhere along the coast, economically valuable deposits aggregating billions of tons; also at Chuquicamata, Antofagasta. Other studied occurrences include: in the Los Manos Cave, Santa Cruz Province, Argentina. In the USA, in Death Valley and along the Armagosa River, Inyo and San Bernardino Cos., California; at Niter Buttes, about 40 km southeast of Lovelock, Churchill Co., Nevada; in Plateau Canyon, 32 km east of Grand Junction, Mesa Co., Colorado; from the Organ Mountains, about 12 km east-northeast of Mesquite, Doña Ana Co., in the Jornada del Muerto lava tubes, near Socorro, Socorro Co., and other places in New Mexico; at the Wupatki fissure caves, near Flagstaff, Coconino Co., Arizona. Numerous other occurrences have been reported.

Name: For NITRogen in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 300–302 [soda-niter]. (2) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, esp. 161. (3) Göttlicher, S. and C.D. Knöchel (1978) Zur Kristallstruktur von Natriumnitrat. Zeits. Krist., 148, 101–105 (in German with English abs.). (4) (1956) NBS Circ. 539, 6, 50.

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Nitrobarite $Ba(NO_3)_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Crystals are pseudo-octahedral, {111} and $\{\overline{1}11\}$, to 4 mm. *Twinning:* On {111}.

Physical Properties: Hardness = n.d. D(meas.) = 3.250 (synthetic). D(calc.) = 3.24 Easily soluble in H_2O; piezoelectric.

Optical Properties: Transparent. *Color:* Colorless, partially brownish black from included "wad"; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic, may be anomalously birefringent in sectors. $n = 1.5714$

Cell Data: *Space Group: Pa*3 (synthetic). $a = 8.1184$ $Z = 4$

X-ray Powder Pattern: Synthetic.
4.689 (100), 2.447 (75), 2.344 (45), 4.062 (35), 2.870 (30), 1.863 (20), 3.633 (14)

Chemistry: (1) Only a qualitative analysis of natural material was made.

Occurrence: Noted on a museum specimen, probably from a nitrate deposit.

Association: "Wad".

Distribution: From Chile, the exact locality not specified.

Name: For NITRate and BARium in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 305–306. (2) Hintze, C. (1930) Handbuch der Mineralogie. Gruyter & Co., Berlin, 1(3.1), 2735–2739 (in German). (3) Nowotny, H. and G. Heger (1983) Structure refinement of strontium nitrate, $Sr(NO_3)_2$, and barium nitrate, $Ba(NO_3)_2$. Acta Cryst., C39, 952–956.
(4) (1974) NBS Mono. 25, 11, 14.

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Nitrocalcite $Ca(NO_3)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare acicular crystals, in tufted and flowerlike aggregates, to 3 cm; more commonly as a cottony or massive efflorescence.

Physical Properties: *Cleavage:* Observed. Hardness = "Soft". D(meas.) = 1.90 (synthetic). D(calc.) = 1.91 Soluble in H_2O, taste sharp and bitter; deliquescent above about 54% relative humidity.

Optical Properties: Transparent. *Color:* Colorless to milky white; colorless in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (–) (synthetic). *Orientation:* $X \perp$ cleavage. $\alpha = 1.465(3)$ $\beta = 1.498(3)$ $\gamma = 1.504(3)$ 2V(meas.) = 50(2)°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 14.8999(12)$ $b = 9.1551(5)$ $c = 6.2786(7)$ $\beta = 106.22(1)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 24-1406).
5.14 (100), 7.72 (70), 3.580 (70), 5.42 (65), 4.36 (55), 3.121 (55), 2.810 (55)

Chemistry: (1) Identified by correspondence of optical data and X-ray powder pattern with that of synthetic material.

Occurrence: Typically formed in caves and on alkaline soils, which may be seasonal.

Association: Niter, nitromagnesite (caves); alunite, aragonite, berlinite, collophane, crandallite, francoanellite, gypsum, huntite, hydromagnesite, leucophosphite, nesquehonite, niter (Paddy's River mine, Australia).

Distribution: From the Pulo di Molfetta caves, Apulia, Italy. At Limagne, Auvergne, France. In David's and Chaos Caves, Transvaal, South Africa. From Ludwig Cave, north Namibia. In the USA, in Kartchner Caverns, near Benson, Cochise Co., Arizona. From Paddy's River mine, Australian Capital Territory. Additional localities reported earlier require modern confirmation.

Name: For NITROgen and CALCium in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 306–307. (2) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, esp. 161–162. (3) Leclair, A. and J.C. Monier (1977) Liaisons hydrogène dans les cristaux de $Ca(NO_3)_2.4H_2O\alpha$. Acta Cryst., 33, 1861–1866 (in French with English abs.).

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Nitromagnesite $Mg(NO_3)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As stalactites, flocculent to earthy efflorescences, and crusts.

Physical Properties: Hardness = n.d. D(meas.) = 1.46–1.58 D(calc.) = 1.64 Soluble in H_2O, taste bitter; hygroscopic.

Optical Properties: Transparent. *Color:* Colorless to white, may be yellow from contained bat urine. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Z = b$. *Dispersion:* $r < v$, weak. $\alpha = 1.34(1)$ $\beta = 1.506(3)$ $\gamma = 1.506(3)$ 2V(meas.) = 5°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 6.194(2)$ $b = 12.71(3)$ $c = 6.600(2)$ $\beta = 92.99(2)°$ Z = 2

X-ray Powder Pattern: Synthetic.
3.295 (100), 2.925 (75), 4.433 (55), 5.840 (45), 4.154 (35), 3.190 (35), 2.688 (35)

Chemistry: (1) No analyses of natural material have been made. Identification depends on coincidence of properties with synthetic material.

Occurrence: A rare cave deposit in humidities up to 78%, typically formed as a leachate of bat guano; may be a component of mixed salts.

Association: Nitrocalcite.

Distribution: In the USA, from Nicojack Cave, Madison Co., Kentucky, and in a cave near Corydon, Harrison Co., Indiana. At Independence Cave, Botswana. In Namibia, from Arnhem, Gâuab, Elephant, Uisib I, and Kimberlite Caves. In the Pulo di Molfetta caves, Apulia, Italy.

Name: For NITROgen and MAGNESium in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128717.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 307. (2) Hill, C. and P. Forti (1997) Cave minerals of the world (2nd edition), National Speleological Soc., Huntsville, Alabama, 162. (3) Mozzi, R.L. and W.R. Bekebrede (1961) Cell dimensions and space group of magnesium nitrate hexahydrate. Acta Cryst., 14, 1296–1297.

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Niveolanite $NaBe(CO_3)(OH) \cdot 1\text{-}2H_2O$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. Typically as fibrous "wool-like"aggregates, to 2 cm; also as aggregates of acicular crystals with tetragonal or octagonal cross-sections, to 1 cm. Crystals elongate parallel to [100] with forms {100} and {100}.

Physical Properties: *Cleavage*: None. *Tenacity*: Brittle (acicular), flexible (fibrous). *Fracture*: Splintery. Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.82 to 2.06 (respectively for less and greater hydration, readily reversible). Weak effervescence in HCL. Readily hygroscopic.

Optical Properties: Transparent. *Color*: Colorless fibers, aggregates snow-white to pearl white. *Streak*: White. *Luster*: Silky.
Optical Class: Uniaxial (+). ω = 1.469(1) ε = 1.502(1)

Cell Data: *Space Group*: *P*4/*mcc*. a = 13.1304(19) c = 5.4189(11) Z = 8

X-ray Powder Pattern: Poudrette Quarry, Mont-Saint Hilaire, Quebec, Canada.
13.01 (100), 3.256 (95), 9.20 (62), 2.489 (60), 2.693 (44), 2.605 (37), 3.611 (34)

Chemistry:

	(1)
Na_2O	19.81
K_2O	0.07
CaO	3.88
BeO	16.65
CO_2	29.81
H_2O	26.93
Total	97.15

(1) Poudrette Quarry, Mont-Saint Hilaire, Quebec, Canada; multiple analyses by electron microprobe, ICP-OES and LOI, H_2O calculated, OH:H_2O by charge balance, OH, H_2O, CO_3 confirmed by IR; corresponding to $(Na_{0.94}Ca_{0.10})_{\Sigma=1.04}Be_{0.98}(CO_3)_{1.00}(OH)_{1.10}\cdot 1.66H_2O$.

Occurrence: A late stage mineral in cavities in the core of a hydrothermally altered peralkaline pegmatite.

Association: Albite, aegirine, natrolite, gonnardite, siderite, petersenite-(Ce), franconite, dawsonite ; more rarely analcime, quartz, eudidymite, catapleiite, gaidonnayite, monazite-(Ce), calcite, adamsite-(Y), shomiokite-(Y), galena, sphalerite, rutile.

Distribution: Poudrette Pegmatite, Poudrette Quarry, Mont-Saint Hilaire, Quebec, Canada.

Name: From the Latin *niveus*, snow white, and *lana*, wool, in allusion to the typical habit.

Type Material: A.E. Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, 3631/1, and the Canadian Museum of Nature, Ottawa, CNMMC 86052.

References: (1) Pekov, I.V., N.V. Zubkova, N.V. Chukanov, A.A. Agakhanov, D.I. Belakovskiy, L. Horváth, Y.E. Filinchuk, E.R. Gobechiya, D.Y. Pushcharovsky, and M.K. Rabadanov (2008) Niveolanite, the first natural beryllium carbonate, a new mineral species from Mont Saint-Hilaire, Quebec, Canada. Can. Mineral., 46, 1343–1354. (2) (2009) Amer. Mineral., 94, 1080-1081 (abs. ref. 1).

Nobleite $CaB_6O_9(OH)_2•3H_2O$

Crystal Data: Monoclinic. *Point Group: 2/m.* Platy rhombic to pseudohexagonal crystals, flattened on {100}, elongated along [010] or [001], showing large {100}, {001}, {110}, {011}, {111}, to 3 mm; as a post-mine mammillary coating. Contact twins common on {100}.

Physical Properties: *Cleavage:* Perfect on {100}; indistinct on {001}. *Fracture:* Uneven. *Tenacity:* Sectile, flexible, inelastic. Hardness = ~3 D(meas.) = 2.09(1) D(calc.) = 2.098 Slightly to moderately soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to white; colorless in transmitted light. *Streak:* White. *Luster:* Subvitreous, pearly on cleavages.
Optical Class: Biaxial (+). $\alpha = 1.500(3)$ $\beta = 1.520(2)$ $\gamma = 1.554(2)$ 2V(meas.) = n.d. 2V(calc.) = 76° *Orientation:* $Y = b$; $X \wedge a = 29°$; $Z \wedge c = -7°$. *Dispersion:* $r > v$, weak.

Cell Data: *Space Group:* $P2_1/a$. $a = 14.56(5)$ $b = 8.016(20)$ $c = 9.838(20)$ $\beta = 111° 45(10)'$ $Z = 4$

X-ray Powder Pattern: Near the De Bely mine, California, USA; strong preferred orientation due to platy {100} cleavage.
6.79 (100), 3.39 (31), 5.18 (9), 2.566 (9), 3.12 (7), 2.309 (7), 4.68 (5)

Chemistry:

	(1)	(2)
B_2O_3	60.80	61.98
Fe_2O_3	0.15	
CaO	16.96	16.64
SrO	0.11	
Na_2O	0.26	
K_2O	0.06	
Li_2O	0.02	
H_2O^+	20.82	
H_2O^-	1.02	
H_2O		21.38
insol.	0.08	.
Total	100.28	100.00

(1) Near the De Bely mine, California, USA; SrO and alkalies by flame photometry, H_2O by the Penfield method; corresponds to $Ca_{1.01}B_{5.84}O_9(OH)_2•3H_2O$. (2) $CaB_6O_9(OH)_2•3H_2O$.

Occurrence: Typically a recent incrustation produced by weathering of colemanite and priceite veins in altered olivine basalt and basaltic clastic rocks (near the De Bely mine, California, USA).

Association: Colemanite, meyerhofferite, gowerite, ulexite, ginorite, sassolite, gypsum, manganese oxide (near the De Bely mine, California, USA).

Distribution: In the USA, in the Furnace Creek district, Death Valley, Inyo Co., California, from one km north-northwest of the De Bely mine, and several other places; coarsely crystalline in the Corkscrew mine. From the Sijes district, Salta Province, Argentina. From drill core at Piskanja, Jarandol basin, Serbia.

Name: To honor Dr. Levi Fatzinger Noble (1882-1965), geologist with the U.S. Geological Survey, who studied the Death Valley borate deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA; 136416, 147960.

References: (1) Erd, R.C., J.F. McAllister, and A.C. Vlisidis (1961) Nobleite, another new hydrous calcium borate from the Death Valley region, California. Amer. Mineral., 46, 560-571. (2) Karanović, L., A. Rosić, and D. Poleti (2004) Crystal structure of nobleite, $Ca[B_6O_9(OH)_2]·3H_2O$, from Jarandol (Serbia). Eur. J. Mineral. 16, 825-833. (3) (2005) Amer. Mineral., 90, 772 (abs. ref. 2).

Nolanite $(V^{3+}, Fe^{3+}, Fe^{2+}, Ti)_{10}O_{14}(OH)_2$

Crystal Data: Hexagonal. *Point Group:* $6mm$. As euhedral hexagonal plates, to 1 mm, exhibiting {0001}, $\{10\bar{1}0\}$, and $\{10\bar{1}1\}$; as exsolution lamellae in vanadian magnetite; commonly aggregated into crusts and massive vein fillings.

Physical Properties: Hardness = ~5 VHN = 710–760, 734 average (20 g load).
D(meas.) = 4.65 D(calc.) = 4.60

Optical Properties: Opaque, slightly translucent in thin fragments. *Color:* Black; dark gray to dark grayish violet in reflected light. *Streak:* Brownish black. *Luster:* Submetallic.
Optical Class: Uniaxial. *Pleochroism:* Dark brown to deep blue. *Anisotropism:* Moderate; light to dark gray.
R_1–R_2: (470) 11.0–12.7, (546) 11.8–13.5, (589) 12.3–14.0

Cell Data: *Space Group:* $P6_3mc$. $a = 5.846$–5.897 $c = 9.254$–9.295 $Z = 1$

X-ray Powder Pattern: Saskatchewan, Canada.
3.44 (100), 2.66 (90), 2.49 (90), 1.495 (60), 4.66 (55), 2.23 (50), 2.46 (40)

Chemistry:

	(1)	(2)
Ti	3.7	6.7
V	45.0	33.5
Al	0.9	0.8
Fe	15.9	24.0
Mn	< 0.1	0.1
Mg	< 0.1	0.1
Na	0.1	0.2
Total		

(1–2) Kalgoorlie, Western Australia; by electron microprobe; V and Fe valences and $(OH)^{1-}$ from crystal structure determinations, corresponding respectively to $(V^{3+}_{6.9}Fe^{3+}_{1.6}Fe^{2+}_{0.6}Ti_{0.6}Al_{0.3})_{\Sigma=10.0}O_{14}(OH)_2$ and $(V^{3+}_{5.2}Fe^{3+}_{2.4}Fe^{2+}_{1.1}Ti_{1.1}Al_{0.2})_{\Sigma=10.0}O_{14}(OH)_2$.

Occurrence: In hydrothermal uranium deposits (Saskatchewan, Canada); in gold deposits in metamorphosed greenstones (Kalgoorlie, Western Australia).

Association: Dolomite, calcite, quartz, uraninite, pyrite, chalcopyrite, galena, ilmenite, hematite, carnotite (Saskatchewan, Canada); gold, gold tellurides, vanadian muscovite, tourmaline, tivanite, vanadian hematite, vanadian magnetite (Kalgoorlie, Western Australia).

Distribution: From Fish-Hook Bay, Lake Athabaska, and at the Ace mine, the Consolidated Nicholson Mine No. 2, and the Pitche claims, Beaverlodge Lake, Saskatchewan, Canada. From Wild Steer Canyon, Paradox Valley, Montrose Co., Colorado, and in the Campbell mine, Bisbee, Cochise Co., Arizona, USA. In several mines at Kalgoorlie, Western Australia. From the Mounana uranium mine, Franceville, Gabon.

Name: To honor Dr. Thomas Brennan Nolan (1901–1992), formerly Director of the U.S. Geological Survey, Washington, D.C., USA.

Type Material: The Natural History Museum, London, England, 1965,206; National Museum of Natural History, Washington, D.C., USA, 112965.

References: (1) Robinson, S.C., H.T. Evans, Jr., W.T. Schaller, and J.J. Fahey (1957) Nolanite, a new iron-vanadium mineral from Beaverlodge, Saskatchewan. Amer. Mineral., 42, 619–628. (2) Gatehouse, B.M., I.E. Gray, and E.H. Nickel (1983) The crystal chemistry of nolanite, $(V, Fe, Ti, Al)_{10}O_{14}(OH)_2$, from Kalgoorlie, Western Australia. Amer. Mineral., 68, 833–839.

Nontronite $(Ca_{0.5}, Na)_{0.3}Fe^{3+}_2(Si, Al)_4O_{10}(OH)_2 \cdot nH_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely as small bladed crystals, radial or reticulated, spherulitic; commonly cryptocrystalline, claylike, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal, splintery. Hardness = 1–2 D(meas.) = 2.2–2.3 D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent to nearly opaque. *Color:* Yellow, olive-green, green, orange, brown, may be zoned. *Luster:* Waxy, resinous, dull.
Optical Class: Biaxial (–). *Pleochroism:* X = yellowish; Y = yellow-green to dark brown; Z = olive-green to light brown. *Orientation:* $X \simeq c$; $Y = b$; $Z \simeq a$. *Absorption:* $Z > Y > X$ or $Y > Z > X$. $\alpha = 1.567$–1.600 $\beta = 1.604$–1.632 $\gamma = 1.605$–1.643 2V(meas.) = 25°–68°

Cell Data: *Space Group:* $C2/m$. $a = 5.23$–5.26 $b = 9.08$–9.12 $c = 14.8$–15.8 $\beta = \sim 90°$ Z = n.d.

X-ray Powder Pattern: Nontron, France.
15.4 (vs), 4.56 (vs), 2.64 (vs), 2.56 (vs), 1.52 (vs), 2.43 (s), 1.72 (s)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.82	40.25	CaO		2.29
TiO_2		0.03	H_2O^+		7.25
Al_2O_3	4.30	5.50	H_2O^-		15.09
Fe_2O_3	35.88	29.44	H_2O	9.66	
MgO	0.35	0.53	Total	99.01	100.38

(1) Nontron, France. (2) Colfax, Washington, USA; corresponds to $Ca_{0.43}(Fe^{3+}_{1.93}Mg_{0.07}Al_{0.06})_{\Sigma=2.06}(Si_{3.50}Al_{0.50})_{\Sigma=4.00}O_{10}(OH)_2 \cdot nH_2O$.

Mineral Group: Smectite group.

Occurrence: A weathering product of basalts, kimberlites, and other ultramafic igneous rocks; in poorly-drained volcanic ash soils; in some hydrothermally altered mineral deposits, midocean ridge basalts, and contact metamorphosed limestones. An authigenic mineral in recent marine sediments.

Association: Quartz, "opal," "hornblende," pyroxenes, olivine, mica, kaolinite.

Distribution: Some localities for well-characterized material include: near Saint-Pardoux, Dordogne, France. At Froland, Norway. From Vittensten, Sweden. In Russia, at Okhansk, Perm. From Geilsdorf and Wolkenstein, Saxony, Germany. At Faratsiho, Madagascar. In the Burra copper mine, South Australia, and the Tamworth copper mine, Attunga, New South Wales, Australia. In the USA, in the Spruce Pine district, Mitchell Co., North Carolina; near Colfax and Garfield, Whitman Co., Washington; from Petaluma, Sonoma Co., Crestmore, Riverside Co., and near Woody, Kern Co., California. In New Mexico, at Santa Rita, Grant Co.; from Morenci, Greenlee Co., the Globe-Miami district, Gila Co., the Twin Buttes mine, Pima Co., and at Ray, Pinal Co., Arizona. From Santa Eulalia, Chihuahua, Mexico.

Name: For the occurrence near Saint-Pardoux, Nontron Arrondissement, France.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 89645.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 701–702 [chloropal]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 226–245. (3) Nagelschmidt, G. (1938) On the atomic arrangement and variability of members of the montmorillonite group. Mineral. Mag., 25, 140–155. (4) Isphording, W.C. (1975) Primary nontronite from the Venezuelan Guayana. Amer. Mineral., 60, 840–848. (5) Besson, G., A.S. Bookin, L.G. Dainyak, M. Rautureau, S.I. Tsipursky, C. Tchoubar, and V.A. Drits (1983) Use of diffraction and Mössbauer methods for the structural and crystallochemical characterization of nontronites. J. Applied Cryst., 16, 374–383.

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Norbergite $Mg_3(SiO_4)(F,OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals rare, to 2.5 cm, thick tabular, typically rounded and highly modified; granular.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 3.177 D(calc.) = 3.186 May fluoresce canary-yellow under SW UV.

Optical Properties: Transparent to translucent. *Color:* Tan, yellow, yellow-orange, orange-brown, pink with purplish tint, white; in thin section, pale yellow to colorless. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (+). *Pleochroism:* X = pale yellow; Y = very pale yellow; Z = colorless. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, slight. $\alpha = 1.563$–1.567 $\beta = 1.567$–1.579 $\gamma = 1.590$–1.593 2V(meas.) = 44°–50°

Cell Data: *Space Group: Pmcn.* $a = 8.747(6)$ $b = 4.710(4)$ $c = 10.271(8)$ $Z = 4$

X-ray Powder Pattern: Synthetic $Mg_3SiO_4F_2$.
3.058 (100), 2.230 (80), 2.639 (75), 2.255 (70), 1.7241 (50), 1.4763 (45), 2.408 (35)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	27.56	29.74	MgO	59.35	58.73
TiO_2	0.01	0.42	CaO		0.15
Al_2O_3	0.11		F	13.49	16.77
Fe_2O_3	0.28		H_2O^+	2.68	1.52
FeO	1.91	0.06	H_2O^-	0.00	
MnO	0.12	0.01	$-O = F_2$	5.68	7.07
ZnO		0.05	Total	99.83	100.38

(1) Norberg, Sweden; corresponds to $(Mg_{3.01}Fe^{2+}_{0.05}Fe^{3+}_{0.01})_{\Sigma=3.07}Si_{0.94}O_4[F_{1.45}(OH)_{0.61}]_{\Sigma=2.06}$.
(2) Franklin, New Jersey, USA; by electron microprobe, corresponds to $Mg_{2.93}Si_{1.00}O_4[F_{1.77}(OH)_{0.34}]_{\Sigma=2.11}$.

Mineral Group: Humite group.

Occurrence: In contact metamorphic zones in limestones and dolostones into which plutonic rocks or pegmatites have introduced fluorine.

Association: Dolomite, calcite, tremolite, grossular, wollastonite, forsterite, monticellite, cuspidine, fluoborite, ludwigite, fluorite, phlogopite.

Distribution: In the Östanmossa and other iron mines, Norberg, Västmanland, Sweden. At Piukkala, near Pargas, Finland. Near Loch Ness, Inverness-shire, Scotland. From the Nicoll quarry, Franklin, Sussex Co., New Jersey. Around Edenville, Orange Co., and in the Balmat mines, St. Lawrence Co., New York, USA. At Monte Somma and Nocera, Campania, Italy.

Name: From its first locality at Norberg, Sweden.

Type Material: n.d.

References: (1) Geijer, P. (1926) Norbergite and fluoborite, two new minerals from the Norberg mining district. Geol. Fören. Förhandl. Stockholm, 48, 84–85. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 379–417. (3) Gibbs, G.V. and P.H. Ribbe (1969) The crystal structure of the humite minerals: I. Norbergite. Amer. Mineral., 54, 376–390. (4) (1960) NBS Circ. 539, 10, 39.

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Nordenskiöldine $CaSn^{4+}(BO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Small crystals are thin to thick tabular, may have rounded {0001}, with {$11\overline{2}0$}, {$10\overline{1}1$}; in subparallel aggregates massive.

Physical Properties: *Cleavage:* Perfect on {0001}; indistinct on {$10\overline{1}1$}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 4.09–4.20 D(calc.) = 4.18

Optical Properties: Transparent. *Color:* Colorless, milky white, sulfur-yellow, lemon-yellow, wine-yellow; colorless in transmitted light. *Luster:* Vitreous, pearly on {0001}. *Optical Class:* Uniaxial (–). $\omega = 1.774–1.778$ $\epsilon = 1.660–1.661$

Cell Data: *Space Group:* $R\overline{3}$. $a = 4.858(1)$ $c = 16.080(2)$ Z = 3

X-ray Powder Pattern: Jiangsu Province, China.
5.342 (100), 2.900 (28), 1.810 (13), 3.720 (11), 2.673 (8), 4.061 (7), 2.424 (4)

Chemistry:

	(1)	(2)	(3)
B_2O_3	[23.18]	25.00	25.19
SnO_2	53.75	51.26	54.52
FeO		0.40	
MgO		0.14	
CaO	20.45	20.48	20.29
rem.	2.62	1.32	
Total	[100.00]	98.60	100.00

(1) Arø Island, Norway; remnant is B_2O_3 (?) 1.72% and ZrO_2 0.90%. (2) Jiangsu Province, China; remnant is SiO_2 0.39%, TiO_2 0.14%, Al_2O_3 0.24%, Cr_2O_3 0.01%, MnO 0.01%, BaO 0.11%, SrO 0.04%, H_2O^+ 0.38%; corresponds to $(Ca_{1.02}Fe_{0.02}Mg_{0.01})_{\Sigma=1.05}Sn_{1.06}(BO_3)_2$. (3) $CaSn(BO_3)_2$.

Occurrence: Very rare in an alkalic pegmatite (Arø Island, Norway); in a hydrothermal deposit in metasomatized marble (Arandis, Namibia); in skarns (China).

Association: Meliphanite, homilite, zircon, molybdenite, cancrinite, analcime, feldspar (Arø Island, Norway); tourmaline, cassiterite, stannite, chalcopyrite, pyrrhotite, siderite, calcite (Arandis, Namibia).

Distribution: From Arø Island, Langesundsfjord, Norway. At the Stiepelman mine, Arandis, Namibia. In the Titovskoye deposit, polar Sakha, Russia. In China, from the Damoshan deposit, Gejiu tin district, Yunnan Province, at the Dading tin-iron deposits, Guizhou Province, and in an undisclosed deposit, Wuxian Co., Jiangsu Province. On Brooks Mountain, Alaska, USA. At the MW prospect, near Smart River, Cassiar Mountains, Yukon Territory, Canada.

Name: Honors Nils Adolf Erik Nordenskiöld (1832–1901), Swedish mineralogist, geologist, and explorer.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway, 19973; Swedish Museum of Natural History, Stockholm, Sweden, g30699.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 332–333. (2) Effenberger, H. and J. Zemann (1986) The detailed crystal structure of nordenskiöldine, $CaSn(BO_3)_2$. Neues Jahrb. Mineral., Monatsh., 111–114. (3) Chen Sisong, Wei Jinsheng, and Huang Kebing (1987) The discovery of nordenskiöldine in Jiangsu Province. Acta Petrolog. Mineralog., 6(4), 364–367 (in Chinese with English abs.).

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Nordgauite $MnAl_2(PO_4)_2(F, OH)_2 \cdot 5H_2O$

Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As tabular, on {100}, to prismatic crystals, to 200 μm; in compact nodules and fibrous hemispherical aggregates.

Physical Properties: *Cleavage:* n.d. *Fracture:* n.d. *Tenacity:* n.d. Hardness = n.d.
D(meas.) = 2.35 D(calc.) = 2.46

Optical Properties: Transparent to translucent. *Color:* Off-white, snow white. *Streak:* White.
Luster: Earthy, slightly waxy to silky (aggregates).
Optical Class: Biaxial. $n = 1.57$

Cell Data: *Space Group:* $P\bar{1}$. $a = 9.920(4)$ $b = 9.933(3)$ $c = 6.087(2)$ $\alpha = 92.19(3)°$
$\beta = 100.04(3)°$ $\gamma = 97.61(3)°$ $Z = 2$

X-ray Powder Pattern: Hagendorf-Süd pegmatite, Bavaria, Germany.
9.806 (100), 7.432 (40), 4.119 (20), 2.951 (16), 4.596 (12), 3.225 (12), 3.215 (12)

Chemistry:

	(1)
CaO	0.96
MgO	0.12
MnO	14.29
FeO	0.60
ZnO	0.24
Al_2O_3	22.84
P_2O_5	31.62
F	5.13
H_2O	2.86
-O=F	2.16
Total	96.50

(1) Hagendorf-Süd pegmatite, Bavaria, Germany; average of 8 electron microprobe analyses, H_2O by CHN, corresponding to $(Mn_{0.90}Ca_{0.08}Fe_{0.04}Zn_{0.01}Mg_{0.01})_{\sum=1.04}Al_{2.01}(PO_4)_2[F_{1.21}(OH)_{0.90}]_{\sum=2.11} \cdot 5.25H_2O$.

Occurrence: A late stage secondary hydrothermal mineral in altered zwieselite-triplite masses in a zoned granite pegmatite.

Association: Apatite-(CaF), sphalerite, uraninite, a columbite-tantalite phase, metastrengite, whiteite-jahnsite (inclusions).

Distribution: From the Hagendorf-Süd pegmatite, Bavaria, Germany.

Name: For *Nordgau*, the oldest name for that part of northeastern Bavaria in which Hagendorf is situated, and where mining has taken place since the 13th century.

Type Material: Museum Victoria, Melbourne, Australia (M48795; M51231).

References: (1) Birch, W.D., I.E. Grey, S.J. Mills, A. Pring, C. Bougerol, A. Ribaldi-Tunnicliffe, N.C. Wilson, and E. Keck (2011) Nordgauite, $MnAl_2(PO_4)_2(F,OH)_2 \cdot 5H_2O$, a new mineral from the Hagendorf-Süd pegmatite, Bavaria, Germany: description and crystal structure. Mineral. Mag., 75(2), 269–278. (2) (2013) Amer. Mineral., 98, 280-281 (abs. ref. 1).

Nordite-(La) $(Na,Mn)_3(Sr,Ca)(La,Ce)(Zn,Mg)Si_6O_{17}$

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Crystal Data: Orthorhombic; may be metamict. *Point Group:* $2/m\ 2/m\ 2/m$. Rare crystals are poorly formed, elongated along [001] and tabular on {100}. As lamellae, to 1 cm; as radial fibrous aggregates of curved and lamellar crystals.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.43–3.48 D(calc.) = [3.41]

Optical Properties: Semitransparent. *Color:* Light brown; pale brown in thin section. *Streak:* White. *Luster:* Vitreous, greasy on fracture.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. α = 1.619–1.620 β = 1.630–1.640 γ = 1.642–1.644 2V(meas.) = 31°–32°

Cell Data: *Space Group: Pcca.* $a = 14.27(3)$ $b = 5.16(1)$ $c = 19.45(15)$ Z = 4

X-ray Powder Pattern: Lovozero massif, Russia.
2.95 (100), 2.86 (100), 1.764 (80), 1.144 (80), 3.31 (60), 2.77 (60), 2.42 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	45.53	45.07	ZnO		3.90
ThO_2		0.26	MgO	2.00	1.66
Y_2O_3	0.95		CaO	4.46	3.74
La_2O_3	10.48	11.52	SrO	7.40	7.11
Ce_2O_3	8.77	9.38	BaO		0.35
Fe_2O_3	1.84	1.15	Na_2O	11.70	11.20
FeO		2.12	K_2O	0.08	
MnO	6.04	3.29	Cl	trace	
			Total	99.25	100.75

(1) Lovozero massif, Russia. (2) Do.; corresponds to $(Na_{2.81}Mn_{0.19})_{\Sigma=3.00}(Sr_{0.54}Ca_{0.46})_{\Sigma=1.00}(La_{0.52}Ce_{0.42}Ca_{0.06})_{\Sigma=1.00}(Zn_{0.38}Mg_{0.32}Mn_{0.17}Fe_{0.13})_{\Sigma=1.00}(Si_{5.85}Fe_{0.15})_{\Sigma=6.00}O_{17.04}$. Analyses are known of material with Ce > La but with no other properties described.

Occurrence: Extremely rare in pegmatites in sodalite syenite in a differentiated alkalic massif.

Association: Sodalite, ussingite, murmanite, chkalovite, belovite, steenstrupine, lomonosovite, eudialyte, microcline, nepheline, aegirine, sphalerite, neptunite, lamprophyllite.

Distribution: In the valley of the Chinglusuai River and elsewhere in the Lovozero massif, Kola Peninsula, Russia.

Name: From the mineral's "northern origin" and *lanthanum* content.

Type Material: n.d.

References: (1) Gerasimovsky, V.E. (1941) Nordite, a new mineral of the Lovozero Tundras. Doklady Acad. Nauk SSSR, 32, 496–498 (in Russian). (2) (1943) Amer. Mineral., 28, 282–283 (abs. ref. 1). (3) Bakakin, V.V., N.V. Belov, S.V. Borisov, and L.P. Solovyeva [Solov'eva] (1970) The crystal structure of nordite and its relationship to melilite and datolite-gadolinite. Amer. Mineral., 55, 1167–1181. (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 316–317.

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Nordstrandite $Al(OH)_3$

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Crystal Data: Triclinic. *Point Group:* 1. Thick tabular crystals, rhombic or blocky, to 2 mm; less commonly acicular; in radiating clusters, polycrystalline aggregates, which may be tubular, or in pellets.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = 3 D(meas.) = 2.41–2.43 D(calc.) = [2.45]

Optical Properties: Transparent to opaque. *Color:* Nearly colorless, white, cream; coral-pink to reddish brown with included goethite, may be zoned. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (+). *Orientation:* $Z \wedge c \simeq 32°$. *Dispersion:* $r < v$, moderate. $\alpha = 1.580$ $\beta = 1.583$ $\gamma = 1.596$–1.613 2V(meas.) = 18°–24° 2V(calc.) = 10°–22°

Cell Data: *Space Group:* $P1$. $a = 6.125$–6.167 $b = 6.923$–6.936 $c = 5.074$–5.082 $\alpha = 95.62°-95.93°$ $\beta = 98.62°-99.08°$ $\gamma = 83.22°-83.53°$ Z = 4

X-ray Powder Pattern: Guam.
4.789 (100), 2.263 (15), 4.322 (12), 4.207 (10), 2.392 (9), 2.016 (8), 1.9008 (8)

Chemistry:

	(1)	(2)	(3)
SiO_2	4.14	0.06	
Al_2O_3	63.97	65.6	65.36
Fe_2O_3	0.25		
CaO		0.00	

	(1)	(2)	(3)
Na_2O		0.01	
H_2O^+	29.05	[34.33]	34.64
H_2O^-	1.59		
Total	99.00	[100.00]	100.00

(1) Guam. (2) Mont Saint-Hilaire, Canada; by electron microprobe, H_2O by difference. (3) $Al(OH)_3$.

Polymorphism & Series: Polymorphous with bayerite, doyleite, and gibbsite.

Occurrence: Commonly in residual soils derived from limestones; in dolomitic oil shale, marine siltstone, chalk; in pegmatite, miarolitic cavities, and xenoliths in nepheline syenites.

Association: Quartz, kaolinite, diaspore, goethite (Gunong Kapor, Borneo); natrolite, tetranatrolite, analcime, sodalite, albite, microcline, dawsonite (Mont Saint-Hilaire, Canada).

Distribution: On Gunong Kapor, near Bau, western Sarawak, Borneo, Malaysia. On the Mt. Alifan-Mt. Lamlan ridge, south Guam. From Narssârssuk, Greenland. In Canada, at Mont Saint-Hilaire, and in the Francon quarry, Montreal Island, Montreal, Quebec; from the Princess sodalite mine, Bancroft, Ontario. In the Green River Formation, Rio Blanco Co., Colorado, USA. From Newhaven, East Sussex, England. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. From Stradnerkogel, south of Wilhelmsdorf, Styria, Austria. At Terlan, Trentino-Alto Adige, Italy. From Ajatskoe, Kazakhstan. In the Khibiny massif, Kola Peninsula, and the Listvennoye deposit, Yenisei Ridge, Siberia, Russia. Additional localities are increasingly becoming known.

Name: For Robert A. Van Nordstrand, Sinclair Research Laboratories, Harvey, Illinois, USA, who synthesized the compound, later named for him, then transferred to the natural mineral.

Type Material: Royal Ontario Museum, Toronto, Canada, M145608; Harvard University, Cambridge, Massachusetts, 108353; National Museum of Natural History, Washington, D.C., USA, 117275, 145608.

References: (1) Wall, J.R.D., E.B. Wolfenden, E.H. Beard, and T. Deans (1962) Nordstrandite in soil from West Sarawak, Borneo. Nature, 196, 264–265. (2) Hathaway, J.C. and S.O. Schlanger (1962) Nordstrandite from Guam. Nature, 196, 265–266. (3) (1963) Amer. Mineral., 48, 214–215 (abs. refs. 1 and 2). (4) Saalfeld, H. and O. Jarchow (1968) Die Kristallstruktur von Nordstrandite, $Al(OH)_3$. Neues Jahrb. Mineral., Abh., 109, 185–191 (in German with English abs.). (5) Chao, G.Y. and J. Baker (1982) Nordstrandite from Mont St-Hilaire, Quebec. Can. Mineral., 20, 77–85.

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Nordströmite $Pb_3CuBi_7(S,Se)_{14}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous, to 3.5 mm.

Physical Properties: *Cleavage:* Good, parallel to crystal elongation. Hardness = 2–2.5 VHN = 130–143 (25 g load). D(meas.) = n.d. D(calc.) = 7.12

Optical Properties: Opaque, presumably. *Color:* Lead-gray; white with a gray tint in reflected light. *Anisotropism:* Dark gray to brown.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/m$. $a = 17.97(8)$ $b = 4.11(2)$ $c = 17.62(8)$ $\beta = 94.3(2)°$ $Z = 2$

X-ray Powder Pattern: Falun, Sweden.
3.066 (10), 2.242 (7), 3.583 (5), 3.882 (3b), 3.484 (3), 3.427 (3), 3.012 (3)

Chemistry:

	(1)
Pb	21.73
Cu	2.04
Bi	51.95
Se	11.16
S	10.88
Total	[97.76]

(1) Falun, Sweden; by electron microprobe, original total given as 97.75%; corresponding to $Pb_{3.06}Cu_{0.94}Bi_{7.24}(S_{9.88}Se_{4.12})_{\Sigma=14.00}$.

Occurrence: Of hydrothermal origin.

Association: Wittite, friedrichite, bismuthinite (Falun, Sweden); gold, chalcopyrite, neyite, quartz (Johnny Lyon Hills, Arizona, USA).

Distribution: From Falun, Kopparberg, Sweden [TL]. In the Johnny Lyon Hills, north of Benson, Cochise Co., Arizona, USA.

Name: To honor T. Nordström (1843–1920), Swedish mining engineer who first studied the sulfosalts from Falun.

Type Material: Royal Ontario Museum, Toronto, Canada, M12992.

References: (1) Mumme, W.G. (1980) Seleniferous lead–bismuth sulphosalts from Falun, Sweden: weibullite, wittite, and nordströmite. Amer. Mineral., 65, 789–796. (2) Mumme, W.G. (1980) The crystal structure of nordströmite $CuPb_3Bi_7(S,Se)_{14}$, from Falun, Sweden: a member of the junoite homologous series. Can. Mineral., 18, 343–352.

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Norrishite $KLiMn_2^{3+}Si_4O_{12}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As platy crystals and flakes, to 1.5 mm.

Physical Properties: *Cleavage:* {001}, perfect; {010} and {100}, poor. Hardness = 2.5 D(meas.) = 3.264(2) D(calc.) = 3.255

Optical Properties: Translucent. *Color:* Black to brown-black; in transmitted light, bright yellow, lime-green or olive-green, honey-brown, may be color zoned with a green core and yellow rim. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = yellow; Y = lime-green to olive-green; Z = yellow-brown. *Orientation:* $Z = b$; $Y \wedge a = 20°$. *Dispersion:* $r > v$, strong. $\alpha = 1.636(1)$ $\beta = 1.687(1)$ $\gamma = 1.785(5)$ 2V(meas.) = 74.0° 2V(calc.) = 75.2°

Cell Data: *Space Group:* $C2/m$, $C2$, or Cm. $a = 5.289(3)$ $b = 8.914(3)$ $c = 10.062(7)$ $\beta = 98.22(5)°$ Z = 2

X-ray Powder Pattern: Hoskins mine, Australia.
10.01 (10), 3.329 (8), 3.160 (7), 3.571 (6), 2.365 (6), 4.464 (5), 2.620 (5)

Chemistry:

	(1)
SiO_2	50.37
TiO_2	0.15
Al_2O_3	1.31
Fe_2O_3	< 0.02
Mn_2O_3	34.68
MgO	0.32
CaO	0.00
BaO	0.13
Li_2O	3.1
Na_2O	0.04
K_2O	10.39
F	< 0.09
Cl	< 0.01
H_2O^+	0.66
Total	101.15

(1) Hoskins mine, Australia; by electron microprobe, average of four analyses; H_2O by gravimetric analysis, Li by atomic emission and AA, oxidation state by titration; corresponds to $(K_{0.98}Ba_{0.01})_{\Sigma=0.99}(Mn^{3+}_{2.00}Li_{0.95}Mg_{0.02})_{\Sigma=2.97}(Si_{3.84}Al_{0.10})_{\Sigma=3.94}O_{11.66}(OH)_{0.34}$.

Mineral Group: Mica group.

Occurrence: A major to minor component of manganiferous schists, formed through metamorphism of a stratiform manganese deposit.

Association: Manganoan-alkalic amphibole, manganoan-alkalic clinopyroxene, manganoan pectolite-sérandite, braunite, calcium carbonates, barium carbonates, albite, potassic feldspar, quartz, barite.

Distribution: From the Hoskins mine, three km west of Grenfell, New South Wales, Australia.

Name: In honor of Dr. Keith Norrish of the Division of Soils, Commonwealth Scientific and Industrial Research Organization, Australia.

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Type Material: Australian Museum, Sydney; Australian National University, Canberra, A.C.T.; University of New England, Armidale, New South Wales, Australia.

References: (1) Eggleton, R.A. and P.M. Ashley (1989) Norrishite, a new manganese mica, $K(Mn_2^{3+}Li)Si_4O_{12}$, from the Hoskins mine, New South Wales, Australia. Amer. Mineral., 74, 1360–1367. (2) Tyrna, P.L. and S. Guggenheim (1991) The crystal structure of norrishite, $KLiMn_2^{3+}Si_4O_{12}$: an oxygen-rich mica. Amer. Mineral., 76, 266–271.

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Norsethite $BaMg(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$ or 32. Platy crystals, flattened on {0001}, rhombohedral $\{10\overline{1}1\}$ with {0001}, $\{10\overline{1}0\}$, $\{11\overline{2}0\}$, to 2 mm; may be discoidal, corrugated granular.

Physical Properties: *Cleavage:* Good on $\{10\overline{1}1\}$. *Fracture:* Hackly. Hardness = 3.5 D(meas.) = 3.837 D(calc.) = 3.840 May fluoresce dark red under UV.

Optical Properties: Transparent. *Color:* Colorless to milky white; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.694(1)$ $\epsilon = 1.519(1)$

Cell Data: *Space Group:* $R\overline{3}m$ or $R32$. $a = 5.020(5)$ $c = 16.75(2)$ $Z = 3$

X-ray Powder Pattern: Westvaco trona mine, Wyoming, USA.
3.015 (100), 3.860 (35), 2.656 (35), 2.512 (35), 2.104 (35), 1.931 (35), 1.864 (35)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	31.2	[31.33]	31.25	MgO	13.9	14.08	14.31
SiO_2	0.3			CaO	0.5	0.16	
FeO	0.4	0.61		BaO	52.9	53.76	54.44
ZnO		0.06		Na_2O	0.2		
MnO	0.1			insol.	0.4		
				Total	99.9	[100.00]	100.00

(1) Westvaco trona mine, Wyoming, USA; CO_2 by evolved gas analysis; after deduction of SiO_2 and Na_2O as impurities, corresponding to $(Ba_{0.99}Ca_{0.01})_{\Sigma=1.00}(Mg_{0.97}Fe_{0.03})_{\Sigma=1.00}(CO_3)_{2.01}$. (2) Tapira, Brazil; by electron microprobe, average of 15 analyses, CO_2 by difference; corresponding to $(Ba_{0.98}Ca_{0.01}Fe_{0.01})_{\Sigma=1.00}(Mg_{0.98}Fe_{0.02})_{\Sigma=1.00}(CO_3)_2$. (3) $BaMg(CO_3)_2$.

Mineral Group: Dolomite group.

Occurrence: A rare authigenic mineral in and underlying the Green River Formation; a primary mineral in carbonatites; uncommon in metamorphosed hydrothermal mineral deposits.

Association: Shortite, labuntsovite, searlesite, northupite, loughlinite, barytocalcite, witherite, pyrite, quartz (Westvaco trona mine, Wyoming, USA).

Distribution: In the USA, in the Westvaco trona mine, about 30 km west of Green River, Sweetwater Co., Wyoming; and at Iron Hill, Gunnison Co., Colorado. In Canada, on the Rough claims, north of Sifton Pass, British Columbia; at the Chipman Lake carbonatite, 350 km northeast of Thunder Bay, Ontario; and in the Jason Pb–Zn deposits, Macmillan Pass, Yukon Territory. From the Tapira carbonatite, Minas Gerais, Brazil. At the Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. From the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. In the Foss deposits, Aberfeldy, Perthshire, Scotland. At Långban, Värmland, Sweden. In the Rosh Pinah Zn–Pb–Cu deposit, about 160 km southeast of Aus, Namibia.

Name: Honors Keith Norseth (1927–1991), American engineering geologist, Westvaco trona mine, Wyoming, USA, for his assistance in mineralogical studies.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137148, 162606.

References: (1) Mrose, M.E., E.C.T. Chao, J.J. Fahey, and C. Milton (1961) Norsethite, $BaMg(CO_3)_2$, a new mineral from the Green River Formation, Wyoming. Amer. Mineral., 46, 420–429. (2) Secco, L. and B. Lavina (1999) Crystal chemistry of two natural magmatic norsethites, $BaMg(CO_3)_2$, from an Mg-carbonatite of the alkaline carbonatitic complex of Tapira (SE Brazil). Neues Jahrb. Mineral., Monatsh., 87–96.

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Northupite $Na_3Mg(CO_3)_2Cl$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Octahedra, to 2 cm; globular massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.380–2.407 D(calc.) = 2.40 Slowly decomposes in H_2O, leaving a $MgCO_3$ residue.

Optical Properties: Transparent to translucent. *Color:* Colorless, pale green if ferroan, or due to inclusions may be pale yellow, gray, brown; colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Isotropic, may be sectorially anomalously birefringent. $n = 1.5144$; 1.550 if ferroan.

Cell Data: *Space Group:* $Fd3$. $a = 14.069(2)$ $Z = 16$

X-ray Powder Pattern: John Hay, Jr. Well No. 1, Wyoming, USA.
2.488 (100), 2.706 (71), 8.132 (60), 2.122 (35), 1.758 (30), 4.983 (25), 1.614 (25)

Chemistry:

	(1)	(2)	(3)
SO_3	0.08		
CO_2	35.12	35.72	35.38
MgO	16.08	15.98	16.20
CaO		0.04	
Na_2O	36.99	36.58	37.39
Cl	14.10	14.01	14.25
H_2O	0.72	0.04	
insol.	0.22	0.68	
$-O = Cl_2$	3.16	3.15	3.22
Total	100.15	99.90	100.00

(1) Searles Lake, California, USA; average of two analyses. (2) John Hay, Jr. Well No. 1, Wyoming, USA. (3) $Na_3Mg(CO_3)_2Cl$.

Occurrence: An uncommon mineral, formed probably between 20° C and 50° C, as a lacustrine deposit or at depth in mud and clay; may be primary or a replacement of earlier saline minerals.

Association: Tychite, pirssonite (Searles Lake, California, USA); shortite, trona, pirssonite, gaylussite, labuntsovite, searlesite, norsethite, loughlinite, pyrite, quartz (Green River Formation, Wyoming, USA).

Distribution: In the USA, from Searles Lake, San Bernardino Co., and Borax Lake, Lake Co., California; in the John Hay, Jr. Well No. 1 and the Westvaco trona mine, about 30 km west of Green River, Sweetwater Co., Wyoming. At Lake Katwe and Lake Mahega, Uganda. In the Kanem region, near Lake Chad, Chad. From the Tuzla salt mine, Bosnia-Herzegovina. Around Mt. Erebus, Victoria Land, and on Ross Island, Ross Sea, Antarctica. From the Zabuye Salt Lake, Nagri, Tibet, China.

Name: To honor Charles H. Northup (1861–?), grocer of San Jose, California, USA, who found the first examples.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 278–279. (2) Fahey, J.J. (1962) Saline minerals of the Green River Formation. U.S. Geol. Surv. Prof. Paper 405, 24, 31–34, 47–48. (3) Dal Negro, A., G. Guiseppetti, and C. Tadini (1975) Refinement of the crystal structure of northupite: $Na_3Mg(CO_3)_2Cl$. Tschermaks Mineral. Petrog. Mitt., 22, 158–163.

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Nosean $Na_8Al_6Si_6O_{24}(SO_4)\cdot H_2O$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3n$. Crystals are dodecahedra, to 2 mm; commonly as grains, or massive. *Twinning:* On {111}.

Physical Properties: *Cleavage:* {110}, indistinct. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 2.30–2.40 D(calc.) = 2.21

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, gray-brown, blue, black from iron contamination, may be irregularly distributed; colorless to blue in thin section. *Luster:* Vitreous.
Optical Class: Isotropic; may show weak birefringence in samples containing inclusions.
n = 1.461–1.495

Cell Data: *Space Group:* $P\bar{4}3n$. a = 9.05–9.08 Z = 1

X-ray Powder Pattern: Col de Maza, Morocco.
3.718 (100), 2.625 (49), 6.464 (36), 2.143 (25), 2.876 (24), 1.607 (11), 9.127 (10)

Chemistry:

	(1)	(2)	(3)
SiO_2	36.69	34.95	35.61
Al_2O_3	28.45	29.41	30.21
Fe_2O_3	0.47	1.38	
CaO	0.63	4.40	
Na_2O	23.90	19.01	24.49
K_2O		0.33	
Cl	1.05	0.86	
H_2O	2.15	1.83	1.78
SO_3	7.30	8.11	7.91
$-O = Cl_2$	0.23	0.19	
Total	100.41	100.09	100.00

(1) Laacher See, Germany. (2) Covao, Cape Verde Islands. (3) $Na_8Al_6Si_6O_{24}(SO_4)\cdot H_2O$.

Mineral Group: Sodalite group.

Occurrence: In silica-deficient alkalic volcanic rocks, principally phonolites.

Association: Sanidine, mica, leucite, magnetite, ilmenite, titanite, zircon.

Distribution: In Germany, at the Schellkopf, near Brenk, and elsewhere around the Laacher See, Eifel district; at Dutchlingen and in the Höwenegg quarry, Hegau, Baden-Württemberg. In the Mont-Dore massif, Auvergne, and at Vinsac, Aldis, and Cournil, Cantal, France. At Wolf Rock, Cornwall, England. From Covao, Cape Verde Islands. South of the Col de Maza, Morocco. From the Black Hills, Lawrence Co., South Dakota, and in the Cripple Creek district, Teller Co., Colorado, USA. From the Lovozero massif, Kola Peninsula, Russia. On Hsi Kuang T'a Men Mountain, Chiao Ch'eng Mountains, Shansi Province, China.

Name: After Karl Wilhelm Nose (1753?–1835), German mineralogist, of Brunswick (now Lower Saxony), Germany.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 432.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 289–302. (3) Taylor, D. (1967) The sodalite group of minerals. Contr. Mineral. Petrol., 16, 172–188. (4) Hassan, I. and H.D. Grundy (1989) The structure of nosean, ideally $Na_8[Al_6Si_6O_{24}]SO_4\cdot H_2O$. Can. Mineral., 27, 165–172.

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Nováčekite $Mg(UO_2)_2(AsO_4)_2 \cdot 10-12H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. In lamellar and subparallel aggregates of platy crystals, thick tabular on [001], with rounded $\{h0l\}$, to 3.5 cm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2.5 D(meas.) = 3.25–3.7 D(calc.) = [3.27] Fluoresces dull green to bright lemon-yellow under SW and LW UV. Radioactive.

Optical Properties: Semitransparent. *Color:* Straw-yellow to lemon-yellow. *Luster:* Waxy. *Optical Class:* Uniaxial (–), anomalously biaxial (–). *Pleochroism:* X = nearly colorless; Y = Z = pale yellow to pale yellow-green. *Dispersion:* $r > v$. $\omega = 1.578$ $\epsilon = 1.548$ $\alpha = 1.543$ $\beta = 1.570$ $\gamma = 1.577$ 2V(meas.) = 0°–40°

Cell Data: *Space Group:* $P4_2/n$. $a = 7.18$–7.20 $c = 20.16$–20.22 Z = 2

X-ray Powder Pattern: Schneeberg, Germany.
10.2 (10), 3.58 (9), 5.06 (8), 3.35 (5), 6.80 (4), 2.52 (3), 2.26 (3)

Chemistry:

	(1)	(2)
UO_3	59.74	58.47
P_2O_5	6.87	7.25
As_2O_5	11.23	11.75
CuO	1.73	
MgO	3.41	4.12
H_2O	[17.02]	18.41
Total	[100.00]	100.00

(1) Schneeberg, Germany; H_2O by difference. (2) $Mg(UO_2)_2[(As,P)O_4]_2 \cdot 10H_2O$ with As:P = 1:1.

Mineral Group: Autunite group.

Occurrence: In the oxidized zone of uranium-bearing polymetallic hydrothermal mineral deposits.

Association: Zeunerite, uranophane (Schneeberg, Germany); schoepite, paraschoepite, arsenuranylite, metazeunerite, uranospinite (Cherkasar deposit, Uzbekistan); chalcopyrite, arsenopyrite, sphalerite (Wheal Owles, England).

Distribution: In Germany, from Schneeberg, Saxony; in the Black Forest, from the Schmiedestollen dump, near Wittichen, the Anton mine, Heubachtal, near Schiltach, and the Michael mine, Weiler, near Lahr; from Ellweiler, Rhineland-Palatinate. In the Rabéjac and Mas-d'Alary uranium deposits, south of Lodève, Hérault, France. At Wheals Owles and Edward, St. Just, Cornwall, England. From Needles Eye, Dalbeattie, Kirkcudbrightshire, Scotland. At the Cherkasar uranium deposit, Chaktal Mountains, Uzbekistan. Large crystals from the Pedra Preta mine, Brumado, Bahia, Brazil. In the Las Animas mine, Santa Eulalia, Chihuahua, Mexico. In the USA, from the Woodrow area, Grants district, Valencia Co., New Mexico; and in the Wichita Mountains, Comanche Co., Oklahoma; at the White King mine, Lake Co., Oregon.

Name: To honor Dr. Radim Nováček (1905–1942), Czech mineralogist, for his contributions to the mineralogy of uranium.

Type Material: Harvard University, Cambridge, Massachusetts, 103854, 103855; American Museum of Natural History, New York City, New York, 15777; National Museum of Natural History, Washington, D.C., USA, R5686.

References: (1) Frondel, C. (1951) Studies of uranium minerals (IX): saléeite and novacekite. Amer. Mineral., 36, 680–686. (2) Stern, T.W. and C.S. Annell (1954) A second locality of novacekite. Amer. Mineral., 39, 675–676. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 177–183. (4) Elton, N.J., J.J. Hooper, and A.E. Jeal (1994) Nováčekite and metanováčekite from Cornwall. Mineral. Mag., 58, 513–514.

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Novákite $(Cu, Ag)_{21}As_{10}$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* 2, m, or $2/m$. As irregular aggregates, with grains to 3 cm, and as veinlets in arsenic; botryoidal.

Physical Properties: Hardness = 3–3.5 VHN = n.d. D(meas.) = n.d. D(calc.) = 8.01

Optical Properties: Opaque. *Color:* Steel-gray on fresh surface, tarnishes iridescent and then black; white with pale cream tint in reflected light. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Medium, dark blue-gray and pale brown-ocher.
R_1–R_2: (400) 43.6–49.0, (420) 45.4–50.5, (440) 47.2–52.0, (460) 48.3–53.0, (480) 49.1–53.9, (500) 49.8–54.6, (520) 50.2–55.2, (540) 50.6–55.6, (560) 50.9–56.0, (580) 51.2–56.3, (600) 51.3–56.6, (620) 51.4–56.8, (640) 51.5–56.9, (660) 51.5–57.0, (680) 51.5–57.1, (700) 51.5–57.2

Cell Data: *Space Group:* $C2$, Cm, or $C2/m$. $a = 16.269(3)$ $b = 11.711(2)$ $c = 10.007(2)$ $\beta = 112.74°$ Z = 4

X-ray Powder Pattern: Černý Důl mine, Czech Republic.
1.877 (10), 1.959 (9), 1.180 (9), 1.998 (8), 1.351 (6), 1.225 (6), 6.41 (5)

Chemistry:

	(1)
Cu	60.30
Ag	4.33
As	35.30
Total	99.93

(1) Černý Důl mine, Czech Republic; by electron microprobe, average of 10 analyses; corresponds to $(Cu_{20.14}Ag_{0.85})_{\Sigma=20.99}As_{10.00}$.

Occurrence: In hydrothermal carbonate veins up to 20 cm thick, cutting diopside hornfels lenses in pyroxene gneiss and less commonly in mica schist (Černý Důl mine, Czech Republic).

Association: Arsenic, arsenolamprite, koutekite, silver, löllingite, chalcocite, skutterudite, chalcopyrite, bornite, uraninite, calcite (Černý Důl mine, Czech Republic); algodonite, koutekeite, djurleite, domeykite (Cashin mine, Montrose Co., Colorado, USA).

Distribution: From the Černý Důl mine, Krkonoše (Giant Mountains), Czech Republic [TL]. In the Cashin mine, Montrose Co., Colorado, USA.

Name: In honor of Jiří Novák (1902–1971), Professor of Mineralogy, Charles University, Prague, Czech Republic.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 116992.

References: (1) Johan, Z. and J. Hak (1961) Novákite, $(Cu, Ag)_4As_3$, a new mineral. Amer. Mineral., 46, 885–891. (2) Johan, Z. (1985) The Černy Důl deposit (Czechoslovakia): an example of Ni-, Fe-, Ag-, Cu-arsenide mineralization with extremely high activity of arsenic; new data on paxite, novakite and kutinaite. Tschermaks Mineral. Petrog. Mitt., 34, 167–182.

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Nowackiite $Cu_6Zn_3As_4S_{12}$

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Crystal Data: Hexagonal. *Point Group:* 3. As equant crystals, to 0.3 mm. *Twinning:* On {0001}.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 4.3

Optical Properties: Opaque. *Color:* Lead-gray to black. *Luster:* Metallic.
R_1–R_2: n.d.

Cell Data: *Space Group: R*3. $a = 13.440(1)$ $c = 9.17(1)$ Z = 3

X-ray Powder Pattern: Binntal, Switzerland.
1.019 (100), 1.081 (75), 1.887 (63), 3.127 (61), 1.605 (61), 1.216 (52), 1.085 (20)

Chemistry:

	(1)	(2)	(3)
Cu	31.2	30.9	30.21
Zn	15.9	16.4	15.54
As	22.4	22.8	23.75
S	31.9	32.0	30.50
Total	101.4	102.1	100.00

(1) Binntal, Switzerland; by electron microprobe, corresponding to $Cu_{6.04}Zn_{3.01}As_{3.73}S_{12.70}$.
(2) Do.; by electron microprobe, corresponding to $Cu_{6.02}Zn_{3.11}As_{3.77}S_{12.36}$. (3) $Cu_6Zn_3As_4S_{12}$.

Occurrence: In a hydrothermal deposit in dolostone, noted for a variety of Pb–As–S minerals.

Association: Sphalerite, dolomite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: Honors Professor Werner Nowacki (1909–1989), Swiss mineralogist, University of Berne, Switzerland.

Type Material: University of Bern, Bern, Switzerland, holotype no longer exists, L3892-65.

References: (1) Marumo, F. and G. Burri (1965) Nowackiite, a new copper–zinc arsenosulfosalt from Lengenbach (Binnatal, Kanton Wallis). Chimia (Switzerland), 19, 500–501. (2) (1966) Amer. Mineral., 51, 532 (abs. ref. 1). (3) Marumo, F. (1967) The crystal structure of nowackiite, $Cu_6Zn_3As_4S_{12}$. Zeits. Krist., 124, 352–368. (4) Nowacki, W. (1982) Isotypic state of aktashite ($Cu_6Hg_3As_4S_{12}$) and nowackiite ($Cu_6Zn_3As_4S_{12}$). Kristallografiya (Sov. Phys. Crystal.), 27, 49–50 (in Russian).

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Nsutite $\mathbf{Mn^{4+}_{1-x}Mn^{2+}_{x}O_{2-2x}(OH)_{2x}}$ (x is small)

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Crystal Data: Hexagonal. *Point Group:* n.d. Massive, dense to porous, fine- to coarse-grained; crystals platy or wedgelike, to 50 μm; rarely fibrous, to 2 mm, spherulitic, radiating, colloform; commonly showing shrinkage cracks when coarse.

Physical Properties: Hardness = 8.5 to 6.5 when manganoan. VHN = 1150 to 900 when manganoan (300 g load). D(meas.) = 4.24–4.67; to 3.86 when manganoan and with increasing H_2O content. D(calc.) = 4.86

Optical Properties: Opaque. *Color:* Dark gray to black; in reflected light, white with slightly creamy hue. *Luster:* Metallic to earthy.
Optical Class: Uniaxial. *Anisotropism:* Distinct; light to dark gray. *Bireflectance:* Grayish white with a creamy tint to bluish gray-white.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 9.65$ $c = 4.43$ Z = 12

X-ray Powder Pattern: Nsuta, Ghana; identification by X-ray diffraction is essential.
3.96 (vs), 2.43 (s), 2.13 (s), 1.638 (s), 2.34 (m), 1.615 (w), 1.425 (w)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	1.17	0.46	CaO	0.08	0.72
MnO_2	90.57	93.27	Na_2O	0.06	< 0.05
Al_2O_3	0.22	0.50	K_2O	0.22	0.19
Fe_2O_3	1.07	0.49	H_2O^+	2.64	2.10
MnO	2.60	1.76	H_2O^-	0.33	0.57
NiO	0.14		C	0.03	
MgO	0.12	0.22	Total	99.25	100.28

(1) Nsuta, Ghana; corresponds to $Mn^{4+}_{0.90}Mn^{2+}_{0.03}Fe^{3+}_{0.01}[O_{1.75}(OH)_{0.25}]_{\Sigma=2.00}$. (2) Molango Piedras Negras, Mexico; corresponds to $Mn^{4+}_{0.91}Mn^{2+}_{0.02}Fe^{3+}_{0.01}Ca_{0.01}Si_{0.01}Al_{0.01}[O_{1.80}(OH)_{0.20}]_{\Sigma=2.00}$.

Occurrence: Thought to be supergene, formed under alkaline oxidizing conditions deficient in barium and potassium.

Association: Pyrolusite, cryptomelane, romanèchite, chalcophanite, other Mn oxides, rhodochrosite, quartz, goethite.

Distribution: Widespread, may be in large amounts. Well-characterized material from: Nsuta, Ghana. At Mokuta, Ivory Coast. In the Orient mine, Krugersdorp, Transvaal, and near Kuruman, Cape Province, South Africa. At Tartana, 32 km north of Drama, Macedonia. From Philipsburg, Granite Co., Montana, and the Hardshell mine, Santa Cruz Co., Arizona, USA. From Molango Piedras Negras, Hidalgo, Mexico. On Groote Eylandt, Northern Territory, Australia. In Germany, at Bülten-Adenstadt, Lower Saxony. From Bihain, near Salmchâteau, Belgium.

Name: For Nsuta, Ghana, a prominent occurrence.

Type Material: n.d.

References: (1) Zwicker, W.K., W.O.J. Groeneveld Meijer, and H.W. Jaffe (1962) Nsutite–a widespread manganese oxide mineral. Amer. Mineral., 47, 246–266. (2) Faulring, G.M. (1965) Unit cell determination and thermal transformations of nsutite. Amer. Mineral., 50, 170–179. (3) Ostwald, J. (1984) Some observations on the genesis of nsutite. Neues Jahrb. Mineral., Monatsh., 385–392.

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Nuffieldite $Pb_2Cu(Bi,Sb,Pb)Bi_2S_7$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic to acicular crystals, deeply striated and channelled ‖ [001]; as bundles of these unterminated crystals, to 3 mm.

Physical Properties: *Cleavage:* Indistinct ⊥ [001]; excellent ‖ [001]. *Fracture:* Uneven to flat conchoidal. *Tenacity:* Very brittle; long needles are quite elastic. Hardness = n.d. VHN = 149–178 D(meas.) = 7.01(7) D(calc.) = 7.21

Optical Properties: Opaque. *Color:* Shiny lead-gray to steel-gray on fresh surface, tarnishes to pale iridescent grayish green to reddish brown; in polished section, pale creamy white. *Streak:* Dark greenish gray to black. *Luster:* Bright metallic. *Anisotropism:* Very weak, from bluish gray to grayish red.
R_1–R_2: (400) 35.9–45.5, (420) 36.7–44.6, (440) 37.2–45.9, (460) 37.4–46.3, (480) 37.8–46.6, (500) 38.1–46.6, (520) 37.7–46.6, (540) 37.8–46.3, (560) 37.7–46.2, (580) 37.5–46.1, (600) 37.3–45.8, (620) 36.9–45.4, (640) 36.9–45.1, (660) 36.5–44.9, (680) 36.7–44.4, (700) 36.2–44.0

Cell Data: *Space Group: Pbnm.* $a = 14.387(7)$ $b = 21.011(15)$ $c = 4.046(6)$ $Z = 4$

X-ray Powder Pattern: Lime Creek deposit, Canada.
3.66 (100), 3.54 (100), 4.00 (90), 3.16 (80), 2.54 (70), 1.871 (60), 1.349 (40)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Pb	34.12	36.63	33.77	Sb	1.33	2.15	2.18
Cu	5.81	6.41	5.52	S	17.52	16.51	17.10
Bi	42.00	37.97	42.28	Total	100.78	99.67	100.85

(1) Lime Creek deposit, Canada; by electron microprobe, corresponding to $Pb_{2.00}Cu_{1.17}(Bi_{0.58}Sb_{0.14}Pb_{0.11})_{\Sigma=0.83}Bi_{2.00}S_{7.00}$. (2) Les Houches, France; by electron microprobe, average of seven analyses; corresponding to $Pb_{2.00}Cu_{1.32}(Bi_{0.38}Pb_{0.32}Sb_{0.23})_{\Sigma=0.93}Bi_{2.00}S_{6.75}$. (3) Maleevskoe, Russia; by electron microprobe, average of ten analyses; corresponding to $Pb_{2.00}Cu_{1.13}(Bi_{0.62}Sb_{0.23}Pb_{0.11})_{\Sigma=0.96}Bi_{2.00}S_{6.91}$.

Occurrence: In vugs in a small quartz vein in the Lime Creek stock (Lime Creek deposit, Canada).

Association: Molybdenite, cosalite, aikinite, pyrite, galena, sphalerite (Lime Creek, Canada); neyite, galena, tetrahedrite, chalcopyrite, sphalerite (Alaska mine, Colorado, USA).

Distribution: In Canada, from Patsy Creek, immediately south of the Lime Creek molybdenum deposit, Kitsault, near Alice Arm, British Columbia [TL], and at Izok Lake, Northwest Territories. In the Alaska mine, Poughkeepsie Gulch, San Juan Co., Colorado, USA. From the Secu Valley, Baia Borą district, Romania. In the Spissko-Gemerske Ore Mountains, eastern Slovakia. From Les Houches, Haute-Savoie, France. At Maleevskoe, Rudnyi Altai, Russia. From Akchatau, Kara Oba, and in the Ichkeul'nes skarn copper deposit, Kazakhstan.

Name: In honor of Professor Edward Wilfrid Nuffield (1914–), Canadian mineralogist of the University of Toronto, Toronto, Canada.

Type Material: Canadian Geological Survey, Ottawa, 13448; Royal Ontario Museum, Toronto, Canada.

References: (1) Kingston, P.W. (1968) Studies of mineral sulphosalts: XXI—Nuffieldite, a new species. Can. Mineral., 9, 439–452. (2) (1969) Amer. Mineral., 54, 574 (abs. ref. 1). (3) Mozgova, N.N., S.N. Nenasheva, Y.S. Borodaev, and M.A. Yudovskaya (1994) Nuffieldite from the Maleevskoe massive sulfide deposit, Russia. Can. Mineral., 32, 359–364. (4) Moëlo, Y., A. Meerschaut, and E. Makovicky (1997) Refinement of the crystal structure of nuffieldite, $Pb_2Cu_{1.4}(Pb_{0.4}Sb_{0.2})Bi_2S_7$: structural relationships and genesis of complex lead sulfosalt structures. Can. Mineral., 35, 1497–1508.

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Nukundamite $(Cu, Fe)_4S_4$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Tabular hexagonal crystals, to 2 mm, in fan-shaped groups; also as larger irregular masses, to 4 cm long, rarely with a palmlike branching structure; as fine lamellae in sphalerite.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. VHN = 103–110 (20 g load). D(meas.) = 4.30(7) D(calc.) = 4.53

Optical Properties: Opaque. *Color:* Copper colored. *Luster:* Metallic. *Pleochroism:* Strong, from reddish orange to pale gray. *Anisotropism:* Very strong, in pale green-gray colors.
R_1–R_2: (400) 15.4–23.8, (420) 14.9–23.8, (440) 14.3–23.8, (460) 14.1–23.6, (480) 14.0–23.7, (500) 14.1–23.7, (520) 14.7–23.7, (540) 15.8–23.7, (560) 17.1–23.8, (580) 18.7–23.9, (600) 20.4–24.0, (620) 22.1–24.7, (640) 24.0–26.1, (660) 25.7–27.9, (680) 27.3–30.0, (700) 28.7–30.2

Cell Data: *Space Group:* $P\overline{3}m1$ (synthetic). $a = 3.782(4)$ $c = 11.187(8)$ $Z = 1$

X-ray Powder Pattern: Undu mine, Fiji Islands.
3.143 (100), 2.826 (70), 1.891 (60), 1.847 (55), 2.796 (45), 3.273 (30), 1.568 (25)

Chemistry:

	(1)
Cu	56.51
Fe	9.64
Ag	0.09
As	0.04
S	33.51
Total	99.79

(1) Undu mine, Fiji Islands; by electron microprobe, corresponds to $(Cu_{3.37}Fe_{0.66})_{\Sigma=4.03}S_{3.97}$.

Occurrence: A primary mineral in a Kuroko-type deposit (Undu mine, Fiji Islands); also an alteration product of primary chalcopyrite.

Association: Pyrite, covellite, chalcopyrite, bornite, sphalerite.

Distribution: From the Undu mine, Nukundamu, Vanua Levu, Fiji Islands [TL]. In the Grasberg Cu–Au deposit, Irian Jaya. From Bisbee, Cochise Co., Arizona, and at Bingham, Tooele Co., Utah, USA.

Name: For the Fijian locality at Nukundamu.

Type Material: The Natural History Museum, London, England, 1974,5, E1455; National Museum of Natural History, Washington, D.C., USA, 148128.

References: (1) Rice, C.M., D. Atkin, J.F.W. Bowles, and A.J. Criddle (1979) Nukundamite, a new mineral, and idaite. Mineral. Mag., 43, 194–200. (2) (1980) Amer. Mineral., 65, 407 (abs. ref. 1). (3) Sugaki, A., H. Shima, A. Kitakaze, and T. Mizota (1981) Hydrothermal synthesis of nukundamite and its crystal structure. Amer. Mineral., 66, 398–402.

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Nullaginite $Ni_2(CO_3)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Fibers showing felted texture, cross-vein or in ovoid to irregular nodules, to 2 mm.

Physical Properties: Hardness = n.d. VHN = 25–45 (20 g load). D(meas.) = 3.56(4) D(calc.) = 3.66

Optical Properties: Semitransparent. *Color:* Bright green; pale green in transmitted light. *Luster:* Dull, claylike, silky in cross-vein fibers.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Orientation:* Y or $Z \simeq b$; $X \wedge c = 6°$. *Absorption:* Normal to fiber > along length of fiber. $\alpha = 1.67$ $\beta = 1.78$ $\gamma = 1.78$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 9.236(3)$ $b = 12.001(6)$ $c = 3.091(2)$ $\beta = 90.48(7)°$ Z = 4

X-ray Powder Pattern: Otway deposit, Australia.
2.579 (100), 2.557 (90), 4.619 (40), 3.660 (40), 7.30 (30b), 5.038 (30), 1.545 (30)

Chemistry:

	(1)	(2)
CO_2	[21.02]	20.82
Fe_2O_3	0.24	
Cr_2O_3	0.42	
NiO	68.67	70.66
CuO	0.11	
MgO	0.98	
H_2O	[8.56]	8.52
Total	[100.00]	100.00

(1) Otway deposit, Australia; by electron microprobe, average of five determinations, recalculated to 100% from an elemental analysis totaling 89.43% and estimated to contain pecoraite 8.6%, total thought low due to adsorbed H_2O; $(CO_3)^{2-}$ and $(OH)^{1-}$ calculated from stoichiometry; then corresponds to $(Ni_{1.93}Mg_{0.05}Cr_{0.01})_{\Sigma=1.99}(CO_3)(OH)_2$. (2) $Ni_2(CO_3)(OH)_2$.

Mineral Group: Rosasite group.

Occurrence: A rare mineral formed in the oxidation zone of nickel-rich hydrothermal ore deposits.

Association: Magnesian pecoraite, gaspéite, magnetite, "chlorite", nickeloan serpentine (Otway deposit, Australia).

Distribution: From the Otway nickel deposit, near Spinnaway, Nullagine district, and in the 132 North nickel mine, 4 km southwest of Widgiemooltha, Western Australia.

Name: For the Nullagine district, Western Australia, in which the mineral was first found.

Type Material: Western Australian Museum, Perth, Australia, M.76a.1991, M.76b.1991; The Natural History Museum, London, England, 1982,74.

References: (1) Nickel, E.H. and L.G. Berry (1981) The new mineral nullaginite and additional data on the related minerals rosasite and glaukosphaerite. Can. Mineral., 19, 315–324. (2) (1982) Amer. Mineral., 67, 857–858 (abs. ref. 1).

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Numanoite $Ca_4CuB_4O_6(OH)_6(CO_3)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Massive as a core or zones in borcarite crystals.

Physical Properties: *Cleavage*: Perfect, in two directions. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 4.5 VHN = 376 (25 g load). D(meas.) = 2.96(3) D(calc.) = 2.93
Easily dissolves with effervescence in dilute hydrochloric acid.

Optical Properties: Translucent. *Color*: Blue-green to colorless, colorless to pale blue-green in thin section. *Streak*: White to pale blue-green. *Luster*: Vitreous.
Optical Class: Biaxial (-). α = 1.618(2) β = 1.658(2) γ = 1.672(2) 2V(calc.) = 60°

Cell Data: *Space Group*: *C2/m.* a = 17.799(2) b = 8.389(2) c = 4.451(2) β = 102.49(3)°
Z = 2

X-ray Powder Pattern: Fuka Mine, Okayama Prefecture, Japan.
7.57 (100), 2.671 (84), 2.727 (68), 1.887 (52), 2.272 (48), 2.899 (44), 1.698 (34)

Chemistry:

	(1)
B_2O_3	24.09
CaO	38.11
CuO	10.32
MgO	1.02
ZnO	0.51
CO_2	15.80
H_2O	9.75
Total	99.60

(1) Fuka Mine, Okayama Prefecture, Japan; average of electron microprobe analyses, anionic groups confirmed by IR spectroscopy, CO_2 and H_2O by TGA; corresponding to $Ca_{3.898}(Cu_{0.744}Mg_{0.145}Zn_{0.036})_{\Sigma=0.925}B_{3.969}O_{5.615}(OH)_{6.208}(CO_3)_{2.059}$.

Occurrence: On the wall of cavities in a vein of nifontovite or in fractures in a crystalline limestone near gehlenite-spurrite skarns. Likely formed by Cu- and Mg-bearing late hydrothermal solutions.

Association: Borcarite, nifontovite, bultfonteinite, calcite.

Distribution: In Japan, at the Fuka Mine, Okayama Prefecture.

Name: Honors Tadayuki Numano (1931-2001), Emeritus Professor, Okayama University, Japan.

Type Material: Department of Geology, National Science Museum, Tokyo, Japan, (NSM-M28813).

References: (1) Ohnishi, M., I. Kusachi, J. Yamakawa, M. Tanabe, S. Kishi, and T. Yasuda (2007) Numanoite, $Ca_4CuB_4O_6(OH)_6(CO_3)_2$, a new mineral species, the Cu analogue of borcarite from the Fuka mine, Okayama Prefecture, Japan. Can. Mineral., 45, 307-315. (2) (2007) Amer. Mineral., 92, 1778 (abs. ref. 1).

Nyböite $NaNa_2[Mg_3Al_2](Si_7Al)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* [2/*m*.] As reaction rims on other minerals.

Physical Properties: *Cleavage:* [Perfect on {110}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = n.d. D(calc.) = [3.04]

Optical Properties: Semitransparent. *Color:* [Bluish.] *Luster:* [Vitreous.] *Optical Class:* [Biaxial.] *Pleochroism:* X' = pale violet; Z' = colorless. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* [$C2/m$.] $a = 9.665(1)$ $b = 17.752(2)$ $c = 5.303(1)$ $\beta = 104.11(1)^\circ$ Z = [2]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SiO_2	53.84	50.89
TiO_2	0.16	0.08
Al_2O_3	12.92	12.09
FeO	5.03	9.76
MnO	0.02	0.07
NiO	0.11	
MgO	14.21	12.42
CaO	2.33	2.93
Na_2O	9.26	8.42
K_2O	0.14	0.27
Cl	0.01	
Total	98.03	96.93

(1) Nordfjord, Norway; by electron microprobe, Fe^{2+}:Fe^{3+} calculated; corresponding to $(Na_{0.72}K_{0.24})_{\Sigma=0.96}(Na_{1.67}Ca_{0.33})_{\Sigma=2.00}(Mg_{2.82}Fe^{2+}_{0.18})_{\Sigma=3.00}(Al_{1.43}Mg_{0.32}Fe^{3+}_{0.24}Ti_{0.02})_{\Sigma=2.01}(Si_{7.24}Al_{0.76})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Jianchang, China; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponding to $(Na_{0.75}K_{0.05})_{\Sigma=0.80}(Na_{1.56}Ca_{0.44})_{\Sigma=2.00}(Mg_{2.17}Fe^{2+}_{0.82}Mn_{0.01})_{\Sigma=3.00}(Al_{1.22}Mg_{0.45}Fe^{3+}_{0.33}Ti_{0.01})_{\Sigma=2.01}(Si_{7.20}Al_{0.80})_{\Sigma=8.00}O_{22}(OH)_2$.

Mineral Group: Amphibole (alkali) group: $Fe^{3+}/(Fe^{3+} + Al^{vi})$ 0.5; $Mg/(Mg + Fe^{2+}) \geq 0.5$; $(Na + K)_A \geq 0.5$; $Na_B \geq 1.34$; $(Ca + Na)_B \geq 1.34$; $6.5 < Si < 7.5$.

Occurrence: In a compositionally-layered eclogite that has undergone high-pressure amphibolite facies metamorphism (Nordfjord, Norway).

Association: Taramite, omphacite, jadeitic clinopyroxene, aegirine-augite, paragonite, apatite, albite, garnet, epidote, kyanite, quartz, coesite (Lanshantou, China).

Distribution: In the Nybö eclogite pod, Nordfjord, Norway. From the Dora-Maira massif, Parigi, near Martiniana Po, Piedmont, Italy. In China, near Lanshantou, Jianchang, Jiangsu Province. At Tawmaw, Myitkyina-Mogaung district, Kachin State, northern Myanmar (Burma).

Name: Apparently for the type locality, the Nybö eclogite, Nordfjord, Norway.

Type Material: n.d.

References: (1) Ungaretti, L., D.C. Smith, and G. Rossi (1981) Crystal-chemistry by X-ray structure refinement and electron microprobe analysis of a series of sodic-calcic to alkali amphiboles from the Nybö eclogite pod, Norway. Bull. Minéral., 104, 400–412. (2) (1982) Amer. Mineral., 67, 858 (abs. ref. 1). (3) Hirajima, T., R. Zhang, J. Li, and B. Cong (1992) Petrology of the nyböite-bearing eclogite in the Donghai area, Jiangsu Province, eastern China. Mineral. Mag., 56, 37–46. (4) Rock, N.M.S. and B.E. Leake (1984) The International Mineralogical Association amphibole nomenclature scheme: computerization and its consequences. Mineral. Mag., 48, 211–227.

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Nyerereite $Na_2Ca(CO_3)_2$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $mm2$. Crystals are flat tabular {001}, stubby rectangular, microcrystals may show "swallow-tail" terminations, to 1 mm. *Twinning:* Always polysynthetically twinned ‖ to [001].

Physical Properties: Hardness = n.d. D(meas.) = 2.541(2) D(calc.) = [2.42]

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.511$ $\beta = 1.533$ $\gamma = 1.534$ 2V(meas.) = 29°

Cell Data: *Space Group:* $Cmc2_1$. $a = 5.044(3)$ $b = 8.809(7)$ $c = 12.743(3)$ Z = 4

X-ray Powder Pattern: Oldoinyo Lengai volcano, Tanzania.
3.046 (vvs), 6.377 (vs), 4.385 (vs), 2.536 (vs), 2.071 (vs), 3.181 (ms), 2.161 (ms)

Chemistry:

	(1)	(2)	(3)
SO_3	2.1	1.07	
CO_2	39.0	[39.18]	42.71
P_2O_5		0.47	
CaO	22.2	26.11	27.21
SrO	2.0	2.27	
BaO	0.6	0.28	
Na_2O	26.2	23.56	30.08
K_2O	7.9	6.96	
F	0.23		
Cl	0.42	0.13	
H_2O	0.8		
$-O = (F, Cl)_2$	0.2	0.03	
Total	101.2	[100.00]	100.00

(1) Oldoinyo Lengai volcano, Tanzania. (2) Do.; by electron microprobe, CO_2 by difference. (3) $Na_2Ca(CO_3)_2$.

Polymorphism & Series: Trimorphous with natrofairchildite and zemkorite.

Occurrence: As phenocrysts in carbonate lavas, persistent due to rapid cooling.

Association: Halite, sylvite, fluorite, gregoryite, calcite.

Distribution: In Tanzania, from the Oldoinyo Lengai and Kerimasi volcanos.

Name: To honor Julius Kambarage Nyerere (1922–1999), President of Tanzania when the mineral was found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 113544, 162608.

References: (1) (1975) Amer. Mineral., 60, 487–488 (abs. of unpublished data submitted to IMA in 1963). (2) McKie, D. and E.J. Frankis (1977) Nyerereite: a new volcanic carbonate mineral from Oldoinyo Lengai, Tanzania. Zeits. Krist., 145, 73–95. (3) (1978) Amer. Mineral., 63, 600 (abs. ref. 2). (4) Church, A. and A.P. Jones (1995) Silicate-carbonate immiscibility at Oldoinyo Lengai. J. Petrol., 36(4), 869–889.

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Nyholmite $Cd_3Zn_2(AsO_3OH)_2(AsO_4)_2 \cdot 4H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals, fibrous to bladed, to 0.2 mm; as globules and tufted aggregates, to 1 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Uneven.
Tenacity: Brittle. Hardness = 3-3.5 D(meas.) = n.d. D(calc.) = 4.42 (ideal formula)

Optical Properties: Transparent to translucent. *Color*: Colorless crystals, white in aggregates.
Streak: White. *Luster*: Vitreous.
Optical Class: n.d. $\beta \sim 1.70$

Cell Data: *Space Group*: *C2/c*. $a = 18.062(4)$ $b = 9.341(2)$ $c = 9.844(2)$ $\beta = 96.17(3)°$
Z = 4

X-ray Powder Pattern: Broken Hill, New South Wales, Australia.
3.234 (100), 8.283 (85), 3.079 (65), 2.976 (45), 8.985 (30), 6.169 (25), 4.878 (25)

Chemistry:

	(1)	(2)
P_2O_5	6.29	
As_2O_5	34.55	41.88
Al_2O_3	0.20	
MnO	3.59	
CaO	0.16	
ZnO	9.72	14.83
CuO	3.39	
CdO	34.58	35.09
PbO	0.37	
H_2O_{calc}	8.21	8.21
Total	101.06	100.00

(1) Broken Hill, New South Wales, Australia, average of 14 electron microprobe analyses; corresponding to $Cd_{2.80}Zn_{1.24}Mn_{0.53}Cu_{0.44}Al_{0.04}Ca_{0.03}Pb_{0.02}[(AsO_4)_{3.13}(PO_4)_{0.92}]_{\Sigma=4.05}\ H_{1.91} \cdot 3.79H_2O$.
(2) $Cd_3Zn_2(AsO_3OH)_2(AsO_4)_2 \cdot 4H_2O$.

Occurrence: A late-stage secondary mineral in the weathering zone of a Cd-Zn arsenate deposit.

Association: Goldquarryite, lavendulan-sampleite, scorodite-strengite, gypsum.

Distribution: Block 14 Opencut, Broken Hill, New South Wales, Australia.

Name: Honors Sir Ronald Sydney Nyholm (1917–1971), born at Broken Hill, New South Wales, and Chair and Professor of Chemistry, University College, London, from 1955–1971.

Type Material: South Australian Museum, Adelaide, South Australia (catalog no. G32511).

References: (1) Elliott, P., P. Turner, P. Jensen, U. Kolitsch, and A. Pring (2009) Description and crystal structure of nyholmite, a new mineral related to hureaulite, from Broken Hill, New South Wales, Australia. Mineral. Mag., 73, 723–735. (2) (2010) Amer. Mineral., 95, 1360 (abs. ref. 1).

Oboyerite $H_6(Pb,Ca)_6(Te^{4+}O_3)_3(Te^{6+}O_6)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. In tiny spherules, composed of fibers to 60 μm.

Physical Properties: *Cleavage:* One perfect. Hardness = 1.5 D(meas.) = 6.4(6) D(calc.) = 6.66

Optical Properties: Semitransparent. *Color:* Milk-white.
Optical Class: Biaxial. *Orientation:* Maximum extinction at 37° to elongation. $\alpha = 2.24$ β = n.d. $\gamma = 2.26$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 12.249(8)$ $b = 15.113(6)$ $c = 6.868(3)$ $\alpha = 116.45(4)°$ $\beta = 98.58(4)°$ $\gamma = 85.82(4)°$ Z = 2

X-ray Powder Pattern: Grand Central mine, Arizona, USA.
3.040 (10), 3.180 (7), 2.976 (5), 2.927 (5), 2.862 (5), 1.804 (4b), 9.038 (3)

Chemistry:

	(1)	(2)
TeO_3	16.2	15.54
TeO_2	22.1	21.19
PbO	58.0	59.28
CaO	0.3	
H_2O	4.2	3.99
Total	100.8	100.00

(1) Grand Central mine, Arizona, USA; by microanalysis, H_2O by the Penfield method, after deduction of insoluble as quartz and chlorargyrite. (2) $H_6Pb_6(Te^{4+}O_3)_3(Te^{6+}O_6)_2 \cdot 2H_2O$.

Occurrence: A rare mineral found in specimens on a mine dump, an alteration product of rich gold-bearing telluride ore.

Association: Jarosite, fairbankite, rodalquilarite, mroseite, cerussite, orthoclase, "opal".

Distribution: In the Grand Central mine and the Tombstone Exploration open pit mine, Tombstone, Cochise Co., Arizona, USA.

Name: For Oliver Boyer, an original staker of the Grand Central claim.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,540; National Museum of Natural History, Washington, D.C., USA, 162210.

References: (1) Williams, S.A. (1979) Girdite, oboyerite, fairbankite, and winstanleyite, four new tellurium minerals from Tombstone, Arizona. Mineral. Mag., 43, 453–457. (2) (1980) Amer. Mineral., 65, 809 (abs. ref. 1). (3) Roberts, A.C. (1980) A triclinic cell for oboyerite. Geol. Surv. Canada Paper 80-113, 295.

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Obradovicite $\mathbf{H_4(K,Na)CuFe_2^{3+}(AsO_4)(MoO_4)_5 \cdot 12H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are tabular, showing {100}, {110}, {011}, to 0.1 mm, {100} striated ‖ [001]; generally in dense aggregates.

Physical Properties: Hardness = 2.5 D(meas.) = 3.55(5) D(calc.) = 3.68

Optical Properties: Translucent. *Color:* Pea-green. *Streak:* Pale pea-green. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; in yellows. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* Extreme. *Absorption:* $Z > X = Y$. $\alpha = 1.790$ $\beta = 1.798$ $\gamma = 1.811$ 2V(meas.) = 81°

Cell Data: *Space Group: Pcnm.* $a = 15.046$ $b = 14.848$ $c = 11.056$ Z = 4

X-ray Powder Pattern: Chuquicamata, Chile.
8.906 (10), 10.565 (8), 7.424 (8), 2.969 (6), 5.733 (5), 2.898 (5b), 2.761 (5)

Chemistry:

	(1)
MoO_3	55.29
As_2O_5	8.46
Fe_2O_3	10.12
CuO	5.85
Na_2O	0.56
K_2O	2.48
H_2O	18.33
Total	101.09

(1) Chuquicamata, Chile; corresponding to $H_4(K_{0.71}Na_{0.24})_{\Sigma=0.95}Cu_{0.99}Fe_{1.77}(As_{0.99}O_4)(Mo_{1.03}O_4)_5 \cdot 11.6H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a Cu–Mo ore deposit.

Association: Jarosite, wulfenite, quartz.

Distribution: From Chuquicamata, Antofagasta, Chile.

Name: Honoring Martin T. Obradovic, who provided the type material.

Type Material: Colorado School of Mines, Golden, Colorado; National Museum of Natural History, Washington, D.C., USA, 164185.

References: (1) Finney, J.J., S.A. Williams, and R.D. Hamilton (1986) Obradovicite, a new complex arsenate-molybdate from Chuquicamata, Chile. Mineral. Mag., 50, 283–284. (2) (1987) Amer. Mineral., 72, 1026 (abs. ref. 1).

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O'danielite $H_2Na(Zn,Mg)_3(AsO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral crystalline grains, flattened on {100}, elongated along [001], as intergrown blades, to 3 mm.

Physical Properties: *Cleavage:* {010}, {100}, perfect; {001}, observable. Hardness = ∼3 D(meas.) = > 4.24 D(calc.) = 4.49

Optical Properties: Transparent. *Color:* Pale violet. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$; $Y \wedge c = 18°$. $\alpha = 1.745(4)$ $\beta = 1.753(4)$ $\gamma = 1.778(4)$ 2V(meas.) = ∼60(5)°

Cell Data: *Space Group:* $C2/c$. $a = 12.113(3)$ $b = 12.445(4)$ $c = 6.793(1)$ $\beta = 112.87(1)°$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
6.22 (10), 3.26 (10), 2.78 (8b), 2.72 (8), 3.56 (7), 1.687 (7), 1.664 (6)

Chemistry:

	(1)
As_2O_5	54.4
FeO	0.2
MnO	0.6
ZnO	33.8
MgO	2.9
CaO	0.3
Na_2O	4.7
H_2O	2.8
Total	99.7

(1) Tsumeb, Namibia; by electron microprobe, H_2O by TGA; corresponding to $H_{1.96}(Na_{0.95}Ca_{0.03})_{\Sigma=0.98}(Zn_{2.60}Mg_{0.45}Mn_{0.05}Fe_{0.02})_{\Sigma=3.12}(As_{0.99}O_4)_3$.

Occurrence: A rare secondary mineral in the oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tennantite, chalcocite, cuprian adamite, stranskiite, lavendulan, köttigite, tsumcorite, koritnigite, prosperite.

Distribution: From Tsumeb, Namibia.

Name: To honor Dr. Herbert O'Daniel (1903–1977), Professor of Mineralogy, University of Munich, Munich, Germany, and Editor of Neues Jahrbuch für Mineralogie.

Type Material: University of Stuttgart, Stuttgart, Germany, NM09; National Museum of Natural History, Washington, D.C., USA, 145966.

References: (1) Keller, P., H. Hess, P.J. Dunn, and D. Newbury (1981) O'Danielite, $NaZn_3H_2(AsO_4)_3$, a new mineral from Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 155–160. (2) (1981) Amer. Mineral., 66, 1276 (abs. ref. 1). (3) Keller, P. and H. Hess (1988) Die Kristallstrukturen von O'Danielit, $Na(Zn,Mg)_3H_2(AsO_4)_3$, und Johillerit, $Na(Mg,Zn)_3Cu(AsO_4)_3$. Neues Jahrb. Mineral., Monatsh., 395–404 (in German with English abs.).

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Odinite $(Fe^{3+}, Mg, Al, Fe^{2+})_{2.5}(Si, Al)_2O_5(OH)_4$

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Crystal Data: Monoclinic or hexagonal. *Point Group:* n.d. As clay-sized crystallites within aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.78]

Optical Properties: Semitransparent (?). *Color:* Green to dark green. *Streak:* Gray-green. *Luster:* Silky to earthy.
Optical Class: n.d.

Cell Data: *Space Group:* Cm (1M). $a = 5.373(3)$ $b = 9.326(7)$ $c = 7.363(6)$ $\beta = 104.0(1)°$ Z = [2], or *Space Group:* $P31m$ (1A, probable). $a = 5.366(6)$ $c = 7.161(8)$ Z = [2]

X-ray Powder Pattern: Los Islands, Guinea; mixed monoclinic and hexagonal polytypes. 7.15 (100), 3.58 (85), 1.552 (65), 4.65 (40), 2.67 (40), 2.41 (30), 4.53 (20)

Chemistry:

	(1)		(1)
SiO_2	36.0	CaO	0.13
TiO_2	0.4	Na_2O	trace
Al_2O_3	12.2	K_2O	0.35
Fe_2O_3	19.5	H_2O^+	0.91
FeO	6.21	H_2O^-	4.10
MnO	0.33	CO_2	10.05
MgO	9.7	P_2O_5	0.17
		Total	100.05

(1) Los Islands, Guinea; by a combination of wet chemical analysis and electron microprobe; after exclusion of CaO as $CaCO_3$, K_2O, and P_2O_5 as impurities, corresponds to $(Fe^{3+}_{0.78}Mg_{0.77}Al_{0.56}Fe^{2+}_{0.28}Ti_{0.02}Mn_{0.02})_{\Sigma=2.43}(Si_{1.79}Al_{0.21})_{\Sigma=2.00}O_5(OH)_{4.00}$.

Polymorphism & Series: 1M and 1A polytypes.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Formed in marine waters, a minor component of green clay infillings or replacements of microtests, bioclasts, fecal pellets, or mineral debris on shallow marine shelfs and reef lagoonal areas in tropical latitudes. Probably only present in rocks less than Quaternary in age, as susceptible to alteration to chlorite through weathering.

Association: Quartz, calcite, kaolinite, smectite, illite, chlorite.

Distribution: A minor component of sediments estimated to cover more than 100,000 km^2 of present-day sea bottom. At least eleven independent localities are noted: among these are the reef lagoon southwest of New Caledonia; in the Ogooue River prodelta, Congo Republic; the continental shelf between the Amazon and Orinoco Rivers, Brazil; the Niger River prodelta, Nigeria; off Martinique Island; Los Islands, in the mouth of the Koukoure River, Guinea.

Name: For Dr. Gilles Serge Odin, clay mineralogist of the University P. and M. Curie, Paris, France, who did the initial work on this mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA, 165498; The Natural History Museum, London, England, 1987,532; Museum of Natural History, Paris, 187.7; National School of Mines, Paris, France.

References: (1) Bailey, S.W. (1988) Odinite, a new dioctahedral-trioctahedral Fe^{3+}−rich 1:1 clay mineral. Clay Minerals, 23, 237–247. (2) (1990) Amer. Mineral., 75, 432–433 (abs. ref. 1). (3) Odin, G.S. (1985) La "verdine," facies granulaire vert marine et cotier, distinct de la glauconite: distribution actuelle et composition. Compt. Rendus Acad. Sci. Paris, 301, 105–108 (in French).

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Oenite CoSbAs

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Crystal Data: Orthorhombic. *Point Group:* n.d. As anhedral polycrystalline aggregates, to 300 μm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. VHN = 599 (100 g load). D(meas.) = n.d. D(calc.) = 7.91

Optical Properties: Opaque. *Color:* Silver-white; silver-wite in reflected light. *Streak:* Gray. *Luster:* Metallic.
Optical Class: Biaxial. *Anisotropism:* Weak to distinct; reddish brown to darker pale violet and purplish blue.
R_1–R_2: 55.5–58.2 (470), 55.6–56.8 (546), 55.5–55.8 (589), 55.5–55.0 (650)

Cell Data: *Space Group:* n.d. $a = 3.304(6)$ $b = 6.092(8)$ $c = 10.258(13)$ Z = 4

X-ray Powder Pattern: Tunaberg, Sweden.
2.63 (10), 1.942 (10), 2.53 (8), 1.1182 (8), 1.730 (4), 1.640 (4), 1.3963 (4)

Chemistry:

	(1)	(2)
Co	15.4	23.06
Ni	2.7	
Cu	0.1	
Fe	5.6	
As	26.9	29.31
Sb	47.4	47.63
S	2.0	
Total	100.1	100.00

(1) Tunaberg, Sweden; by electron microprobe, average of 21 analyses; corresponding to $(Co_{0.65}Fe_{0.24}Ni_{0.11})_{\Sigma=1.00}(Sb_{0.96}As_{0.04})_{\Sigma=1.00}(As_{0.85}S_{0.15})_{\Sigma=1.00}$. (2) CoSbAs.

Occurrence: In Cu–Co-bearing skarns.

Association: Chalcopyrite, bismuth, dyscrasite, allargentum, breithauptite, nisbite, tetrahedrite, cobaltite, gudmundite, löllingite, magnetite, galena, sphalerite, other sulfides.

Distribution: From Tunaberg, Bergslagen metallic province, Sweden [TL].

Name: In honor of Dr. Ing Soen Oen (1928–1996), Professor of Mineralogy, University of Amsterdam and Free University of Amsterdam, Amsterdam, The Netherlands, for his contributions to the geology and mineralogy of ore deposits.

Type Material: Geological Institute, University of Amsterdam, Amsterdam; Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands.

References: (1) Dobbe, R.T.M. and M.A. Zakrzewski (1998) Oenite, CoSbAs, a new mineral species from the Tunaberg Cu–Co-sulfide skarns, Bergslagen, Sweden. Can. Mineral., 36, 855–860. (2) (1999) Amer. Mineral., 84, 999 (abs. ref. 1).

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Offretite $(K_2, Ca)_{2.5}Al_5Si_{13}O_{36}\cdot 15H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Crystals form hexagonal prisms, which may be hollow, vertically striated, to 3 mm; in hemispherical forms with radiating structure. Typically in complex overgrowths on erionite and levyne.

Physical Properties: *Cleavage:* {0001}, distinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 2.13 D(calc.) = 2.06

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.489–1.495$ $\epsilon = 1.486–1.492$

Cell Data: *Space Group:* $P\bar{6}m2$. $a = 13.291(2)$ $c = 7.582(6)$ $Z = 1$

X-ray Powder Pattern: Mont Sémiol, France; close to erionite.
11.50 (100), 2.880 (64), 4.352 (59), 3.837 (43), 5.76 (35), 3.322 (22), 6.64 (20)

Chemistry:

	(1)
SiO_2	53.0
Al_2O_3	18.1
MgO	2.0
CaO	4.1
K_2O	3.6
H_2O^+	17.7
H_2O^-	1.1
Total	99.6

(1) Mont Sémiol, France; Na_2O 0.01% by microspectrochemical analysis; corresponds to $(K_{1.1}Ca_{1.1}Mg_{0.7})_{\Sigma=2.9}Al_{5.2}Si_{12.8}O_{36}\cdot 15.2H_2O$.

Mineral Group: Zeolite group.

Occurrence: Lining cavities in basalt.

Association: Zeolites, especially erionite, levyne, celadonite, montmorillonite.

Distribution: From Mont Sémiol (Mont Simiouse), Montbrison, Loire, France. At a number of localities on the Vogelsberg, Hesse, Germany. In the USA, in Oregon, from Milwaukie, Clackamas Co., at Gordon Gulch, Owyhee Dam, Malheur Co., and Ritter Hot Springs, Grant Co.; in Washington, at Rock Island Dam, Douglas Co.; in Arizona, from Queen Creek, 10 km west of Superior, Pinal Co., and from three km south of Horseshoe Dam, Maricopa Co. From southwest of Westwold, British Columbia, Canada. There are many other occurrences, most overgrowing erionite or levyne.

Name: For Professor Albert Jules Joseph Offret (1857–?), of Lyons, France.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1043.
(2) Sheppard, R.A. and A.J. Gude, 3d (1969) Chemical composition and physical properties of the related zeolites offretite and erionite. Amer. Mineral., 54, 875–886. (3) Gard, J.A. and J.M. Tait (1972) The crystal structure of the zeolite offretite, $K_{1.1}Ca_{1.1}Mg_{0.7}[Si_{12.8}Al_{5.2}O_{36}]\cdot 15H_2O$. Acta Cryst., 28, 825–834. (4) Wise, W.S. and R.W. Tschernich (1976) The chemical compositions and origin of the zeolites offretite, erionite, and levyne. Amer. Mineral., 61, 853–863.

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Ogdensburgite $Ca_2(Zn,Mn^{2+})Fe_4^{3+}(AsO_4)_4(OH)_6 \cdot 6H_2O$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. As bladed crystals and platelets, to 2 mm; in thin crusts.

Physical Properties: *Cleavage:* On {001}, perfect; on {010}, {100}, poor. Hardness = ∼2 D(meas.) = 3.11 D(calc.) = 3.39

Optical Properties: Semitransparent. *Color:* Bright reddish orange; dark brownish red on oxidized surfaces. *Streak:* Pale orange. *Luster:* Resinous on cleavages.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = yellow; $Y = Z$ = red-brown. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Absorption:* $X \ll Y < Z$. $\alpha = 1.715(5)$ $\beta = 1.783(5)$ $\gamma = 1.785(5)$ 2V(meas.) = 5°–10°

Cell Data: *Space Group:* $Bmmm$, $Bmm2$, $B2mm$, $Bm2m$, or $B222$. $a = 11.351$–11.381 $b = 14.829$–14.837 $c = 6.555$–6.569 Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
14.8 (100), 4.52 (30), 2.656 (30), 2.793 (25), 2.734 (25), 7.47 (20), 5.70 (20)

Chemistry:

	(1)	(2)
As_2O_5	38.2	40.3
SiO_2	0.5	0.0
Al_2O_3	1.0	0.0
Fe_2O_3	31.3	29.4
MnO	2.2	2.4
ZnO	3.1	3.0
MgO	0.5	0.0
CaO	10.8	10.1
H_2O	[12.4]	14.8
Total	[100.0]	100.0

(1) Sterling Hill, New Jersey, USA; by electron microprobe, average of two analyses; total Fe as Fe_2O_3, confirmed by microchemical test, total Mn as MnO, H_2O by difference. (2) Ojuela mine, Mexico; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, H_2O by moisture evolution analysis; corresponds to $Ca_{1.86}(Zn_{0.38}Mn_{0.35})_{\Sigma=0.73}Fe_{3.80}(AsO_4)_{3.62}(OH)_{5.72} \cdot 5.64H_2O$.

Occurrence: On oxidized ore from a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA); in oxidized ore from an arsenic-rich polymetallic hydrothermal ore deposit (Ojuela mine, Mexico).

Association: Parasymplesite, köttigite, yukonite, legrandite, pharmacosiderite, willemite, franklinite, sphalerite (Sterling Hill, New Jersey, USA); villyaellenite, arseniosiderite, chalcophanite, adamite, Fe–Mn oxides (Ojuela mine, Mexico).

Distribution: From Sterling Hill, Ogdensburg, New Jersey, USA. In the Ojuela mine, Mapimí, Durango, Mexico. At the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: For its occurrence at Ogdensburg, New Jersey, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 146880.

References: (1) Dunn, P.J. (1981) Ogdensburgite, a new calcium-zinc-ferric iron arsenate mineral from Sterling Hill, New Jersey. Mineral. Record, 12, 369–370. (2) (1982) Amer. Mineral., 67, 858 (abs. ref. 1). (3) Kampf, A.R. and P.J. Dunn (1987) Ogdensburgite from Mapimi and new data for the species. Amer. Mineral., 72, 409–412.

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Ohmilite $Sr_3(Ti,Fe^{3+})(Si_2O_6)_2(O,OH)\cdot 2-3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous crystals, to 10 μm, elongated along [010]; as aggregates, to 0.2 mm, rarely spherulitic.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 3.5 D(meas.) = 3.38 D(calc.) = [3.47]

Optical Properties: Semitransparent. *Color:* Light pink to pinkish brown. *Streak:* White. *Optical Class:* Biaxial. *Pleochroism:* Weak; nearly colorless to light pink. *Orientation:* $Y = a$; $Z = b$. $\alpha = 1.649(3)$ $\beta =$ n.d. $\gamma = 1.715(3)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$. a = 10.979(6) $b = 7.799(5)$ $c = 7.818(4)$ $\beta = 100.90(3)^\circ$ Z = 2

X-ray Powder Pattern: Ohmi, Japan.
4.62 (100), 3.83 (90), 2.600 (90), 3.264 (85), 3.037 (80), 5.39 (77), 10.83 (70)

Chemistry:

	(1)
SiO_2	34.79
TiO_2	10.27
Al_2O_3	0.00
Fe_2O_3	0.20
MgO	0.00
CaO	0.00
SrO	47.37
Na_2O	0.00
K_2O	0.00
H_2O	6.68
Total	99.31

(1) Ohmi, Japan; corresponds to $Sr_{3.16}(Ti_{0.98}Fe^{3+}_{0.02})_{\Sigma=1.00}Si_{4.00}O_{12}[O,(OH)]\cdot 2.21H_2O$.

Occurrence: In an amphibolite-quartz-albitite dike cutting serpentinite.

Association: Magnesio-riebeckite, quartz, albite, phlogopite, benitoite, bario-orthojoaquinite, leucosphenite.

Distribution: From Ohmi, Niigata Prefecture, Japan.

Name: For the locality at Ohmi, Japan.

Type Material: n.d.

References: (1) Komatsu, M., K. Chihara, and T. Mizota (1973) A new strontium-titanium hydrous silicate mineral from Ohmi, Niigata Prefecture, central Japan. Mineral. J. (Japan), 7, 298–301. (2) Mizota, T., M. Komatsu, and K. Chihara (1983) A refinement of the crystal structure of ohmilite, $Sr_3(Ti,Fe^{3+})(O,OH)(Si_2O_6)_2\cdot 2–3H_2O$. Amer. Mineral., 68, 811–817.

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Ojuelaite $\mathbf{ZnFe_2^{3+}(AsO_4)_2(OH)_2 \cdot 4H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Acicular crystals or fibers, elongated ‖ [001], to 4 mm, commonly in divergent sprays.

Physical Properties: *Cleavage:* On {010}, observable. Hardness = 3 D(meas.) = 3.39 D(calc.) = 3.39

Optical Properties: Semitransparent. *Color:* Chartreuse to pale yellow-green. *Streak:* Pale yellow. *Luster:* Silky to vitreous.
Optical Class: Biaxial (+). *Pleochroism:* In yellows. *Orientation:* X = b; Z = c.
Absorption: $Z = X > Y$. $\alpha = 1.696$ $\beta = 1.730$ $\gamma = 1.798$ 2V(meas.) = n.d. 2V(calc.) = 73°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.237(1)$ $b = 9.662(3)$ $c = 5.562(1)$ $\beta = 94.36(1)°$ Z = 2

X-ray Powder Pattern: Ojuela mine, Mexico.
4.251 (100), 2.871 (90), 7.03 (82), 4.83 (78), 10.23 (65), 2.630 (63), 2.901 (62)

Chemistry:

	(1)	(3)
As_2O_5	40.5	40.97
Fe_2O_3	27.5	28.47
ZnO	14.6	14.51
H_2O	16.8	16.05
Total	99.4	100.00

(1) Ojuela mine, Mexico; Zn and Fe by AA, As by UV spectrophotometry, H_2O by the Penfield method; corresponds to $Zn_{1.02}Fe^{3+}_{1.96}(AsO_4)_{2.00}(OH)_{1.92} \cdot 3.37H_2O$. (2) Do.; by electron microprobe, analysis not given, stated to correspond to $(Zn_{0.77}Fe^{2+}_{0.23})_{\Sigma=1.00}$ $Fe^{3+}_{2.00}(AsO_4)_{1.94}(OH)_2 \cdot 3.75H_2O$. (3) $ZnFe_2(AsO_4)_2(OH)_2 \cdot 4H_2O$.

Mineral Group: Arthurite group.

Occurrence: A rare mineral in the oxidized zone of arsenic-rich polymetallic hydrothermal ore deposits.

Association: Paradamite, scorodite, smithsonite, "limonite" (Ojuela mine, Mexico); smithsonite, tennantite, goethite (Tsumeb, Namibia).

Distribution: In the Ojuela mine, Mapimí, Durango, and at Pitiquito, Sonora, Mexico. From Sterling Hill, Ogdensburg, New Jersey, USA. At Tsumeb, Namibia.

Name: For the Ojuela mine, Mexico, in which the first specimens were found.

Type Material: University of Pierre and Marie Curie, Paris, France; National Museum of Natural History, Washington, D.C., USA, 145679.

References: (1) Cesbron, F., M. Romero, and S.A. Williams (1981) La mapimite et l'ojuelaïte, deux nouveaux arséniates hydratés de zinc et de fer de la mine Ojuela, Mapimi, Mexique. Bull. Minéral., 104, 582–586 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 623–624 (abs. ref. 1). (3) Keller, P. and W. Bartelke (1982) Tsumeb! – new minerals and their associations. Mineral. Record, 13, 137–147, esp. 144. (4) Hughes, J.M., E.S. Bloodaxe, K.D. Kobel, and J.W. Drexler (1996) The atomic arrangement of ojuelaite, $ZnFe^{3+}_2(AsO_4)_2(OH)_2 \cdot 4H_2O$. Mineral. Mag., 60, 519–521.

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Okanoganite-(Y) $(Na,Ca)_3(Y,Ce)_{12}B_2Si_6O_{27}F_{14}$

Crystal Data: Hexagonal. *Point Group:* 3m. As twinned pseudotetrahedral crystals, to 4 mm, and groups of such crystals. Twinning: With twin plane (0114), producing fourlings, the (0001) face of each individual crystal forming the faces of a pseudotetrahedron.

Physical Properties: Hardness = 4 D(meas.) = 4.35(4) D(calc.) = 4.96

Optical Properties: Transparent to translucent. *Color:* Tan to pale pink; colorless in thin fragments. *Streak:* White.
Optical Class: Uniaxial (-). ω = 1.753(2) ε = 1.740(2)

Cell Data: Space Group: *R3m.* *a* = 10.7108(5) *c* = 27.0398(11) Z = 3

X-ray Powder Pattern: Golden Horn batholith, Washington, USA.
2.970 (100), 2.939 (95), 2.926 (50), 3.11 (48), 1.784 (43), 4.35 (41), 1.978 (35)

Chemistry:

	(1)
SiO_2	14.35
TiO_2	0.50
B_2O_3	3.1
Y_2O_3	20.46
RE_2O_3	44.29
FeO	1.60
PbO	0.63
CaO	3.24
Na_2O	2.74
F	11.15
$-O = F_2$	4.69
Total	97.37

(1) Golden Horn batholith, Washington, USA; by electron microprobe, B by spectrophotometer, RE_2O_3 = La_2O_3 5.88%, Ce_2O_3 15.42%, Pr_2O_3 1.83%, Nd_2O_3 7.70%, Sm_2O_3 1.64%, Gd_2O_3 5.28%, Tb_2O_3 0.44%, Dy_2O_3 2.08%, Ho_2O_3 0.96%, Er_2O_3 1.26%, Tm_2O_3 0.20%, Yb_2O_3 0.79%, Lu_2O_3 0.81%; corresponds to $(Na_{2.13}Ca_{0.80}Pb_{0.07})_{\Sigma=3.00}[(Y,RE)_{10.64}Ca_{0.59}Fe_{0.54}]_{\Sigma=11.77}B_{2.15}(Si_{5.76}Ti_{0.15})_{\Sigma=5.91}O_{27}F_{14.15}$.

Occurrence: In miarolitic cavities in a peralkalic arfvedsonite-bearing granite.

Association: Quartz, microcline, zircon, arfvedsonite, bastnäsite, zektzerite, astrophyllite.

Distribution: From the Golden Horn batholith, near Washington Pass, Okanogan Co., Washington, USA.

Name: For Okanogan Co., Washington, USA, and the yttrium content.

Type Material: National Museum of Natural History, Washington, D.C., USA; 142512-142514.

References: (1) Boggs, R. (1980) Okanoganite, a new rare-earth borofluorosilicate from the Golden Horn batholith, Okanogan County, Washington. Amer. Mineral., 65, 1138-1142.
(2) Boiocchi, M., A. Callegari, L. Ottolini, and A. Maras (2004) The chemistry and crystal structure of okanoganite-(Y) and comparison with vicanite-(Ce). Amer. Mineral., 89, 1540-1545.
(3) (2005) Amer. Mineral., 90, 772-773 (abs. ref. 2).

Okenite $Ca_5Si_9O_{23}\cdot 9H_2O$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As bladed crystals or laths, typically fibrous with [010] as fiber axis. In aggregates of curved crystals, and compact radial fibrous balls, to 4 cm. *Twinning:* About [010], composition plane {102}, lamellar.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Elastic. Hardness = .5–5 D(meas.) = 2.28–2.33 D(calc.) = 2.33

Optical Properties: Transparent to translucent. *Color:* White, slightly yellow; in thin section, colorless. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). $\alpha = 1.530$ $\beta = 1.536$ $\gamma = 1.541$–1.553 2V(meas.) = Large.

Cell Data: *Space Group:* $P\bar{1}$. $a = 9.69(1)$ $b = 7.28(1)$ $c = 22.02(4)$ $\alpha = 92.7(2)^\circ$ $\beta = 100.1(3)^\circ$ $\gamma = 110.9(1)^\circ$ Z = [2]

X-ray Powder Pattern: Bombay, India.
21 (vvs), 8.8 (vs), 3.56 (vs), 2.93 (vs), 3.07 (s), 3.05 (s), 2.98 (ms)

Chemistry:

	(1)	(2)
SiO_2	53.88	55.00
Al_2O_3	0.08	
Fe_2O_3	0.01	
CaO	27.61	28.51
SrO	0.27	
Na_2O	0.12	
K_2O	0.06	
H_2O	18.02	16.49
Total	100.05	100.00

(1) Bombay, India. (2) $Ca_5Si_9O_{23}\cdot 9H_2O$.

Occurrence: Commonly in amygdules in basalts.

Association: Zeolites, apophyllite, prehnite, calcite, quartz, "chalcedony."

Distribution: From Greenland, at Qutdligssat (Kudlisat), Ritenbenk district; on Quqertarsuaq [Disko] Island, at Skarvefjeld and Blæsedal, Godhavn district; and elsewhere. On Bordoy and Streymoy, Faeroe Islands. At Scawt Hill, near Larne, Co. Antrim, Ireland. On the Isle of Mull and on Morven Peak, Grampian Highlands, Scotland. In India, in Maharashtra, from the Syhadree Mountains; the Bombay quarry, Bombay; around Poona; and in the Nasik and Kolhapur districts. At Rio Putagan, Chile. In the Noche Buena mine, Mazapil, Zacatecas, Mexico. In the USA, at Crestmore, Riverside Co., California; in the Fairfax quarry, Centreville, Fairfax Co., Virginia; and at Skookumchuck Dam, near Bucoda, Thurston Co., Washington. In the Jeffrey mine, Asbestos, Quebec, Canada. Other localities are known.

Name: For the German naturalist Lorenz Ocken (1779–1851), of Munich, Germany, the mineral name later shortened.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 565. (2) Gard, J.A. and H.F.W. Taylor (1956) Okenite and nekoite (a new mineral). Mineral. Mag., 31, 5–20. (3) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 22–24. (4) Merlino, S. (1983) Okenite, $Ca_{10}Si_{18}O_{46}\cdot 18H_2O$: the first example of a chain and sheet silicate. Amer. Mineral., 68, 614–622.

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Okhotskite $\mathbf{Ca_2(Mn^{2+},Mg)(Mn^{3+},Al,Fe^{3+})_2Si_3O_{10}(OH)_4}$

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Crystal Data: [Monoclinic] (by analogy to the pumpellyite group). *Point Group:* [$2/m$.] As long prismatic crystals, to 0.2 mm, and as aggregates of prisms.

Physical Properties: *Cleavage:* One set observed in thin section. Hardness = 6
D(meas.) = n.d. D(calc.) = 3.40

Optical Properties: Transparent. *Color:* Deep orange. *Streak:* Pale orange.
Luster: Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = yellow; $Y = Z$ = deep orange.
Orientation: $Y = b$; $Z \wedge c = 9°$–$14°$. *Absorption:* $Z > Y > X$. $\alpha = 1.782(5)$ $\beta = 1.820(5)$ $\gamma = 1.827(5)$ 2V(meas.) = 46(5)° 2V(calc.) = 46°

Cell Data: *Space Group:* [$A2/m$.] $a = 8.887(5)$ $b = 6.000(4)$ $c = 19.53(2)$ $\beta = 97.08(6)°$ Z = 4

X-ray Powder Pattern: Kokuriki mine, Japan.
2.961 (100), 3.87 (70), 2.720 (70), 4.76 (60), 2.665 (45), 2.553 (45), 2.384 (45)

Chemistry:

	(1)
SiO_2	34.25
TiO_2	0.09
Al_2O_3	4.49
Fe_2O_3	6.03
Mn_2O_3	16.69
MnO	9.18
MgO	2.08
CaO	20.11
Na_2O	0.25
K_2O	0.03
H_2O	6.89
Total	100.09

(1) Kokuriki mine, Japan; by electron microprobe, H_2O by TGA, Fe^{3+} confirmed by Mössbauer spectroscopy, Mn^{2+}:Mn^{3+} calculated from stoichiometry; corresponds to $(Ca_{1.91}Na_{0.04})_{\Sigma=1.95}(Mn^{2+}_{0.69}Mg_{0.28})_{\Sigma=0.97}(Mn^{3+}_{1.13}Al_{0.47}Fe^{3+}_{0.40})_{\Sigma=2.00}Si_{3.03}[O_{9.93}(OH)_{4.07}]_{\Sigma=14.00}$.

Mineral Group: Pumpellyite group.

Occurrence: In network veinlets cutting hematite-rich ores.

Association: Hematite, quartz, piemontite, neotocite, bementite, apatite, inesite, rhodochrosite.

Distribution: From the Kokuriki mine, at Hiyoshi, about 20 km north of Kitami City, Hokkaido, Japan.

Name: For the Sea of Okhotsk, near the type locality in Japan.

Type Material: n.d.

References: (1) Togari, K. and M. Akasaka (1987) Okhotskite, a new mineral, an Mn^{3+}-dominant member of the pumpellyite group, from the Kokuriki mine, Hokkaido, Japan. Mineral. Mag., 51, 611–614. (2) (1988) Amer. Mineral., 73, 1495–1496 (abs. ref. 1).

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Oldhamite (Ca, Mg)S

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As single-crystal nodules, to 3 mm (Busti meteorite).

Physical Properties: *Cleavage:* On {001}. Hardness = 4 VHN = n.d. D(meas.) = 2.58 D(calc.) = 2.589

Optical Properties: Transparent. *Color:* Pale chestnut-brown, tarnishes strongly on exposure to wet air; in transmitted light, colorless to pale brown with many internal reflections.
Optical Class: Isotropic. $n = 2.137$
R: n.d.

Cell Data: *Space Group:* $Fm3m$. a = 5.6948 Z = 4

X-ray Powder Pattern: Synthetic CaS.
2.846 (100), 2.013 (70), 1.6439 (21), 1.2737 (20), 1.1627 (14), 1.4238 (10), 0.9491 (8)

Chemistry:

	(1)	(2)	(3)
Ca	53.45	51.0	55.55
Mg	1.49	0.90	
Na		0.04	
Mn		0.17	
Fe	0.32	5.50	
Cu		0.02	
S	44.74	41.6	44.45
Total	[100.00]	99.23	100.00

(1) Bustee meteorite; after deduction of other mineral impurities 7.15% and insoluble 8.46% from an original total of 97.99%, recalculated to 100.00%; then corresponds to $(Ca_{0.96}Mg_{0.04})_{\Sigma=1.00}S_{1.00}$. (2) Kota-Kota meteorite; by electron microprobe, average of 11 determinations, corresponds to $(Ca_{0.98}Fe_{0.08}Mg_{0.03})_{\Sigma=1.09}S_{1.00}$. (3) CaS.

Occurrence: Due to high melting point of 2450 °C, an early nebular condensate; may fill the latest interstices between silicates in enstatite chondrite and achondrite meteorites.

Association: Enstatite, augite, niningerite, osbornite, gypsum, calcite, troilite.

Distribution: In the Bustee [TL], Hvittis, Mayo Belwa, Indarch, Kota-Kota, Adhi-Kot, Norton County, Peña Blanca Spring, Abee, Qingzhen, etc., meteorites.

Name: Honors Thomas Oldham (1816–1878), Irish geologist, Director of the Indian Geological Survey (1850–1876).

Type Material: The Natural History Museum, London, England, 32100.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 208–209. (2) Leitch, C.A. and J.V. Smith (1982) Petrography, mineral chemistry and origin of type I enstatite chondrites. Geochim. Cosmochim. Acta, 46, 2083–2097. (3) Lodders, K. (1996) Oldhamite in enstatite achrondrites (aubrites). Proc. NIPR Symp. Antarct. Meteorites, 9, 127–142. (4) Oftedal, I. (1927) Die Gitterkonstanten von *CaO*, *CaS*, *CaSe*, *CaTe*. Z. Phys. Chem., 128, 154–158 (in German). (5) (1957) NBS Circ. 539, 7, 15.

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Olekminskite $(Sr, Ca, Ba)_2(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* 32. As needlelike crystals, to 0.15 mm, hexagonal to rounded in cross section; in spherulites.

Physical Properties: *Tenacity:* Brittle. Hardness = 3 D(meas.) = 3.70(2) D(calc.) = 3.65–3.68

Optical Properties: Transparent. *Color:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.670(2)$ $\epsilon = 1.527(2)$

Cell Data: *Space Group:* [$P321$] (by analogy to paralstonite). $a = 8.66(2)$ $c = 6.08(2)$ Z = 3

X-ray Powder Pattern: Kedrovyi massif, Russia.
3.50 (100), 2.49 (90), 2.03 (90), 1.305 (70b), 1.928 (60), 1.837 (60), 1.581 (60b)

Chemistry:

	(1)
CO_2	[29.94]
La_2O_3	0.21
Ce_2O_3	0.56
CaO	6.68
SrO	49.86
BaO	11.23
Total	[98.48]

(1) Kedrovyi massif, Russia; by electron microprobe, CO_2 calculated for stoichiometry; corresponds to $Sr_{1.00}(Sr_{0.41}Ca_{0.35}Ba_{0.22}Ce_{0.01})_{\Sigma=0.99}(CO_3)_{2.00}$.

Polymorphism & Series: Forms a series with paralstonite.

Occurrence: In barytocalcite–quartz veins in intrusive breccia in an alkaline massif.

Association: Paralstonite, calcite, barite, ankerite, ancylite-(Ce), narsarsukite, sphalerite, galena.

Distribution: From the Kedrovyi massif, five km southeast of the Murun massif, Aldan Shield, Sakha, Russia.

Name: For Olekminsk, Russia, administrative center for the district in which the Kedrovyi massif is located.

Type Material: Mining Institute, St. Petersburg, 2071/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p461/1.

References: (1) Konev, A.A., E.I. Vorobev, L.F. Piskunova, Z.F. Ushchapovskaya, and G.A. Tichonova (1991) Olekminskite $Sr(Sr, Ca, Ba)(CO_3)_2$ – a new mineral and the new isomorphous series olekminskite-paralstonite. Zap. Vses. Mineral. Obshch., 120(3), 89–96 (in Russian).
(2) (1993) Amer. Mineral., 78, 451 (abs. ref. 1).

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Olenite **$NaAl_3Al_6(BO_3)_3(Si_6O_{18})(O,OH)_4$**

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Crystal Data: Hexagonal. *Point Group:* 3*m*. As the outer zone, to 3 mm thick, of acicular crystals with elbaite cores.

Physical Properties: Hardness = [∼7] (by analogy to the tourmaline group). VHN = 676–820 (100 g load). D(meas.) = 3.010(2) D(calc.) = 3.12

Optical Properties: Transparent. *Color:* Pale pink. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* Weak; *O* = bright pink; *E* = pinkish yellow. $\omega = 1.654(2)$ $\epsilon = 1.635(2)$

Cell Data: *Space Group: R*3*m*. a = 15.803(3) *c* = 7.086(1) Z = 3

X-ray Powder Pattern: Oleny Ridge, Russia.
2.551 (100), 3.43 (80), 3.95 (70), 3.394 (70), 4.18 (40), 6.33 (30), 2.021 (30)

Chemistry:

	(1)		(1)
SiO_2	36.86	MgO	0.00
TiO_2	0.03	CaO	0.26
B_2O_3	[10.90]	Na_2O	1.60
Al_2O_3	46.43	K_2O	0.03
Fe_2O_3	0.14	F	0.06
MnO	0.49	H_2O	[1.36]
ZnO	0.03	Total	[98.19]

(1) Oleny Ridge, Russia; by electron microprobe, total Fe as Fe_2O_3, B_2O_3 and H_2O calculated from stoichiometry, original total given as 98.29%; corresponds to $(Na_{0.51}Ca_{0.05}K_{0.01})_{\Sigma=0.57}(Al_{2.91}Mn_{0.07}Fe^{3+}_{0.02}Ti_{0.01})_{\Sigma=3.01}Al_6(BO_3)_3Si_6O_{18}[O_{2.53}(OH)_{1.44}F_{0.03}]_{\Sigma=4.00}$.

Mineral Group: Tourmaline group.

Occurrence: In pegmatitic veins crosscutting Precambrian metasediments.

Association: Elbaite, quartz, albite, potassic feldspar.

Distribution: On the Oleny Ridge, Voroni massif, Kola Peninsula, Russia.

Name: For the occurrence on the Oleny Ridge, Russia.

Type Material: Mining Institute, St. Petersburg, 580-8/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87568.

References: (1) Sokolov, P.B., M.G. Gorskaya, V.V. Gordienko, M.G. Petrova, Y.L. Kretser, and V.A. Frank-Kamenetskii (1986) Olenite $Na_{1-x}Al_3Al_6B_3Si_6O_{27}(O,OH)_4$ – a new high-alumina mineral of the tourmaline group. Zap. Vses. Mineral. Obshch., 115, 119–123 (in Russian). (2) (1987) Mineral. Abs., 38, 144 (abs. ref. 1). (3) (1988) Amer. Mineral., 73, 441 (abs. ref. 1).

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Olgite $Na(Sr, Ba)PO_4$

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Crystal Data: Hexagonal. *Point Group:* 3. As hexagonal prismatic crystals, to 2 mm, elongated along [0001], with {0001}, {$10\bar{1}0$}, {$11\bar{2}0$}, {$10\bar{1}1$}, {$11\bar{2}1$}; in rounded grains.

Physical Properties: Hardness = 4.5 VHN = 343 D(meas.) = 3.94 D(calc.) = 3.96

Optical Properties: Transparent. *Color:* Bright blue or bluish green; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.623(3)$ $\epsilon = 1.619(3)$

Cell Data: *Space Group:* $P3$. $a = 5.565(2)$ $c = 7.050(3)$ Z = 1

X-ray Powder Pattern: Mt. Karnasurt, Kola Peninsula, Russia.
2.842 (100), 2.763 (100), 1.982 (63), 3.97 (41), 1.607 (37b), 1.647 (30), 6.99 (26)

Chemistry:

	(1)
P_2O_5	32.0
SiO_2	0.11
La_2O_3	2.3
Ce_2O_3	0.43
Pr_2O_3	0.05
Nd_2O_3	0.02
MnO	0.58
CaO	0.63
SrO	21.6
BaO	28.7
Na_2O	13.9
K_2O	0.46
Total	100.78

(1) Mt. Karnasurt, Kola Peninsula, Russia; by electron microprobe, corresponding to $Na_{1.00}(Sr_{0.47}Ba_{0.42}La_{0.03}Ca_{0.02}K_{0.02}Mn_{0.02}Ce_{0.01})_{\Sigma=0.99}P_{0.99}O_4$.

Occurrence: In nepheline syenite pegmatite in a differentiated alkalic massif.

Association: Natrosilite, analcime.

Distribution: On Mts. Karnasurt and Alluaiv, Lovozero massif, and in the Vuonnemiok River valley, Khibiny massif, Kola Peninsula, Russia.

Name: To honor Ol'ga Anisimovna Vorob'eva (1902–1974), Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia, discoverer of the rare-metal deposits in the Lovozero massif.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80179.

References: (1) Khomyakov, A.P., Y.I. Semenov, N.G. Shumyatskaya, I.M. Timoshenkov, I.P. Laputina, and N.N. Smol'yaninova (1980) Ol'git $Na(Sr, Ba)PO_4$ – a new mineral. Zap. Vses. Mineral. Obshch., 109, 347–351 (in Russian). (2) (1981) Amer. Mineral., 66, 438 (abs. ref. 1). (3) Sokolova, E.V., Y.K. Yegorov-Tismenko, N.A. Yamnova, and M.A. Simonov (1984) The crystal structure of olgite $Na(Sr_{0.52}Ba_{0.48})(Sr_{0.58}Na_{0.42})(Na_{0.81}Sr_{0.19})[PO_{3.40}][P_{0.76}O_{3.88}]$. Kristallografiya (Sov. Phys. Crystal.), 29, 1079–1083 (in Russian).

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Oligoclase $Na_{0.9-0.7}Ca_{0.1-0.3}Al_{1.1-1.3}Si_{2.9-2.7}O_8$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals uncommon, flattened and tabular along [010], to 6 cm; more commonly cleavable to compact, massive. *Twinning:* Typically twinned according to the Albite, Carlsbad, and Pericline laws.

Physical Properties: *Cleavage:* Perfect on {001}, less perfect on {010}, imperfect on {110}, (001) ∧ (010) ∼94°. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.63–2.66 D(calc.) = 2.624–2.652

Optical Properties: Transparent to translucent. *Color:* White, may be tinted gray, green, red; colorless in thin section; may be opalescent or iridescent. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+) or (–). *Dispersion:* $r > v$, weak. α = 1.533–1.545 β = 1.537–1.548 γ = 1.542–1.552 2V(meas.) = 84° to −87° to 90° (low); −52° to −73° (high).

Cell Data: *Space Group:* $C\bar{1}$ (low). a = 8.152 b = 12.821 c = 7.139 α = 93.99° β = 116.46° γ = 88.58° Z = 4, or *Space Group:* $C\bar{1}$ (high). a = 8.163 b = 12.875 c = 7.107 α = 93.39° β = 116.27° γ = 90.29° Z = 4

X-ray Powder Pattern: Petrick quarry, Llano Co., Texas, USA (low).
3.18 (100), 4.03 (80), 3.20 (80), 3.76 (70), 2.93 (70), 6.38 (60), 3.69 (60)

X-ray Powder Pattern: Synthetic $Na_{0.7}Ca_{0.3}Al_{1.3}Si_{2.7}O_8$.
3.20 (100), 4.02 (80), 3.74 (80), 3.17 (80), 4.69 (60), 3.63 (70), 3.36 (60)

Chemistry:	(1)	(2)	(3)
SiO_2	64.92	66.04	60.76
Al_2O_3	22.20	21.26	24.82
CaO	2.64	2.13	6.30
Na_2O	9.72	10.57	8.12
K_2O	0.68		
H_2O	0.09		
Total	100.25	100.00	100.00

(1) Monteagle, Ontario, Canada. (2) $Na_{0.90}Ca_{0.10}Al_{1.10}Si_{2.90}O_8$. (3) $Na_{0.70}Ca_{0.30}Al_{1.30}Si_{2.70}O_8$.

Polymorphism & Series: Low- and high-temperature structural modifications are recognized.

Mineral Group: Feldspar group, plagioclase series.

Occurrence: Common in granite, syenite, nepheline syenite, and their pegmatites; in diorite, rhyolite, andesite. In serpentinite and gneiss; in amphibolite facies metamorphic rocks; as clastic grains in sedimentary rocks.

Association: Quartz, orthoclase, sanidine, tourmaline, corundum.

Distribution: A widespread mineral. Fine material from Danviken, near Stockholm, Sweden. At Arendal, on Tromöy Island at Alve, Tvedestrand, and elsewhere in Norway. In Sweden, at Ytterby. From Kemiö (Kimito) Island, Finland. At Silberberg, near Bodenmais, Bavaria, Germany. On Tenerife, Canary Islands. In the USA, at Fine and Macomb, St. Lawrence Co., New York; on Corundum Hill, Chester Co., and at Media, Delaware Co., Pennsylvania; near Hawk, east of Bakersville, Mitchell Co., North Carolina. At Lake Harbour, Baffin Island, Northwest Territories, Canada.

Name: From the Greek for *little* and *fracture*, for cleavages believed inferior to albite.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 325–327, 332–333. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 94–165. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 352–360. (4) Goodyear, J. and W.J. Duffin (1954) The identification and determination of plagioclase felspars by the X-ray powder method. Mineral. Mag., 30, 306–326. (5) Smith, J.V. (1956) The powder patterns and lattice parameters of plagioclase felspars. I. The soda-rich plagioclases. Mineral. Mag., 31, 47–68. (6) Phillips, M.W., A.A. Colville, and P.H. Ribbe (1971) The crystal structures of two oligoclases: a comparison with low and high albite. Zeits. Krist., 133, 43–65.

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Olivenite $Cu_2(AsO_4)(OH)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals may be elongated along [010] or [001], with {100}, {010}, {110}, {101}, many other forms, to 2.5 cm. Commonly curved, lamellar, matted fibrous, globular and reniform; granular, earthy, massive. *Twinning:* On {010}.

Physical Properties: *Cleavage:* {101}, {110}, indistinct. *Fracture:* Conchoidal to irregular. Hardness = 3 D(meas.) = 4.46 D(calc.) = 4.45

Optical Properties: Translucent to opaque. *Color:* Olive-green, greenish brown, brown; grayish green, grayish white, straw-yellow if fibrous; pale green in transmitted light. *Streak:* Olive-green to brown. *Luster:* Adamantine to vitreous, pearly to silky if fibrous. *Optical Class:* Biaxial (+), may be biaxial (–). *Pleochroism:* Weak; in green and yellow. *Orientation:* $Y = c$. *Dispersion:* $r < v$ or $r > v$, strong. *Absorption:* $Y > X = Z$. $\alpha = 1.747$–1.780 $\beta = 1.788$–1.820 $\gamma = 1.829$–1.865 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/n$. $a = 8.5894(2)$ $b = 8.2073(2)$ $c = 5.9285(1)$ $\beta = 90.088(3)°$ Z = 4

X-ray Powder Pattern: Cornwall, England or Tintic, Utah, USA.
2.98 (10), 4.82 (9), 5.91 (7), 2.47 (7), 2.39 (7), 4.19 (6), 2.65 (6)

Chemistry:

	(1)	(2)
As_2O_5	39.80	40.61
CuO	56.65	56.21
H_2O	3.55	3.18
Total	100.00	100.00

(1) Cornwall, England. (2) $Cu_2(AsO_4)(OH)$.

Mineral Group: Forms a series with adamite.

Occurrence: The most common secondary copper arsenate in the oxdized zone of hydrothermal copper deposits.

Association: Conichalcite, clinoclase, tyrolite, cornetite, cornwallite, metazeunerite, scorodite, pharmacosiderite, spangolite, chalcophyllite, brochantite, malachite, azurite, chrysocolla.

Distribution: Many localities. In England, from Cornwall, at the Carharrack mine, Wheals Gorland, Unity, and others in Gwennap, Linkinhorne, and elsewhere; at Alston Moor, Cumbria, and Tavistock, Devon. From the Cap Garonne mine, near le Pradet, Var, France. In the Clara Mine, near Oberwolfach, and many other places in the Black Forest, Germany. At the Kamariza mine, Laurium, Greece. From the Touissit mine, near Oujda, Morocco. Large crystals at Tsumeb, Namibia. In the USA, fine examples from the Mammoth, American Eagle, and other mines in the Tintic district, Juab Co., Utah; at the Majuba Hill mine, Antelope district, Pershing Co., Nevada. In Chile, from Chuquicamata, Antofagasta; Collahuasi, Tarapacá; and the Copiapó district, Atacama. From Ashburton Downs, Western Australia.

Name: In allusion to its common olive-green color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 859–861. (2) Berry, L.G. (1951) Observations on conichalcite, cornwallite, euchroite liroconite and olivenite. Amer. Mineral., 36, 484–503, esp. 502. (3) Burns, P.C. and F.C. Hawthorne (1995) Rietveld refinement of the crystal structure of olivenite: a twinned monoclinic structure. Can. Mineral., 33, 885–888.

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Olkhonskite $(Cr^{3+}, V^{3+})_2Ti_3O_9$

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Crystal Data: [Monoclinic] (by analogy to schreyerite). *Point Group:* $2/m$ or m. Platy crystals, to 150 μm, included in rutile.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 1412 (65 g load). D(meas.) = n.d. D(calc.) = 4.48

Optical Properties: Opaque. *Color:* Black; light gray in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Biaxial. *Pleochroism:* Weak; in browns. *Anisotropism:* Weak. *Bireflectance:* Noted.
R_1–R_2: (400) — , (420) — , (440) 22.5–19.6, (460) 21.1–18.2, (480) 20.1–18.2, (500) 20.3–18.2, (520) 19.8–18.4, (540) 20.0–18.5, (560) 20.3–18.5, (580) 20.2–18.4, (600) 20.1–18.4, (620) 20.5–18.4, (640) 21.0–18.5, (660) 21.3–19.5, (680) 22.4–20.7, (700) 22.6–20.8

Cell Data: *Space Group:* $C2/c$, Cc, $P2_1/c$, $P2/c$, or Pc. a = 7.03(1) b = 5.02(1) c = 18.83(1) β = 119.60(5)° Z = 4

X-ray Powder Pattern: Ol'khon Gate Strait, Lake Baikal, Russia.
2.75 (10), 1.386 (10), 2.88 (7), 2.43 (7), 1.426 (7), 2.14 (5), 1.660 (5)

Chemistry:

	(1)	(2)
TiO_2	60.83	61.35
Al_2O_3	0.63	
V_2O_3	16.17	19.19
Cr_2O_3	21.77	19.46
FeO	0.21	
Total	99.61	100.00

(1) Ol'khon Gate Strait, Lake Baikal, Russia; by electron microprobe, average of 12 analyses, total Fe as FeO; corresponding to $(Cr_{1.12}V_{0.85}Al_{0.05}Fe_{0.01})_{\Sigma=2.03}Ti_{2.98}O_{9.00}$. (2) $(Cr, V)_2Ti_3O_9$ with Cr:V = 1:1.

Occurrence: In quartzite schists, enriched in Cr–V–Ti, interbedded with carbonate-silicate rocks.

Association: Rutile, eskolaite, karelianite, schreyerite, vuorelainenite, quartz, oligoclase, orthoclase.

Distribution: On the western shore of Lake Baikal, 4.5 km south of Ol'khon Gate Strait, Siberia, Russia.

Name: For the Ol'khonskaya series of metamorphic rocks in which the mineral occurs.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, r1001.

References: (1) Koneva, A.A., L.F. Piskunova, Z.F. Ushchapovskaya, and A.A. Konev (1994) Olkhonskite $(Cr, V)_2Ti_3O_9$ – a new mineral from the Priolkhon'ye. Zap. Vses. Mineral. Obshch., 123(4), 98–103 (in Russian). (2) (1996) Amer. Mineral., 81, 251–252 (abs. ref. 1). (3) (1996) Mineral. Abs., 47, 110 (abs. ref. 1).

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Olmsteadite $KFe_2^{2+}(Nb,Ta)O_2(PO_4)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are prismatic, elongated along [010], thick tabular ‖ {100} to thin tabular ‖ {001}, to 1 mm. Forms include {001}, {100}, {111}, $\{1\bar{1}1\}$, {110}, {101}.

Physical Properties: Hardness = 4 D(meas.) = 3.31–3.36 D(calc.) = 3.41

Optical Properties: Semitransparent. *Color:* Deep brown, red-brown to black. *Streak:* Olive-green. *Luster:* Subadamantine, may be bronzy. *Optical Class:* Biaxial (+). *Pleochroism:* Marked; X = blue-green or dark blue; Y = yellow or light brown; Z = brown to dark brown. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Absorption:* $X \gg Z > Y$. $\alpha = 1.725$–1.765 $\beta = 1.755$–1.775 $\gamma = 1.815$–1.835 2V(meas.) = ∼60°

Cell Data: *Space Group:* $Pb2_1m$. $a = 7.512(1)$ $b = 10.000(3)$ $c = 6.492(2)$ Z = 1

X-ray Powder Pattern: Big Chief mine, South Dakota, USA.
6.006 (10), 3.03 (7), 3.047 (6), 2.856 (6), 7.512 (5), 6.492 (5), 4.409 (5)

Chemistry:

	(1)	(2)	(3)
P_2O_5	26.6	28.3	28.29
Nb_2O_5	17.8	23.2	26.49
Ta_2O_5	7.6	0.2	
FeO	24.6	23.0	28.65
MnO	2.9	4.9	
K_2O	7.8	8.6	9.39
H_2O			7.18
Total	87.3	88.2	100.00

(1) Big Chief mine, South Dakota, USA; by electron microprobe, average of five analyses, original total given as 85.0%. (2) Hesnard mine, South Dakota, USA; by electron microprobe, average of two analyses. (3) $KFe_2NbO_2(PO_4)_2 \cdot 2H_2O$.

Occurrence: A rare mineral, presumably formed by hydrothermal leaching of primary phosphates and columbite-tantalite in complex granite pegmatites.

Association: Siderite, quartz (Big Chief mine, South Dakota, USA); rockbridgeite (Hesnard mine, South Dakota, USA).

Distribution: From the Big Chief mine, one km south of Glendale; the White Cap mine, three km south of Keystone; and the Hesnard mine, three km southwest of Keystone, Pennington Co., South Dakota, USA.

Name: Honoring Milo Olmstead, Rapid City, South Dakota, USA, amateur collector of microscopic minerals, who called attention to the mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA, 135924.

References: (1) Moore, P.B., T. Araki, A.R. Kampf, and I.M. Steele (1976) Olmsteadite, $K_2Fe_2^{2+}[Fe_2^{2+}(Nb,Ta)_2^{5+}O_4(H_2O)_4(PO_4)_4]$, a new species, its crystal structure and relation to vauxite and montgomeryite. Amer. Mineral., 61, 5–11. (2) Dunn, P.J., D.R. Peacor, D.B. Sturman, R.A. Ramik, W.L. Roberts, and J.A. Nelen (1986) Johnwalkite, the Mn-analogue of olmsteadite, from South Dakota. Neues Jahrb. Mineral., Monatsh., 115–120.

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Olsacherite $Pb_2(Se^{6+}O_4)(SO_4)$

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Crystal Data: Orthorhombic. *Point Group:* 222 or $mm2$. Sharp needlelike crystals, to 2 mm, elongated along [010], and bounded by {010}, {101}, {111}, {$1\bar{1}1$}.

Physical Properties: *Cleavage:* Good on {101}; fair on {010}. *Tenacity:* Very brittle. Hardness = 3–3.5 D(meas.) = n.d. D(calc.) = 6.55 Pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous, dull if coated.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.935(2)$ $\beta = 1.966(2)$ $\gamma = 1.983(2)$ 2V(meas.) = 80° 2V(calc.) = 84°

Cell Data: *Space Group:* $P22_12$, $P222$, or $Pmm2$. $a = 8.42(1)$ $b = 10.96(1)$ $c = 7.00(1)$ Z = 4

X-ray Powder Pattern: Pacajake mine, Bolivia.
3.338 (100), 3.234 (100), 3.015 (100), 2.086 (70), 2.786 (60), 3.845 (50), 4.316 (40)

Chemistry:

	(1)	(2)
SO_3	14.2	12.25
SeO_3	16.2	19.43
PbO	71.2	68.32
Total	101.6	100.00

(1) Pacajake mine, Bolivia; by electron microprobe, corresponding to $Pb_{2.00}(SeO_4)_{0.80}(SO_4)_{1.12}$. (2)$Pb_2(SeO_4)(SO_4)$.

Occurrence: A rare secondary mineral in the oxidized zone of selenium-bearing hydrothermal mineral deposits.

Association: Penroseite (Pacajake mine, Bolivia); chalcomenite, ahlfeldite, lepidocrocite, goethite (El Dragón mine, Bolivia).

Distribution: From the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, and in the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí, Bolivia. At Cerro de Cacheuta, Mendoza Province, Argentina. From the Baccu Locci mine, near Villaputzu, Sarrabus district, Sardinia, Italy.

Name: To honor Juan Augusto Olsacher (1903–1964), Professor of Mineralogy, Córdoba University, Córdoba, Argentina, who studied Argentinian selenium-bearing minerals.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 110966.

References: (1) Hurlbut, C.S., Jr. and L.F. Aristarain (1969) Olsacherite, $Pb_2(SO_4)(SeO_4)$, a new mineral from Bolivia. Amer. Mineral., 54, 1519–1527.

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Olshanskyite $Ca_3B_4(OH)_{18}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Platy crystals, to 1 cm; in cross-fiber veinlets and anhedral massive. *Twinning:* Polysynthetic, very common.

Physical Properties: Hardness = 3.5–4 D(meas.) = 2.19–2.23 D(calc.) = 2.31

Optical Properties: Semitransparent. *Color:* Colorless, white to pale brown; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* Negative elongation, extinction at a small angle. *Dispersion:* $r > v$, weak. α = 1.553–1.557 β = 1.562–[1.568] γ = 1.567–1.570
2V(meas.) = 54°–60°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.991(5)$ $b = 14.740(11)$ $c = 7.975(3)$
$\alpha = 94.53(4)°$ $\beta = 69.08(3)°$ $\gamma = 112.44(5)°$ Z = 3

X-ray Powder Pattern: Fuka, Japan.
2.873 (100), 6.79 (52), 4.49 (49), 6.72 (40), 2.573 (35), 7.42 (34), 8.63 (32)

Chemistry:

	(1)	(2)	(3)
SiO_2	0.36		
CO_2	2.36		
B_2O_3	27.95	29.64	29.65
Al_2O_3	0.15		
Fe_2O_3	0.17		
MgO	1.79		
CaO	34.81	34.50	35.82
H_2O^+	32.27	34.54	34.53
H_2O^-	0.55	1.21	
Total	100.41	99.89	100.00

(1) Titovskoye deposit, Russia; after deduction of MgO as szaibélyite, CO_2 as calcite, quartz, and "limonite", corresponds to $Ca_{3.00}B_{4.00}(OH)_{18.55}$. (2) Fuka, Japan; corresponds to $Ca_{2.89}B_{4.00}(OH)_{18}$. (3) $Ca_3B_4(OH)_{18}$.

Occurrence: In magnesian skarn (Titovskoye deposit, Russia); formed by alteration of nifontovite and some other anhydrous borate, near gehlenite-spurrite skarn (Fuka, Japan).

Association: Sakhaite, szaibélyite, calcite, "limonite", quartz (Titovskoye deposit, Russia); nifontovite, frolovite, pentahydroborite, takedaite, sibirskite, parasibirskite, borcarite, bultfonteinite, calcite (Fuka, Japan).

Distribution: From the Titovskoye boron deposit, Tas-Khayakhtakh Range, Polar Sakha, Russia. Large crystals at Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: To honor Yakov Iosifovich Ol'shanskii (1912–1958), specialist in physical geochemistry, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1493/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 71541–71544.

References: (1) Bogomolov, M.A., I.B. Nikitina, and N.N. Pertsev (1969) Olshanskyite, a new calcium borate. Doklady Acad. Nauk SSSR, 184, 1398–1401 (in Russian). (2) (1969) Amer. Mineral., 54, 1737–1738 (abs. ref. 1). (3) Kusachi, I. and C. Henmi (1994) Nifontovite and olshanskyite from Fuka, Okayama Prefecture, Japan. Mineral. Mag., 58, 279–284. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 157.

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Olympite $LiNa_5(PO_4)_2$

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Crystal Data: Orthorhombic. *Point Group:* 222. Oval grains, to 5 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼4 VHN = 274–395, 310 average (40–50 g load). D(meas.) = 2.8 D(calc.) = 2.85 Easily soluble in cold H_2O; decomposes rapidly in air.

Optical Properties: Translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). $\alpha = 1.510(2)$ $\beta = 1.510(2)$ $\gamma = 1.512(2)$ 2V(meas.) = 46(1)°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 10.124(2)$ $b = 14.794(2)$ $c = 10.132(3)$ Z = 8

X-ray Powder Pattern: Mt. Rasvumchorr, Kola Peninsula, Russia. 2.582 (10), 4.18 (9), 2.531 (7), 2.433 (7), 1.472 (7), 3.58 (6), 3.70 (5)

Chemistry:

	(1)	(2)
P_2O_5	42.50	45.52
CO_2	2.30	
MnO	0.50	
Li_2O	n.d.	4.79
Na_2O	54.50	49.69
Total	99.80	100.00

(1) Mt. Rasvumchorr, Kola Peninsula, Russia; MnO and CO_2 attributed to sidorenkite impurity.
(2) $LiNa_5(PO_4)_2$.

Occurrence: An ultra-alkalic phase in nepheline syenite pegmatites in differentiated alkalic massifs.

Association: Sidorenkite, dorfmanite, nahpoite, villiaumite, shafranovskite, aegirine (Mt. Rasvumchorr, Kola Peninsula, Russia); natrite, natrosilite (Lovozero massif, Kola Peninsula, Russia).

Distribution: On Mt. Rasvumchorr, Khibiny massif, and in the Lovozero massif, Kola Peninsula, Russia.

Name: For the 1980 Summer Olympic Games, in Moscow, USSR.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5533; Mining Institute, St. Petersburg, 1208/1; I.M.G.R.E., Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80180.

References: (1) Khomyakov, A.P., A.V. Bykova, and Y.A. Malinovskii (1980) Olympite Na_3PO_4 – a new mineral. Zap. Vses. Mineral. Obshch., 109, 476–479. (2) (1981) Amer. Mineral., 66, 438 (abs. ref. 1). (3) Rastsvetaeva, R.K. and A.P. Khomyakov (1994) A comparative crystal-chemical study of lithium-sodium phosphates (lithiophosphate, nalipoite, olympite, and Na_3PO_4). Crystallography Reports, 39, 35–41.

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Omeiite $(Os, Ru)As_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, or $mm2$. Crystals are tabular or elongated ‖ [010], to 20 μm.

Physical Properties: *Cleavage:* Parallel to elongation. *Tenacity:* Brittle. Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 11.20

Optical Properties: Opaque. *Color:* Dull steel-gray; in polished section, white with a yellow tint in air, milky yellow in oil. *Luster:* Metallic. *Pleochroism:* Weak, yellow to grayish yellow. *Anisotropism:* Distinct.
R_1–R_2: n.d.

Cell Data: *Space Group:* *Pnnm* or *Pnn*2. $a = 5.409$ $b = 6.167$ $c = 3.021$ $Z = 2$

X-ray Powder Pattern: Danba, China.
2.63 (100), 1.915 (100), 2.67 (80), 4.06 (60), 2.06 (60), 2.01 (60), 1.209 (60)

Chemistry:

	(1)
Os	48.9
Ru	4.0
Ir	0.6
Ni	0.3
Fe	0.2
Co	0.1
As	44.2
Total	98.3

(1) Danba, China; by electron microprobe, average of six analyses; corresponding to $(Os_{0.87}Ru_{0.14}Ir_{0.01})_{\Sigma=1.02}As_{2.00}$.

Polymorphism & Series: Forms a series with anduoite.

Occurrence: In a Cu–Ni sulfide deposit associated with an ultramafic body.

Association: Pyrrhotite, pentlandite, chalcopyrite, violarite, cubanite, bornite, sphalerite, galena, linnaeite, magnetite, testibiopalladite, sudburyite, michenerite, sperrylite, kotulskite, gold, argentian gold.

Distribution: From Danba, Sichuan Province, China [TL].

Name: For Omeishan, a well-known mountain in Sichuan Province, China.

Type Material: Museum of Geology, National Bureau of Geology [Beijing?], China.

References: (1) Ren Yingxin, Hu Qinde, and Xu Jingao (1978) A preliminary study on the new mineral of the platinum group – omeiite, $OsAs_2$. Acta Geol. Sinica, 52, 163–167 (in Chinese with English abs.). (2) (1979) Amer. Mineral., 64, 464 (abs. ref. 1).

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Omongwaite $Na_2Ca_5(SO_4)_6{\cdot}3H_2O$

Crystal Data: Monoclinic. *Point Group*: 2. Crystals, elongated on [001], with pseudohexagonal cross-sections and sphenoidal terminations, to 0.2 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: n.d.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.720

Optical Properties: Transparent. *Color*: Colorless. *Streak*: n.d. *Luster*: n.d.
Optical Class: Biaxial. *n*(calc) = 1.540 2V(meas.) = n.d. 2V(calc.) = n.d. *Orientation*: $Z \sim c$.

Cell Data: *Space Group*: *C2*. $a = 12.08(3)$ $b = 6.96(1)$ $c = 6.39(2)$ $\beta = 90.2(3)°$ $Z = 1$

X-ray Powder Pattern: Omongwa pan, southwestern Kalahari, Namibia.
3.015 (100), 2.819 (100), 6.005 (75), 3.481 (50), 2.139 (<25), 1.8534 (<25), 1.7437 (<25)

Chemistry:

	(1)	(2)
SO_3	56.16	54.78
CaO	30.82	31.98
Na_2O	5.25	7.07
K_2O	3.21	
H_2O	6.25	6.17
Total	101.69	100.00

(1) Omongwa pan, southwestern Kalahari, Namibia; average of 175 electron microprobe analyses, H_2O calculated from structure analysis, H_2O and SO_4 confirmed by Raman spectroscopy, corresponding to $(Na_{1.47}K_{0.59})_{\Sigma=2.06}Ca_{4.76}S_{6.07}O_{24}{\cdot}3H_2O$. (2) $Na_2Ca_5(SO_4)_6{\cdot}3H_2O$.

Occurrence: As inclusions in gypsum in a dry lake, closed-basin evaporite deposit.

Association: Gypsum.

Distribution: From the Omongwa pan, near Aminuis, 140 km SSE of Gobabis, southwestern Kalahari, Namibia.

Name: For the locality from which the first specimens were obtained, the Omongwa pan, Namibia; "omongwa" meaning "salt" in the Otjiherero language.

Type Material: Royal Museum for Central Africa, Tervuren, Belgium (catalog no. RGM 15.908).

References: (1) Mees, F., F. Hatert, and R. Rowe (2008) Omongwaite, $Na_2Ca_5(SO_4)_6{\cdot}3H_2O$, a new mineral from recent salt lake deposits, Namibia. Mineral. Mag., 72, 1307–1318. (2) (2009) Amer. Mineral., 94, 1499-1500 (abs. ref. 1).

Omphacite $(Ca, Na)(Mg, Fe, Al)Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely in rough crystals, to 5 cm; anhedral, granular to massive. *Twinning:* Single and polysynthetic twinning on {100}, common.

Physical Properties: *Cleavage:* Good on {110}, (110) ∧ $(1\bar{1}0)$ ~87°; parting on {100}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.16–3.43 D(calc.) = [3.36]

Optical Properties: Translucent. *Color:* Green to dark green; colorless to pale green in thin section. *Luster:* Vitreous to silky.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = colorless; Y = very pale green; Z = very pale green, blue-green. *Orientation:* $Y = b$; $Z \wedge c = 36°–48°$. *Dispersion:* $r > v$, moderate. $\alpha = 1.662–1.701$ $\beta = 1.670–1.712$ $\gamma = 1.685–1.723$ 2V(meas.) = 56°–84°

Cell Data: *Space Group:* $C2/c$ or $P2/n$. $a = 9.45–9.68$ $b = 8.57–8.90$ $c = 5.23–5.28$ $\beta = 105° – 108°$ Z = 4

X-ray Powder Pattern: Hareidland, Sunmøre, Norway.
2.976 (100), 1.402 (80), 2.127 (70), 2.118 (70), 2.019 (70), 4.4 (50), 3.19 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	54.08	55.25	MnO	trace	0.04
TiO_2	0.14	0.23	MgO	11.51	7.23
Al_2O_3	9.20	16.17	CaO	17.50	12.34
Fe_2O_3	0.83	1.64	Na_2O	4.20	6.19
Cr_2O_3		0.04	K_2O	0.04	0.11
FeO	2.18	1.36	H_2O^+	0.46	
			Total	100.14	100.60

(1) Kupplerbrunn, Austria; corresponds to $(Ca_{0.58}Na_{0.32})_{\Sigma=0.90}(Mg_{0.61}Al_{0.31}Fe^{2+}_{0.06}Ti_{0.04}Fe^{3+}_{0.02})_{\Sigma=1.04}(Si_{1.93}Al_{0.07})_{\Sigma=2.00}O_6$. (2) Yakutia, Russia; corresponds to $(Ca_{0.46}Na_{0.42}K_{0.01})_{\Sigma=0.89}(Al_{0.58}Mg_{0.38}Fe^{3+}_{0.04}Fe^{2+}_{0.04}Ti_{0.01})_{\Sigma=1.05}(Si_{1.92}Al_{0.08})_{\Sigma=2.00}O_6$.

Polymorphism & Series: A clinopyroxene solid solution of jadeite (25%–75%), augite (25%–75%), and aegirine (0%–25%).

Mineral Group: Pyroxene group.

Occurrence: A major constituent of eclogite, commonly in kimberlite pipes; from some ophiolites and glaucophane-bearing blueschist facies rocks.

Association: Garnet, quartz, kyanite, corundum (eclogite); "hornblende," scapolite, epidote, glaucophane (blueschists).

Distribution: A widespread mineral. Some localities for studied material are: in Germany, from Hof, near Bayreuth, Bavaria. At Kupplerbrunn, Saualpe, and Gertrusk, Carinthia, Austria. From Eiksundsal, Sunmøre, Naustdal, Vanelvsdalen, and Möre, Norway. In Russia, in the Yakutia diamond pipes, as at Mir, Zagadochnaya, and Obnazhennya. From Kimberley, Cape Province, South Africa. At Shibukawa, Gumma Prefecture, and in the Ohmi district, Niigata Prefecture, Japan. In the USA, on the Tiburon Peninsula, Marin Co., and on into Sonoma Co., California.

Name: From the Greek for *unripe grape*, in allusion to its green color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 357.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 424–459. (3) Matsumoto, T., M. Tokonami, and N. Morimoto (1975) The crystal structure of omphacite. Amer. Mineral., 60, 634–641. (4) Warner, J. (1964) X-ray crystallography of omphacite. Amer. Mineral., 49, 1461–1467.

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Onoratoite $Sb_8O_{11}Cl_2$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. Needlelike crystals, elongated along [010], flattened ∥ {001}, showing {100}, {201}, {401}, and {412}, to 5 mm. *Twinning:* May be twinned on {001}.

Physical Properties: Hardness = n.d. D(meas.) = 5.3 D(calc.) = 5.49

Optical Properties: Transparent. *Color:* Colorless to white.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c \simeq 12°$; $Y \wedge a \simeq 8°$; $Z \wedge b \simeq 0°$–$14°$. α = n.d. β = 2.18–2.23 γ = 2.23–2.26 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 18.92$ $b = 4.03$ $c = 10.31$ $\alpha =\sim 90°$ $\beta =\sim 110°$ $\gamma =\sim 90°$ Z = [2]

X-ray Powder Pattern: Cetine mine, Italy.
3.190 (100), 2.677 (60), 3.041 (50), 2.822 (50), 2.598 (30), 2.544 (30), 1.807 (30)

Chemistry:

	(1)	(2)
Sb_2O_3	87.90	87.54
$SbCl_3$	12.10	12.46
H_2O	0.00	
Total	100.00	100.00

(1) Cetine mine, Italy; by TGA. (2) $Sb_8O_{11}Cl_2$.

Occurrence: An oxidation product of stibnite in an antimony deposit in highly silicified evaporites.

Association: Stibnite, stibiconite, cetineite, peretaite, klebelsbergite, quartz.

Distribution: In the Cetine mine, 20 km southwest of Siena, Tuscany, Italy.

Name: To honor Ettore Onorato (1899–1971), Italian mineralogist.

Type Material: University of Rome, Rome, Italy, 24308.

References: (1) Belluomini, M.F., M. Fornaseri, and M. Nicoletti (1968) Onoratoite, a new antimony oxychloride from Cetine di Cotorniano, Rosia (Siena, Italy). Mineral. Mag., 36, 1037–1044. (2) (1969) Amer. Mineral., 54, 1219 (abs. ref. 1). (3) Menchetti, S., C. Sabelli, and R. Trosti-Ferroni (1984) The structures of onoratoite, $Sb_8O_{11}Cl_2$ and $Sb_8O_{11}Cl_2 \cdot 6H_2O$. Acta Cryst., C40, 1506–1510.

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Oosterboschite $(Pd, Cu)_7Se_5$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* n.d. As irregular grains, to 0.4 mm. *Twinning:* Polysynthetic, two orthogonal sets of fine lamellae always observed in polished section.

Physical Properties: Hardness = 4.5–5 VHN = 340 (100 g load). D(meas.) = n.d. D(calc.) = 8.48

Optical Properties: Opaque. *Color:* In polished section, pale yellow with a cream tint. *Anisotropism:* Medium strong, in bluish gray to brownish gray.
R_1–R_2: (400) 38.4–45.1, (420) 39.9–46.5, (440) 41.4–47.9, (460) 42.8–49.2, (480) 43.9–50.3, (500) 44.9–51.2, (520) 45.6–51.7, (540) 46.0–51.8, (560) 46.0–51.6, (580) 46.1–51.3, (600) 46.3–51.2, (620) 46.7–51.4, (640) 47.2–51.6, (660) 47.7–51.8, (680) 48.2–52.0, (700) 48.6–52.2

Cell Data: *Space Group:* n.d. $a = 10.42$ $b = 10.60$ $c = 14.43$ Z = 8

X-ray Powder Pattern: Musonoi mine, Congo.
2.647 (100), 2.600 (80), 1.847 (80), 2.736 (70d), 2.244 (70d), 1.935 (70), 1.903 (70)

Chemistry:

	(1)	(2)
Pd	44.9	44.1
Cu	17.1	16.7
Se	38.8	39.2
Total	100.8	100.0

(1) Musonoi mine, Congo; by electron microprobe, corresponds to $(Pd_{4.28}Cu_{2.73})_{\Sigma=7.01}Se_{5.00}$.
(2) Do.; corresponds to $(Pd_{4.17}Cu_{2.64})_{\Sigma=6.81}Se_{5.00}$.

Occurrence: In the zone of oxidation (Musonoi mine, Congo).

Association: Verbeekite, trogtalite, selenian digenite, covellite (Musonoi mine, Congo); gold, chrisstanleyite, verbeekite (Hope's Nose, England).

Distribution: From the Musonoi Cu–Co mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire) [TL]. At the Copper Hills prospect, East Pilbara region, Western Australia. From Hope's Nose, Torquay, Devon, England.

Name: For Robert Oosterbosch (1908–), Belgian mining engineer, for many years involved in the development of the Shaba mines.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, R. Pierrot, and T. Verbeek (1970) L'oosterboschite $(Pd, Cu)_7Se_5$, une nouvelle espèce minérale, et la trogtalite cupro-palladifére de Musonoi (Katanga). Bull. Soc. fr. Minéral., 93, 476–481 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1553 (abs. ref. 1).

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Orcelite $Ni_{5-x}As_2$ (x = 0.23)

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Crystal Data: Hexagonal. *Point Group:* n.d. As inclusions in pentlandite and rimming maucherite, to 0.05 mm; as disseminated grains.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = 6.5 D(calc.) = 8.50

Optical Properties: Opaque. *Color:* Rose-bronze, browner than nickeline; pale orange in polished section. *Luster:* Metallic. *Pleochroism:* Low, weaker than nickeline. *Anisotropism:* Noticeable, without distinct colors. *Bireflectance:* Weak.
R: (400) 42.3, (420) 42.9, (440) 43.6, (460) 44.5, (480) 45.5, (500) 46.7, (520) 47.8, (540) 49.1, (560) 50.5, (580) 51.8, (600) 53.3, (620) 54.7, (640) 56.0, (660) 57.2, (680) 58.2, (700) 59.0

Cell Data: *Space Group:* n.d. $a = 6.815(3)$ $c = 12.498(7)$ $Z = 6$

X-ray Powder Pattern: Tiébaghi massif, New Caledonia.
1.977 (10), 1.918 (10), 2.110 (4), 1.810 (4), 1.737 (4), 1.380 (4), 1.650 (3)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	57.00	64.41	64.3	65.14
Fe			0.2	
As	31.50	35.59	35.1	34.86
S	1.00		0.1	
SiO_2	4.00			
Fe_2O_3	0.85			
MgO	3.80			
H_2O	1.50			
Total	99.65	100.00	99.7	100.00

(1) Tiébaghi massif, New Caledonia; includes 9.15% antigorite as impurity. (2) Do.; analysis (1) with Ni and As recalculated to 100%. (3) Nebral, Spain; by electron microprobe. (4) $Ni_{5-x}As_2$, x = 0.23.

Occurrence: As inclusions in pentlandite in serpentinized harzburgite.

Association: Pentlandite, heazlewoodite, millerite, parkerite, maucherite, breithauptite, magnetite, nickel, copper, chalcopyrite, chalcocite, galena.

Distribution: From the Tiébaghi massif, New Caledonia [TL]. On Table Mountain and Blow-Me-Down Mountain, Newfoundland, and in the Nipissing mine, Cobalt, Ontario, Canada. In the Ronda massif, at Nebral, Málaga Province, Spain. From the Cliff region, Unst, Shetland, Scotland. In the Kauniinvaara ultramafic lens, near Lake Kauniinlampi, eastern Finland. From the Vozhmin massif, Karelia, Russia. At Polling, Salzburg, Austria. From Vourinos, Greece. At Beni Bousera, Morocco.

Name: For Professor Jean Orcel (1896–1978), French mineralogist.

Type Material: Museum of Natural History, Paris; National School of Mines, Paris, France.

References: (1) Caillère, S., J. Avias, and J. Falgueirettes (1959) Découverte en Nouvelle Calédonie d'une minéralisation arsénicale sous forme d'un nouvel arséniure de nickel, Ni_2As. Compt. Rendus Acad. Sci. Paris, 249, 1771–1773 (in French). (2) (1960) Amer. Mineral., 45, 753–754 (abs. ref. 1). (3) Caillère, S., J. Avias, and J. Falgueirettes (1961) Sur un nouvel arséniure de nickel (Ni_2As). L'orcélite. Bull. Soc. fr. Minéral., 84, 9–12. (4) Lorand, J.P. and M. Pinet (1984) L'orcelite des peridotites de Beni Bousera (Maroc), Ronda (Espagne), Table Mountain et Blow-Me-Down Mountain (Terre-Neuve) et du Pinde Septentrional (Grèce). Can. Mineral., 22, 553–560 (in French with English abs.). (5) Oen, I.S., C. Kieft, E.A.J. Burke, and A.B. Westerhof (1980) Orcelite and associated minerals in the Ni – Fe – As – S system in chromitites and orthopyroxenites of Nebral, Málaga, Spain. Bull. Minéral., 103, 198–208.

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Ordóñezite $ZnSb_2^{5+}O_6$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Tetragonal pyramidal crystals, to 2 mm, showing {001}, {110}, and {011}, universally twinned, in drusy or stalactitic masses. *Twinning:* Common on {013}, repeated.

Physical Properties: *Fracture:* Conchoidal. Hardness = 6.5 D(meas.) = 6.635 D(calc.) = 6.657

Optical Properties: Semitransparent. *Color:* Very light to very dark brown, colorless to pearl-gray, light yellowish olive to dark olive. *Luster:* Adamantine.
Optical Class: Uniaxial (+). $\omega = > 2.0$ $\epsilon = > 2.0$

Cell Data: *Space Group:* $P4/mnm$. $a = 4.67(1)$ $c = 9.24(1)$ Z = 2

X-ray Powder Pattern: Santín mine, Mexico.
1.72 (100), 3.26 (90), 2.55 (80), 1.38 (60), 1.19 (60), 1.64 (50), 1.47 (50)

Chemistry:

	(1)
Sb_2O_5	80.49
SiO_2	0.00
Al_2O_3	0.00
ZnO	20.07
Total	100.56

(1) Santín mine, Mexico; corresponds to $Zn_{1.00}Sb_{2.02}O_6$.

Mineral Group: Ferrotapiolite group.

Occurrence: Deposited at a late stage with pneumatolytic tin ore in fractures in rhyolite (Santín mine, Mexico).

Association: Cassiterite, hematite, quartz, cristobalite, "hyalite", montmorillonite (Santín mine, Mexico); byströmite, chenevixite, malachite (El Antimonio, Mexico).

Distribution: At the Santín mine, about eight km from Santa Caterina, Guanajuato, and from El Antimonio, 27 km southwest of Agua Prieta, Sonora, Mexico.

Name: For Ezequiel Ordóñez (1867–1950), noted Mexican geologist, formerly Director of the Geological Institute of Mexico.

Type Material: The Natural History Museum, London, England, 1965,208; Harvard University, Cambridge, Massachusetts, 110282; National Museum of Natural History, Washington, D.C., USA, R9127.

References: (1) Switzer, G. and W.F. Foshag (1955) Ordoñezite, zinc antimonate, a new mineral from Guanajuato, Mexico. Amer. Mineral., 40, 64–69.

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Örebroite $Mn_3^{2+}(Sb^{5+},Fe^{3+})(SiO_4)(O,OH)_3$

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Crystal Data: Hexagonal. *Point Group:* 3. As fine-grained, polycrystalline intergrowths and massive.

Physical Properties: *Fracture:* Irregular. Hardness = ∼4 D(meas.) = n.d. D(calc.) = 4.77 Weakly magnetic, probably due to inclusions of magnetite.

Optical Properties: Nearly opaque. *Color:* Dark brown. *Streak:* Reddish brown.
Luster: Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.857(3)$ $\epsilon = 1.875(3)$

Cell Data: *Space Group:* $P3$ (probable). $a = 8.183(7)$ $c = 4.756(9)$ $Z = 2$

X-ray Powder Pattern: Sjö mine, Sweden.
3.096 (100), 1.778 (90), 2.334 (70), 2.838 (50), 1.550 (50), 2.680 (40), 4.08 (30)

Chemistry:

	(1)
SiO_2	15.2
WO_3	0.0
Al_2O_3	0.3
Fe_2O_3	9.2
Sb_2O_5	15.8
As_2O_5	1.6
V_2O_5	0.0
MnO	54.6
MgO	0.8
H_2O	[2.8]
Total	[100.3]

(1) Sjö mine, Sweden; by electron microprobe, H_2O by analogy to welinite; corresponds to $Mn_{3.04}(Fe^{3+}_{0.46}Sb_{0.38}Mg_{0.08}As_{0.06}Al_{0.02})_{\Sigma=1.00}Si_{1.00}[O,(OH)]_{\Sigma=\sim 7}$.

Occurrence: A fine-grained aggregate with antimonates.

Association: Calcite, hausmannite, magnetite, dolomite.

Distribution: At the Sjö mine, near Grythyttan, Örebro, Sweden.

Name: For the town of Örebro, Sweden, about 60 km southeast of the Sjö mine.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, RM 93:0255; National Museum of Natural History, Washington, D.C., USA, 163008.

References: (1) Dunn, P.J., D.R. Peacor, R.C. Erd, and R.A. Ramik (1986) Franciscanite and örebroite, two new minerals from California and Sweden, related to redefined welinite. Amer. Mineral., 71, 1522–1526.

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Oregonite Ni_2FeAs_2(?)

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Crystal Data: Hexagonal. *Point Group:* n.d. As fine-grained pebbles, having a smooth brown crust; polygonal grains, to 0.5 mm.

Physical Properties: *Tenacity:* Ductile. Hardness = 5 VHN = n.d. D(meas.) = n.d. D(calc.) = 6.92

Optical Properties: Opaque. *Color:* In polished section, white. *Anisotropism:* Weak.
R: (400) 41.7, (420) 43.0, (440) 44.3, (460) 45.3, (480) 46.1, (500) 46.7, (520) 47.2, (540) 48.0, (560) 48.9, (580) 50.1, (600) 51.3, (620) 52.8, (640) 54.2, (660) 55.4, (680) 56.4, (700) 57.2

Cell Data: *Space Group:* n.d. $a = 6.083$ $c = 7.130$ $Z = 3$

X-ray Powder Pattern: Josephine Creek, Oregon, USA.
2.314 (vs), 2.120 (vs), 1.991 (s), 1.789 (s), 1.757 (s), 1.739 (s), 3.571 (m)

Chemistry: Composition established by X-ray fluorescence, analysis not given.

Occurrence: As water-rolled pebbles in clinochlore and serpentine (Oregon, USA).

Association: Copper, bornite, chalcopyrite, molybdenite, chromite (Oregon, USA); pyrrhotite, magnetite (Cyprus).

Distribution: From Josephine Creek, west of Kerby, Josephine Co., Oregon, USA [TL]. In the Alexo mine, near Timmins, Ontario, Canada. From near Skouriotissa, Cyprus. In the Ijim massif, west Sayan, Russia.

Name: For the state of Oregon, USA.

Type Material: n.d.

References: (1) Ramdohr, P. and M. Schmitt (1959) Oregonit, ein neues Nickel–Eisenarsenid mit metallartigen Eigenschaften. Neues Jahrb. Mineral., Monatsh., 239–247 (in German).
(2) (1960) Amer. Mineral., 45, 1130 (abs. ref. 1). (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 399.

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Orickite $(Na,K)_{0.4}CuFeS_2 \cdot 0.3H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. As grains and laths, to 150 μm.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* Conchoidal. Hardness = ~3.5 VHN = n.d. D(meas.) = n.d. D(calc.) = 4.212 Weakly magnetic.

Optical Properties: Opaque. *Color:* Brass-yellow. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak, pale yellow to slightly deeper yellow. *Anisotropism:* Strong, from grayish brown to grayish blue.
R_1–R_2: (470) 34.7, (546) 39.9, (589) 42.8, (650) 46.9

Cell Data: *Space Group:* n.d. $a = 3.695(1)$ $c = 6.16(1)$ $Z = 4$

X-ray Powder Pattern: Near Orick, California, USA.
3.08 (100), 3.20 (90), 1.85 (70), 2.84 (60), 1.73 (55), 1.583 (30), 2.20 (20)

Chemistry:

	(1)
Na	0.4
K	0.2
Cu	31.7
Fe	31.0
S	33.6
H_2O	[3.1]
Total	[100.0]

(1) Near Orick, California, USA; by electron microprobe, average of six grains, H_2O by difference (1.5% to 5.1% oxygen qualitatively determined, presumed to be in H_2O); then corresponds to $(Na_{0.03}K_{0.01})_{\Sigma=0.04}Cu_{0.95}Fe_{1.06}S_{2.00} \cdot 0.33H_2O$.

Occurrence: In an alkalic mafic diatreme, in small pegmatitic clots thought to have crystallized late in the consolidation of the Coyote Peak intrusive.

Association: Djerfisherite, rasvumite, bartonite, erdite, coyoteite, phlogopite, schorlomite, acmite, sodalite, cancrinite, pectolite, natrolite, magnetite, calcite.

Distribution: From Coyote Peak, near Orick, Humboldt Co., California, USA [TL].

Name: For the town of Orick, California, USA, near the locality.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150336.

References: (1) Erd, R.C. and G.K. Czamanske (1983) Orickite and coyoteite, two new sulfide minerals from Coyote Peak, Humboldt Co., California. Amer. Mineral., 68, 245–254.

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Orientite $Ca_2Mn^{2+}Mn_2^{3+}Si_3O_{10}(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals exhibit {110}, {001}, and poorly developed to absent {100}; thin to thick tabular on {001}, pseudohexagonal in outline, to 1 mm. In rosettes of crystals, drusy aggregates, framboidal, finely disseminated.

Physical Properties: *Cleavage:* Perfect to imperfect on {001}; may be a parting. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 3.05–3.33 D(calc.) = 3.48

Optical Properties: Transparent to translucent. *Color:* Light reddish brown, chocolate-brown when enclosing manganese oxides. *Streak:* Brown. *Luster:* Resinous, semimetallic; pitchy to dull when included.
Optical Class: Biaxial (+) or (–). *Dispersion:* $r < v$, very strong. *Pleochroism:* X = red-brown to brownish yellow; Y = yellow to reddish brown; Z = brownish yellow to deep brownish red. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Absorption:* $Z > Y > X$. α = 1.756–1.765 β = 1.777–1.79 γ = 1.794–1.81 2V(meas.) = 67°–83°

Cell Data: *Space Group: Ccmm.* $a = 9.074(4)$ $b = 6.121(2)$ $c = 19.130(7)$ Z = 4

X-ray Powder Pattern: Manganese Lake, Michigan, USA.
9.448 (100), 4.740 (100), 3.026 (45), 4.070 (35), 3.270 (30), 4.509 (25), 4.388 (15)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	32.48	31.21	31.89	MgO		0.46	
Al_2O_3	1.08	0.00		CaO	22.47	20.25	19.84
Fe_2O_3	1.56	0.00		K_2O		0.09	
Mn_2O_3	33.19	33.64	41.90	H_2O	7.93	[7.93]	6.37
V_2O_5		0.96		SO_3		1.00	
CuO		2.09		Total	98.71	[97.63]	100.00

(1) Oriente Province, Cuba; recalculated for total Mn as Mn_2O_3. (2) Manganese Lake, Michigan, USA; average of three analyses, by electron microprobe, total Mn as Mn_2O_3, H_2O from (1). (3) $Ca_2Mn^{2+}Mn_2^{3+}Si_3O_{10}(OH)_4$ with total Mn as Mn_2O_3.

Occurrence: In manganese orebodies in latite and andesite tuffs, agglomerates, and limestones (Oriente Province, Cuba); replacing calcite in fissures and lenses in basalt (Manganese Lake, Michigan, USA).

Association: Todorokite, manganite, pyrolusite, neotocite, barite, quartz, calcite (Oriente Province, Cuba); braunite, manganite, calcite (Manganese Lake, Michigan, USA).

Distribution: In Cuba, in Oriente Province, about 10 km south of Bueycito; and near Banes, north of Antilla. In the USA, from near Manganese Lake, Copper Harbor, Keweenaw Co., Michigan. In the Wessels mine, near Kuruman, Cape Province, South Africa. In the Cerchiara mine, near Faggiona, La Spezia, Liguria, Italy.

Name: For the occurrence in Oriente Province, Cuba.

Type Material: National Museum of Natural History, Washington, D.C., USA, 93819; The Natural History Museum, London, England, 1923,1029.

References: (1) Hewett, D.F. and E.V. Shannon (1921) Orientite, a new hydrous silicate of manganese and calcium from Cuba. Amer. J. Sci., 1, 491–506. (2) Moore, P.B., J. Ito, and I.M. Steele (1979) MacFallite and orientite: calcium manganese (III) silicates from upper Michigan. Mineral. Mag., 43, 325–331. (3) Sclar, C.B. (1961) Optical crystallography of orientite from Oriente Province, Cuba. Amer. Mineral., 46, 226–232. (4) Moore, P.B., J. Shen, and T. Araki (1985) Crystal chemistry of the $^{2}_{\infty}[M_2^{3+}\Phi_2(TO_4)_2]$ sheet: structural principles and crystal structures of ruizite, macfallite and orientite. Amer. Mineral., 70, 171–181.

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Orlandiite $Pb_3(Se^{4+}O_3)Cl_4 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Flattened and elongated crystals, to 0.1 mm, with ragged terminations.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.66

Optical Properties: Semitransparent. *Color:* Colorless to white. *Luster:* Vitreous to silky. *Optical Class:* [Biaxial.] $n = 1.96(5)$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.136(3)$ $b = 8.430(6)$ $c = 9.233(7)$ $\alpha = 62.58(7)°$ $\beta = 71.84(4)°$ $\gamma = 75.13(4)°$ Z = 2

X-ray Powder Pattern: Baccu Locci mine, Italy; intensities calculated from the crystal structure.
4.00 (100), 3.258 (75), 3.188 (75), 3.818 (55), 3.731 (44), 2.103 (40), 2.728 (38)

Chemistry:

	(1)	(2)
SO_2	0.20	
SeO_2	12.31	12.22
FeO	0.42	
CuO	0.39	
CdO	0.11	
ZnO	0.35	
PbO	74.18	73.71
Cl	14.35	15.61
H_2O	[2.34]	1.98
$-O = Cl_2$	3.24	3.52
Total	[101.41]	100.00

(1) Baccu Locci mine, Italy; by electron microprobe, H_2O from crystal-structure analysis, confirmed by IR; corresponds to $Pb_3(SeO_3)[Cl_{3.68}(OH)_{0.32}]_{\Sigma=4.00} \cdot H_2O$. (2) $Pb_3(SeO_3)Cl_4 \cdot H_2O$.

Occurrence: In the oxidized zone of a hydrothermal base-metal deposit, in a selenium-rich part.

Association: Chalcomenite, atacamite, pseudoboléite, chlorargyrite.

Distribution: From the Baccu Locci Pb–As mine, near Villaputzu, Sarrabus district, Sardinia, Italy.

Name: To honor Paolo Orlandi (1946–), Professor of Mineralogy, University of Pisa, Pisa, Italy, who has described a variety of new minerals from Italy.

Type Material: University of Milan, Milan, Italy.

References: (1) Campostrini, I., C.M. Gramaccioli, and F. Demartin (1999) Orlandiite, $Pb_3Cl_4(SeO_3) \cdot H_2O$, a new mineral species, and an associated lead-copper selenite chloride from the Baccu Locci mine, Sardinia, Italy. Can. Mineral., 37, 1493–1498. (2) (2000) Amer. Mineral., 85, 1563 (abs. ref. 1).

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Orlymanite $Ca_4Mn_3^{2+}Si_8O_{20}(OH)_6 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$ or 3. As fibrous crystals, with fibrils ‖ [1000], forming spheres, to 3 mm; in irregular botryoidal aggregates.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = 4–5 D(meas.) = 2.7–2.8 D(calc.) = 2.93

Optical Properties: Translucent. *Color:* Dark brown; in transmitted light, light to dark brown. *Streak:* Light brown. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = pale brown; E' = dark brown. $\omega = 1.598$ ϵ = n.d.

Cell Data: *Space Group:* $P\bar{3}$ or $P3$. $a = 9.60(2)$ $c = 35.92(10)$ Z = 5

X-ray Powder Pattern: Wessels mine, South Africa.
3.60 (100), 1.840 (90), 3.13 (80b), 7.15 (70), 4.18 (70), 2.545 (40b), 2.469 (40b)

Chemistry:

	(1)
SiO_2	46.8
Al_2O_3	0.2
Fe_2O_3	0.8
MnO	19.7
MgO	1.6
CaO	21.6
Na_2O	0.6
H_2O	8.68
Total	100.0

(1) Wessels mine, South Africa; by electron microprobe, H_2O by the Penfield method; corresponds to $(Ca_{18.6}Mn_{13.4}Mg_{2.4}Na_{0.7}Fe_{0.5})_{\Sigma=35.6}(Si_{37.7}Al_{0.2})_{\Sigma=37.9}O_{111} \cdot 23.3H_2O$.

Occurrence: Apparently as a vein mineral in a manganese ore body.

Association: Inesite, hematite, calcite.

Distribution: In a specimen attributed to the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: In honor of Orlando Lyman (?–1986), founder of the Lyman House Memorial Museum in Hilo, Hawaii, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 166368.

References: (1) Peacor, D.R., P.J. Dunn, and J.A. Nelen (1990) Orlymanite, $Ca_4Mn_3Si_8O_{20}(OH)_6 \cdot 2H_2O$, a new mineral from South Africa: a link between gyrolite-family and conventional phyllosilicate minerals? Amer. Mineral., 75, 923–927.

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Orpheite $H_6Pb_{10}Al_{20}(PO_4)_{12}(SO_4)_5(OH)_{40}\cdot 11H_2O(?)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As rhombohedral crystals, to 0.5 mm; as colloform crusts with radial and granular structure and replacements of pyromorphite.

Physical Properties: *Cleavage:* On {0001}, indistinct. Hardness = 3.5 VHN = 261 (50 g load). D(meas.) = 3.75(1) D(calc.) = 3.84 May fluoresce turquoise-blue.

Optical Properties: Transparent. *Color:* Colorless, gray; pale blue, pale green, yellow-green with copper impurity, may be finely zoned. *Streak:* White to pale blue. *Luster:* Vitreous, dull in aggregates.
Optical Class: Uniaxial (+); uniaxial (–) in part. $\omega = 1.682$–1.704 $\epsilon = 1.670$–1.691

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.00(2)$ $c = 16.72(2)$ $Z = 0.32$

X-ray Powder Pattern: Madjarovo deposit, Bulgaria; close to hinsdalite. (ICDD 29-756).
5.66 (100), 2.967 (97), 3.50 (67), 1.901 (33), 1.749 (26), 4.91 (22), 2.209 (22)

Chemistry:

	(1)
SO_3	8.32
P_2O_5	17.09
As_2O_5	0.07
Al_2O_3	20.20
CuO	0.52
PbO	40.63
CaO	1.27
H_2O^+	12.30
H_2O^-	0.01
LOI	0.10
Total	100.51

(1) Madjarovo deposit, Bulgaria; estimated to contain pyromorphite about 4%; corresponds to $H_{6.00}(Pb_{9.05}Ca_{1.10})_{\Sigma=10.15}(Al_{19.75}Cu_{0.30})_{\Sigma=20.05}[(PO_4)_{12.00}(AsO_4)_{0.05}]_{\Sigma=12.05}(SO_4)_{5.15}(OH)_{39.80}\cdot 11.10H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a polymetallic deposit.

Association: Pyromorphite, anglesite, kaolinite, Fe–Mn hydroxides.

Distribution: From the Madjarovo Pb–Zn deposit, eastern Rhodopes Mountains, 60 km southeast of Haskovo, Bulgaria.

Name: For *Orpheus*, mythical singer in the Rhodopes Mountains.

Type Material: Natural History Museum, Sofia; University of Sofia, Sofia, Bulgaria, 1833.

References: (1) Kolkovski, B. (1971–1972) Orpheite, a new mineral from Madjarovo deposit, eastern Rhodopes Mountain, Bulgaria. Ann. Univ. Sofia, Fac. Geol. Geogr., 64, 107–130 (in English). (2) (1974) Mineral. Abs., 25, 240 (abs. ref. 1). (3) (1976) Amer. Mineral., 61, 176 (abs. ref. 1).

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Orpiment As_2S_3

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Commonly in foliated columnar or fibrous aggregates, with cleavages as much as 60 cm across; may be reniform or botryoidal; also granular or powdery; rarely as prismatic crystals, to 10 cm. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Perfect on {010}, imperfect on {100}; cleavage lamellae are flexible. *Tenacity:* Sectile. Hardness = 1.5–2 VHN = n.d. D(meas.) = 3.49 D(calc.) = 3.48

Optical Properties: Transparent. *Color:* Lemon-yellow to golden or brownish yellow. *Streak:* Pale lemon-yellow. *Luster:* Resinous, pearly on cleavage surface. *Optical Class:* Biaxial (–). *Pleochroism:* In reflected light, strong, white to pale gray with reddish tint; in transmitted light, Y = yellow, Z = greenish yellow. *Orientation:* $X = b$; $Z \wedge c = 2°$. *Dispersion:* $r > v$, strong. $\alpha = 2.4$ (Li). $\beta = 2.81$ (Li). $\gamma = 3.02$ (Li). 2V(meas.) = 76° *Anisotropism:* Barely observable because of strong internal reflections.

R_1–R_2: (400) 33.0–36.5, (420) 31.0–35.2, (440) 28.9–33.9, (460) 27.4–31.5, (480) 26.0–30.3, (500) 24.9–29.3, (520) 24.0–28.4, (540) 23.3–27.8, (560) 22.8–27.3, (580) 22.3–26.9, (600) 22.0–26.5, (620) 21.7–26.3, (640) 21.5–26.0, (660) 21.2–25.7, (680) 21.0–25.5, (700) 20.8–25.3

Cell Data: *Space Group:* $P2_1/n$. $a = 11.475(5)$ $b = 9.577(4)$ $c = 4.256(2)$ $\beta = 90°41(5)'$ $Z = 4$

X-ray Powder Pattern: Baia Sprie (Felsőbánya), Romania.
4.85 (100), 4.02 (50), 2.47 (40), 1.755 (40), 3.22 (30), 2.79 (30), 2.72 (30)

Chemistry: Stated to be very near As_2S_3.

Occurrence: In low-temperature hydrothermal veins, hot springs and fumaroles; also commonly as an alteration product of arsenic minerals, especially realgar.

Association: Stibnite, realgar, arsenic, calcite, barite, gypsum.

Distribution: Not uncommon in small amounts, but rare in fine specimens. In the USA, crystallized from Mercur, Tooele Co., Utah; in Nevada, at the Getchell mine, Humboldt Co.; from the White Caps mine, Manhattan, Nye Co.; with fine examples from in the Twin Creeks mine, Humboldt Co. At Tajov, Slovakia. From Křeševo, Bosnia-Herzegovina. At Alšar (Allchar), near Rošden, Macedonia. Fine crystals from the Zarshuran gold deposit, 35 km north of Takab, northwestern Iran. From Jelamerk, Turkey. In Russia, at Loukhoumi, Caucasus Mountains, and Men-Kyule, Sakha. From Racha Luyumi, Georgia. Large crystals from the Shimen mine, 33 km southeast of Shimen, Hunan Province, China. Exceptional specimens from the Quiruvilca mine, La Libertad, Peru.

Name: From the Latin *auripigmentum*, *golden paint*, in allusion to the color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 266–269. (2) Mullen, D.J.E. and W. Nowacki (1972) Refinement of the crystal structures of realgar, AsS and orpiment, As_2S_3. Zeits. Krist., 136, 48–65. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 80–81. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 400.

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Orschallite $Ca_3(SO_3)_2(SO_4)\cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Pseudocubic crystals, to 0.3 mm.

Physical Properties: *Fracture:* Irregular. Hardness = ∼4 D(meas.) = 1.90(3) D(calc.) = 1.87

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.4941(4)$ $\epsilon = 1.4960(4)$

Cell Data: *Space Group:* $R\overline{3}c$. $a = 11.350(1)$ $c = 28.321(2)$ $Z = 6$

X-ray Powder Pattern: Hannebacher Ley volcano, Germany.
5.73 (100), 8.11 (80), 2.69 (80), 3.63 (60), 3.28 (40), 2.11 (40), 4.87 (30)

Chemistry: (1) Hannebacher Ley volcano, Germany; characterized by the identity of the X-ray pattern with that of synthetic material, as well as crystal-structure analysis of the natural mineral.

Occurrence: A rare species, an intermediate stage in oxidation of sulfides to sulfates, preserved in a melilite nepheline leucitite quenched during a submarine volcanic eruption.

Association: Clinopyroxene, apatite, phillipsite, calcite.

Distribution: From the Hannebacher Ley volcano, one km east-northeast of Hannebach, Eifel, Germany.

Name: To honor P. Orschall, Cologne, Germany, who discovered the mineral.

Type Material: Institute of Mineralogy and Crystallography, University of Vienna, Vienna, Austria.

References: (1) Weidenthaler, C., E. Tillmanns, and G. Hentschel (1993) Orschallite, $Ca_3(SO_3)_2SO_4 \cdot 12H_2O$, a new calcium-sulfite-sulfate-hydrate mineral. Mineral. Petrol., 48, 167–177. (2) (1994) Amer. Mineral., 79, 572 (abs. ref. 1).

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Orthobrannerite $U^{4+}U^{6+}Ti_4O_{12}(OH)_2$

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Crystal Data: Orthorhombic; metamict. *Point Group:* n.d. As prismatic crystals, to 1.2 cm, showing {001}, {120}, {021}, {110}, {140}, rarely {210}, {180}, striated ‖ [001].

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 515–532 (100–250 g load). D(meas.) = 5.46 D(calc.) = 5.46 Strongly radioactive.

Optical Properties: Semitransparent. *Color:* Black; in reflected light, grayish white with reddish brown internal reflections. *Streak:* Dark brown to black. *Luster:* Adamantine. *Optical Class:* Isotropic. $n = 2.328$
R: 15–17

Cell Data: *Space Group:* n.d. $a = 7.37$ $b = 11.67$ $c = 6.33$ Z = 2

X-ray Powder Pattern: China; after heating at 1000 °C.
3.17 (10), 2.45 (9), 1.659 (9), 3.89 (8), 4.87 (7), 1.203 (6), 2.29 (5)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	31.08	32.01	RE_2O_3	0.28	
Nb_2O_5	0.19		Fe_2O_3	0.40	
Ta_2O_5	0.01		PbO	0.17	
SiO_2	0.65		CaO	0.44	
TiO_2	35.35	35.75	H_2O^+	1.11	2.02
ThO_2	1.03		H_2O^-	0.76	
UO_2	28.75	30.22	Total	100.22	100.00

(1) China; corresponds to $(U^{6+}_{0.48}U^{4+}_{0.47}Ca_{0.04}Th_{0.02}RE_{0.01})_{\Sigma=1.02}(Ti_{1.97}Fe_{0.02}Nb_{0.01})_{\Sigma=2.00}O_{6.01}(OH)_{0.93}$. (2) $U^{4+}U^{6+}Ti_4O_{12}(OH)_2$.

Polymorphism & Series: Dimorphous with brannerite (?).

Occurrence: In weathered biotite pyroxene syenite (Yunan, China); in an alkalic lamprophyre (Szechwan, China).

Association: n.d.

Distribution: From undefined localities in Yunan and Szechwan Provinces, China.

Name: As an ORTHOrhombic dimorph of *brannerite*.

Type Material: n.d.

References: (1) X-ray Laboratory, Peking Institute of Uranium Geology and X-ray Laboratory, Wuhan Geological College (1978) Orthobrannerite – a new mineral of the brannerite group. Acta Geol. Sinica, 52(3), 241–251 (in Chinese with English abs.). (2) (1979) Amer. Mineral., 64, 656 (abs. ref. 1).

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Orthochamosite $(Fe^{2+}, Mg, Fe^{3+})_5Al(Si_3Al)O_{10}(OH, O)_8$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $3m$ (pseudohexagonal). Fine-grained.

Physical Properties: Hardness = ~2 D(meas.) = 3.078 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* Pale green.
Optical Class: [Biaxial.] n = 1.640–1.650 2V(meas.) = n.d.

Cell Data: *Space Group:* $C3m$ (pseudohexagonal). a = 5.355 b = 9.293 c = 7.043 Z = 1

X-ray Powder Pattern: Ayrshire, Scotland.
7.04 (10), 3.513 (10), 2.514 (9), 1.552 (7), 2.137 (6), 2.673 (4), 1.765 (4)

Chemistry:

	(1)		(1)
SiO_2	22.03	Na_2O	0.08
TiO_2	3.63	K_2O	0.03
Al_2O_3	22.91	H_2O^+	10.65
Fe_2O_3	0.46	H_2O^-	0.63
Cr_2O_3	0.05	CO_2	0.40
FeO	36.68	P_2O_5	0.18
MnO	0.04	SO_3	0.27
MgO	1.91	org.	0.03
CaO	0.07	Total	100.05

(1) Ayrshire, Scotland.

Polymorphism & Series: Dimorphous with chamosite.

Mineral Group: Chlorite group.

Occurrence: In a lateritic clay derived from the alteration of olivine basalts (Ayrshire, Scotland).

Association: Siderite, clay minerals.

Distribution: From coalfields in Ayrshire, Scotland. At Kaňk, near Kutna Horá, Czech Republic. From Sainte-Barbe, Meurthe-et-Moselle, France. In Sweden, at Mangruvan, Örebro. From Saalfeld, Thuringia, Germany.

Name: As an ORTHOhexagonal dimorph of *chamosite*.

Type Material: n.d.

References: (1) Brindley, G.W. (1951) The crystal structure of some chamosite minerals. Mineral. Mag., 29, 502–522. (2) Novák, F., J. Vtelensky, J. Losert, F. Kupa, and Z. Valcha (1958) The orthochamosite from the ore veins of Kank near Kutna Hora – a new specific mineral. Frantisek Slavik Memorial Vol., Czech Acad. Sci., 1957, 315–344 (in Czech with English summary). (3) (1958) Amer. Mineral., 43, 792 (abs. ref. 2).

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Orthochrysotile $Mg_3Si_2O_5(OH)_4$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* n.d. Fibrous along [100]; asbestiform.

Physical Properties: *Tenacity:* Brittle, in part. Hardness = 2.5 D(meas.) = n.d. D(calc.) = [2.58]

Optical Properties: Translucent. *Color:* Yellow, white, gray, green. *Luster:* Greasy, silky in aggregates.
Optical Class: Biaxial (–). α = 1.532–1.549 β = n.d. γ = 1.545–1.556 2V(meas.) = n.d.

Cell Data: *Space Group:* *C* [*sic*]. a = 5.32 *b* = 9.17 *c* = 14.64 Z = 4

X-ray Powder Pattern: Transvaal, South Africa. (ICDD 25-645).
7.36 (100), 3.66 (80), 1.531 (65), 4.56 (50), 2.50 (50), 2.604 (40), 1.310 (40)

Chemistry: Material positively known to be this species apparently has not been analyzed.

Polymorphism & Series: Polymorphous with antigorite, clinochrysotile, lizardite, and parachrysotile; also denoted as chrysotile-2Or$_{c1}$.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Commonly intermixed with clinochrysotile in veinlets cutting serpentinite.

Association: Clinochrysotile.

Distribution: Probably not uncommon, but difficult to characterize as intermixed with the more common clinochrysotile. The structure was determined on material from Cuddapah, Andhra Pradesh, India.

Name: Refers to the mineral's ORTHOrhombic structure, with *chrysotile* from the Greek for *golden* and *fiber*.

Type Material: n.d.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 170–190. (2) Whittaker, E.J.W. (1956) The structure of chrysotile. III. Ortho-chrysotile. Acta Cryst., 9, 862–864. (3) Wicks, F.J. and E.J.W. Whittaker (1975) A reappraisal of the structure of the serpentine minerals. Can. Mineral., 13, 227–243. (4) Yada, K. (1979) Microstructures of chrysotile and antigorite by high-resolution electron microscopy. Can. Mineral., 17, 679–691. (5) Bayliss, P. (1981) Unit cell data of serpentine group minerals. Mineral. Mag., 44, 153–156. (6) Wicks, F.J. and D.S. O'Hanley (1988) Serpentine minerals: structures and petrology. In: S.W. Bailey, Ed., Hydrous phyllosilicates. Rev. Mineral. 19, MSA, 91–167.

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Orthoclase $KAlSi_3O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly short prismatic along [100] or [001], tabular on [010], to 20 cm. Cleavable, granular, massive. *Twinning:* Common as simple, contact, or penetration twins according to the Carlsbad, Baveno, or Manebach laws.

Physical Properties: *Cleavage:* Perfect on {001} and {010}; partings on {100}, {110}, $\{\bar{1}10\}$, and $\{\bar{2}01\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.55–2.63 D(calc.) = 2.563

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, pale yellow, flesh-red, green; colorless in thin section; may exhibit opalescence or schiller iridescence. *Streak:* White. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge a = 14°$–$6°$; $Y \wedge c = -13°$ to $-21°$. *Dispersion:* $r > v$, distinct. α = 1.518–1.520 β = 1.522–1.524 γ = 1.522–1.525 2V(meas.) = 35°–75°

Cell Data: *Space Group:* $C2/m$. a = 8.5632(11) b = 12.963(14) c = 7.299(11) β = 116.073(9)° Z = 4

X-ray Powder Pattern: Selkingen, Switzerland. (ICDD 19-931).
3.31 (100), 3.77 (80), 4.22 (70), 3.24 (65), 3.29 (60), 2.992 (50), 3.47 (45)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	65.39	64.76	Na_2O	1.08	
Al_2O_3	18.45	18.32	K_2O	14.76	16.92
BaO	0.02		Rb_2O	0.49	
			Total	100.19	100.00

(1) Himalaya mine, Mesa Grande district, California, USA; by electron microprobe, corresponds to $(K_{0.86}Na_{0.10})_{\Sigma=0.96}Al_{1.00}Si_{3.00}O_8$. (2) $KAlSi_3O_8$.

Polymorphism & Series: Dimorphous with microcline; forms a series with celsian.

Mineral Group: Feldspar (alkali) group; (Al,Si) commonly only partially ordered.

Occurrence: The common feldspar of granites, granite pegmatites, and syenites. In cavities in basalts; in high-grade metamorphic rocks and as a result of potassic hydrothermal alteration; also authigenic and detrital.

Association: Albite, muscovite, biotite, "hornblende," schorl, beryl.

Distribution: Widespread. Fine examples from St. Gotthard, Ticino, and at Val Giuv, Tavetsch, Graubünden, Switzerland. In the Zillertal, Tirol, Austria. From Baveno, Piedmont, in the Pfitschtal, Trentino-Alto Adige, and at San Piero in Campo, Elba, Italy. At Epprechtstein, Bavaria, Carlsbad, Bohemia, and Manebach, Thuringia, Germany. From Cornwall, England. In Russia, from the Mursinka-Alabashka area, near Yekaterinburg (Sverdlovsk), Ural Mountains. In the USA, from Maine, at Paris and Buckfield, Oxford Co; at Cornog, Chester Co., and Blue Hill and Lieperville, Delaware Co., Pennsylvania. In California, from the Pala and Mesa Grande districts, San Diego Co.; in Colorado, on Mt. Antero, Chaffee Co.; at Crystal Pass, Goodsprings, Clark Co., Nevada. From Guanajuato, Mexico. At Tanokamiyama, Shiga Prefecture, Japan. Gem crystals from Ampandrandava, Fianarantsoa, and Itrongay, near Betroka, Madagascar.

Name: From the Greek for *straight* and *fracture*, in allusion to the cleavage angle.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 314–321. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 6–93. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 345–348. (4) Prince, E., G. Donnay, and R.F. Martin (1973) Neutron diffraction refinement of an ordered orthoclase structure. Amer. Mineral., 58, 500–507. (5) Su, S.-C., F.D. Bloss, P.H. Ribbe, and D.B. Stewart (1984) Optic axial angle, a precise measure of Al,Si ordering in T_1 tetrahedral sites of K-rich alkali feldspars. Amer. Mineral., 69, 440–448.

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Orthoericssonite $BaMn_2^{2+}Fe^{3+}OSi_2O_7(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As thick plates, to 2 cm, tabular ‖ {100}, which invariably include ericssonite. *Twinning:* Rarely on {100}, observed in thin section.

Physical Properties: *Cleavage:* Perfect on {100}, fair on {011}. *Tenacity:* Brittle. Hardness = 4.5–5.5 D(meas.) = 4.21–4.22 D(calc.) = 4.27 Weakly magnetic.

Optical Properties: Translucent. *Color:* Deep reddish black; in thin section, brown to yellowish brown. *Streak:* Deep brown. *Luster:* Submetallic to pearly on the cleavage. *Optical Class:* Biaxial (+); properties indistinguishable from ericssonite. *Pleochroism:* X = pale greenish tan, yellowish brown; Y = reddish brown; Z = deep brown. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, perceptible to strong. *Absorption:* $Z > Y > X$. α = 1.802–1.807 β = 1.833–1.840 γ = 1.888–1.890 2V(meas.) = 43°–50°

Cell Data: *Space Group: Pnmn.* $a = 20.37$ $b = 7.03$ $c = 5.34$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.510 (10), 2.687 (7b), 2.132 (7), 10.12 (6), 2.780 (6b), 1.752 (6), 1.597 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	20.83	24.97	23.83	MgO		0.70	
TiO_2		0.74		SrO		5.35	
Al_2O_3		0.35		BaO	29.81	21.26	30.41
Fe_2O_3	14.47	14.98	15.83	Li_2O		0.01	
As_2O_5	1.23			Na_2O		0.08	
FeO		7.91		K_2O		0.23	
MnO	24.38	21.49	28.14	H_2O	1.52	1.11	1.79
PbO	1.40			CO_2		0.61	
				Total	93.64	99.79	100.00

(1) Långban, Sweden; by electron microprobe, intergrown with ericssonite, oxidation states and H_2O separately determined. (2) Hijikuzu mine, Japan. (3) $BaMn_2FeOSi_2O_7(OH)$.

Polymorphism & Series: Dimorphous with ericssonite.

Occurrence: In a fine-grained manganoan aegirine zone in well-banded tephroite-rhodonite-manganoan aegirine skarn (Långban, Sweden); in metamorphosed manganese ore (Hijikuzu mine, Japan).

Association: Ericssonite, tephroite, rhodonite, manganoan aegirine, hedyphane, andradite, hausmannite, långbanite, richterite (Långban, Sweden); jacobsite, rhodonite, aegirine, tephroite, yoshimuraite (Hijikuzu mine, Japan).

Distribution: From Långban, Värmland, Sweden. In the Hijikuzu mine, Iwate Prefecture, Japan.

Name: For its ORTHOrhombic crystallization and relation to *ericssonite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120061.

References: (1) Moore, P.B. (1971) Ericssonite and orthoericssonite, two new members of the lamprophyllite group, from Långban, Sweden. Lithos, 4, 137–145. (2) (1971) Amer. Mineral., 56, 2157 (abs. ref. 1). (3) Matsubara, S. and K. Nagashima (1975) Orthoericssonite from the Hijikuzu mine, Iwate Prefecture, Japan. Mineral. J. (Japan), 7, 513–525. (4) Matsubara, S. (1980) The crystal structure of orthoericssonite. Mineral. J. (Japan), 10, 107–121.

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Orthojoaquinite-(Ce) $NaBa_2Ce_2Fe^{2+}Ti_2Si_8O_{26}(OH,F)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Bent flakes, to 1 mm, in banded gneissic or irregular masses; as intimate intergrowths with joaquinite-(Ce).

Physical Properties: *Cleavage:* {001}. Hardness = 5–5.5 VHN = 350–430
D(meas.) = 4.1 D(calc.) = [4.14]

Optical Properties: Transparent. *Color:* Brown. *Luster:* Silky.
Optical Class: Biaxial (+). *Pleochroism:* Strong in yellow-greens. $\alpha = 1.754$ $\beta = 1.760$
$\gamma = 1.797$ 2V(meas.) = 40°

Cell Data: *Space Group:* $Ccmm$, $Ccm2_1$, or $Cc2m$. $a = 10.48$ $b = 9.66$ $c = 22.26$
Z = [4]

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
2.80 (100), 5.58 (68), 2.95 (17), 1.596 (13), 2.91 (11), 3.00 (9), 2.232 (8)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	34.97	33.82	CaO	0.21	
TiO_2	11.83	9.20	SrO	3.20	
ThO_2	0.27	0.38	(Ca, Sr)O		0.03
Y_2O_3	0.70		BaO	22.44	21.46
RE_2O_3	18.46	22.59	Na_2O	1.87	2.41
Fe_2O_3		0.39	K_2O	0.03	0.22
Nb_2O_5		2.31	F		0.38
FeO	4.09	4.78	H_2O	[1.88]	1.50
MnO	0.00	0.70	$-O = F_2$		0.16
MgO	0.05		Total	[100.00]	100.01

(1) San Benito Co., California, USA; by electron microprobe, average of six points on five grains, intergrown with joaquinite-(Ce) of presumably nearly identical composition; RE_2O_3 = La_2O_3 2.14%, Ce_2O_3 10.69%, Pr_2O_3 1.25%, Nd_2O_3 3.21%, Sm_2O_3 0.70%, Gd_2O_3 0.26%, Dy_2O_3 0.21%, Er_2O_3 0.00%, H_2O by difference; corresponds to $Na_{0.83}K_{0.01}Ba_{2.01}Ca_{0.05}Mg_{0.02}(Ce_{0.90}RE_{0.72}Sr_{0.42})_{\Sigma=2.04}Fe_{0.78}Ti_{2.04}Th_{0.02}Si_{8.00}O_{24.68}(OH)_{3.32}$. (2) Ilímaussaq intrusion, Greenland; RE = La 44.5%, Ce 41.6%, Pr 4.4%, and Nd 9.5%.

Polymorphism & Series: Dimorphous with joaquinite-(Ce).

Mineral Group: Joaquinite group.

Occurrence: In a natrolite vein cutting a glaucophane schist inclusion in a serpentinite body (San Benito Co., California, USA); in nepheline-sodalite syenite pegmatites (Ilímaussaq intrusion, Greenland).

Association: Joaquinite-(Ce), benitoite, neptunite, natrolite (San Benito Co., California, USA); joaquinite-(Ce), natrolite, analcime, sodalite, steenstrupine, riebeckite (Ilímaussaq intrusion, Greenland).

Distribution: At the Gem mine, San Benito Co., California, USA. In southern Greenland, in the Ilímaussaq intrusion, along the Narssaq River, near Kvanefjeld.

Name: For its ORTHOrhombic symmetry, and relation to *joaquinite*-(Ce).

Type Material: n.d.

References: (1) Wise, W.S. (1982) Strontiojoaquinite and bario-orthojoaquinite: two new members of the joaquinite group. Amer. Mineral., 67, 809–816. (2) Laird, J. and A.L. Albee (1972) Chemical composition and physical, optical, and structural properties of benitoite, neptunite, and joaquinite. Amer. Mineral., 57, 85–102. (3) Dowty, E. (1975) Crystal structure of joaquinite. Amer. Mineral., 60, 872–878. (4) Semenov, E.I., V.I. Bukin, Y.A. Balashov, and H. Sørensen (1967) Rare earths in minerals of the joaquinite group. Amer. Mineral., 52, 1762–1769.

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Orthominasragrite $V^{4+}O(SO_4)\cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Irregular grains, to 200 μm, in crusts and efflorescences.

Physical Properties: Hardness = ∼1 D(meas.) = n.d. D(calc.) = 2.00 Readily dissolves in H_2O.

Optical Properties: Semitransparent. *Color:* Pale blue to bright blue. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (+), pseudouniaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$.
$\alpha = 1.529(2)$ $\beta = 1.534(2)$ $\gamma = 1.534(2)$ 2V(meas.) = 2° 2V(calc.) = 0°

Cell Data: *Space Group:* $Pmn2_1$. $a = 7.242(1)$ $b = 9.319(2)$ $c = 6.192(1)$ Z = 2

X-ray Powder Pattern: Temple Mountain, Utah, USA.
4.70 (100b), 3.322 (50), 2.865 (40), 2.602 (30), 3.734 (20), 3.622 (20), 3.108 (20)

Chemistry:

	(1)	(2)
SO_3	31.97	31.64
VO_2	33.88	32.77
H_2O	[36.30]	35.59
Total	[102.15]	100.00

(1) Temple Mountain, Utah, USA; by electron microprobe, H_2O from crystal-structure analysis; corresponds to $V_{1.01}O_{1.00}(S_{0.99}O_4)\cdot 5H_2O$. (2) $VO(SO_4)\cdot 5H_2O$.

Polymorphism & Series: Dimorphous with minasragrite.

Occurrence: In a silicified tree, formed as an oxidation product of pyrite reacting with vanadium-rich organic material.

Association: Minasragrite, pyrite, szomolnokite, kornelite, ferricopiapite, rozenite, montroseite, sulfur.

Distribution: From the [North Mesa No. 5 mine,] North Mesa mine group, Temple Mountain district, Emery County, Utah, USA.

Name: As the ORTHOrhombic polymorph of *minasragrite*.

Type Material: Canadian Museum of Nature, Ottawa, 83269; Canadian Geological Survey, Ottawa, Canada.

References: (1) Hawthorne, F.C., M. Schindler, J.D. Grice, and P. Haynes (2001) Orthominasragrite, $V^{4+}O(SO_4)(H_2O)_5$, a new mineral species from Temple Mountain, Emery County, Utah, U.S.A. Can. Mineral., 39, 1325–1331. (2) (2002) Amer. Mineral., 87, 997 (abs. ref. 1).

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Orthopinakiolite $(Mg, Mn^{2+})_2Mn^{3+}BO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As acicular crystals.

Physical Properties: Hardness = 6 D(meas.) = 3.935–4.03 D(calc.) = 4.06

Optical Properties: Opaque. *Color:* Black. *Luster:* Metallic.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.
R_1–R_2: n.d.

Cell Data: *Space Group: Pnnm.* $a = 18.357(4)$ $b = 12.591(2)$ $c = 6.068(1)$ Z = 16

X-ray Powder Pattern: Långban, Sweden.
2.59 (10), 5.17 (9), 2.52 (9), 2.03 (9), 2.20 (8), 1.523 (8), 3.01 (7)

Chemistry:

	(1)
SiO_2	0.78
B_2O_3	13.92
Fe_2O_3	10.52
Mn_2O_3	34.04
MnO	16.36
PbO	1.22
MgO	22.36
CaO	1.35
Total	100.55

(1) Långban, Sweden. (2) Do.; by electron microprobe, Mg 16.7%, Fe 5.8%, Mn 34.4%, stated to correspond to $(Mg_{1.42}Mn^{2+}_{0.43})_{\Sigma=1.85}Mn^{3+}_{0.88}Fe^{3+}_{0.22}BO_5$.

Occurrence: A very rare species formed in veinlets in granular dolomite in a metamorphosed Fe–Mn orebody.

Association: Hausmannite, manganophyllite, dolomite, calcite.

Distribution: From Långban, Värmland, Sweden.

Name: As an ORTHOrhombic mineral related to *pinakiolite*.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 420106.

References: (1) Randmets, R. (1960) Orthopinakiolite, a new modification of $Mg_3Mn^{2+}Mn^{3+}_2B_2O_{10}$ from Långban, Sweden. Arkiv Mineral. Geol., 2(42), 551–555. (2) (1961) Amer. Mineral., 46, 768 (abs. ref. 1). (3) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 324–325 [pinakiolite]. (3) Takéuchi, Y., N. Haga, T. Kato, and Y. Miura (1978) Orthopinakiolite, $Me_{2.95}O_2[BO_3]$: its crystal structure and relation to pinakiolite, $Me_{2.90}O_2[BO_3]$. Can. Mineral., 16, 475–485.

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Orthoserpierite $Ca(Cu,Zn)_4(SO_4)_2(OH)_6 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Typically as platy crystals, flattened on {001}, elongated along [010], to 0.2 mm, in rosettes, fibrous masses, and crusts.

Physical Properties: *Fracture:* Splintery. Hardness = n.d. D(meas.) = 3.00(5) D(calc.) = 3.07 Fluoresces mauve under LW and SW UV.

Optical Properties: Transparent. *Color:* Sky-blue. *Streak:* Pale green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = colorless or very pale green; $Y = Z$ = pale green. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, medium strong. $\alpha = 1.586(2)$ $\beta = 1.645(2)$ $\gamma = 1.650(2)$ 2V(meas.) = 32(2)° 2V(calc.) = 32°

Cell Data: *Space Group:* $Pca2_1$. $a = 22.10(2)$ $b = 6.20(2)$ $c = 20.39(2)$ Z = 8

X-ray Powder Pattern: Chessy, France.
10.21 (100), 5.10 (90), 3.400 (90), 2.384 (60), 3.184 (50), 2.610 (50), 2.558 (50)

Chemistry:

	(1)	(2)
SO_3	21.20	
CuO	43.61	42.4
ZnO	7.29	7.8
CaO	9.33	7.1
H_2O	[18.57]	
Total	[100.00]	

(1) Chessy, France; by electron microprobe, H_2O by difference; $Ca_{1.08}(Cu_{3.54}Zn_{0.58})_{\Sigma=4.12}(SO_4)_{1.71}(OH)_{6.98} \cdot 3.18H_2O$. (2) Glücksrad mine, Germany; partial analysis.

Polymorphism & Series: Dimorphous with serpierite.

Occurrence: A rare secondary mineral formed in the dump from a hydrothermal copper mine (Chessy, France); precipitated from vadose waters transecting the oxidized zone of a hydrothermal copper deposit (Copper Creek district, Arizona, USA).

Association: Devilline, gypsum, calcite (Chessy, France); chrysocolla, malachite (Copper Creek district, Arizona, USA).

Distribution: From Chessy, near Lyon, Rhône, France. In the Tynagh mine, near Loughrea, Co. Galway, Ireland. From Vezzani, Corsica, France. In the Glücksrad mine, near Oberschulenberg, Harz Mountains, Germany. From near the Childs-Aldwinkle mine, Copper Creek district, Pinal Co., Arizona, and at Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: As an ORTHOrhombic mineral related to *serpierite*.

Type Material: Natural History Museum, Geneva, Switzerland, 435/76.

References: (1) Sarp, H. (1985) Orthoserpiérite $Ca(CuZn)_4(SO_4)_2(OH)_6 \cdot 3H_2O$, un nouveau minéral de la Mine de Chessy, France, polymorphe de la serpiérite. Schweiz. Mineral. Petrog. Mitt., 65, 1–7 (in French with English abs.). (2) (1987) Amer. Mineral., 72, 1026 (abs. ref. 1). (3) Krause, W. and H. Täuber (1992) Zum Kenntnisstand der Minerale Serpierit, Orthoserpierit und Devillin. Aufschluss, 43(1), 1–25 (in German).

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Orthowalpurgite $Bi_4(UO_2)O_4(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are tabular on {010}, usually elongated along [100], with {010}, {001}, {104}, {100}, to 0.3 mm; in parallel or fan-shaped aggregates.

Physical Properties: *Cleavage:* Indistinct on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4.5 VHN = 330 (25 g load). D(meas.) = n.d. D(calc.) = 6.51 Radioactive.

Optical Properties: Transparent. *Color:* Yellow. *Streak:* Pale yellow. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.91(2)$ $\beta = 2.00(2)$ $\gamma = [2.05]$ 2V(meas.) = 70(3)°

Cell Data: *Space Group: Pbcm.* $a = 5.492(1)$ $b = 13.324(2)$ $c = 20.685(3)$ Z = 4

X-ray Powder Pattern: Schmiedestollen, Germany.
3.208 (100), 10.354 (94), 3.088 (76), 3.277 (56), 2.999 (50), 2.852 (46), 5.610 (40)

Chemistry:

	(1)	(2)
UO_3	17.86	19.28
As_2O_5	16.11	15.49
Bi_2O_3	64.21	62.80
H_2O	[2.43]	2.43
Total	[100.61]	100.00

(1) Schmiedestollen, Germany; by electron microprobe, average of eight analyses, H_2O from theory; corresponds to $Bi_{4.06}(UO_2)_{0.92}O_{3.89}(AsO_4)_{2.07} \cdot 1.99H_2O$. (2) $Bi_4(UO_2)O_4(AsO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with walpurgite.

Occurrence: A very rare mineral, probably formed by weathering of an earlier bismuth-bearing sulfide.

Association: Preisingerite, anatase, quartz.

Distribution: On the dump of the Schmiedestollen, near Wittichen, Black Forest, Germany.

Name: As an *ortho*rhombic dimorph of *walpurgite*.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany.

References: (1) Krause, W., H. Effenberger, and F. Brandstätter (1995) Orthowalpurgite, $(UO_2)Bi_4O_4(AsO_4)_2 \cdot 2H_2O$, a new mineral from the Black Forest, Germany. Eur. J. Mineral., 7, 1313–1324. (2) (1996) Amer. Mineral., 81, 1014 (abs. ref. 1).

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Osakaite $Zn_4SO_4(OH)_6 \cdot 5H_2O$

Crystal Data: Triclinic. *Point Group*: 1. As hexagonal platy crystals (0.05 mm wide and 0.01 mm thick) or as stalactitic aggregates, to 2 cm.

Physical Properties: *Cleavage*: Perfect, {001}. *Fracture*: Uneven. *Tenacity*: Flexible.
Hardness = 1 VHN = 20.3 D(meas.) = n.d. D(calc.) = 2.75
Dissolves readily in dilute hydrochloric acid.

Optical Properties: Transparent. *Color*: White or pale blue to colorless. *Streak*: White to pale blue. *Luster*: Pearly.
Optical Class: Biaxial (–). α = 1.532(2) β = 1.565(2) γ = 1.567(2) 2V(calc.) = 27.2°
Positive elongation.

Cell Data: *Space Group*: *P*1 [by analogy to the synthetic phase]. a =8.358(5) b = 8.337(4)
c = 11.027(2) α = 94.79(2)° β = 83.16(2)° γ = 119.61(4)° Z = 2

X-ray Powder Pattern: Hirao Mine, Osaka Prefecture, Japan.
10.96 (100), 2.717 (21), 1.574 (18), 3.642 (17), 5.47 (16)

Chemistry:

	(1)
ZnO	55.30
CuO	3.44
SO_3	14.66
H_2O	26.01

(1) Hirao Mine, Osaka Prefecture, Japan; ICP-AES and thermogravimetric analyses, OH^-, H_2O and SO_4 confirmed by infrared spectroscopy, corresponding to $(Zn_{3.75}Cu_{0.24})_{\Sigma=3.99}(SO_4)_{1.01}(OH)_{5.96} \cdot 4.99H_2O$.

Occurrence: A secondary mineral on mine walls and fractures produced by reaction of oxygenated groundwater with a polymetallic sulfide deposit.

Association: Hydrozincite, smithsonite, “chlorite,” and “limonite”.

Distribution: At the Hirao Mine, Osaka Prefecture, Japan.

Name: For the region (Osaka) in Japan containing the mine that produced the first specimens.

Type Material: National Science Museum, Tokyo, Japan (NSM-M28983).

References: (1) Ohnishi, M., I. Kusachi, and S. Kobayashi (2007) Osakaite, $Zn_4SO_4(OH)_6 \cdot 5H_2O$, a new mineral species from the Hirao Mine, Osaka, Japan. Can. Mineral., 45, 1511-1517. (2) (2008) Amer. Mineral., 93, 1688-1689 (abs. ref. 1).

Osarizawaite $PbCuAl_2(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}\ 2/m$. Hexagonal crystals, flattened on {0001}, with $\{10\overline{1}1\}$, to 20 μm, which may be hollow rings due to dissolution of a central zoned phase; typically earthy, powdery.

Physical Properties: *Tenacity:* Friable. Hardness = n.d. D(meas.) = 3.89–4.037 D(calc.) = 4.167–4.20

Optical Properties: Semitransparent. *Color:* Greenish yellow; greenish yellow to yellowish green in thin section.
Optical Class: Uniaxial (+), may be biaxial. *Pleochroism:* O = dark yellow; E = pale yellowish. $\omega = 1.712(3)$ $\epsilon = 1.732(2)$ 2V(meas.) = 0°–15°

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.05$–7.075 $c = 17.23$–17.25 $Z = 3$

X-ray Powder Pattern: Osarizawa mine, Japan.
3.00 (100), 5.79 (70), 3.52 (60), 2.87 (60), 2.28 (60), 2.23 (30), 1.918 (30)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	24.80	26.02	25.87	PbO	35.41	33.15	36.07
Al_2O_3	13.36	17.51	16.48	H_2O^+	9.20	10.42	8.73
Fe_2O_3	4.79	0.77		H_2O^-		0.09	
CuO	12.20	11.83	12.85	insol.		0.19	
ZnO	0.24			Total	[100.00]	99.98	100.00

(1) Osarizawa mine, Japan; H_2O by TGA; recalculated to 100% from an original total of 99.09% after deduction of SiO_2 2.18% as quartz, CO_2 0.45%, and H_2O^- 4.05%; then corresponds to $Pb_{1.02}(Cu_{0.99}Zn_{0.02})_{\Sigma=1.01}(Al_{1.70}Fe_{0.38})_{\Sigma=2.08}(SO_4)_2(OH)_{6.30}$. (2) Mt. Edgar Station, Australia; corresponds to $Pb_{0.91}Cu_{0.92}(Al_{2.11}Fe_{0.06})_{\Sigma=2.17}(SO_4)_{2.00}(OH)_{6.17} \bullet 0.47H_2O$. (3) $PbCuAl_2(SO_4)_2(OH)_6$.

Mineral Group: Alunite group.

Occurrence: An uncommon mineral in the oxidized zone of hydrothermal Pb–Zn–Cu deposits.

Association: Anglesite, beaverite, hidalgoite, duftite, bindheimite, conichalcite, olivenite, quartz, clay, goethite.

Distribution: From the Osarizawa copper mine, Kazuno, Akita Prefecture, Japan. In Australia, on the Mt. Edgar Station, 56 km east-southeast of Marble Bar, at Whim Creek, Pilbara district, and in the Teutonic Bore deposit, 300 km north of Kalgoorlie, Western Australia. At the Tui mine, Mt. Te Aroha, New Zealand. In the Ortiz mine, Capillitas, Catamarca Province, Argentina. From the Herminia mine, Sierra Gorda district, southwest of Calama, Antofagasta, and in the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. At Onovas, Sonora, Mexico. In the USA, in Arizona, from Bisbee and Tombstone, Cochise Co.; in the Omega mine, Helvetia, and at the Silver Hill mine, Waterman Mountains, Pima Co.; from the Fat Jack mine, Bradshaw Mountains, Yavapai Co.; in the Church Hills, Millard Co., Utah; at the Titusville mine, San Juan Co., and in the Silver Cliff district, Custer Co., Colorado. From Alderly Edge, Cheshire, England. At the Cap Garonne mine, near le Pradet, Var, France. In the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: For its first-noted occurrence in the Osarizawa mine, Japan.

Type Material: National Science Museum, Tokyo, Japan, M-15598.

References: (1) Taguchi, Y. (1961) On osarizawaite, a new mineral of the alunite group, from the Osarizawa mine, Japan. Mineral. J. (Japan), 3, 181–194. (2) (1962) Amer. Mineral., 47, 1216–1217 (abs. ref. 1). (3) Morris, R.C. (1962) Osarizawaite from Western Australia. Amer. Mineral., 47, 1079–1093. (4) Paar, W.H., J. Burgstaller, and T.T. Chen (1980) Osarizawaite-beaverite intergrowths from Sierra Gorda, Chile. Mineral. Record, 11, 101–104. (5) Giuseppetti, G. and C. Tadini (1980) The crystal structure of osarizawaite. Neues Jahrb. Mineral., Monatsh., 401–407.

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Osarsite $(Os, Ru)AsS$

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Crystal Data: Monoclinic. *Point Group:* n.d. As polycrystalline intergrowths, granular, to 150 μm.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 8.44

Optical Properties: Opaque. *Color:* Gray in reflected light. *Luster:* Metallic. *Anisotropism:* Weak but distinct in air.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 5.933(1)$ $b = 5.916(2)$ $c = 6.009(2)$ $\beta = 112°21(2)'$ $Z = 4$

X-ray Powder Pattern: Gold Bluff, California, USA.
3.79 (100), 1.892 (100), 1.870 (80), 2.74 (70), 2.78 (60), 2.01 (60), 1.832 (60)

Chemistry:

	(1)	(2)
Os	35.6	37.6
Ru	18.1	10.3
Ir	2.0	0.74
Pd	0.6	
Pt	0.4	
Rh	0.2	
Ni	0.9	3.2
Fe		2.5
Co		2.0
As	30.6	32.6
S	11.5	13.2
Total	99.9	102.14

(1) Gold Bluff, California, USA; by electron microprobe, corresponding to $(Os_{0.49}Ru_{0.47}Ni_{0.04}Ir_{0.03}Pd_{0.02})_{\Sigma=1.05}As_{1.06}S_{0.94}$. (2) Kola Peninsula, Russia; by electron microprobe, corresponding to $(Os_{0.47}Ru_{0.24}Ni_{0.13}Fe_{0.11}Co_{0.08}Ir_{0.01})_{\Sigma=1.04}As_{1.03}S_{0.97}$.

Mineral Group: Arsenopyrite group.

Occurrence: In a platinum-bearing sample of placer sand (Gold Bluff, California, USA).

Association: Irarsite, ruthenarsenite, sperrylite, iridarsenite, osmiridium, anduoite, laurite, ruarsite.

Distribution: In the USA, from Gold Bluff, Humboldt Co., California, USA [TL], and in the Salmon River placers, Goodnews Bay, Alaska. In Russia, from near Zlatoust, Ural Mountains; on the Kola Peninsula; and in the Neozhidannyy Creek placers, Tuva. From the Witwatersrand, Transvaal, South Africa. At Anduo, Tibet, China. From Vourinos, Greece.

Name: For the content of OSmium and ARSenic.

Type Material: National Museum of Natural History, Washington, D.C., USA, 123218.

References: (1) Snetsinger, K.G. (1972) Osarsite, a new osmium–ruthenium sulfarsenide from California. Amer. Mineral., 57, 1029–1036. (2) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 123, 160.

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Osbornite TiN

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Octahedra, to about 0.1 mm, in oldhamite; as dendritic and globular inclusions in corundum.

Physical Properties: Hardness = n.d. VHN = 1372 (20 g load). D(meas.) = n.d. D(calc.) = [5.38]

Optical Properties: Opaque. *Color:* Golden yellow. *Luster:* Metallic.
Optical Class: Isotropic.
R: (440) 20.3, (460) 25.0, (480) 31.6, (500) 38.6, (520) 45.3, (540) 45.3, (560) 55.7, (580) 60.0, (600) 63.5, (620) 66.4, (640) 68.8, (660) 70.8, (680) 72.6, (700) 74.3

Cell Data: *Space Group:* $F4/m\ \overline{3}\ 2/m$ (synthetic). $a = 4.24173(12)$ $Z = 4$

X-ray Powder Pattern: Synthetic. (ICDD 38-1420).
2.1207 (100), 2.4492 (72), 1.4997 (45), 1.2789 (19), 0.9485 (14), 1.2245 (12), 0.8658 (12)

Chemistry: (1) Bustee meteorite; qualitative presence of Ti determined colorimetrically; confirmation as TiN by behavior similar to synthetic TiN on conversion to TiO_2. (2) "Russia"; by electron microprobe, Ti ∼80%, N present, with O and C absent.

Occurrence: Embedded in oldhamite in an achondrite meteorite (Bustee meteorite); as inclusions in corundum, in weathered detritus from a pipelike body containing breccias with an alkalic ultramafic cement ("Russia").

Association: Oldhamite, diopside (Bustee meteorite); corundum, iron, perovskite, iron silicides ("Russia").

Distribution: In the Bustee meteorite. In Russia, from an undefined locality "near the junction of the Azov block with the Donbas".

Name: For George Osborn, who sent to London the meteorite in which the species was found.

Type Material: The Natural History Museum, London, England, 32100.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 124. (2) Bannister, F.A. (1941) Osbornite, meteoritic titanium nitride. Mineral. Mag., 36, 36–44. (3) J.L. Wyatt and N.J. Grant (1954) Nitriding of titanium with ammonia. Trans. Amer. Soc. Metals, 46, 540–564. (4) Tatarintsev, V.I., S.M. Sandomirskaya, and S.M. Tsymbal (1987) First find of titanium nitride (osbornite) in terrestrial rocks. Doklady Acad. Nauk SSSR, 296, 1458–1461 (in Russian).

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Oskarssonite AlF_3

Crystal Data: Hexagonal. *Point Group*: $\bar{3}\,2/m$. Forms a fine grained powder.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 3.184

Optical Properties: Translucent. *Color*: White to grayish yellow. *Streak*: n.d.
Luster: n.d.
Optical Class: Uniaxial (+). ω = 1.3765 ε = 1.3770 [Synthetic AlF_3]

Cell Data: *Space Group*: $R\bar{3}\,c$. a = 4.9817(4) c = 12.387(1) Z = 6

X-ray Powder Pattern: Eldfell volcano, Heimaey Island, Vestmannaeyjar archipelago, Iceland.
3.54 (100), 1.771 (20), 1.59 (15), 2.131 (13), 1.574 (10), 2.06 (8), 1.61(8)

Chemistry:

	(1)	(2)
Al	31.70	32.13
F	58.41	67.87
O	9.22	.
Total	99.33	100.00

(1) Eldfell volcano, Heimaey Island, Iceland; average of 5 electron microprobe analyses; corresponding to $Al(F_{2.62}(OH)_{0.49})_{\Sigma=3.11}$. (2) AlF_3.

Occurrence: As sublimate encrustations deposited at 90 °C close to the surface of fumarole vents.

Association: Anhydrite, bassanite, gypsum, jarosite, anatase, hematite, opal, ralstonite, jacobssonite, meniaylovite.

Distribution: From the Eldfell volcano, Heimaey Island, Vestmannaeyjar archipelago, Iceland; also reported from Mount Erebus, Antarctica.

Name: Honors Niels Oskarsson (b. 1944), a prominent Icelandic volcanologist, in recognition of his work on Icelandic fumaroles.

Type Material: Icelandic Institute of Natural History, Gardabaer, Iceland (NI 24489), and the mineral collection, Natural History Museum of Denmark, Copenhagen (# 2012.112, 2012.113, 2012.114).

References: (1) Jacobsen, M.J., T. Balić-Žunić, D. Mitolo, A. Katerinopoulou, A. Garavelli, and S.P. Jacobsson (2014) Oskarssonite, AlF_3, a new fumarolic mineral from Eldfell volcano, Heimaey, Iceland. Mineral. Mag., 78(1), 215-222. (2) (2014) Amer. Mineral., 99, 1809-1810 (abs. ref. 1).

Osmium (Os, Ir, Ru)

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Rare crystals are hexagonal tabular, to 3 mm; commonly as euhedral prismatic inclusions in Pt–Fe alloys.

Physical Properties: Hardness = n.d. VHN = 1206–1246 (25 g load). D(meas.) = 22.48 D(calc.) = 22.59

Optical Properties: Opaque. *Color:* White with a bluish gray tinge in reflected light. *Pleochroism:* Noticeable. *Anisotropism:* Strong, reddish orange.
R_1–R_2: (400) — , (420) 62.7–63.9, (440) 63.9–64.7, (460) 63.9–64.6, (480) 63.8–64.4, (500) 63.3–63.8, (520) 62.7–63.2, (540) 62.1–62.7, (560) 61.5–61.8, (580) 60.9–61.4, (600) 60.4–60.7, (620) 59.9–60.2, (640) 59.6–59.8, (660) 59.3–59.9, (680) 59.2–60.0, (700) 59.4–60.0

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.7341$ $c = 4.3197$ $Z = 2$

X-ray Powder Pattern: Synthetic osmium.
2.076 (100), 2.367 (35), 2.160 (35), 1.3668 (20), 1.2300 (20), 1.1551 (20), 1.595 (18)

Chemistry:

	(1)	(2)	(3)
Os	94.1	84.8	98.8
r	5.4	12.0	0.3
Ru	0.8	2.2	
Pt	0.1	1.7	
Rh		0.5	
Pd		0.1	0.2
Total	100.4	101.3	99.3

(1) Atlin, Canada; by electron microprobe. (2) Joubdo stream, Ethiopia; by electron microprobe. (3) Gusevogorskii pluton, Russia; by electron microprobe, average of four analyses.

Occurrence: With other platinum-group elements and alloys, in ultramafic rocks and placers derived therefrom.

Association: Ruthenirídosmine, iridosmine, osmiridium (Ruby Creek, Canada); bowieite, platinum, Ir–Pt alloys, laurite, silicate inclusions (Salmon River, Alaska, USA); isoferroplatinum, cuprorhodsite, malanite, cuproiridsite, iridosmine, laurite, erlichmanite, cooperite, sperrylite, chalcopyrite, bornite (Russia).

Distribution: From Ruby Creek, Atlin, British Columbia, Canada. In the USA, at Fox Gulch and the Salmon River, Goodnews Bay, Alaska. From Rio Pilpe, Colombia. In the Santiago River placers, Esmeraldas Province, Ecuador. In Russia, in the the Gusevogorskii pluton, and the Kytlym and Uktus complexes, Ural Mountains; from the Neozhidannyy Creek placers, Tuva; and in the Pustaya River placers, Kamchatka Peninsula. At the Harold's Grave and Cliff quarries, Baltasound-Haroldswick area, Unst, Shetland, Scotland. In Ethiopia, in the Joubdo stream, on the Birbir river. From the Witwatersrand, Transvaal, South Africa. At Anduo, Tibet, China. From the Sorashigawa placers, ?? Prefecture, Japan. Additional minor localities are known.

Name: From the Greek word for *odor*, in reference to the pungent and irritating odor when heated in air.

References: (1) Harris, D.C. and L.J. Cabri (1991) Nomenclature of platinum-group-element alloys: review and revision. Can. Mineral., 29, 231–237. (2) (1992) Amer. Mineral., 77, 212–213 (abs. ref. 1). (3) Begizov, V.D., L.F. Borisenko, and Y.D. Uskov (1975) Sulfides and natural solid solutions of platinum metals from ultramafic rocks of the Gusevogorskii pluton, Urals. Doklady Acad. Nauk SSSR, 225, 1408–1411 (in Russian). (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 124–125. (5) (1955) NBS Circ. 539, 4, 8. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 401.

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Osumilite-(Mg) $(K,Na)(Mg,Fe^{2+})_2(Al,Fe^{3+})_3(Si,Al)_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals tabular to prismatic, elongated ‖ [0001], to 0.1 mm. Also anhedral, massive.

Physical Properties: Hardness = n.d. D(meas.) = 2.58–2.68 D(calc.) = [2.59]

Optical Properties: Semitransparent. *Color:* Colorless, pink, blue, black. *Luster:* Pearly. *Optical Class:* Uniaxial (+); anomalously biaxial. *Pleochroism:* Faint; O = colorless to pink; E = colorless to pale blue. ω = 1.540–1.547 ϵ = 1.541–1.546 2V(meas.) = 5°–15°

Cell Data: *Space Group:* $P6/mcc$. $a = 10.08$ $c = 14.35$ Z = [2]

X-ray Powder Pattern: Near Nain, Canada. (ICDD 30-942).
3.22 (100), 5.01 (60), 4.11 (60), 3.72 (60), 2.915 (60), 2.767 (60), 7.1 (40)

Chemistry:

	(1)	(2)
SiO_2	64.35	62.75
TiO_2	0.06	0.08
Al_2O_3	19.38	21.65
FeO	2.16	0.94
MnO	0.24	0.00
MgO	9.46	9.07
CaO	0.13	0.10
Na_2O	0.27	0.28
K_2O	3.98	4.60
Total	100.03	99.47

(1) Tieveragh, Ireland; by electron microprobe, corresponds to $(K_{0.84}Na_{0.09}Ca_{0.02})_{\Sigma=0.95}(Mg_{1.69}Fe^{2+}_{0.30}Mn_{0.03})_{\Sigma=2.02}(Al_{2.36}Mg_{0.63}Ti_{0.01})_{\Sigma=3.00}(Si_{10.60}Al_{1.40})_{\Sigma=12.00}O_{30}$. (2) Mt. Riiser-Larsen, Antarctica; by electron microprobe, corresponds to $(K_{0.97}Na_{0.09}Ca_{0.02})_{\Sigma=1.08}(Mg_{2.82}Fe^{2+}_{0.13}Mn_{0.03}Ti_{0.01})_{\Sigma=2.99}(Al_{2.59}Mg_{0.41})_{\Sigma=3.00}(Si_{10.37}Al_{1.63})_{\Sigma=12.00}O_{30}$.

Mineral Group: Milarite group.

Occurrence: In fused xenoliths and contact metamorphic rocks.

Association: Cordierite, sodic plagioclase, sanidine, "hypersthene," tridymite, quartz, biotite, zircon, magnetite, hematite, graphite.

Distribution: Following are a few localities for material with characterized Fe^{2+}:Mg. From Tieveragh, Co. Antrim, Ireland. At Vikeså, Rogaland, Norway. From Iriki, Kagoshima Prefecture; at Haneyama, Oita Prefecture; on the Akagi volcano, Gumma Prefecture; and from Rishiri Island, Japan. On the Malyi Nepiskol volcano, Caucasus Mountains, Russia. From Reference Peak, Mt. Riiser-Larsen, and nearby, in Enderby Land, Antarctica. In the Nain complex, at Ikkinikulluit Brook, Labrador, Newfoundland, Canada.

Name: For the relation to *osumilite* and predominance of *magnesium*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128117, 137452.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 541–558. (2) Chinner, G.A. and P.D. Dixon (1973) Irish osumilite. Mineral. Mag., 39, 189–192. (3) Berg, J.H. and E.P. Wheeler, II (1976) Osumilite of deep-seated origin in the contact aureole of the anorthositic Nain complex, Labrador. Amer. Mineral., 61, 29–37. (4) Armbruster, T. and R. Oberhänsli (1988) Crystal chemistry of double-ring silicates: structural, chemical, and optical variation in osumilites. Amer. Mineral., 73, 585–594.

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Osumilite $\mathbf{(K,Na)(Fe^{2+},Mg)_2(Al,Fe^{3+})_3(Si,Al)_{12}O_{30}}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals tabular to prismatic, elongated ‖ [0001], to 5 mm. Also anhedral and massive. *Twinning:* Rarely, ⊥ {0001}.

Physical Properties: *Cleavage:* Indistinct, ‖ and ⊥ {0001}. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.58–2.68 D(calc.) = 2.71

Optical Properties: Translucent. *Color:* Black, dark blue, dark brown, pink, gray; light blue or light pink in thin section. *Luster:* Vitreous.
Optical Class: Uniaxial (+) or (–); anomalously biaxial. *Pleochroism: O* = light blue to bluish purple, pale pink, pale yellow-brown; *E* = colorless to brown. ω = 1.539–1.547 ϵ = 1.545–1.551 2V(meas.) = 28°–45°

Cell Data: *Space Group:* $P6/mcc$. a = 10.08–10.17 c = 14.26–14.35 Z = 2

X-ray Powder Pattern: Sakkabira, Japan; nearly identical to merrihueite.
3.24 (vs), 7.17 (s), 5.08 (s), 2.930 (s), 4.41 (m), 3.74 (m), 2.776 (m)

Chemistry:

	(1)	(2)
SiO_2	60.51	59.45
TiO_2	0.04	0.06
Al_2O_3	21.60	24.56
FeO	9.27	12.85
MnO	0.99	0.52
MgO	3.05	0.41
CaO	0.00	0.00
BaO	0.04	0.01
Na_2O	0.67	0.10
K_2O	3.46	1.59
Total	99.63	99.55

(1) Sakkabira, Japan; by electron microprobe, corresponds to $(K_{0.76}Na_{0.22})_{\Sigma=0.98}(Fe^{2+}_{1.33}Mg_{0.65})_{\Sigma=1.98}(Al_{2.72}Mg_{0.13}Mn_{0.14}Ti_{0.01})_{\Sigma=3.00}(Si_{10.36}Al_{1.64})_{\Sigma=12.00}O_{30}\bullet 1.03H_2O$.
(2) Bellerberg volcano, Germany; by electron microprobe, corresponds to $(K_{0.35}Na_{0.03})_{\Sigma=0.38}(Fe^{2+}_{1.84}Mg_{0.11})_{\Sigma=1.95}(Al_{3.13}Mn_{0.08}Ti_{0.01})_{\Sigma=3.22}(Si_{10.17}Al_{1.83})_{\Sigma=12.00}O_{30}$.

Mineral Group: Milarite group.

Occurrence: In cavities and the groundmass of rhyolite and dacite, and in high-grade contact metamorphic rocks and xenoliths.

Association: Tridymite, cristobalite, quartz, oligoclase, potassic feldspar, fayalite, "hypersthene," biotite, magnetite, zircon.

Distribution: Localities for which Fe^{2+}:Mg has been established to be of this species include: in Japan, from Sakkabira and Hayato, Kagoshima Prefecture, and from the Asama volcano, northwest of Tokyo, Yamanashi Prefecture. In the USA, at Obsidian Cliffs, Lane Co., Oregon. In the Funtanifigu quarry, Monte Arci, near Oristano, Sardinia, Italy. From the Bellerberg and Nickenicher Sattel volcanos, Eifel district, Germany.

Name: After Osumi Province, an old province in Sakkabira, on Kyushu, Japan.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 104744.

References: (1) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 541–558. (2) Miyashiro, A. (1956) Osumilite, a new silicate mineral, and its crystal structure. Amer. Mineral., 41, 104–116. (3) Armbruster, T. and R. Oberhänsli (1988) Crystal chemistry of double-ring silicates: structural, chemical, and optical variation in osumilites. Amer. Mineral., 73, 585–594.

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Oswaldpeetersite $(UO_2)_2CO_3(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Acicular crystals, showing {100}, {010}, {001}, heavily striated lengthwise, to 0.1 mm, in subparallel radiating groups.

Physical Properties: *Cleavage:* Parallel elongation. *Fracture:* Uneven. *Tenacity:* "Weak". Hardness = 2–3 D(meas.) = > 4.10. D(calc.) = 4.54 Radioactive.

Optical Properties: Transparent. *Color:* Canary-yellow. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = very pale yellow to colorless; Z = pale yellow. *Orientation:* $Z = a$; positive elongation. $\alpha = 1.583(2)$ $\beta = 1.669(2)$ $\gamma = 1.712(2)$ 2V(meas.) = n.d. 2V(calc.) = 67.4(2)°

Cell Data: *Space Group:* $P2_1/c$. $a = 4.1425(6)$ $b = 14.098(3)$ $c = 18.374(5)$ $\beta = 103.62(1)°$ Z = 4

X-ray Powder Pattern: Jomac mine, Utah, USA.
3.32 (100), 4.55 (96), 3.029 (85), 8.95 (65), 7.54 (63), 3.46 (62), 2.273 (62)

Chemistry:

	(1)	(2)
CO_2	[6.23]	6.23
UO_3	81.47	81.01
H_2O	12.30	12.76
Total	[100.00]	100.00

(1) Jomac mine, Utah, USA; by electron microprobe, H_2O by TGA, CO_2 by difference, presence of $(CO_3)^{2-}$, $(OH)^{1-}$, and H_2O confirmed by IR; corresponds to $(UO_2)_{2.03}(CO_3)_{1.01}(OH)_{2.05} \cdot 3.85H_2O$. (2) $(UO_2)_2CO_3(OH)_2 \cdot 4H_2O$.

Occurrence: In a sedimentary Colorado-Plateau-type U–V deposit.

Association: Gypsum, cuprite, antlerite, goethite, lepidocrocite, mbobomkulite, hydrombobomkulite, sklodowskite.

Distribution: From the Jomac uranium mine, Brown's Rim, White Canyon district, San Juan Co., Utah, USA.

Name: To honor Maurice Oswald Peeters (1945–), Catholic University of Leuven, Leuven, Belgium, structural crystallographer who has done research in uranium mineralogy.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC5166.

References: (1) Vochten, R., M. Deliens, and O. Medenbach (2001) Oswaldpeetersite, $(UO_2)_2CO_3(OH)_2 \cdot 4H_2O$, a new basic uranyl carbonate mineral from the Jomac uranium mine, San Juan County, Utah, U.S.A. Can. Mineral., 39, 1685–1689. (2) (2003) Amer. Mineral., 88, 252 (abs. ref. 1).

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Otavite $CdCO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. Rhombohedra, $\{10\overline{1}1\}$, to 2 mm, typically in thin crusts. *Twinning:* Observed.

Physical Properties: *Cleavage:* On $\{10\overline{1}1\}$. Hardness = [3.5–4] (by analogy to the calcite group). D(meas.) = 4.96 (synthetic). D(calc.) = 5.03

Optical Properties: Semitransparent. *Color:* White, yellowish brown to reddish brown if impure; colorless in transmitted light. *Luster:* Vitreous to adamantine.
Optical Class: [Uniaxial (–).] $\omega = 1.830$ $\epsilon = 1.605$

Cell Data: *Space Group:* $R\overline{3}c$ (synthetic). $a = 4.93$ $c = 16.27$ Z = 6

X-ray Powder Pattern: Synthetic.
2.95 (100), 3.78 (80), 2.46 (35), 1.825 (35), 2.066 (25), 1.838 (25), 1.582 (16)

Chemistry:

	(1)	(2)
CO_2		29.55
CdO	70.2	43.12
ZnO		27.33
Total		100.00

(1) Tsumeb, Namibia; partial analysis, identification depending on Cd:Zn ratio and on correspondence of the X-ray powder pattern with that of synthetic material. (2) $(Cd, Zn)CO_3$ with Cd:Zn = 1:1.

Mineral Group: Calcite group.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal base-metal deposits.

Association: Smithsonite, cerussite, hydrozincite, hemimorphite, azurite, malachite, rosasite, olivenite, pyromorphite, calcite, fluorite.

Distribution: From Tsumeb, Namibia. In Russia, found in the Bilyakchan fracture system, southern Verkhoyan'ya, in the Orenburg district, Southern Ural Mountains, and at Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains. In the Montevecchio Pb–Zn mine, Sardinia, Italy. At Laurium, Greece. In the Coldstones quarry, Pateley Bridge, North Yorkshire, England. From Broken Hill, New South Wales, Australia. At the Niujiaotang zinc deposit, Duyun, Guizhou Province, China. From the Mo Ba Pb–Zn deposit, North Vietnam. In the USA, in the Blanchard mine, near Bingham, Hansonburg district, Socorro Co., New Mexico; from Franklin, Sussex Co., New Jersey.

Name: For the Otavi district, Namibia, within which lies Tsumeb, the discovery locality.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 181. (2) Borodin, V.L., V.I. Lyutin, V.V. Ilyukhin, and N.V. Belov (1979) Isomorphism between calcite–otavite. Doklady Acad. Nauk SSSR, 245, 1099–1101 (in Russian). (3) (1957) NBS Circ. 539, 7, 11.

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Otjisumeite $PbGe_4O_9$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* 1 or $\overline{1}$. In sprays of subparallel pseudohexagonal crystals, elongated along [001], to 1 mm; may be fibrous.

Physical Properties: *Cleavage:* {001}, interrupted. Hardness = ∼3 D(meas.) = n.d. D(calc.) = 5.77

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Streak:* White. *Luster:* Greasy to subadamantine.
Optical Class: Biaxial (+). *Orientation:* $X \wedge c = 3°–5°$. $\alpha = 1.920(5)$ $\beta = [1.922]$ $\gamma = 1.943(5)$ 2V(meas.) = 20(5)°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 6.945(12)$ $b = 6.958(11)$ $c = 9.279(6)$ $\alpha = 102.94(10)°$ $\beta = 103.05(11)°$ $\gamma = 114.77(12)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
2.95 (10), 3.41 (5), 2.22 (5), 4.20 (4), 1.847 (4), 1.782 (4), 5.87 (3)

Chemistry:

	(1)
GeO_2	64.7
PbO	35.5
Total	100.2

(1) Tsumeb, Namibia; by electron microprobe, corresponding to $Pb_{1.03}Ge_{3.99}O_9$.

Occurrence: In cavities in oxidized germanium-bearing sulfides in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tennantite, germanite, reniérite, chalcocite, schaurteite, siderite, calcite, quartz, gypsum.

Distribution: From Tsumeb, Namibia.

Name: From *Otjisume*, the Herero name for Tsumeb, Namibia.

Type Material: University of Stuttgart, Stuttgart, Germany, NM06; National Museum of Natural History, Washington, D.C., USA, 149053.

References: (1) Keller, P., H. Hess, and P.J. Dunn (1981) Otjisumeit, $PbGe_4O_9$, ein neues Mineral aus Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 49–55 (in German with English abs.). (2) (1987) Amer. Mineral., 72, 1026–1027 (abs. ref. 1).

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Ottemannite Sn_2S_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As small laths. *Twinning:* Commonly twinned.

Physical Properties: Hardness = ∼2 VHN = n.d. D(meas.) = 4.87 (synthetic). D(calc.) = 4.806

Optical Properties: Opaque. *Color:* In polished section, gray with orange-brown internal reflections. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: n.d.

Cell Data: *Space Group: Pnam.* a = 8.79(3) $b = 14.02(5)$ $c = 3.74(1)$ Z = 4

X-ray Powder Pattern: Synthetic.
4.131 (100), 5.495 (75), 2.670 (45), 7.003 (40), 2.747 (35), 3.740 (35), 3.257 (30)

Chemistry: Composition determined by identity of X-ray powder pattern with synthetic material.

Occurrence: In zones of oxidation or secondary enrichment in hydrothermal tin deposits.

Association: Stannite, cassiterite, herzenbergite, berndtite.

Distribution: In Bolivia, from Cerro Rico, Potosí [TL] and at the Maria-Teresa mine, near Huari, between Oruro and Uyuni. From the Stiepelmann mine, near Arandis, Namibia.

Name: To honor Joachim Ottemann (1914–), German mineralogist, Heidelberg, Germany.

Type Material: National Museum of Natural History, Washington, D.C., USA, 114486, C5354.

References: (1) Moh, G.H. and F. Berndt (1964) Two new natural tin sulfides, Sn_2S_3 and SnS_2. Neues Jahrb. Mineral., Monatsh., 94–95. (2) (1965) Amer. Mineral., 50, 2107 (abs. ref. 1). (3) Moh, G.H. (1966) Das binäre System Zinn–Schwefel und seine Minerale (abs.). Fortschr. Mineral., 42, 211. (4) (1966) Amer. Mineral., 51, 1551 (abs. ref. 3). (5) Mosburg, S., D.R. Ross, P.M. Bethke, and P. Toulmin (1961) X-ray powder data for herzenbergite, teallite, and tin trisulfide. U.S. Geol. Sur. Prof. Paper 424-C, C347–C348. (6) Kniep, R., D. Mootz, U. Severin, and H. Wunderlich (1982) Structure of tin(II)tin(IV) trisulfide, a redetermination. Acta Cryst., 38, 2022–2023.

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Ottrélite $(Mn^{2+}, Fe^{2+}, Mg)_2Al_4Si_2O_{10}(OH)_4$

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Crystal Data: Monoclinic or triclinic. *Point Group:* m or $2/m$, or 1 or $\bar{1}$. In pseudohexagonal flakes, up to 4 mm, and as fine-grained scaly aggregates. *Twinning:* Polysynthetic, ‖ [001].

Physical Properties: *Cleavage:* {001}, perfect; {110}, likely. Hardness = 6–7 D(meas.) = 3.52(2) D(calc.) = [3.48]

Optical Properties: Translucent. *Color:* Pistachio-green, greenish to dark gray; in transmitted light, gray-green. *Streak:* Greenish, grayish. *Luster:* Vitreous to nearly adamantine on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* X = olive-yellow; Y = pale yellow with greenish tinge; Z = very light yellow to almost colorless. *Orientation:* $X = b$; $Z \wedge \perp (001) =$ 11°–23°. *Dispersion:* $r > v$, strong. $\alpha = 1.709$–1.725 $\beta = 1.712$–1.726 $\gamma = 1.716$–1.732 2V(meas.) = 46°–70°

Cell Data: *Space Group:* Cc or $C2/c$. $a = 9.505(6)$ $b = 5.484(4)$ $c = 18.214(15)$ $\beta = 101°46(2)'$ Z = [4]

X-ray Powder Pattern: Ottré, Belgium.
4.460 (100), 2.973 (80), 2.686 (45), 2.439 (40), 1.585 (40), 2.461 (25), 2.375 (20)

Chemistry:

	(1)
SiO_2	23.88
Al_2O_3	40.69
Fe_2O_3	1.67
FeO	8.02
MnO	12.60
MgO	4.39
CaO	0.11
Na_2O	0.00
K_2O	0.00
H_2O^+	7.15
quartz	1.4
Total	99.91

(1) Ottré, Belgium; corresponds to $(Mn_{0.88}Fe^{2+}_{0.55}Mg_{0.54}Fe^{3+}_{0.03})_{\Sigma=2.00}(Al_{3.93}Fe^{3+}_{0.07})_{\Sigma=4.00}$ $(Si_{1.97}Al_{0.03})_{\Sigma=2.00}O_{10.03}(OH)_{3.94}$.

Polymorphism & Series: Monoclinic and triclinic polytypes are known.

Mineral Group: Chloritoid group.

Occurrence: Formed under nonshearing stress conditions in veins and cavities within low- to medium-grade metamorphic rocks; also a medium-temperature hydrothermal alteration mineral.

Association: Dickite, kaolinite, rutile, andalusite, chlorite, pyrophyllite, davreuxite, quartz.

Distribution: In Belgium, in the Ardennes Mountains, from Ottré, Salmchâteau, and Vielsalm.

Name: For its occurrence at Ottré, Belgium.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 642.
(2) Fransolet, A.-M. (1978) Données nouvelles sur l'ottrélite d'Ottré, Belgique. Bull. Minéral., 101, 548–557 (in French with English abs.). (3) Halferdahl, L.B. (1961) Chloritoid: its composition, X-ray and optical properties, stability and occurrences. J. Petrol., 2, 49–135.

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Otwayite $Ni_2(CO_3)(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Fiber bundles, to several hundred μm, in divergent interlocking sprays perpendicular to veinlet walls; as spherules, claylike coatings.

Physical Properties: Hardness = n.d. VHN = 130–360 (5 g load). D(meas.) = 3.41 D(calc.) = 3.346

Optical Properties: Opaque to translucent. *Color:* Bright green; pale green in transmitted light. *Luster:* Silky to waxy.
Optical Class: Biaxial. *Pleochroism:* Weak; deepest color $\perp$ fiber axis. *Orientation:* Parallel extinction, length-fast. $\alpha = 1.65$ β = n.d. $\gamma = 1.72$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 10.18$ $b = 27.4$ $c = 3.22$ Z = 8

X-ray Powder Pattern: Otway deposit, Western Australia.
6.84 (10), 5.67 (8), 2.737 (6), 3.022 (5), 2.529 (5), 2.24 (5), 2.370 (4)

Chemistry:

	(1)	(2)
CO_2	19.57	19.18
NiO	62.87	65.11
MgO	1.14	
H_2O	16.42	15.71
Total	100.00	100.00

(1) Otway deposit, Western Australia; by AA, colorimetry, and direct determination of C and H, recalculated to 100% from an original total of 99.01% after deduction of SiO_2 0.28% as pecoraite; then corresponding to $(Ni_{1.90}Mg_{0.06})_{\Sigma=1.96}(CO_3)_{1.01}(OH)_{1.92} \cdot 1.10H_2O$. (2) $Ni_2(CO_3)(OH)_2 \cdot H_2O$. (3) Lord Brassey mine, Tasmania, Australia; average of 14 analyses, $(CO_3)^{2-}$, $(SO_4)^{2-}$, $(OH)^{1-}$, and H_2O confirmed by IR; stated to correspond to $Ni_2[(CO_3)_{0.84}(SO_4)_{0.16}]_{\Sigma=1.00}(OH)_2 \cdot 2H_2O$.

Occurrence: In veinlets in serpentinite (Otway prospect, Western Australia; Lord Brassey mine, Tasmania, Australia).

Association: Magnesite, pecoraite, gaspéite, paraotwayite, millerite, polydymite, nickeloan chrysotile, apatite (Otway deposit, Western Australia); theophrastite, hellyerite, zaratite, magnetite (Lord Brassey mine, Tasmania, Australia).

Distribution: In Australia, from the Otway nickel deposit, near Spinnaway, Nullagine district, and in the 132 North nickel mine, 4 km southwest of Widgiemooltha, Western Australia; at the Lord Brassey mine, near Heazlewood, Tasmania.

Name: To honor Charles Albert Otway (1922–), prospector of Gosnells, Western Australia, owner of the Otway prospect.

Type Material: Western Australian Museum, Perth, Australia, M.60.1991; National Museum of Natural History, Washington, D.C., USA, 142804.

References: (1) Nickel, E.H., B.W. Robinson, and R.D. MacDonald (1977) Otwayite, a new nickel mineral from Western Australia. Amer. Mineral., 62, 999–1002. (2) Henry, D.A. and W.D. Birch (1992) Otwayite and theophrastite from the Lord Brassey mine, Tasmania. Mineral. Mag., 56, 252–255.

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Oulankaite $(Pd,Pt)_5(Cu,Fe)_4SnTe_2S_2$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Ourayite $Ag_3Pb_4Bi_5S_{13}$(?)

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As irregular laths, to < 0.1 mm.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = [7.18]

Optical Properties: Opaque. *Color:* In polished section, galena-white. *Pleochroism:* Weak in oil. *Anisotropism:* Distinct to strong, pale gray to bluish black.
R_1–R_2: n.d.

Cell Data: *Space Group:* $Bbmm$ or $Bb2_1m$. $a = 13.457(1)$ $b = 44.042(4)$ $c = 4.100(10)$ $Z = 4$

X-ray Powder Pattern: Old Lout mine, Colorado, USA.
3.43 (100), 2.96 (90), 2.09 (90), 2.04 (70), 1.79 (70), 3.33 (60), 2.85 (60)

Chemistry:

	(1)	(2)
Ag	12.5	12.38
Cu	0.5	
Pb	29.5	31.70
Bi	41.4	39.97
Sb	0.2	
S	16.0	15.95
Total	100.1	100.00

(1) Old Lout mine, Colorado, USA; by electron microprobe, corresponding to $Ag_{3.02}Cu_{0.20}Pb_{3.71}Bi_{5.16}Sb_{0.04}S_{13.00}$. (2) $Ag_3Pb_4Bi_5S_{13}$.

Occurrence: In a hydrothermal sulfide vein (Old Lout mine, Colorado, USA); with topaz and fluorite in a cryolite body (Ivigtut, Greenland); with base-metal sulfides in diopside tactite (Pitiquito, Mexico).

Association: Galena, matildite (Old Lout mine, Colorado, USA); berryite, aikinite, galena, matildite, pyrite, bismuth, gold (Ivigtut, Greenland); sphalerite, galena, chalcopyrite (Pitiquito, Mexico).

Distribution: In the USA, in Colorado, near Ouray, San Juan Co., from the Old Lout mine [TL], in the Alaska mine, Poughkeepsie Gulch; in the Wombat mine, Montezuma district, Summit Co.; and from the Comstock mine, La Plata Co.; at South Mountain, Owyhee Co., Idaho. From a tungsten prospect, 40 km south of Pitiquito, Sonora, Mexico. At the Ivigtut cryolite deposit, southwestern Greenland.

Name: For Ouray, Colorado, USA, near where the mineral was first discovered.

Type Material: Royal Ontario Museum, Toronto, Canada, M4100.

References: (1) Karup-Møller, S. (1977) Mineralogy of some Ag–(Cu)–Pb–Bi sulfide associations. Bull. Geol. Soc. Denmark, 26, 41–68. (2) Makovicky, E. and S. Karup-Møller (1977) Chemistry and crystallography of the lillianite homologous series. Neues Jahrb. Mineral., Abh., 131, 56–82. (3) (1979) Amer. Mineral., 64, 243–244 (abs. refs. 1 and 2). (4) Makovicky, E. and S. Karup-Møller (1984) Ourayite from Ivigtut, Greenland. Can. Mineral., 22, 565–575.

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Oursinite $(Co,Mg)(UO_2)_2Si_2O_7 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ or $2/m\ 2/m\ 2/m$. In radiating aggregates of acicular crystals elongated ‖ [001], to 1 mm.

Physical Properties: *Cleavage:* On $\{hk0\}$. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.674 Radioactive.

Optical Properties: Transparent. *Color:* Pale yellow.
Optical Class: Biaxial (–). *Orientation:* $Y = c$. $\alpha = 1.624(2)$ $\beta = 1.640(2)$ $\gamma = 1.650(2)$
2V(meas.) = n.d. 2V(calc.) = 76°

Cell Data: *Space Group:* *Aba*2 or *Abam*. a = 12.74(1) $b = 17.55(2)$ $c = 7.050(6)$
Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
8.73 (100), 2.853 (90), 7.20 (70), 4.141 (70), 5.16 (50), 3.528 (40), 4.55 (35)

Chemistry:

	(1)
SiO_2	13.21
UO_3	66.71
NiO	0.30
CoO	6.56
MgO	0.42
H_2O	[12.80]
Total	[100.00]

(1) Shinkolobwe, Congo; by electron microprobe, average of seven analyses, H_2O by difference; corresponds to $(Co_{0.78}Mg_{0.09}Ni_{0.04})_{\Sigma=0.91}(UO_2)_{2.07}Si_{1.95}O_7 \cdot 6.30H_2O$.

Occurrence: A secondary mineral in brecciated dolostone containing uraninite.

Association: Soddyite, kasolite, schoepite, sklodowskite, torbernite, lepersonnite, bijvoetite, curite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: From the French *oursin*, meaning *sea urchin*, in allusion to the mineral's appearance.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM1321.

References: (1) Deliens, M. and P. Piret (1983) L'oursinite $(Co_{0.86}Mg_{0.10}Ni_{0.04})O \cdot 2UO_3 \cdot 2SiO_2 \cdot 6H_2O$, nouveau minéral de Shinkolobwe, Shaba, Zaïre. Bull. Minéral., 106, 305–308 (in French with English abs.). (2) (1984) Amer. Mineral., 69, 567 (abs. ref. 1).

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Overite $CaMgAl(PO_4)_2(OH)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are platy to lathlike, flattened on {010} and elongated along [001], to 4 mm; forms include {010}, {100}, {110}, {121}, {021}. Commonly in subparallel aggregates, massive.

Physical Properties: *Cleavage:* {010}, perfect; {100}, poor. Hardness = 3.5–4
D(meas.) = 2.53 D(calc.) = 2.51

Optical Properties: Semitransparent. *Color:* Light apple-green to colorless; in transmitted light, colorless. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, weak.
$\alpha = 1.568(2)$ $\beta = 1.574(2)$ $\gamma = 1.580(2)$ 2V(meas.) = 75(10)°

Cell Data: *Space Group: Pbca.* $a = 14.723(14)$ $b = 18.746(16)$ $c = 7.107(4)$ Z = 8

X-ray Powder Pattern: Fairfield, Utah, USA. (ICDD 16-157).
2.832 (100), 9.4 (80), 5.29 (60), 2.889 (60), 3.70 (50), 1.975 (50), 3.42 (40)

Chemistry:

	(1)	(2)
P_2O_5	38.9	38.32
Al_2O_3	13.7	13.77
MgO	11.2	10.88
CaO	16.1	15.14
H_2O	22.04	21.89
Total	101.9	100.00

(1) Fairfield, Utah, USA; by electron microprobe, H_2O separately determined.
(2) $CaMgAl(PO_4)_2(OH)\cdot 4H_2O$.

Mineral Group: Overite group.

Occurrence: In phosphate nodules (Fairfield, Utah, USA); in a complex granite pegmatite (Tanco pegmatite, Canada).

Association: Variscite, apatite (Fairfield, Utah, USA).

Distribution: Found at the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah, USA. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada.

Name: To honor Edwin J. Over (1903–1963), mineral collector, Colorado Springs, Colorado, USA, who first found the mineral.

Type Material: Harvard University, Cambridge, Massachusetts, 95482; National Museum of Natural History, Washington, D.C., USA, R7898.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 979–980. (2) Moore, P.B. (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. II. Redefinition of overite, an isotype of segelerite. III. Isotypy of robertsite, mitridatite, and arseniosiderite. Amer. Mineral., 59, 48–59. (3) Moore, P.B. and T. Araki (1977) Overite, segelerite, and jahnsite: a study in combinatorial polymorphism. Amer. Mineral., 62, 692–702.

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Owensite $(Ba,Pb)_6(Cu,Fe,Ni)_{25}S_{27}$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Owyheeite $Ag_3Pb_{10}Sb_{11}S_{28}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Massive to coarsely fibrous, acicular, striated longitudinally ‖ [001]; rarely as minute felted hairlike crystals.

Physical Properties: *Cleavage:* {001}. *Tenacity:* Very brittle. Hardness = 2.5 VHN = 92–121 (110 g load). D(meas.) = 6.22–6.51 D(calc.) = 6.43

Optical Properties: Opaque. *Color:* Pale silvery gray, tarnishes blue or yellow; pale gray in reflected light. *Streak:* Reddish brown. *Luster:* Metallic. *Pleochroism:* Distinct. *Anisotropism:* Strong, yellowish white and gray.
R_1–R_2: (400) 41.0–45.2, (420) 40.5–45.2, (440) 39.8–45.2, (460) 39.6–45.2, (480) 39.2–45.4, (500) 38.9–45.3, (520) 38.6–45.1, (540) 38.3–44.7, (560) 38.0–44.2, (580) 37.7–43.7, (600) 37.4–43.1, (620) 37.1–42.5, (640) 36.6–41.8, (660) 36.2–41.1, (680) 35.4–40.1, (700) 34.8–39.3

Cell Data: *Space Group: Pnam.* $a = 22.82$ $b = 27.20$ $c = 8.19$ $Z = 8$

X-ray Powder Pattern: Poorman mine, Idaho, USA.
3.25 (100), 3.49 (70), 2.84 (60), 2.05 (60), 2.90 (50), 2.23 (50), 3.37 (40)

Chemistry:

	(1)	(2)	(3)	(4)
Pb	40.77	43.86	46.9	44.72
Ag	7.40	6.14	6.5	6.99
Cu	0.75	1.55		
Fe	0.46	0.05		
Sb	30.61	29.26	28.7	28.91
S	20.81	19.06	18.4	19.38
Total	100.80	99.92	100.5	100.00

(1) Poorman mine, Idaho, USA; corresponds to $Ag_{2.96}(Pb_{8.49}Cu_{0.61}Fe_{0.36})_{\Sigma=9.46}Sb_{10.85}S_{28.00}$. (2) Sheba mine, Nevada, USA; average of two analyses, corresponds to $Ag_{2.68}(Pb_{9.97}Cu_{1.15}Fe_{0.04})_{\Sigma=11.16}Sb_{11.32}S_{28.00}$. (3) Freiberg, Saxony, Germany; by electron microprobe, corresponding to $Ag_{2.94}Pb_{11.04}Sb_{11.50}S_{28.00}$. (4) $Ag_3Pb_{10}Sb_{11}S_{28}$.

Occurrence: In veins of hydrothermal origin.

Association: Galena, sphalerite, pyrite, arsenopyrite, chalcopyrite, tetrahedrite, pyrargyrite, diaphorite, miargyrite, jamesonite, boulangerite, ramdohrite, andorite, meneghinite.

Distribution: In the USA, in Idaho, from the Poorman mine, Silver City district, Owyhee Co., Idaho [TL] and at the Banner mine, Boise Co.; from the Sheba mine, Star City, and at Rochester and in the Kaiser Tunnel, Morey district, Nye Co., Nevada; from the Domingo and Garfield mines, Gunnison Co., Colorado; at the McAlpine mine, Tuolumne Co., California. From the Alma property and Rambler mine, Slocan mining division, British Columbia; and the Tintina silver mines, Yukon Territory, Canada. From Yecora, five km west of Iglesia, Sonora, Mexico. At Marmato, Colombia. From the Wongabah mine, Drake and Rivertree mining fields, New South Wales, and at the Meerschaum mine, near Omeo, Victoria, Australia. From the Rajpura Dariba polymetallic deposit, Rajasthan, India. At the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia. From Kutná Hora, Czech Republic. At Bourneix, Haute-Vienne, France. From Roc-Blanc, Morocco. In the Srednegolgotaiskoe gold deposit, eastern Transbaikalia, Siberia, Russia. Known from a few other localities.

Name: For the locality in Owyhee Co., Idaho, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 94054.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 423. (2) Robinson, S.C. (1949) Owyheeite. Amer. Mineral., 34, 398–402. (3) Moëlo, Y., N. Mozgova, P. Picot, N. Bortnikov, and Z. Vrubleskaya (1984) Cristallochimie de l'owyheeite: nouvelles données. Tschermaks Mineral. Petrog. Mitt., 32, 271–284 (in French with English abs.). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 404.

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Oxammite $(NH_4)_2C_2O_4 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. Rare in crystals, typically in lamellar and pulverulent masses.

Physical Properties: *Cleavage:* On {001}, distinct. Hardness = 2.5 D(meas.) = ∼1.5 D(calc.) = 1.541 Soluble in H_2O.

Optical Properties: Transparent to opaque. *Color:* Colorless to pale yellow; colorless in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, distinct.
$\alpha = 1.438$ $\beta = 1.547$ $\gamma = 1.595$ 2V(meas.) = 62°

Cell Data: *Space Group:* $P2_12_12$ (synthetic). $a = 8.035$ $b = 10.32$ $c = 3.801$ Z = 2

X-ray Powder Pattern: Guañape Islands, Peru.
6.37 (10), 2.88 (8), 2.68 (8), 2.60 (8), 3.83 (7), 3.08 (7), 3.28 (6)

Chemistry:

	(1)	(2)	(3)
C_2O_4	53.30	61.93	54.97
NH_4	21.95	25.39	22.53
H_2O	24.75	12.68	22.50
Total	[100.00]	100.00	100.00

(1) Guañape Islands, Peru; recalculated to 100% after deduction of organic material 5.5%.
(2) $(NH_4)_2C_2O_4 \cdot H_2O$. (3) $(NH_4)_2C_2O_4 \cdot 2H_2O$.

Occurrence: Derived from bird or bat guano; in subfossil bird eggs and on subfossil birds.

Association: Mascagnite (Guañape Islands, Peru).

Distribution: From the Guañape Islands, south of Trujillo, Peru. In Petrogale Cave, near Madura, Western Australia. On Hamar an Nafur Island, Gulf of Masirah, Oman.

Name: As an OXalate of AMMonia.

Type Material: University of Virginia, Charlottesville, Virginia, apparently lost in a fire in 1916; Yale University, New Haven, Connecticut, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1103–1104. (2) Frondel, C. (1950) Notes on arcanite, ammonian aphthitalite and arcanite. Amer. Mineral., 35, 596–598. (3) Winchell, H. and R.J. Benoit (1951) Taylorite, mascagnite, aphthitalite, lecontite, and oxammite from guano. Amer. Mineral., 36, 590–601. (4) Taylor, J.C. and T.M. Sabine (1972) Isotope and bonding effects in ammonium oxalate monohydrate, determined by the combined use of neutron and X-ray diffraction analyses. Acta Cryst., 28, 3340–3351. (5) (1957) NBS Circ. 539, 7, 5.

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Oyelite $Ca_{10}B_2Si_8O_{29}\cdot 12.5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As aggregates of nearly parallel acicular crystals, to 3 mm.

Physical Properties: Hardness = 5 D(meas.) = 2.62 D(calc.) = [2.66]

Optical Properties: Semitransparent. *Color:* White; colorless in thin section.
Luster: Vitreous.
Optical Class: Biaxial. $\alpha = 1.602$ $\beta = 1.606$ $\gamma = 1.613$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 11.25$ $b = 7.25$ $c = 20.46$ Z = [2]

X-ray Powder Pattern: Fuka, Japan.
10.23 (100), 2.917 (60), 3.411 (25), 2.558 (15), 2.046 (13), 3.784 (10)

Chemistry:

	(1)	(2)
SiO_2	35.3	35.97
B_2O_3	4.8	5.21
Al_2O_3	0.3	
CaO	41.2	41.97
Na_2O	0.1	
H_2O^+	16.7	16.85
H_2O^-	0.7	
CO_2	0.4	
Total	99.5	100.00

(1) Fuka, Japan. (2) $Ca_{10}B_2Si_8O_{29}\cdot 12.5H_2O$.

Occurrence: In a vein in gehlenite-spurrite skarn (Fuka, Japan).

Association: Bultfonteinite, scawtite, xonotlite, calcite (Fuka, Japan).

Distribution: At Fuka, near Bicchu, Okayama Prefecture, Japan. From Crestmore, Riverside Co., California, USA. In the N'Chwaning mine, near Kuruman, Cape Province, South Africa.

Name: For Dr. Jiro Oye, late Professor of Mineralogy, Okayama University, Okayama, Japan.

Type Material: National Science Museum, Tokyo, Japan, M23576; National Museum of Natural History, Washington, D.C., USA, 148213.

References: (1) Kusachi, I., C. Henmi, and K. Henmi (1984) An oyelite-bearing vein at Fuka, the town of Bitchu, Okayama Prefecture, Japan. J. Japan. Assoc. Min. Petr. Econ. Geol., 79, 267–275. (2) (1986) Amer. Mineral., 71, 230 (abs. ref. 1). (3) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 37–38 [tobermorite 10Å hydrate].

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Pääkkönenite Sb_2AsS_2

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. As rare crystals, to 30 μm, and in irregular grains. *Twinning:* Finely spaced polysynthetic twinning is present; synthetic crystals are twinned on {001}.

Physical Properties: *Cleavage:* In one direction. *Tenacity:* Brittle. Hardness = ∼2 VHN = 66–87, 77 average (10 g load). D(meas.) = n.d. D(calc.) = 5.21

Optical Properties: Opaque. *Color:* Dark gray; very pale gray in reflected light, with bright red internal reflections. *Streak:* Gray with a brownish tint. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong.

R_1–R_2: (400) — , (420) — , (440) 40.9–52.1, (460) 39.8–51.7, (480) 38.7–50.8, (500) 38.0–49.8, (520) 37.5–48.7, (540) 37.2–47.8, (560) 36.9–47.0, (580) 36.7–46.3, (600) 36.5–45.8, (620) 36.5–45.5, (640) 36.4–45.3, (660) 36.2–45.1, (680) 36.2–45.4, (700) 36.0–45.3

Cell Data: *Space Group:* $C2/m$ (synthetic). $a = 10.75(2)$ $b = 3.959(3)$ $c = 12.49(2)$ $\beta = 115.28(8)°$ Z = 4

X-ray Powder Pattern: Kalliosalo deposit, Finland.
2.87 (10), 2.68 (6), 3.90 (4), 3.13 (4), 2.27 (3), 1.750 (3), 2.08 (2)

Chemistry:

	(1)	(2)
Sb	66.9	63.65
As	18.6	19.59
S	15.5	16.76
Total	101.0	100.00

(1) Kalliosalo deposit, Finland; by electron microprobe, average of five analyses; corresponding to $Sb_{2.14}As_{0.97}S_{1.89}$. (2) Sb_2AsS_2.

Occurrence: In hydrothermal mineral deposits with other Sb–As-bearing minerals.

Association: Arsenopyrite, arsenic, löllingite, stibnite, antimony (Kalliosalo deposit, Finland); stibarsen, arsenic, stibnite, sphalerite, siderite, quartz (Příbram, Czech Republic); vaughanite, stibarsen, realgar, arsenic (Hemlo mine, Canada).

Distribution: From the Kalliosalo deposit, Seinäjoki region, Finland [TL]. At Příbram, Czech Republic. In the Hemlo gold deposit, Hemlo, Ontario, Canada.

Name: To honor Viekko Pääkkönen (1907–1980), Finnish geologist, who studied the ore deposits of the type region.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Borodaev, Y.S., N.N. Mozgova, N.A. Ozerova, N.S. Bortnikov, P. Oivanen, and V. Iletuinen (1981) Pääkkönenite, Sb_2AsS_2, a new mineral from the Seinäjoki ore region in Finland. Zap. Vses. Mineral. Obshch., 110, 480–487 (in Russian). (2) (1982) Amer. Mineral., 67, 858 (abs. ref. 1). (3) Bonazzi, P., D. Borrini, F. Mazzi, and F. Olmi (1995) Crystal structure and twinning of Sb_2AsS_2, the synthetic analogue of pääkkönenite. Amer. Mineral., 80, 1054–1058. (4) Cureton, F. and B. Cureton (1994) Second occurrence of paakkonenite. Mineral. Record, 25, 386.

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Pabstite $Ba(Sn,Ti)Si_3O_9$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Rarely in crystals showing a trigonal outline; commonly as anhedral grains or aggregates, to 1 cm.

Physical Properties: Hardness = ~6 D(meas.) = 4.03 D(calc.) = 4.07 Fluoresces bluish white under SW UV.

Optical Properties: Semitransparent. *Color:* Colorless to white with a pink tinge on a fresh surface; in thin section, shows anomalous interference colors in blue-violet or golden yellow.
Luster: Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.685(2)$ $\epsilon = 1.674(2)$

Cell Data: *Space Group:* $P\bar{6}c2$. $a = 6.7037(7)$ $c = 9.824(1)$ $Z = 2$

X-ray Powder Pattern: Santa Cruz, California, USA.
3.762 (100), 2.775 (90), 5.829 (30), 3.363 (30), 1.987 (20), 2.912 (18), 1.807 (17)

Chemistry:

	(1)
SiO_2	37.7
TiO_2	3.8
SnO_2	24.4
BaO	33.2
Total	99.1

(1) Santa Cruz, California, USA; by electron microprobe, corresponding to $Ba_{1.03}(Sn_{0.77}Ti_{0.23})_{\Sigma=1.00}Si_{2.99}O_9$.

Occurrence: As fracture fillings and disseminated grains in recrystallized siliceous limestone which shows evidence of contact metamorphism.

Association: Calcite, quartz, tremolite, witherite, phlogopite, diopside, forsterite, taramellite.

Distribution: In the USA, in the Kalkar quarry, Santa Cruz, Santa Cruz Co., California.

Name: For Dr. Adolf Pabst (1899–1990), Professor of Mineralogy, University of California, Berkeley, California, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 119605; National Museum of Natural History, Washington, D.C., USA, 145632.

References: (1) Gross, E.B., J.E.N. Wainwright, and B.W. Evans (1965) Pabstite, the tin analogue of benitoite. Amer. Mineral., 50, 1164–1169. (2) Hawthorne, F.C. (1987) The crystal chemistry of the benitoite group minerals and structural relations in (Si_3O_9) ring structures. Neues Jahrb. Mineral., Monatsh., 16–30.

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Paceite $CaCu(C_2H_3O_2)_4 \cdot 6H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Isolated crystals are short prisms, showing {100}, {001}, {111}, to 1 mm.

Physical Properties: *Cleavage:* On {100} and {110}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = n.d. D(calc.) = 1.472 Soluble in H_2O.

Optical Properties: Translucent. *Color:* Dark sky-blue. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Uniaxial (+) (synthetic). *Pleochroism:* O = pale blue with a greenish tint; E = pale blue with a grayish tint. *Absorption:* $O \geq E$. $\omega = 1.439(2)$ $\epsilon = 1.482(3)$

Cell Data: *Space Group:* $I4/m$. $a = 11.155(4)$ $c = 16.236(17)$ $Z = 4$

X-ray Powder Pattern: Potosi pit, Australia.
7.896 (100), 3.530 (20), 5.586 (15), 8.132 (8), 9.297 (6), 2.497 (4), 3.042 (3)

Chemistry:

	(1)	(2)
Cu	14.1	14.19
Ca	9.0	8.95
C	21.25	21.45
H	5.3	5.40
O	[50.35]	50.01
Total	[100.00]	100.00

(1) Potosi pit, Australia; by AA, C and H by CHN analyzer, average of two analyses, O by difference; corresponds to $Ca_{1.02}Cu_{1.00}C_{8.00}H_{23.77}O_{14.23}$. (2) $CaCu(C_2H_3O_2)_4 \cdot 6H_2O$.

Occurrence: Formed in ferruginous gossan by reaction of oxidized zone metallic minerals with decaying vegetable matter provided by leaf litter and possibly mine timbers.

Association: Hoganite, linarite, malachite, azurite, cuprian smithsonite, cerussite, goethite, hematite, quartz.

Distribution: From the Potosi Ag–Pb–Zn mine, two km northeast of Broken Hill, New South Wales, Australia.

Name: To honor Frank L. Pace (1948–), Broken Hill, miner and collector of Broken Hill minerals, who first noted the mineral.

Type Material: Broken Hill Geocentre, Broken Hill; Australian Museum, Sydney; Museum of Victoria, Melbourne, Australia, M47465.

References: (1) Hibbs, D.E., U. Kolitsch, P. Leverett, J.L. Sharpe, and P.A. Williams (2002) Hoganite and paceite, two new acetate minerals from the Potosi mine, Broken Hill, Australia. Mineral. Mag., 66, 459–464. (2) Klop, E.A., A.J.M. Duisenberg, and A.L. Spek (1983) Reinvestigation of the structure of calcium copper acetate hexahydrate, $CaCu(C_2H_3O_2)_4.6H_2O$. Acta Cryst., C39, 1342–1344.

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Pachnolite $NaCaAlF_6 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic along [001], with dominant {110}, striated ‖ {001}, and acute termination by {111}, {221}, etc., and {001}, with rhombic section, to 8 cm; cleavable to granular, stalactitic, porcelaneous massive. *Twinning:* On {100}, apparently universal, giving a grid pattern in thin section.

Physical Properties: *Cleavage:* {001}, good to indistinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.965–3.008 D(calc.) = 2.97

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 69(1)°$. *Dispersion:* $r < v$, weak; strong horizontal dispersion. $\alpha = 1.4065(1)$ $\beta = 1.4104(1)$ $\gamma = 1.4191(2)$ 2V(meas.) = 66.3°–76° ($2V_\gamma$).

Cell Data: *Space Group:* $F2/d$. a = 12.117(4) $b = 10.414(3)$ $c = 15.680(4)$ $\beta = 90.37(2)°$ Z = 16

X-ray Powder Pattern: Ivigtut, Greenland.
3.95 (100), 1.971 (90), 2.79 (70), 2.16 (50), 3.02 (20), 3.26 (10), 2.92 (10)

Chemistry:

	(1)	(2)	(3)
Na	10.23	10.23	10.35
Ca	18.14	18.06	18.05
Al	12.50	12.14	12.15
F	51.54	51.33	51.34
H_2O	8.19	8.10	8.11
Total	100.60	99.86	100.00

(1) Ivigtut, Greenland. (2) St. Peters Dome, Colorado, USA. (3) $NaCaAlF_6 \cdot H_2O$.

Polymorphism & Series: Dimorphous with thomsenolite.

Occurrence: As an alteration product of cryolite and other alkali aluminum fluorides, most commonly in pegmatites.

Association: Cryolite, thomsenolite, chiolite, elpasolite, ralstonite, sellaite, fluorite.

Distribution: In the Ivigtut cryolite deposit, southwestern Greenland. From near Lake Gjerdingen, Nordmarka, Norway. In the Hagendorf pegmatite, Bavaria, Germany. In the USA, at St. Peters Dome, near Pikes Peak, El Paso Co., and in the Goldie carbonatite, McClure Mountain-Iron Mountain, Fremont Co., Colorado; at the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada; from the Morefield pegmatite mine, Amelia, Amelia Co., Virginia. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina.

Name: From the Greek for *frost* and *stone*, in allusion to its appearance.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 114–116. (2) Pauly, H. and O.V. Petersen (1983) Pachnolite: new optical data with a note on artificial precipitates. Neues Jahrb. Mineral., Monatsh., 241–250. (3) Hawthorne, F.C. and R.B. Ferguson (1983) The crystal structure of pachnolite. Can. Mineral., 21, 561–566.

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Paděraite $AgPb_2Cu_6^{1+}Bi_{11}S_{22}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Platy fragments, in granular to parallel fibrous aggregates, to several mm.

Physical Properties: *Fracture:* Uneven. Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 6.91

Optical Properties: Opaque. *Color:* Steel-gray on fresh fractures, turning brown to black; in polished section, creamy white. *Anisotropism:* Moderate.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/m$. $a = 28.44$ $b = 3.95$ $c = 17.55$ $\beta = 106.1°$ $Z = 2$

X-ray Powder Pattern: Calculated from structure.
3.06 (100), 3.63 (74), 3.21 (61), 2.85 (43), 2.66 (38), 3.18 (34), 2.19 (30)

Chemistry:

	(1)	(2)	(3)
Ag	3.26	1.00	2.76
Pb	6.71	6.47	10.60
Cu	9.45	11.74	9.76
Cd		0.01	
Bi	61.40	61.24	58.83
S	18.90	18.35	18.05
Total	99.72	98.81	100.00

(1) Băiţa, Romania; by electron microprobe, average of six analyses on two grains; corresponds to $Ag_{1.13}Pb_{1.21}Cu_{5.55}Bi_{10.97}S_{22.00}$. (2) Ocna de Fier, Romania; by electron microprobe, average of 37 analyses; corresponds to $Ag_{0.36}Pb_{1.20}Cu_{7.11}Bi_{11.28}S_{22.05}$. (3) $AgPb_2Cu_6Bi_{11}S_{22}$.

Occurrence: Intimately intergrown with other Pb–Bi sulfosalts.

Association: Hammarite, pekoite, bismuthinite, cuprobismutite, hodrushite, chalcopyrite, grossular, andradite.

Distribution: In Romania, from Băiţa (Rézbánya) [TL], and in the Paulus mine, Ocna de Fier (Morávicza; Vaskő). At Banská Štiavnica (Schemnitz), Slovakia.

Name: Honors Dr. Karel Paděra (1923–), Czech mineralogist, Charles University, Prague, Czech Republic, who first worked on the mineral.

Type Material: Charles University, Prague, Czech Republic, 11329; National Museum of Natural History, Washington, D.C., USA, 164244.

References: (1) Mumme, W.G. and L. Žák (1985) Paděraite, $Cu_{5.9}Ag_{1.3}Pb_{1.6}Bi_{11.2}S_{22}$, a new mineral of the cuprobismutite–hodrushite group. Neues Jahrb. Mineral., Monatsh., 557–567. (2) Mumme, W.G. (1986) The crystal structure of paderaite, a mineral of the cuprobismutite series. Can. Mineral., 24, 513–521. (3) Cook, N.J. and C.L. Ciobanu (2003) Lamellar minerals of the cuprobismutite series and related paděraite: a new occurrence and implications. Can. Mineral., 41, 441–456.

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Padmaite PdBiSe

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Pahasapaite $Li_8(Ca,Li,K,Na)_{11}Be_{24}(PO_4)_{24}\cdot 38H_2O$

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Crystal Data: Cubic. *Point Group:* 23. As isolated euhedral, but usually malformed crystals, to about 1 mm, displaying {110} and {111}.

Physical Properties: Hardness = ∼4.5 D(meas.) = 2.28(4) D(calc.) = 2.24

Optical Properties: Transparent. *Color:* Colorless to pale pink. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.523(2)$

Cell Data: *Space Group: I*23. a = 13.781(4) Z = 1

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
9.60 (100), 3.684 (90), 3.248 (90), 2.935 (90), 2.702 (60), 4.35 (40), 2.237 (40)

Chemistry:

	(1)	(2)
P_2O_5	46.0	48.22
BeO	n.d.	16.99
CaO	8.5	8.73
Li_2O	4.8	4.91
Na_2O	0.2	0.17
K_2O	1.6	1.60
H_2O	18.0	19.38
Total		100.00

(1) Tip Top mine, South Dakota, USA; partial analysis by electron microprobe, H_2O by TGA, Li and presence of Be confirmed by ion microprobe. (2) $Li_8(Ca_{5.5}Li_{3.6}K_{1.2}Na_{0.2})_{\Sigma=10.5}Be_{24}(PO_4)_{24}\cdot 38H_2O$.

Mineral Group: Zeolite group.

Occurrence: A rare late-stage mineral in seams in fractured beryl crystals, within the inner-intermediate zone of a complex granite pegmatite.

Association: Englishite, roscherite, eosphorite–childrenite, tiptopite, montgomeryite.

Distribution: At the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: From *Pahasapa*, the Lakota Sioux word for the Black Hills, in allusion to the type locality.

Type Material: National Museum of Natural History, Washington, D.C., USA, 159879.

References: (1) Rouse, R.C., D.R. Peacor, P.J. Dunn, T.J. Campbell, W.L. Roberts, F.J. Wicks, and D. Newbury (1987) Pahasapaite, a beryllophosphate zeolite related to synthetic zeolite rho, from the Tip Top Pegmatite of South Dakota. Neues Jahrb. Mineral., Monatsh., 433–440. (2) (1988) Amer. Mineral., 73, 1496 (abs. ref. 1). (3) Rouse, R.C., D.R. Peacor, and S. Merlino (1989) Crystal structure of pahasapaite, a beryllophosphate mineral with a distorted zeolite rho framework. Amer. Mineral., 74, 1195–1202.

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Painite $CaZrAl_9O_{15}(BO_3)$.

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Crystal Data: Hexagonal. *Point Group:* 6. Elongated crystals, pseudo-orthorhombic, showing $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, $\{12\bar{3}0\}$, $\{13\bar{4}0\}$, $\{11\bar{2}1\}$, $\{11\bar{2}2\}$, $\{11\bar{2}3\}$, $\{20\bar{2}1\}$, $\{10\bar{1}1\}$, and $\{0001\}$, to 1.5 cm.

Physical Properties: Hardness = ∼8 D(meas.) = 4.01–4.03 D(calc.) = 3.996–4.020

Optical Properties: Transparent. *Color:* Deep garnet-red, brownish red-orange. *Optical Class:* Uniaxial (–). *Pleochroism:* Ruby-red ∥ [0001]; pale brownish orange or pale red-orange ⊥ [0001]. $\omega = 1.8159$ $\epsilon = 1.7875$

Cell Data: *Space Group:* $P6_3$. $a = 8.715(2)$ $c = 8.472(2)$ Z = 2

X-ray Powder Pattern: Near Ohngaing, Myanmar.
5.76 (vs), 2.520 (vs), 3.70 (s), 2.370 (s), 2.008 (s), 1.726 (ms), 1.423 (ms)

Chemistry:

	(1)	(2)
B_2O_3	n.d.	5.17
ZrO_2	18.77	18.31
Al_2O_3	69.02	68.19
CaO	7.17	8.33
H_2O	n.d.	
Total	94.96	100.00

(1) Near Ohngaing, Myanmar; by electron microprobe, B determined present by wet chemical analysis, IR, and crystal-structure analysis. (2) $CaZrAl_9O_{15}(BO_3)$.

Occurrence: In gem gravels.

Association: Corundum, phlogopite.

Distribution: From near Ohngaing village, Sagaing, Mogok district, Myanmar (Burma).

Name: For Arthur Charles Davy Pain (?–1971), British gem collector, who first noted the species.

Type Material: The Natural History Museum, London, England, 1954,192; National Museum of Natural History, Washington, D.C., USA, 142506.

References: (1) Claringbull, G.F., M.H. Hey, and C.J. Payne (1957) Painite, a new mineral from Mogok, Burma. Mineral. Mag., 31, 420–425. (2) (1957) Amer. Mineral., 42, 580 (abs. ref. 1). (3) Moore, P.B. and T. Araki (1976) Painite, $CaZrB[Al_9O_{18}]$: its crystal structure and relation to jeremejevite, $B_5[\square_3Al_6(OH)_3O_{15}]$, and fluoborite, $B_3[Mg_9(F,OH)_9O_9]$. Amer. Mineral., 61, 88–94. (4) Shigley, J.E., A.R. Kampf, and G.R. Rossman (1986) New data on painite. Mineral. Mag., 50, 267–270.

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Palarstanide $Pd_5(Sn, As)_2$

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Crystal Data: Hexagonal. *Point Group:* n.d. As distinct hexagonal prisms and minute elongated anhedral grains with rectangular outlines, rarely as sinuous grains, to 1.5 mm.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Brittle. Hardness = n.d. VHN = 470(30) (50 g load). D(meas.) = n.d. D(calc.) = 10.27

Optical Properties: Opaque. *Color:* Steel-gray; grayish white with slight rose tint in reflected light. *Luster:* Metallic. *Pleochroism:* Distinct in oil. *Anisotropism:* Slight, dark gray to brownish gray. *Bireflectance:* Barely perceptible in air, distinct in oil.
R_1–R_2: (400) — , (420) 46.0–49.2, (440) 47.1–50.1, (460) 48.1–51.1, (480) 49.7–51.9, (500) 50.8–52.8, (520) 52.1–53.5, (540) 53.2–54.5, (560) 54.2–55.4, (580) 55.1–56.4, (600) 56.3–57.4, (620) 57.2–58.3, (640) 58.5–59.3, (660) 59.3–60.1, (680) 59.9–60.6, (700) 60.0–61.0

Cell Data: *Space Group:* n.d. $a = 7.50$ $c = 10.34$ Z = [3]

X-ray Powder Pattern: Majak mine, Russia.
2.22 (10), 2.50 (4), 1.986 (4), 1.784 (3), 1.187 (3), 2.46 (2), 2.20 (2)

Chemistry:

	(1)
Pd	65.1
Pt	4.7
Au	1.0
Cu	0.1
Pb	4.6
Sn	13.2
As	7.2
Sb	3.0
Bi	1.0
Total	99.9

(1) Majak mine, Russia; by electron microprobe, average of four analyses; corresponds to $(Pd_{4.75}Pt_{0.19}Pb_{0.17}Au_{0.04}Cu_{0.01})_{\Sigma=5.16}(Sn_{0.86}As_{0.75}Sb_{0.19}Bi_{0.04})_{\Sigma=1.84}$.

Occurrence: Intergrown with other minerals in massive ores of cubanite, chalcopyrite and talnakhite.

Association: Pentlandite, rustenburgite–atokite, Pt–Fe alloy, polarite, sperrylite, majakite, Au–Ag–Cu alloys.

Distribution: From the Majak mine, Talnakh area, Noril'sk region, western Siberia, Russia [TL].

Name: For the principal elements, PALladium, ARsenic and tin, STANnum.

Type Material: Geological Exploration Institute, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81391.

References: (1) Begizov, V.D., E.M. Zav'yalov, and E.G. Pavlov (1981) Palarstanide, $Pd_8(Sn, As)_3$, a new mineral. Zap. Vses. Mineral. Obshch., 110, 487–492 (in Russian). (2) (1982) Amer. Mineral., 67, 858–859 (abs. ref. 1). (3) Evstigneeva, T.L. and A.D. Genkin (1986) The Pd, Sn, Sb, and As minerals; their relationships and crystal chemistry. In: Proceedings 13th General Meeting IMA, Varna, Sept. 19-25, 1982, Sifia, 165–174. Sofia Publ. House, Bulgarian Acad. Sci. (in Russian). (4) (1989) Amer. Mineral., 74, 1219–1220 (abs. ref. 3).

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Palenzonaite $NaCa_2Mn_2^{2+}(VO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. In dodecahedral crystals, to 6 mm, and as anhedral grains.

Physical Properties: *Fracture:* Subconchoidal. Hardness = 5–5.5 D(meas.) = 3.63(2) D(calc.) = 3.78–3.79

Optical Properties: Transparent. *Color:* Wine-red; in thin section, wine-red. *Streak:* Brownish red. *Luster:* Adamantine. *Optical Class:* Isotropic. $n = 1.965(5)$

Cell Data: *Space Group:* $Ia3d$. $a = 12.534(2)$ Z = 8

X-ray Powder Pattern: Molinello mine, Italy.
2.803 (100), 2.558 (60), 3.132 (55), 1.675 (40), 1.738 (20), 2.673 (19), 5.12 (11)

Chemistry:

	(1)
As_2O_5	5.14
V_2O_5	39.34
SiO_2	3.32
MnO	25.19
CaO	23.70
Na_2O	3.40
Total	100.09

(1) Molinello mine, Italy; by electron microprobe, average of three analyses, total Mn as MnO; corresponds to $Na_{0.62}Ca_{2.37}Mn_{1.99}[(V_{0.81}Si_{0.10}As_{0.08})_{\Sigma=0.99}O_4]_3$.

Occurrence: A rare mineral in narrow veinlets cutting a manganese deposit hosted within radiolarian cherts (Molinello mine, Italy).

Association: Manganoan calcite, saneroite, ganophyllite, axinite (Molinello mine, Italy); medaite, saneroite, pyrobelonite, fianelite, parsettensite, rhodochrosite, kutnohorite, aegirine, quartz (Fianel mine, Switzerland).

Distribution: From the Molinello manganese mine, near Chiavari, Val Graveglia, Liguria, Italy. At the Fianel mine, Val Ferrera, Graubünden, Switzerland.

Name: In honor of Professor Andrea Palenzona, amateur mineralogist and discoverer of the mineral.

Type Material: University of Genoa, Genoa, Italy; Royal Ontario Museum, Toronto, Canada.

References: (1) Basso, R. (1987) The crystal structure of palenzonaite, a new vanadate garnet from Val Graveglia (Northern Apennines, Italy). Neues Jahrb. Mineral., Monatsh., 136–144.
(2) (1988) Amer. Mineral., 73, 930 (abs. ref. 1).

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Palermoite $(Li, Na)_2(Sr, Ca)Al_4(PO_4)_4(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Long prismatic crystals, showing {100}, {010}, {110}, {031}, {011}, striated ‖ [100], to 5 mm; granular.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, fair. *Fracture:* Fibrous to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 3.22 D(calc.) = 3.26 White cathodoluminescence in X-ray beam.

Optical Properties: Semitransparent. *Color:* Colorless, white, pale pink. *Streak:* White. *Luster:* Vitreous to subadamantine.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, moderate.
$\alpha = 1.627$ $\beta = 1.642$ $\gamma = 1.644$ 2V(meas.) = ∼20°

Cell Data: *Space Group: Imcb.* $a = 11.556(5)$ $b = 15.847(7)$ $c = 7.315(4)$ Z = 4

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
3.089 (100), 4.360 (64), 3.129 (60), 2.905 (53), 3.320 (52), 2.596 (48), 2.436 (46)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	42.89	43.65	BaO	0.10	
Al_2O_3	30.83	30.18	Li_2O	4.00	n.d.
Fe_2O_3	0.30		Na_2O	1.32	
FeO		0.35	K_2O	0.10	
MgO	0.10	0.02	H_2O^+	5.36	n.d.
CaO	1.39	1.65	H_2O^-	0.30	
SrO	12.93	11.34	Total	99.69	

(1) Palermo #1 mine, New Hampshire, USA; corresponds to $(Li_{1.74}Na_{0.28}K_{0.01})_{\Sigma=2.03}(Sr_{0.81}Ca_{0.16}Fe_{0.02}Mg_{0.02})_{\Sigma=1.01}Al_{3.93}(PO_4)_{3.92}(OH)_{3.87}$. (2) Giogo di Toirano, Italy; partial analysis by electron microprobe, total Fe as FeO.

Occurrence: A late hydrothermal product in a complex zoned granite pegmatite (Palermo #1 mine, New Hampshire, USA); near quartz veins in sandstones and conglomerates subjected to greenschist metamorphism (Giogo di Toirano, Italy).

Association: Siderite, childrenite–eosphorite, beraunite, crandallite, whitlockite, brazilianite, goyazite, apatite, quartz (Palermo #1 mine, New Hampshire, USA); lazulite, goyazite, brazilianite (Giogo di Toirano, Italy).

Distribution: In the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, USA. From Giogo di Toirano, near Bardineto, Liguria, Italy. In the Xiyuantou pegmatite, Nanping, Fujian Province, China.

Name: For its occurrence at the Palermo #1 mine, New Hampshire, USA.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 101342.

References: (1) Mrose, M.E. (1953) Palermoite and goyazite, two strontium minerals from the Palermo mine, North Groton, New Hampshire. Amer. Mineral., 38, 354 (abs.). (2) Frondel, C. and J. Ito (1965) Composition of palermoite. Amer. Mineral., 50, 777–779. (3) Moore, P.B. and T. Araki (1975) Palermoite, $SrLi_2[Al_4(OH)_4(PO_4)_4]$: its atomic arrangement and relationship to carminite, $Pb_2[Fe_4(OH)_4(AsO_4)_4]$. Amer. Mineral., 60, 460–465. (4) Cortesogno, L., L. Gaggero, and G. Lucchetti (1987) Phosphate mineralizations in a permo-triassic sequence (Giogo di Toirano, Italy). Neues Jahrb. Mineral., Monatsh., 305–313.

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Palladium Pd

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rarely as small octahedra; may be discoidal, then forming rosettes, to 3 μm; commonly in grains, which may have a radial fibrous texture.

Physical Properties: *Tenacity:* Ductile, malleable. Hardness = 4.5–5 VHN = n.d. D(meas.) = 11.9 D(calc.) = 12.04

Optical Properties: Opaque. *Color:* Whitish steel-gray. *Luster:* Metallic.
R: (400) 60.6, (420) 62.0, (440) 63.4, (460) 64.6, (480) 65.6, (500) 66.4, (520) 67.2, (540) 67.8, (560) 68.3, (580) 68.9, (600) 69.5, (620) 70.2, (640) 70.9, (660) 71.7, (680) 72.5, (700) 73.4

Cell Data: *Space Group:* $Fm3m$ (synthetic). a = 3.8898 Z = 4

X-ray Powder Pattern: Potaro River, Guyana.
2.259 (100), 1.184 (60), 1.957 (50), 1.387 (40), 1.132 (20), 0.9824 (10), 0.9019 (4b)

Chemistry:

	(1)
Pd	77.2
Hg	22.6
Total	99.8

(1) Potaro River, Guyana; by electron microprobe.

Occurrence: An oxidation product of palladium-bearing sulfides and as a primary phase in platinum deposits.

Association: Pt–Fe alloys, Pd–Hg minerals, gold, Au–Ag alloy, lead, sobolevskite.

Distribution: In Brazil [TL], in Minas Gerais, from placers in the Bom Succeso Stream, northwest of Serro; and around Itabira, as at the Cauê iron mine. In placers in the Department of Chocó, Cauca, Colombia. In Russia, from placers in the Ural Mountains. In Poland, at the Lubin copper mine, near Legnica, Zechstein copper district, and in the weathered cover of the Szklary massif. From the Transvaal, South Africa. In Guyana, in placers on the Potaro River.

Name: In honor of the discovery of the planetoid *Pallas*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 109–110. (2) Hull, ?? and ?? Davy (1921) ??title?? Strukturbereicht??, 1, 70–??. [Os,Ir also, cf]?? (2) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 125–126, 160. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 342.

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Palladoarsenide Pd_2As

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As irregular grains in chalcopyrite, long and veinletlike, vermiform, with curving boundaries, to 0.4 mm.

Physical Properties: *Cleavage:* Perfect in two directions. *Tenacity:* Brittle. Hardness = n.d. VHN = 277–357, 326 average (20 g load). D(meas.) = n.d. D(calc.) = 10.42

Optical Properties: Opaque. *Color:* Steel-gray; grayish white with slight rose tint in polished section. *Luster:* Metallic. *Anisotropism:* Moderate, dark gray with bluish tint to red-brown in air, dark gray to brownish gray with red tint in oil.
R_1–R_2: (400) 44.2–45.1, (420) 46.8–46.8, (440) 48.4–48.8, (460) 49.4–50.3, (480) 50.2–51.6, (500) 51.2–53.1, (520) 51.9–54.1, (540) 52.5–54.8, (560) 53.3–55.4, (580) 53.9–55.8, (600) 54.6–56.3, (620) 55.4–57.1, (640) 56.0–57.6, (660) 56.6–58.1, (680) 57.1–58.6, (700) 57.8–59.2

Cell Data: *Space Group:* $P2/m$. $a = 9.25(1)$ $b = 8.47(2)$ $c = 10.44(2)$ $\beta = 94.0°$
$Z = 18$

X-ray Powder Pattern: Komsomol'skii mine, Russia.
2.14 (10), 2.21 (9), 2.60 (7), 1.955 (7), 2.35 (6), 2.31 (6), 2.13 (5)

Chemistry:

	(1)	(2)	(3)	(4)
Pd	67.8	74.0	73.4	73.96
Pt		0.10	0.43	
Au	1.5	0.11	n.d.	
Ag	3.5	n.d.	n.d.	
Ni		n.d.	0.23	
Cu		0.34	n.d.	
Sb			0.04	
As	26.0	24.4	24.2	26.04
Te		1.3	0.54	
Total	98.8	100.25	98.84	100.00

(1) Komsomol'skii mine, Russia; by electron microprobe, corresponding to $(Pd_{1.87}Ag_{0.09}Au_{0.02})_{\Sigma=1.98}As_{1.02}$. (2) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $(Pd_{2.01}Cu_{0.02})_{\Sigma=2.03}(As_{0.94}Te_{0.03})_{\Sigma=0.97}$. (3) Lac des Iles complex, Canada; by electron microprobe, corresponding to $(Pd_{2.02}Pt_{0.01}Ni_{0.01})_{\Sigma=2.04}(As_{0.95}Te_{0.01})_{\Sigma=0.96}$. (4) Pd_2As.

Occurrence: As minute grains in chalcopyrite in veins along the footwall of a Cu–Ni sulfide deposit (Talnakh area, Russia); from heavy-mineral concentrates (Stillwater complex, Montana, USA).

Association: Chalcopyrite, sperrylite, gold, kotulskite (Talnakh area, Russia).

Distribution: In the Komsomol'skii mine, Oktyabr Cu–Ni deposit, Talnakh area, Noril'sk district, western Siberia, Russia [TL]. At the Elatsite porphyry copper deposit, Srednogorie zone, Bulgaria. From the Konttijarvi intrusions, northern Finland. In the USA, in the Banded and Upper Zones of the Stillwater complex, Montana. In Canada, at the Lac des Iles complex, Ontario. From Kambalda, 56 km south of Kalgoorlie, Western Australia. At the Onverwacht mine, on the Merensky Reef, Bushveld complex, Transvaal, South Africa.

Name: For PALLADium and ARSENic in its chemical composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Begizov, V.D., V.I. Meschankina, and L.S. Dubakina (1974) Palladoarsenide, Pd_2As, a new natural palladium arsenide from the copper–nickel deposits of the Oktyabr deposits. Zap. Vses. Mineral. Obshch., 103, 104–107 (in Russian). (2) (1975) Amer. Mineral., 60, 162 (abs. ref. 1). (3) Cabri, L.J., J.H.G. Laflamme, J.M. Stewart, J.F. Rowland, and T.T. Chen (1975) New data on some palladium arsenides and antimonides. Can. Mineral., 13, 321–335. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 408.

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Palladobismutharsenide $Pd_2(As, Bi)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As irregular grains, to 165 μm.

Physical Properties: Hardness = n.d. VHN = 429–483, 450 average (25 g load).
D(meas.) = n.d. D(calc.) = 10.8

Optical Properties: Opaque. *Color:* In polished section, pale cream. *Luster:* Metallic. *Anisotropism:* Weak to distinct; in air from gray to extinction, in oil varying from gray to brownish gray or brown at extinction.
R_1–R_2: (470) 53.6–54.5, (546) 52.1–53.0, (589) 53.6–54.6, (650) 55.8–56.1

Cell Data: *Space Group:* $Pmcn$ or $P2_1cn$. $a = 7.504(4)$ $b = 18.884(1)$ $c = 6.841(7)$
Z = 20

X-ray Powder Pattern: Stillwater complex, Montana, USA.
2.224 (100), 2.505 (90), 2.089 (60), 2.596 (40), 1.880 (40), 2.380 (30), 1.211 (30)

Chemistry:

	(1)
Pd	67.3
As	19.1
Bi	13.4
Total	99.8

(1) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $Pd_{1.99}(As_{0.81}Bi_{0.20})_{\Sigma=1.01}$.

Occurrence: From heavy mineral concentrates (Stillwater complex, Montana, USA).

Association: Palladoarsenide, an undetermined (Pd,Te,Bi) mineral, calcite.

Distribution: In the Banded and Upper Zones, Stillwater complex, Montana, USA [TL].

Name: For the composition, palladium, bismuth, and arsenic.

Type Material: Royal Ontario Museum, Toronto, Canada, M34218; National Museum of Natural History, Washington, D.C., USA, 135407.

References: (1) Cabri, L.J., T.T. Chen, J.W. Stewart, and J.H.G. Laflamme (1976) Two new palladium–arsenic–bismuth minerals from the Stillwater Complex, Montana. Can. Mineral., 14, 410–413. (2) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 126–127.

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Palladodymite $(Pd, Rh)_2As$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Palladseite $Pd_{17}Se_{15}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As grains, to 0.5 mm; as euhedral inclusions and infilling fractures in iron oxides.

Physical Properties: Hardness = n.d. VHN = 390–437, 414 average (100 g load). D(meas.) = 8.30 (synthetic). D(calc.) = 8.15

Optical Properties: Opaque. *Color:* In reflected light, white in air, light gray in oil. R: (400) 42.4, (420) 42.8, (440) 43.3, (460) 43.8, (480) 44.3, (500) 44.8, (520) 45.4, (540) 45.7, (560) 45.8, (580) 45.7, (600) 45.6, (620) 45.6, (640) 45.6, (660) 45.7, (680) 45.8, (700) 46.2

Cell Data: *Space Group:* $Pm3m$. a = 10.635 Z = 2

X-ray Powder Pattern: Itabira district, Brazil.
1.887 (vvs), 2.832 (vs), 2.571 (s), 2.430 (s), 2.040 (s), 1.723 (s)

Chemistry:

	(1)	(2)	(3)
Pd	55.77	57.03	60.43
Pt		1.31	
Fe		0.37	
Cu	3.99	3.17	
Hg	1.66	1.45	
Ag		0.33	
Se	38.59	36.66	39.57
S		0.31	
Total	100.01	100.63	100.00

(1) Itabira district, Brazil; by electron microprobe, corresponding to $(Pd_{15.47}Cu_{1.85}Hg_{0.24})_{\Sigma=17.56}Se_{14.44}$. (2) Cauê mine, Itabira district, Brazil; by electron microprobe, average of seven analyses; corresponding to $(Pd_{15.83}Cu_{1.47}Hg_{0.21}Pt_{0.20}Fe_{0.20}Ag_{0.09})_{\Sigma=18.00}(Se_{13.71}S_{0.29})_{\Sigma=14.00}$. (3) $Pd_{17}Se_{15}$.

Occurrence: Sparingly in residual concentrates from gold washings (Itabira district, Brazil); in specularite and magnetite (Cauê mine, Itabira district, Brazil).

Association: Arsenopalladinite, isomertieite, atheneite (Itabira district, Brazil); palladian gold, isomertieite, sudovikovite (Cauê mine, Itabira district, Brazil).

Distribution: In Brazil, in Minas Gerais, from gold placers in the Itabira district [TL], and at the Cauê iron mine; from the Serra Pelada Au–Pd–Pt deposit, Pará.

Name: For the chemical composition, PALLADium and SElenium.

Type Material: The Natural History Museum, London, England, 1977,500 and 1934,72; National Museum of Natural History, Washington, D.C., USA, 142504.

References: (1) Davis, R.J., A.M. Clark, and A.J. Criddle (1977) Palladseïte, a new mineral from Itabira, Minas Gerais, Brazil. Mineral. Mag., 41, 123. (2) (1977) Amer. Mineral., 62, 1059 (abs. ref. 1). (3) Cabral, A.R., B. Lehmann, R. Kwitko, H.F. Galbiatti, and M.C. Pereira (2002) Palladesite and its oxidation: evidence from Au-Pd vein-type mineralization (jacutinga), Cauê iron-ore mine, Quadrilátero Ferrífero, Minas Gerais, Brazil. Mineral. Mag., 66, 327–336. (4) Geller, S. (1962) The crystal structure of $Pd_{17}Se_{15}$. Acta Cryst., 15, 713–721.

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Palmierite $(K, Na)_2Pb(SO_4)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As minute crytals, platy on {0001} with hexagonal outline, modified by $\{10\overline{1}0\}$, $\{10\overline{1}1\}$, $\{10\overline{1}2\}$, $\{10\overline{1}3\}$, $\{10\overline{1}5\}$.

Physical Properties: Hardness = n.d. D(meas.) = 4.363 (synthetic). D(calc.) = 4.33 Rapidly decomposed by H_2O, leaving a $PbSO_4$ residue.

Optical Properties: Semitransparent. *Color:* Colorless or white; colorless in transmitted light. *Luster:* Vitreous, pearly on {0001}.
Optical Class: Uniaxial (–), large birefringence. $\omega = 1.712$ $\epsilon =$ n.d.

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic). $a = 5.4950(6)$ $c = 20.849(4)$ $Z = 3$

X-ray Powder Pattern: Synthetic.
3.138 (100), 2.749 (70), 4.333 (45), 6.948 (35), 2.557 (35), 2.068 (35), 2.156 (30)

Chemistry:

	(1)	(2)
SO_3	21.80	33.53
PbO	40.65	46.74
Na_2O	2.60	
K_2O	9.10	19.73
NaCl	2.64	
Total	76.79	100.00

(1) Vesuvius, Italy; neglecting NaCl, corresponds to $(K_{1.36}Na_{0.59})_{\Sigma=1.95}Pb_{1.28}(SO_4)_{1.92}$.
(2) $K_2Pb(SO_4)_2$.

Occurrence: A rare fumarolic sublimate.

Association: Aphthitalite, ferronatrite, jarosite, euchlorine, hematite.

Distribution: From Vesuvius, Campania, Italy.

Name: Honors Luigi Palmieri (1807–1896), Italian physicist, Director of the Vesuvius Observatory, Italy.

Type Material: University of Naples, Naples, 17516; Natural History Museum, Paris, France, 107.476, 107.477; The Natural History Museum, London, England, 1927,1049.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 403–404. (2) Bellanca, A. (1946) La struttura della palmierite. Periodico di Mineral, 15(1–3), 5–25 (in Italian). (3) (1977) NBS Mono. 25, 14.

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Palygorskite $(Mg,Al)_2Si_4O_{10}(OH)\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tiny laths, flattened on {100}, elongated along [001], to 1 cm. Commonly fibrous, forming tangled mats termed "mountain leather," also compact.

Physical Properties: *Cleavage:* Good on {110}. *Tenacity:* Tough. Hardness = 2–2.5 D(meas.) = > 1.0–2.6 D(calc.) = [2.35]

Optical Properties: Semitransparent. *Color:* White, grayish, yellowish, gray-green; colorless in thin section. *Luster:* Earthy to waxy.
Optical Class: Biaxial (–). *Pleochroism:* For colored varieties; X = pale yellow; $Y = Z$ = pale yellow-green. *Orientation:* $Z \wedge c$ = small. *Absorption:* $Z = Y > X$. α = 1.522–1.528 β = 1.530–1.546 γ = 1.533–1.548 2V(meas.) = 30°–61°

Cell Data: *Space Group:* $C2/m$. $a = 12.78$ $b = 17.86$ $c = 5.24$ $\beta = 95.78°$ Z = 4

X-ray Powder Pattern: Sapillo Creek, New Mexico, USA.
10.44 (100), 4.262 (22), 4.466 (20), 2.539 (20), 3.096 (16), 3.679 (15), 6.36 (13)

Chemistry:

	(1)
SiO_2	55.03
Al_2O_3	10.24
Fe_2O_3	3.53
MgO	10.49
K_2O	0.47
H_2O^+	10.13
H_2O^-	9.73
Total	99.62

(1) Attapulgus, Georgia, USA; corresponds to $(Mg_{0.99}Al_{0.68}Fe^{3+}_{0.18}Ca_{0.16}Ti_{0.04})_{\Sigma=2.05}(Si_{3.92}Al_{0.08})_{\Sigma=4.00}O_{10}(OH)\cdot 4H_2O$.

Occurrence: An alteration product of magnesium silicates in soils and sediments; in lacustrine marls, carbonate rocks, and mafic igneous rocks; in clay gouge associated with fault movement.

Association: Calcite, dolomite, talc, chlorite, quartz, "chalcedony," "opal," montmorillonite.

Distribution: Widespread; some localities for studied material include: at Palygorskaya, near the Popovka River, Perm, Russia. In the USA, at Attapulgus, Decatur Co., Georgia; near Sapillo Creek, Grant Co., New Mexico; in the Pend Oreille mine, Metaline Falls, Stevens Co., Washington; at the New Melones Dam, Calaveras Co., California; and at Gustavus, Alexander Archipelago, Alaska. In the Warren quarry, Enderby, Leicestershire, England. At Tafraout, Morocco. In the Hyderabad deposit, Andhra Pradesh, India.

Name: For the type locality, Palygorskaya, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, N824/7; Harvard University, Cambridge, Massachusetts, USA, 105018.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 398 [paligorskite]. (2) Bradley, W.F. (1940) The structural scheme of attapulgite. Amer. Mineral., 25, 405–410. (3) Christ, C.L., J.C. Hathaway, P.B. Hostetler, and A.O. Shepard (1969) Palygorskite: new X-ray data. Amer. Mineral., 54, 198–205. (4) Serna, C., G.E. VanScoyoc, and J.L. Ahlrichs (1977) Hydroxyl groups and water in palygorskite. Amer. Mineral., 62, 784–792. (5) Chisholm, J.E. (1992) Powder-diffraction patterns and structural models for palygorskite. Can. Mineral., 30, 61–73.

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Panasqueiraite $CaMg(PO_4)(OH,F)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Anhedral, to about 1 mm; fine-grained massive, in aggregates.

Physical Properties: *Cleavage:* On {010}, poor. Hardness = 5 D(meas.) = 3.22 D(calc.) = 3.21 Blue cathodoluminescence under the electron beam.

Optical Properties: Semitransparent. *Color:* Pink. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 22°$. $\alpha = 1.590(2)$ $\beta = 1.596(2)$ $\gamma = 1.616(2)$ 2V(meas.) = 51(2)°

Cell Data: *Space Group:* $C2/c$ or Cc. a = 6.535(3) $b = 8.753(4)$ $c = 6.919(4)$ $\beta = 112.33(4)°$ Z = 4

X-ray Powder Pattern: Panasqueira, Portugal; nearly identical to isokite. 2.626 (100), 3.02 (86), 3.20 (67), 2.584 (45), 1.722 (33), 2.783 (31), 1.658 (30)

Chemistry:

	(1)
P_2O_5	39.6
FeO	0.4
MnO	0.0
MgO	22.9
CaO	31.0
F	3.1
OH	[6.7]
$-O = (F_2, OH)$	4.4
Total	[99.3]

(1) Panasqueira, Portugal; by electron microprobe, $(OH)^{1-}$ calculated from stoichiometry; corresponds to $Ca_{0.99}(Mg_{1.02}Fe_{0.01})_{\Sigma=1.03}(PO_4)_{1.00}[(OH)_{0.71}F_{0.29}]_{\Sigma=1.00}$.

Occurrence: A rare mineral in vein selvages in a hydrothermal Sn–W deposit.

Association: Fluorapatite, wolfeite, topaz, muscovite, sphalerite, quartz, chalcopyrite, pyrrhotite, siderite, arsenopyrite, chlorite, vivianite, althausite, thadeuite.

Distribution: From the Panasqueira Sn–W deposit, Portugal.

Name: For Panasqueira, Portugal, the type locality.

Type Material: Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA, 144521.

References: (1) Isaacs, A.M. and D.R. Peacor (1981) Panasqueiraite, a new mineral: the OH-equivalent of isokite. Can. Mineral., 19, 389–392. (2) (1982) Amer. Mineral., 67, 859 (abs. ref. 1). (3) Isaacs, A.M. and D.R. Peacor (1985) Panasqueiraite, a new mineral: the OH-equivalent of isokite. Erratum. Can. Mineral., 23, 131.

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Panethite $(Na, Ca)(Mg, Fe^{2+})PO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As anhedral grains, to 1 mm. *Twinning:* Simple twinning observed.

Physical Properties: Hardness = n.d. D(meas.) = 2.9–3.0 D(calc.) = [2.96]

Optical Properties: Transparent. *Color:* Pale amber.
Optical Class: Biaxial (–). $\alpha = 1.567(1)$ $\beta = 1.576(1)$ $\gamma = 1.579(1)$ 2V(meas.) = 51°

Cell Data: *Space Group:* $P2_1/n$. $a = 10.18(1)$ $b = 14.90(2)$ $c = 25.87(3)$ $\beta = 91.1°$
Z = 48

X-ray Powder Pattern: Dayton meteorite.
3.007 (10), 2.710 (7), 5.10 (6), 3.236 (5), 2.749 (5), 4.210 (4), 3.951 (4)

Chemistry:

	(1)
P_2O_5	47.7
FeO	5.3
MnO	1.7
MgO	24.1
CaO	5.6
Na_2O	15.2
K_2O	0.9
Total	100.5

(1) Dayton meteorite; by electron microprobe, average of six grains, total Fe as FeO, total Mn as MnO; corresponds to $(Na_{0.77}Ca_{0.14}K_{0.03})_{\Sigma=0.94}(Mg_{0.88}Fe_{0.11}Mn_{0.04})_{\Sigma=1.03}P_{0.98}O_4$.

Occurrence: A very rare mineral in phosphate nodules in an iron meteorite.

Association: Brianite, whitlockite, albite, enstatite, schreibersite, kamacite, taenite, graphite, sphalerite, troilite.

Distribution: In the Dayton very fine octahedrite meteorite.

Name: Honoring Professor Friedrich Adolf Paneth (1887–1958), Austrian chemist, Director of the Max Planck Institute for Chemistry, Mainz, Germany, for his contributions to the study of meteorites.

Type Material: National Museum of Natural History, Washington, D.C., USA, 1506.

References: (1) Fuchs, L.H., E. Olsen, and E.P. Henderson (1967) On the occurrence of brianite and panethite, two new phosphate minerals from the Dayton meteorite. Geochim. Cosmochim. Acta, 31, 1711–1719. (2) (1968) Amer. Mineral., 53, 509 (abs. ref. 1).

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Panunzite $(K, Na)AlSiO_4$

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Crystal Data: Hexagonal. *Point Group:* 6. As hexagonal prisms, up to 4 mm.

Physical Properties: *Cleavage:* $\{10\bar{1}0\}$ and {0001}, poor. Hardness = 5.5 D(meas.) = 2.59 D(calc.) = 2.62

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.540(1)$ $\epsilon = 1.535(1)$

Cell Data: *Space Group:* $P6_3$. $a = 20.513(8)$ $c = 8.553(3)$ Z = 32

X-ray Powder Pattern: Monte Somma, Italy.
3.071 (100), 3.929 (70), 2.558 (40), 2.914 (30), 4.277 (25), 2.380 (20), 2.268 (20)

Chemistry:

	(1)	(2)
SiO_2	39.60	37.99
Al_2O_3	31.90	32.23
Fe_2O_3	0.35	
FeO	0.15	
MgO	0.11	
CaO	0.43	
SrO	0.01	
BaO	0.12	
Na_2O	5.74	
K_2O	21.52	29.78
Rb_2O	0.07	
H_2O	0.12	
Total	100.12	100.00

(1) Monte Somma, Italy; alkalis determined by flame photometry. (2) $KAlSiO_4$.

Polymorphism & Series: Polymorphous with kaliophilite, kalsilite, and trikalsilite.

Occurrence: Within cavities of pyroxene-rich ejecta blocks that are part of a recent volcanoclastic deposit.

Association: Nepheline, augite, biotite.

Distribution: From Monte Somma and Vesuvius, Campania, Italy.

Name: For Dr. Achille Panunzi, Professor of Chemistry, University of Naples, Naples, Italy, who discovered the ejecta blocks in which the mineral occurs.

Type Material: University of Naples, Naples, Italy.

References: (1) Franco, E. and M. de Gennaro (1988) Panunzite, a new mineral from Mt. Somma-Vesuvio, Italy. Amer. Mineral., 73, 420–421. (2) Merlino, S., E. Franco, C.A. Mattia, M. Pasero, and M. de Gennaro (1985) The crystal structure of panunzite (natural tetrakalsilite). Neues Jahrb. Mineral., Monatsh., 322–328.

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Paolovite Pd_2Sn

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As irregular grains embedded in other minerals. *Twinning:* Polysynthetic.

Physical Properties: Hardness = n.d. VHN = 329–378 (10 g load). D(meas.) = n.d. D(calc.) = 11.08

Optical Properties: Opaque. *Color:* Lilac-rose. *Luster:* Metallic. *Pleochroism:* Dark lilac-rose to pale rose.
R_1–R_2: (400) — , (420) 44.4–46.5, (440) 44.6–47.2, (460) 45.0–48.2, (480) 45.5–49.1, (500) 45.9–50.3, (520) 46.7–51.6, (540) 47.7–52.8, (560) 49.0–54.1, (580) 50.9–55.4, (600) 52.9–56.7, (620) 55.3–57.7, (640) 57.7–59.2, (660) 59.8–59.5, (680) 61.5–60.3, (700) 62.7–60.6

Cell Data: *Space Group: Pbnm.* $a = 8.11(1)$ $b = 5.662(6)$ $c = 4.324(2)$ $Z = 4$

X-ray Powder Pattern: Oktyabr deposit, Russia.
2.28 (100), 2.16 (70), 1.955 (50), 2.36 (40), 1.397 (40), 1.315 (40), 1.120 (40)

Chemistry:

	(1)	(2)	(3)
Pd	64.8	64.3	64.19
Pt	2.5		
Sn	35.5	35.0	35.81
Sb	0.3		
Bi	0.2		
Total	103.3	99.3	100.00

(1) Oktyabr deposit, Russia; by electron microprobe, corresponding to $(Pd_{1.98}Pt_{0.04})_{\Sigma=2.02}Sn_{0.98}$.
(2) Western Platinum mine, South Africa; by electron microprobe, corresponding to $Pd_{2.02}Sn_{0.98}$.
(3) Pd_2Sn.

Occurrence: In Cu–Ni sulfide ores; in cubanite–chalcopyrite, cubanite–talnakhite, and cubanite–mooihoekite assemblages (Oktyabr deposit, Russia).

Association: Cubanite, chalcopyrite, galena, talnakhite, mooihoekite, magnetite, sperrylite, sobolevskite, taimyrite, polarite, maslovite, atokite–rustenbergite, froodite, silver, palladium, bismuth.

Distribution: In Russia, from the Oktyabr deposit, Talnakh area, Noril'sk region, western Siberia [TL] and in the Kingash massif, eastern Sayan. At the Atok, Western Platinum, and Rustenberg mines, in the Merensky Reef, Bushveld complex, Transvaal, South Africa. From Little Darling Creek, east of Broken Hill, New South Wales, Australia. In the Strathcona deposit, Sudbury, and the Geordie Lake intrusion, Coldwell complex, Ontario, Canada.

Name: For the chemical composition, PAlladium and *olovo*, *tin* (in Russian).

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75509.

References: (1) Genkin, A.D., T.L. Evstigneeva, L.N. Vyal'sov, I.P. Laputina, and N.V. Groneva (1974) Paolovite, Pd_2Sn, a new mineral from copper–nickel sulfide ores. Geol. Rudn. Mestorozhd., 16, 98–103 (in Russian). (2) (1974) Amer. Mineral., 59, 1331–1332 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 410.

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Papagoite $CaCuAlSi_2O_6(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Equant crystals, to 3 mm, slightly flattened on {001} with faces in the [010] zone well developed and striated. Also as sheets and rings of microcrystalline radiating aggregates enclosed in quartz crystals; in massive veneers.

Physical Properties: *Cleavage:* Distinct on {100}, noted in thin section. Hardness = 5–5.5 D(meas.) = 3.25 D(calc.) = 3.25

Optical Properties: Translucent to transparent. *Color:* Cerulean blue. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless to very pale greenish blue; Y = blue; Z = deep greenish blue. *Orientation:* $Z = b$; $X \wedge c = 44°$. *Dispersion:* $r > v$, very faint. *Absorption:* $Z > Y > X$. $\alpha = 1.607(1)$ $\beta = 1.641$ $\gamma = 1.672$ 2V(meas.) = 78(1)°

Cell Data: *Space Group:* $C2/m$. $a = 12.926(3)$ $b = 11.496(3)$ $c = 4.696(1)$ $\beta = 100.81(2)°$ Z = 4

X-ray Powder Pattern: Ajo, Arizona, USA.
2.874 (100), 4.29 (90), 2.204 (90), 3.44 (80), 2.795 (80), 6.33 (70), 4.61 (70)

Chemistry:

	(1)
SiO_2	33.60
TiO_2	0.26
Al_2O_3	15.78
FeO	0.27
MnO	0.10
CuO	23.53
MgO	0.09
CaO	17.02
H_2O^+	9.01
H_2O^-	0.04
Total	99.70

(1) Ajo, Arizona, USA; corresponds to $Ca_{1.02}Cu_{0.99}Mg_{0.01}Fe^{2+}_{0.01}Ti_{0.01}Al_{0.98}Si_{1.87}O_6(OH)_{3.04}$.

Occurrence: In narrow veinlets in altered granodiorite porphyry (Ajo, Arizona, USA); included in quartz crystals (Messina, South Africa).

Association: Aurichalcite, shattuckite, ajoite, barite (Ajo, Arizona, USA): quartz, ajoite (Messina, South Africa).

Distribution: In the New Cornelia mine, Ajo, Pima Co., Arizona, USA. In South Africa, from Messina, Transvaal. At the Sinclair mine, near Lüderitz, Namibia.

Name: For the Tohono O'odam (formerly Papago) Indians who inhabit the region around Ajo, Arizona, USA.

Type Material: n.d.

References: (1) Hutton, C.O. and A.C. Vlisidis (1960) Papagoite, a new copper-bearing mineral from Ajo, Arizona. Amer. Mineral., 45, 599–611. (2) Groat, L.A. and F.C. Hawthorne (1987) Refinement of the crystal structure of papagoite, $CaCuAlSi_2O_6(OH)_3$. Mineral. Petrol., 37, 89–96.

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Para-alumohydrocalcite $CaAl_2(CO_3)_2(OH)_4 \cdot 6H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Crystals, to 0.01 mm, in radially fibrous spherules.

Physical Properties: Hardness = 1.75(5) D(meas.) = 2.0 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White; colorless in thin section.
Optical Class: Biaxial (–). *Orientation:* Positive elongation, extinction inclined 10°–12°.
$\alpha = 1.473$ β = n.d. $\gamma = 1.502$ 2V(meas.) = 69(7)°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Gaurdak deposit, Turkmenistan.
7.90 (100), 2.64 (32), 6.20 (30), 3.32 (28), 3.90 (25), 2.68 (24), 4.04 (20)

Chemistry:

	(1)	(2)
SiO_2	0.35	
CO_2	22.42	22.56
Al_2O_3	25.88	26.13
MgO	0.16	
CaO	14.06	14.37
H_2O^+	27.37	
H_2O^-	9.36	
H_2O		36.94
Total	99.60	100.00

(1) Vodin deposit, Russia; corresponds to $(Ca_{0.98}Mg_{0.01})_{\Sigma=0.99}Al_{2.00}(CO_3)_{2.00}(OH)_{4.00} \cdot 6.0H_2O$.
(2) $CaAl_2(CO_3)_2(OH)_4 \cdot 6H_2O$.

Occurrence: In the oxidized zone of sulfur deposits, formed by decomposition of allophane (Vodin deposit, Russia; Gaurdak deposit, Turkmenistan).

Association: Gypsum, calcite, halloysite (Vodin deposit, Russia; Gaurdak deposit, Turkmenistan); allophane, scarbroite, dundasite (Hampstead Farm quarry, England).

Distribution: From the Vodin sulfur deposit, Samara district, Russia. At the Gaurdak sulfur deposit, Turkmenistan. In Hampstead Farm quarry, Chipping Sodbury, Avon, and from Boughton, near Northampton, England.

Name: From the Greek *para*, for *near*, and its relation to *alumohydrocalcite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81064.

References: (1) Srebrodol'skii, B.I. (1977) Paraalumohydrocalcite – a new mineral. Zap. Vses. Mineral. Obshch., 106, 336–337 (in Russian). (2) Srebrodol'skii, B.I. (1974) Alumohydrocalcite. Izvest. Akad. Nauk., SSSR, Ser. Geol., 10, 88-96 (in Russian). (3) (1978) Amer. Mineral., 63, 794 (abs. refs. 1–2). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 159–160.

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Parabariomicrolite $BaTa_4O_{10}(OH)_2 \cdot 2H_2O$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. Individual crystals, to 0.1 mm, topotactically replacing microlite crystals, to 1 cm; less commonly as open-space fillings. *Twinning:* Possibly due to the topotactic replacement.

Physical Properties: *Cleavage:* {001} and {101}, good. *Tenacity:* Brittle. Hardness = 4
D(meas.) = n.d. D(calc.) = 5.97

Optical Properties: Translucent. *Color:* White to pale pink. *Streak:* White.
Luster: Vitreous to pearly.
Optical Class: Uniaxial. $\omega = > 2.0$ $\epsilon = > 2.0$

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. a = 7.4290(6) c = 18.505(2) Z = 3

X-ray Powder Pattern: Alto do Giz pegmatite, Brazil; after removal of lines due to microlite contaminant.
3.040 (100), 3.172 (65), 6.18 (50), 2.641 (50), 1.591 (42), 3.085 (41), 1.857 (39)

Chemistry:

	(1)	(2)
Nb_2O_5	1.5	
Ta_2O_5	80.6	81.00
PbO	0.4	
CaO	0.0	
SrO	0.8	
BaO	10.5	14.05
Na_2O	0.4	
K_2O	0.3	
H_2O		4.95
$H_2O + F$	[5.5]	
Total	[100.0]	100.00

(1) Alto do Giz pegmatite, Brazil; by electron microprobe, H_2O + F by difference; corresponding to $(Ba_{0.73}Na_{0.13}Sr_{0.08}K_{0.07}Pb_{0.02})_{\Sigma=1.03}(Ta_{3.88}Nb_{0.12})_{\Sigma=4.00}O_{10}(OH)_2 \cdot 2H_2O$.
(2) $BaTa_4O_{10}(OH)_2 \cdot 2H_2O$.

Occurrence: An alteration product of microlite crystals, in a decomposed zoned pegmatite.

Association: Microlite, simpsonite, tantalite, manganotantalite, tapiolite, natrotantite, alumotantite, stibiotantalite, beryl, spodumene, petalite.

Distribution: In the Alto do Giz pegmatite, near Parelhas, Rio Grande do Norte, Brazil.

Name: From the Greek for *near* and its relation to *bariomicrolite*.

Type Material: Royal Ontario Museum, Toronto, Canada, M22607; National Museum of Natural History, Washington, D.C., USA, 104739.

References: (1) Ercit, T.S., F.C. Hawthorne, and P. Černý (1986) Parabariomicrolite, a new species, and its structural relationship to the pyrochlore group. Can. Mineral., 24, 655–663.
(2) (1988) Amer. Mineral., 73, 194 (abs. ref. 1).

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Parabrandtite $Ca_2Mn^{2+}(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* 1. As aggregates of subparallel crystals, to 1.5 mm.

Physical Properties: *Cleavage:* On {010} and {110}, perfect. Hardness = 3–4
D(meas.) = 3.55(8) D(calc.) = 3.60

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $\theta = 48.4°$; $\psi = 132.7°$; $\phi = 64.6°$. *Dispersion:* $r > v$, weak. $\alpha = 1.701(2)$ $\beta = 1.721(2)$ $\gamma = 1.751(2)$ 2V(meas.) = 79.9(4)° 2V(calc.) = 79.7°

Cell Data: *Space Group:* $[P1]$ (by analogy to talmessite). $a = 5.89(1)$ $b = 7.031(7)$ $c = 5.64(1)$ $\alpha = 96.77(10)°$ $\beta = 109.32(10)°$ $\gamma = 108.47(8)°$ Z = 1

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
2.811 (100), 3.090 (80), 3.61 (70), 3.231 (50), 2.778 (50), 5.11 (40), 3.37 (40)

Chemistry:

	(1)
As_2O_5	51.3
FeO	0.2
MnO	14.7
ZnO	0.7
MgO	0.8
CaO	25.1
H_2O	8.3
Total	101.1

(1) Sterling Hill, New Jersey, USA; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by TGA-EGA; corresponds to $(Ca_{1.94}Mn_{0.06})_{\Sigma=2.00}(Mn_{0.84}Mg_{0.09}Zn_{0.04}Fe_{0.01})_{\Sigma=0.98}(As_{0.96}O_{3.90})_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with brandtite.

Mineral Group: Fairfieldite group.

Occurrence: Very rare, in a vein in primary ore from a metamorphosed stratiform zinc orebody.

Association: Sarkinite, franklinite, willemite, calcite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: From the Greek *para*, for *near*, and its dimorphous relation to *brandtite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163210.

References: (1) Dunn, P.J., D.R. Peacor, S.-C Su, F.J. Wicks, and F.J. Parker (1987) Parabrandtite, the manganese analog of talmessite, from Sterling Hill, Ogdensburg, New Jersey. Neues Jahrb. Mineral., Abh., 157, 113–119. (2) (1988) Amer. Mineral., 73, 1496 (abs. ref. 1).

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Parabutlerite $Fe^{3+}(SO_4)(OH)\cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, elongated and striated along [001], to 3 mm, which may have complex form development, showing {110}, {011}, {012}, {111}, and a dozen other forms; massive. *Twinning:* On {142}, rare.

Physical Properties: *Cleavage:* Poor on {110}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.55 D(calc.) = 2.538

Optical Properties: Transparent. *Color:* Pale orange, pale orange-brown; pale yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless to pale yellow; Y = pale yellow to greenish yellow; Z = pale yellow to brownish yellow. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, moderate. α = 1.589–1.598 β = 1.660–1.663 γ = 1.737–1.750
2V(meas.) = 43.5°–87°

Cell Data: *Space Group: Pmnb.* $a = 7.38$ $b = 20.13$ $c = 7.22$ Z = 8

X-ray Powder Pattern: Alcaparrosa, Chile.
4.99 (FFF), 3.11 (FFF), 5.83 (F), 3.60 (mF), 2.499 (mF), 1.839 (mf), 4.07 (m)

Chemistry:

	(1)	(2)
SO_3	39.15	38.96
Fe_2O_3	39.21	39.06
H_2O	22.00	21.98
insol.	0.23	
Total	100.59	100.00

(1) Alcaparrosa, Chile. (2) $Fe(SO_4)(OH)\cdot 2H_2O$.

Polymorphism & Series: Dimorphous with butlerite.

Occurrence: An uncommon mineral in the oxidized zone of pyritic veins, may be formed by alteration of other sulfates.

Association: Copiapite, cuprocopiapite, butlerite, jarosite, melanterite, fibroferrite.

Distribution: From Chuquicamata, at Quetena, west of Calama, and Alcaparrosa, near Cerritos Bayos, southwest of Calama, Antofagasta, Chile. In the Santa Elena mine, Quebrada de La Alcaparrosa, San Juan Province, Argentina. In the USA, at the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah. At Saghand, near Yazd, Iran. From the Auguste mine, Fuchsberg, near Halle, Saxony-Anhalt, Germany. At Agrokipia, Cyprus. From Iskazentgyörgy and Nyirád, Hungary.

Name: From the Greek *para*, for *near*, and its relation to *butlerite*.

Type Material: American Museum of Natural History, New York City, New York, 4629-30; Harvard University, Cambridge, Massachusetts, 94834; National Museum of Natural History, Washington, D.C., USA, 115159.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 610–611. (2) Borène, J. (1970) Structure cristalline de la parabutlérite. Bull. Soc. fr. Minéral., 93, 185–189 (in French with English abs.). (3) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French).

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Paracelsian $BaAl_2Si_2O_8$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals prismatic, dominated by {110} and {120}, with chisel-shaped termination by {201}, to 5 cm; confused aggregates of crystals; massive. *Twinning:* Simple twinning on {100}; lamellar on {201}.

Physical Properties: *Cleavage:* {110}, poor; (110) ∧ $(1\bar{1}0) = 87°$. *Fracture:* Subconchoidal. Hardness = ∼6 D(meas.) = 3.29–3.32 D(calc.) = 3.342

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.5702$ $\beta = 1.5824$ $\gamma = 1.5869$ 2V(meas.) = 50°35′–52°42′

Cell Data: *Space Group:* $P2_1/a$. $a = 9.065$–9.076 $b = 9.568$–9.588 $c = 8.577$–8.578 $\beta = 90.01°$–$90.21°$ Z = 4

X-ray Powder Pattern: Benallt mine, Wales.
4.00 (100), 3.80 (70), 2.99 (50), 2.73 (50), 2.56 (50), 3.59 (45), 2.37 (45)

Chemistry:

	(1)	(2)
SiO_2	33.01	32.01
Al_2O_3	27.16	27.16
Fe_2O_3	0.28	
MgO	0.14	
CaO	0.06	
BaO	38.53	40.83
Na_2O	0.15	
K_2O	0.54	
H_2O	0.05	
Total	99.92	100.00

(1) Benallt mine, Wales. (2) $BaAl_2Si_2O_8$.

Polymorphism & Series: Dimorphous with celsian.

Mineral Group: Feldspar group.

Occurrence: In a band through shales and sandstones, associated with a metamorphosed manganese deposit (Benallt mine, Wales).

Association: Celsian (Benallt mine, Wales).

Distribution: From Candoglia, Valle d'Ossola, Piedmont, Italy. In the Benallt mine, Rhiw, Lleyn Peninsula, Wales.

Name: A combination of the Greek *para*, for *near*, and the mineral's dimorph, *celsian*.

Type Material: n.d.

References: (1) Tacconi, E. (1905) Di un silicato di alluminio e bario [paracelsian] dei calcefiri di Candoglia in valle del Toce. Rend. R. Istit. Lombardo Sci. Lett., Milano, 38, 636–643, esp. 642 (in Italian). (2) (1907) Mineral. Mag., 14, 406 (abs. ref. 1). (3) Spencer, L.J. (1942) Barium feldspars, (celsian and paracelsian) from Wales. Mineral. Mag., 26, 231–245. (4) Smith, J.V. (1953) The crystal structure of paracelsian, $BaAl_2Si_2O_8$. Acta Cryst., 6, 613–620. (5) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 166–178. (6) Chiari, G., G. Gazzoni, J.R. Craig, G.V. Gibbs, and S.J. Louisnathan (1985) Two independent refinements of the structure of paracelsian, $BaAl_2Si_2O_8$. Amer. Mineral., 70, 969–974.

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Parachrysotile $Mg_3Si_2O_5(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Fibrous along [010]; asbestiform.

Physical Properties: Hardness = 2.5 (?) D(meas.) = ~2.55 D(calc.) = [2.56]

Optical Properties: Semitransparent. *Color:* Yellow, white, gray, green [for chrysotile].
Luster: Silky in aggregates.
Optical Class: [Biaxial.] α = 1.532–1.549 [for chrysotile]. β = n.d. γ = 1.545–1.556
2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 5.3$ $b = 9.24(2)$ $c = 14.7(1)$ Z = [4]

X-ray Powder Pattern: n.d.

Chemistry: Compositional data is lacking.

Polymorphism & Series: Antigorite, clinochrysotile, lizardite, and orthochrysotile are polymorphs.

Mineral Group: Kaolinite-serpentine group.

Occurrence: A minor component of many serpentines.

Association: Clinochrysotile, orthochrysotile.

Distribution: Widespread, probably, but requires careful characterization. From the Jeffrey mine, Asbestos, Quebec, Canada. At Shabani, Zimbabwe.

Name: From the Greek *para*, for *near*, and *chrysotile* from *golden* and *fiber*.

Type Material: n.d.

References: (1) Whittaker, E.J.W. and J. Zussman (1956) The characterization of serpentine minerals by X-ray diffraction. Mineral. Mag., 31, 107–126. (2) (1957) Amer. Mineral., 42, 585 (abs. ref. 1). (3) Whittaker, E.J.W. (1956) The structure of chrysotile. IV. Para-chrysotile. Acta Cryst., 9, 865–867. (4) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 170–190. (5) Middleton, A.P. and E.J.W. Whittaker (1979) The nature of parachrysotile. Can. Mineral., 17, 693–697.

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Paracoquimbite $Fe_2^{3+}(SO_4)_3 \cdot 9H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Small rhombohedral crystals $\{01\overline{1}2\}$, equant pseudocubic or prismatic, with complex form development, may be sceptered on coquimbite; also granular, massive. *Twinning:* On {0001}, common.

Physical Properties: *Cleavage:* On $\{01\overline{1}2\}$ and $\{10\overline{1}4\}$, imperfect. Hardness = 2.5 D(meas.) = 2.11(1) D(calc.) = 2.115 Soluble in H_2O, taste astringent.

Optical Properties: Transparent. *Color:* Pale violet. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.550(2)$ $\epsilon = 1.555(2)$

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.926(9)$ $c = 51.300(21)$ Z = 12

X-ray Powder Pattern: Calculated from the crystal structure. (ICDD 27-254). 8.88 (100), 7.62 (39), 3.367 (33), 5.465 (29), 4.605 (29), 8.55 (20), 4.713 (16)

Chemistry:

	(1)	(2)
SO_3	41.38	42.74
Al_2O_3	trace	
Fe_2O_3	29.79	28.41
H_2O	28.69	28.85
Total	99.86	100.00

(1) Tierra Amarilla, Chile. (2) $Fe_2(SO_4)_3 \cdot 9H_2O$.

Polymorphism & Series: Dimorphous with coquimbite.

Occurrence: A rare mineral formed in the oxidized zone of pyritic hydrothermal orebodies, especially in arid regions.

Association: Coquimbite, römerite, szomolnokite, quenstedtite, ferricopiapite, rozenite, voltaite.

Distribution: In Chile, from Tierra Amarilla, southeast of Copiapó, Atacama; at Chuquicamata, Alcaparrosa, near Cerritos Bayos, southwest of Calama, and Quetena, west of Calama, Antofagasta. At Myoban Spa, Oita Prefecture, Japan. From the Kamariza mine, Laurium, Greece. At Steamboat Springs, Washoe Co., Nevada, USA.

Name: From the Greek for *near* and its relation to *coquimbite*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 534–535. (2) Robinson, P.D. and J.H. Fang (1971) Crystal structures and mineral chemistry of hydrated ferric sulphates: II. The crystal structure of paracoquimbite. Amer. Mineral., 56, 1567–1572. (3) Fang, J.H. and P.D. Robinson (1974) Polytypism in coquimbite and paracoquimbite. Neues Jahrb. Mineral., Monatsh., 89–91.

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Paracostibite CoSbS

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As irregular and subhedral grains, to 130 μm.

Physical Properties: Hardness = n.d. VHN = 654–763 (100 g load). D(meas.) = 6.9 D(calc.) = 6.97

Optical Properties: Opaque. *Color:* White with a faint grayish tinge. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak, faint pink to pale buff.
R_1–R_2: (400) 47.8–47.9, (420) 48.0–48.5, (440) 48.2–48.9, (460) 48.2–49.2, (480) 48.2–49.4, (500) 48.4–49.6, (520) 48.7–49.6, (540) 48.9–49.4, (560) 49.0–49.3, (580) 49.2–49.2, (600) 49.5–49.3, (620) 49.7–49.6, (640) 49.9–49.9, (660) 50.2–50.3, (680) 50.3–50.6, (700) 50.5–50.9

Cell Data: *Space Group: Pbca.* $a = 5.842(3)$ $b = 5.951(3)$ $c = 11.666(4)$ $Z = 8$

X-ray Powder Pattern: Trout Bay, Canada.
2.555 (10), 2.035 (8), 5.81 (8), 1.853 (8), 2.826 (7), 2.654 (7), 2.976 (4)

Chemistry:

	(1)	(2)	(3)
Co	26.4	25.0	27.70
Fe	0.4	0.4	
Ni	0.8	1.0	
Sb	56.8	57.6	57.23
As		2.1	
S	14.9	14.5	15.07
Total	99.3	100.6	100.00

(1) Trout Bay, Canada; by electron microprobe, average of five analyses; corresponds to $(Co_{0.96}Ni_{0.03}Fe_{0.02})_{\Sigma=1.01}Sb_{1.00}S_{1.00}$. (2) Wheal Cock, England; by electron microprobe; corresponds to $(Co_{0.91}Ni_{0.04}Fe_{0.01})_{\Sigma=0.96}(Sb_{1.01}As_{0.06})_{\Sigma=1.07}S_{0.97}$. (3) CoSbS.

Polymorphism & Series: Dimorphous with costibite.

Occurrence: In drill core from a massive base-metal sulfide deposit in a carbonatized chlorite-anthophyllite schist that is most likely an altered mafic rock, in a sequence of metavolcanics and metasediments (Trout Bay, Canada); in Pb–Zn–Cu–Ag ore deposits remobilized by hydrothermal solutions from younger granite emplacement (Bergslagen, Sweden).

Association: Sphalerite, chalcopyrite, galena, pyrargyrite, pyrrhotite, antimonial silver (Trout Bay, Canada); costibite, nisbite, chalcopyrite, pyrrhotite, galena, sphalerite, gersdorffite, ullmannite (Bergslagen, Sweden).

Distribution: In drill core from Trout Bay, 32 km west of Red Lake, Kenora district, Ontario, Canada [TL]. At Wheal Cock, Botallack, St. Just, Cornwall, England. In the Gruvåsen and Getön deposits, Bergslagen metallic province, Sweden.

Name: For CObalt and antimony, STIBium, in the chemical composition and probable structural relation to pararammelsbergite.

Type Material: Canadian Museum of Nature, Ottawa; Canadian Geological Survey, Ottawa, 12163; Royal Ontario Museum, Toronto, Canada.

References: (1) Cabri, L.J., D.C. Harris, and J.M. Stewart (1970) Paracostibite (CoSbS) and nisbite ($NiSb_2$), new minerals from the Red Lake Area, Ontario, Canada. Can. Mineral., 10, 232–246. (2) (1971) Amer. Mineral., 56, 631 (abs. ref. 1). (3) Rowland, J.F., E.J. Gabe, and S.R. Hall (1975) The crystal structures of costibite (CoSbS) and paracostibite (CoSbS). Can. Mineral., 13, 188–196. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 411.

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Paradamite $Zn_2(AsO_4)(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Rarely as equant crystals, striated and rounded; in sheaflike aggregates, to 1 cm.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = n.d. D(meas.) = 4.55(2) D(calc.) = 4.595

Optical Properties: Transparent. *Color:* Pale yellow. *Streak:* White. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). $\alpha = 1.726(2)$ $\beta = 1.771(2)$ $\gamma = 1.780(2)$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.638(3)$ $b = 5.827(3)$ $c = 6.692(2)$ $\alpha = 103.25(4)°$ $\beta = 104.37(3)°$ $\gamma = 87.72(4)°$ Z = 2

X-ray Powder Pattern: Ojuela mine, Mexico.
6.33 (10), 3.71 (10), 2.99 (9), 2.84 (9), 2.49 (8), 3.08 (7), 2.11 (7)

Chemistry:

	(1)	(2)
As_2O_5	40.17	40.09
Fe_2O_3	0.12	
FeO	0.45	
ZnO	56.22	56.77
H_2O^+	3.44	3.14
H_2O^-	0.00	
Total	100.40	100.00

(1) Ojuela mine, Mexico. (2) $Zn_2(AsO_4)(OH)$.

Polymorphism & Series: Dimorphous with adamite.

Occurrence: A rare secondary mineral in the oxidized zone of some hydrothermal polymetallic base-metal deposits.

Association: Mimetite, adamite, ojuelaite, mapimite, "limonite" (Ojuela mine, Mexico); köttigite, adamite, smithsonite, wulfenite, chalcocite (Tsumeb, Namibia).

Distribution: From the Ojuela mine, Mapimí, Durango, Mexico. At Tsumeb, Namibia.

Name: From the Greek *para*, for *near*, and its dimorphous relation to *adamite*.

Type Material: The Natural History Museum, London, England, 1969,184; Harvard University, Cambridge, Massachusetts, 106376; National Museum of Natural History, Washington, D.C., USA, R9492, 106378, 107443, 112518, 125506.

References: (1) Switzer, G. (1956) Paradamite, a new zinc arsenate from Mexico. Science, 123, 1039. (2) (1956) Amer. Mineral., 41, 958 (abs. ref. 1). (3) Hawthorne, F.C. (1979) Paradamite. Acta Cryst., 35, 720–722. (4) Bennett, T.J. (1980) Crystal structure of paradamite. Amer. Mineral., 65, 353–354.

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Paradocrasite $Sb_2(Sb, As)_2$

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Crystal Data: Monoclinic. *Point Group:* 2. As aggregates of equant, polygonal grains and short, to 0.5 mm, stubby prisms that may be striated parallel to their length; prisms rarely curved, in nests of curved, grooved, pseudohexagonal plates. *Twinning:* Polysynthetically twinned on {010} as parallel lamellae 25 μm wide, on $\{\overline{2}01\}$ as short tapering lamellae and on $\{\overline{1}10\}$ and {001}.

Physical Properties: *Cleavage:* Parting {010} perfect, several others less perfect, paralleling the twinning composition planes. *Tenacity:* Brittle. Hardness = n.d. VHN = 118 (100 g load). D(meas.) = 6.52 D(calc.) = 6.44

Optical Properties: Opaque. *Color:* Bright white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Distinct, from yellowish white with a slightly pinkish tint, to very pale gray in air; in oil, strong, from pale pinkish gray with a very faint blue-green tint. *Anisotropism:* Strong, in vivid pinks, pale orange, yellow, pale greenish blue and pale green.
R_1–R_2: n.d.

Cell Data: *Space Group:* $C2$. $a = 7.252(1)$ $b = 4.172(4)$ $c = 4.431(2)$ $\beta = 123°8.4(1.4)'$
Z = 1

X-ray Powder Pattern: Broken Hill, Australia.
3.06 (100), 2.09 (70), 2.21 (60), 3.72 (40), 1.730 (40), 1.521 (40), 1.392 (40)

Chemistry:

	(1)
Sb	82.9
As	18.6
Total	101.5

(1) Broken Hill, Australia; by electron microprobe, corresponding to $Sb_{2.93}Sb_{1.07}$.

Occurrence: Replacing calcite (Broken Hill, Australia).

Association: Antimonian löllingite, stibarsen, calcite (Broken Hill, Australia).

Distribution: From the Consols mine, Broken Hill, New South Wales, Australia [TL]. At Atlin, British Columbia, Canada. In Mexico, from the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora. In the Szklary serpentinite massif, southwest Poland.

Name: From the Greek for *unexpected alloy*.

Type Material: National Museum of Natural History, Washington, D.C., USA, R419.

References: (1) Leonard, B.F., C.W. Mead, and J.J. Finney (1971) Paradocrasite, $Sb_2(Sb, As)_2$, a new mineral. Amer. Mineral., 56, 1127–1146. (2) Cureton, F. (1996) Letters. Mineral. Record, 26, 70–71.

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Parafransoletite $Ca_3Be_2(PO_4)_2(PO_3OH)_2 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Individual crystals are spearhead-shaped, flattened on {010}, elongated along [100], showing prominent {010}, {011}, {13$\overline{1}$}, {$\overline{1}$31}, {14$\overline{4}$}, to 0.4 mm. Generally as doubly-terminated crystals, sheaf- and bow-tielike, and radial aggregates. *Twinning:* Common on {010}.

Physical Properties: *Fracture:* Even to uneven. *Tenacity:* Brittle. Hardness = ~2.5 D(meas.) = 2.54(1) D(calc.) = 2.56

Optical Properties: Transparent to translucent. *Color:* Colorless, white. *Luster:* Vitreous, silky in aggregates.
Optical Class: Biaxial (+). *Orientation:* $\theta = 85°$; $\psi = -13°$; $\phi = 98°$. $\alpha = 1.562(2)$ $\beta = 1.564(2)$ $\gamma = 1.588(2)$ 2V(meas.) = n.d. 2V(calc.) = 33°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.3275(13)$ $b = 7.6959(13)$ $c = 7.0606(13)$ $\alpha = 94.903(5)°$ $\beta = 96.820(5)°$ $\gamma = 101.865(5)°$ Z = 1

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
3.032 (100), 3.619 (80), 2.595 (60), 7.52 (50), 2.334 (40), 2.485 (25), 1.870 (25)

Chemistry:

	(1)	(2)
P_2O_5	47.9	47.93
BeO	7.7	8.45
CaO	28.2	28.41
H_2O	15.1	15.21
Total	98.9	100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, H_2O by Karl Fischer titration; corresponds to $Ca_{3.02}Be_{1.85}(PO_4)_{4.05}(OH)_{2.05} \cdot 4H_2O$. (2) $Ca_3Be_2(PO_4)_2(PO_3OH)_2 \cdot 4H_2O$.

Polymorphism & Series: Dimorphous with fransoletite.

Occurrence: A rare secondary hydrothermal mineral on fracture surfaces in beryl in a complex granite pegmatite.

Association: Beryl, mitridatite, whitlockite, hurlbutite, roscherite, montgomeryite, englishite, robertsite.

Distribution: From the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: From the Greek *para*, for *near*, and its dimorphous relation to *fransoletite*.

Type Material: Natural History Museum, Los Angeles, California, 35696; National Museum of Natural History, Washington, D.C., USA, 168432.

References: (1) Kampf, A.R., P.J. Dunn, and E.E. Foord (1992) Parafransoletite, a new dimorph of fransoletite from the Tip Top Pegmatite, Custer, South Dakota. Amer. Mineral., 77, 843–847. (2) Kampf, A.R. (1992) Beryllophosphate chains in the structures of fransoletite, parafransoletite, and ehrleite and some general comments on beryllophosphate linkages. Amer. Mineral., 77, 848–856.

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Parageorgebokiite β-$Cu_5O_2(SeO_3)_2Cl_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As slightly flattened grains.

Physical Properties: *Cleavage*: None observed. *Fracture*: n.d. *Tenacity*: Brittle.
Hardness = 3-4 D(meas.) = n.d. D(calc.) = 4.70

Optical Properties: Transparent. *Color*: Green. *Streak*: n.d.
Luster: Strongly vitreous. *Pleochroism*: $X = Y$ = grass green; Z = yellowish green.
Optical Class: Biaxial (+). $\alpha = 2.05(1)$ $\beta = 2.05(1)$ $\gamma = 2.08(1)$ 2V(meas.) $\approx 0°$
2V(calc.) = 0(5)° *Orientation*: $X = a$.

Cell Data: *Space Group*: $P2_1/c$. $a = 5.3982(5)$ $b = 8.0543(8)$ $c = 11.128(1)$
$\beta = 99.258(2)°$ $Z = 2$

X-ray Powder Pattern: Tolbachik Eruption, Kamchatka Peninsula, Russia.
3.01 (100), 3.22 (90), 2.61 (80B), 2.270 (70), 2.117 (60), 2.58 (40), 1.953 (40)

Chemistry:

	(1)
CuO	57.98
PbO	0.66
SeO_2	33.02
Cl	11.28
$-O=Cl_2$	2.55
Total	100.39

(1) Tolbachik Eruption, Kamchatka Peninsula, Russia, average of 12 electron microprobe analyses, corresponding to $Cu_{4.91}Pb_{0.02}O_{1.86}(SeO_3)_2Cl_{2.14}$.

Polymorphism & Series: Dimorphous with georgbokiite.

Occurrence: On the walls of fumaroles, crystallized at 400 to 625°.

Association: Intergrown intimately with cotunnite, ilinskite, chloromenite, burnsite, allochalcoselite; with ralstonite, tolbachite, melanothallite, chalcocyanite, euchlorine, Fe oxides, tenorite, gold, sophiite.

Distribution: Second cinder cone, North breach, Great Fissure Tolbachik Eruption, Kamchatka Peninsula, Russia.

Name: As the dimorph of the species, *georgebokiite*, named to honor Georgiĭ Borisovich Bokiĭ, (1909–2000), a corresponding member of the Russian Academy of Sciences and a prominent Russian crystal chemist.

Type Material: n.d.

References: (1) Vergasova, L. P., S. V. Krivovichev, S. K. Filatov, S. N. Britvin, P. C. Burns, and V. V. Anan'ev (2007) Parageorgbokiite, β-$Cu_5O_2(SeO_3)_2Cl_2$, a New Mineral Species from Volcanic Exhalations, Kamchatka Peninsula, Russia, Geology of Ore Deposits, 49(7), 518-521.
(2) Krivovichev, S.V., S.K. Filatov, P.C. Burns, L.P. Vergasova (2007) The crystal structure of parageorgbokiite, β-$Cu_5O_2(SeO_3)_2Cl_2$. Can. Mineral., 45, 929–934. (3) (2008) Amer. Mineral., 93, 704 (abs. ref. 2).

Paragonite $NaAl_2(Si_3Al)O_{10}(OH)_2$

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Crystal Data: Monoclinic; hexagonal in part. *Point Group:* $2/m$ or m. Crystals thin tabular ‖ {001}; commonly fine scaly, compact, massive. *Twinning:* By rotation of 180° about [310] or [$\bar{3}$10].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Flexible, elastic. Hardness = 2.5–3 D(meas.) = 2.85 D(calc.) = 2.907

Optical Properties: Transparent to translucent. *Color:* Colorless, pale yellow, grayish, grayish white, greenish, light apple-green; colorless in thin section, may show faint color tint. *Luster:* Pearly.
Optical Class: Biaxial (–). *Orientation:* $Y \simeq a$; $Z = b$; $X \wedge c \simeq 5°$. *Dispersion:* $r > v$. *Absorption:* Very faint; $Z \geq Y > X$. α = 1.564–1.580 β = 1.594–1.609 γ = 1.600–1.609 2V(meas.) = 0°–40°

Cell Data: *Space Group:* $C2/c$ ($2M_1$). $a = 5.13(3)$ $b = 8.89(5)$ $c = 19.32(10)$ $\beta = 95°10(30)'$ Z = 4

X-ray Powder Pattern: Pizzo Forno, Switzerland; $2M_1$.
4.44 (100), 2.536 (90), 9.7 (80), 2.430 (80), 1.486 (80b), 2.921 (70), 2.831 (70)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	46.81	45.95	FeO		0.53	BaO		0.01
TiO_2		0.07	MnO		trace	Na_2O	6.40	7.39
Al_2O_3	40.06	40.47	MgO	0.65	0.13	K_2O		0.51
Fe_2O_3	trace		CaO	1.26	0.27	H_2O^+	4.82	[4.67]
						Total	100.00	[100.00]

(1) Pizzo Forno, Switzerland; corresponds to $(Na_{0.79}Ca_{0.09})_{\Sigma=0.88}(Al_{1.97}Mg_{0.06})_{\Sigma=2.03}(Si_{2.97}Al_{1.03})_{\Sigma=4.00}O_{10}(OH)_2$. (2) Zermatt-Saas region, Switzerland; by electron microprobe, average of four analyses, H_2O by difference; corresponding to $(Na_{0.92}K_{0.04}Ca_{0.02})_{\Sigma=0.98}(Al_{1.99}Fe_{0.03}Mg_{0.01})_{\Sigma=2.03}(Si_{2.94}Al_{1.06})_{\Sigma=4.00}O_{10}(OH)_2$.

Polymorphism & Series: $2M_1$, 3A polytypes.

Mineral Group: Mica group.

Occurrence: Uncommon, but may be in large amounts, in low- to medium-grade metamorphic schists and phyllites, in muscovite-biotite gneisses, quartz veins, fine-grained sediments, and glaucophane-bearing rocks.

Association: Kyanite, staurolite, muscovite, quartz, glaucophane, chlorite, garnet, tourmaline, calcite, actinolite.

Distribution: A few well-studied occurrences follow. On Pizzo Forno, Ticino, and in Val Täsch, Zermatt, Valais, Switzerland. From Prägraten, Tirol, Austria. At Ochsenkopf, Schwarzenberg, Saxony, Germany. In Italy, at Borgofrance, near Ivrea, Piedmont, and in the Pfitschtal, Trentino-Alto Adige. From Miass, Ilmen Mountains, Southern Ural Mountains, Russia. In the Ivigtut cryolite deposit, southwestern Greenland. In the USA, from Corundum Hill, Chester Co., Pennsylvania; in the Leadville district, Lake Co., Colorado.

Name: From the Greek, *paragon*, for *misleading*, as it looks like talc.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 623–624. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 31–34. (3) Hildebrand, F.A. (1953) Minimizing the effects of preferred orientation in X-ray powder diffraction patterns. Amer. Mineral., 38, 1051–1056. (4) Zen, E-An, M. Ross, and P. Bearth (1964) Paragonite from Täsch Valley near Zermatt, Switzerland. Amer. Mineral., 49, 183–190. (5) Sidorenko, O.V., B.B. Zvyagin, and S.V. Soboleva (1977) The crystal structure of 3T paragonite. Kristallografiya (Sov. Phys. Crystal.), 22, 976–981 (in Russian). (6) Lin, C.-Y. and S.W. Bailey (1984) The crystal structure of paragonite-$2M_1$. Amer. Mineral., 69, 122–127.

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Paraguanajuatite $Bi_2(Se,S)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Intimately intergrown with guanajuatite.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = 2 VHN = 27–50 (10 g load). D(meas.) = 6.2–7.0 D(calc.) = [7.704]

Optical Properties: Opaque. *Color:* Pale yellow, commonly tarnished lead-gray. *Luster:* Metallic. *Pleochroism:* Distinct in air. *Anisotropism:* Distinct.

R_1–R_2: (400) 46.9–56.2, (420) 47.5–56.6, (440) 48.0–56.8, (460) 48.6–57.2, (480) 49.3–57.7, (500) 49.9–58.0, (520) 50.2–58.1, (540) 50.3–58.2, (560) 50.2–58.1, (580) 50.0–58.0, (600) 49.7–57.8, (620) 49.2–57.4, (640) 48.6–56.8, (660) 48.1–56.2, (680) 47.4–55.5, (700) 46.9–55.0

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic Bi_2Se_3). $a = 4.133$ $c = 28.62$ $Z = 3$

X-ray Powder Pattern: Synthetic Bi_2Se_3.
3.03 (100), 2.23 (60), 1.404 (40), 4.80 (30), 2.07 (30), 1.907 (30), 1.320 (30)

Chemistry:

	(1)	(2)
Bi	62.8	63.64
Se	36.4	30.08
Te		5.13
S	0.8	1.48
Total	100.0	100.33

(1) Mexico; by electron microprobe, corresponds to $Bi_{1.86}(Se_{2.85}S_{0.15})_{\Sigma=3.00}$. (2) Kawazu mine, Japan; by electron microprobe, corresponds to $Bi_{1.97}(Se_{2.47}Te_{0.26}S_{0.30})_{\Sigma=3.03}$.

Polymorphism & Series: Dimorphous with guanajuatite.

Mineral Group: Tetradymite group.

Occurrence: Intergrown with guanajuatite in contact metamorphic as well as in hydrothermal veins (Santa Catarina mine, Mexico).

Association: Guanajuatite, bismuthinite, ferroselite (Santa Catarina mine, Mexico).

Distribution: From Mexico, in Guanajuato, in the Santa Catarina [TL] and Leon mines. From Falun, Kopparberg, Sweden. At the Kawazu mine, Shizuoka Prefecture, Japan.

Name: From the supposed relation to guanajuatite.

Type Material: n.d.

References: (1) Ramdohr, P. (1948) Los especes mineralogicas guanajuatite y paraguanajuatite. Comite Direct. Invest. Recursos Minerales Mexico, Bol. 20, 1–15 (in Spanish). (2) (1949) Amer. Mineral., 34, 619 (abs. ref. 1). (3) Godovikov, A.A. and V.A. Klyakhin (1966) Guanajuatite and paraguanajuatite. Akad. Nauk SSSR, Sibirsk. Otdel., Geol. Geofiz., 7, 67–76 (in Russian). (4) (1967) Amer. Mineral., 52, 1588 (abs. ref. 3). (5) Shmizu, M., A. Kato, and S. Matsubara (1988) Hemusite and paraguanajuatite from the Lawazu mine, Shizuoka Prefecture, Japan. Mineral. J. (Japan), 14, 92–100. (6) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 28. (7) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 71–74. (8) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 702–703. (9) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 413.

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Parahopeite $Zn_3(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are elongated along [001], flattened on {100}, with prominent {100}, {$1\overline{1}0$}, {110}, {010}, {322}, {011}, {$1\overline{1}1$}, {001}, many other forms, to 1.5 cm. Typically in subparallel fanlike aggregates. *Twinning:* Common on {100}, polysynthetic.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 3.5–4 D(meas.) = 3.31 D(calc.) = [3.32]

Optical Properties: Transparent. *Color:* Colorless, yellow-brown, golden brown; in transmitted light, colorless. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (+). *Orientation:* $X \simeq a$; $Y \wedge c = 30°$ on {100}. *Dispersion:* $r < v$, perceptible. $\alpha = 1.614(3)$ $\beta = 1.625(3)$ $\gamma = 1.637(3)$ 2V(meas.) = $\sim 90°$

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.768(5)$ $b = 7.550(5)$ $c = 5.276(5)$ $\alpha = 93°25'$ $\beta = 91°11'$ $\gamma = 91°22'$ Z = 1

X-ray Powder Pattern: Kabwe, Zambia. (ICDD 24-1461).
7.53 (100), 2.981 (80), 4.44 (70), 5.27 (40), 2.887 (40), 5.78 (30), 3.77 (30)

Chemistry:

	(1)	(2)	(3)
P_2O_5	31.6	33.3	30.98
SiO_2		0.01	
FeO		3.23	
MnO		1.21	
ZnO	53.0	42.2	53.29
MgO		3.5	
CaO		0.04	
H_2O	15.6	[16.5]	15.73
Total	100.2	[100.0]	100.00

(1) Kabwe, Zambia. (2) Reaphook Hill, Australia; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by difference; corresponds to $(Zn_{2.26}Mg_{0.37}Fe_{0.19})_{\Sigma=2.82}(PO_4)_{2.04} \cdot 4H_2O$. (3) $Zn_3(PO_4)_2 \cdot 4H_2O$.

Polymorphism & Series: Dimorphous with hopeite.

Occurrence: A secondary mineral in the oxidized zone of some zinc-bearing hydrothermal mineral deposits.

Association: Hemimorphite, tarbuttite, hopeite, scholzite, spencerite, pyromorphite.

Distribution: From Kabwe (Broken Hill), Zambia. In the Hudson Bay mine, Salmo, and on the Oxide claim, near Ymir, British Columbia, Canada. In England, at Roughton Gill, Caldbeck Fells, Cumbria; in the Turf Pits mine, Grassington Moor, and the Cockhill mine, Bewerley, northern Yorkshire. In Germany, from the Glücksrad mine, near Oberschulenberg, Harz Mountains; from Hagendorf, Bavaria; at Richelsdorf, Hesse. Large crystals on Reaphook Hill, near Blinman, Flinders Ranges, South Australia. From an undisclosed locality in Guangdong Province, China.

Name: From the Greek *para*, for *near*, and its dimorphous relation to *hopeite*.

Type Material: The Natural History Museum, London, England, 1907,980.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 733–734. (2) Hill, R.J. and A.R. Milnes (1974) Phosphate minerals from Reaphook Hill, Flinders Ranges, South Australia. Mineral. Mag., 39, 684–695. (3) Chao, G.Y. (1969) Refinement of the crystal structure of parahopeite. Zeits. Krist., 130, 261–266.

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Parajamesonite $Pb_4FeSb_6S_{14}$

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Crystal Data: Orthorhombic or lower. *Point Group:* n.d. Crystals columnar with imperfect, rounded faces and without good terminations, to 8 mm.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = 5.482 D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Gray. *Luster:* Metallic.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Herja, Romania.
4.21 (80-90), 3.78 (50), 4.67 (30), 2.49 (20), 2.23 (20), 2.02 (20), 3.29 (10)

Chemistry:

	(1)	(2)
Pb	39.81	40.15
Fe	2.98	2.71
Sb	34.74	35.39
S	21.96	21.75
insol.	0.13	
Total	99.62	100.00

(1) Herja, Romania; corresponds to $Pb_{3.93}Fe_{1.09}Sb_{5.91}S_{14.00}$. (2) $Pb_4FeSb_6S_{14}$.

Polymorphism & Series: Dimorphous with jamesonite.

Occurrence: In a hydrothermal deposit, later formed than other associated sulfides.

Association: Galena, pyrrhotite, chalcopyrite, tetrahedrite.

Distribution: From Herja (Kisbánya), Baia Mare (Nagybánya) district, Romania [TL].

Name: For the paramorphous relation to jamesonite.

Type Material: n.d.

References: (1) Zsivny, V. and I. v. Náray-Szabó (1947) Parajamesonit, ein neues Mineral von Kisbánya. Schweiz. Mineral. Petrog. Mitt., 27, 183–189 (in German). (2) (1949) Amer. Mineral., 34, 133 (abs. ref. 1).

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Parakeldyshite $Na_2ZrSi_2O_7$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As cleavable masses, to several cm; three cleavages result in a pseudorhombohedral aspect. *Twinning:* Polysynthetic on {100}, with several other sets intersecting.

Physical Properties: *Cleavage:* Perfect on {001}; very good on {110} and {1$\bar{1}$0}; good on {011}. Hardness = 5.5–6 D(meas.) = 3.37–3.39 D(calc.) = 3.40 Fluoresces deep cream under SW UV and a very weak cream under LW UV; alters readily to a snow-white coating.

Optical Properties: Translucent. *Color:* White, with a light bluish tinge. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X \simeq b$; $Y \simeq c$; $Z \simeq a$. $\alpha = 1.670$ (α') $\beta = 1.692$–1.697 (β') $\gamma = 1.713$–1.718 (γ') 2V(meas.) = 83°–84° 2V(calc.) = 88°

Cell Data: *Space Group:* $P\bar{1}$ (probable). $a = 5.419(1)$ $b = 6.607(2)$ $c = 8.806(2)$ $\alpha = 71.50(2)°$ $\beta = 87.15(3)°$ $\gamma = 85.63(2)°$ Z = 2

X-ray Powder Pattern: Bratthagen, Norway.
3.963 (10), 2.913 (9), 4.234 (7), 2.703 (7), 6.00 (6), 2.718 (6), 2.905 (5)

Chemistry:

	(1)	(2)
SiO_2	38.80	39.22
TiO_2	trace	0.13
ZrO_2	38.70	40.07
HfO_2	0.60	
Al_2O_3		0.21
Fe_2O_3	0.29	0.18
MgO		0.03
CaO	3.50	0.27
Na_2O	17.97	19.33
K_2O	1.13	0.25
H_2O^+	trace	0.48
H_2O^-		0.00
Total	100.39	100.17

(1) Khibiny massif, Russia. (2) Bratthagen, Norway; corresponds to $[Na_{1.90}(H_3O)_{0.05}K_{0.02}Ca_{0.02}]_{\Sigma=1.99}(Zr_{0.99}Fe_{0.01})_{\Sigma=1.00}(Si_{1.99}Al_{0.01})_{\Sigma=2.00}O_7$.

Occurrence: As masses in nepheline syenite pegmatites which cut a foyaite (Bratthagen, Norway).

Association: Alkalic feldspar, nepheline, aegirine, pyrophanite, loparite, biotite (Bratthagen, Norway); sodalite, analcime, tetranatrolite, aegirine, eudialyte (Mont Saint-Hilaire, Canada).

Distribution: From Mt. Takhtarvumchorr and elsewhere in the Khibiny massif, and on Mt. Alluaiv and elsewhere in the Lovozero massif, Kola Peninsula, Russia. At Bratthagen, near Larvik, Norway. From Mont Saint-Hilaire, Quebec, Canada.

Name: From the Greek *para*, for *near*, and its relation to *keldyshite*.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3270, 4457; Mining Institute, St. Petersburg, 1079/1–2, vis4361; Vernadsky Geological Museum, Moscow, 517151; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 78461, 78462.

References: (1) Khomyakov, A.P. (1977) Parakeldyshite – a new mineral. Doklady Acad. Nauk SSSR, 237, 703–705 (in Russian). (2) (1978) Chem. Abs., 92335 (abs. ref. 1). (3) Raade, G. and M.H. Mladeck (1977) Parakeldyshite from Norway. Can. Mineral., 15, 102–107. (4) (1979) Amer. Mineral., 64, 656–657 (abs. ref. 3). (5) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 158.

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Parakhinite $PbCu_3Te^{6+}O_6(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* 3. Hexagonal crystals, may be equant, to 0.5 mm, showing {0001}, {11$\bar{2}$0}, and {11$\bar{2}$4}, prismatic to pyramidal. *Twinning:* Sectorial twinning observed in polarized light.

Physical Properties: *Cleavage:* On {0001}, fair. *Tenacity:* Brittle. Hardness = 3.5
D(meas.) = 6.5–7.0 D(calc.) = 6.302

Optical Properties: Semitransparent. *Color:* Dark green, bottle-green. *Streak:* Green. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellowish green; E = emerald-green.
Dispersion: Strong. *Absorption:* $O > E$. $\omega = 2.155$ $\epsilon = 2.120$

Cell Data: *Space Group:* $P3_2$. $a = 5.765(2)$ $c = 18.001(9)$ Z = 3

X-ray Powder Pattern: Tombstone, Arizona, USA.
3.336 (10), 2.490 (10), 4.800 (8), 1.558 (8), 2.913 (7), 2.245 (6), 1.997 (5)

Chemistry:

	(1)	(2)	(3)
TeO_3	25.7	27.6	26.79
CuO	32.8	35.3	36.41
PbO	31.9	34.3	34.05
H_2O	7.8	[2.75]	2.75
Total	98.2	[100.0]	100.00

(1) Tombstone, Arizona, USA; traces of quartz noted as insoluble. (2) Analysis (1) recalculated to 100.0% with theoretical H_2O as determined by crystal-structure analysis; corresponding to $Pb_{1.04}Cu_{3.00}Te_{1.06}O_6(OH)_2$. (3) $PbCu_3TeO_6(OH)_2$.

Polymorphism & Series: Dimorphous with khinite.

Occurrence: A very rare secondary mineral formed under acid oxidizing conditions from gold–telluride ores in massive vein quartz.

Association: Dugganite, xocomecatlite, bromargyrite, other tellurium oxysalts.

Distribution: From the Emerald and Empire mines, Tombstone, Cochise Co., Arizona, USA.

Name: From the Greek for *near* and its dimorphous relation to *khinite*.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,543; Harvard University, Cambridge, Massachusetts, 119094; National Museum of Natural History, Washington, D.C., USA, 164352.

References: (1) Williams, S.A. (1978) Khinite, parakhinite, and dugganite, three new tellurates from Tombstone, Arizona. Amer. Mineral., 63, 1016–1019. (2) Burns, P.C., M.A. Cooper, and F.C. Hawthorne (1995) Parakhinite, $Cu_3^{2+}PbTe^{6+}O_6(OH)_2$: crystal structure and revision of chemical formula. Can. Mineral., 33, 33–40.

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Paralaurionite PbCl(OH)

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are thin to thick tabular ‖ {100}, or elongated along [001], to 3 cm; {100} is usually dominant, but may show many other forms. *Twinning:* Almost all crystals are twinned by contact on {100}.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Flexible, due to twin gliding, but not elastic. Hardness = Soft. D(meas.) = 6.05–6.15 D(calc.) = 6.28

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale greenish, yellowish, yellow-orange, rarely violet; colorless in transmitted light. *Luster:* Subadamantine. *Optical Class:* Biaxial (–). *Pleochroism:* Noted in violet material. *Orientation:* $Y = b$; $Z \wedge c = 25°$. *Dispersion:* $r < v$, strong. *Absorption:* $Y > X = Z$. $\alpha = 2.05(1)$ $\beta = 2.15(1)$ $\gamma = 2.20(1)$ 2V(meas.) = Medium to large.

Cell Data: *Space Group:* $C2/m$. $a = 10.865(4)$ $b = 4.006(2)$ $c = 7.233(3)$ $\beta = 117.24(4)°$ Z = 4

X-ray Powder Pattern: Laurium, Greece.
5.14 (10), 3.21 (10), 2.51 (9), 2.98 (7), 3.49 (6), 2.44 (6), 2.01 (6)

Chemistry:

	(1)	(2)	(3)
Pb	78.1	77.75	79.80
O	[3.6]	6.00	3.08
Cl	14.9	12.84	13.65
H_2O	3.4	3.51	3.47
insol.		0.09	
Total	[100.0]	100.19	100.00

(1) Laurium, Greece. (2) Tiger, Arizona, USA. (3) PbCl(OH).

Polymorphism & Series: Dimorphous with laurionite.

Occurrence: A secondary mineral formed through alteration of lead-bearing slag by sea water or in hydrothermal polymetallic mineral deposits.

Association: Laurionite, penfieldite, fiedlerite, phosgenite (Laurium, Greece); leadhillite, matlockite, cerussite, hydrocerussite, diaboleite, wherryite (Tiger, Arizona, USA).

Distribution: In slag from: Laurium, Greece. Along Baratti Beach, Tuscany, Italy. From the Meadowfoot smelter, near Wanlockhead, Dumfriesshire, Scotland. At Juliushütte, Astfeld, Harz Mountains, Germany. From the Argent Pb–Ag mine, about 100 km east of Johannesburg, Transvaal, South Africa. In mineral deposits at: Wheal Rose, near Sithney, and at Daymer Bay, Padstow, Cornwall, and at the Wesley mine, near Higher Pitts, Mendip Hills, and the Merehead quarry, near Shepton Mallet, Somerset, England. Exceptional crystals from the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA. In Chile, from the San Rafael and Santa Ana mines, near Caracoles, Sierra Gorda district, Antofagasta. Large crystals from the Touissit mine, near Oujda, and from Mibladen, Morocco.

Name: From the Greek for *near*, for the dimorphous relation to *laurionite*.

Type Material: The Natural History Museum, London, England, 84034.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 64–66. (2) Merlino, S., M. Pasero, and N. Perchiazzi (1993) Crystal structure of paralaurionite and its OD relationship with laurionite. Mineral. Mag., 57, 323–328. (3) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 58.

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Paralstonite $BaCa(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* 32. As hexagonal pyramids bounded by $\{22\overline{4}1\}$, rarely dipyramidal, striated ‖ [0001], faces divided by slightly re-entrant, irregular sutures, to 1 mm.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–4.5
D(meas.) = 3.60(2) D(calc.) = 3.62 Fluoresces pale to bright orange under LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, smoky white to pale gray; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.672(3)$ $\epsilon = 1.527(3)$

Cell Data: *Space Group:* $P321$. $a = 8.692(3)$ $c = 6.148(4)$ Z = 3

X-ray Powder Pattern: Minerva No. 1 mine, Illinois, USA; essentially identical to alstonite. 3.550 (100), 2.510 (67), 2.048 (21), 6.15 (18), 1.943 (18), 1.853 (15), 4.35 (11)

Chemistry:

	(1)	(2)	
CO_2	[30.0]	[30.1]	29.59
CaO	18.8	19.42	18.86
SrO	5.2	0.50	
BaO	45.6	51.23	51.55
Total	[99.6]	[101.25]	100.00

(1) Minerva No. 1 mine, Illinois, USA; by electron microprobe, CO_2 calculated for stoichiometry; corresponds to $Ba_{0.87}Ca_{0.98}Sr_{0.15}(CO_3)_{2.00}$. (2) Kedrovyi massif, Russia; by electron microprobe, CO_2 calculated for stoichiometry; corresponds to $Ba_{0.98}Ca_{1.01}Sr_{0.01}(CO_3)_{2.00}$. (3) $BaCa(CO_3)_2$.

Polymorphism & Series: Trimorphous with alstonite and barytocalcite; forms a series with olekminskite.

Occurrence: A rare mineral in low-temperature hydrothermal Pb–Zn deposits.

Association: Calcite, alstonite, fluorite, sphalerite (Minerva No. 1 mine, Illinois, USA); olekminskite, calcite, barite, ankerite, ancylite-(Ce), narsarsukite, sphalerite, galena (Kedrovyi massif, Russia).

Distribution: From the Minerva No. 1 and Annabel Lee mines, Cave-in-Rock, Hardin Co., Illinois, USA. At the Kedrovyi massif, five km southeast of the Murun massif, Aldan Shield, Sakha, Russia.

Name: From the Greek for *near* and its morphological and chemical relation with *alstonite*.

Type Material: Canadian Geological Survey, Ottawa, 13380; Royal Ontario Museum, Toronto, Canada; National Museum of Natural History, Washington, D.C., USA, 145915.

References: (1) Roberts, A.C. (1979) Paralstonite, a new mineral from the Minerva No. 1 mine, Cave-in-Rock, Illinois. Geological Survey of Canada Paper 79-1C, 99–100. (2) (1979) Amer. Mineral., 64, 1332 (abs. ref. 1). (3) Effenberger, H. (1980) Die Kristallstruktur des Minerals Paralstonit. Neues Jahrb. Mineral., Monatsh., 353–363 (in German with English abs.). (4) (1981) Amer. Mineral., 66, 219 (abs. refs. 1, 2, and 3). (5) Konev, A.A., E.I. Vorobev, L.F. Piskunova, Z.F. Ushchapovskaya, and G.A. Tichonova (1991) Olekminskite $Sr(Sr, Ca, Ba)(CO_3)_2$ – a new mineral and the new isomorphous series olekminskite-paralstonite. Zap. Vses. Mineral. Obshch., 120(3), 89–96 (in Russian).

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Paramelaconite $Cu_2^{1+}Cu_2^{2+}O_3$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals, to 7.5 cm, prismatic ‖ [001], showing {010} heavily striated ‖ [001], {011}, and {001}; massive.

Physical Properties: *Fracture:* Flat conchoidal. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 6.04–6.11 D(calc.) = 5.93

Optical Properties: Opaque. *Color:* Black to purplish black, pitch-black on fractures; white with pinkish brown tint in reflected light. *Streak:* Brownish black. *Luster:* Brilliant metallic to adamantine.
Optical Class: Uniaxial. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I4_1/amd$. $a = 5.837$ $c = 9.932$ $Z = 4$

X-ray Powder Pattern: Bisbee, Arizona, USA.
2.490 (vs), 1.575 (s), 1.251 (s), 2.050 (m), 1.449 (m), 1.430 (m), 2.888 (w)

Chemistry:

	(1)	(2)
Cu	81.80	84.12
O		15.88
Total		100.00

(1) Bisbee, Arizona, USA; by electrolytic determination of total Cu. (2) $Cu_2^{1+}Cu_2^{2+}O_3$.

Occurrence: A very rare secondary mineral in hydrothermal copper deposits.

Association: Cuprite, tenorite, connellite, malachite, goethite (Bisbee, Arizona, USA); cuprite, tenorite, chrysocolla, malachite, plancheite, dioptase, atacamite (Algomah mine, Michigan, USA).

Distribution: From the Copper Queen mine, Bisbee, Cochise Co., Arizona, and at the Algomah mine, Ontonagon Co., Michigan, USA.

Name: From the Greek for *near* and *melaconite*, which in turn was named for *black* and *dust*, now a synonym for tenorite.

Type Material: Seaman Mineral Museum, Michigan Technical University, Houghton, Michigan, 13396; American Museum of Natural History, New York City, New York, 4630; Harvard University, Cambridge, Massachusetts, 97919; National Museum of Natural History, Washington, D.C., USA, 112878; The Natural History Museum, London, England, 1967,37.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 510–511. (2) Frondel, C. (1941) Paramelaconite: a tetragonal oxide of copper. Amer. Mineral., 26, 657–672. (3) Williams, S.A. (1962) Paramelaconite and associated minerals from the Algomah mine, Ontonagon County, Michigan. Amer. Mineral., 47, 778–779. (4) O'Keeffe, M. and J.-O. Bovin (1978) The crystal structure of paramelaconite, Cu_4O_3. Amer. Mineral., 63, 180–185. (5) Morgan, P.E.D., D.E. Partin, B.L. Chamberland, and M. O'Keeffe (1996) Synthesis of paramelaconite: Cu_4O_3. J. Solid State Chem, 121, 33–37.

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Paramendozavilite $NaAl_4Fe^{3+}_7(PO_4)_5(P^{5+}Mo^{6+}_{12}O_{40})(OH)_{16}\cdot 56H_2O$

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Crystal Data: Monoclinic or triclinic. *Point Group:* n.d. Crystals, in coatings. *Twinning:* Observed optically ‖ cleavage, polysynthetic.

Physical Properties: *Cleavage:* One, perfect. Hardness = 1 D(meas.) = 3.35 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Pale yellow. *Streak:* Very pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* In pale yellows. *Orientation:* Extinction oblique to cleavage. *Absorption:* $Z > Y > X$. $\alpha = 1.686$ $\beta = 1.710$ $\gamma = 1.720$ 2V(meas.) = 60°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Cumobabi deposit, Mexico.
14.36 (10), 9.48 (10), 7.38 (7), 10.18 (6), 7.98 (5), 6.56 (5), 12.90 (4)

Chemistry:

	(1)	(2)
MoO_3	42.01	42.13
P_2O_5	10.32	10.39
Al_2O_3	4.65	4.97
Fe_2O_3	13.36	13.63
MgO	0.16	
CaO	0.59	
Na_2O	0.54	0.76
Cl	0.65	
H_2O	28.05	28.12
$-O = Cl_2$	0.15	
Total	100.18	100.00

(1) Cumobabi deposit, Mexico. (2) $NaAl_4Fe_7(PO_4)_5(PMo_{12}O_{40})(OH)_{16}\cdot 56H_2O$.

Occurrence: In the oxidized zone of a molybdenum-bearing pegmatitic breccia in granodiorite.

Association: Mendozavilite, biotite, kaolinite.

Distribution: From the Cumobabi molybdenum deposit, southwest of Cumpas, Sonora, Mexico.

Name: From the Greek *para*, for *near* and its chemical relation to *mendozavilite*.

Type Material: The Natural History Museum, London, England, 1984,476.

References: (1) Williams, S. A. (1986) Mendozavilite and paramendozavilite, two new minerals from Cumobabi, Sonora. Boletín de Mineralogía, 2(1), 13–19 (in English). (2) (1988) Amer. Mineral., 73, 194 (abs. ref. 1).

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Paramontroseite VO_2

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As pseudomorphs after montroseite crystals.

Physical Properties: Hardness = Soft. D(meas.) = n.d. D(calc.) = 4.09 Rapidly transforms topotactically from montroseite in air.

Optical Properties: Opaque. *Color:* Black to grayish black. *Streak:* Black.
Luster: Submetallic.
Optical Class: Biaxial.
R_1–R_2: n.d.

Cell Data: *Space Group: Pbnm.* $a = 4.905$ $b = 9.422$ $c = 2.916$ Z = 4

X-ray Powder Pattern: Bitter Creek mine, Colorado, USA. (ICDD 25-1003).
3.39 (100), 2.645 (50), 4.35 (35), 2.213 (35), 1.426 (35), 2.479 (25), 2.179 (25)

Chemistry:

	(1)	(2)
V_2O_4	72.5	66.90
SiO_2		6.12
Al_2O_3		3.00
V_2O_3	10.5	11.10
FeO	8.8	8.26
H_2O	5.0	4.82
Total	[96.8]	100.20

(1) Bitter Creek mine, Colorado, USA; partial analysis. (2) Matchless mine, Colorado, USA.

Occurrence: In relatively unoxidized Colorado Plateau-type U–V ores in sandstones, formed by dehydrogenation of montroseite (Colorado, Utah, and Arizona, USA).

Association: Montroseite, corvusite.

Distribution: All localities for montroseite are considered for paramontroseite: in the USA, in the Uravan district, from the Bitter Creek, Jo Dandy, and other mines, Montrose Co., the West Sunday mine, Big Gypsum Valley, San Miguel Co., and the Matchless mine, Gateway district, Mesa Co., Colorado; in the Juniper mine, near Thompson, Grand Co., the Rex No. 2 mine, Temple Mountain, and Mi Vida mine, Monticello district, Emery Co., Utah. In the Martin, Mesa 4-1/2, and Cove mines, Carrizo Mountains, and the Monument No. 2 mine, Monument Valley, Apache Co., Arizona; in the Grants district, McKinley Co., New Mexico; and in the Runge mine, Edgemont, Fall River Co., South Dakota. At Příbram, and in the Novoveska Huta deposit, Czech Republic. In the Urcal deposit, La Rioja, and in the Huemul mine, Malargüe district, Mendoza Province, Argentina. From the Mounana uranium mine, Franceville, Gabon.

Name: From the Greek for *near*, for its paramorphic relation to *montroseite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106897, 106898.

References: (1) Evans, H.T., Jr. and M.E. Mrose (1955) A crystal chemical study of montroseite and paramontroseite. Amer. Mineral., 40, 861–875. (2) Weeks, A.D., E.A. Cisney, and A.N. Sherwood (1953) Montroseite, a new vanadium oxide from the Colorado Plateaus. Amer. Mineral., 38, 1235–1241.

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Paranatisite $Na_2TiO(SiO_4)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As interstitial grains, to 1 mm, and aggregates, to 5 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5 D(meas.) = 3.12(5) D(calc.) = 3.07

Optical Properties: Transparent to translucent. *Color:* Yellow, yellow-orange, orange-brown. *Streak:* White. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* Weak; $X = Y$ = brown; Z = yellow. *Orientation:* X = b; Y = a; Z = c. *Dispersion:* $r > v$, weak. $\alpha = 1.740(2)$ $\beta = 1.741(2)$ $\gamma = 1.765(2)$ 2V(meas.) = 20(1)° 2V(calc.) = 23°

Cell Data: *Space Group: Pmma.* $a = 9.827(3)$ $b = 9.167(2)$ $c = 4.799(2)$ Z = 4

X-ray Powder Pattern: Khibiny massif, Russia.
2.748 (100), 1.443 (35), 1.475 (33), 1.720 (30), 1.680 (30), 2.257 (25), 1.660 (22)

Chemistry:

	(1)
SiO_2	29.69
TiO_2	35.70
Nb_2O_5	0.14
FeO	2.61
MnO	0.39
CaO	0.05
Na_2O	28.04
F	1.0
H_2O	1.6
$-O = F_2$	0.4
Total	98.82

(1) Khibiny massif, Russia; by electron microprobe, average of three analyses, H_2O by coulometry; corresponds to $(Na_{1.83}Mn_{0.01})_{\Sigma=1.84}(Ti_{0.90}Fe_{0.07})_{\Sigma=0.97}Si[O_{5.58}(OH)_{0.36}F_{0.11}]_{\Sigma=5.04}$.

Polymorphism & Series: Dimorphous with natisite.

Occurrence: In ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Nepheline, potassic feldspar, aegirine, aenigmatite, natisite, lamprophyllite, lorenzenite, shcherbakovite, delhayelite, villiaumite, lepidomelane.

Distribution: On Mts. Yukspor and Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: From the Greek *para*, for *near*, and its relation to *natisite*.

Type Material: Mining Institute, St. Petersburg, 2055/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 545/3.

References: (1) Khomyakov, A.P., L.I. Polezhaeva, and E.V. Sokolova (1992) Paranatisite Na_2TiSiO_5 – a new mineral. Zap. Vses. Mineral. Obshch., 121(6), 133–137 (in Russian).
(2) (1994) Amer. Mineral., 79, 764 (abs. ref. 1).

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Paranatrolite $Na_2Al_2Si_3O_{10}•3H_2O$

Crystal Data: Monoclinic; pseudo-orthorhombic. *Point Group: m*. As radial fibrous, sheaflike, parallel columnar crystal aggregates, to 5 mm; as epitaxial overgrowths on natrolite, or crusts on other minerals; in veinlets, massive.

Physical Properties: *Cleavage:* None. *Fracture:* Conchoidal. Hardness = 5-5.5
D(meas.) = 2.21-2.29 D(calc.) = 2.20

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (-). α = 1.493(2) β = 1.499(2) γ = 1.505(2) 2V(meas.) = 0°-10°

Cell Data: *Space Group: Cc*. a = 18.971(4) b = 19.204(3) c = 6.5952(12) β = 91.601(18)°
Z = 8

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.94 (100), 5.92 (60), 4.44 (40), 4.78 (30), 6.76 (20), 3.26 (15), 3.12 (15)

Chemistry:

	(1)
SiO_2	40.18
Al_2O_3	28.36
CaO	0.30
Na_2O	15.12
K_2O	2.50
H_2O^+	13.59
Total	100.05

(1) Khibiny massif, Russia; corresponds to $(Na_{1.99}K_{0.22}Ca_{0.02})_{\Sigma=2.23}Al_{2.27}Si_{2.73}O_{10}•3.08H_2O$.
(2) Mont Saint-Hilaire, Canada; partial analysis; composition and formula based on tetranatrolite, corresponding to $(Na_{1.75}Ca_{0.10}K_{0.09})_{\Sigma=1.94}Fe_{0.01}Al_{1.95}Si_{3.02}O_{10}•2.98H_2O$.

Mineral Group: Zeolite group.

Occurrence: In miarolitic cavities and pegmatitic dikes within nepheline syenite in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in pegmatites in nepheline syenites in differentiated alkalic massifs (Kola Peninsula, Russia). Dehydrates in air to tetranatrolite.

Association: Natrolite, tetranatrolite (Mont Saint-Hilaire, Canada).

Distribution: At Mont Saint-Hilaire and from near Saint-Amable, Québec, Canada. In the Lovozero and Khibiny (e.g. Mount Kukisvumchorr) massifs, Kola Peninsula, Russia. At the Schellkopf, near Brenk, Eifel district, Germany. From Island Magee, Co. Antrim, Ireland.

Name: From the Greek *para*, for near, and its relation to natrolite.

Type Material: Royal Ontario Museum, Toronto, M35546; Canadian Museum of Nature, Ottawa, Canada, 37132.

References: (1) Chao, G.Y. (1980) Paranatrolite, a new zeolite from Mont St-Hilaire, Québec. Can. Mineral., 18, 85-88. (2) (1981) Amer. Mineral., 66, 1276-1277 (abs. ref. 1). (3) Khomyakov, A.P., G.Y. Cherepivskaya, and M.G. Mikheeva (1986) First paranatrolite finds in the USSR. Doklady Acad. Nauk SSSR, 288, 214-217 (in Russian). (4) Seryotkin, Yu.V., V.V. Bakakin, and I.A. Belitsky (2004) The crystal structure of paranatrolite. Eur. J. Mineral., 16, 545-550.

Paraniite-(Y) $Ca_2Y(AsO_4)(WO_4, MoO_4)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Rough crystals, to 3 mm, are elongated bipyramids.

Physical Properties: *Cleavage:* On {001}, distinct. *Fracture:* Uneven to subconchoidal. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.95 Moderately strong yellow-orange fluorescence under SW UV.

Optical Properties: Semitransparent. *Color:* Creamy yellow. *Luster:* Vitreous to adamantine.
Optical Class: Uniaxial (+). $\omega = 1.87(1)$ $\epsilon = 1.92(1)$

Cell Data: *Space Group:* $I4_1/a$. $a = 5.135(1)$ $c = 33.882(5)$ Z = 4

X-ray Powder Pattern: Pizzo Cervandone, Italy.
3.059 (100), 1.901 (32), 1.562 (32), 2.571 (19), 4.674 (18), 1.674 (17), 1.818 (16)

Chemistry:

	(1)	(2)	(3)
MoO_3		10.6	
WO_3	51.61	45.0	57.70
As_2O_5	16.92	15.1	14.30
UO_2	0.25		
Y_2O_3	16.15	12.5	14.05
Gd_2O_3	0.70		
Dy_2O_3	1.87		
Er_2O_3	1.37		
Yb_2O_3	0.81		
CaO	12.35	15.4	13.95
Total	102.03	98.6	100.00

(1) Pizzo Cervandone, Italy; by electron microprobe, corresponds to $[Ca_{1.64}(Y,RE)_{0.36}]_{\Sigma=2.00}(Y,RE)_{1.00}(As_{0.96}W_{0.04})_{\Sigma=1.00}O_4[(W_{0.89}As_{0.11})_{\Sigma=1.00}O_4]_2$. (2) Fianel mine, Switzerland; by analytical electron microscope corresponds to $Ca_{2.10}Y_{0.85}(As_{1.00}O_4)[(W_{0.74}Mo_{0.28})_{\Sigma=1.02}O_4]_2$. (3) $Ca_2Y(AsO_4)(WO_4)_2$.

Occurrence: A very rare mineral found in a fissure in gneiss in an area anomalously high in arsenic (Pizzo Cervandone, Italy); as inclusions in scheelite–powellite in quartz–dolomite veinlets in dolomite breccia lenses cutting hematite–quartz-carbonate ore (Fianel mine, Switzerland).

Association: Scheelite–powellite, beryl, roméite, betafite, fluorapatite, bergslagite, barite, manganoan dolomite, quartz (Fianel mine, Switzerland).

Distribution: On the east flank of Pizzo Cervandone, Alpe Devero, Valle d'Ossola, Piedmont, Italy. At the Fianel mine, Val Ferrera, Graubünden, Switzerland.

Name: Honoring Fausto Parani, amateur mineral collector of Montecrestese, Italy, who found the mineral.

Type Material: Museo di Centro Studi "P. Ginocchi", Crodo, Italy.

References: (1) Demartin, F., C.M. Gramaccioli, and T. Pilati (1994) Paraniite-(Y), a new tungstate arsenate mineral from Alpine fissures. Schweiz. Mineral. Petrog. Mitt., 74, 155–160. (2) (1995) Amer. Mineral., 80, 631 (abs. ref. 1). (3) Brugger, J., R. Gieré, B. Grobéty, and E. Uspensky (1998) Scheelite-powellite and paraniite-(Y) from the Fe-Mn deposit at Fianel, Eastern Swiss Alps. Amer. Mineral., 83, 1100–1110.

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Paraotwayite $\mathbf{Ni(OH)_{2-x}(SO_4, CO_3)_{0.5x}}$ (x ~0.6)

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Crystal Data: Monoclinic. *Point Group:* n.d. Fibrous massive, parallel to sub-parallel, may be cross-vein fibrous, to 0.5 mm.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 223(22) average (20 g load). D(meas.) = 3.30 D(calc.) = 3.52

Optical Properties: Semitransparent. *Color:* Emerald-green; green in transmitted light. *Streak:* White. *Luster:* Silky.
Optical Class: Biaxial. *Pleochroism:* Weak; bluish green ∥ length; yellowish green ⊥ length. *Orientation:* Extinction parallel; length-slow. $\alpha = 1.655$ β = n.d. $\gamma = 1.705$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 7.89(1)$ $b = 2.96(1)$ $c = 13.63(3)$ $\beta = 91.1(2)°$ Z = 6

X-ray Powder Pattern: Otway prospect, Western Australia.
6.81 (10), 5.083 (8), 2.239 (8), 3.859 (5), 2.946 (4), 1.973 (3), 7.95 (2)

Chemistry:

	(1)
NiO	66.25
MgO	0.24
H_2O	17.42
CO_2	4.67
SO_3	11.80
Total	100.38

(1) Otway prospect, Western Australia; by electron microprobe, H_2O and CO_2 by CHN analyzer, $(OH)^{1-}$ calculated for charge balance; corresponds to $(Ni_{0.99}Mg_{0.01})_{\Sigma=1.00}(OH)_{1.43}(SO_4)_{0.17}(CO_3)_{0.12} \cdot 0.37H_2O$.

Occurrence: A very rare secondary mineral in veinlets in altered ore from a hydrothermal nickel deposit in a serpentinized peridotite.

Association: Millerite, polydymite, nickeloan chrysotile, dolomite, gaspéite.

Distribution: From the Otway prospect, near Spinnaway, Nullagine district, Western Australia.

Name: From the Greek for *near*, and for its similarity to *otwayite*.

Type Material: Western Australian Museum, Perth, M.71.1991; Museum Victoria, Melbourne, Australia, M36824; National Museum of Natural History, Washington, D.C., USA, 164243.

References: (1) Nickel, E.H. and J. Graham (1987) Paraotwayite, a new nickel hydroxide mineral from Western Australia. Can. Mineral., 25, 409–411. (2) (1988) Amer. Mineral., 73, 1496 (abs. ref. 1).

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Parapierrotite $Tl(Sb,As)_5S_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As terminated crystals, to 1 cm, prismatic along [001], with prominent {100}, {110}, and {100}.

Physical Properties: Hardness = 2.5–3 VHN = n.d. D(meas.) = 5.07 D(calc.) = 5.04

Optical Properties: Opaque. *Color:* Black; white with a creamy tint in reflected light, with rare red-purple internal reflections. *Luster:* Semimetallic. *Pleochroism:* Weak in air, grayish white to brownish gray in oil. *Anisotropism:* Distinct, brownish gray to bluish gray.
R_1–R_2: (400) 33.1–35.1, (420) 33.1–34.4, (440) 33.1–33.7, (460) 32.1–33.1, (480) 31.6–32.6, (500) 31.0–32.3, (520) 30.5–31.9, (540) 30.0–31.5, (560) 29.5–31.1, (580) 28.9–30.6, (600) 28.4–30.2, (620) 28.0–29.8, (640) 27.6–29.5, (660) 27.2–29.0, (680) 26.1–28.5, (700) 26.4–28.4

Cell Data: *Space Group:* $P2_1/n$. $a = 8.098(5)$ $b = 19.415(12)$ $c = 9.059(6)$ $\beta = 91.96(8)^\circ$ $Z = 4$

X-ray Powder Pattern: Alšar, Macedonia.
3.493 (100), 2.832 (100), 4.15 (90), 3.696 (90), 2.913 (90), 2.356 (90), 3.599 (70)

Chemistry:

	(1)	(2)	(3)
Tl	19.3	19.4	20.2
Sb	50.8	51.8	50.8
As	5.3	5.0	3.7
S	24.7	25.4	24.5
Total	100.1	101.6	99.2

(1–3) Alšar, Macedonia; by electron microprobe, the average corresponding to $Tl_{1.01}(Sb_{4.36}As_{0.64})_{\Sigma=5.00}S_{8.01}$.

Polymorphism & Series: Dimorphous with pierrotite.

Occurrence: Of hydrothermal origin, in cavities in realgar (Alšar, Macedonia).

Association: Realgar (Alšar, Macedonia); avicennite (Lookout Pass, Utah, USA).

Distribution: From Alšar (Allchar), near Rošden, Macedonia [TL]. At the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France. In the Hemlo gold deposit, Thunder Bay district, Ontario, Canada. From near Lookout Pass, Tooele Co., Utah, USA.

Name: For its relation to pierrotite.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, J. Hak, and M. Kvaček (1975) La parapierrotite, un nouveau minéral thallifère d'Allchar (Yougoslavie). Tschermaks Mineral. Petrog. Mitt., 22, 200–210 (in French with English abs.). (2) (1976) Amer. Mineral., 61, 504 (abs. ref. 1). (3) Engle, P. (1980) Die Kristallstruktur von synthetischem Parapierrotit, $TlSb_5S_8$. Zeits. Krist., 151, 203–216 (in German with English abs.). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 415.

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Pararammelsbergite $NiAs_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 2 mm, tabular on {001}; in rounded grains, also massive and in dendrites.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = ∼5 VHN = 681–830 (100 g load). D(meas.) = 7.12 D(calc.) = 7.24

Optical Properties: Opaque. *Color:* Tin-white. *Luster:* Metallic. *Anisotropism:* Strong, in russet-brown, brown, yellow, gray.
R_1–R_2: (400) 57.3–57.7, (420) 57.7–57.9, (440) 58.1–58.1, (460) 58.6–58.4, (480) 58.9–58.7, (500) 59.1–59.0, (520) 59.1–59.2, (540) 59.0–59.6, (560) 58.8–60.0, (580) 58.7–60.4, (600) 58.5–60.7, (620) 58.2–60.9, (640) 58.0–61.1, (660) 57.8–61.2, (680) 57.6–61.3, (700) 57.4–61.3

Cell Data: *Space Group: Pcba.* $a = 5.753$ $b = 5.799$ $c = 11.407$ Z = 8

X-ray Powder Pattern: Synthetic.
2.559 (100), 2.521 (95), 2.371 (65), 2.337 (65), 1.741 (65), 2.855 (50), 2.827 (50)

Chemistry:

	(1)	(2)	(3)
Ni	28.1	25.79	28.15
Co	0.4	1.26	
Cu		0.77	
As	68.5	71.23	71.85
S	2.6	0.02	
Total	99.6	99.07	100.00

(1) Moose Horn mine, Canada; corresponds to $(Ni_{0.96}Co_{0.01})_{\Sigma=0.97}(As_{1.84}S_{0.16})_{\Sigma=2.00}$.
(2) Černý Důl mine, Czech Republic; by electron microprobe, corresponds to $(Ni_{0.92}Co_{0.04}Cu_{0.02})_{\Sigma=0.98}As_{2.00}$. (3) $NiAs_2$.

Polymorphism & Series: Trimorphous with rammelsbergite and krutovite.

Occurrence: In hydrothermal veins bearing Ni–Co sulfide mineralization.

Association: Nickeline, skutterudite, cobaltite, löllingite, gersdorffite, rammelsbergite.

Distribution: In Canada, in Ontario, from the Moose Horn mine, Elk Lake, Gowganda [TL]; at the Hudson Bay [TL] and other mines in Cobalt; and from the Keeley mine, South Lorrain Township [TL]; at the D uranium deposit, Saskatchewan; on the Camsell River, six km south of Conjurer Bay, in the Great Bear Lake silver deposits, Northwest Territories. At Franklin, Sussex Co., New Jersey, USA. From Dobšiná (Dobschau), Slovakia. At the Černý Důl mine, Krkonoše (Giant Mountains), Czech Republic. In Germany, from Bieber, near Hanau, and in the Steinbruch quarry, Keimberg, near Wolfhagen, Hesse. At the San Juan de Plan mine, Gistain, Huesca Province, Spain. In the Shorbulaksk mercury deposit, Azerbaijan. At Bou Azzer, Morocco. In the Talmessi and Meskani mines, Anarak district, Iran.

Name: For its chemical similarity to rammelsbergite.

Type Material: Royal Ontario Museum, Toronto, Canada, M12411, M11772, M14242.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 310–311. (2) Fleet, M.E. (1972) The crystal structure of pararammelsbergite. Amer. Mineral., 57, 1–9. (3) Johan, Z. (1985) The Černy Důl deposit (Czechoslovakia): an example of Ni-, Fe-, Ag-, Cu-arsenide mineralization with extremely high activity of arsenic; new data on paxite, novakite and kutinaite. Tschermaks Mineral. Petrog. Mitt., 34, 167–182. (4) Bennett, S.L. and R.D. Heyding (1966) Arsenides of the transition metals. Can. J. Chem., 44, 3017–3030. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 416.

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Pararealgar AsS

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Crystal Data: Monoclinic. *Point Group:* m or $2/m$. As fine powder, rarely as granular (to < 0.02 mm) aggregates.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 1–1.5 VHN = n.d. D(meas.) = 3.52(5) D(calc.) = 3.499

Optical Properties: Translucent when coarsely granular. *Color:* Bright yellow when powdery, to yellow-orange and orange-brown when granular, with internal reflections from gold to red-orange. *Streak:* Bright yellow. *Luster:* Vitreous to resinous.
Optical Class: n.d. *Pleochroism:* High. $n = > 2.02$ *Anisotropism:* Distinct.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 9.902(2)$ $b = 9.655(1)$ $c = 8.502(1)$ $\beta = 97.29(1)^\circ$
$Z = 16$

X-ray Powder Pattern: Mount Washington, Canada.
5.14 (100), 5.56 (91), 3.75 (78), 2.795 (71), 3.025 (51), 3.299 (50), 3.105 (33)

Chemistry:

	(1)	(2)
As	69.81	70.03
S	29.97	29.97
Total	99.78	100.00

(1) Mount Washington, Canada; by electron microprobe, average of two analyses. (2) AsS.

Polymorphism & Series: Trimorphous with alacránite and realgar.

Occurrence: An alteration product of realgar in stibnite-bearing quartz veins, the alteration typically a result of exposure to light.

Association: Realgar, stibnite, tetrahedrite, arsenopyrite, duranusite, arsenic, arsenolite, sulfur, lepidocrocite, pyrite.

Distribution: In Canada, in British Columbia, from Mount Washington, Comox district, on Vancouver Island [TL]; at Siwash Creek, in the Kamloops district; and from the Gray Rock property, head of Traux Creek, in the Bridge River Area, Lillooet district; from Ontario, in the Hemlo gold deposit, Thunder Bay district. From the Golconda and Getchell mines, Humboldt Co., Nevada, USA. At the Lengenbach quarry, Binntal, Valais, Switzerland. From the Geschieber vein, Jáchymov (Joachimsthal), Czech Republic. At Wittichen, Black Forest, Germany. Probably to be found at a number of other arsenic-rich localities.

Name: In allusion to its chemical identity with realgar.

Type Material: Canadian Geological Survey, Ottawa, Canada, 61566, 61567.

References: (1) Roberts, A.C., H.G. Ansell, and M. Bonardi (1980) Pararealgar, a new polymorph of AsS, from British Columbia. Can. Mineral., 18, 525–527. (2) (1981) Amer. Mineral., 66, 1277 (abs. ref. 1). (3) Bonazzi, P., S. Menchetti, and G. Pratesi (1995) The crystal structure of pararealgar, As_4S_4. Amer. Mineral., 80, 400–403.

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Pararobertsite $Ca_2Mn_3^{3+}O_2(PO_4)_3 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Platy triangular crystals, tabular on {100}, to 0.2 mm, and in subparallel aggregates.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Brittle. Hardness = Very soft. D(meas.) = 3.22(4) D(calc.) = 3.22

Optical Properties: Transparent. *Color:* Red. *Streak:* Brownish red. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = yellowish brown; $Y = Z$ = reddish brown. *Orientation:* $Y = b$; $Z \wedge c = 4(2)°$. *Absorption:* $Z = Y > X$. $\alpha = 1.79(1)$ $\beta = 1.81(1)$ $\gamma = 1.83(1)$ 2V(meas.) = 84(2)° 2V(calc.) = 85°

Cell Data: *Space Group:* $P2_1/c$. $a = 8.825(3)$ $b = 13.258(4)$ $c = 11.087(3)$ $\beta = 101.19(4)°$ Z = 4

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
8.69 (100), 2.772 (70), 5.66 (60), 2.884 (60), 2.611 (60), 2.163 (60), 5.44 (50)

Chemistry:

	(1)	(2)
P_2O_5	35.2	34.57
Fe_2O_3	0.1	
Mn_2O_3	38.0	38.45
CaO	18.3	18.21
H_2O	[8.4]	8.77
Total	[100.0]	100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, total Fe as Fe_2O_3, total Mn as Mn_2O_3, H_2O by difference; corresponds to $Ca_{2.01}(Mn_{2.97}Fe_{0.01})_{\Sigma=2.98}O_{1.88}(PO_4)_{3.06} \cdot 2.88H_2O$.
(2) $Ca_2Mn_3O_2(PO_4)_3 \cdot 3H_2O$.

Polymorphism & Series: Dimorphous with robertsite.

Occurrence: A rare secondary mineral in a complex zoned granite pegmatite.

Association: Whitlockite, carbonate-apatite, quartz.

Distribution: In the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: From the Greek *para*, for *near*, and its relation to *robertsite*.

Type Material: Royal Ontario Museum, Toronto, Canada, M43771; National Museum of Natural History, Washington, D.C., USA, 149606.

References: (1) Roberts, A.C., B.D. Sturman, P.J. Dunn, and W.L. Roberts (1988) Pararobertsite, $Ca_2Mn_3^{3+}(PO_4)_3O_2 \cdot 3H_2O$, a new mineral species from the Tip Top pegmatite, Custer County, South Dakota, and its relationship to robertsite. Can. Mineral., 27, 451–455.
(2) (1990) Amer. Mineral., 75, 1211 (abs. ref. 1).

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Paraschachnerite Ag_3Hg_2

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As crystals, to 1 cm, but typically much smaller. *Twinning:* Always twinned in a complex fashion; twin plane {110}; trillings common.

Physical Properties: Hardness = > 3.5 VHN = 79–93, average 87 (100 g load). D(meas.) = n.d. D(calc.) = 12.98

Optical Properties: Opaque. *Color:* In polished section, creamy white. *Luster:* Metallic. *Pleochroism:* Brownish rose-white to creamy white. *Anisotropism:* Distinct.
R_1–R_2: (400) 65.9–67.0, (420) 67.9–69.0, (440) 69.8–70.9, (460) 71.5–72.6, (480) 73.3–74.4, (500) 74.9–76.2, (520) 76.5–77.8, (540) 78.1–79.3, (560) 79.5–80.7, (580) 80.6–81.8, (600) 81.5–82.8, (620) 82.3–83.5, (640) 82.9–84.0, (660) 83.6–84.6, (680) 84.0–85.1, (700) 84.6–85.5

Cell Data: *Space Group:* $Cmcm$ (probable) or $Cmc2$, $Cmc2_1$. $a = 2.961$ $b = 5.13$ $c = 4.83$ $Z = 2$

X-ray Powder Pattern: Landsberg, Germany.
2.267 (10), 2.404 (6), 1.263 (6), 1.361 (5), 1.481 (4), 0.8310 (4), 2.564 (3)

Chemistry:

	(1)	(2)
Ag	43.2	44.65
Hg	56.6	55.35
Total	100.0	100.00

(1) Landsberg, Germany; by electron microprobe. (2) Ag_3Hg_2.

Occurrence: Formed in the oxidized zone by the alteration of moschellandsbergite (Landsberg, Germany); thought to be a primary mineral (Kremikovci deposit, Bulgaria).

Association: Schachnerite, mercurian silver, acanthite, cinnabar, "limonite", ankerite (Landsberg, Germany); mercurian silver, cinnabar, many secondary copper minerals (Kremikovci deposit, Bulgaria); schachnerite, sphalerite, chalcopyrite, pyrite, pyrrhotite, gudmundite, cubanite, ilmenite, galena (Sala, Sweden).

Distribution: From the Vertraun auf Gott mercury mine, at Landsberg, near Obermoschel, Rhineland-Palatinate, Germany [TL]. In the Kremikovci deposit, Sofia district, Bulgaria. From Sala, Västmanland, Sweden.

Name: For the relation to schachnerite.

Type Material: Technical University, Berlin, Germany; National Museum of Natural History, Washington, D.C., USA, 145618, 150256.

References: (1) Seeliger, E. and A. Mücke (1972) Para-schachnerite, $Ag_{1.2}Hg_{0.8}$, und Schachnerite, $Ag_{1.1}Hg_{0.9}$, von Landsberg bei Obermoschel, Pfalz. Neues Jahrb. Mineral., Abh., 117, 1–18 (in German with English abs.). (2) (1973) Amer. Mineral., 58, 347 (abs. ref. 1). (3) Zakrzewski, M.A. and E.A.J. Burke (1987) Schachnerite, paraschachnerite and silver amalgam from the Sala mine, Sweden. Mineral. Mag., 51, 318–321. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 417.

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Paraschoepite $UO_3 \cdot 1{-}2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals short prismatic to tabular on [001], to several mm, showing large {001}, {100}, and {010}, commonly terminated by numerous {*hkl*} forms.

Physical Properties: *Cleavage:* Perfect on {001}; good on {010}. *Tenacity:* Very brittle. Hardness = 2–3 D(meas.) = n.d. D(calc.) = [4.47–4.73] Radioactive.

Optical Properties: Translucent. *Color:* Yellow with a slightly greenish hue; yellow in transmitted light, showing zonation. *Streak:* Yellow.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless to pale yellow; $Y = Z$ = yellow to golden yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.700$–1.705 $\beta = 1.750$–1.760 $\gamma = 1.770$ 2V(meas.) = 40°

Cell Data: *Space Group: Pbca.* $a = 14.12(4)$ $b = 16.83(5)$ $c = 15.22(5)$ Z = 32

X-ray Powder Pattern: Shinkolobwe, Congo; identical to metaschoepite.
5.09 (100), 3.45 (25), 3.39 (17), 2.89 (7), 2.48 (7b), 2.542 (6), 1.774 (6)

Chemistry:

	(1)
UO_3	89.26
PbO	0.00
H_2O	10.73
Total	99.99

(1) Shinkolobwe, Congo; corresponds to $UO_3 \cdot 1.9H_2O$.

Occurrence: An alteration product of schoepite from the oxidized zone of uranium-bearing mineral deposits.

Association: Schoepite, becquerelite, uraninite (Shinkolobwe, Congo); schoepite, arsenuranylite, metazeunerite, uranospinite, nováčekite (Cherkasar deposit, Uzbekistan).

Distribution: At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From the Cherkasar uranium deposit, Chatkal Mountains, Uzbekistan.

Name: From the Greek for *near*, and for its relation to *schoepite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 94712.

References: (1) Schoep, A. and S. Stradiot (1947) Paraschoepite and epiianthinite, two new uranium minerals from Shinkolobwe (Belgian Congo). Amer. Mineral., 32, 344–350. (2) Schoep, A. and S. Stradiot (1948) Crystals of paraschoepite. Amer. Mineral., 33, 513–514. (3) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates [schoepite-III]. Amer. Mineral., 45, 1026–1061. (4) Christ, C.L. (1965) Phase transformations and crystal chemistry of schoepite. Amer. Mineral., 50, 235–239.

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Parascholzite $CaZn_2(PO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Crystals are flattened on {100}, and elongated along [001], to 2 cm; commonly twinned and intergrown with scholzite. *Twinning:* By reflection on {100}, also the composition plane; may be simple, but typically polysynthetic.

Physical Properties: *Cleavage:* The composition plane of polysynthetic twins is a parting surface. Hardness = ∼4 D(meas.) = 3.12(3) D(calc.) = 3.10

Optical Properties: Semitransparent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 13(1)°$. *Dispersion:* $r > v$.
$\alpha = 1.587(2)$ $\beta = 1.588(2)$ $\gamma = 1.603(2)$ 2V(meas.) = 25(2)° 2V(calc.) = 29°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 17.864(5)$ $b = 7.422(2)$ $c = 6.674(2)$
$\beta = 106°27(1)'$ Z = 4

X-ray Powder Pattern: Hagendorf, Germany.
8.55 (100), 2.804 (80), 4.158 (50), 3.406 (40), 2.779 (40), 4.53 (30), 2.586 (30)

Chemistry:

	(1)	(2)
P_2O_5	35.7	35.77
FeO	0.5	
MnO	1.4	
ZnO	40.1	41.02
CaO	12.8	14.13
H_2O	8.8	9.08
Total	99.3	100.00

(1) Hagendorf, Germany; by electron microprobe, H_2O by the Penfield method; corresponds to $(Ca_{0.92}Mn_{0.08})_{\Sigma=1.00}(Zn_{1.98}Fe_{0.03})_{\Sigma=2.01}(PO_4)_{2.02} \cdot 1.97H_2O$. (2) $CaZn_2(PO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with scholzite.

Occurrence: A secondary mineral produced by alteration of primary phosphates in complex granite pegmatites.

Association: Scholzite, vivianite, phosphophyllite, strengite (Hagendorf, Germany).

Distribution: Large crystals from Hagendorf, Bavaria, Germany. At Kabwe (Broken Hill), Zambia. On Reaphook Hill, near Blinman, Flinders Ranges, South Australia. In the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: From the Greek *para*, for *near*, and its dimorphous relation to *scholzite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, B14318, B14345.

References: (1) Sturman, B.D., R.C. Rouse, and P.J. Dunn (1981) Parascholzite, a new mineral from Hagendorf, Bavaria, and its relationship to scholzite. Amer. Mineral., 66, 843–851.

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Parascorodite $Fe^{3+}AsO_4 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\overline{6}m2$, $6mm$, $\overline{3}\ 2/m$, or $3m$. Tabular to prismatic hexagonal crystals, to 1 μm, may be fan-shaped, in crudely hemispherical aggregates. *Twinning:* Observed.

Physical Properties: *Fracture:* Earthy to conchoidal in compact masses. Hardness = Soft. D(meas.) = 3.213(3) D(calc.) = 3.212

Optical Properties: Semitransparent. *Color:* Yellowish white, greenish gray; very pale yellow to brown in transmitted light. *Streak:* Yellowish-white.
Optical Class: Uniaxial, very low birefringence. $n = > 1.72$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P6_3/mcm$, $P\overline{6}c2$, $P6_3cm$, $P\overline{3}c1$, or $P3c1$. $a = 8.9327(5)$ $c = 9.9391(8)$ $Z = 6$

X-ray Powder Pattern: Kaňk, Czech Republic.
4.076 (100), 2.806 (68), 3.053 (67), 4.973 (61), 2.661 (59), 2.520 (54), 4.184 (44)

Chemistry:

	(1)	(2)
SO_3	1.53	
P_2O_5	0.84	
As_2O_5	44.45	49.79
Al_2O_3	0.17	
Fe_2O_3	34.55	34.60
H_2O^+	16.81	
H_2O^-	1.60	
H_2O		15.61
Total	99.95	100.00

(1) Kaňk, Czech Republic; average of two analyses, corresponding to $(Fe_{0.98}Al_{0.01})_{\Sigma=0.99}[(AsO_4)_{0.88}(SO_4)_{0.04}(PO_4)_{0.03}]_{\Sigma=0.95} \cdot 2.05H_2O$. (2) $FeAsO_4 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with scorodite.

Occurrence: A rare secondary mineral in mine dumps, presumed to be a pre-mining weathering product of arsenopyrite (Kaňk, Czech Republic).

Association: Scorodite, pitticite, bukovskýite, kaňkite, zýkaite, gypsum, jarosite, iron hydroxides (Kaňk, Czech Republic); scorodite, kaňkite, arsenic, pyrite, proustite (Svornost mine, Czech Republic).

Distribution: From the Kuntery mine, Kaňk, Kutná Hora district, and in the Svornost mine, Jáchymov (Joachimsthal), Czech Republic.

Name: From the Greek *para*, for *near*, and the dimorphic relation to *scorodite*.

Type Material: National Museum, Prague, Czech Republic, P1p 25/98.

References: (1) Ondruš, P., R. Skála, C. Viti, F. Veselovskỳ, F. Novák, and J. Jansa (1999) Parascorodite, $FeAsO_4 \cdot 2H_2O$ – a new mineral from Kaňk near Kutná Hora, Czech Republic. Amer. Mineral., 84, 1439–1444.

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Parasibirskite $CaH(BO_3)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tabular, in subparallel aggregates, to 40 μu.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = n.d. VHN = 109–155, 121 average (25 g load). D(meas.) = 2.50(1) D(calc.) = 2.54

Optical Properties: Semitransparent. *Color:* White; colorless in thin section.
Luster: "Weak", pearly.
Optical Class: Biaxial (+). $\alpha = 1.556(2)$ $\beta = 1.593(2)$ $\gamma = 1.663(2)$ 2V(meas.) = n.d. 2V(calc.) = 74.8°

Cell Data: *Space Group:* $P2_1/m$. $a = 6.722(4)$ $b = 5.437(2)$ $c = 3.555(2)$ $\beta = 93.00(5)°$ Z = 1

X-ray Powder Pattern: Fuka, Japan.
2.237 (100), 6.73 (70), 2.975 (60), 3.354 (30), 2.855(20), 1.776 (20), 4.23 (10)

Chemistry:

	(1)	(2)
B_2O_3	34.10	34.85
CaO	56.06	56.13
H_2O	9.97	9.02
Total	100.13	100.00

(1) Fuka, Japan; CaO by electron microprobe, B_2O_3 by ICP, H_2O by loss on ignition and TGA; corresponding to $Ca_{0.99}H_{1.10}B_{0.97}O_3$. (2) $CaH(BO_3)$.

Polymorphism & Series: Dimorphous with sibirskite.

Occurrence: A late-stage hydrothermal alteration of takedaite in a borate-rich vein cutting limestone and gehlenite-spurrite skarn.

Association: Takedaite, frolovite, olshanskyite, sibirskite, pentahydroborite, calcite.

Distribution: From Fuka, near Bicchu, Okayama Prefecture, Japan

Name: As a polymorph of *sibirskite*.

Type Material: National Science Museum, Tokyo, Japan.

References: (1) Kusachi, I., Y. Takechi, C. Henmi, and S. Kobayashi (1998) Parasibirskite, a new mineral from Fuka, Okayama Prefecture, Japan. Mineral. Mag., 62, 521–525. (2) (1999) Amer. Mineral., 84, 686 (abs. ref. 1).

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Paraspurrite $Ca_5(SiO_4)_2(CO_3)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As intergrown crystals, up to 2 cm. *Twinning:* Polysynthetic on {001}.

Physical Properties: *Cleavage:* Poor on {001}. Hardness = n.d. D(meas.) = 3.00 D(calc.) = 3.01

Optical Properties: Transparent to translucent. *Color:* Colorless in thin section. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y \wedge a = 30°$; $Z \wedge c = 30°$. $\alpha = 1.650$ $\beta = 1.672$ $\gamma = 1.677$ 2V(meas.) = 47°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.473(10)$ $b = 6.706(5)$ $c = 27.78(3)$ $\beta = 90.58(7)°$ Z = 8

X-ray Powder Pattern: Darwin, California, USA.
3.47 (100), 6.92 (78), 1.983 (63), 2.698 (48), 2.716 (42), 2.647 (39), 4.62 (37)

Chemistry:

	(1)	(2)
SiO_2	27.25	27.03
TiO_2	0.02	
Al_2O_3	0.37	
Fe_2O_3	0.12	
MnO	0.02	
MgO	0.19	
CaO	62.78	63.07
Na_2O	0.03	
CO_2		9.90
P_2O_5	0.13	
LOI	8.97	
Total	99.88	100.00

(1) Darwin, California, USA; loss on ignition by TGA, taken as CO_2. (2) $Ca_5(SiO_4)_2(CO_3)$.

Polymorphism & Series: Dimorphous with spurrite.

Occurrence: The dominant phase in a sequence of thermally metamorphosed siliceous carbonate rocks of the granulite facies.

Association: Gehlenite, vesuvianite, apatite, larnite.

Distribution: From near Darwin, Inyo Co., California, USA.

Name: From the Greek *para*, for *near*, and its relation to *spurrite*.

Type Material: n.d.

References: (1) Colville, A.A. and P.A. Colville (1977) Paraspurrite, a new polymorph of spurrite from Inyo County, California. Amer. Mineral., 62, 1003–1005.

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Parasterryite $Ag_4Pb_{20}(Sb_{14.5}As_{9.5})_{\Sigma=24}S_{58}$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As striated [100] acicular crystals to 4 mm. *Twinning*: Polysynthetic twins parallel elongation.

Physical Properties: *Cleavage*: Poor perpendicular to elongation. *Fracture*: Conchoidal. *Tenacity*: Brittle.
Hardness = 3-4 VHN = 196 (25 g load). D(meas.) = n.d. D(calc.) = 5.747

Optical Properties: Opaque. *Color*: Black, white in reflected light. *Streak*: Black. *Luster*: Metallic. *Pleochroism*: Weak, grayish white to white. *Anisotropism*: Distinct, gray to dark gray (with brownish and greenish tint).
Optical Class: n.d.
R_1-R_2: (470) 35.1-40.8 $(19.4\text{-}22.2)_{oil}$, (586) 33.5-39.3 $(19.3\text{-}21.7)_{oil}$, (586) 32.7-38.2 $(18.7\text{-}21.1)_{oil}$, (650) 31.4-36.5 $(17.3\text{-}19.5)_{oil}$

Cell Data: *Space Group: P*$2_1/c$. (pseudo-orthrombic) a = 8.3965(5) b = 27.9540(4) c = 43.8840(13) β = 90.061(12)° Z = 4

X-ray Powder Pattern: Pollone deposit, near Pietrasanta, Apuan Alps, Tuscany, Italy.
3.62 (100), 3.35 (95), 2.945 (85), 2.885 (80), 3.23 (65), 3.42 (45), 3.01 (45)

Chemistry:

	(1)
Cu	0.09
Ag	4.36
Hg	0.15
Pb	47.00
Sb	19.57
As	7.73
S	20.56
Total	99.46

(1) Pollone deposit, near Pietrasanta, Apuan Alps, Tuscany, Italy; average of 32 electron microprobe analyses, corresponding to $Cu_{0.13}Ag_{3.65}Hg_{0.07}Pb_{20.41}(S_{b14.49}As_{9.25})_{\Sigma=23.74}S_{57.72}$.

Occurrence: In vugs within hydrothermal barite–quartz veins embedded in barite-pyrite lenses in complexly sheared and metamorphosed sedimentary rocks.

Association: Acanthite, famatinite, geocronite-jordanite, pyrargyrite-prustite, Sb-rich rathite, sphalerite (overgrowth on sterryite), tetrahedrite, xanthoconite.

Distribution: Pollone deposit,Valdicastello Carducci, near Pietrasanta, Apuan Alps, Tuscany, Italy.

Name: For the similarity to *sterryite* with the Greek prefix *para* meaning "near".

Type Material: Natural History Museum, University of Pisa, Italy (19347), and at the Mineralogy Museum, School of Mines, Paris, France (82522).

References: (1) Moëlo, Y., P. Orlandi, C. Guillot-Deudon, C. Biagioni, W. Paar, and M. Evain (2011) Lead-antimony sulfosalts from Tuscany (Italy). XI. The new mineral species parasterryite, $Ag_4Pb_{20}(Sb_{14.5}As_{9.5})_{\Sigma24}S_{58}$, and associated sterryite, $Cu(Ag,Cu)_3Pb_{19}(Sb,As)_{22}(As\text{-}As)S_{56}$, from the Pollone mine, Tuscany, Italy. Canadian Mineralogist, 49, 623-638. (2) Moëlo, Y., C. Guillot-Deudon, M. Evain, P. Orlandi, and C. Biagioni (2012) Comparative modular analysis of two complex sulfosalt structures: sterryite, $Cu(Ag,Cu)_3Pb_{19}(Sb,As)_{22}(As\text{-}As)S_{56}$, and parasterryite, $Ag_4Pb_{20}(Sb,As)_{24}S_{58}$. Acta Crystallographica Section B, 68, 480-492. (3) (2014) Amer. Mineral., 99, 872-873 (abs. refs. 1 and 2).

Parasymplesite $Fe_3^{2+}(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals are elongated along [001], flattened on {010}, with prominent {010}, {100}, {$\bar{2}$01}, {110}, {221}, {$\bar{5}$02}, {$\bar{4}$01}, many others, to 5 mm; usually in radiating sprays.

Physical Properties: *Cleavage:* On {010}, perfect. *Tenacity:* Flexible. Hardness = 2–3 D(meas.) = 3.07–3.12 D(calc.) = 3.10–3.13

Optical Properties: Semitransparent. *Color:* Pale blue to greenish blue, green to leek-green; in transmitted light, pale blue to colorless. *Streak:* Very pale blue or green. *Luster:* Vitreous to waxy.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = bluish green to pale blue; Y = yellowish to colorless; Z = brownish yellow to colorless. *Orientation:* $X = b$; $Z \wedge c = 29°$–$31°$. *Dispersion:* $r < v$. *Absorption:* $X > Y = Z$. $\alpha = 1.620$–1.628 $\beta = 1.648$–1.660 $\gamma = 1.685$–1.705 2V(meas.) = 86° 2V(calc.) = 85°

Cell Data: *Space Group:* $C2/m$. $a = 10.335(4)$ $b = 13.491(8)$ $c = 4.777(2)$ $\beta = 105.04(4)°$ Z = 2

X-ray Powder Pattern: Ojuela mine, Mapimí, Mexico.
6.68 (100), 3.013 (90), 7.91 (70), 3.237 (50), 2.749 (50), 4.407 (40), 2.469 (40)

Chemistry:

	(1)	(2)	(3)
As_2O_5	38.43	38.12	38.99
Fe_2O_3	0.81		
FeO	37.72	18.98	36.56
ZnO		16.86	
H_2O^+	12.70		
H_2O^-	10.67		
H_2O			24.45
Total	100.33		100.00

(1) Kiura mine, Japan. (2) Ojuela mine, Mapimí, Mexico; by electron microprobe, partial analysis; corresponds to $(Fe_{1.68}Zn_{1.33})_{\Sigma=3.00}(AsO_4)_2 \cdot 8H_2O$. (3) $Fe_3(AsO_4)_2 \cdot 8H_2O$.

Polymorphism & Series: Dimorphous with symplesite; forms a series with köttigite.

Mineral Group: Vivianite group.

Occurrence: A rare secondary mineral in the oxide zone of some arsenic-rich hydrothermal base-metal mineral deposits.

Association: Symplesite, köttigite, pharmacosiderite, scorodite, arsenopyrite, löllingite.

Distribution: From the Kiura mine, Oita Prefecture, Japan. At the Kaatiala pegmatite, Kuortane, Finland. In the Glück Auf mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, France. In Germany, in the Richelsdorf Mountains, Hesse; from St. Andreasberg, Harz Mountains; at the Clara mine, near Oberwolfach, and from Weiler, near Lahr, Black Forest; at Ramsbeck, North Rhein-Westphalia. From Mitterberg, Salzburg, Austria. At Laurium, Greece, in slag. From Bou Azzer, Morocco. Large crystals from the Ojuela mine, Mapimí, Durango, Mexico. At the White Elephant mine, near Pringle, Pennington Co., South Dakota, USA. In the Puttapa zinc mine, near Beltana, South Australia.

Name: From the Greek *para*, for *near*, and its dimorphous relation to *symplesite*.

Type Material: National Science Museum, Tokyo, Japan, M24052.

References: (1) Ito, T., H. Minato, and K. Sakurai (1954) Parasymplesite, a new mineral polymorphous with symplesite. Proc. Japan Acad., 30, 318–324. (2) (1955) Amer. Mineral., 40, 368 (abs. ref. 1). (3) Sturman, B.D. (1976) New data for köttigite and parasymplesite. Can. Mineral., 14, 437–441. (4) Cesbron, F., M.-C. Sichère, and H. Vachey (1977) Propriétés cristallographiques et comportment thermique des termes de la série koettigite–parasymplésite. Bull. Minéral., 100, 310–314 (in French with English abs.).

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Paratacamite $Cu_2Cl(OH)_3$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. As rhombohedral crystals, with prominent $\{10\bar{1}1\}$, $\{02\bar{2}1\}$, $\{01\bar{1}2\}$, $\{0001\}$, a number of other forms; twins elongated along $[10\bar{1}1]$, to 1.5 cm; granular massive, powdery as incrustations. *Twinning:* Common on $\{10\bar{1}1\}$, may be polysynthetic.

Physical Properties: *Cleavage:* $\{10\bar{1}1\}$, good. *Fracture:* Conchoidal to uneven. Hardness = 3 D(meas.) = 3.72–3.74 D(calc.) = 3.75

Optical Properties: Translucent to nearly opaque. *Color:* Green to dark green, greenish black; in transmitted light, green. *Streak:* Green. *Luster:* Vitreous.
Optical Class: Uniaxial (+); commonly anomalously biaxial. *Dispersion:* $r > v$.
ω = 1.843–1.844 ϵ = 1.848–1.849 2V(meas.) = $\leq 50°$

Cell Data: *Space Group:* $R\bar{3}$. $a = 13.654(5)$ $c = 14.041(6)$ Z = 24

X-ray Powder Pattern: Sierra Gorda [district], Chile; almost identical to clinoatacamite. (ICDD 19-389).
5.46 (100), 2.750 (80), 2.258 (60), 1.704 (45), 1.813 (35), 2.888 (30), 4.67 (25)

Chemistry:

	(1)	(2)	(3)
Cu	14.27	14.60	14.88
CuO	56.10	55.98	55.87
Cl	15.97	16.29	16.60

	(1)	(2)	(3)
H_2O^+		13.10	
H_2O^-		0.03	
H_2O	14.10		12.65
Total	100.44	[100.00]	100.00

(1) Generosa mine, Chile; same material later shown by electron microprobe to also contain Zn 2.45%. (2) Remolinos, Chile; recalculated to 100% after deduction of insoluble 0.97%. (3) $Cu_2Cl(OH)_3$.

Polymorphism & Series: Polymorphous with atacamite, botallackite, and clinoatacamite.

Occurrence: An oxidation product of other copper minerals, especially under arid, saline conditions; in fumarolic deposits; a weathering product of sulfides in subsea black smoker deposits.

Association: Clinoatacamite, caracolite, schwartzembergite, osarizawaite-beaverite, boleite (Sierra Gorda district, Chile).

Distribution: In Chile, from the Generosa and Herminia mines, Sierra Gorda district, the Queténa mine, west of Calama, and at Chuquicamata, Antofagasta; from Nantoko, Copiapó district, and Remolinos, Atacama. At the Cerro Negro volcano, Nicaragua. In the USA, at the Lost Soldier mine, Weeks, Churchill district, and at the Douglas Hill mine and Mason Pass, Yerington district, Lyon Co., Nevada; large crystals from Bisbee, Cochise Co., and in the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona. From the Botallack and other mines, St. Just, and several other places in Cornwall, England. On Vesuvius, Campania, Italy. At Laurium, Greece, in slag. In the Tchah Khuni and Kali Kafi mines, near Anarak, Iran. In Australia, from Moonta-Wallaroo, and at the Dome Rock mine, north of Mingary, South Australia; in the Nangaroo mine, Murrin-Murrin, and the Carr Boyd Rocks mine, Western Australia; and at Broken Hill, New South Wales. Along the Mid-Atlantic Ridge, in the TAG hydrothermal field. A few other localities have been confirmed.

Name: From the Greek for *near*, and for its relation to *atacamite*.

Type Material: The Natural History Museum, London, England, 86958; National Museum of Natural History, Washington, D.C., USA, 95146.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 74–76. (2) Fleet, M.E. (1975) The crystal structure of paratacamite, $Cu_2(OH)_3Cl$. Acta Cryst., 31, 183–187. (3) Jambor, J.L., J.E. Dutrizac, A.C. Roberts, J.D. Grice, and J.T. Szymański (1996) Clinoatacamite, a new polymorph of $Cu_2(OH)_3Cl$, and its relationship to paratacamite and "anarakite". Can. Mineral., 34, 61–72. (4) Grice, J.D., J.T. Szymański, and J.L. Jambor (1996) The crystal structure of clinoatacamite, a new polymorph of $Cu_2(OH)_3Cl$. Can. Mineral., 34, 73–78.

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Paratellurite TeO_2

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Crystal Data: Tetragonal. *Point Group:* 422. Rarely in prismatic crystals, to 3 mm; commonly fine-grained massive.

Physical Properties: Hardness = 1 D(meas.) = 5.60 D(calc.) = 6.017

Optical Properties: Semitransparent. *Color:* Grayish white. *Luster:* Resinous to waxy. *Optical Class:* Uniaxial. $\omega = > 2.05$ $\epsilon = > 2.05$

Cell Data: *Space Group:* $P4_12_1$ or $P4_32_12$ (synthetic). $a = 4.810(1)$ $c = 7.613(2)$ Z = 4

X-ray Powder Pattern: Moctezuma mine, Mexico.
2.988 (100), 3.404 (86), 1.873 (55), 1.661 (22), 2.407 (20), 3.107 (13), 4.068 (12)

Chemistry:

	(1)	(2)	(3)
Te	78.0	78.5	79.95
O			20.05
Total			100.00

(1–2) Moctezuma mine, Mexico. (3) TeO_2.

Polymorphism & Series: Dimorphous with tellurite.

Mineral Group: Rutile group.

Occurrence: As thin seams in tellurium from a hydrothermal Au–Te deposit (Moctezuma mine, Mexico).

Association: Tellurite, tellurium (Moctezuma mine, Mexico); krennerite, tellurium, rodalquilarite, emmonsite, anglesite (Tombstone, Arizona, USA).

Distribution: Type material was stated to be from Cananea, but undoubtedly originated from the nearby Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the USA, from the Joe Shaft, Tombstone, and in the Campbell mine, Bisbee, Cochise Co., Arizona; at the Klondyke mine, Saguache Co., and the Last Chance mine, Boulder Co., Colorado; in the Silver King mine, Ward district, White Pine Co., Nevada. From the Kawazu mine, three km north of Shimoda, Shizuoka Prefecture, Japan. At Salmchâteau, near Ottré, Belgium.

Name: From the Greek for *near*, and for its relation to *tellurite*.

Type Material: Royal Ontario Museum, Toronto, Canada, M25007; National Museum of Natural History, Washington, D.C., USA, C5995, R8861.

References: (1) Switzer, G. and H.E. Swanson (1960) Paratellurite, a new mineral from Mexico. Amer. Mineral., 45, 1272–1274. (2) Kondratyuk, I.P., L.A. Muradyan, Y.V. Pisarevskii, and V.I. Simonov (1987) Precision X-ray structural investigation of acousto-optical single crystals of α-TeO_2. Kristallografiya (Sov. Phys. Crystal.), 32, 609–617 (in Russian).

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Paraumbite $K_3Zr_2HSi_6O_{18}\cdot nH_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Equant crystals, to 1 mm; massive.

Physical Properties: *Cleavage:* {010}, perfect micaceous; {100} and {110}, less perfect. *Fracture:* Uneven. Hardness = ~4.5 VHN = 280–504, 384 average. D(meas.) = 2.59 D(calc.) = 2.92

Optical Properties: Translucent to transparent. *Color:* Colorless to white, gray, pale green. *Streak:* White. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.588(2)$ $\beta = 1.601(2)$ $\gamma = 1.610(2)$ 2V(meas.) = 82°

Cell Data: *Space Group:* $P2cm$. a = 10.34–10.39 b = 13.25–13.29 c = 14.55–14.57 Z = 4

X-ray Powder Pattern: Khibiny massif, Russia.
5.95 (10b), 3.01 (9b), 6.46 (8), 3.47 (7), 2.90 (7), 2.56 (6), 4.06 (6b)

Chemistry:

	(1)
SiO_2	39.58
TiO_2	0.89
ZrO_2	27.87
HfO_2	0.32
Fe_2O_3	0.10
CaO	0.00
Na_2O	0.12
K_2O	15.39
H_2O	[15.73]
Total	[100.00]

(1) Khibiny massif, Russia; by electron microprobe, H_2O by difference; corresponds to $(K_{2.92}Na_{0.03})_{\Sigma=2.95}(Zr_{2.02}Ti_{0.10}Hf_{0.01}Fe_{0.01})_{\Sigma=2.14}Si_{5.89}O_{18}H_{0.94}\cdot 7.34H_2O$.

Occurrence: Replacing wadeite in a pegmatite in a differentiated alkalic massif (Khibiny massif, Russia); in altered pegmatite and sodalite xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Eudialyte, wadeite, gaidonnayite, natrolite, pectolite, potassic feldspar (Khibiny massif, Russia); gaidonnayite (Mont Saint-Hilaire, Canada).

Distribution: On Mt. Eveslogchorr, Khibiny massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: From the Greek *para*, for *near*, and its relation to *umbite*.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5842, 5843; Mineralogical Museum, St. Petersburg University, St. Petersburg, 17065; Mining Institute, St. Petersburg, 1630/1; Il'menskii Preserve Museum, Miass, 13095vr; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82760, vis3464, vis4544, vis4545, vis5045.

References: (1) Khomyakov, A.P., A.A. Voronkov, Y.S. Kobyashev, and L.I. Polezhaeva (1983) Umbite and paraumbite, new potassium zirconosilicates from the Khibina alkalic massif. Zap. Vses. Mineral. Obshch., 112, 461–469 (in Russian). (2) (1984) Amer. Mineral., 69, 813–814 (abs. ref. 1).

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Paravauxite $Fe^{2+}Al_2(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Short prismatic [001] crystals, may be thick tabular {010}, to 3 cm; forms include {010}, {110}, {100}, {$\overline{1}$10}, {1$\overline{2}$0}, {011}, {001}, {0$\overline{1}$1}, many others. As subparallel to radial aggregates.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.36 D(calc.) = [2.37]

Optical Properties: Transparent to translucent. *Color:* Pale greenish white to colorless; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, pearly on cleavages. *Optical Class:* Biaxial (+). *Orientation:* *X* (61°,56°); *Y* (180°,55°); *Z* (-61°,54°) [using (ϕ,ρ)]. α = 1.552–1.554 β = 1.558–1.559 γ = 1.572–1.573 2V(meas.) = 72°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.233$ $b = 10.541$ $c = 6.962$ $\alpha = 106.9°$ $\beta = 110.8°$ $\gamma = 72.1°$ Z = 1

X-ray Powder Pattern: Llallagua, Bolivia.
9.82 (10), 6.38 (9), 4.20 (9), 3.18 (8), 2.85 (6), 2.58 (5), 4.91 (4)

Chemistry:

	(1)	(2)
P_2O_5	29.58	29.70
SiO_2	0.02	
Al_2O_3	21.48	21.34
Fe_2O_3	0.60	
FeO	13.59	15.03
H_2O^+	18.07	
H_2O^-	16.08	
H_2O		33.93
Total	99.42	100.00

(1) Llallagua, Bolivia. (2) $FeAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$.

Polymorphism & Series: Dimorphous with metavauxite.

Mineral Group: Paravauxite group.

Occurrence: A rare mineral in hydrothermal tin veins (Llallagua, Bolivia); in complex granite pegmatites.

Association: Vauxite, metavauxite, wavellite, sigloite, crandallite, childrenite, quartz (Llallagua, Bolivia).

Distribution: From Llallagua, Potosí, Bolivia. At the Foote mine, Kings Mountain, Cleveland Co., North Carolina; from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, USA. At Santa Eulalia, Chihuahua, Mexico. From Hagendorf, and in the Silbergrube quarry, near Waidhaus, Bavaria, Germany. In the Bendada pegmatite, near Guarda, Portugal. From the Leveäniemi mine, Svappavaara, near Kiruna, Sweden.

Name: From the Greek *para*, for *near*, and its chemical relation to *vauxite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 112735, 136012, R5467.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 972–973. (2) Hurlbut, C.S., Jr. and R. Honea (1962) Sigloite, a new mineral from Llallagua, Bolivia. Amer. Mineral., 47, 1–8. (3) Baur, W.H. (1969) The crystal structure of paravauxite, $Fe^{2+}Al_2(PO_4)_2(OH)_2(OH_2)_6 \cdot 2H_2O$. Neues Jahrb. Mineral., Monatsh., 430–433.

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Pargasite $NaCa_2[(Mg,Fe^{2+})_4Al](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As stout prismatic crystals, to 3 cm; granular. *Twinning:* Simple or multiple twinning ∥ {100}, common.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; partings on {100}, {001}. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 3.04–3.17 D(calc.) = 3.209

Optical Properties: Transparent to translucent. *Color:* Bluish green, grayish black, light brown, bright green (chromian); in thin section, very light brown, bluish green. *Luster:* [Vitreous.]
Optical Class: Biaxial (+). *Pleochroism:* X = colorless, greenish yellow; Y = light brown, bluish green, green; Z = light brown, bluish green. *Orientation:* $Y = b$; $Z \wedge c \simeq 26°$. *Dispersion:* $r > v$, weak. α = 1.613–1.65 β = 1.618–1.66 γ = 1.635–1.67 2V(meas.) = 90°–120°

Cell Data: *Space Group:* $C2/m$. a = 9.910(1) b = 18.022(1) c = 5.312(1) β = 105.78(1)° Z = 2

X-ray Powder Pattern: Pargas, Finland. (ICDD 23-1406).
3.124 (100), 8.43 (40), 3.269 (35), 2.930 (35), 2.698 (30), 2.805 (25), 2.155 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	48.10	41.50	42.47	CaO	12.50	10.65	11.87
TiO_2	0.10	1.66	0.26	Na_2O	2.54	3.22	2.40
Al_2O_3	11.05	14.40	17.81	K_2O	1.24	0.32	0.69
Fe_2O_3	0.67		0.92	F	1.90		
Cr_2O_3			0.89	H_2O^+	0.71		1.78
FeO	1.65	12.60	4.49	H_2O^-	0.11		
MnO		0.12	0.15	P_2O_5			0.05
MgO	20.60	11.88	16.33	$-O = F_2$	0.80		
				Total	100.37	96.35	[100.11]

(1) Pargas, Finland; corresponds to $(Na_{0.69}K_{0.22})_{\Sigma=0.91}Ca_{1.88}(Mg_{4.32}Al_{0.59}Fe^{2+}_{0.19}Fe^{3+}_{0.07}Ti_{0.01})_{\Sigma=5.18}(Si_{6.76}Al_{1.24})_{\Sigma=8.00}O_{22}[F_{0.84}(OH)_{0.67}]_{\Sigma=1.51}$. (2) Sanbagawa schists, Ehime Prefecture, Japan; by electron microprobe, corresponds to $(Na_{0.93}K_{0.06})_{\Sigma=0.99}Ca_{1.70}(Mg_{2.64}Fe^{2+}_{1.52}Al_{0.72}Ti_{0.19}Fe^{3+}_{0.05}Mn_{0.02})_{\Sigma=5.14}(Si_{6.19}Al_{1.81})_{\Sigma=8.00}O_{22}(OH)_2$. (3) Merkerstein, Tanzania; original total given as 100.19%, corresponds to $(Na_{0.66}K_{0.13})_{\Sigma=0.79}Ca_{1.81}(Mg_{3.46}Al_{1.04}Fe^{2+}_{0.53}Fe^{3+}_{0.10}Cr_{0.10}Ti_{0.03}Mn_{0.02})_{\Sigma=5.28}(Si_{6.05}Al_{1.95})_{\Sigma=8.00}O_{22}(OH)_{1.69}$.

Polymorphism & Series: Forms a series with ferropargasite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.7$; Fe^{3+} Al^{vi}; $(Na + K)_A \geq 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si < 6.25$; $Ti < 0.5$.

Occurrence: A common component of "hornblendes" in skarns metamorphosed from siliceous limestones; schists and amphibolites; also from andesitic volcanic and altered ultramafic rocks.

Association: Diopside, phlogopite, corundum, spinel, calcite (skarn); "hypersthene," augite, plagioclase (metabasalts and andesitic volcanics).

Distribution: Many localities, but rarely in good crystals. At Parainen (Pargas), Finland. From Långban, Värmland, Sweden. On the Saualpe, Carinthia, Austria. At Vesuvius, Campania, Italy. From Franklin, Sussex Co., New Jersey, USA. At Wolfe Lake, Ontario, Canada. In Pakistan, from Aliabad, Hunza Valley.

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Name: For the locality at Parainen (Pargas), Finland.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 385–398. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 263–314. (3) Leake, B.E. (1971) On aluminous and edenitic hornblendes. Mineral. Mag., 38, 389–407. (4) Charles, R.W. (1980) Amphiboles on the join pargasite-ferropargasite. Amer. Mineral., 65, 996–1001. (5) Makino, K. and K. Tomita (1989) Cation distribution in the octahedral sites of hornblendes. Amer. Mineral., 74, 1097–1105.

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Parisite-(Ce) **$Ca(Ce,La)_2(CO_3)_3F_2$**

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group: m.* Steep doubly-terminated pyramidal crystals, many forms, but oscillatory and sceptered due to intergrowths ‖ pseudo-{0001} with bastnäsite-(Ce), synchysite-(Ce), röntgenite-(Ce), cordylite, to 24 cm.

Physical Properties: *Cleavage:* On pseudo-{0001}, probably a parting. *Fracture:* Subconchoidal to splintery. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 4.33 D(calc.) = [4.38] May exhibit dark red cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Brownish yellow, orange, orange-brown, brown, wax-yellow, grayish yellow, lilac; colorless to yellow in transmitted light. *Streak:* Pale yellow. *Luster:* Vitreous to resinous, pearly on {0001} parting. *Optical Class:* Uniaxial (+). *Pleochroism:* Weak; O = pale yellow; E = golden yellow. *Absorption:* $O < E$. $\omega = 1.671$–1.676 $\epsilon = 1.771$–1.757

Cell Data: *Space Group: Cc.* $a = 12.3049$ $b = 7.1056$ $c = 28.2478$ $\beta = 98.2416°$ Z = 12

X-ray Powder Pattern: Mont Saint-Hilaire, Canada; identical with parisite-(Nd). 3.565 (100), 2.838 (100), 2.060 (80), 1.938 (60), 1.882 (50), 1.658 (50), 14.03 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	24.22	[24.58]	24.58	Eu_2O_3		0.20	
Y_2O_3	trace			Fe_2O_3	0.20		
La_2O_3		15.10	30.33	CaO	10.70	10.70	10.44
$(La,Dy)_2O_3$	29.74			Na_2O	0.20		
Ce_2O_3	30.67	28.87	30.56	K_2O	0.10		
Pr_2O_3		3.00		F	6.82	5.34	7.07
Nd_2O_3		11.65		$-O = F_2$	2.87	2.24	2.98
Sm_2O_3		1.46		Total	99.78	[98.65]	100.00

(1) Muzo, Colombia. (2) Do.; by electron microprobe, average of four analyses, CO_2 from ideal formula; corresponds to $Ca_{1.02}(Ce_{0.94}La_{0.50}Nd_{0.37}Pr_{0.10}Sm_{0.05})_{\Sigma=1.96}(CO_3)_3F_{1.51}$. (3) $Ca(Ce,La)_2(CO_3)_3F_2$ with Ce:La = 1:1.

Polymorphism & Series: 2M, pseudo-(3R, 4H, 6R, 8H, 10H, 14H, 16H, 18R, 25R, 30R, 36R, 42R, 48R) polytypes are known.

Occurrence: An accessory mineral in differentiated alkalic massifs, granite pegmatites, and RE-rich carbonatites.

Association: Bastnäsite, synchysite, cordylite, ancylite, calcite, fluorite, quartz.

Distribution: Many localities, most minor. Fine crystals from the Muzo district, Boyacá Province, Colombia. In the USA, in Montana, very large crystals at the Snowbird deposit and the nearby Cedar Log prospect, Mineral Co., and from Pyrites, 13 km east of Florence, Ravalli Co.; at Quincy, Norfolk Co., Massachusetts. From Mont Saint-Hilaire, Quebec, Canada. At Holmestrand, Vestfold, Norway. In the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France. From Monterfano, Lombardy, Italy. Around Gallt y Wenallt, Gwynedd, Wales. In the Khibiny massif, Kola Peninsula, Russia. On Mt. Malosa, Zomba district, Malawi. At Ifasina, Torendrika, Madagascar. In the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire). At the Shirashi pegmatite, Kobe, Kyoto Prefecture, Japan. In the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China. At Nam Nam Xe, Vietnam.

Name: Honors J.J. Paris, Manager of the emerald mine at Muzo, Colombia.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 282–285. (2) Ni, Y., J.E. Post, and J.M. Hughes (2000) The crystal structure of parisite-(Ce), $Ce_2CaF_2(CO_3)_3$. Amer. Mineral., 85, 251–258. (3) Cheang, K. (1977) Structure and polytypism in synchysite and parisite from Mont St. Hilaire, Quebec. MS thesis, Carleton University, Ottawa, Canada.

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Parisite-(Nd) $Ca(Nd,Ce)_2(CO_3)_3F_2$

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Crystal Data: [Monoclinic.] [by analogy to parisite-Ce)]. *Point Group:* n.d. Large grains.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4–5 D(meas.) = 4.20–4.50 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Yellowish brown; pale yellowish brown in thin section. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (+). $\omega = 1.679$ $\epsilon = 1.754$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Stated to be identical to parisite-(Ce).

Chemistry: (1) Bayan Obo, China; average of two analyses, RE = Y 0.2%, La 9.6%, Ce 35.9%, Pr 7.7%, Nd 40.6%, Sm 4.5%, Eu 0.4%, Gd 1.0%, Dy 0.2%, Yb 0.1%.

Occurrence: In carbonatite-derived dolomitic marble.

Association: Calcite, aegirine, sodic amphibole, quartz.

Distribution: In the Bayan Obo Fe–Nb–RE deposit, 130 km north of Baotou, Inner Mongolia, China.

Name: For its relation to *parisite*, with *neodymium* as its dominant rare-earth element.

Type Material: n.d.

References: (1) Zhang Peishan and Tao Kejie (1986) Bayan Obo mineralogy. Science Publisher, Beijing, China, 208 pp. (in Chinese with English abs.). (2) (1988) Amer. Mineral., 73, 1496–1497 (abs. ref. 1). (3) Zhang Peishan, Yang Zhuming, Tao Kejie, and Yang Xueming (1995) Mineralogy and geology of rare earths in China. Science Press, Beijing, China, 209 pp. esp. p. 104 (in English).

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Parkerite $Ni_3(Bi,Pb)_2S_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As grains, to < 1 mm, the rhombic shape of which is controlled by intersecting parting and cleavage planes. *Twinning:* Lamellar twinning on {111}.

Physical Properties: *Cleavage:* {001}, perfect; parting on {111}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3 VHN = n.d. D(meas.) = 8.50 D(calc.) = 8.53

Optical Properties: Opaque. *Color:* Bright bronze, tarnishing darker and duller; pale cream in polished section. *Streak:* Black, shining. *Luster:* Metallic. *Pleochroism:* Perceptible. *Anisotropism:* Strong; greenish gray to yellowish brown.
R_1–R_2: (400) 43.1–45.0, (420) 44.2–46.0, (440) 45.1–47.0, (460) 45.9–47.8, (480) 46.6–48.4, (500) 47.1–49.0, (520) 47.6–49.5, (540) 48.0–49.9, (560) 48.4–50.4, (580) 48.8–50.7, (600) 49.2–51.1, (620) 49.6–51.5, (640) 50.0–51.9, (660) 50.4–52.3, (680) 50.7–52.7, (700) 51.0–53.0

Cell Data: *Space Group:* $C2/m$ (probable). $a = 11.066(1)$ $b = 8.085(1)$ $c = 7.965(1)$ $\beta = 134.0°$ Z = 4

X-ray Powder Pattern: Synthetic $Ni_3Bi_2S_2$.
2.836 (100), 2.864 (65), 2.336 (55), 3.98 (30), 4.04 (25), 1.989 (25), 1.648 (25)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	30.3	26.8	29.7	26.76
Bi	60.1	63.6	50.8	63.50
Pb		trace	9.5	
S	9.1	9.2	9.6	9.74
Total	99.5	99.6	99.6	100.00

(1) Langis mine, Canada; by electron microprobe; corresponds to $Ni_{3.64}Bi_{2.03}S_{2.00}$. (2) Sudbury, Canada; corresponds to $Ni_{3.18}Bi_{2.12}S_{2.00}$. (3) Insizwa, South Africa; by electron microprobe; corresponds to $Ni_{3.28}(Bi_{1.62}Pb_{0.31})_{\Sigma=1.93}S_{2.00}$. (4) $Ni_3Bi_2S_2$.

Occurrence: As grains in other hydrothermal sulfide and arsenide minerals.

Association: Galena, bismuth, bismuthinite, tetradymite, hessite, cubanite, maucherite, nickeline, sperrylite, gold, chalcopyrite, pyrrhotite, pentlandite, siegenite, bravoite.

Distribution: In South Africa, from the Insizwa Cu–Ni deposit, Waterfall Gorge, Eastern Cape, South Africa [TL], and in the Loolekop carbonatite, Phalaborwa, Transvaal. In Canada, at the Strathcona mine, Sudbury, and from the Langis mine, Casey Township, Cobalt-Gowganda area, Ontario; in the Gaspe copper mine, Quebec; and at the Gros Cap area, near Great Slave Lake, Northwest Territories. In the Noril'sk region, western Siberia; from the Karik'yavr Cu–Ni deposit, Kola Peninsula; and in the Allarechensk region, Murmansk, Russia. At the Zinkwand mine, Schladminger, Styria, Austria. From Nebral, Málaga Province, Spain. In the Rakha copper deposit, Bihar, India. From the Ban Phuc Ni–Cu–PGE deposit, northwest Vietnam. At Kambalda, 56 km south of Kalgoorlie, Western Australia.

Name: After Professor Robert Lüling Parker (1893–1973), Swiss Federal Institute of Technology, Zurich, Switzerland.

Type Material: n.d.

References: (1) Michener, C.E. and M.A. Peacock (1943) Parkerite ($Ni_3Bi_2S_2$) from Sudbury, Ontario: redefinition of the species. Amer. Mineral., 28, 343–355. (2) Peacock, M.A. and J. McAndrew (1950) On parkerite and shandite and the crystal structure of $Ni_3Pb_2S_2$. Amer. Mineral., 35, 425–439. (3) Petruk, W., D.C. Harris, and J.M. Stewart (1969) Langisite, a new mineral, and the rare minerals cobalt pentlandite, siegenite, parkerite and bravoite from the Langis mine, Cobalt–Gowganda area, Ontario. Can. Mineral., 9, 597–616. (4) Fleet, M.E. (1973) The crystal structure of parkerite ($Ni_3Bi_2S_2$). Amer. Mineral., 58, 435–439. (5) Brower, W.S., H.S. Parker, and R.S. Roth (1974) Reexamination of synthetic parkerite and shandite. Amer. Mineral., 59, 296–301. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 418.

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Parkinsonite $(Pb, Mo)_4O_4Cl$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$, $\bar{4}2m$, $4mm$, or 422. As bladed crystals, to 0.3 mm, and crystalline aggregates, embedded in other lead minerals.

Physical Properties: *Cleavage:* {001}, perfect; {100}, possible, fair. *Tenacity:* Sectile. Hardness = 2–2.5 VHN = 113–133, 122 average (50 g load). D(meas.) = 7.32 (synthetic). D(calc.) = 7.39

Optical Properties: Translucent. *Color:* Bright red, purplish red, brownish red; brownish red in transmitted light; in reflected light, gray with deep red to red-orange internal reflections. *Streak:* Scarlet to grenadine-red. *Luster:* Adamantine, pearly to resinous.
Optical Class: Uniaxial (–); anomalously biaxial. *Pleochroism:* Strong; O = brownish red; E = greenish yellow. ω = [2.58] ϵ = [2.42] 2V(meas.) = Small. *Anisotropism:* Weak to moderate. *Bireflectance:* Moderate.
R_1–R_2: (400) 22.6–21.8, (420) 22.4–21.2, (440) 22.3–20.5, (460) 22.2–19.9, (480) 21.9–19.4, (500) 21.6–18.9, (520) 21.2–18.5, (540) 20.6–18.1, (560) 20.2–17.8, (580) 19.8–17.5, (600) 19.4–17.2, (620) 19.1–17.1, (640) 18.9–17.0, (660) 18.7–16.9, (680) 18.6–16.7, (700) 18.5–16.7

Cell Data: *Space Group:* $I4/mmm$, $I\bar{4}2m$, $I\bar{4}m2$, $I4mm$, or $I422$. a = 3.9922(3) c = 22.514(3) Z = 2

X-ray Powder Pattern: Merehead quarry, England.
2.983 (100), 2.816 (78), 1.989 (75), 1.658 (51), 1.586 (33), 3.507 (32), 1.263 (24)

Chemistry:

	(1)
MoO_3	8.0
PbO	88.4
Cl	4.4
$-O = Cl_2$	1.0
Total	[99.8]

(1) Merehead quarry, England; by electron microprobe, average of six analyses, original total given as 100.8%; corresponds to $(Pb_{3.17}Mo_{0.44})_{\Sigma=3.61}O_{4.01}Cl_{0.99}$.

Occurrence: A very rare mineral in nodules in manganese oxide ores in veins, fissures, and pockets in limestone.

Association: Mendipite, chloroxiphite, diaboleite, cerussite, paralaurionite, wulfenite, calcite, manganese oxides (Merehead quarry, England).

Distribution: In the Merehead quarry, Cranmore, and from the Wesley mine, Didsbury, near Bristol, Somerset, England.

Name: For Reginald F.D. Parkinson (1928–), British mineral collector and dealer, Shepton Mallet, Somerset, England, who first found the mineral.

Type Material: The Natural History Museum, London, England, 1987,478–479.

References: (1) Symes, R.F., G. Cressey, A.J. Criddle, C.J. Stanley, J.G. Francis, and G.C. Jones (1994) Parkinsonite, $(Pb, Mo, \square)_8O_8Cl_2$, a new mineral from Merehead Quarry, Somerset. Mineral. Mag., 58, 59–68. (2) (1994) Amer. Mineral., 79, 1011 (abs. ref. 1).

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Parnauite $Cu_9(AsO_4)_2(SO_4)(OH)_{10}\cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals lathlike, elongated ‖ [001], flattened ‖ [010], to 4 mm, forming "bowties", rosettes, and fans; as scales and compact crusts.

Physical Properties: Hardness = ∼2 D(meas.) = 3.09(4) D(calc.) = [3.09]

Optical Properties: Semitransparent. *Color:* Pale blue, green, dark green, blue-green, less commonly yellow-green.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = pale green; Y = yellow-green; Z = blue-green. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Absorption:* $Z > Y > X$. $\alpha = 1.680(3)$ $\beta = 1.704(3)$ $\gamma = 1.712(3)$ $2V(meas.) = 60(5)°$

Cell Data: *Space Group:* $P2_122$ (possible). $a = 14.98(1)$ $b = 14.223(8)$ $c = 6.018(8)$ Z = [2]

X-ray Powder Pattern: Majuba Hill, Nevada, USA.
14.3 (100), 4.52 (60), 10.38 (24), 4.00 (21), 2.849 (19), 7.14 (10), 6.42 (8)

Chemistry:

	(1)	(2)
SO_3	6.33	6.45
P_2O_5	2.56	
As_2O_5	13.69	18.50
CO_2	0.7	
Al_2O_3	0.42	
CuO	58.10	57.64
H_2O	17.7	17.41
Total	99.50	100.00

(1) Majuba Hill, Nevada, USA; by electron microprobe, average of ten spots, H_2O and CO_2 by CHN analyzer; corresponds to $Cu_{8.76}Al_{0.10}[(AsO_4)_{1.43}(PO_4)_{0.43}]_{\Sigma=1.86}(SO_4)_{0.94}(CO_3)_{0.19}(OH)_{9.98}\cdot 6.81H_2O$. (2) $Cu_9(AsO_4)_2(SO_4)(OH)_{10}\cdot 7H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal Cu–Sn orebody in rhyolite porphyries and breccias (Majuba Hill, Nevada, USA).

Association: Spangolite, chalcophyllite, chenevixite, goudeyite, malachite, azurite, brochantite, chrysocolla (Majuba Hill, Nevada, USA); cyanotrichite, brochantite, lavendulan, mansfieldite–scorodite, chalcopyrite, cornubite (Cap Garonne mine, France); chrysocolla, brochantite, malachite, tyrolite, connellite (Gwaithyrafon mine, Wales).

Distribution: In the USA, fine examples from the Majuba Hill mine, Antelope district, Pershing Co., and the Burrus mine, Pyramid district, Washoe Co., Nevada; the Grandview Mine, Grand Canyon, Coconino Co., and the Harquehala mine, Yuma Co., Arizona; the Tucker's tunnel uranium deposit, near Durango, Hinsdale Co., Colorado; and at Gold Hill, Tooele Co., Utah. At the Cap Garonne mine, near le Pradet, Var, France. From Neubulach, Wittichen, and in the Clara mine, near Oberwolfach, Black Forest, Germany. At L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. In the Tynagh mine, near Loughrea, Co. Galway, Ireland. In England, from Cornwall, at Wheals Gorland and Unity, Gwennap; in the Penberthy Croft mine, St. Hilary; from the South Tolcarne mine, Camborne; at the Mulberry Stockworks, Lanivet; in the Marke Valley mine, Linkinhorne. From the Gwaithyrafon mine, Cwmsymlog, Wales. At Tsumeb, Namibia.

Name: To honor John L. Parnau (1906–1990), American mineral collector of Campbell, California, USA, who contributed to knowledge of the type locality at Majuba Hill, Nevada, USA.

Type Material: University of California, Santa Barbara, California, 8090; National Museum of Natural History, Washington, D.C., USA, 144004.

References: (1) Wise, W.S. (1978) Parnauite and goudeyite, two new copper arsenate minerals from the Majuba Hill mine, Pershing County, Nevada. Amer. Mineral., 63, 704–708.

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Parsettensite $(K, Na, Ca)(Mn, Al)_7Si_8O_{20}(OH)_8 \cdot 2H_2O(?)$

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Crystal Data: Orthorhombic (?), pseudohexagonal. *Point Group:* n.d. Micaceous, compact, massive.

Physical Properties: *Cleavage:* One perfect, micaceous. Hardness = ~1.5
D(meas.) = 2.590 D(calc.) = [2.76]

Optical Properties: Semitransparent. *Color:* Copper-red to tan. *Luster:* Submetallic to metallic.
Optical Class: Uniaxial (–). *Pleochroism:* Colorless to light yellow and greenish yellow.
$\omega = 1.576$ $\epsilon = 1.546$

Cell Data: *Space Group:* n.d. $a = 5.6$ $b = 9.8$ $c = 12.6$ Z = [1]

X-ray Powder Pattern: Parsettens Alpe, Switzerland.
12.1 (100), 2.65 (100), 2.79 (80), 1.634 (80), 4.2 (60), 1.617 (60), 3.84 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	42.90	42.81	BaO		0.28
TiO_2		0.10	Na_2O	0.20	0.70
B_2O_3		0.08	K_2O	0.94	0.80
Al_2O_3	4.35	4.70	H_2O^+	9.66	9.30
Fe_2O_3	0.35	0.18	H_2O^-	3.15	
Mn_2O_3	6.36		HCl	0.02	
V_2O_5	0.32		CO_2	0.25	
MnO	28.27	33.50	P_2O_5		0.01
MgO	2.70	2.60	Total	99.92	100.86
CaO	trace	5.80			

(1) Parsettens Alpe, Switzerland. (2) Val Graveglia, Italy; corresponds to $(Ca_{1.17}Na_{0.25}K_{0.19})_{\Sigma=1.61}(Mn_{5.38}Al_{1.04}Mg_{0.73})_{\Sigma=7.15}Si_{8.04}O_{20}(OH)_8 \cdot 3.65H_2O$.

Occurrence: In and peripheral to manganese deposits.

Association: Tinzenite, sursassite, piemontite, rhodonite, manganoan calcite, rhodochrosite, quartz, albite, barite (Parsettens Alpe, Italy); quartz, caryopilite, ganophyllite (Val Graveglia, Italy).

Distribution: From the Parsettens Alpe, in Val d'Err, Tinzen, and at the Fianel mine, Val Ferrera, Graubünden, Switzerland. In the Molinello manganese mine, near Chiavari, Val Graveglia, Liguria, Italy. At Watson's Beach, southeastern Otago, New Zealand. In the Kumahata mine, Shiga Prefecture, and the Noda-Tamagawa mine, Iwate Prefecture, Japan. At the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA. In the N'Chwaning mine, near Kuruman, Cape Province, South Africa.

Name: For the original locality, Parsettens Alpe, Switzerland.

Type Material: Federal Institute of Technology, Zurich, Switzerland, 194806; The Natural History Museum, London, England; Harvard University, Cambridge, Massachusetts, USA, 90497.

References: (1) Jakob, J. (1924) Vier Mangansilikate aus dem Val d'Err (Kt. Graubünden). Schweiz. Mineral. Petrog. Mitt., 3, 227–237 (in German). (2) (1924) Mineral. Abs., 2, 251–252 (abs. ref. 1). (3) (1925) Amer. Mineral., 10, 107 (abs. ref. 1). (4) Geiger, T. (1948) Manganerze in den Radiolariten Graubündens. Beitrage Geol. Schweiz., 27, 37–42 (in German). (5) (1949) Mineral. Abs., 10, 491 (abs. ref. 4). (6) Cortesogno, L., G. Lucchetti, and A.M. Penco (1979) Le mineralization a manganese nei diaspri delle ofioliti Liguri: mineralogia e genesi. Rend. Soc. Ital. Mineral. Petrol., 35, 151–197 (in Italian with English abs.). (7) Ozawa, T., T. Takahata, and P.R. Buseck (1986) A hydrous manganese phyllosilicate with 12 Å basal spacing. Int. Mineral. Assoc. 14th Mtng. (abs. with prog.), 194.

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Parsonite $Pb_2(UO_2)(PO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals are lathlike, elongated along [001] and flattened on {010}, showing {001}, {101}, {100}. As radial-fibrous spherulites, to 3 mm; commonly as crusts and powdery aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5–3 D(meas.) = 5.72–5.75 D(calc.) = 6.21–6.47 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Pale citron-yellow, yellow, honey-brown, greenish brown, rarely pale rose; pale yellow in transmitted light. *Luster:* Subadamantine to slightly greasy.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 6°$–$36°$ or $X \wedge c = 6°$–$23°$.
Dispersion: Strong. $\alpha = 1.795$–1.875 $\beta =$ n.d. $\gamma = 1.815$–1.890 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.862$ $b = 10.425$ $c = 6.684$ $\alpha = 101°26'$ $\beta = 98°15'$ $\gamma = 86°17'$ Z = 2

X-ray Powder Pattern: Ruggles mine, New Hampshire, USA.
4.25 (10), 3.28 (8), 2.13 (6), 1.661 (6), 1.852 (5), 3.97 (4), 3.44(4)

Chemistry:

	(1)	(2)
UO_3	34.68	31.42
P_2O_5	14.46	15.59
PbO	47.43	49.03
H_2O	3.43	3.96
Total	100.00	100.00

(1) Ruggles mine, New Hampshire, USA. (2) $Pb_2(UO_2)(PO_4)_2 \cdot 2H_2O$.

Occurrence: A secondary mineral in the oxidized zone of some hydrothermal uranium deposits.

Association: Torbernite, kasolite, dewindtite (Kasolo, Congo); autunite, phosphuranylite (Ruggles mine, New Hampshire, USA); pyromorphite, torbernite, autunite (Lachaux, France).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Wölsendorf, Bavaria, Gemany. In France, at Gourniaud, Reliez, Rophin, and elsewhere around Lachaux, Puy-de-Dôme, the principal ore of uranium; at La Faye, near Grury, Saône-et-Loire. From Tragos, east of Mangualde, Portugal. At Arcu su Linnarbu, near Capoterra, Sardinia, Italy. In the Ranger mine, Jabiru, Northern Territory, Australia. In the USA, in the Ruggles mine, near Grafton, Grafton Co., New Hampshire; from the Eight Mile Park pegmatite district, Fremont Co., and on the Big Red No. 39 and 22 claims, Tomichi-Whitepine district, Gunnison Co., Colorado. A few additional localities are known.

Name: Honoring Arthur Leonard Parsons (1873–1957), Professor of Mineralogy, University of Toronto, Toronto, Canada.

Type Material: National School of Mines, Paris, France, 123.89.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 913–914. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 233–236. (3) Mazzi, F., C.L. Garavelli, and F. Rinaldi (1959) Richerche strutturali sulla parsonite [*sic*]. *Rend. Soc. Mineral. Ital., 25, 364–365 (in Italian).*

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Parthéite $CaAl_2Si_2O_8 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As pseudohexagonal crystals elongated $\parallel$ [001], with {100} and {110}, forming radiating fibrous aggregates and subhedral grains, to 0.3 mm.

Physical Properties: *Cleavage:* {100}, {110}, distinct. Hardness = 4 D(meas.) = 2.39–2.45 D(calc.) = 2.41

Optical Properties: Transparent. *Color:* White, dark blue [*sic*]; in transmitted light, colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 23°–30°$. *Dispersion:* $r > v$, moderate. $\alpha = 1.547–1.550$ $\beta = 1.549–1.552$ $\gamma = 1.559–1.565$ 2V(meas.) = 45°–48°

Cell Data: *Space Group:* $C2/c$. $a = 21.555(3)$ $b = 8.761(1)$ $c = 9.304(2)$ $\beta = 91.55(2)°$ $Z = 8$

X-ray Powder Pattern: Doğanbaba, Turkey.
10.79 (100), 8.12 (80), 6.10 (70), 3.740 (50), 3.600 (40), 3.190 (40), 3.046 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.24	36.64	CaO	16.38	16.70
TiO_2		< 0.01	Na_2O	0.32	0.12
Al_2O_3	31.99	31.76	K_2O	0.23	0.06
Fe_2O_3		0.05	H_2O^+		14.14
FeO		0.04	H_2O^-		0.32
MnO		< 0.01	H_2O	[10.83]	
MgO		0.25	CO_2		< 0.05
			Total	[99.99]	[100.08]

(1) Doğanbaba, Turkey; by electron microprobe, H_2O by difference; corresponds to $(Ca_{1.0}Na_{0.03}K_{0.01})_{\Sigma=1.04}Al_{2.1}Si_{2.2}O_8 \cdot 2.06H_2O$. (2) Denezhkin Kamen complex, Russia; original total given as 99.76%; corresponds to $(Ca_{0.96}Mg_{0.02}Na_{0.01})_{\Sigma=0.99}Al_{2.02}Si_{1.98}O_8 \cdot 2.54H_2O$.

Polymorphism & Series: Dimorphous with lawsonite.

Occurrence: In rodingite dikes within an ophiolite (Doğanbaba, Turkey); in veins cutting a gabbroic intrusive complex (Denezhkin Kamen complex, Russia).

Association: Prehnite, thomsonite, augite (Doğanbaba, Turkey); chlorite, tremolite (Denezhkin Kamen complex, Russia).

Distribution: From Belenköysirti Hill, seven km southeast of the village of Doğanbaba, Taurus Mountains, Burdur Province, Turkey. In Russia, in the Denezhkin Kamen complex, Ural Mountains.

Name: In honor of Professor Erwin Parthé, crystallographer at the University of Geneva, Geneva, Switzerland.

Type Material: Museum of Natural History, Geneva, Switzerland, 435/10; National Museum of Natural History, Washington, D.C., USA, 146562; The Natural History Museum, London, England, 1984,742.

References: (1) Sarp, H., J. Deferne, H. Bizouard, and B.W. Liebich (1979) La parthéite, $CaAl_2Si_2O_8 \cdot 2H_2O$, un nouveau silicate naturel d'aluminum et de calcium. Schweiz. Mineral. Petrog. Mitt., 59, 5–13 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 1068 (abs. ref. 1). (3) Ivanov, O.K. and Y.V. Mozzherin (1982) Parthéite from gabbro-pegmatites of Denezhkin Kamen, Urals (first occurrence in the USSR). Zap. Vses. Mineral. Obshch., 111, 209–214 (in Russian). (4) (1982) Chem. Abs., 96, 220671 (abs. ref. 3). (5) Engel, N. and K. Yvon (1984) The crystal structure of parthéite. Zeits. Krist., 169, 165–175. (6) Sarp, H. (1985) Quelques données nouvelles sur la parthéite et son étude au spectrophotomètre á l'infrarouge. Schweiz. Mineral. Petrog. Mitt., 65, 129–135 (in French with English abs.).

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Partzite $Cu_2Sb_2(O,OH)_7(?)$

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Crystal Data: Cubic. *Point Group:* n.d. Massive.

Physical Properties: *Fracture:* Conchoidal to even. Hardness = 3–4 D(meas.) = 2.98–3.96 D(calc.) = [5.5]

Optical Properties: Semitransparent. *Color:* Olive-green, yellowish green, blackish green, tarnishes black.
Optical Class: Isotropic. n = 1.61–1.82

Cell Data: *Space Group:* n.d. $a = 10.25$ Z = 8

X-ray Powder Pattern: Blind Spring district, California, USA.
2.95 (10), 5.91 (9), 1.81 (8), 3.08 (7), 1.54 (7), 2.56 (5), 1.73 (4)

Chemistry:

	(1)
Sb_2O_4	47.65
FeO	2.33
CuO	32.11
PbO	2.01
Ag_2O	6.12
H_2O	8.29
Total	98.51

(1) Blind Spring district, California, USA; corresponds to $(Cu_{1.83}Ag_{0.24}Pb_{0.04})_{\Sigma=2.11}(Sb_{1.41}Fe_{0.15})_{\Sigma=1.56}(O,OH,H_2O)_{7.00}$.

Mineral Group: Stibiconite group.

Occurrence: An alteration product of antimony-bearing sulfides.

Association: Bindheimite, lewisite, stibiconite (Tres Alamos Wash, Arizona, USA).

Distribution: In the USA, from several mines in the Blind Spring district, Mono Co., California; at Gilbert, Gilbert district, Esmeralda Co., Nevada; and in Tres Alamos Wash, Johnny Lyon Hills, Cochise Co., Arizona. In Germany, at Müschede, near Neheim-Hüsten, Westphalia; from Imsbach and Puderbach, Rhineland-Palatinate; and in the Clara Mine, near Oberwolfach, Black Forest. At Veitsch, Styria, Austria. On Mt. Monger, near Doigs, Western Australia.

Name: For August F.W. Partz, who first recognized the mineral as a silver ore.

Type Material: Indiana University, Bloomington, Indiana, Z81; Harvard University, Cambridge, Massachusetts, USA, 80284, 83279.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 599. (2) Mason, B. and C.J. Vitaliano (1953) The mineralogy of the antimony oxides and antimonates. Mineral. Mag., 30, 100–112.

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Parwelite $(Mn^{2+},Mg)_5Sb^{5+}As^{5+}SiO_{12}$

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Crystal Data: Monoclinic. *Point Group:* m. Crystals rounded, stubby prismatic, to 1 cm, showing an elongated diamond-shaped cross section.

Physical Properties: *Cleavage:* Fair to poor on {010}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 4.62 D(calc.) = 4.64

Optical Properties: Transparent to translucent. *Color:* Yellowish brown, orange, tan, with a slight olive tinge. *Streak:* Pale brownish orange. *Luster:* Subadamantine, oily. *Optical Class:* Biaxial (+). *Dispersion:* $r > v$, strong. $\alpha = 1.85(1)$ $\beta = 1.85(1)$ $\gamma = 1.88(1)$ 2V(meas.) = 27(3)°

Cell Data: *Space Group:* Aa. $a = 10.048(2)$ $b = 19.418(5)$ $c = 9.735(5)$ $\beta = 95.83(1)°$ Z = 8

X-ray Powder Pattern: Långban, Sweden.
2.734 (10), 2.915 (9.5), 4.84 (5), 3.411 (5), 9.65 (4), 2.422 (4), 1.7112 (3)

Chemistry:

	(1)
SiO_2	7.01
Sb_2O_3	20.01
As_2O_3	22.02
FeO	0.05
MnO	44.30
PbO	0.40
MgO	4.50
CaO	1.50
Total	99.79

(1) Långban, Sweden; by electron microprobe and wet chemical analysis; corresponds to $(Mn^{2+}_{4.15}Mg_{0.75}Ca_{0.18})_{\Sigma=5.08}Sb^{5+}_{0.92}As^{5+}_{1.00}Si_{1.00}O_{12}$.

Occurrence: In a high-temperature skarn assemblage, in recrystallized manganoan carbonate ores.

Association: Långbanite, spessartine, hausmannite, berzeliite, caryinite.

Distribution: At Långban, Värmland, Sweden.

Name: For Dr. Alexander Parwel, Swedish chemist, Swedish National History Museum, Stockholm, Sweden, who has performed many analyses of Långban minerals, including this one.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, NRMS 26758; National Museum of Natural History, Washington, D.C., USA, 120065.

References: (1) Moore, P.B. (1968) Parwelite, $(Mn,Mg)_5Sb(Si,As)_2O_{10-11}$, a new mineral from Långban. Arkiv Mineral. Geol., 4, 467–472. (2) (1970) Amer. Mineral., 55, 323 (abs. ref. 1). (3) Moore, P.B. and T. Araki (1977) Parwelite, $Mn^{II}_{10}Sb^{V}_2As^{V}_2Si_2O_{24}$, a complex anion-deficient derivative structure. Inorganic Chem., 16, 1839–1847.

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Pascoite $Ca_3V_{10}^{5+}O_{28}\cdot 17H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals minute, lathlike with oblique terminations, in granular crusts.

Physical Properties: *Cleavage:* {010}, distinct. *Fracture:* Conchoidal. Hardness = ~2.5 D(meas.) = 2.455 D(calc.) = 2.465 Soluble in H_2O.

Optical Properties: Translucent. *Color:* Dark red-orange to yellow-orange, dirty yellow on partial dehydration. *Streak:* Cadmium-yellow. *Luster:* Vitreous to subadamantine. *Optical Class:* Biaxial (–). *Pleochroism:* X = light cadmium yellow; Y = cadmium yellow; Z = orange. *Orientation:* OAP $\perp$ {010}. *Dispersion:* Crossed, strong. *Absorption:* $Z > Y > X$. $\alpha = 1.775(5)$ $\beta = 1.815(5)$ $\gamma = 1.825(5)$ 2V(meas.) = 50°–56°

Cell Data: *Space Group:* $C2$. $a = 16.834(3)$ $b = 10.156(2)$ $c = 10.921(2)$ $\beta = 93°8(3)'$ Z = 2

X-ray Powder Pattern: Minasragra, Peru.
5.5 (10), 4.67 (10), 5.1 (8), 7.3 (7), 3.01 (7), 8.8 (6), 4.45 (6)

Chemistry:

	(1)	(2)
V_2O_5	64.6	65.71
MoO_3	0.3	
CaO	12.6	12.16
H_2O^+	7.8	
H_2O^-	13.8	
H_2O		22.13
undetermined	0.9	
Total	100.0	100.00

(1) Minasragra, Peru. (2) $Ca_3V_{10}O_{28}\cdot 17H_2O$.

Occurrence: Leached out of near-surface vanadium oxides by ground waters; as efflorescences in mine tunnels.

Association: Carnotite.

Distribution: At Minasragra, 46 km from Cerro de Pasco, Peru. From the Urcal deposit, La Rioja Province, Argentina. In the USA, in Colorado, from the Hawkeye, Burro, and Deremo-Snyder mines, near Slick Rock, San Miguel Co.; in the Bitter Creek, Mill No. 1, and Peanut mines, Uravan district, Montrose Co.; at the Corvusite and La Sal No. 2 mines, Gateway district, Mesa Co.; and from the Rifle mine, Garfield Co. At the Black Ape mine, Thompsons district, Grand Co., the Crescent No. 3 claim, Crescent Creek, Garfield Co., and the Mi Vida mine, Big Indian district, San Juan Co., Utah. In Arizona, at the Monument No. 2 mine, Monument Valley; in the Mesa No. 1, No. 5, and No. 6 mines, Lukachukai Mountains, and the Zona No. 1 claim, Carrizo Mountains, Apache Co. From the Ambrosia Lakes district, McKinley Co., New Mexico.

Name: For the original locality, near Cerro de Pasco, Peru.

Type Material: Harvard University, Cambridge, Massachusetts, 101701; National Museum of Natural History, Washington, D.C., USA, 87662, 93297.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1055–1056. (2) Weeks, A.D. and M.E. Thompson (1954) Identification and occurrence of uranium and vanadium minerals from the Colorado Plateaus. U.S. Geol. Sur. Bull. 1009-B, 54–55. (3) Swallow, A.G., F.R. Ahmed, and W.H. Barnes (1966) The crystal structure of pascoite, $Ca_3V_{10}O_{28}\cdot 17H_2O$. Acta Cryst., 21, 397–405. (4) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 76–77.

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Crystal Data: Hexagonal. *Point Group*: $\bar{3}$. As elongated scalenohedral crystals to 100 μm, typically zoned with V-rich senaite.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 6-6.5 VHN = 834-865, 847 average (500 g load). D(meas.) = n.d. D(calc.) = 4.315

Optical Properties: Opaque. *Color*: Dark gray to black; grayish in reflected light.
Streak: Black. *Luster*: Submetallic.
Optical Class: Biaxial (-). [by analogy to senaite]
R_1-R_2: (471.1) 18.4-18.2, (548.3) 17.9-17.7, (586.6) 17.6-17.3, (652.3) 17.0-16.8

Cell Data: *Space Group*: $R\bar{3}$. a = 10.3894(5) c = 20.8709(8) Z = 3

X-ray Powder Pattern: Molinello mine, Val Graveglia, Liguria, Italy.
3.417 (100), 2.260 (85), 2.149 (65), 2.896 (61), 1.809 (57), 2.858 (36), 2.765 (27)

Chemistry:

	(1)		(1)
Na_2O	0.35	La_2O_3	0.02
MgO	0.05	Ce_2O_3	0.03
MnO	7.70	TiO_2	32.78
ZnO	1.15	ThO_2	0.05
SrO	2.36	UO_3	0.36
PbO	8.01	V_2O_5	41.27
FeO	2.80	Total	98.64
Fe_2O_3	1.71		

(1) Molinello mine, Val Graveglia, Liguria, Italy; average of 11 electron microprobe analyses, Fe^{2+}/Fe^{3+} calculated from structure analysis; corresponding to $(Pb_{0.61}Sr_{0.39})_{\Sigma=1.00}(V^{5+}_{7.78}Ti^{4+}_{7.03}Mn^{2+}_{1.86}Fe^{2+}_{0.67}Fe^{3+}_{0.37}Zn_{0.24}Na_{0.19}U_{0.02}Mg_{0.02}\square_{2.82})_{\Sigma=21.00}O_{38}$.

Mineral Group: Crichtonite group.

Polymorphism & Series: Forms a solid solution series with senaite.

Occurrence: In micro-cavities and fractures in a piece of fossilized wood, presumably precipitated from oxidized ground water.

Association: Quartz, chalcocite, volborthite; more rarely metatyuyamunite, pyrophanite.

Distribution: From the upper part of the Molinello mine, Val Graveglia, Ne, Genoa Province, Liguria, Italy.

Name: Honors Marco Pasero (b. 1958), Professor of Mineralogy, University of Pisa, Italy, for his contributions to mineralogy and crystallography in general, and especially Italian mineralogy.

Type Material: In Italy, at the Museum of Natural History, University of Florence (# 3111/I), and in the mineralogical collections of the Natural History Museum, University of Turin (# 15900).

References: (1) Mills, S.J., L. Bindi, M. Cadoni, A.R. Kampf, M.E. Ciriotti, and G. Ferraris (2012) Paseroite, $PbMn^{2+}(Mn^{2+},Fe^{2+})_2(V^{5+},Ti,Fe^{3+},\square)_{18}O_{38}$, a new member of the crichtonite group. European Journal of Mineralogy, 24(6), 1061-1067. (2) (2014) Amer. Mineral., 99, 2156 (abs. ref. 1).

Patrónite $VS_4(?)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive, and as aggregates of columnar crystals.

Physical Properties: *Cleavage:* Pronounced columnar cleavage. Hardness = Very low. VHN = n.d. D(meas.) = 2.82(1) D(calc.) = 2.834

Optical Properties: Opaque. *Color:* Lead-gray on fresh surface, gray-black on old; dark gray in reflected light. *Luster:* Metallic. *Pleochroism:* Strong.
R_1–R_2: (400) 20.2–29.9, (420) 20.0–30.0, (440) 19.8–30.1, (460) 19.8–30.8, (480) 20.0–31.9, (500) 20.1–32.6, (520) 20.1–32.9, (540) 20.0–32.8, (560) 19.8–32.4, (580) 19.6–31.4, (600) 19.1–30.5, (620) 18.9–29.6, (640) 18.8–29.6, (660) 19.0–29.8, (680) 19.2–30.3, (700) 19.5–31.0

Cell Data: *Space Group:* $I2/c$. $a = 6.775(5)$ $b = 10.42(1)$ $c = 12.11(1)$ $\beta = 100.8(2.0)°$ Z = 8

X-ray Powder Pattern: Synthetic VS_4.
5.604 (100), 5.181 (65), 2.473 (30), 2.216 (30), 2.047 (25), 3.151 (20), 2.962 (20)

Chemistry: Composition established by comparison of X-ray patterns with synthetic material.

Occurrence: As interstitial filling in the core of a porous 2.5 m layer of admixed vanadium-bearing minerals. These vanadian materials are in fissures that cut red shales and that were probably filled by a remobilized asphaltite deposit.

Association: Sulfur, bravoite, pyrite, minasragrite, stanleyite, dwornikite, quartz, vanadian lignite, natural coke.

Distribution: A major ore mineral in what was the world's richest vanadium deposit, at Minasragra, 46 km from Cerro de Pasco, Peru [TL].

Name: After Antenor Rizo-Patrón (1866–1948), Peruvian metallurgist, discoverer of the Peruvian occurrence.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 347. (2) Tudo, J. (1965) Sur l'etude du sulfate de vanadyle et de sa réduction par l'hydrogène sulfuré: les sulfures de vanadium. Rev. Chim. Minérale, 2, 53–117 (in French). (3) Allmann, R., I. Baumann, A. Kutoglu, H. Rösch, and E. Hellner (1963) Die Kristallstruktur des Patronits $V(S_2)_2$. Naturwiss., 51, 263–264 (in German). (4) Kutoglu, A. and R. Allmann (1972) Strukturverfeinerung des Patronits, $V(S_2)_2$. Neues Jahrb. Mineral., Monatsh., 339–345 (in German with English abs.).

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Pattersonite $PbFe_3(PO_4)_2(OH)_4[(H_2O)_{0.5}(OH)_{0.5}]_2$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As slightly elongated to rosette-like aggregates of subparallel plates, to 0.5 mm, exhibiting rough forms {110}, {001}, and {011}.

Physical Properties: *Cleavage*: One poor direction. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 4.5 VHN = 530 (25 g load). D(meas.) = > 4.04 D(calc.) = 4.17

Optical Properties: Translucent. *Color*: Dark yellow. *Streak*: Very pale yellow. *Luster*: Adamantine.
Optical Class: Biaxial (-). α = 1.86(1) β = 1.917 (calc) γ = 1.93(1) 2Vα = 50(5)°
Dispersion: Very strong, $r > v$. *Pleochroism*: Weak; *X* = nearly colorless to very pale yellow; *Y* = pale yellow to yellow; *Z* = yellow to dark yellow. *Absorption*: $Z > Y > X$.
Orientation: (polar coordinates in terms of φ and ρ based on (010) = 0°/90°), *X* (−113°/85°); *Y* (155°/70°); *Z* (−10°/21°).

Cell Data: *Space Group*: $P\bar{1}$. a = 5.309(1) b = 7.211(1) c = 7.349(1) α = 87.74(3)° β = 86.38(3)° γ = 71.40(3)° Z = 1

X-ray Powder Pattern: Vereinigung mine, Taunus, Hesse, Germany.
4.848 (100), 6.839 (64), 3.547 (57), 3.417 (52), 3.022 (51), 3.667 (47), 2.8339 (45)

Chemistry:

	(1)
PbO	33.10
Fe_2O_3	35.64
P_2O_5	20.97
H_2O	9.32
Total	98.79

(1) Vereinigung mine, Taunus, Hesse, Germany; average of 46 electron microprobe analyses, H_2O from structure determination, anionic groups confirmed by IR, corresponding to $Pb_{1.00}\ Fe_{3.02}(PO_4)_{1.98}(OH)_{5.12}(H_2O)_{0.94}$

Mineral Group: Alunite group.

Occurrence: A secondary mineral on goethite in a weathered metallic sulfide mineral vein.

Association: Kintoreite, goethite, pyromorphite.

Distribution: On the dumps of the Vereinigung mine, near Eisenbach, ~5 km north of Bad Camberg, Taunus, Hesse, Germany.

Name: Honors Arthur Lindo Patterson (1902–1966), who developed a method employing a Fourier series to generate a three-dimensional function, the now well-known "Patterson function" in crystal-structure determination.

Type Material: Natural History Museum, Vienna, Austria.

References: (1) Kolitsch, U., H.-J. Bernhardt, W. Krause, and G. Blass (2008) Pattersonite, $PbFe_3(PO_4)_2(OH)_4[(H_2O)_{0.5}(OH)_{0.5}]_2$, a new supergene phosphate mineral: description and crystal structure. Eur. J. Mineral., 20, 281–288. (2) (2009) Amer. Mineral., 94, 401-402 (abs. ref. 1).

Paulingite $(K, Na, Ca)_{3-4}(Si, Al)_{21}O_{42} \cdot 17-22H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. As dodecahedra, modified by the cube and a trapezohedron, may be faintly striated, up to 1 cm. *Twinning:* Lamellae seen optically may indicate twinning.

Physical Properties: Hardness = ~5 D(meas.) = 2.085(5) D(calc.) = 2.10

Optical Properties: Transparent. *Color:* Colorless, yellow, bright orange. *Luster:* Vitreous. *Optical Class:* Isotropic; very rarely, may show faint, isolated, birefringent lamellae in thin section. $n = 1.473–1.484$

Cell Data: *Space Group:* $Im3m$. a = 35.049–35.114 Z = 32

X-ray Powder Pattern: Wenatchee, Washington, USA.
8.29 (10), 6.88 (10), 4.78 (9), 3.261 (9), 3.078 (9), 3.582 (8), 3.346 (8)

Chemistry:

	(1)	(2)
SiO_2	63.53	62.65
Al_2O_3	16.43	18.36
Fe_2O_3	0.16	0.08
MgO	0.02	0.00
CaO	3.46	6.94
SrO	0.00	0.00
BaO	0.90	0.50
Na_2O	0.97	0.89
K_2O	6.87	3.57
Total	[92.34]	[92.99]

(1) Wenatchee, Washington, USA; by electron microprobe, average of five partial analyses; corresponds to $K_{2.22}Ca_{0.94}Na_{0.48}Ba_{0.09}Fe_{0.03}(Si_{16.10}Al_{4.91})_{\Sigma=21.01}O_{42} \cdot 22H_2O$. (2) Ritter, Oregon, USA; by electron microprobe, average of four partial analyses, H_2O determined separately by loss on heating as 18.5%; corresponds to $Ca_{1.85}K_{1.14}Na_{0.43}Ba_{0.05}(Si_{15.60}Al_{5.39})_{\Sigma=20.99}O_{42} \cdot 17.40H_2O$.

Mineral Group: Zeolite group.

Occurrence: In vesicles in basalt flows.

Association: Zeolites, pyrite, calcite.

Distribution: In the USA, at Rock Island Dam, on the Columbia River, Wenatchee, Douglas Co., Washington; from near Riggins, Idaho Co., Idaho; and at Three Mile Creek, near Ritter, Grant Co., Oregon. On Chase Creek, at the junction with Charcoal Creek, north of Falkland, British Columbia, Canada. Large crystals from the Giant's Causeway and Craigahulliar, Portrush, Co. Antrim, Ireland. At Kladno and Vinařice, Czech Republic. In the Höwenegg quarry, Hegau, Baden-Württemberg, and in the Ortenberg quarry, Vogelsberg, Hesse, Germany.

Name: For Linus Carl Pauling (1901–1994), Nobel Laureate, Professor of Chemistry, California Institute of Technology, Pasadena, California, USA.

Type Material: n.d.

References: (1) Kamb, W.B. and W.C. Oke (1960) Paulingite, a new zeolite, in association with erionite and filiform pyrite. Amer. Mineral., 45, 79–91. (2) Gordon, E.K., S. Samson, and W.B. Kamb (1966) Crystal structure of the zeolite paulingite. Science, 154, 1004–1007. (3) Tschernich, R. and W.S. Wise (1982) Paulingite: variations in composition. Amer. Mineral., 67, 799–803. (4) Andersson, S. and L. Fälth (1983) An alternative description of the paulingite structure. J. Solid State Chemistry, 46, 265–268.

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Paulkellerite $Bi_2Fe^{3+}O_2(PO_4)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, wedge-shaped with curved faces, to 0.8 mm, showing prominent {110} and {011}, with minor $\{\overline{1}01\}$.

Physical Properties: Hardness = ∼4 D(meas.) = > 4.2 D(calc.) = [6.23]

Optical Properties: Transparent. *Color:* Pale greenish yellow. *Streak:* Very pale yellow. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z = c$; $X \wedge a = 25°$. $\alpha = 1.762(2)$ $\beta = 1.767(2)$ $\gamma = 1.825(5)$ 2V(meas.) = 37(2)° 2V(calc.) = 34°

Cell Data: *Space Group:* $C2/c$. $a = 11.380(3)$ $b = 6.660(3)$ $c = 9.653(3)$ $\beta = 115.34(2)°$ Z = 4

X-ray Powder Pattern: Neuhilfe mine, Schneeberg, Germany.
3.123 (10), 2.162 (4), 2.804 (3), 1.442 (3), 5.125 (2), 3.913 (2), 3.338 (2)

Chemistry:

	(1)	(2)
P_2O_5	11.3	11.18
Bi_2O_3	71.6	73.40
Fe_2O_3	14.5	12.58
H_2O	2.9	2.84
Total	100.3	100.00

(1) Neuhilfe mine, Schneeberg, Germany; by electron microprobe, total Fe as Fe_2O_3, confirmed by microchemical tests, H_2O by TGA-EGA; corresponds to $Bi_{1.90}Fe_{1.12}(P_{0.98}O_4)(OH)_{1.99}$.
(2) $Bi_2FeO_2(PO_4)(OH)_2$.

Occurrence: A rare secondary mineral in Bi–Ni–Co ores in a hydrothermal ore deposit.

Association: Bismuth, skutterudite, pyrite, erythrite, bismutoferrite.

Distribution: From the Neuhilfe mine, Schneeberg, Saxony, Germany.

Name: To honor Dr. Paul Keller (1940–), Professor of Mineralogy, University of Stuttgart, Stuttgart, Germany, for his contributions to the mineralogy of secondary minerals from ore deposits.

Type Material: Mining Academy, Freiberg, Germany; Canadian Museum of Nature, Ottawa, Canada, 53450; National Museum of Natural History, Washington, D.C., USA, 163777.

References: (1) Dunn, P.J., J.D. Grice, F.J. Wicks, and R.A. Gault (1988) Paulkellerite, a new bismuth iron phosphate mineral from Schneeberg, Germany. Amer. Mineral., 73, 870–872.
(2) Grice, J.D. and L.A. Groat (1988) The crystal structure of paulkellerite. Amer. Mineral., 73, 873–875.

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Paulkerrite $\mathbf{K(Mg,Mn^{2+})_2(Fe^{3+},Al)_2Ti(PO_4)_4(OH)_3 \cdot 15H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Equant crystals, to 0.2 mm, may be flattened on {010}, elongated along [001]; forms noted are {010}, {100}, {111}. *Twinning:* Multiple, parallel {010}, possible.

Physical Properties: *Cleavage:* On {100}, perfect. *Fracture:* Even. Hardness = ∼3 D(meas.) = 2.36(4) D(calc.) = 2.36

Optical Properties: Transparent. *Color:* Light yellowish brown to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong.
$\alpha = 1.591$–1.598 $\beta = 1.615$–$[1.624]$ $\gamma = 1.639$–1.643 2V(meas.) = ∼80°

Cell Data: *Space Group: Pbca.* $a = 10.49(7)$ $b = 20.75(13)$ $c = 12.44(2)$ Z = 4

X-ray Powder Pattern: 7U7 Ranch, Arizona, USA.
6.20 (100), 10.3 (90), 7.46 (80), 3.13 (70), 3.75 (40), 2.872 (40), 3.95 (30)

Chemistry:

	(1)
P_2O_5	29.4
TiO_2	9.8
Al_2O_3	1.6
Fe_2O_3	12.2
MnO	7.1
MgO	4.6
K_2O	4.4
F	0.9
H_2O	[30.4]
$-O = F_2$	0.4
Total	[100.0]

(1) 7U7 Ranch, Arizona, USA; by electron microprobe, total Fe as Fe_2O_3, confirmed by microchemical test, total Mn as MnO, H_2O by difference; corresponds to $K_{0.90}(Mg_{1.04}Mn_{0.96})_{\Sigma=2.00}(Fe_{1.47}Al_{0.30}Ti_{0.18}Mg_{0.06})_{\Sigma=2.01}Ti_{1.00}(PO_4)_{3.98}[(OH)_{2.64}F_{0.46}]_{\Sigma=3.00} \cdot 14.98H_2O$.

Occurrence: An alteration product of triplite in complex zoned granite pegmatites.

Association: Triplite, bermanite, phosphosiderite, leucophosphite, strengite, switzerite (7U7 Ranch, Arizona, USA).

Distribution: From the 7U7 Ranch, 40 km west of Hillside, Bagdad district, Yavapai Co., Arizona, USA. In the Bendada pegmatite, near Guarda, Portugal.

Name: To honor Dr. Paul Francis Kerr (1897–1981), Professor of Mineralogy, Columbia University, New York City, New York, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R7778, 120405, 163777.

References: (1) Peacor, D.R., P.J. Dunn, and W.B. Simmons (1984) Paulkerrite, a new titanium phosphate from Arizona. Mineral. Record, 15, 303–306. (2) (1985) Amer. Mineral., 70, 875 (abs. ref. 1).

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Paulmooreite $Pb_2As_2^{3+}O_5$

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Crystal Data: Monoclinic. *Point Group:* 2 or $2/m$. Crystals are tabular on {100} or {001}, to 0.5 mm, showing {100}, {001}, {011}, less commonly {$\bar{2}$01}, {110}, {111}.

Physical Properties: *Cleavage:* {100}, good. *Tenacity:* Very brittle. Hardness = ∼3
D(meas.) = 6.95(5) D(calc.) = 6.86

Optical Properties: Semitransparent. *Color:* Colorless to light orange. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (+); birefringence ∼0.110. *Orientation:* $Y = b$; $Z \wedge a = 10(1)°$. *Dispersion:* $r > v$, very strong. α = n.d. β = 1.9–2.0 γ = n.d. 2V(meas.) = 65(5)°

Cell Data: *Space Group:* $P2_1$; structure refined in $P2_1/a$. $a = 13.584(4)$ $b = 5.650(2)$ $c = 8.551(3)$ $\beta = 108.78(2)°$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.30 (100), 2.905 (80), 2.761 (80), 3.02 (70), 1.768 (70), 2.024 (60), 1.726 (60)

Chemistry:

	(1)	(2)
As_2O_3	30.07	30.71
PbO	69.23	69.29
Total	99.30	100.00

(1) Långban, Sweden; by electron microprobe. (2) $Pb_2As_2O_5$.

Occurrence: A very rare secondary mineral in a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Hematite, magnetite, andradite, mimetite, calcite (Långban, Sweden).

Distribution: From Långban, Värmland, Sweden. At Laurium, Greece, in slag.

Name: To honor Professor Paul Brian Moore (1940–), American mineralogist and structural crystallographer, University of Chicago, Chicago, Illinois, USA, for his many contributions to mineralogy.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 252356; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA, 134973, 142974.

References: (1) Dunn, P.J., D.R. Peacor, and B.D. Sturman (1979) Paulmooreite, a new lead arsenite mineral from Långban, Sweden. Amer. Mineral., 64, 352–354. (2) Araki, T., P.B. Moore, and G.D. Brunton (1980) The crystal structure of paulmooreite, $Pb_2[As_2O_5]$: dimeric arsenite groups. Amer. Mineral., 65, 340–345.

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Pavonite $AgBi_3S_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tiny bladed crystals elongated parallel to [010]; typically intergrown with homologous species, and massive.

Physical Properties: *Cleavage:* Indistinct. Hardness = 2 VHN = 188 (50 g load). D(meas.) = 6.8 (synthetic). D(calc.) = [6.80]

Optical Properties: Opaque. *Color:* Lead-gray to tin-white; in polished section, white. *Luster:* Metallic. *Pleochroism:* Strong, gray-pink-white and blue-gray-white in oil. *Anisotropism:* Strong, in pale to intense blue and light tan to brown. R_1–R_2: (400) 46.3–50.7, (420) 46.1–50.5, (440) 45.9–50.3, (460) 45.6–50.0, (480) 45.3–49.8, (500) 45.0–49.5, (520) 44.5–49.0, (540) 44.0–48.4, (560) 43.4–47.8, (580) 42.9–47.3, (600) 42.5–47.0, (620) 42.2–46.7, (640) 42.0–46.4, (660) 41.9–46.2, (680) 41.7–46.0, (700) 41.6–45.8

Cell Data: *Space Group:* $C2/m$. $a = 13.35$ $b = 4.03$ $c = 16.34$ $\beta = 94.5°$ $Z = 4$

X-ray Powder Pattern: Synthetic $AgBi_3S_5$ (easily confused with benjaminite). 2.858 (100), 3.59 (90), 3.38 (80), 3.46 (40), 5.45 (35), 2.259 (35), 4.08 (30)

Chemistry:

	(1)	(2)		(1)	(2)
Ag	11.1	12.05	Bi	64.5	70.04
Cu	1.7		S	18.3	17.91
Pb	3.5		Total	99.1	100.00

(1) Porvenir mine, Bolivia; by electron microprobe, corresponding to $(Ag_{0.90}Cu_{0.23})_{\Sigma=1.13}(Bi_{2.70}Pb_{0.15})_{\Sigma=2.85}S_{5.00}$. (3) $AgBi_3S_5$.

Occurrence: In hydrothermal base-metal sulfide vein deposits.

Association: Cupropavonite, bismuthinite, chalcopyrite, aikinite, hodrušhite.

Distribution: In Bolivia, from the Porvenir [TL] and Bolivar mines, Cerro Bonete, about 75 km south-southwest of Esmoraca, Potosí. In the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. In the USA, in Colorado, in the Silver Bell mine, Red Mountain, Ouray Co.; at the Old Lout, Gladiator, and Alaska mines, Poughkeepsie Gulch, near Ouray, San Juan Co.; and at several other minor occurrences. In Nevada, at Manhattan, and from the Outlaw mine, Round Mountain district, Nye Co., and Pioche, Lincoln Co.; and in the Apache Hills mine, southeast of Hachita, Grant Co., New Mexico. In Canada, in the Keeley mine, South Lorrain Township, Ontario. From Portugal, at Panasqueira and in the Vale das Gatas tungsten mine, near Vila Real. From the Waschgang Au–Cu deposit, Goldberg Mountains, Upper Carinthia, Austria. At the Ikuno mine, Hyogo Prefecture, Japan. From the Shanhu W–Sn deposit, Guangxi Province, China.

Name: From the Latin *pavo*, *peacock*, honoring Professor Martin Alfred Peacock (1898–1950), Canadian mineralogist, University of Toronto, Toront, Canada.

Type Material: University of Toronto, Toronto, Canada; Harvard University, Cambridge, Massachusetts, USA.

References: (1) Nuffield, E.W. (1954) Studies of mineral sulpho-salts: XVIII—pavonite, a new mineral. Amer. Mineral., 39, 409–415. (2) Van Hook, H.J. (1960) The ternary system Ag_2S–Bi_2S_3–PbS. Econ. Geol., 55, 759–788. (3) Karup-Møller, S. (1972) New data on pavonite, gustavite and some related sulfosalt minerals. Neues Jahrb. Mineral., Abh., 117, 19–38. (4) Harris, D.C. and T.T. Chen (1975) Studies of type pavonite material. Can. Mineral., 13, 408–410. (5) Makovicky, E., W.G. Mumme, and J.A. Watts (1977) The crystal structure of synthetic pavonite, $AgBi_3S_5$, and the definition of the pavonite homologous series. Can. Mineral., 15, 339–348. (6) Karup-Møller, S. and E. Makovicky (1979) On pavonite, cupropavonite, benjaminite, and "oversubstituted" gustavite. Bull. Minéral., 102, 351–367. (7) Ilinca, G. and E. Makovicky (1999) X-ray powder diffraction properties of pavonite homologues. Eur. J. Mineral., 11, 691–708.

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Paxite $CuAs_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive, intergrown with novákite, koutekite, and arsenic. *Twinning:* Polysynthetic along {010}.

Physical Properties: *Cleavage:* Perfect along {010}. Hardness = 3.5–4 VHN = 146 (25 g load). D(meas.) = 5.4 D(calc.) = 5.97

Optical Properties: Opaque. *Color:* Pale steel-gray on fresh surface; in polished section, very pale gray. *Streak:* Black. *Luster:* Metallic, tarnishing black. *Anisotropism:* Very strong; in pale gray-green and dark brown with violet tint.
R_1–R_2: (400) 46.4–48.2, (420) 45.8–48.4, (440) 45.2–48.6, (460) 44.8–48.4, (480) 44.6–48.0, (500) 44.6–48.5, (520) 44.5–49.2, (540) 44.2–49.5, (560) 43.8–49.4, (580) 43.5–49.1, (600) 43.4–48.9, (620) 43.5–48.8, (640) 43.7–48.6, (660) 43.8–48.3, (680) 43.7–47.9, (700) 43.3–47.6

Cell Data: *Space Group:* $P2_1/c$. $a = 5.839(2)$ $b = 5.111(2)$ $c = 8.084(3)$ $\beta = 99.7°$ $Z = 10$

X-ray Powder Pattern: Černý Důl mine, Czech Republic.
3.144 (10), 2.616 (10), 2.495 (9), 3.604 (7), 1.795 (7), 1.687 (6), 3.295 (5)

Chemistry:

	(1)	(2)
Cu	30.35	29.77
As	69.91	70.23
Total	100.26	100.00

(1) Černý Důl mine, Czech Republic; by electron microprobe, average of 10 analyses. (2) $CuAs_2$.

Occurrence: In hydrothermal calcite veins cutting diopside hornfels lenses, in pyroxene gneisses and mica schists. Probably a late-stage reaction product formed at the expense of novákite and arsenic below 130 °C (Černý Důl mine, Czech Republic).

Association: Novákite, koutekite, arsenic, arsenolamprite, silver, löllingite, nickeline, chalcocite, skutterudite, bornite, chalcopyrite, tiemannite, clausthalite, uraninite, hematite, fluorite (Černy Důl mine, Czech Republic); lautite, kutínaite (Niederbeerbach, Germany); domeykite, algodonite, koutekite (Mohawk, Michigan, USA).

Distribution: From the Černý Důl mine, Krkonoše (Giant Mountains), Czech Republic [TL]. At Mühltal, Niederbeerbach, Odenwald, Hesse, Germany. From Mohawk, Keeweenaw Co., Michigan, USA.

Name: From the Latin *pax*, *peace*.

Type Material: Charles University, Prague, Czech Republic; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 162605.

References: (1) Johan, Z. (1961) Paxite—Cu_2As_3, a new copper arsenide from Černý Důl in the Giant Mts. (Krkonoše). Acta Univer. Carolinae, Geologica, 77–88 (1962) (in Czech with English abs.). (2) (1962) Amer. Mineral., 47, 1484–1485 (abs. ref. 1). (3) Johan, Z. (1985) The Černy Důl deposit (Czechoslovakia): an example of Ni-, Fe-, Ag-, Cu-arsenide mineralization with extremely high activity of arsenic; new data on paxite, novakite and kutinaite. Tschermaks Mineral. Petrog. Mitt., 34, 167–182.

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Pašavaite $Pd_3Pb_2Te_2$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As rounded irregular grains, to 0.02 mm, included in polarite.

Physical Properties: *Cleavage*: Weak on {001}. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 2 VHN = 233 (25 g load). D(meas.) = 9.9 D(calc.) = 10.18
Most properties determined on synthetic material.

Optical Properties: Opaque. *Color*: Gray. *Streak*: Gray; pale pink with a brownish tint in plane polarized light. *Luster*: Metallic. *Pleochroism*: Brownish to light pink. *Anisotropism:* Strong. *Optical Class*: n.d.
R_1-R_2: (470) 49.9-42.4, (546) 51.8-44.6, (589) 52.2-45.7, (650) 52.8-46.9

Cell Data: *Space Group*: *Pmmn*. *a* = 8.599(1) *b* = 5.9381(6) *c* = 6.3173(8) Z = 2

X-ray Powder Pattern: Synthetic $Pd_{2.99}Pb_{2.00}Te_{2.01}$.
3.0495 (100), 2.1637 (71), 2.5456 (63), 2.2786 (42), 1.8906 (42), 6.3152 (34), 2.4424 (34)

Chemistry:

	(1)	(2)
Pd	31.51	32.17
Pb	41.54	41.78
Bi	0.19	
Te	25.75	25.93
Total	98.99	99.88

(1) Talnakh deposit, Noril'sk-Talnakh mining camp, Russia; average of 4 electron microprobe analyses, corresponding to $Pd_{2.96}(Pb_{2.01}Bi_{0.01})Te_{2.02}$. (2) Average of 7 electron microprobe analyses of synthetic material, corresponding to $Pd_{2.99}Pb_{2.00}Te_{2.01}$.

Occurrence: Likely formed from late-stage residual liquids segregated from a Ni-Cu sulfide melt derived from a highly differentiated mafic intrusion.

Association: Polarite, sperrylite.

Distribution: Talnakh deposit, Noril'sk-Talnakh mining camp, Taimyr autonomous District, Russia.

Name: Honors Jan Pašava (b. 1957), a geologist with the Czech Geological Survey.

Type Material: Department of Mineralogy, National Museum, Prague, Czech Republic (catalog no. P1p 15/2007).

References: (1) Vymazalová, A., F. Laufek, M. Drábek, J. Haloda, T. Sidorinová, and J. Plášil (2009) Pašavaite, $Pd_3Pb_2Te_2$, a new platinum-group mineral species from the Noril'sk-Talnakh Ni-Cu camp, Russia. Can. Mineral., 47, 53–62. (2) (2009) Amer. Mineral., 94, 1500 (abs. ref. 1).

Pearceite $(Ag,Cu)_{16}As_2S_{11}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As short, tabular pseudohexagonal prisms with bevelled edges, showing triangular striations on {001}; as rosettes of such crystals, to 3 cm.

Physical Properties: *Fracture:* Conchoidal to irregular. Hardness = 3 VHN = 130–142 (100 g load). D(meas.) = 6.15(2) D(calc.) = 6.07

Optical Properties: Opaque, translucent in very thin fragments. *Color:* Dull black; in polished section, white, with very dark red internal reflections. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Very weak in air, fair in oil. *Anisotropism:* Moderate, typically dark violet. R_1–R_2: (400) 34.8–34.3, (420) 34.2–34.2, (440) 33.4–34.1, (460) 32.5–33.8, (480) 31.5–33.2, (500) 30.6–32.8, (520) 29.8–32.5, (540) 29.3–32.3, (560) 29.0–32.0, (580) 29.0–31.7, (600) 29.1–31.2, (620) 29.1–30.7, (640) 28.9–30.2, (660) 28.6–29.8, (680) 28.0–29.3, (700) 27.4–29.1.

Cell Data: *Space Group:* $C2/m$. $a = 12.64$ $b = 7.29$ $c = 11.90$ $\beta = 90.0°$ $Z = 2$

X-ray Powder Pattern: Aspen, Colorado, USA.
2.97 (100), 2.80 (90), 2.47 (60), 2.30 (60), 1.827 (60), 2.34 (50), 1.992 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Ag	56.90	63.54	77.46	As	7.01	7.29	6.72
Cu	14.85	10.70		Sb	0.30	0.43	
Zn	2.81			S	18.13	17.07	15.82
Fe		0.60		Total	100.00	99.63	100.00

(1) Molly Gibson mine, Colorado, USA; recalculated to 100% after deducting 12.81% impurities; then corresponds to $(Ag_{10.44}Cu_{4.62}Zn_{0.85})_{\Sigma=15.91}(As_{1.85}Sb_{0.05})_{\Sigma=1.90}S_{11.19}$. (2) Arqueros, Chile; corresponds to $(Ag_{12.19}Cu_{3.48}Fe_{0.22})_{\Sigma=15.89}(As_{2.01}Sb_{0.07})_{\Sigma=2.08}S_{11.02}$. (3) $Ag_{16}As_2S_{11}$.

Polymorphism & Series: Forms a series with polybasite.

Occurrence: In hydrothermal deposits formed at low to medium temperatures.

Association: Acanthite, silver, proustite, quartz, barite, calcite.

Distribution: In the USA, in Montana, large crystals from the Drumlummon mine, Marysville, Lewis and Clark Co. [TL]; at Neihart, Cascade Co.; and from about 13 km north of Niarada, in the Flathead mine, Flathead Co.; in Colorado, at the Molly Gibson mine, Aspen, Pitkin Co., and from Rico, Dolores Co.; in Utah, in the Tintic district, Juab Co., at Eureka and elsewhere; in the Lakeview district, Bonner Co., Idaho; at the Ophir mine, Comstock district, Storey Co., Nevada. In Canada, from the Morrison mine, and in the Ross mine, Holtyre, Ontario, and at the Husky mine, Yukon Territory. In Mexico, from the Veta Rica mine, Sierra Mojada, Coahuila, and as large crystals in the Reyes mine, Guanajuato. From Arqueros, Coquimbo, Chile. At Banská Štiavnica (Schemnitz), Slovakia. From the Clara mine, near Oberwolfach, Black Forest, Germany. In Spain, from Francoli, Tarragona Province. In Italy, at Boarezzo, Lombardy. In the Sark's Hope mine, Sark, Channel Islands. From Seikoshi, Shizuoka Prefecture, Japan. Additional minor localities are known.

Name: For Dr. Richard Pearce (1837–1927), Cornish–American chemist and metallurgist, Denver, Colorado, USA.

Type Material: Yale University, New Haven, Connecticut, 3.4270, 3.4292, 3.4293; The Natural History Museum, London, England, 84843.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 353–355. (2) Peacock, M.A. and L.G. Berry (1947) Studies of mineral sulfo-salts: XIII—polybasite and pearceite. Mineral. Mag., 28, 1–13. (3) Frondel, C. (1963) Isodimorphism of the polybasite and pearceite series. Amer. Mineral., 48, 565–572. (4) Hall, H.T. (1967) The pearceite and polybasite series. Amer. Mineral., 52, 1311–1321. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 420.

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Peatite-(Y) $Li_4Na_{12}Y_{12}(PO_4)_{12}(CO_3)_4F_8$

Crystal Data: Orthorhombic. *Point Group*: 222. As equant, well-formed, isolated or small clusters of pseudocubes to 1 mm, also as overgrowths on ramikite-(Y). Crystals display dominant {100}, {010}, and {001}, and minor {110}, {101}, and {011}; crystal faces striated parallel to the face diagonal.

Physical Properties: *Cleavage*: Very good on {100}, {010}, {001}. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = ~ 3 D(meas.) = n.d. D(calc.) = 3.62(1)

Optical Properties: Translucent. *Color*: Colorless, pale pink to purple. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (n.d.). α = n.d. β = 1.601(1) γ = n.d. 2V(meas.) = n.d. 2V(calc.) = n.d. *Pleochroism:* None. *Dispersion*: None.

Cell Data: *Space Group*: *P*222. a = 11.167(2) b = 11.164(2) c = 11.162(2) Z = 1

X-ray Powder Pattern: Poudrette pegmatite, Mont Saint-Hilaire, Canada.
2.63 (100), 2.99 (83), 4.56 (57), 3.95 (57), 3.54 (46), 2.149 (42), 2.71 (38)

Chemistry:

	(1)	(2)		(1)	(2)
Na_2O	12.95	12.81	ZrO_2	0.67	
CaO	1.15		ThO_2	0.37	
Y_2O_3	37.32	46.68	P_2O_5	27.29	29.35
Gd_2O_3	0.61		F	4.35	5.24
Dy_2O_3	3.08		$-O=F_2$	1.83	2.21
Ho_2O_3	0.67		CO_2	[5.79]	6.07
Er_2O_3	2.88		H_2O	[0.31]	
Tm_2O_3	0.28		Li_2O	[1.96]	2.06
Yb_2O_3	1.78		Total	99.75	100.00

(1) Poudrette pegmatite, Mont Saint-Hilaire, Canada; average of 4 electron microprobe analyses, H_2O, CO_2 and Li_2O calculated from stoichiometry and their presence confirmed by LA-ICP-MS and Raman analyses; corresponding to $Li_4Na_{12}(Y_{10.06}Na_{0.72}Ca_{0.62}Dy_{0.50}Er_{0.46}Yb_{0.28}Zr_{0.17}Ho_{0.11}Gd_{0.10}Tm_{0.04}Th_{0.04}Tb_{0.02})_{\Sigma=13.12}(PO_4)_{11.70}(CO_3)_4[F_{6.97}(OH)_{1.03}]_{\Sigma=8}$. (2) $Li_4Na_{12}Y_{12}(PO_4)_{12}(CO_3)_4F_8$.

Occurrence: A late-stage product possibly related to the in situ alteration of the pre-existing mineral assemblage present in the core of a zoned peralkaline pegmatite dike encased in a hornfels xenolith.

Association: Ramikite-(Y), albite, rhodochrosite, siderite, chabazite-Na, synchysite-(Ce), sabinaite.

Distribution: From the Poudrette pegmatite, Mont Saint-Hilaire, La Vallée-du-Richelieu, Montérégie (formerly Rouville County), Québec, Canada.

Name: Honors Cynthia Peat (1925-1999), a former X-ray technician at the Royal Ontario Museum, Toronto, Ontario, Canada, an avid mineralogist who spent decades studying and unraveling the complex mineralogy of Mont Saint-Hilaire.

Type Material: The Royal Ontario Museum, Toronto, Ontario, Canada (M53894).

References: (1) McDonald, A.M., M.E. Back, R.A. Gault, and L. Horváth (2013) Peatite-(Y) and ramikite-(Y), two new Na-Li-Y±Zr phosphate-carbonate minerals from the Poudrette pegmatite, Mont Saint-Hilaire, Quebec. Can. Mineral., 51, 569-596. (2) (2014) Amer. Mineral., 99, 2441 (abs. ref. 1).

Pecoraite $Ni_3Si_2O_5(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* n.d. As curved plates, tubes, and spirals, to 0.4 μm; granular, to 5 mm; massive.

Physical Properties: Hardness = n.d. D(meas.) = 3.084 with absorbed H_2O. D(calc.) = [3.47]

Optical Properties: Transparent to translucent. *Color:* Bright green to blue-green. *Luster:* Vitreous.
Optical Class: Biaxial (probable). n = 1.56–1.63, with absorbed H_2O; 1.650 dried. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 5.26$ $b = 9.16$ $c = 14.7$ $\beta = 92°$ Z = [4]

X-ray Powder Pattern: Wolf Creek meteorite.
7.43 (100), 3.66 (75), 1.529 (75), 4.50 (62), 2.620 (62), 2.447 (50)

Chemistry:

	(1)
SiO_2	31.0
Al_2O_3	1.4
FeO	0.7
NiO	51.5
MgO	0.5
CaO	0.4
H_2O^+	9.7
H_2O^-	4.1
Total	99.3

(1) Wolf Creek meteorite; after deduction of H_2O^- and Ca as cassidyite ~1%, corresponds to $(Ni_{2.70}Al_{0.11}Mg_{0.05}Fe^{2+}_{0.04})_{\Sigma=2.90}Si_{2.02}O_5(OH)_4$.

Polymorphism & Series: Dimorphous with népouite.

Mineral Group: Kaolinite-serpentine group.

Occurrence: Formed by weathering of Ni-Fe meteorite fragments in a desert environment (Wolf Creek meteorite); along shears in Archaean ultramafic rocks (Otway prospect, Western Australia); in geodes (St. Louis, Missouri, USA).

Association: Maghemite, quartz, goethite, cassidyite, reevesite (Wolf Creek meteorite); millerite, gaspéite, otwayite, nullaginite (Otway prospect, Western Australia); millerite (St. Louis, Missouri, USA).

Distribution: In the Wolf Creek meteorite. From the Otway prospect, near Spinnaway, Nullagine district, and in Rocky's Reward pit, near Agnew, Western Australia. From about 30 km west of St. Louis, St. Louis Co., Missouri, and in the Nickel mine, Riddle, Douglas Co., Oregon, USA. At Tscheremschanskoe, Ural Mountains, Russia.

Name: To honor Dr. William Thomas Pecora (1913–1972), Director of the U.S. Geological Survey, geologist and student of nickel silicate deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128111.

References: (1) Faust, G.T., J.J. Fahey, B. Mason, and E.J. Dwornik (1969) Pecoraite, $Ni_6Si_4O_{10}(OH)_8$, nickel analog of clinochrysotile, formed in the Wolf Creek Meteorite. Science, 165, 59–60. (2) (1969) Amer. Mineral., 54, 1740–1741 (abs. ref. 1). (3) Nickel, E.H. (1973) An occurrence of gaspéite and pecoraite in the Nullagine region of Western Australia. Mineral. Mag., 39, 113–115. (4) Bayliss, P. (1981) Unit cell data of serpentine group minerals. Mineral. Mag., 44, 153–156. (5) Milton, C., E.J. Dwornik, and R.B. Finkelman (1983) Pecoraite, the nickel analogue of chrysotile, $Ni_3Si_2O_5(OH)_4$ from Missouri. Neues Jahrb. Mineral., Monatsh., 513–523.

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Pectolite $NaCa_2Si_3O_8(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals may be tabular, but also commonly acicular, to 15 cm; radiating fibrous, spheroidal, or columnar; fine-grained, massive. *Twinning:* Twin axis [010] with composition plane ~{100}, common.

Physical Properties: *Cleavage:* Perfect on {100} and {001}. *Fracture:* Uneven. *Tenacity:* Brittle; tough when compact. Hardness = 4.5–5 D(meas.) = 2.84–2.90 D(calc.) = [2.87] May be triboluminescent.

Optical Properties: Translucent to opaque. *Color:* Colorless, whitish, grayish, yellowish; in thin section, colorless. *Luster:* Silky, subvitreous.
Optical Class: Biaxial (+). *Orientation:* $X \wedge c = 10°–19°$; $Y \wedge a = 10°–16°$; $Z \wedge b = 2°$. *Dispersion:* $r > v$, weak to very strong. $\alpha = 1.592–1.610$ $\beta = 1.603–1.615$ $\gamma = 1.630–1.645$ 2V(meas.) = 50°–63°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.9882(1)$ $b = 7.03996$ $c = 7.0247(1)$ $\alpha = 90.520°$ $\beta = 95.181°$ $\gamma = 102.469°$ Z = 2

X-ray Powder Pattern: Bergen Hill, New Jersey, USA.
2.921 (10), 3.10 (8), 3.90 (6), 3.33 (6b), 3.28 (6b), 2.739 (6), 2.600 (6)

Chemistry:

	(1)
SiO_2	54.18
Fe_2O_3	0.18
FeO	0.42
CaO	33.36
Na_2O	8.72
K_2O	0.88
H_2O	2.74
Total	100.48

(1) Thetford mines, Quebec, Canada; corresponds to $(Na_{0.93}K_{0.06})_{\Sigma=0.99}(Ca_{1.98}Fe^{2+}_{0.02})_{\Sigma=2.00}(Si_{2.99}Fe^{3+}_{0.01})_{\Sigma=3.00}O_8(OH)_{1.01}$.

Polymorphism & Series: A M2abc polytype exists; forms a series with sérandite.

Occurrence: A primary mineral in nepheline syenites. A hydrothermal mineral in cavities in basalts and diabases; in serpentinites and peridotites; from metamorphosed high-calcium rocks.

Association: Zeolites, datolite, prehnite.

Distribution: Numerous localities. On Mt. Baldo and Mt. Monzoni, Trentino-Alto Adige, Italy. In Germany, from Niederkirchen, near Wolfstein, and Rauschermühle, Rhineland-Palatinate. In Scotland, at Lendalfoot, Ayrshire. From Zlto, Sweden. In Russia, from the Lovozero and Khibiny massifs, Kola Peninsula. In the USA, from Paterson, Passaic Co., and Bergen Hill, Hudson Co., New Jersey; at Magnet Cove, Hot Spring Co., and on Granite Mountain, near Little Rock, Pulaski Co., Arkansas. In Canada, in fine crystals from the Jeffrey mine, Asbestos, and at Mont Saint-Hilaire, Quebec. At Ahmadnagar, Maharashtra, India. From Bou Agrao, High Atlas Mountains, Morocco. At Pilansberg, Transvaal, South Africa.

Name: From the Greek for *compact*, in allusion to its resistance to pulverization.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 373–374. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 564–574. (3) Hildebrand, F.A. (1953) Minimizing the effects of preferred orientation in X-ray powder diffraction patterns. Amer. Mineral., 38, 1051–1056. (4) Prewitt, C.T. (1967) Refinement of the structure of pectolite, $Ca_2NaHSi_3O_9$. Zeits. Krist., 125, 298–316. (5) Müller, W.F. (1976) On stacking disorder and polytypism in pectolite and serandite. Zeits. Krist., 144, 401–408.

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Peisleyite $Na_3Al_{16}(PO_4)_{10}(SO_4)_2(OH)_{17}\cdot 20H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Flakes, to 2 μm, aggregated into chalky masses.

Physical Properties: *Tenacity:* Brittle. Hardness = ~3 D(meas.) = 2.12 D(calc.) = 2.11

Optical Properties: Semitransparent. *Color:* White. *Luster:* Earthy.
Optical Class: Biaxial. $n = 1.510$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 13.31(0.6)$ $b = 12.62(0.6)$ $c = 23.15(1)$
$\beta = 110.0(0.3)^\circ$ Z = 2

X-ray Powder Pattern: Tom's quarry, Australia.
12.63 (100), 7.82 (35), 5.41 (35), 7.59 (30), 4.35 (20), 10.85 (15), 6.43 (15)

Chemistry:

	(1)
SO_3	7.33
P_2O_5	29.10
SiO_2	0.83
Al_2O_3	35.03
Fe_2O_3	0.17
MgO	0.02
CaO	0.71
Na_2O	3.83
K_2O	0.03
H_2O	22.54
Total	99.59

(1) Tom's quarry, Australia; Fe, Mg, Ca, Na, K by AA, H_2O by loss on ignition, original total given as 99.60%; corresponds to $(Na_{2.88}Ca_{0.30}Mg_{0.01}K_{0.01})_{\Sigma=3.20}(Al_{16.00}Fe_{0.05})_{\Sigma=16.05}(PO_4)_{9.55}(SiO_4)_{0.32}(SO_4)_{2.13}(OH)_{17.45}\cdot 20.40H_2O$.

Occurrence: A rare secondary mineral in phosphate beds in limestone.

Association: Wavellite.

Distribution: From Tom's Phosphate quarry, near Kapunda, South Australia.

Name: Honoring Mr. Vincent Peisley (1941–), Brahma Lodge, Australia, who first collected the species.

Type Material: Museum Victoria, Melbourne, Australia, M35630.

References: (1) Pilkington, E.S., E.R. Segnit, and J.A. Watts (1982) Peisleyite, a new sodium aluminium sulphate phosphate. Mineral. Mag., 46, 449–452. (2) (1983) Amer. Mineral., 68, 849–850 (abs. ref. 1).

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Pekoite **$PbCuBi_{11}(S, Se)_{18}$**

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are prismatic, to 2 mm; in banded exsolution intergrowths epitaxial with gladite.

Physical Properties: *Cleavage:* {010}, good. Hardness = n.d. VHN = n.d.
D(meas.) = n.d. D(calc.) = 6.8

Optical Properties: Opaque. *Color:* Lead-gray; white to cream in reflected light.
Streak: Lead-gray. *Luster:* Metallic.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1am$. $a = 11.472(2)$ $b = 33.744(6)$ $c = 4.016(1)$ $Z = 2$

X-ray Powder Pattern: Juno mine, Australia.
3.140 (100), 3.025 (40), 3.622 (30), 1.971 (30), 3.564 (25), 3.593 (20), 2.554 (20)

Chemistry:

	(1)
Pb	5.1
Cu	1.3
Bi	73.6
Se	7.4
S	14.3
Total	101.7

(1) Juno mine, Australia; by electron microprobe, corresponds to $Pb_{0.82}Cu_{0.68}Bi_{11.74}(S_{14.87}Se_{3.13})_{\Sigma=18.00}$

Occurrence: In magnetite pipes that cut felsic sediments and pyroclastics; the pipes are probably hydrothermal replacements associated with volcanism (Juno mine, Australia).

Association: Gladite, junoite, emplectite, magnetite, chalcopyrite (Juno mine, Australia); paděraite, hammarite, chalcopyrite, grossular, andradite (Băiţa, Romania).

Distribution: From the Juno mine, Tennant Creek, Northern Territory, Australia [TL]. Found near Narechen Basni, southern Rhodope Mountains, and at the Svishti Plaz gold deposit, Balkan Mountains, Bulgaria. In the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. At the Funiushan copper skarn deposit, near Nanjing, Jiangsu Province, China. From Băiţa (Rézbánya), Tincova, and Sasca Montană, Romania. At the Waschgang Au–Cu deposit, Goldberg Mountains, Upper Carinthia, Austria. In the Loch Shin monzogranite, near Lairg, Scotland. At the Tanco pegmatite, Bernic Lake, Manitoba, Canada. In the USA, from the Germania Consolidated mine, Fruitland, Stevens Co., Washington; and the Comstock mine, Dos Cabezas Mountains, Cochise Co., Arizona.

Name: For the Peko mine, near the Juno mine, Tennant Creek, Australia.

Type Material: Geology Department, University of New England, Australia, R27788.

References: (1) Mumme, W.G., E. Welin, and B.J. Wuensch (1976) Crystal chemistry and proposed nomenclature for sulfosalts intermediate in the system bismuthinite–aikinite (Bi_2S_3–$CuPbBiS_3$). Amer. Mineral., 61, 15–20. (2) Mumme, W.G. and J.A. Watts (1976) Pekoite, $CuPbBi_{11}S_{18}$, a new member of the bismuthinite–aikinite mineral series: its crystal structure and relationship with naturally- and synthetically-formed members. Can. Mineral., 14, 322–333. (3) Large, R.R. and W.G. Mumme (1975) Junoite, "wittite", and related seleniferous bismuth sulfosalts from Juno mine, Northern Territory, Australia. Econ. Geol., 70, 369–383. (4) Mumme, W.G. and J.A. Watts (1976) Additional physical, optical and x-ray data for pekoite. Can. Mineral., 14, 578. (5) Topa, D., E. Makovicky, and W.H. Paar (2002) Composition ranges and exolution pairs for the members of the bismuthinite–aikinite series from Felbertal, Austria. Can. Mineral., 40, 849–869.

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Pekovite $SrB_2Si_2O_8$

Crystal Data: Orthorhombic. *Point Group:* 2/*m* 2/*m* 2/*m*. As equant grains to 0.2 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6.5-7 VHN = 953 (100 g load). D(meas.) = 3.35(2) D(calc.) = 3.36

Optical Properties: Transparent to translucent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous, slightly greasy.
Optical Class: Biaxial (-). α = 1.597(2) β(calc) = 1.627(2) γ = 1.632(2) 2V(meas) = 43(3)° 2V(calc) = n.d. *Dispersion:* Moderate, $v > r$. *Pleochroism*: None.

Cell Data: *Space Group: Pnma*. a = 8.155(2) b = 7.919(1) c = 8.921(1) Z = 4

X-ray Powder Pattern: Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan. 3.62 (100), 3.51 (90), 2.786 (90), 3.31 (80), 1.982 (70B), 5.94 (60), 3.01 (60)

Chemistry:

	(1)
CaO	0.38
SrO	34.15
B_2O_3	23.39
SiO_2	41.56
Total	99.48

(1) Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan; electron microprobe analysis, corresponding to $(Sr_{0.97}Ca_{0.02})_{\Sigma=0.99}B_{1.97}Si_{2.02}O_8$.

Occurrence: Within a block of quartz in the moraine of the Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan. The Dara-i-Pioz massif at the head of the glacier contains B-rich alkaline rocks and pegmatites.

Association: In quartz, intergrown with pectolite, highly strontian fluorite, and aegirine.

Distribution: Dara-i-Pioz glacier, Alai mountain range, Tien Shan, northern Tajikistan.

Name: Honors Russian mineralogist Igor Viktorovich Pekov (b. 1967), an expert on the mineralogy of alkaline rocks.

Type Material: A.E. Fersman Mineralogical Museum, Moscow, Russia.

References: (1) Pautov, L.A., A.A. Agakhanov, E. Sokolova, and F.C. Hawthorne (2004) Maleevite, $BaB_2Si_2O_8$, and pekovite, $SrB_2Si_2O_8$, new mineral species from the Dara-i-Pioz alkaline massif, northern Tajikistan: description and crystal structure. Can. Mineral., 42, 107–119. (2) (2005) Amer. Mineral., 90, 272-273 (abs. ref. 1).

Pellouxite $\sim(Cu,Ag)_2Pb_{21}Sb_{23}S_{55}ClO$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals acicular along [010] to tabular flattened on (100), to 1 mm, with lozenge-shaped cross sections.

Physical Properties: *Cleavage:* Good on $\{20\bar{1}\}$. *Tenacity:* Brittle; flexible fibers. *Fracture:* n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.97

Optical Properties: Opaque. *Color:* Black; in reflected light, red internal reflections at grain edges and defects. *Streak:* Brown. *Luster:* Metallic. *Bireflectance:* Weak, white to white-gray. *Anisotropism*: Distinct.
Optical Class: n.d.
R*(*air)-R*(*oil): (470) 38.3-23.8, (546) 37.3-22.4, (589) 36.9-21.5, (650) 35.2-19.6

Cell Data: Space Group: *C*2/*m*. a = 55.824(11) b = 4.0892(8) c = 24.128(5) β = 113.14(3)° Z = 4

X-ray Powder Pattern: Buca della Vena mine, Apuan Alps, Tuscany, Italy.
3.423 (100), 4.002 (38), 3.562 (31), 2.948 (27), 3.009 (25), 3.878 (24), 2.048 (20), 2.265 (19)

Chemistry:

	(1)	(2)
Pb	47.17	47.55
Sb	31.16	30.94
Cu	0.89	0.95
Ag	0.59	0.61
S	19.08	19.38
Cl	0.33	0.39
O	0.39	0.18
Total	99.60	100.00

(1) Buca della Vena mine, Apuan Alps, Tuscany, Italy; average of 15 electron microprobe analyses, presence of O based on structure analysis, corresponds to $(Cu_{0.64}Ag_{0.25})Pb_{10.36}Sb_{11.64}S_{27.07}Cl_{0.42}O_{1.11}$.
(2) Ideal formula corresponds to $(Cu_{1.36}Ag_{0.52})Pb_{20.88}Sb_{23.12}S_{55}ClO$.

Mineral Group: Zinkenite group.

Occurrence: Formed by high chlorinity hydrothermal fluids in cavities and vugs in calcite veins that cut a Ba-Fe deposit, as well as, the enclosing greenschist facies phyllite and dolomitic limestone.

Association: Zinkenite, boulangerite, robinsonite, tintinaite, and, rarely, scainiite and pillaite; and tetrahedrite, bournonite, sphalerite, cinnabar, galena, andorite, chalcostibite, gersdorffite.

Distribution: From the Buca della Vena mine, near Ponte Stazzemese, Apuan Alps, Tuscany, Italy.

Name: Honors Professor Alberto Pelloux (1868-1947), curator of the mineralogical Museum, University of Genoa, Italy, and past President of the "Società Geologica Italiana".

Type Material: n.a.

References: (1) Orlandi, P., Y. Moëlo, A. Meerschaut, P. Palvadeau, and P. Leone (2004) Lead-antimony sulfosalts from Tuscany (Italy). VI. Pellouxite, $\sim(Cu,Ag)_2Pb_{21}Sb_{23}S_{55}ClO$, a new oxy-chloro-sulfosalt from Buca della Vena mine, Apuan Alps. Eur. J. Mineral., 16, 839-844.
(2) Palvadeau, P., A. Meerschaut, P. Orlandi, and Y. Moëlo (2004) Lead-antimony sulfosalts from Tuscany (Italy). VII. Crystal structure of pellouxite, $\sim(Cu,Ag)_2Pb_{21}Sb_{23}S_{55}ClO$, an expanded monoclinic derivative of $Ba_{12}Bi_{24}S_{48}$ hexagonal sub-type (zinkenite group). Eur. J. Mineral., 16, 845-855. (3) (2005) Amer. Mineral., 90, 1230-1231 (abs. refs. 1 & 2).

Pellyite $\mathbf{Ba_2Ca(Fe^{2+},Mg)_2Si_6O_{17}}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals rare, tabular on {010}, to 1 cm; crystalline, fine granular; massive.

Physical Properties: *Cleavage:* Prismatic, poorly developed. *Fracture:* Conchoidal. Hardness = 6 D(meas.) = 3.51 D(calc.) = 3.48

Optical Properties: Translucent. *Color:* Colorless to pale yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, very strong. $\alpha = 1.627$–1.643 $\beta = 1.629$–1.645 $\gamma = 1.641$–1.649 2V(meas.) = 53°–61°

Cell Data: *Space Group: Amma.* $a = 14.209(6)$ $b = 15.677(4)$ $c = 7.151(2)$ Z = 4

X-ray Powder Pattern: Ross River, Canada.
3.43 (100), 3.19 (65), 2.308 (60), 3.46 (55), 3.83 (50), 2.117 (50), 3.17 (45)

Chemistry:

	(1)	(2)
SiO_2	40.50	41.03
Al_2O_3	3.53	3.59
FeO	12.46	12.23
MnO	0.57	1.44
ZnO	1.05	0.20
MgO	1.46	0.76
CaO	6.25	6.06
BaO	34.16	34.10
Total	99.98	99.41

(1) Ross River, Canada; corresponding to $Ba_{1.88}Ca_{0.94}(Fe_{1.46}Mg_{0.31}Zn_{0.11}Mn_{0.07})_{\Sigma=1.95}(Si_{5.72}Al_{0.58})_{\Sigma=6.30}O_{17}$. (2) Big Creek, California, USA; by electron microprobe, corresponding to $Ba_{1.89}Ca_{0.91}(Fe_{1.45}Mn_{0.17}Mg_{0.16}Zn_{0.02})_{\Sigma=1.80}(Si_{5.76}Al_{0.59})_{\Sigma=6.35}O_{17}$.

Occurrence: In lenses and bands of barium silicate rocks developed in metamorphic skarns near the contact with granite or granodiorite.

Association: Barite, hedenbergite, quartz, taramellite, gillespite, sanbornite, alforsite, witherite, andradite.

Distribution: From near the headwaters of the Ross and Pelly Rivers, about three km southwest of Gillespite Lake [Gunn claim, Itsy Mountains, near Macmillan Pass], Yukon Territory, Canada. From Trumbull Peak, near Incline, Mariposa Co., and at Big Creek, Fresno Co., California, USA. In the La Madrelena mine, Tres Pozos, Baja California, Mexico.

Name: For the Pelly River, Canada, near the headwaters of which it was first recognized.

Type Material: University of British Columbia, Vancouver, Canada, S-79-21844; National Museum of Natural History, Washington, D.C., USA, 148587.

References: (1) Montgomery, J.H., R.M. Thompson, and E.P. Meagher (1972) Pellyite: a new barium silicate mineral from the Yukon Territory. Can. Mineral., 11, 444–447. (2) Meagher, E.P. (1976) The atomic arrangement of pellyite: $Ba_2Ca(Fe,Mg)_2Si_6O_{17}$. Amer. Mineral., 61, 67–73. (3) Pabst, A. and J. Harris (1984) Pellyite: new localities and new data. Can. Mineral., 22, 653–658.

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Penfieldite $Pb_2Cl_3(OH)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}$. Crystals, to 3 cm, commonly prismatic ‖ [0001], or steeply pyramidal, terminated by {0001}, with many less-common forms; may be in groups in parallel. *Twinning:* About $[21\overline{3}0]$ on {0001} and on $\{41\overline{5}4\}$, both as contact twins.

Physical Properties: *Cleavage:* {0001}, distinct. Hardness = n.d. D(meas.) = 5.82–6.61 D(calc.) = 6.00 Soluble in H_2O leaving a yellowish white lead oxychloride residue.

Optical Properties: Transparent. *Color:* Colorless, white, may be yellowish or bluish with impurities; colorless in transmitted light. *Luster:* Adamantine to greasy.
Optical Class: Uniaxial (+). $\omega = 2.13(1)$ $\epsilon = 2.21(1)$

Cell Data: *Space Group:* $P\overline{6}$. $a = 11.393(3)$ $c = 4.024(1)$ Z = 36

X-ray Powder Pattern: Laurium, Greece.
3.73 (FFF), 3.14 (FF), 3.31 (F), 2.744 (F), 2.563 (F), 2.266 (F), 5.70 (mF)

Chemistry:

	(1)	(2)	(3)
Pb	76.55	78.41	77.06
O	1.47	[3.30]	1.49
F		0.09	
Cl	19.82	19.31	19.78
H		[0.21]	
H_2O	1.59		1.67
insol.	0.14		
Total	99.57	[101.32]	100.00

(1) Laurium, Greece. (2) Baratti Beach, Italy; by electron microprobe, average of three points; corresponding to $Pb_2Cl_{2.88}[(OH)_{1.09}F_{0.03}]_{\Sigma=1.12}$. (3) $Pb_2Cl_3(OH)$.

Occurrence: An alteration product of lead-bearing slag immersed in seawater (Laurium, Greece; Baratti Beach, Italy); in an oxidized hydrothermal lead deposit (Sierra Gorda district, Chile).

Association: Paralaurionite, phosgenite (Laurium, Greece); fiedlerite, cotunnite (Baratti Beach, Italy).

Distribution: From Laurium, Greece, in slag. Along Baratti Beach, Tuscany, Italy, in slag. At the Margarita mine, Sierra Gorda district, southwest of Calama, Antofagasta, Chile.

Name: To honor Professor Samuel Lewis Penfield (1856–1906), American mineralogist and mineral chemist, Yale University, New Haven, Connecticut, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 66–67. (2) Cesbron, F. and H.-J. Schubnel (1968) Nouvelles données sur la penfieldite. Bull. Soc. fr. Minéral., 91, 407–408 (in French). (3) Merlino, S., M. Pasero, N. Perchiazzi, and A. Gianfagna (1995) X-ray and electron diffraction study of penfieldite: average structure and multiple cells. Mineral. Mag., 59, 341–347.

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Penikisite $Ba(Mg,Fe^{2+})_2Al_2(PO_4)_3(OH)_3$

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Crystal Data: Triclinic, pseudomonoclinic, or monoclinic. *Point Group:* $\overline{1}$ or 1. In crystals, in zoned intergrowth with kulanite.

Physical Properties: *Cleavage:* On {010} and {100}, fair to good. Hardness = ∼4
D(meas.) = 3.79(2) D(calc.) = 3.82

Optical Properties: Transparent to translucent. *Color:* Blue to green. *Streak:* Very pale green to white. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = grass-green; Y = blue-green; Z = pale pink. *Orientation:* $Y \wedge b = 0°$–$19°$; $Z \wedge c = -6°$. *Dispersion:* $r \gg v$, asymmetrical, suggesting a triclinic structure. *Absorption:* $X \approx Y > Z$. $\alpha = 1.684(2)$ $\beta = 1.688(2)$ $\gamma = 1.705(2)$
2V(meas.) = 56° 2V(calc.) = 52.2°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 8.999$ $b = 12.069$ $c = 4.921$ $\alpha = \sim 90°$ $\beta = 100°31'$ $\gamma = \sim 90°$ Z = 2

X-ray Powder Pattern: Cross-cut Creek, Canada; almost identical to kulanite.
3.094 (100), 2.915 (80), 2.649 (70), 8.81 (60), 3.028 (60), 2.684 (60), 4.49 (55)

Chemistry:

	(1)
P_2O_5	37.1
Al_2O_3	18.0
FeO	9.5
MnO	0.0
MgO	6.5
CaO	1.4
BaO	24.9
H_2O	3.9
Total	101.3

(1) Cross-cut Creek, Canada; by electron microprobe, total Fe as FeO; corresponds to $Ba_{0.96}(Mg_{0.95}Fe_{0.78}Ca_{0.15})_{\Sigma=1.88}Al_{2.09}(P_{1.03}O_{4.15})_3(OH)_{2.56}$.

Polymorphism & Series: Forms a series with kulanite.

Mineral Group: Bjarebyite group.

Occurrence: A very rare weathering product in fractures in sideritic iron formation.

Association: Kulanite, quartz, siderite, fluorapatite, rapidcreekite, brazilianite, arrojadite, anatase, goyazite.

Distribution: From Cross-cut Creek, Big Fish River–Blow River area, and in the Hess River area, Yukon Territory, Canada.

Name: Honoring Mr. Gunar Penikis (1936–1979), Ross River, Yukon Territory, Canada, a codiscoverer of the Rapid Creek phosphate occurrences.

Type Material: Royal Ontario Museum, Toronto, Canada, M34172.

References: (1) Mandarino, J.A., B.D. Sturman, and M.I. Corlett (1977) Penikisite, the magnesium analogue of kulanite, from Yukon Territory. Can. Mineral., 15, 393–395. (2) (1979) Amer. Mineral., 64, 657 (abs. ref. 1).

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Penkvilksite $Na_4Ti_2Si_8O_{22}\cdot 5H_2O$

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Crystal Data: Monoclinic or orthorhombic. *Point Group:* n.d. Crystal plates, to 7 μm and very thin, and microscopic radial fibrous masses, in lumps and clotted masses, to 3 cm; compact, porcelaneous.

Physical Properties: *Cleavage:* One perfect, probably basal. Hardness = 5, in aggregate. D(meas.) = 2.58(2) D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* White to pale gray, brownish, or greenish. *Luster:* Pearly or silky on fresh fracture; dull on the surface.
Optical Class: Biaxial (+). $\alpha = 1.637(2)$ $\beta = 1.640(2)$ $\gamma = 1.662(2)$ 2V(meas.) = n.d. 2V(calc.) = 42°

Cell Data: *Space Group:* n.d. $a = 7.48(5)$ $b = 8.77(5)$ c = n.d. α = n.d. β = n.d. $\gamma = 90°$ Z = n.d.

X-ray Powder Pattern: Lovozero massif, Russia.
8.2 (10), 3.37 (9), 2.84 (8), 3.32 (7), 3.10 (7), 3.07 (7), 1.713 (7)

Chemistry:

	(1)		(1)
SiO_2	54.69	CaO	1.60
TiO_2	15.91	SrO	0.01
ZrO_2	2.17	Na_2O	13.13
Al_2O_3	0.76	K_2O	0.09
Fe_2O_3	0.19	F	0.05
Nb_2O_5	1.08	H_2O^+	7.43
Ta_2O_5	0.06	H_2O^-	2.84
MnO	0.01	P_2O_5	0.02
MgO	trace	$-O = F_2$	0.02
		Total	100.02

(1) Lovozero massif, Russia; corresponds to $(Na_{3.7}Ca_{0.3})_{\Sigma=4.0}[Ti_{1.7}Zr_{0.2}(Nb,Fe,Al)_{0.1}]_{\Sigma=2.0}(Si_{7.9}Al_{0.1})_{\Sigma=8.0}O_{22}\cdot 5H_2O$.

Occurrence: In the central natrolite zone of a pegmatite in a differentiated alkalic massif (Lovozero massif, Russia); in a pegmatite vein and in a marble xenolith in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Aegirine, natrolite, mountainite, raite (Lovozero massif, Russia); microcline, aegirine, catapleiite, ancylite, nenadkevichite, pectolite, apophyllite, monteregianite, vesuvianite, tadzhikite (Mont Saint-Hilaire, Canada).

Distribution: From the Jubilee pegmatite, on Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: From the Lapp *penk*, for *curly*, and *vilkis*, for *white*, for its typical appearance.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3244, 3781; Mining Institute, St. Petersburg, 1065/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75126; National School of Mines, Paris, France; The Natural History Museum, London, England, 1994,24.

References: (1) Bussen, I.V., Y.P. Men'shikov, A.M. Mer'kov, A.P. Nedorezova, E.I. Uspenskaya, and A.P. Khomyakov (1974) Penkvilksite, a new hydrosilicate of titanium and sodium. Doklady Acad. Nauk SSSR, 217, 1161–1164 (in Russian). (2) (1975) Amer. Mineral., 60, 340–341 (abs. ref. 1). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 283–359, esp. 329.

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Pennantite $\mathbf{Mn_5^{2+}Al(Si_3Al)O_{10}(OH)_8}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$ or 1. As lamellar crystals and flakes, to 0.5 mm; in grains and platy aggregates, sometimes forming rosettelike clusters.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Flexible, inelastic. Hardness = 2–2.5 D(meas.) = 2.89–3.07 D(calc.) = [3.18]

Optical Properties: Translucent to nearly opaque. *Color:* Orange-brown, reddish brown, brown, dark red, dark green, black; in transmitted light, orange, pinkish, reddish orange. *Luster:* Pearly on cleavage faces.
Optical Class: Biaxial (–). *Pleochroism:* X = pinkish orange, orange-buff, reddish brown; Y = Z = orange, yellowish orange, very dark brown. *Absorption:* $Y = Z > X$. α = 1.615–1.664 β = n.d. γ = 1.622–1.673 2V(meas.) = 0° to very small.

Cell Data: *Space Group:* $C\bar{1}$ or $C1$. $a = 5.45$ $b = 9.50$ $c = 14.40$ $\alpha = 90.0°$ $\beta = 97.3°$ $\gamma = 90.0°$ Z = 2

X-ray Powder Pattern: Benallt mine, Wales.
7.1 (100), 3.57 (80), 2.43 (80), 14.3 (40), 2.70 (40), 2.03 (40), 4.75 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	22.64	21.29	23.9	ZnO		0.97	15.9
Al_2O_3	18.60	19.07	19.1	MgO	[1.48]	0.00	3.4
Fe_2O_3	4.43	6.67	2.6	BaO	1.33	0.00	
MnO	38.93	39.82	27.4	H_2O	[9.40]	12.11	[7.7]
				Total	[96.81]	99.93	[100.0]

(1) Benallt mine, Wales; MgO and H_2O determined on an impure sample; corresponds to $(Mn^{2+}_{3.92}Al_{1.32}Fe^{3+}_{0.39}Mg_{0.26}Ba_{0.08})_{\Sigma=5.97}(Si_{2.70}Al_{1.30})_{\Sigma=4.00}O_{10}(OH)_{8.00}$. (2) Ushkatyn deposit, Kazakhstan; corresponds to $(Mn_{4.00}Al_{1.31}Fe^{3+}_{0.60}Zn_{0.09})_{\Sigma=6.00}(Si_{2.59}Al_{1.41})_{\Sigma=4.00}O_{10}[(OH)_{7.51}O_{0.49}]_{\Sigma=8.00}$. (3) Franklin, New Jersey, USA; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponds to $(Mn_{2.6}Zn_{1.3}Al_{1.3}Mg_{0.6}Fe^{3+}_{0.2})_{\Sigma=6.0}(Si_{2.7}Al_{1.3})_{\Sigma=4.0}O_{10}(OH)_8$.

Mineral Group: Chlorite group.

Occurrence: Formed during hydrothermal alteration of manganese deposits, as crusts on manganese minerals, and in veins cutting ore.

Association: Banalsite, analcime, paragonite, pyrophanite, garnet, barite, ganophyllite, kutnohorite, kellyite, willemite, prehnite, datolite, roeblingite, clinohedrite, hancockite, friedelite.

Distribution: In the Benallt mine, Rhiw, Lleyn Peninsula, Wales. From the Ushkatyn and Dzhumart deposits, Atasu district, Kazakhstan. In the Harstigen mine, near Persberg, Värmland, Sweden. At Bald Knob, near Sparta, Alleghany Co., North Carolina, and Franklin, Sussex Co., New Jersey, USA.

Name: For the Welsh mineralogist Thomas Pennant (1726–1798).

Type Material: The Natural History Museum, London, England, 1947,295–296; Harvard University, Cambridge, Massachusetts, 104705; National Museum of Natural History, Washington, D.C., USA, 105855.

References: (1) Smith, W.C., F.A. Bannister, and M.H. Hey (1946) Pennantite, a new manganese-rich chlorite from Benallt mine, Rhiw, Carnarvonshire. Mineral. Mag., 27, 217–220. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 131–163. (3) Kayupova, M.M. (1965) Pennantite from the Ushkatyn deposit, central Kazakhstan. Doklady Acad. Nauk SSSR, 163, 189–192 (in Russian). (4) (1965) Chem. Abs., 63, 11176 (abs. ref. 3). (5) Peacor, D.R., E.J. Essene, W.B. Simmons, Jr., and W.C. Bigelow (1974) Kellyite, a new Mn-Al member of the serpentine group from Bald Knob, North Carolina, and new data on grovesite. Amer. Mineral., 59, 1153–1156. (6) Bayliss, P. (1983) Polytypes of pennantite. Can. Mineral., 21, 545–547.

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Penobsquisite $Ca_2Fe^{2+}B_9O_{13}Cl(OH)_6 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Euhedral crystals, triangular in outline, tabular on {100}, elongated along [010], to 1.5 mm, showing {100}, {101}, {10$\bar{1}$}, {111}, {110}, {1$\bar{1}$0}, {$\bar{2}$1$\bar{2}$}, {$\bar{1}\bar{1}$2}.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼3
D(meas.) = 2.26(3) D(calc.) = 2.27

Optical Properties: Transparent to translucent. *Color:* Pale yellow. *Streak:* White.
Luster: Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 16.6°$. $\alpha = 1.550(2)$ $\beta = 1.554(2)$ $\gamma = 1.592(2)$ 2V(meas.) = 33(2)° 2V(calc.) = 36.6°

Cell Data: *Space Group:* $P2_1$. $a = 11.620(3)$ $b = 9.407(2)$ $c = 8.726(1)$ $\beta = 98.58(2)°$
Z = 2

X-ray Powder Pattern: Penobsquis mine, Canada.
7.29 (10), 8.65 (3), 2.113 (3), 5.32 (2), 4.50 (2), 2.958 (2), 2.744 (2)

Chemistry:

	(1)
B_2O_3	[48.50]
FeO	7.48
MnO	0.23
MgO	1.82
CaO	17.27
Cl	5.77
H_2O	[19.52]
$-O = Cl_2$	1.30
Total	[99.29]

(1) Penobsquis mine, Canada; by electron microprobe, average of three analyses, total Fe as Fe^{2+}, total Mn as Mn^{2+}, H_2O confirmed by IR, B_2O_3 and H_2O calculated from stoichiometry; corresponding to $Ca_{1.99}(Fe_{0.67}Mg_{0.29}Mn_{0.02})_{\Sigma=0.98}B_9O_{12.95}Cl_{1.05}(OH)_{5.99} \cdot 4.01H_2O$.

Occurrence: A very rare residual mineral, obtained by dissolution of halite in a drillcore through a marine evaporite series.

Association: Halite, sellaite, fluorite, boracite, hilgardite, pringleite, trembathite, brianroulstonite, hematite, malachite.

Distribution: From the Penobsquis evaporite deposit, near Sussex, New Brunswick, Canada.

Name: For the Penobsquis mine, Canada, first source of the mineral.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81524.

References: (1) Grice, J.D., R.A. Gault, and J. Van Velthuizen (1996) Penobsquisite: a new borate mineral with a complex framework structure. Can. Mineral., 34, 657–665. (2) (1997) Amer. Mineral., 82, 208 (abs. ref. 1).

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Penroseite $(Ni, Co, Cu)Se_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As reniform masses with radiating columnar structure.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {011}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 500–583 (100 g load). D(meas.) = 6.58–6.74 D(calc.) = 6.7

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, creamy grayish white. *Streak:* Black. *Luster:* Metallic, tarnishes rapidly.
R: (400) 40.2, (420) 40.1, (440) 40.1, (460) 40.2, (480) 40.4, (500) 40.7, (520) 41.1, (540) 41.5, (560) 41.9, (580) 42.3, (600) 42.8, (620) 43.3, (640) 43.6, (660) 44.0, (680) 44.1, (700) 44.2

Cell Data: *Space Group:* $Pa3$. $a = 5.991$ $Z = 4$

X-ray Powder Pattern: Colquechaca, Bolivia.
2.68 (100), 2.45 (100), 1.806 (90), 1.599 (40), 3.02 (30), 1.662 (30), 1.151 (30)

Chemistry:

	(1)	(2)
Ni	22.9	12.5
Co	3.2	9.2
Cu	2.1	5.7
Se	71.7	72.3
Total	99.9	99.7

(1) Colquechaca, Bolivia; by electron microprobe, corresponds to $(Ni_{0.84}Co_{0.12}Cu_{0.07})_{\Sigma=1.03}Se_{1.97}$.
(2) Hope's Nose, England; by electron microprobe, corresponds to $(Ni_{0.46}Co_{0.34}Cu_{0.20})_{\Sigma=1.00}Se_{2.00}$.

Polymorphism & Series: Dimorphous with kullerudite.

Mineral Group: Pyrite group.

Occurrence: In hydrothermal veins.

Association: Naumannite, clausthalite, gersdorffite, tiemannite, pyrite, chalcopyrite (Pacajake mine, Bolivia); clausthalite, sederholmite, trüstedtite (Kuusamo, Finland).

Distribution: From the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, Potosí, Bolivia [TL]. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From Hope's Nose, Torquay, Devon, England. In Germany, in the Harz Mountains, at Tilkerode. At Kuusamo, northeastern Finland.

Name: In honor of Dr. Richard Alexander Fullerton Penrose, Jr. (1863–1931), American economic geologist, of Philadelphia, Pennsylvania, USA.

Type Material: The Natural History Museum, London, England, 1926,1; Harvard University, Cambridge, Massachusetts, 87472; National Museum of Natural History, Washington, D.C., USA, 95302, R7247.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 294–296. (2) Early, J.W. (1950) Description and synthesis of the selenide minerals. Can. Mineral., 35, 337–364. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 806–807. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 422.

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Pentagonite $Ca(V^{4+}O)Si_4O_{10}\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals prismatic, to 1 mm, with dominant {110}, {201}, and $\{00\bar{1}\}$, elongated ‖ [001]; commonly as spherulitic rosettes, up to 5 mm. *Twinning:* Cyclical by reflection across {110}, common; as $(110) \wedge (1\bar{1}0) = 72.7°$, multiple twins result having pentagonal basal patterns closely simulating five-fold symmetry.

Physical Properties: *Cleavage:* Good on {010}. *Tenacity:* Brittle. Hardness = ~3–4 D(meas.) = n.d. D(calc.) = 2.33

Optical Properties: Transparent. *Color:* Greenish blue. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Pronounced; $X = Z$ = colorless; Y = blue. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, strong. $\alpha = 1.533(2)$ $\beta = 1.544(2)$ $\gamma = 1.547(2)$ 2V(meas.) = 50(2)°

Cell Data: *Space Group:* $Ccm2_1$. $a = 10.298(4)$ $b = 13.999(7)$ $c = 8.891(2)$ $Z = 4$

X-ray Powder Pattern: Owyhee Dam, Oregon, USA.
6.071 (100), 3.920 (100), 3.755 (100), 8.298 (70), 3.500 (36), 2.569 (36), 4.446 (25)

Chemistry: Semi-quantitative XRF indicates Ca:V:Si as in cavansite, and H_2O is also the same as their unit cells have the same volume.

Polymorphism & Series: Dimorphous wih cavansite.

Occurrence: In coatings on a tuff.

Association: Cavansite, heulandite, stilbite, analcime, apophyllite, calcite.

Distribution: In the USA, about three km south of Owyhee Dam, Malheur Co., Oregon.

Name: For the unusual pseudosymmetrical five-fold or *pentagonal* habit of the twinned crystals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120584, 122769.

References: (1) Staples, L.W., H.T. Evans, Jr., and J.R. Lindsay (1973) Cavansite and pentagonite, new dimorphous calcium vanadium silicate minerals from Oregon. Amer. Mineral., 58, 405–411. (2) Evans, H.T., Jr. (1973) The crystal structures of cavansite and pentagonite. Amer. Mineral., 58, 412–424.

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Pentahydrite $MgSO_4 \cdot 5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Typically as efflorescences.

Physical Properties: Hardness = n.d. D(meas.) = 1.896 D(calc.) = 1.90 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White, pale blue or pale green from impurities. *Optical Class:* Biaxial (–). *Dispersion:* $r < v$. α = 1.482–1.495 β = 1.492–1.512 γ = 1.493–1.518 2V(meas.) = 55°

Cell Data: *Space Group:* $P\overline{1}$ (synthetic). $a = 6.314(5)$ $b = 10.505(18)$ $c = 6.030(6)$ $\alpha = 81°7(12)'$ $\beta = 109°49(12)'$ $\gamma = 105°5(3)'$ Z = 2

X-ray Powder Pattern: Synthetic.
4.93 (100), 3.26 (40), 5.15 (30), 3.65 (30), 2.95 (30), 1.995 (35), 2.79 (25)

Chemistry:

	(1)	(2)	(3)
SO_3	38.51	38.13	38.05
FeO		0.23	
MnO		0.14	
NiO		0.11	
MgO	19.35	17.91	19.15
CaO		0.13	
H_2O	42.03	42.97	42.80
Total	99.89	99.62	100.00

(1) Cripple Creek, Colorado, USA. (2) The Geysers, California, USA. (3) $MgSO_4 \cdot 5H_2O$.

Mineral Group: Chalcanthite group.

Occurrence: An efflorescence on shales (Grand Junction, Colorado, USA); an efflorescence on mine timbers (Virginia City, Nevada, USA); in acid sulfate soils (Basse-Casamance Valley, Senegal).

Association: Alunogen, chalcanthite.

Distribution: Modern confirmation of some localities listed would be desirable. In the USA, from Cripple Creek, Teller Co., and northwest of Grand Junction, in the West Salt Creek watershed, Mesa Co., Colorado; at The Geysers, Sonoma Co., California; from Virginia City, Comstock district, Storey Co., Nevada. At Copaquire, Tarapacá, Chile. In the Basse-Casamance Valley, Senegal.

Name: From the Greek *penta*, for *five*, alluding to the amount of water in its composition.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 492–493. (2) Baur, W.H. and J.L. Rolin (1972) Salt hydrates. IX. The comparison of the crystal structure of magnesium sulfate pentahydrate with copper sulfate pentahydrate and magnesium chromate pentahydrate. Acta Cryst., 28, 1448–1455. (3) von Hodenberg, R.F. and R. Kühn (1967) Zur Kenntnis der Magnesiumsulfathydrate und der Effloreszenzen des Kieserits von Hartsalzen. Kali und Steinsalz, 4, 326–340 (in German).

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Pentahydroborite $CaB_2O(OH)_6 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Anhedral granular.

Physical Properties: Hardness = 2.5 D(meas.) = 2.00–2.03 D(calc.) = 2.02 Fluoresces violet under LW UV.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). α = 1.530–1.532 β = 1.536–1.539 γ = 1.542–1.546
2V(meas.) = 73°–79°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.845(4)$ $b = 6.525(5)$ $c = 8.124(5)$ $\alpha = 111.62(5)°$ $\beta = 111.19(4)°$ $\gamma = 73.44(5)°$ Z = 2

X-ray Powder Pattern: Novofrolovskoye deposit, Russia.
7.04 (10), 2.99 (9), 3.54 (8), 1.937 (8), 2.88 (6), 3.20 (5), 2.49 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	2.80		
B_2O_3	28.35	32.09	32.27
Al_2O_3	1.13		
Fe_2O_3	1.87		
MgO	0.66		
CaO	27.27	25.71	25.99
H_2O^+	37.78		
H_2O		41.60	41.74
Total	99.86	99.40	100.00

(1) Novofrolovskoye deposit, Russia. (2) Fuka, Japan. (3) $CaB_2O(OH)_6 \cdot 2H_2O$.

Occurrence: In boron-rich iron-ore skarns (Novofrolovskoye deposit, Russia); in a volcanogenic-sedimentary borate deposit (near the Studenitsa Cloister, Yugoslavia).

Association: Andradite–grossular, magnetite, szaibélyite (Novofrolovskoye deposit, Russia); colemanite, howlite, ulexite, studenitsite (near the Studenitsia Cloister, Yugoslavia).

Distribution: In Russia, from the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains, and at the Solongo boron deposit, Buryatia, Siberia. From the Sayak-IV boron deposit, northeast Balkhash region, Kazakhstan. Found near the Studenitsa Cloister, 280 km south of Belgrade, Yugoslavia. In Japan, at Fuka, near Bicchu, Okayama Prefecture.

Name: For the composition, originally described as a hydrated borate with five molecules of water per formula unit.

Type Material: All-Union Research Institute of Mineral Resources, Moscow, Russia.

References: (1) Malinko, S.V. (1961) New boron minerals – uralborite and pentahydroborite. Zap. Vses. Mineral. Obshch., 90, 673–681 (in Russian). (2) (1962) Amer. Mineral., 47, 1482 (abs. ref. 1). (3) Lisitsyn, A.E., S.V. Malinko, and G.S. Rumyantsev (1965) New discoveries of frolovite and pentahydroborite. Doklady Acad. Nauk SSSR, 164, 171–173 (in Russian). (4) Kazanskaya, E.V., T.N. Chemodina, Y.K. Evorov-Tismenko, M.A. Simonov, and H.V. Belov (1977) Refinement of the crystal structure of pentahydroborite. Kristallografiya (Sov. Phys. Crystal.), 22, 66–68 (in Russian). (5) Fujiwara, T., H. Okada, I. Nakai, K. Nagashima, M. Takada, K. Masutomi, and T. Isobe (1982) Pentahydroborite from Fuga [*sic], Okayama Prefecture. Geoscience Magazine, 33, 11–20 (in Japanese). (6) (1985) Mineral. Abs., 36, 207 (abs. ref. 5). (7) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 161–162.*

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Pentlandite $(Fe, Ni)_9S_8$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, commonly in granular aggregates; rarely in crystals, to 10 cm, embedded in other sulfides.

Physical Properties: *Cleavage:* Parting on {111}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 VHN = 268–285 (100 g load). D(meas.) = 4.6–5.0 D(calc.) = 4.956

Optical Properties: Opaque. *Color:* Pale bronze-yellow; reddish brown when argentian. *Streak:* Pale bronze-brown. *Luster:* Metallic.
R: (400) 32.8, (420) 35.1, (440) 37.1, (460) 39.2, (480) 41.1, (500) 42.9, (520) 44.5, (540) 46.1, (560) 47.6, (580) 48.5, (600) 49.6, (620) 50.7, (640) 51.8, (660) 52.7, (680) 53.4, (700) 54.2

Cell Data: *Space Group: Fm3m.* a = 9.928(1) Z = 4

X-ray Powder Pattern: Worthington mine, Sudbury, Canada.
1.775 (100), 3.028 (80), 1.931 (50), 2.896 (40), 5.780 (30), 2.301 (30), 1.307 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Fe	30.68	25.6	43.1	S	32.74	32.4	33.6
Ni	34.48	30.8	19.3	insol.	0.56		
Co	1.28	11.0	4.1	Total	99.74	99.8	100.1

(1) Worthington mine, Sudbury, Canada; corresponds to $(Ni_{4.60}Fe_{4.30}Co_{0.17})_{\Sigma=9.07}S_{8.00}$. (2) Mt. Colin, Australia; by electron microprobe; corresponds to $(Ni_{4.16}Fe_{3.63}Co_{1.48})_{\Sigma=9.27}S_{8.00}$. (3) Mt. Dun area, New Zealand; by electron microprobe; corresponds to $(Fe_{5.89}Ni_{2.51}Co_{0.53})_{\Sigma=8.93}S_{8.00}$.

Polymorphism & Series: Forms a series with cobalt pentlandite.

Mineral Group: Pentlandite group.

Occurrence: Commonly intimately associated with pyrrhotite; in ultramafic rocks and perhaps derived from them by magmatic segregation; also found in mantle xenoliths and undersea "black smoker" deposits; rarely in meteorites.

Association: Pyrrhotite, troilite, chalcopyrite, cubanite, mackinawite, magnetite.

Distribution: The most important ore of nickel, occurring at many localities. From Craignure, near Inverary, Strathclyde, Scotland [TL]. At Wheals Jane and Falmouth, Kea, Cornwall, England. In Norway, from Espedalen, near Lillehammar, Opland. At Outokumpu, Vuonos, Miihkali, and Hietajärvi, in east Finland; in west Finland at the Hitura nickel deposit; and in north Finland at Rarrua. In South Africa, from the Rustenburg district, in the Merensky Reef, Bushveld complex, Transvaal. In New Zealand, in the Mount Dun area, Nelson Province. In Australia, in northwest Queensland, at Lime Creek and Mount Colin; from Coolgardie and Kambalda, 56 km south of Kalgoorlie, Western Australia; and at the Lord Brassey mine, Heazlewood, Tasmania. In the Kamishi mine, Iwate Prefecture, Japan. In Canada, from a number of mines at Sudbury, Ontario, and in the Voisey's Bay Ni–Cu–Co deposit, Labrador.

Name: To honor Joseph Barclay Pentland (1797–1873), Irish natural scientist and historian, who first noted the mineral.

Type Material: The Natural History Museum, London, England, 26622–26223.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 242–243. (2) Hall, S.R. and J.M. Stewart (1973) The crystal structure of argentian pentlandite $(Fe, Ni)_8AgS_8$, compared with the refined structure of pentlandite $(Fe, Ni)_9S_8$. Can. Mineral., 12, 169–177. (3) Riley, J.F. (1977) The pentlandite group $(Fe, Ni, Co)_9S_8$: new data and an appraisal of structure-composition relationships. Mineral. Mag., 41, 345–349. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 424.

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Penzhinite $(Ag, Cu)_4Au(S, Se)_4$

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Crystal Data: Hexagonal. *Point Group:* 622. Intergrowths of elongate or platy grains, to 7 μm.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 8.35

Optical Properties: Opaque. *Color:* In reflected light, pale gray. *Anisotropism:* Evident; creamy yellow and greenish gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_322$. $a = 13.779$ $c = 16.980$ $Z = 18$

X-ray Powder Pattern: Sergeevskoye deposit, Russia.
2.59 (10), 2.71 (9), 2.14 (9), 2.11(9), 1.989 (6), 3.38 (5), 1.784 (5)

Chemistry:

	(1)
Ag	51.3
Au	24.3
Cu	3.1
Se	7.1
S	13.8
Total	99.6

(1) Sergeevskoye deposit, Russia; by electron microprobe, corresponding to $(Ag_{3.65}Cu_{0.32})_{\Sigma=3.97}Au_{0.97}(S_{3.31}Se_{0.69})_{\Sigma=4.00}$.

Occurrence: In a near-surface Au–Ag deposit.

Association: Gold, aguilarite, chalcopyrite, galena.

Distribution: From the Sergeevskoye Au–Ag deposit, 60 km northeast of Pevirechenskii, near the Penzhina River, northern Kamchatka, Russia [TL].

Name: For the Penzhina River, near the Kamchatka Peninsula, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82766.

References: (1) Bochek, L.I., S.M. Sandomirskaya, N.G. Chuvikina, and V.P. Khvorostov (1984) A new selenium-containing sulfide of silver, gold, and copper – penzhinite $(Ag, Cu)_4Au(S, Se)_4$. Zap. Vses. Mineral. Obshch., 113, 356–360 (in Russian). (2) (1985) Amer. Mineral., 70, 875–876 (abs. ref. 1).

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Peprossiite-(Ce) $(Ce, La)Al_2B_3O_9$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Crystals show a platy hexagonal outline, to 4 mm, in booklike aggregates or rosettes.

Physical Properties: *Cleavage:* Perfect on {0001}; distinct on $\{11\bar{2}0\}$. Hardness = ∼2 D(meas.) = 3.45(5) D(calc.) = 3.476

Optical Properties: Transparent to translucent. *Color:* Pale yellow, lemon-yellow; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.703(2)$ $\epsilon = 1.711(5)$

Cell Data: *Space Group:* $P\bar{6}2m$. $a = 4.612(1)$ $c = 9.374(3)$ Z = 1

X-ray Powder Pattern: Monte Cavalluccio, Italy.
3.67 (100), 3.04 (100), 2.458 (75), 2.308 (50), 2.020 (50), 1.953 (50), 1.855 (50)

Chemistry:

	(1)
B_2O_3	29.56
ThO_2	1.68
Al_2O_3	29.40
Ce_2O_3	18.62
La_2O_3	14.53
Pr_2O_3	4.37
Nd_2O_3	2.11
Dy_2O_3	0.06
CaO	1.34
H_2O	[0.08]
Total	[101.75]

(1) Monte Cavalluccio, Italy; by electron microprobe, B_2O_3 by ion microprobe, H_2O calculated for stoichiometry; then corresponds to $(Ce_{0.40}La_{0.32}Pr_{0.09}Ca_{0.09}Nd_{0.05}Th_{0.02})_{\Sigma=0.97}$ $Al_{2.04}B_{3.00}[O_{8.97}(OH)_{0.03}]_{\Sigma=9.00}$.

Occurrence: A very rare mineral, formed in cavities in sanidine ejecta by circulation of pneumatolytic to hydrothermal fluids, probably above 350 °C (Monte Cavalluccio, Italy).

Association: Sanidine, aegirine–augite, hellandite, zircon, titanite, magnetite (Monte Cavalluccio, Italy).

Distribution: In Italy, from Monte Cavalluccio, Campagnano, Lazio; at Cura di Vetralla and Capranico Vicano, Viterbo.

Name: To honor Giuseppe ("Pep") Rossi (1938–1989), mineralogist and crystallographer, University of Pavia, Pavia, Italy.

Type Material: University of Rome, Rome, Italy; Natural History Museum, Paris, France.

References: (1) Della Ventura, G., G.C. Parodi, A. Mottana, and M. Chaussidon (1993) Peprossite-(Ce), a new mineral from Campagnano (Italy): the first anhydrous rare-earth-element borate. Eur. J. Mineral., 5, 53–58. (2) (1993) Amer. Mineral., 78, 1109 (abs. ref. 1). (3) Callegari, A., F. Caucia, F. Mazzi, R. Oberti, L. Ottolini, and L. Ungaretti (2000) The crystal structure of peprossiite-(Ce), an anhydrous REE and Al mica-like borate with square-pyramidal coordination for Al. Amer. Mineral., 85, 586–592.

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Peretaite $\mathbf{CaSb_4^{3+}O_4(SO_4)_2(OH)_2 \cdot 2H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are flattened on {100}, may be elongated along [001], bounded by {100}, {310}, {110}, {122}, {001}, {010}, {210}, {$\bar{2}$01}, {302}, {601}, to 5 mm; as divergent sprays of laths, botryoidal, massive. *Twinning:* On {100}, very common.

Physical Properties: *Cleavage:* On {100}, perfect. VHN = 170–190, 180 average (15 g load). Hardness = n.d. D(meas.) = > 3.8 D(calc.) = 4.06

Optical Properties: Transparent. *Color:* Colorless, pink to red from incrustations of valentinite. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z = c$; $X \wedge b = \sim 28°$. $\alpha = 1.841(1)$ $\beta =$ n.d. $\gamma = 1.935(1)$ 2V(meas.) = Very large.

Cell Data: *Space Group:* $C2/c$. $a = 24.665(4)$ $b = 5.6006(9)$ $c = 10.185(1)$ $\beta = 95.98(1)°$ Z = 4

X-ray Powder Pattern: Pereta mine, Italy; shows some preferred orientation due to {100} cleavage.
12.19 (100), 3.06 (67), 2.451 (31), 3.10 (24), 6.12 (21), 2.532 (20), 2.068 (17)

Chemistry:

	(1)	(2)
SO_3	17.62	18.77
Sb_2O_3	69.09	68.33
CaO	6.44	6.57
H_2O	6.0	6.33
Total	99.15	100.00

(1) Pereta mine, Italy; CaO by AA, H_2O by TGA; corresponds to $Ca_{1.01}Sb_{4.17}O_4(SO_4)_{1.94}(OH)_{2.65} \cdot 2H_2O$. (2) $CaSb_4O_4(SO_4)_2(OH)_2 \cdot 2H_2O$.

Occurrence: Of rare occurrence, formed by the action of H_2SO_4 solutions on stibnite in the oxidized zone of a limestone-hosted hydrothermal antimony-bearing deposit.

Association: Stibnite, pyrite, kermesite, sulfur, valentinite, onoratoite, klebelsbergite, gypsum, calcite, quartz.

Distribution: In Italy, from the Pereta and Cetine mines, and at Micciano, near Larderello, Val di Cecina, Tuscany.

Name: For its occurrence at the Pereta mine, Italy.

Type Material: University of Florence, Florence, 164/I; Pisa University, Pisa, Italy; National Museum of Natural History, Washington, D.C., USA, 148481, 148482.

References: (1) Cipriani, N., S. Menchetti, P. Orlandi, and C. Sabelli (1980) Peretaite, $CaSb_4O_4(OH)_2(SO_4)_2 \cdot 2H_2O$, a new mineral from Pereta, Tuscany, Italy. Amer. Mineral., 65, 936–939. (2) Menchetti, S. and C. Sabelli (1980) Peretaite, $CaSb_4O_4(OH)_2(SO_4)_2 \cdot 2H_2O$: its atomic arrangement and twinning. Amer. Mineral., 65, 940–946.

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Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ 2/*m*. As radial discoidal, platy hexagonal crystals, in rough spherules, to 1 mm.

Physical Properties: *Cleavage*: Imperfect on {0001}. Fr*acture*: n.d. *Tenacity*: Brittle. Hardness = ~5. D(meas.) = 2.64(1) D(calc.) = 2.49

Optical Properties: Translucent to nearly opaque. *Color*: Light brown, white. *Streak*: White. *Luster*: Dull, vitreous on cleavage surface.
Optical Class: Uniaxial (+). *Dispersion*: *r* > *v*; moderate. $\omega = 1.564(2)$ $\varepsilon = 1.577(4)$

Cell Data: *Space Group*: $P\bar{3}m1$. $a = 7.021(1)$ $c = 20.218$ Z = 1

X-ray Powder Pattern: Bell Pit, Maine, USA.
2.882 (100), 5.80 (71), 6.08 (50), 3.510 (50), 3.115 (50), 1.757 (50), 6.71 (35)

Chemistry:

	(1)	(2)	(3)
SiO_2	13.64	13.72	13.47
TiO_2	0.09		
Al_2O_3	27.09	27.17	29.33
FeO	0.26		
MgO	0.02		
CaO	12.26	12.81	11.66
Na_2O	0.02		
F	0.10		
H_2O	[24.62]	24.69	[24.2]
P_2O_5	21.90	21.61	21.34
Total	[100.00]	100.00	[100.00]

(1) Bell Pit, Maine, USA; by electron microprobe, average of three analyses, H_2O by difference; corresponding to $3(CaO)3.5(Al_2O_3)3(SiO_2)2(P_2O_5)18(H_2O)$.
(2) $Ca_3Al_7(SiO_4)_3(PO_4)_4(OH)_3 \cdot 16.5H_2O$. (3) Emmons mine, Maine, USA; average of 4 electron microprobe analyses, H_2O by difference, presence of Sr confirmed by EDS analysis; corresponding to $(Ca,Sr)_3Al_{7.7}Si_3P_4O_{23.5}(OH)_{14.1} \cdot 8H_2O$ or $3[(Ca,Sr)O]3.85(Al_2O_3)3(SiO_2)2(P_2O_5)15H_2O$.

Occurrence: As isolated masses in a vuggy, amblygonite-rich pegmatite (Bell Pit, Maine, USA).

Association: Siderite, wardite, amblygonite, eosphorite, sphalerite (Bell Pit, Maine, USA); fluellite, minyulite, wavellite (Tom's quarry, South Australia).

Distribution: In the USA, from Oxford Co., Maine, in the Bell Pit and Dunton mines, Newry; the Emmons quarry, Greenwood; and in the Ski Pike quarry, Cobble Hill, West Paris; at the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., Nevada. From Tom's quarry, Kapunda, and the Moculta quarry, Mount Lofty Ranges, South Australia.

Name: Honors Frank Croydon Perham (b. 1934), American geologist and pegmatite miner of West Paris, Maine, USA.

Type Material: The Natural History Museum, London, England (1976,424); National Museum of Natural History, Washington, D.C., USA, (135740, 143393).

References: (1) Dunn, P.J. and D.E. Appleman (1977) Perhamite, a new calcium aluminum silico-phosphate mineral, and a re-examination of viseite. Mineral. Mag., 41, 437-442. (2) (1978) Amer. Mineral., 63, 794 (abs. ref. 1). (3) Mills, S., G. Mumme, I. Grey, and P. Bordet (2006) The crystal structure of perhamite. Mineral. Mag., 70, 201-209. (4) (2007) Amer. Mineral., 92, 1542 (abs. ref. 1).

Periclase MgO

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As small octahedra, less commonly cubo-octahedra or dodecahedra, may be clustered; granular, massive.

Physical Properties: *Cleavage:* {001}, perfect; on {111}, good; may exhibit parting on {011}. Hardness = 5.5 D(meas.) = 3.56–3.68 D(calc.) = 3.58 Slightly soluble in H_2O when powdered, to give an alkaline reaction.

Optical Properties: Transparent. *Color:* Colorless, grayish white, yellow, brownish yellow; may be green or black with inclusions; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.735$–1.745

Cell Data: *Space Group:* $Fm3m$. $a = 4.203$–4.212 $Z = 4$

X-ray Powder Pattern: Synthetic.
2.106 (100), 1.489 (52), 0.9419 (17), 0.8600 (15), 1.216 (12), 2.431 (10), 1.0533 (5)

Chemistry:

	(1)
FeO	5.97
MgO	93.86
Total	99.83

(1) Monte Somma, Italy.

Mineral Group: Periclase group.

Occurrence: A product of the high-temperature metamorphism of magnesian limestones and dolostone.

Association: Forsterite, magnesite (Monte Somma, Italy); brucite, hydromagnesite, ellestadite (Crestmore quarry, California, USA); fluorellestadite, lime, periclase, magnesioferrite, hematite, srebrodolskite, anhydrite (Kopeysk, Russia).

Distribution: On Monte Somma, Campania, Italy. At Predazzo, Tirol, Austria. From Carlingford, Co. Louth, Ireland. At Broadford, Isle of Skye, and Camas Mòr, Isle of Muck, Scotland. From León, Spain. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. From Nordmark and Långban, Värmland, Sweden. In mines around Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia. In the USA, at the Crestmore quarry, Riverside Co., California; from Tombstone, Cochise Co., Arizona; in the Gabbs mine, Gabbs district, Nye Co., Nevada. In Canada, at Oka, Quebec. From ten km west of Cowell, Eyre Peninsula, South Australia.

Name: From the Greek for *to break around*, in allusion to the perfect cubic cleavage.

Type Material: Natural History Museum, Paris, France, 96.1201.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 499–500. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 1–4. (3) Hazen, R.M. (1976) Effects of temperature and pressure on the cell dimension and X-ray temperature factors of periclase. Amer. Mineral., 61, 266–271. (4) (1953) NBS Circ. 539, 1, 37.

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Perite $PbBiO_2Cl$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. Platy crystals, to 0.5 mm.

Physical Properties: *Cleavage:* {001}, fair. Hardness = 3 D(meas.) = 8.16 D(calc.) = 8.24

Optical Properties: Semitransparent. *Color:* Sulfur-yellow to straw-yellow.
Luster: Adamantine.
Optical Class: Biaxial. $n = > 2.4$ 2V(meas.) = n.d.

Cell Data: *Space Group: Bmmb.* $a = 5.627(50)$ $b = 5.575(20)$ $c = 12.425(90)$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
2.86 (10), 1.620 (9), 3.77 (8), 1.251 (8), 2.78 (7), 2.07 (7), 1.970 (7)

Chemistry:

	(1)
Bi_2O_3	45.74
$PbCl_2$	26.33
PbO	23.69
MnO	0.46
MgO	0.07
CaO	1.44
H_2O^+	0.10
H_2O^-	0.04
CO_2	1.19
insol.	1.00
Total	100.06

(1) Långban, Sweden; after deduction of calcite and hausmannite, corresponds to $Pb_{1.01}Bi_{0.98}O_{3.96}Cl_{0.95}(OH)_{0.06}$.

Occurrence: In fissures in skarn in a metamorphosed Fe–Mn deposit (Långban, Sweden); in oxidized bismuth-bearing base metal deposits.

Association: Hausmannite, calcite (Långban, Sweden); galena, cerussite, plattnerite, kaolinite, muscovite, tourmaline (Glen Florrie Station, Western Australia); kettnerite, hemimorphite, embolite, fluorite, chrysocolla, quartz (Blue Bell claims, California, USA).

Distribution: From Långban, Värmland, Sweden. At Laurium, Greece, in slag. In the USA, from the Blue Bell claims, near Baker, San Bernardino Co., California; at a prospect about 13 km northeast of Benson, Cochise Co., and in the US Mine, near Wickenburg, Maricopa Co., Arizona; in a prospect on the west side of Cucomungo Wash, Tule Canyon district, Esmeralda Co., Nevada. On Glen Florrie Station, 1000 km north of Perth, Western Australia.

Name: Honors Per Adolf Geijer (1886–1976), Swedish economic geologist with the Geological Survey of Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; The Natural History Museum, London, England, 1980,106.

References: (1) Gillberg, M. (1960) Perite, a new oxyhalide mineral from Långban, Sweden. Arkiv Mineral. Geol., 2(44), 565–570. (2) (1961) Amer. Mineral., 46, 765 (abs. ref. 1). (3) Bridge, P.J. (1976) A second occurrence of perite. Mineral. Mag., 40, 537.

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Perlialite $K_9Na(Ca,Sr)Al_{12}Si_{24}O_{72}\cdot 15H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals acicular, in fibrous aggregates, radiating, to 2 cm.

Physical Properties: *Tenacity:* Flexible and elastic. Hardness = 4–5 D(meas.) = 2.14 D(calc.) = 2.15

Optical Properties: Semitransparent. *Color:* White. *Luster:* Pearly.
Optical Class: Uniaxial (+). $\omega = 1.483(2)$ $\epsilon = 1.488(2)$

Cell Data: *Space Group:* $P6/mmm$. $a = 18.5432(4)$ $c = 7.5310(3)$ Z = 1

X-ray Powder Pattern: Khibiny massif, Russia.
16.0 (10), 4.62 (10), 1.306 (10), 3.20 (9), 2.674 (8), 1.548 (8), 6.0 (7)

Chemistry:

	(1)
SiO_2	50.72
TiO_2	0.01
Al_2O_3	20.13
Fe_2O_3	0.92
FeO	0.21
MgO	0.07
CaO	0.96
SrO	1.65
Na_2O	0.98
K_2O	14.86
H_2O	9.52
Total	100.03

(1) Khibiny massif, Russia; corresponds to $K_{9.07}Na_{0.91}(Ca_{0.49}Sr_{0.46}Fe^{2+}_{0.08})_{\Sigma=1.03}(Al_{11.35}Fe^{3+}_{0.33}Mg_{0.05})_{\Sigma=11.73}Si_{24.27}O_{72.12}\cdot 15.2H_2O$.

Mineral Group: Zeolite group.

Occurrence: In nepheline-microcline and sodalite-astrophyllite veins in nepheline-feldspar and sodalite-microcline pegmatites in a differentiated alkalic massif (Khibiny massif, Russia).

Association: Pectolite, kalsilite, aegirine, wadeite, yuksporite (Khibiny massif, Russia).

Distribution: On Mts. Eveslogchorr and Yukspor, Khibiny massif, Kola Peninsula, and in the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: For LIliya ALekseevna PERekrest (1928–), Instructor in Mineralogy, Kirov Mining School, Kirovsk, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5773/1–2; Mineralogical Museum, St. Petersburg University, St. Petersburg, 17945, 17953; Mining Institute, St. Petersburg, 1675/1–2; Il'menskii Preserve Museum, Miass, 4971; Vernadsky Geological Museum, Moscow, 57643; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 83417.

References: (1) Men'shikov, Y.P. (1984) Perlialite, $K_9Na(Ca,Sr)[Al_{12}Si_{24}O_{72}]\cdot 15H_2O$ – a new potassium zeolite from the Khibiny massif. Zap. Vses. Mineral. Obshch., 113, 607–612 (in Russian). (2) (1985) Amer. Mineral., 70, 1331 (abs. ref. 1). (3) (1986) Mineral. Abs., 37, 99 (abs. ref. 1). (4) Artoli, G. and Å. Kvick (1990) Synchrotron X-ray Rietveld study of perlialite, the natural counterpart of synthetic zeolite-L. Eur. J. Mineral., 2, 749–759.

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Perloffite $\mathbf{Ba(Mn^{2+},Fe^{2+})_2Fe_2^{3+}(PO_4)_3(OH)_3}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals resemble spearheads, to 1 mm, showing {001}, {$\bar{1}$01}, {021}, {$\bar{1}$31}. Parallel and radial growths are common; may be massive.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = ∼5 D(meas.) = n.d. D(calc.) = 4.00

Optical Properties: Semitransparent. *Color:* Black, dark brown, deep clove-brown, khaki-brown, greenish brown, reddish brown. *Streak:* Greenish yellow. *Luster:* Vitreous to subadamantine.
Optical Class: Biaxial (–). *Pleochroism:* $X = Z$ = dark greenish brown; Y = light greenish brown. *Orientation:* $X = b$; $Y \wedge c = -42°$. *Dispersion:* $r \ll v$. *Absorption:* $X = Z > Y$.
$\alpha = 1.793(5)$ $\beta = 1.803(5)$ $\gamma = 1.808(5)$ 2V(meas.) = 70°–80°

Cell Data: *Space Group:* $P2_1/m$. a = 9.223(5) b = 12.422(8) c = 4.995(2) $\beta = 100.39(4)°$ Z = 2

X-ray Powder Pattern: Big Chief mine, South Dakota, USA.
3.166 (10), 2.73 (8b), 2.982 (5), 3.105 (4), 2.939 (4), 2.070 (4), 5.12 (3)

Chemistry:

	(1)	(2)
P_2O_5	30.5	30.75
As_2O_5		0.46
Al_2O_3	0.3	1.19
Fe_2O_3	26.7	25.75
MnO	14.3	14.74
MgO	0.6	0.20
CaO	1.5	1.53
BaO	19.6	24.43
H_2O	n.d.	n.d.
Total	93.5	99.05

(1) Big Chief mine, South Dakota, USA; by electron microprobe, 11 points on 3 crystals, converted from elemental analysis; total Mn as MnO, total Fe reported as Fe_2O_3 then Fe^{2+}:Fe^{3+} apportioned for stoichiometry; corresponds to $(Ba_{0.89}Ca_{0.09})_{\Sigma=0.98}(Mn_{1.41}Fe^{2+}_{0.37}Mg_{0.11}Ca_{0.11})_{\Sigma=2.00}(Fe^{3+}_{1.96}Al_{0.04})_{\Sigma=2.00}(PO_4)_3(OH)_3$. (2) Spring Creek mine, Australia; by electron microprobe, total Mn as MnO; total Fe reported as Fe_2O_3 then Fe^{2+}:Fe^{3+} apportioned for stoichiometry; corresponds to $Ba_{1.09}(Mn_{1.43}Fe^{2+}_{0.38}Ca_{0.19}Mg_{0.03})_{\Sigma=2.03}(Fe^{3+}_{1.84}Al_{0.16})_{\Sigma=2.00}[(P_{0.99}As_{0.01})_{\Sigma=1.00}O_4]_3(OH)_3$.

Mineral Group: Bjarebyite group.

Occurrence: A rare secondary mineral in a complex zoned granite pegmatite (Big Chief mine, South Dakota, USA).

Association: Ludlamite, huréaulite, siderite, triphylite (Big Chief mine, South Dakota, USA); barite, copper, apatite (Spring Creek mine, Australia).

Distribution: From the Big Chief mine, one km south of Glendale, Pennington Co., South Dakota, USA. In the Spring Creek copper mine, near Wilmington, South Australia. At Hagendorf, Bavaria, Germany.

Name: Honoring Louis Perloff (1907–2004), American lawyer and collector of microscopic minerals, Tryon, North Carolina, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 135925, 137015.

References: (1) Kampf, A.R. (1977) A new mineral: perloffite, the Fe^{3+} analogue of bjarebyite. Mineral. Record, 8, 112–114. (2) (1977) Amer. Mineral., 62, 1059 (abs. ref. 1). (3) Birch, W.D. and W.G. Mumme (1988) Hentschelite and perloffite from the Spring Creek Copper Mine, South Australia. Mineral. Mag., 52, 408–411.

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Permingeatite Cu_3SbSe_4

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $\bar{4}2m$. As microscopic grains containing hakite inclusions. *Twinning:* Observed in polished section.

Physical Properties: Hardness = 4–4.5 VHN = 234 (50 g load). D(meas.) = n.d. D(calc.) = 5.82

Optical Properties: Opaque. *Color:* In polished section, pale brownish pink. *Luster:* Metallic. *Anisotropism:* Strong, with bright colors in rose and green.
R_1–R_2: (400) 28.9–29.1, (420) 28.4–30.2, (440) 27.9–31.4, (460) 26.9–30.5, (480) 26.5–29.2, (500) 26.1–27.4, (520) 26.0–26.0, (540) 25.6–24.9, (560) 24.8–24.7, (580) 24.3–24.9, (600) 24.1–25.4, (620) 24.1–26.2, (640) 24.5–27.3, (660) 25.5–28.6, (680) 26.4–29.5, (700) 27.6–30.1

Cell Data: *Space Group:* $I\bar{4}2m$ (probable). $a = 5.631(2)$ $c = 11.230(5)$ $Z = 2$

X-ray Powder Pattern: Předbořice, Czech Republic.
3.251 (10), 1.503 (10d), 1.986 (9), 1.697 (8), 1.148 (7), 1.290 (6), 1.408 (5)

Chemistry:

	(1)	(2)
Cu	30.7	30.3
Sb	17.4	19.4
As	1.5	
Se	50.4	50.3
Total	100.0	100.0

(1) Předbořice, Czech Republic; by electron microprobe, corresponds to $Cu_{3.01}(Sb_{0.89}As_{0.12})_{\Sigma=1.01}Se_{3.98}$. (2) Cu_3SbSe_4.

Mineral Group: Stannite group.

Occurrence: A product of epithermal hydrothermal mineralization.

Association: Berzelianite, hakite, eskebornite, umangite, naumannite, hematite, clausthalite, ferroselite, klockmannite, chalcopyrite, pyrite, gold, tetrahedrite, uraninite, goethite, calcite.

Distribution: From the Předbořice uranium deposit, near Krásna Hora, Czech Republic [TL].

Name: For François Permingeat (1917–1988), French mineralogist, University of Paul-Sabatier, Toulouse, France.

Type Material: Charles University, Prague, Czech Republic; National School of Mines, Paris, France.

References: (1) Johan, Z., P. Picot, R. Pierrot, and M. Kvaček (1971) La permingeatite Cu_3SbSe_4, un nouveau minéral du groupe de la luzonite. Bull. Soc. fr. Minéral., 94, 162–165 (in French). (2) (1972) Amer. Mineral., 57, 1554–1555 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 429.

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Perovskite $CaTiO_3$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$. Commonly resemble distorted cubes, to 12 cm, striated ‖ [001] and [110], rarely cubo-octahedra or octahedra, with additional forms, skeletal, dendritic; reniform, granular massive. *Twinning:* 90°and 180° about [101], rarely 180° about [121], giving complex penetration twins; lamellar and sectored.

Physical Properties: *Cleavage:* {001}, imperfect. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 3.98–4.26 D(calc.) = 4.02 (synthetic).

Optical Properties: Opaque, transparent in thin fragments. *Color:* Iron-black, brown, reddish brown to yellow; colorless to dark brown in transmitted light; dark bluish gray in reflected light. *Streak:* White to grayish white. *Luster:* Adamantine to metallic; may be dull.
Optical Class: Biaxial (+); commonly isotropic. *Pleochroism:* Weak; $Z > X$. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$. $n = 2.34$–2.37 $2V(meas.) = 90°$
R: (400) 19.2, (420) 18.8, (440) 18.4, (460) 18.0, (480) 17.6, (500) 17.3, (520) 17.0, (540) 16.8, (560) 16.6, (580) 16.4, (600) 16.2, (620) 16.1, (640) 16.0, (660) 16.0, (680) 15.9, (700) 15.9

Cell Data: *Space Group: Pnma* (synthetic). $a = 5.447(1)$ $b = 7.654(1)$ $c = 5.388(1)$
Z = 4

X-ray Powder Pattern: Synthetic.
2.701 (100), 1.911 (50), 2.719 (40), 1.557 (25), 1.563 (16), 3.824 (14), 1.567 (14)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5		25.99		FeO		5.69	
SiO_2		0.33		MgO	trace		
TiO_2	58.67	38.70	58.75	CaO	40.69	23.51	41.25
Al_2O_3		0.82		Na_2O		1.72	
RE_2O_3		3.08		K_2O		0.44	
				Total	99.36	100.28	100.00

(1) Val d'Aosta, Italy. (2) Vogtsberg, Germany; corresponds to $(Ca_{0.61}Fe^{2+}_{0.12}Na_{0.08}RE_{0.03}K_{0.01})_{\Sigma=0.85}(Ti_{0.71}Nb_{0.29}Al_{0.02}Si_{0.01})_{\Sigma=1.03}O_3$. (3) $CaTiO_3$.

Mineral Group: Perovskite group; $Ca_A > 0.5$; $Ti_B > 0.5$.

Occurrence: An accessory mineral in alkaline mafic rocks, as nepheline syenites, kimberlites, carbonatites, commonly deuteric; in calcareous skarns. A common accessory in Ca–Al-rich inclusions in some carbonaceous chondrites.

Association: Åkermanite–gehlenite, nepheline, titanite, ilmenite, magnetite.

Distribution: Many localities. Large crystals at the Akhmatovsk mines, near Zlatoust, Ural Mountains, and from the Lovozero massif, Kola Peninsula, Russia. At Norrvik, and on Alnö Island, Sweden. From Zermatt, Valais, Switzerland. At Schelingen and Vogtsberg, Kaiserstuhl, Baden-Württemberg; Oberwiesenthal, Saxony; and in the Eifel district, Germany. In Italy, from St. Ambrogio and the Val di Susa, Piedmont, and in the Val Malenco, Lombardy. At the Jacupiranga mine, São Paulo, Brazil. Large crystals from the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland. At Oka, Quebec, Canada. In the USA, from the Crestmore quarry, Riverside Co., and near the Gem mine, San Benito Co., California; in a large deposit in the Iron Hill carbonatite, Gunnison Co., Colorado; at Magnet Cove, Hot Spring Co., Arkansas.

Name: To honor Count Lev Alekseevich Perovskii (1792–1856), Russian mineralogist, of St. Petersburg, Russia.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 730–735. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 48–55. (3) Keller, L.P. amd P.R. Buseck (1994) Twinning in meteoric and synthetic perovskite. Amer. Mineral., 79, 73–79. (4) Buttner, R.H. and E.N Maslen (1992) Electron difference density and structural parameters in $CaTiO_3$. Acta Cryst., 48, 644–649. (5) (1971) NBS Mono. 25, 9, 17.

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Perraultite $Na_2KBaMn_8^{2+}(Ti,Nb)_4Si_8O_{32}(OH,F,H_2O)_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. Prismatic crystals, flattened on {010} and elongated along [100], with {001}, {010}, {100}, and {$h0l$}, to 1 mm. *Twinning:* Simple contact twins, with {001} as twin and composition plane, common.

Physical Properties: *Cleavage:* Very good on {001}. *Fracture:* Uneven to irregular. *Tenacity:* Very brittle. Hardness = ∼4 D(meas.) = 3.71(5) D(calc.) = 3.808

Optical Properties: Opaque to translucent, transparent in small fragments. *Color:* Orange-brown. *Streak:* Pale brown. *Luster:* Vitreous on fresh surfaces to slightly waxy on exposed faces.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = light yellow; Z = dark brown. *Orientation:* $X = b$; $Y \wedge a = 19°$. *Dispersion:* $r < v$, strong. $\alpha = 1.785(2)$ $\beta = 1.81(1)$ $\gamma = 1.82(1)$ 2V(meas.) = 66(1)° 2V(calc.) = 64°

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 10.820(2)$ $b = 13.843(4)$ $c = 20.93(1)$ $\beta = 95.09(2)°$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
3.474 (100), 10.43 (42), 2.606 (40), 3.186 (15), 2.804 (15), 2.867 (13), 3.573 (11)

Chemistry:

	(1)		(1)
SiO_2	27.32	MgO	0.06
TiO_2	9.44	BaO	8.88
ZrO_2	0.12	Na_2O	3.52
Al_2O_3	0.03	K_2O	2.68
Nb_2O_5	13.35	F	0.84
FeO	1.12	H_2O	3.49
MnO	31.14	$-O = F_2$	0.35
		Total	101.64

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of three analyses, H_2O by TGA; corresponds to $Na_{2.02}K_{1.00}Ba_{1.02}(Mn_{7.73}Fe_{0.27}Mg_{0.03})_{\Sigma=8.03}(Ti_{2.08}Nb_{1.77}Zr_{0.02})_{\Sigma=3.87}(Si_{8.01}Al_{0.01})_{\Sigma=8.02}O_{32}[(OH)_{5.62}F_{0.78}(H_2O)_{0.60}]_{\Sigma=7.00}$.

Occurrence: In pegmatite dikes in nepheline syenite in an intrusive alkalic gabbro-syenite complex.

Association: Kupletskite, catapleiite, microcline, albite, aegirine, rhodochrosite, natrolite, tetranatrolite, lorenzenite, polylithionite, ancylite, fluorite, calcite, pyrochlore.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Professor Guy Perrault, École Polytechnique, Montreal, Canada, for his work on the mineralogy of Mont Saint-Hilaire.

Type Material: Canadian Museum of Nature, Ottawa, 50037; Royal Ontario Museum, Toronto, Canada, M41005.

References: (1) Chao, G.Y. (1991) Perraultite, a new hydrous Na-K-Ba-Mn-Ti-Nb silicate species from Mont Saint-Hilaire, Quebec. Can. Mineral., 29, 355–358. (2) (1991) Amer. Mineral., 76, 2023 (abs. ref. 1). (3) Mandarino, J.A. and V. Anderson (1989) Monteregian treasures. Cambridge Univ. Press, 163. (4) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 329. (5) (1991) Amer. Mineral., 76, 300 (abs. refs. 3 and 4).

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Perrierite $(Ce, La, Ca)_4(Fe^{2+}, Mg)_2(Ti, Fe^{3+})_3Si_4O_{22}$

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Crystal Data: Monoclinic; commonly metamict. *Point Group:* $2/m$. As elongated prismatic crystals, to 7 mm, resembling epidote, with 15 forms recognized; granular, massive. *Twinning:* Common on {100}.

Physical Properties: *Fracture:* Uneven to conchoidal. Hardness = 5.5 D(meas.) = 4.29–4.45 D(calc.) = 4.77

Optical Properties: Nearly opaque to translucent. *Color:* Black, brownish, dark reddish brown. *Streak:* Brown. *Luster:* Resinous, lustrous to dull.
Optical Class: Biaxial (–). *Pleochroism:* Marked; X = yellow; Y = opaque to dark red-violet; Z = opaque to dark brown. *Orientation:* $Z = b$; $X \wedge a = 24°$. *Dispersion:* $r > v$, strong. *Absorption:* Strong; $Z \geq Y \gg X$. α = 1.90–1.95 β = [2.01] γ = 2.02–2.06 2V(meas.) = ∼60°

Cell Data: *Space Group:* $P2_1/a$. a = 13.59–13.61 b = 5.61–5.62 c = 11.63–11.73 β = 113.28°–113.95° Z = 2

X-ray Powder Pattern: Nettuno, Italy; close to chevkinite.
2.92 (100), 1.94 (78), 2.15 (55), 1.65 (55), 1.34 (55), 1.24 (47), 2.81 (46)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	19.31	20.64	La_2O_3	6.83	21.01	CaO	4.11	3.94
TiO_2	23.24	19.15	RE_2O_3		4.65	SrO		1.28
ThO_2	4.05	0.68	Fe_2O_3	1.26		Na_2O	1.05	0.47
Al_2O_3	0.67	0.38	FeO	4.05	8.17	K_2O	trace	trace
Y_2O_3	1.51	0.40	MnO		1.70	H_2O	0.61	
Ce_2O_3	31.80	18.24	MgO	0.81	0.40	Total	99.30	[101.10]

(1) Nettuno, Italy. (2) Bjørkedalen, Norway; by electron microprobe, original total given as 101.11%; $RE_2O_3 = Pr_2O_3$ 2.16%, Nd_2O_3 2.25%, Tb_2O_3 0.13%, Yb_2O_3 0.11%; corresponds to $(La_{1.51}Ce_{1.30}Ca_{0.47}RE_{0.37}Na_{0.18}Sr_{0.14}Th_{0.03})_{\Sigma=4.00}(Ti_{2.81}Fe^{2+}_{1.33}Ca_{0.36}Mn_{0.28}Mg_{0.12}Al_{0.09})_{\Sigma=4.99}Si_{4.02}O_{22}$.

Polymorphism & Series: Dimorphous with chevkinite.

Occurrence: In sands derived from weathered tuffs (Nettuno, Italy); in pockets in "hypersthene" granodiorite (Burley Farm, Virginia, USA); in syenite pegmatites (Oslo, Norway).

Association: Microcline, aegirine, loparite, pyrophanite (Oslo, Norway).

Distribution: In Italy, at Nettuno, Lazio, and on Mt. Amiata, Tuscany. In the USA, in Virginia, on the Burley Farm and at Wares Gap, Amherst Co., north of Chamblissburg, Bedford Co., and on Hat Creek and east of Roseland, Nelson Co.; in Nebraska, at Chimney Rock, Morrill Co.; from near Yucca Mountain, Nye Co., Nevada. At the Desmont mine, near Wilberforce, and west of Golden Lake, Ontario, Canada. From near Bangalore, Karnataka, and at Kanjamalaiu, near Salem, Tamil Nadu, India. At Omiya, Kyoto Prefecture, Japan. In the Orlovsk massif, Altai Mountains, and the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia, Russia. From Mantyharju, Finland. At Sogndal, Bjørkedalen, and Sandefjord, near Oslo, Norway. From Bingre, Mozambique.

Name: For Carlo Perrier (1886–1948), Italian mineralogist.

Type Material: n.d.

References: (1) Bonatti, S. and G. Gottardi (1950) Perrierite, nuovo minerale ritrovato nella sabbia di Nettuno (Roma). Atti Rend. Accad. Lincei, Ser. 8, 9, 361–368 (in Italian). (2) (1951) Amer. Mineral., 36, 926 (abs. ref. 1). (3) Bonatti, S. and G. Gottardi (1953) Nuovi dati sulla perrierite. Rend. Soc. Ital. Mineral. Petrol., 9, 208–225 (in Italian with English abs.). (4) Calvo, C. and R. Faggiani (1974) A re-investigation of the crystal structures of chevkinite and perrierite. Amer. Mineral., 59, 1277–1285. (5) Segalstad, T.V. and A.O. Larsen (1978) Chevkinite and perrierite from the Oslo Region, Norway. Amer. Mineral., 63, 499–505.

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Perrierite-(La) $(La,Ce,Ca)_4Fe^{2+}(Ti,Fe^{3+})_4(Si_2O_7)_2O_8$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As simply terminated prismatic crystals to 1 mm, columnar along [010] or flattened on (001).

Physical Properties: *Cleavage:* Distinct on (001). *Fracture:* n.d. *Tenacity:* Brittle. Hardness = 6 D(meas.) = n.d. D(calc.) = 4.791

Optical Properties: Translucent to nearly opaque. *Color:* Black. *Streak:* Brown. *Luster:* Vitreous.
Optical Class: Biaxial (-). α =1.94(1) β= 2.020(15) γ = 2.040(15) 2V(meas) = 50(10)° 2V(calc) = 51° *Dispersion:* Very strong, $r < v$. *Pleochroism*: *Z* = dark brown; *Y* = brown; *X* = light yellow-brown. *Absorption*: Z > Y > X.

Cell Data: *Space Group: P2₁/a*. a =13.668(1) b = 5.6601(6) c = 11.743(1) β = 113.64(1)° Z = 2

X-ray Powder Pattern: Dellen quarry, near Mendig, Eifel Mts., Rhineland-Palatinate, Germany. 2.96 (100), 2.80 (50), 2.14 (50), 1.947 (50), 5.19 (40), 3.53 (40), 1.657 (40)

Chemistry:	(1)
CaO	3.26
La_2O_3	22.92
Ce_2O_3	19.64
Pr_2O_3	0.83
Nd_2O_3	2.09
MgO	0.25
MnO	2.25
FeO	3.16
Fe_2O_3	5.28
$A1_2O_3$	2.59
TiO_2	16.13
Nb_2O_5	0.75
SiO_2	20.06
Total	99.21

(1) Dellen quarry, near Mendig, Eifel Mts., Rhineland-Palatinate, Germany; average of 7 electron microprobe analyses, Fe^{2+}/Fe^{3+} ratio from structure analysis; corresponding to $(La_{1.70}Ce_{1.45}Nd_{0.15}Pr_{0.06}Ca_{0.70})_{\Sigma=4.06}(Fe^{2+}_{0.53}Mn_{0.38}Mg_{0.08})_{\Sigma=0.99}(Ti_{2.44}Fe^{3+}_{0.80}Al_{0.62}Nb_{0.07})_{\Sigma=3.93}Si_{4.04}O_{22}$.

Mineral Group: Chevkinite group.

Occurrence: In miarolitic cavities in sanidinite lava rock, probably pneumatolytic.

Association: Sanidine, phlogopite, pyrophanite, zirconoiite, jakobsite, magnetite, fluorcalciopyrochlore, zircon.

Distribution: In the Dellen quarry, near Mendig, Laacher See region, Eifel Mts., Rhineland-Palatinate (Rheinland-Pfalz), Germany.

Name: For the La-dominant member of the *perrierite* structure type.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia; 4059/1.

References: (1) Chukanov, N.V., G. Blass, I.V. Pekov, D.I. Belakovskiy, K.V. Van, R.K. Rastsvetaeva, and S.M. Aksenov, (2011) Perrierite-(La), $(La,Ce,Ca)_4(Fe^{2+},Mn)(Ti,Fe^{3+},Al)_4(Si_2O_7)_2O_8$ - a new mineral species from the Eifel volcanic region, Germany. Zap. Ross. Mineral. Obshch., 140(6), 34-44 (in Russian, English abstract). (2) (2013) Amer. Mineral., 98, 1081-1082 (abs. ref. 1).

Perroudite $Hg_5^{2+}Ag_4S_5(Cl,I,Br)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Fibrous tufted aggregates of crystals, to 0.07 mm, prismatic on [001], flattened on {100}, which may have hollow terminations. *Twinning:* Observed as contact twins on {0*hl*} [*sic*].

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = Soft. VHN = n.d. D(meas.) = n.d. D(calc.) = 6.60–6.92

Optical Properties: Transparent. *Color:* Bright red. *Streak:* Reddish orange.
Luster: Vitreous to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* Very intense; X = dark brownish red; Y = yellow; Z = brownish yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, very strong. $\alpha = 2.3$ $\beta = 2.4$ γ = n.d. 2V(meas.) = ∼70°
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_12_12$. $a = 17.43(2)$ $b = 12.24(2)$ $c = 4.35(1)$ Z = 2

X-ray Powder Pattern: Cap Garonne mine, France.
3.012 (100), 2.965 (80), 3.945 (60), 2.638 (35), 3.694 (30), 2.740 (30), 2.446 (30)

X-ray Powder Pattern: Coppin Pool, Australia.
2.982 (100), 2.724 (40), 3.948 (30), 2.629 (20), 2.442 (20), 2.141 (20), 2.071 (20)

Chemistry:

	(1)	(2)	(3)
Hg	53.08	51.95	57.68
Ag	22.86	23.54	19.43
S	6.67	9.07	8.79
I	10.32	10.80	6.45
Cl	2.89	2.83	3.56
Br	3.67	0.96	2.11
Total	99.49	99.15	98.02

(1) Cap Garonne mine, France; by electron microprobe, average of five analyses on two crystals; corresponds to $Hg_{5.04}Ag_{4.03}S_{3.96}(Cl_{1.55}I_{1.55}Br_{0.87})_{\Sigma=3.97}$. (2) Broken Hill, Australia; by electron microprobe, average of seven analyses; corresponding to $Hg_{5.00}Ag_{4.20}S_{5.45}(I_{1.60}Cl_{1.55}Br_{0.25})_{\Sigma=3.40}$. (3) Coppin Pool, Australia; by electron microprobe, average of 32 analyses on two specimens; corresponds to $Hg_{5.18}Ag_{4.75}S_{6.00}(Cl_{2.40}I_{1.81}Br_{0.98})_{\Sigma=5.19}$.

Occurrence: An alteration of tennantite in sandstones and conglomerates (Cap Garonne mine, France); in a quartz vein carrying oxidized galena (Coppin Pool, Australia).

Association: Mercurian and argentian tennantite, secondary copper minerals (Cap Garonne mine, France); iodargyrite, gold, kaolinite (Broken Hill, Australia); anglesite, cerussite, phosgenite, covellite, pyromorphite, cinnabar (Coppin Pool, Australia).

Distribution: From the Cap Garonne mine, near le Pradet, Var, France [TL]. At the Schöne Aussicht mine, near Dernbach, North Rhine-Westphalia, Germany. In Australia, from Broken Hill, New South Wales; at Coppin Pool, Pilbara district, and from the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia.

Name: For Professor Pierre Perroud (1943–), Voltaire College, Geneva, Switzerland, for his work on Cap Garonne mine minerals.

Type Material: Natural History Museum, Geneva, Switzerland; Government Chemical Laboratories, Perth; Museum Victoria, Melbourne, Australia.

References: (1) Sarp, H., W.D. Birch, P.F. Hlava, A. Pring, D.K.B. Sewell, and E.H. Nickel (1987) Perroudite, a new sulfide-halide of Hg and Ag from Cap-Garonne, Var, France, and from Broken Hill, New South Wales, and Coppin Pool, Western Australia. Amer. Mineral., 72, 1251–1256. (2) Mumme, W.G. and E.H. Nickel (1987) Crystal structure and crystal chemistry of perroudite: a mineral from Coppin Pool, Western Australia. Amer. Mineral., 72, 1257–1262.

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Perryite $(Ni, Fe)_8(Si, P)_3$

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Crystal Data: Hexagonal (synthetic). *Point Group:* $3m$. In narrow laths, to 1 cm long, exsolved ‖ {111}, and in blebs along grain boundaries of kamacite in meteorites.

Physical Properties: *Tenacity:* Ductile. Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.63(1)

Optical Properties: Opaque. *Color:* Cream-yellow in reflected light. *Optical Class:* Uniaxial. *Anisotropism:* Distinct. *Bireflectance:* Weak. R: n.d.

Cell Data: *Space Group:* $R3c$ (synthetic). $a = 6.640(2)$ $c = 37.982(7)$ $Z = 12$

X-ray Powder Pattern: Synthetic.
1.977 (100), 1.924 (100), 2.150 (64), 2.103 (64), 1.778 (41), 2.613 (33), 2.585 (33)

Chemistry:

	(1)	(2)
Fe	4.0	9.4
Co	0.04	0.05
Ni	80.5	75.6
Cu	0.29	0.20
Si	12.0	11.8
P	4.1	3.4
Total	100.93	100.45

(1) Horse Creek meteorite; by electron microprobe, corresponds to $(Ni_{7.35}Fe_{0.39})_{\Sigma=7.74}(Si_{2.28}P_{0.72})_{\Sigma=3.00}$. (2) Mt. Egerton meteorite; by electron microprobe, corresponds to $(Ni_{7.29}Fe_{1.00})_{\Sigma=8.29}(Si_{2.37}P_{0.63})_{\Sigma=3.00}$.

Occurrence: In anomalously silicon-rich mesosiderite and enstatite chondrite meteorites, probably formed by exsolution from kamacite.

Association: Kamacite, troilite, schreibersite (Horse Creek, Kota-Kota meteorites); kamacite, enstatite (South Oman meteorite).

Distribution: In the Horse Creek and Mount Egerton iron meteorites, and the Kota-Kota, South Oman, St. Marks, Norton County, Indarch, and other enstatite chondrite meteorites.

Name: For Stuart Hoffman Perry (1874–1957), American newspaperman and leading private collector of meteorites, who originally described the Horse Creek meteorite.

Type Material: National Museum of Natural History, Washington, D.C., USA.

References: (1) Fredriksson, K. and E.P. Henderson (1965) The Horse Creek, Baca County, Colorado, iron meteorite. Trans. Amer. Geophys. Union, 46, 121 (abs.). (2) (1967) Amer. Mineral., 52, 559 (abs. ref. 1). (3) Reed, S.J.B. (1968) Perryite in the Kota-Kota and South Oman enstatite chondrites. Mineral. Mag., 36, 850–854. (4) Wai, C.M. (1970) The metal phase of Horse Creek, Mount Egerton, and Norton County enstatitic meteorites. Mineral. Mag., 37, 905–908. (5) Buchwald, V.F. (1975) Handbook of iron meteorites, v. II, 661–664. (6) Okada, A., K. Kobayashi, T. Ito, and T. Sakurai (1991) Structure of synthetic perryite, $(Ni, Fe)_8(Si, P)_3$. Acta Cryst., C47, 1358–1361. (7) Saini, G.S., L.D. Calvert, and J.B. Taylor (1964) Compounds of the type M_5X_2: Pd_5As_2, Ni_5Si_2, and Ni_5P_2. Can. J. Chem., 42, 1511–1517.

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Petalite $LiAlSi_4O_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular on {010}, or elongated ‖ [100], to 2 m; some faces may be striated. Commonly foliated cleavable, massive. *Twinning:* Common on {001}, lamellar.

Physical Properties: *Cleavage:* Perfect on {001}, poor on {201}; (001) ∧ (201) = 38.5°. *Fracture:* Imperfectly conchoidal. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 2.412–2.422 D(calc.) = [2.40] Thermoluminescent.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, rarely reddish or greenish; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on {001}. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$; $X \wedge a = -2°$ to $-8°$. *Dispersion:* $r > v$, weak, crossed. $\alpha = 1.504$–1.507 $\beta = 1.510$–1.513 $\gamma = 1.516$–1.523 2V(meas.) = 82°–84°

Cell Data: *Space Group:* $P2/a$. $a = 11.737$ $b = 5.171$ $c = 7.630$ $\beta = 112.54°$ Z = 2

X-ray Powder Pattern: Harare, Zimbabwe (Salisbury, Rhodesia) (?). (ICDD 14-90). 3.731 (100), 3.672 (34) 3.649 (24), 3.510 (16), 1.934 (7), 2.570 (6), 2.071 (5)

Chemistry:

	(1)
SiO_2	77.80
Al_2O_3	16.41
Fe_2O_3	0.008
MgO	0.038
CaO	0.018
Li_2O	4.45
Na_2O	0.048
K_2O	0.076
H_2O^-	0.08
LOI	0.43
Total	99.358

(1) Rubicon pegmatite, Namibia; Si and Al by XRF, other elements by AA, loss on ignition taken as H_2O^+; corresponds to $Li_{0.92}Al_{0.99}Si_{3.99}O_{10}$.

Occurrence: In granite pegmatites, locally constituting an ore of lithium.

Association: Spodumene, pollucite, lepidolite, tourmaline, topaz, albite, microcline, quartz.

Distribution: On the Island of Utö, and in the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. Around San Piero in Campo, Elba, Italy. From Hirvikallio, Tammela, and Pajula, Finland. From the Rubicon pegmatite, south of Karibib, Namibia. At Bikita, Zimbabwe. In the USA, at Peru, Oxford Co., Maine; from Bolton, Worcester Co., Massachusetts; in California, on Queen and Hiriart Mountains, Pala, and in the Clark vein at Rincon, San Diego Co. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada. In Brazil, from Minas Gerais, in the Maxixe, Lavra Velha, and Lavra do Genipapo pegmatites, near Araçuaí, and in the Taquaral mine, Itinga. In the Londonderry quarry, Coolgardie, Western Australia. At Nagatareyama, Fukuoka Prefecture, Japan. Additional minor localities are known.

Name: From the Greek for *leaf*, in allusion to its perfect basal cleavage.

Type Material: Mining Academy, Freiberg, Germany, 26512.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 311–312. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 271–275. (3) Tagai, T., H. Ried, W. Joswig, and M. Korekawa (1982) Kristallgraphische Untersuchungen eines Petalits mittels Neutronenbeugung und Transmission-elektronenmikroskopie. Zeits. Krist., 160, 159–170 (in German with English abs.). (4) Černý, P. and D. London (1983) Crystal chemistry and stablity of petalite. Tschermaks Mineral. Petrog. Mitt., 31, 81–96.

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Petarasite $Na_5Zr_2Si_6O_{18}(OH,Cl)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals equant, commonly doubly terminated, to 6.5 cm; in irregular grains.

Physical Properties: *Cleavage:* Perfect on {110}, very good on {010}, and distinct on {001}. *Fracture:* Subconchoidal. Hardness = 5–5.5 D(meas.) = 2.88(1) D(calc.) = 2.915

Optical Properties: Transparent to translucent or opaque. *Color:* Light to dark greenish yellow, yellow, dark yellow, pale yellowish brown, brown; in transmitted light, colorless to light greenish yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; $Y = Z$ = pale greenish yellow. *Orientation:* $X = b$; $Z \wedge c = 41.5°$. *Dispersion:* $r < v$, weak. *Absorption:* $Y = Z > X$.
$\alpha = 1.595$–1.596 $\beta = 1.598$–1.600 $\gamma = 1.631$–1.632 2V(meas.) = 29°–43° 2V(calc.) = 28°

Cell Data: *Space Group:* $P2_1/m$. $a = 10.7956(8)$ $b = 14.4928(16)$ $c = 6.6229(6)$ $\beta = 113.214(5)°$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
4.10 (100), 2.924 (100), 7.25 (70), 6.09 (40), 3.220 (30), 3.041 (30), 1.729 (20)

Chemistry:

	(1)
SiO_2	42.9
TiO_2	0.07
ZrO_2	29.5
CaO	0.88
Na_2O	17.3
K_2O	0.25
Cl	2.04
H_2O	7.09
$-O = Cl_2$	0.46
Total	99.57

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of five analyses, H_2O by TGA; one of the H_2O molecules is assumed to be adsorbed based on the crystal structure analysis and IR absorption studies; corresponds to $(Na_{4.69}Ca_{0.13}K_{0.05})_{\Sigma=4.87}(Zr_{2.01}Ti_{0.01})_{\Sigma=2.02}Si_6O_{18}[(OH)_{0.60}Cl_{0.48}]_{\Sigma=1.08}\cdot 3.01H_2O$.

Mineral Group: Lovozerite group.

Occurrence: In a biotite-microcline xenolith and in pegmatitic veins in a nepheline syenite in an intrusive alkalic gabbro-syenite complex.

Association: Biotite, microcline, catapleiite, apatite, zircon, natrolite, nepheline, cancrinite, eudialyte, aegirine, mosandrite, analcime, ancylite, fluorite, sodalite, låvenite, astrophyllite, pyrochlore, calcite, rhodochrosite, albite, arfvedsonite, galena, pyrrhotite.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: In honor of Dr. Peter Tarasoff, amateur mineralogist, Dollard-des-Ormeaux, Quebec, Canada.

Type Material: Royal Ontario Museum, Toronto, M36456–M36458; Canadian Geological Survey, Ottawa; Canadian Museum of Nature, Ottawa, Canada, 43721, 43630, 43631; National Museum of Natural History, Washington, D.C., USA, 148593, 148594.

References: (1) Chao, G.Y., T.T. Chen, and J. Baker (1980) Petarasite, a new hydrated sodium zirconium hydroxychlorosilicate mineral from Mont St.-Hilaire, Quebec. Can. Mineral., 18, 497–502. (2) Ghose, S., C. Wan and G.Y. Chao (1980) Petarasite, $Na_5Zr_2Si_6O_{18}(Cl,OH)\cdot 2H_2O$, a zeolite-type zirconosilicate. Can. Mineral., 18, 503–509. (3) (1981) Amer. Mineral., 66, 1277 (abs. refs. 1 and 2). (4) Perrault, G., G.Y. Chao, and T.T. Chen (1981) Additional data on petarasite from Mont St. Hilaire, Quebec. Can. Mineral., 19, 411–413.

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Petedunnite $Ca(Zn, Mn^{2+}, Fe^{2+}, Mg)Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As portions of an anhedral crystal consisting of a mosaic of 10–100 μm-sized subgrains containing abundant inclusions.

Physical Properties: *Cleavage:* {110}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.68

Optical Properties: Translucent. *Color:* Dark green; in transmitted light, light yellow to pale green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = light yellow; Z = light green. *Orientation:* $Y = b$; $Z \wedge c = 35°–45°$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > X = Y$. $\alpha = 1.68(1)$ $\beta = 1.69(1)$ $\gamma = 1.70(1)$ 2V(meas.) = 70°–90°

Cell Data: *Space Group:* $C2/c$. $a = 9.82(2)$ $b = 9.00(1)$ $c = 5.27(2)$ $\beta = 105.6(2)°$
Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
3.02 (100), 2.537 (80), 2.96 (40), 2.589 (30), 2.022 (30), 6.49 (10), 2.227 (10)

Chemistry:

	(1)
SiO_2	48.4
Al_2O_3	1.2
Fe_2O_3	3.8
FeO	5.7
MnO	5.8
ZnO	12.6
MgO	2.4
CaO	21.3
Na_2O	0.7
Total	101.9

(1) Franklin, New Jersey, USA; by electron microprobe, Fe^{2+}:Fe^{3+} by charge balance; corresponds to $(Ca_{0.92}Na_{0.06}Mn_{0.02})_{\Sigma=1.00}(Zn_{0.37}Fe^{2+}_{0.19}Mn_{0.18}Mg_{0.14}Fe^{3+}_{0.12})_{\Sigma=1.00}(Si_{1.94}Al_{0.06})_{\Sigma=2.00}O_6$.

Mineral Group: Pyroxene group.

Occurrence: In a metamorphosed stratiform zinc deposit, apparently formed under relatively high activity of sulfur and oxygen.

Association: Calcite, gahnite, willemite, genthelvite, garnet, albite, sphalerite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: In honor of Dr. Pete J. Dunn, Department of Mineral Sciences, Smithsonian Institution, Washington, D.C., USA, for his contributions to the mineralogy of Franklin and Sterling Hill, New Jersey, USA.

Type Material: Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA, 162211.

References: (1) Essene, E.J. and D.R. Peacor (1987) Petedunnite ($CaZnSi_2O_6$), a new zinc clinopyroxene from Franklin, New Jersey, and phase equilibria for zincian pyroxenes. Amer. Mineral., 72, 157–166.

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Peterbaylissite $Hg_3^{1+}(CO_3)(OH)\cdot 2H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral to subhedral crystals, to 0.2 mm, elongated parallel [001], wedgelike, may be platy; isolated and in clusters.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = < 5
D(meas.) = n.d. D(calc.) = 7.14

Optical Properties: Opaque. *Color:* Black to dark red-brown; in polished section, gray with slight blue tinge. *Streak:* Dark brownish black. *Luster:* Submetallic to adamantine. *Optical Class:* Biaxial. *Anisotropism:* Weak, dark gray to brown. *Bireflectance:* Weak to moderate.

R_1–R_2: (400) 12.0–13.2, (420) 11.8–12.8, (440) 11.6–12.6, (460) 11.5–12.3, (480) 11.3–12.1, (500) 11.2–11.9, (520) 11.1–11.7, (540) 11.0–11.6, (560) 10.9–11.5, (580) 10.9–11.5, (600) 10.8–11.4, (620) 10.7–11.3, (640) 10.8–11.2, (660) 10.6–11.2, (680) 10.6–11.2, (700) 10.6–11.2

Cell Data: *Space Group: Pcab.* $a = 11.130(2)$ $b = 11.139(3)$ $c = 10.725(3)$ Z = 8

X-ray Powder Pattern: Clear Creek claim, California, USA.
2.648 (100), 2.969 (70), 2.786 (70), 2.419 (60), 4.84 (50), 6.35 (40), 4.95 (40)

Chemistry:

	(1)	(2)
CO_2	n.d.	6.16
Hg_2O	87.4	87.54
H_2O	n.d.	6.30
Total		100.00

(1) Clear Creek claim, California, USA; by electron microprobe, average of two analyses; $(CO_3)^{2-}$, $(OH)^{1-}$, H_2O, confirmed by IR, the chemical formula determined by crystal-structure analysis. (2) $Hg_3(CO_3)(OH)\cdot 2H_2O$.

Polymorphism & Series: Dimorphous with clearcreekite.

Occurrence: Very rare in a mercury deposit in silicate–carbonate rock, hydrothermally altered from serpentinite, probably formed as an alteration product of cinnabar.

Association: Ferroan magnesiochromite, ferroan magnesite, cinnabar, metacinnabar, mercury, quartz.

Distribution: From near the Clear Creek mercury mine, New Idria district, San Benito Co., California, USA.

Name: Honoring Dr. Peter Bayliss (1936–), Professor of Mineralogy, University of Calgary, Calgary, Canada, for his many contributions to mineralogy.

Type Material: The Natural History Museum, London, England, 1993,431 and E.1492; Canadian Geological Survey, Ottawa, Canada, 67533.

References: (1) Roberts, A.C., T.S. Ercit, L.A. Groat, A.J. Criddle, R.C. Erd, and R.S. Williams (1995) Peterbaylissite, $Hg_3^{1+}(CO_3)(OH)\cdot 2H_2O$, a new mineral species from the Clear Creek claim, San Benito Co., California. Can. Mineral., 33, 47–53. (2) (1995) Amer. Mineral., 80, 1074–1075 (abs. ref. 1).

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Petersenite-(Ce) $Na_4(Ce,La,Nd)_2(CO_3)_5$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* 2. Crystals are prismatic to acicular, to 7 mm, typically in parallel aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = ∼3 D(meas.) = 3.69(3) D(calc.) = 3.67

Optical Properties: Transparent to translucent. *Color:* Gray with a pinkish tint, yellow, mauve. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+) or (–). *Orientation:* $X = b$; $Z = a$; $Y \wedge c = 30°$. *Dispersion:* Moderate. $\alpha = 1.623(1)$ $\beta = 1.636(1)$ $\gamma = 1.649(1)$ 2V(meas.) = 89.7°–90° 2V(calc.) = 89.8°

Cell Data: *Space Group:* $P2_1$. $a = 20.872$–20.89 $b = 6.338$–6.367 $c = 10.60$–10.601 $\beta = 120.50° - 120.8°$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.607 (10), 5.22 (5), 3.70 (4), 9.13 (3), 4.13 (3), 2.148 (3), 1.921 (3)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	[32.92]	[33.69]	Sm_2O_3	0.60	0.39
ThO_2		0.78	CaO	1.32	5.52
Y_2O_3		0.04	SrO	1.70	4.10
La_2O_3	14.49	11.97	BaO	0.32	0.42
Ce_2O_3	23.66	17.80	Na_2O	17.38	17.51
Pr_2O_3	2.00	1.54	Total	[100.21]	[98.96]
Nd_2O_3	5.82	5.20			

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of analyses on three grains, CO_2 calculated from crystal-structure analysis; corresponds to $(Na_{3.75}Ca_{0.16})_{\Sigma=3.91}(Ce_{0.96}La_{0.59}Nd_{0.23}Sr_{0.11}Pr_{0.08}Sm_{0.02}Ba_{0.01})_{\Sigma=2.00}(CO_3)_5$. (2) Mt. Koashva, Kola Peninsula, Russia; by electron microprobe, CO_2 calculated for stoichiometry; corresponds to $(Na_{3.70}Ca_{0.30})_{\Sigma=4.00}(Ce_{0.71}La_{0.48}Ca_{0.34}Sr_{0.25}Nd_{0.20}Pr_{0.06}Th_{0.02}Ba_{0.02}Sm_{0.01})_{\Sigma=2.09}(CO_3)_5$.

Occurrence: A rare component in pegmatites in nepheline–sodalite syenite near a contact with a hornfels unit, associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in the core of a large pegmatite in a differentiated alkalic massif (Mt. Koashva, Kola Peninsula, Russia).

Association: Aegirine, albite, microcline, "biotite", "chlorite", polylithionite, calcite, rhodochrosite, analcime, catapleiite, epididymite, eudialyte, serandite, fluorite, galena, sphalerite, trona, shomiokite-(Y), adamsite-(Y) (Mont Saint-Hilaire, Canada); aegirine, nacaphite, vitusite-(Ce), pectolite, thermonatrite, lomonosovite, sazykinaite-(Y) (Mt. Koashva, Kola Peninsula, Russia).

Distribution: From Mont Saint-Hilaire, Quebec, Canada. On Mt. Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: To honor Dr. Ole Valdemar Petersen (1939–), Curator, Geology Museum, Copenhagen, Denmark, for his work on the mineralogy of alkaline rocks.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81511.

References: (1) Grice, J.D., J. Van Velthuizen, and R.A. Gault (1994) Petersenite-(Ce), a new mineral from Mont Saint-Hilaire, and its structural relationship to other REE carbonates. Can. Mineral., 32, 405–414. (2) (1995) Amer. Mineral., 80, 406 (abs. ref. 1). (3) Pekov, I.V., N.V. Chukanov, and Y.V. Belovitskaya (1998) Khanneshite and petersenite-(Ce) from the Khibiny massif. Zap. Vses. Mineral. Obshch., 127(2), 92–100 (in Russian with English abs.).

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Petersite-(Y) $(Ca, Y, Ce, Nd)Cu_6(PO_4)_3(OH)_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6. As prismatic crystals, showing only $\{10\bar{1}0\}$ and {0001}, to 0.1 mm, in clusters and radiating sprays, which may be nearly spherical.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.41 D(calc.) = 3.40

Optical Properties: Semitransparent. *Color:* Bright yellowish green. *Luster:* Highly vitreous on $\{10\bar{1}0\}$ to dull on {0001}.
Optical Class: Uniaxial (+). *Pleochroism:* Strong; O = light yellowish green; E = green.
Absorption: $E \gg O$. $\omega = 1.666(4)$ $\epsilon = 1.747(4)$

Cell Data: *Space Group:* $P6_3/m$ or $P6_3$. $a = 13.288(5)$ $c = 5.877(5)$ Z = 2

X-ray Powder Pattern: Laurel Hill, New Jersey, USA.
11.6 (100), 2.433 (60), 4.36 (50), 3.49 (40), 2.877 (40), 2.509 (30), 1.961 (20)

Chemistry:

	(1)
P_2O_5	23.1
Y_2O_3	2.5
La_2O_3	1.0
Ce_2O_3	2.5
Nd_2O_3	1.2
Sm_2O_3	1.2
FeO	0.8
CuO	52.1
CaO	2.4
H_2O	[13.2]
Total	[100.0]

(1) Laurel Hill, New Jersey, USA; total Fe as FeO, determined by microchemical test, H_2O by difference; corresponds to $(Ca_{0.40}Y_{0.20}Ce_{0.14}Nd_{0.12}Fe_{0.10}Sm_{0.06}La_{0.06})_{\Sigma=1.08}$ $Cu_{6.04}(PO_4)_3(OH)_{5.80} \cdot 3.39H_2O$.

Mineral Group: Mixite group.

Occurrence: A very rare secondary mineral in biotite-plagioclase hornfels near a diabase stock cutting Triassic sediments (Laurel Hill, New Jersey, USA).

Association: Chalcopyrite, malachite, chrysocolla, hematite, chlorite, "opal" (Laurel Hill, New Jersey, USA); malachite, quartz (Herrensegen mine, Germany).

Distribution: From Laurel Hill, Secaucas, Hudson Co., New Jersey, USA. In Germany, from the Herrensegen mine, near Schapbach, and the Silberbrünnle mine, near Gengenbach (Nd-rich), Black Forest. At the Sa Duchessa mine, Oridda district, Sardinia. From the Hanama quarry, Hai-Yama, Shiga Prefecture, Japan.

Name: To honor the brothers Thomas A. Peters (1947–), Curator of minerals at the Paterson Museum, Paterson, New Jersey, USA, and Joseph Peters (1951–), on the mineralogy curatorial staff of the American Museum of Natural History, New York City, New York, USA, and for *yttrium* as the dominant rare-earth element.

Type Material: National Museum of Natural History, Washington, D.C., USA, 148973.

References: (1) Peacor, D.R. and P.J. Dunn (1982) Petersite, a REE and phosphate analog of mixite. Amer. Mineral., 67, 1039–1042.

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Petewilliamsite $(Ni,Co)_{30}(As_2O_7)_{15}$

Crystal Data: Monoclinic. *Point Group:* 2. As crudely formed equant grains, to 0.5 mm, with rounded crystal faces.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = <5 D(meas.) = n.d. D(calc.) = 4.904

Optical Properties: Translucent. *Color:* Dark violet-red to dark brownish red, dark gray in reflected light with orange to multicolored internal reflections. *Streak:* Pale reddish brown to purplish brown. *Luster:* Vitreous. Megascopically indistinguishable from brownish purple xanthiosite.
R = (470) 9.59, (546) 9.32, (589) 9.27, (650) 9.33

Cell Data: *Space Group: C2.* a = 33.256(5) b = 8.482(1) c = 14.191(2) β = 104.145(3)°
Z = 2

X-ray Powder Pattern: Johanngeorgenstadt, Saxony, Germany.
3.118 (100), 3.005 (60), 2.567 (50), 1.637 (50), 4.235 (30), 1.507(30B), 2.452 (20)

Chemistry:

	(1)	(2)
NiO	19.45	18.47
CoO	18.39	17.74
CuO	3.40	3.35
CaO	0.17	
FeO	0.04	
As_2O_5	60.32	60.45
Total	101.77	100.00

(1) Johanngeorgenstadt, Saxony, Germany; average of 3 electron microprobe analyses, corresponding to $(Ni^{2+}_{14.66}Co^{2+}_{13.82}Cu^{2+}_{2.41}Ca_{0.17}Fe^{2+}_{0.03})_{\Sigma=31.09}(As^{5+}_{1.97}O_7)_{15}$.
(2) $(Ni_{14.1}Co_{13.5}Cu_{2.4})_{\Sigma=30}(As_2O_7)_{15}$.

Occurrence: Known from one specimen; therein the product of oxidation of nickeline.

Association: Xanthiosite, aerugite, paganoite, nickeline, bismuth, bunsenite, rooseveltite, quartz.

Distribution: Johanngeorgenstadt, Saxony, Germany.

Name: Honors geochemist–crystallographer Professor Peter Allan Williams (b. 1950) of the University of Western Sydney, New South Wales, Australia.

Type Material: Systematic Reference Series of the National Mineral Collection, Geological Survey of Canada, Ottawa, Ontario (#68097), and the Natural History Museum, London, England; BM 2003, 6.

References: (1) Roberts, A.C., P.C. Burns, R.A. Gault, A.J. Criddle, and M.N. Feinglos (2004) Petewilliamsite, $(Ni,Co)_{30}(As_2O_7)_{15}$, a new mineral from Johanngeorgenstadt, Saxony, Germany: description and crystal structure. Mineral. Mag., 68, 231–240. (2) (2005) Amer. Mineral., 90, 273 (abs. ref. 1).

Petitjeanite $Bi_3O(PO_4)_2(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are poorly developed, tabular on {100}, elongated along [001], showing {010}, {001}, {011}, small {$\overline{1}$10}, to 0.2 mm, in spherical aggregates and crusts. *Twinning:* Common, interpenetrant, by rotation about [010].

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 VHN = 360(30) (25 g load). D(meas.) = n.d. D(calc.) = 6.99

Optical Properties: Transparent to translucent in thin fragments. *Color:* White, pale pink, pale to dark yellow; may be dark brown to nearly black. *Streak:* White. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, distinct. $\alpha = 2.06(2)$ β = n.d. $\gamma = 2.13(2)$ $2V(meas.) = 75(5)^\circ$

Cell Data: *Space Group:* [$P\overline{1}$] (by analogy to preisingerite). $a = 9.798(3)$ $b = 7.250(3)$ $c = 6.866(2)$ $\alpha = 88.28(2)^\circ$ $\beta = 115.27(2)^\circ$ $\gamma = 110.70(3)^\circ$ Z = 2

X-ray Powder Pattern: Gadernheim, Germany; very similar to preisingerite and schumacherite.
3.188 (100), 3.135 (95), 3.247 (87), 3.026 (75), 2.953 (47), 4.437 (46), 2.165 (41)

Chemistry:

	(1)	(2)	(3)
P_2O_5	14.34	14.72	16.70
As_2O_5	2.99	2.93	
V_2O_5	0.01	0.02	
Bi_2O_3	76.04	75.26	82.24
PbO	3.39	4.88	
H_2O	[1.18]	[1.25]	1.06
Total	[97.95]	[99.06]	100.00

(1–2) Gadernheim, Germany; by electron microprobe, averages of five and eight analyses, H_2O calculated for charge balance; (1) corresponds to $(Bi_{2.86}Pb_{0.13})_{\Sigma=2.99}O_{0.85}[(PO_4)_{1.77}(AsO_4)_{0.23}]_{\Sigma=2.00}(OH)_{1.15}$. (3) $Bi_3O(PO_4)_2(OH)$.

Polymorphism & Series: Forms series with preisingerite and schumacherite.

Occurrence: A rare secondary mineral in a silicified barite vein (Gadernheim, Germany).

Association: Bismutite, mixite, reichenbachite, pyromorphite, malachite (Gadernheim, Germany).

Distribution: In Germany, from Gadernheim, and on the Hohenstein, near Reichenbach, Hesse; at the Pucher shaft, Schneeberg, Saxony. From near Smrkovec, Slavkovský Les Mountains, about 10 km north-northeast of Mariánské Lázně (Marienbad), Czech Republic.

Name: Honoring Klaus Petitjean, amateur mineral collector who has discovered several new species in the Reichenbach, Germany district.

Type Material: Mineralogy Institute, Ruhr University, Bochum, Germany.

References: (1) Krause, W., K. Belendorff, and H.-J. Bernhardt (1993) Petitjeanite, Bi_3O additional data for the corresponding arsenate and vanadate, preisingerite and schumacherite. Neues Jahrb. Mineral., Monatsh., 487–503. (2) (1994) Amer. Mineral., 79, 764–765 (abs. ref. 1).

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Petrovicite $PbHgCu_3BiSe_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals are tabular, to a few tenths of one mm.

Physical Properties: *Cleavage:* Imperfect, parallel to flattening of crystals. Hardness = ∼3 VHN = 102 (25 g load). D(meas.) = n.d. D(calc.) = 7.707

Optical Properties: Opaque. *Color:* In polished section, cream colored. *Luster:* Strong metallic. *Anisotropism:* Weak; dark green and violet.

R_1–R_2: (400) 44.0–44.4, (420) 44.1–44.8, (440) 44.2–45.2, (460) 44.3–45.4, (480) 44.4–45.7, (500) 44.7–46.1, (520) 45.1–46.3, (540) 45.2–46.5, (560) 45.2–46.4, (580) 45.1–46.2, (600) 45.1–46.0, (620) 45.0–45.9, (640) 44.9–45.8, (660) 44.9–45.7, (680) 44.8–45.6, (700) 44.8–45.5

Cell Data: *Space Group:* $Pnam$ or $Pna2_1$. $a = 16.176(5)$ $b = 14.684(5)$ $c = 4.331(3)$ $Z = 4$

X-ray Powder Pattern: Petrovice deposit, Czech Republic.
3.120 (100), 2.961 (100), 3.546 (80), 3.186 (80), 3.621 (70), 2.720 (50), 2.262 (50)

Chemistry:

	(1)	(2)	(3)
Pb	16.7	17.3	17.24
Hg	17.4	17.9	16.69
Cu	16.0	15.3	15.85
Bi	16.6	17.4	17.38
Se	34.4	32.6	32.84
Total	101.1	100.5	100.00

(1) Petrovice deposit, Czech Republic; by electron microprobe, corresponding to $Pb_{0.95}Hg_{1.02}Cu_{2.97}Bi_{0.93}Se_{5.13}$. (2) Do.; corresponding to $Pb_{1.01}Hg_{1.08}Cu_{2.91}Bi_{1.01}Se_{4.99}$. (3) $PbHgCu_3BiSe_5$.

Occurrence: In hydrothermal dolomite-calcite veins with other selenides.

Association: Berzelianite, eucairite, crookesite, tyrrellite, ferroselite, bukovite, kruťaite, athabascaite, umangite, eskebornite, calcite, dolomite.

Distribution: From the Petrovice uranium deposit, near Ždár, Czech Republic [TL].

Name: For its occurrence in the Petrovice deposit, Czech Republic.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., M. Kvaček, and P. Picot (1976) La petrovicite, $Cu_3HgPbBiSe_5$, un nouveau minéral (in French with English abs.). Bull. Soc. fr. Minéral., 99, 310–313. (2) (1977) Amer. Mineral., 62, 594–595 (abs. ref. 1).

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Petrovskaite **AgAu(S, Se)**

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As fine-grained rims, to 20 μm, on gold.

Physical Properties: *Tenacity:* Brittle. Hardness = 2–2.5 VHN = 39.9–47.8
D(meas.) = n.d. D(calc.) = 9.5

Optical Properties: Opaque. *Color:* Dark gray to black. *Streak:* Dark gray. *Luster:* Dull metallic. *Anisotropism:* Slight.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. $a = 4.943(9)$ $b = 6.670(9)$ $c = 7.221(9)$ $\beta = 95.68(7)^\circ$ Z = 4

X-ray Powder Pattern: Maikain deposit, Kazakhstan (intensities from synthetic AgAuS).
2.77 (10), 2.63 (5), 2.39 (4), 2.254 (4), 1.471 (4), 7.25 (3), 3.87 (3)

Chemistry:

	(1)
Au	58.6
Ag	31.0
S	9.54
Se	1.35
Total	100.5

(1) Maikain deposit, Kazakhstan; by electron microprobe, average of seven analyses; corresponding to $Ag_{0.96}Au_{0.99}(S_{0.99}Se_{0.06})_{\Sigma=1.05}$.

Occurrence: At a depth of about 60–65 m in a gold deposit.

Association: Gold, chlorargyrite.

Distribution: In the Maikain gold deposit, Pavlodar district, northeast Kazakhstan [TL].

Name: In honor of Nina Vasil'evna Petrovskaya (1910–1991), Russian mineralogist, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia, specialist in gold deposits.

Type Material: Central Siberian Geological Museum, Novosibirsk, III-70/1; Mineralogical Museum, St. Petersburg University, St. Petersburg, 17109; Mining Institute, St. Petersburg, Russia, 2006/1.

References: (1) Nesterenko, G.V., A.I. Kuznetsova, N.A. Pal'chik, and Y.G. Lavrent'ev (1984) Petrovskaite, AuAg(S, Se), a new selenium-containing sulfide of gold and silver. Zap. Vses. Mineral. Obshch., 113, 602–607 (in Russian). (2) (1985) Amer. Mineral., 70, 1331 (abs. ref. 1).

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Petrukite $(Cu, Fe, Zn)_2(Sn, In)S_4$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Petscheckite $U^{4+}Fe^{2+}(Nb,Ta)_2O_8$

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Crystal Data: Hexagonal; metamict. *Point Group:* $\overline{3}\ 2/m$. In elongated hexagonal crystals, to 4 cm.

Physical Properties: Hardness = ∼5 D(meas.) = ∼7 D(calc.) = 7.2 Radioactive.

Optical Properties: Opaque. *Color:* Black; white with orange tinge in reflected light, with red-brown internal reflections. *Streak:* Brownish black. *Luster:* Metallic.
Optical Class: Isotropic.
R: ∼15

Cell Data: *Space Group:* $P\overline{3}1m$ for material heated to 650 °C. $a = 6.42$ $c = 4.02$ Z = 1

X-ray Powder Pattern: Berere, Madagascar; after heating at 650 °C.
4.02 (10), 3.21 (10), 2.51 (8), 1.697 (4d), 1.850 (3), 2.01 (2), 1.861 (2)

Chemistry:

	(1)
$(Nb,Ta)_2O_5$	45.99
UO_2	40.5
ZrO_2	0.42
Al_2O_3	0.71
Fe_2O_3	10.01
FeO	0.10
MnO	1.32
CaO	0.49
K_2O	0.05
Total	99.59

(1) Berere, Madagascar; ["oxy-petscheckite" with Fe^{2+} oxidized to Fe^{3+}] corresponding to $(U_{0.91}Ca_{0.05}Zr_{0.02}K_{0.01})_{\Sigma=0.99}(Fe^{3+}_{0.64}Mn^{2+}_{0.11}Al_{0.08}Fe^{2+}_{0.01})_{\Sigma=0.84}(Nb_{1.55}Ta_{0.33}Fe_{0.12})_{\Sigma=2.00}O_8$.

Occurrence: An accessory mineral in a zoned pegmatite.

Association: Magnetite, columbite, liandratite, pyrochlore, strüverite, monazite, ilmenite, garnet, tourmaline, beryl, quartz, feldspar.

Distribution: From the Antsakoa I pegmatite, near Berere, about 40 km northeast of Tsaratanana, Madagascar.

Name: Honors Eckehard Petsch, of Idar-Oberstein, Germany, who prospected extensively in Madagascar.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145619.

References: (1) Mücke, A. and H. Strunz (1978) Petscheckite and liandratite, two new pegmatite minerals from Madagascar. Amer. Mineral., 63, 941–946.

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Petterdite $\mathbf{PbCr_2^{3+}(CO_3)_2(OH)_4 \cdot H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 15 μm, roughly rectangular, flattened on {010} and elongated along [001] or [100], with frayed and corroded terminations in the direction of [001]. These are loosely stacked and randomly aggregated in botryoidal, earthy to porous crusts.

Physical Properties: *Cleavage:* On {100}, fair; on {010}, possible. Hardness = ∼2 (by analogy with dundasite). D(meas.) = n.d. D(calc.) = 3.947

Optical Properties: Translucent. *Color:* Pale to deep lilac, pinkish violet, pale gray. *Streak:* Pale violet. *Luster:* Pearly to earthy.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = colorless to pale grayish pink; Z = grayish pink. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Absorption:* $X < Z$. $\alpha = 1.704(5)$ $\beta = \sim 1.802$ $\gamma = 1.842(5)$ 2V(meas.) = n.d. 2V(calc.) = ∼62°

Cell Data: *Space Group:* [*Pbnm*] (by analogy to dundasite). $a = 9.079(3)$ $b = 16.321(9)$ $c = 5.786(7)$ Z = 4

X-ray Powder Pattern: Red Lead mine, Tasmania, Australia.
7.937 (100), 3.633 (70), 4.686 (50b), 3.270 (40), 2.718 (40), 2.690 (40), 6.091 (30)

Chemistry:

	(1)	(2)
Sb_2O_5	0.67	
CO_2	18.3	17.02
Cr_2O_3	22.64	29.38
Al_2O_3	3.65	
PbO	43.33	43.15
SrO	1.40	
H_2O	[10.01]	10.45
Total	[100.00]	100.00

(1) Red Lead mine, Tasmania, Australia; by electron microprobe, total Sb as Sb_2O_5, total Cr as Cr_2O_3, CO_2 by CHN analyzer, H_2O by difference; presence of $(CO_3)^{2-}$, $(OH)^{1-}$, and H_2O confirmed by IR; corresponds to $(Pb_{0.99}Sr_{0.07})_{\Sigma=1.06}(Cr_{1.52}Al_{0.36}Sb_{0.02})_{\Sigma=1.90}(CO_3)_{2.12}(OH)_{3.62} \cdot 1.02H_2O$. (2) $PbCr_2(CO_3)_2(OH)_4 \cdot H_2O$.

Occurrence: A rare secondary species probably formed by alteration of galena by Cr-bearing meteoric waters (Red Lead mine, Australia); in the oxidation zone of a hydrothermal vein cutting serpentinite (Callenberg mine, Germany).

Association: Anglesite, crocoite, "limonite" (Red Lead mine, Australia); crocoite, cerussite, bindheimite, pyromorphite, galena (Callenberg mine, Germany).

Distribution: From the Red Lead mine, Dundas, Tasmania, Australia. In the Callenberg nickel mine, near Hohenstein-Ernstthal, Saxony, Germany.

Name: Honors William Frederick Petterd (1849–1910), mineral collector who published several catalogs of Tasmanian mineral occurrences.

Type Material: Museum Victoria, Melbourne, Australia, M38601.

References: (1) Birch, W.D., U. Kolitsch, T. Witzke, L. Nasdala, and R.S. Bottrill (2000) Petterdite, the Cr-dominant analogue of dundasite, a new mineral species from Dundas, Tasmania, Australia and Callenberg, Saxony, Germany. Can. Mineral., 38, 1467–1476. (2) (2001) Amer. Mineral., 86, 1113 (abs. ref. 1).

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Petzite Ag_3AuTe_2

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Crystal Data: Cubic. *Point Group:* 432. Massive, fine granular to compact and as irregular shaped blebs, to 2 mm.

Physical Properties: *Cleavage:* {001}. *Fracture:* Subconchoidal. *Tenacity:* Slightly sectile to brittle. Hardness = 2.5–3 VHN = 48 (10 g load). D(meas.) = 8.7–9.4 D(calc.) = 8.74

Optical Properties: Opaque. *Color:* Bright steel-gray to iron-gray to iron-black, commonly tarnished from bronze-yellow to sooty black; in reflected light, grayish white with a pale bluish tint. *Luster:* Metallic. *Anisotropism:* Noticeable in part.
R: (400) 45.0, (420) 43.7, (440) 42.4, (460) 41.4, (480) 40.6, (500) 39.9, (520) 39.3, (540) 38.8, (560) 38.5, (580) 38.3, (600) 38.2, (620) 38.1, (640) 38.0, (660) 37.8, (680) 37.8, (700) 37.8

Cell Data: *Space Group:* $I4_132$. $a = 10.385(4)$ $Z = 8$

X-ray Powder Pattern: Botés, Romania.
2.77 (100), 2.12 (80), 2.03 (70), 2.44 (60), 2.32 (60), 7.31 (50), 1.893 (50)

Chemistry:

	(1)	(2)	(3)
Ag	41.37	41.87	41.71
Au	23.42	25.16	25.39
Te	33.00	33.21	32.90
Hg	2.26		
Cu	0.16		
Total	100.21	100.24	100.00

(1) Kalgoorlie, Australia. (2) Mother Lode district, California, USA. (3) Ag_3AuTe_2.

Occurrence: With other tellurides in vein-controlled gold deposits.

Association: Gold, hessite, sylvanite, krennerite, calaverite, altaite, montbrayite, melonite, frohbergite, tetradymite, rickardite, vulcanite, pyrite.

Distribution: Noted in small amounts at a number of localities other than those listed here. In Romania, from Săcărîmb (Nagyág) [TL], Botés, and Baia Sprie (Felsőbánya). At the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. From the Byn'govsk Au–Te deposit, Central Ural Mountains, Russia. In the Zhana-Tyube Au–Te deposit, northern Kazakhstan. In the USA, at Gold Hill, Boulder Co., Lake City, Hinsdale Co., and Leadville, Lake Co., Colorado; from California, in the Golden Rule and Norwegian mines, Tuttletown, and the Jamestown mine, Tuolumne Co., in the Stanislaus and Melones mines, Carson Hill district, Calaveras Co., and in other mines along the Mother Lode; from the Buster mine, Olinghouse district, Washoe Co., and elsewhere in Nevada. In Canada, at the Hollinger mine, Timmins, and the Lake Shore mine, Kirkland Lake, Ontario; in Quebec, at the Robb-Montbray mine, Montbray Township, the Noranda mine at Rouyn, the Horne mine at Noranda, and many other localities. From El Indio, east of Coquimbo, Chile. At Kalgoorlie, Western Australia. From the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands. At the Bulawan deposit, Negros Occidental, Phillipines.

Name: After W. Petz, who first analyzed the mineral.

Type Material: Harvard University, Cambridge, Massachusetts, 99348; National Museum of Natural History, Washington, D.C., USA, R9556.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 186–187. (2) Frueh, A.J., Jr. (1959) The crystallography of petzite, Ag_3AuTe_2. Amer. Mineral., 44, 693–701. (3) Chamid, S., E.A. Pobedimskaya, E.M. Spiridonov, and N.V. Belov (1978) Refinement of the structure of petzite $AuAg_3Te_2$. Kristallografiya (Sov. Phys. Crystal.), 23, 483–486 (in Russian). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 434.

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Pezzottaite $Cs(Be_2Li)Al_2Si_6O_{18}$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ 2/*m*. As hexagonal tabular crystals, to 10 cm, or equant to elongated flat crystals. Well-formed crystals display dominant {001} and subordinate {100} and {101}. Also as subparallel or interpenetrant crystal aggregates.

Physical Properties: *Cleavage:* Imperfect on {001}. *Tenacity:* Brittle. *Fracture:* Conchoidal to irregular. Hardness = 8 D(meas.) = 2.97-3.14 (variable with Cs content) D(calc.) = 3.06

Optical Properties: Transparent to translucent. *Color:* Raspberry-red to pink. *Streak:* Colorless to white. *Luster:* Vitreous. Some specimens display chatoyancy.
Optical Class: Uniaxial (-). ε = 1.611 ω = 1.620 *Pleochroism:* Strong, *E* = Orange-red, *O* = Purple-violet.

Cell Data: Space Group: $R\bar{3}\,c$. a = 15.946(4) c = 27.803(8) Z = 18

X-ray Powder Pattern: Sakavalana pegmatite, Fianarantsoa province, central Madagascar. 3.271 (100), 2.871 (52), 3.027 (41), 3.019 (29), 2.215 (14), 1.636 (14), 2.229 (12), 1.749 (12)

Chemistry:

	(1)		(1)
SiO_2	54.58	Rb_2O	0.44
TiO_2	0.01	Cs_2O	18.23
Al_2O_3	16.88	Li_2O	2.12
FeO	0.02	BeO	8.14
MnO	0.02	H_2O	0.28
CaO	0.22	Total	101.54
Na_2O	0.46		
K_2O	0.14		

(1) Sakavalana pegmatite, Fianarantsoa province, central Madagascar; laser ablation ICP mass spectroscopic analysis, IR spectroscopy confirms H_2O; corresponds to $(Cs_{0.83}Rb_{0.03}Na_{0.10}K_{0.02}Ca_{0.02})_{\Sigma=1.00}(Be_{2.10}Li_{0.92})Al_{2.14}Si_{5.86}O_{18}$.

Occurrence: A late-stage hydrothermal mineral in miarolitic pockets in and near the core of a differentiated, rare-element, granitic pegmatite dike.

Association: Smoky quartz, K-feldspar (‘amazonite’), albite (‘cleavelandite’), tourmaline-group minerals, spodumene, lithian muscovite, danburite.

Distribution: From the Sakavalana pegmatite, Ampandramaika-Malakialina pegmatite district, a few kilometers northwest of Ambatovita village, Fianarantsoa province, central Madagascar. Also reported from Afghanistan and Myanmar.

Name: Honors Federico Pezzotta (b. 1965), mineralogist at the Natural History Museum, Milan, Italy, in recognition of his contributions to Madagascar mineralogy.

Type Material: National Museum of Natural History, Washington, D.C., USA; the Canadian Museum of Nature, Ottawa, Canada, and the Natural History Museum, Bern, Switzerland (NMBE-36990).

References: (1) Laurs, B.M., W.B. Simmons, G.R. Rossman, E.P. Quinn, S.F. Mc-Clure, A. Peretti, T. Armbruster, F.C. Hawthorne, A.U. Falster, D. Günther, M.A. Cooper, and B. Grobéty (2003) Pezzottaite from Ambatovita, Madagascar: A new gem mineral. Gems & Gemology, 39, 284-301. (2) Hawthorne, F.C., M.A. Cooper, W.B. Simmons, A.U. Falster, B.M. Laurs, T. Armbruster, G.R. Rossman, A. Peretti, D. Günter [sic], and B. Grobéty (2004) Pezzottaite, $Cs(Be_2Li)Al_2Si_6O_{18}$, a spectacular new beryl-group mineral from the Sakavalana pegmatite, Fianarantsoa Province, Madagascar. Mineral. Record, 35, 369-78. (3) (2005) Amer. Mineral., 90, 1231 (abs. refs. 1 & 2). (4) Gatta, G. Diego, I. Adamo, M. Meven, and E. Lambruschi (2012) A single-crystal neutron and X-ray diffraction study of pezzottaite, $Cs(Be_2Li)Al_2Si_6O_{18}$. Physics and Chemistry of Minerals, 39(10), 829-840.

Pharmacolite $Ca(HAsO_4)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Rarely as crystals, flattened on {010}, elongated along [001], showing {110}, {010}, {011}, {$\bar{1}$12}, several other forms. Commonly acicular, fibrous, to 1.5 cm; may be botryoidal to stalactitic.

Physical Properties: *Cleavage:* On {010}, perfect. *Fracture:* Uneven. *Tenacity:* Flexible. Hardness = 2–2.5 D(meas.) = 2.53–2.725 D(calc.) = 2.703

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale gray; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = -29°$. *Dispersion:* $r > v$. $\alpha = 1.583$ $\beta = 1.589$ $\gamma = 1.594$ 2V(meas.) = 79°24′

Cell Data: *Space Group:* Ia. $a = 5.9745(5)$ $b = 15.4340(15)$ $c = 6.2797(6)$ $\beta = 114°50(1)'$ Z = 4

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France.
4.30 (10), 7.7 (9), 2.70 (9), 2.66 (9), 3.08 (8), 3.02 (8), 5.1 (7)

Chemistry:

	(1)	(2)
P_2O_5	0.30	
As_2O_5	50.54	53.19
SiO_2	0.70	
Fe_2O_3	0.35	
MgO	0.50	
CaO	23.90	25.96
H_2O	23.80	20.85
Total	100.09	100.00

(1) Sainte-Marie-aux-Mines, France. (2) $Ca(HAsO_4)\cdot 2H_2O$.

Occurrence: An uncommon secondary mineral formed by oxidation of earlier arsenic-bearing minerals.

Association: Picropharmacolite, hörnesite, haidingerite.

Distribution: In Germany, from Wittichen, Black Forest, in the Anton and Sofia mines; at St. Andreasberg, Harz Mountains; in the Rosenkrantz mine, Schneeberg, Saxony. At Nowa Ruda, Poland. Long crystals from Jáchymov (Joachimsthal), Czech Republic. At Săcărîmb, Romania. From Sainte-Marie-aux-Mines, Haut-Rhin, France. Found at Bou Azzer, Morocco. In the USA, at the Getchell mine, Potosi district, Humboldt Co., and the White Caps mine, Manhattan district, Nye Co., and the Gold Bar mine, Antelope district, Eureka Co., Nevada; at Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in the OK mine, San Gabriel Canyon, Los Angeles Co., California. Some additional older localities may require modern confirmation.

Name: From the Greek for *poison*, as an arsenic-containing mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 706–708. (2) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésiens naturels. Bull. Soc. fr. Minéral., 87, 169–211 (in French).
(3) Ferraris, G. (1969) The crystal structure of pharmacolite, $CaH(AsO_4)\cdot 2H_2O$. Acta Cryst., 25, 1544–1550. (4) Ferraris, G., D.W. Jones, and J. Yerkess (1971) Determination of hydrogen atom positions in the crystal structure of pharmacolite, $CaHAsO_4\cdot 2H_2O$, by neutron diffraction. Acta Cryst., 27, 349–354.

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Pharmacosiderite $KFe_4^{3+}(AsO_4)_3(OH)_4 \cdot 6{-}7H_2O$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Commonly in good crystals, dominantly cubic, striated diagonally, with minor {111}, {$\bar{1}$11}, {011}, {122}, to 2 cm. May be granular or earthy. *Twinning:* Lamellar, visible optically; rarely as twinned tetrahedra.

Physical Properties: *Cleavage:* On {001}, good to imperfect. *Fracture:* Uneven. *Tenacity:* Somewhat sectile. Hardness = 2.5 D(meas.) = 2.797 D(calc.) = 2.90 Weakly piezoelectric and pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Olive-green, grass-green, emerald-green, honey-yellow, yellowish brown, dark brown; less commonly hyacinth-red, brownish red; in transmitted light, green, yellow, pale brown, biaxially sectored. *Luster:* Adamantine to greasy.
Optical Class: Isotropic; commonly anomalously biaxial (+) or biaxial (–), with weak birefringence, perhaps showing six biaxial sectors. *Dispersion:* $r > v$ or $r < v$, strong. n = 1.687–1.704 α = 1.660–1.697 β = 1.661–1.700 γ = 1.663–1.704 2V(meas.) = Large.

Cell Data: *Space Group:* $P\bar{4}3m$. a = 7.93–7.98 Z = 1

X-ray Powder Pattern: Pednandrea mine, Cornwall, England. (ICDD 34-155).
4.61 (100), 8.0 (90), 2.408 (80), 3.259 (70), 2.822 (65), 1.7844 (65), 1.5959 (60)

Chemistry:

	(1)	(2)
P_2O_5	1.20	
As_2O_5	37.16	39.88
Fe_2O_3	37.58	36.95
K_2O	4.54	5.45
H_2O	18.85	17.72
Total	99.33	100.00

(1) Cornwall, England; K is exchangeable for H, Ba, Na, etc. (2) $KFe_4(AsO_4)_3(OH)_4 \cdot 6.5H_2O$

Occurrence: An oxidation product of arsenic-bearing sulfides.

Association: Scorodite, beudantite, carminite, arseniosiderite, symplesite, jarosite, "limonite".

Distribution: Many localities, in small amounts. In England, in Cornwall, from the Carharrack and Tincroft mines and Wheals Gorland and Unity, Gwennap, and a number of other localities; at many mines in Caldbeck Fells, Cumbria. From Vaulry, Haute-Vienne, and at the Cap Garonne mine, near le Pradet, Var, France. In Germany, from Dernbach and Horhausen, Rhineland-Palatinate; at the Clara mine, near Oberwolfach, and elsewhere in the Black Forest; from Schneeberg, Saxony, Germany. From Nova Bana, near Baňská Štiavnica (Schemnitz), Slovakia. In the USA, in the Mammoth mine, Tintic district, Juab Co., Utah; from the Northumberland mine, Nye Co., and as large crystals at the Majuba Hill mine, Antelope district, Pershing Co., Nevada. From Tsumeb, Namibia. At Broken Hill, New South Wales, Australia.

Name: From the Greek for *poison*, for the arsenic content, and *iron* in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 995–997. (2) Buerger, M.J., W.A. Dollase, and I. Garaycochea-Wittke (1967) The structure and composition of the mineral pharmacosiderite. Zeits. Krist., 125, 92–108. (3) Greis, O., G. Mutter, and W. Eysel (1981) Pulverröntgenographische Untersuchungen an verschiedenen Pharmakosideriten $A[Fe_4(OH)_4(AsO_4)_3] \cdot (5{-}7)H_2O$. Zeits. Krist., 156, 48–49 (in German). (4) Mutter, G., W. Eysel, O. Greis, and K. Schmetzer (1984) Crystal chemistry of natural and ion-exchanged pharmacosiderites. Neues Jahrb. Mineral., Monatsh., 183–192.

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Phaunouxite $Ca_3(AsO_4)_2 \cdot 11H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As acicular crystals, to 1.5 mm, elongated and striated along [001], with {100}, {010}, small {*hk*0}, {$\overline{1}$11}, usually in fan-shaped aggregates.

Physical Properties: *Cleavage:* On {100}, perfect. Hardness = n.d. D(meas.) = 2.28(2) D(calc.) = 2.275 Slowly topotactically dehydrates to rauenthalite in dry air.

Optical Properties: Semitransparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y \wedge c = 13°$; OAP $\sim\perp$ {001}. $\alpha = 1.532(2)$ $\beta = 1.542(2)$ $\gamma = 1.556(2)$ 2V(meas.) = $\sim 80°$

Cell Data: *Space Group:* $P\overline{1}$. $a = 12.563(7)$ $b = 12.181(6)$ $c = 6.205(4)$ $\alpha = 88.94(3)°$ $\beta = 91.67(3)°$ $\gamma = 113.44(4)°$ Z = 2

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France; close to rauenthalite. 11.49 (10), 6.23 (9), 3.276 (9), 5.42 (8), 2.443(7), 2.963 (6), 2.810 (6)

Chemistry:

	(1)	(2)
As_2O_5	39.0	38.54
CaO	28.2	28.22
H_2O	31.5	33.24
Total	98.7	100.00

(1) Sainte-Marie-aux-Mines, France; by AA, H_2O by the Penfield method.
(2) $Ca_3(AsO_4)_2 \cdot 11H_2O$.

Occurrence: A very rare post-mine low-temperature reaction product of carbonate gangue with arsenical solutions derived from arsenic (Sainte-Marie-aux-Mines, France).

Association: Picropharmacolite, pharmacolite, sainfeldite, rauenthalite, ferrarisite, löllingite, calcite, aragonite (Sainte-Marie-aux-Mines, France).

Distribution: From the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, France. In the Svatá Anna uranium deposit, Planá, near Mariánské Lázně (Marienbad), Czech Republic. At Schlema-Hartenstein, Saxony, and from the Bauhaus district, Richelsdorf Mountains, Hesse. In the Muckross mine, Co. Kerry, Ireland.

Name: From *Phaunoux*, the French name for the Rauenthal Valley, France, within which the mineral was first found.

Type Material: University of Torino, Torino, Italy; University of Strasbourg, Strasbourg; Natural History Museum, Paris; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 142221.

References: (1) Bari, H., M. Catti, G. Ferraris, G. Ivaldi, and F. Permingeat (1982) Phaunouxite, $Ca_3(AsO_4)_2 \cdot 11H_2O$, a new mineral strictly associated with rauenthalite. Bull. Minéral., 105, 327–332. (2) (1983) Amer. Mineral., 68, 850 (abs. ref. 1). (3) Catti, M. and G. Ivaldi (1983) On the topotactic dehydration $Ca_3(AsO_4)_2 \cdot 11H_2O$ (phaunouxite) → $Ca_3(AsO_4)_2 \cdot 10H_2O$ (rauenthalite) and structures of both minerals. Acta Cryst., 39, 4–10.

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Phenakite Be_2SiO_4

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. Crystals rhombohedral, tabular to prismatic, less commonly long prismatic to acicular, to 20 cm. In columnar aggregates, as spherulites, and granular. *Twinning:* Penetration twins, by rotation about [0001].

Physical Properties: *Cleavage:* Distinct on $\{11\bar{2}0\}$, imperfect on $\{10\bar{1}1\}$.
Fracture: Conchoidal. *Tenacity:* Brittle. Hardness = 7.5–8 D(meas.) = 2.93–3.00
D(calc.) = 2.960 Bright blue cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Colorless, yellow, pink, brown; may be mottled. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.650–1.656$ $\epsilon = 1.667–1.670$

Cell Data: *Space Group:* $R\bar{3}$. $a = 12.472$ $c = 8.252$ Z = 18

X-ray Powder Pattern: Minas Gerais, Brazil.
3.119 (100), 3.66 (80), 2.518 (75), 2.358 (70), 2.187 (60), 2.079 (50), 6.24 (40)

Chemistry:

	(1)	(2)
SiO_2	52.92	54.57
Al_2O_3	trace	
BeO	45.82	45.43
MgO	0.13	
CaO	0.20	
Na_2O	0.63	
K_2O	0.26	
LOI	0.21	
Total	100.17	100.00

(1) Ural Mountains, Russia. (2) Be_2SiO_4.

Occurrence: In pegmatites, greisens, and alpine and hydrothermal veins.

Association: Topaz, beryl, chrysoberyl, fluorite, muscovite, quartz.

Distribution: Numerous localities; some for fine crystals are: along the Tokovaya River, near Yekaterinburg (Sverdlovsk), Ural Mountains, and at Miass, Ilmen Mountains, Southern Ural Mountains, Russia. At several places around Kragerö, Norway. In France, in the Vosges Mountains, at Framont, Alsace. From near Reckingen, Valais, and many other places in Switzerland. At Leckbachrinne, Habachtal, Salzburg, Austria. In the USA, from near Florissant, El Paso Co., and on Mt. Antero, Chaffee Co., Colorado; on Bald Face Mountain, North Chatham, Carroll Co., New Hampshire; at Amelia, Amelia Co., Virginia. In Brazil, exceptional crystals in the São Miguel de Piracicaba pegmatite, 50 km east of Belo Horizonte, and at Catuqi, Minas Gerais; in the Socotó mine, northwest of Salvador, Bahia, and elsewhere. At Klein Spitzkopje, Namibia. From Anjanabonoina, Madagascar.

Name: From the Greek for *deceiver*, in allusion to its similarity to quartz when colorless.

Type Material: Mining Institute, St. Petersburg, Russia, 617/22.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 462–463.
(2) Pough, F.H. (1936) Phenakit, seine Morphologie und Paragenesis. Neues Jahrb. Mineral., Monatsh., 71, 291–341 (in German). (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 81–85. (4) Zachariasen, W.H. (1971) Refined crystal structure of phenacite Be_2SiO_4. Kristallografiya (Sov. Phys. Crystal.), 16, 1161–1166 (in Russian). (5) (1959) NBS Circ. 539, 8, 11–13.

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Philipsbornite $PbAl_3(AsO_4)_2(OH)_5 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As pseudocubic rhombohedral crystals, with $\{10\overline{1}1\}$, $\{01\overline{1}2\}$, $\{0001\}$, to 100 μm; usually as massive to earthy crusts.

Physical Properties: *Fracture:* Conchoidal. Hardness = [∼4.5] (by analogy to hidalgoite). D(meas.) = > 4.1 D(calc.) = 4.33–4.45

Optical Properties: Translucent to transparent. *Color:* Colorless, grayish green; yellowish in transmitted light.
Optical Class: Biaxial in pseudocubic sectors, anomalously isotropic. $n = 1.790(3)$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.11$–7.17 $c = 17.05$–17.18 $Z = 3$

X-ray Powder Pattern: Tsumeb, Namibia.
3.042 (100), 5.85 (60), 3.592 (50), 2.281 (30), 1.944 (30), 5.73 (20), 3.538 (20)

Chemistry:

	(1)	(2)	(3)
CrO_3	6.3		
SO_3	1.3		
P_2O_5		0.3	
As_2O_5	28.6	34.4	34.36
Al_2O_3	22.3	18.5	22.86
Fe_2O_3	0.6	5.7	
MnO	0.3		
CuO	0.9		
ZnO	1.1		
PbO	32.0	31.7	33.36
H_2O	9.4	9.4	9.42
Total	102.8	100.0	100.00

(1) Dundas, Tasmania; by electron microprobe, total Fe as Fe_2O_3, H_2O by LOI; corresponding to $(Pb_{0.90}Mn_{0.03})_{\Sigma=0.93}(Al_{2.76}Zn_{0.09}Cu_{0.07}Fe_{0.05})_{\Sigma=2.97}[(AsO_4)_{1.57}(CrO_4)_{0.40}(SO_4)_{0.10}]_{\Sigma=2.07}$ $H_{6.58}O_{5.72}$. (2) Tsumeb, Namibia; by electron microprobe, average of four analyses, total Fe as Fe_2O_3, H_2O by TGA. (3) $PbAl_3(AsO_4)_2(OH)_5 \cdot H_2O$.

Mineral Group: Crandallite group.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal polymetallic mineral deposits.

Association: Crocoite, hidalgoite, gorceixite (Tasmania); azurite, tsumcorite, bayldonite, malachite, hematite, quartz (Tsumeb, Namibia).

Distribution: In Australia, from the Dundas district, Tasmania, and in the Anticline and Bali Lo prospects, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia. At Tsumeb, Namibia. From Cínovec (Zinnwald), and at Moldava, 20 km northwest of Teplice, Czech Republic. In Germany, from the Clara mine, near Oberwolfach, in the Michael mine, Weiler, near Lahr, and at Neubulach, Black Forest.

Name: Honors Hellmut von Philipsborn (1892–1983), Professor Emeritus of Mineralogy, University of Bonn, Bonn, Germany.

Type Material: National Museum of Natural History, Washington, D.C., USA, 148463.

References: (1) Walenta, K., M. Zwiener, and P.J. Dunn (1982) Philipsbornit, ein neues Mineral der Crandallitreihe von Dundas auf Tasmanien. Neues Jahrb. Mineral., Monatsh., 1–5 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 859 (abs. ref. 1). (3) Schmetzer, K., G. Tremmel, and O. Medenbach (1982) Philipsbornit, $PbAl_3H[(OH)_6|(AsO_4)_2]$, aus Tsumeb, Namibia - ein zweites Vorkommen. Neues Jahrb. Mineral., Monatsh., 248–254 (in German with English abs.).

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Philipsburgite $(Cu,Zn)_6(AsO_4,PO_4)_2(OH)_6 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [010], with prominent {100}, bounded by {010}, {001}, {111}, may be curved, with chisel-shaped terminations, to 1 mm, typically in subparallel rosettes, spherules, and crusts.

Physical Properties: Hardness = 3–4 D(meas.) = 4.07(10) D(calc.) = 4.04

Optical Properties: Transparent to translucent. *Color:* Bright emerald-green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Moderate; X = pale green; $Y = Z$ = medium green. *Orientation:* $Z = b$; $Y \wedge c = 7°$. *Dispersion:* $r > v$, strong. *Absorption:* $Y = Z > X$.
$\alpha = 1.729(2)$ $\beta = 1.774(2)$ $\gamma = 1.775(2)$ 2V(meas.) = 16(2)° 2V(calc.) = 17°

Cell Data: *Space Group:* $P2_1/c$. $a = 12.33(8)$ $b = 9.20(4)$ $c = 10.69(3)$ $\beta = 96.92(35)°$
Z = 4

X-ray Powder Pattern: Black Pine mine, Montana, USA.
2.559 (100), 4.05 (90), 12.2 (80), 2.666 (60), 1.534 (60), 3.405 (50), 6.21 (40)

Chemistry:

	(1)	(2)
P_2O_5	8.7	5.2
As_2O_5	16.3	25.5
CuO	46.3	51.4
ZnO	18.2	11.8
H_2O	9.9	
Total	99.4	

(1) Black Pine mine, Montana, USA; by electron microprobe, H_2O by TGA-EGA; corresponding to $(Cu_{4.30}Zn_{1.65})_{\Sigma=5.95}[(AsO_4)_{1.05}(PO_4)_{0.90}]_{\Sigma=1.95}(OH)_{6.03} \cdot 1.04H_2O$. (2) Potts Gill mine, England; by electron microprobe, partial analysis; corresponds to $(Cu_{4.92}Zn_{1.08})_{\Sigma=6.00}$ $[(AsO_4)_{1.48}(PO_4)_{0.52}]_{\Sigma=2.00}(OH)_6 \cdot H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal base-metal deposits.

Association: Bayldonite, chrysocolla, mimetite, quartz (Black Pine mine, Montana, USA); cornwallite, bayldonite, mimetite, malachite (Potts Gill mine, England).

Distribution: In the USA, from the Black Pine mine, about 14.5 km northwest of Philipsburg, Granite Co., Montana; large crystals in the Gold Hill mine, Tooele Co., and in the Centennial Eureka mine, Tintic district, Juab Co., Utah. In England, at the Potts Gill mine and the Low Pike vein, Caldbeck Fells, Cumbria; from Wheal Carpenter, Gwinear, and the Penberthy Croft mine, St. Hilary, Cornwall. At the Clara mine, near Oberwolfach, Black Forest, and from Schwarzenberg, Saxony, Germany. From Brixlegg, Tirol, Austria. In the Sa Duchessa mine, Oridda district, Sardinia, Italy. At the Christiana mine, Kamariza district, Laurium, Greece.

Name: For the town of Philipsburg, Montana, USA, near which the mineral was first found.

Type Material: Royal Ontario Museum, Toronto, Canada, M41000; National Museum of Natural History, Washington, D.C., USA, 161201.

References: (1) Peacor, D.R., P.J. Dunn, R.A. Ramik, B.D. Sturman, and L.G. Zeihen (1985) Philipsburgite, a new copper zinc arsenate hydrate related to kipushite, from Montana. Can. Mineral., 23, 255–258. (2) (1986) Amer. Mineral., 71, 1279 (abs. ref. 1). (3) Braithwaite, R.S.W. and G. Ryback (1988) Philipsburgite from the Caldbeck Fells and kipushite from Montana, and their infrared spectra. Mineral. Mag., 52, 529–533. (4) Kokinos, M. and W.S. Wise (1993) The Gold Hill mine, Tooele County, Utah. Mineral. Record, 24, 11–22.

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Phillipsite $(K, Na, Ca)_{1-2}(Si, Al)_8O_{16}\cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals always twinned, pseudosymmetrical; striated ‖ [001] on {010}, to 2 cm. Equant to prismatic, or in spherical radiating aggregates. *Twinning:* Cruciform single and double penetration twins on {001}, {021}, {110}, ubiquitous.

Physical Properties: *Cleavage:* {010}, {100}, distinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 2.20 D(calc.) = 2.242

Optical Properties: Translucent to opaque. *Color:* Colorless, white, reddish, yellowish; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge a = 46°–65°$. *Dispersion:* $r < v$.
$\alpha = 1.483–1.504$ $\beta = 1.484–1.509$ $\gamma = 1.486–1.514$ 2V(meas.) = 60°–80°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.865(2)$ $b = 14.300(4)$ $c = 8.668(2)$ $\beta = 124.20(3)°$ Z = 2

X-ray Powder Pattern: Casal Brunori quarry, near Rome, Lazio, Italy.
3.206 (100), 7.16 (66), 7.18 (63), 4.12 (41), 3.277 (37), 4.13 (36), 2.753 (36)

Chemistry:

	(1)
SiO_2	46.03
Al_2O_3	21.43
$FeO + Fe_2O_3$	0.99
CaO	5.73
Na_2O	3.13
K_2O	5.59
H_2O	17.22
Total	100.12

(1) Mazé, Japan; corresponds to $(K_{0.79}Na_{0.68}Ca_{0.68}Fe_{0.08})_{\Sigma=2.23}(Si_{5.12}Al_{2.81})_{\Sigma=7.93}O_{16}\cdot 6.39H_2O$.

Mineral Group: Zeolite group.

Occurrence: Typically in cavities in basalt, of hydrothermal origin; an authigenic mineral in saline lake and hot spring deposits and calcareous deep-sea sediments.

Association: Zeolites, apophyllite, calcite, nosean, nepheline, olivine, melilite, celadonite.

Distribution: Many localities, although uncommon in large crystals. Well authenticated localities include: from Aci Castello, Sicily, and at Capo di Bove and other localities around Rome, Lazio, Italy. At Annerod, near Giessen, Hesse, and Asbach, Westerwald, Germany. Along the Giant's Causeway, Co. Antrim, Ireland. In the USA, from Oregon, at Wall Creek, near Monument, and Mount Vernon, Grant Co.; at Cape Lookout, Tillamook Co.; Spray, Wheeler Co.; and many other localities. At Mazé, Niigata Prefecture, Japan. At Richmond, Victoria, and Gads Hill, near Liena, Tasmania, Australia.

Name: For William Phillips (1775–1828), noted British mineralogist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 578–581. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 386–399. (3) Harada, K., S. Iwamoto, and K. Kihara (1967) Erionite, phillipsite and gonnardite in the amygdales of altered basalt from Mazé, Niigata Prefecture, Japan. Amer. Mineral., 52, 1785–1794. (4) Galli, E. and A.G. Loschi Ghittoni (1972) The crystal chemistry of phillipsites. Amer. Mineral., 57, 1125–1145. (5) Rinaldi, R., J.J. Pluth, and J.V. Smith (1974) Zeolites of the phillipsite family. Refinement of the crystal structures of phillipsite and harmotome. Acta Cryst., 30, 2426–2433. (6) Gottardi, G. and E. Galli (1985) Natural zeolites. Springer, 326–328.

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Philolithite

$\mathbf{Pb_{12}Mn^{2+}(Mg,Mn^{2+})_2}$
$\mathbf{(Mn^{2+},Mg)_4O_6(SO_4)(CO_3)_4Cl_4(OH)_{12}}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are square tabular, {001}, {111}, modified by {110}, {112}, to 0.3 mm; may be aggregated in crusts. *Twinning:* Sectorial in four zones about [001], observed optically.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–4
D(meas.) = n.d. D(calc.) = 5.91

Optical Properties: Semitransparent. *Color:* Pale to medium apple-green. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (+), anomalous. *Pleochroism:* Very weak; pale green to pale yellow-green. *Orientation:* $X \wedge a = 45°$. $n = > 1.92$. ω = n.d. ϵ = n.d. 2V(meas.) = 60°

Cell Data: *Space Group:* $P4_2/nnm$. a = 12.627(9) c = 12.595(9) Z = 2

X-ray Powder Pattern: Långban, Sweden.
2.975 (100), 3.99 (30), 2.752 (30), 8.95 (20), 7.30 (20), 2.473 (20), 1.716 (20)

Chemistry:

	(1)	(2)
SO_3	1.7	[2.2]
CO_2	[4.9]	[4.9]
MnO	10.3	8.7
PbO	73.7	75.9
MgO	1.8	2.1
Cl	3.4	4.4
H_2O	[3.0]	[3.0]
$-O = Cl_2$	0.8	1.0
Total	[98.0]	[100.2]

(1) Långban, Sweden; by energy dispersive analysis, presence of $(SO_4)^{2-}$, $(CO_3)^{2-}$, $(OH)^{1-}$ confirmed by IR; $(CO_3)^{2-}$, H_2O calculated from crystal-structure analysis; corresponds to $Pb_{12.29}(Mn_{5.41}Mg_{1.66})_{\Sigma=7.07}O_{6.45}(SO_4)_{0.79}(CO_3)_{4.14}Cl_{3.57}(OH)_{12.40}$. (2) Do.; by electron microprobe; $(SO_4)^{2-}$, $(CO_3)^{2-}$, H_2O calculated from crystal-structure analysis; corresponds to $Pb_{12.32}(Mn_{4.45}Mg_{1.89})_{\Sigma=6.34}O_{5.31}(SO_4)_{1.00}(CO_3)_{4.04}Cl_{4.50}(OH)_{12.07}$.

Occurrence: Very rare in a metamorphosed Fe–Mn orebody.

Association: Lead, copper, mendipite, braunite, hausmannite, pyrochroite, manganoan phlogopite, allactite, calcite.

Distribution: From Långban, Värmland, Sweden.

Name: From the Greek for *loving* and *stone*, in honor of the Friends of Mineralogy organization.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 37389, 225116; Canadian Museum of Nature, Ottawa, Canada, 58623; Los Angeles Co. Museum, Los Angeles, California, USA, 41794.

References: (1) Kampf, A.R., P.B. Moore, E.J. Jonsson, and G.H. Swihart (1998) Philolithite, a new mineral from Långban, Värmland, Sweden. Mineral. Record, 29, 201–206. (2) (1999) Amer. Mineral., 84, 686–687 (abs. ref. 1). (3) Moore, P.B., A.R. Kampf, and P.K. Sen Gupta (2000) The crystal structure of philolithite, a trellis-like open framework based on cubic closest-packing of anions. Amer. Mineral., 85, 810–816.

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Philrothite $TlAs_3S_5$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As irregular grains to 200 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3-3.5 VHN = 120-137 (25 g load). D(meas.) = n.d. D(calc.) = 4.635

Optical Properties: Opaque. *Color*: Black. *Streak*: Dark brown. *Luster*: Metallic. *Bireflectance:* Moderate. *Pleochroism:* Weak, dark gray to light gray. *Anisotropism:* Gray to bluish gray.
Optical Class: n.d.
R_1-R_2: (471) 26.5-28.8, (548) 25.4-27.2, (586) 24.6-26.3, (652) 24.0-25.1

Cell Data: *Space Group*: $P2_1/c$. a = 8.013(2) b = 24.829(4) c = 11.762(3) β = 132.84(2)°
Z = 8

X-ray Powder Pattern: Calculated pattern.
3.677 (100), 2.764 (77), 2.769 (76), 12.415 (52), 2.894 (52), 2.324 (52), 3.015 (46)

Chemistry:

	(1)	(2)
Tl	26.28	34.67
Pb	6.69	
Ag	2.50	
Cu	0.04	
Hg	0.07	
As	32.50	38.13
Sb	3.15	
S	26.35	27.20
Total	97.58	100.00

(1) Lengenbach quarry, Valais, Switzerland; average of 5 electron microprobe analyses, corresponding to $(Tl_{0.79}Pb_{0.20})_{\Sigma=0.99}(As_{2.66}Sb_{0.16}Ag_{0.14}Cu_{<0.01}Hg_{<0.01})_{\Sigma=2.97}S_{5.04}$. (2) $TlAs_3S_5$.

Occurrence: A product of late-stage Tl- and As-bearing hydrothermal solutions during alpine metamorphism.

Association: Realgar, smithite, rutile, sartorite.

Distribution: From the Lengenbach quarry, Binn Valley, Valais, Switzerland.

Name: Honors Philippe Roth (b. 1963), President of the FGL (Forschungsgemeinschaft Lengenbach) and an expert on Lengenbach minerals.

Type Material: Museum of Mineralogy, Department of Geosciences, University of Padova, Italy (MMP M12605).

References: (1) Bindi, L., F. Nestola, E. Makovicky, A. Guastoni, and L. De Battisti (2014) Tl-bearing sulfosalt from the Lengenbach quarry, Binn Valley, Switzerland: Philrothite, $TlAs_3S_5$. Mineral. Mag., 78(1), 1-9. (2) (2014) Amer. Mineral., 99, 1810 (abs. ref. 1).

Phlogopite $KMg_3Si_3AlO_{10}(F,OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals six-sided, thick tabular to prismatic, commonly tapered, to 10 m and 270 t. Also coarse-grained, platy, and as small scales. *Twinning:* Composition plane {001}, twin axis [310].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Thin laminae flexible and elastic, tough. Hardness = 2–3 D(meas.) = 2.78–2.85 D(calc.) = 2.79

Optical Properties: Transparent to translucent. *Color:* Brownish red, dark brown, yellowish brown, green, white; colorless, pale yellow, or green in thin section. *Streak:* White. *Luster:* Pearly to submetallic on cleavage.
Optical Class: Biaxial (–). *Pleochroism:* X = yellow; $Y = Z$ = brownish red, green, yellow. *Orientation:* $Y = b$; $Z \wedge a = 0°–5°$. *Dispersion:* $r < v$. *Absorption:* $Z > Y \gg X$.
$\alpha = 1.530–1.590$ $\beta = 1.557–1.637$ $\gamma = 1.558–1.637$ 2V(meas.) = 0°–15°

Cell Data: *Space Group:* $C2/m$ (1M). $a = 5.3078(4)$ $b = 9.1901(5)$ $c = 10.1547(8)$ $\beta = 100.08(1)°$ Z = 2

X-ray Powder Pattern: South Burgess Township (?), Ontario, Canada (1M).
9.94 (100), 3.348 (100), 2.614 (30), 2.011 (30), 3.390 (20), 2.513 (16), 2.429 (16)

Chemistry:

	(1)		(1)		(1)
SiO_2	42.0	ZnO	0.01	K_2O	8.46
TiO_2	0.22	MgO	28.6	Rb_2O	0.01
Al_2O_3	12.7	CaO	0.04	F	5.85
FeO	0.25	BaO	1.70	H_2O^+	1.51
MnO	0.08	Li_2O	0.01	$-O = F_2$	[2.46]
NiO	0.02	Na_2O	1.19	Total	[100.19]

(1) Franklin, New Jersey, USA; corresponds to $(K_{0.76}Na_{0.16}Ba_{0.05})_{\Sigma=0.97}(Mg_{2.98}Fe^{2+}_{0.01})_{\Sigma=2.99}$ $Si_{2.95}Al_{1.05}O_{10}[F_{1.30}(OH)_{0.70}]_{\Sigma=2.00}$.

Polymorphism & Series: 1M, $2M_1$, 3A polytypes; forms a series with biotite.

Mineral Group: Mica group.

Occurrence: In metamorphosed dolostones and magnesium-rich limestones; in ultramafic rocks as kimberlites, peridotites, lamproites, and serpentinites.

Association: Dolomite, calcite, diopside, tremolite, scapolite, vesuvianite, apatite, titanite, epidote, olivine, augite, magnetite.

Distribution: Some localities for well-crystallized material include: in the USA, from Antwerp and Natural Bridge, Jefferson Co., and Edwards and Pierrepont, St. Lawrence Co., New York; from Franklin, Sussex Co., New Jersey. In Canada, large crystals from the Lacey mine, Frontenac Co., and in North and South Burgess Townships, Ontario; from near Perkin's Mills, and elsewhere in Gatineau Co., Quebec. In the Slyudyanka region, near Lake Baikal, Siberia, Russia. At Ødegården, near Feset, Norway. From Campolungo, near St. Gotthard, Ticino, Switzerland. In the Val di Fassa, Trentino-Alto Adige, and on Monte Braccio, Val Malenco, Lombardy, Italy. From Saharakara and Ampandrandava, Madagascar. At Anxiety Point, Nancy Sound, New Zealand.

Name: From the Greek for *firelike*, referring to an oft-seen reddish tint.

Type Material: Mining Academy, Freiberg, Germany, 24966.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 632–634. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 42–54. (3) Smith, J.V. and H.S. Yoder, Jr. (1956) Experimental and theoretical studies of the mica polymorphs. Mineral. Mag., 31, 209–235. (4) Hazen, R.M. and C.W. Burnham (1973) The crystal structures of one-layer phlogopite and annite. Amer. Mineral., 58, 889–900. (5) Rayner, J.H. (1974) The crystal structure of phlogopite by neutron diffraction. Mineral. Mag., 39, 850–856.

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Phoenicochroite $Pb_2O(CrO_4)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Imperfect crystals, tabular on {100} or {$\overline{2}$01}, elongated along [010] or [001], showing {010}, {100}, {110}, {$\overline{2}$01}, {$\overline{2}$11}, {310}, to 1 cm; may be in reticulated intergrowths, thin coatings, and massive.

Physical Properties: *Cleavage:* Perfect on {$\overline{2}$01}; poor on {001}, {010}, {011}. *Tenacity:* Sectile. Hardness = 2.5–3.5 D(meas.) = 7.01 D(calc.) = 7.075

Optical Properties: Translucent, transparent on thin edges. *Color:* Dark cochineal-red to hyacinth-red, lemon-yellow on exposure; red-orange, orange, yellow-orange in transmitted light. *Streak:* Brick-red to yellowish orange. *Luster:* Adamantine to resinous, glistening. *Optical Class:* Biaxial (+). *Pleochroism:* Weak. *Orientation:* $X = b$; $Y \wedge c = -2°$; $Z \wedge c = 88°$. *Dispersion:* $r > v$, , moderately strong to strong. *Absorption:* $X < Y < Z$. α = 2.34–2.38 β = 2.38–2.44 γ = 2.65 2V(meas.) = 58° 2V(calc.) = 60°

Cell Data: *Space Group:* $C2/m$. $a = 14.001(7)$ $b = 5.675(3)$ $c = 7.137(5)$ $\beta = 115.22°$ Z = 4

X-ray Powder Pattern: Beresovsk, Russia.
3.39 (10), 2.989 (10), 3.60 (7), 6.40 (4), 3.26 (4), 4.42 (3), 2.840 (3)

Chemistry:

	(1)	(2)
CrO_3	80.88	81.70
PbO	18.08	18.30
Total	98.96	100.00

(1) Potter-Kramer mine, Arizona, USA; by AA. (2) $Pb_2O(CrO_4)$.

Occurrence: A rare secondary mineral in the oxidized zone of chromium-bearing hydrothermal lead deposits.

Association: Crocoite, vauquelinite, fornacite, hemihedrite, iranite, pyromorphite, mimetite, cerussite, leadhillite, galena, calcite, fluorite, quartz.

Distribution: From the Preobrazhensky mine, Beresovsk district, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. In the Hopeful vein, near Leadhills, Lanarkshire, Scotland. At the Adelaide Proprietary mine, Dundas, Tasmania, Australia. From the Santa Ana mine, Sierra Gorda district, southwest of Calama, Antofagasta, Chile. In the USA, in Arizona, from south of Wickenburg, at the Pack Rat and Potter-Kramer claims, the Moon Anchor mine, and near the Purple Pansy mine; northeast of Wickenburg, along Amazon Wash, near its confluence with the Hassayampa River, all in Maricopa Co.; in the Florence Lead-Silver mine, Tortilla Mountains, Pinal Co. In Nevada, from about 14 km northwest of Nelson, El Dorado district, Clark Co., and at the Silver Dollar claim, north of Columbus, Candelaria Hills, Esmeralda Co. From the Seh-Changi mine, near Neyband, Khorassan, and in the Tchah Khuni mine, Anarak district, Iran. At the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa.

Name: From the Greek for *deep red* and *color*, in allusion to its typical color.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 649–650. (2) Williams, S.A., W.J. McLean, and J.W. Anthony (1970) A study of phoenicochroite – its structure and properties. Amer. Mineral., 55, 784–792.

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Phosgenite $Pb_2(CO_3)Cl_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are short prismatic to prismatic [001]; rarely thick tabular {001}; commonly terminated by {001} or with large {111}, to 30 cm; granular, massive.

Physical Properties: *Cleavage:* {001} and {110}, distinct; {100}, indistinct. *Fracture:* Conchoidal. *Tenacity:* Sectile, flexible $\perp$ [001]. Hardness = 2–3, varying with direction. D(meas.) = 6.12–6.15 D(calc.) = 6.124 May fluoresce yellow under LW UV, X-rays, and electron beams.

Optical Properties: Transparent to translucent. *Color:* Pale yellow to yellowish brown, pale brown, smoky brown, smoky violet; colorless, pale rose, gray, yellowish gray, pale green; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (+); anomalously biaxial. *Pleochroism:* Weak; in thick sections; O = pink; E = pale green. $\omega = 2.118$ $\epsilon = 2.145$

Cell Data: *Space Group:* $P4/mbm$. $a = 8.160(4)$ $c = 8.883(6)$ $Z = 4$

X-ray Powder Pattern: In a lead pot from Wookey Hole Cavern, England.
2.79 (vvs), 3.61 (vs), 4.40 (s), 2.56 (s), 4.04 (ms), 2.21 (m), 1.800 (m)

Chemistry:

	(1)	(2)
CO_2	8.13	8.07
PbO	81.78	81.86
Cl	12.91	13.00
$-O = Cl_2$	2.91	2.93
Total	99.91	100.00

(1) Altai district, Siberia. (2) $Pb_2(CO_3)Cl_2$.

Occurrence: Uncommon, typically formed by alteration of galena in the oxidized zone of hydrothermal lead deposits, or by reaction of sea water with other lead minerals.

Association: Cerussite, anglesite, matlockite, laurionite.

Distribution: In England, fine crystals from the Bage and other mines, near Matlock, Derbyshire, and from a number of mines in Cornwall. On Sardinia, Italy, fine crystals from Monteponi and Montevecchio, near Iglesias, and from Gibbas, near Cagliari. In slag from Laurium, Greece. At Tarnowitz, Poland. From the Syzjanov mine, Altai district, Siberia, Russia. Large fine crystals from the Touissit mine, near Oujda, Morocco. At Sidi Amor ben Salem, Tunisia. Large crystals from Tsumeb, Namibia. From Broken Hill, New South Wales, and in the Comet mine, Dundas, Tasmania, Australia. Found at Boleo, near Santa Rosalia, Baja California, Mexico. In the USA, large masses from the Terrible mine, Isle, Custer Co., Colorado; in the Mammoth mine, Tiger, Pinal Co., Arizona; at the Stevenson-Bennett mine, Organ Mountains, Doña Ana Co., New Mexico. From a number of other localities but in small amounts.

Name: From *phosgene*, $COCl_2$, composed of elements in the mineral's composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 256–259. (2) Giuseppetti, G. and C. Tadini (1974) Reexamination of the crystal structure of phosgenite, $Pb_2Cl_2(CO_3)$. Tschermaks Mineral. Petrog. Mitt., 21, 101–109. (3) Midgley, H.G. (1958) A further occurrence of phosgenite. Mineral. Mag., 31, 883.

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Phosinaite-(Ce) $Na_{13}Ca_2CeSi_4O_{12}(PO_4)_4$

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Crystal Data: Orthorhombic. *Point Group:* 222. As columnar crystals, to 1 cm, with {011} predominant, and {100}, {010}, {001}; as irregular accumulations.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {010} and {011}.
Hardness = 3.5 VHN = 207–340 D(meas.) = 2.62–3.00 D(calc.) = [3.36]

Optical Properties: Transparent. *Color:* Colorless, pale rose to brownish rose.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. α = 1.567–1.570
β = 1.569–1.572 γ = 1.570–1.573 2V(meas.) = 68°–70°

Cell Data: *Space Group:* $P2_12_12$. $a = 7.234(3)$ $b = 14.670(4)$ $c = 12.231(4)$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
2.74 (100), 7.44 (55), 2.566 (55), 6.92 (50), 3.51 (40), 3.62 (30), 3.94 (20)

Chemistry:

	(1)	(2)
SiO_2	18.30	23.78
RE_2O_3	13.44	13.80
Fe_2O_3		0.49
MnO	trace	1.90
CaO	12.20	5.39
Li_2O		0.24
Na_2O	28.10	28.78
K_2O	0.74	0.47
H_2O	6.07	4.41
P_2O_5	21.30	20.50
Total	100.15	99.76

(1) Khibiny massif, Russia. (2) Lovozero massif, Russia; spectrographic analyses show RE = Y 0.6%, La 16.8%, Ce 53.9%, Pr 4.4%, Nd 19.5%, Sm 3.0%, Eu 0.5%, Gd 0.7%, Tb 0.3%, Er 0.3%.

Occurrence: Filling interstices between large crystals of anorthoclase in alkalic pegmatites in a differentiated alkalic massif (Khibiny massif, Russia); in ussingite veinlets in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Anorthoclase, nepheline, aegirine, lomonosovite, lamprophyllite (Khibiny massif, Russia); belovite, nordite, neptunite, vuonnemite (Lovozero massif, Russia).

Distribution: On Mt. Koashva, Khibiny massif, and Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For PHOsphorus, SIlicon, and sodium, NAtrium, in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 4456; Mining Institute, St. Petersburg, 1210/1; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76195; National School of Mines, Paris, France.

References: (1) Kapustin, Y.L., A.P. Khomyakov, E.I. Semenov, E.M. Es'kova, A.V. Bykova, and Z.V. Pudovkina (1974) Phosinaite, a new rare-earth mineral. Zap. Vses. Mineral. Obshch., 103, 567–570 (in Russian). (2) (1975) Amer. Mineral., 60, 488 (abs. ref. 1). (3) Krutik, V.M., D.Y. Pushcharovskii, A.P. Khomyakov, E.A. Pobedimskaya, and N.V. Belov (1981) Crystal structure and typomorphism of phosinaite. Kristallografiya (Sov. Phys. Crystal.), 26, 1197–1203 (in Russian).

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Phosphammite $(NH_4)_2HPO_4$

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Crystal Data: Monoclinic (synthetic). *Point Group:* $2/m$. As crystals, to 0.5 mm; typically in crusts.

Physical Properties: Hardness = n.d. D(meas.) = 1.61 D(calc.) = 1.61

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge a = 43.5°$. $\alpha = 1.508$ $\beta = 1.518$ $\gamma = 1.530$ 2V(meas.) = 80°–85° 2V(calc.) = 85°

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 8.03$ $b = 6.68$ $c = 11.02$ $\beta = 113°38'$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 29-111).
5.05 (100), 5.57 (75), 4.94 (65), 3.22 (65), 3.78 (50), 3.14 (45), 3.06 (45)

Chemistry: (1) Identification depends on the coincidence of the X-ray powder pattern and optical data with that of synthetic material.

Occurrence: Probably a crystallization product of the liquid fraction of guano.

Association: Ammonian aphthitalite, urea, weddellite (Toppin Hill Cave, Western Australia); biphosphammite (Guañape Island, Peru).

Distribution: On Guañape Island, south of Trujillo, Peru. In Toppin Hill Cave, about 320 km northeast of Kalgoorlie, Western Australia. At San Pedro, Martin Island, Mexico.

Name: As a PHOSPHate of AMMonium.

Type Material: Western Australian Museum, Perth, Australia, S4688.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 807.
(2) Bridge, P.J. (1973) Urea, a new mineral, and neotype phosphammite from Western Australia. Mineral. Mag., 39, 346–348. (3) Smith, J.P., L.R. Lehr, and W.E. Brown (1957) Crystallographic properties of diammonium phosphate, $(NH_4)_2HPO_4$. Acta Cryst., 10, 709.

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Phosphoellenbergerite $Mg_{14}(PO_4)_6(PO_3OH, CO_3)_2(OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, tabular on [010] to pseudo-octahedral, with prominent {010}, {100}, {001}, {021}, many other forms, to 1 cm. May be fibrous to massive.

Physical Properties: *Cleavage:* On {010}, poor. *Fracture:* Uneven. Hardness = 4–4.5 D(meas.) = 3.10–3.29 D(calc.) = 3.32

Optical Properties: Transparent to translucent. *Color:* Pale green, olive-green, brownish green; reddish brown if oxidized. *Luster:* Vitreous to subresinous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, distinct. $\alpha = 1.663$–1.672 $\beta = 1.674$–1.680 $\gamma = 1.699$–1.700 2V(meas.) = 66°–70° 2V(calc.) = 68°

Cell Data: *Space Group: Pbna* (synthetic). $a = 9.460(2)$ $b = 10.024(3)$ $c = 8.670(2)$ Z = 4

X-ray Powder Pattern: Hagendorf, Germany; close to reddingite.
3.18 (10), 2.724 (8), 4.25 (7), 2.639 (7), 2.408 (7), 2.222 (7), 1.615 (7)

Chemistry:

	(1)	(2)
P_2O_5	34.39	34.61
FeO	37.52	26.27
MnO	13.63	25.94
CaO	1.20	
H_2O	13.32	13.18
Total	100.06	100.00

(1) Hagendorf, Germany, average of two analyses; corresponds to $(Fe^{2+}_{2.15}Mn^{2+}_{0.80}Ca_{0.10})_{\Sigma=3.05}(PO_4)_2 \cdot 3.05H_2O$. (2) $(Fe, Mn)_3(PO_4)_2 \cdot 3H_2O$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with reddingite.

Occurrence: An alteration product of triphylite in zoned complex granite pegmatites.

Association: Ludlamite, vivianite, huréaulite, lithiophilite, siderite.

Distribution: Large crystals from Hagendorf, Bavaria, Germany. At the Mangualde pegmatite, near Mesquitela, Portugal. In the USA, in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from the Dan Patch mine, 1.5 km west of Keystone, Pennington Co., and the Bull Moose and Tip Top mines, near Custer, Custer Co., South Dakota. At the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina.

Name: For PHOSPHOrus and iron, FERRum, in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150230.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 727–729. (2) Moore. P.B. and T. Araki (1976) A mixed-valence solid-solution series: crystal structures of phosphoferrite, $Fe^{II}_3(H_2O)_3[PO_4]_2$, and kryzhanovskite, $Fe^{III}_3(OH)_3[PO_4]_2$. Inorg. Chem., 15, 316–321. (3) Tennyson, C. (1954) Phosphoferrit und Reddingit von Hagendorf. Neues Jahrb. Mineral., Abh., 87, 185–217 (in German). (4) Moore, P.B. (1971) The $Fe^{2+}_3(H_2O)_n(PO_3)_2$ homologous series: crystal-chemical relationships and oxidized equivalents. Amer. Mineral., 56, 1–17. (5) Moore, P.B., T. Araki, and A.R. Kampf (1980) Nomenclature of the phosphoferrite structure type: refinements of landesite and kryzhanovskite. Mineral. Mag., 43, 789–795.

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, tabular on [010] to pseudo-octahedral, with prominent {010}, {100}, {001}, {021}, many other forms, to 1 cm. May be fibrous to massive.

Physical Properties: *Cleavage:* On {010}, poor. *Fracture:* Uneven. Hardness = 4–4.5 D(meas.) = 3.10–3.29 D(calc.) = 3.32

Optical Properties: Transparent to translucent. *Color:* Pale green, olive-green, brownish green; reddish brown if oxidized. *Luster:* Vitreous to subresinous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, distinct. $\alpha = 1.663$–1.672 $\beta = 1.674$–1.680 $\gamma = 1.699$–1.700 2V(meas.) = 66°–70° 2V(calc.) = 68°

Cell Data: *Space Group: Pbna* (synthetic). $a = 9.460(2)$ $b = 10.024(3)$ $c = 8.670(2)$ $Z = 4$

X-ray Powder Pattern: Hagendorf, Germany; close to reddingite.
3.18 (10), 2.724 (8), 4.25 (7), 2.639 (7), 2.408 (7), 2.222 (7), 1.615 (7)

Chemistry:

	(1)	(2)
P_2O_5	34.39	34.61
FeO	37.52	26.27
MnO	13.63	25.94
CaO	1.20	
H_2O	13.32	13.18
Total	100.06	100.00

(1) Hagendorf, Germany, average of two analyses; corresponds to $(Fe_{2.15}Mn_{0.80}Ca_{0.10})_{\Sigma=3.05}(PO_4)_2 \cdot 3.05H_2O$. (2) $(Fe,Mn)_3(PO_4)_2 \cdot 3H_2O$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with reddingite.

Occurrence: An alteration product of triphylite in zoned complex granite pegmatites.

Association: Ludlamite, vivianite, huréaulite, lithiophilite, siderite.

Distribution: Large crystals from Hagendorf, Bavaria, Germany. At the Mangualde pegmatite, near Mesquitela, Portugal. In the USA, in the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; from the Dan Patch mine, 1.5 km west of Keystone, Pennington Co., and the Bull Moose and Tip Top mines, near Custer, Custer Co., South Dakota. At the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina.

Name: For PHOSPHOrus and iron, FERRum, in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150230.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 727–729. (2) Moore. P.B. and T. Araki (1976) A mixed-valence solid-solution series: crystal structures of phosphoferrite, $Fe_3^{II}(H_2O)_3[PO_4]_2$, and kryzhanovskite, $Fe_3^{III}(OH)_3[PO_4]_2$. Inorg. Chem., 15, 316–321. (3) Tennyson, C. (1954) Phosphoferrit und Reddingit von Hagendorf. Neues Jahrb. Mineral., Abh., 87, 185–217 (in German). (4) Moore, P.B. (1971) The $Fe_3^{2+}(H_2O)_n(PO_3)_2$ homologous series: crystal-chemical relationships and oxidized equivalents. Amer. Mineral., 56, 1–17. (5) Moore, P.B., T. Araki, and A.R. Kampf (1980) Nomenclature of the phosphoferrite structure type: refinements of landesite and kryzhanovskite. Mineral. Mag., 43, 789–795.

Phosphofibrite $\mathbf{KCuFe^{3+}_{15}(PO_4)_{12}(OH)_{12}\cdot 12H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are fibrous, to 0.5 mm, in radial aggregates.

Physical Properties: *Cleavage:* One, nearly perfect, pinacoidal. Hardness = ∼4
D(meas.) = 2.90 D(calc.) = 2.94

Optical Properties: Translucent. *Color:* Yellow or yellowish green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* Y = elongation. *Dispersion:* $r \ll v$. $\alpha = 1.755(4)$ β = n.d. $\gamma = 1.790(4)$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* *Pbmn* or *Pnmn*. $a = 14.40$ $b = 18.76$ $c = 10.40$ Z = 2

X-ray Powder Pattern: Clara mine, Germany.
9.50 (100), 3.23 (60), 3.13 (60), 4.35 (50), 2.99 (50), 2.77 (50), 2.10 (50)

Chemistry:

	(1)	(2)
P_2O_5	34.0	34.07
Al_2O_3	1.5	
Fe_2O_3	46.6	47.90
CuO	2.6	3.18
K_2O	1.9	1.88
H_2O	[13.4]	12.97
Total	[100.0]	100.00

(1) Clara mine, Germany; by electron microprobe and microchemical methods, H_2O by difference; corresponding to $K_{1.00}Cu_{0.81}(Fe_{14.52}Al_{0.73})_{\Sigma=15.25}(P_{0.99}O_{3.97})_{12}(OH)_{12.36}\cdot 12.33H_2O$.
(2) $KCuFe_{15}(PO_4)_{12}(OH)_{12}\cdot 12H_2O$.

Occurrence: In a hydrothermal polymetallic barite–fluorite deposit.

Association: Beraunite, strengite, barian pharmacosiderite, quartz.

Distribution: From the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: For *phospho*rus in the composition and its characteristic *fibrous* habit.

Type Material: n.d.

References: (1) Walenta, K. and P.J. Dunn (1984) Phosphofibrit, ein neues Eisenphosphat aus der Grube Clara im mittleren Schwarzwald (BRD). Chem. Erde, 43, 11–16 (in German).
(2) (1984) Amer. Mineral., 69, 1192 (abs. ref. 1).

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Phosphogartrellite $PbCuFe^{3+}(PO_4)_2(OH,H_2O)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As steeply terminated crystals, to 50 μm, in parallel growths and aggregates.

Physical Properties: Hardness = 4.5 D(meas.) = n.d. D(calc.) = 5.05

Optical Properties: Transparent in thin fragments. *Color:* Bright green. *Streak:* Yellow. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). $\alpha = 1.90(2)$ $\beta = [1.93]$ $\gamma = 2.00(2)$ 2V(meas.) = 70(5)°

Cell Data: *Space Group:* $[P\overline{1}]$ (by analogy to gartrellite). $a = 5.320(2)$ $b = 5.528(2)$ $c = 7.434(3)$ $\alpha = 67.61(3)°$ $\beta = 69.68(5)°$ $\gamma = 70.65(4)°$ Z = 1

X-ray Powder Pattern: Hohenstein, Germany.
4.360 (100), 2.885 (89), 3.250 (70), 2.868 (69), 4.720 (67), 4.502 (61), 2.459 (53)

Chemistry:

	(1)	(2)
P_2O_5	22.05	25.74
As_2O_5	4.58	
Fe_2O_3	14.14	14.48
CuO	14.41	14.42
PbO	39.02	40.46
CaO	0.20	
H_2O	[4.83]	4.90
Total	99.23	100.00

(1) Hohenstein, Germany; by electron microprobe, total Fe as Fe_2O_3, confirmed by microchemical tests, H_2O calculated from stoichiometry, presence of both $(OH)^{1-}$ and H_2O confirmed by IR; corresponds to $(Pb_{0.99}Ca_{0.02})_{\Sigma=1.01}Cu_{1.02}Fe_{1.00}[(PO_4)_{1.75}(AsO_4)_{0.23}]_{\Sigma=1.98}[(OH)_{1.12}(H_2O)_{0.96}]_{\Sigma=2.08}$. (2) $PbCuFe(PO_4)_2(OH)\bullet H_2O$.

Mineral Group: Tsumcorite group.

Occurrence: A rare secondary mineral, probably formed by oxidation of earlier sulfides in silicified barite veins.

Association: Hentschelite, pyromorphite, malachite, cuprite.

Distribution: In Germany, on the Hohenstein, near Reichenbach, and at Gadernheim, near Bensheim, Hesse.

Name: As the *phosphate* analog of *gartrellite*.

Type Material: Mineralogical Institute, Ruhr University, Bochum, Germany.

References: (1) Krause, W., K. Belendorff, H.-J. Bernhardt, and K. Petitjean (1998) Phosphogartrellite, $PbCuFe(PO_4)_2(OH)\bullet H_2O$, a new member of the tsumcorite group. Neues Jahrb. Mineral., Monatsh., 111–118. (2) (1998) Amer. Mineral., 83, 1117 (abs. ref. 1).

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Phosphoinnelite $Ba_4Na_3Ti_3Si_4O_{14}(PO_4, SO_4)_2(O, F)_3$

Crystal Data: Triclinic. [*Point Group*: 1 or $\bar{1}$] (by analogy to innelite). As lath-shaped, split, and distorted crystals, to 6 mm, exhibiting prominent {010}, striations parallel to elongation; typically as bunch-, sheaf-, and rosettelike aggregates.

Physical Properties: *Cleavage*: Perfect on {010}, good on {100}. *Tenacity*: Brittle. *Fracture*: Stepped. Hardness = 4.5-5. D(meas.) = 3.82(5) D(calc.) = 3.92

Optical Properties: Transparent. *Color*: Yellow–brown, honey, occasionally brown. *Streak*: Pale yellow. *Luster*: Vitreous, greasy on broken surfaces. *Optical Class*: Biaxial (+). α = 1.730(5) β = 1.745(3) γ = 1.764(3) 2V(meas.) = ~ 90° 2V(calc) = 84° *Orientation*: $Z \wedge c \sim 5°$.

Cell Data: [*Space Group*: $P\bar{1}$ or $P1$] (by analogy to innelite). a = 5.38(2) b = 7.10(2) c = 14.76(5) α = 99.00(7)° β = 94.94(6)° γ = 90.14(8)° Z = 1

X-ray Powder Pattern: Kovdor massif, Kola Peninsula, Russia (identical to innelite). 14.5 (100), 2.683 (90), 2.133 (80), 3.455 (40), 2.810 (40), 2.059 (40), 3.382 (35)

Chemistry:

	(1)		(1)
Na_2O	6.06	SiO_2	17.83
K_2O	0.04	TiO_2	16.88
CaO	0.15	Nb_2O_5	0.74
SrO	0.99	P_2O_5	5.93
BaO	41.60	SO_3	5.29
MnO	1.07	F	0.14
Fe_2O_3	1.55	$-O=F_2$	0.06
Al_2O_3	0.27	Total	99.12

(1) Kovdor massif, Kola Peninsula, Russia; average of 14 electron microprobe analyses, absence of OH, H_2O confirmed by IR, corresponding to $(Ba_{3.59}Sr_{0.13}K_{0.01})_{\Sigma=3.73}(Na_{2.59}Mg_{0.21}Mn_{0.20}Ca_{0.04})_{\Sigma=3.04}(Ti_{2.80}Fe^{3+}_{0.26}Nb_{0.07})_{\Sigma=3.13}(Si_{3.93}Al_{0.07})_{\Sigma=4}O_{14}$ $[(P_{1.11}S_{0.87})_{\Sigma=1.98}O_{7.96}](O_{2.975}F_{0.10})_{\Sigma=3.075}$.

Polymorphism & Series: Forms a series with innelite.

Occurrence: A late stage mineral in a hydrothermally altered peralkaline pegmatite that crosscuts calcite carbonatite associated with an ultramafic alkaline pluton.

Association: Thompsonite-Ca, golyshevite, pectolite, cancrinite, pyroxene, CO_3-bearing fluorapatite.

Distribution: Kovdor massif, Kola Peninsula, Russia.

Name: For its chemical composition as the P-analog of innelite.

Type Material: A.E. Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, 3288/1.

References: (1) Pekov, I.V., N.V. Chukanov, I.M. Kulikova, and D.I. Belakovsky (2006) Phosphoinnelite, $Ba_4Na_3Ti_3Si_4O_{14}(PO_4, SO_4)_2(O, F)_3$, a new mineral from peralkaline pegmatites of the Kovdor massif, Kola Peninsula. Zap. Ross. Mineral. Obshch., 135(3), 52–60 (in Russian, English abstract); (2007) Geology of Ore Deposits, 49, 530–536 (in English). (2) (2009) Amer. Mineral., 94, 1081 (abs. ref. 1).

Phosphophyllite $Zn_2(Fe^{2+},Mn^{2+})(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tend to be thick tabular on {100}, with {110}, {011}, {$\bar{1}$02}, {111}, {$\bar{3}$11}, many other forms, to 13 cm. *Twinning:* Common on {100}, as contact twins giving "fishtail" shapes and as penetration twins, may be polysynthetic; rare on {$\bar{1}$02}.

Physical Properties: *Cleavage:* On {100}, perfect; on {010}, {$\bar{1}$02}, distinct.
Tenacity: Brittle. Hardness = 3–3.5 D(meas.) = 3.08–3.13 D(calc.) = 3.12

Optical Properties: Transparent. *Color:* Pale bluish green, sea-green, colorless; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 50°$. *Dispersion:* $r > v$, perceptible.
$\alpha = 1.595–1.599$ $\beta = 1.614–1.617$ $\gamma = 1.616–1.620$ 2V(meas.) = ∼45°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.378–10.397$ $b = 5.084–5.098$ $c = 10.553–10.574$
$\beta = 121.00°–121.14(2)°$ Z = 2

X-ray Powder Pattern: Potosí, Bolivia.
4.438 (100), 8.86 (85), 3.383 (60), 2.833 (50), 2.818 (45), 2.222 (30), 1.4806 (30)

Chemistry:

	(1)	(2)
P_2O_5	32.51	32.29
FeO	12.24	16.18
MnO	4.96	0.14
ZnO	34.26	34.59
H_2O	16.52	15.99
Total	100.49	99.19

(1) Hagendorf, Germany. (2) Potosí, Bolivia; by electron microprobe, H_2O by the Penfield method.

Occurrence: Typically a secondary mineral in zoned complex granite pegmatites, an alteration product of sphalerite and Fe–Mn phosphates; in hydrothermal vein deposits.

Association: Triplite, triphylite, sphalerite, apatite, vivianite, rockbridgeite, strengite, phosphosiderite, fairfieldite (Hagendorf, Germany).

Distribution: From Hagendorf, Bavaria, Germany. At Přibyslavice, Czech Republic. From the Norrö pegmatite, on Rånö Island, Sweden. Extraordinary crystals in the Unificada mine, Cerro Rico, and from the Siglo XX mine, Llallagua, Potosí; in the Morococala mine, near Oruro, Bolivia. In the USA, at the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; at Red Hill, Rumford, and from Newry, Oxford Co., Maine. On Reaphook Hill, near Blinman, Flinders Ranges, South Australia. From Kabwe (Broken Hill), Zambia.

Name: From *phosphate* in the composition, and the Greek for *cleavage*.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 738–739. (2) Hill, R.J. (1977) The crystal structure of phosphophyllite. Amer. Mineral., 62, 812–817. (3) Hill, R.J. (1976) Crystal data for phosphophyllite, $Zn_2Fe(PO_4)_2 \cdot 4H_2O$. J. Appl. Crystallog., 9, 503–504. (4) Dunn, P.J. and J. Norberg (1977) Phosphophyllite, variation in composition. Amer. Mineral., 62, 818. (5) Ericsson, T. and A.G. Nord (1984) Mössbauer studies of two natural phosphophyllites. Neues Jahrb. Mineral., Monatsh., 193–197. (6) Wilson, W.E. and A. Petrov (1999) Famous mineral localities: Cerro Rico de Potosí, Bolivia. Mineral. Record, 30, 9–36.

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Phosphorrösslerite $Mg(PO_3OH)\cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals equant or short prismatic [100], may be skeletal; forms noted include {010}, {100}, {110}, {011}, {120}, {111}, {140}, {$\bar{1}$11}. Also in botryoids, druses, and crusts.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 1.725(4) D(calc.) = 1.741 Soluble in H_2O; alters to newberyite on exposure.

Optical Properties: Semitransparent, opaque on exposure. *Color:* Colorless, pale yellow or honey-brown when included with iron oxides or organic material, turning white on exposure. *Luster:* Vitreous, changing to dull on exposure.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 6.5°$. *Dispersion:* $r > v$. $\alpha = 1.477$ $\beta = 1.485$ $\gamma = 1.486$ 2V(meas.) = 38°10′

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 11.32(1)$ $b = 25.36(2)$ $c = 6.574(5)$ $\beta = 95°11(18)'$ Z = 8

X-ray Powder Pattern: Synthetic. (ICDD 19–761).
3.29 (100), 2.82 (100), 4.55 (90), 4.42 (90), 4.13 (90), 4.02 (90), 2.704 (90)

Chemistry:

	(1)	(2)
P_2O_5	28.07	28.80
MgO	16.28	16.36
H_2O	54.51	54.84
insol.	0.08	
Total	98.94	100.00

(1) Schellgaden, Austria. (2) $Mg(PO_3OH)\cdot 7H_2O$.

Occurrence: In cold (10 °C) wet muck in an abandoned mine.

Association: n.d.

Distribution: From the Stüblbau works, Schellgaden, Austria.

Name: As the *phosphate* analog of *rösslerite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 107177.

References: (1) Friedrich, O.M. and J. Robitsch (1939) Phosphorrösslerit ($MgHPO_4\cdot 7H_2O$) als Mineral aus dem Stüblbau zu Schellgaden. Zentralb. Mineral. Geol. Paleon., Abt. A, Nr. 5, 142–155 (in German). (2) (1940) Amer. Mineral., 25, 313–314 (abs. ref. 1). (3) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 713–714. (4) Street, R.L.T. and A. Whitaker (1973) The isostructurality of rösslerite and phosphorrösslerite. Zeits. Krist., 137, 246–255.

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Phosphosiderite $Fe^{3+}PO_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, tabular on {010}, to stout prismatic [001], with prominent {010}, {110}, {001}, {011}, many others, to 2.5 cm. May be radial fibrous, in botryoidal or reniform crusts and masses. *Twinning:* On {101}, common, typically as interpenetrations.

Physical Properties: *Cleavage:* {010}, good; {001}, indistinct. *Fracture:* Uneven. Hardness = 3.5–4 D(meas.) = 2.74–2.76 D(calc.) = 2.72–2.73

Optical Properties: Transparent to translucent. *Color:* Peach-blossom-red, reddish violet, reddish purple, yellow-orange, may be dark blue, moss-green to nearly colorless; in transmitted light, typically rose-red to colorless. *Luster:* Vitreous to subresinous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale rose-red; Y = carmine-red; Z = colorless. *Orientation:* $Y = b$; $X \wedge c = \sim 4°$. *Dispersion:* $r > v$, very strong. α = 1.692–1.703 β = 1.725–1.728 γ = 1.738–1.739 2V(meas.) = 62°–66°

Cell Data: *Space Group:* $P2_1/n$. a = 5.329–5.330 b = 9.798–9.809 c = 8.710–8.714 β = 90.51°−90.60° Z = 4

X-ray Powder Pattern: The Kreuzberg, Germany. (ICDD 33-666).
4.689 (100), 2.787 (85), 4.363 (75), 3.610 (50), 2.572 (40), 4.912 (35), 2.013 (25)

Chemistry:

	(1)	(2)	(3)
P_2O_5	38.85	37.71	37.99
Fe_2O_3	44.30	44.38	42.73
H_2O	17.26	17.31	19.28
Total	100.41	99.40	100.00

(1) Kalterborn mine, Germany. (2) The Kreuzberg, Germany; average of two analyses.
(3) $FePO_4 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with strengite.

Occurrence: Typically an alteration product of triphylite in zoned complex granite pegmatites; may be a component of soils; replacing bones or shells.

Association: Triphylite, barbosalite, leucophosphite, laueite, huréaulite, strengite, turquoise.

Distribution: At many localities in small amounts. In Germany, from the Kalterborn mine, near Eiserfeld, North Rhine-Westphalia; on the Kreuzberg, Pleystein; and at Hagendorf and Waidhaus, Bavaria, Germany. From the La Vilate quarry, near Chanteloube, Haute-Vienne, France. At the Mangualde pegmatite, near Mesquitela, and the Bendada pegmatite, near Guarda, Portugal. From the Leveäniemi mine, near Kiruna, Sweden. In the Bomi Hill Caves, Liberia. At the Ficus and West Driefontein Caves, Transvaal, South Africa. In the Alto Ligonha district, Mozambique. In the USA, from the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., New Hampshire; at Mullica Hill, Gloucester Co., New Jersey; near Bethel Church, Pike Co., Indiana; in the Williams pegmatites, about eight km south of Rockford, Coosa Co., Alabama. Large crystals from the Bull Moose mine, five km southeast of Custer, Custer Co., South Dakota; from the Champion mine, Mono Co., and the Stewart mine, Pala, San Diego Co., California; from near Manhattan, Manhattan district, Nye Co., Nevada. At Rapid Creek, Yukon Territory, Canada. In the Sapucaia, Córrego do Urucum, and Énio pegmatite mines, around Galiléia, Minas Gerais, Brazil. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina.

Name: From *phospho*rus and the Greek for *iron* in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 769–771 [metastrengite]. (2) Moore, P.B. (1966) The crystal structure of metastrengite [phosphosiderite] and its relationship to strengite and phosphophyllite. Amer. Mineral., 51, 168–176. (3) Fanfani, L., P.F. Zanazzi, and S.G. Carobbi (1966) La struttura cristallina della metastrengite [phosphosiderite]. Atti Rend. Accad. Lincei, 40, 880–889 (in Italian).

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Phosphovanadylite $(Ba,Ca)(V^{4+},Al)_4(O,OH)_8(PO_4)_2 \cdot 12H_2O$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. Pseudocubes, to 50 μm, in aggregates and crusts.

Physical Properties: Hardness = n.d. D(meas.) = 2.16(3) D(calc.) = [2.13]

Optical Properties: Transparent. *Color:* Pale greenish blue; greenish black on oxidation after long exposure to air. *Streak:* Very pale greenish blue. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.566(4)$

Cell Data: *Space Group:* $I\overline{4}3m$. $a = 15.470(4)$ $Z = 6$

X-ray Powder Pattern: Enoch Valley mine, Idaho, USA.
3.164 (100), 2.582 (37), 2.445 (36), 7.73 (34), 10.8 (29), 2.738 (29), 2.827 (28)

Chemistry:

	(1)
P_2O_5	22.7
V_2O_4	45.6
Al_2O_3	3.7
ZnO	0.4
CdO	0.1
CaO	1.8
BaO	9.2
Na_2O	0.2
K_2O	0.9
F	0.03
H_2O	n.d.
Total	

(1) Enoch Valley mine, Idaho, USA; by electron microprobe, partial analysis, H_2O and $(OH)^{1-}$ from structure analysis; corresponds to $(Ba_{0.38}Ca_{0.20}K_{0.06}Na_{0.02})_{\Sigma=0.66}(V_{3.44}Al_{0.46})_{\Sigma=3.90}$ $P_2[O_{10.34}OH_{5.66}]_{\Sigma=16.00} \cdot 12H_2O$.

Occurrence: A rare mineral coating organic-rich phosphatic mudstone in the Phosphoria Formation.

Association: Sincosite.

Distribution: From the Enoch Valley phosphate mine, Soda Springs, Caribou Co., Idaho, USA.

Name: For *phospho*rus and *vanadyl* vanadium in the composition.

Type Material: n.d.

References: (1) Medrano, M.D., H.T. Evans, Jr., H.-R. Wenk, and D.Z. Piper (1998) Phosphovanadylite: a new vanadium phosphate mineral with a zeolite-type structure. Amer. Mineral., 83, 889–895.

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Phosphowalpurgite $(UO_2)Bi_4O_4(PO_4)_2•2H_2O$

Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As tabular crystals with {010} dominant, to 1 mm; as small clusters of irregular crystals, to 1 cm. "Exhibits simple twinning."

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = < 5 D(meas.) = n.d. D(calc.) = 6.36

Optical Properties: Translucent. *Color:* Brownish grey. *Streak:* Light brownish grey. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial. n = 1.9-2.0

Cell Data: *Space Group: P* $\bar{1}$. a = 7.060(3) b = 10.238(4) c = 5.464(3) α = 101.22(4)° β = 109.93(3)° γ = 87.93(4)° Z = 1

X-ray Powder Pattern: Smrkovec, Slavkovský Les Mountains, Czech Republic.
10.059 (100), 3.084 (95), 3.125 (86), 3.251 (72), 3.005 (52), 3.346 (43), 2.726 (42)

Chemistry:

	(1)	(2)		(1)	(2)
CaO	0.04		P_2O_5	7.65	10.17
Cu	0.30		V_2O_5	0.12	
PbO	0.24		As_2O_5	4.15	
Fe_2O_3	0.40		UO_3	18.73	20.49
Bi_2O_3	65.39	66.76	H_2O	2.59	2.58
SiO_2	0.18		Total	100.09	100.00

(1) Smrkovec, Slavkovský Les Mountains, Czech Republic; average of 8 electron microprobe analyses, H_2O molecule confirmed by IR and amount calculated from stoichiometry; corresponds to $[(UO_2)_{0.91}Ca_{0.08}Fe_{0.07}Cu_{0.05}Pb_{0.01}]_{\Sigma=1.12}Bi_{3.91}O_{3.91}[(PO_4)_{1.50}(AsO_4)_{0.50}(SiO_4)_{0.04}(VO_4)_{0.02}]_{\Sigma=2.06}•2.00H_2O$.
(2) $(UO_2)Bi_4O_4(PO_4)_2•2H_2O$.

Polymorphism & Series: Forms a series with walpurgite.

Occurrence: A secondary mineral formed by weathering of primary bismuth and uraninite in hydrothermal quartz veins.

Association: "Apatite", atelestite, bismutoferrite, bismutite, eulytite, hechtsbergite, metatorbernite, mixite, petitjeanite, preisingerite, pucherite, retgersite, schumacherite, smrkovecite, walpurgite.

Distribution: From the dumps of an abandoned mine near Smrkovec, 10 km NNE of Mariánské Lázně, Slavkovský Les Mountains, western Bohemia, Czech Republic.

Name: Signifies the (PO_4)-dominant composition, *phospho*, and structural relationship to *walpurgite*.

Type Material: Department of Mineralogy and Petrology, National Museum, Prague, Czech Republic; P1p 10/2001.

References: (1) Sejkora, J., J. Čejka, J. Hloušek, M. Novák, and V. Šrein (2004) Phosphowalpurgite, the (PO_4)-dominant analogue of walpurgite, from Smrkovec, Slavkovský Les Mountains, Czech Republic. Can. Mineral. 42(4), 963-972. (2) (2005) Amer. Mineral., 90, 770 (abs. ref. 1).

Phosphuranylite $(H_3O)_3KCa(UO_2)_7O_4(PO_4)_4 \cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In thin scales, irregular to rectangular in outline, to 2 mm. Commonly as scaly crusts, thin films, and coatings.

Physical Properties: *Cleavage:* One, perfect, ‖ flattening. Hardness = 2–2.5 D(meas.) = ∼4.1 D(calc.) = 4.575–4.631 Radioactive.

Optical Properties: Semitransparent. *Color:* Deep golden yellow, lemon-yellow, honey-yellow.
Optical Class: Biaxial (–), commonly nearly uniaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = golden yellow. *Orientation:* $Z \perp$ flattening. *Dispersion:* $r > v$, strong. *Absorption:* $X < Y = Z$; may be $X < Y < Z$. α = 1.658–1.695 β = 1.699–1.77 γ = 1.699–1.77 2V(meas.) = 0°–35°

Cell Data: *Space Group:* $Cmcm$. a = 15.779–15.899 b = 13.702–13.790 c = 17.253–17.330 Z = 4

X-ray Powder Pattern: Flat Rock mine, North Carolina, USA; nearly identical to dewindtite.
7.83 (10), 3.969 (9), 5.829 (8), 3.363 (6), 3.121 (6), 2.858 (6), 1.895 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3	76.4	78.1	76.58	CaO	2.3	2.1	2.15
P_2O_5	11.1	10.3	10.86	K_2O	n.d.	2.5	1.80
PbO	trace	0.2		H_2O	n.d.	[6.8]	8.61
				Total		[100.0]	100.00

(1) Rosmaneira, Portugal; partial analysis. (2) Bois Noirs, France; by electron microprobe, H_2O by difference. (3) $(H_3O)_3KCa(UO_2)_7O_4(PO_4)_4 \cdot 8H_2O$.

Occurrence: A secondary mineral typically occurring in the weathering zone of granite pegmatites, coating cracks and fissures near altered uraninite; in paleochannels in sandstone Colorado Plateau-type U–V deposits.

Association: Uraninite, autunite, meta-autunite, uranophane, uranophane-beta, becquerelite, curite, parsonsite, torbernite, metatorbernite, saléeite, sabugalite, haiweeite, uranian "opal".

Distribution: In the USA, from the Flat Rock and Buchanan pegmatite mines, Mitchell Co., North Carolina; in the Ruggles mine, near Grafton, and the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; at Newry, Oxford Co., Maine; from Branchville, Fairfield Co., Connecticut; at the Barker (Ferguson) mine, five km southeast of Keystone, Pennington Co., South Dakota; from the DeLongchamps and Red Bluff mines, Pyramid district, Washoe Co., and several other occurrences in Nevada. In Brazil, at the Énio and Córrego do Urucum pegmatites, near Galiléia, Minas Gerais; in the Perus district, 25 km north of São Paulo. From Pamplonita, Colombia. At Peveragno, Piedmont, and Arcu su Linnarbu, near Capoterra, Cagliari, Sardinia, Italy. From the La Crouzille mine and Margnac mine, Compreignac, Haute-Vienne, and at Bois Noirs, Loire, France. From Wölsendorf, Bavaria, Germany. In Portugal, at Carrasca, Sabugal, Mangualde, and elsewhere. From Shinkolobwe, Katanga (Shaba) Province, and at the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire). At Vatovory, Madagascar. In the Saddle Ridge mine, South Alligator Valley, Northern Territory, Australia. Known from a number of other minor localities.

Name: For *phosph*orus and *uranyl* uranium in the composition.

Type Material: Pennsylvania State University, State College, Pennsylvania; Yale University, New Haven, Connecticut, USA, 3249–3251.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 876. (2) Frondel, C. (1950) Studies of uranium minerals (V): phosphuranylite. Amer. Mineral., 35, 756–763. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 222–227. (4) Demartin, F., V. Diella, S. Donzelli, C.M. Gramaccioli, and T. Pilat (1991) The importance of accurate crystal structure determination of uranium minerals. I. Phosphuranylite $KCa(H_3O)_3(UO_2)_7(PO_4)_4O_4 \cdot 8H_2O$. Acta Cryst., 47, 439–446.

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Phuralumite $Al_2(UO_2)_3(PO_4)_2(OH)_6 \cdot 10H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, elongated along [001], flattened on [010], with {110}, {$\bar{1}$01}, {001}, to 0.5 mm, in crystalline veinlets and crusts.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = ∼3 D(meas.) = 3.5 D(calc.) = 3.52 Radioactive.

Optical Properties: Semitransparent. *Color:* Lemon-yellow.
Optical Class: Biaxial (–). *Pleochroism:* X = bright yellow; $Y = Z$ = pale yellow. *Orientation:* $X = b$; $Y \wedge c = 0°$–$8°$. $\alpha = [1.559]$ $\beta = 1.616$ $\gamma = 1.624$ 2V(meas.) = 40°

Cell Data: *Space Group:* $P2_1/a$. $a = 13.836(6)$ $b = 20.918(6)$ $c = 9.428(3)$ $\beta = 112.44(3)°$ Z = 4

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
10.4 (100), 3.08 (80), 5.17 (70), 3.40 (50), 3.47 (40), 8.0 (20), 2.95 (20)

Chemistry:

	(1)	(2)
UO_3	65.9	64.22
P_2O_5	10.3	10.62
Al_2O_3	7.6	7.63
H_2O	[16.2]	17.53
Total	[100.0]	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, H_2O by difference. (2) $Al_2(UO_2)_3(PO_4)_2(OH)_6 \cdot 10H_2O$.

Occurrence: A rare secondary mineral in the oxidized uraniferous zone of a complex granite pegmatite.

Association: Meta-autunite, phosphuranylite, threadgoldite, upalite.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: For PHosphorus, URanium, and ALUMinum in the composition.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG6201, RMG6195, RMG6197, RMG9852.

References: (1) Deliens, M. and P. Piret (1979) Les phosphates d'uranyle et d'aluminum de Kobokobo. II. La phuralumite $Al_2(UO_2)_3(PO_4)_2(OH)_6 \cdot 10H_2O$ et l'upalite $Al(UO_2)_3(PO_4)_2(OH)_3$, nouveaux minéraux. Bull. Minéral., 102, 333–337 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 208 (abs. ref. 1). (3) Piret, P., J. Piret-Meunier, and J.-P. Declercq (1979) Structure of phuralumite. Acta Cryst., 35, 1880–1882.

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Phurcalite $Ca_2(UO_2)_3O_2(PO_4)_2 \cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Platy crystals, flattened on [010] and elongated along [001], terminated by {001}, {110}, {111}, to 5 mm. Typically in radiating aggregates and thin crusts.

Physical Properties: *Cleavage:* {010}, {001}, perfect to good; {100}, good. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 86–95, 90.5 average (5 g load). D(meas.) = 4.22(4) D(calc.) = 4.220 Radioactive; may fluoresce green under SW UV.

Optical Properties: Transparent. *Color:* Yellow. *Streak:* Pale yellow. *Luster:* Vitreous to adamantine, may be silky in aggregates.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless to pale yellow; Y = very pale yellow to pale yellow; Z = bright yellow to golden yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, medium. *Absorption:* $X < Y < Z$. α = 1.670–1.680 β = 1.720–1.732 γ = 1.749–1.775 2V(meas.) = 68°–82°

Cell Data: *Space Group: Pbca.* a = 17.33–17.426 b = 15.87–16.062 c = 13.548–13.598 Z = 8

X-ray Powder Pattern: Bergen, Germany.
8.05 (100), 3.10 (80), 3.09 (80), 2.878 (70), 3.39 (50), 4.24 (30), 4.00 (30)

Chemistry:

	(1)	(2)	(3)	(4)
UO_3	70.9	72.0	69.88	69.30
P_2O_5	11.5	9.4	11.52	11.46
As_2O_5		1.4		
SiO_2			0.23	
CaO	8.3	8.7	9.40	9.06
K_2O			0.20	
H_2O	[9.3]	8.5	11.62	10.18
Total	[100.0]	100.0	102.85	100.00

(1) Bergen, Germany; by electron microprobe, H_2O by difference. (2) Merrivale quarry, England; by electron microprobe, H_2O by TGA. (3) Perus, Brazil; by electron microprobe, average of 19 analyses, H_2O by elemental analyzer; corresponds to $(Ca_{1.97}K_{0.05})_{\Sigma=2.02}(UO_2)_{2.87}O_{1.97}[(PO_4)_{1.90}(SiO_4)_{0.04}]_{\Sigma=1.94} \cdot 7.57H_2O$. (4) $Ca_2(UO_2)_3O_2(PO_4)_2 \cdot 7H_2O$.

Occurrence: A secondary mineral in cracks and fractures in granite and granite pegmatites.

Association: Autunite, meta-autunite, uranophane, other secondary uranium minerals.

Distribution: From Bergen, Saxony; at Wittichen, Black Forest; and from Waidhaus, Bavaria. In the Merrivale quarry, Dartmoor, Devon, England. At Nisa, Portugal. From Davignac, Corrèze, France. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In the USA, on the Ram claims, Pinto Mountains, Riverside Co., and at the Shale Hills, near Taft, Kern Co., California; from the Posey mine, Red Canyon, San Juan Co., and in the La Sal Mountains, Grand Co., Utah. Fine crystals from Perus, São Paulo, Brazil. At the La Gloria pegmatite, Córdoba Province, Argentina.

Name: For PHosphorus, URanium, and CALcium in the composition.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG13388; National Museum of Natural History, Washington, D.C., USA, 144187.

References: (1) Deliens, M. and P. Piret (1978) La phurcalite, $Ca_2(UO_2)_3(PO_4)_2(OH)_4 \cdot 4H_2O$, nouveau minéral. Bull. Minéral., 101, 356–358 (in French with English abs.). (2) (1979) Amer. Mineral., 64, 243 (abs. ref. 1). (3) Braithwaite, R.S.W., W.H. Paar, and J.E. Chisholm (1989) Phurcalite from Dartmoor, southwest England, and its identity with 'nisaite' from Portugal. Mineral. Mag., 53, 583–589. (4) Atencio, D., R. Neumann, A.J.G.C. Silva, and Y.P. Mascarenhas (1991) Phurcalite from Perus, São Paulo, Brazil, and redetermination of its crystal structure. Can. Mineral., 29, 95–105.

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Phyllotungstite $HCaFe_3^{3+}(WO_4)_6 \cdot 10H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. Crystals are flattened on {001}, to 0.25 mm, showing {100}, {010}, {110}, {001}, in radial aggregates and scaly crusts. *Twinning:* On {110}.

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* Irregular. Hardness = ∼2
D(meas.) = > 4.03 D(calc.) = 5.26

Optical Properties: Translucent. *Color:* Yellow to yellow-brown. *Streak:* Pale yellow. *Luster:* Pearly.
Optical Class: Biaxial (–), may be uniaxial (–). *Orientation:* $Z = c$. *Dispersion:* $r \gg v$.
$\alpha = 2.10(1)$ β = n.d. $\gamma = 2.185(1)$ 2V(meas.) = 18°

Cell Data: *Space Group:* $Pmmm$, $Pmm2$, or $P222$. $a = 7.29$ $b = 12.59$ $c = 19.55$
Z = 3

X-ray Powder Pattern: Clara mine, Germany.
3.13 (10), 3.25 (8), 1.822 (8), 6.33 (7), 2.92 (7), 2.45 (7), 6.01 (6)

Chemistry:

	(1)	(2)
WO_3	72.7	74.16
Fe_2O_3	13.3	12.77
PbO	2.1	
CaO	1.8	2.99
H_2O	[10.1]	10.08
Total	[100.0]	100.00

(1) Clara mine, Germany; H_2O by difference, corresponds to $H(Ca_{0.61}Pb_{0.18})_{\Sigma=0.79}Fe_{3.15}(WO_4)_{5.93} \cdot 10.2H_2O$. (2) $HCaFe_3(WO_4)_6 \cdot 10H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal polymetallic barite–fluorite deposit.

Association: Ferritungstite, scheelite, pyrite, fluorite, hematite, quartz.

Distribution: From the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: From the Greek for *leaf*, reflecting its crystal habit, and *tungsten* in its composition.

Type Material: University of Stuttgart, Stuttgart, Germany; National Museum of Natural History, Washington, D.C., USA, 161199.

References: (1) Walenta, K. (1984) Phyllotungstit, ein neues sekundäres Wolframmineral aus der Grube Clara im mittleren Schwarzwald. Neues Jahrb. Mineral., Monatsh., 529–535 (in German with English abs.). (2) (1986) Amer. Mineral., 71, 846 (abs. ref. 1).

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Pickeringite $MgAl_2(SO_4)_4 \cdot 22H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Acicular to hairlike crystals, with many forms measured although terminated crystals are very rare; in radial or matted aggregates; typically as incrustations and efflorescences.

Physical Properties: *Cleavage:* Poor on {010}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = 1.73–1.79 D(calc.) = 1.84 Soluble in H_2O, astringent taste.

Optical Properties: Semitransparent. *Color:* Colorless, white; may be pale shades of yellow, green, or red from metallic impurities; colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = 36°$. $\alpha = 1.475$ $\beta = 1.480$ $\gamma = 1.483$ 2V(meas.) = 60°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.1844(2)$ $b = 24.2715(9)$ $c = 21.2265(7)$ $\beta = 100.326(4)°$ Z = 4

X-ray Powder Pattern: Tucumcari, New Mexico, USA. (ICDD 12-299).
4.82 (100), 3.510 (90), 4.32 (35), 4.122 (30), 3.791 (30), 6.08 (20), 4.97 (20)

Chemistry:

	(1)	(2)
SO_3	37.84	37.29
Al_2O_3	12.30	11.87
MgO	4.35	4.69
CaO	0.09	
H_2O	44.66	46.15
insol.	0.50	
Total	99.74	100.00

(1) Quetena, Chile. (2) $MgAl_2(SO_4)_4 \cdot 22H_2O$.

Polymorphism & Series: Forms a series with halotrichite.

Mineral Group: Halotrichite group.

Occurrence: A common secondary mineral formed by alteration of pyrite in aluminous rocks or in coal seams; in the oxidized zone of pyritic hydrothermal mineral deposits, typically in arid regions, typically post-mining; a fumarolic product; formed in caves.

Association: Kalinite, alunogen, epsomite, melanterite, copiapite, gypsum.

Distribution: Widespread, so only a few localities are listed. In Chile, abundant from Cerros Pintados, 80 km southeast of Iquique, Tarapacá; at Quetena, west of Calama, and Chuquicamata, Antofagasta. In the USA, in New Mexico, from near Tucumcari, Quay Co.; at The Geysers, Sonoma Co., California; from Alum Point, Salt Lake Co., Utah. In Canada, at Newport, Nova Scotia, and from the junction of the two main branches of the Smoky River, Alberta. In Germany, at Wetzelstein, near Saalfeld, and from near Lehesten, Thuringia. On Valachov Hill, near Skřivaň, Czech Republic. At Cervenica (Opálbánya), Slovakia. In Italy, from Baia di Levante, Vulcano, Lipari Islands; on Mt. Etna, Sicily; and on Elba. At volcanoes on the Kamchatka Peninsula, Russia.

Name: To honor John Pickering (1777–1846), American lawyer and philologist of Boston, Massachusetts, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 523–526. (2) Quartieri, S., M. Triscari, and A. Viani (2000) Crystal structure of the hydrated sulphate pickeringite $MgAl_2(SO_4)_4.22H_2O$: X-ray powder diffraction study. Eur. J. Mineral., 12, 1131–1138.

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Picotpaulite $TlFe_2S_3$

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Crystal Data: Orthorhombic. *Point Group:* 222, $mm2$, or $2/m\ 2/m\ 2/m$. Crystals are typically pseudohexagonal plates, showing {001}, {110}, {010}, {140}, rare {232}, {234}, {236}, to 2 mm. *Twinning:* Penetration twins on {120} mimic hexagonal symmetry.

Physical Properties: Hardness = n.d. VHN = ∼41 (15 g load). D(meas.) = n.d. D(calc.) = 5.20

Optical Properties: Opaque. *Color:* In polished section, creamy white. *Luster:* Metallic. *Pleochroism:* Strong. *Anisotropism:* Strong; in gray-violet tints.
R_1–R_2: (400) 23.5–28.7, (420) 24.5–30.3, (440) 25.5–31.9, (460) 25.8–32.4, (480) 25.4–32.0, (500) 24.6–31.3, (520) 24.3–31.0, (540) 24.2–31.0, (560) 24.4–31.4, (580) 24.6–32.2, (600) 25.2–33.1, (620) 25.7–33.8, (640) 26.5–34.7, (660) 27.3–35.6, (680) 28.2–36.6, (700) 29.2–37.6

Cell Data: *Space Group:* $C222$, $Cmm2$, $Amm2$, or $Cmmm$. $a = 5.40(2)$ $b = 10.72(5)$ $c = 9.04(4)$ $Z = 4$

X-ray Powder Pattern: Alšar, Macedonia.
2.912 (100), 4.26 (90), 3.80 (70), 3.33 (70), 5.40 (50), 4.53 (50), 2.556 (50)

Chemistry:

	(1)	(2)	(3)
Tl	46.8	47.8	49.57
Pb	2.8	1.9	
Fe	28.6	28.2	27.09
S	24.1	23.9	23.34
Total	102.3	101.8	100.00

(1) Alšar, Macedonia; by electron microprobe, corresponding to $(Tl_{0.91}Pb_{0.05})_{\Sigma=0.96}Fe_{2.04}S_{3.00}$. (2) Do.; $(Tl_{0.93}Pb_{0.04})_{\Sigma=0.97}Fe_{2.03}S_{3.00}$. (3) $TlFe_2S_3$.

Occurrence: In a hydrothermal ore deposit with other arsenic and thallium minerals.

Association: Realgar, lorandite, raguinite, pyrite.

Distribution: From Alšar (Allchar), near Rošden, Macedonia [TL].

Name: In honor of Paul Picot (1931–), French mineralogist with the B.R.G.M., Orléans, France.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1983,703.

References: (1) Johan, Z., R. Pierrot, H.-J. Schubnel, and F. Permingeat (1970) La picotpaulite, $TlFe_2S_3$, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 93, 545–549 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1909 (abs. ref. 1).

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Picromerite $K_2Mg(SO_4)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Equant crystals, to 5 cm, showing {001}, {010}, {100}, {110}, {011}, {$\bar{2}$01}, {$\bar{1}$11}, several other forms; incrusting other salts; massive.

Physical Properties: *Cleavage:* On {$\bar{2}$01}, perfect (synthetic). Hardness = 2.5 D(meas.) = 2.028 (synthetic). D(calc.) = 2.031 Soluble in H_2O, taste bitter.

Optical Properties: Transparent. *Color:* Colorless or white; pale red, pale yellow, gray due to impurities; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge a = -1°$. *Dispersion:* $r > v$, weak.
$\alpha = 1.461$ $\beta = 1.463$ $\gamma = 1.476$ 2V(meas.) = 47°54′

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 9.066$ $b = 12.254$ $c = 6.128$
$\beta = 104°47'$ Z = 2

X-ray Powder Pattern: Synthetic.
3.71 (100), 4.06 (95), 4.16 (85), 3.06 (70), 2.964 (60), 3.16 (40), 2.813 (40)

Chemistry:

	(1)	(2)
SO_3	39.74	39.76
MgO	10.40	10.01
K_2O	23.28	23.39
Cl	0.28	
H_2O	26.87	26.84
$-O = Cl_2$	[0.06]	
Total	[100.51]	100.00

(1) Leopoldshall, Germany. (2) $K_2Mg(SO_4)_2 \cdot 6H_2O$.

Mineral Group: Picromerite group.

Occurrence: Principally occurs in oceanic bedded salt deposits; a volcanic sublimate in fumaroles; in a sulfate-rich hydrothermal ore deposit.

Association: Halite, anhydrite, kainite, epsomite (oceanic salt deposits); hohmannite, metavoltine, metasideronatrite (Chuquicamata, Chile).

Distribution: From Vesuvius, Campania, Italy. In Germany, in Saxony-Anhalt, from the Leopoldshall-Stassfurt district, and at Aschersleben; large crystals from the Ellers mine, Neuhof, near Fulda, Hessen; in the Adolfsglück mine, Schwarmstedt, Lower Saxony. At Kalusz, Stebnyk, and Golyn, Ukraine. From Whitby, Yorkshire, England. At volcanoes on the Kamchatka Peninsula, Russia. From the Qarhan salt lake, Qinghai Province, China. At Chuquicamata, Antofagasta, Chile.

Name: From the Greek for *bitter* and *part*, in allusion to the magnesium in its composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 453–454. (2) Carapezza, M. and L. Riva di Sanseverino (1970) Crystallography and genesis of double sulfates and their hydrates. III. Picromerite, $K_2Mg(SO_4)_2 \cdot 6H_2O$: a methodological check. Mineral. Petrog. Acta, 16, 5–11. (3) (1970) NBS Mono. 25, 8.

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Picropharmacolite $Ca_4Mg(AsO_4)_2(HAsO_3OH)_2 \cdot 11H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Prismatic crystals, rectangular, elongated along [001], to 1 cm; typically in radial aggregates, globular crusts, and fibrous concretions.

Physical Properties: *Cleavage:* {100}, {010}, perfect. Hardness = 1.5–2
D(meas.) = 2.62(2) D(calc.) = 2.60

Optical Properties: Semitransparent. *Color:* White; in transmitted light, colorless.
Luster: Feeble pearly to silky.
Optical Class: Biaxial (+). *Orientation:* $Z \wedge c = 8(1)°$. *Dispersion:* $r < v$, rather strong.
$\alpha = 1.557$–[1.566] $\beta = 1.566$–1.571 $\gamma = 1.577$–1.579 2V(meas.) = 50(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 13.547$–13.549 $b = 13.500$–13.562 $c = 6.710$–6.737
$\alpha = 99.63°-99.85°$ $\beta = 96.12°-96.41°$ $\gamma = 91.52°-91.60°$ Z = 2

X-ray Powder Pattern: Richelsdorf, Germany.
13.50 (FFF), 3.18 (F), 9.20 (mF), 3.78 (mF), 3.06 (mF), 2.92 (m), 4.84 (mf)

Chemistry:

	(1)	(2)
As_2O_5	46.93	48.88
MgO	3.73	4.28
CaO	25.77	23.85
H_2O	24.01	22.99
Total	100.44	100.00

(1) Freiberg, Germany. (2) $Ca_4Mg(AsO_4)_2(HAsO_4)_2 \cdot 11H_2O$.

Occurrence: An oxidation product of arsenic-bearing sulfides in reaction with surrounding calcic rocks; a recent efflorescence in mine workings.

Association: Erythrite, pharmacolite.

Distribution: In Germany, from Richelsdorf, Hesse; at Freiberg, Marienberg, Annaberg, and Schneeberg, Saxony; fine examples in the Anton mine, Heubachtal, near Schiltach, and at Wittichen, Black Forest. At Sainte-Marie-aux-Mines, Haut-Rhin, France. From Jáchymov (Joachimsthal), Czech Republic. At the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, Russia. In the Wanthwaite mine, St. John's in the Vale, Cumbria, England. At Silver Glen, Alva, Clackmannanshire, Scotland. From Bou Azzer, Morocco. At Matra, Corsica. In the USA, from Sterling Hill, Ogdensburg, Sussex Co., New Jersey; long fibers at the Getchell mine, Potosi district, Humboldt Co., Nevada.

Name: From the Greek for *bitter*, in allusion to its magnesium content, and its chemical similarity to *pharmacolite*.

Type Material: National School of Mines, Paris, France, 95.497.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 740–741. (2) Pierrot, R. (1961) Nouvelles données sur la picropharmacolite. Bull. Soc. fr. Minéral., 84, 391–396 (in French). (3) Yakhontova, L.K. (1968) Magnesium-calcium and calcium arsenates from the oxidation zone of an arsenide deposit. Trudy Mineral. Muzeya, Akad. Nauk SSSR, 18, 154–167 (in Russian). (4) Abbona, F. and G. Ferraris (1976) On the crystal chemistry of picropharmacolite. Amer. Mineral., 61, 326–328. (5) Catti, M., G. Ferraris, and G. Ivaldi (1981) The crystal structure of picropharmacolite, $Ca_4Mg(HAsO_4)_2(AsO_4)_2 \cdot 11H_2O$. Amer. Mineral., 66, 385–391.

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Piemontite-(Pb) $CaPbAl_2Mn^{3+}[Si_2O_7][SiO_4]O(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As imperfect blocky crystals or as random aggregates to 2 mm.

Physical Properties: *Cleavage*: Perfect on {001}, distinct on {010}. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = 6 D(meas.) = n.d. D(calc.) = 4.282

Optical Properties: Translucent. *Color*: Purplish red. *Streak*: Pink. *Luster*: Vitreous. *Optical Class*: Biaxial (-). α = 1.835(10) β = 1.885(10) γ = 1.895(10) 2V(meas.) = 30-40° 2V(calc.) = 47° *Pleochroism:* Moderate, *Z* = red-brown, *Y* = light red-brown, *X* = pale lilac. *Dispersion*: *r* < *v*, strong. *Absorption*: Z > *Y* > *X*. *Orientation*: *Y* = *b*, *X* ^ *c* = 23°, optic plane = (010).

Cell Data: *Space Group*: $P2_1/m$. *a* = 8.938(1) *b* = 5.6810(6) *c* = 10.289(1) β = 114.17(1)° Z = 2

X-ray Powder Pattern: Nežilovo village, Jacupica Mountains, Macedonia.
2.931 (100), 3.518 (77), 8.12 (68), 2.610 (66), 2.736 (57), 4.67 (53), 2.843 (51)

Chemistry:

	(1)
CaO	11.86
PbO	26.34
Al_2O_3	14.04
Mn_2O_3	8.61
Fe_2O_3	8.75
SiO_2	28.90
H_2O	[1.47]
Total	99.97

(1) Nežilovo village, Jacupica Mountains, Macedonia; average of 32 electron microprobe analyses, H_2O calculated from stoichiometry and Mn^{3+} confirmed by K-edge XANES spectroscopy; corresponding to $Ca(Pb_{0.73}Ca_{0.30})(Al_{0.65}Fe^{3+}_{0.34})Al(Mn^{3+}_{0.67}Fe^{3+}_{0.33})(Si_{2.96}Al_{0.04})O_{12}(OH)$.

Mineral Group: Epidote group.

Occurrence: From the Precambrian "Mixed Series" of metamorphic and igneous rocks in the central part of the Pelagonian massif.

Association: Barite, dolomite, calcite, hematite, cymrite, Zn- and Mn-bearing phlogopite, intermediate members of epidote-(Pb)–epidote–piemontite series, hedyphane, nežilovite, rinmanite, gahnite, tilasite, rutile, Zn-rich aegirine-augite, eckermannite-ferroglaucophane, senaite, roméite, As-fluorapatite, bindheimite, mimetite, chromite, braunite.

Distribution: From near Nežilovo village, 40 km SW of Veles, Babuna river valley, Jacupica Mountains, Macedonia.

Name: As a lead (*Pb*) dominant member of the epidote group.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 4193/1).

References: (1) Chukanov, N.V., D.A. Varlamov, F. Nestola, D.I. Belakovskiy, J. Goettlicher, S.N. Britvin, A. Lanza, and S. Jančev (2012) Piemontite-(Pb), $CaPbAl_2Mn^{3+}[Si_2O_7][SiO_4]O(OH)$, a new mineral species of the epidote supergroup. Neues Jahrbuch für Mineralogie, Abhandlungen, 189/3, 275-286. (2) (2014) Amer. Mineral., 99, 2441-2442 (abs. ref. 1).

Piemontite $Ca_2(Al,Mn^{3+},Fe^{3+})_3(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In prismatic, bladed or acicular crystals, to 8 cm; in clusters of radiating crystals; as anhedral grains and grain aggregates. *Twinning:* {100}, lamellar, uncommon.

Physical Properties: *Cleavage:* {001}, perfect; {100}, poor. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 3.46–3.54 D(calc.) = [3.45]

Optical Properties: Translucent to nearly opaque. *Color:* Reddish brown, deep red, purplish red to almost black; in thin section, yellow, pink, violet to deep red. *Streak:* Reddish. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = light yellow, orange to pink; Y = pale violet to deep lavender; Z = pink to deep red. *Orientation:* $Y = b$; $X \wedge c = 2°–9°$. *Dispersion:* $r > v$, strong; less commonly $r < v$. *Absorption:* $Z > Y > X$. $\alpha = 1.730–1.794$ $\beta = 1.740–1.807$ $\gamma = 1.762–1.829$ 2V(meas.) = 64°–106°

Cell Data: *Space Group:* $P2_1/m$. a = 8.878(10) $b = 5.692(5)$ $c = 10.201(10)$ $\beta = 115.40(20)°$ Z = 2

X-ray Powder Pattern: Sörhårås, Sweden.
2.91 (FFb), 3.50 (F), 2.84 (F), 2.698 (F), 2.677 (F), 2.602 (F), 2.415 (F)

Chemistry:

	(1)		(1)
SiO_2	37.31	MgO	0.00
TiO_2	0.06	CaO	20.64
Al_2O_3	18.20	Na_2O	0.67
Fe_2O_3	8.46	K_2O	0.30
Mn_2O_3	12.33	H_2O^+	0.14
FeO	0.00	H_2O^-	0.00
MnO	1.89	Total	100.00

(1) St. Marcel, Italy; corresponds to $(Ca_{1.78}Mn^{2+}_{0.13}Na_{0.10}K_{0.03})_{\Sigma=2.04}(Al_{1.73}Mn^{3+}_{0.76}Fe^{3+}_{0.51})_{\Sigma=3.00}Si_{3.00}O_{12}[O_{0.45}(OH)_{0.08}]_{\Sigma=0.53}$.

Mineral Group: Epidote group.

Occurrence: In regionally metamorphosed rocks of the greenschist to amphibolite facies; in metasomatized manganese deposits; in low-temperature hydrothermal veins in altered rhyolites, andesites, and diorites.

Association: Epidote, tremolite, glaucophane, orthoclase, quartz, calcite.

Distribution: Many localities. In the Praborna mine, south of St. Marcel, Val d'Aosta, Piedmont, Italy. In Sweden, on Sörhårås and Rakten, Ultevis, Norrbotten, and at Jakobsberg and Långban, Värmland. At Tachgagalt, Anti-Atlas Mountains, Morocco. In the USA, at Garnet Lake and in the Agnew Meadow mine, Madera Co., and in the Braito mine, Plumas Co., California; in the Tucson Mountains, Pima Co., Arizona; at the Idarado mine, Ouray Co., Colorado; in Yuba Canyon, Peavine Mountain, Washoe Co., Nevada; and on Pine Mountain, Adams Co., Pennsylvania. In the Wessels mine, near Kuruman, Cape Province, South Africa. At the Kajlidongri mine, Jhabua district, Madhya Pradesh, India. From Otakiyama, Tokushima Prefecture, and other places in Japan. Large crystals from eight km northeast of Old Boolcoomata, South Australia.

Name: After the Piemonte (Piedmont) region in northwestern Italy.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 521–522. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 135–150. (3) Asklund, A.M. (1966) Sur les paramètres cristallographiques de la piémontite. Bull. Soc. fr. Minéral., 89, 246–250 (in French). (4) Dollase, W.A. (1969) Crystal structure and cation ordering of piemontite. Amer. Mineral., 54, 710–717.

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Pierrotite $TlSb_3As_2S_8$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As polycrystalline aggregates.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = 4.97 D(calc.) = 4.75

Optical Properties: Translucent. *Color:* Gray-black; in polished section, white, with red internal reflections; dark red in thin section. *Luster:* Metallic, lively. *Anisotropism:* Moderate. R_1–R_2: (400) 35.9–39.6, (420) 35.2–38.8, (440) 34.5–38.0, (460) 33.7–37.2, (480) 33.1–36.6, (500) 32.5–36.0, (520) 31.9–35.5, (540) 31.3–35.0, (560) 30.7–34.5, (580) 30.2–34.0, (600) 29.7–33.4, (620) 29.1–32.8, (640) 28.6–32.1, (660) 28.0–31.5, (680) 27.4–30.9, (700) 26.7–30.3

Cell Data: *Space Group:* $Pna2_1$. $a = 38.746(8)$ $b = 8.816(2)$ $c = 7.989(2)$ $Z = 8$

X-ray Powder Pattern: Jas Roux, France.
3.59 (100), 3.49 (90), 2.70 (90), 3.63 (80), 2.84 (80), 2.347 (80), 2.52 (60)

Chemistry:

	(1)	(2)
Tl	20.95	20.94
Sb	37.65	37.43
As	15.54	15.35
S	26.57	26.28
Total	100.71	100.00

(1) Jas Roux, France; by electron microprobe, average of seven analyses. (2) $TlSb_3As_2S_8$.

Polymorphism & Series: Dimorphous with parapierrotite.

Occurrence: In quartz veins (Jas Roux, France).

Association: Stibnite, realgar, pyrite, an unnamed amorphous mineral of composition $Tl(As,Sb)_{10}S_{16}$ (Jas Roux, France); chabourneite, parapierrotite (Alšar, Macedonia).

Distribution: From the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France [TL]. At Alšar (Allchar), near Rošden, Macedonia. From near Lookout Pass, Tooele Co., Utah, USA.

Name: Honors Roland Pierrot (1930–), French mineralogist, Head of Mineralogy, B.R.G.M., Orléans, France.

Type Material: National School of Mines, Paris, France.

References: (1) Guillemin, C., Z. Johan, C. Laforêt, and P. Picot (1970) La pierrotite, $Tl_2(Sb,As)_{10}S_{17}$, une nouvelle espèce minérale. Bull. Soc. fr. Minéral., 93, 66–71 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1909–1910 (abs. ref. 1). (3) Engel, P., M. Gostojić, and W. Nowacki (1983) The crystal structure of pierrotite, $Tl_2(As,Sb)_{10}S_{16}$. Zeits. Krist., 165, 209–215.

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Pigeonite $(Mg, Fe^{2+}, Ca)(Mg, Fe^{2+})Si_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, to 1 cm; granular, massive. *Twinning:* Commonly twinned simply or multiply on {100} or {001}.

Physical Properties: *Cleavage:* Good on {110}, (110) $\wedge$ $(1\bar{1}0)$ ~87°; partings on {100}, {010}, and {001}. *Fracture:* [Uneven] (by analogy to the pyroxene group). *Tenacity:* [Brittle.] Hardness = 6 D(meas.) = 3.17–3.46 D(calc.) = [3.53]

Optical Properties: Semitransparent. *Color:* Brown, greenish brown-black; in thin section, colorless, pale yellow-green, brownish green. *Luster:* [Vitreous.]
Optical Class: Biaxial (+). *Pleochroism:* Weak to moderate; X = colorless, pale green, brown; Y = pale brown, pale brownish green, brownish pink; Z = colorless, pale green, pale yellow. *Orientation:* $X = a$; $Z \wedge c = 32°–44°$. *Dispersion:* $r < v$ or $r > v$, moderate. $\alpha = 1.682–1.732$ $\beta = 1.684–1.732$ $\gamma = 1.705–1.757$ 2V(meas.) = 0°–30°

Cell Data: *Space Group:* $P2_1/c$. $a = 9.706(2)$ $b = 8.950(1)$ $c = 5.246(1)$ $\beta = 108.59(1)°$ Z = 4

X-ray Powder Pattern: Yumoto, Hakone volcano, Japan.
3.021 (100), 2.903 (100), 3.210 (80), 2.908 (80), 2.578 (60), 1.6265 (60), 1.4935 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	50.56	51.47	MgO	16.10	21.68
TiO_2	0.58	0.29	CaO	7.05	1.45
Al_2O_3	1.41	1.56	Na_2O	0.26	0.07
Fe_2O_3	0.12	1.42	K_2O	0.23	0.03
FeO	23.17	21.72	H_2O^-	0.07	0.02
MnO	0.54	0.52	Total	100.09	100.23

(1) Hakone volcano, Japan; corresponds to $(Mg_{0.92}Fe^{2+}_{0.73}Ca_{0.29}Ti_{0.02}Mn_{0.02}Na_{0.02}K_{0.01})_{\Sigma=2.01}(Si_{1.94}Al_{0.06})_{\Sigma=2.00}O_6$. (2) Bushveld complex, South Africa; corresponds to $(Mg_{1.21}Fe^{2+}_{0.68}Ca_{0.06}Fe^{3+}_{0.03}Mn_{0.02}Ti_{0.01})_{\Sigma=2.01}(Si_{1.93}Al_{0.07})_{\Sigma=2.00}O_6$.

Mineral Group: Pyroxene group.

Occurrence: Common in rapidly cooled siliceous volcanic rocks. Inverted varieties with exsolved augite are found in layered mafic intrusives. From metamorphosed iron formations. Also in meteorites.

Association: Augite, olivine.

Distribution: Many localities worldwide. Studied material from: in the USA, at Pigeon Point, Cook Co., Minnesota; in the Goose Creek quarry, Leesburg, Loudoun Co., Virginia. From the Cobalt area, Ontario, Canada. In the Skaergaard intrusion, Kangerdlugssuaq Fjord, Greenland. From the Bushveld complex, Transvaal, South Africa. At the Hakone volcano, Iwate Prefecture, Japan. On the Isles of Mull and Rhum, and at Ardnamurchan, Argyllshire, Scotland. From the Vogelsberg area, Hesse, Germany.

Name: For the occurrence at Pigeon Point, Minnesota, USA.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 86. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 162–196. (3) Kuno, H. and H.H. Hess (1953) Unit cell dimensions of clinoenstatite and pigeonite in relation to other common clinopyroxenes. Amer. J. Sci., 251, 741–752. (4) Morimoto, N. and N. Güven (1970) Refinement of the crystal structure of pigeonite. Amer. Mineral., 55, 1195–1209.

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Pillaite $Pb_9Sb_{10}S_{23}ClO_{0.5}$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Pilsenite Bi_4Te_3

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Rare tabular crystals; massive, commonly interlayered with very thin layers of hessite.

Physical Properties: Hardness = Soft. VHN = 48–60, 53 average (25 g load).
D(meas.) = n.d. D(calc.) = [8.4]

Optical Properties: Opaque. *Color:* Tin-white to pale steel-gray. *Luster:* Metallic. *Anisotropism:* Noticeable.
R_1–R_2: (400) 61.6–62.9, (420) 62.3–63.4, (440) 62.8–64.0, (460) 63.2–64.4, (480) 63.5–64.8, (500) 63.7–65.3, (520) 63.9–65.8, (540) 64.1–66.2, (560) 64.3–66.7, (580) 64.4–67.0, (600) 64.5–67.3, (620) 64.5–67.4, (640) 64.5–67.6, (660) 64.6–67.7, (680) 64.6–67.7, (700) 64.6–67.8

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.446(2)$ $c = 41.94(2)$ $Z = 3$

X-ray Powder Pattern: Nagybörzsöny, Hungary.
3.25 (vs), 2.36 (s), 2.22 (s), 1.998 (s), 1.833 (s), 1.485 (s), 4.68 (m)

Chemistry:

	(1)	(2)	(3)
Bi	65.2	68.8	68.59
Ag	0.1		
Pb	1.1	0.3	
Fe	0.0		
Te	31.1	30.4	31.41
S	0.1		
Total	[97.6]	99.5	100.00

(1) Nagybörzsöny, Hungary; by electron microprobe, average of four analyses; corresponds to $(Bi_{3.86}Pb_{0.07}Ag_{0.01})_{\Sigma=3.94}(Te_{3.02}S_{0.04})_{\Sigma=3.06}$. (2) Nagybörzsöny, Hungary; by electron microprobe, corresponds to $(Bi_{4.05}Pb_{0.02})_{\Sigma=4.07}Te_{2.93}$. (3) Bi_4Te_3.

Occurrence: Of hydrothermal origin.

Association: Hessite, joséite, bismuthinite (Nagybörzsöny, Hungary); tsumoite (Sylvanite, New Mexico, USA); argentian pentlandite, hessite, argentian tetrahedrite (Koronuda deposit, Macedonia).

Distribution: From Nagybörzsöny, Börzsöny Mountains, near Esztergom (Gran), Hungary [TL]. At Săcărîmb (Nagyág), Romania. In the Koronuda Au–Cu deposit, Macedonia. From the Bereznyakov gold deposit, Southern Ural Mountains, Russia. At Sylvanite, Hidalgo Co., New Mexico, USA. In the Corrego Criminosa gold district, Goias, Brazil. From the Huangshandong Cu–Ni deposit, Hami, Xinjiang Province, China.

Name: For the type locality, Nagybörzsöny (Deutsch-Pilsen), Hungary.

Type Material: Loránd Eötvös University, Budapest, Hungary, A-563.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 167 [wehrlite = pilsenite]. (2) Ozawa, T. and H. Shimazaki (1982) Pilsenite redefined and wehrlite discredited. Proc. Japan Acad., 58, Ser. B, 291–294 (in English). (3) (1984) Amer. Mineral., 69, 215 (abs. ref. 1). (4) Yamana, K., K. Kihara, and T. Matsumoto (1979) ??title?? Acta Cryst., 35, 147–149. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 438–439. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 436.

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Pinakiolite $(Mg, Mn^{2+})_2(Mn^{3+}, Sb^{5+})BO_5$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are typically rectangular, to 2 cm, platy on {010}, or short prismatic [001], may be bent. *Twinning:* Common on {011}, forming contact and cruciform interpenetration twins.

Physical Properties: *Cleavage:* Good on {010}. *Tenacity:* Very brittle. Hardness = 6
D(meas.) = 3.88 D(calc.) = 3.79–4.09

Optical Properties: Opaque to translucent. *Color:* Black, olive-green, yellowish brown; deep reddish brown in transmitted light. *Streak:* Brownish gray. *Luster:* Metallic, brilliant on {010}, to pearly.
Optical Class: Biaxial (–). *Pleochroism:* X = deep reddish brown; Z = reddish yellow.
Orientation: $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, moderate (?). $\alpha = 1.908(5)$
$\beta = 2.05(1)$ $\gamma = 2.06(10)$ 2V(meas.) = 32(1)°

Cell Data: *Space Group:* $C2/m$. $a = 21.773$–21.808 $b = 5.977$–6.162 $c = 5.327$–5.341
$\beta = 94.37°$–$95.83°$ Z = 8

X-ray Powder Pattern: Långban, Sweden.
2.51 (10), 2.70 (9), 5.42 (8), 1.986 (6), 2.165 (4), 1.623 (4), 1.496 (4)

Chemistry:

	(1)	(2)
Sb_2O_5		18.09
B_2O_3	16.05	16.61
Fe_3O_4	2.12	
Al_2O_3		0.22
Fe_2O_3		0.06
Mn_2O_3	34.93	22.55
MnO	15.70	11.33
PbO	0.78	
MgO	29.30	32.02
CaO	1.12	
Total	[100.00]	100.88

(1) Långban, Sweden; recalculated to 100% after deduction of SiO_2 1.21%, H_2O 0.47%. (2) Do.; B_2O_3 by ICP spectroscopy, total Sb as Sb_2O_5, Mn^{2+}:Mn^{3+} calculated for charge balance; corresponds to $(Mg_{1.68}Mn^{2+}_{0.32})_{\Sigma=2.00}(Mn^{3+}_{0.60}Sb^{5+}_{0.22}Al_{0.01})_{\Sigma=0.83}BO_5$.

Occurrence: A rare mineral in banded granular dolomite in a metamorphosed Fe–Mn orebody.

Association: Hausmannite, tephroite, berzeliite, manganophyllite, dolomite, calcite.

Distribution: From Långban, Värmland, Sweden.

Name: From the Greek for *a small tablet*, in allusion to the thin tabular habit.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 531826.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 324–325. (2) Moore, P.B. and T. Araki (1974) Pinakiolite, $Mg_2Mn^{3+}O_2[BO_3]$; warwickite, $Mg(Mg_{0.5}Ti_{0.5})O[BO_3]$; wightmanite, $Mg_5(O)(OH)_5[BO_3]\bullet nH_2O$: crystal chemistry of complex 3 Å wallpaper structures. Amer. Mineral., 59, 985–1004. (3) Hansen, S., U. Hålenius, and B. Lindqvist (1988) Antimony-rich pinakiolite from Långban, Sweden: a new structural variety. Neues Jahrb. Mineral., Monatsh., 231–239. (4) Norrestam, R. and S. Hansen (1990) Structural investigation of an antimony-rich pinakiolite, $Mg_{1.90}Mn_{0.91}Sb_{0.19}O_2BO_3$, from Långban, Sweden. Zeits. Krist., 191, 105–116. (5) Cooper, M.A. and F.C. Hawthorne (1998) The crystal structure of blatterite, $Sb^{5+}_3(Mn^{3+}, Fe^{3+})_9(Mn^{2+}, Mg)_{35}(BO_3)_{16}O_{32}$, and structural hierarchy in Mn^{3+}−bearing zigzag borates. Can. Mineral., 36, 1171–1193. (6) Thompson, R.M. and J.A. Gower (1954) A magnesium borate from Isére, France and Swift River, Yukon Territory, with X-ray powder data for some anhydrous borates. Amer. Mineral., 39, 522–524.

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Pinalite $Pb_3W^{6+}O_5Cl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As bladed acicular crystals, to 0.5 mm, elongated along [001], flattened on {010}, terminated by {$h0l$}; in slightly divergent sprays. *Twinning:* About [010], yielding penetration twins by rotation.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.78

Optical Properties: Transparent. *Color:* Bright yellow, golden, orange, pale yellow.
Luster: Adamantine.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, moderate.
$\alpha = 2.490$ $\beta = 2.495$ $\gamma = 2.505$ 2V(meas.) = 70° 2V(calc.) = 70.5°

Cell Data: *Space Group: Amam.* $a = 11.073(2)$ $b = 13.067(3)$ $c = 5.617(1)$ $Z = 4$

X-ray Powder Pattern: Mammoth-St. Anthony mine, Arizona, USA.
2.926 (10), 3.778 (9), 1.642 (5), 3.284 (4), 2.814 (4), 6.52 (3), 2.770 (3)

Chemistry:

	(1)	(2)
WO_3	23.3	24.24
PbO	70.7	70.02
Cl	7.1	7.41
$-O = Cl_2$	1.6	1.67
Total	99.5	100.00

(1) Mammoth-St. Anthony mine, Arizona, USA; by electron microprobe, corresponding to $Pb_{3.09}W_{0.98}O_{5.04}Cl_{1.95}$. (2) $Pb_3WO_5Cl_2$.

Occurrence: A late-stage secondary mineral in the oxidized zone of a base-metal deposit.

Association: Chromian leadhillite, cerussite, matlockite, diaboleite, caledonite, connellite, iranite, murdochite, fluorite, quartz.

Distribution: From the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA.

Name: For Pinal Co., Arizona, USA (in turn named for the Pinal Indians), where the mineral was first noted to occur.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 53775; Harvard University, Cambridge, Massachusetts, 119858; National Museum of Natural History, Washington, D.C., USA, 165890.

References: (1) Dunn, P.J., J.D. Grice, and R.A. Bideaux (1989) Pinalite, a new lead tungsten chloride mineral from the Mammoth mine, Pinal County, Arizona. Amer. Mineral., 74, 934–935.
(2) Grice, J.D. and P.J. Dunn (2000) Crystal-structure determination of pinalite. Amer. Mineral., 85, 806–809.

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Pinchite $Hg_5O_4Cl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As euhedral crystals, to 1 mm, blocky to tabular, may be distorted, showing {001}, {010}, {100}, and {012}.

Physical Properties: Hardness = Very soft. D(meas.) = 9.5 D(calc.) = 9.25

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black to dark brown. *Streak:* Reddish brown.
Optical Class: Biaxial; very strong birefringence. *Pleochroism:* Strong; red to black. $n = > 2.0$
2V(meas.) = n.d.

Cell Data: *Space Group: Ibam.* $a = 11.619(3)$ $b = 6.105(2)$ $c = 11.710(3)$ Z = 4

X-ray Powder Pattern: Terlingua, Texas, USA.
2.837 (100), 2.695 (80), 3.94 (60), 2.919 (50), 3.256 (35), 2.169 (20), 1.791 (15)

Chemistry:

	(1)
HgO	94.5
Cl	6.3
Br	0.2
$-O = (Cl, Br)_2$	[1.4]
Total	[99.6]

(1) Terlingua, Texas, USA; by neutron activation, corresponding to $Hg_{5.00}O_{4.00}Cl_{2.04}Br_{0.03}$.

Occurrence: A secondary mineral in a hydrothermal mercury deposit.

Association: Montroydite, terlinguaite.

Distribution: From Terlingua, Brewster Co., Texas, USA.

Name: To honor William Wallace Pinch (1940–), American mineral collector of Rochester, New York, USA, who first noted the species.

Type Material: Canadian Museum of Nature, Ottawa; Royal Ontario Museum, Toronto, Canada, M33258; Harvard University, Cambridge, Massachusetts, 119858; National Museum of Natural History, Washington, D.C., USA, 128440, 132391, 160256.

References: (1) Sturman, B.D. and J.A. Mandarino (1974) Pinchite, a new mercury oxychloride from Terlingua, Texas. Can. Mineral., 12, 417–418. (2) (1976) Amer. Mineral., 61, 340 (abs. ref. 1). (3) Hawthorne, F.C., M. Cooper, and P.K. Sen Gupta (1994) The crystal structure of pinchite, $Hg_5Cl_2O_4$. Amer. Mineral., 79, 1199–1203.

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Pingguite $Bi_6Te_2^{4+}O_{13}$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystals, to 0.6 μm, columnar, in granular aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = 5–6 VHN = 449–572, 510 average (50 g load). D(meas.) = 8.44 D(calc.) = 8.64

Optical Properties: Semitransparent. *Color:* Yellowish green. *Streak:* Pale yellow-green. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial. $n = > 2$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.
R: (546) 13.25

Cell Data: *Space Group:* n.d. $a = 5.689(1)$ $b = 10.791(1)$ $c = 5.308(1)$ Z = 1

X-ray Powder Pattern: Yangjiava, China.
3.146 (100), 2.841 (80), 2.694 (20), 1.695 (20), 1.956 (10), 1.631 (10), 2.651 (9)

Chemistry:

	(1)	(2)
TeO_2	20.17	18.59
Bi_2O_3	79.56	81.41
Total	99.73	100.00

(1) Yangjiava, China; by electron microprobe, average of 15 analyses; corresponds to $Bi_{5.80}Te_{2.15}O_{13.00}$. (2) $Bi_6Te_2O_{13}$.

Occurrence: In the oxidation zone of a gold deposit.

Association: Malachite, pyromorphite, bismutite, gold, "electrum", scheelite, quartz, calcite, "limonite".

Distribution: From Yangjiava, Pinggu Co., Beijing Municipality, China [TL].

Name: For its occurrence in Pinggu Co., China.

Type Material: Geological Museum of China, Beijing, China.

References: (1) Sun Zhifu, Luo Keding, Tan Falan, and Zhang Jingyi (1994) Pingguite; a new bismuth tellurite mineral. Acta Mineralogica Sinica, 14(4), 315–321 (in Chinese with English abs.). (2) (1996) Amer. Mineral., 81, 767 (abs. ref. 1). (3) (1999) Mineral. Abs., 50, 254 (abs. ref. 1).

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Pinnoite $MgB_2O(OH)_6$

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Crystal Data: Tetragonal. *Point Group:* 4. Uncommon as short prismatic crystals, elongated along [001], showing {110}, {011}, {112}, {122}, to 1 mm; may be radial fibrous, typically crystalline granular.

Physical Properties: *Fracture:* Uneven. Hardness = 3.5 D(meas.) = 2.27 D(calc.) = 2.21 Soluble in boiling H_2O.

Optical Properties: Translucent. *Color:* Sulfur-yellow, straw-yellow, greenish yellow, pistachio-green; pale yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.565$ $\epsilon = 1.575$

Cell Data: *Space Group:* $P4_2$. $a = 7.6140(13)$ $c = 8.1898(8)$ Z = 4

X-ray Powder Pattern: Stassfurt, Germany. (ICDD 25-1119).
5.39 (100), 2.309 (70), 2.045 (50), 3.61 (40), 3.14 (40), 2.252 (35), 1.905 (30)

Chemistry:

	(1)	(2)
B_2O_3	42.50	42.46
Fe	0.15	
MgO	24.45	24.58
Cl	0.18	
H_2O	32.85	32.96
Total	100.13	100.00

(1) Stassfurt, Germany; average of several analyses. (2) $MgB_2O(OH)_6$.

Occurrence: Typically in bedded marine salt deposits; an efflorescence around salt springs and lakes.

Association: Boracite, kaliborite.

Distribution: In Germany, in Saxony-Anhalt, from the Stassfurt-Leopoldshall district, at Schmidtmannshall, near Aschersleben. From the Inder borate deposit, Kazakhstan. At the Da Quidam saline lake, Qinghai-Xizang Plateau, Tibet, China. In the USA, from the Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., California. At Socacastro, Salta Province, Argentina.

Name: To honor Oberbergrat Pinno, Chief Councillor of Mines, Halle, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 334–335. (2) Genkina, E.A. and Y.A. Malinovskii (1983) Refinement of the structure of pinnoite: location of hydrogen atoms. Kristallografiya (Sov. Phys. Crystal.), 28, 803–805 (in Russian).

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Pintadoite $Ca_2V_2^{5+}O_7 \cdot 9H_2O$

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Crystal Data: n.d. *Point Group:* n.d. As crusts and stains.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Slowly soluble in H_2O; on evaporation yielding twinned lathlike crystals.

Optical Properties: Semitransparent. *Color:* Light to dark green.
Optical Class: n.d. ; moderate to high birefringence. *Pleochroism:* Slight; in yellow-greens.
n = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
V_2O_5	42.4	39.87
CaO	22.6	24.59
H_2O	35.0	35.54
Total	[100.0]	100.00

(1) Frisco No. 2 claim, Utah, USA; recalculated to 100% after deduction of gypsum and insoluble material. (2) $Ca_2V_2O_7 \cdot 9H_2O$.

Occurrence: As an efflorescence on sandstone in protected outcrops.

Association: Gypsum, quartz.

Distribution: In the USA, from the Frisco No. 2 and Ed Whitney claims, about 30 km north of Monticello, Pintado Canyon, San Juan Co., Utah; in the Coffins prospect, McElmo Creek area, Montezuma Co., and the Jo Dandy Hill mines, Uravan district, Montrose Co., Colorado.

Name: For Pintado Canyon, Utah, USA, where the mineral occurs.

Type Material: Harvard University, Cambridge, Massachusetts, 98962; National Museum of Natural History, Washington, D.C., USA, R5714, 93657.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1053.

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Piretite $\mathbf{Ca(UO_2)_3(Se^{4+}O_3)_2(OH)_4 \cdot 4H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals are tabular on {001}, to acicular, striated parallel to elongation, exhibiting an irregular outline with {100}, {010}, {001}, may be hollow, to 5 mm; in stacked and curved aggregates.

Physical Properties: *Cleavage:* On {001}, good. *Fracture:* Uneven. *Tenacity:* "Weak". Hardness = 2.5 D(meas.) = 4.00 D(calc.) = 3.87 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Lemon-yellow. *Luster:* Pearly. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, weak. $\alpha = [1.54]$ $\beta = 1.73(1)$ $\gamma = 1.75(1)$ 2V(meas.) = 33(5)°

Cell Data: *Space Group:* $Pmnm$ or $Pmn2_1$. $a = 7.010(3)$ $b = 17.135(7)$ $c = 17.606(4)$ Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
3.50 (100), 3.033 (100), 8.80 (80), 3.095 (50), 8.57 (40), 1.924 (40), 4.29 (30)

Chemistry:

	(1)	(2)
UO_3	72.0	68.96
SeO_2	19.3	17.84
CaO	3.57	4.51
H_2O	8.00	8.69
Total	102.9	100.00

(1) Shinkolobwe, Congo; by electron microprobe, average of five analyses, H_2O by TGA, IR confirms the presence of $(UO_2)^{2+}$, $(SeO_3)^{2-}$, H_2O; corresponds to $Ca_{0.76}(UO_2)_{3.02}(SeO_3)_{2.09}(OH)_{3.38} \cdot 3.64H_2O$. (2) $Ca(UO_2)_3(SeO_3)_2(OH)_4 \cdot 4H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a uranium deposit in limestone.

Association: Uraninite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Professor Paul Piret (1932–1999), crystallographer, Catholic University of Louvain, Louvain, Belgium, who described numerous new mineral species.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC 4717.

References: (1) Vochten, R., N. Blaton, O. Peeters, and M. Deliens (1996) Piretite, $Ca(UO_2)_3(SeO_3)_2(OH)_4 \cdot 4H_2O$, a new calcium uranyl selenite from Shinkolobwe, Shaba, Zaire. Can. Mineral., 34, 1315–1322. (2) (1997) Amer. Mineral., 82, 1040 (abs. ref. 1).

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Pirquitasite Ag_2ZnSnS_4

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Crystal Data: Tetragonal. *Point Group:* $\overline{4}2m$ or $\overline{4}$. As irregular grains, to 0.5 mm, intergrown with other minerals. *Twinning:* Polysynthetic.

Physical Properties: Hardness = n.d. VHN = 170–251 (25 g load). D(meas.) = n.d. D(calc.) = 4.822

Optical Properties: Opaque. *Color:* Brownish gray in reflected light, with red internal reflections. *Luster:* Metallic. *Anisotropism:* Strong, from brick-red to pale green.
R_1–R_2: (400) 23.9–24.4, (420) 23.4–24.0, (440) 22.9–23.6, (460) 22.6–23.4, (480) 22.4–23.2, (500) 22.3–23.0, (520) 22.2–23.0, (540) 22.2–23.0, (560) 22.2–23.0, (580) 22.3–23.2, (600) 22.5–23.3, (620) 22.6–23.3, (640) 22.8–22.8, (660) 22.6–22.2, (680) 22.0–21.7, (700) 21.5–21.4

Cell Data: *Space Group:* $I\overline{4}2m$ or $I\overline{4}$. a = 5.786(4) c = 10.829(6) Z = 2

X-ray Powder Pattern: Pirquitas deposit, Argentina.
3.267 (100), 1.976 (80), 1.735 (80), 2.049 (60), 2.901 (40), 1.289 (40), 1.165 (40)

Chemistry:

	(1)	(2)	(3)
Ag	39.72	39.6	40.85
Cu	0.06	1.5	
Zn	11.40	6.7	12.38
Fe	1.31	4.8	
Sn	23.12	23.0	22.48
S	24.42	24.0	24.29
Total	100.03	99.6	100.00

(1) Pirquitas deposit, Argentina; by electron microprobe, corresponding to $(Ag_{1.93}Cu_{0.01})_{\Sigma=1.94}(Zn_{0.92}Fe_{0.12})_{\Sigma=1.04}Sn_{1.02}S_{4.00}$. (2) Do.; by electron microprobe, corresponding to $(Ag_{1.96}Cu_{0.13})_{\Sigma=2.09}(Zn_{0.55}Fe_{0.46})_{\Sigma=1.01}Sn_{1.04}S_{4.00}$. (3) Ag_2ZnSnS_4.

Polymorphism & Series: Forms a series with hocartite.

Mineral Group: Stannite group.

Occurrence: As hydrothermal mineralization in veins associated with subvolcanic environments, similar to the classic Bolivian tin and silver deposits (Pirquitas deposit, Argentina).

Association: Hocartite, pyrite, marcasite, wurtzite, franckeite, miargyrite, aramayoite, chalcostibite, stannite, kesterite, rhodostannite, cassiterite (Pirquitas deposit, Argentina).

Distribution: From the Pirquitas deposit, Rinconada Department, Jujuy Province, Argentina [TL]. At the Toyoha mine, Hokkaido, Japan.

Name: For the type locality at the Pirquitas deposit in Argentina.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z. and P. Picot (1982) La pirquitasite, Ag_2ZnSnS_4, un nouveau membre du groupe de la stannite. Bull. Minéral., 105, 229–235 (in French with English abs.). (2) (1983) Amer. Mineral., 68, 1249 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 437.

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Pirssonite $Na_2Ca(CO_3)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Hemimorphic crystals, to 2 cm, showing {010}, {110}, {111}, {131}, {311}, large $\{\bar{1}11\}$; granular, massive, may be as efflorescences.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–3.5
D(meas.) = 2.352–2.382 D(calc.) = 2.367 Pyroelectric; soluble in H_2O, leaving $CaCO_3$.

Optical Properties: Transparent. *Color:* Colorless to white, may be pale yellow or gray if included; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, slight.
$\alpha = 1.504$ $\beta = 1.509$–1.510 $\gamma = 1.573$–1.575 $2V(meas.) = 31°26'$ $2V(calc.) = 27°$

Cell Data: *Space Group:* $Fdd2$. $a = 11.32(2)$ $b = 20.06(2)$ $c = 6.00(2)$ $Z = 8$

X-ray Powder Pattern: John Hay, Jr. Well No. 1, Wyoming, USA.
2.506 (100), 2.654 (90), 2.565 (80), 5.133 (71), 2.020 (71), 4.928 (60), 3.153 (50)

Chemistry:

	(1)	(2)
SiO_2	0.29	
CO_2	36.07	36.35
Al_2O_3	0.13	
CaO	23.38	23.16
Na_2O	25.70	25.61
K_2O	0.15	
H_2O	14.73	14.88
Total	100.45	100.00

(1) Searles Lake, California, USA; average of two analyses. (2) $Na_2Ca(CO_3)_2 \cdot 2H_2O$.

Occurrence: A rare component of saline lake-bed sediments; in a differentiated alkalic massif.

Association: Northupite, trona, gaylussite (Borax Lake, California, USA); shortite, bradleyite, northupite, gaylussite, trona (John Hay, Jr. Well No. 1, Wyoming, USA).

Distribution: In the USA, in California, from Searles Lake, San Bernardino Co., at Borax Lake, Lake Co., in Deep Spring Lake, Inyo Co., and at Owens Lake, Mono Co.; in the John Hay, Jr. Well No. 1, about 30 km west of Green River, Sweetwater Co., Wyoming. On the Arizaro, Pastos Grandes, and Pozuelos playas, Salta Province, Argentina. From the Jequetepeque River Valley, northwest Peru. On the Otjiwalundo Salt Pan, about 400 km west-northwest of Otavi, Namibia. In the Beypazari Basin, Ankara, Turkey. On Mt. Kukisvumchorr, Khibiny massif, and Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: To honor Professor Louis Valentine Pirsson (1860–1919), American petrographer and mineralogist, Yale University, New Haven, Connecticut, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 232–233. (2) Fahey, J.J. and M.E. Mrose (1962) Saline minerals of the Green River Formation. U.S. Geol. Sur. Prof. Paper 405, 24, 35–36, 48–49. (3) Corazza, E. and C. Sabelli (1967) The crystal structure of pirssonite, $CaNa_2(CO_3)_2 \cdot 2H_2O$. Acta Cryst., 23, 763–766.

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Pitiglianoite $K_2Na_6Si_6Al_6O_{24}(SO_4)\cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6. Hexagonal prisms, consisting of $\{10\bar{1}0\}$ and {0001}, elongated along [0001], to 4 mm.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = ~5 D(meas.) = 2.37(4) D(calc.) = 2.394

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.508(1)$ $\epsilon = 1.506(1)$

Cell Data: *Space Group:* $P6_3$. a = 22.121(3) $c = 5.221(1)$ Z = 3

X-ray Powder Pattern: Pitigliano, Italy.
4.77 (vs), 3.27 (vs), 6.39 (s), 3.69 (m), 2.769 (m), 2.650 (m), 5.54 (w)

Chemistry:

	(1)
SiO_2	34.99
Al_2O_3	29.05
CaO	0.07
Na_2O	17.10
K_2O	9.41
Cl	0.01
H_2O	[3.46]
SO_3	7.58
Total	[101.67]

(1) Pitigliano, Italy; by electron microprobe, average of seven analyses, H_2O calculated from theoretical composition; corresponding to $K_{2.08}Na_{5.75}Ca_{0.01}Si_{6.07}Al_{5.93}O_{24}(S_{0.99}O_4)\cdot 2.00H_2O$.

Mineral Group: Cancrinite group.

Occurrence: In metasomatized blocks of volcanic ejecta.

Association: Apatite, diopside, grossular.

Distribution: From Case Collina, Pitigliano, near Grosseto, Tuscany, Italy.

Name: For the locality at Pitigliano, Italy.

Type Material: University of Pisa, Pisa, Italy.

References: (1) Merlino, S., M. Mellini, E. Bonaccorsi, M. Pasero, L. Leoni, and P. Orlandi (1991) Pitiglianoite, a new feldspathoid from southern Tuscany, Italy: chemical composition and crystal structure. Amer. Mineral., 76, 2003–2008.

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Pitticite $\mathbf{Fe^{3+}_x(AsO_4)_y(SO_4)_z \cdot nH_2O}$

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Crystal Data: Amorphous. *Point Group:* n.d. Always massive, gellike, typically reniform, botryoidal, stalactitic, in thin opaline crusts, crazed and crackled when dry; earthy.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle when opaline. Hardness = 2–3 D(meas.) = 2.2–2.5 D(calc.) = n.d.

Optical Properties: Transparent to opaque. *Color:* Reddish brown, yellowish brown, brownish red to brownish black; yellow, gray to nearly white; may exhibit deep red internal reflections. *Streak:* Yellow to white. *Luster:* Waxy, vitreous, greasy, may be dull, earthy.
Optical Class: Isotropic. n = 1.616–1.66

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Amorphous to X-rays.

Chemistry:

	(1)	(2)
SO_3	7.28 – 17.97	6.1 – 16.5
P_2O_5	0.00 – 1.27	0.0 – 3.4
As_2O_5	14.54 – 33.99	13.0 – 39.9
SiO_2		0.0 – 0.1
Al_2O_3		0.2 – 1.3
Fe_2O_3	32.54 – 34.85	28.8 – 38.2
ZnO		0.3 – 0.4
MgO		0.2 – 0.7
CaO		0.1 – 0.2
H_2O^+		12.07 – 13.91
H_2O^-		12.05 – 13.10
H_2O	24.54 – 29.64	
Total	99.34 – 100.40	96.9 – 104.6

(1) Five localities; by wet methods, ranges. (2) Seven localities; by electron microprobe, ranges, H_2O by the Penfield method.

Occurrence: A late secondary mineral typically formed by oxidation of earlier arsenic-bearing species; may be deposited from mine and spring waters.

Association: Haidingerite, pharmacolite, pharmacosiderite, diadochite, scorodite, erythrite, melanterite, gypsum, alunite, "limonite".

Distribution: In Germany, from Freiberg, Schneeberg, Schwarzenberg, Marienberg, Johanngeorgenstadt, and other districts in Saxony; at St. Andreasberg, Harz Mountains. From Jáchymov (Joachimsthal), at Příbram, and near Kaňk, Kutná Hora district, Czech Republic. In England, in Cornwall, at Wheal Sparnon, Redruth; the Penberthy Croft mine, St. Hilary; the Botallack mine, St. Just; the Dolcoath mine, Camborne, Cornwall. In the USA, in the Tintic district, Juab Co., Utah; at the White Caps mine, Manhattan district, Nye Co., Nevada; from Sterling Hill, Ogdensburg, Sussex Co., New Jersey. At Djebel Debar, Algeria. A number of other localities are suggested for this poorly-defined species.

Name: From the Greek for *pitch*, for its typical resinous appearance.

Type Material: Mining Academy, Freiberg, Germany, 21860.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1014–1015. (2) Dunn, P.J. (1983) New data for pitticite and a second occurrence of yukonite at Sterling Hill, New Jersey. Mineral. Mag., 46, 261–264.

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Pittongite $(Na, H_2O)_x[(W, Fe)(O, OH)_3]$ $x \approx 0.7$

Crystal Data: Hexagonal. *Point Group*: $\bar{6}\,m2$. As thin curved plates with ragged outlines, to 0.5 μm; in aggregates, to 2 mm; as compact masses.

Physical Properties: *Cleavage*: None observed. *Fracture*: n.d. *Tenacity*: n.d.
Hardness = 2-3 D(meas.) = > 4.4 D(calc.) = 5.715

Optical Properties: Transparent. *Color*: Cream yellow. *Streak*: Cream.
Luster: Pearly to earthy.
Optical Class: Uniaxial (-). n = 2.085

Cell Data: *Space Group*: $P\bar{6}\,m2$. a = 7.286(1) c = 50.49(1) Z = 36

X-ray Powder Pattern: New England District, Victoria, Australia.
3.153(100), 3.111(91), 1.823(76), 1.578(64), 3.306(62), 2.450(59), 5.956(52)

Chemistry:

	(1)
Na_2O	2.97
K_2O	0.06
CaO	0.39
Fe_2O_3	5.66
Al_2O_3	0.51
WO_3	84.15
H_2O	4.73
Total	98.47

(1) New England District, Victoria, Australia, average of electron microprobe and CHN analyses, corresponding to $(Na_{0.22}H_2O_{0.44}Ca_{0.02}K_{0.003})_{\Sigma=0.683}(W_{0.82}Fe^{3+}_{0.16}Al_{0.02})_{\Sigma=1.00}[O_{2.70}(OH)_{0.30}]_{\Sigma=3.00}$.

Occurrence: Formed by weathering ferberite in hydrothermal quartz veins associated with granite by chemical reaction with acidic, oxidizing solutions containing sodium.

Association: Ferberite, quartz**,** bismuth, gold, bismuthinite, koechlinite, elsmoreite.

Distribution: From mine dumps near the main shaft of a tungsten deposit (Bass and Watson's) 6 km west of Linton (near Ballarat), New England District, Victoria, Australia.

Name: For a former village near the deposit, *Pittong* (an Australian indigenous word for *father*).

Type Material: Museum Victoria, Melbourne, Australia (M48268).

References: (1) Birch, W.D., I.E. Grey, S.J. Mills, C. Bougerol, A. Pring, and S. Ansermet (2007) Pittongite, a new tungstate with a mixed-layer, pyrochlore-hexagonal tungsten bronze structure, from Victoria, Australia. Can. Mineral., 45, 857-864. (2) (2008) Amer. Mineral., 93, 704 (abs. ref. 2).

Piypite $K_2Cu_2O(SO_4)_2$

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Crystal Data: Tetragonal. *Point Group:* 4. As acicular to columnar crystals, elongated along [001], to 3 cm, square in section and commonly hollow, in mosslike aggregates. *Twinning:* Assumed found in crystal structure analysis.

Physical Properties: *Cleavage:* Perfect, parallel to elongation. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 3.0–3.10 D(calc.) = 3.0–3.22 Soluble in H_2O, leaving an insoluble residue.

Optical Properties: Transparent to translucent. *Color:* Emerald-green, dark green, black. *Streak:* Yellowish green. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (+). *Pleochroism:* Distinct; O = pale green, yellowish green; E = deep green, pale yellowish green. *Orientation:* Positive elongation. $\omega = 1.583–1.598$ $\epsilon = 1.695–1.711$

Cell Data: *Space Group:* $I4$. $a = 13.60–13.67$ $c = 4.94–4.98$ Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia.
9.63 (100), 3.039 (70), 6.79 (40), 3.006 (30), 4.305 (20), 2.666 (20), 1.924 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	34.2	35.88	38.73	F	0.6		
CuO	34.72	41.45	38.48	Cl	3.01	3.91	
ZnO	0.62			H_2O^-	1.7		
PbO	0.27			insol.	0.85		
Cu_2O	3.67			$-O = (F, Cl)_2$	0.93	0.88	
Na_2O	1.12	2.89		Total	[99.86]	100.63	100.00
K_2O	20.03	17.38	22.79				

(1) Tolbachik volcano, Russia; Na_2O, K_2O by flame photometry, CuO, PbO, ZnO by AA; F by fluorine selective electrode, $(SO_4)^{2-}$ confirmed by IR, original total given as 99.94%; after deduction of CuCl as nantokite, NaCl as halite, F, H_2O, and insoluble tenorite, corresponds to $(K_{1.97}Na_{0.01}Pb_{0.01})_{\Sigma=1.99}(Cu_{2.02}Zn_{0.04})_{\Sigma=2.06}O(SO_4)_{1.98}$. (2) Vesuvius, Italy; by electron microprobe, average of four analyses. (3) $K_2Cu_2O(SO_4)_2$.

Occurrence: A rare fumarolic sublimate, formed above 500 °C.

Association: Halite, sylvite, langbeinite, tenorite, hematite, tolbachite, dolerophanite, urusovite, aphthitalite, ponomarevite, cotunnite, chalcocyanite, sofiite, euchlorine, averievite, fedotovite, alarsite, alumoklyuchevskite, nabokoite, lammerite (Tolbachik volcano, Russia); paratacamite (Vesuvius, Italy).

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. On Vesuvius, Campania, Italy,

Name: Honors Boris Ivanovich Piyp (1906–1966), Russian vulcanologist, Director of the Far Eastern Institute of Volcanology, Petropavlovsk-Kamchatskii, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1331/1.

References: (1) Vergasova, L.P., S.K. Filatov, Y.K. Serafimova, and G.L. Starova (1984) Piypite, $K_2Cu_2O(SO_4)_2$, a new mineral of volcanic sublimates. Doklady Acad. Nauk SSSR, 275, 714–717 (in Russian). (2) (1985) Amer. Mineral., 70, 437–438 (abs. ref. 1). (3) Clark, A.M., E.E. Fejer, and A.G. Couper (1984) Caratiite, a new sulphate-chloride of copper and potassium, from the lavas of the 1869 Vesuvius eruption. Mineral. Mag., 49, 537–539. (4) Effenberger, H. and J. Zemann (1984) The crystal structure of caratiite. [= piypite] Mineral. Mag., 48, 541–546. (5) Filatov, S.K. and L.P. Vergasova (1989) Discrediting of caratiite and priority for piypite. Zap. Vses. Mineral. Obshch., 118(3), 88–90 (in Russian).

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Plagionite $Pb_5Sb_8S_{17}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Thick crystals, to 1 cm, tabular on {001}, with numerous well developed prisms and pinacoids; may be prismatic along $[20\overline{1}]$; striated ‖ [110]. Also massive, granular to compact.

Physical Properties: *Cleavage:* Very good on {112}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5 VHN = 134–163 (100 g load). D(meas.) = 5.54 D(calc.) = 5.55

Optical Properties: Opaque. *Color:* Blackish lead-gray; pale white in reflected light. *Streak:* Blackish lead-gray, deep red-brown. *Luster:* Metallic. *Pleochroism:* Noticeable in some orientations. *Anisotropism:* Distinct in oil.
R_1–R_2: (400) 37.0–45.4, (420) 36.8–45.1, (440) 36.8–44.8, (460) 36.8–44.5, (480) 36.7–44.2, (500) 36.7–43.9, (520) 36.6–43.6, (540) 36.4–43.0, (560) 36.2–42.4, (580) 35.8–41.6, (600) 35.3–40.7, (620) 34.7–39.7, (640) 33.9–38.8, (660) 33.1–37.7, (680) 32.1–36.7, (700) 31.3–35.9

Cell Data: *Space Group:* $C2/c$. $a = 13.4857(8)$ $b = 11.8656(4)$ $c = 19.9834(7)$ $\beta = 107.168(4)^\circ$ $Z = 4$

X-ray Powder Pattern: Wolfsberg, Germany.
3.21 (100), 3.26 (90), 2.911 (90), 3.87 (80), 3.77 (70), 2.622 (60), 3.61 (50)

Chemistry:

	(1)	(2)	(3)
Pb	41.24	40.28	40.55
Ag		0.18	
Sb	37.35	38.30	38.12
S	21.10	21.43	21.33
Total	99.69	100.19	100.00

(1) Wolfsberg, Germany. (2) Oruro, Bolivia. (3) $Pb_5Sb_8S_{17}$.

Occurrence: In hydrothermal vein deposits.

Association: Cassiterite, franckeite, andorite, semseyite, zinkenite, twinnite, robinsonite, geocronite, boulangerite, galena, pyrite.

Distribution: In Germany, from Wolfsberg, in the Harz Mountains [TL], and Arnsberg, North Rhine-Westphalia. In France, at Leyraux, Cantal; Chazelles, Haute-Loire; Les Cougnasses and Riou Beyrou, Hautes-Alpes; and Bournac, Montagne Noire, Finistère. From Bound Cliff, St. Endellion, Cornwall, England. In the Bwlch mine, Deganwy, Gwynedd, Wales. At the Rujevac Sb–Zn–Pb deposit, western Serbia. From the Azatec deposit, Caucasus Mountains, Armenia. In the Bal'Kumeisk deposit, Sakha, Russia. At the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In Canada, from the Porter claim, Carbon Hill, Wheaton River district, Yukon Territory. From the San José mine, Oruro, Bolivia. Additional occurrences are known, either poorly located or the species not fully characterized.

Name: From the Greek for *oblique*, in reference to the crystal morphology.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 464–465. (2) Nuffield, E.W. and M.A. Peacock (1945) Studies of mineral sulpho-salts: VIII — plagionite and semseyite. Univ. Toronto Studies, Geol. Ser., 49, 17–39. (3) Jambor, J.L. (1969) Sulphosalts of the plagionite group. Mineral. Mag., 37, 442–446. (4) Cho, S.-A. and B.J. Wuensch (1970) Crystal chemistry of the plagionite group. Nature, 225, 444–445. (5) Cho, S.-A. and B.J. Wuensch (1974) The crystal structure of plagionite, $Pb_5Sb_8S_{17}$, the second member in the homologous series $Pb_{3+2n}Sb_8Sb_{15+2n}$. Zeits. Krist., 139, 351–378. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 438.

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Plancheite $Cu_8Si_8O_{22}(OH)_4 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals fibrous by extension on [001], striated; commonly as compact radial aggregates.

Physical Properties: Hardness = 6 D(meas.) = 3.65–3.80 D(calc.) = [3.85]

Optical Properties: Translucent. *Color:* Pale blue to deep blue, pale greenish blue.
Luster: Satiny.
Optical Class: Biaxial (+). *Pleochroism:* Marked; X = very pale blue; $Y = Z$ = blue.
Orientation: $X = c$; $Y = b$; $Z = a$. *Absorption:* $Z > X > Y$. $\alpha = 1.697$ $\beta = 1.718$ $\gamma = 1.741$
2V(meas.) = 88.5°

Cell Data: *Space Group: Pcnb.* $a = 19.043(3)$ $b = 20.129(5)$ $c = 5.269(1)$ Z = 4

X-ray Powder Pattern: La Rioja, Argentina.
10.11 (100), 4.06 (85), 6.94 (70), 4.87 (50), 9.56 (40), 3.95 (40), 3.31 (40)

Chemistry:

	(1)	(2)
SiO_2	37.16	41.05
Fe_2O_3	trace	
CuO	59.20	54.34
H_2O	4.50	4.61
Total	100.86	100.00

(1) Mindouli, Congo. (2) $Cu_8Si_8O_{22}(OH)_4 \cdot H_2O$.

Occurrence: A rare secondary mineral in the oxidized portion of copper deposits.

Association: Chrysocolla, dioptase, malachite, conichalcite, tenorite.

Distribution: From Mindouli, Renéville, and Tshiniama, Congo Republic. In Congo (Zaire), fine material from Tantara, Mindigi, and M'sesa, near Kambove, Katanga (Shaba) Province. From Tsumeb, Guchab, and Okatumba, about 80 km east of Windhoek, Namibia. In England, at the Driggith mine, Caldbeck Fells, Cumbria; the Gunheath china clay pit, St. Austell, Cornwall; and the Engine vein, Alderley Edge, Cheshire. In the USA, in Arizona, from the Table Mountain mine, Galiuro Mountains, and the Azurite mine, Tortolita Mountains, Pinal Co.; in the Bighorn district, south of Aguila, Maricopa Co.; in the Harquehala Mountains, Yuma Co.; and elsewhere. In Michigan, from the Algomah mine, Ontonagon Co. In the Kurokawa mine, Gifu Prefecture, and the Kisanmori mine, Akita Prefecture, Japan. From La Rioja, Argentina.

Name: For a Mr. Planche, who provided the original material for characterization.

Type Material: n.d.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 81–82. (2) Evans, H.T., Jr. and M.E. Mrose (1977) The crystal chemistry of the hydrous copper silicates, shattuckite and planchéite. Amer. Mineral., 62, 491–502.

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Planerite $Al_6(PO_4)_2(PO_3OH)_2(OH)_8 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Microcrystalline, generally spherulitic, to 2 mm; in botryoidal crusts and massive.

Physical Properties: *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = 5
D(meas.) = 2.65–2.68 D(calc.) = 2.71

Optical Properties: Translucent on edges. *Color:* White, verdigris-green, lime-green, pale blue-green; olive-green on exposure. *Luster:* Dull, chalky to earthy.
Optical Class: [Biaxial.] $n = 1.60(1)$

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.505(2)$ $b = 9.723(3)$ $c = 7.814(2)$ $\alpha = 111.43°$ $\beta = 115.56°$ $\gamma = 68.69°$ Z = 1

X-ray Powder Pattern: "Gumeshevsk copper mines," Russia.
3.745 (100), 6.809 (90), 3.692 (60), 4.727 (36), 3.090 (36), 3.285 (35), 6.182 (28)

Chemistry:

	(1)	(2)	(3)
P_2O_5	33.94	37.1	37.76
Al_2O_3	37.48	40.1	40.68
Fe_2O_3		0.8	
FeO	3.52		
CuO	3.72		
H_2O	20.93	21.1	21.56
Total	99.59	99.1	100.00

(1) "Gumeshevsk copper mines," Russia. (2) Mt. Ida, Arkansas, USA; by electron microprobe, total Fe as Fe_2O_3, H_2O by the Penfield method; corresponds to $(Al_{5.92}Fe_{0.08})_{\Sigma=6.00}(PO_4)_{1.92}(PO_3OH)_{2.00}(OH)_8 \cdot 4.07H_2O$. (3) $Al_6(PO_4)_2(PO_3OH)_2(OH)_8 \cdot 4H_2O$.

Polymorphism & Series: Forms a series with turquoise.

Mineral Group: Turquoise group.

Occurrence: A rare secondary mineral formed in phosphate-rich aluminous deposits.

Association: Wavellite, variscite, metavariscite (Mt. Ida, Arkansas, USA).

Distribution: From Mt. Chernovskaya, near the Chernaya River, Middle Ural Mountains, Russia. At Poniklá, Jilemnice, Czech Republic. From Bruguers, Barcelona Province, Spain. In the USA, at General Trimble's mine, Chester Co., Pennsylvania; in Arkansas, from the Mauldin Mountain quarry, near Mt. Ida, Montgomery Co., at the Coon Creek mine and Buckeye Mountain, Polk Co., and on Dug Hill, near Avant, Garland Co.; at Erin, Clay Co., Alabama; from Brewer, east of Cedartown, Polk Co., Georgia; at Cripple Creek, Teller Co., Colorado; from the Rain mine, Carlin district, Elko Co., Nevada. At Toyoda, near Kochi, Shikoku Prefecture, Japan. More localities are likely as additional turquoise group specimens are re-examined.

Name: To honor Dimitrii Ivanovich Planer (1821–1882), mineralogist and Director of the Gumeshevsk copper mines, Polevskoi, Russia, who discovered the mineral at some distance east from those mines.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 5404; National Museum of Natural History, Washington, D.C., USA, R9710.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 762. (2) Foord, E.E. and J.E. Taggart, Jr. (1998) A reexamination of the turquoise group: the mineral aheylite, planerite (redefined), turquoise and coeruleolactite. Mineral. Mag., 62, 93–111. (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 166–167.

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Platarsite $(Pt, Rh, Ru)AsS$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As subhedral grains, the largest being a triangular crystal, to 1.1 mm; may be inclusions in platinum nuggets, chromite, and silicate minerals.

Physical Properties: Hardness = n.d. VHN = 902–1033; 1379–1584, 1486 average (50 g load). D(meas.) = 8.0 D(calc.) = 8.375

Optical Properties: Opaque. *Color:* In polished section, gray. *Luster:* Metallic.
R: (400) — , (420) 47.7, (440) 47.4, (460) 47.3, (480) 47.3, (500) 47.1, (520) 47.5, (540) 48.0, (560) 48.2, (580) 48.7, (600) 49.0, (620) 49.9, (640) 48.9, (660) 49.5, (680) 49.8, (700) 49.6

Cell Data: *Space Group: Pa*3. $a = 5.790(1)$ Z = 4

X-ray Powder Pattern: Onverwacht mine, South Africa; all reflections broad.
1.746 (100), 2.896 (90), 3.345 (80), 1.114 (70), 2.047 (60), 2.590 (50), 2.364 (50)

Chemistry:

	(1)	(2)	(3)
Pt	26.9	30.4	22.4
Rh	12.8	10.8	8.0
Ru	11.4	9.1	6.4
Ir	3.6	5.9	17.5
Os	0.58	0.10	2.7
As	31.7	33.2	31.2
S	13.0	10.7	10.7
Total	99.98	100.2	98.9

(1) Onverwacht mine, South Africa; by electron microprobe, corresponding to $(Pt_{0.34}Rh_{0.30}Ru_{0.28}Ir_{0.05})_{\Sigma=0.97}As_{1.04}S_{0.99}$. (2) Do.; by electron microprobe, corresponding to $(Pt_{0.40}Rh_{0.27}Ru_{0.23}Ir_{0.08})_{\Sigma=0.98}As_{1.15}S_{0.86}$. (3) Western Platinum mine, South Africa; by electron microprobe, corresponding to $(Pt_{0.31}Ir_{0.25}Rh_{0.21}Ru_{0.17}Os_{0.04})_{\Sigma=0.98}As_{1.12}S_{0.90}$.

Mineral Group: Cobaltite group.

Occurrence: In dunite pipes and replacement pegmatite deposits; in layered mafic intrusions and ophiolites; in placers.

Association: Stibiopalladinite, ruthenarsenite, mertieite-II, genkinite, Pt–Fe–Cu–Ni alloys, bornite, chromite.

Distribution: From the Onverwacht [TL], Driekop, Union, and Western Platinum mines, in the Merensky Reef, Bushveld complex, Transvaal, South Africa. At Fox Gulch, Goodnews Bay, Alaska, USA. From Chromwerk, Kraubath ultramafic massif, Styria, Austria. At the Braganca massif, northern Portugal. In Russia, in placers on the Pustaya River, Kamchatka, and Neozhidannyy Creek, Tuva; and in the Imandra complex, Kola Peninsula. From the Munni Munni layered intrusion, Pilbara Block, Western Australia.

Name: For the composition.

Type Material: Royal Ontario Museum, Toronto; Canadian Museum of Nature, Ottawa, Canada; National Museum of Natural History, Washington, D.C., USA, 136485; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Cabri, L.J., J.H.G. Laflamme, and J.M. Stewart (1977) Platinum-group minerals from Onverwacht. II. Platarsite, a new sulfarsenide of platinum. Can. Mineral., 15, 385–388. (2) Szymański, J.T. (1979) The crystal structure of platarsite, $Pt(As,S)_2$, and a comparison with sperrylite, $PtAs_2$. Can. Mineral., 17, 117–123. (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 128–129. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 439.

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Platinum Pt

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Cubic crystals, typically distorted, to 1.5 cm; commonly as grains or scales, rarely as nuggets or lumps up to 30 kg. *Twinning:* On {111}, as interpenetrant contact twins.

Physical Properties: *Fracture:* Hackly. *Tenacity:* Malleable and ductile. Hardness = 4–4.5 VHN = 297–339 (100 g load). D(meas.) = 14–19 D(calc.) = 21.472 Nonmagnetic to distinctly magnetic when rich in iron.

Optical Properties: Opaque. *Color:* Whitish steel-gray to dark gray; in polished section, white. *Luster:* Metallic.
R: (400) 60.5, (420) 62.3, (440) 63.8, (460) 65.1, (480) 66.3, (500) 67.5, (520) 68.6, (540) 69.5, (560) 70.2, (580) 70.7, (600) 71.2, (620) 71.6, (640) 71.8, (660) 72.1, (680) 72.4, (700) 72.8

Cell Data: *Space Group:* $Fm3m$. a = 3.9231 Z = 4

X-ray Powder Pattern: Synthetic.
2.265 (100), 1.9616 (53), 1.1826 (33), 1.3873 (31), 0.8008 (29), 0.9000 (22), 0.8773 (20)

Chemistry:

	(1)	(2)	(3)
Pt	86.20	79.48	92.2
Ir	0.85	0.82	
Ir–Os	0.95	1.41	
Rh	1.40	0.75	1.2
Pd	0.50	0.49	1.3
Au	1.00	0.49	
Cu	0.60		0.5
Fe	7.80	16.50	5.3
gangue	0.95		
Total	100.25	99.94	100.5

(1) Chocó, Colombia; corresponds to $Pt_{0.71}Fe_{0.22}Rh_{0.02}Cu_{0.02}Ir_{0.01}Os_{0.01}Pd_{0.01}$. (2) Birbir River, Ethiopia; corresponds to $Pt_{0.56}Fe_{0.40}Rh_{0.01}Ir_{0.01}Os_{0.01}Pd_{0.01}$. (3) Nizhni Tagil, Russia; by electron microprobe, corresponds to $Pt_{0.79}Fe_{0.16}Rh_{0.02}Pd_{0.02}Cu_{0.01}$.

Occurrence: Chiefly in placer deposits, or in mafic and ultramafic igneous rocks; rarely in hydrothermal quartz veins or contact metamorphic deposits.

Association: Pt–Fe alloys, chalcopyrite, chromite, magnetite.

Distribution: From many deposits world-wide. In the Pinto River, near Papayan, in the Department of Chocó, Cauca, Colombia [TL]. In the USA, from Platinum Creek, Goodnews Bay, Alaska; in California, in a number of placers, as in Trinity Co.; and at Oroville, Butte Co. In Oregon, at Cape Blanco, Port Orford, Curry Co. In Canada, at Rivière-du-Loup and Rivière des Plantes, Beauce Co., Quebec; in British Columbia, in the Kamloops district, on the Fraser and Tranquille Rivers, and in the Similkameen district, on Granite, Cedar, and Olivine Creeks, tributaries to the Tulameen River; in Alberta, near Edmonton. In Russia, in the Ural Mountains, in a large district surrounding Nizhni Tagil; good crystals from the Konder massif, Aldan Shield, Sakha. In South Africa, at a number of deposits along the Merensky Reef of the Bushveld complex, Transvaal.

Name: From the Spanish *platina*, diminutive of *plata*, *silver*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 106–109. (2) Cabri, L.J. and C.E. Feather (1975) Platinum–iron alloys; nomenclature based on a study of natural and synthetic alloys. Can. Mineral., 13, 117–126. (3) Harris, D.C. and L.J. Cabri (1991) Nomenclature of platinum-group element alloys: review and revision. Can. Mineral., 29, 231–237. (4) Hull, ?? and ?? Davey (1921) ??title?? Strukturberichte??, 1, 71–?? (5) (1953) NBS Circ. 539, 1, 31. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 441.

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Plattnerite PbO_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Commonly as crystals, prismatic ‖ [001], showing {010}, {011}, {110}, {131}, {001}, to 5 mm; may be nodular or botryoidal, fibrous and concentrically zoned, massive. *Twinning:* On {011}, as contact and penetration twins, rarely polysynthetic.

Physical Properties: *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 9.564 D(calc.) = 9.563

Optical Properties: Opaque to slightly translucent. *Color:* Jet-black, iron-black, brownish black; yellowish in transmitted light; gray-white in reflected light, with red-brown internal reflections. *Streak:* Chestnut-brown. *Luster:* Bright metallic to adamantine; tarnishing dull on exposure.
Optical Class: Uniaxial. *Pleochroism:* Distinct. $n = 2.30(5)$ *Anisotropism:* Noticeable; midnight-blue.
R_1–R_2: (400) 18.5–21.3, (420) 18.4–21.9, (440) 18.5–21.5, (460) 18.5–20.2, (480) 18.5–19.8, (500) 18.4–19.4, (520) 18.2–18.9, (540) 17.9–18.4, (560) 17.5–18.0, (580) 17.0–17.4, (600) 16.5–16.9, (620) 16.0–16.4, (640) 15.5–15.9, (660) 15.0–15.4, (680) 14.4–15.0, (700) 14.0–14.5

Cell Data: *Space Group:* $P4_2/mnm$. $a = 4.9525(4)$ $c = 3.3863(4)$ Z = 2

X-ray Powder Pattern: Ojuela mine, Mexico.
3.500 (100), 2.793 (94), 1.855 (80), 2.469 (40), 1.524 (23), 0.823 (20), 1.568 (19)

Chemistry:

	(1)
PbO_2	99.6
CuO	0.1
Total	99.7

(1) Ojuela mine, Mexico; by electron microprobe.

Polymorphism & Series: Dimorphous with scrutinyite.

Mineral Group: Rutile group.

Occurrence: In weathered hydrothermal base-metal deposits, oxidized typically in arid climates.

Association: Cerussite, smithsonite, hemimorphite, leadhillite, hydrozincite, rosasite, aurichalcite, murdochite, pyromorphite, wulfenite, calcite, quartz.

Distribution: From Leadhills, Lanarkshire, and Wanlockhead, Dumfriesshire, Scotland. In the Tchah Milleh mine, near Anarak, and the Dareh Zandjir mine, near Anjireh, Iran. From Tsumeb, Namibia. In the USA, large masses from the Coeur d'Alene district, Shoshone Co., and in the Democrat mine, Gilmore district, Lemhi Co., Idaho; from the Goodsprings district, Clark Co., and the Diamond mine, near Eureka, Eureka Co., Nevada. In the 79 mine, Gila Co., the Defiance mine, Gleeson, Cochise Co., the Glove mine, Santa Cruz Co., and elsewhere in Arizona; at the Mex-Tex mine, near Bingham, Hansonburg district, Socorro Co., and Granite Gap, San Simon district, Hidalgo Co., New Mexico. From the Ojuela mine, Mapimí, Durango, and at Santa Eulalia, Chihuahua, Mexico. Other minor localities are known.

Name: To honor Carl Friedrich Plattner (1800–1858), Professor of Metallurgy and Assaying, Mining Academy, Freiberg, Germany.

Type Material: Mining Academy, Freiberg, Germany, 10045.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 581–583. (2) White, J.S., Jr. (1970) New data for plattnerite. Mineral. Record, 1, 75–80. (3) D'Antonio, P. and A. Santoro (1980) Powder neutron diffraction study of chemically prepared β–lead dioxide. Acta Cryst., 36, 2394–2397. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 442.

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Playfairite $Pb_{16}Sb_{18}S_{43}$

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Crystal Data: Monoclinic. *Point Group:* 2, m, or $2/m$. Tabular crystals heavily striated parallel to elongation. *Twinning:* Exhibits very fine twin lamellae.

Physical Properties: *Cleavage:* {100}, perfect. Hardness = n.d. VHN = 154 (50 g load). D(meas.) = n.d. D(calc.) = 5.72

Optical Properties: Opaque. *Color:* Lead-gray to black. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Strong, white to brownish gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2$, Pm, $P2/m$, $P2_1$ or $P2_1/m$. $a = 45.4$ $b = 8.29$ $c = 21.3$ $\beta = 92°30(30)'$ Z = 4

X-ray Powder Pattern: Madoc, Canada.
3.39 (100), 3.32 (100), 2.785 (70), 2.086 (60), 3.98 (40), 3.49 (40), 2.97 (40)

Chemistry:

	(1)	(2)	(3)	(4)
Pb	51.0	47.2	50.7	48.15
Sb	28.0	28.2	26.3	31.83
As	2.4	2.8	3.3	
S	18.8	20.3	21.3	20.02
Cl		0.18		
Total	100.2	98.68	101.6	100.00

(1) Madoc, Canada; by electron microprobe, average of three analyses, corresponding to $Pb_{17.32}(Sb_{16.18}As_{2.25})_{\Sigma=18.43}S_{41.25}$. (2) Do.; by electron microprobe, corresponding to $Pb_{15.46}(Sb_{15.71}As_{2.54})_{\Sigma=18.25}Cl_{0.34}S_{42.95}$. (3) Novoye, Kyrgyzstan; by electron microprobe; corresponding to $Pb_{16.12}(Sb_{14.23}As_{2.90})_{\Sigma=17.13}S_{45.75}$. (4) $Pb_{16}Sb_{18}S_{43}$.

Occurrence: As masses and stringers through dolomitic and calcitic marbles. At the edges of other sulfosalt minerals, and extending into them along microscopic veinlets.

Association: Boulangerite, jamesonite, antimonian baumhauerite, zinkenite, semseyite, geocronite, robinsonite, madocite, launayite (Madoc, Canada); sphalerite, pyrite, galena, sorbyite, twinnite, guettardite, baumhauerite, realgar, orpiment, cinnabar, fluorite, quartz (Novoye, Kyrgyzstan).

Distribution: From Madoc, Ontario, Canada [TL]. At Novoye, Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan.

Name: In honor of John Playfair (1748–1819), Professor of Natural Philosophy, Edinburgh, Scotland.

Type Material: Canadian Geological Survey, Ottawa, 12168; Canadian Museum of Nature, Ottawa, Canada.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Ontario. Part 2 — mineral descriptions. Can. Mineral., 9, 191–213. (2) (1968) Amer. Mineral., 53, 1424 (abs. ref. 1). (3) Mozgova, N.N., N.S. Bortnikov, Y.S. Borodaev, and A.I. Tzépine (1982) Sur la non-stoechiométrie des sulfosels antimonieux arséniques de plomb. Bull. Minéral., 105, 3–10 (in French with English abs.). (4) Jambor, J.L., J.G.H. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100.

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Plimerite $ZnFe^{3+}_4(PO_4)_3(OH)_5$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. Crystals acicular to elongated on [001], bladed or prismatic, to 0.5 mm, with dominant forms {100}, {010}, 001}; as hemispherical radiating sprays, to 3 mm.

Physical Properties: *Cleavage*: Perfect on {100} and {010}, distinct on {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3.5-4 D(meas.) = 3.67(5) D(calc.) = 3.62

Optical Properties: Translucent. *Color*: Pale olive-green to dark green, almost black; pale green to dark olive-green as aggregates. *Streak*: Pale grayish-green. *Luster*: Vitreous. *Optical Class*: Biaxial (-). α = 1.765(5) β = 1.764(4) γ = 1.767(4) 2V(calc.) = – 63° *Orientation*: X = *c*; Y = *a;* Z = *b*. *Pleochroism*: X = pale greenish-brown; Y = pale brown; Z = pale bluish-green. *Absorption*: *Z* > *X* > *Y*.

Cell Data: *Space Group*: *Bbmm*. *a* = 13.811(3) *b* = 16.718(3) *c* = 5.141(10) *Z* = 4

X-ray Powder Pattern: Broken Hill, western New South Wales, Australia.
3.168 (100), 2.575 (90), 2.414 (75), 2.753 (60), 3.369 (55), 4.638 (50), 3.388 (50)

Chemistry:

	(1)	(2)
P_2O_5	32.37	32.32
As_2O_5	0.09	
Al_2O_3	4.48	
Fe_2O_3	29.82	48.49
FeO	2.98	
MnO	0.02	
MgO	0.00	
CaO	0.17	
CuO	0.00	
ZnO	20.17	12.35
PbO	0.36	
H_2O	6.84	6.84
Total	97.30	100.00

(1) Broken Hill, western New South Wales, Australia; electron microprobe analysis, H_2O assigned from structure analysis, Fe^{3+}/Fe^{2+} by Mössbauer spectroscopy, corresponding to $Fe^{3+}_{2.53}Zn_{1.68}Al_{0.60}Fe^{2+}_{0.28}Ca_{0.02}Pb_{0.01}P_{3.09}As_{0.01}O_{17}H_{5.15}$. (2) $ZnFe^{3+}_4(PO_4)_3(OH)_5$.

Occurrence: A secondary mineral in the weathering zone in seams and cavities of a quartz-garnet-goethite-rich rock.

Association: Hinsdalite-plumbogummite, calcian pyromorphite, libethenite, brochantite, malachite, tsumebite, strengite (Broken Hill); scholzite, parahopeite, collinsite-hillite, zincian eosphorite (Reaphook Hill).

Distribution: Block 14 Opencut, Broken Hill, western New South Wales, and Reaphook Hill, Flinders Range, South Australia, Australia.

Name: Honors Ian Plimer, Professor of Mining Geology, the University of Adelaide and Emeritus Professor of Earth Sciences, University of Melbourne, for his contributions to the geology of ore deposits, in particular the Broken Hill deposit.

Type Material: Department of Mineralogy, South Australian Museum, Adelaide, South Australia (catalog no. G32005).

References: (1) Elliott, P., U. Kolitsch, G. Giester, E. Libowitzky, C. McCammon, A. Pring, W.D. Birch, and J. Brugger (2009) Description and crystal structure of a new mineral—plimerite, $ZnFe_4^{3+}(PO_4)_3(OH)_5$ - the Zn-analogue of rockbridgeite and frondelite, from Broken Hill, New South Wales, Australia. Mineral. Mag., 73, 131–148. (2) (2010) Amer. Mineral., 95, 206-207 (abs. ref. 1).

Plombièrite $Ca_5H_2Si_6O_{18}\cdot 6H_2O(?)$

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Crystal Data: Orthorhombic; typically amorphous. *Point Group:* n.d. A hardened gel; powdery, compact, massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ~4
D(meas.) = 2.02–2.20 D(calc.) = [2.27]

Optical Properties: Transparent to translucent. *Color:* White, pink to red-brown.
Optical Class: Biaxial (+) (relic). n = 1.50–1.55 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. a = 11.24 b = 7.30 c = 28.0 Z = [4]

X-ray Powder Pattern: Ballycraigy, Ireland.
3.17 (msb), 3.01 (msb), 2.81 (ms), 1.83 (ms), 5.48 (wb), 2.07 (w), 1.67 (w)

Chemistry:

	(1)	(2)	(3)	(4)
SiO_2	40.6	40.4	41.43	47.00
Al_2O_3	1.3	2.4		
Fe_2O_3		0.8		
MgO		0.3		
CaO	34.1	32.6	32.94	36.56
H_2O	23.2	23.3	[25.63]	16.44
Total	99.2	99.8	[100.00]	100.00

(1) Plombières, France. (2) Ballycraigy, Ireland. (3) Hatrurim Formation, Israel; by electron microprobe, H_2O by difference. (4) $Ca_5H_2Si_6O_{18}\cdot 6H_2O$.

Occurrence: A gelatinous substance which hardens in air, formed from thermal waters (Plombières, France); a natural gel formed from hydration of bredigite and larnite at a diabase-chalk contact (Ballycraigy, Ireland).

Association: Zeolites (Plombières, France).

Distribution: From Plombières, Vosges, and from Boisséjour, near Ceyrat, Puy-de-Dôme, France. At Ballycraigy and Scawt Hill, near Larne, and Carneal, Co. Antrim, Ireland. From Klöch, Styria, Austria. In the Hatrurim Formation, Israel. In the USA, at Crestmore, Riverside Co., California. At Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For the French locality at Plombières.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 570.
(2) McConnell, J.D.C. (1954) The hydrated calcium silicates riversideite, tobermorite, and plombierite. Mineral. Mag., 30, 293–305. (3) McConnell, J.D.C. (1955) The hydration of larnite ($\beta-Ca_2SiO_4$) and bredigite ($\alpha_1-Ca_2SiO_4$) and the properties of the resulting gelatinous mineral plombierite. Mineral. Mag., 30, 672–680. (4) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 32–34. (5) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 47.

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Plumbobetafite $(Pb, U, Ca)(Nb, Ti)_2O_6(OH, F)$

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Crystal Data: Cubic; may be metamict. *Point Group:* $[4/m\ \overline{3}\ 2/m]$ (by analogy to betafite). As octahedra, with curved faces, or as rounded cubic grains, to 3 mm.

Physical Properties: *Fracture:* Irregular. *Tenacity:* [Brittle.] Hardness = [~3–5.5] D(meas.) = 4.64 D(calc.) = [4.13] Radioactive.

Optical Properties: Semitransparent. *Color:* Pale yellowish, may have brownish black cores. *Luster:* Adamantine.
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group:* $[Fd3m.]$ a = 10.33(1) Z = [8]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	13.73		Fe_2O_3	1.14	
WO_3		6.71	MnO	0.34	
Nb_2O_5	30.96	7.81	PbO	20.70	67.15
Ta_2O_5	1.64	0.81	CaO	2.11	0.11
SiO_2	2.15		Na_2O	0.83	
TiO_2	13.30	15.51	K_2O	0.14	
SnO_2		1.12	F	1.51	
ThO_2	0.15		H_2O^+	2.62	
UO_2	1.70		SO_3	0.55	
B_2O_3	0.23		$-O = F_2$	0.63	
RE_2O_3	4.63		LOI	1.75	
			Total	[99.55]	99.22

(1) Burpala massif, Russia; original total given as 99.71%, RE = La 20.6%, Ce 61.0%, Pr 4.4%, Nd 10.5%, Sm 1.0%, Gd 0.5%, Dy 0.5%, Y 1.5%; after deduction of SiO_2, corresponds to $(Pb_{0.44}U_{0.25}Ca_{0.18}Na_{0.12}RE_{0.12})_{\Sigma=1.11}(Nb_{1.12}Ti_{0.78}Fe_{0.07}Ta_{0.02})_{\Sigma=1.99}O_6[(OH)_{0.58}F_{0.42}]_{\Sigma=1.00}$.
(2) Keivy massif, Russia; by electron microprobe, corresponding to $(Pb_{2.05}Ca_{0.01})_{\Sigma=2.06}(Ti_{1.32}Nb_{0.39}W_{0.20}Sn_{0.05}Ta_{0.03}Fe_{0.01})_{\Sigma=2.00}O_6(OH)$.

Mineral Group: Pyrochlore group, betafite subgroup; $Pb_A > 20\%$; $2Ti_B \geq (Nb + Ta)_B$.

Occurrence: An accessory mineral in a pegmatitic dike in nepheline syenite (Burpala massif, Russia).

Association: Microcline, quartz, albite, aegirine, riebeckite (Burpala massif, Russia).

Distribution: In the Burpala massif, 120 km north of Lake Baikal, eastern Siberia, and from the Keivy massif, Kola Peninsula, Russia.

Name: Ostensibly for its content of lead, PLUMBum, and relation to other *betafite* members of the pyrochlore group.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Ganzeev, A.A., A.F. Efimov, and G.V. Lyubomilova (1969) Plumbobetafite – a new mineral variety of the pyrochlore group. Trudy Mineral. Muzeya Akad. Nauk SSSR, 19, 135–137 (in Russian). (2) (1970) Amer. Mineral., 55, 1068–1069 (abs. ref. 1). (3) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (4) Voloshin, A.V., Y.A. Pakhomovskii, and A.Y. Bakhchisaraytsev (1993) Plumbobetafite in amazonite pegmatites of western Keivy (Kola Peninsula). Mineral. Zhurnal, 15(2), 76–80 (in Russian with English abs.).

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Plumboferrite $\mathbf{Pb_2Fe^{3+}_{11-x}Mn^{2+}_xO_{19-2x}}$ (x = 1/3)

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Thick tabular crystals, to 1 cm, with dominant $\{10\bar{1}1\}$ and {0001}, may have very complex form development; commonly cleavable massive.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = 6.5 VHN = 824–946, 882 average (100 g load). D(meas.) = 6.07 D(calc.) = 6.09–6.12

Optical Properties: Opaque. *Color:* Black; light gray in reflected light. *Streak:* Nearly black. *Luster:* Submetallic.
Optical Class: Uniaxial (–). *Bireflectance:* Weak.
R_1–R_2: (400) 27.3–29.4, (420) 26.9–28.7, (440) 26.5–28.0, (460) 26.1–27.5, (480) 25.8–26.9, (500) 25.5–26.4, (520) 25.2–25.9, (540) 24.9–25.5, (560) 24.6–25.0, (580) 24.1–24.6, (600) 23.6–24.0, (620) 23.1–23.5, (640) 22.6–23.0, (660) 22.2–22.6, (680) 21.8–22.1, (700) 21.4–21.7

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.931(1)$ $c = 23.551(2)$ Z = 2

X-ray Powder Pattern: Jakobsberg, Sweden.
2.9438 (100), 3.922 (85), 11.78 (40), 2.8132 (30), 2.6473 (30), 5.888 (25), 1.6919 (16)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2		0.10	PbO	33.03	34.18
TiO_2	0.08	0.21	MgO	0.34	0.29
Al_2O_3		0.01	CaO	0.40	
Fe_2O_3	63.01	63.91	Na_2O	0.17	
Sb_2O_3	0.25	0.00	K_2O	0.13	
FeO	0.78		H_2O		
MnO	1.41	1.24	insol.	0.15	
			Total	99.75	99.94

(1) Jakobsberg, Sweden. (2) Do.; by electron microprobe, average of several determinations, total Fe as Fe_2O_3, O from charge balance; corresponding to $(Pb_{2.03}Mn_{0.23}Mg_{0.10}Fe_{10.59}Ti_{0.03}Si_{0.02})_{\Sigma=13.00}O_{18.35}$.

Occurrence: In metamorphosed lead-bearing Fe–Mn orebodies.

Association: Hematite, jacobsite, magnesioferrite, lindqvistite, hedyphane, svabite, barite, hematophanite, copper, cuprite, calcite, andradite, phlogopite (Jakobsberg, Sweden).

Distribution: From Jakobsberg, Värmland, and at the Sjö mine, near Grythyttan, Örebro, Sweden.

Name: From the Latin for lead, PLUMBum, and FERROus iron in its composition.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 81:224.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 726–727. (2) Holtstam, D., R. Norrestam, and A. Sjödin (1995) Plumboferrite: new mineralogical data and atomic arrangement. Amer. Mineral., 80, 1065–1072.

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Plumbogummite $PbAl_3(PO_4)_2(OH)_5 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals hexagonal or bladed, prismatic, to 5 mm, in parallel to subparallel aggregates; microscopically radially fibrous or spherulitic; usually as crusts, botryoidal, reniform, stalactitic, globular, compact massive.

Physical Properties: *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 4.01 D(calc.) = [4.08]

Optical Properties: Transparent to translucent. *Color:* Grayish white, grayish blue, yellowish gray, yellowish brown, green, pale blue. *Streak:* White. *Luster:* Vitreous, resinous to dull. *Optical Class:* Uniaxial (+); segments of crystals may be biaxial. ω = 1.653–1.688 ϵ = 1.675–1.704

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.017(1)$ $c = 16.75(1)$ Z = 3

X-ray Powder Pattern: Ivanhoe mine, Australia.
2.969 (10), 5.71 (9), 2.220 (8), 3.51 (7), 1.905 (6), 3.44 (5), 4.93 (4)

Chemistry:

	(1)	(2)
SO_3	0.67	
P_2O_5	22.47	24.42
As_2O_5	0.04	
Al_2O_3	25.45	26.32
Fe_2O_3	0.01	
CuO	0.92	
PbO	38.90	38.41
H_2O	[11.54]	10.85
Total	[100.00]	100.00

(1) Ivanhoe mine, Australia; by electron microprobe, H_2O by difference, $(OH)^{1-}$ confirmed by IR; leading to $Pb_{1.02}Cu_{0.07}Al_{2.92}[(PO_4)_{1.85}(SO_4)_{0.05}]_{\Sigma=1.90}(OH)_{5.29} \cdot 0.73H_2O$.
(2) $PbAl_3(PO_4)_2(OH)_5 \cdot H_2O$.

Mineral Group: Crandallite group.

Occurrence: An uncommon secondary mineral in the oxidized zone of lead deposits.

Association: Pyromorphite, mimetite, duftite, cerussite, anglesite, wulfenite.

Distribution: In France, from Huelgoat, Finistère. In England, from Roughton Gill, Red Gill, Dry Gill, and other mines, Caldbeck Fells, Cumbria; in Cornwall, from Wheal Gorland, Gwennap; at the Penberthy Croft mine, St. Hilary; in the Buttern Hill placers, Altarnum; and from Wheal Alfred, Gwinear. At Leadhills, Lanarkshire, and Wanlockhead, Dumfriesshire, Scotland. From the Horcajo mines, 35 km south of Brazatortas, Cuidad Real Province, Spain. At Moldava, 20 km northwest of Teplice, Czech Republic. In the USA, at the Canton mine, Cherokee Co., Georgia; from the Tyrone mine, Santa Rita, Grant Co., and the Mex-Tex mine, near Bingham, Hansonburg district, Socorro Co., New Mexico; in the Hahns Peak district, Routt Co., Colorado; at the Copper Cities deposit, Gila Co., Arizona; in the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., and the San Rafael mine, Nye Co., Nevada. In Australia, from the Ivanhoe mine, Tennant Creek district, Northern Territory; in the Teutonic Bore deposit, 300 km north of Kalgoorlie, Western Australia; at Broken Hill, New South Wales. Several other minor localities are known.

Name: From the Latin for *lead* and *gum*, which it may resemble.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 831–832. (2) Slansky, E. (1977) Plumbogummite from Ivanhoe mine, Northern Territory, Australia. Neues Jahrb. Mineral., Monatsh., 45–53.

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Plumbojarosite $Pb_{0.5}Fe_3^{3+}(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As hexagonal crystals, platy on {0001}, with $\{10\overline{1}4\}$, $\{01\overline{1}2\}$, to 0.1 mm; commonly aggregated into crusts and compact masses, pulverulent, earthy.

Physical Properties: *Cleavage:* On $\{10\overline{1}4\}$, fair. *Tenacity:* Talclike. Hardness = "Soft". D(meas.) = 3.64–3.67 D(calc.) = [3.66]

Optical Properties: Semitransparent. *Color:* Golden brown to dark brown. *Luster:* Vitreous, silky to dull.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellow-brown; E = nearly colorless. $\omega = 1.875$ $\epsilon = 1.786$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 7.305$–7.315 $c = 33.564$–33.788 Z = 6

X-ray Powder Pattern: Cookes Peak district, New Mexico, USA.
3.066 (100), 5.933 (94), 1.829 (70), 3.114 (46), 1.976 (45), 6.232 (34), 3.657 (31)

Chemistry:

	(1)	(2)
SO_3	27.06	28.33
SiO_2	0.51	
Al_2O_3	0.10	
Fe_2O_3	42.37	42.37
CuO	0.27	
PbO	19.84	19.74
MgO	0.01	
CaO	0.05	
Na_2O	0.21	
K_2O	0.17	
H_2O	9.56	9.56
Total	100.15	100.00

(1) Cookes Peak district, New Mexico, USA. (2) $Pb_{0.5}Fe_3^{3+}(SO_4)_2(OH)_6$

Mineral Group: Alunite group.

Occurrence: Formed by the reaction between galena and oxidizing pyrite in lead deposits, typically in arid regions.

Association: Jarosite, anglesite, "limonite".

Distribution: Uncommon but occurring at many localities, at some constituting an ore of lead. In the USA, from the Cookes [Cooks] Peak district, Luna Co., and many other occurrences in New Mexico; from many localities in Utah, as in the American Forks and East Tintic districts, Utah Co.; at the Boss, Kirby, Yellow Pine, and other mines, Goodsprings district, Clark Co., Nevada; from Tombstone, Cochise Co., and elsewhere in Arizona; at Leadville, Lake Co., Colorado; in the Darwin district, Inyo Co., California. In England, from the Treore mine, St. Teath, the Penberthy Croft mine, St. Hilary, and Wheal Carpenter, Gwinear, Cornwall. At Laurium, Greece. From Bolkardag, Adana Province, Turkey. At Akchagyl, Ukraine. From Tsumeb, Namibia.

Name: As the lead, *plumbum*, analog of *jarosite*.

Type Material: Yale University, New Haven, Connecticut, 3.3608, 3.6809; National Museum of Natural History, Washington, D.C., USA, 86551, R6308.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 568–570. (2) Mumme, W.G. and T.R. Scott (1966) The relationship between basic ferric sulfate and plumbojarosite. Amer. Mineral., 51, 443–453. (3) Jambor, J.L. and J.E. Dutrizac (1983) Beaverite-plumbojarosite solid solutions. Can. Mineral., 21, 101–113. (4) Szymański, J.T. (1985) The crystal structure of plumbojarosite $Pb[Fe_3(SO_4)_2(OH)_6]_2$. Can. Mineral., 23, 659–668.

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Plumbomicrolite $(Pb,Ca)_2(Ta,Nb)_2O_6(OH)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. In octahedral or cubo-octahedral crystals, to 20 cm, and massive.

Physical Properties: *Fracture:* [Uneven] (by analogy to the pyrochlore group). *Tenacity:* [Brittle.] Hardness = 6 VHN = 610–670 (40 g load). D(meas.) = 6.5–8.2 D(calc.) = 6.70–8.73 (varying with Ta/Nb content).

Optical Properties: Opaque, translucent in thin fragments. *Color:* Yellow to orange, green to yellowish green, dark brown to black. *Luster:* Greasy.
Optical Class: Isotropic.
R: (545) 18.2

Cell Data: *Space Group:* $Fd3m$. $a = 10.56$–10.61 $Z = 8$

X-ray Powder Pattern: Kivu Province, Congo.
1.867 (100), 1.593 (99), 2.642 (65), 1.526 (32), 3.01 (31), 0.8928 (29), 1.181 (27)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Nb_2O_5	11.10	11.20	As_2O_3	0.07		CaO	1.00	2.80
Ta_2O_5	50.40	33.46	Sb_2O_3	0.80		BaO	0.20	
SiO_2	0.65	0.00	Bi_2O_3	0.04		Na_2O	0.63	0.63
TiO_2	0.21	0.00	FeO	0.34		K_2O	< 0.01	
ZrO_2	0.06		MnO	0.02		Cs_2O	~1.60	
SnO_2	3.55	4.45	CuO	0.04		F	< 0.01	
Al_2O_3	0.63	0.00	PbO	26.00	44.40	H_2O^+	1.20	1.31
Fe_2O_3		1.74	MgO	0.02		H_2O^-	0.20	0.20
						Total	98.78	100.19

(1) Kivu Province, Congo; after deduction of estimated cassiterite 3% and mica 0.5%, corresponds to $(Pb_{0.74}Na_{0.13}Ca_{0.11}Cs_{0.07}Sb_{0.03}Fe_{0.03}Ba_{0.01})_{\Sigma=1.12}(Ta_{1.45}Nb_{0.53}Ti_{0.02})_{\Sigma=2.00}O_{6.04}\bullet 0.42H_2O$.
(2) Mt. Ploskaya, Kola Peninsula, Russia; corresponds to $(Pb_{1.39}Ca_{0.35}Na_{0.14})_{\Sigma=1.88}(Ta_{1.05}Nb_{0.59}Sn_{0.21}Fe^{3+}_{0.15})_{\Sigma=2.00}O_{6.11}(OH)_{0.89}$.

Mineral Group: Pyrochlore group, microlite subgroup; $Pb_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Ta_B \geq Nb_B$.

Occurrence: In alluvium near lithium-rich pegmatites (Kivu Province, Congo); in microcline pegmatites in an alkalic massif (Mt. Ploskaya, Kola Peninsula, Russia).

Association: Cassiterite, manganotantalite, microlite, simpsonite, mica (Kivu Province, Congo); albite, cassiterite, galena, uranium minerals, hingganite-(Yb) (Mt. Ploskaya, Kola Peninsula, Russia).

Distribution: At an unspecified locality [Mumba district, Masisi] in Kivu Province, Congo (Zaire). From about 15 km north-northwest of Lutsiro, near the Sebeya River, western Rwanda. As large crystals on Mt. Ploskaya, Keivy massif, Kola Peninsula, Russia.

Name: For lead, PLUMBum, in its composition, and its relation to *microlite*.

Type Material: van Wambeke collection, Brussels, Belgium.

References: (1) Safiannikoff, A. and L. van Wambeke (1961) Sur un terme plombifère du groupe pyrochlore-microlite. Bull. Soc. fr. Minéral., 84, 382–384 (in French with English abs.). (2) (1962) Amer. Mineral., 47, 1220–1221 (abs. ref. 1). (3) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (4) Voloshin, A.V., V.V. Bukanov, and L.I. Polezhaeva (1981) Plumbomicrolite and plumbopyrochlore from the amazonite pegmatites of the Kola Peninsula. Mineral. Zhurnal, 3, 20–34 (in Russian). (5) Stepanov, V.I., V.V. Bukanov, and A.V. Bykova (1982) Plumbomicrolite from amazonite pegmatite of Mount Ploskaya, its first find in the USSR. Doklady Acad. Nauk SSSR, 263, 183–185 (in Russian).

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Plumbonacrite $Pb_5O(CO_3)_3(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $6mm$. As aggregates of scaly crystals, to 0.1 mm.

Physical Properties: Hardness = n.d. D(meas.) = 7.07 (synthetic). D(calc.) = [7.069]

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Pearly. *Optical Class:* [Uniaxial.] ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P6_3cm$ (synthetic). a = 9.0921(7) c = 24.923(3) Z = 6

X-ray Powder Pattern: Synthetic; near to hydrocerussite.
2.619 (10), 4.26 (8), 3.357 (7), 1.699 (5), 2.953 (4), 2.235 (4), 3.98 (3)

Chemistry:

	(1)	(2)
CO_2	4.76	10.43
PbO	92.85	88.15
H_2O	2.01	1.42
insol.	0.78	
Total	100.40	100.00

(1) Wanlockhead, Scotland. (2) $Pb_5O(CO_3)_3(OH)_2$.

Occurrence: Rare in the oxidized zone of hydrothermal polymetallic deposits.

Association: Anglesite, linarite, galena (Tiger, Arizona, USA).

Distribution: From Wanlockhead, Dumfriesshire, Scotland. In the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA.

Name: From the Latin for *lead* and the French *nacre*, for *mother-of-pearl*, in allusion to its composition and nacreous luster.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 270 [hydrocerussite, part]. (2) Olby, J.K. (1966) The basic lead carbonates. J. Inorg. Nucl. Chem., 28, 2507–2512. (3) Haacke, D.F. and P.A. Williams (1981) Stability of plumbonacrite. J. Inorg. Nucl. Chem., 43, 406. (4) Krivovichev, S.V. and P.C. Burns (2000) Crystal chemistry of basic lead carbonates. II. Crystal structure of synthetic "plumbonacrite". Mineral. Mag., 64, 1069–1075.

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Plumbopalladinite Pd_3Pb_2

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Crystal Data: Hexagonal. *Point Group:* 6*mm* (synthetic). As grains, to 0.7 mm, in tiny aggregates.

Physical Properties: Hardness = ∼5 VHN = 407–441 (50 g load). D(meas.) = n.d. D(calc.) = 12.36

Optical Properties: Opaque. *Color:* Bright white with faint rose tint in reflected light. *Pleochroism:* Noticeable in air. *Anisotropism:* Strong, orange-brown to dark brown.
R_1–R_2: (400) — , (420) — , (440) 43.5–46.6, (460) 44.6–48.2, (480) 45.8–49.5, (500) 47.5–50.8, (520) 49.0–52.6, (540) 50.7–54.4, (560) 52.4–55.8, (580) 53.9–57.1, (600) 55.2–58.0, (620) 56.6–59.2, (640) 58.3–60.8, (660) 60.0–62.6, (680) 61.4–64.4, (700) 62.8–66.1

Cell Data: *Space Group:* $P6_3mc$ (synthetic). $a = 4.470$ $c = 5.719$ $Z = 1$

X-ray Powder Pattern: Talnakh area, Russia.
2.30 (10), 2.23 (10), 1.207 (6), 3.20 (5), 1.302 (5), 1.760 (4), 1.602 (4)

Chemistry:

	(1)	(2)
Pd	42.35	43.51
Pb	55.12	56.49
Ag	2.07	
Cu	0.22	
Sn	0.47	
Bi	0.80	
Sb	0.08	
Total	101.11	100.00

(1) Talnakh area, Russia; by electron microprobe, average of four analyses; corresponds to $(Pd_{2.86}Ag_{0.14})_{\Sigma=3.00}(Pb_{1.91}Bi_{0.03}Sn_{0.03}Cu_{0.02}Sb_{0.01})_{\Sigma=2.00}$. (2) Pd_3Pb_2.

Occurrence: In Ni–Cu sulfide ores (Talnakh area, Russia).

Association: Cubanite, talnakhite, polarite, stannopalladinite, silver, sphalerite, galena (Talnakh area, Russia).

Distribution: From the Majak mine, Talnakh area, Noril'sk region, western Siberia, Russia [TL]. At the Stillwater complex, Montana, USA.

Name: For the chemical composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72999.

References: (1) Genkin, A.D., T.L. Evstigneeva, L.N. Vyal'sov, I.P. Laputina, and N.V. Troneva (1970) Plumbopalladinite, a new mineral from copper–nickel ores. Geol. Rudn. Mestorozhd., 5, 63–68 (in Russian). (2) (1971) Amer. Mineral., 56, 1121 (abs. ref. 1).

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Plumbopyrochlore $(Pb, Y, U, Ca)_{2-x}Nb_2O_6(OH)$

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Crystal Data: Cubic. *Point Group:* $[4/m\ \overline{3}\ 2/m]$ (by analogy to the pyrochlore group). As octahedral crystals, granular, and rims on columbite crystals.

Physical Properties: *Fracture:* [Uneven.] *Tenacity:* [Brittle.] Hardness = [∼5]
D(meas.) = 5.04 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Red, greenish yellow, zoned with brown cores.
Luster: [Vitreous to resinous.]
Optical Class: Isotropic. n = 2.08–2.025

Cell Data: *Space Group:* $[Fd3m.]$ a = 10.534–10.57 Z = 8

X-ray Powder Pattern: Tai-Keu deposit, Russia.
3.02 (10), 1.861 (9), 1.581 (9), 1.077 (8), 1.017 (8), 1.209 (7), 2.615 (6)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	1.82		Al_2O_3	0.64	
WO_3		0.66	RE_2O_3	4.87	
Nb_2O_5	40.68	19.68	Fe_2O_3	2.87	0.42
Ta_2O_5	3.58	3.72	MnO		0.02
SiO_2	2.82		PbO	38.68	65.59
TiO_2	0.81	7.72	CaO	1.17	0.08
SnO_2	0.61	1.80	H_2O	1.00	
			Total	99.55	99.69

(1) Tai-Keu deposit, Russia; corresponding to $(Pb_{0.80}Y_{0.24}U_{0.10}Ca_{0.09})_{\Sigma=1.23}(Nb_{1.42}Si_{0.22}Fe_{0.17}Ta_{0.07}Al_{0.05}Sn_{0.02})_{\Sigma=1.95}O_{6.18}\bullet 0.52H_2O$. (2) Keivy massif, Russia; by electron microprobe, corresponding to $(Pb_{2.08}Ca_{0.01})_{\Sigma=2.09}(Nb_{1.05}Ti_{0.68}Ta_{0.12}Sn_{0.08}Fe_{0.04}W_{0.02})_{\Sigma=1.99}O_6(OH)$.

Mineral Group: Pyrochlore group and subgroup; $Pb_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: In metasomatically altered granitic rocks (Ural Mountains, Russia).

Association: Quartz, microcline, albite, aegirine (Ural Mountains, Russia); plumbobetafite, columbite (Keivy massif, Russia).

Distribution: From the Tai-Keu RE–Nb deposit, between Vorkuta and Labytrangi, Polar Ural Mountains, and in the Keivy massif, Kola Peninsula, Russia. At Khan Bogda, Gobi Desert, Mongolia. In the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia. At Oka, Quebec, Canada.

Name: For lead, PLUMBum, in its composition, and its relation to *pyrochlore*.

Type Material: Vernadsky Geological Museum, Moscow, 48596; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67255, 67256.

References: (1) Skorobogatova, N.V., G.A. Sidorenko, K.A. Dorofeeva, and T.I. Stolyarova (1966) Plumbopyrochlore. Geol. Mestorozhd. Redk. Elem., 30, 84–95 (in Russian). (2) (1970) Amer. Mineral., 55, 1068 (abs. ref. 1). (3) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (4) Voloshin, A.V., Y.A. Pakhomovskii, and A.Y. Bakhchisaraytsev (1993) Plumbobetafite in amazonite pegmatites of western Keivy (Kola Peninsula). Mineral. Zhurnal, 15(2), 76–80 (in Russian with English abs.).

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Plumboselite $Pb_3O_2(SeO_3)$

Crystal Data: Orthorhombic. *Point Group: mm*2. In subparallel to divergent clusters of fibers elongated parallel to [001] and flattened on {010}, to 0.3 mm.

Physical Properties: *Cleavage:* None observed. *Fracture:* n.d. *Tenacity:* Brittle.
Hardness = 2-3 D(meas.) = n.d. D(calc.) = 7.814

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White.
Luster: Dull to adamantine.
Optical Class: Biaxial. *Orientation*: $X = c$. $n = 2.115$ [Gladstone-Dale relationship].

Cell Data: *Space Group: Cmc*2_1. $a = 10.5384(11)$ $b = 10.7452(13)$ $c = 5.7577(7)$ $Z = 4$

X-ray Powder Pattern: Tsumeb mine, Namibia.
3.155 (100), 1.956 (26), 2.886 (22), 1.713 (21), 2.691 (17), 1.2711 (17), 1.8864 (13)

Chemistry:

	(1)	(2)
CaO	0.09	-
PbO	84.92	85.78
SeO_2	14.95	14.22
Total	99.96	100.00

(1) Tsumeb mine, Namibia; average of 7 electron microprobe analyses, corresponding to $Pb_{2.92}Ca_{0.01}Se_{1.03}O_5$. (2) $Pb_3O_2(SeO_3)$.

Occurrence: A secondary mineral in the oxidized zone of a polymetallic sulfide deposit.

Association: Clausthalite, smithsonite, mimetite, vaterite.

Distribution: From the Tsumeb mine, Otjikoto Region, Namibia.

Name: For the mineral's essential chemical composition, *plumbo* (for lead) and *sel* (for selenite).

Type Material: Mineral Sciences Department, Natural History Museum of Los Angeles County, California, USA (63264).

References: (1) Kampf, A.R., S. J. Mills, and W.W. Pinch (2011) Plumboselite, $Pb_3O_2(SeO_3)$, a new oxidation-zone mineral from Tsumeb, Namibia. Mineralogy and Petrology, 101, 75–80.
(2) (2013) Amer. Mineral., 98, 281 (abs. ref. 1).

Plumbotellurite $PbTe^{4+}O_3$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As fine-grained aggregates in rims around and replacing altaite.

Physical Properties: Hardness = n.d. VHN = 30–42, 38 average (10 g load).
D(meas.) = 7.2 D(calc.) = 7.16

Optical Properties: Semitransparent. *Color:* Grayish yellow, gray, or pale brown; colorless in transmitted light; gray or brownish gray in reflected light. *Streak:* Yellowish gray.
Optical Class: Biaxial (+). $\alpha = 2.19$ $\beta = 2.23$ $\gamma = 2.35$ 2V(meas.) = $\sim 50°$
Anisotropism: Distinct.

Cell Data: *Space Group:* n.d. $a = 8.423$ $b = 13.739$ $c = 9.199$ Z = 12

X-ray Powder Pattern: Zhana-Tyube deposit, Kazakhstan.
3.17 (100), 3.099 (35), 3.21 (32), 2.980 (29), 2.857 (25), 2.725 (18), 2.102 (12)

Chemistry:

	(1)	(2)
SO_3	0.1	
TeO_2	42.0	41.69
SeO_2	0.1	
Bi_2O_3	0.6	
Sb_2O_3	0.1	
PbO	58.4	58.31
Total	101.3	100.00

(1) Zhana-Tyube deposit, Kazakhstan; by electron microprobe, average of three analyses; original elemental analysis here converted to oxides; corresponds to $(Pb_{1.01}Bi_{0.01})_{\Sigma=1.02}Te_{1.01}O_{2.96}$.
(2) $PbTeO_3$.

Polymorphism & Series: Dimorphous with fairbankite.

Occurrence: A secondary mineral, formed by alteration of altaite near the base of the oxidation zone of a tellurium-rich mineral deposit.

Association: Altaite.

Distribution: From the Zhana-Tyube Au–Te deposit, northern Kazakhstan.

Name: For lead, *plumbum*, and *tellurium* in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81598.

References: (1) Spiridonov, E.M. and O.I. Tananeyva (1982) Plumbotellurite, $\alpha-PbTeO_3$, a new mineral. Doklady Acad. Nauk SSSR, 262, 1231–1235 (in Russian). (2) (1982) Amer. Mineral., 67, 1075 (abs. ref. 1).

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Plumbotsumite $Pb_5Si_4O_8(OH)_{10}$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* 222. As irregular to skeletal pseudohexagonal crystals, tabular on {001}, to 1 mm; rarely stacked ‖ [001] and exhibiting parallel striations; massive. *Twinning:* Microscopic lamellar twinning visible on cleavage surfaces, penetration twinning on {110} also common.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ∼2 D(meas.) = 5.6 D(calc.) = 5.56

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Streak:* White. *Luster:* Resinous to adamantine; pearly on cleavage surfaces.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$. $\alpha = 1.922(5)$ $\beta = 1.933(4)$ $\gamma = 1.938(4)$ 2V(meas.) = 32(5)°

Cell Data: *Space Group:* $C222_1$. $a = 15.875(4)$ $b = 9.261(3)$ $c = 29.364(9)$ Z = 10

X-ray Powder Pattern: Tsumeb, Namibia.
3.65 (100b), 3.12 (80b), 14.70 (70), 2.47 (70), 7.99 (60), 1.633 (60), 1.476 (60)

Chemistry:

	(1)	(2)
SiO_2	16.5	16.62
PbO	76.7	77.15
H_2O	6.2	6.23
Total	99.4	100.00

(1) Tsumeb, Namibia; by electron microprobe, H_2O by TGA. (2) $Pb_5Si_4O_8(OH)_{10}$.

Occurrence: A secondary mineral developed in the oxidized zone above complex galena-bearing ores.

Association: Alamosite, melanotekite (Tsumeb, Namibia); wulfenite (Tiger, Arizona, USA).

Distribution: From Tsumeb, Namibia. In the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA.

Name: For lead, PLUMBum, in the mineral's composition, and the type locality, TSUMeb, Namibia.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Germany, NM10; National Museum of Natural History, Washington, D.C., USA, 148301.

References: (1) Keller, P. and P.J. Dunn (1982) Plumbotsumit, $Pb_5(OH)_{10}Si_4O_8$, ein neues Bleisilikat von Tsumeb, Namibia. Chem. Erde, 41, 1–6 (in German). (2) (1982) Amer. Mineral., 67, 1075–1076 (abs. ref. 1).

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Poitevinite $(Cu, Fe^{2+})SO_4 \cdot H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. Very fine-grained, vermiform to powdery.

Physical Properties: Hardness = 3–3.5 D(meas.) = 3.30 D(calc.) = 3.30

Optical Properties: Semitransparent. *Color:* Salmon-pink.
Optical Class: Biaxial. $\alpha = 1.610$ (α') $\beta =$ n.d. $\gamma = 1.636$ (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.12(1)$ $b = 5.160(1)$ $c = 7.535(2)$ $\alpha = 107.06(1)°$ $\beta = 107.40(1)°$ $\gamma = 92.73(1)°$ Z = 2

X-ray Powder Pattern: Avoca claim, Canada.
3.450 (100), 3.437 (83), 3.074 (79), 3.336 (49), 2.507 (48), 4.735 (46), 3.268 (30)

Chemistry:

	(1)
SO_3	44.33
FeO	18.20
CuO	21.84
ZnO	3.74
H_2O	12.07
Total	[100.18]

(1) Avoca claim, Canada; recalculated to original total of 100.18% after deduction of quartz 1.09%; corresponds to $(Cu_{0.50}Fe_{0.46}Zn_{0.08})_{\Sigma=1.04}SO_4 \cdot 1.2H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a base-metal hydrothermal mineral prospect.

Association: Quartz, gypsum, pyrite, bonattite, scorodite.

Distribution: From the Avoca claim, Hat Creek, Bonaparte River area, Lillooet district, British Columbia, Canada.

Name: To honor Dr. Theophile Eugène Poitevin (1888–1978), Canadian mineralogist, Geological Survey of Canada.

Type Material: National School of Mines, Paris, France; Canadian Geological Survey, Ottawa, 12122; Royal Ontario Museum, Toronto, Canada, M25440; National Museum of Natural History, Washington, D.C., USA, 142995.

References: (1) Jambor, J.L., G.R. Lachance, and S. Courville (1964) Poitevinite, a new mineral. Can. Mineral., 8, 109–110. (2) (1965) Amer. Mineral., 50, 263 (abs. ref. 1). (3) Giester, G., C.L. Lengauer, and G. Redhammer (1994) Characterization of the $FeSO_4 \cdot H_2O$–$CuSO_4 \cdot H_2O$ solid-solution series, and the nature of poitevinite, $(Cu, Fe)SO_4 \cdot H_2O$. Can. Mineral., 32, 873–884.

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Pokrovskite $Mg_2(CO_3)(OH)_2 \cdot 0.5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ (by analogy to malachite). Crystals are prismatic to acicular, to 7 mm, in sheaves; as spherulitic aggregates, may be cross-vein fibrous, asbestiform.

Physical Properties: Hardness = ∼3 D(meas.) = 2.51–2.52 D(calc.) = 2.58

Optical Properties: Semitransparent, may be opaque due to inclusions. *Color:* White with a flesh tint. *Streak:* White. *Luster:* Dull.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = 8°$; elongation, negative. $\alpha = 1.537$ $\beta = 1.619$ $\gamma = 1.619$ 2V(meas.) = 18°

Cell Data: *Space Group:* $P2_1/a$ (by analogy to malachite). $a = 9.43(1)$ $b = 12.27(1)$ $c = 3.395(3)$ $\beta = 96.60(9)°$ Z = 4

X-ray Powder Pattern: Zlatogorsk massif, Kazakhstan.
2.60 (10b), 2.17 (9), 6.10 (7), 4.70 (7), 3.73 (7), 1.661 (7b), 1.385 (5)

Chemistry:

	(1)	(2)
SiO_2	< 0.10	
CO_2	28.78	29.02
Al_2O_3	< 0.05	
Fe_2O_3	1.90	
MnO	1.02	
MgO	50.80	53.16
CaO	0.39	
BaO	0.10	
Na_2O	0.10	
K_2O	< 0.10	
H_2O^+	16.72	17.82
H_2O^-	0.44	
Total	100.50	100.00

(1) Zlatogorsk massif, Kazakhstan; $(OH)^{1-}$ and H_2O confirmed by IR, corresponds to $(Mg_{1.93}Fe_{0.04}Mn_{0.02})_{\Sigma=1.99}(CO_3)(OH)_2 \cdot 0.42H_2O$. (2) $Mg_2(CO_3)(OH)_2 \cdot 0.5H_2O$.

Occurrence: An uncommon species in ultramafic bodies of dunite or serpentinite.

Association: Dolomite, magnesite, sjögrenite (Zlatogorsk intrusion, Kazakhstan); coalingite, mcguinnessite (Cedar Hill quarry, Pennsylvania, USA).

Distribution: From a drillhole in the Zlatogorsk massif, 90 km west-southwest of Kokchetav, Kazakhstan. In the USA, at the Hunting Hill quarry, Montgomery Co., Maryland; in the Cedar Hill quarry, Lancaster Co., Pennsylvania; at the Addie quarry, Jackson Co., North Carolina; from the Gabbs mine, Gabbs district, Nye Co., Nevada; at Lytton, Sonoma Co., California.

Name: Honors Pavel Vladimirovich Pokrovskii (1912–1979), Russian mineralogist, Institute of Geology and Geochemistry, Sverdlovsk, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Ivanov, O.K., Y.A. Malinovskii, and Y.V. Mozherin (1984) Pokrovskite. $Mg_2[(CO_3)(OH)_2] \cdot 0.5H_2O$ – a new mineral from the Zlatogorskaya layered intrusive (Kazakhstan). Zap. Vses. Mineral. Obshch., 113, 90–95. (2) (1985) Amer. Mineral., 70, 217 (abs. ref. 1).

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Polarite Pd_2PbBi

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As grains, to 0.3 mm.

Physical Properties: Hardness = n.d. VHN = 168–232 (50 g load). D(meas.) = n.d. D(calc.) = 12.51

Optical Properties: Opaque. *Color:* White with yellowish tint in reflected light. *Luster:* Metallic. *Anisotropism:* Slight; gray to pale brown in oil.
R: (400) — , (420) — , (440) 55.4, (460) 56.8, (480) 55.9, (500) 56.4, (520) 58.2, (540) 59.2, (560) 59.6, (580) 59.6, (600) 59.9, (620) 59.5, (640) 60.9, (660) 61.2, (680) 60.9, (700) 61.8

Cell Data: *Space Group:* $Ccm2_1$. $a = 7.191$ $b = 8.693$ $c = 10.681$ $Z = 16$

X-ray Powder Pattern: Talnakh area, Russia.
2.65 (100), 2.16 (90), 2.25 (50), 1.638 (50), 2.50 (30), 1.400 (30), 1.220 (30)

Chemistry:

	(1)	(2)	(3)	(4)
Pd	32.8	33.1	35.0	33.84
Pt			2.0	
Pb	34.0	29.0		32.94
Bi	33.4	36.4	59.4	33.22
Te			5.2	
Total	100.2	98.5	101.6	100.00

(1) Talnakh area, Russia; by electron microprobe, corresponds to $Pd_{1.95}Pb_{1.04}Bi_{1.01}$. (2) Do.; by electron microprobe, corresponds to $Pd_{1.99}Pb_{0.90}Bi_{1.11}$. (3) Union mine, South Africa; by electron microprobe, corresponds to $(Pd_{1.98}Pt_{0.06})_{\Sigma=2.04}(Bi_{1.71}Te_{0.24})_{\Sigma=1.95}$. (4) Pd_2PbBi.

Occurrence: In hydrothermal Cu–Ni–Fe sulfide veins (Talnakh area, Russia).

Association: Chalcopyrite, talnakhite, cubanite, stannopalladinite, paolovite, sobolevskite, sperrylite, cabriite, palarstanide, nickeloan platinum, sphalerite, silver (Talnakh area, Russia).

Distribution: From the Majak mine, Talnakh area, Noril'sk district, Polar Ural Mountains, western Siberia, Russia [TL]. At the Union mine, in the Merensky Reef, Bushveld complex, Transvaal, South Africa. From Fox Gulch, Goodnews Bay, Alaska, USA.

Name: For its occurrence in the Polar Ural Mountains, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73002; Canadian Museum of Nature, Ottawa, Canada, 10401; National Museum of Natural History, Washington, D.C., USA, 160244.

References: (1) Genkin, A.D., T.L. Evstigneeva, N.V. Troneva, and L.N. Vyal'sov (1969) Polarite, Pd(Pb, Bi) a new mineral from copper–nickel sulfide ores. Zap. Vses. Mineral. Obshch., 98, 708–715 (in Russian). (2) (1970) Amer. Mineral., 55, 1810 (abs. ref. 1). (3) Cabri, L.J. and R.J. Traill (1966) New palladium minerals from Noril'sk, western Siberia. Can. Mineral., 8, 541–550. (4) Mayer, H. (1979) ??title?? J. Less-Common Metals, 66, 1–??. (5) Tarkian, M. (1987) Compositional variations and reflectance of the common platinum-group minerals. Mineral. Petrol., 36, 169–190. (6) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 130–131.

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Poldervaartite $(Ca, Mn^{2+})_2(SiO_3OH)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are prismatic, with {110}, {100}, {010}, and {001}, to 7 mm; aggregates in sheaves.

Physical Properties: *Tenacity:* Very brittle. Hardness = 5 D(meas.) = 2.91(2) D(calc.) = 2.90 Fluoresces deep red under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Streak:* [White.] *Luster:* Vitreous on fractures to subvitreous on crystal faces.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = colorless; Y = light gray; Z = bluish gray. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, weak. $\alpha = 1.634(2)$ $\beta = 1.640(4)$ $\gamma = 1.656(2)$ $2V(meas.) = 65(5)^\circ$ $2V(calc.) = 63^\circ$

Cell Data: *Space Group: Pbca.* $a = 9.398(1)$ $b = 9.139(2)$ $c = 10.535(2)$ $Z = 8$

X-ray Powder Pattern: Wessels mine, South Africa.
3.231 (100), 4.18 (45), 2.846 (42), 2.391 (42), 2.789 (35), 2.042 (28), 3.27 (26)

Chemistry:

	(1)
SiO_2	29.8
FeO	0.1
MnO	18.7
MgO	0.0
CaO	41.5
H_2O^+	9.4
Total	99.5

(1) Wessels mine, South Africa; by electron microprobe, H_2O by TGA; corresponds to $(Ca_{1.47}Mn_{0.53})_{\Sigma=2.00}Si_{0.99}O_{3.96} \cdot 1.04H_2O$.

Occurrence: In a pocket in massive manganese ores in a bedded manganese ore deposit.

Association: Braunite, hausmannite, henritermierite, bultfonteinite, hematite, calcite.

Distribution: In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: To honor Arie Poldervaart (1918–1964), Professor of Petrology, Columbia University, New York City, New York, USA.

Type Material: American Museum of Natural History, New York, New York, USA, T100728.

References: (1) Dai, Y., G.E. Harlow, and A.R. McGhie (1993) Poldervaartite, $Ca(Ca_{0.5}Mn_{0.5})(SiO_3OH)(OH)$, a new acid nesosilicate from the Kalahari manganese field, South Africa: crystal structure and description. Amer. Mineral., 78, 1082–1087.

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Polhemusite $(Zn, Hg)S$

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Crystal Data: Tetragonal. *Point Group:* $4/m$ or $4/m\ 2/m\ 2/m$. As stubby prisms and dipyramids, to 25 μm; as microscopic grains. *Twinning:* Knee-shaped twins with {605} as composition plane; contact twins on {*hkl*} less common; twinning on {*h*0*l*} may also be present, developing trains of prisms and discontinuous lamellae.

Physical Properties: *Cleavage:* Rare. Hardness = n.d. VHN = 262 (25 g load). D(meas.) = n.d. D(calc.) = 4.23–5.63

Optical Properties: Nearly opaque; translucent in thin section. *Color:* Black; gray in polished section, with intense red internal reflections. *Luster:* Resinous to adamantine. *Pleochroism:* Very slightly brownish gray to slightly lavender-gray. *Anisotropism:* Moderate in air, strong in oil.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P4/n$, $P4_2/n$, $P4/nbm$, $P4/nmm$, $P4_2/nnm$, or $P4_2/ncm$. $a = 8.71$ $c = 14.74$ $Z = 24 - 32(?)$

X-ray Powder Pattern: B and B deposit, Idaho, USA.
3.08 (vs), 1.888 (s), 3.16 (ms), 1.608 (ms), 3.60 (m), 1.222 (m), 1.086 (m)

Chemistry:

	(1)
Zn	49.1
Hg	25.8
Fe	0.5
S	26.7
Total	102.1

(1) B and B deposit, Idaho, USA; by electron microprobe, average analysis of 15 grains, corresponding to $(Zn_{0.87}Hg_{0.15}Fe_{0.01})_{\Sigma=1.03}S_{0.97}$.

Occurrence: As part of a replacement deposit of stibnite (B and B deposit, Idaho, USA).

Association: Stibnite, cinnabar, mercurian sphalerite, zincian metacinnabar (B and B deposit, Idaho, USA); realgar (Getchell mine, Nevada, USA).

Distribution: In the USA, from the B and B deposit, Big Creek district, Valley Co., Idaho [TL], and in the Getchell mine, Potosi district, Humboldt Co., Nevada.

Name: In honor of Clyde Polhemus Ross (1891–1965), American economic geologist.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145549.

References: (1) Leonard, B.F., G.A. Desborough, and C.W. Mead (1978) Polhemusite, a new Hg–Zn sulfide from Idaho. Amer. Mineral., 63, 1153–1161.

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Polkanovite $Rh_{12}As_7$

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Crystal Data: Cubic. *Point Group:* n.d. Massive with other sulfides.

Physical Properties: Hardness = n.d. VHN = 119–124 (50 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Brownish gray; in reflected light, white with cream-red tint. *Streak:* Dark gray. *Anisotropism:* Distinct.
R_1–R_2: (470) 43.5–44.5, (535) 43.0–44.0, (591) 44.0–45.0, (658) 45.5–46.5

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Fe	29.3	25.2
Pb	14.6	23.0
Cu	3.6	2.6
Ge	4.5	4.8
As	1.8	1.1
S	34.2	34.2
Total	[88.0	90.9

(1) Lower Silesia, Poland; by electron microprobe, original total given as 92.0%; corresponds to $(Fe_{1.97}Pb_{0.26}Cu_{0.21})_{\Sigma=2.44}(Ge_{0.23}As_{0.09})_{\Sigma=0.31}S_{4.00}$. (2) Do.; by electron microprobe, corresponds to $(Fe_{1.69}Pb_{0.42}Cu_{0.15})_{\Sigma=2.26}(Ge_{0.25}As_{0.06})_{\Sigma=0.31}S_{4.00}$.

Polymorphism & Series: Forms a series with morozeviczite.

Occurrence: In epigenetic veinlets and metasomatic replacement zones replacing sandstone and older sulfides, in brecciated sandstones underlying copper-bearing shales.

Association: Marcasite, chalcopyrite, bornite, chalcocite, tennantite, sphalerite, galena.

Distribution: From the Polkovice mine, near Legnica, Zechstein copper district, Lower Silesia, Poland [TL].

Name: For the Polkovice mine, Poland.

Type Material: Jagellonian University, Kraków, Poland.

References: (1) Haranczyk, C. (1975) Morozeviczite and polkovicite, typochemical minerals of Mesozoic mineralization of the Fore-Sudenten monocline. Rudy i Metalle, 20, 288–293 (in Polish). (2) (1981) Amer. Mineral., 66, 437–438 (abs. ref. 1).

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Polkovicite $(Fe, Pb)_3(Ge, Fe)_{1-x}S_4$ (x = 0.18 to 0.69)

Crystal Data: Cubic. *Point Group:* n.d. Massive with other sulfides.

Physical Properties: Hardness = n.d. VHN = 119–124 (50 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Brownish gray; in reflected light, white with cream-red tint. *Streak:* Dark gray. *Anisotropism:* Distinct.
R_1–R_2: (470) 43.5–44.5, (535) 43.0–44.0, (591) 44.0–45.0, (658) 45.5–46.5

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
Fe	29.3
Pb	14.6
Cu	3.6
Ge	4.5
As	1.8
S	34.2
Total	88.0

(1) Lower Silesia, Poland; by electron microprobe.

Polymorphism & Series: Forms a series with morozeviczite.

Occurrence: In epigenetic veinlets and metasomatic replacement zones replacing sandstone and older sulfides, in brecciated sandstones underlying copper-bearing shales.

Association: Marcasite, chalcopyrite, bornite, chalcocite, tennantite, sphalerite, galena.

Distribution: From the Polkovice mine, Lower Silesia, Poland.

Name: For the Polkovice mine, Poland.

Type Material: Jagellonian University, Kraków, Poland.

References: (1) Haranczyk, C. (1975) Morozeviczite and polkovicite, typochemical minerals of Mesozoic mineralization of the Fore-Sudenten monocline. Rudy Metalle, 20, 288–293 (in Polish).
(2) (1981) Amer. Mineral., 66, 437 (abs. ref. 1).

Pollucite $(Cs,Na)(AlSi_2)O_6 \cdot nH_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Crystals rare, cubes, dodecahedra, or trapezohedra, commonly striated, up to 12 cm; as rounded grains, fine-grained, massive. Commonly heterogenous below ~200 μm, into domains enriched in (Cs,Al), (Na,Si), or (Cs,Na,Al) with exsolved quartz.

Physical Properties: *Cleavage:* In traces. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 VHN = 658–794 D(meas.) = 2.68–3.03 D(calc.) = 2.94

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, or tinted pink, blue, violet; colorless in thin section. *Luster:* Vitreous; greasy to dull on the exterior. *Optical Class:* Isotropic; may show weak sectional birefringence. n = 1.507–1.525

Cell Data: *Space Group: Ia3d.* a = 13.682(3) Z = 16

X-ray Powder Pattern: Nagatara, Fukuoka Prefecture, Japan. (ICDD 25-194). 3.42 (100), 2.913 (45), 3.65 (30), 2.416 (24), 1.736 (22), 1.860 (18), 2.218 (17)

Chemistry:

	(1)	(2)	(3)
SiO_2	47.57	43.26	47.56
Al_2O_3	16.12	16.67	16.40
Fe_2O_3		0.01	
CaO	0.35	0.65	0.28
Na_2O	1.69	0.76	2.08
K_2O	0.01	0.01	0.02
Rb_2O	1.48	1.41	1.24
Cs_2O	30.07	34.30	29.79
Total	97.29	[97.07]	[97.37]

(1) Maskwa Lake, Manitoba, Canada; by electron microprobe, average of three analyses; corresponds to $(Cs_{0.58}Na_{0.15}Rb_{0.04}Ca_{0.02})_{\Sigma=0.79}Al_{0.86}Si_{2.15}O_6 \cdot nH_2O$. (2) Do.; original total given as 97.06%, corresponds to $(Cs_{0.70}Na_{0.07}Rb_{0.04}Ca_{0.03})_{\Sigma=0.84}Al_{0.94}Si_{2.07}O_6 \cdot nH_2O$. (3) Do.; original total given as 97.36%, corresponds to $(Cs_{0.57}Na_{0.18}Rb_{0.04}Ca_{0.01})_{\Sigma=0.80}Al_{0.87}Si_{2.14}O_6 \cdot nH_2O$.

Polymorphism & Series: Forms a series with analcime.

Mineral Group: Zeolite group.

Occurrence: In lithium-rich granite pegmatites; may be in kiloton amounts.

Association: Quartz, spodumene, petalite, amblygonite, lepidolite, elbaite, cassiterite, columbite, apatite, eucryptite, muscovite, potassic feldspar, albite, microcline.

Distribution: In fine crystals at several places around San Piero in Campo, Elba, Italy. In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. At Bikita, Zimbabwe. From Karibib, Namibia. In the USA, from a number of localities in Oxford Co., Maine; at Portland and Haddam, Middlesex Co., Connecticut; in the Tin Mountain mine, near Custer, Custer Co., South Dakota; in the Pala and Mesa Grande districts, San Diego Co., California. In large amounts in the Tanco pegmatite, Bernic Lake, Manitoba, Canada. From the Taquaral district, Itinga, Minas Gerais, Brazil. Large crystals from the Shengus, Skardu, and Gilgit districts, Pakistan. At Nilaw, Nuristan district, Laghman Province, Afghanistan. Additional minor occurrences are known.

Name: From *Pollux*, genative *Pollucis*, of classical mythology, brother of Castor, for its common association with "castorite" (petalite).

Type Material: Mining Academy, Freiberg, Germany, 27111.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 343–344. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 60–65. (3) Beger, R.M. (1969) The crystal structure and chemical composition of pollucite. Zeits. Krist., 129, 280–302. (4) Černý, P. (1974) The present status of the analcime-pollucite series. Can. Mineral., 12, 334–341. (5) Teertstra, D.K., P. Černý, and R. Chapman (1992) Compositional heterogeneity of pollucite from High Grade Dyke, Maskwa Lake, southeastern Manitoba. Can. Mineral., 30, 687–697.

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Polybasite $(Ag, Cu)_{16}Sb_2S_{11}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are pseudohexagonal, tabular on {001}, to 6 cm; triangular patterns formed by striae on {001}; also massive. *Twinning:* {110} as twin plane, repeated.

Physical Properties: *Cleavage:* Imperfect on {001}. *Fracture:* Uneven. Hardness = 2–3 VHN = n.d. D(meas.) = 6.1 D(calc.) = 6.36

Optical Properties: Nearly opaque; in thin fragments, translucent and dark red in transmitted light. *Color:* Iron-black; in polished section, very pale gray with rare red internal reflections. *Streak:* Black. *Luster:* Metallic.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Orientation:* $X = c$; $Y = a$. $n = > 2.72$ (Li). 2V(meas.) = 22° *Anisotropism:* Moderate.
R_1–R_2: (400) 33.9–32.5, (420) 33.6–32.8, (440) 33.4–33.0, (460) 33.0–33.9, (480) 32.4–34.0, (500) 31.9–33.8, (520) 31.3–33.4, (540) 30.8–32.8, (560) 30.5–32.2, (580) 30.2–31.7, (600) 29.8–31.1, (620) 29.3–30.5, (640) 29.1–29.3, (660) 27.3–29.1, (680) 27.2–28.4, (700) 26.7–27.8

Cell Data: *Space Group:* $C2/m$. $a = 26.17$ $b = 15.11$ $c = 23.89$ $\beta = 90°00'$ Z = 16

X-ray Powder Pattern: Keeley mine, South Lorrain Township, Ontario, Canada.
3.00 (100), 3.19 (90), 2.88 (80), 2.53 (60), 1.892 (60), 2.70 (50), 2.42 (40)

Chemistry:

	(1)	(2)
Ag	67.95	68.90
Cu	6.07	5.21
Fe	0.76	0.09
Sb	5.15	8.85
As	3.88	1.07
S	16.37	15.33
Total	100.18	99.45

(1) Beaverdell, British Colombia, Canada; corresponds to $(Ag_{14.58}Cu_{1.31})_{\Sigma=15.89}(Sb_{1.88}As_{0.19})_{\Sigma=2.07}S_{11.03}$. (2) Arizpe, Mexico; corresponds to $(Ag_{14.39}Cu_{1.85}Fe_{0.04})_{\Sigma=16.28}(Sb_{1.64}As_{0.32})_{\Sigma=1.96}S_{10.77}$.

Polymorphism & Series: Forms a series with pearceite.

Occurrence: In silver veins of low to medium temperature of formation.

Association: Pyrargyrite, tetrahedrite, stephanite, other silver sulfosalts, acanthite, gold, quartz, calcite, dolomite, barite.

Distribution: Common in small amounts, may be a major ore mineral; only rarely as fine specimens. In Germany, from the Neuer Morgenstern [TL] and other mines, Freiberg, Saxony, and at St. Andreasberg, Harz Mountains. From Banská Hodruša, near Banská Štiavnica (Schemnitz), Slovakia. At Příbram, Czech Republic. In the USA, in Colorado, from the Ouray district, Ouray Co.; the Gilman district, Eagle Co.; and the Red Mountain district, San Juan Co.; in Nevada, at Tonopah, Nye Co., Goldfield, Esmeralda Co., and in the Comstock Lode, Virginia City, Storey Co. Fine crystals from the Husky mine, Elsa, Yukon Territory, Canada. At Tres Puntas, near Copiapó, Atacama, Chile. In Mexico, at many localities, with especially fine examples from the Las Chiapas mine, Arizpe, Sonora; Fresnillo, Chihuahua; and at Guanajuato. From Sabana Grande, Honduras.

Name: From the Greek for *many* and *base*, in allusion to the many metallic bases present.

Type Material: Mining Academy, Freiberg, Germany, 6867.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 351–353. (2) Frondel, C. (1963) Isodimorphism of the polybasite and pearceite series. Amer. Mineral., 48, 565–572. (3) Hall, H.T. (1967) The pearceite and polybasite series. Amer. Mineral., 52, 1311–1321. (4) Peacock, M.A. and L.G. Berry (1947) Studies of the mineral sulpho-salts: XIII – Polybasite and pearceite. Mineral. Mag., 28, 1–13. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 447.

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Polycrase-(Y) $(Y, Ca, Ce, U, Th)(Ti, Nb, Ta)_2O_6$

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Crystal Data: Orthorhombic; commonly metamict. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are stout prismatic ‖ [001], typically flattened on {010}, may be striated ‖ [001] by twinning, to 5 cm; commonly in parallel to radiating aggregates; massive. *Twinning:* Common on {201}; rare on {101} or {013}.

Physical Properties: *Fracture:* Conchoidal to subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6.5 VHN = 671–755 D(meas.) = 4.7–5.9, may be less when altered. D(calc.) = n.d. Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black, brownish black, greenish black; brown to yellow-brown in transmitted light. *Streak:* Yellowish, grayish, or reddish brown. *Luster:* Brilliant submetallic, waxy to resinous on fractures.
Optical Class: Isotropic. $n = 2.25$
R: (470) 15.5, (546) 14.6, (589) 13.4, (650) 13.9

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8	10.50	6.48	Fe_2O_3	2.63	0.78
Nb_2O_5	12.73	20.31	FeO	0.51	
Ta_2O_5	13.89		MnO	trace	
SiO_2	0.74		PbO	0.20	0.64
TiO_2	27.70	34.41	MgO	0.12	
ThO_2	1.34	5.22	CaO	0.09	
$(Al, Ce)_2O_3$	0.62	0.44	H_2O		2.04
$(Y, Er)_2O_3$	25.64	29.28	LOI	3.00	
			Total	99.71	99.60

(1) Maberly, Canada. (2) Santa Clara, Brazil.

Occurrence: In granite pegmatites; rarely as a detrital mineral.

Association: Gadolinite, columbite, xenotime, monazite, allanite, zircon, garnet, beryl, magnetite, fluorite.

Distribution: Less common than euxenite. Some localities for well-characterized material include: from Rasvåg, Hidra (Hitterö) Island, near Flekkefjord, and many other places in Norway. At Slättåkra, Län Jönköping, Sweden. In Lyndoch Township, and about eight km south of Maberly, Ontario, Canada. In the USA, from Zirconia, Henderson Co., North Carolina; at Marietta, Greenville Co., South Carolina; in the Overlook quarry, Day, Saratoga Co., New York; from the Trout Creek Pass pegmatite district, in Park Co., east of Buena Vista, Colorado; at the Baringer Hill pegmatite, 26 km west of Burnet, Llano Co., Texas. From Santa Clara, near Tocantins, Minas Gerais, Brazil. At Cooglegong, Western Australia. Probably from many places in Madagascar but analyses are lacking for the distinction from abundant euxenite.

Name: From the Greek for *many* and *a mixture*, in reference to the large number of chemical elements contained.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 787–792. (2) Ewing, R. (1973) Vickers hardness and reflectance determinations for metamict AB_2O_6−type rare earth Ti-Nb-Ta oxides. Amer. Mineral., 58, 942–944. (3) Weitzel, H. and H. Schröcke (1980) Kristallstrukturverfeinerungen von Euxenit, $Y(Nb_{0.5}Ti_{0.5})_2O_6$, und M-Fergusonit, $YNbO_4$. Zeits. Krist., 152, 69–82 (in German with English abs.).

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Polydymite $NiNi_2S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are dominantly octahedral, to 1 cm; also massive, granular to compact. *Twinning:* On {111}.

Physical Properties: *Cleavage:* Imperfect on {001}; reported on {111}. *Fracture:* Subconchoidal to uneven. Hardness = 4.5–5.5 VHN = 379–427 (100 g load). D(meas.) = 4.5–4.8 D(calc.) = 4.83

Optical Properties: Opaque. *Color:* Pale gray to steel-gray, tarnishing to copper-red. *Luster:* Metallic, brilliant on fresh surface.

R: (400) 44.3, (420) 44.8, (440) 45.3, (460) 45.7, (480) 46.0, (500) 46.2, (520) 46.2, (540) 46.0, (560) 45.8, (580) 45.8, (600) 46.2, (620) 46.9, (640) 48.0, (660) 49.6, (680) 51.2, (700) 53.0

Cell Data: *Space Group: Fd3m.* a = 9.405 Z = 8

X-ray Powder Pattern: Siegen, Germany.
2.87 (100), 1.678 (80), 2.37 (60), 1.825 (50), 0.994 (50), 1.060 (40), 3.36 (30)

Chemistry:

	(1)	(2)	(3)
Ni	54.30	55.2	57.86
Fe	3.98	3.1	
Co	0.63	0.8	
S	41.09	41.2	42.14
Total	[100.00]	100.3	100.00

(1) Grünau mine, Germany; recalculated to 100% after deducting gersdorffite and ullmannite 5%; then corresponds to $(Ni_{2.83}Fe_{0.22}Co_{0.03})_{\Sigma=3.08}S_{3.92}$. (2) Madziwa mine, Zimbabwe; by electron microprobe, corresponds to $(Ni_{2.87}Fe_{0.17}Co_{0.04})_{\Sigma=3.08}S_{3.92}$. (3) Ni_3S_4.

Polymorphism & Series: Forms a series with linnaeite.

Mineral Group: Linnaeite group.

Occurrence: In hydrothermal veins.

Association: Chalcopyrite, pyrrhotite, pyrite, millerite, gersdorffite, ullmannite, sphalerite, galena, bismuthinite, quartz, siderite.

Distribution: In Germany, in the Grünau mine, Daaden, near Siegen [TL], and at Ramsbeck, North Rhine-Westphalia. From Saint Marina, Khaskovo district, Bulgaria. At Kunratice and Rozany, Czech Republic. From Novo-Aidyrlinsk, Southern Ural Mountains, and the Noril'sk region, western Siberia, Russia. In the USA, from Hamilton, Hancock Co., Illinois; in the Miliken (Sweetwater) mine, Reynolds Co., Missouri; and at the Copper King mine, Gold Hill district, Boulder Co., Colorado. In the Madziwa (Dry Nickel) mine, Bindura; and at Shamva, Zimbabwe. Large cystals from Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Jabal Mardah, Saudi Arabia. From Kalgoorlie, Western Australia.

Name: From the Greek for *many* and *twin*, as the mineral is observed in twinned forms.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 262–265. (2) Vaughan, D.J. and J.R. Craig (1985) The crystal chemistry of iron-nickel thiospinels. Amer. Mineral., 70, 1036–1043. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 78. (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 686–691. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 448.

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Polyhalite $K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$

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Crystal Data: Triclinic, pseudo-orthorhombic. *Point Group:* $\overline{1}$. Rare crystals, tabular {010}, or elongated along [001], to 2 mm; complex development, with 28 forms recorded; fibrous, foliated, massive. *Twinning:* Common on {010}, {100}, characteristically polysynthetic.

Physical Properties: *Cleavage:* On $\{10\overline{1}\}$, perfect; on {010}, a parting. Hardness = 3.5 D(meas.) = 2.78 D(calc.) = 2.76 Soluble in H_2O, with precipitation of gypsum and perhaps syngenite.

Optical Properties: Transparent. *Color:* Colorless, white, gray; commonly salmon-pink to brick-red from included iron oxide; colorless in transmitted light. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (–). α = 1.547–1.548 β = 1.560–1.562 γ = 1.567 2V(meas.) = 62°–70°

Cell Data: *Space Group:* $P\overline{1}$. $a = 11.689$ $b = 16.332$ $c = 7.598$ $\alpha = 91.65°$ $\beta = 90°$ $\gamma = 91.9°$ Z = 4

X-ray Powder Pattern: Netherlands. (ICDD 21-982).
3.18 (100), 2.913 (25), 2.890 (25), 2.849 (25), 2.945 (20), 6.00 (14), 2.904 (14)

Chemistry:

	(1)	(2)
SO_3	52.40	53.12
MgO	6.48	6.68
CaO	18.75	18.60
K_2O	15.66	15.62
H_2O	6.07	5.98
rem.	0.27	
Total	99.63	100.00

(1) McDowell Well, Glasscock Co., Texas, USA. (2) $K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$.

Occurrence: Common in marine salt deposits, where it may constitute the major component, present in billion-ton amounts; diagenetic in playa muds, formed from gypsum in the presence of Mg–K-rich solutions; rare as a fumarolic sublimate.

Association: Halite, anhydrite, glauberite, carnallite, kieserite, langbeinite, vanthoffite.

Distribution: In Austria, from Ischl, Bad Aussée, and Altaussée, Upper Austria; at Hallstatt, Styria; and from Hall, Tirol. In Germany, from the Stassfurt-Westeregeln district, Saxony-Anhalt, and at Berchtesgaden, Bavaria. On Vesuvius, Campania, Italy. In England, in the Boulby potash mine, northwest of Whitby, Yorkshire, England. From Maman, Iran. At Tuz Goelue, Turkey. In the Nagaur-Ganganagar Basin, Rajasthan, India. From the Qarhan alt lake, Quadam Basin, Qinghai Province, China. In the USA, in the Carlsbad potash district, Eddy Co., and adjacent parts of Texas; in the Paradox Basin, Grand Co., and elsewhere in Utah.

Name: From the Greek for *many* and *salt*, in allusion to the mineral's complex composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 458–461. (2) Schlatti, M., K. Sahl, A. Zemann, and J. Zemann (1970) Die Kristallstruktur des Polyhalits, $K_2Ca_2Mg[SO_4]_4 \cdot 2H_2O$. Tschermaks Mineral. Petrog. Mitt., 14, 75–86 (in German with English abs.).

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Polylithionite $KLi_2AlSi_4O_{10}(F,OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Pseudohexagonal crystals, tabular ‖ {001}, to 10 cm. As irregularly shaped aggregates of fine scaly crystals.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven. Hardness = 2–3 D(meas.) = 2.58–2.82 D(calc.) = 2.84 May fluoresce lemon-yellow under SW UV.

Optical Properties: Transparent. *Color:* Bright to pale pink, cream to white, colorless, pale brown to yellow-brown, bluish, greenish; in transmitted light, colorless. *Luster:* Pearly to waxy when fine-grained.
Optical Class: Biaxial (–). $\alpha = 1.53$ $\beta = 1.551$–1.556 $\gamma = 1.555$–1.559 2V(meas.) = 0°–43°

Cell Data: *Space Group:* $C2/m$. $a = 5.189$ $b = 8.974$ $c = 10.067$ $\beta = 100°27'$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
3.27 (10), 2.56 (10), 1.969 (10), 1.493 (10), 1.631 (9), 1.290 (9), 4.89 (8)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	60.83	59.25	Li_2O	6.23	9.04
TiO_2	trace		Na_2O	2.06	7.63
Al_2O_3	13.11	12.57	K_2O	11.13	5.37
Fe_2O_3	0.18	0.93	F	4.50	7.32
MnO	0.12		H_2O^+	1.71	
MgO	0.24		H_2O^-	0.33	
CaO	0.73		$-O = F_2$	1.89	3.08
			Total	99.28	99.03

(1) Mt. Karnasurt, Kola Peninsula, Russia; corresponds to $K_{0.95}(Li_{1.67}Na_{0.27}Ca_{0.05}Mg_{0.02}Mn_{0.01})_{\Sigma=2.02}(Al_{1.03}Fe^{3+}_{0.01})_{\Sigma=1.04}Si_{4.05}O_{10.25}[F_{0.95}(OH)_{0.91}]_{\Sigma=1.86}$. (2) Ilímaussaq intrusion, Greenland.

Mineral Group: Mica group.

Occurrence: In irregular segregations and veinlets, as a late-stage and metasomatic replacement mineral, in syenite pegmatites in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Microcline, natrolite, taeniolite, steenstrupine, aegirine, analcime, epistolite.

Distribution: On the Kangerdluarssuk Plateau and elsewhere in the Ilímaussaq intrusion, southern Greenland. In Russia, found on Mts. Karnasurt and Lepkhe-Nelm, Lovozero massif, Kola Peninsula. In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. At Vøra, Sandefjord, Oslo region, Norway. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada. In the USA, at Point of Rocks, Colfax Co., New Mexico. On Mt. Malosa, Zomba district, Malawi.

Name: From the Greek *poly*, for *many* or *much*, and in allusion to its high LITHIum content.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 626–627. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 25–29. (3) Vlasov, K.A., M.V. Kuz'menko, and E.M. Es'kova (1966) The Lovozero alkali massif. Akad. Nauk SSSR, 425–429 (in English). (4) Raade, G. and A. Larsen (1980) Polylithionite from syenite pegmatite at Vøra, Sandefjord, Oslo Region, Norway. Norsk. Geol. Tidsskr., 60, 117–124. (5) Chem. Abs., 94, 50381 (abs. ref. 4). (6) Takeda, H. and C.W. Burnham (1969) Fluor-polylithionite: a lithium mica with nearly hexagonal $(Si_2O_5)^{2-}$ ring. Mineral. J. (Japan), 6, 102–109.

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Polyphite $Na_{17}Ca_3Mg(Ti,Mn)_4(Si_2O_7)_2(PO_4)_6O_3F_5$

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Crystal Data: Triclinic. *Point Group:* 1. As flakes, flattened on {001}, to 3 mm, some epitaxially overgrown on lomonosovite and sobolovite.

Physical Properties: *Cleavage:* {001}, perfect; {110} and {100}, less perfect. *Fracture:* Steplike. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.07 D(calc.) = 3.00

Optical Properties: Translucent to transparent. *Color:* Light brown. *Luster:* Vitreous, resinous on fractures, pearly to adamantine on cleavages. *Streak:* White. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = yellowish. *Dispersion:* $r < v$, strong. *Absorption:* $Z \geq Y > X$. $\alpha = 1.600$ $\beta = 1.658$ $\gamma = 1.676$ 2V(meas.) = 56°

Cell Data: *Space Group:* $P1$. $a = 5.412(2)$ $b = 7.079(3)$ $c = 26.56(1)$ $\alpha = 95.21(4)°$ $\beta = 93.51(2)°$ $\gamma = 90.10(3)°$ Z = 1

X-ray Powder Pattern: Lovozero massif, Russia.
2.937 (10), 2.702 (9), 2.659 (8), 2.048 (8b), 1.771 (5b), 1.730 (5), 4.37 (4)

Chemistry:

	(1)		(1)
SiO_2	13.2	CaO	8.3
TiO_2	12.0	SrO	0.3
ZrO_2	1.6	BaO	0.9
Nb_2O_5	2.7	Na_2O	28.0
FeO	0.2	F	5.1
MnO	5.6	P_2O_5	23.3
MgO	1.3	$-O = (F,Cl)_2$	2.1
		Total	100.4

(1) Lovozero massif, Russia; by electron microprobe, average of three analyses; corresponds to $(Na_{16.45}Mn_{0.43})_{\Sigma=16.88}(Ca_{2.70}Ba_{0.11}Sr_{0.05})_{\Sigma=2.86}(Mg_{0.59}Mn_{0.36}Fe_{0.05})_{\Sigma=1.00}(Ti_{2.71}Mn_{0.65}Nb_{0.37}Zr_{0.24})_{\Sigma=3.97}(Si_2O_7)_2(P_{1.00}O_4)_6O_{2.58}F_{4.89}$.

Occurrence: In ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Nepheline, sodalite, analcime, potassic feldspar, albite, arfvedsonite, aegirine, cancrisilite, ussingite, makatite, villiaumite, quadruphite, lomonosovite, sobolovite, additional minor minerals.

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: From the Greek *poly*, for *many*, and PHosphorus, for the multiple phosphate anions in the chemical formula.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, r545/4.

References: (1) Khomyakov, A.P., G.N. Nechelyustov, E.A. Sokolova, and G.I. Dorokhova (1992) Quadruphite $Na_{14}CaMgTi_4[Si_2O_7]_2[PO_4]_4O_4F_2$ and polyphite $Na_{17}Ca_3Mg(Ti,Mn)_4[Si_2O_7]_2[PO_4]_6O_2F_6$ – new minerals of the lomonosovite group. Zap. Vses. Mineral. Obshch., 121(1), 105–112 (in Russian). (2) (1993) Amer. Mineral., 78, 1316–1317 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 240 (abs. ref. 1).

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Ponomarevite $K_4Cu_4OCl_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral pseudohexagonal plates, to about 0.1 mm, in nodules, skeletal forms, droplike clusters; most commonly in fine-grained incrustations, to 3 cm thick.

Physical Properties: *Cleavage:* Imperfect on {001} and {110}. *Tenacity:* Brittle. Hardness = 2.8 VHN = 66–97, 71 average (10 g load). D(meas.) = 2.78(1) D(calc.) = 2.72 Soluble in H_2O; alters to mitscherlichite on exposure.

Optical Properties: Transparent in thin fragments when fresh; becoming opaque on exposure. *Color:* Brick-red with a golden tint, dark red, black, probably due to admixed molysite; on exposure becomes grass-green by alteration to mitscherlichite. *Streak:* Red-orange. *Luster:* Vitreous, resinous to greasy in aggregates.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 30°$. $\alpha = 1.686(5)$ $\beta = 1.718(5)$ $\gamma = 1.720(5)$ 2V(meas.) = 28(5)°

Cell Data: *Space Group:* $C2/c$. $a = 14.740(3)$ $b = 14.900(3)$ $c = 8.948(2)$ $\beta = 104.9(1)°$ Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia.
2.801 (100), 7.31 (80), 2.787 (80), 6.074 (70), 2.470 (65), 3.654 (60), 3.048 (60)

Chemistry:

	(1)	(2)
CuO	38.02	40.73
ZnO	0.31	
PbO	0.03	
Na_2O	2.76	
K_2O	20.6	24.12
F	0.03	
Cl	42.5	45.39
H_2O^+	0.37	
H_2O^-	0.62	
$-O = (F, Cl)_2$	9.6	10.24
SO_3	1.25	
insol.	3.3	
Total	100.19	100.00

(1) Tolbachik volcano, Russia; Cu, Pb, Zn by AA, K, Na by flame photometry; after deduction of mitscherlichite 3.3%, SO_3 as thenardite 2.2%, insoluble and H_2O^-, corresponds to $(K_{3.53}Na_{0.49})_{\Sigma=4.02}(Cu_{3.97}Zn_{0.03})_{\Sigma=4.00}O_{1.10}Cl_{9.82}$. (2) $K_4Cu_4OCl_{10}$.

Occurrence: As a fracture filling and in fumaroles, deposited from 280–400 °C.

Association: Halite, sylvite, tenorite, tolbachite, dolerophanite, piypite, chalcocyanite, cotunnite, sofiite, klyuchevskite, kamchatkite.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Vasilii Vasil'evich Ponomarev (1940–1976), Russian vulcanologist, Institute of Volcanology, Petropavlovsk-Kamchatskii, Russia, who early studied the Tolbachik volcano.

Type Material: Mining Institute, St. Petersburg, Russia, 1483/1.

References: (1) Vergasova, L.P., S.K. Filatov, Y.K. Serafimova, and T.F. Semenova (1988) Ponomarevite $K_4Cu_4OCl_{10}$ – a new mineral from volcanic sublimates. Doklady Acad. Nauk SSSR, 300, 1197–1200 (in Russian). (2) Semenova, T.F., I.V. Rozhdestvenskaya, S.K. Filatov, and L.P. Vergasova (1989) Crystal structure of the new mineral ponomarevite, $K_4Cu_4OCl_{10}$. Doklady Acad. Nauk SSSR, 304, 427–430 (in Russian). (3) (1990) Amer. Mineral., 75, 709 (abs. refs. 1 and 2).

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Portlandite $Ca(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Hexagonal plates, to 6 cm; commonly fibrous, powdery, massive.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Sectile; cleavage flakes flexible. Hardness = 2 D(meas.) = 2.23 D(calc.) = 2.26 (synthetic). Soluble in H_2O, yielding an alkaline solution.

Optical Properties: Transparent. *Color:* Colorless, white to greenish white; colorless in transmitted light. *Luster:* Pearly on cleavages.
Optical Class: Uniaxial (–). $\omega = 1.575$ $\epsilon = 1.547$

Cell Data: *Space Group:* $P\overline{3}m1$ (synthetic). $a = 3.589(8)$ $c = 4.911(14)$ $Z = 1$

X-ray Powder Pattern: Synthetic.
2.628 (100), 4.90 (74), 1.927 (42), 1.796 (36), 3.112 (23), 1.687 (21), 1.484 (13)

Chemistry: Analyses of natural material appear not to have been made.

Occurrence: An alteration product of calcium silicates in larnite-spurrite contact metamorphic rocks (Scawt Hill, Ireland); in fumaroles (Vesuvius, Italy); as a precipitate from alkaline springs derived from ultramafic rocks (Jebel Awq, Oman); in burning coal measures (Chelyabinsk coal basin, Russia); in sedimentary deposits metamorphosed at high-temperature and low-pressure by spontaneous combustion of bitumen (Hatrurim Formation, Israel; Maqarin area, Jordan).

Association: Afwillite, calcite, larnite, spurrite (Scawt Hill, Ireland); calcite, halite (Jebel Awq, Oman); calcite, brownmillerite, hydrocalumite, mayenite, ettringite (Eifel district, Germany).

Distribution: From Scawt Hill, Larne, Co. Antrim, Ireland. On Vesuvius, Campania, Italy. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. In the Chelyabinsk coal basin, Southern Ural Mountains, Russia. From the Hatrurim Formation, Israel. In the Maqarin area, north Jordan. From Jebel Awq, Northern Oman Mountains, Oman. Large crystals and masses in the Wessels mine, near Kuruman, Cape Province, South Africa. From Cerro de la Coronita, near Cuernavaca, Morelos, Mexico.

Name: For its relation to a principal hydrolysis product of Portland cement.

Type Material: The Natural History Museum, London, England, 1933,307.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 641–642. (2) Neal, C. and G. Stanger (1984) Calcium and magnesium hydroxide precipitation from alkaline groundwaters in Oman, and their significance to the process of serpentinization. Mineral. Mag., 48, 237–241. (3) von Bezing, K.L., R.D. Dixon, D. Pohl, and G. Cavallo (1991) The Kalahari manganese field: an update. Mineral. Record, 22, 279–297, esp. 289. (4) Desgranges, L., D. Grebille, G. Calvarin, G. Chevrier, N. Floquet, and J.-C. Niepce (1993) Hydrogen thermal motion in calcium hydroxide: $Ca(OH)_2$. Acta Cryst., 49, 812–817. (5) (1953) NBS Circ. 539, 1, 58.

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Posnjakite $Cu_4(SO_4)(OH)_6 \cdot H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* m. Tabular crystals, pseudohexagonal, to 3 mm; as rich crystalline coatings to massive films, granular.

Physical Properties: *Tenacity:* Brittle. Hardness = 1.5–3 D(meas.) = 3.32 D(calc.) = 3.35

Optical Properties: Semitransparent. *Color:* Blue to dark blue. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale blue to colorless; Y = blue to dark blue; Z = greenish blue to blue. *Absorption:* $Y \gg Z > X$. $\alpha = 1.625$ $\beta = 1.680$ $\gamma = 1.706$ 2V(meas.) = 57°

Cell Data: *Space Group:* Pm. $a = 10.578(5)$ $b = 6.345(3)$ $c = 7.863(3)$ $\beta = 117.98(5)°$ Z = 2

X-ray Powder Pattern: Nura-Taldy deposits, Kazakhstan.
7.0 (10), 3.46 (8), 2.70 (7), 2.61 (7), 2.41 (7), 2.015 (7), 1.538 (7)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	17.25	17.02	MgO	0.05	
Fe_2O_3	0.38		CaO	0.34	
CuO	65.53	67.66	H_2O	16.70	15.32
			Total	100.25	100.00

(1) Festival deposit, Siberia, Russia; corresponds to $(Cu_{3.90}Fe^{3+}_{0.03})_{\Sigma=3.93}(S_{1.03}O_4)(OH)_6 \cdot 1.5H_2O$.
(2) $Cu_4(SO_4)(OH)_6 \cdot H_2O$.

Occurrence: A secondary mineral formed in the oxidized zone of copper-bearing hydrothermal mineral deposits, commonly of post-mine origin; may occur in slags.

Association: Brochantite, langite, devilline, serpierite, woodwardite, wroewolfeite, aurichalcite, azurite, malachite, chalcopyrite.

Distribution: Numerous minor localities. From the Nura-Taldy tungsten deposits, central Kazakhstan. In England, fine examples from Cornwall, as at the Drakewalls mine, Gunnislake, and the Fowey Consols mine, Tywardreath. Large crystals in the Penrhiw mine, Ystumtuen, Dyfed, Wales. At the Muckross mine, Co. Kerry, Ireland. In France, in the Salsigne mine, 15 km north of Carcassone, Aude. At Mitterberg, Salzburg, and Brixlegg, Tirol, Austria. From Špania Dolina (Herrengrund), Slovakia. In the USA, in the Yellow Pine mine, Crisman, Boulder Co., Colorado, and at the Majuba Hill mine, Antelope district, Pershing Co., Nevada. In Canada, from the Ives mine, near Eastman, Quebec, and in the Rocher Deboule mine, near Hazelton, British Columbia. From the Marharahara copper mine, near Woodville, New Zealand. At Tsumeb, Namibia.

Name: To honor Eugene Valdemar Posnjak (1888–1949), Geophysical Laboratory, Washington, D.C., USA, who investigated the $CuO-SO_3-H_2O$ system.

Type Material: Mining Institute, St. Petersburg, Russia, 1386/1.

References: (1) Komkov, A.I. and E.I. Nefedov (1967) Posnjakite – a new mineral. Zap. Vses. Mineral. Obshch., 96, 58–62 (in Russian). (2) (1967) Amer. Mineral., 52, 1582–1583 (abs. ref. 1). (3) Mellini, M. and S. Merlino (1979) Posnjakite $^2_\infty[Cu_4(OH)_6(H_2O)O]$ octahedral sheets in its structure. Zeits. Krist., 149, 249–257. (4) Yakhontova, L.K., V.P. Postnikova, Y.V. Vlasova, and N.Y. Sergeyeva (1981) New data on posnjakite, serpierite, and woodwardite. Doklady Acad. Nauk SSSR, 256, 1221-1225 (in Russian).

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Postite $Mg(H_2O)_6Al_2(OH)_2(H_2O)_8(V_{10}O_{28})\cdot 13H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m.* As needle-like prisms with pyramidal terminations, to 1 mm; typically in divergent and "jackstraw" masses.

Physical Properties: *Cleavage*: Perfect ‖ [001] likely on {100} and {010}, good on {001}. *Fracture*: Splintery. *Tenacity*: Brittle. Hardness = 2 D(meas.) = n.d. D(calc.) = 2.226

Optical Properties: Transparent. *Color*: Golden yellow. *Streak*: Yellow.
Luster: Subadamantine.
Optical Class: Biaxial (+). α = 1.727(3) β = 1.733(3), γ = 1.745(3) 2V(calc.) = 71°
Orientation: $X = c$, $Y = b$, $Z = a$.

Cell Data: *Space Group*: *Pccn*. a = 16.3357(6) b = 24.2434(17) c = 11.7343(4) Z = 4

X-ray Powder Pattern: San Juan County, Utah, USA.
8.937 (100), 12.190 (90), 3.771 (24), 8.248 (22), 2.9831 (19), 1.9907 (17), 6.801 (14)

Chemistry:

	(1)
Na_2O	0.15
K_2O	0.03
MgO	3.04
CaO	0.16
SrO	0.10
Al_2O_3	7.71
V_2O_5	71.00
H_2O	17.81
Total	100.00

(1) San Juan County, Utah, USA; average of 10 electron microprobe analyses, partially dehydrated crystals, H_2O calculated from stoichiometry; corresponding to $(Mg_{0.97}Na_{0.06}Ca_{0.04}Sr_{0.01}K_{0.01})_{\Sigma=1.09}$ $Al_{1.94}[(OH)_{1.92}(H_2O)_{0.08}]_{\Sigma=2.00}(V_{10}O_{28})\cdot 27H_2O$.

Mineral Group: Pascolite family.

Occurrence: From the oxidation of montroseite-corvusite assemblages in a moist environment in Colorado-type sandstone-hosted uranium deposits.

Association: Corvusite, montroseite.

Distribution: From the Vanadium Queen mine, La Sal Creek Canyon, and the Blue Cap mine, Lyon Canyon Creek, San Juan County, Utah, USA.

Name: Honors Jeffrey E. Post (b. 1954), Curator-in-Charge of the National Gem and Mineral Collection, U.S. National Museum of Natural History (Smithsonian Institution), for his contributions to mineralogy, crystallography and geochemistry, and particularly to the scientific understanding of manganese oxide minerals.

Type Material: Natural History Museum of Los Angeles County, Los Angeles, California, USA (# 63564 -Vanadium Queen mine, # 63563 - Blue Cap mine).

References: (1) Kampf, A.R., J.M. Hughes, J. Marty, and B. Nash (2012) Postite, $Mg(H_2O)_6Al_2(OH)_2(H_2O)_8(V_{10}O_{28})\cdot 13H_2O$, a new mineral species from the La Sal mining district, Utah: crystal structure and descriptive mineralogy. Can. Mineral., 50(1), 45-53. (2) (2014) Amer. Mineral., 99, 2156-2157 (abs. ref. 1).

Potarite PdHg

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As small grains or nuggets, up to 1 cm, exhibiting octahedral points and having indistinct, slightly divergent columnar or fibrous structure.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5 VHN = 126–137 (100 g load) on granula material. D(meas.) = 14.88 D(calc.) = 15.09

Optical Properties: Opaque. *Color:* Silver-white; in polished section, cream to creamish white. *Streak:* Silver-white. *Luster:* Metallic, bright. *Anisotropism:* Noted on inclusions in the fine-granular, apparently isotropic principal component; brown with an orange tinge.
R_1–R_2: (400) 41.6–41.6, (420) 42.5–43.5, (440) 43.8–45.2, (460) 45.7–47.0, (480) 47.8–48.8, (500) 49.4–50.4, (520) 50.9–52.0, (540) 52.2–53.2, (560) 53.4–54.4, (580) 54.4–55.4, (600) 55.4–56.4, (620) 56.3–57.3, (640) 57.2–58.4, (660) 58.2–59.5, (680) 59.2–60.7, (700) 60.2–62.1

Cell Data: *Space Group:* $P4/mmm$. $a = 3.026$ $c = 3.702$ $Z = 1$

X-ray Powder Pattern: Potaro River area, Guyana.
2.33 (100), 1.269 (70), 0.849 (50), 0.818 (50), 1.395 (40), 0.957 (20), 0.924 (20)

Chemistry:

	(1)	(2)	(3)
Pd	34.5	33.2	34.66
Hg	64.3	67.0	65.34
Cu	0.5	0.1	
Total	99.3	100.3	100.00

(1) Potaro River area, Guyana; by electron microprobe. (2) Do.; by electron microprobe (2) PdHg.

Occurrence: In chromitite and dunite ultramafics; in placers for gold and diamonds.

Association: Platinum, palladium, gold, Pd–Hg compounds; pentlandite, chalcopyrite, pyrrhotite, millerite.

Distribution: In Guyana, in placers in the Kangaruma district, Potaro River area, and at Amu Creek, Essequibo River. From Morro de Pilar, and in placers in the Bom Succeso Stream, northwest of Serro, Minas Gerais, Brazil. From Fox Gulch, Goodnews Bay, Alaska, and in the Boss mine, Goodsprings district, Clark Co., Nevada, USA. In the Starchrome chromitite, Thetford Mines ophiolite, Quebec, Canada. From the Kytlym and Uktus complexes, Ural Montains, Russia. At the Herbeira ultramafic massif, Cabo Ortegal, [notinColombiaG]??, Spain. From the Brancaga massif, northern Portugal. On the Island of Zabargad (Zabirget or St. Johns), in the Red Sea, Egypt. At the Copper Hills prospect, East Pilbara region, and in the Munni Munni layered intrusive, West Pilbara region, Western Australia. From the Inazumi-yama ultramafic complex, Honshu, Japan. A few additional occurrences have been noted.

Name: For the locality on the Potaro River, Guyana.

Type Material: The Natural History Museum, London, England, 1924,192, E238; National Museum of Natural History, Washington, D.C., USA, 95350.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 105. (2) Terada, K. and F.W. Cagle, Jr. (1960) The crystal structure of potarite (PdHg) with some comments on allopalladium. Amer. Mineral., 45, 1093–1097. (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 131, 156. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 449.

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Potassium alum $KAl(SO_4)_2 \cdot 12H_2O$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Rarely as tiny octahedra, which may be strung along fibers; stalactitic, columnar, mealy or granular, massive efflorescences. *Twinning:* Very rare on {111}.

Physical Properties: *Cleavage:* On {111}, interrupted. *Fracture:* Conchoidal.
Hardness = 2–2.5 D(meas.) = 1.757 D(calc.) = 1.754 Soluble in H_2O, taste sweetish and astringent; deliquesces at 91° C.

Optical Properties: Transparent. *Color:* Colorless, white; colorless in transmitted light.
Luster: Vitreous.
Optical Class: Isotropic; may be weakly anomalously birefringent and sectored. $n = 1.456$

Cell Data: *Space Group:* $Pa3$. $a = 12.157(3)$ Z = 4

X-ray Powder Pattern: Synthetic.
4.293 (100), 3.250 (55), 4.053 (45), 5.44 (40), 2.789 (35), 3.039(25), 4.96 (20)

Chemistry:

	(1)	(2)
SO_3	34.00	33.75
Al_2O_3	10.40	10.75
Fe_2O_3	0.80	
Na_2O	1.35	
K_2O	5.75	9.93
$(NH_4)_2O$	2.42	
H_2O	45.37	45.57
rem.	0.77	
Total	100.86	100.00

(1) Vesuvius, Italy; remnant Cr_2O_3 0.16%, Mn_2O_3 0.01%, CaO 0.36%, Cl 0.24%.
(2) $KAl(SO_4)_2 \cdot 12H_2O$.

Occurrence: Formed from argillaceous rocks or coal containing oxidizing pyrite or marcasite; may be a fumarolic or solfataric precipitate.

Association: Alunogen, pickeringite, epsomite, melanterite, gypsum, sulfur.

Distribution: In Italy, on Vesuvius, from the Grotta della Zolfo and at Cap Miseno, near Naples, Campania; in the Cetine mine, 20 km southwest of Siena, Tuscany; from the Grotte de Faraglione and along the Baia de Levante, Vulcano, Lipari Islands. In Germany, from Duttweiler, near Saarbrücken, Saarland, and at Arzberg, Fichtelgebirge, Bavaria. From Chuquicamata, Antofagasta, Chile. In the USA, in California, at the Sulfur Bank cinnabar mine, Lake Co., The Geysers, Sonoma Co., and the Nortonville coal mine, Contra Costa Co.; at Silver Peak, Esmeralda Co., Nevada; from Alum Cave Bluff, Sevier Co., Tennessee. Noted in a number of caves, as at the Mbobo Mkulu Cave, near Ngodwana, Eastern Transvaal, South Africa. In the Feengrotten, near Saalfeld, Thuringia, and the Alaunhöhle, near Dresden, Saxony, Germany.

Name: For its content of *potassium* and as an *alum*, *alumen*, Pliny, part.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 471–473 [potash alum]. (2) Larsen, A.C. and D.T. Cromer (1967) Refinement of the alum structures. III. X-ray study of the α alums, K, Rb and $NH_4Al(SO_4)_2.12H_2O$. Acta Cryst., 22, 793–800. (3) (1966) NBS Circ. 539, 6.

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Potosíite $\mathbf{Pb_6Sn_2^{4+}Fe^{2+}Sb_2^{5+}S_{16}}$

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Crystal Data: Triclinic, pseudotetragonal or pseudohexagonal. *Point Group:* 1 or $\overline{1}$. As tabular crystals to 3 cm; may be in felted masses. *Cleavage:* Perfect ‖ (001); less perfect ‖ (010).

Physical Properties: Hardness = n.d. VHN = 71.7 (50 g load); 94–115 (100 g load). D(meas.) = n.d. D(calc.) = 6.20

Optical Properties: Opaque. *Color:* White in reflected light. *Luster:* Metallic. *Pleochroism:* Faint, from bluish gray to yellowish gray. *Anisotropism:* Moderate, bluish gray to grayish pale yellow.
R_1–R_2: (400) 38.0–38.9, (420) 37.5–38.5, (440) 37.3–38.2, (460) 37.0–38.0, (480) 36.6–37.7, (500) 36.2–37.4, (520) 35.8–37.1, (540) 35.2–36.7, (560) 34.7–36.3, (580) 34.3–36.0, (600) 33.9–35.7, (620) 33.5–35.5, (640) 33.1–35.3, (660) 32.7–35.0, (680) 32.2–34.7, (700) 31.8–34.4

Cell Data: *Space Group:* $P1$ or $P\overline{1}$, with two incommensurate cells, one pseudotetragonal with: $a = 5.915(10)$ $b = 5.938(13)$ $c = 17.239(17)$ $\alpha = 91.63(28)°$ $\beta = 91.02(25)°$ $\gamma = 90.84(21)°$ and the other pseudohexagonal with: $a = 6.253(7)$ $b = 3.734(5)$ $c = 17.229(19)$ $\alpha = 90.80(19)°$ $\beta = 91.71(16)°$ $\gamma = 90.18(14)°$ Z = n.d.

X-ray Powder Pattern: Andacaba deposit, Bolivia.
2.876 (100), 3.45 (90), 4.32 (30), 2.936 (10), 2.067 (10), 2.159 (9), 1.920 (8)

Chemistry:

	(1)	(2)	(3)
Pb	55.23	55.3	55.78
Ag	0.21	0.3	
Sn	11.57	10.7	10.65
In		0.5	
Fe	2.32	2.4	2.51
Sb	10.58	10.6	10.92
S	19.80	20.4	20.14
Total	99.71	100.2	100.00

(1) Andacaba deposit, Bolivia; by electron microprobe, average of seven analyses; corresponding to $(Pb_{6.00}Ag_{0.04})_{\Sigma=6.04}Sn_{2.20}Fe_{0.94}Sb_{1.96}S_{13.91}$. (2) Herb claim, Canada; by electron microprobe, average of six analyses; corresponding to $(Pb_{5.91}Ag_{0.07}In_{0.09})_{\Sigma=6.07}Sn_{1.99}Fe_{0.95}Sb_{1.93}S_{14.07}$. (3) $Pb_6Sn_2FeSb_2S_{14}$.

Occurrence: On layered sulfide ore in a complex xenothermal-type hydrothermal tin deposit associated with subvolcanic granitic intrusive bodies (Andacaba deposit, Bolivia); in hydrothermal veins cutting rhyolite intrusions into highly kaolinized granite (Herb claim, Canada).

Association: Galena, sphalerite, semseyite, cerussite, cassiterite, quartz (Andacaba deposit, Bolivia); galena, pyrite, sphalerite, arsenopyrite, quartz (Herb claim, Canada); arsenopyrite, pyrrhotite, stannite, jamesonite, pyrite, sphalerite, kutnahorite, quartz (Hoei mine, Japan).

Distribution: In the Andacaba deposit, Potosí, Bolivia [TL]. From the Herb claim, Turnagain River area, Cassiar district, British Columbia, Canada. Large crystals from the the Hoei tin mine, Oita Prefecture, Japan.

Name: For the type locality in Potosí, Bolivia.

Type Material: Mining Academy, Freiberg, Germany, 67345.

References: (1) Wolf, M., H.-J. Hunger, and K. Bewilogua (1981) Potosiite, ein neues Mineral der Kylindrite-Franckeite-Gruppe. Freiberger Forschungshefte, 364, 113–133 (in German). (2) (1983) Amer. Mineral., 68, 1249–1250 (abs. ref. 1). (3) Kissin, S.A. and D.R. Owens (1986) The properties and modulated structure of potosiite from the Cassiar district, British Columbia. Can. Mineral., 24, 45–50. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 450.

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Pottsite $HPbBi(VO_4)_2 \cdot 2H_2O$

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Crystal Data: Tetragonal. *Point Group:* 422. Crystals are prismatic or dipyramidal, showing dominant {101}, with {110}, {103}, {211}, to 1 mm; typically in druses.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = ~7.0 D(calc.) = 7.31

Optical Properties: Semitransparent. *Color:* Bright yellow. *Streak:* Very pale yellow. *Luster:* Adamantine.
Optical Class: Uniaxial (–). $\omega = 2.40$ (Li) $\epsilon = 2.30$ (Li)

Cell Data: *Space Group:* $I4_122$. $a = 11.084$ $c = 12.634$ $Z = 10$

X-ray Powder Pattern: Near Potts, Nevada. USA.
3.062 (10), 4.618 (9), 3.210 (4), 2.476 (4), 4.168 (3), 2.252 (3), 2.184 (3)

Chemistry:

	(1)	(2)
V_2O_5	26.6	26.63
Bi_2O_3	34.0	34.11
PbO	32.4	32.67
H_2O	6.71	6.59
Total	99.7	100.00

(1) Near Potts, Nevada, USA; by electron microprobe, average of three analyses, H_2O on a separate sample by the Penfield method; corresponds to $H_{1.02}Pb_{0.99}Bi_{1.00}(VO_4)_{1.99} \cdot 2H_2O$.
(2) $HPbBi(VO_4)_2 \cdot 2H_2O$.

Occurrence: Found in the oxidation zone of a tungsten-bearing tactite.

Association: Scheelite, junoite, bismutite, clinobisvanite, duhamelite, cerussite, vanadinite.

Distribution: Found at the Linka mine, Spencer Hot Springs district, Lander Co., about 30 km northwest of Potts, and northeast of Chalk Mountain, Clan Alpine Mountains, Churchill Co., Nevada, USA.

Name: For Potts, Nevada, USA, nearby the type locality.

Type Material: The Natural History Museum, London, England.

References: (1) Williams, S.A. (1988) Pottsite, a new vanadate from Lander Co., Nevada. Mineral. Mag., 52, 389–390. (2) (1989) Amer. Mineral., 74, 503 (abs. ref. 1).

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Poubaite $PbBi_2Se_2(Te,S)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. In euhedral to subhedral lathlike crystals, to 80 μm.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. VHN = 74–122, 99 average (25 g load). D(meas.) = n.d. D(calc.) = 7.85

Optical Properties: Opaque. *Color:* In polished section, creamy white. *Luster:* Metallic. *Pleochroism:* Maximum parallel to elongation, creamy. *Anisotropism:* Strong, in pale grayish blue.

R_1–R_2: (400) — , (420) 46.0–50.3, (440) 46.6–51.4, (460) 47.2–52.2, (480) 47.6–52.7, (500) 48.0–53.0, (520) 48.3–53.2, (540) 48.5–53.3, (560) 48.6–53.3, (580) 48.8–53.3, (600) 48.8–53.3, (620) 48.9–53.2, (640) 49.0–53.2, (660) 49.0–53.1, (680) 49.1–53.1, (700) 49.1–53.0

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.252$ $c = 40.095$ $Z = 3$

X-ray Powder Pattern: Oldřichov, Czech Republic.
3.093 (100), 2.127 (80), 2.251 (70b), 1.752 (60), 1.352 (60), 4.048 (50), 2.727 (50)

Chemistry:

	(1)	(2)
Pb	22.95	18.74
Bi	40.29	42.58
Cu	0.61	0.00
Se	15.48	13.90
Te	17.47	23.15
S	2.10	1.08
Total	98.90	99.45

(1) Oldřichov, Czech Republic; by electron microprobe, corresponding to $Pb_{1.09}Cu_{0.09}Bi_{1.90}Se_{1.93}(Te_{1.35}S_{0.64})_{\Sigma=1.99}$. (2) Otish Mountains deposit, Canada; by electron microprobe, average of six analyses; corresponding to $Pb_{0.92}Bi_{2.08}Se_{1.80}(Te_{1.85}S_{0.34})_{\Sigma=2.19}$.

Occurrence: In hydrothermal dolomite-calcite-quartz veins in the western contact of the Bor granite massif with gneisses and amphibolites, associated with a selenide-sulfide-telluride aggregate and uraninite (Oldřichov, Czech Republic); in a vein-type uranium deposit with other tellurides and selenides (Otish Mountains deposit, Canada).

Association: Selenian rucklidgeite, several incompletely characterized new species (Oldřichov, Czech Republic); součekite, wittichenite (Otish Mountains deposit, Canada).

Distribution: From Oldřichov, near Tachov, Czech Republic [TL]. In the Otish Mountains uranium deposit, Elliot Lake district, Quebec, Canada.

Name: For Professor Zdenek Pouba (1902–1971), economic geologist, Charles University, Prague, Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 21241; National School of Mines, Paris, France.

References: (1) Čech, F. and I. Vavřín (1978) Poubaite, $PbBi_2(Se,Te,S)_4$, a new mineral. Neues Jahrb. Mineral., Monatsh., 9–19. (2) (1978) Amer. Mineral., 63, 1283 (abs. ref. 1). (3) Johan, Z., P. Picot, and F. Ruhlmann (1987) The ore mineralogy of the Otish Mountains uranium deposit, Quebec: skippenite, Bi_2Se_2Te, and watkinsonite, $Cu_2PbBi_4(Se,S)_8$, two new mineral species. Can. Mineral., 25, 625–638.

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Poudretteite $KNa_2B_3Si_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As roughly equant, barrel-shaped prismatic crystals, deeply etched, to 5 mm.

Physical Properties: *Fracture:* Splintery to conchoidal. *Tenacity:* Brittle. Hardness = ~5
D(meas.) = 2.51(1) D(calc.) = 2.53

Optical Properties: Transparent. *Color:* Colorless to very pale pink. *Streak:* White.
Luster: Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.516(1)$ $\epsilon = 1.532(1)$

Cell Data: *Space Group:* $P6/mcc$. $a = 10.239(1)$ $c = 13.484(3)$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
5.13 (100), 3.253 (100), 2.815 (60), 2.686 (50), 2.956 (40), 1.818 (40), 6.74 (30)

Chemistry:

	(1)
SiO_2	77.7
B_2O_3	11.4
BeO	0.0
Li_2O	0.0
Na_2O	6.2
K_2O	5.2
Total	100.5

(1) Mont Saint-Hilaire, Canada; by electron microprobe; corresponds to $K_{1.00}(Na_{1.87}K_{0.04})_{\Sigma=1.91}B_{3.05}Si_{12.14}O_{30}$.

Mineral Group: Milarite group.

Occurrence: In marble xenoliths within nepheline syenite breccias in an intrusive alkalic gabbro-syenite complex.

Association: Pectolite, apophyllite, aegirine.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: Honors the Poudrette family, operators of the quarry where type material was discovered.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 51743 and 51791; National Museum of Natural History, Washington, D.C., USA, 163776.

References: (1) Grice, J.D., T.S. Ercit, J. Van Velthuizen, and P.J. Dunn (1987) Poudretteite, $KNa_2B_3Si_{12}O_{30}$, a new member of the osumilite group from Mont Saint-Hilaire, Quebec, and its crystal structure. Can. Mineral., 25, 763–766. (2) (1988) Amer. Mineral., 73, 1497 (abs. ref. 1).

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Poughite $Fe_2^{3+}(Te^{4+}O_3)_2(SO_4)\cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are diamond-shaped, flattened parallel to {010}, showing {010}, {101}, {011}, {120}, {100}; in small botryoidal rosettes of crystals, typically in drusy crusts.

Physical Properties: *Cleavage:* On {010}, perfect; on {101}, good. Hardness = ∼2.5 D(meas.) = 3.758 D(calc.) = 3.775

Optical Properties: Semitransparent. *Color:* Dark yellow, honey-yellow, lemon-yellow, brownish yellow, greenish yellow.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless; Y = pale greenish yellow; Z = pale yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, strong. *Absorption:* $X < Y < Z$. $\alpha = 1.72(1)$ $\beta = 1.985(1)$ $\gamma = 1.990(1)$ 2V(meas.) = 15°–20°

Cell Data: *Space Group:* $P2_1nb$. $a = 9.66(2)$ $b = 14.20(2)$ $c = 7.86(2)$ Z = 4

X-ray Powder Pattern: Moctezuma mine, Mexico.
7.10 (10), 5.74 (10), 3.239 (7), 3.564 (6), 3.336 (6), 3.053 (6), 2.940 (5)

Chemistry: (1) The natural mineral was determined to be identical to the synthetic compound by correspondence of X-ray powder patterns.

Occurrence: An alteration product of pyrite in the oxidized zone of a hydrothermal Au–Te deposit (Moctezuma mine, Mexico).

Association: Pyrite, emmonsite, jarosite, "limonite", quartz (Moctezuma mine, Mexico); mandarinoite (El Plomo mine, Honduras).

Distribution: From the El Plomo mine, Ojojona district, Tegucigalpa, Honduras. At the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the USA, from the Lone Pine mine, Wilcox district, Catron Co., New Mexico; in the Klondike mine, Bonanza district, Saguache Co., Colorado. From the Tambo mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. At the Kobetsuzawa gold mine, Sapporo, Hokkaido Prefecture, Japan.

Name: To honor Dr. Frederick Harvey Pough (1906–), Reno, Nevada, USA, American mineralogist and gemmologist, for his numerous contributions to these sciences.

Type Material: Natural History Museum, Paris, France, 175.77; American Museum of Natural History, New York City, New York, 16832; Harvard University, Cambridge, Massachusetts, 109696; National Museum of Natural History, Washington, D.C., USA, 128388, 164338–164340.

References: (1) Gaines, R.V. (1968) Poughite, a new tellurite mineral from Mexico and Honduras. Amer. Mineral., 53, 1075–1080. (2) Pertlik, F. (1971) Die Kristallstruktur von Poughit, $Fe_2[TeO_3]_2[SO_4]\cdot 3H_2O$. Tschermaks Mineral. Petrog. Mitt., 15, 279–290 (in German with English abs.).

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Povondraite $NaFe_3^{3+}Fe_6^{3+}(BO_3)_3Si_6O_{18}(O,OH)_4$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Equant but distorted prisms, terminated by trigonal pyramids, in subparallel aggregates, to several mm.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = ~7 D(meas.) = 3.26(3) D(calc.) = 3.33

Optical Properties: Nearly opaque. *Color:* Black. *Streak:* Brown. *Luster:* Resinous, more or less splendent.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = yellow-brown, dark brown, brown-black; E = dark red-brown, light brown. ω = 1.800–1.820 ϵ = 1.743–1.751

Cell Data: *Space Group:* $R3m$. $a = 16.186(2)$ $c = 7.444(1)$ $Z = 3$

X-ray Powder Pattern: San Francisco mine, Bolivia.
2.63 (10), 6.63 (9), 4.05 (9), 3.05 (9), 3.61 (8), 5.13 (7), 4.71 (7)

Chemistry:

	(1)
SiO_2	30.7
TiO_2	0.0
B_2O_3	[9.0]
Al_2O_3	1.4
Fe_2O_3	45.0
V_2O_3	trace
FeO	1.7
MgO	6.5
K_2O	1.0
Na_2O	2.1
H_2O	[2.4]
Total	[99.8]

(1) San Francisco mine, Bolivia; by electron microprobe, Fe^{2+}:Fe^{3+} and B_2O_3 calculated from stoichiometry, H_2O from charge balance; corresponds to $(Na_{0.80}K_{0.26})_{\Sigma=1.06}(Fe^{3+}_{2.28}Mg_{0.53}Fe^{2+}_{0.27})_{\Sigma=3.08}(Fe^{3+}_{4.29}Mg_{1.36}Al_{0.32})_{\Sigma=5.97}(BO_3)_3Si_{5.96}O_{18}[(OH)_{3.12}O_{0.99}]_{\Sigma=4.00}$.

Mineral Group: Tourmaline group.

Occurrence: Very rare, in fractures and lining cavities in schist metamorphosed from sedimentary rocks.

Association: Quartz, potassic feldspar, muscovite, schorl, riebeckite, magnesite.

Distribution: In the San Francisco mine, near Villa Tunari, Alto Chapare, Cochabamba, Bolivia.

Name: For Dr. Pavel Povondra, Charles University, Prague, Czech Republic, in recognition of work on the chemistry of the tourmaline group.

Type Material: Royal Ontario Museum, Toronto, Canada, M35899; National Museum of Natural History, Washington, D.C., USA, 144478.

References: (1) Grice, J.D., T.S. Ercit, and F.C. Hawthorne (1993) Povondraite, a redefinition of the tourmaline ferridravite. Amer. Mineral., 78, 433–436. (2) Walenta, K. and P.J. Dunn (1979) Ferridravite, a new mineral of the tourmaline group from Bolivia. Amer. Mineral., 64, 945–948.

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Powellite $CaMoO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals are dipyramidal {111}, with {011}, {112}, less commonly flat tabular to paper-thin on {001}, with many minor forms, to 8 cm; may be aggregated into crusts, pulverulent, ocherous, massive.

Physical Properties: *Cleavage:* {112}, {011}, {001}, all indistinct. *Fracture:* Uneven. Hardness = 3.5–4 D(meas.) = 4.26 D(calc.) = 4.255 Fluoresces creamy white or yellow to golden yellow under SW UV.

Optical Properties: Transparent to translucent. *Color:* Straw-yellow, greenish yellow, yellow-brown, brown, colorless, may be zoned; blue to nearly black. *Luster:* Subadamantine, resinous, pearly.
Optical Class: Uniaxial (+). *Pleochroism:* In deeply colored specimens; O = blue; E = green. $\omega = 1.974$ $\epsilon = 1.984$

Cell Data: *Space Group:* $I4_1/a$ (synthetic). $a = 5.222(1)$ $c = 11.425(3)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.10 (100), 1.929 (30), 4.76 (25), 1.588 (20), 2.61 (16), 2.86 (14), 1.848 (14)

Chemistry:

	(1)	(2)
MoO_3	71.67	71.96
CuO	0.34	
CaO	28.11	28.04
rem.	0.34	
Total	100.46	100.00

(1) Western Altai, Russia; CuO probably from malachite. (2) $CaMoO_4$.

Polymorphism & Series: Forms a series with scheelite.

Occurrence: An uncommon secondary mineral, typically formed in the oxidation zone of molybdenum-bearing hydrothermal mineral deposits, rarely in basalts, tactites, and granite pegmatites.

Association: Molybdenite, ferrimolybdite, stilbite, laumontite, apophyllite.

Distribution: In the USA, from the Peacock Lode, Seven Devils district, Adams Co., Idaho; large crystals at the Isle Royale, Calumet & Hecla, Tamarack, and other mines, Houghton Co., Michigan; in the Pine Creek tungsten mine, near Bishop, Inyo Co., California; from the Tonopah-Divide mine, Divide district, Esmeralda Co., and many other places in Nevada. At Huepac, Sonora, Mexico. In Chile, from Chuquicamata, Antofagasta; at Inca de Oro and in the Las Escobas mine, near Copiapó, Atacama. From Ultevis, Lappland, Sweden. At Traprain Law, near Haddington, East Lothian, Scotland. Extraordinary crystals from Pandulena Hill, eight km south of Nasik, Maharashtra, India. At Tsumeb, Namibia. There are a number of other older localities known, most now considered quite minor.

Name: Honors Major John Wesley Powell (1834–1902), American geologist and explorer, and Director of the U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 80674.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1079–1081. (2) Hazen, R.M., L.W. Finger, and J.W.E. Mariathasan (1985) High-pressure crystal chemistry of scheelite-type tungstates and molybdates. J. Phys. Chem. Solids, 46, 253–263. (3) (1956) NBS Circ. 539, 6, 22.

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Poyarkovite Hg_3ClO

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. Granular, porous to dense, to 1 mm. *Twinning:* Frequently observed under the microscope.

Physical Properties: *Fracture:* Irregular to conchoidal. *Tenacity:* Very brittle. Hardness = 2–2.5 VHN = 173–201, 188 average (20 g load). D(meas.) = 9.80 (dense granular). D(calc.) = 9.88

Optical Properties: Translucent. *Color:* Deep raspberry-red to cherry-red, turns black on exposure; deep red or brownish red in transmitted light; white in reflected light. *Streak:* Red. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial. *Pleochroism:* Slight. $n = > 2.0$ 2V(meas.) = n.d.
Anisotropism: Strong; azure to blue.
R_1–R_2: (440) 25.0–31.0, (460) 24.5–31.0, (480) 22.5–31.0, (500) 22.5–30.0, (520) 22.2–29.2, (540) 22.0–28.4, (560) 21.6–27.2, (580) 20.9–25.5, (600) 20.0–23.5, (620) 18.5–22.1, (640) 17.0–20.7

Cell Data: *Space Group:* $C2/m$, $C2/c$, Cm, Cc, or $C2$. $a = 18.82$ $b = 9.02$ $c = 16.79$ $\beta = 112°24'$ $Z = 24$

X-ray Powder Pattern: Khaydarkan, Kyrgyzstan.
2.83 (10), 2.74 (8), 1.799 (6.5), 2.60 (6), 3.09 (5), 2.96 (4), 1.883 (4)

Chemistry:

	(1)	(2)
Hg	91.30	92.12
O	2.36	2.45
Cl	5.30	5.43
Total	98.96	100.00

(1) Khaydarkan, Kyrgyzstan; by electron microprobe, average of ten analyses; corresponds to $Hg_{3.03}Cl_{1.00}O_{0.99}$. (2) Hg_3ClO.

Occurrence: In an oxidized mercury deposit.

Association: Eglestonite, calomel, terlinguaite, montroydite, kuznetsovite, shakhovite, chursinite, corderoite, mercury, cinnabar, livingstonite.

Distribution: In the Khaydarkan mercury deposit, Fergana Valley, Alai Range, south Kyrgyzstan.

Name: Honors Vladimir Erastovich Poyarkov (1907–1975), Institute of Mineral Resources, Alma-Ata, Kyrgyzstan, investigator of mercury deposits, one of the first discoverers of the Khaydarkan deposit.

Type Material: Central Siberian Geological Museum, Siberian Division, Academy of Sciences, Novosibirsk, Russia.

References: (1) Vasil'ev, V.I., Y.G. Lavrent'ev, and N.A. Pal'chik (1981) Poyarkovite – Hg_3ClO –a new natural mercury oxyhalide. Zap. Vses. Mineral. Obshch., 110, 501–506 (in Russian). (2) (1982) Amer. Mineral., 67, 860 (abs. ref. 1). (3) (1982) Mineral. Abs., 33, 170 (abs. ref. 1).

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Prehnite $Ca_2Al_2Si_3O_{10}(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Uncommon as crystals, tabular ‖ {001} or prismatic to steep pyramidal, to 4.5 cm. Aggregates are fanlike, reniform, globular, stalactitic; granular, compact. *Twinning:* Fine lamellar.

Physical Properties: *Cleavage:* Good on {001}, poor on {110}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 2.80–2.95. D(calc.) = [2.90]

Optical Properties: Semitransparent to translucent. *Color:* Light to dark green, white, yellow, gray, pink; colorless in thin section. *Streak:* White. *Luster:* Vitreous, weak pearly on {001}. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.611–1.632$ $\beta = 1.615–1.642$ $\gamma = 1.632–1.665$ 2V(meas.) = 65°–69°

Cell Data: *Space Group:* $P2cm$. $a = 4.646(2)$ $b = 5.491(3)$ $c = 18.52(3)$ Z = 2

X-ray Powder Pattern: Ashcroft, British Columbia, Canada.
3.08 (100), 2.55 (100), 3.48 (90), 1.77 (70), 3.28 (60), 2.37 (40), 2.31 (40)

Chemistry:

	(1)	(2)
SiO_2	41.67	43.71
TiO_2	0.12	
Al_2O_3	24.44	24.72
Fe_2O_3	1.03	
FeO	0.32	
MgO	0.25	
CaO	27.25	27.20
Na_2O	0.18	
K_2O	0.18	
H_2O^+	4.44	4.37
Total	99.88	100.00

(1) Ashcroft, British Columbia, Canada. (2) $Ca_2Al_2Si_3O_{10}(OH)_2$.

Occurrence: A secondary or hydrothermal mineral in veins and cavities in mafic volcanic rocks; less commonly in granite gneiss or syenite; a typical product of low-grade metamorphism.

Association: Zeolites, datolite, pectolite, calcite, epidote, copper.

Distribution: Numerous localities worldwide; some for the best crystals or rich material follow. At the Cape of Good Hope, Cape Province, South Africa. From Copper Valley, Brandberg Mountains, Namibia. In France, from La Combe-de-la-Selle, near Bourg d'Oisans, Isère. From Habachtal, Salzburg, and Ankogel, Austria. At Radauthal, near Harzburg, Harz Mountains, Germany. From near Campitello, Val di Fassa, Trentino-Alto Adige, Italy. At Comperio, Graubünden, and St. Gotthard, Ticino, Switzerland. In the USA, from Paterson, Passaic Co., and Bergen Hill, Hudson Co., New Jersey; in the Fairfax quarry, Centreville, Fairfax Co., Virginia; in the Roncari quarry, East Granby, Hartford Co., Connecticut; in the Hampden quarry, West Springfield, Hampden Co., Massachusetts. Fine crystals in the Jeffrey mine, Asbestos, Quebec, Canada. From the Khandivali quarry, Bombay, Maharashtra, India. In Copper Valley, Brandberg Mountains, Namibia. Around Coonabarabran, Warrumbungle Ranges, and in the Emu quarry, Prospect Hill, near Sydney, New South Wales, Australia. From the Rennick Glacier, North Victoria Land, Antarctica.

Name: For Colonel Hendrik von Prehn (1733–1785), who discovered the mineral.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 530–532. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 263–266. (3) Nuffield, E.W. (1943) Prehnite from Ashcroft, British Columbia. Univ. Toronto Studies, Geol. Ser., 49. (4) Zunic, T.B., S. Scavnicar, and G. Molin (1990) Crystal structure of prehnite from Komiza. Eur. J. Mineral., 2, 731–734.

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Preisingerite $Bi_3O(AsO_4)_2(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are typically rounded, tabular {010}, rhomboidal in outline, displaying {100}, {$\overline{1}$11}, {$\overline{2}$10}, with several others, to 0.2 mm; generally in loose aggregates.

Physical Properties: *Cleavage:* One, indistinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4.5 D(meas.) = ∼6 D(calc.) = 7.24

Optical Properties: Translucent. *Color:* White to grayish white; colorless in transmitted light. *Streak:* White. *Luster:* Subadamantine to adamantine.
Optical Class: Biaxial (+). α = [2.130] (calculated from reflectivities). β = [2.16] γ = [2.195] 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.993(3)$ $b = 7.404(3)$ $c = 6.937(3)$ $\alpha = 87.82(2)°$ $\beta = 115.01(2)°$ $\gamma = 111.07(2)°$ Z = 2

X-ray Powder Pattern: San Francisco de los Andes, Argentina; very similar to petitjeanite and schumacherite.
3.281 (100), 3.263 (97), 3.194 (87), 3.091 (74), 3.016 (38), 4.524 (35), 1.967 (31)

Chemistry:

	(1)	(2)
P_2O_5	0.7	
As_2O_5	23.0	24.51
Bi_2O_3	75.8	74.53
PbO	0.5	
H_2O	1.1	0.96
Total	[101.1]	100.00

(1) San Francisco de los Andes, Argentina; by electron microprobe, elemental analysis here converted to oxides, H_2O by TGA. (2) $Bi_3O(AsO_4)_2(OH)$.

Polymorphism & Series: Forms series with petitjeanite and schumacherite.

Occurrence: A rare secondary mineral in the oxidized zone of some arsenic-bearing hydrothermal mineral deposits.

Association: Rooseveltite, mixite, beudantite, bismuthite (Argentina); bismutostibiconite, atelestite, beyerite (Clara mine, Germany).

Distribution: From the San Francisco de los Andes and Cerro Negro de la Aguadita Bi–As–Cu deposits, San Juan Province, Argentina. At Tazna, Potosí, Bolivia. In Germany, from the Sauschwart mine, Schneeberg, and at Mühlleithen, Saxony; in the Black Forest, at the Clara mine, near Oberwolfach, from the Schmiedestollen, near Wittichen, in the Ödsbach Valley, near Oberkirch, and at Neubulach; from Reichenbach, near Bensheim, Hesse. In the Moldava fluorite mine, about 20 km northwest of Teplice, Krušné hory Mountains, and from near Smrkovec, Slavkovský Les Mountains, about 10 km north-northeast of Mariánské Lázně (Marienbad), Czech Republic. In the Mammoth mine, Tintic district, Juab Co., Utah, USA.

Name: To honor Anton Preisinger (1925–), Professor of Mineralogy, University of Technology, Vienna, Austria.

Type Material: Natural History Museum, Vienna, Austria, L7689.

References: (1) Bedlivy, D. and K. Mereiter (1982) Preisingerite, $Bi_3O(OH)(AsO_4)_2$, a new species from San Juan Province, Argentina: its description and crystal structure. Amer. Mineral., 67, 833–840. (2) Krause, W., K. Belendorff, and H.-J. Bernhardt (1993) Petitjeanite, $Bi_3O(OH)(PO_4)_2$, a new mineral, and additional data for the corresponding arsenate and vanadate, preisingerite and schumacherite. Neues Jahrb. Mineral., Monatsh., 487–503.

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Preiswerkite $Na(Mg_2Al)(Al_2Si_2)O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are platy, to 1 mm. *Twinning:* Common about [310].

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2.5 D(meas.) = 2.96 D(calc.) = 2.94

Optical Properties: Translucent. *Color:* Pale green; in thin section, colorless. *Optical Class:* Biaxial (–). $\alpha = 1.560(4)$ $\beta = 1.614(2)$ $\gamma = 1.615(2)$ 2V(meas.) = 5°–7°

Cell Data: *Space Group:* $C2/c$. $a = 5.228(7)$ $b = 9.049(10)$ $c = 9.819(12)$ $\beta = 100.41(13)°$ Z = 2

X-ray Powder Pattern: Geisspfad complex, Switzerland.
2.572 (100), 1.508 (100), 2.457 (70), 4.52 (60), 2.149 (60), 9.64 (50), 3.215 (50)

Chemistry:

	(1)
SiO_2	29.9
Al_2O_3	35.4
FeO	2.8
MgO	18.7
CaO	0.09
Na_2O	7.35
K_2O	0.19
H_2O	4.6
Total	99.03

(1) Geisspfad complex, Switzerland; by electron microprobe, H_2O determined separately on an impure concentrate; corresponds to $(Na_{0.98}K_{0.02}Ca_{0.01})_{\Sigma=1.01}(Mg_{1.91}Fe_{0.16})_{\Sigma=2.07}Al_{2.86}Si_{2.05}O_{10}(OH)_{2.10}$.

Polymorphism & Series: 1M, $2M_1$ polytypes.

Mineral Group: Mica group.

Occurrence: Formed in a rodingite dike during upper-greenschist to lower-amphibolite facies metamorphism (Geisspfad complex, Switzerland).

Association: Aluminian pargasite, zoisite (Geisspfad complex, Switzerland).

Distribution: In the Geisspfad ultramafic complex, Binntal, Valais, Switzerland. From Liset, Selje district, southwestern Norway.

Name: For H. Preiswerk (1876–1940), Professor in Basel, Switzerland.

Type Material: Natural History Museum, Bern, Switzerland, B2548; The Natural History Museum, London, England, 1982,455.

References: (1) Keusen, H.R. and T. Peters (1980) Preiswerkite, an Al-rich trioctahedral sodium mica from the Geisspfad ultramafic complex (Penninic Alps). Amer. Mineral., 65, 1134–1137. (2) Oberti, R., L. Ungaretti, A. Tlili, D.C. Smith, and J.-L. Robert (1993) The crystal structure of preiswerkite. Amer. Mineral., 78, 1290–1298.

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Preobrazhenskite $Mg_3B_{11}O_{15}(OH)_9$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 4 cm; in nodules and granular massive.

Physical Properties: Hardness = 4.5–5 D(meas.) = n.d. D(calc.) = 2.45

Optical Properties: Semitransparent. *Color:* Colorless, lemon-yellow, dark gray. *Optical Class:* Biaxial (+), nearly uniaxial (+). $\alpha = 1.570$ $\beta = 1.570$ $\gamma = 1.595$ 2V(meas.) = n.d.

Cell Data: *Space Group: Pbcm.* $a = 16.291(4)$ $b = 9.181(2)$ $c = 10.571(2)$ $Z = 4$

X-ray Powder Pattern: Inder deposit, Kazakhstan.
5.28 (10), 3.79 (10), 3.230 (9), 3.187 (9), 2.821 (9), 2.769 (9), 2.641 (9)

Chemistry:

	(1)	(2)
SiO_2	0.30	
B_2O_3	65.90	65.47
R_2O_3	0.17	
MgO	20.65	20.67
CaO	0.00	
H_2O^+	13.39	13.86
H_2O^-	0.16	
Total	100.57	100.00

(1) Inder deposit, Kazakhstan; after washing to remove soluble halides. (2) $Mg_3B_{11}O_{15}(OH)_9$.

Occurrence: In fine-grained halite–polyhalite rock.

Association: Inyoite, halite, polyhalite, kieserite, anhydrite, aksaite, boracite, ginorite, halurgite, strontioborite, metaborite, kaliborite.

Distribution: In Kazakhstan, in and under the Inder borate deposit, and from the Chalkar salt dome, Ak-saĭ Valley, Uralsk district.

Name: To honor Pavel Ivanovich Preobrazhenskii (1874–1944), investigator of Russian salt deposits, Institute of Halurgy, St. Petersburg, and Institute of Mining and Chemical Stock, Moscow, Russia, a discoverer of the Inder deposit, Kazakhstan.

Type Material: Mining Institute, St. Petersburg, 1497/1–2,5; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 57015.

References: (1) Yarzhemskii, Y.Y. (1956) Preobrazhenskite, a new borate from the salt strata of the Inder uplift. Doklady Acad. Nauk SSSR, 111, 1087–1090 (in Russian). (2) (1957) Amer. Mineral., 42, 704 (abs. ref. 1). (3) Ostrovskaya, I.V. and I.B. Nikitina (1969) The formula of preobrazhenskite. Tr. Mineral. Muz. Akad. Nauk SSSR, 19, 206–209 (in Russian). (4) (1970) Amer. Mineral., 55, 1071–1072 (abs. ref. 3). (5) Burns, P.C. and F.C. Hawthorne (1994) Structure and hydrogen bonding in preobrazhenskite, a complex heteropolyhedral borate. Can. Mineral., 32, 387–396. (6) Kondrat'eva, V. (1969) X-ray determination of borates, 153. (7) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 170.

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Pretulite $ScPO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Dipyramidal crystals, {211}, with small {100}, {111}, and as anhedral grains, to 200 μm.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = n.d. D(calc.) = 3.71 Weak orange fluorescence under SW UV; bright blue cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Pink to white. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (+). $\omega = 1.790(5)$ $\epsilon = 1.86(1)$

Cell Data: *Space Group:* $I4_1/amd$. a = 6.589 (1) $c = 5.806(1)$ Z = 4

X-ray Powder Pattern: Höllkogel, Austria.
3.293 (100), 2.4636 (42), 1.6470 (33), 1.6927 (30), 2.0546 (21), 2.1777 (20), 1.7432 (9)

Chemistry:

	(1)	(2)
P_2O_5	50.02	50.72
Sc_2O_3	47.38	49.28
Y_2O_3	1.45	
Total	98.85	100.00

(1) Höllkogel, Austria; by electron microprobe, average of 50 determinations on 8 grains; corresponds to $(Sc_{0.98}Y_{0.02})_{\Sigma=1.00}P_{1.00}O_{4.00}$. (2) $ScPO_4$.

Occurrence: Rare in lazulite-quartz veins in phyllite-mica schist.

Association: Lazulite, muscovite, clinochlore, fluorapatite, rutile, chlorapatite, paragonite, augelite, wardite, hydroxylherderite, goyazite, florencite-(Ce), xenotime-(Y), corundum, bearthite.

Distribution: In Austria, from the Höllkogel, 12 km south-southwest of Mürzzuschlag, at Fürstenbauer, and additional localities near the Pretulalpe, Styria.

Name: For the Pretulalpe, Austria, on which the species was first discovered.

Type Material: Landesmuseum Joanneum, Graz; Natural History Museum, Vienna, Austria.

References: (1) Bernhard, F., F. Walter, K. Ettinger, J. Taucher, and K. Mereiter (1998) Pretulite, $ScPO_4$, a new scandium mineral from the Styrian and Lower Austrian lazulite occurrences, Austria. Amer. Mineral., 83, 625–630.

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Priceite $Ca_2B_5O_7(OH)_5 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are platy with a rhombic outline, to 20 μm, aggregated in books; typically cryptocrystalline, nodular to massive.

Physical Properties: *Fracture:* Conchoidal to earthy. *Tenacity:* Tough to friable. Hardness = 3–3.5, if compact. D(meas.) = 2.42 D(calc.) = 2.427

Optical Properties: Semitransparent. *Color:* White, colorless in transmitted light. *Luster:* Porcelaneous to earthy.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, rather strong. $\alpha = 1.571$–1.575 $\beta = 1.590$–1.596 $\gamma = 1.591$–1.597 2V(meas.) = 32(2)° 2V(calc.) = 42°56′

Cell Data: *Space Group:* $P2_1/c$. $a = 11.623(1)$ $b = 6.976(1)$ $c = 12.350(1)$ $\beta = 110.70(1)°$ Z = 4

X-ray Powder Pattern: Death Valley, California, USA.
10.92 (10), 3.63 (10), 5.46 (8), 3.49 (7), 2.72 (6), 2.18 (5), 4.29 (4)

Chemistry:

	(1)	(2)
B_2O_3	49.90	49.84
CaO	32.06	32.11
H_2O	18.04	18.05
Total	[100.00]	100.00

(1) Death Valley, California, USA; average of three analyses, recalculated from an original average total of 99.57%. (2) $Ca_2B_5O_7(OH)_5 \cdot H_2O$.

Occurrence: Deposited from hot spring and solfataric deposits, also a component of borate-enriched evaporites; may be derived from colemanite.

Association: Colemanite, ulexite, gypsum, aragonite, calcite.

Distribution: In the USA, from eight km north of Chetco, Curry Co., Oregon; in California, from a number of occurrences around Death Valley, as the Monte Blanco area, in Corkscrew Wash, and the Furnace Creek district, Inyo Co. From the Penobsquis and Salt Springs evaporite deposits, near Sussex, New Brunswick, Canada. At Mesa del Almo, 13 km southeast of Magdalena, Sonora, Mexico. In Turkey, from the Sultançayir borate deposit, Bursa Province, and in several deposits in the Bigadiç borate district, Balıkesir Province. From the Inder borate deposit, Kazakhstan. At Meldon, Okehampton, Devon, England. From the Pöhla mine, Schwarzemberg, Saxony, Germany. At Radotin, Czech Republic.

Name: To honor Thomas Price (1837–?), metallurgist, San Francisco, California, USA, who provided the first chemical analyses of the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 341–343. (2) Kramer, H. and R.D. Allen (1956) A restudy of bakerite, priceite, and veatchite. Amer. Mineral., 41, 689–700. (3) Fleet, M.E. and S. Muthupari (2000) Boron K-edge XANES of borate and borosilicate minerals. Amer. Mineral., 85, 1009–1021. (4) Wallwork, K.S., A. Pring, M.R. Taylor, and B.A. Hunter (2002) The structure of priceite, a basic hydrated calcium borate, by *ab initio* powder-diffraction methods. Chem. Abs., 40, 1199–1206.

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Priderite $(K, Ba)(Ti, Fe^{3+})_8O_{16}$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Rectangular prismatic to tabular crystals, to 1 cm.

Physical Properties: *Cleavage:* {001}, perfect; another, perpendicular, fair. *Fracture:* Conchoidal. Hardness = n.d. VHN = 161 D(meas.) = 3.86(8) D(calc.) = 3.948 Weakly paramagnetic.

Optical Properties: Semitransparent. *Color:* Black; yellowish brown in thin section. *Streak:* Gray. *Luster:* Adamantine. *Optical Class:* Uniaxial (+). *Pleochroism:* O = deep reddish brown; E = deep reddish brown to black. $\omega = > 2.10$ ϵ = n.d.

Cell Data: *Space Group:* $I4/m$. $a = 10.139(2)$ $c = 2.9664(9)$ Z = 1

X-ray Powder Pattern: West Kimberley area, Australia. 3.19 (s), 7.13 (m), 5.04 (m), 2.470 (m), 1.887 (m), 1.585 (mw), 2.222 (w)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
TiO_2	70.6	74.75	72.00	BaO	6.7	7.54	15.00
Al_2O_3	2.3	0.05	0.60	SrO		0.00	
Fe_2O_3	12.4	11.57	11.40	Na_2O	0.6	0.27	0.40
MgO	0.0	1.44		K_2O	5.6	5.94	0.40
CaO	trace			Total	98.2	101.57	99.80

(1) West Kimberley area, Australia; corresponds to $(K_{0.87}Ba_{0.32}Na_{0.14})_{\Sigma=1.33}(Ti_{6.48}Fe^{3+}_{1.14}Al_{0.33})_{\Sigma=7.95}O_{16}$. (2) Do.; by electron microprobe, total Fe as Fe_2O_3; corresponding to $(K_{0.90}Ba_{0.35}Na_{0.06})_{\Sigma=1.31}(Ti_{6.68}Fe^{3+}_{1.03}Mg_{0.25}Al_{0.01})_{\Sigma=7.97}O_{16}$. (3) Kovdor massif, Russia; by electron microprobe, total Fe as Fe_2O_3; corresponds to $(Ba_{0.66}Na_{0.16}K_{0.11})_{\Sigma=0.93}(Ti_{6.05}Fe^{3+}_{1.90}Al_{0.16})_{\Sigma=8.11}O_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: In some ultrapotassic lamproites, ultramafics, and carbonatites.

Association: Leucite, potassian richterite, titanian phlogopite, jeppeite, shcherbakovite, wadeite, perovskite, apatite (West Kimberley area, Australia); potassian feldspar, phlogopite, potassian richterite, olivine, titanite, anatase, ilmenite, calcite (Corsica, France).

Distribution: From the Kimberley district, Western Australia, as in the Wolgidee Hills and the Argyle diamond mine. In the USA, from the Leucite Hills, Sweetwater Co., Wyoming; at Smoky Butte, Garfield Co., Montana; and in the Prairie Creek diatreme, near Murfreesboro, Pike Co., Arkansas. On the island of Corsica, France, near Sisco, north of Bastia. From the Sisimiut area, west Greenland. In the Kovdor and Khibiny massifs, Kola Peninsula, Russia.

Name: For Rex Tregilgas Prider (1910–), Professor of Geology, University of Western Australia, Perth, Australia, who provided the first pure sample of the species.

Type Material: University of Western Australia, Perth, Australia, 18760; The Natural History Museum, London, England.

References: (1) Norrish, K. (1951) Priderite, a new mineral from the leucite-lamproites of the west Kimberley area, Western Australia. Mineral. Mag., 29, 496–501. (2) (1951) Amer. Mineral., 36, 793 (abs. ref. 1). (3) Velde, D. (1968) A new occurrence of priderite. Mineral. Mag., 36, 867–870. (4) Zhuravleva, L.N., K.V. Yurkina, and E.G. Ryabeva (1978) Priderite – first find in the USSR. Doklady Acad. Nauk SSSR, 239, 435–438 (in Russian). (5) Post, J.E., R.B. Von Dreele, and P.R. Buseck (1982) Symmetry and cation displacements in hollandites: structure refinements of hollandite, cryptomelane, and priderite. Acta Cryst., 38, 1056–1065. (6) Birch, W.D. (1985) A note on large crystals of priderite, jeppeite, wadeite and other minerals from Walgidee [*sic*] Hills, Western Australia. Aust. Mineral., 1(50), 298–302.

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Pringleite $Ca_9B_{26}O_{34}Cl_4(OH)_{24}\cdot 13H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* 1. Subhedral to anhedral crystals, to 2 mm, in platy aggregates. *Twinning:* Rarely observed, simple twinning.

Physical Properties: *Cleavage:* On {110}, good. *Fracture:* Even to slightly conchoidal. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.22(1) D(calc.) = 2.11

Optical Properties: Transparent to translucent. *Color:* Colorless to very pale yellow; colorless in transmitted light; blue-gray in reflected light. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y \wedge a = 40°$; $Z \wedge b = 46°$. *Dispersion:* $r \ll v$, strong. $\alpha = 1.537(1)$ $\beta = 1.548(1)$ $\gamma = 1.570(1)$ 2V(meas.) = 77(1)° 2V(calc.) = 71.4°

Cell Data: *Space Group:* $P1$. $a = 12.746(2)$ $b = 13.019(3)$ $c = 9.693(2)$ $\alpha = 102.2(2)°$ $\beta = 102.1(2)°$ $\gamma = 85.6(1)°$ Z = 1

X-ray Powder Pattern: Potash Corporation of America mine, Penobsquis, Canada. 7.69 (100), 9.21 (70), 5.74 (60), 4.63 (40), 3.845 (35), 2.199 (30b), 2.058 (30)

Chemistry:

	(1)	(2)
B_2O_3	46.75	45.94
CaO	26.29	25.62
Cl	6.48	7.20
H_2O	[21.94]	22.86
$-O = Cl_2$	1.46	1.62
Total	[100.00]	100.00

(1) Potash Corporation of America mine, Penobsquis, Canada; by electron microprobe, average of five analyses, H_2O by difference; corresponds to $Ca_{9.27}B_{26.56}O_{34.98}Cl_{3.62}(OH)_{24.64}\cdot 11.76H_2O$. (2) $Ca_9B_{26}O_{34}Cl_4(OH)_{24}\cdot 13H_2O$.

Polymorphism & Series: Dimorphous with ruitenbergite.

Occurrence: Rare, in an evaporite deposit.

Association: Hilgardite-1A, halite, ruitenbergite, sylvite, anhydrite, quartz, clays.

Distribution: From the Potash Corporation of America mine, Penobsquis evaporite deposit, near Sussex, New Brunswick, Canada.

Name: To honor Gordon J. Pringle (1944–), mineralogist, Geological Survey of Canada, Ottawa, Canada.

Type Material: Geological Survey of Canada, Ottawa, 66920; Canadian Museum of Nature, Ottawa, Canada, 82047.

References: (1) Roberts, A.C., J.A.R. Sterling, J.D. Grice, P.C. Burns, B.V. Roulston, J.D. Curtis, and J.L. Jambor (1993) Pringleite and ruitenbergite, polymorphs of $Ca_9B_{26}O_{34}(OH)_{24}Cl_4\cdot 13H_2O$, two new mineral species from Sussex, New Brunswick. Can. Mineral., 31, 795–800. (2) (1995) Amer. Mineral., 80, 1011–1012 (abs. ref. 1). (3) Grice, J.D., P.C. Burns, and F.C. Hawthorne (1994) Determination of the megastructures of the borate polymorphs pringleite and ruitenbergite. Can. Mineral., 32, 1–14.

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Probertite $NaCaB_5O_7(OH)_4 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are acicular to elongated along [001], flattened on {100} or {110}, with {100}, {110}, {010}, {011}, with several other forms noted, to 5 cm; in rosettes or flat radial groups, fibrous.

Physical Properties: *Cleavage:* On {110}, perfect. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.135–2.141 D(calc.) = 2.132 Decomposes partially in hot H_2O.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, pale yellow. *Luster:* Vitreous, may be satiny.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 12°$–$13°$. *Dispersion:* $r > v$.
$\alpha = 1.514$–1.517 $\beta = 1.524$–1.525 $\gamma = 1.543$–1.544 2V(meas.) = 73°

Cell Data: *Space Group:* $P2_1/a$. $a = 13.428(2)$ $b = 12.560(2)$ $c = 6.588(1)$
$\beta = 99.97(1)°$ Z = 4

X-ray Powder Pattern: Boron, California, USA.
9.12 (100), 2.807 (35), 6.62 (20), 3.52 (20), 2.935 (20), 2.884 (20), 2.172 (20)

Chemistry:

	(1)	(2)
B_2O_3	50.44	49.56
CaO	15.45	15.97
Na_2O	8.53	8.82
H_2O	25.58	25.65
Total	[100.00]	100.00

(1) Baker mine, California, USA; average of two analyses, recalculated to 100% after deduction of insoluble 3.73%. (2) $NaCaB_5O_7(OH)_4 \cdot 3H_2O$.

Occurrence: In lake-bed deposits, the boron supplied by hydrothermal spring activity; may be an ore of boron.

Association: Kernite, colemanite, ulexite, borax.

Distribution: In the USA, in California, from the Baker, Western Borax, and Suckow mines, Kramer borate deposit, Boron, Kern Co.; in several mines around Ryan, and at the Eagle Borax Spring, Furnace Creek district, Inyo Co.; in the Sterling borax mine, Lang, Los Angeles Co.; and from the Pacific Coast Borax Co. mine, Calico Hills, north of Daggett, San Bernardino Co.; at Southard, Blaine Co., Oklahoma. From the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. From one km south of Oficina Santa Luisa, Atacama, Chile. In the Günevi deposit, Bigadiç borate district, Balıkesir Province, Turkey. At the Gorleben salt dome, Lower Saxony, Germany. From the Piskanja deposit, Jarandol Basin, Serbia, Yugoslavia. In the Bakhmut depression and the Donets Basin, Ukraine.

Name: To honor Frank Holman Probert (1876–1940), Dean of the Mining College, University of California, Berkeley, California, USA, who provided the first specimens.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95832–95833.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 343–345. (2) Clark, J.R. and C.L. Christ (1959) Studies of borate minerals (V): reinvestigation of the X-ray crystallography of ulexite and probertite. Amer. Mineral., 44, 712–719. (3) Menchetti, S., C. Sabelli, and R. Trosti-Ferroni (1982) Probertite, $CaNa[B_5O_7(OH)_4].3H_2O$: a refinement. Acta Cryst., 38, 3072–3075.

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Prosopite $CaAl_2(F,OH)_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, prismatic ‖ [001], flattened on {010}, with {021}, {111}, and {$\overline{2}21$} also noted, to 6 mm; commonly granular or powdery.

Physical Properties: *Cleavage:* {111}, perfect. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 2.880–2.894 D(calc.) = 2.898

Optical Properties: Transparent when fresh; becomes translucent on exposure. *Color:* Colorless, grayish to white, rarely turquoise-blue; colorless in transmitted light. *Luster:* Vitreous, weak. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = -35°$. *Dispersion:* $r > v$, strong. $\alpha = 1.500–1.501$ $\beta = 1.503$ $\gamma = 1.509–1.510$ 2V(meas.) = 63°–66° 2V(calc.) = 66.5°

Cell Data: *Space Group:* $C2/c$. $a = 6.67–6.76$ $b = 11.12–11.19$ $c = 7.32–7.38$ $\beta = 94.93°–95.00°$ Z = 4

X-ray Powder Pattern: St. Peters Dome, Colorado, USA.
4.35 (10), 2.13 (6), 1.837 (6), 1.813 (6), 3.07 (5), 1.913 (5), 3.24 (4)

Chemistry:

	(1)	(2)	(3)
Na	0.33		
Mg	0.11		
Ca	16.19	16.45	16.84
Al	23.37	21.79	22.67
F	35.01	34.07	31.92
O	[12.58]		13.44
O + H		28.61	
H_2O	12.41		15.13
Total	[100.00]	100.92	100.00

(1) Altenberg, Germany; O by difference. (2) Yenisei Ridge, Russia. (3) $CaAl_2(F,OH)_8$ with F:OH = 1:1.

Occurrence: Disseminated in fluorine-rich granites, greisens, and granite pegmatites; more rarely in base-metal deposits.

Association: Fluorite, cryolite, thomsenolite, pachnolite, gearksutite, ralstonite, weberite, jarlite, siderite, hematite, cassiterite, quartz.

Distribution: In Germany, from Altenberg, Saxony. At Horní Slavkov (Schlaggenwald), Czech Republic. From Perga, Volyn, Ukraine. In Russia, from Miass, Ilmen Mountains, Southern Ural Mountains; on the Yenisei Ridge, Siberia; and in the Zharchikhinsk molybdenum deposit, on the west side of Lake Baikal, eastern Siberia. In the Ivigtut cryolite deposit, southwestern Greenland. From Mt. Bischoff, Tasmania, Australia. In the USA, at St. Peters Dome, near Pikes Peak, El Paso Co., and in the Goldie carbonatite, McClure Mountain-Iron Mountain, Fremont Co., Colorado; in the Dugway district, Tooele Co., Utah; at the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada; from the Grand Reef mine, Aravaipa district, Graham Co., and 16 km north of Bouse, La Paz Co., Arizona; in the Morefield pegmatite mine, Amelia, Amelia Co., Virginia. In Mexico, at the Santa Rosa mine, Mazapil, Zacatecas, Mexico. From Tsumeb, Namibia.

Name: From the Greek for *mask*, the mineral's character being initially masked by pseudomorphism.

Type Material: Mining Academy, Freiberg, Germany, 12818.

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References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 121–123. (2) Pudovkina, Z.V. and Y.A. Pyatenko (1970) Structure of prosopite, $Ca[Al_2F_4(OH)_4]$, and some crystallochemical features of fluoroaluminates. Doklady Acad. Nauk SSSR, 190, 665–667 (in Russian). (3) Nozhkin, A.D., T.A. Korneva, V.N. Korolyuk, and V.N. Stolpovskaya (1979) Prosopite from fluorite veins of the Yenisei Ridge. Doklady Acad. Nauk SSSR, 247, 1478–1481 (in Russian). (4) Petersen, O.V. (1986) On the prosopite, $CaAl_2F_4(OH)_4$, from Ivigtut. Neues Jahrb. Mineral., Monatsh., 329–335. (5) Ferguson, R.B. (1949) Observations on some aluminum fluoride minerals. Amer. Mineral., 34, 383–397.

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Prosperite $CaZn_2(AsO_4)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As slender prismatic crystals, slightly bent and twisted, elongated along [001], showing {100}, {$\bar{1}$01}, {110}, {$\bar{1}$11}, and others, to 1 cm. Crystals are typically composite, multiply terminated, in subparallel to radiating groups and dense aggregates.

Physical Properties: Hardness = 4.5 D(meas.) = 4.31(1) D(calc.) = 4.40

Optical Properties: Semitransparent. *Color:* White to colorless, pale blue in aggregates. *Streak:* White. *Luster:* Vitreous to silky.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 27°$. *Dispersion:* $r \gg v$. $\alpha = 1.746(2)$ $\beta = 1.748(2)$ $\gamma = 1.768(2)$ 2V(meas.) = 34(2)° 2V(calc.) = 36°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 19.238(2)$ $b = 7.731(1)$ $c = 9.765(1)$ $\beta = 104.47(1)°$ Z = 8

X-ray Powder Pattern: Tsumeb, Namibia.
2.723 (10), 2.992 (9), 3.11 (8), 3.78 (7), 3.36 (6), 2.614 (6), 3.86 (5)

Chemistry:

	(1)	(2)
As_2O_5	47.92	49.25
CuO	1.35	
ZnO	33.22	34.88
CaO	13.02	12.01
H_2O	4.0	3.86
Total	99.51	100.00

(1) Tsumeb, Namibia; by electron microprobe, H_2O by TGA; corresponds to $Ca_{1.09}(Zn_{1.91}Cu_{0.08})_{\Sigma=1.99}(As_{0.98}O_{3.98})_2 \cdot 1.04H_2O$. (2) $CaZn_2(AsO_4)_2 \cdot H_2O$.

Occurrence: A rare secondary mineral in partly altered sulfide ore from a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tennantite, chalcocite, mercurian silver, cuprite, cuprian adamite, cuprian austinite, conichalcite, stranskiite, lavendulan, köttigite, tsumcorite, koritnigite, o'danielite.

Distribution: From Tsumeb, Namibia.

Name: To honor Prosper John Williams (1910–), of Toronto, Canada, South African-Canadian mineral dealer, supplier of many Tsumeb specimens.

Type Material: Royal Ontario Museum, Toronto, Canada, M35388, M35389, M35391; The Natural History Museum, London, England, 1978,19; National Museum of Natural History, Washington, D.C., USA, 143732, 143733.

References: (1) Gait, R.I., B.D. Sturman, and P.J. Dunn (1979) Prosperite, $HCaZn_2(AsO_4)_2(OH)$, a new mineral from Tsumeb, South West Africa (Namibia). Can. Mineral., 17, 87–92. (2) (1980) Amer. Mineral., 65, 208 (abs. ref. 1). (3) Keller, P., H. Riffel, and H. Hess (1982) Die Kristallstruktur von Prosperit, $Ca_2Zn_4[H_2O/(AsO_4)_4]$. Zeits. Krist., 158, 33–42 (in German with English abs.).

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Protasite $Ba(UO_2)_3O_3(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. As thin pseudohexagonal platelets, flattened on {010}, to 0.5 mm; spherulitic, massive. *Twinning:* By 60° rotation about [010], yielding sector twinning, universal.

Physical Properties: *Cleavage:* Good on {010}. *Fracture:* Hackly. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 5.39(5) D(calc.) = 5.827(3) Radioactive.

Optical Properties: Transparent. *Color:* Bright orange. *Luster:* Subadamantine. *Optical Class:* Biaxial (–). $\alpha = 1.78$ $\beta = 1.80$–1.83 $\gamma = 1.82$–1.83 2V(meas.) = 60°–81°

Cell Data: *Space Group:* Pn. $a = 12.2949(16)$ $b = 7.2206(10)$ $c = 6.9558(8)$ $\beta = 90.401(15)°$ Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
3.14 (100), 7.06 (50), 3.58 (35), 3.11 (35), 2.496 (35), 2.395 (25), 1.976 (25)

Chemistry:

	(1)	(2)	(3)
UO_3	78.0	78.22	79.20
SiO_2		0.32	
PbO		2.63	
CaO		0.67	
BaO	15.0	9.48	14.15
K_2O		0.39	
H_2O	[7.0]	[8.29]	6.65
Total	[100.0]	[100.00]	100.00

(1) Shinkolobwe, Congo; by electron microprobe, H_2O by difference, presence confirmed by crystal-structure analysis; corresponding to $Ba_{1.08}(UO_2)_{3.00}O_3(OH)_2 \cdot 2.27H_2O$. (2) Russia; by electron microprobe, corresponding to $(Ba_{0.70}Ca_{0.13}Pb_{0.13}K_{0.04})_{\Sigma=1.00} \cdot (UO_2)_3O_3(OH)_2 \cdot 3H_2O$. (3) $Ba(UO_2)_3O_3(OH)_2 \cdot 3H_2O$.

Occurrence: In the oxidized zone of uranium-bearing mineral deposits.

Association: Uraninite, uranophane (Shinkolobwe, Congo); bauranoite, metacalciouranoite (Russia).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At an undisclosed locality [Streltsovskoe U–Mo deposit, eastern Transbaikal] in Russia.

Name: To honor Professor Jean Protas (1932–), French mineralogist, University of Nancy, Nancy, France, who first synthesized the compound, and for his work with uranium oxide minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 150732.

References: (1) Pagoaga, M.K., D.E. Appleman, and J.M. Stewart (1986) A new barium uranyl oxide hydrate mineral, protasite. Mineral. Mag., 50, 125–128. (2) (1987) Amer. Mineral., 72, 224 (abs. ref. 1). (3) Pagoaga, M.K., D.E. Appleman, and J.M. Stewart (1987) Crystal structures and crystal chemistry of the uranyl oxide hydrates becquerelite, billietite, and protasite. Amer. Mineral., 72, 1230–1238. (4) Belova, L.N. and V.P. Rogova (1988) First protasite find in the USSR. Doklady Acad. Nauk SSSR, 303, 1200–1202 (in Russian).

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Proudite $Cu_{0-1}Pb_{7.5}Bi_{9.3-9.7}(S,Se)_{22}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As elongate to acicular grains or irregular laths.

Physical Properties: *Cleavage:* One good cleavage parallel to grain elongation, a second at an apparent angle of 40° to the first. Hardness = n.d. VHN = 38–87 (50 g load). D(meas.) = n.d. D(calc.) = 7.08

Optical Properties: Opaque. *Color:* Silver-gray; in polished section, creamy white. *Pleochroism:* Strong, from cream-white to white. *Anisotropism:* Strong, from cream-gray to tan. R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/m$. $a = 31.96(1)$ $b = 4.12(1)$ $c = 36.69(3)$ $\beta = 109.52(3)°$ $Z = 4$

X-ray Powder Pattern: Juno mine, Australia.
2.960 (100), 2.059 (86), 3.494 (65), 2.066 (60), 3.834 (48), 3.224 (48), 3.447 (42)

Chemistry:

	(1)	(2)
Cu	0.5	1.38
Pb	33.7	33.78
Bi	43.3	42.39
Se	14.0	12.02
S	9.9	10.43
Total	101.4	100.00

(1) Juno mine, Australia; by electron microprobe, average of 11 analyses; corresponds to $Cu_{0.36}Pb_{7.36}Bi_{9.38}S_{13.97}Se_{8.03}$. (2) "ideal" proudite – $Cu_{1.00}Pb_{7.50}Bi_{9.33}S_{15.00}Se_{7.00}$.

Occurrence: With large, presumably hydrothermal magnetite bodies (Juno mine, Australia).

Association: Gold, junoite, selenian heyrovskýite, krupkaite, magnetite (Juno mine, Australia).

Distribution: In Australia, from the Juno mine, Tennant Creek, Northern Territory [TL]. At Janos, Chihuahua, Mexico.

Name: Honors John S. Proud (1907–1997), a Director of the Peko-Wallsend mining company, developers of the Tennant Creek deposits.

Type Material: n.d.

References: (1) Mumme, W.G. (1976) Proudite from Tennant Creek, Northern Territory, Australia: its crystal structure and relationship to weibullite and wittite. Amer. Mineral., 61, 839–852. (2) Large, R.R. and W.G. Mumme (1975) Junoite, "wittite", and related seleniferous bismuth sulfosalts from Juno mine, Northern Territory, Australia. Econ. Geol., 70, 369–383.

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Proustite Ag_3AsS_3

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Crystals prismatic, to 8 cm; commonly rhombohedral with dominant $\{01\bar{1}2\}$ or $\{10\bar{1}1\}$; also scalenohedral with prominent $\{12\bar{3}1\}$; massive, compact. *Twinning:* On $\{10\bar{1}4\}$ to produce trillings; also common on $\{10\bar{1}1\}$ and on $\{0001\}$, $\{01\bar{1}2\}$.

Physical Properties: *Cleavage:* Distinct on $\{10\bar{1}1\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2–2.5 VHN = 70–105 (25 g load). D(meas.) = 5.57 D(calc.) = 5.625

Optical Properties: Translucent, darkens with exposure to light. *Color:* Scarlet-vermilion. *Streak:* Vermilion. *Luster:* Adamantine.
Optical Class: Uniaxial (–). *Pleochroism:* Moderate; cochineal-red to blood-red. $\omega = 3.0877$ $\epsilon = 2.7924$ *Anisotropism:* Strong.
R_1–R_2: (400) 36.9–39.6, (420) 36.8–39.5, (440) 36.7–39.4, (460) 35.8–38.2, (480) 34.0–36.8, (500) 32.5–35.0, (520) 31.2–33.5, (540) 30.0–32.3, (560) 29.0–31.2, (580) 28.2–30.3, (600) 27.5–29.6, (620) 26.9–29.0, (640) 26.3–28.5, (660) 25.9–28.2, (680) 25.4–27.9, (700) 25.0–27.6

Cell Data: *Space Group: R3c.* $a = 10.79$ $c = 8.69$ $Z = 6$

X-ray Powder Pattern: Cobalt, Canada.
2.76 (10), 3.28 (8), 3.18 (8), 2.56 (8), 2.48 (8), 1.929 (2), 1.672 (2)

Chemistry:

	(1)	(2)	(3)
Ag	64.12	64.65	65.42
Sb	0.08	trace	
As	15.90	15.25	15.14
S	19.28	20.18	19.44
rem.	0.75	0.70	
Total	100.13	100.78	100.00

(1) Cobalt, Canada; remainder Fe 0.25%, (Co,Ni) 0.12%, insoluble 0.38%. (2) Veta Rica mine, Coahuila, Mexico; remainder is Cu. (3) Ag_3AsS_3.

Polymorphism & Series: Dimorphous with xanthoconite.

Occurrence: A late-forming mineral in hydrothermal deposits, in the oxidized and enriched zone, associated with other silver minerals and sulfides.

Association: Silver, arsenic, xanthoconite, stephanite, acanthite, tetrahedrite, chlorargyrite.

Distribution: Occurs at many localities, but rarely in fine crystals or as an important ore mineral. From Germany, in the Himmelsfürst mine, Erbisdorf, near Freiberg; and at Niederschlema, Saxony. In Romania, at Săcărîmb (Nagyág). From Jáchymov (Joachimsthal) and Příbram, Czech Republic. At Sainte-Marie-aux-Mines, Haut-Rhin, France. From Sarrabus, Sardinia, Italy. In the USA, in Colorado, at Red Mountain, San Juan Co., and at Georgetown, Clear Creek Co.; in Idaho, large masses at the Poorman mine, Silver City district, Owyhee Co.; in Nevada, in the Star mine, Cherry Creek district, White Pine Co. In Canada, from the Keeley mine, South Lorrain Township, Ontario. In Chile, at Chañarcillo, south of Copiapó, Atacama, as exceptional crystals. From Mexico, at Batopilas, Chihuahua, and Sombrerete, Zacatecas.

Name: To honor Joseph Louis Proust (1754–1826), celebrated French chemist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 366–369. (2) Toulmin, P. (1963) Proustite–pyrargyrite solid solutions. Amer. Mineral., 48, 725–736. (3) Engel, P. and W. Nowacki (1966) Die Verfeinerung der Kristallstruktur von Proustit, Ag_3AsS_3, und Pyrargyrit, Ag_3SbS_3. Neues Jahrb. Mineral., Monatsh., 181–184 (in German). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 124.

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Przhevalskite $Pb(UO_2)_2(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. Crystals are tabular, to 1 mm, in foliated aggregates.

Physical Properties: *Cleavage:* On {001}, good. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.38 Radioactive.

Optical Properties: Semitransparent. *Color:* Bright yellow with faint greenish tint. *Luster:* Adamantine, vitreous to pearly.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale yellow; Z = deep yellow. *Orientation:* Extinction parallel, elongation negative. $\alpha = 1.739$ $\beta = 1.749(2)$ $\gamma = 1.752(2)$ 2V(meas.) = $\sim 30°$

Cell Data: *Space Group:* n.d. $a = 7.24$ $c = 18.22$ Z = 2

X-ray Powder Pattern: Synthetic.
3.610 (10), 9.080 (9), 1.619 (6), 1.530 (6), 9.490 (5), 2.629 (5), 1.960 (5)

Chemistry:

	(1)	(2)
UO_3	46.55	56.68
P_2O_5	11.47	14.06
SiO_2	4.10	
Al_2O_3	3.48	
PbO	21.06	22.12
H_2O	6.69	7.14
Total	93.35	100.00

(1) Dzherkamar deposit, Tajikistan; SiO_2 and Al_2O_3 considered as "metahalloysite" impurity.
(2) $Pb(UO_2)_2(PO_4)_2 \cdot 4H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a uranium deposit.

Association: Torbernite, autunite, dumontite, dewindtite, uranophane, wulfenite, hydrous Fe–Mn oxides, "metahalloysite".

Distribution: In the Dzherkamar uranium deposit, ten km southeast of Adraman, Karamazar Mountains, Tajikistan.

Name: Honoring Nikolai Mikhailovich Przheval'skii (1839–1888), Russian geographer and explorer of Central Asia.

Type Material: n.d.

References: (1) Soboleva, M.V. and I.A. Pudovkina (1957) Uranium Minerals Handbook, 408 pp, esp. 203–205 (in Russian). (2) Getseva, R.V. and K.T. Savel'eva (1956) Handbook for the determination of uranium minerals, 260 pp, esp. 213 (in Russian). (3) (1958) Amer. Mineral., 43, 381–382 (abs. refs. 1 and 2). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 170–171.

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Pseudoboleite $Pb_{31}Cu_{24}Cl_{62}(OH)_{48}$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m\ 2/m\ 2/m$. Very rarely as single crystals, to 1 mm; commonly intergrown with and overgrown on boleite with mutually ∥ {001}.

Physical Properties: *Cleavage:* {001}, perfect; {101}, nearly perfect. Hardness = 2.5 D(meas.) = 4.85 D(calc.) = 5.07

Optical Properties: Translucent. *Color:* Indigo blue. *Luster:* Pearly on cleavages. *Optical Class:* Uniaxial (–). $\omega = 2.03$ $\epsilon = 2.00$

Cell Data: *Space Group:* $I4/mmm$. $a = 15.24(2)$ $c = 30.74(5)$ $Z = 2$

X-ray Powder Pattern: Chancay, Peru; may totally obscure the pattern of intergrown boleite. (ICDD 22-470).
4.43 (100), 3.83 (100), 2.707 (95), 2.334 (65), 2.551 (60), 2.389 (60), 1.990 (60)

Chemistry:

	(1)	(2)	(3)
AgCl	1.6		
Pb	53.5	57.7	56.37
CuO	16.5	16.9	16.75
Cl	20.2	19.8	19.29
H_2O	5.5	5.6	7.59
insol.	0.8		
Total	98.1	[100.0]	100.00

(1) Boleo, Mexico. (2) Analysis (1) corrected to 100.0% after deduction of AgCl 1.6% as boleite and insoluble 0.8%. (3) $Pb_{31}Cu_{24}Cl_{62}(OH)_{48}$.

Occurrence: A secondary mineral formed through reaction of chloride with primary sulfides in the oxidized zone of Pb–Cu deposits; in smelter slag immersed in and leached by sea water.

Association: Boleite, cumengeite, atacamite, anglesite, cerussite, phosgenite, gypsum (Boleo, Mexico).

Distribution: In Mexico, in the Amelia mine, Boleo, near Santa Rosalía, Baja California, and from an undefined locality in Sonora. In the USA, in the Mammoth-St. Anthony mine, Tiger, Pinal Co., and the Banner mine, Pima Co., Arizona. From Laurium, Greece, in slag. At Tolcarne Beach, Newquay, Cornwall, England. From Mantos Blancos, and at several mines around Caracoles, Sierra Gorda district, Antofagasta, Chile. In Peru, at Chancay.

Name: From the Greek for *false* and *boleite*, as it was mistaken for that species.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 80–81. (2) Winchell, R.E. and R.C. Rouse (1974) The mineralogy of the boleite group. Mineral. Record, 5, 280–287. (3) Giuseppetti, G., F. Mazzi, and C. Tadini (1992) The crystal structure of pseudoboleite: $Pb_{31}Cu_{24}Cl_{62}(OH)_{48}$; its relations with the structures of boleite and cumengite. Neues Jahrb. Mineral., Monatsh., 113–126.

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Pseudobrookite $(Fe^{3+}, Fe^{2+})_2(Ti, Fe^{3+})O_5$

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Crystal Data: Monoclinic. *Point Group:* 2. Commonly in short to long prismatic crystals, elongated along [010], to 7 cm, may be equant, flattened on {001}, with {*hk*0} striated ‖ [010], terminated by {0*kl*}; typically in radiating sheaves.

Physical Properties: *Cleavage:* {102}, distinct. *Fracture:* Uneven to subconchoidal. Hardness = 6 D(meas.) = 4.33–4.39 D(calc.) = 4.39

Optical Properties: Opaque, transparent in thin fragments. *Color:* Dark reddish brown, brownish black, black; in transmitted light, yellowish brown or reddish brown. *Streak:* Reddish brown to ocher-yellow. *Luster:* Metallic adamantine, may be tarnished iridescent, greasy on fractures.
Optical Class: Biaxial (+). *Pleochroism:* In browns. *Orientation:* $Y = a$; $Z = c$; $X \wedge a \simeq 26°$. *Dispersion:* $r < v$. *Absorption:* $X < Y > Z$. $\alpha = 2.35–2.38$ $\beta = 2.36–2.39$ $\gamma = 2.38–2.42$
2V(meas.) = ∼50°
R_1–R_2: (400) 22.8–24.0, (420) 21.9–23.1, (440) 21.2–22.3, (460) 20.5–21.4, (480) 19.8–20.7, (500) 19.4–20.4, (520) 19.0–19.9, (540) 18.5–19.3, (560) 18.1–18.8, (580) 17.8–18.5, (600) 17.5–18.1, (620) 17.3–17.9, (640) 17.1–17.7, (660) 17.0–17.6, (680) 16.8–17.4, (700) 16.7–17.3

Cell Data: *Space Group:* $C2$ (synthetic Fe_2TiO_5). $a = 22.23$ $b = 3.73$ $c = 9.80$ $\beta = 116.2°$ Z = 8

X-ray Powder Pattern: Synthetic Fe_2TiO_5. (ICDD 9-182).
3.483 (100), 2.748 (80), 4.902 (45), 1.54 (35), 1.862 (30), 2.402 (25), 1.971 (25)

Chemistry:

	(1)	(2)	(3)
TiO_2	41.93	38.8	33.34
Fe_2O_3	57.08	61.8	66.66
MgO	0.99	0.3	
Total	[100.00]	100.9	100.00

(1) Aranyer Berg, Romania; recalculated to 100% after deduction of SiO_2 1.29%. (2) Cuchillo, New Mexico, USA; by electron microprobe, total Fe as Fe_2O_3. (3) Fe_2TiO_5.

Occurrence: Formed by pneumatolytic processes in titanium-rich andesite, rhyolite, basalt, etc., and by reactions with xenoliths within these; commonly in lithophysae.

Association: Hematite, magnetite, bixbyite, ilmenite, enstatite-ferrosilite, tridymite, quartz, sanidine, topaz, spessartine, beryl, mica, cassiterite, apatite.

Distribution: Many of the localities following are minor; others are known. On Măgura Uroiului (Aranyer Berg), near Piski, Romania. In Germany, near Mayen, Eifel district. From Riveau Grande, Mt. Dore, Puy-de-Dôme, France. At Vesuvius, Campania, Italy. From Jumilla, Murcia Province, Spain. On Fayal and San Miguel Islands, Azores. On Kilimanjaro, Tanzania. From Réunion Island, Indian Ocean. In the USA, fine crystals from the Thomas Range, Juab Co., Utah; at Crater Lake, West Klamath Co., and Lemolo Lake, Douglas Co., Oregon; at a number of places in the Black Range, Sierra Co., New Mexico. From Cerro los Remedios, Durango, Mexico.

Name: From the Greek for *false* and *brookite*, as it was for some time thought to be that mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 736–738. (2) Ottemann, J. and G. Frenzel (1965) Der Chemismus der Pseudobrookite von Vulkaniten. Schweiz. Mineral. Petrog. Mitt., 45, 819–836 (in German with English abs.). (3) Bowles, J.F.W. (1988) Definition and range of composition of naturally occurring minerals with the pseudobrookite structure. Amer. Mineral., 73, 1377–1383. (4) Shiojiri, M., S. Sekimoto, T. Maeda, Y. Ikeda, and K. Iwauchi (1984) Crystal structure of Fe_2TiO_5. Phys. Stat. Sol. (a), 84, 55–64. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 454.

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Pseudocotunnite $K_2PbCl_4(?)$

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Crystal Data: Orthorhombic (probable). *Point Group:* $2/m\ 2/m\ 2/m$. Needlelike crystals, elongated ‖ [001], may be lathlike, flattened on {010} or {100}, to 5 mm; as warty aggregates, dendritic crusts.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.25 Soluble in warm H_2O.

Optical Properties: Semitransparent. *Color:* Colorless to white, yellow, greenish yellow. *Luster:* Dull.
Optical Class: Biaxial; medium strong birefringence. *Orientation:* $Z = c$. n = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* *Pnma* (synthetic). $a = 11.80(5)$ $b = 5.77(5)$ $c = 9.82(5)$ Z = 4

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na	1.53		
K	17.11	18.97	18.30
Pb	43.00	47.67	48.50
Ca	2.13		
Cl	36.23	33.36	33.20
Total	100.00	[100.00]	100.00

(1) Vesuvius, Italy; SO_4 and F in traces. (2) Analysis (1) recalculated to 100% after deduction of Na and Ca as chlorides. (3) K_2PbCl_4.

Occurrence: In volcanic fumaroles.

Association: Tenorite, cotunnite.

Distribution: On Vesuvius, Campania, Italy.

Name: From the Greek for *false*, and the mineral's supposed resemblance to *cotunnite*.

Type Material: Natural History Museum, Paris, France, 108.1573.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 96–97. (2) Bellanca, A. (1952) Sulla struttura della pseudocotunnite. Rend. Soc. Ital. Mineral. Petrol., 8, 53 (in Italian).

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Pseudograndreefite $Pb_6(SO_4)F_{10}$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* 222. Crystals are square, tabular on {010}, showing {010}, {100}, {001}, {210}, {012}, in subparallel aggregation, to 4 mm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼2.5
D(meas.) = 7.0(1) D(calc.) = 7.08 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White.
Luster: Subadamantine.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, strong.
$\alpha = 1.864(5)$ $\beta = 1.865(5)$ $\gamma = 1.873(5)$ 2V(meas.) = 30(3)° 2V(calc.) = 39°

Cell Data: *Space Group:* $F222$. $a = 8.5182(5)$ $b = 19.5736(11)$ $c = 8.4926(5)$ Z = 4

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
3.204 (100), 1.779 (70b), 2.999 (30), 2.212 (25), 1.364 (25b), 3.89 (20), 2.123 (20)

Chemistry:

	(1)	(2)
SO_3	4.7	5.24
PbO	84.9	87.57
F	13.1	12.42
$-O = F_2$	5.5	5.23
Total	97.2	100.00

(1) Grand Reef mine, Arizona, USA; by electron microprobe, H_2O shown absent by IR; corresponding to $Pb_{5.91}(S_{0.91}O_{3.29})F_{10.71}$. (2) $Pb_6(SO_4)F_{10}$.

Occurrence: In a vug isolated from acidic sulfate-rich solutions in the oxidized zone of a low-temperature Pb–Cu–Ag deposit.

Association: Grandreefite, laurelite, aravaipaite, galena, fluorite, anglesite, linarite, caledonite, quartz.

Distribution: From the Grand Reef mine, about six km northeast of Klondyke, Aravaipa district, Graham Co., Arizona, USA.

Name: From the Greek for *false*, and its relation to *grandreefite*.

Type Material: Natural History Museum, Los Angeles, California, 33608; National Museum of Natural History, Washington, D.C., USA, 166056.

References: (1) Kampf, A.R., P.J. Dunn, and E.E. Foord (1989) Grandreefite, pseudograndreefite, laurelite, and aravaipaite: four new minerals from the Grand Reef mine, Graham County, Arizona. Amer. Mineral., 74, 927–933.

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Pseudolaueite $Mn^{2+}Fe_2^{3+}(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic to thick tabular pseudohexagonal crystals, with {100}, {001}, {110}, rare {011}, {$\overline{2}$01}, to 2 mm.

Physical Properties: Hardness = 3 D(meas.) = 2.463 D(calc.) = 2.51

Optical Properties: Semitransparent. *Color:* Pale yellow-orange, light to dark yellow, orange-brown.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = pale yellow; Z = yellow. *Orientation:* $Z = b$; $X \wedge c = 2°$; $Y \wedge a = 12°$. $\alpha = 1.626$ $\beta = 1.650$ $\gamma = 1.686$ 2V(meas.) = n.d. 2V(calc.) = 80°

Cell Data: *Space Group:* $P2_1/a$. $a = 9.647$ $b = 7.428$ $c = 10.194$ $\beta = 104.63°$ Z = 2

X-ray Powder Pattern: Hagendorf, Germany.
9.926 (10), 5.869 (7), 3.472 (4), 4.678 (3), 3.908 (3), 3.186 (3), 3.069 (3)

Chemistry: (1) Hagendorf, Germany; analysis not given, stated to correspond to $(Mn_{0.78}Al_{0.20}Ca_{0.02})_{\Sigma=1.00}(Fe^{3+}_{1.80}Fe^{2+}_{0.10}Mg_{0.07}Mn_{0.04})_{\Sigma=2.01}(PO_4)_2(OH)_2 \cdot 8H_2O$.

Polymorphism & Series: Trimorphous with laueite and stewartite.

Occurrence: As incrustations and replacements of stewartite crystals in a complex zoned granite pegmatite (Hagendorf, Germany).

Association: Stewartite, laueite, strunzite, triphylite, Fe–Mn oxides (Hagendorf, Germany).

Distribution: From Hagendorf, Bavaria, Germany. In Portugal, at the Mangualde pegmatite, near Mesquitela, and in the Bendada pegmatite, near Guarda. From the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; at the White Elephant mine, near Pringle, Custer Co., South Dakota, USA.

Name: From the Greek for *false* and its relation to *laueite*, as it is not that species.

Type Material: University of Chicago, Chicago, Illinois, USA, P239.

References: (1) Strunz, H. (1956) Pseudolaueit, ein neues Mineral. Naturwiss., 43, 128 (in German). (2) (1956) Amer. Mineral., 41, 815 (abs. ref. 1). (3) Baur, W.H. (1969) A comparison of the crystal structures of pseudolaueite and laueite. Amer. Mineral., 54, 1312–1323. (4) Moore, P.B. (1975) Laueite, pseudolaueite, stewartite and metavauxite: a study in combinatorial polymorphism. Neues Jahrb. Mineral., Abh., 123, 148–159.

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Pseudolyonsite $Cu_3(VO_4)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m.* As needles to 0.5 mm or in sprays or openwork clusters to 1 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle, needles flexible and elastic. Hardness = 2-3 D(meas.) = n.d. D(calc.) = 4.749

Optical Properties: Translucent to opaque. *Color*: Dark red with brownish tint; gray with a weak bluish tint in reflected light, with strong red internal reflections. *Streak*: Reddish brown.
Luster: Adamantine to semi-metallic. *Anistropism*: Distinct.
Optical Class: n.d.
R_1-R_2: (470) 17.05-19.6, (546) 16.1-18.15, (589) 15.85-17.7, (650) 15.55-17.4

Cell Data: *Space Group*: $P2_1/c$. a = 6.2695(4) b = 8.0195(3) c = 6.3620(3) β = 111.96(1)°
Z = 2

X-ray Powder Pattern: Tolbachik volcano, Kamchatka Peninsula, Russia.
2.761 (100), 3.22 (87), 3.30 (79), 2.894 (74), 2.419 (67), 4.70 (60), 2.479 (59)

Chemistry:

	(1)	(2)
V_2O_5	40.37	43.25
CuO	48.83	56.75
ZnO	7.6	
MoO_3	1.89	
SiO_2	0.14	
Total	98.83	100.00

(1) Tolbachik volcano, Kamchatka Peninsula, Russia; average of 4 electron microprobe analyses; corresponding to $(Cu_{2.58}Zn_{0.44})_{\Sigma=3.02}(V_{1.88}Mo_{0.06}Si_{0.02})_{\Sigma=1.96}O_8$. (2) $Cu_3(VO_4)_2$.

Polymorphism & Series: Dimorphous with mcbirneyite and the natural analogue of synthetic monoclinic $Cu_3(VO_4)_2$.

Occurrence: Formed by late post-eruptive degassing in cavities from several centimeters to 1.5 m in size under the surface crust of volcanic cinder - typically as overgrowths on acicular piypite.

Association: Piypite, palmierite, lyonsite, hematite.

Distribution: From the Yadovitaya (''Poisonous'') fumarole, Second cone, Tolbachik volcano, Kamchatka Peninsula, Far East Asia, Russia.

Name: For its close visual (color, luster, habit) similarity to *lyonsite*.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 3879/1).

References: (1) Zelenski, M.E., N.V. Zubkova, I.V. Pekov, M. M. Boldyreva, D.Yu. Pushcharovsky, and A.N. Nekrasov (2011) Pseudolyonsite, $Cu_3(VO_4)_2$, a new mineral species from the Tolbachik volcano, Kamchatka Peninsula, Russia. Eur. J. Mineral., 23, 475-481. (2) (2012) Amer. Mineral., 97, 760-761 (abs. ref. 1).

Pseudomalachite $Cu_5(PO_4)_2(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are rare, to 6 mm, typically rough and rounded, with prominent {110}, {201}, {311}, {100}, {001}, and others. Commonly compact radiating and spherical, may be fibrous, in paintlike crusts and films, botryoidal, massive. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Splintery. Hardness = 4.5–5 D(meas.) = 4.15–4.35 D(calc.) = 4.34

Optical Properties: Translucent. *Color:* Dark emerald-green, dark green, blackish green, bluish green; green to bluish green in transmitted light. *Streak:* Pale green to pale bluish green. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–), may be biaxial (+). *Pleochroism:* Weak; X = bluish green to pale green; Y = yellowish green; Z = deep bluish green to blue-green. *Orientation:* $Z = b$; X $\wedge$ c = 21°–23°. *Dispersion:* $r < v$, strong; may be $r > v$. α = 1.789–1.80 β = 1.835–1.86 γ = 1.845–1.88 2V(meas.) = 46°–50°

Cell Data: *Space Group:* $P2_1/a$. a = 17.02–17.08 b = 5.75–5.77 c = 4.47–4.50 $\beta = 90°57'–91°32'$ Z = 2

X-ray Powder Pattern: Ehl and Rheinbreitbach, Germany.
4.48 (10), 2.39 (8), 2.42 (6), 3.46 (5), 2.32 (5), 2.23 (5), 1.728 (5)

Chemistry:

	(1)	(2)
P_2O_5	23.86	24.65
FeO	0.19	
CuO	69.25	69.09
H_2O	6.76	6.26
Total	100.06	100.00

(1) Rheinbreitbach, Germany; corresponds to $(Cu_{4.98}Fe_{0.02})_{\Sigma=5.00}(PO_4)_{1.93}(OH)_{4.30}$.
(2) $Cu_5(PO_4)_2(OH)_4$.

Polymorphism & Series: Trimorphous with ludjibaite and reichenbachite.

Occurrence: A secondary mineral in the oxidized zone of hydrothermal copper deposits.

Association: Libethenite, malachite, cornetite, chrysocolla, quartz.

Distribution: Many localities, but usually in small amounts. In Germany, at Ehl, near Linz, and rich specimens from Virneberg, near Rheinbreitbach, Rhineland-Palatinate. At L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. From Nizhni Tagil and Bogoslovsk, Ural Mountains, Russia. In England, at Caldbeck Fells, Cumbria; also from a number of mines in Cornwall. From Kakanda and M'sesa, near Kambove, Katanga Province, Congo (Shaba Province, Zaire). At Mindouli, Congo Republic. From the Bwana Mkubwa, Ndola, and the Nchanga mines, Chingola, Zambia. In the USA, from the Perkiomen and Ecton mines, Montgomery Co., Pennsylvania; in the Empire-Nevada mine, Yerington district, Lyon Co., Nevada; at Lone Star mine, near Safford, Graham Co., from Harquehala, La Paz Co., and elsewhere in Arizona. At Chuquicamata, Antofagasta, Chile. Rich examples from the West Bogan mine, near Tottenham, New South Wales, and at the Burra Burra mine, Mt. Lofty Ranges, South Australia.

Name: From the Greek for *false*, as the mineral closely resembles *malachite*.

Type Material: Mining Academy, Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 799–801. (2) Berry, L.G. (1950) On pseudomalachite and cornetite. Amer. Mineral., 35, 365–385. (3) Shoemaker, G.L., J.B. Anderson, and E. Kostiner (1977) Refinement of the crystal structure of pseudomalachite. Amer. Mineral., 62, 1042–1048.

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Pseudorutile $Fe_2^{3+}Ti_3O_9$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As thin, irregular plates having fibrous texture; fine-grained, massive, replacing ilmenite crystals and grains.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = ∼3.8 D(calc.) = [4.82] Magnetic.

Optical Properties: Opaque, transparent when very thin. *Color:* Dark steel-gray on fresh fractures, light brown to black; deep red in transmitted light. *Streak:* Reddish brown. *Luster:* Submetallic to metallic.
Optical Class: Uniaxial; moderate birefringence. *Pleochroism:* Very weak; in reds. *Absorption:* $Z > X$. $n = \sim 2.62$

Cell Data: *Space Group:* $P6_322$. $a = 14.375(6)$ $c = 4.615(3)$ Z = [6]

X-ray Powder Pattern: South Neptune Island, South Australia.
1.6860 (100), 2.481 (80), 2.187 (70), 2.784 (20d), 3.897 (15d), 2.2993 (8), 1.6253 (6d)

Chemistry:

	(1)	(2)
TiO_2	58.84	60.01
Fe_2O_3	34.65	39.99
Mn_2O_3	0.60	
FeO	1.24	
H_2O^+	3.24	
Total	98.57	100.00

(1) South Neptune Island, South Australia; corresponds to $(Fe^{3+}_{1.81}Fe^{2+}_{0.07}Mn^{3+}_{0.03})_{\Sigma=1.91}$ $Ti_{3.08}O_9 \cdot 0.75H_2O$. (2) $Fe_2Ti_3O_9$.

Occurrence: An intermediate product of the weathering of ilmenite.

Association: Ilmenite, rutile, anatase, hematite, gadolinite.

Distribution: On South Neptune Island, South Australia. In the USA, around Lakehurst, Ocean Co., New Jersey. Other occurrences have been tentatively noted in ilmenite-rich beach sands.

Name: From the Greek for *false* and its relation to *rutile*.

Type Material: Museum Victoria, Melbourne, Australia, M42789.

References: (1) Teufer, G. and A.K. Temple (1966) Pseudorutile – a new mineral intermediate between ilmenite and rutile in the natural alteration of ilmenite. Nature, 211, 179–181. (2) Grey, I.E. and A.F. Reid (1975) The structure of pseudorutile and its role in the natural alteration of ilmenite. Amer. Mineral., 60, 898–906. (3) Grey, I.E., J.A. Watts, and P. Bayliss (1994) Mineralogical nomenclature: pseudorutile revalidated and neotype given. Mineral. Mag., 58, 597–600.

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Pseudosinhalite $Mg_2Al_3B_2O_9(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As a topotactic replacement of sinhalite grains. *Twinning:* Polysynthetic on a very fine scale, observed optically.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.508

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$. $n = 1.72$ $\alpha = 1.691(1)$ (synthetic) $\beta = 1.713(1)$ $\gamma = 1.730(1)$ 2V(meas.) = 80°

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy to synthetic). $a = 7.49(1)$ $b = 4.33(1)$ $c = 9.85(1)$ $\beta = 110.7(1)°$ Z = 2

X-ray Powder Pattern: Tayozhnoye deposit, Russia.
2.14 (100), 1.625 (100), 2.102 (60), 3.21 (40), 2.61 (40), 1.607 (40), 1.399 (40)

Chemistry:

	(1)	(2)
B_2O_3	[21.75]	22.30
Al_2O_3	46.88	48.99
FeO	1.99	
MgO	25.12	25.82
H_2O	[2.81]	2.89
Total	[98.55]	100.00

(1) Tayozhnoye deposit, Russia; by electron microprobe, average of 14 analyses; total Fe as FeO, B_2O_3 and H_2O calculated for stoichiometry; corresponds to $(Mg_{1.98}Fe_{0.09})_{\Sigma=2.07}$ $Al_{2.93}B_{2.00}O_9(OH)$. (2) $Mg_2Al_3B_2O_9(OH)$.

Occurrence: A rare mineral in a contact-metasomatic boron-rich iron deposit, a product of retrograde alteration of sinhalite in magnesium-bearing skarn.

Association: Forsterite, spinel, ludwigite, warwickite, suanite, szaibélyite, brucite, clinohumite, sinhalite, hydrotalcite.

Distribution: From the Tayozhnoye iron deposit, 550 km south of Yakutsk, Sakha, Russia.

Name: From the Greek for *false*, in recognition of its close relation to *sinhalite*.

Type Material: Institute for Mineralogy, Ruhr University, Bochum, Germany.

References: (1) Schreyer, W., N.N. Pertsev, O. Medenbach, M. Burchard, and D. Dettmar (1998) Pseudosinhalite: discovery of the hydrous MgAl−borate as a new mineral in the Tayozhnoye, Siberia, skarn deposit. Mineral. Petrol., 133, 382–388. (2) (1999) Amer. Mineral., 84, 1196–1197 (abs. ref. 1). (3) Daniels, P., S. Krosse, G. Werdling, and W. Schreyer (1997) "Pseudosinhalite", a new hydrous MgAl−borate: synthesis, phase characterization, crystal structure, and *PT*-stability. Mineral. Petrol., 128, 261–271. (4) Strunz, H. and E. Nickel (2000) Pseudosinhalite is a structural isotype of chondrodite. (2000) Amer. Mineral., 85, 1828–1829.

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Pucherite $BiVO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, equant to tabular {001}, with curved faces and composite structure, may be acicular, to 4 mm; many forms, including {001}, {111}, {011}, {112}. As coatings of minute crystals, ocherous, massive.

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 4 D(meas.) = n.d. D(calc.) = 6.69

Optical Properties: Transparent to opaque. *Color:* Dark brownish red, reddish brown, yellowish brown; yellow-brown in transmitted light. *Streak:* Yellow. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, extreme. $\alpha = 2.41(2)$ $\beta = 2.50(2)$ $\gamma = 2.51(2)$ 2V(meas.) = 19(5)°

Cell Data: *Space Group: Pnca.* $a = 5.328(2)$ $b = 5.052(2)$ $c = 12.003(3)$ Z = 4

X-ray Powder Pattern: Schneeberg, Germany. (ICDD 12-293).
3.499 (100), 2.702 (100), 4.644 (55), 3.982 (55), 2.992 (45), 1.992 (45b), 2.133 (40)

Chemistry:

	(1)	(2)
P_2O_5	trace	
V_2O_5	27.31	28.07
Bi_2O_3	73.39	71.93
Total	100.70	100.00

(1) Schneeberg, Germany. (2) $BiVO_4$.

Polymorphism & Series: Trimorphous with clinobisvanite and dreyerite.

Occurrence: A rare alteration product of other bismuth minerals in the oxidized zone of some hydrothermal ore deposits; in zoned granite pegmatites.

Association: Bismuth, bismutite, beyerite, bismuthinite, schumacherite, clinobisvanite.

Distribution: In Germany, well-crystallized from the Pucher shaft, Wolfgang Maassen mine, and elsewhere near Schneeberg, Saxony; at Reichenbach, near Bensheim, Hesse; in the Clara Mine, near Oberwolfach, Black Forest. On Mt. Bity, at Samiresy, and Ampangabe, Madagascar. From Mutala, Mozambique. At the Golconda prospect, near Harare, Zimbabwe. In the USA, from the Harding mine, Taos Co., New Mexico; at the Stewart, Pala Chief, and other mines, Pala district, and in the Little Three mine, Ramona district, San Diego Co., California. From São José, Brejauba, and at Matto Dentro, Minas Gerais, Brazil. From near Koktokay [Kyokfogoi], Xinjiang Uygur Autonomous Region, China. In Australia, from Morass Creek, north of Benambra, Victoria; in the Londonderry quarry, southwest of Coolgardie, Western Australia.

Name: For its original occurrence at the Pucher shaft, Schneeberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1050–1052. (2) Granzin, J. and D. Pohl (1984) Refinement of pucherite. Zeits. Krist., 169, 289–294.

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Pumpellyite-(Fe^{2+}) $Ca_2(Fe^{2+},Fe^{3+},Mg)Al_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As rosettes and spherulites in stringers.

Physical Properties: Hardness = [~5] (by analogy to the pumpellyite group).
D(meas.) = 3.31 D(calc.) = [3.35]

Optical Properties: Semitransparent. *Color:* [Greenish black.] *Luster:* [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; Y = deep grass-green; Z = yellowish brown to reddish brown. *Orientation:* $Z \wedge c = 5°$. $\alpha = 1.728$ $\beta = 1.748$ $\gamma = 1.754$
2V(meas.) = $-60°$ to $30°$

Cell Data: *Space Group:* n.d. $a = 8.89(2)$ $b = 6.03(3)$ $c = 19.19(4)$ $\beta = 97°49(12)'$
Z = 4

X-ray Powder Pattern: Noril'sk, Russia.
2.91 (100), 3.79 (64), 2.75 (60), 2.22 (36), 2.66 (34), 4.76 (30), 4.43 (27)

Chemistry:

	(1)
SiO_2	34.83
TiO_2	0.10
Al_2O_3	10.10
Fe_2O_3	18.05
FeO	9.09
MnO	0.02
MgO	0.94
CaO	20.50
Na_2O	0.18
H_2O^+	5.62
Total	99.43

(1) Noril'sk, Russia; corresponds to $(Ca_{1.94}Na_{0.03}Fe^{2+}_{0.02})_{\Sigma=1.99}(Fe^{2+}_{0.65}Fe^{3+}_{0.25}Mg_{0.12})_{\Sigma=1.02}(Al_{1.06}Fe^{3+}_{0.95})_{\Sigma=2.01}Si_{3.08}O_{11}(OH)_2 \cdot 1.32H_2O$.

Polymorphism & Series: Forms two series, with julgoldite-(Fe^{2+}), and with pumpellyite-(Mg).

Mineral Group: Pumpellyite group.

Occurrence: In the contact zone around an intrusive.

Association: Prehnite, babingtonite, clinopyroxene, calcite.

Distribution: From near Noril'sk, western Siberia, Russia.

Name: For its membership in the *pumpellyite* group and dominant *ferrous iron* content.

Type Material: n.d.

References: (1) Zolotukhin, V.V., Y.R. Vasil'yev, and N.I. Zyuzin (1965) Iron-rich pumpellyite from the Noril'sk district and a new diagram for pumpellyites. Doklady Acad. Nauk SSSR, 165, 1156–1159 (in Russian). (2) Passaglia, E. and G. Gottardi (1973) Crystal chemistry and nomenclature of pumpellyites and julgoldites. Can. Mineral., 12, 219–223. (3) (1976) Amer. Mineral., 61, 176–177 (abs. ref. 2). (4) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 201–247.

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Pumpellyite-(Fe^{3+})

$Ca_2(Fe^{3+}, Mg, Fe^{2+})$
$(Al, Fe^{3+})_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2/*m*. Fibrous.

Physical Properties: Hardness = [~5] (by analogy to the pumpellyite group).
D(meas.) = n.d. D(calc.) = [3.25]

Optical Properties: Semitransparent. *Color:* [Greenish black.] *Luster:* [Vitreous.]
Optical Class: Biaxial. α = n.d. β = 1.713 γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 8.8340$ $b = 5.9528$ $c = 19.1849$ $\beta = 97.451°$ Z = 4

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SiO_2	35.75	36.75
TiO_2	0.12	0.05
Al_2O_3	18.70	18.81
Fe_2O_3	11.10	13.59
Mn_2O_3		0.03
Cr_2O_3		0.01
FeO	2.80	
MnO	0.05	
MgO	3.12	2.64
CaO	20.72	21.09
Na_2O	0.44	0.03
K_2O	0.06	
H_2O^+	6.63	[7.00]
Total	99.49	[100.00]

(1) Bulla, Italy; corresponds to $(Ca_{1.84}Na_{0.07}Fe^{2+}_{0.06})_{\Sigma=1.97}(Fe^{3+}_{0.48}Mg_{0.38}Fe^{2+}_{0.14})_{\Sigma=1.00}$ $(Al_{1.78}Fe^{3+}_{0.21})_{\Sigma=1.99}(Si_{2.96}Al_{0.04})_{\Sigma=3.00}O_{11}(OH)_2 \cdot 1.66H_2O$. (2) Do.; by electron microprobe, H_2O fixed at 7%.

Mineral Group: Pumpellyite group.

Occurrence: In altered porphyritic rocks.

Association: Plagioclase, hematite.

Distribution: From Bulla, Trentino-Alto Adige, Italy.

Name: For its membership in the *pumpellyite* group and dominant *ferric iron* content.

Type Material: n.d.

References: (1) Passaglia, E. (1972) Pumpellyite fortemente ferrifera rimvenuta a Bulla (Bolzano). Period. Mineral., 41, 273–280 (in Italian). (2) Passaglia, E. and G. Gottardi (1973) Crystal chemistry and nomenclature of pumpellyites and julgoldites. Can. Mineral., 12, 219–223. (3) (1976) Amer. Mineral., 61, 176–177 (abs. ref. 2). (4) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 201–247. (5) Artioli, G. (1991) XANES studies of Fe in pumpellyite-group minerals. Neues Jahrb. Mineral., Monatsh., 413–421.

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Pumpellyite-(Mg) $Ca_2MgAl_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals bladed, typically elongated along [010]; in stellate clusters, fibrous, or dense mats. *Twinning:* Common on {001} and {100}.

Physical Properties: *Cleavage:* Distinct on {001} and {100}. Hardness = 5.5
D(meas.) = 3.18(3) D(calc.) = 3.20

Optical Properties: Translucent to nearly opaque. *Color:* Green, bluish green, greenish black, brown; colorless, green, yellow, brown in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = nearly colorless to pale greenish yellow; Y = blue-green; Z = almost colorless to brownish yellow. *Orientation:* $Z \wedge c = 20°–25°$. *Dispersion:* $r < v$, strong; less commonly $r > v$. *Absorption:* $Y > Z \geq X$. $\alpha = 1.695–1.702$ $\beta = 1.703–1.709$ $\gamma = 1.717–1.722$ 2V(meas.) = 80°

Cell Data: *Space Group:* $A2/m$. $a = 8.83(1)$ $b = 5.90(1)$ $c = 19.17(2)$ $\beta = 97°7(5)'$
Z = 4

X-ray Powder Pattern: Calumet, Michigan, USA.
2.90 (100), 3.79 (50), 2.74 (50), 2.452 (40), 2.64 (30), 2.210 (30), 1.597 (30)

Chemistry:

	(1)		(1)
SiO_2	37.18	CaO	23.08
Al_2O_3	23.50	Na_2O	0.19
Fe_2O_3	5.29	K_2O	trace
FeO	2.09	H_2O^+	6.28
MnO	0.13	H_2O^-	0.06
MgO	3.18	Total	[100.98]

(1) Calumet and Hecla mine, Michigan, USA; original total given as 100.97%, corresponds to $(Ca_{1.99}Na_{0.03})_{\Sigma=2.02}(Mg_{0.38}Fe^{3+}_{0.32}Al_{0.22}Fe^{2+}_{0.14}Mn_{0.01})_{\Sigma=1.07}Al_{2.00}Si_{2.99}O_{11}(OH)_{2.43}$.

Polymorphism & Series: Forms two series, with pumpellyite-(Fe^{2+}), and with julgoldite-(Fe^{2+}).

Mineral Group: Pumpellyite group.

Occurrence: A widespread product of low-grade metamorphism of amygdaloidal basalts and diabases; in glaucophane schists and in graywackes.

Association: Chlorite, epidote, actinolite, lawsonite, glaucophane, prehnite, zeolites, quartz.

Distribution: In the USA, in Michigan, at Calumet, Houghton Co., and elsewhere on the Keweenaw Peninsula and Isle Royale; at Skaggs Springs, 24 km northwest of Healdsburg, and at Novato and Porter Creek, Sonoma Co., and elsewhere in California. From Lendalfoot, Aryshire, Scotland. At Great Penhaver Point, Roseland, and in the Penlee quarry, Newlyn, Cornwall, England. From Knipane, Iveland, Norway. In Germany, at Herbornseelbach, Hesse. At Wienern, Styria, Austria. From Obřī Důl (Riesengrund), Czech Republic. Around Tiso, Trentino-Alto Adige, Italy. In Japan, from Oonara, Sanbagawa, Gumma Prefecture, and many other localities. From New Zealand, in the Tasingatura district, South Island.

Name: For Raphael Pumpelly (1837–1923), pioneer student of the paragenesis of copper deposit minerals of the Keweenaw Peninsula, Michigan, USA, and dominant *magnesium* content.

Type Material: Harvard University, Cambridge, Massachusetts, 90919; National Museum of Natural History, Washington, D.C., USA, 95279–95281; The Natural History Museum, London, England, 1926,225–226.

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References: (1) Palache, C. and H.E. Vasser (1925) Some minerals of the Keweenawan copper deposits: pumpellyite, a new mineral; sericite; saponite. Amer. Mineral., 10, 412–418. (2) Coombs, D.S. (1953) The pumpellyite mineral series. Mineral. Mag., 30, 113–135. (3) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 201–247. (4) Yoshiasa, A. and T. Matsumoto (1985) Crystal structure refinement and crystal chemistry of pumpellyite. Amer. Mineral., 70, 1011–1019.

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Pumpellyite-(Mn^{2+})

$Ca_2(Mn^{2+},Mg)(Al,Mn^{3+},Fe)_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Platy crystals, to 0.1 mm, elongated along [010] and tabular on {001}; fine granular.

Physical Properties: *Cleavage:* One perfect, presumably {001}, seen in thin section. Hardness = ~5 in aggregate. D(meas.) = n.d. D(calc.) = 3.34

Optical Properties: Semitransparent. *Color:* Light grayish pink to brownish pink. *Streak:* Light grayish pink. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = pale pink; $Y = Z$ = brownish pink. $\alpha = 1.752(2)$ $\beta = 1.795(5)$ $\gamma = 1.800(5)$ 2V(meas.) = ~40°

Cell Data: *Space Group:* $A2/m$. $a = 8.923$ $b = 5.995$ $c = 19.156$ $\beta = 97°8'$ Z = 4

X-ray Powder Pattern: Ochiai mine, Japan.
2.930 (100), 2.725 (90), 4.75 (65), 3.844 (65), 2.654 (55), 2.533 (50), 2.205 (45)

Chemistry:

	(1)
SiO_2	35.66
TiO_2	0.02
Al_2O_3	13.40
Fe_2O_3	2.43
Mn_2O_3	7.74
MnO	13.41
MgO	0.89
CaO	20.69
Na_2O	0.01
H_2O	[5.75]
Total	[100.00]

(1) Ochiai mine, Japan; by electron microprobe, H_2O by difference; corresponds to $(Ca_{1.89}Mn^{2+}_{0.08})_{\Sigma=1.97}(Mn^{2+}_{0.89}Mg_{0.11})_{\Sigma=1.00}(Al_{1.34}Mn^{3+}_{0.50}Fe^{3+}_{0.16})_{\Sigma=2.00}Si_{3.03}O_{11}(OH)_2 \cdot 1.26H_2O$.

Mineral Group: Pumpellyite group.

Occurrence: In braunite ore in a syngenetic bedded manganese deposit developed in low-grade metamorphic rocks.

Association: Braunite, piemontite, clinozoisite, caryopilite, johannsenite, rhodochrosite, albite, quartz, calcite.

Distribution: In the Ochiai mine, 3.5 km west of Barazawa, Yamanashi Prefecture, Japan.

Name: For its membership in the *pumpellyite* group and dominant *manganous manganese* content.

Type Material: National Science Museum, Tokyo, Japan, M23125; National Museum of Natural History, Washington, D.C., USA, 147159, 147160.

References: (1) Kato, A., S. Matsubara, and R. Yamamoto (1981) Pumpellyite-(Mn^{2+}) from the Ochiai mine, Yamanashi Prefecture, Japan. Bull. Minéral., 104, 396–399. (2) (1983) Amer. Mineral., 68, 1250 (abs. ref. 1).

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Punkaruaivite $LiTi_2[Si_4O_{11}(OH)](OH)_2 \cdot H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Crystals bladed, to 3 mm, flattened on {100} and exhibiting forms {100}, {001}, {011}; in sheaflike and divergent aggregates, to 4 mm.

Physical Properties: *Cleavage*: Perfect on {100}. *Fracture*: Step-like. *Tenacity*: Brittle. Hardness = 4.5 D(meas.) = 2.60(5) D(calc.) = 2.55

Optical Properties: Transparent to translucent. *Color*: Yellowish brown to colorless; brownish yellow in transmitted light. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.658(2)$ $\beta = 1.696(2)$ $\gamma = 1.726(5)$ 2V(meas.) = 85(5)°
2V(calc.) = 82° O*rientation*: $X = b$; $Y \wedge c = 12°$. *Pleochroism*: Weak; Y = light brownish yellow; X = brownish yellow.

Cell Data: *Space Group*: *C*2/*c*. $a = 26.688(2)$ $b = 8.7568(7)$ $c = 5.2188(5)$
$\beta = 91.189(2)°$ $Z = 4$

X-ray Powder Pattern: Mt. Punkaruaiv, Kola Peninsula, Russia.
13.3 (100), 6.23 (80), 3.50 (80), 3.01 (70), 2.81 (70), 4.38 (60), 4.16 (40)

Chemistry:

	(1)
Li_2O	3.22
Na_2O	0.29
K_2O	0.14
CaO	0.01
MnO	0.31
FeO	0.21
Al_2O_3	0.05
SiO_2	51.35
TiO_2	32.50
Nb_2O_5	1.06
H_2O	10.50
Total	99.64

(1) Mt. Punkaruaiv, Kola Peninsula, Russia; average of 5 electron microprobe and flame photometric analyses, IR confirms OH, and H_2O, corresponding to $(Li_{1.02}Na_{0.04}K_{0.01})_{\Sigma=1.07}(Ti_{1.92}Nb_{0.04}Mn_{0.02}Fe^{3+}_{0.01})_{\Sigma=1.99}(OH)_{2.00}[Si_{4.03}O_{11.03}(OH)_{0.97}] \cdot 1.26H_2O$.

Occurrence: A hydrothermal vein mineral in a ussingite-aegirine-microcline bearing pegmatite in nepheline syenite (Mt. Punkaruaiv); in natrolite-microcline foyalite (Mt. Eveslogschorr).

Association: Belovite-(Ce), chlakovite, ferronordite-(Ce), gmelenite-Ca, manganoneptunite, manganonordite-(Ce), sphalerite, ussingite (Mt. Punkaruaiv); belovite-(La), chivruaiite, kuzmenkoite-Mn, monazite-(La), murmanite, natrolite (Mt. Eveslogschorr).

Distribution: Mt. Punkaruaiv, Lovozero massif and Mt. Eveslogschorr, Khibiny massif, Kola Peninsula, Russia.

Name: For Mt. Punkaruaiv, Kola Peninsula, Russia, one of the first described localities.

Type Material: Mineralogical Museum, St. Petersburg State University, Russia; Geological and Mineralogical Museum of the Geological Institute of the Kola Science Centre of the Russian Academy of Sciences, Apatity, Russia (no. 6441).

References: (1) Yakovenchuk, V.N., G.Y. Ivanyuk, Y.A Pakhomovsky, E.A. Selivanoya, Y.P. Men'Shikov, J.A. Korchak, S.V. Krivovichev, D.V. Spiridonova, and O.A. Zalkind (2010) Punkaruaivite, $LiTi_2[Si_4O_{11}(OH)](OH)_2 \cdot H_2O$, a new mineral species from hydrothermal assemblages, Khibiny and Lovozero alkaline massifs, Kola Peninsula, Russia. Can. Mineral., 48, 41–50. (2) (2010) Amer. Mineral., 95, 1599-1600 (abs. ref. 1).

Purpurite $(Mn^{3+}, Fe^{3+})PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Massive; cleavage fragments to 20 cm.

Physical Properties: *Cleavage:* {100}, good; {010}, imperfect; surfaces may be curved or crinkled. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 3.2–3.4 D(calc.) = 3.69

Optical Properties: Translucent to opaque. *Color:* Reddish purple to deep rose-red; commonly surficially dark brown to brownish black from alteration. *Streak:* Pale purple to pale red. *Luster:* Satiny on fresh fractures.
Optical Class: Biaxial (+). *Pleochroism:* X = greenish gray, gray to rose-red; $Y = Z$ = blood-red to purplish red; optic axis sections show anomalous green interference colors. *Orientation:* $X = a$. *Dispersion:* Moderate. *Absorption:* $Z = Y > X$ or $Z > Y \gg X$. $\alpha = 1.85(2)$ $\beta = 1.86(2)$ $\gamma = 1.92(2)$ 2V(meas.) = 38°

Cell Data: *Space Group: Pmnb.* $a = 5.8237(6)$ $b = 9.766(1)$ $c = 4.7771(5)$ Z = 4

X-ray Powder Pattern: Namibia. (ICDD 37–478).
4.293 (100), 4.883 (70), 2.4423 (70), 3.455 (65), 2.912 (60), 2.946 (35), 2.4099 (30)

Chemistry:

	(1)	(2)
P_2O_5	47.30	47.20
Fe_2O_3	15.89	26.55
Mn_2O_3	29.25	26.25
CaO	1.48	
Na_2O	0.84	
Li_2O	trace	
H_2O	5.26	
insol.	0.52	
Total	100.54	100.00

(1) Faires tin mine, North Carolina, USA. (2) $(Mn, Fe)PO_4$ with Mn:Fe = 1:1.

Polymorphism & Series: Forms a series with heterosite.

Occurrence: Derived from oxidation and leaching of primary Mn–Fe phosphates, particularly lithiophilite, in complex granite pegmatites; rarely, formed by reaction between bat guano and Fe–Mn deposits resulting from seawater ingress.

Association: Lithiophilite, sicklerite, many secondary Fe–Mn phosphates.

Distribution: A number of minor localities. In the USA, from the Faires tin mine, Kings Mountain, Gaston Co., North Carolina; at several mines in the Pala and Rincon districts, San Diego Co., California; in the White Picacho district, Yavapai Co., Arizona; large cleavages from the Crystal Mountain district, Larimer Co., Colorado; at the Custer Mountain mine and other pegmatites in Custer Co., South Dakota; from Branchville, Fairfield Co., Connecticut; at Greenwood and Rumford, Oxford Co., Maine. From the Mangualde pegmatite, near Mesquitela, Portugal. At the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. In the Viitaniemi pegmatite, near Eräjärvi, Finland. From the La Vilate quarry, near Chanteloube, Haute-Vienne, France. At Wodgina, Western Australia. From the Karibib district, Namibia. In the Gunong Keriang Cave, Malaysia.

Name: From the Latin for *purple*, in allusion to its typical color.

Type Material: National Museum of Natural History, Washington, D.C., USA, 93883.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 675–677.

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Pushcharovskite $Cu(AsO_3OH)\cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals are tabular on {010}, elongated along [100], fluted, acicular, fibrous, to 0.5 mm, in subparallel radiating aggregates. *Twinning:* Polysynthetic on {010}.

Physical Properties: *Cleavage:* Perfect on {010}; good on {001}. *Fracture:* Fibrous. *Tenacity:* Fragile [*sic*]. Hardness = n.d. D(meas.) = 3.35(2) D(calc.) = 3.34(1)

Optical Properties: Transparent. *Color:* Pale green to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z \wedge a = 18.4°$ on {010}. *Dispersion:* $r > v$, medium. $\alpha = 1.602(2)$ $\beta = 1.642(2)$ $\gamma = 1.725(5)$ 2V(meas.) = 70(3)° 2V(calc.) = 73(1)°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 6.435(2)$ $b = 11.257(4)$ $c = 18.662(9)$ $\alpha = 74.90(6)°$ $\beta = 86.48(7)°$ $\gamma = 83.59(4)°$ Z = 12

X-ray Powder Pattern: Cap Garonne mine, France.
11.00 (100), 2.920 (60), 2.816 (50), 2.592 (50), 3.171 (30), 18.3 (25), 2.492 (25)

Chemistry:

	(1)	(2)
As_2O_5	52.31	51.89
CuO	35.70	35.91
H_2O	12.00	12.20
Total	100.01	100.00

(1) Cap Garonne mine, France; by electron microprobe, average of seven analyses, H_2O by TGA; corresponds to $Cu_{1.00}(As_{1.01}O_3OH)\cdot 0.98H_2O$. (2) $Cu(AsO_3OH)\cdot H_2O$.

Polymorphism & Series: Dimorphous with geminite.

Occurrence: A very rare secondary mineral from the oxidized zone of a polymetallic hydrothermal base metal deposit (Cap Garonne mine, France).

Association: Tennantite, covellite, geminite, lindackerite, yvonite, mahnertite, arsenopyrite, bismuth, chalcopyrite, quartz.

Distribution: In France, from the Cap Garonne mine, near le Pradet, Var, and at the Salsigne mine, 15 km north of Carcassone, Aude.

Name: To honor Professor Dmitry Y. Pushcharovskiy, crystallographer, Moscow State University, Moscow, Russia.

Type Material: Natural History Museum, Geneva, Switzerland.

References: (1) Sarp, H. and J. Sanz-Gysler (1997) La pushcharovskite, $Cu(AsO_3, OH)\cdot H_2O$, un nouveau minéral de la mine de Cap Garonne, Var (France). Archs Sci. Genève, 50(3), 177–186 (in French with English abs.). (2) (1999) Amer. Mineral., 84, 196–197 (abs. ref. 1).

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Putnisite $SrCa_4Cr_8^{3+}(CO_3)_8SO_4(OH)_{16}\cdot 25H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As pseudocubic crystals to 0.5 mm.

Physical Properties: *Cleavage*: One excellent and two good parallel to {100}, {010}, and {001}. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 1.5-2 D(meas.) = 2.20(3) D(calc.) = 2.23

Optical Properties: Translucent. *Color*: Pale to dark purple. *Streak*: Pink. *Luster*: Vitreous. *Optical Class*: Biaxial (-). α =1.552(3) β = 1.583(3) γ = 1.599(3) *Orientation*: Uncertain. *Pleochroism*: Distinct, *X* = pale bluish gray, *Y* = pale purple, *Z* = pale purple.

Cell Data: *Space Group*: *Pnma*. *a* = 15.351(3) *b* = 20.421(4) *c* = 18.270(4) Z = 4

X-ray Powder Pattern: Halls Knoll gossan, Western Australia, Australia.
13.58 (100), 7.66 (80), 6.67 (43), 5.084 (19), 3.689 (16), 4.901 (13), 7.09 (10)

Chemistry:

	(1)
Na_2O	0.17
MgO	0.08
CaO	10.81
SrO	5.72
BaO	0.12
CuO	0.29
Cr_2O_3	31.13
SO_3	3.95
SiO_2	0.08
Cl^-	0.28
CO_2	[17.94]
H_2O	[30.30]
-O=Cl	0.06
Total	100.81

(1) Halls Knoll gossan, Western Australia, Australia; average of 11 electron microprobe analyses, CO_2 and H_2O calculated from crystal structure analysis and confirmed by infrared spectroscopy, OH^- calculated for charge balance; corresponding to $Cr^{3+}_{8.02}Ca_{3.78}Sr_{1.08}Na_{0.11}Cu^{2+}_{0.07}Mg_{0.04}Ba_{0.02}[(SO_4)_{0.96}(SiO_4)_{0.03}]_{\Sigma=0.99}(CO_3)_{7.98}(OH)_{16.19}Cl_{0.15}\cdot 24.84H_2O$.

Occurrence: A product of the oxidation of a massive nickel sulfide deposit in komatiitic/dioritic rocks.

Association: Quartz, a near-amorphous dark green mineral.

Distribution: From the Halls Knoll gossan, Polar Bear peninsula, Southern Lake Cowan, 40 km north of Norseman, Western Australia, Australia.

Name: Honors Australian mineralogists Christine and Andrew Putnis of the Institut für Mineralogie, Universtität Münster, Germany, in recognition of their outstanding contributions to mineralogy.

Type Material: South Australian Museum, Adelaide, South Australia, (registration number G33429) and at the Canadian Museum of Nature, Ottawa, Canada (CMNMC 86133).

References: (1) Elliott, P., G. Giester, R. Rowe, and A. Pring (2014) Putnisite, $SrCa_4Cr_8^{3+}(CO_3)_8SO_4(OH)_{16}\cdot 25H_2O$, a new mineral from Western Australia: description and crystal structure. Mineral. Mag., 78(1), 131-144. (2) (2014) Amer. Mineral., 99, 1810-1811 (abs. ref. 1).

Putoranite $Cu_9(Fe,Ni)_9S_{16}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rarely as crystals; typically as small grains, to 0.1 mm, finely intergrown with mooihoekite, in aggregates. *Twinning:* Polysynthetic.

Physical Properties: Hardness = n.d. VHN = 263 (50 g load). D(meas.) = n.d. D(calc.) = 6.14

Optical Properties: Opaque. *Color:* Pale yellow in reflected light, similar to mooihoekite and chalcopyrite. *Anisotropism:* Nickelian variety distinctly anisotropic.
R: (400) — , (420) — , (440) — , (460) 24.4, (480) 25.1, (500) 30.0, (520) 31.8, (540) 38.0, (560) 40.0, (580) 41.2, (600) 41.2, (620) 40.9, (640) 41.9, (660) 41.6, (680) 41.2, (700) 41.0

Cell Data: *Space Group:* *Pn3m* (by analogy to synthetic material). $a = 5.30$ $Z = 3$

X-ray Powder Pattern: Oktyabr mine, Russia.
3.05 (10), 1.873 (9), 1.596 (6), 1.081 (5), 1.216 (3), 2.65 (2), 1.326 (2)

Chemistry:

	(1)	(2)
Cu	35.68	32.99
Fe	31.22	32.11
Ni	0.51	1.63
S	32.49	33.14
Total	99.90	99.87

(1) Oktyabr mine, Russia; by electron microprobe, average of seven samples; corresponding to $Cu_{8.87}(Fe_{8.83}Ni_{0.14})_{\Sigma=8.97}S_{16.00}$. (2) Do.; by electron microprobe, average of twelve samples, corresponding to $Cu_{8.04}(Fe_{8.90}Ni_{0.43})_{\Sigma=9.33}S_{16.00}$.

Occurrence: In massive Cu–Ni-sulfide ores (Oktyabr mine, Russia); in Cu–Ni mineralization in peridotite (Sopcha massif, Russia).

Association: Mooihoekite, talnakhite, cabriite, cubanite, pentlandite, magnetite, galena, sphalerite, platinum group minerals, silver, alabandite, valleriite, mackinawite, manganoan shadlunite, djerfisherite (Oktyabr mine, Russia).

Distribution: In Russia, from the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia [TL], and in the Sopcha massif, Monchegorsk pluton, Kola Peninsula.

Name: For Putoran Mountain, east of Noril'sk, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81312.

References: (1) Filimonova, A.A., T.L. Evstigneeva, and I.P. Laputina (1980) Putoranite and nickel-bearing putoranite – new minerals of the chalcopyrite group. Zap. Vses. Mineral. Obshch., 109, 335–341 (in Russian). (2) (1981) Amer. Mineral., 66, 638–639 (abs. ref. 1).

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Crystal Data: Isometric. *Point Group*: $\bar{4}$ 3*m*. As irregular masses intergrown with associated minerals, to 3 mm.

Physical Properties: *Cleavage:* One direction distinct in polished sections. *Tenacity:* Brittle. *Fracture:* Irregular to subconchoidal, rarely splintery. Hardness = 3-3.5 VHN = 188 (50 g load). D(meas.) = n.d. D(calc.) = 5.778

Optical Properties: Opaque. *Color:* Iron-black with a violet tint; pale rose to pale violet in plane-polarized reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R_{air}–R_{oil}: (470) 28.9-13.5, (589) 25.8-1.1, (650) 25.3-10.9

Cell Data: Space Group: $F\bar{4}$ 3*m*. a = 10.1250(12) Z = 4

X-ray Powder Pattern: Rosario shaft, Capillitas mining district, Catamarca Province, Argentina. 2.943 (100), 1.805 (70), 3.074 (60), 1.962 (50), 5.896 (30), 2.083 (30), 1.725 (25), 2.343 (20)

Chemistry:

	(1)	(2)
Cu	32.71	32.48
Ag	39.83	38.71
Ge	7.62	7.89
S	20.59	20.92
Total	100.75	100.00

(1) Rosario shaft, Capillitas mining district, Catamarca Province, Argentina; average of 29 electron microprobe analyses, corresponds to $(Cu_{4.73}Ag_{3.40})_{\Sigma=8.13}Ge_{0.97}S_{5.91}$. (2) $(Cu_{4.7}Ag_{3.3})_{\Sigma=8}GeS_6$.

Occurrence: Fills cavities and vugs in bornite-chalcocite ore associated with andesitic rocks which host porphyry Cu-Au and epithermal vein-type mineral deposits.

Association: Catamarcaite, hübnerite, Ge-stannoidite, luzonite, sphalerite, tennantite, thalcusite, wittichenite, chalcocite, bornite.

Distribution: From dumps near the Rosario shaft, Capillitas mining district, Department of Andalgalá, Catamarca Province, Argentina.

Name: Honors Hubert Putz (b. 1973), who discovered the first specimens and who has made a significant contribution to the mineralogy of Ge in the Capillitas deposit.

Type Material: Division of Mineralogy, University of Salzburg, Austria (14835-14837); the Systematic References Series, National Mineral Collection of Canada, Geological Survey of Canada, Ottawa, Canada (NMCC 68096); and the Laboratory for Chemical and Mineralogical Crystallography, University of Bern, Switzerland.

References: (1) Paar, W.H., A.C. Roberts, P. Berlepsch, T. Armbruster, D. Topa, and G. Zagler (2004) Putzite, $(Cu_{4.7}Ag_{3.3})_{\Sigma=8}GeS_6$, a new mineral species from Capillitas, Catamarca, Argentina: Description and crystal structure. Can. Mineral., 42(6), 1757-1769. (2) (2005) Amer. Mineral., 90, 1231-1232 (abs. ref. 1).

Pyrargyrite Ag_3SbS_3

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals commonly prismatic ‖ [0001], showing hemimorphism, typically with prominent development of rhombohedra; also steep scalenohedra with $\{05\bar{5}1\}$, to 6 cm; massive, granular. *Twinning:* On $\{10\bar{1}4\}$ as twins of complex aggregates of individuals and as lamellar twins; less commonly on $\{10\bar{1}1\}$ and about $[11\bar{2}0]$; rarely on $\{01\bar{1}2\}$.

Physical Properties: *Cleavage:* Distinct on $\{10\bar{1}1\}$, very imperfect on $\{01\bar{1}2\}$. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5 VHN = n.d. D(meas.) = 5.82 D(calc.) = 5.855

Optical Properties: Translucent, darkens with exposure to light. *Color:* Deep red. *Streak:* Purplish red. *Luster:* Adamantine.
Optical Class: Uniaxial (–). *Pleochroism:* Distinct in air. $\omega = 3.084$ (Li). $\epsilon = 2.881$ (Li).
Anisotropism: Strong, in pale yellow and gray-blue.
R_1–R_2: (400) 35.0–41.0, (420) 34.8–40.8, (440) 34.6–40.6, (460) 34.0–40.2, (480) 32.8–39.5, (500) 31.0–37.4, (520) 29.6–35.4, (540) 28.2–34.0, (560) 27.2–32.7, (580) 26.4–31.7, (600) 25.6–30.9, (620) 25.0–30.2, (640) 24.4–29.6, (660) 23.8–29.0, (680) 23.4–28.5, (700) 22.9–28.1

Cell Data: *Space Group: R3c.* a = 11.047 $c = 8.719$ Z = 6

X-ray Powder Pattern: Beaverdell, British Columbia, Canada.
2.79 (10) 3.21 (8), 3.35 (5), 2.58 (5), 2.54 (5), 1.965 (2), 1.870 (2)

Chemistry:

	(1)	(2)	(3)
Ag	59.82	60.17	59.76
Sb	22.00	21.64	22.48
As	0.08	0.52	
S	17.82	17.65	17.76
Total	99.72	99.98	100.00

(1) Săcărîmb (Nagyág), Romania. (2) Freiberg, Germany. (3) Ag_3SbS_3.

Polymorphism & Series: Dimorphous with pyrostilpnite.

Occurrence: Formed in hydrothermal veins as a primary late-stage, low-temperature mineral; also formed by secondary processes.

Association: Silver, acanthite, tetrahedrite, other silver sulfosalts, calcite, dolomite, quartz.

Distribution: An important ore of silver, not uncommon in oxidized silver deposits, but rarely in fine specimens. In Germany, from the Harz Mountains, at St. Andreasberg; and in the Himmelsfürst mine, Erbisdorf, near Freiberg, Saxony. From Hiendelaencina, Guadalajara Province, Spain. At Jáchymov (Joachimsthal) and from Příbram, Czech Republic. In the USA, in Nevada, at the Comstock Lode, Virginia City, Storey Co., in the Hecla Rosebud mine, Rosebud district, Pershing Co., and from the Reese River district, Lander Co.; in Idaho, in the Poorman mine, Silver City district, Owyhee Co. In Canada, from Cobalt, Ontario. In Bolivia, at Colquechaca, Potosí. From many localities in Mexico, especially at Fresnillo, Zacatecas, and Guanajuato. From Chañarcillo, south of Copiapó, Atacama, Chile. At San Cristobal, Junin, and in the San Genaro mine, Huancavelica, Peru. From Broken Hill, New South Wales, Australia.

Name: From the Greek for *fire* and *silver*, in allusion to its composition and color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 362–366. (2) Toulmin, P. (1963) Proustite–pyrargyrite solid solutions. Amer. Mineral., 48, 725–736. (3) Engel, P. and W. Nowacki (1966) Die Verfeinerung der Kristallstruktur von Proustit, Ag_3AsS_3, und Pyrargyrit, Ag_3SbS_3. Neues Jahrb. Mineral., Monatsh., 181–184 (in German). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 123. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 774–777.

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Pyrite FeS_2

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Typically cubic, pyritohedral, octahedral, and combinations of these and other forms, to 25 cm or more. Striated conforming to pyritohedral symmetry; may be elongated to acicular. Commonly granular, globular, framboidal, stalactitic. *Twinning:* Twin axis [001] and twin plane {011}, penetration and contact twins.

Physical Properties: *Cleavage:* Indistinct on {001}; partings on {011} and {111}, indistinct. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 1505–1520 (100 g load). D(meas.) = 5.018 D(calc.) = 5.013 Paramagnetic; a semiconductor.

Optical Properties: Opaque. *Color:* Pale brass-yellow, tarnishes darker and iridescent; in polished section creamy white. *Streak:* Greenish black to brownish black. *Luster:* Metallic, splendent. *Anisotropism:* Rarely.
R: (400) 38.2, (420) 40.5, (440) 42.8, (460) 45.5, (480) 48.5, (500) 51.0, (520) 52.6, (540) 53.8, (560) 54.6, (580) 55.0, (600) 55.2, (620) 55.5, (640) 56.0, (660) 56.4, (680) 56.8, (700) 57.0

Cell Data: *Space Group:* $Pa3$. $a = 5.4179(11)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
1.6332 (100), 2.7088 (85), 2.4281 (65), 2.2118 (50), 1.9155 (40), 3.128 (35), 1.4479 (25)

Chemistry:

	(1)	(2)	(3)	(4)
Fe	46.49	29.30	33.32	46.55
Ni		16.69	0.19	
Co		trace	13.90	
S	53.49	53.40	52.45	53.45
Total	99.98	99.39	99.86	100.00

(1) Elba, Italy; remainder 0.04% SiO_2. (2) Mill Close mine, Derbyshire, England. (3) Gladhammar, Sweden. (4) FeS_2.

Polymorphism & Series: Dimorphous with marcasite; forms a series with cattierite.

Mineral Group: Pyrite group.

Occurrence: Formed under a wide variety of conditions. In hydrothermal veins as very large bodies, as magmatic segregations, as an accessory mineral in igneous rocks, in pegmatites; in contact metamorphic deposits, also in metamorphic rocks; as diagenetic replacements in sedimentary rocks.

Association: Pyrrhotite, marcasite, galena, sphalerite, arsenopyrite, chalcopyrite, many other sulfides and sulfosalts, hematite, fluorite, quartz, barite, calcite.

Distribution: The most abundant and widespread sulfide. Only a few localities for large or fine crystals can be mentioned. From Rio Marina, on Elba, and at Traversella, Piedmont, Italy. From Ambasaguas and Navajun, Logroño Province, Spain, sculptural groups of crystals. At Aktchitao, Kazakhstan. In the USA, in the Ibex mine, Leadville, Lake Co., Colorado; in Illinois, as "suns" at Sparta, Randolph Co.; very large crystals from the Santo Niño mine, near Duquesne, Santa Cruz Co., Arizona. In Pennsylvania, at the French Creek mines, Chester Co., and in the Carleton talc mine, Chester, Windsor Co., Vermont. From Butte, Silver Bow Co., Montana; at the Spruce claim, King Co., Washington; as "bars" from the Buick mine, Bixby, Iron Co., Missouri. In Peru, from many districts, with exceptional crystals from the Quiruvilca mine, La Libertad, and Huanzala, Huanaco.

Name: From the Greek for *fire*, as sparks may be struck from it.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 282–290. (2) Brostigen, G. and A. Kjekshus (1969) Redetermined crystal structure of FeS_2 (pyrite). Acta Chem. Scand., 23, 2186–2188. (3) Dódony, I., M. Pósfai, and P.R. Buseck (1996) Structural relationship between pyrite and marcasite. Amer. Mineral., 81, 119–125. (4) (1955) NBS Circ. 539, 5, 29.

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Pyroaurite $Mg_6Fe_2^{3+}(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Thin to thick crystals, tabular {0001}, commonly overgrowing sjögrenite in parallel; in fibrous mats.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Laminae flexible, not elastic. Hardness = 2.5 D(meas.) = 2.13(1) D(calc.) = 2.102

Optical Properties: Transparent. *Color:* Pale yellow, pale brown, green, colorless; colorless in transmitted light. *Luster:* Waxy to vitreous, may be pearly.
Optical Class: Uniaxial (–); may be biaxial due to strain. *Pleochroism:* O = pale yellow, brown, pink; E = colorless. $\omega = 1.564(3)$ $\epsilon = 1.543(3)$ 2V(meas.) = Small.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 3.1094(2)$ $c = 23.4117(9)$ Z = 3/8

X-ray Powder Pattern: Canada; indistinguishable from desautelsite.
7.6 (10), 3.89 (7), 1.981 (5), 2.62 (4), 2.33 (4), 1.556 (2), 1.526 (2)

Chemistry:

	(1)	(2)
SiO_2	0.41	
Al_2O_3	0.11	
Fe_2O_3	23.19	24.13
FeO	0.10	
MnO	0.28	
MgO	35.44	36.55
H_2O^+	33.62	32.67
CO_2	7.01	6.65
Total	100.16	100.00

(1) Långban, Sweden; mixture of pyroaurite and sjögrenite. (2) $Mg_6Fe_2(CO_3)(OH)_{16}\cdot 4H_2O$.

Polymorphism & Series: Dimorphous with sjögrenite.

Mineral Group: Hydrotalcite group.

Occurrence: In low-temperature hydrothermal veins; in serpentinite and ophiolites; an authigenic weathering product.

Association: Sjögrenite, calcite, magnesite, aragonite, hydromagnesite, artinite, dolomite, brucite, clinopyroxene, olivine, talc, phlogopite, spinel.

Distribution: From Långban and Nordmark, Värmland, Sweden. Occurs in the Val Malenco, Lombardy, the Val d'Astico, Vicenza, and the Val Ramazzo, Liguria, Italy. At Kraubath, Styria, Austria. From near Leslie, Aberdeenshire, Scotland. In Russia, in the Vozhmin massif, and in the Mir and other diamond-bearing kimberlite pipes, Sakha. From Yoshikawa, Aichi Prefecture, Japan. In Canada, found near Kilmar, Quebec; at Rutherglen, Nipissing, and in Langmuir Township, Ontario. In the USA, at Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in the Hunting Hill quarry, Rockville, Montgomery Co., Maryland; in the Cedar Hill quarry, Lancaster Co., Pennsylvania; and near the Gem mine, San Benito Co., California. From Phalaborwa, Transvaal, South Africa. Several other localities are known.

Name: From the Greek for *fire* and *gold*, for the golden yellow color developed on heating.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 656–658. (2) Mumpton, F.A., H.W. Jaffe, and C.S. Thompson (1965) Coalingite, a new mineral from the New Idria serpentine, Fresno and San Benito Counties, California. Amer. Mineral., 50, 1893–1913. (3) Ingram, L. and H.W.F. Taylor (1967) The crystal structures of sjögrenite and pyroaurite. Mineral. Mag., 36, 465–479. (4) Allmann, R. (1968) The crystal structure of pyroaurite. Acta Cryst., 24, 972–977.

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Pyrobelonite $PbMn^{2+}(VO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals elongated prismatic to acicular along [010], prominent {101}, {111}, {212}, {210}, {013}, several others, may be curved, anhedral, to 1 cm; massive, in veinlets.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5
D(meas.) = 5.82 D(calc.) = 5.79

Optical Properties: Transparent. *Color:* Fire-red to black; gray in reflected light, with red and orange internal reflections. *Streak:* Yellow-orange, reddish. *Luster:* Adamantine, may be submetallic.
Optical Class: Biaxial (–). *Pleochroism:* In shades of red-brown. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$. *Absorption:* $Y > X = Z$. $\alpha = 2.32$ $\beta = 2.36$ $\gamma = 2.37$
2V(meas.) = 29° *Anisotropism:* Strong. *Bireflectance:* Observable.
R_1–R_2: (400) 17.0–19.7, (420) 16.7–19.3, (440) 16.5–18.9, (460) 16.2–18.5, (480) 16.0–18.2, (500) 15.7–17.8, (520) 15.5–17.4, (540) 15.2–17.0, (560) 15.0–16.7, (580) 14.8–16.5, (600) 14.7–16.3, (620) 14.6–16.1, (640) 14.5–16.0, (660) 14.3–15.8, (680) 14.2–15.7, (700) 14.1–15.6

Cell Data: *Space Group: Pnma.* $a = 7.644$–7.663 $b = 6.182$–6.191 $c = 9.508$–9.522
$Z = 4$

X-ray Powder Pattern: Långban, Sweden.
3.24 (10), 5.14 (7), 2.635 (7), 2.323 (7), 3.672 (6.5), 1.667 (6.5), 2.914 (5)

Chemistry:

	(1)	(2)	(3)
V_2O_5	23.04	22.74	23.07
MnO	17.64	16.40	18.00
PbO	57.00	57.86	56.64
H_2O			2.29
Total	97.68	97.00	100.00

(1) Långban, Sweden; by electron microprobe, average of five analyses, total Mn as MnO.
(2) Tŷ Coch, Wales; by electron microprobe, average of five analyses, total Mn as MnO.
(3) $PbMn(VO_4)(OH)$.

Mineral Group: Descloizite group.

Occurrence: Typically in metamorphosed Fe–Mn mineral deposits.

Association: Hausmannite, manganite, pyrochroite, barite, calcite (Långban, Sweden); vanadinite, braunite, hausmannite, romanèchite, Fe–Mn oxides, barite, calcite, quartz (Tŷ Coch, Wales); medaite, palenzonaite, saneroite, fianelite, parsettensite, rhodochrosite, kutnohorite, aegirine, quartz (Fianel mine, Switzerland).

Distribution: From Långban, Värmland, Sweden. At Tŷ Coch, near South Cornelly, Glamorgan district, Wales. From the Fianel mine, Val Ferrera, Graubünden, Switzerland. In the Iron Monarch quarry, Iron Knob, South Australia. At Franklin, Sussex Co., New Jersey, USA.

Name: From the Greek for *fire* and *needle*, in allusion to the color and habit.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 94381.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 815–816. (2) Criddle, A.J. and R.F. Symes (1977) Mineralization at Tŷ Coch, Glamorgan (Mid Glamorgan), Wales: the second occurrence of pyrobelonite. Mineral. Mag., 41, 85–90. (3) Donaldson, D.M. and W.H. Barnes (1955) The structures of the minerals of the descloizite and adelite groups: II–pyrobelonite. Amer. Mineral., 40, 580–596. (4) Moore, P.B. (1967) Gabrielsonite, $PbFe(AsO_4)(OH)$, a new member of the descloizite-pyrobelonite group, from Långban. Arkiv. Mineral. Geol., 4, 401–405. (5) Barnes, W.H. and F.R. Ahmed (1969) A note on the unit cell constants, and X-ray diffraction powder pattern, of pyrobelonite. Can. Mineral., 10, 117–123.

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Pyrochlore $(Ca, Na)_2Nb_2O_6(OH, F)$

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Crystal Data: Cubic; typically metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. Typically octahedra, modified by {001}, {011}, {112}, {113}, to 7 cm; granular, massive. *Twinning:* On {111}, rare.

Physical Properties: *Cleavage:* {111}, may be a parting. *Fracture:* Subconchoidal to uneven, splintery. *Tenacity:* Brittle. Hardness = 5–5.5 VHN = 542–665 (100 g load). D(meas.) = 4.45 to 4.90 if uranoan. D(calc.) = 4.33 (for $CaNaNb_2O_6F$). May be radioactive.

Optical Properties: Translucent to opaque. *Color:* Black to brown, chocolate-brown, reddish brown, amber-orange, red-orange. *Streak:* Brown. *Luster:* Vitreous to resinous.
Optical Class: Isotropic, weak anomalous anisotropism. n = 1.9–2.2
R: (400) 11.3, (420) 11.2, (440) 11.1, (460) 11.0, (480) 11.0, (500) 10.9, (520) 10.8, (540) 10.7, (560) 10.6, (580) 10.5, (600) 10.5, (620) 10.4, (640) 10.4, (660) 10.4, (680) 10.4, (700) 10.4

Cell Data: *Space Group: Fd3m.* a = 10.35–10.47 Z = 8

X-ray Powder Pattern: Blue River, British Columbia, Canada.
3.00 (100), 1.838 (60), 1.568 (50), 5.98 (25), 3.13 (20), 2.60 (20), 1.194 (20)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
UO_3		10.68	ThO_2	0.20		Na_2O	6.20	
U_3O_8	0.03		UO_2		8.42	F	4.61	0.49
Nb_2O_5	65.8	34.27	RE_2O_3	2.56		H_2O	[1.74]	11.42
Ta_2O_5	0.04	4.27	Fe_2O_3	0.56	3.80	P_2O_5	0.07	
SiO_2	0.17	2.68	MnO	0.00	0.22	S	0.04	
TiO_2	2.59	9.79	PbO		0.41	$-O = F_2$	1.94	0.21
ZrO_2	0.60		CaO	15.8	13.62	Total	[100.00]	100.11
SnO_2	0.00	0.25	SrO	0.93				

(1) Oka, Canada; diopside+apatite+pyrite 0.3%, H_2O by difference; corresponds to $(Ca_{1.06}Na_{0.74}Sr_{0.03}RE_{0.06})_{\Sigma=1.89}(Nb_{1.86}Ti_{0.12}Fe^{3+}_{0.03}Zr_{0.02})_{\Sigma=2.03}O_{5.94}F_{0.91}(OH)_{0.25}$. (2) Hybla, Canada.

Polymorphism & Series: Forms a series with microlite.

Mineral Group: Pyrochlore group and subgroup; $(Na + Ca)_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: In pegmatites in nepheline syenites and other alkalic rocks; in granite pegmatites and greisens; characteristic in carbonatites; detrital.

Association: Zircon, aegirine, apatite, perovskite, columbite.

Distribution: Numerous localities. From Fredriksvärn, Larvik, and the Langesundsfjord, Norway. On Alnö Island, Sweden. From near Schelingen, Kaiserstuhl, Baden-Württemberg, and in the Eifel district, Germany. In Russia, at Miass and Vishnevogorsk, Ilmen Mountains, Southern Ural Mountains; large crystals from the Tatarkskoye deposit, Yenisei Ridge, Siberia; and in the Lovozero massif, Kola Peninsula. On San Miguel Island, Azores. From Oka, Quebec; Hybla, Ontario; and elsewhere in Canada. At Narssârssuk, Greenland. From the Mbeya carbonatite, Panda Hill, near Mbeya, Tanzania. On Rouma Isle, Los Islands, Guinea. In the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia.

Name: From the Greek for *fire* and *green*, to which color the mineral usually turns on ignition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 747–757. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 326–333. (3) Hogarth, D.D. (1961) A study of pyrochlore and betafite. Can. Mineral., 6, 610–633. (4) Perrault, G. (1968) La composition chimique et la structure cristalline du pyrochlore d'Oka, P.Q. Can. Mineral., 9, 383–402 (in French with English abs.). (5) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (6) Gaertner, H.R. (1930) Die Kristallstrukturen von Loparit und Pyrochlor. Neues Jahrb. Mineral., Monatsh., 61, 1–30 (in German).

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Pyrochroite $Mn^{2+}(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. Crystals commonly tabular on {0001}, rhombohedral with $\{10\overline{1}1\}$, $\{10\overline{1}2\}$; rarely prismatic along [0001], with $\{11\overline{2}0\}$, {0001}, to 1 cm; foliated, cleavable massive, to 10 cm; coarse- to fine-grained.

Physical Properties: *Cleavage:* {0001}, perfect. *Tenacity:* Flexible, in thin flakes. Hardness = 2.5 D(meas.) = 3.25(2) D(calc.) = 3.25

Optical Properties: Transparent in thin flakes, becoming opaque on exposure.
Color: Colorless, pale green, pale blue, or pink; on exposure becomes bronze-brown then black; in transmitted light, colorless, flesh-red, amethystine blue-purple; brown when altered.
Luster: Pearly on cleavages.
Optical Class: Uniaxial (–); anomalously biaxial. *Pleochroism:* O = brown; E = lighter brown.
Absorption: Strong; $O > E$. $\omega = 1.723$ $\epsilon = 1.681$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 3.323$–3.34 $c = 4.68$–4.738 Z = 1

X-ray Powder Pattern: Långban, Sweden.
4.6 (10), 2.48 (3), 2.76 (2), 1.542 (2) 3.09 (1), 2.41 (1), 2.04 (1)

Chemistry:

	(1)	(2)
FeO	0.4	
MnO	77.3	79.75
MgO	1.7	
CaO	trace	
H_2O	20.9	20.25
Total	100.3	100.00

(1) Långban, Sweden. (2) $Mn(OH)_2$.

Mineral Group: Brucite group.

Occurrence: A primary mineral in some volcanogenic massive sulfide deposits; a hydration product of manganosite, in turn metamorphosed from rhodochrosite.

Association: Hausmannite, rhodochrosite, manganosite, galaxite, tephroite, alabandite, lead, barite, calcite, dolomite.

Distribution: In Sweden, from Persberg, Långban, and Nordmark, Värmland; in the Sjö mine, near Grythyttan, Örebro. From Ljubija and Prijedor, Bosnia-Herzegovina. At Gonzen, near Sarganz, Graubünden, Switzerland. From Almylak, Uzbekistan. In the USA, at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and in Alum Rock Park, near San Jose, Santa Clara Co., California. An ore in the Noda-Tamagawa mine, Iwate Prefecture; in the Kaso mine, Tochigi Prefecture; Hamayokokawa mine, Nagano Prefecture; the Taguchi mine, Aichi Prefecture; and the Ioi mine, Shiga Prefecture, Japan. From the N'Chwaning and Wessels mines, near Kuruman, Cape Province, South Africa. In the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia.

Name: From the Greek for *fire* and *color*, as there is a color change on ignition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 639–641. (2) Watanabe, T., A. Kato, and J. Ito (1960) The minerals of the Noda-Tamagawa mine, Iwaté Prefecture, Japan. II. Pyrochroite ore (Kimiman-kô) and its origin. Mineral. J. (Japan), 3, 30–41. (3) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Pyrolusite $Mn^{4+}O_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Uncommon in crystals, prismatic ‖ [001], long to short, square cross-section, with fibrous texture, to 8 cm; columnar, reniform, concretionary, dendritic, granular to powdery massive. *Twinning:* Repeated on {031}, {032}, rare; may be polysynthetic.

Physical Properties: *Cleavage:* {110}, perfect. *Fracture:* Uneven. Hardness = 6–6.5, to 2 when massive. D(meas.) = 5.06(2) D(calc.) = [5.19]

Optical Properties: Opaque. *Color:* Light steel-gray, iron-gray to iron-black, may have a bluish cast when massive; in reflected light, white with creamy yellow tint. *Streak:* Black, bluish black. *Luster:* Metallic.
Optical Class: Uniaxial. *Anisotropism:* Strong; in yellows. *Bireflectance:* Weak; yellow to yellow-gray.
R_1–R_2: (400) 18.4–29.4, (420) 18.6–30.0, (440) 18.8–30.6, (460) 18.9–31.2, (480) 19.0–31.6, (500) 19.0–31.7, (520) 18.9–31.6, (540) 18.8–31.4, (560) 18.6–31.2, (580) 18.5–30.8, (600) 18.4–30.4, (620) 18.3–30.0, (640) 18.2–29.5, (660) 18.2–28.9, (680) 18.1–28.4, (700) 18.1–28.0

Cell Data: *Space Group:* $P4_2/mnm$ (synthetic). $a = 4.4041(1)$ $c = 2.8765(1)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.110 (100), 2.407b (55), 1.6234 (55), 1.3064 (20), 1.3045 (20), 2.110 (16), 1.5554 (14)

Chemistry:

	(1)
MnO_2	98.72
$Fe_2O_3 + Al_2O_3$	0.09
H_2O	0.91
insol.	0.23
Total	99.95

(1) Horni Blatna, Czech Republic.

Polymorphism & Series: Trimorphous with akhtenskite and ramsdellite.

Mineral Group: Rutile group.

Occurrence: Formed under highly oxidizing conditions in manganese-bearing hydrothermal deposits and rocks; in bogs and lakes, under shallow marine conditions; commonly an alteration product of manganite.

Association: Manganite, hollandite, hausmannite, braunite, chalcophanite, goethite, hematite.

Distribution: A common manganese oxide, with many localities. Well-studied material from: in Germany, at Elgersburg, Friedrichroda, and Öhrenstock, near Ilmenau, Thuringia; at Eibenstock, Saxony; in the Lindener Mark mine, near Giessen, and at Oberrossbach, Hesse; from the Eisenkaute mine, Marienberg, Rhineland-Palatinate, long crystals, and elsewhere. In good crystals from Horni Blatna (Platten), Czech Republic. At Markhemville and Hillsboro, New Brunswick, Canada. In the USA, large deposits at Ironwood, Gogebic Co., Michigan; from Leadville, Lake Co., Colorado; at Lake Valley, Sierra Co., New Mexico; in the Artillery Mountains, Mohave Co., Arizona.

Name: From the Greek for *fire* and *to wash*, as it is used to remove tints from glass.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 562–566. (2) Bolzan, A.A., C. Fong, B.J. Kennedy, and C.J. Howard (1993) Powder neutron diffraction study of pyrolusite, β−MnO_2. Aust. J. Chem., 46, 939–944. (3) Ramdohr, P. (1980) The ore minerals and their intergrowths, (4th edition), 1025–1028. (4) (1972) NBS Mono. 25, 10, 39.

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Pyromorphite $Pb_5(PO_4)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals short to long prismatic, may be acicular [0001], with prominent $\{10\bar{1}0\}$, $\{0001\}$, $\{10\bar{1}1\}$, $\{20\bar{2}1\}$, hoppered terminations typical, to 8 cm, rarely tabular to equant; radiating to branching groups, tapering to a point. Commonly rounded, globular, reniform, botryoidal. *Twinning:* On $\{11\bar{2}2\}$, very rare.

Physical Properties: *Cleavage:* On $\{10\bar{1}1\}$, interrupted. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 7.04 D(calc.) = 7.14 Piezoelectric if biaxial; may fluoresce yellow to orange under LW and SW UV.

Optical Properties: Transparent to translucent. *Color:* Dark grass-green, green, yellow, yellow-orange, reddish orange, yellow-brown, brown, tan, grayish, may be colorless; colorless or nearly so in transmitted light. *Streak:* White. *Luster:* Resinous to subadamantine. *Optical Class:* Uniaxial (–), may be anomalously biaxial (–), sectored. *Pleochroism:* Weak. *Absorption:* $O < E$. $\omega = 2.058$ $\epsilon = 2.048$

Cell Data: *Space Group:* $P6_3/m$ (synthetic). $a = 9.987$ $c = 7.330$ Z = 2

X-ray Powder Pattern: Synthetic.
2.985 (100), 2.959 (100), 2.885 (60), 4.132 (45), 3.271 (36), 2.063 (34), 3.377 (27)

Chemistry:

	(1)	(2)
P_2O_5	16.11	15.70
As_2O_5	0.13	
PbO	81.33	82.28
Cl	2.71	2.61
$-O = Cl_2$	0.61	0.59
Total	99.67	100.00

(1) Wissen, Germany. (2) $Pb_5(PO_4)_3Cl$.

Mineral Group: Apatite group.

Occurrence: A secondary mineral in the oxidized zone of lead deposits; rarely a volcanic sublimate.

Association: Cerussite, anglesite, smithsonite, willemite, galena.

Distribution: Many localities, even for fine examples. A few include: in Germany, from the Friedrichssegen and other mines, near Bad Ems, Rhineland-Palatinate. At Příbram, Czech Republic. In England, from Wheal Alfred, Phillack, and elsewhere in Cornwall; at Roughton Gill, Caldbeck Fells, Cumbria. Large masses from the Horcajo mines, 35 km south of Brazatortas, Ciudad Real Province, Spain. In France, large crystals from Poullaouen, Finistère; fine groups at the Les Farges mine, Ussel, Corréze, France. From Beresovsk, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. In the USA, at the Wheatley mines, Phoenixville, Chester Co., Pennsylvania; large crystal groups from the Bunker Hill and other mines, Kellogg, Coeur d'Alene district, Shoshone Co., Idaho. At the Society Girl mine, Moyie, British Columbia, Canada. From San Juan Guazapares, Chihuahua, Mexico. At Broken Hill, New South Wales, and Mt. Isa, Queensland, Australia. From the Touissit mine, near Oujda, Morocco. At Kabwe (Broken Hill), Zambia.

Name: From the Greek for *fire* and *form*, as melted globules will recrystallize.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 889–895. (2) Dai, Y. and J.M. Hughes (1989) Crystal-structure refinements of vanadinite and pyromorphite. Can. Mineral., 27, 189–192. (3) Cockbain, A.G. (1968) Lead apatite solid-solution series. Mineral. Mag., 36, 1171–1173. (4) Baker, W.E. (1966) An X-ray diffraction study of synthetic members of the pyromorphite series. Amer. Mineral., 51, 1712–1721.

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Pyrope $Mg_3Al_2(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Subhedral to euhedral crystals, showing the dodecahedron or trapezohedral forms, to 20 cm; also granular, massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7–7.5
D(meas.) = 3.582 D(calc.) = 3.563

Optical Properties: Transparent to translucent. *Color:* Purple-red, pinkish red, red-orange, deep red to almost black; some examples are bluish green in daylight and wine-red in artificial light; colorless to pink in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.714$

Cell Data: *Space Group: Ia3d.* $a = 11.459$ Z = 8

X-ray Powder Pattern: Synthetic.
2.562 (100), 2.865 (60), 1.5312 (50), 2.443 (40), 1.5890 (30), 2.247 (25), 2.339 (20)

Chemistry:

	(1)	(2)
SiO_2	45.21	44.71
TiO_2	0.00	
Al_2O_3	25.55	25.29
FeO	0.91	
MnO	0.02	
MgO	28.83	30.00
CaO	0.28	
Total	100.80	100.00

(1) Dora-Maira massif, Italy; by electron microprobe, corresponding to $(Mg_{2.87}Fe_{0.05}Ca_{0.02})_{\Sigma=2.94}Al_{2.01}Si_{3.02}O_{12}$. (2) $Mg_3Al_2(SiO_4)_3$.

Polymorphism & Series: Forms two series, with almandine, and with knorringite.

Mineral Group: Garnet group.

Occurrence: In ultramafic rocks, as peridotites, kimberlites, eclogites, serpentinites, and in "hornblende"-garnet-plagioclase rocks and anorthosites. Also in amphibole and biotite schists, and as a detrital mineral.

Association: Ilmenite, phlogopite, olivine, "hornblende," plagioclase, pyroxenes, diamond, kyanite, rutile, chlorite, titanite, glaucophane, omphacite.

Distribution: Widespread. The following localities have all produced substantial amounts of gem material. Around Měrunice (Meronitz), Czech Republic. Immense crystals in the Dora-Maira massif, Parigi, near Martiniana Po, Piedmont, Italy. In Germany, from Zöblitz and Greifendorf, Saxony. From South Africa, especially at the diamond mines around Kimberley, Cape Province. Along the Umba River and in the Pare Mountains, Tanzania. In the USA, at Masons' Mountain, near Cowee Creek, Macon Co., North Carolina, and from Buell Park, near Fort Defiance, Apache Co., Arizona. In Australia, 20 km from Bingara, New South Wales, and at Proston, Anakie, and Ruby Vale, Queensland. From San Martin and Quines, San Luis, Argentina. At Gravata, Pernambuco, Brazil.

Name: From the Greek for *firelike* because of its fire-red color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 437–447. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 468–698, esp. 498–535. (3) Chopin, C. (1984) Coesite and pure pyrope in high-grade blueschists of the Western Alps: a first record and some consequences. Contr. Mineral. Petrol., 86, 107–118. (4) (1966) NBS Mono. 25, 4, 24.

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Pyrophanite $Mn^{2+}TiO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Rare crystals, showing {0001}, {11$\overline{2}$0}, {10$\overline{1}$2}, {02$\overline{2}$1}, as thin hexagonal plates, in rosettes, to 2 cm; granular, scaly, in aggregates; an exsolution from franklinite and spinel.

Physical Properties: *Cleavage:* {02$\overline{2}$1}, perfect; {10$\overline{1}$2}, less perfect. *Fracture:* Conchoidal to subconchoidal. Hardness = 5–6 VHN = 435–579, average 511 (50 g load). D(meas.) = 4.537 D(calc.) = 4.596

Optical Properties: Opaque, translucent in thin fragments. *Color:* Deep blood-red to black; orange in transmitted light. *Streak:* Ocher-yellow, with greenish tinge. *Luster:* Metallic to submetallic.
Optical Class: Uniaxial (–). $\omega = 2.48$ $\epsilon = 2.21$
R_1–R_2: (400) 23.5–19.9, (420) 22.7–19.6, (440) 21.8–18.9, (460) 21.1–18.2, (480) 20.4–17.6, (500) 19.9–17.1, (520) 19.4–16.7, (540) 19.0–16.3, (560) 18.8–16.1, (580) 18.5–15.9, (600) 18.3–15.7, (620) 18.2–15.6, (640) 18.0–15.5, (660) 17.8–15.4, (680) 17.8–15.3, (700) 17.6–15.2

Cell Data: *Space Group:* $R\overline{3}$ (synthetic). $a = 5.13948(7)$ $c = 14.2829(4)$ Z = 6

X-ray Powder Pattern: Synthetic.
2.785 (100), 2.569 (70), 1.8887 (40), 1.7469 (40), 1.5220 (35), 2.262 (30), 1.4838 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	1.58		
TiO_2	50.49	53.0	52.96
Fe_2O_3	1.16		
Sb_2O_3	0.48		
FeO		4.5	
MnO	46.92	42.4	47.04
Total	100.63	99.9	100.00

(1) Pajsberg, Sweden. (2) Chvaletice, Czech Republic; by electron microprobe, total Fe as FeO. (3) $MnTiO_3$.

Polymorphism & Series: Forms a series with ilmenite.

Mineral Group: Ilmenite group.

Occurrence: Principally in metamorphosed manganese deposits; less commonly as an accessory mineral in granite, amphibolite, serpentinite; a very rare component in chondritic meteorites.

Association: Ilmenite, geikielite, hematite, spinel, gahnite, chromite, magnetite, ganophyllite, manganophyllite, hendricksite, garnet, calcite.

Distribution: At the Harstigen mine, near Persberg, Värmland, Sweden. From near Ensila, Finland. At Bratthagen, near Larvik, Norway. In the Benallt mine, Rhiw, Gwynned, Wales. At Dalroy Burn, Dalroy, Inverness-shire, Scotland. From Chvaletice, Czech Republic. From Broken Hill, New South Wales, Australia. In Japan, at the Noda-Tamagawa mine, Iwate Prefecture; the Kasama mine, Ibaragi Prefecture; the Taguchi mine, Aichi Prefecture; and others. Fine crystals from Mont Saint-Hilaire, Quebec, Canada. In the USA, from Sterling Hill, Ogdensburg, Sussex Co., New Jersey; at Bald Knob, near Galax, Alleghany Co., North Carolina; on Granite Mountain, near Little Rock, Pulaski Co., Arkansas. Around Manicaragua, Cuba. Additional localities are known, in small amounts.

Name: From the Greek for *fire* and *to appear*, in allusion to its red color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 534–541. (2) Kidoh, K., K. Tanaka, F. Marumo, and H. Takei (1984) Electron density distribution in ilmenite-type crystals. II. Manganese(II) titanium(IV) trioxide. Acta Cryst., 40, 329–332. (3) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 603. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 464. (5) (1978) NBS Mono. 25, 15, 42.

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Pyrophyllite $Al_2Si_4O_{10}(OH)_2$

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Crystal Data: Monoclinic or triclinic. *Point Group:* $2/m$ ($2M_1$); $\bar{1}$ or 1 (1A). As lamellar crystals, to 8 cm; in compact spherulitic aggregates of needlelike radiating crystals; as fine grained foliated laminae, granular, massive.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible but inelastic. Hardness = 1–2 D(meas.) = 2.65–2.90 D(calc.) = [2.81]

Optical Properties: Translucent to opaque. *Color:* White, pale blue, yellow, apple-green, grayish green, brownish green; in thin section, colorless. *Luster:* Pearly to dull. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $Y \simeq a$. *Dispersion:* $r > v$, weak. $\alpha = 1.534$–1.556 $\beta = 1.586$–1.589 $\gamma = 1.596$–1.601 2V(meas.) = 53°–62°

Cell Data: *Space Group:* $C\bar{1}$ or $C1$. $a = 5.160(2)$ $b = 8.966(3)$ $c = 9.347(6)$ $\alpha = 91.18(4)°$ $\beta = 100.46(4)°$ $\gamma = 89.64(3)°$ Z = 2

X-ray Powder Pattern: Tres Cerritos, California, USA.
3.037 (8), 4.53 (4), 8.97 (3), 2.400 (3b), 1.828 (3), 1.377 (3), 1.362 (3)

Chemistry:

	(1)
SiO_2	65.96
TiO_2	trace
Al_2O_3	28.25
Fe_2O_3	0.18
H_2O^+	5.27
H_2O^-	0.14
Total	99.80

(1) Tres Cerritos, California, USA; corresponds to $(Al_{1.97}Fe^{3+}_{0.01})_{\Sigma=1.98}(Si_{3.65}Al_{0.35})_{\Sigma=4.00}O_{10}(OH)_2$.

Polymorphism & Series: $2M_1$, 1A polytypes.

Occurrence: Somewhat uncommon, found both in hydrothermal veins and in bedded deposits in schistose metamorphic rocks.

Association: Kyanite, andalusite, topaz, mica, quartz.

Distribution: Some localities for rich or well-crystallized material follow. In Russia, at Krassik, between Pyschminsk and Beresov, Ural Mountains. From St. Niklas, Zermatt, Valais, Switzerland. In Sweden, at Västanå, Kristianstad. From near Ottré, Ardennes Mountains, Belgium. In the USA, found near Ogilby, Imperial Co., at Tres Cerritos, Mariposa Co., and the Champion mine, White Mountains, Mono Co., California; from near Quartzsite, La Paz Co., Arizona; at Staley, Randolph Co., Glendon and Robbins, Moore Co., and Hillsborough, Orange Co., North Carolina; in the Brewer mine, Chesterfield Co., South Carolina; on Graves Mountain, Lincoln Co., Georgia. From Ibitiara, Bahia, Brazil, in large crystals. In a number of mines in Nagano Prefecture, and elsewhere in Japan.

Name: From the Greek for *fire* and *leaf*, in allusion to its tendency to exfoliate into fan shapes when heated.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 691–692. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 115–120. (3) Gruner, J.W. (1934) The crystal structures of talc and pyrophyllite. Zeits. Krist., 88, 412–419. (4) Lee, J.H. and S. Guggenheim (1981) Single crystal X-ray refinement of pyrophyllite-1*Tc*. Amer. Mineral., 66, 350–357.

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Pyrosmalite-(Fe) $(Fe^{2+}, Mn^{2+})_8Si_6O_{15}(OH, Cl)_{10}$

Crystal Data: Hexagonal. *Point Group*: n.d. As subhedral to euhedral platy crystals, to 1mm; in radiating crystal aggregates.

Physical Properties: *Cleavage*: {0001}, good. Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.14]

Optical Properties: Semitransparent. Color: In transmitted light, colorless.
Optical Class: Uniaxial (-). ω = 1.677(2) ε = 1.652(2)

Cell Data: Space Group: n.d. a = 13.33(3) c = 7.11(2) Z = [2]

X-ray Powder Pattern: Pegmont deposit, Australia.
2.675 (10), 7.13 (8), 3.564 (6), 2.243 (6), 1.833 (4), 1.667 (4), 1.513 (4)

Chemistry:

	(1)
SiO_2	34.17
Al_2O_3	0.00
FeO	49.54
MnO	4.36
MgO	0.64
Cl	4.00
H_2O	[8.19]
$-O = Cl_2$	0.90
Total	[100.00]

(1) Pegmont deposit, Australia; by electron microprobe, H_2O by difference; corresponds to $(Fe_{7.14}Mn_{0.64}Mg_{0.16})_{\Sigma=7.94}Si_{5.89}O_{14.42}[(OH)_{9.41}Cl_{1.17}]_{\Sigma=10.58}$.

Polymorphism & Series: Forms a series with pyrosmalite-(Mn).

Occurrence: Intergrown with sulfdes, formed during metamorphism of a stratiform Pb-Zn deposit; a retrograde reaction product derived from clinopyroxene in saline fluid inclusions in contact metamorphic rocks.

Association: Fayalite, greenalite, galena, sphalerite, clinopyroxene, hornblende, grunerite, garnet, biotite, magnetite, apatite.

Distribution: From the Pegmont lead-zinc deposit, 175 km southeast of Mt. Isa, Queensland, Australia. In Canada from the Ni-Cu-PGE deposits of Sudbury, Ontario and the PGE-Au-As deposits of the Thomson nickel belt, Manitoba. From the Banská Štiavnica district, Slovakia.

Name: For its high Fe iron content and relation to *pyrosmalite-(Mn)*; *pyrosmalite* from the Greek for *fire* and *odor*, for the odor when heated.

Type Material: n.d.

References: (1) Vaughan, J.P. (1986) The iron end-member of the pyrosmalite series from the Pegmont lead-zinc deposit, Queensland. Mineral. Mag., 50, 527-531. (2) Vaughan, J.P. (1987) Ferropyrosmalite and nomenclature in the pyrosmalite series. Mineral. Mag., 51, 174. (3) (1988) Amer. Mineral., 73, 933-934 (abs. refs. 1 and 2). (4) Koděra, P., P.J. Murphy, and A. H. Rankin (2003) Retrograde mineral reactions in saline fluid inclusions: The transformation ferropyrosmalite ↔ clinopyroxene. Amer. Mineral., 88, 151–158. (5) Burke, E.A.J. (2008) Tidying up mineral names: an IMA-CNMNC scheme for suffixes, hyphens and diacritical marks. Mineral. Record, 39, 131-135.

Pyrosmalite-(Mn) $(Mn^{2+}, Fe^{2+})_8Si_6O_{15}(OH, Cl)_{10}$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}$ 2/*m*. As thick prismatic hexagonal crystals, to 4 cm, in subparallel groups. In granular aggregates showing schistose or foliated structure; massive.

Physical Properties: *Cleavage*: Perfect on {0001}, {1010} less perfect. Hardness = 4-4.5
D(meas.) = 3.06-3.19 D(calc.) = 3.14

Optical Properties: Translucent. *Color*: Blackish green, pistachio-green, liver-brown, brown, gray. *Luster*: Pearly on {0001}.
Optical Class: Uniaxial (-). *Pleochroism*: *O* = greenish yellow; *E* = colorless. ω = 1.669-1.670 ε = 1.631

Cell Data: *Space Group*: $P\bar{3}\,m1$. a = 13.422(5) c = 7.165(2) Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
7.16 (100), 2.683 (90), 3.583 (80), 2.251 (70), 1.672 (50), 1.523 (50), 3.419 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	34.13	33.42	CaO	0.00	1.29
As_2O_5	0.13		Cl	3.80	3.78
FeO	12.43	17.05	$H2O^+$	8.18	9.36
MnO	39.09	32.96	$H2O^-$	0.07	
ZnO	1.94	1.92	$-O = Cl_2$	0.86	0.85
MgO	0.74	trace	Total	99.58	99.00

(1) Sterling Hill, New Jersey, USA; corresponds to $(Mn_{5.76}Fe_{1.84}Mg_{0.16}Zn_{0.24})_{\sum=8.00}Si_6O_{15}(OH, Cl)_{10}$. (2) Broken Hill, Australia; corresponds to $(Mn_{4.96}Fe_{2.56}Zn_{0.24}Ca_{0.24})_{\sum=8.00}Si_6O_{15}(OH, Cl)_{10}$.

Polymorphism & Series: Dimorphous with brokenhillite; forms a series with pyrosmalite-(Fe).

Occurrence: As veinlets in the franklinite ore of a metamorphosed stratiform zinc deposit (Sterling Hill, New Jersey, USA).

Association: Friedelite, bementite, willemite (Sterling Hill, New Jersey, USA); spessartine, manganoan tremolite, quartz (Takanosu mine, Japan); rhodonite, manganoan fayalite, bustamite, manganoan hedenbergite, galena (Broken Hill, Australia).

Distribution: At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. In the Kyurazawa mine, Ashio, Tochigi Prefecture, Japan. Large composite crystals from Broken Hill, New South Wales, Australia. Pyrosmalite series minerals (with Mn:Fe around one) occur at: Nordmark, Värmland, and Dannemora, Kopparberg, Sweden. In the Takanosu mine, Takarazawa, Tochigi Prefecture, Japan. From Nant Fracon, Wales. In the Treburland mine, Altarnun, Cornwall, England. At Port Radium, Northwest Territories, Canada. In the Lar mine, Tierra Amarilla, Copiapó, Chile.

Name: For its high manganese content and relation to *pyrosmalite-(Fe)*; *pyrosmalite* from the Greek for *fire* and *odor*, for the odor when heated.

Type Material: Harvard University, Cambridge, Massachusetts, 104214, 104215; National Museum of Natural History, Washington, D.C., USA, C6216.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 465-466. (2) Frondel, C. and L.H. Bauer (1953) Manganpyrosmalite and its polymorphic relation to friedelite and schallerite. Amer. Mineral., 38, 755-760. (3) Stillwell, F.L. and J. McAndrew (1957) Pyrosmalite in the Broken Hill lode, New South Wales. Mineral. Mag., 31, 371-380. (4) Kato, T. and Y. Takéuchi (1983) The pyrosmalite group of minerals: I. Structure refinement of manganpyrosmalite. Can. Mineral., 21, 1-6. (5) Burke, E.A.J. (2008) Tidying up mineral names: an IMA-CNMNC scheme for suffixes, hyphens and diacritical marks. Mineral. Record, 39, 131-135.

Pyrostilpnite Ag_3SbS_3

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular {010} giving flat rhombic forms; also laths by elongation ‖ [001], to 1 mm; as subparallel sheaflike aggregates. *Twinning:* On {100} with (100) as composition plane.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Somewhat flexible in thin plates. Hardness = 2 VHN = 95–115, 107 average (100 g load). D(meas.) = 5.94 D(calc.) = 5.97

Optical Properties: Transparent. *Color:* Hyacinth-red; lemon-yellow by transmitted light. *Streak:* Yellow-orange. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 8$–$11°$. α = Very high. β = Very high. γ = Very high.
R_1–R_2: (400) 36.3–36.9, (420) 36.3–36.5, (440) 36.1–35.8, (460) 35.7–35.1, (480) 34.9–34.2, (500) 33.9–33.2, (520) 32.3–31.8, (540) 30.8–30.3, (560) 29.6–29.2, (580) 28.6–28.2, (600) 27.8–27.5, (620) 27.1–26.7, (640) 26.6–26.2, (660) 26.2–25.8, (680) 25.9–25.4, (700) 25.6–25.2

Cell Data: *Space Group:* $P2_1/c$. $a = 6.84$ $b = 15.84$ $c = 6.24$ $\beta = 117°09'$ $Z = 4$

X-ray Powder Pattern: Příbram, Czech Republic.
2.85 (100), 2.65 (50), 2.42 (50), 1.895 (50b), 1.887 (50b), 1.824 (20b), 1.813 (20b)

Chemistry:

	(1)	(2)	(3)
Ag	59.44	59.7	59.76
Sb	22.30	23.7	22.48
S	18.11	16.8	17.76
Total	99.85	100.2	100.00

(1) St. Andreasberg, Germany. (2) Do.; by electron microprobe. (3) Ag_3SbS_3.

Polymorphism & Series: Dimorphous with pyrargyrite.

Occurrence: In low-temperature hydrothermal veins as a late-stage mineral.

Association: Pyrargyrite, stephanite, acanthite, silver, miargyrite, xanthoconite, andorite, fizelyite.

Distribution: In Germany, from St. Andreasberg, Harz Mountains [TL]. At Hiendelaencina, Guadalajara Province, Spain. In the Czech Republic, from Příbram and at Třebsko. In England, at St. Teath, Cornwall. In Australia, from Broken Hill, New South Wales; and in the Long Tunnel, at Heazlewood, Tasmania. From the Kushikino mine, Kagoshima Prefecture, Japan. In the USA, in the Silver City district, Owyhee Co., Idaho; at the Bulldog mine, Creede, Mineral Co., Colorado; and from Randsburg, San Bernardino Co., California. In Canada, at Cobalt, Ontario; in the Van silver mine, near Whistler, and at the Silvana mine, Sandon, British Columbia. In Chile, from Chañarcillo, south of Copiapó, Atacama. At Cerro Rico, Potosí, Bolivia. In small amounts from other localities.

Name: From the Greek for *fire* and *shining*, in allusion to its color and luster.

Type Material: Mining Academy, Freiberg, Germany, 6200.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 369–370. (2) Peacock, M.A. (1950) Studies of mineral sulpho-salts: XV. xanthoconite and pyrostilpnite. Mineral. Mag., 29, 346–358. (3) Kutoglu, A. (1968) Die Struktur des Pyrostilpnits (Feuerblende) Ag_3SbS_3. Neues Jahrb. Mineral., Monatsh., 145–160 (in German with English abs.). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 465. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 777–778.

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Pyroxferroite $(Fe^{2+}, Mn^{2+}, Ca)SiO_3$

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Crystal Data: Triclinic. *Point Group:* 1 or $\bar{1}$. As rudimentary crystals and discrete grains.

Physical Properties: *Cleavage:* Good on {010}, poor on {001}. Hardness = n.d.
D(meas.) = 3.68–3.76 D(calc.) = 3.82–3.83

Optical Properties: Semitransparent. *Color:* Yellow; lighter yellow in thin section.
Optical Class: Biaxial (+). *Pleochroism:* Faint; pale yellow to yellow-orange.
Absorption: $X' > Z'$. α = 1.748–1.756 β = 1.750–1.758 γ = 1.767–1.768
2V(meas.) = 34°–40°

Cell Data: *Space Group:* $P1$ or $P\bar{1}$. $a = 6.6213$ $b = 7.5506$ $c = 17.3806$ $\alpha = 114.267°$
$\beta = 82.684°$ $\gamma = 94.756°$ Z = 14

X-ray Powder Pattern: Sea of Tranquillity, Moon.
2.934 (100), 2.674 (60), 3.09 (45), 4.68 (40), 2.156 (40), 2.579 (35), 1.410 (35)

Chemistry:

	(1)
SiO_2	46.8
TiO_2	0.5
Al_2O_3	0.3
FeO	44.6
MnO	0.8
MgO	0.8
CaO	6.0
Na_2O	trace
Total	99.8

(1) Sea of Tranquillity, Moon; by electron microprobe, corresponding to $(Fe^{2+}_{0.81}Ca_{0.14}Mn_{0.03}Mg_{0.03})_{\Sigma=1.01}(Si_{0.98}Ti_{0.01}Al_{0.01})_{\Sigma=1.00}O_3$.

Polymorphism & Series: Forms a series with pyroxmangite.

Occurrence: As discrete grains in microgabbros or diabase (Sea of Tranquillity, Moon).

Association: Clinopyroxene, plagioclase, ilmenite, cristobalite, tridymite, fayalite, fluorapatite, potassic feldspar (Sea of Tranquillity, Moon).

Distribution: From the Sea of Tranquillity and Oceanus Procellarum, Moon. From near Iva, Anderson Co., South Carolina, USA. From Väster Silfberg, Värmland, Sweden. At Simsiö, Lapua, Finland. In the Isanago mine, Kyoto Prefecture, Japan.

Name: From PYROXene and FERROus iron, and for its relation to *pyroxmangite*.

Type Material: Lunar Science Institute, Houston, Texas, USA.

References: (1) Chao, E.C.T., J.A. Minkin, C. Frondel, C. Klein, Jr., J.C. Drake, L. Fuchs, B. Tani, J.V. Smith, A.T. Anderson, P.B. Moore, G. R. Zechman, Jr., R.J. Traill, A.G. Plant, J.A.V. Douglas, and M.R. Dence (1970) Pyroxferroite, a new calcium-bearing iron silicate from Tranquillity Base. Geochim. Cosmochim. Acta, Suppl. Proc. Apollo XI Lunar Sci. Conf. 1, 65–79. (2) (1970) Amer. Mineral., 55, 2137 (abs. ref. 1). (3) Burnham, C.W. (1971) The crystal structure of pyroxferroite from Mare Tranquillitatis. Geochim. Cosmochim. Acta, Suppl. Proc. Second Lunar Sci. Conf. 2, 47–57. (4) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 601–613 [pyroxmangite].

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Pyroxmangite $Mn^{2+}SiO_3$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals typically tabular on {001}, to 10 cm; porphyroblastic, granular. *Twinning:* Lamellar on {010}, simple on {001}, uncommon.

Physical Properties: *Cleavage:* Perfect on {110}, {1$\bar{1}$0}, (110) ∧ (1$\bar{1}$0) = 92°; poor on {010}, {001}. Hardness = 5.5–6 D(meas.) = 3.61–3.80 D(calc.) = [3.75]

Optical Properties: Semitransparent. *Color:* Pink, red, commonly covered with brown or black oxidation products; colorless to faint lilac in thin section. *Luster:* Pearly to vitreous. *Optical Class:* Biaxial (+). *Dispersion:* $r > v$, moderate. α = 1.728–1.748 β = 1.730–1.742 γ = 1.746–1.758 2V(meas.) = 37°–46°

Cell Data: *Space Group:* $C\bar{1}$. a = 9.690 b = 10.505 c = 17.391 α = 112.17° β = 102.85° γ = 82.93° Z = 14

X-ray Powder Pattern: Synthetic.
2.967 (100), 2.188 (45), 4.73 (35), 2.680 (35), 1.422 (30), 3.47 (25), 3.04 (25)

Chemistry:

	(1)
SiO_2	45.74
Al_2O_3	trace
Fe_2O_3	trace
FeO	0.39
MnO	52.42
MgO	0.68
CaO	0.46
$Na_2O + K_2O$	0.05
H_2O	0.32
Total	100.06

(1) Ajiro mine, Gifu Prefecture, Japan; corresponds to $(Mn^{2+}_{0.93}Mg_{0.02}Ca_{0.01})_{\Sigma=0.96}Si_{0.96}O_3$.

Polymorphism & Series: Forms a series with pyroxferroite.

Occurrence: In regionally metamorphosed manganese ore deposits and manganiferous rocks, perhaps with lower temperature history than rhodonite-bearing rocks.

Association: Spessartine, tephroite, alleghanyite, hausmannite, pyrophanite, alabandite, rhodonite, rhodochrosite.

Distribution: Exceptional material in the Taguchi and other mines, Shidara, Aichi Prefecture; from Iwaizumi, Iwate Prefecture; and at many other places in Japan. Large crystals at Broken Hill, New South Wales, Australia. From Simsiö, Lapua, Finland. In Sweden, at Fillinge. From Glen Beag, Glenelg district, Inverness-shire, Scotland. In the USA, in Colorado, from the American tunnel, Silverton, San Juan Co., the Galena district, Hinsdale Co., and the Idarado mine, Ouray Co.

Name: A combination of PYROXene and MANGanese, in allusion to the mineral's structure and composition.

Type Material: "Type material" from Iva, South Carolina, USA, has been redefined as pyroxferroite, as Fe > Mn.

References: (1) Ford, W.E. and W.M. Bradley (1913) Pyroxmangite, a new member of the pyroxene group and its alteration product, skemmatite. Amer. J. Sci., 36, 169–174. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 601–613. (3) Ohashi, Y. and L.W. Finger (1975) Pyroxenoids: a variation in chemistry of natural rhodonites and pyroxmangites. Carnegie Inst. Washington, Ann. Rep., 1974–1975, 561–564. (4) Maresch, W.V. and A. Mottana (1976) The pyroxmangite-rhodonite transformation for the $MnSiO_3$ composition. Contr. Mineral. Petrol., 55, 69–79.

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Pyrrhotite $\mathbf{Fe_{1-x}S}$ (x = 0 to 0.17)

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Crystals typically tabular or platy on {0001}, to 40 cm; steep pyramidal faces or short pyramidal; as rosettes showing nearly parallel aggregation on {0001}; commonly massive, granular. *Twinning:* On $\{10\bar{1}2\}$.

Physical Properties: *Cleavage:* Parting on {0001}, distinct. *Fracture:* Uneven to subconchoidal. Hardness = 3.5–4.5 VHN = 373–409 (100 g load). D(meas.) = 4.58–4.65 D(calc.) = 4.69 Magnetic, varying in intensity inversely with iron content.

Optical Properties: Opaque. *Color:* Bronze-yellow to pinchbeck-brown; tarnishes quickly, rarely to iridescence. *Streak:* Dark grayish black. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: (400) 27.9–31.0, (420) 28.6–32.2, (440) 29.4–33.6, (460) 30.3–34.8, (480) 31.4–36.2, (500) 32.4–37.6, (520) 33.4–38.6, (540) 34.5–39.6, (560) 35.5–40.4, (580) 36.5–41.2, (600) 37.4–42.0, (620) 38.3–42.6, (640) 39.1–43.0, (660) 39.9–43.5, (680) 40.7–43.9, (700) 41.4–44.1

Cell Data: *Space Group:* Depends on polytype. $a = 6.865$ $b = 11.9$ $c = 22.72$ $\beta = 90°5'$ Z = 64

X-ray Powder Pattern: Santa Eulalia, Mexico.
2.08 (10), 2.65 (6), 1.728 (5), 3.00 (4), 1.328 (4), 1.105 (4), 1.052 (3)

Chemistry:

	(1)	(2)	(3)
Fe	60.18	59.83	61.57
S	39.82	39.55	38.53
rem.		0.55	
Total	100.00	99.93	100.10

(1) Homestake mine, Lead, Lawrence Co., South Dakota, USA; corresponds to $Fe_{0.87}S_{1.00}$. (2) Kongsberg, Norway; average of two analyses, corresponds to $Fe_{0.87}S_{1.00}$. (3) Setregruben, Østfold, Norway; corresponds to $Fe_{0.92}S_{1.00}$.

Polymorphism & Series: Numerous polytypes, with 4-M, 6-M, 5-H, 7-H, and 11-H known, and a high-temperature hexagonal polymorph which may remain stable at ordinary temperatures.

Occurrence: Mainly in mafic igneous rocks, typically as magmatic segregations; also in pegmatites, and in high-temperature hydrothermal and replacement veins, and in sedimentary and metamorphic rocks; in iron meteorites.

Association: Pyrite, marcasite, chalcopyrite, pentlandite, many other sulfides, magnetite, calcite, dolomite.

Distribution: Massive material occurs at many localities. Well-crystallized from Herja (Kisbánya), Baia Mare (Nagybánya) district, Romania. From the Stari Trg mine, Trepča, Serbia. In Val Passiria, Trentino-Alto Adige, and at Bottino, near Servezza, Tuscany, Italy. In Germany, in the Harz Mountains, at St. Andreasberg. From the Bristenstock tunnel, Uri, Switzerland. In Sweden, at Falun, Kopparberg. In Russia, very large crystals at Dal'negorsk, Primorskiy Kray. Large crystals from the Morro Velho gold mine, Nova Lima, Minas Gerais, Brazil. At the Potosí and San Antonio mines, Santa Eulalia, Chihuahua, Mexico. From the Bluebell mine, Riondel, British Columbia, Canada.

Name: From the Greek for *redness*, in allusion to its color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 231–235. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 145–157. [change this to new vol V??must - and review - if H polymorphs should have hexagonal system added also??] (3) Francis, C.A. and J.R. Craig (1976) Pyrrhotite: the *nA* (or 2*A*, 3*C*) superstructure reviewed. Amer. Mineral., 61, 21–25. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 466. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 60.

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Qandilite $(Mg, Fe^{2+})_2(Ti, Fe^{3+}, Al)O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedral crystals and granular, to 2.3 mm.

Physical Properties: *Cleavage:* {111}, perfect. *Tenacity:* Brittle. Hardness = ∼7 VHN = 960–1045, average 998 (100 g load). D(meas.) = 4.03–4.08 D(calc.) = 4.04 Strongly magnetic.

Optical Properties: Opaque. *Color:* Iron-black; light gray with a pinkish tint in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R: (400) 14.8, (420) 14.2, (440) 13.8, (460) 13.5, (480) 13.3, (500) 13.2, (520) 13.1, (540) 13.1, (560) 13.0, (580) 13.0, (600) 13.0, (620) 13.0, (640) 13.0, (660) 12.9, (680) 12.9, (700) 12.9

Cell Data: *Space Group:* $Fd3m$ (synthetic Mg_2TiO_4). $a = 8.4376(5)$ $Z = 8$

X-ray Powder Pattern: Dupezeh Mountain, Iraq.
2.533 (100), 1.486 (60), 1.617 (50), 2.101 (45), 2.971 (30), 1.0938 (30), 0.9704 (25)

Chemistry:

	(1)	(2)
SiO_2	0.02	
TiO_2	26.41	27.34
Al_2O_3	4.83	3.33
Fe_2O_3	28.27	27.01
Cr_2O_3		0.13
FeO	10.32	14.62
MnO	0.76	1.89
MgO	29.62	26.47
Total	100.23	100.79

(1) Dupezeh Mountain, Iraq; by electron microprobe, average of four grains, Fe^{2+} and Fe^{3+} by wet methods; corresponds to $(Mg_{1.32}Fe^{3+}_{0.41}Fe^{2+}_{0.26}Mn_{0.02})_{\Sigma=2.01}(Ti_{0.60}Fe^{3+}_{0.23}Al_{0.17})_{\Sigma=1.00}O_4$.
(2) Konder massif, Russia; by electron microprobe.

Mineral Group: Spinel group.

Occurrence: In a forsterite skarn (Dupezeh Mountain, Iraq); in a periclase-forsterite skarn (Kangerdlugssuaq, Greenland); in the contact zone of an alkaline ultramafic massif (Konder massif, Russia).

Association: Forsterite, spinel, perovskite, calcite (Dupezeh Mountain, Iraq); geikielite, spinel, periclase, forsterite (Konder massif, Russia).

Distribution: On Dupezeh Mountain, near Hero Town, Qala-Dizeh, Iraq. From near Kangerdlugssuaq, Greenland. In the Konder massif, Aldan Shield, Sakha, Russia.

Name: For the occurrence in rocks of the Qandil Group, Iraq.

Type Material: Strathclyde University, Glasgow; Royal Scottish Museum, Edinburgh, Scotland; National Science Museum, Tokyo, Japan; National School of Mines, Paris, France.

References: (1) Al-Hermezi, H.M. (1985) Qandilite, a new spinel end-member, Mg_2TiO_4, from the Qala-Dizeh region, NE Iraq. Mineral. Mag., 49, 739–744. (2) (1988) Amer. Mineral., 73, 930 (abs. ref. 1). (3) Wechsler, B.A. and R.B. Von Dreele (1989) Structure refinements of Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ by time-of-flight neutron powder diffraction. Acta Cryst., 45, 542–549. (4) Oktyabrsky, R.A., S.A. Shcheka, A.M. Lennikov, and T.B. Afanasyeva (1992) The first occurrence of qandilite in Russia. Mineral. Mag., 56, 385–389.

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Qilianshanite $H_3Na(HCO_3)(BO_3)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals are tabular to prismatic, to 2 mm, commonly in massive aggregates. *Twinning:* Polysynthetic.

Physical Properties: *Cleavage:* {100} and {010}, perfect. Hardness = ∼2
D(meas.) = 1.706 D(calc.) = 1.639 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y \wedge a = 1°$; $Z \wedge c = 9°$. *Dispersion:* $r < v$, medium. $\alpha = [1.351]$ $\beta = 1.459(2)$ $\gamma = 1.486(2)$ 2V(meas.) = 50°

Cell Data: *Space Group:* $C2$. $a = 16.119(8)$ $b = 6.928(4)$ $c = 6.730(3)$ $\beta = 100.46(4)°$
Z = 4

X-ray Powder Pattern: Juhongtu deposit, China.
3.464 (100), 3.173 (59), 6.36 (25), 1.731 (19), 4.203 (6), 2.608 (5), 2.642 (3)

Chemistry:

	(1)	(2)
CO_2	16.99	24.20
B_2O_3	20.02	19.14
MgO	0.05	
CaO	0.22	
Na_2O	17.92	17.04
H_2O	43.11	39.62
Total	98.31	100.00

(1) Juhongtu deposit, China; corresponds to $H_{8.86}Na_{1.08}Ca_{0.01}C_{0.71}B_{1.06}O_{8.00}$.
(2) $H_3Na(HCO_3)(BO_3)\cdot 2H_2O$, confirmed by crystal-structure analysis.

Occurrence: Formed by reaction of borate-rich waters with earlier sodium carbonates in a borate deposit.

Association: Tincalconite, nahcolite, calcite, quartz.

Distribution: From the Juhongtu borate deposit, Qilian Mountains, Qinghai Province, China.

Name: For its occurrence in the Qilian Mountains, China.

Type Material: National Museum of Geology, Beijing, China.

References: (1) Luo Shiqing, Lu Jian'an, Wang Liben, and Zhu Jingqing (1993) Qilianshanite – a new boric carbonate mineral. Acta Mineral. Sinica, 13(2), 97–101 (in Chinese with English abs.). (2) (1994) Amer. Mineral., 79, 765 (abs. ref. 1). (3) Wang Liben, Shi Jianqiu, and Zhou Kangling (1994) Crystal structure of qilianshanite. Geol. Rev., 40(4), 347–353 (in Chinese with English abs.).

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Qingheiite $Na_2(Mn^{2+}, Mg, Fe^{2+})_2(Al, Fe^{3+})(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Short prismatic to tabular anhedral grains, to 4 mm.

Physical Properties: *Cleavage:* On {010}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.3–5.6 D(meas.) = 3.718 D(calc.) = 3.61

Optical Properties: Semitransparent. *Color:* Jade-green to light yellowish green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = light yellowish green; Y = jade-green; Z = dark bluish green. *Dispersion:* $r \gg v$, strong. $\alpha = 1.678$ $\beta = 1.684$ $\gamma = 1.691$
2V(meas.) = 80°

Cell Data: *Space Group:* $P2_1/n$. $a = 11.856(3)$ $b = 12.411(3)$ $c = 6.421(1)$ $\beta = 114.45(2)°$ Z = [4]

X-ray Powder Pattern: Qinghe Co., China. (ICDD 41-1418).
2.685 (10), 3.472 (9), 2.512 (9), 6.21 (8), 2.860 (7), 1.739 (7), 3.082 (6)

Chemistry:

	(1)		(1)
P_2O_5	45.63	ZnO	0.23
TiO_2	0.05	MgO	9.75
Al_2O_3	4.53	CaO	0.93
Fe_2O_3	[2.24]	Li_2O	0.02
Cr_2O_3	0.04	Na_2O	8.73
FeO	[3.94]	K_2O	0.04
MnO	23.60	Total	[99.73]

(1) Qinghe Co., China; by electron microprobe, original total given as 99.72%, total Mn as MnO; with Fe partitioned to fill M2, corresponds to $Na_{1.31}(Mn_{1.50}Mg_{1.13}Fe^{2+}_{0.27}Ca_{0.08}Zn_{0.02})_{\Sigma=3.00}(Al_{0.42}Fe^{3+}_{0.11})_{\Sigma=0.53}(PO_4)_{3.00}$.

Occurrence: In a muscovite-rich pegmatite.

Association: Muscovite, quartz, microcline, braunite, pyrolusite.

Distribution: From an undisclosed locality in Qinghe Co., Xinjiang Uygur Autonomous Region, China.

Name: For Qinghe Co., China.

Type Material: n.d.

References: (1) Ma Zhesheng, Shi Nicheng, and Peng Zhizhong (1983) Crystal structure of a new phosphatic mineral – qingheiite. Scientia Sinica, Series B, 26, 876–884 (in English). (2) (1984) Amer. Mineral., 69, 567–568 (abs. ref. 1). (3) (1987) Mineral. Abs., 38, 349 (abs. ref. 1).

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Qitianlingite $(Fe^{2+}, Mn^{2+})_2(Nb, Ta)_2W^{6+}O_{10}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, thin tabular ∥ {001}, to 0.2 mm.

Physical Properties: *Cleavage:* {100}, distinct. Hardness = n.d. VHN = 520–580 (50 g load). D(meas.) = 6.30 D(calc.) = 6.423 Moderately magnetic.

Optical Properties: Semitransparent. *Color:* Black; yellowish white in reflected light. *Streak:* Dark brown. *Luster:* Semimetallic to metallic.
Optical Class: Biaxial. *Anisotropism:* Weak. *Bireflectance:* Weak.
R_1–R_2: 12–14

Cell Data: *Space Group: Pbcn.* $a = 23.706(7)$ $b = 5.723(2)$ $c = 5.045(3)$ Z = 4

X-ray Powder Pattern: Qitianling, China.
2.96 (10), 1.773 (8), 3.65 (7), 2.52 (7), 2.87 (6), 1.385 (6), 1.194 (6)

Chemistry:

	(1)
WO_3	32.30
Nb_2O_5	34.06
Ta_2O_5	11.73
TiO_2	1.23
SnO_2	0.36
FeO	14.64
MnO	6.01
Total	100.33

(1) Qitianling, China; by electron microprobe, corresponding to $(Fe_{1.34}Mn_{0.56})_{\Sigma=1.90}(Nb_{1.69}Ta_{0.35}Ti_{0.10}Sn_{0.02})_{\Sigma=2.16}W_{0.92}O_{10}$.

Occurrence: In a pegmatite dike in granite.

Association: Quartz, potassic feldspar, albite, muscovite, zinnwaldite, cassiterite, wolframite, "wolframoixiolite".

Distribution: From near Qitianling, Hunan Province, China.

Name: For Qitianling, China, near where the mineral was first collected.

Type Material: National Museum of Geology, Beijing, China.

References: (1) Yang Guangming, Wang Su, Peng Zhizhong, and Bu Jingzhen (1985) Qitianlingite – a newly discovered superstructure complex oxide. Acta Mineral. Sinica, 5(3), 193–198 (in Chinese with English abs.). (2) (1988) Amer. Mineral., 73, 1497 (abs. ref. 1). (3) Peng Zhizhong, Wang Su, Ma Zhesheng, and Yang Guangming (1988) The crystal structure of qitianlingite ($Fe_2Nb_2WO_{10}$). Kexue Tongbao, 33(10), 856–861 (in English).

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Quadridavyne $(Na,K)_6Ca_2Si_6Al_6O_{24}Cl_4$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals hexagonal, prismatic, elongated along [0001], to 2 mm, showing dominant $\{10\bar{1}0\}$ and $\{0001\}$. *Twinning:* On $\{10\bar{1}0\}$, commonly observed.

Physical Properties: *Cleavage:* $\{0001\}$, perfect; $\{11\bar{2}0\}$, distinct. *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = 2.335(5) D(calc.) = 2.354

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.529(1)$ $\epsilon = 1.532(1)$

Cell Data: *Space Group:* $P6_3/m$. $a = 25.771(6)$ $c = 5.371(1)$ $Z = 4$

X-ray Powder Pattern: Ottaviano, Italy; can be distinguished from davyne only by single-crystal diffraction.
3.71 (vs), 3.31 (vs), 4.80 (s), 2.788 (s), 2.677 (m), 2.474 (m), 2.147 (m)

Chemistry:

	(1)
SiO_2	33.09
Al_2O_3	27.62
CaO	11.35
Na_2O	11.21
K_2O	5.93
Cl	12.13
SO_3	1.08
$-O = Cl_2$	2.74
Total	99.67

(1) Ottaviano, Italy; by electron microprobe, average of five analyses; corresponding to $(Na_{3.97}K_{1.38})_{\Sigma=5.35}Ca_{2.22}(Si_{6.05}Al_{5.95})_{\Sigma=12.00}O_{23.90}[Cl_{3.76}(SO_4)_{0.15}]_{\Sigma=3.91}$.

Mineral Group: Cancrinite group.

Occurrence: In volcanic ash containing metasomatized and hydrothermally altered lavas and scoriae, from the 1906 eruption of Vesuvius.

Association: n.d.

Distribution: From Ottaviano, near Naples, Campania, Italy.

Name: From the Latin *quad*, for *four*, as the mineral has four times the unit cell volume of the related mineral species *davyne*.

Type Material: University of Pisa, Pisa, Italy, 10014.

References: (1) Bonaccorsi, E., S. Merlino, P. Orlandi, M. Pasero, and G. Vezzalini (1994) Quadridavyne, $[(Na,K)_6Cl_2][Ca_2Cl_2][Si_6Al_6O_{24}]$, a new feldspathoid mineral from Vesuvius area. Eur. J. Mineral., 6, 481–487.

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Quadruphite $Na_{14}CaMgTi_4(Si_2O_7)_2(PO_4)_4O_4F_2$

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Crystal Data: Triclinic. *Point Group:* 1. As flakes, flattened on {001}, to 3 mm, some epitaxially overgrown on lomonosovite and sobolovite.

Physical Properties: *Cleavage:* {001}, perfect; {110} and {100}, less perfect. *Fracture:* Steplike. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.12 D(calc.) = 3.11

Optical Properties: Translucent to transparent. *Color:* Light brown. *Luster:* Vitreous, resinous on fractures, pearly to adamantine on cleavages. *Streak:* White.
Optical Class: Biaxial (–). *Pleochroism:* Pronounced; X = colorless; $Y = Z$ = yellowish.
Dispersion: $r < v$, strong. *Absorption:* $Z \geq Y > X$. $\alpha = 1.630$ $\beta = 1.678$ $\gamma = 1.697$
2V(meas.) = 62°

Cell Data: *Space Group:* $P1$. $a = 5.415(2)$ $b = 7.081(3)$ $c = 20.34(1)$ $\alpha = 86.85(4)°$ $\beta = 94.40(4)°$ $\gamma = 89.94(3)°$ Z = 1

X-ray Powder Pattern: Lovozero massif, Russia.
2.880 (10), 2.702 (8b), 2.636 (7), 2.050 (5), 1.600 (5), 1.662 (4b), 1.713 (3)

Chemistry:

	(1)		(1)
SiO_2	16.5	CaO	5.3
TiO_2	13.7	SrO	0.4
ZrO_2	4.1	BaO	1.1
Nb_2O_5	3.8	Na_2O	28.1
FeO	0.3	F	3.4
MnO	4.3	P_2O_5	19.2
MgO	1.1	$-O = (F, Cl)_2$	1.4
		Total	99.9

(1) Lovozero massif, Russia; by electron microprobe, average of three analyses; corresponds to $Na_{13.21}(Ca_{1.38}Ba_{0.10}Sr_{0.06})_{\Sigma=1.54}(Mg_{0.40}Mn_{0.28}Fe_{0.06})_{\Sigma=0.74}(Ti_{2.50}Mn_{0.60}Zr_{0.48}Nb_{0.42})_{\Sigma=4.00}(Si_2O_7)_2(P_{0.98}O_4)_4O_{3.04}F_{2.61}$.

Occurrence: In ultra-agpaitic pegmatites in a differentiated alkalic massif.

Association: Nepheline, sodalite, analcime, potassic feldspar, albite, arfvedsonite, aegirine, cancrisilite, ussingite, makatite, villiaumite, polyphite, lomonosovite, sobolovite, additional minor minerals.

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: From the Latin *quadruplex*, for *four*, and PHosphorus, for the four phosphate anions in the chemical formula.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, p545/5; The Natural History Museum, London, England, 1994,25.

References: (1) Khomyakov, A.P., G.N. Nechelyustov, E.A. Sokolova, and G.I. Dorokhova (1992) Quadruphite $Na_{14}CaMgTi_4[Si_2O_7]_2[PO_4]_4O_4F_2$ and polyphite $Na_{17}Ca_3Mg(Ti,Mn)_4[Si_2O_7]_2[PO_4]_6O_2F_6$ – new minerals of the lomonosovite group. Zap. Vses. Mineral. Obshch., 121(1), 105–112 (in Russian). (2) (1993) Amer. Mineral., 78, 1316 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 240 (abs. ref. 1).

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Quartz SiO_2

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Crystal Data: Hexagonal. *Point Group:* 32. As enantimorphic prismatic crystals, with $\{10\bar{1}0\}$ terminated by $\{10\bar{1}1\}$ and $\{01\bar{1}1\}$, striated $\perp$ [0001]; may be morphologically complex, with over 500 forms noted, to 6 m and 36 t. Pseudocubic or dipyramidal to tapering, needlelike, with trigonal outline; may be flattened, distorted, rarely "twisted." Parallel to divergent groups; drusy, fine-grained to microcrystalline ("chalcedony"), massive. *Twinning:* Very common, penetration twins on the Dauphiné law, about [0001], and the Brazil law, with $\{11\bar{2}0\}$ as contact plane; contact twins on the Japan law, with $\{11\bar{2}2\}$ as contact plane, may be repeated; and several other laws.

Physical Properties: *Cleavage:* Rarely observable, poor on $\{10\bar{1}1\}$, $\{01\bar{1}1\}$, $\{10\bar{1}0\}$, some others; rhombohedral parting. *Fracture:* Conchoidal. *Tenacity:* Brittle, tough when massive. Hardness = 7, variable by direction and form. D(meas.) = 2.65; 2.59–2.63 when massive. D(calc.) = 2.66 Piezoelectric and pyroelectric, may be triboluminescent.

Optical Properties: Transparent to nearly opaque. *Color:* Colorless, white; from chemical or particulate inclusions, rose-pink to rose-red, yellow to yellowish brown, green, blue, bluish violet, brown to black; zoned or mottled. *Streak:* White. *Luster:* Vitreous; waxy to dull when massive.
Optical Class: Uniaxial (+). $\omega = 1.544$ $\epsilon = 1.553$

Cell Data: *Space Group:* $P3_121$ or $P3_221$. a = 4.9135(4) c = 5.4050(2) Z = 3

X-ray Powder Pattern: Synthetic.
3.342 (100), 4.257 (22), 1.8179 (14), 1.5418 (9), 2.457 (8), 2.282 (8), 1.3718 (8)

Chemistry: SiO_2 with traces of other elements.

Polymorphism & Series: Cristobalite, tridymite, coesite, and stishovite are polymorphs; stable below 573 °C.

Occurrence: In hydrothermal veins, epithermal to alpine; characteristic of granites and granite pegmatites; in sandstones and quartzites, less abundant in other rock types; in hydrothermal metal deposits. Common in carbonate rocks; a residual mineral in soils and sediments.

Association: Calcite, fluorite, feldspars, epidote, chlorite, micas, zeolites, many other species.

Distribution: Extraordinarily common. Fine specimens from many places in the Alps of Switzerland and Austria. At Carrara, Tuscany, Italy. From Bourg d'Oisans, Isère, France. At Mursinka, Ural Mountains, in the Dodo mine, about 100 km west-northwest of Saranpaul, Subpolar Ural Mountains, and elsewhere in Russia. From Sakangyi, Katha district, Myanmar (Burma). Large twins from Yamanashi Prefecture and many other places in Japan. At Tamboholehehibe and elsewhere in Madagascar. From Brazil, in large amounts from many localities in Rio Grande do Sul, Minas Gerais, Goiás, and Bahia. Around Artigas, Uruguay. At Thunder Bay, Lake Superior, Ontario, Canada. In the USA, from Mt. Ida to Hot Springs, Ouachita Mountains, Arkansas; at Middleville, Herkimer Co., New York; in North Carolina, especially in Alexander and Lincoln Cos. From the Pala and Mesa Grande districts, San Diego Co., California; the El Capitan Mountains, Lincoln Co., New Mexico; the Crystal Park area, Beaverhead Co., and Little Pipestone Creek, Jefferson Co., Montana; and in the Pikes Peak area, El Paso Co., Colorado. From Mexico, in Veracruz and Guerrero.

Name: Of obscure origin in the Middle Ages, first applied to gangue in Saxony, Germany.

References: (1) Frondel, C. (1962) Dana's system of mineralogy, (7th edition), v. III, silica minerals, 9–250. (2) Le Page, Y. and G. Donnay (1976) Refinement of the crystal structure of low-quartz. Acta Cryst., 32, 2456–2459. (3) (1981) NBS Mono. 25, 18, 61.

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Queitite $Pb_4Zn_2(SiO_4)(Si_2O_7)(SO_4)$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals tabular on {001} and elongated along [010], dominant forms {001}, {112}, {110}, {101}, to 1.5 cm. *Twinning:* On {100} and {001}.

Physical Properties: *Cleavage:* {010} and {001}, observed in traces. Hardness = ∼4
D(meas.) = n.d. D(calc.) = 6.07

Optical Properties: Transparent. *Color:* Pale yellow or colorless; distinct anomalous interference colors in thin section. *Streak:* White. *Luster:* Greasy.
Optical Class: Biaxial (+) (probable). *Orientation:* $X = b$; $Z \simeq a$. *Dispersion:* $r < v$, strong.
$\alpha = 1.899(4)$ $\beta = 1.901$ $\gamma = 1.903(4)$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1$. $a = 11.362(2)$ $b = 5.266(1)$ $c = 12.655(3)$
$\beta = 108.16(2)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.18 (100), 1.635 (80), 1.490 (60), 1.486 (60), 3.77 (50), 3.59 (50), 2.99 (50)

Chemistry:

	(1)	(2)
SiO_2	14.33	14.52
ZnO	12.37	12.97
PbO	67.10	66.71
SO_3	6.06	6.04
Total	99.86	100.24

(1–2) Tsumeb, Namibia; by electron microprobe, with traces of Fe, Ca, Mg; the average corresponds to $Pb_{3.87}Zn_{2.01}Si_{3.10}O_{11}(S_{0.98}O_4)$.

Occurrence: On corroded sulfides in a partially oxidized lead ore from a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia); with other oxidized Pb-Cu minerals in a vug in quartz from a hydrothermal Pb-Zn-Cu ore deposit (Red Gill mine, England).

Association: Galena, sphalerite, tennantite, willemite, melanotekite, leadhillite, alamosite, larsenite, quartz (Tsumeb, Namibia); cerussite, leadhillite, susannite, caledonite, quartz (Red Gill mine, England).

Distribution: At Tsumeb, Namibia. From the Lucky Cuss mine, Tombstone, Cochise Co., Arizona, USA. In the Red Gill mine, Caldbeck Fells, Cumbria, England. From Leadhills, Lanarkshire, Scotland.

Name: For Clive Sedric Queit, mineral dealer of Tsumeb, Namibia.

Type Material: University of Stuttgart, Stuttgart, Germany, NM03; Harvard University, Cambridge, Massachusetts, 117115; National Museum of Natural History, Washington, D.C., USA, 143780, 147463.

References: (1) Keller, P., P.J. Dunn, and H. Hess (1979) Queitite, $Pb_4Zn_2(SO_4)(SiO_4)(Si_2O_7)$, a new mineral from Tsumeb, South West Africa. Neues Jahrb. Mineral., Monatsh., 203–209 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 407 (abs. ref. 1). (3) Hess, H. and P. Keller (1980) Die Kristallstruktur von Queitit, $Pb_4Zn_2[SO_4|SiO_4|Si_2O_7]$. Zeits. Krist., 151, 287–299 (in German with English abs.).

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Quenselite $PbMn^{3+}O_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, flattened on {010}, elongated ‖ [100] or [001], showing {100}, {010}, {001}, {011}, {101}, {$10\overline{3}$}, {111}; striated on {110} ‖ [100].

Physical Properties: *Cleavage:* Perfect on {001}, nearly micaceous. *Tenacity:* Flexible, in thin laminae; somewhat malleable. Hardness = 2.5 VHN = 171–268, average 221 (100 g load). D(meas.) = 6.84 D(calc.) = 7.133

Optical Properties: Opaque, translucent on thin edges. *Color:* Pitch-black; deep brown in transmitted light. *Streak:* Dark brownish gray. *Luster:* Metallic to adamantine. *Optical Class:* Biaxial (+) (?). *Orientation:* $X = b$; $Y \simeq c$. *Absorption:* $Z > X$. $n = \sim 2.30$ 2V(meas.) = n.d. *Anisotropism:* Strong.

R_1–R_2: (400) 28.1–32.6, (420) 26.7–30.9, (440) 25.3–29.2, (460) 24.0–27.7, (480) 23.0–26.3, (500) 22.1–25.1, (520) 21.4–24.2, (540) 20.8–23.4, (560) 20.4–22.8, (580) 20.0–22.2, (600) 19.7–21.8, (620) 19.5–21.5, (640) 19.4–21.3, (660) 19.2–21.0, (680) 19.2–20.9, (700) 19.2–20.9

Cell Data: *Space Group:* $P2/a$. $a = 5.61$ $b = 5.70$ $c = 9.15$ $\beta = 93.0°$ Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.04 (10), 2.72 (8), 3.68 (7), 3.60 (7), 2.95 (6), 2.44 (4), 2.08 (4)

Chemistry:

	(1)	(2)
MnO	23.44	22.80
PbO	70.21	71.74
MgO	0.30	
CaO	0.15	
Na_2O	0.28	
K_2O	0.17	
O	2.40	2.57
H_2O	3.05	2.89
Total	[100.00]	100.00

(1) Långban, Sweden; recalculated to 100% after deduction of $CaCO_3$ 1.46%, Fe_2O_3 0.28%.
(2) $PbMnO_2(OH)$.

Occurrence: In a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Calcite, barite, hausmannite, braunite (Långban, Sweden).

Distribution: From Långban, Värmland, Sweden. At Tirodi, Madhya Pradesh, India. From Luce Bay, Wigtownshire, Scotland.

Name: Honors Professor Percy Dudgeon Quensel (1881–1966), Swedish mineralogist and petrologist, Stockholm University, Stockholm, Sweden.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 729–730. (2) Rouse, R.C. (1971) The crystal structure of quenselite. Zeits. Krist., 134, 321–332. (3) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Quenstedtite $Fe_2^{3+}(SO_4)_3 \cdot 10-11H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. Tabular crystals, flattened on {010}, or short prismatic along [100], to 1 mm, which may be highly modified in the [001] and [100] zones, with about 30 forms observed; commonly in crusts and aggregates. *Twinning:* Common on {010}.

Physical Properties: *Cleavage:* Perfect on {010}; good on {100}. Hardness = 2.5 D(meas.) = 2.11–2.15 D(calc.) = 2.14 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Pale violet, reddish violet; colorless to pale rose in transmitted light.
Optical Class: Biaxial (+). *Orientation:* X (–43°,45°); Y (128°,43°); Z (–138°,88°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. *Dispersion:* $r < v$, strong, horizontal. $\alpha = 1.547$ $\beta = 1.566$ $\gamma = 1.594$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.184(5)$ $b = 23.60(2)$ $c = 6.539(5)$ $\alpha = 94.18(8)°$ $\beta = 101.73(8)°$ $\gamma = 96.27(8)°$ Z = 2

X-ray Powder Pattern: Tierra Amarilla, Chile.
4.08 (FFF), 5.78 (FF), 4.19 (FF), 3.80 (F), 5.03 (mF), 5.57 (mf), 5.34 (mf)

Chemistry:

	(1)	(2)	(3)
SO_3	39.83	41.41	40.16
Fe_2O_3	27.66	27.53	26.70
CaO	0.40		
H_2O	31.35	31.06	33.14
Total	99.24	100.00	100.00

(1) Tierra Amarilla, Chile; a separate determination by the Penfield method gave H_2O 33.4%, also crystal-structure analysis indicates 11 H_2O positions, two of which are interlayer zeolitic. (2) $Fe_2(SO_4)_3 \cdot 10H_2O$. (3) $Fe_2(SO_4)_3 \cdot 11H_2O$.

Occurrence: An uncommon mineral formed in the oxidized zone of pyrite-rich mineral deposits especially in arid regions.

Association: Coquimbite, copiapite, römerite.

Distribution: In Chile, from Tierra Amarilla, southeast of Copiapó, Atacama, and at Alcaparrosa, near Cerritos Bayos, southwest of Calama, Antofagasta. From the Sulphur Hole prospect, near Borate, about 10 km northeast of Yermo, Calico Mountains, San Bernardino Co., California, USA. At Baňská Štiavnica (Schemnitz), Slovakia. In Germany, in the Richelsdorfer Mountains, Hesse. From the Dyakhtardakh cassiterite–sulfide deposit, northeastern Sakha, Russia.

Name: To honor Professor Friedrich August Quenstedt (1809–1889), German mineralogist and paleontologist, University of Tübingen, Tübingen, Germany.

Type Material: National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 535–536. (2) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French). (3) Thomas, J.N., P.D. Robinson, and J.H. Fang (1974) Crystal structures and mineral chemistry of hydrated ferric sulfates. IV. The crystal structure of quenstedtite. Amer. Mineral., 59, 582–586.

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Quetzalcoatlite $\mathbf{Zn_6Cu_3(Te^{6+}O_6)_2(OH)_6 \cdot [0.24AgCl \cdot 0.30PbCl_2]}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Needlelike hexagonal crystals, to 0.4 mm, bounded by $\{10\bar{1}0\}$ and $\{0001\}$, in sprays and crystalline crusts.

Physical Properties: *Cleavage:* On $\{10\bar{1}0\}$, fair. *Tenacity:* Brittle. Hardness = 3
D(meas.) = 6.05(30) D(calc.) = 4.82

Optical Properties: Semitransparent. *Color:* Capri blue; green in transmitted light.
Streak: Pale blue, almost white. *Luster:* Pearly to dull.
Optical Class: Uniaxial (–). *Pleochroism:* O = blue-green; E = almost colorless. *Orientation:* Parallel extinction, length-fast. $\omega = 1.802$ $\epsilon = 1.740$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\bar{3}1m$. $a = 10.145(1)$ $c = 4.9925(9)$ Z = 1

X-ray Powder Pattern: Moctezuma mine, Mexico.
8.752 (100), 2.748 (70), 2.520 (42b), 3.531 (40), 3.273 (31), 1.766 (28), 5.054 (21)

Chemistry:

	(1)	(2)	(3)
TeO_3	33.4	31.71	31.02
CuO	20.0	20.31	21.08
ZnO	39.4	43.10	43.13
H_2O		[4.88]	4.77
Total		[100.00]	100.00

(1) Moctezuma mine, Mexico; by electron microprobe, average of 20 analyses on 3 grains, H_2O 10.1% by the Penfield method on one sample; as part of the H_2O is probably zeolitic, $(OH)^{1-}$ here calculated for charge balance; then corresponds to $Zn_{5.75}Cu_{2.98}(TeO_6)_{2.26}(OH)_{3.90}$. (2) Blue Bell claims, California, USA; average of 9 analyses on 3 grains; recalculated to 100% from an original total of 96.59% after deduction of Ag_2O 4.33%, PbO 0.83%, and Cl 2.39% as impurities in structural channels, H_2O calculated by difference, $(OH)^{1-}$ here calculated for charge balance; then corresponds to $Zn_{6.04}Cu_{2.91}(Te^{6+}O_6)_{2.05}(OH)_{5.60} \cdot 0.28H_2O$. (3) $Zn_6Cu_3(TeO_6)_2(OH)_6$.

Occurrence: A rare mineral in the oxidized zone of tellurium-bearing hydrothermal ore deposits.

Association: Hessite, galena, bornite, cerussite, azurite, chlorargyrite, teineite, quartz, barite, clay (Moctezuma mine, Mexico); khinite, dugganite, chlorargyrite, gold (Old Guard mine, Arizona, USA).

Distribution: From the Oriental (Bambollita) mine, northeast of the Moctezuma mine, Moctezuma, Sonora, Mexico. In the USA, at the Old Guard mine, Tombstone, Cochise Co., Arizona; from the Blue Bell claims, San Bernardino Co., California; and at the Centennial Eureka mine, Tintic district, Juab Co., Utah.

Name: For *Quetzalcoatl*, the Toltec and Aztec feathered serpent god of the sea, in allusion to its sea-blue color.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1986,55; National Museum of Natural History, Washington, D.C., USA, 135055.

References: (1) Williams, S. (1973) Quetzalcoatlite, $Cu_4Zn_8(TeO_3)_3(OH)_{18}$, a new mineral from Moctezuma, Sonora. Mineral. Mag., 39, 261–263. (2) Burns, P.C., J.J. Pluth, J.V. Smith, P. Eng, I. Steele, and R.M. Housley (2000) Quetzalcoatlite: a new octahedral-tetrahedral structure from a 2 x 2 x 40 μm^3 crystal at the Advanced Photon Source-GSE-CARS facility. Amer. Mineral., 85, 604–607.

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Rabbittite $Ca_3Mg_3(UO_2)_2(CO_3)_6(OH)_4 \cdot 18H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals are acicular, elongated along [001], in bundles and as an efflorescence.

Physical Properties: *Cleavage:* {001}, probable, and two prismatic. Hardness = 2.5 D(meas.) = 2.57 D(calc.) = [2.69] Radioactive; slowly soluble in H_2O; fluoresces pale cream-yellow under SW UV.

Optical Properties: Semitransparent. *Color:* Pale green, greenish yellow. *Luster:* Silky. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c \simeq 15°$. $\alpha = 1.502(5)$ $\beta = 1.508(2)$ $\gamma = 1.525(5)$ 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. $a = 32.6(1)$ $b = 23.8(1)$ $c = 9.45(5)$ $\beta = \sim 90°$ Z = 8

X-ray Powder Pattern: Lucky Strike No. 2 mine, Utah, USA.
8.24 (10), 7.79 (8), 4.37 (8), 4.71 (7), 5.83 (5b), 4.81 (5), 1.28 (5)

Chemistry:

	(1)	(2)
UO_3	37.4	38.51
CO_2	17.8	17.77
MgO	9.2	8.14
CaO	10.6	11.33
H_2O	24.5	24.25
insol.	0.5	
Total	100.0	100.00

(1) Lucky Strike No. 2 mine, Utah, USA; H_2O by loss on ignition less CO_2.
(2) $Ca_3Mg_3(UO_2)_2(CO_3)_6(OH)_4 \cdot 18H_2O$.

Occurrence: A rare secondary mineral, which may be of post-mine origin.

Association: Sodium-zippeite, magnesium-zippeite, fourmarierite, gypsum, bieberite, cobaltocalcite.

Distribution: From the Lucky Strike No. 2 mine, Emery Co., Utah, USA. At Jáchymov (Joachimsthal), Czech Republic.

Name: To honor John Charles Rabbitt (1907–1957), Chief, Trace Elements Section, U.S. Geological Survey.

Type Material: Harvard University, Cambridge, Massachusetts, 105099; National Museum of Natural History, Washington, D.C., USA, 112741, 162619.

References: (1) Thompson, M.E., A.D. Weeks, and A.M. Sherwood (1955) Rabbittite, a new uranyl carbonate from Utah. Amer. Mineral., 40, 201–206.

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Rabéjacite $Ca(UO_2)_4(SO_4)_2(OH)_6 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystals are flattened on {001}, or acicular, elongated along [001], to 0.1 mm; in rosettes, rounded nodules, and microcrystalline crusts.

Physical Properties: Hardness = 3 D(meas.) = > 4.1 D(calc.) = 4.31 Radioactive; pale yellow fluorescence under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Bright yellow, amber-yellow, brownish yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; Y = very pale yellow; Z = sulfur-yellow. *Orientation:* $X = c$; Y and $Z \perp [001]$. *Dispersion:* $r > v$, weak. $\alpha = [1.617]$ $\beta = 1.710(2)$ $\gamma = 1.758(2)$ 2V(meas.) = 68(2)°

Cell Data: *Space Group:* n.d. $a = 8.73(1)$ $b = 17.09(2)$ $c = 15.72(2)$ Z = 4

X-ray Powder Pattern: Rabéjac deposit, France.
7.90 (100), 3.49 (80), 3.38 (70), 3.98 (40), 4.17 (30), 2.844 (30b), 2.163 (15)

Chemistry:

	(1)	(2)	(3)
SO_3	10.91	10.43	10.52
UO_3	80.12	76.63	75.15
CaO	2.89	2.76	3.68
H_2O	10.18	10.18	10.65
Total	104.10	[100.00]	100.00

(1) Rabéjac deposit, France; by electron microprobe, average of 20 analyses, H_2O by chromatography; corresponds to $Ca_{0.76}(UO_2)_{4.15}(SO_4)_{2.02}(OH)_{5.78} \cdot 5.86H_2O$. (2) Analysis (1) normalized to 100.00%. (3) $Ca(UO_2)_4(SO_4)_2(OH)_6 \cdot 6H_2O$.

Occurrence: A rare secondary mineral in the oxidation zone of uranium deposits, formed by alteration of uraninite.

Association: Gypsum, johannite, uraninite.

Distribution: In France, from the Rabéjac uranium deposit, seven km south-southeast of Lodève, and at the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault. From La Creusa, near Les Marécottes, Valais, Switzerland. At Jáchymov (Joachimsthal), Czech Republic.

Name: For its first-noted occurrence in the Rabéjac deposit, France.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC 4409, RC 4410.

References: (1) Deliens, M. and P. Piret (1994) La rabejacite, $Ca(UO_2)_4(SO_4)_2(OH)_6 \cdot 6H_2O$, nouveau sulfate d'uranyle et de calcium des gîtes du Lodévois, Hérault, France. Eur. J. Mineral., 5, 873–877 (in French with English abs.). (2) (1994) Amer. Mineral., 79, 572 (abs. ref. 1).

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Crystal Data: Tetragonal. *Point Group:* $4/m$, 4, $\bar{4}$, 422, $4mm$, $\bar{4}2m$, or $4/m\ 2/m\ 2/m$. Flame-like aggregates and veinlets up to 20 μm across, in rims and intergrowths with other tellurides and sulfides.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 8.89

Optical Properties: Opaque. *Color:* Rose-brown in reflected light. *Anisotropism:* Distinct. R_1–R_2: 23.7–24.3 (400), 24.7–25.2 (420), 25.6–26.1 (440), 26.6–27.1 (460), 27.6–28.2 (480), 28.6–29.2 (500), 29.6–30.1 (520), 30.3–31.0 (540), 31.1–31.8 (560), 31.8–32.4 (580), 32.4–32.9 (600), 32.7–33.3 (620), 33.0–33.5 (640), 33.2–33.6 (660), 33.2–33.6 (680), 33.2–33.6 (700)

Cell Data: *Space Group:* $P4/m$, $P4$, $P\bar{4}$, $P422$, $P4mm$, $P\bar{4}2m$, $P4/mmm$ or $P\bar{4}m2$. $a = 5.71(5)$ $c = 3.77(5)$ $Z = 1$

X-ray Powder Pattern: Champion Reef mine, India. Electron diffraction. 3.16 (100), 3.78 (60), 1.92 (50), 1.78 (50), 2.73 (40), 2.29 (40), 1.59 (40)

Chemistry:

	(1)	(2)
Pb	29.17	31.35
Te	59.80	57.92
S	0.77	
Cl	9.90	10.73
Total	99.64	100.00

(1) Champion Reef mine, India; by electron microprobe, leading to $Pb_{0.94}Te_{3.06}(Cl_{1.84}S_{0.16})_{\Sigma=2.00}$. (2) $PbTe_3Cl_2$.

Occurrence: Of primary origin, in a hydrothermal gold-quartz vein containing sulfides and tellurides.

Association: Galena, altaite, kolarite, cotunnite, volynskite, hessite, pyrrhotite, chalcopyrite, ullmannite, hawleyite, cadmian tetrahedrite, cadmian sphalerite.

Distribution: From the Champion Reef mine, Kolar Gold Fields, Karnataka, India.

Name: For B.P. Radhakrishna, Indian geologist.

Type Material: Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, USSR.

References: (1) Genkin, A.D., Y.G. Safonov, V.N. Vasudev, B. Krishna Rao, V.A. Boronikhin, L.N. Vyalsov, A.I. Gorshkov, and A.V. Mokhov (1985) Kolarite $PbTeCl_2$ and radhakrishnaite $PbTe_3(Cl,S)_2$, new mineral species from the Kolar gold deposit, India. Can. Mineral., 23, 501–506. (2) (1986) Amer. Mineral., 71, 1545–1546 (abs. ref. 1).

Radtkeite Hg_3S_2ClI

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. In euhedral crystals, to 30 μm, tabular and prismatic, with well-developed prisms and pinacoids, perhaps with fluted terminations; may be hollow tubular, capped at one end, and curved; commonly granular, or as coatings.

Physical Properties: *Cleavage:* {010}, perfect; {001}, {100}, very good; {0*kl*}, {*h*0*l*}, and {*hk*0}, good (synthetic). *Fracture:* Splintery, hackly, conchoidal (synthetic). Hardness = 2–3 (synthetic). VHN = 65–75 D(meas.) = 7.0(1) (synthetic). D(calc.) = 7.05(1)

Optical Properties: Opaque to translucent. *Color:* Bright yellow-orange to dull orange; on exposure to light immediately darkens through yellow-brown to black; pale gray with yellowish tint in reflected light, with abundant canary-yellow internal reflections. *Streak:* Yellow-orange, blackening on exposure to light. *Luster:* Nearly adamantine (synthetic).
Optical Class: Biaxial (+). *Pleochroism:* Bright orange, orange with a rosy tint, or orange with a green tint. $\alpha = > 2.0$ $\beta = > 2.0$ $\gamma = > 2.0$ 2V(meas.) = $\sim 35°$

Cell Data: *Space Group:* $Fmmm$, $Fmm2$, or $F222$ (synthetic). $a = 16.92(2)$ $b = 20.25(2)$ $c = 9.110(3)$ Z = 16

X-ray Powder Pattern: McDermitt mine, Nevada, USA.
2.64 (100), 2.71 (44), 3.90 (41), 2.58 (29), 2.53 (28), 2.281 (26), 2.96 (24)

Chemistry:

	(1)	(2)
Hg	73.4	72.66
Cl	3.6	4.28
Br	0.0	
I	14.8	15.32
S	8.2	7.74
Total	100.0	100.00

(1) McDermitt mine, Nevada, USA; by electron microprobe, average of ten analyses; corresponds to $Hg_3S_{2.10}Cl_{0.82}I_{0.96}$. (2) Hg_3S_2ClI.

Occurrence: In tuffaceous rhyolitic lake-bed sediments, formed as a reaction product between halide-bearing hydrothermal solutions and cinnabar or corderoite.

Association: Cinnabar, corderoite, quartz, gypsum.

Distribution: In the McDermitt mercury mine, Opalite district, Humboldt Co., Nevada, USA.

Name: For Arthur S. Radtke (1936–), American mineralogist and geochemist, U.S. Geological Survey, Palo Alto, California, USA.

Type Material: Mackay School of Mines, University of Nevada, Reno, Nevada; National Museum of Natural History, Washington, D.C., USA, 168450.

References: (1) McCormack, J.K., F.W. Dickson, and M.P. Leshendok (1991) Radtkeite, Hg_3S_2ClI, a new mineral from the McDermitt mercury deposit, Humboldt County, Nevada. Amer. Mineral., 76, 1715–1721.

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Crystal Data: Orthorhombic. *Point Group:* n.d. As pseudohexagonal plates pseudomorphic after an unknown mineral, consisting of fibers intimately mixed with pyrite.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = 6.4(2) D(calc.) = 6.29

Optical Properties: Opaque. *Color:* Brilliant bronze; in polished section, creamy grayish white perpendicular to the fibers, and rose colored parallel. *Luster:* Metallic. *Pleochroism:* Strong, grayish white to rose. *Anisotropism:* Strong, with orange dominant. R_1–R_2: (400) 23.7–28.0, (420) 24.1–30.4, (440) 24.5–32.8, (460) 24.8–33.6, (480) 25.0–31.8, (500) 25.1–29.8, (520) 25.2–30.2, (540) 25.4–32.1, (560) 25.6–34.3, (580) 25.7–36.3, (600) 25.8–38.0, (620) 26.0–39.5, (640) 26.3–40.7, (660) 26.6–41.5, (680) 26.9–42.0, (700) 27.2–42.4

Cell Data: *Space Group:* n.d. $a = 12.40(5)$ $b = 10.44(5)$ $c = 5.26(5)$ $Z = 8$

X-ray Powder Pattern: Allchar, Yugoslavia.
2.89 (vvs), 4.17 (s), 3.35 (s), 2.64 (m), 2.35 (m), 4.70 (w), 6.03 (vw)

Chemistry:

	(1)	(2)	(3)
Tl	62.50	61.3	63.01
Fe	17.10	19.7	17.22
S	19.50	20.2	19.77
Total	99.10	101.2	100.00

(1–2) Allchar, Yugoslavia; by electron microprobe. (3) $TlFeS_2$.

Occurrence: Formed in a hydrothermal deposit.

Association: Pyrite, lorandite, orpiment, realgar, vrbaite.

Distribution: From Allchar, Macedonia, Yugoslavia.

Name: For Professor E. Raguin, National School of Mines, Paris, France.

Type Material: National School of Mines, Paris, France.

References: (1) Laurent, Y., P. Picot, R. Pierrot, and T. Ivanov (1969) La raguinite, $TlFeS_2$, une nouvelle espèce minérale et le problème de l'allcharite. Bull. Soc. fr. Minéral., 92, 38–48 (in French with English abs.). (2) (1969) Amer. Mineral., 54, 1495 (abs. ref. 1). (3) Johan, Z., P. Picot, and R. Pierrot (1969) Nouvelles données sur la raguinite. Bull. Soc. fr. Minéral., 92, 237 (in French). (4) (1969) Amer. Mineral., 54, 1741 (abs. ref. 3).

Raite $Na_4Mn_4^{2+}Si_8(O,OH)_{24}\cdot 9H_2O(?)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals acicular, to 2 mm; in radiating clusters.

Physical Properties: *Cleavage:* Perfect on {100}, {010}, and {001}. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.32–2.39 D(calc.) = [2.51]

Optical Properties: Semitransparent. *Color:* Gold, brown, reddish brown, yellow, tan, rose, lavender, bronze. *Streak:* Yellow. *Luster:* Vitreous, may be silky.
Optical Class: Biaxial (+). *Pleochroism:* Distinct; X = nearly colorless; Y = yellowish; Z = golden brown. *Orientation:* $Z \wedge c = 0°–30°$. $\alpha = 1.540(2)$ $\beta = 1.542(2)$ $\gamma = 1.550(2)$ 2V(meas.) = n.d. 2V(calc.) = 53°

Cell Data: *Space Group:* $C222$. $a = 30.44–30.6$ $b = 5.31–5.371$ $c = 18.20–18.25$ Z = 4

X-ray Powder Pattern: Lovozero massif, Russia.
11.4 (100), 2.939 (100), 2.650 (100), 4.5 (80), 3.8 (60b), 2.482 (60), 1.640 (60)

Chemistry:

	(1)		(1)
SiO_2	46.20	MnO	15.00
TiO_2	3.11	MgO	0.20
ZrO_2	0.16	CaO	1.24
Al_2O_3	0.12	Na_2O	11.24
RE_2O_3	0.16	K_2O	0.17
Fe_2O_3	1.86	H_2O^+	8.01
$(Nb,Ta)_2O_5$	0.44	H_2O^-	11.36
FeO	0.37	CO_2	0.40
		Total	100.04

(1) Lovozero massif, Russia.

Occurrence: On the walls of fractures filled with nepheline in alkalic pegmatite in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Nepheline, aegirine, mountainite, natrolite, zorite (Lovozero massif, Russia); aegirine, albite, nepheline, sodalite, sérandite, analcime, ancylite, epididymite, eudialyte, nenadkevichite (Mont Saint-Hilaire, Canada).

Distribution: From the Jubilee pegmatite, on Mt. Karnasurt, near the valley of the Ilmajok River, Lovozero massif, and in the Khibiny massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: In honor of the international group of scientists, captained by Thor Heyerdahl, crewing the papyrus ship *Ra* (1969–1970).

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3206, 3271; Mineralogical Museum, St. Petersburg University, St. Petersburg, 19047; Mining Institute, St. Petersburg, 1060/1–4; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74489.

References: (1) Mer'kov, A.N., I.V. Bussen, E.A. Goiko, E.A. Kul'chitskaya, Y.P. Men'shikov, and A.P. Nedorezova (1973) Raite and zorite, new minerals from the Lovozero Tundra. Zap. Vses. Mineral. Obshch., 102, 54–62 (in Russian). (2) (1973) Amer. Mineral., 58, 1113–1114 (abs. ref. 1). (3) Khomyakov, A.P., E.M. Es'kova, G.E. Cherepivskaya, V.V. Kaptsov, and A.D. Timchenko (1982) New data on raite. Nov. Dannye Miner., 30, 205–207 (in Russian). (4) (1983) Chem. Abs., 219080 (abs. ref. 3). (5) Mandarino, J.A. and V. Anderson (1989) Monteregian treasures. Cambridge Univ. Press, 174.

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Rajite $CuTe_2^{4+}O_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular to bladed crystals, elongated along [100], to 1.5 mm, with strongly curved faces; may be in bundles.

Physical Properties: *Cleavage:* On {010}. *Tenacity:* Brittle. Hardness = 4
D(meas.) = 5.75(6) D(calc.) = 5.77

Optical Properties: Semitransparent. *Color:* Bright Duesbury green. *Streak:* Pale green. *Luster:* Resinous, dull if altered.
Optical Class: Biaxial (+). *Pleochroism:* Weak; in watery greens. *Orientation:* $Y = b$; $X \wedge c = 22°$; $Z \wedge a = 3°$. *Absorption:* $Z > Y > X$. $\alpha = 2.115$ $\beta = 2.135$ $\gamma = 2.26$ 2V(meas.) = 40°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.866$ $b = 9.314$ $c = 7.598$ $\beta = 109.1°$ Z = 4

X-ray Powder Pattern: Lone Pine mine, New Mexico, USA.
3.064 (100), 4.654 (8), 3.348 (8), 3.111 (7), 2.744 (7), 3.793 (6b), 2.844 (5)

Chemistry:

	(1)	(2)
TeO_2	80.91	80.05
CuO	18.03	19.95
CaO	1.06	
Total	[100.00]	100.00

(1) Lone Pine mine, New Mexico, USA; average of three analyses, each corrected to 100.00% for remnant SiO_2 as quartz; corresponds to $(Cu_{0.90}Ca_{0.08})_{\Sigma=0.98}Te_{2.01}O_5$. (2) $CuTe_2O_5$.

Occurrence: A very rare mineral, coating fractures in intensely silicified rhyolite breccia.

Association: Mackayite, quartz.

Distribution: At a prospect near the Lone Pine mine, Wilcox district, Catron Co., New Mexico, USA.

Name: To honor Robert Allen Jenkins (1944–), American geologist and mineralogist, Phelps Dodge Corporation, who found the first specimens.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,547; Harvard University, Cambridge, Massachusetts, USA, 119101.

References: (1) Williams, S.A. (1979) Rajite, naturally occuring cupric pyrotellurite, a new mineral. Mineral. Mag., 43, 91–92. (2) (1979) Amer. Mineral., 64, 1331 (abs. ref. 1).

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Rakovanite $Na_3\{H_3[V_{10}O_{28}]\}\cdot 15H_2O$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. Multi-faceted crystals are blocky to prismatic along [100], with striations parallel to [100], to 1 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1 D(meas.) = n.d. D(calc.) = 2.407

Optical Properties: Transparent. *Color:* Orange. *Streak:* Orange-yellow. *Luster:* Subadamantine. *Optical Class:* Biaxial (+). $\alpha = 1.776(5)$ $\beta = 1.803(5)$ $\gamma = 1.910(6)$ 2V = 56(1)° *Dispersion:* $r < v$; strong, parallel. *Orientation:* $X = b$; $Z \wedge c = 8°$. *Pleochroism*: X = light yellow; Y = orange-yellow; Z = yellowish orange. *Absorption*: $Z > Y > X$.

Cell Data: *Space Group:* $P2_1/n$. $a = 12.0248(17)$ $b = 17.121(3)$ $c = 18.140(3)$ $\beta = 106.242(8)°$ $Z = 4$

X-ray Powder Pattern: Sunday and West Sunday mines, Colorado, USA.
11.270 (100), 7.696 (81), 8.709 (78), 6.892 (63), 2.935 (42), 2.798 (31), 3.445 (24)

Chemistry:

	(1)	(2)
Na_2O	8.02	7.15
K_2O	0.29	
MgO	0.01	
CaO	0.04	
V_2O_5	81.2	69.97
Al_2O_3	0.04	
H_2O		22.87
Total		100.00

(1) Sunday and West Sunday mines, Colorado, USA; average of 10 electron microprobe analyses of partially dehydrated material, H_2O confirmed by structure analysis, corresponding to $(Na_{2.90}K_{0.07}Ca_{0.01}Al_{0.01})_{\Sigma=2.99}\{H_{2.98}[V_{10}O_{28}]\}\cdot 15H_2O$. (2) $Na_3\{H_3[V_{10}O_{28}]\}\cdot 15H_2O$.

Mineral Group: Pascoite group.

Occurrence: A secondary mineral as crystalline crusts on sandstone fractures in mine walls in the oxidized zone of a montroseite-corvusite assemblage.

Association: Calcite, montroseite, corvusite, hughesite, hewettite, pascoite, munirite, paramontrosite, rosasite, sherwoodite.

Distribution: From the Sunday and West Sunday mines, Slick Rock district, San Miguel County, Colorado, USA.

Name: Honors Dr. John Rakovan (b. 1964), professor, Department of Geology and Environmental Earth Science, Miami University, Oxford, Ohio, USA.

Type Material: Mineral Sciences Department, Natural History Museum of Los Angeles County, California, USA (63357, 63358).

References: (1) Kampf, A.R., J.M. Hughes, J. Marty, M.E. Gunter, and B. Nash (2011) Rakovanite, $Na_3\{H_3[V_{10}O_{28}]\}\cdot 15H_2O$, a new member of the pascoite family with a protonated decavanadate polyanion. Can. Mineral., 49(2), 595-604. (2) (2013) Amer. Mineral., 98, 281 (abs. ref. 1).

Ralstonite $Na_xMg_xAl_{2-x}(F,OH)_6 \cdot H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are dominantly octahedral or cubic, less commonly cubo-octahedral, to 1 cm.

Physical Properties: *Cleavage:* {111}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 2.56–2.62 D(calc.) = 2.56

Optical Properties: Transparent to translucent. *Color:* Colorless to white, milky; may be surficially discolored yellow by iron oxides; colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Isotropic; anomalously uniaxial or biaxial, sectored. n = 1.399–1.427

Cell Data: *Space Group:* $Fd3m$. a = 9.91(4) Z = 8

X-ray Powder Pattern: Ivigtut, Greenland.
5.74 (100), 1.765 (86), 2.88 (75), 3.01 (53), 1.508 (40), 1.923 (38), 2.29 (32)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Na	4.27	9.86	5.4	Cl			0.05
K	0.12		0.02	O			[23.2]
Mg	4.39	10.28	5.6	H			[1.9]
Ca	0.03	0.95	0.02	OH	[19.46]	[4.22]	
Al	24.25	14.67	22.3	H_2O	8.43	8.65	
F	39.91	51.36	41.6	Total	[100.86]	[99.99]	[100.09]

(1) Ivigtut, Greenland; $(OH)^{1-}$ calculated for charge balance, corresponds to $Na_{0.35}Mg_{0.35}Al_{1.65}[F_{3.88}(OH)_{2.12}]_{\Sigma=6.00} \cdot 0.88H_2O$. (2) Do.; original total given as 96.29%, recalculated after deduction of mica 3.5%; original H_2O 10.30%, $(OH)^{1-}$ calculated for charge balance; then corresponds to $Na_{0.88}Mg_{0.88}Al_{1.12}[F_{5.5}(OH)_{0.5}]_{\Sigma=6.0} \cdot 0.99H_2O$. (3) Do.: by electron microprobe, H and O by difference.

Occurrence: In some granite pegmatites and greisenized zones rich in fluorine; in a hydrothermal antimony deposit in silicified limestones.

Association: Thomsenolite, cryolite, pachnolite, chiolite, elpasolite, colquiriite, gearksutite, weberite, prosopite, fluorite.

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland. In the USA, at St. Peters Dome, near Pikes Peak, El Paso Co., and in the Goldie carbonatite, McClure Mountain-Iron Mountain, Fremont Co., Colorado; in the Morefield pegmatite mine, Amelia, Amelia Co., Virginia; from the Quitman Mountains, Hudspeth Co., Texas; in the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada. From near Colquiri, Oruro, Bolivia. In the Mt. Cleveland tin mine, western Tasmania, Australia. From near Lake Gjerdingen, Nordmarka, Norway. In the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. At Perga, Volyn, Ukraine. From West Kayrakty, Kazakhstan. In the Zharchikhinsk molybdenum deposit, on the west side of Lake Baikal, eastern Siberia, and at the Tolbachik fissure volcano, Kamchatk Peninsula, Russia. Several other localities are reported but are minor or require authentication.

Name: Honoring Reverend J. Grier Ralston, of Norristown, Pennsylvania, USA, who first noted the species.

Type Material: Yale University, New Haven, Connecticut, USA, 1.4437.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 126–127. (2) Pauly, H. (1965) Ralstonite from Ivigtut, South Greenland. Amer. Mineral., 50, 1851–1864. (3) Effenberger, H. and F. Kluger (1984) Ralstonit: ein Beitrag zur Kenntnis von Zusammensetzung und Kristallstruktur. Neues Jahrb. Mineral., Monatsh., 97–108 (in German with English abs.).

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Rambergite MnS

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are long prismatic or thick lance-shaped, to 1 cm. *Twinning:* Lamellar twinning on {010}.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2 VHN = 206 (20 g load). D(meas.) = 5.43 D(calc.) = [5.64]

Optical Properties: Opaque. *Color:* Gray-black; in polished section, white. *Streak:* Gray-black. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Moderate. R_1–R_2: (400) 39.3–43.1, (420) 38.8–42.8, (440) 38.3–42.5, (460) 37.8–42.2, (480) 37.4–42.0, (500) 36.9–41.6, (520) 36.5–41.2, (540) 36.0–40.9, (560) 35.7–40.5, (580) 35.3–40.2, (600) 34.8–39.7, (620) 34.4–39.2, (640) 34.0–38.7, (660) 33.4–38.0, (680) 32.8–37.3, (700) 32.0–36.4

Cell Data: *Space Group:* $P2_1/n$. $a = 19.24$ $b = 13.08$ $c = 8.73$ $\beta = 90.28°$ Z = [2]

X-ray Powder Pattern: Chocaya, Bolivia.
3.32 (100), 2.94 (60), 2.78 (50), 2.21 (50), 3.48 (30), 3.04 (30), 3.82 (20)

Chemistry:

	(1)	(2)	(3)
Ag	8.96	9.6	8.80
Pb	33.84	35.7	33.82
Sb	34.91	36.1	36.44
S	21.14	19.6	20.94
Total	98.85	101.0	100.00

(1) Chocaya, Bolivia; by electron microprobe, corresponds to $Ag_{3.02}Pb_{5.95}Sb_{10.44}S_{24.00}$. (2) Do.; by electron microprobe, average of ten analyses; corresponds to $Ag_{3.49}Pb_{6.77}Sb_{11.64}S_{24.00}$. (3) $Ag_3Pb_6Sb_{11}S_{24}$.

Occurrence: In medium- to low-temperature hydrothermal silver deposits.

Association: Sphalerite, pyrite, andorite, andorite, jamesonite, quartz (Chocaya, Bolivia); andorite (Bear Basin, Washington, USA).

Distribution: In Bolivia, from the Guadaloupe mine, Chocaya, Potosí [TL], at Oruro, and Tatasi. In the Pirquitas deposit, Riconada Department, Jujuy Province, Argentina. In the USA, at the Round Valley tungsten mine, Bishop Creek area, Inyo Co., California; and at Bear Basin, King Co., Washington. In the Zlata Bana deposit, Slanske vrchy Mountains, Slovakia. From the Fenghuangshan silver deposit, Guangxi Province, China. At the Alyaskitovoye Sn–W deposit, Sakha, Russia.

Name: Honors Professor Paul Ramdohr (1890–1985), German mineralogist, University of Berlin, Berlin, Germany, for his studies of opaque ore minerals.

Type Material: The Natural History Museum, London, England, 1931,535; Harvard University, Cambridge, Massachusetts, 98835; National Museum of Natural History, Washington, D.C., USA, R6595.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 450–451. (2) Donnay, J.D.H. and G. Donnay (1954) Syntaxic intergrowths in the andorite series. Amer. Mineral., 39, 161–171. (3) Borodaev, Y.S., O.L. Sveshnikova, and N.N. Mozgova (1971) The inhomogeneity of ramdohrite. Doklady Acad. Nauk SSSR, 199, 1138–1141 (in Russian). (4) Makovicky, E. and W.G. Mumme (1983) The crystal structure of ramdohrite, $Pb_6Sb_{11}Ag_3S_{24}$, and its implications for the andorite group and zinckenite. Neues Jahrb. Mineral., Abh., 147, 58–79. (5) Moëlo, Y., E. Makovicky, and S. Karup-Møller (1984) New data on the minerals of the andorite series. Neues Jahrb. Mineral., Monatsh., 175–182. (6) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 731–733.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are long prismatic or thick lance-shaped, from 0.5–1 cm. *Twinning:* Lamellar twinning on (010).

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2 VHN = 206 (20 g load). D(meas.) = 5.43 D(calc.) = [5.64]

Optical Properties: Opaque. *Color:* Gray-black; in polished section, white. *Streak:* Gray-black. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Moderate. R_1–R_2: (400) 39.3–43.1, (420) 38.8–42.8, (440) 38.3–42.5, (460) 37.8–42.2, (480) 37.4–42.0, (500) 36.9–41.6, (520) 36.5–41.2, (540) 36.0–40.9, (560) 35.7–40.5, (580) 35.3–40.2, (600) 34.8–39.7, (620) 34.4–39.2, (640) 34.0–38.7, (660) 33.4–38.0, (680) 32.8–37.3, (700) 32.0–36.4

Cell Data: *Space Group:* $P2_1/n$. $a = 19.24$ $b = 13.08$ $c = 8.73$ $\beta = 90.28°$ Z = [2]

X-ray Powder Pattern: Chocaya mine, Bolivia.
3.32 (100), 2.94 (60), 2.78 (50), 2.21 (50), 3.48 (30), 3.04 (30), 3.82 (20)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	8.96	8.79	9.6	8.80
Pb	33.84	34.46	35.7	33.82
Fe		0.21		
Cd		0.60		
In		0.20		
Sb	34.91	34.40	36.1	36.44
S	21.14	20.41	19.6	20.94
Total	98.85	99.07	100.8	100.00

(1–2) Chocaya mine, Bolivia; by electron microprobe. (3) Do.; by electron microprobe, average of ten analyses. (4) $Ag_3Pb_6Sb_{11}S_{24}$.

Occurrence: Found in fine-grained quartz in a vein of hydrothermal origin (Chocaya mine, Bolivia).

Association: Pyrite, stannite, andorite, jamesonite, sphalerite, quartz (Chocaya mine, Bolivia); andorite (Bear Basin, Washington, USA).

Distribution: In Bolivia, from the Colorado Ag-Sn vein, Chocaya mine, Potosí, and from Tatasi. In the USA, at the Round Valley tungsten mine, Bishop Creek area, Inyo Co., California; and at Bear Basin, King Co., Washington.

Name: For Professor Paul Ramdohr (1890–1985), German mineralogist.

Type Material: National Museum of Natural History, Washington, D.C., USA, R6595.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 450–451. (2) Donnay, J.D.H. and G. Donnay (1954) Syntaxic intergrowths in the andorite series. Amer. Mineral., 39, 161–171. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 731–733. (4) Borodaev, Y.S., O.L. Sveshnikova, and N.N. Mozgova (1971) The inhomogeneity of ramdohrite. Doklady Acad. Nauk SSSR, 199, 1138–1141 (in Russian). (5) (1972) Amer. Mineral., 57, 1560 (abs. ref. 4). (6) Makovicky, E. and W.G. Mumme (1983) The crystal structure of ramdohrite, $Pb_6Sb_{11}Ag_3S_{24}$, and its implications for the andorite group and zinckenite. Neues Jahrb. Mineral., Abh., 147, 58–79. (7) Moëlo, Y., E. Makovicky, and S. Karup-Møller (1984) New data on the minerals of the andorite series. Neues Jahrb. Mineral., Monatsh., 175–182. (8) (1985) Amer. Mineral., 70, 219–220 (abs. ref. 7).

Rameauite $K_2CaU^{6+}_6O_{20}\cdot 9H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$ or m. As crystals, to 1 mm, pseudohexagonal in section, steep pyramidal, flattened on {010}, and elongated along [001], with {010}, {100}, {001}, and {110}. *Twinning:* Universal, on {100}.

Physical Properties: *Cleavage:* Good on {010}. Hardness = n.d. D(meas.) = 5.60 D(calc.) = 5.55

Optical Properties: Semitransparent. *Color:* Orange.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 4°$–$6°$. α = n.d. $\beta = 1.95$ $\gamma = 1.97$ 2V(meas.) = 32°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 13.97$ $b = 14.26$ $c = 14.22$ $\beta = 121°1(5)'$ Z = 4

X-ray Powder Pattern: Margnac mine, France.
7.12 (vvs), 3.495 (vvs), 3.139 (vvs), 3.124 (vvs), 3.566 (vs), 3.473 (vs), 3.185 (vs)

Chemistry:

	(1)
UO_3	84.
CaO	2.4
SrO	0.0
BaO	0.0
K_2O	5.0
H_2O^+	8.2
Total	99.6

(1) Margnac mine, France; by electron microprobe, H_2O by TGA; corresponds to $K_{2.16}Ca_{0.87}U_{6.00}O_{20}\cdot 9.3H_2O$.

Occurrence: In the oxidation zone of uranium deposits.

Association: Calcite, uranophane, uraninite, "gummite".

Distribution: From the Margnac mine, Compreignac, Haute-Vienne, France. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). Found in the Orphan mine, Grand Canyon, Coconino Co., Arizona, USA.

Name: For Jacques Rameau (?–1960), prospector for the French Atomic Energy Commission, Paris, France, who discovered the Margnac 2 deposit.

Type Material: University of Pierre and Marie Curie, Paris; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 137454.

References: (1) Cesbron, F., W.L. Brown, P. Bariand, and J. Geffroy (1972) Rameauite and agrinierite, two new hydrated complex uranyl oxides from Margnac, France. Mineral. Mag., 38, 781–789. (2) (1973) Amer. Mineral., 58, 805 (abs. ref. 1).

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Ramikite-(Y) $Li_4Na_{12}(Y,Ca,REE)_6Zr_6(PO_4)_{12}(CO_3)_4O_4(F,OH)_4$

Crystal Data: Triclinic. *Point Group*: 1. As cores of equant, well-formed pseudocubes to 1 mm; intimately intergrown with peatite-(Y).

Physical Properties: *Cleavage*: Weak to poor on {100}, {010}, {001} probable.
Fracture: Splintery. *Tenacity*: Brittle. Hardness = ~ 3 D(meas.) = n.d. D(calc.) = 3.60(1)

Optical Properties: Translucent. *Color*: Yellowish white. *Streak*: White. *Luster*: Sub-vitreous to dull.
Optical Class: Biaxial (n.d.). α = n.d. β = 1.636(1) γ = n.d. 2V(meas.) = n.d.
2V(calc.) = n.d. *Pleochroism:* None. *Dispersion*: None.

Cell Data: *Space Group*: *P*1. a = 10.9977(6) b = 10.9985(6) c = 10.9966(6)
α = 90.075(4)° β = 89.984(4)° γ = 89.969(4)° Z = 1

X-ray Powder Pattern: Poudrette pegmatite, Mont Saint-Hilaire, Canada.
3.89 (100), 2.94 (98), 2.59 (98), 7.80 (79), 11.04 (76), 6.36 (75), 3.48 (68)

Chemistry:

	(1)	(2)		(1)	(2)
Na_2O	11.25	12.77	ZrO_2	23.40	25.39
CaO	4.15		ThO_2	0.49	
La_2O_3	0.11		HfO_2	0.69	
Y_2O_3	16.48	23.26	P_2O_5	28.10	29.25
Nd_2O_3	0.08		F	0.62	
Dy_2O_3	1.11		$–O=F_2$	0.26	
Ce_2O_3	0.10		CO_2	[5.92]	6.04
Er_2O_3	1.18		H_2O	[0.92]	1.24
Tm_2O_3	0.28		Li_2O	[2.01]	2.05
Yb_2O_3	0.57		Total	99.75	100.00
Al_2O_3	0.14				

(1) Poudrette pegmatite, Mont Saint-Hilaire, Canada; average of 22 electron microprobe analyses, H_2O, CO_2 and Li_2O calculated from stoichiometry and their presence confirmed by LA-ICP-MS and Raman analyses; corresponding to $Li_4(Na_{10.79}Ca_{1.21})_{\Sigma=12}(Y_{4.34}Ca_{0.99}Dy_{0.18}Er_{0.18}Yb_{0.09}La_{0.02}Ce_{0.02}Nd_{0.01})_{\Sigma=5.83}(Zr_{5.65}Hf_{0.10}Th_{0.06})_{\Sigma=5.81}[(P_{0.98}Al_{0.01})_{\Sigma=0.99}O_4]_{12}(CO_3)_4O_4[(OH)_{3.03}F_{0.97}]_{\Sigma=4}$.
(2) $Li_4Na_{12}Y_6Zr_6(PO_4)_{12}(CO_3)_4O_4(OH)_4$.

Occurrence: A late-stage product possibly related to the in situ alteration of the pre-existing mineral assemblage present in the core of a zoned peralkaline pegmatite dike encased in a hornfels xenolith.

Association: Peatite-(Y), albite, rhodochrosite, siderite, chabazite-Na, synchysite-(Ce), sabinaite.

Distribution: From the Poudrette pegmatite, Mont Saint-Hilaire, La Vallée-du-Richelieu, Montérégie (formerly Rouville County), Québec, Canada.

Name: Honors Robert A.J. Ramik (*b.*1951), an analytical technician and mineralogist in the Department of Natural History, Royal Ontario Museum, Toronto, Ontario, Canada.

Type Material: The Royal Ontario Museum, Toronto, Ontario, Canada (M53893).

References: (1) McDonald, A.M., M.E. Back, R.A. Gault, and L. Horváth (2013) Peatite-(Y) and ramikite-(Y), two new Na-Li-Y±Zr phosphate-carbonate minerals from the Poudrette pegmatite, Mont Saint-Hilaire, Quebec. Can. Mineral., 51, 569-596. (2) (2014) Amer. Mineral., 99, 2441 (abs. ref. 1).

Rammelsbergite $NiAs_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rare as prismatic crystals, elongated along [010], to 5 mm; commonly massive, granular, radial, fibrous. *Twinning:* On {101}.

Physical Properties: *Cleavage:* {101}, distinct. Hardness = 5.5–6 VHN = 630–758 (100 g load). D(meas.) = 7.1(1) D(calc.) = 7.091

Optical Properties: Opaque. *Color:* Tin-white with a faint pinkish hue; in polished section, pure white. *Streak:* Grayish black. *Luster:* Metallic. *Pleochroism:* Weak, in yellow to pinkish hue and bluish white. *Anisotropism:* Strong, especially in blues.
R_1–R_2: (400) 56.1–59.8, (420) 56.6–60.2, (440) 56.8–61.0, (460) 56.6–61.1, (480) 56.1–60.9, (500) 56.2–60.8, (520) 56.5–60.8, (540) 56.8–60.9, (560) 57.0–60.9, (580) 57.0–60.9, (600) 56.9–60.6, (620) 56.8–60.1, (640) 56.6–59.6, (660) 56.4–58.9, (680) 56.6–58.5, (700) 56.7–58.0

Cell Data: *Space Group: Pnnm* (synthetic). $a = 4.7582(7)$ $b = 5.7949(8)$ $c = 3.5440(4)$ Z = 2

X-ray Powder Pattern: Synthetic (nearly identical to ferroselite).
2.552 (100), 2.476 (90), 2.843 (65), 1.870 (55), 1.696 (30), 1.771 (25), 1.790 (20)

Chemistry:

	(1)	(2)	(3)
Ni	27.84	28.6	28.15
Co	1.80	0.5	
Fe	trace	0.1	
As	67.32	71.0	71.85
Sb	0.83		
S	2.03	0.4	
Total	99.82	100.6	100.00

(1) University mine, Cobalt, Canada. (2) Coniston mines, England; by electron microprobe. (3) $NiAs_2$.

Polymorphism & Series: Trimorphous with pararammelsbergite and krutovite.

Mineral Group: Löllingite group.

Occurrence: In hydrothermal veins formed at medium temperatures with other Ni–Co minerals.

Association: Skutterudite, safflorite, löllingite, nickeline, bismuth, silver, algodonite, domeykite, uraninite.

Distribution: In Germany, at Schneeberg, Saxony [TL]; at Eisleben and Mansfeld, Saxony-Anhalt; from Bieber, near Hanau, Hesse. In the Lölling-Hüttenberg district, Carinthia, Austria. From the Polkovice copper mine, near Legnica, Zechstein copper district, Lower Silesia, Poland. In France, at Sainte-Marie-aux-Mines, Haut-Rhin. From the Coniston mines, Cumbria, England. In the Leadhills-Wanlockhead district, Dumfries, Scotland. At the Sedmochislenitsi mine, Vratsa district, western part of the Stara Planina (Balkan Mountains), Bulgaria. From Lainijaur, Västerbotten, Sweden. Large crystals at Bou Azzer, Morocco. In the USA, from the Mohawk mine, Keweenaw Co., Michigan. In Canada, at the Eldorado mine, Great Bear Lake, Northwest Territories; in various mines around Cobalt, Ontario, and other scattered localities. In the Ulsan mine, Kyongsang Province, South Korea. Known from a number of other occurrences world-wide.

Name: To honor Karl Friedrich Rammelsberg (1813–1899), mineral chemist of Berlin, Germany.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 309–310. (2) Kjekshus, A., T. Rakke, and A.F. Andresen (1974) Compounds with the marcasite type crystal structure. IX. Structural data for $FeAs_2$, $FeSe_2$, $NiAs_2$, $NiSb_2$, and $CuSe_2$. Acta Chem. Scand., 28, 996–1000. (3) (1960) NBS Circ. 539, 10, 42. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 473. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 839–845.

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Ramsbeckite $(Cu,Zn)_{15}(SO_4)_4(OH)_{22}\cdot 6H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Crystals are tabular with large {001}, also {210}, {110}, {100}, giving a slightly rounded rhombic outline, to 3 mm. *Twinning:* Observed, repeated, forming cylindrical aggregates.

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 3.39–3.41 D(calc.) = 3.37

Optical Properties: Transparent to translucent. *Color:* Green, blue-green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = pale blue-green, emerald-green; $Y = Z$ = blue-green, yellow-green. *Orientation:* $Y = b$; $X \wedge c = 5°$; $Z \wedge a = 5°$. *Absorption:* $X > Y = Z$. $\alpha = 1.624$–1.669 $\beta = 1.674$–1.703 $\gamma = 1.678$–1.707 2V(meas.) = 36°–38° 2V(calc.) = 38.0°

Cell Data: *Space Group:* $P2_1/a$. $a = 16.088$–16.110 $b = 15.576$–15.602 $c = 7.102$–7.112 $\beta = 90.0°-90.27°$ Z = 2

X-ray Powder Pattern: Bastenberg mine, Ramsbeck, Germany.
7.090 (100), 3.549 (25), 1.776 (20), 3.254 (13), 4.400 (12), 3.232 (12), 3.244 (11)

Chemistry:

	(1)	(2)	(3)
SO_3	17.4	17.6	17.51
CuO	44.5	43.8	43.49
ZnO	15.8	18.1	22.25
H_2O	19.3	[20.5]	16.75
Total	97.0	[100.0]	100.00

(1) Bastenberg mine, Ramsbeck, Germany; SO_4 by photometry, CuO, ZnO by AA, H_2O by gas chromatography, $(OH)^{1-}$ computed for charge balance; corresponds to $(Cu_{10.30}Zn_{3.58})_{\Sigma=13.88}(SO_4)_{4.00}(OH)_{19.76}\cdot 9.84H_2O$. (2) Ecton mine, Pennsylvania, USA; by electron microprobe, H_2O by difference, $(OH)^{1-}$ computed for charge balance; corresponds to $(Cu_{10.03}Zn_{4.05})_{\Sigma=14.08}(SO_4)_{4.00}(OH)_{20.17}\cdot 10.64H_2O$. (3) $(Cu,Zn)_{15}(SO_4)_4(OH)_{22}\cdot 6H_2O$ with Cu:Zn = 2:1.

Occurrence: Rarely formed by supergene oxidation in dump materials and slag.

Association: Chalcopyrite, linarite, brochantite, serpierite, schulenbergite, smithsonite, hydrozincite, connellite, chalcophyllite (Germany); linarite, anglesite, pyromorphite, posnjakite, serpierite (Ecton mine, Pennsylvania, USA).

Distribution: In Germany, from the Bastenberg mine, Ramsbeck, North Rhine-Westphalia; at the Rammelsberg mine, near Goslar, the Glücksrad mine, near Oberschulenberg, the Wildemann mine, and elsewhere in the Harz Mountains; from the Friedrichssegen mine, near Bad Ems, Rhineland-Palatinate; and in the Marie mine, near Wilnsdorf, Siegerland. From the Waterbank mine, Wetton, Staffordshire, England. In Wales, at the Dylife mine, Machynlleth, Powys; in the Brynarian mine, Talybont, the Penrhiw mine, Ystumtuen, and the Frongoch mine, Dyfed. In the Veneziana mine, near Torrebelvicino, Veneto, Italy. From the Ecton mine, Audubon, Montgomery Co., Pennsylvania, USA.

Name: For Ramsbeck, Germany, near the location from which the species was first noted.

Type Material: University of Göttingen, Göttingen, Germany.

References: (1) Hodenberg, R.v., W. Krause, G. Schnorrer-Köhler, and H. Täuber (1985) Ramsbeckite, $(Cu,Zn)_7(SO_4)_2(OH)_{10}\cdot 5H_2O$, a new mineral. Neues Jahrb. Mineral., Monatsh., 550–556. (2) (1987) Amer. Mineral., 72, 225 (abs. ref. 1). (3) Peacor, D.R., P.J. Dunn, and B.D. Sturman (1987) Ramsbeckite: an American occurrence at the Ecton mine, Pennsylvania. Mineral. Record, 18, 131–132. (4) Effenberger, H. (1988) Ramsbeckite, $(Cu,Zn)_{15}(OH)_{22}(SO_4)_4\cdot 6H_2O$: revision of the chemical formula based on a structure determination. Neues Jahrb. Mineral., Monatsh., 38–48. (5) Orlandi, P. and N. Perchiazzi (1989) Ramsbeckite, $(Cu,Zn)_{15}(OH)_{22}(SO_4)_4\cdot 6H_2O$, a first occurrence for Italy from "La Veneziana" mine, Valle dei Mercanti, Vicenza. Eur. J. Mineral., 1, 147–149.

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Ramsdellite $Mn^{4+}O_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 1 cm, are commonly pseudomorphs after groutite crystals; platy, fibrous, massive.

Physical Properties: *Cleavage:* Prominent, on three pinacoids and a prism. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 4.65–4.83 D(calc.) = 4.84

Optical Properties: Opaque. *Color:* Steel-gray to iron-black; yellowish white in reflected light. *Streak:* Black, may have brownish tint. *Luster:* Brilliant metallic. *Optical Class:* Biaxial. *Anisotropism:* Strong; pale yellow. *Bireflectance:* Distinct. R_1–R_2: n.d.

Cell Data: *Space Group: Pbnm.* $a = 4.533(5)$ $b = 9.27(1)$ $c = 2.866(5)$ $Z = 4$

X-ray Powder Pattern: Lake Valley, New Mexico, USA.
4.08 (10), 2.53 (8), 1.60 (7), 1.64 (6), 2.13 (5), 1.88 (5), 1.46 (5)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.36	0.42	CaO	1.12	0.00
MnO_2	95.02	97.14	BaO	0.00	0.00
Al_2O_3	0.72	0.48	Na_2O	n.d.	0.31
Fe_2O_3	0.22	0.34	K_2O	n.d.	0.41
MnO	0.00	0.00	H_2O^+	1.39	
ZnO	0.25	n.d.	H_2O^-	0.05	
MgO	0.00	0.12	H_2O		1.24
			Total	99.13	100.46

(1) Locality unknown; type material. (2) Lake Valley, New Mexico, USA.

Polymorphism & Series: Trimorphous with akhtenskite and pyrolusite.

Occurrence: A secondary mineral in manganese deposits, formed by inversion of pyrolusite or oxidative dehydrogenation of groutite.

Association: Pyrolusite, hollandite, cryptomelane, coronadite.

Distribution: Some localities for well-characterized material are: in the USA, from Lake Valley, Sierra Co., New Mexico; in the Artillery Mountains, Mohave Co., and at the Mistake mine, Yavapai Co., Arizona; from the Idarado mine, near Telluride, San Miguel Co., Colorado; in the Monroe-Tener mine, near Chisholm, St. Louis Co., Minnesota. Along the East River, Pictou Co., Nova Scotia, Canada. In Mexico, at Los Gavilanes, Baja California. In India, from Dongari Buzurg, Bhandara, Madhya Pradesh. At the Iron Monarch quarry, Iron Knob, South Australia. From the Otoshibetsu and Tanno mines, Hokkaido, and elsewhere in Japan. At Horni Blatna (Platten), Czech Republic. From Bütten-Adenstadt, Lower Saxony, and the Clara Mine, near Oberwolfach, Black Forest, Germany. At Gebel To Yu, Yoider, and Um Bogna, Egypt. From Hotazel, near Kuruman, Cape Province, South Africa.

Name: For Professor Lewis Stephen Ramsdell (1895–1975), American mineralogist, University of Michigan, Ann Arbor, Michigan, USA.

Type Material: University of Michigan, Ann Arbor, Michigan, USA.

References: (1) Fleischer, M. and W.E. Richmond (1943) The manganese oxide minerals: a preliminary report. Econ. Geol., 38, 269–286, esp. 278. (2) Byström, A.M. (1949) The crystal structure of ramsdellite, an orthorhombic modification of MnO_2. Acta Chem. Scand., 3, 163–173. (3) Fleischer, M., W.E. Richmond, and H.T. Evans, Jr. (1962) Studies of the manganese oxides. V. Ramsdellite, MnO_2, an orthorhombic dimorph of pyrolusite. Amer. Mineral., 47, 47–58. (4) Ramdohr, P. (1980) The ore minerals and their intergrowths, (4th edition), 1026–1027.

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Ranciéite $(Ca, Mn^{2+})Mn_4^{4+}O_9 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. As fine lamellar to polycrystalline aggregates; in stalactites and incrustations.

Physical Properties: Hardness = n.d. D(meas.) = 3.336 D(calc.) = n.d.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black, brown, violet; brown in transmitted light. *Streak:* Pale reddish brown with a lilac to purple hue.
Luster: Bright metallic.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 2.83$–2.86 $c = 7.53$–7.55 Z = n.d.

X-ray Powder Pattern: Rancié, France; close to takanelite, variable with hydration.
7.50 (10), 3.71 (5), 2.70 (4), 2.46 (4), 2.34 (4), 9.55 (2), 2.04 (1)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2		0.62	0.09	CaO	2.30	8.10	8.20
MnO_2	70.80	75.04	76.22	Na_2O		0.12	
Al_2O_3		0.12	0.61	K_2O		0.26	0.25
Fe_2O_3	9.20	0.12	0.15	H_2O^+		11.09	
MnO		3.31		H_2O^-		1.53	
CuO		0.02		H_2O	15.00		[14.48]
MgO	1.35	0.16		P_2O_5		0.10	
				Total	98.65	100.59	[100.00]

(1) Rancié, France. (2) Oriente Province, Cuba; corresponding to $(Ca_{0.76}Mn^{2+}_{0.22})_{\Sigma=0.98}$ $Mn^{4+}_{4.14}O_9 \cdot 3.36H_2O$. (3) Sheliya deposit, Russia; by electron microprobe, Mn^{4+}:Mn^{3+}:Mn^{2+} calculated from site occupancy and charge balance considerations; corresponding to $(Ca_{0.70}Mn^{2+}_{0.22}$ $Al_{0.06}K_{0.02})_{\Sigma=1.00}(Mn^{4+}_{3.75}Mn^{3+}_{0.12}Fe^{3+}_{0.01})_{\Sigma=3.88}O_9 \cdot 3.86H_2O$.

Polymorphism & Series: Forms a series with takanelite.

Occurrence: A product of weathering or alteration of manganese deposits, commonly formed in limestone or in caves in limestone.

Association: Todorokite, calcite,"limonite".

Distribution: Some well-authenticated localities are: in France, at Rancié, near Vicdessos, Ariège; at Prader, Pyrénées-Oriental; at Montmirat, Lozève; and elsewhere. From near Newbiggin, Teesdale, Durham, England. At Barranco de Maspalomas, Grand Canary Island, Spain. In a cave at Kefali, near Itea, Greece. From Monte Gelato, near Mazzano Romano, Latium, Italy. In the Sheliya deposit, Ural Mountains, Russia. At Winterberg, Harz Mountains, Germany. From Oriente Province, Cuba. In the USA, from Batesville, Independence Co., Arkansas; in Mammoth Cave, Kentucky; at the Anson Betts mine, Plainfield, Hampshire Co., Massachusetts; in Paxton's Cave, near Bolling Springs, Alleghany Co., Virginia; at Courtland, Cochise Co., and Ajo, Pima Co., Arizona.

Name: For its first-noted occurrence at Rancié, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 572. (2) Richmond, W.E., M. Fleischer, and M.E. Mrose (1969) Studies on manganese oxide minerals. IX. Rancieite. Bull. Soc. fr. Minéral., 92, 191–195. (3) Chukhrov, F.V., A.I. Gorshkov, E.S. Rudnitskaya, V.V. Beresovkaya, and A.V. Sivtsov (1980) Manganese minerals in clay: a review. Clays and Clay Minerals, 28, 346–453. (4) Kim, S.J. (1993) Chemical and structural variations in rancieite–takanelite solid solution series. Neues Jahrb. Mineral., Monatsh., 233–240.

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Rankachite $CaFe^{2+}V_4^{5+}W_8^{6+}O_{36}\cdot 12H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crusts of needlelike to lathlike crystals, elongated along [001], flattened on {100} or {010}, to 2 mm; in rosettes and subparallel to radial aggregates.

Physical Properties: *Cleavage:* One direction, good, parallel to the plane of flattening. *Fracture:* Uneven. Hardness = ∼2.5 D(meas.) = > 4.03 D(calc.) = [4.55]

Optical Properties: Opaque to translucent. *Color:* Dark brown to brownish yellow. *Streak:* Brown. *Luster:* Subadamantine to resinous, may be dull. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; $X = Y$ = yellowish brown; Z = reddish brown to opaque. *Orientation:* $X \perp$ plane of flattening; $Z = c$. *Dispersion:* $r \ll v$, strong. $\alpha = 1.770(5)$ $\beta = 1.925(5)$ $\gamma = 1.970(5)$ 2V(meas.) = 58°

Cell Data: *Space Group:* *Pmmn* (probable). $a = 8.17$ $b = 42.02$ $c = 5.45$ Z = [2]

X-ray Powder Pattern: Clara mine, Germany.
10.64 (10), 5.44 (7), 4.57 (6), 4.08 (6), 3.51 (6), 3.26 (6), 3.04 (6)

Chemistry:

	(1)	(2)
WO_3	70.2	72.38
V_2O_5	13.9	14.19
FeO	3.2	2.80
CaO	2.7	2.19
H_2O	8.8	8.44
Total	98.8	100.00

(1) Clara mine, Germany; by electron microprobe, corresponding to $Ca_{1.26}Fe_{1.12}V_{3.92}W_{7.78}H_{25.04}O_{48}$. (2) $CaFeV_4W_8O_{36}\cdot 12H_2O$.

Occurrence: An alteration product of scheelite and iron sulfides in the oxidation zone of a hydrothermal base-metal deposit.

Association: Scheelite, pyrite, marcasite, quartz.

Distribution: From the mill dump of the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: For the Rankach Valley, Germany, in which the Clara mine is located.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160380.

References: (1) Walenta, K. and P.J. Dunn (1984) Rankachit, ein neues Mineral aus der Grube Clara im mittleren Schwarzwald. Neues Jahrb. Mineral., Monatsh., 289–295 (in German with English abs.). (2) (1985) Amer. Mineral., 70, 876 (abs. ref. 1).

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Rankamaite $(Na, K, Pb, Li)_3(Ta, Nb, Al)_{11}(O, OH)_{30}$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* 222, $mm2$, or $2/m\ 2/m\ 2/m$. Straight to wavy fibers, aggregated into rounded grains, to 1 cm; these may be concentrically layered, in nodular masses surrounding simpsonite.

Physical Properties: Hardness = 3–4 D(meas.) = 5.5 D(calc.) = [6.02]

Optical Properties: Semitransparent. *Color:* White to cream-white, may be yellowish due to iron staining; bluish gray to brownish in thin section. *Luster:* Silky.
Optical Class: Biaxial. *Orientation:* $X \perp c$; $Z = c$. $\alpha = > 2.10$ $\beta = > 2.10$ $\gamma = > 2.10$
2V(meas.) = n.d.

Cell Data: *Space Group:* $C222$, $Cmm2$, $Cm2m$, or $Cmmm$. $a = 17.19$ $b = 17.70$ $c = 3.933$ Z = 2

X-ray Powder Pattern: Mumba district, Congo; shows some preferred orientation.
2.970 (100), 3.011 (80), 3.375 (60), 3.467 (52), 3.935 (41), 4.112 (34), 1.7363 (32)

Chemistry:

	(1)	(2)
Nb_2O_5	17.40	15.69
Ta_2O_5	69.47	73.60
SiO_2	0.96	
Fe_2O_3		1.06
Al_2O_3	3.40	2.18
PbO	2.63	1.81
CaO		0.05
Na_2O	2.31	1.86
K_2O	1.80	2.16
Li_2O	0.11	
H_2O^+	1.55	
H_2O^-	0.35	
Total	99.98	98.41

(1) Mumba district, Congo; after deduction of muscovite impurity, corresponds to $(Na_{1.72}K_{0.76}Pb_{0.28}Li_{0.17})_{\Sigma=2.93}(Ta_{6.88}Nb_{3.03}Al_{1.18})_{\Sigma=11.09}[O_{26.26}(OH)_{3.74}]_{\Sigma=30.00}$. (2) [Congo]; by electron microprobe, corresponding to $(Na_{1.41}K_{1.08}Pb_{0.19})_{\Sigma=2.68}(Ta_{7.84}Nb_{2.78}Al_{1.01}Fe_{0.31})_{\Sigma=11.94}[O, (OH)]_{30}$.

Occurrence: Apparently a replacement of simpsonite, the result of intense sodium metasomatism in some Li-Ta-Nb-bearing granite pegmatites.

Association: Simpsonite, microlite, cassiterite, beryl, manganotantalite, muscovite, kaolinite (Mumba district, Congo); lithiotantite (Eastern Kazakhstan).

Distribution: In heavy-mineral concentrates from alluvial deposits in the Mumba district, Masisi, Kivu Province, Congo (Zaire). From an undisclosed locality [Kalba Mountains] in eastern Kazakhstan.

Name: To honor Professor Kalervo Rankama (1913–1995), Finnish geochemist, University of Helsinki, Helsinki, Finland.

Type Material: n.d.

References: (1) von Knorring, O., A. Vorma, and P.H. Nixon (1969) Rankamaite, a new tantalum mineral from Kivu, Congo. Bull. Geol. Soc. Finland, 41, 47–56. (2) (1970) Amer. Mineral., 55, 1814 (abs. ref. 1). (3) Voloshin, A.V., Y.P. Men'shikov, and Y.A. Pakhomovskii (1982) Sosedkoite, $(K, Na)_5Al_2(Ta, Nb, Sb)_{22}O_{60}$ – a new mineral from granite pegmatite. Doklady Acad. Nauk SSSR, 264, 442–445 (in Russian).

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Rankinite $Ca_3Si_2O_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rarely as prismatic crystals, to 8 mm; as subhedral flattened or tabular grains; as elongated irregular poikiloblastic patches; massive.

Physical Properties: Hardness = 5.5 D(meas.) = 2.96–3.00 D(calc.) = 2.99–3.00

Optical Properties: Transparent to translucent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge a = 15°$. *Dispersion:* $r > v$, weak. $\alpha = 1.640–1.643$ $\beta = 1.643–1.646$ $\gamma = 1.650–1.652$ 2V(meas.) = 62°–69°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.557(1)$ $b = 8.885(3)$ $c = 7.858(1)$ $\beta = 119.586(6)°$ Z = 4

X-ray Powder Pattern: Tokatoka, New Zealand.
2.717 (100), 3.18 (80), 4.48 (70), 3.84 (70), 3.03 (60), 1.819 (60), 3.20 (50)

Chemistry:

	(1)
SiO_2	41.3
CaO	58.4
Total	99.7

(1) Tunguska River basin, Russia; corresponds to $Ca_{3.02}Si_{1.99}O_7$.

Polymorphism & Series: Dimorphous with kilchoanite.

Occurrence: In high-temperature calc-silicate skarns.

Association: Larnite, melilite, spurrite, kilchoanite, nagelschmidtite, gehlenite, cuspidine, monticellite, andradite, perovskite, magnetite.

Distribution: From Scawt Hill, near Larne, Co. Antrim, Ireland. Found near Kilchoan, Ardamurchan, Argyllshire, and Camas Mòr, Isle of Muck, Scotland. From Golden Gully, Tokatoka district, about 150 km north of Auckland, New Zealand. At Fuka, near Bicchu, Okayama Prefecture, Japan. In the Christmas Mountains, Brewster Co., Texas, USA. In the Hatrurim Formation, at Hatrurim and Ma'aleh Adumim, Israel. In the Lower Tunguska River basin, central Siberia, Russia.

Name: For Dr. George Atwater Rankin (1884–?), physical chemist of the Geophysical Laboratory, Washington, D.C., USA, an early student of the system lime-alumina-silica.

Type Material: The Natural History Museum, London, England, 1956,386.

References: (1) Tilley, C.E. (1942) Tricalcium silicate (rankinite), a new mineral from Scawt Hill, Co. Antrim. Mineral. Mag., 26, 190–196. (2) (1942) Amer. Mineral., 27, 720 (abs. ref. 1). (3) Black, P.M. (1969) Rankinite and kilchoanite from Tokatoka, New Zealand. Mineral. Mag., 37, 517–519. (4) Saburi, S., I. Kusachi, C. Henmi, A. Kawahara, K. Henmi, and I. Kawada (1976) Refinement of the crystal structure of rankinite. Mineral. J. (Japan), 8, 240–246. (5) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 272–277.

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Ransomite $CuFe_2^{3+}(SO_4)_4 \cdot 6H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Needlelike crystals, to 2 mm, in radiating tufts and crusts.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 2.5 D(meas.) = 2.632 D(calc.) = 2.735 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Bright sky-blue; pale blue in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (+). $\alpha = 1.631(5)$ $\beta = 1.643(5)$ $\gamma = 1.695(5)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 4.811(2)$ $b = 16.217(4)$ $c = 10.403(2)$ $\beta = 93°01(02)'$ Z = 2

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SO_3	46.30	47.97
Al_2O_3	1.52	
Fe_2O_3	22.57	23.92
CuO	11.29	11.92
H_2O	18.82	16.19
Total	100.50	100.00

(1) United Verde mine, Arizona, USA. (2) $CuFe_2(SO_4)_4 \cdot 6H_2O$.

Occurrence: Very rare, formed as the result of a mine fire (United Verde mine, Arizona, USA); coating oxidizing copper-bearing pyrite (Campbell shaft, Arizona, USA).

Association: Pyrite, voltaite, römerite (Campbell shaft, Arizona, USA).

Distribution: In the USA, in Arizona, from the United Verde mine, Jerome, Yavapai Co., and in the Campbell shaft, Bisbee, Cochise Co.

Name: To honor Frederick Leslie Ransome (1868–1935), American mining geologist, U.S. Geological Survey and California Institute of Technology, Pasadena, California, USA.

Type Material: The Natural History Museum, London, England, 1985,401; Mineral Museum, University of Arizona, M50; Harvard University, Cambridge, Massachusetts, 90541; National Museum of Natural History, Washington, D.C., USA, 95955.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 519–520. (2) Wood, M.M. (1970) The crystal structure of ransomite. Amer. Mineral., 55, 729–734.

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Crystal Data: Monoclinic, pseudo-orthorhombic (?). *Point Group:* n.d. As nodules, to 1 mm, composed of rounded tabular plates, flattened on [010], which may aggregate to form botryoidal crusts.

Physical Properties: *Cleavage:* Two, irregular, ‖ [001] and [100]. Hardness = ~3 D(meas.) = 3.4 D(calc.) = 3.39 Radioactive.

Optical Properties: Semitransparent. *Color:* Golden yellow.
Optical Class: Biaxial (–). *Pleochroism:* Strong; pale greenish yellow to pale yellow.
Orientation: Oblique extinction. $\alpha = 1.643(2)$ $\beta = 1.664(2)$ $\gamma = 1.670(2)$ 2V(meas.) = n.d. 2V(calc.) = 56°

Cell Data: *Space Group:* n.d. $a = 11.10$ $b = 17.7$ $c = 18.0$ $\beta = \sim 90°$ Z = 14

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
9.00 (100b), 3.133 (80), 4.70 (50), 2.978 (40b), 1.850(40), 4.45 (30), 3.53 (20)

Chemistry:

	(1)	(2)
UO_3	54.5	55.42
P_2O_5	13.2	13.75
Al_2O_3	9.9	9.88
H_2O	20.3	20.95
Total	97.9	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, H_2O by TGA; corresponds to $HAl_{1.02}(UO_2)_{1.00}(PO_4)_{0.98}(OH)_3 \cdot 4H_2O$. (2) $HAl(UO_2)PO_4(OH)_3 \cdot 4H_2O$.

Occurrence: A rare secondary mineral in the oxidized uraniferous zone of a complex granite pegmatite.

Association: Meta-autunite, phosphuranylite, phuralumite, upalite, moreauite, threadgoldite.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: For resemblance of the mineral's color to that of the buttercup, *ranunculus* in Latin.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG6201; National Museum of Natural History, Washington, D.C., USA, 145686.

References: (1) Deliens, M. and P. Piret (1979) Ranunculite, $AlH(UO_2)(PO_4)(OH)_3 \cdot 4H_2O$, a new mineral. Mineral. Mag., 43, 321–323. (2) (1980) Amer. Mineral., 65, 407 (abs. ref. 1).

Rapidcreekite $Ca_2(SO_4)(CO_3)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As acicular crystals, elongated along [001], flattened on {010}, with minor {100}, {001}, to 3 mm, in radiating sprays, isolated and in crusts.

Physical Properties: *Cleavage:* Perfect on {010}; good on {100}. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 2.21(1) D(calc.) = 2.239

Optical Properties: Transparent. *Color:* White to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.516(1)$ $\beta = 1.518(1)$ $\gamma = 1.531(1)$ 2V(meas.) = 45(3)° 2V(calc.) = 43°

Cell Data: *Space Group: Pcnb.* $a = 15.517(2)$ $b = 19.226(3)$ $c = 6.1646(8)$ Z = 8

X-ray Powder Pattern: Rapid Creek, Canada; strongest lines close to gypsum.
7.78 (100), 3.11 (80), 4.31 (70), 3.88 (70), 2.797 (60), 2.917 (50), 2.555 (50)

Chemistry:

	(1)	(2)
SO_3	26.1	25.97
CO_2	14.0	14.28
CaO	36.3	36.38
H_2O	23.6	23.37
Total	100.0	100.00

(1) Rapid Creek, Canada; by electron microprobe, CO_2 and H_2O by TGA-EGA; corresponding to $Ca_{1.99}(SO_4)_{1.00}(CO_3)_{0.98}\cdot 4.02H_2O$. (2) $Ca_2(SO_4)(CO_3)\cdot 4H_2O$.

Occurrence: A rare secondary mineral formed along joint and bedding-plane surfaces of quartz-rich sideritic iron formation.

Association: Kulanite, gypsum, aragonite.

Distribution: From Crosscut Creek, a tributary of Rapid Creek, Yukon Territory, Canada.

Name: For its occurrence in the Rapid Creek district, Canada.

Type Material: Geological Survey of Canada, Ottawa, 64346; Canadian Museum of Nature, Ottawa, Canada, 49502, 50824.

References: (1) Roberts, A.C., H.G. Ansell, and I.R. Johnson (1986) Rapidcreekite, a new hydrated calcium sulfate-carbonate from the Rapid Creek area, Yukon Territory. Can. Mineral., 24, 51–54. (2) (1987) Amer. Mineral., 72, 225 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1996) The crystal structure of rapidcreekite, $Ca_2(SO_4)(CO_3)\cdot 4H_2O$, and its relation to the structure of gypsum. Can. Mineral., 34, 99–106.

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Raspite $PbWO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are typically flattened on {100}, elongated along [010] or [100], may be flat tabular on $\{\overline{1}01\}$; prominent forms are {100}, {011}, {001}, {010}, several others modifying, to 1.3 cm. *Twinning:* On {100}, common as interpenetration twins; also on $\{\overline{1}02\}$.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = 2.5–3 D(meas.) = 8.46 D(calc.) = 8.45

Optical Properties: Semitransparent. *Color:* Yellowish brown, pale yellow, gray. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c \simeq 30°$. $\alpha = 2.27(2)$ $\beta = 2.27(2)$ $\gamma = 2.30(2)$ 2V(meas.) = $\sim 0°$

Cell Data: *Space Group:* $P2_1/a$. $a = 13.555(11)$ $b = 4.976(2)$ $c = 5.561(3)$ $\beta = 107.63(7)°$ Z = 4

X-ray Powder Pattern: Broken Hill, Australia. (ICDD 16-156).
3.224 (100), 2.760 (60), 3.619 (55), 2.705 (55), 1.812 (25), 3.593 (20), 3.478 (20)

Chemistry:

	(1)	(2)
WO_3	48.32	50.95
PbO	49.06	49.05
rem.	1.43	
Total	98.81	100.00

(1) Broken Hill, Australia; remnant is Fe_2O_3 and MnO. (2) $PbWO_4$.

Polymorphism & Series: Dimorphous with stolzite.

Occurrence: An uncommon secondary mineral formed in the oxidized zone of tungsten-bearing hydrothermal base metal deposits; inverts to stolzite above 410 °C.

Association: Stolzite, yttrotungstite, alumotungstite, cuprotungstite, ferritungstite.

Distribution: From the Proprietary mine, Broken Hill, and the Cordillera mine, near Tuena, New South Wales, Australia. At the Otani mine, Kyoto Prefecture, Japan. In the Kramat Pulai mine, Kinta district, Perak, Malaysia. From the Sumidoro gold placers, Municipio do Mariana, Minas Gerais, Brazil. At Gifurwe, Rwanda. In the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: To honor Charles Rasp (1846–1907), German–Australian prospector who discovered the Broken Hill deposit.

Type Material: Natural History Museum, Vienna, Austria, G6263.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1089–1090. (2) Fujita, T., I. Kawada, and K. Kato (1977) Raspite from Broken Hill. Acta Cryst., 33, 162–164.

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Rasvumite KFe_2S_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In grains, to 2 mm, which are aggregates of very fine, commonly curved needles; massive crusts.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = n.d. VHN = 243–433; 40–43 (15 g load). D(meas.) = 3.1 D(calc.) = 3.029 Slightly magnetic.

Optical Properties: Opaque. *Color:* Steel-gray, becoming iridescent purple or bronze, to dull black with oxidation. *Luster:* Metallic. *Pleochroism:* Strong. *Anisotropism:* Strong.
R_1–R_2: (400) 16.7–30.1, (420) 16.9–30.5, (440) 17.1–30.8, (460) 17.3–30.2, (480) 17.5–29.6, (500) 17.6–29.4, (520) 17.9–29.4, (540) 18.1–29.4, (560) 18.5–29.8, (580) 19.0–30.3, (600) 19.6–31.0, (620) 20.1–31.7, (640) 20.6–32.5, (660) 20.8–33.2, (680) 20.9–33.6, (700) 21.0–33.8

Cell Data: *Space Group: Cmcm.* $a = 9.049(6)$ $b = 11.019(7)$ $c = 5.431(4)$ Z = 4

X-ray Powder Pattern: Coyote Peak, California, USA.
5.513 (100), 6.98 (62), 3.403 (43), 3.492 (17), 1.778 (14), 2.935 (12), 2.905 (12)

Chemistry:

	(1)	(2)	(3)
K	16.3	15.2	15.83
Fe	45.2	46.1	45.22
S	38.0	38.5	38.95
Total	99.5	99.8	100.00

(1) Khibiny massif, Russia; by electron microprobe. (2) Coyote Peak, California, USA; by electron microprobe. (3) KFe_2S_3.

Occurrence: Typically an alteration product of pyrrhotite; in differentiated alkalic massifs (Russia); in an alkalic mafic diatreme (Coyote Peak, California, USA); in sodalite syenite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in natrocarbonate lavas (Oldoinyo Lengai volcano, Tanzania); in a contact-metamorphosed xenolith (Oslo rift, Norway).

Association: Djerfisherite, chlorbartonite, pyrrhotite, cubanite, potassic feldspar, nepheline, acmite (Russia); pyrrhotite, nepheline, acmite, analcime, alkalic feldspar (Point of Rocks, New Mexico, USA); ussingite, villiaumite, siderenkite, sodalite (Mont Saint-Hilaire, Canada).

Distribution: In Russia, on the Kola Peninsula, from Mts. Rasvumchorr [TL], Koashva, and Yukspor, and in the Kirov apatite mine, Mt. Kukisvumchorr [TL], Khibiny massif; at the Lovozero massif. From the Oslo rift, southern Norway. In the USA, at Coyote Peak, near Orick, Humboldt Co., California, and from Point of Rocks, Colfax Co., New Mexico. From Mont Saint-Hilaire, Quebec, Canada. On Oldoinyo Lengai volcano, Tanzania.

Name: For its occurrence on Mt. Rasvumchorr, Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3627; Mining Institute, St. Petersburg, 1095/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73142, 73143, 73584, 73975.

References: (1) Sokolova, M.N., M.G. Dobrovol'skaya, N.I. Organova, M.E. Kazalova, and A.L. Dmitrik (1970) A sulfide of iron and potassium — the new mineral rasvumite. Zap. Vses. Mineral. Obshch., 99, 712–720 (in Russian). (2) (1971) Amer. Mineral., 56, 1121–1122 (abs. ref. 1). (3) Czamanske, G.R., R.C. Erd, M.N. Sokolova, M.G. Dobrovol'skaya, and M.T. Dmitrieva (1979) New data on rasvumite and djerfisherite. Amer. Mineral., 64, 776–778. (4) Clark, J.R. and G.E. Brown, Jr. (1980) Crystal structure of rasvumite, KFe_2S_3. Amer. Mineral., 65, 477–482. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 474.

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Rathite $(Pb, Tl)_3As_5S_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic to short prismatic and striated parallel to [100]. size??ckBinnbooks??MinSchweiz?? *Twinning:* Polysynthetic on {001}, producing crystals of pseudo-orthorhombic habit; commonly seen in polished section.

Physical Properties: *Cleavage:* Perfect on {001}; parting on {010}. *Fracture:* Subconchoidal. Hardness = 3 VHN = 161 D(meas.) = 5.37(4) D(calc.) = 5.31

Optical Properties: Not fully opaque. ??ckBinnbooks??MinSchweiz?? *Color:* Lead-gray, may tarnish to iridescence; in polished section, white with deep red internal reflections. *Streak:* Chocolate-brown. *Luster:* Metallic. *Pleochroism:* Strong. *Anisotropism:* Intense; olive-green or yellow and bluish violet.

R_1–R_2: (400) 40.0–45.2, (420) 39.2–44.8, (440) 38.4–44.3, (460) 37.8–43.7, (480) 37.2–43.7, (500) 36.6–42.8, (520) 36.0–42.3, (540) 35.4–41.8, (560) 34.7–41.0, (580) 34.0–40.2, (600) 33.3–39.3, (620) 32.6–38.4, (640) 31.9–37.6, (660) 31.3–36.7, (680) 30.7–35.9, (700) 30.2–35.2

Cell Data: *Space Group:* $P2_1/c$. $a = 8.496(1)$ $b = 7.969(1)$ $c = 25.122(3)$ $\beta = 100.704(2)^\circ$ Z = 4

X-ray Powder Pattern: Binntal, Switzerland.
2.75 (100), 3.60 (80), 3.39 (70), 2.87 (70), 4.19 (60), 2.97 (60), 2.22 (50)

Chemistry:

	(1)	(2)
Pb	41.2	36.61
Tl	3.6	5.36
Ag		4.13
As	27.0	27.31
Sb		1.94
S	28.	24.48
Total	99.8	99.82

(1) Binntal, Switzerland; by electron microprobe, corresponds to $(Pb_{2.78}Tl_{0.22})_{\Sigma=3.00}Ag_{0.58}As_{4.40}S_{10.00}$. (2) Do.; by electron microprobe, average of 11 analyses; corresponds to $(Pb_{2.31}Tl_{0.34})_{\Sigma=2.65}Ag_{0.50}(As_{4.77}Sb_{0.21})_{\Sigma=4.98}S_{10.00}$.

Occurrence: In crystalline dolostone with other Pb–As–S minerals.

Association: Liveingite, baumhauerite, sartorite, hutchinsonite, tennantite, pyrite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: In honor of Gerhard von Rath (1830–1888), Professor of Mineralogy, Bonn, Germany.

Type Material: University of Fribourg, Fribourg, Switzerland, B742.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 455–457. (2) Marumo, F. and W. Nowacki (1965) The crystal structure of rathite-I. Zeits. Krist., 122, 433–456. (3) Berlepsch, P., T. Armbruster, and D. Topa (2002) Structural and chemical variations in rathite, $Pb_8Pb_{4-x}(Tl_2As_2)_x(Ag_2As_2)As_{16}S_{40}$: modulations of a parent structure. Zeits. Krist., 217, 581–590. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 152–153. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 475.

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Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As pseudo-tetragonal lamellar crystals, to 0.5 mm, with {001} prominent; also as divergent fan-like or open-book splayed clusters, to 2 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Laminated. *Tenacity*: Brittle. Hardness = ~ 2 D(meas.) = n.d. D(calc.) = 3.427 Radioactive.

Optical Properties: Transparent to translucent. *Color*: Light yellowish green, colorless in transmitted light. *Streak*: White. *Luster*: Vitreous, pearly on {001}. *Optical Class*: Biaxial (-). α = 1.550(3) β = 1.578(1) γ = 1.581(1) 2V*(*meas.) = 40(5)° 2V*(*calc.) = 36° *Dispersion*: None. *Orientation: X* ~ ⊥ (001), *Y* and *Z* are close to the diagonals in the (001) plane of square-shape crystals.

Cell Data: *Space Group*: $P\bar{1}$. a = 7.100(3) b = 7.125(3) c = 10.751(4) α = 106.855(7) β = 104.366(7) γ = 90.420(6)° Z = 1 or [I-centered cell] a = 7.100(3) b = 7.125(3) c = 19.955(8) α = 92.406(14) β = 94.924(14) γ = 90.420(6)° Z = 2

X-ray Powder Pattern: Belorechenskoye deposit, Northern Caucasus, Russia.
9.97 (100), 3.539 (93), 4.936 (62), 3.388 (43), 4.533 (41), 2.488 (27), 2.233 (27)

Chemistry:

	(1)	(2)
MgO	0.71	
CoO	0.07	
NiO	5.38	7.07
ZnO	0.08	
P_2O_5	1.08	
As_2O_5	20.26	21.75
UO_3	54.22	54.13
H_2O	[17.10]	17.05
Total	98.90	100.00

(1) Belorechenskoye deposit, Northern Caucasus, Russia; average of 12 electron microprobe analyses, H_2O by difference, presence of H_2O, PO_4, UO_2, $As^{3+}O_4$ groups confirmed by IR spectroscopy; corresponding to $(Ni_{0.76}Mg_{0.19}Co_{0.01}Zn_{0.01})_{\Sigma=0.97}U_{2.00}O_4(As_{1.86}P_{0.16})_{\Sigma=2.02}O_8 \cdot 10H_2O$. (2) $Ni(UO_2)_2(As^{3+}O_3)_2 \cdot 10H_2O$.

Mineral Group: Autunite group.

Occurrence: A secondary mineral found in small cavities and cracks in slightly oxidized uraninite-bearing dolomite veins.

Association: Dymkovite ,uraninite, nickeline, gersdorffite, goethite, "limonite", annabergite.

Distribution: From adit #1, Belorechenskoye deposit, Belaya River basin, 60 km south of Maikop, Adygea Republic, Northern Caucasus, Russia.

Name: According to the naming rules for the autunite group as the hydrated analog of *metarauchite*, $Ni(UO_2)_2(AsO_4)_2 \cdot 8H_2O$ - the root name honors Czech mineral collector Ludek Rauch (1951-1983).

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (3997/1).

References: (1) Pekov, I.V., V.V. Levitskiy, S.V. Krivovichev, A.A. Zolotarev, I.A. Bryzgalov, A.E. Zadov, and N.V. Chukanov (2012) New nickel-uranium-arsenic mineral species from the oxidation zone of the Belorechenskoye deposit, Northern Caucasus, Russia: I. Rauchite, $Ni(UO_2)_2(AsO_4)_2 \cdot 10H_2O$, a member of the autunite group. European Journal of Mineralogy, 24(5), 913-922. (2) (2015) Amer. Mineral., 100, 336-338 (abs. ref. 1).

Rauenthalite $Ca_3(AsO_4)_2 \cdot 10H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Euhedral crystals, elongated along [001], to 0.5 mm, isolated or in spherulitic aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.36 D(calc.) = 2.362

Optical Properties: Semitransparent. *Color:* Snow-white to colorless.
Optical Class: Biaxial (+). *Orientation:* $Y \wedge c = 5°–10°$. α = [1.540]–1.546 β = 1.552(2) γ = 1.570–1.576 2V(meas.) = 85(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 12.564(8)$ $b = 12.169(7)$ $c = 6.195(4)$ $\alpha = 89.09(3)°$ $\beta = 79.69(3)°$ $\gamma = 118.58(4)°$ Z = 2

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France; close to phaunouxite.
10.8 (FFF), 3.36 (FF), 2.44 (F), 6.2 (mF), 2.58 (mF), 2.06 (mF), 3.79 (f)

Chemistry:

	(1)	(2)
As_2O_5	39.94	39.75
MgO	0.00	
CaO	28.92	29.09
H_2O	31.04	31.16
Total	99.90	100.00

(1) Sainte-Marie-aux-Mines, France; average of two analyses, H_2O by TGA; corresponds to $Ca_{2.98}(AsO_4)_{2.00} \cdot 9.9H_2O$. (2) $Ca_3(AsO_4)_2 \cdot 10H_2O$.

Occurrence: A post-mine low-temperature reaction product of carbonate gangue with arsenical solutions derived from arsenic (Sainte-Marie-aux-Mines, France).

Association: Phaunouxite, picropharmacolite, pharmacolite, sainfeldite, ferrarisite, löllingite, calcite, aragonite (Sainte-Marie-aux-Mines, France); picropharmacolite, lavendulan, cobaltian hörnesite, guérinite, roselite, gypsum (Anton mine, Germany).

Distribution: From the Gabe-Gottes mine, Sainte-Marie-aux-Mines, Haut-Rhin, and at the Salsigne mine, 15 km north of Carcassone, Aude, France. In the Svatá Anna uranium deposit, Planá, near Mariánské Lázně (Marienbad), and Jáchymov (Joachimsthal), Czech Republic. In Germany, at the Anton mine, Heubachtal, near Schiltach, and from Wittichen, Black Forest; at St. Andreasberg, Harz Mountains; in the Bauhaus district, Richelsdorf Mountains, Hesse; from Schneeberg, Saxony. In the Muckross mine, Co. Kerry, Ireland. At the Getchell mine, Potosi district, Humboldt Co., Nevada, USA.

Name: For the Rauenthal vein system, on which Sainte-Marie-aux-Mines, France, is located.

Type Material: National School of Mines, Paris, France.

References: (1) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésiens naturels. Bull. Minéral., 87, 169–211, esp. 177–180 (in French). (2) (1965) Amer. Mineral., 50, 805–806 (abs. ref. 1). (3) Catti, M. and G. Ivaldi (1983) On the topotactic dehydration $Ca_3(AsO_4)_2 \cdot 11H_2O$ (phaunouxite) → $Ca_3(AsO_4)_2 \cdot 10H_2O$ (rauenthalite) and structures of both minerals. Acta Cryst., 39, 4–10. (4) Walenta, K. (1972) Die Sekundärmineralien der Co-Ni-Ag-Bi-U-Erzgänge im Gebiet von Wittichen im mittleren Schwarzwald. Aufschluss, 23, 279–329, esp. 311 (in German).

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Rauvite $Ca(UO_2)_2V^{5+}_{10}O_{28}\cdot 16H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Microcrystalline; a hardened gellike precipitate in massive botryoidal crusts and thin coatings.

Physical Properties: *Tenacity:* Sectile to brittle. Hardness = n.d. D(meas.) = 2.92 D(calc.) = n.d. Dehydrates on exposure forming a crackled surface.

Optical Properties: Semitransparent. *Color:* Purplish black, bluish black, brownish red, brownish yellow-orange. *Streak:* Yellowish brown to olive. *Luster:* Adamantine to waxy. *Optical Class:* Biaxial (–). n = 1.88–1.95

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Temple Rock, Utah, USA.
10.7 (10), 2.95 (5), 3.49 (4), 2.62 (3), 3.87 (2), 5.83 (1), 2.22 (1)

Chemistry:

	(1)	(2)	(3)
UO_3	28.1	31.49	31.33
V_2O_5	49.0	48.28	49.81
V_2O_4	2.8	1.44	
Al_2O_3		0.70	
CaO	2.7	2.76	3.07
H_2O	17.5	15.49	15.79
insol.		0.61	
Total	100.1	100.77	100.00

(1) Temple Rock, Utah, USA; recalculated after deduction of 27.06% impurities. (2) Monument No. 2 mine, Arizona, USA. (3) $Ca(UO_2)_2V_{10}O_{28}\cdot 16H_2O$.

Occurrence: An uncommon mineral in the oxidized zones of U–V ores in Colorado Plateau-type deposits.

Association: Carnotite, corvusite, uvanite, hewettite, metatorbernite, tyuyamunite, gypsum.

Distribution: In the USA, from Temple Rock and Flat Top, Emery Co., and at the Cactus Rat mine group, Yellow Cat district, 24 km southeast of Thompson, Grand Co., Utah; in Colorado, at the Small Spot, Arrowhead, and Corvusite mines, Gateway district, Mesa Co., at the Hummer, Bitter Creek, Jo Dandy, and J.J. mines, Paradox Valley, Montrose Co.; from the Monument No. 2 mine, Monument Valley, Apache Co., and Monument No. 1 and Mitten No. 2 mines, Navajo Co., Arizona; at the Road Hog No. 3A claim, Coal Canyon, Fall River Co., South Dakota. In the Hatrurim Formation, Israel.

Name: For the chemical elements RAdium, Uranium, and Vanadium.

Type Material: Harvard University, Cambridge, Massachusetts, 134565; National Museum of Natural History, Washington, D.C., USA, 95060, R5715.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1058. (2) Weeks, A.D. and M.E. Thompson (1954) Identification and occurrence of uranium and vanadium minerals from the Colorado Plateaus. U.S. Geol. Sur. Bull. 1009-B, 34–35. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 263–264.

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Ravatite $C_{14}H_{10}$

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Crystal Data: Monoclinic. *Point Group:* 2. Thin platy polycrystalline crystals, of irregular shape and porous, to about 0.1 mm, in crusts.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Sectile. Hardness = ∼1 D(meas.) = 1.11(2) D(calc.) = 1.207(1) Pale yellow fluorescence under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, or pale grey with inclusions. *Luster:* Vitreous to waxy.
Optical Class: Biaxial (+) or (–). α = n.d. β = ∼1.75 γ = ∼1.95 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1$. a = 8.392(5) b = 6.181(3) c = 9.558(5) β = 98.48(12)° Z = 2

X-ray Powder Pattern: Ravat, Tajikistan; shows strong preferred orientation on {001}. 9.434 (100), 4.028 (13), 4.941 (11), 4.724 (11), 3.371 (10), 4.546 (5), 3.4441 (3)

Chemistry:

	(1)	(2)
C	93.41	94.34
H	5.51	5.66
Total	98.92	100.00

(1) Ravat, Tajikistan; by CHN analyzer; corresponds to $C_{14.1}H_{9.9}$. (2) $C_{14}H_{10}$ [phenanthrene].

Occurrence: A rare sublimate formed in burning coal seams at < 50 °C–60 °C.

Association: Other hydrocarbons, selenium.

Distribution: From near the former village of Ravat, left bank of the Jagnob River Valley, Tajikistan.

Name: For its occurrence near Ravat, Tajikistan.

Type Material: Mining Academy, Freiberg, Germany, 74120.

References: (1) Nasdala, L. and I.V. Pekov (1993) Ravatite, $C_{14}H_{10}$, a new organic mineral species from Ravat, Tadzhikistan. Eur. J. Mineral., 5, 699–705. (2) (1994) Amer. Mineral., 79, 389 (abs. ref. 1).

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Rayite $(Ag,Tl)_2Pb_8Sb_8S_{21}$

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Crystal Data: Monoclinic. *Point Group:* n.d. As tabular grains, to 30 μm, and as patches in other minerals.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 6.13

Optical Properties: Opaque. *Color:* Lead-gray; white with greenish and bluish tints in reflected light. *Streak:* Lead-gray. *Luster:* Metallic. *Pleochroism:* Greenish to greenish blue. *Anisotropism:* Perceptible, from dark blue to dark reddish brown.
R_1–R_2: (400) 38.3–41.8, (420) 38.0–41.3, (440) 37.8–40.9, (460) 37.6–40.6, (480) 37.6–40.4, (500) 37.5–40.1, (520) 37.5–39.9, (540) 37.5–39.6, (560) 37.4–39.4, (580) 37.2–38.9, (600) 37.0–38.4, (620) 36.7–37.9, (640) 36.3–37.5, (660) 35.9–37.3, (680) 35.6–37.2, (700) 35.3–37.1

Cell Data: *Space Group:* n.d. $a = 13.60(2)$ $b = 11.96(3)$ $c = 24.49(5)$ $\beta = 103.94(12)°$ Z = 4 *Space Group:* n.d. ; (synthetic $(Ag_{1.5}Tl_{0.5})_2Pb_8Sb_8S_{21}$). $a = 21.57$ $b = 23.43$ $c = 8.10$ $\beta = 100°7'$ Z = 8

X-ray Powder Pattern: Rajpura-Dariba deposit, India.
3.37 (100), 3.26 (90), 2.98 (50), 3.90 (30), 3.74 (30), 2.06 (30), 2.88 (20)

Chemistry:

	(1)
Ag	4.54
Tl	2.04
Pb	47.06
Cu	0.03
Sb	27.42
S	19.59
Total	100.68

(1) Rajpura-Dariba deposit, India; by electron microprobe, average of four samples; if related to semseyite ($Pb_9Sb_8S_{21}$), corresponds to $(Ag_{1.45}Tl_{0.34}Cu_{0.02}Pb_{7.81})_{\Sigma=9.62}Sb_{7.74}S_{21.00}$; if related to boulangerite ($Pb_5Sb_4S_{11}$), corresponds to $(Ag_{0.76}Tl_{0.18}Cu_{0.01}Pb_{4.09})_{\Sigma=5.04}Sb_{4.06}S_{11.00}$.

Occurrence: In a Precambrian polymetallic massive-sulfide deposit interbedded with kyanite-graphite schists, diopside-bearing calc-silicates, and meta-cherts.

Association: Galena, meneghinite, owyheeite.

Distribution: From the Rajpura-Dariba polymetallic deposit, Udaipur district, Rajasthan, India [TL].

Name: To honor Professor Santosh K. Ray (1908–1976), Indian petrologist, President College, Calcutta, India.

Type Material: Indian Institute of Technology, Kharagpur, India; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia.

References: (1) Basu, K., N.S. Bortinikov, A. Mookherjee, N.N. Mozgova, A.I. Tsepin, and L.N. Vyal'sov (1983) Rare minerals from Rajpura-Dariba, Rajasthan, India. IV: A new Pb–Ag–Tl–Sb sulfosalt, rayite. Neues Jahrb. Mineral., Monatsh., 296–304. (2) (1984) Amer. Mineral., 69, 211 (abs. ref. 1). (3) Choudhury, K.R. (1989) Synthesis of rayite/Tl-Ag boulangerite. Indian J. Earth Sciences, 16(2), 136–140.

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Realgar AsS

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, to 12 cm, and striated ‖ [001]; more commonly massive, coarse to fine granular, or as incrustations. *Twinning:* As contact twins on {100}

Physical Properties: *Cleavage:* Good on {010}; less so on {$\overline{1}$01}, {100}, {120}, and {110}. *Tenacity:* Sectile, also slightly brittle. Hardness = 1.5–2 VHN = n.d. D(meas.) = 3.56 D(calc.) = 3.59 Disintegrates on long exposure to light to a powder composed of pararealgar or arsenolite and orpiment.

Optical Properties: Transparent when fresh. *Color:* Red to yellow-orange; in polished section, pale gray, with abundant yellow to red internal reflections. *Streak:* Red-orange to red. *Luster:* Resinous to greasy.
Optical Class: Biaxial (–). *Pleochroism:* Nearly colorless to pale golden yellow. *Orientation:* $X \wedge c = -11°$. *Dispersion:* $r > v$, very strong, inclined. $\alpha = 2.538$ $\beta = 2.684$ $\gamma = 2.704$ 2V(meas.) = 40°34′ *Anisotropism:* Strong, in polished section.
R: (400) 29.9, (420) 28.6, (440) 27.4, (460) 26.3, (480) 25.2, (500) 24.2, (520) 23.3, (540) 22.4, (560) 21.7, (580) 21.1, (600) 20.6, (620) 20.3, (640) 20.0, (660) 19.7, (680) 19.5, (700) 19.3

Cell Data: *Space Group:* $P2_1/n$. $a = 9.325(3)$ $b = 13.571(5)$ $c = 6.587(3)$ $\beta = 106°23(5)'$ Z = 16

X-ray Powder Pattern: Alšar, Macedonia.
5.40 (100), 3.19 (90), 2.94 (80), 2.73 (80), 1.859 (60), 2.49 (50), 2.14 (50)

Chemistry:

	(1)	(2)
As	69.54	70.03
S	30.29	29.97
rem.	0.11	
Total	99.94	100.00

(1) Binntal, Switzerland; remainder SiO_2. (2) AsS.

Polymorphism & Series: Trimorphous with alacránite and pararealgar.

Occurrence: Most commonly as a low-temperature hydrothermal vein mineral associated with As–Sb minerals; also as volcanic sublimations and in hot spring deposits; in carbonate and clay sedimentary rocks.

Association: Orpiment, arsenolite, other arsenic minerals, calcite, barite.

Distribution: Only localities for finely crystallized material are given. In Germany, from Schneeberg, Saxony, and at St. Andreasberg, Harz Mountains. In the Lengenbach quarry, Binntal, Valais, Switzerland. In Romania, from Baia Sprie (Felsőbánya), Cavnic (Kapnikbánya), and at Săcărîmb (Nagyág). In the Czech Republic, from Jáchymov (Joachimsthal). At Alšar (Allchar), near Rošden, Macedonia. From Men-Kyule, Sakha, Russia. At Saimoku, ?? Prefecture, Japan. In the Shimen mine, 33 km southeast of Shimen, Hunan Province, China. In the USA, fine large crystals at the Getchell mine, Potosi district, Humboldt Co., Nevada; in Tooele Co., Utah, at Mercur; in Washington, in the Monte Cristo district, Snohomish Co., and in the Royal Reward mine, in the Green River Gorge, King Co.

Name: From the Arabic *rahj al ghar* for *powder of the mine*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 255–258. (2) Mullen, D.J.E. and W. Nowacki (1972) Refinement of the crystal structures of realgar, AsS and orpiment, As_2S_3. Zeits. Krist., 136, 48–65. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 69–70. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 477.

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Rebulite $Tl_5Sb_5As_8S_{22}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals exhibit the forms {100}, {001} and {111}; all faces in the zone [010] are striated, to 2 mm.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = 4.81 D(calc.) = 4.90

Optical Properties: Opaque. *Color:* Dark gray. *Streak:* Brownish red. *Luster:* Submetallic to metallic.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 17.441(5)$ $b = 7.363(2)$ $c = 32.052(7)$ $\beta = 105.03(7)^\circ$ Z = 4

X-ray Powder Pattern: Alšar, Macedonia.
3.076 (100), 3.368 (90), 2.948 (75), 2.186 (75), 4.004 (65), 4.147 (45), 3.107 (5)

Chemistry:

	(1)	(2)
Tl	32.76	34.81
Sb	22.88	20.74
As	20.46	20.42
S	24.33	24.03
Total	100.43	100.00

(1) Alšar, Macedonia; by electron microprobe; corresponds to $Tl_{4.65}Sb_{5.45}As_{7.92}S_{22.00}$.
(2) $Tl_5Sb_5As_8S_{22}$.

Occurrence: In a hydrothermal As–Tl deposit.

Association: Simonite, $TlHgAsS_3$ (christite or routhierite), realgar.

Distribution: From Alšar (Allchar), near Rošden, Macedonia [TL].

Name: To honor a Slovenian geologist or mining engineer named Rebula, who discovered the mineral.

Type Material: n.d.

References: (1) Balić-Žunić, T., S. Šćavničar, and P. Engel (1982) The crystal structure of rebulite, $Tl_5Sb_5As_8S_{22}$. Zeits. Krist., 160, 109–125. (2) (1983) Amer. Mineral., 68, 644 (abs. ref. 1). (3) Rieck, B. (1993) Allchar, Macedonia. Mineral. Record, 24, 437–449.

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Rectorite $(Na, Ca)Al_4(Si, Al)_8O_{20}(OH)_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As aggregates of microscopic crystals, producing foliae or matted masses resembling the "mountain leather" variety of palygorskite.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible but not elastic; plastic and greasy when hydrated. Hardness = < 1 D(meas.) = n.d. D(calc.) = [2.34]

Optical Properties: Semitransparent (?). *Color:* White. *Luster:* Pearly to greasy when massive.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 5.13$ $b = 8.88$ $c = 23.85$ $\beta = 96.3°$ Z = [2]

X-ray Powder Pattern: Baluchistan Province, Pakistan, air dried sample; after heating to 600 °C, $d_{(001)}$ = 19.3 Å; after ethylene glycol treatment $d_{(001)}$ = 26.8 Å.
23.8 (100), 11.9 (65), 3.40 (16), 2.971 (16), 1.970 (12), 4.75 (10), 1.827 (4)

Chemistry:

	(1)
SiO_2	52.72
Al_2O_3	36.60
Fe_2O_3	0.25
MgO	0.51
CaO	0.45
Na_2O	2.83
K_2O	0.26
H_2O^+	7.76
Total	101.38

(1) Blue Mountain district, Arkansas, USA.

Polymorphism & Series: A 1:1 regular interstratification of a dioctahedral mica and a dioctahedral smectite.

Occurrence: In some low-temperature hydrothermal argillic alteration zones, along veins and pervasively replacing potassic feldspar. In altered bentonites; may develop from muscovite during diagenesis of shales.

Association: Quartz, cookeite, ankerite, apatite, pyrite, sphalerite, galena, rutile (Jeffrey quarry, Arkansas, USA).

Distribution: In the USA, from the Blue Mountain district, Garland Co., and in the Jeffrey quarry, North Little Rock, Pulaski Co., Arkansas; and in Buckeye Gulch, eight km from Leadville, Lake Co., Colorado. In France, from Allevard, Isère, and near Sibert, Rhône. From the Fort Sandeman district, Baluchistan Province, Pakistan. Reported from numerous other localities but the material is not as well characterized as from the foregoing.

Name: For E.W. Rector (1849–1917), lawyer of Hot Springs, Arkansas, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 80607.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 687. (2) Korolev, Y.M. (1961) The structure of allevardite. Kristallografiya (Sov. Phys. Crystal.), 5, 848–852 (in Russian). (3) Brown, G. and A.H. Weir (1963) The identity of rectorite and allevardite. Proc. Inter. Clay Conf., 27–36. (4) (1964) Amer. Mineral., 49, 446 (abs. ref. 3). (5) Kodama, H. (1966) The nature of the component layers of rectorite. Amer. Mineral., 51, 1035–1055. (6) Korolev, Y.M. (1971) Some features of rectorite from Pakistan. Kristallografiya (Sov. Phys. Crystal.), 16, 250–253 (in Russian). (7) Bailey, S.W. (1982) Nomenclature for regular interstratifications. Amer. Mineral., 67, 394–398.

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Reddingite $Mn_3^{2+}(PO_4)_2 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, usually pseudo-octahedral, to 3 mm, with prominent {111}, {212}, {221}, {010}, {223}, {122}, other minor forms; commonly granular, massive.

Physical Properties: *Cleavage:* On {010}, poor. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 3.10–3.24 D(calc.) = 3.26

Optical Properties: Transparent to translucent. *Color:* Pale rose-pink to pale brownish yellow, colorless; red to red-orange on oxidization. *Streak:* White. *Luster:* Vitreous to subresinous.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Y = pinkish brown; Z = pale yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, distinct. $\alpha = 1.643$–1.655 $\beta = 1.648$–1.662 $\gamma = 1.674$–1.683 2V(meas.) = 41°–65°

Cell Data: *Space Group: Pbna.* $a = 9.49$ $b = 10.08$ $c = 8.70$ Z = 4

X-ray Powder Pattern: Hagendorf, Germany; close to phosphoferrite.
3.20 (10), 2.737 (8), 4.28 (7), 2.657 (7), 2.422 (7), 2.234 (7), 1.625 (7)

Chemistry:

	(1)	(2)
P_2O_5	34.52	34.72
FeO	5.43	
MnO	46.29	52.06
CaO	0.78	
Na_2O	0.31	
H_2O	13.08	13.22
Total	100.41	100.00

(1) Branchville, Connecticut, USA; average of two analyses, after deduction of SiO_2 as quartz, corresponds to $(Mn_{2.68}Fe_{0.31}Ca_{0.06}Na_{0.02})_{\Sigma=3.07}(PO_4)_{2.00} \cdot 3.00H_2O$. (2) $Mn_3(PO_4)_2 \cdot 3H_2O$.

Polymorphism & Series: Forms a series with phosphoferrite.

Occurrence: A rare secondary hydrothermal alteration product in zoned complex granite pegmatites.

Association: Dickinsonite, triploidite, triplite, lithiophilite, fairfieldite, eosphorite, huréaulite, rhodochrosite.

Distribution: In the USA, from Branchville, Fairfield Co., Connecticut; in Maine, at the Bennett quarry, Buckfield, and the Emmons quarry, Greenwood, Oxford Co., and the Berry quarry, Poland, Androscoggin Co. At Hagendorf, Bavaria, Germany. Large crystals from near Galiléia, Minas Gerais, Brazil.

Name: For Redding Township, Connecticut, USA, within which the first specimens were collected, near Branchville.

Type Material: Yale University, New Haven, Connecticut, USA, 3.5850, 3.5851.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 727–729. (2) Tennyson, C. (1954) Phosphoferrit und Reddingit von Hagendorf. Neues Jahrb. Mineral., Abh., 87, 185–217 (in German). (3) Kleber, W. and J.D.H. Donnay (1961) The heteromorphism of phosphoferrite–reddingtonite. Zeits. Krist., 115, 161–168. (4) King, V.T. and E.E. Foord (1994) Mineralogy of Maine, 303–304.

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Redingtonite $(Fe^{2+}, Mg, Ni)(Cr, Al)_2(SO_4)_4 \cdot 22H_2O$

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Crystal Data: Monoclinic (by analogy to the halotrichite group). *Point Group:* 2. Fibrous, in massive parallel aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 1.761 D(calc.) = n.d. Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White, purple on fractures across the fiber length. *Luster:* Silky.
Optical Class: Biaxial, weakly birefringent. *Orientation:* Extinction inclined $\leq 38°$. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SO_3	35.35	34.98
Al_2O_3	5.14	5.57
Fe_2O_3	0.19	
Cr_2O_3	7.51	8.30
FeO	4.58	7.85
MnO	trace	
NiO	1.00	
MgO	1.85	
H_2O^+	14.34	
H_2O^-	27.08	
H_2O		43.30
insol.	3.46	
Total	100.50	100.00

(1) Redington mine, California, USA; corresponds to $(Fe_{0.60}Mg_{0.43}Ni_{0.13})_{\Sigma=1.16}(Al_{0.95}Cr_{0.93})_{\Sigma=1.88}(SO_4)_4 \cdot 21.57H_2O$. (2) $Fe(Cr, Al)_2(SO_4)_4 \cdot 22H_2O$ with Cr:Al = 1:1.

Mineral Group: Halotrichite group.

Occurrence: An oxidation product of pyrite.

Association: Magnesiocopiapite, pyrite.

Distribution: From the Redington mercury mine, Knoxville, Napa Co., California, USA.

Name: For its occurrence in the Redington mine, California, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 529.

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Redledgeite $BaTi_6Cr_2^{3+}O_{16}\cdot H_2O$

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Crystal Data: Tetragonal, or monoclinic, pseudotetragonal. *Point Group:* $4/m$ or $2/m$. As dipyramidal crystals, to 2 mm; also finely fibrous.

Physical Properties: Hardness = 6.5 D(meas.) = 3.72 D(calc.) = 4.413

Optical Properties: Opaque, transparent on thin edges or in fibrous crystals. *Color:* Black or pale green to dark yellow-green; in reflected light, may have vivid green internal reflections when iron-free. *Luster:* Adamantine.
Optical Class: Uniaxial or biaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I4_1/m$, with $a = 14.320(2)$ $c = 5.893(1)$ Z = 4, or
Space Group: $I2/m$, with $a = 10.129(2)$ $b = 2.951(1)$ $c = 10.135(1)$ $\beta = 90.05°$ Z = 1

X-ray Powder Pattern: Red Ledge mine, California, USA; close to mannardite.
3.195 (100), 2.470 (60), 1.583 (60), 3.570 (50), 1.885 (50), 1.393 (50), 2.217 (40)

Chemistry:

	(1)	(2)	(3)
TiO_2	59.7	58.6	59.72
Fe_2O_3	0.9	1.0	
V_2O_3	0.4	0.7	
Cr_2O_3	17.4	17.0	18.94
BaO	20.2	20.8	19.10
H_2O	[2.1]		2.24
Total	[100.7]	98.1	100.00

(1) Red Ledge mine, California, USA; by electron microprobe, Ba + H_2O calculated = 2; corresponds to $Ba_{1.06}(Ti_{6.00}Cr_{1.84}Fe_{0.09}V_{0.05})_{\Sigma=7.98}O_{16}\cdot 0.94H_2O$. (2) Do.; by electron microprobe, average of 21 analyses; corresponds to $Ba_{1.10}(Ti_{5.95}Cr_{1.82}Fe_{0.10}V_{0.08})_{\Sigma=7.95}O_{16}$. (3) $BaTi_6Cr_2^{3+}O_{16}\cdot H_2O$.

Mineral Group: Cryptomelane group.

Occurrence: On chrome ore from a gold deposit.

Association: Chromite, chromian clinochlore, knorringite.

Distribution: In the USA, from the Red Ledge mine, Washington district, Nevada Co., California.

Name: For the Red Ledge mine, California, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95846; The Natural History Museum, London, England, 1928,336.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 560 [chromrutile]. (2) Strunz, H. (1961) "Chromrutile" von der Red Ledge Mine ist kein Rutil. Redledgeit. Neues Jahrb. Mineral., Monatsh., 107–111 (in German with English abs.). (3) Strunz, H. (1963) Redledgeit, eine TiO_2−Einlagerungsstruktur analog Kryptomelane. Neues Jahrb. Mineral., Monatsh., 116–119 (in German with English abs.). (4) Scott, J.D. and G.R. Peatfield (1986) Mannardite $[Ba\cdot H_2O](Ti_6V_2^{3+})O_{16}$, a new mineral species, and new data on redledgeite. Can. Mineral., 24, 55–66. (5) Szymański, J.T. (1986) The crystal structure of mannardite, a new hydrated cryptomelane group (hollandite) mineral with a doubled short axis. Can. Mineral., 24, 67–78. (6) Gatehouse, B.M., G.C. Jones, A. Pring, and R.F. Symes (1986) The chemistry and structure of redledgeite. Mineral. Mag., 50, 709–715.

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Reederite-(Y) $Na_{15-x}(Y,Ce)_2(CO_3)_9(SO_3F)(Cl,F)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}$. Tabular to blocky grains, to 2 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3–3.5 D(meas.) = 2.91(3) D(calc.) = 2.85

Optical Properties: Transparent. *Color:* Yellow to orange-brown. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–), may be anomalously biaxial (–). $\omega = 1.548(1)$ $\epsilon = 1.537(1)$ 2V(meas.) = 15°

Cell Data: *Space Group:* $P\overline{6}$. $a = 8.763(1)$ $c = 10.736(2)$ Z = 1

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.532 (100), 4.39 (80), 2.774 (80), 2.240 (80), 6.20 (40), 2.067 (30), 3.801 (20)

Chemistry:

	(1)		(1)
SO_3	5.07	Er_2O_3	1.19
CO_2	[31.91]	Yb_2O_3	0.37
Al_2O_3	1.31	FeO	0.42
Y_2O_3	10.24	MnO	1.23
La_2O_3	1.39	CaO	0.70
Ce_2O_3	3.54	Na_2O	34.04
Pr_2O_3	0.36	F	1.86
Nd_2O_3	1.99	Cl	2.05
Sm_2O_3	0.52	$-O = (F,Cl)_2$	1.24
Gd_2O_3	0.80	Total	[99.14]
Dy_2O_3	1.39		

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of ten analyses, total Fe as FeO, total Mn as MnO, presence of $(CO_3)^{2-}$ confirmed by IR, calculated from stoichiometry and crystal-structure analysis; corresponds to $(Na_{13.63}Al_{0.32}Mn_{0.22}Ca_{0.16}Fe_{0.07})_{\Sigma=14.40}(Y_{1.13}Ce_{0.27}Nd_{0.15}La_{0.11}Dy_{0.09}Er_{0.08}Gd_{0.06}Sm_{0.04}Pr_{0.03}Yb_{0.02})_{\Sigma=1.98}(CO_3)_{9.00}(SO_3F)_{0.79}(Cl_{0.72}F_{0.43})_{\Sigma=1.15}O_{0.74}$.

Occurrence: A very rare mineral in a sodalite xenolith in syenite in an intrusive alkalic gabbro-syenite complex.

Association: Trona, shortite, petersenite-(Ce), catapleiite, analcime, manganotychite.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Dr. Richard James Reeder (1953–), Professor of Geochemistry, State University of New York, Stony Brook, New York, USA, for his contributions to carbonate mineralogy.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81520.

References: (1) Grice, J.D., R.A. Gault, and G.Y. Chao (1995) Reederite-(Y), a new sodium rare-earth carbonate mineral with a unique fluorosulfate anion. Amer. Mineral., 80, 1059–1064.

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Reedmergnerite $NaBSi_3O_8$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As stubby prismatic to platy crystals, commonly wedge-shaped, may have jagged terminations; in aggregates, to 10 cm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 6–7 D(meas.) = 2.70–2.78 D(calc.) = 2.779

Optical Properties: Transparent. *Color:* Colorless to tan or yellowish pink.
Luster: Vitreous.
Optical Class: Biaxial (–). α = 1.554–1.558 β = 1.565 γ = 1.572–1.573
2V(meas.) = 74°–81°

Cell Data: *Space Group:* $C\bar{1}$. a = 7.8388(9) b = 12.3730(10) c = 6.8082(7)
α = 93.324(8)° β = 116.381(9)° γ = 92.014(8)° Z = 4

X-ray Powder Pattern: Duchesne Co., Utah, USA.
3.037 (100), 3.561 (90), 3.076 (90), 3.225 (85), 3.876 (65), 2.841 (55), 6.076 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	73.13	68.63	73.26	BaO	0.09		
TiO_2	0.03			Na_2O	12.15	10.11	12.59
B_2O_3	14.27	16.80	14.15	K_2O	0.03		
Al_2O_3	0.15	0.90		F		0.09	
Fe_2O_3	0.08			H_2O	0.08	0.98	
MgO	0.09	2.20		P_2O_5		0.08	
CaO		0.70		Total	100.10	100.49	100.00

(1) Duchesne Co., Utah, USA. (2) Dara-i-Pioz massif, Tajikistan. (3) $NaBSi_3O_8$.

Mineral Group: Feldspar group.

Occurrence: As authigenic crystals along bedding laminations, in brown dolomitic rock and black oil shale from well cuttings (Duchesne Co., Utah, USA); in a pegmatite in an alkalic massif (Dara-i-Pioz massif, Tajikistan).

Association: Eitelite, shortite, nahcolite, searlesite, leucosphenite, aegirine, analcime, magnesio-riebeckite (Duchesne Co., Utah, USA); leucosphenite, eudialyte, stillwellite, pyrochlore, microcline, aegirine, polylithionite, albite, quartz (Dara-i-Pioz massif, Tajikistan).

Distribution: In the vicinity of the Joseph Smith #1 well, near Duchesne, Duchesne Co., Utah; and at Wind Mountain, Otero Co., New Mexico, USA. In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. From the Lovozero massif, Kola Peninsula, Russia.

Name: Honors Frank S. Reed (1894–?) and John L. Mergner (1894–?), petrographic technicians with the U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106865.

References: (1) Milton, C., E.C.T. Chao, J.M. Axelrod, and F.S. Grimaldi (1960) Reedmergnerite, $NaBSi_3O_8$, the boron analog of albite, from the Green River Formation, Utah. Amer. Mineral., 45, 188–199. (2) Dusmatov, V.D., N.A. Popova, and L.K. Kabanova (1967) First find of reedmergnerite in the USSR. Dokl. Acad. Nauk Tadzh. SSR, 10, 51–53 (in Russian). (3) (1968) Chem. Abs., 71149 (abs. ref. 2). (4) Fleet, M.E. (1992) Tetrahedral-site occupancies in reedmergnerite and synthetic boron albite ($NaBSi_3O_8$). Amer. Mineral., 77, 76–84. (5) Grew, E.S., M.G. Yates, D.I. Belakovskiy [Belakovskii], R.C. Rouse, S.-C. Su, and N. Marquez (1994) Hyalotekite from reedmergnerite-bearing peralkaline pegmatite, Dara-i-Pioz, Tajikistan, and from Mn skarn, Långban, Sweden: a new look at an old mineral. Mineral. Mag., 58, 285–297.

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Reevesite $Ni_6Fe_2^{3+}(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $[\bar{3}\ 2/m]$ (by analogy to pyroaurite). As hexagonal platelets, to 0.1 mm, in fine-grained aggregates.

Physical Properties: Hardness = n.d. D(meas.) = ~2.80–2.88 D(calc.) = 2.78–2.87

Optical Properties: Semitransparent. *Color:* Bright yellow, greenish yellow; golden yellow in thin section.
Optical Class: Uniaxial (–). $\omega = 1.72$–1.735 $\epsilon = 1.63$–1.65

Cell Data: *Space Group:* $R\bar{3}m$. $a = 6.15$–6.164 $c = 45.54$–45.61 $Z = 3/8$

X-ray Powder Pattern: Wolf Creek meteorite.
7.63 (100), 2.60 (81), 3.80 (73), 2.30 (61), 1.946 (48), 1.508 (34), 1.537 (33)

Chemistry:

	(1)	(2)	(3)
SiO_2		1.33	
Fe_2O_3	18.1	20.23	18.40
CoO		0.20	
NiO	52.1	46.22	51.63
MgO		0.61	
H_2O			24.90
CO_2			5.07
Total			100.00

(1) Wolf Creek meteorite; by electron microprobe, partial analysis of maximally nickel-rich material; corresponds to $(Ni_{5.19}Fe^{2+}_{0.14})_{\Sigma=5.33}Fe^{3+}_{2.00}(CO_3)(OH)_{16}\cdot 4H_2O$. (2) Bon Accord, South Africa; by electron microprobe; two partial elemental analyses, here converted to oxides and averaged; corresponds to $(Ni_{5.56}Fe^{2+}_{0.28}Mg_{0.14}Co_{0.02})_{\Sigma=6.00}Fe^{3+}_{2.00}(CO_3)(OH)_{16}\cdot 4H_2O$.
(3) $Ni_6Fe_2(CO_3)(OH)_{16}\cdot 4H_2O$.

Mineral Group: Hydrotalcite group.

Occurrence: An alteration product of a highly weathered iron-nickel meteorite (Wolf Creek meteorite); altered from violarite in nickel ore at a contact between quartzite and ultramafic rocks (Bon Accord, South Africa); on chromatite (Unst, Scotland).

Association: Goethite, nickelian maghemite, jarosite, nickel-rich serpentine, apatite, lipscombite (Wolf Creek meteorite); violarite, ferroan trevorite, willemseite, nimite, "opal", quartz (Bon Accord, South Africa); honessite, hydrohonessite, theophrastite (Unst, Scotland).

Distribution: In the Wolf Creek meteorite. Found three km west of the Scotia talc mine, Bon Accord area, Barberton, Transvaal, South Africa. In the Hagdale quarry, Unst, Shetland Islands, Scotland. From Ca' de Ladri, Emilia-Romagna, Italy. In the USA, on the Victor claim, Clear Creek, San Benito Co., California; in the Fremont district, Hidalgo and Luna Co., New Mexico; and at Barrett Camp, Dragoon Mountains, Cochise Co., Arizona. From the Otway prospect, near Spinnaway, Nullagine district, Western Australia.

Name: To honor Dr. Frank Reeves (1886–?), American geologist who discovered the Wolf Creek meteorite crater.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 119552–119554.

References: (1) White, J.S., Jr., E.P. Henderson, and B. Mason (1967) Secondary minerals produced by weathering of the Wolf Creek meteorite. Amer. Mineral., 52, 1190–1197. (2) De Waal, S.A. and E.A. Viljoen (1971) Nickel minerals from Barberton, South Africa: IV. Reevesite, a member of the hydrotalcite group. Amer. Mineral., 56, 1077–1081. (3) Taylor, H.W.F. (1973) Crystal structures of some double hydroxide minerals. Mineral. Mag., 39, 377–389.

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Refikite $C_{20}H_{32}O_2$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals are small scales, or acicular.

Physical Properties: *Tenacity:* "Fragile". Hardness = "Very soft". D(meas.) = n.d. D(calc.) = 1.087 M.P. 182 °C.

Optical Properties: Semitransparent. *Color:* White. *Luster:* Resinous. *Optical Class:* Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_12_12$. $a = 10.43$ $b = 22.35$ $c = 7.98$ Z = 4

X-ray Powder Pattern: Kolbermoor, Germany.
5.50 (10), 6.09 (9), 5.20 (7), 7.97 (3), 4.28 (2), 11.2 (1), 4.82 (1)

Chemistry:

	(1)	(2)
C	77.77	78.90
H	11.18	10.59
O	11.05	10.51
Total	100.00	100.00

(1) Near Teramo, Italy. (2) $C_{20}H_{32}O_2$ (δ-13-dihydro-*d*-pimaric acid).

Occurrence: In lignite (near Teramo, Italy); in roots of fossil spruce in a swamp (Kolbermoor, Germany).

Association: n.d.

Distribution: From Montório al Vomano, 10 km southwest of Teramo, Abruzzi, Italy. Found near Kolbermoor, Bavaria, Germany. At Krásno, Czech Republic.

Name: To honor Refik Bey (?–1865), Turkish journalist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1006–1007.
(2) Strunz, H. and B. Contag (1965) Evenkit, Flagstaffit, Idrialin und Reficit. Neues Jahrb. Mineral., Monatsh., 19–25 (in German).

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Reichenbachite $Cu_5(PO_4)_2(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are lancet-shaped, to 0.3 mm; may be in spherical aggregates or botryoidal crusts.

Physical Properties: *Fracture:* Irregular. Hardness = ∼3.5 D(meas.) = n.d. D(calc.) = 4.370

Optical Properties: Semitransparent. *Color:* Dark green to pale blue. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Very weak; X = bright emerald-green; Z = emerald-green. *Orientation:* $Y = b$; $Z \wedge a = 29(2)°$. *Dispersion:* $r < v$, weak. $\alpha = 1.782(2)$ $\beta = [1.833]$ $\gamma = 1.867(5)$ 2V(meas.) = 76.3(4)°

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 9.186(2)$ $b = 10.684(2)$ $c = 4.461(2)$ $\beta = 92.31(1)°$ Z = 2

X-ray Powder Pattern: Reichenbach, Germany.
4.470 (100), 2.10 (100), 3.132 (30), 3.012 (30), 2.814 (25), 2.945 (20), 2.357 (20)

Chemistry:

	(1)	(2)
P_2O_5	22.25	24.65
As_2O_5	2.11	
SiO_2	0.10	
CuO	68.19	69.09
H_2O	[6.09]	6.26
Total	[98.74]	100.00

(1) Reichenbach, Germany; by electron microprobe, H_2O calculated for $4(OH)^{1-}$; corresponds to $Cu_{5.07}[(P_{0.93}As_{0.06})_{\Sigma=0.99}O_4]_2(OH)_4$. (2) $Cu_5(PO_4)_2(OH)_4$.

Polymorphism & Series: Trimorphous with ludjibaite and pseudomalachite.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal copper deposits.

Association: Pseudomalachite, malachite, duftite, bayldonite, mimetite, quartz (Reichenbach, Germany).

Distribution: In Germany, from Reichenbach, and at Gadernheim, near Bensheim, Hesse. At the Old Gunnislake mine, Calstock, Cornwall, England. From L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. At the Miguel Vacas mine, Vila Viçosa, near Estremoz, Portugal. From Brown's Prospect, Rum Jungle, Alligator River district, Northern Territory, Australia. At Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). From Binghampton, Yavapai Co., Arizona, USA.

Name: For Reichenbach, Germany, the original locality.

Type Material: Natural History Museum, Mainz; Mineralogical Museum, Würzburg University, Würzburg, Germany.

References: (1) Sieber, N.H.W., E. Tillmanns, and O. Medenbach (1987) Hentschelite, $CuFe_2(PO_4)_2(OH)_2$, a new member of the lazulite group, and reichenbachite, $Cu_5(PO_4)_2(OH)_4$, a polymorph of pseudomalachite, two new copper phosphate minerals from Reichenbach, Germany. Amer. Mineral., 72, 404–408. (2) Anderson, J.B., G.L. Shoemaker, E. Kostiner, and F.A. Ruszala (1977) The crystal structure of synthetic $Cu_5(PO_4)_2(OH)_4$, a polymorph of pseudomalachite. Amer. Mineral., 62, 115–121.

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Reinerite $Zn_3(As^{3+}O_3)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are rough, pseudohexagonal, showing {010}, {110}, {001}, and {012}, striated ‖ [001], to 4.7 cm.

Physical Properties: *Cleavage:* On {110}, {011}, {111}, good. Hardness = 5–5.5
D(meas.) = 4.270 D(calc.) = 4.283

Optical Properties: Transparent. *Color:* Light yellow-green, changing to sea-blue on exposure.
Luster: Vitreous to adamantine on fracture surfaces.
Optical Class: Biaxial (–). $\alpha = 1.749$ $\beta = 1.790$ $\gamma = 1.821$

Cell Data: *Space Group: Pbam.* $a = 6.0883(2)$ $b = 14.3941(5)$ $c = 7.8022(2)$ $Z = 4$

X-ray Powder Pattern: Tsumeb, Namibia.
3.9954 (1000), 2.6455 (290), 1.5488 (191), 3.2025 (187), 2.7826 (176), 2.6023 (145), 3.3942 (143)

Chemistry:

	(1)	(2)
As_2O_3	43.83	44.76
ZnO	56.01	55.24
Total	99.84	100.00

(1) Tsumeb, Namibia; by electron microprobe. (2) $Zn_3(As^{3+}O_3)_2$.

Occurrence: Extremely rare in a deep oxidation zone in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Chalcocite, bornite, willemite, smithsonite, hydrozincite, hemimorphite, adamite, olivenite, gebhardite.

Distribution: From Tsumeb, Namibia.

Name: To honor Willy Reiner (1895–1965), Senior Chemist, Tsumeb Corporation, Tsumeb, Namibia, who analyzed this material.

Type Material: n.d.

References: (1) Geier, B.H. and K. Weber (1958) Reinerit $Zn_3[AsO_3]_2$, ein neues Mineral der Tsumeb Mine Südwestafrika. Neues Jahrb. Mineral., Monatsh., 160–167 (in German). (2) (1959) Amer. Mineral., 44, 207 (abs. ref. 1). (3) Ghose, S., P. Boving, W.A. LaChapelle, and C. Wan (1977) Reinerite, $Zn_3(AsO_3)_2$: an arsenite with a novel type of Zn-tetrahedral double chain. Amer. Mineral., 62, 1129–1134. (4) Breidstein, B. (1994) Powder diffraction data of natural reinerite $Zn_3(AsO_3)_2$. Neues Jahrb. Mineral., Monatsh., 174–178.

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Reinhardbraunsite $Ca_5(SiO_4)_2(OH,F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral to subhedral grains, up to 3 mm. *Twinning:* Single and multiple twinning on {001}, noted only in minute recrystallized grains.

Physical Properties: *Cleavage:* Distinct on {001}. *Fracture:* Conchoidal. Hardness = 5–6 D(meas.) = 2.85(2) D(calc.) = 2.885

Optical Properties: Transparent to translucent. *Color:* Light pink; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 18(1)°$. *Dispersion:* $r > v$, distinct.
$\alpha = 1.606(2)$ $\beta = 1.617(2)$ $\gamma = 1.620(2)$ 2V(meas.) = 44°–50°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.458(2)$ $b = 5.052(1)$ $c = 8.840(2)$ $\beta = 108.91(1)°$ Z = 2

X-ray Powder Pattern: Bellerberg volcano, Germany.
1.902 (100), 3.035 (80), 2.903 (75), 3.322 (50), 2.941 (50), 1.894 (50), 1.658 (45)

Chemistry:

	(1)
SiO_2	26.97
CaO	65.68
F	4.24
H_2O	[2.66]
P_2O_5	0.69
$-O = F_2$	1.78
Total	[98.46]

(1) Bellerberg volcano, Germany; by electron microprobe, H_2O calculated from stoichiometry, original total given as 98.65%; corresponds to $Ca_{5.10}(Si_{1.96}P_{0.04})_{\Sigma=2.00}O_8[(OH)_{1.24}F_{0.97}]_{\Sigma=2.21}$.

Occurrence: In contact metamorphosed and metasomatized calcium-rich xenoliths in scoria.

Association: Ellestadite, cuspidine, gehlenite, brownmillerite, mayenite, periclase.

Distribution: From the Ettringer Bellerberg volcano, near Mayen, Eifel district, Germany.

Name: For Dr. Reinhard Brauns (1861–1937), Professor of Mineralogy at the University of Bonn, Bonn, Germany.

Type Material: Mineralogical-Petrological Institute, University of Bonn, Bonn, Germany.

References: (1) Hamm, H.-M. and G. Hentschel (1983) Reinhardbraunsite, $Ca_5(SiO_4)_2$ equivalent of synthetic "calcio-chondrodite." Neues Jahrb. Mineral., Monatsh., 119–129.
(2) (1983) Amer. Mineral., 68, 1039–1040 (abs. ref. 1). (3) Kirfel, A., H.-M. Hamm, and G. Will (1983) The crystal structure of reinhardbraunsite, $Ca_5(SiO_4)_2(OH,F)_2$, a new mineral of the calcio-chondrodite type. Tschermaks Mineral. Petrog. Mitt., 31, 137–150.

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Rémondite-(Ce) $Na_3(Ca,Ce,Na,La)_3(CO_3)_5$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* 2. Crystals, to 5 cm; massive, filling veinlets.

Physical Properties: *Cleavage:* Imperfect. *Fracture:* Conchoidal. Hardness = 3–3.5 D(meas.) = 3.43(1) D(calc.) = 3.46

Optical Properties: Transparent in thin splinters. *Color:* Red-orange, amber-yellow; may show a color change between daylight and artificial light. *Luster:* Vitreous. *Optical Class:* Biaxial (+). $\alpha = 1.632(2)$ $\beta = 1.633(2)$ $\gamma = 1.638(2)$ 2V(meas.) = 40(6)° 2V(calc.) = 48°

Cell Data: *Space Group:* $P2_1$. $a = 10.412(4)$ $b = 6.291(3)$ $c = 10.414(4)$ $\beta = 119.80(5)°$ Z = 2

X-ray Powder Pattern: Ebounja, Cameroon; similar to rémondite-(La). 2.589 (100), 3.006 (70), 2.609 (70), 2.132 (70), 2.617 (50), 2.127 (50), 5.17 (40)

Chemistry:

	(1)		(1)
CO_2	35.24	Dy_2O_3	0.07
Y_2O_3	0.24	Ho_2O_3	0.01
La_2O_3	11.60	Er_2O_3	0.03
Ce_2O_3	14.99	Yb_2O_3	0.03
Pr_2O_3	1.49	Lu_2O_3	< 0.01
Nd_2O_3	3.34	CaO	10.54
Sm_2O_3	0.50	SrO	3.98
Eu_2O_3	0.09	Na_2O	17.16
Gd_2O_3	0.24	Total	99.55

(1) Ebounja, Cameroon; by electron microprobe, 18 analyses of one grain, CO_2 by TGA; corresponds to $Na_{3.00}(Ca_{1.17}Ce_{0.57}Na_{0.46}La_{0.44}Sr_{0.24}Nd_{0.12}Pr_{0.06}Sm_{0.02}Y_{0.01}Gd_{0.01})_{\Sigma=3.10}(CO_3)_5$.

Occurrence: In a nepheline syenite (Ebounja, Cameroon); associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Burbankite, aegirine, calcite (Ebounja, Cameroon).

Distribution: From Ebounja, near Kribi, Cameroon. Large crystals found at Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Dr. Guy Rémond (1935–), physicist, Bureau de Recherches Géologiques et Minières, Orléans, France, for his work on the physics of minerals, and the predominance of *cerium* over other rare-earth elements in the composition.

Type Material: National School of Mines, Paris, France.

References: (1) Cesbron, F., C. Gilles, P. Pelisson, and J.-C. Saugues (1988) La remondite-(Ce), un nouveau carbonate de terres rares de la famille de la burbankite. Compt. Rendus Acad. Sci. Paris, 307, 915–920 (in French with English abs.). (2) Ginderow, D. (1989) Structure de $Na_3M_3(CO_3)_5$ (M = terre rare, Ca, Na, Sr), rattaché à la burbankite. Acta Cryst., C45, 185–187 (in French with English abs.). (3) (1990) Amer. Mineral., 75, 433 (abs. ref. 1–2).

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Rémondite-(La) $Na_3(La, Ce, Ca)_3(CO_3)_5$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* 2. Irregular grains, to 5 μm, in roughly prismatic aggregates.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼3
D(meas.) = 3.5(1) D(calc.) = 3.57

Optical Properties: Translucent. *Color:* Bright yellow-orange, may show a color change between daylight and artificial light; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.615(2)$ $\beta = 1.619(3)$ $\gamma = 1.622(3)$ 2V(meas.) = 80(10)°
2V(calc.) = 85(5)°

Cell Data: *Space Group:* $[P2_1]$ [by analogy to rémondite-(Ce)]. $a = 10.49(1)$ $b = 6.417(4)$ $c = 10.50(1)$ $\beta = 119.8(1)°$ Z = 2

X-ray Powder Pattern: Mt. Koashva, Kola Peninsula, Russia; similar to rémondite-(Ce).
2.623 (10), 3.036 (9), 2.143 (8), 3.70 (7), 2.041 (6), 1.939 (6), 5.28 (5)

Chemistry:

	(1)		(1)
CO_2	[32.97]	Sm_2O_3	0.37
ThO_2	1.34	CaO	5.13
Y_2O_3	0.00	SrO	2.93
La_2O_3	19.75	BaO	0.18
Ce_2O_3	16.67	Na_2O	15.48
Pr_2O_3	0.99	K_2O	0.58
Nd_2O_3	2.27	Total	98.66

(1) Mt. Koashva, Kola Peninsula, Russia; by electron microprobe, average of 11 analyses, CO_2 calculated for stoichiometry; corresponds to $Na_{2.87}(La_{0.80}Ce_{0.68}Ca_{0.61}Na_{0.46}Sr_{0.18}Nd_{0.09}K_{0.08}Pr_{0.04}Th_{0.03}Sm_{0.01}Ba_{0.01})_{\Sigma=2.99}(CO_3)_5$.

Occurrence: Of late hydrothermal origin, very rare in a small pegmatite in a differentiated alkalic massif.

Association: Cancrisilite, microcline, sodalite, villiaumite, natrolite, pectolite, lomonosovite, barytolamprophyllite, catapleiite, natron, thermonatrite, sazykinaite-(Y), niobian rinkite, vitusite-(Ce), fluorcaphite.

Distribution: From Mt. Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: For its relation to *rémondite*-(Ce), and the predominance of *lanthanum* over other rare-earth elements in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Pekov, I.V., N.V. Chukanov, N.N. Kononkova, A.E. Zadov, and Y.V. Belovitskaya (2000) Remondite-(La), $Na_3(La, Ce, Ca)_3(CO_3)_5$ – a new mineral of the burbankite family from Khibiny massif, Kola Peninsula. Zap. Vses. Mineral. Obshch., 129(1), 53–60 (in Russian with English abs.). (2) (2001) Amer. Mineral., 86, 377 (abs. ref. 1).

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Reniérite $(Cu, Zn)_{11}Fe_4(Ge, As)_2S_{16}$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $\bar{4}2m$. As rare equant crystals, to 3 mm; disseminated granular aggregates, irregular patches, and as regular lamellae replacing germanite grains. *Twinning:* Polysynthetic.

Physical Properties: Hardness = 3.5 VHN = 340–363, 351 average (25 g load). D(meas.) = 4.38 D(calc.) = 4.40 Magnetic.

Optical Properties: Opaque. *Color:* Bronze; in polished section, orange-brown. *Luster:* Metallic. *Pleochroism:* Orange to brown or bronze with violet tint. *Anisotropism:* Strong, yellow to reddish orange.
R_1–R_2: (400) 19.6–20.3, (420) 19.1–19.8, (440) 18.7–19.3, (460) 18.7–19.0, (480) 19.8–19.4, (500) 21.9–20.8, (520) 24.5–23.0, (540) 27.1–25.3, (560) 29.6–27.5, (580) 31.2–29.4, (600) 32.6–30.9, (620) 33.8–32.1, (640) 34.7–33.1, (660) 35.3–33.7, (680) 35.6–34.2, (700) 36.0–34.6

Cell Data: *Space Group:* $P\bar{4}2c$. $a = 10.6226(5)$ $c = 10.5506(8)$ $Z = 2$

X-ray Powder Pattern: Kipushi, Congo.
3.06 (100), 1.87 (80), 1.595 (60), 2.65 (30), 1.214 (30), 4.31 (20), 1.083 (20)

Chemistry:

	(1)	(2)		(1)	(2)
Cu	41.63	41.6	Ge	7.75	7.3
Fe	13.73	13.0	Ga		0.5
Zn	3.53	2.7	As	0.87	2.0
Pb	trace		S	31.51	32.6
			Total	99.02	99.7

(1) Kipushi, Congo; corresponds to $(Cu_{10.67}Zn_{0.88})_{\Sigma=11.55}Fe_{4.00}(Ge_{1.74}As_{0.19})_{\Sigma=1.93}S_{16.00}$.
(2) Tsumeb, Namibia; by electron microprobe, corresponds to $(Cu_{10.30}Zn_{0.65})_{\Sigma=10.95}$ $Fe_{3.66}(Ge_{1.58}As_{0.42}Ga_{0.11})_{\Sigma=2.11}S_{16.00}$.

Occurrence: Rare in some Ge-bearing hydrothermal polymetallic deposits.

Association: Germanite, tennantite, enargite, digenite, bornite, chalcopyrite, sphalerite.

Distribution: From the Prince-Léopold mine, Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire) [TL]. At M'Passa, 150 km west of Brazzaville, Niari Province, Congo Republic. From Tsumeb, Namibia. At Kabwe (Broken Hill), Zambia. In Bulgaria, in the Chelopech deposit, Sofia, and at the Radka deposit, Pazardzhik. From Akhtala, Armenia. At the San Giovanni mine, Iglesiente, Sardinia, Italy. In the Repparfjord copper deposit, Finnmark, Norway. At Vaygach, Arkhangel'sk; the Urup deposit, Caucasus Mountains, and other less-well-defined localities in Russia. In Japan, at the Shakanai and Furutobe mines, Akita Prefecture. From the Rajpura-Dariba polymetallic deposit, Udaipur district, Rajasthan, India. In the Ruby Creek deposit, southern Brooks Range, Alaska; and at the Inexco #1 mine, Jamestown, Boulder Co., Colorado, USA. From Pinar del Rio, Cuba.

Name: For Armand Marie Vincent Joseph Reniér (1876–1951), Belgian geologist and Director of the Belgian Geological Survey.

Type Material: National School of Mines, Paris, France.

References: (1) Vaes, J.F. (1948) La reniérite (anciennement appelée "bornite orange") un sulfure germanifère provenant de la Mine Prince-Léopold, Kipushi (Congo Belge). Ann. (Bull.) Soc. Géol. Belgique, 72, 20–32 (in French). (2) (1950) Amer. Mineral., 35, 136 (abs. ref. 1). (3) Murdoch, J. (1953) X-ray investigation of colusite, germanite and reniérite. Amer. Mineral., 38, 794–801. (4) Springer, G. (1969) Microanalytical investigations into germanite, renierite, briartite, and gallite. Neues Jahrb. Mineral., Monatsh., 435–441. (5) Bernstein, L.R. (1986) Renierite, $Cu_{10}ZnGe_2Fe_4S_{16}$—$Cu_{11}GeAsFe_4S_{16}$: a coupled solid solution series. Amer. Mineral., 71, 210–221. (6) Bernstein, L.R., D.G. Reichel, and S. Merlino (1989) Renierite crystal structure refined from Reitveld analysis of powder neutron-diffraction data. Amer. Mineral., 74, 1177–1181. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 479.

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Reppiaite $Mn_5^{2+}(VO_4)_2(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As striated irregular grains, flattened on {100}, to 300 μm; in fine-grained aggregates.

Physical Properties: Hardness = ∼3 VHN = 90–110, 100 average (15 g load).
D(meas.) = 3.92 D(calc.) = 3.91

Optical Properties: Transparent. *Color:* Red-orange. *Streak:* Yellow-orange.
Luster: Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Very weak; yellow-orange to deep orange. *Dispersion:* Medium. $\alpha = 1.803(2)$ (α') β = n.d. $\gamma = 1.810(5)$ (γ') 2V(meas.) = Large.

Cell Data: *Space Group:* $C2/m$. $a = 9.614(4)$ $b = 9.561(3)$ $c = 5.396(3)$ $\beta = 98.39(1)°$
Z = 2

X-ray Powder Pattern: Gambatesa mine, Italy.
2.680 (VS), 4.76 (S), 3.00 (M), 2.656 (M), 2.155 (M), 1.565 (M), 1.510 (M)

Chemistry:

	(1)	(2)
As_2O_5	6.87	
V_2O_5	25.79	31.77
MnO	61.17	61.94
H_2O	[6.17]	6.29
Total	[100.00]	100.00

(1) Gambatesa mine, Italy; by electron microprobe, average of ten analyses from two samples, total Mn as MnO, H_2O by difference; corresponding to $Mn_{5.01}[(V_{0.82}As_{0.18})_{\Sigma=1.00}O_4]_2(OH)_{3.98}$.
(2) $Mn_5(VO_4)_2(OH)_4$.

Occurrence: A rare mineral, deposited from V–As-bearing hydrothermal solutions in fractures cutting manganiferous cherts.

Association: Hausmannite, tephroite, Mn–Ca carbonates.

Distribution: From the Gambatesa mine, near Reppia, Val Graveglia, Liguria, Italy.

Name: For Reppia, Italy, a village near the locality where the mineral was first found.

Type Material: University of Genoa, Genoa, Italy.

References: (1) Basso, R., G. Lucchetti, L. Zefiro, and A. Palenzona (1992) Reppiaite, $Mn_5(OH)_4(VO_4)_2$, a new mineral from Val Graveglia (Northern Appenines, Italy). Zeits. Krist., 201, 223–234. (2) (1993) Amer. Mineral., 78, 452 (abs. ref. 1).

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Retgersite $NiSO_4 \cdot 6H_2O$

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Crystal Data: Tetragonal. *Point Group:* 422. Rare in crude single crystals, to 3 mm; as fibers, elongated along [001], may be twisted spire- and hornlike, and in veinlets; most commonly as efflorescences.

Physical Properties: *Cleavage:* On {001}, perfect; on {110}, in traces, microscopically observed. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.04 D(calc.) = 2.075 Soluble in H_2O, taste slightly bitter and metallic.

Optical Properties: Semitransparent. *Color:* Deep emerald-green tinged with blue; pale green in transmitted light. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.510–1.511$ $\epsilon = 1.486$

Cell Data: *Space Group:* $P4_12_12$. $a = 6.783(1)$ $c = 18.288(2)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
4.25 (100), 4.57 (40), 2.964 (20), 4.64 (18), 2.721 (18), 2.571 (14), 3.39 (12)

Chemistry:

	(1)	(2)	(3)
SO_3	30.32	29.77	30.46
FeO	0.63	0.09	
CoO		0.12	
NiO	26.87	28.31	28.42
MgO	0.65	0.63	
CaO		0.33	
H_2O	[41.53]	40.35	41.12
Total	[100.00]	99.60	100.00

(1) Cottonwood Canyon, Nevada, USA; H_2O by difference. (2) Jáchymov, Czech Republic; H_2O by TGA, corresponds to $(Ni_{1.01}Mg_{0.04}Ca_{0.02})_{\Sigma=1.07}S_{0.99}O_4 \cdot 5.99H_2O$. (3) $NiSO_4 \cdot 6H_2O$.

Polymorphism & Series: Dimorphous with nickelhexahydrite.

Occurrence: An uncommon secondary mineral in the oxidization zone of nickel-bearing hydrothermal mineral deposits, formed from H_2O solution between 31.5 °C and 53.5 °C.

Association: Nickeline, gersdorffite, nickelian pyrite, morenosite, chalcanthite, annabergite.

Distribution: Crystallized from Minasragra, 46 km from Cerro de Pasco, Peru. In the USA, in Cottonwood Canyon, at the Nickel and Lovelock mines, Table Mountain district, Churchill Co., Nevada; from the Gap Nickel mine, Lancaster Co., Pennsylvania; at Mine La Motte, Fredericktown, Madison Co., Missouri. From Key Lake, Saskatchewan, Canada. In Germany, at Lichtenberg, near Bayreuth, Bavaria; at Lobenstein, Thuringia; and from Antweiler, Eifel; in the Rammelsberg mine, near Goslar, Harz Mountains. From "Menimuir Burn", near Cassencarie, Kirkcudbrightshire, Scotland. At the Newdigate colliery, near Bedworth, southwest of Nuneaton, Warwickshire, England. From the 132 North nickel mine, 4 km southwest of Widgiemooltha, and at Kambalda, 56 km south of Kalgoorlie, Western Australia. In the Allarechensk deposit, Kola Peninsula, and from the Noril'sk region, western Siberia, Russia. At Chelmiec, Poland. From Jáchymov (Joachimsthal), and near Smrkovec, about 10 km north-northeast of Mariánské Lázně (Marienbad), Czech Republic.

Name: To honor Jan Willem Retgers (1856–1896), Dutch physical chemist and chemical crystallographer, who studied the crystallography of many synthetic compounds.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 100822.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 497–498. (2) Sejkora, J. and T. Řídkošil (1993) Retgersite from Jáchymov, Krušné hory Mountains, Czech Republic. Neues Jahrb. Mineral., Monatsh., 393–400.
(3) Stadnicka, K., A.M. Glazer, and M. Koralewski (1987) Structure, absolute configuration and optical activity of α-nickel sulphate hexahydrate. Acta Cryst., 43, 319–325. (4) (1957) NBS Circ. 539, 7, 36.

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Retzian-(Ce) $(Mn^{2+},Mg)_2(Ce,Nd)(AsO_4)(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are elongated along [001], may be tabular on {010}, with large {010}, {001}, {101}, {110}, small {130}, to 0.5 mm, usually in parallel growths.

Physical Properties: *Fracture:* Conchoidal to uneven. Hardness = 4 D(meas.) = 4.15 D(calc.) = 4.45

Optical Properties: Subtranslucent. *Color:* Dark chocolate-brown to chestnut-brown; brown in transmitted light. *Streak:* Pale brown. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (+). *Pleochroism:* X = colorless to yellow; Y = yellow to brown; Z = red-brown to crimson. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, weak. *Absorption:* $Z > Y > X$. $\alpha = 1.777(5)$ $\beta = 1.788(5)$ $\gamma = 1.800(5)$ 2V(meas.) = Large. 2V(calc.) = 88°

Cell Data: *Space Group: Pban.* $a = 5.670(3)$ $b = 12.03(1)$ $c = 4.863(4)$ Z = 2

X-ray Powder Pattern: Moss mine, Sweden; very similar to retzian-(La) and retzian-(Nd). 2.717 (10), 3.528 (8), 1.848 (5), 6.00 (4), 1.619 (4), 4.84 (3), 2.335 (3)

Chemistry:

	(1)		(1)
As_2O_5	27.1	Gd_2O_3	1.9
Y_2O_3	1.7	FeO	1.1
La_2O_3	3.0	MnO	27.3
Ce_2O_3	14.5	ZnO	0.8
Pr_2O_3	2.4	MgO	1.2
Nd_2O_3	6.8	CaO	0.6
Sm_2O_3	1.6	H_2O	8.3
Eu_2O_3	1.0	Total	99.3

(1) Moss mine, Sweden; by electron microprobe, total Mn as MnO, H_2O by DTA-TGA on a separate sample; corresponds to $(Mn_{1.77}Mg_{0.13}Fe_{0.07}Zn_{0.05}Ca_{0.05})_{\Sigma=2.07}(Ce_{0.40}Nd_{0.19}La_{0.08}Y_{0.07}Pr_{0.07}Sm_{0.04}Gd_{0.05}Eu_{0.03})_{\Sigma=0.93}(AsO_4)_{1.08}(OH)_{3.69}$.

Occurrence: A rare mineral in cavities in porous dolomite.

Association: Jacobsite, pyrochroite.

Distribution: From the Moss mine, near Nordmark, Värmland, Sweden.

Name: Honoring Professor Anders Johan Retzius (1742–1821), University of Lund, Lund, Sweden, Swedish naturalist, and for *cerium*, its dominant rare earth element.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; National Museum of Natural History, Washington, D.C., USA, 145882.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 794–795. (2) Moore, P.B. (1967) Crystal chemistry of the basic manganese arsenate minerals 1. The crystal structures of flinkite, $Mn_2^{2+}Mn^{3+}(OH)_4(AsO_4)$ and retzian, $Mn_2^{2+}Y^{3+}(OH)_4(AsO_4)$. Amer. Mineral., 52, 1603–1613. (3) Moore, P.B. (1968) Contributions to Swedish mineralogy. I. Studies on the basic arsenates of manganese: retzian, hemafibrite, synadelphite, arsenoclasite, arseniopleite, and akrochordite. Arkiv. Mineral. Geol., 4(5), 425–444. (4) Dunn, P.J. and B.D. Sturman (1982) Retzian-(Nd), a new mineral from Sterling Hill, New Jersey and a redefinition of retzian. Amer. Mineral., 67, 841–845.

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Retzian-(La) $(Mn^{2+},Mg)_2(La,Ce,Nd)(AsO_4)(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are pseudohexagonal, flattened on [001], showing large {001}, {110}, {010}, small {150}, to 0.5 mm.

Physical Properties: *Fracture:* Even. Hardness = 3–4 D(meas.) = > 4.2 D(calc.) = 4.49

Optical Properties: Transparent. *Color:* Dark reddish brown. *Streak:* Pale brown.
Luster: Vitreous on {010} and fractures, otherwise dull.
Optical Class: Biaxial (+). *Pleochroism:* Very weak; pale brown to pale violet-brown.
Orientation: $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > Y > X$.
$\alpha = 1.766(5)$ $\beta = 1.773(5)$ $\gamma = 1.788(5)$ 2V(meas.) = 82(9)° 2V(calc.) = 69°

Cell Data: *Space Group: Pban.* $a = 5.670(7)$ $b = 12.01(1)$ $c = 4.869(8)$ Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA; very similar to retzian-(Ce) and retzian-(Nd).
2.715 (100), 3.51 (80), 1.848 (50), 1.456 (40), 5.98 (30), 4.84 (30), 1.615 (30)

Chemistry:

	(1)
As_2O_5	26.5
Y_2O_3	2.5
La_2O_3	10.6
Ce_2O_3	8.8
Pr_2O_3	5.1
Nd_2O_3	8.2
Sm_2O_3	2.2
MnO	25.2
ZnO	1.2
MgO	3.7
H_2O	[7.7]
Total	[101.7]

(1) Sterling Hill, New Jersey, USA; by electron microprobe, total Mn as MnO, H_2O calculated from stoichiometry; corresponds to $(Mn_{1.54}Mg_{0.40}Zn_{0.06})_{\Sigma=2.00}(La_{0.28}Ce_{0.23}Nd_{0.21}Pr_{0.13}Y_{0.10}Sm_{0.05})_{\Sigma=1.00}(AsO_4)_{1.04}(OH)_{3.70}$.

Occurrence: A very rare late phase in fractures in a metamorphosed stratiform zinc orebody.

Association: Willemite, franklinite, calcite, todorokite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For its dominant rare earth, *lanthanum*, and relation to *retzian*-(Ce).

Type Material: National Museum of Natural History, Washington, D.C., USA, 160290.

References: (1) Dunn, P.J., D.R. Peacor, and W.B. Simmons (1984) Retzian-(La), a new mineral from Sterling Hill, Sussex Co., New Jersey. Mineral. Mag., 48, 533-535. (2) (1985) Amer. Mineral., 70, 1332 (abs. ref. 1). (3) Moore, P.B. (1967) Crystal chemistry of the basic manganese arsenate minerals 1. The crystal structures of flinkite, $Mn_2^{2+}Mn^{3+}(OH)_4(AsO_4)$ and retzian, $Mn_2^{2+}Y^{3+}(OH)_4(AsO_4)$. Amer. Mineral., 52, 1603–1613.

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Retzian-(Nd) $(Mn^{2+}, Mg)_2(Nd, La, Ce)(AsO_4)(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 3 mm, elongated along [100], showing principally {010}, {001}, {110}, {201}, {130}; commonly in parallel aggregates. *Twinning:* Radial, spokelike, trillings or sixlings, rare.

Physical Properties: *Fracture:* Uneven. Hardness = 3–4 D(meas.) = > 4.2 D(calc.) = 4.45

Optical Properties: Semitransparent. *Color:* Pinkish brown to reddish brown, zoned darker in the center. *Streak:* Very pale brown. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow; Y = reddish brown; Z = brown. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, weak. *Absorption:* $Z > Y \gg X$. $\alpha = 1.774(2)$ $\beta = 1.782(2)$ $\gamma = 1.798(2)$ 2V(meas.) = 69(1)° 2V(calc.) = 71°

Cell Data: *Space Group: Pban.* $a = 5.690(5)$ $b = 12.12(1)$ $c = 4.874(3)$ Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA; very similar to retzian-(Ce) and retzian-(La).
2.726 (100), 3.534 (60), 4.89 (30), 1.857 (30), 6.05 (20), 1.625 (20), 1.463(20)

Chemistry:

	(1)		(1)
As_2O_5	26.9	Gd_2O_3	1.9
Y_2O_3	1.6	FeO	0.4
La_2O_3	7.6	MnO	25.9
Ce_2O_3	7.8	ZnO	1.8
Pr_2O_3	4.2	MgO	2.0
Nd_2O_3	10.9	CaO	0.0
Sm_2O_3	2.4	H_2O	[8.3]
Eu_2O_3	0.9	Total	[102.6]

(1) Sterling Hill, New Jersey, USA; by electron microprobe, total Mn as MnO, H_2O by DTA-TGA on a separate sample of retzian-(Ce); corresponds to $(Mn_{1.63}Mg_{0.22}Zn_{0.10}Fe_{0.03})_{\Sigma=1.98}(Nd_{0.29}La_{0.21}Ce_{0.21}Pr_{0.11}Sm_{0.07}Y_{0.06}Gd_{0.05}Eu_{0.02})_{\Sigma=1.02}(AsO_4)_{1.04}(OH)_{3.90}$.

Occurrence: A very rare late phase in fractures in a metamorphosed stratiform zinc orebody.

Association: Rhodochrosite, kraisslite, sonolite, zincite, sphalerite, chlorophoenicite, willemite, franklinite, calcite, barite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For its dominant rare earth, *neodymium*, and relation to *retzian*-(Ce).

Type Material: The Natural History Museum, London, England, 1983,238; Geological Survey of Canada, Ottawa; Royal Ontario Museum, Toronto, Canada; American Museum of Natural History, New York City, New York; Harvard University, Cambridge, Massachusetts, 119000; National Museum of Natural History, Washington, D.C., USA, 143762.

References: (1) Dunn, P.J. and B.D. Sturman (1982) Retzian-(Nd), a new mineral from Sterling Hill, New Jersey and a redefinition of retzian. Amer. Mineral., 67, 841–845. (2) Moore, P.B. (1967) Crystal chemistry of the basic manganese arsenate minerals 1. The crystal structures of flinkite, $Mn_2^{2+}Mn^{3+}(OH)_4(AsO_4)$ and retzian, $Mn_2^{2+}Y^{3+}(OH)_4(AsO_4)$. Amer. Mineral., 52, 1603–1613.

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Revdite $Na_{16}Si_{16}O_{27}(OH)_{26}\cdot 28H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals prismatic, with sharply pointed terminations, to 2 mm; as spherical fibrous aggregates and irregular rounded masses.

Physical Properties: *Cleavage:* Perfect on {100}, less perfect on {010}. *Tenacity:* Fibers are flexible. Hardness = ∼2 D(meas.) = 1.94 D(calc.) = 1.93 Dissolves slowly in water at room temperature, giving an alkaline reaction.

Optical Properties: Transparent. *Color:* Colorless to white. *Luster:* Vitreous to pearly, silky.
Optical Class: Biaxial (–). *Orientation:* $Y \wedge c = 0°$–$10°$. $\alpha = 1.469(2)$ $\beta = 1.482(2)$ $\gamma = 1.490(2)$ 2V(meas.) = 75° 2V(calc.) = 75.6°

Cell Data: *Space Group:* $C2$. $a = 5.383(4)$ $b = 9.972(9)$ $c = 6.907(4)$ $\beta = 96.78(1)°$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
4.46 (100), 13.37 (76), 3.34 (71), 2.501 (48), 3.79 (42), 2.879 (38), 2.230 (24)

Chemistry:

	(1)	(2)
SiO_2	45.21	43.78
Na_2O	22.25	22.58
K_2O	0.08	
H_2O	32.50	33.64
Total	100.04	100.00

(1) Lovozero massif, Russia. (2) $Na_{16}Si_{16}O_{27}(OH)_{26}\cdot 28H_2O$.

Occurrence: In ussingite veinlets cutting nepheline syenites in a differentiated alkalic massif (Lovozero massif, Russia); in sodalite xenoliths in syenite in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Ussingite (Lovozero massif, Russia); ussingite, villiaumite, kogarkoite, lovozerite, eudialyte (Mont Saint-Hilaire, Canada).

Distribution: From Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For Revda, a town near Mt. Karnasurt, on which the mineral occurs.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5531; Mining Institute, St. Petersburg, 1204/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81394.

References: (1) Khomyakov, A.P., G.E. Cherepivskaya, T.A. Kurova, and V.P. Vlasyuk (1980) Revdite, a new mineral. Zap. Vses. Mineral. Obshch., 109, 565–569 (in Russian). (2) (1982) Amer. Mineral., 67, 1076 (abs. ref. 1). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 331. (4) (1992) Rastsvetaeva, R.K., M.G. Mikheeva, N.A. Yamnova, and D.Y. Pushcharovskii (1992) Crystal structure of revdite $Na_{16}[Si_4O_6(OH)_5]_2[Si_8O_{15}(OH)_6](OH)_{10}\cdot 28H_2O$. Kristallografiya (Sov. Phys. Crystal.), 37, 1177–1184 (in Russian).

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Reyerite $(Na,K)_2Ca_{14}Al_2Si_{22}O_{58}(OH)_8 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. In radiating aggregates of thin hexagonal plates. Massive, and intergrown with chlorite.

Physical Properties: *Cleavage:* Perfect on {0001}, micaceous. Hardness = 3.5–4.5 D(meas.) = 2.51–2.58 D(calc.) = 2.59

Optical Properties: Transparent to translucent. *Color:* Colorless to white, pale green with chlorite inclusions. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.563–1.568$ $\epsilon = 1.558–1.563$

Cell Data: *Space Group:* $P\bar{3}$. $a = 9.767$ $c = 19.067$ Z = 1

X-ray Powder Pattern: Niaqornat, Greenland; can resemble gyrolite or truscottite.
3.17 (vs), 2.855 (s), 2.659 (s), 1.846 (s), 4.23 (ms), 3.52 (m), 3.035 (m)

Chemistry:

	(1)	(2)	(3)
SiO_2	53.2	54.7	53.4
Al_2O_3	3.8	4.4	4.7
CaO	32.3	31.6	31.8
Na_2O	2.3	3.5	1.5
K_2O	1.6	2.2	5.2
H_2O	6.0	[3.6]	[3.4]
Total	99.2	[100.0]	[100.0]

(1) Niaqornat, Greenland. (2) Do.; by electron microprobe, H_2O by difference; corresponds to $(Na_{2.7}K_{1.1})_{\Sigma=3.8}Ca_{13.6}Al_{2.1}Si_{21.9}O_{60}(OH)_{4.6} \cdot 5H_2O$. (3) Rawlings quarry, Virginia, USA; by electron microprobe, H_2O by difference; corresponds to $(K_{1.1}Na_{2.7})_{\Sigma=3.8}Ca_{13.9}Al_{2.3}Si_{21.7}O_{60}(OH)_{5.2} \cdot 5H_2O$.

Occurrence: In tuff (Niaqornat, Greenland); in basalt, within the contact aureole of a volcanic plug (Isle of Mull, Scotland); in a low-grade regionally metamorphosed diabase dike (Rawlings quarry, Virginia, USA).

Association: Calcite, chlorite, gyrolite, analcime, pectolite, thomsonite, natrolite.

Distribution: In Greenland, at Niaqornat (Niakornak). In Scotland, at 'S Airde Beinn, five km west of Tobermory, Isle of Mull, and at Allt Coir' a' Ghobhainn, near Drynoch, Isle of Skye. In the USA, in the Rawlings quarry, south of McKenney, Brunswick Co., Virginia.

Name: For Professor Eduard Reyer (1849–1914), geologist of Vienna, Austria.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 88. (2) Chalmers, R.A., V.C. Farmer, R.I. Harker, S. Kelly, and H.F.W. Taylor (1964) Reyerite. Mineral. Mag., 33, 821–840. (3) Clement, S.C. and P.H. Ribbe (1973) New locality, formula, and proposed structure for reyerite. Amer. Mineral., 58, 517–522. (4) Merlino, S. (1988) The structure of reyerite, $(Na,K)_2Ca_{14}Si_{22}Al_2O_{58}(OH)_8 \cdot 6H_2O$. Mineral. Mag., 52, 247–256.

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Rhabdophane-(Ce) $(Ce,La)PO_4 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As stalactitic, globular, or botryoidal incrustations with internally radial fibrous structure.

Physical Properties: *Fracture:* Uneven to conchoidal. Hardness = 3–3.5
D(meas.) = 3.77–4.01 D(calc.) = 4.19 (synthetic $CePO_4 \cdot H_2O$).

Optical Properties: Translucent. *Color:* Brown, pale pink, yellowish white, creamy, may be pale green. *Luster:* Greasy to dull.
Optical Class: Uniaxial (+). *Pleochroism:* O = colorless; E = brownish. *Orientation:* Positive elongation. $\omega = 1.654–1.700$ $\epsilon = 1.703–1.744$

Cell Data: *Space Group:* $P6_222$. $a = 7.055(5)$ $c = 6.439(3)$ $Z = 3$

X-ray Powder Pattern: Clara mine, Germany.
3.03 (10), 6.09 (9), 2.83 (9), 4.41 (8), 3.51 (7), 2.16 (6), 1.865 (6)

Chemistry:

	(1)	(2)
P_2O_5	24.64	28.04
SiO_2	3.76	
$(Al,Fe)_2O_3$	1.93	
$(Ce,Y)_2O_3$	61.69	
Ce_2O_3		64.84
H_2O	7.50	7.12
Total	99.52	100.00

(1) Cornwall, England. (2) $CePO_4 \cdot H_2O$.

Occurrence: A very rare mineral in some hydrothermal ore deposits.

Association: Sphalerite (Fowey Consols mine, England); barite, fluorite, chalcopyrite, tetrahedrite (Clara mine, Germany).

Distribution: In England, from an unknown locality Cornwall. In Germany, at the Clara mine, near Oberwolfach, Black Forest; from Waldstein, Fichtelgebirge, Bavaria; at the Krufter Ofen volcano, Eifel district. In the Ilímaussaq intrusion, Greenland. At Mont Saint-Hilaire and from near Saint-Amable, Quebec, Canada. At Iron Hill, Powderhorn district, Gunnison Co., Colorado, and in the Majuba Hill mine, Antelope district, Pershing Co., Nevada, USA. From the Lovozero and Kovdor massifs, Kola Peninsula, and at the Kiya alkalic massif, Yenisei Ridge, Siberia, Russia. In the Sumi region, Ukraine. From Karonge, Burundi.

Name: From the Greek for *a rod* and *to appear*, for the characteristic bands due to cerium in its emission spectrum, and the dominant rare earth, *cerium*.

Type Material: The Natural History Museum, London, England, Ludlam collection.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 774. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 293–297. (3) Walenta, K. (1978) Chukhrovit-(Ce) and rhabdophan-(Ce) aus der Grube Clara bei Oberwolfach, im mittleren Schwarzwald. Chem. Erde, 38, 331–339 (in German). (4) Mooney, R.C.L. (1950) X-ray diffraction study of cerous phosphate and related crystals. I. Hexagonal modification. Acta Cryst., 3, 337–340.

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Rhabdophane-(La) $(La, Ce)PO_4 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Radiating and fanlike aggregates of fine fibrous crystals, to 0.05 mm; may be in druses.

Physical Properties: *Fracture:* Subconchoidal. Hardness = 3–3.5 D(meas.) = 4.4 D(calc.) = 4.3

Optical Properties: Semitransparent. *Color:* Pale pink, yellowish to dark brown.
Luster: Greasy to silky.
Optical Class: Uniaxial (+). $\omega = 1.692$ $\epsilon = 1.732$

Cell Data: *Space Group:* $[P6_222]$ [by analogy to rhabdophane-(Ce)]. $a = 7.03(1)$ $c = 6.41(1)$ Z = 3

X-ray Powder Pattern: Kazakhstan (?).
1.86 (7), 3.03(6), 2.85 (4), 2.157 (4b), 2.133 (4b), 1.76 (2), 1.68 (2)

Chemistry:

	(1)
SO_3	0.34
P_2O_5	25.17
SiO_2	5.3
ThO_2	0.67
Al_2O_3	2.06
RE_2O_3	58.11
Fe_2O_3	0.43
PbO	0.15
MgO	0.04
CaO	0.56
BaO	0.16
H_2O	6.88
Total	99.87

(1) Kazakhstan (?); RE by XRF; Y = 0.5%, La = 49%, Ce = 8.4%, Pr = 14.6%, Nd = 3.3%, Sm = 12.5%, Eu = 1.3%, Gd = 4.2%, Tb = 0.4%, Dy = 2.2%, Ho = 0.2%, Er = 1.3%, Tm = 0.2Yb = 1.7

Occurrence: A secondary mineral in faults cutting weathered sediments, probably derived from a porphyritic granite.

Association: Clay minerals, "opal".

Distribution: From an undisclosed locality, probably in Kazakhstan. On Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. At the Silberbrünnle mine, near Gengenbach, Black Forest, Germany. From Gakara, Burundi.

Name: For its dominant rare earth, *lanthanum*, and relation to *rhabdophane*-(Ce).

Type Material: n.d.

References: (1) Dumler, F.L., K.P. Skornyakova, and G.G. Shul'ga (1969) Lanthanum rhabdophane in the weathered mantle on limestones – a new type of rare earth mineralization. Zap. Vses. Mineral. Obshch., 98, 593–600 (in Russian).

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Rhabdophane-(Nd) $(Nd, Ce, La)PO_4 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Botryoidal masses and thin films.

Physical Properties: Hardness = [3–3.5] [by analogy to rhabdophane-(Ce)].
D(meas.) = n.d. D(calc.) = [4.79]

Optical Properties: Semitransparent. *Color:* Pale Pink, pale yellow. *Luster:* [Greasy.]
Optical Class: [Uniaxial (+).] ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P6_222$. $a = 6.960$ $c = 6.372$ $Z = 3$

X-ray Powder Pattern: Salisbury, Connecticut, USA.
3.02 (vsb), 4.40 (s), 2.83 (s), 2.15 (s), 6.07 (m), 3.49 (m), 1.859 (m)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8		0.42	Tb_4O_7	0.4	
P_2O_5	23.1	28.59	Dy_2O_3	0.6	1.69
CO_2	3.2		Ho_2O_3	0.3	0.40
Y_2O_3	8.9	4.02	Er_2O_3	1.1	1.12
La_2O_3	18.9	12.19	Tm_2O_3	0.2	0.50
CeO_2	0.5		Yb_2O_3	0.9	0.40
Ce_2O_3		11.85	Lu_2O_3	0.2	
Pr_2O_3		1.02	Fe_2O_3		0.38
Pr_6O_{11}	0.5		CaO		0.26
Nd_2O_3	26.6	21.18	F	0.3	
Sm_2O_3	4.5	3.49	H_2O^+	5.9	
Eu_2O_3	0.9	1.78	H_2O^-	1.1	
Gd_2O_3	4.4	3.24	H_2O		[7.13]
Tb_2O_3		0.34	$-O = F_2$	[1.3]	
			Total	[101.2]	[100.00]

(1) Salisbury, Connecticut, USA. (2) Fowey Consols mine, Cornwall, England; by electron microprobe, H_2O by difference; corresponds to $(Nd_{0.31}La_{0.19}Ce_{0.18}Y_{0.09}Sm_{0.05}Gd_{0.04}Eu_{0.03}Dy_{0.02}Pr_{0.02}Er_{0.02}Ca_{0.01}Fe_{0.01}Tm_{0.01}Tb_{0.01}Ho_{0.01}Yb_{0.01})_{\Sigma=1.01}PO_4 \cdot 0.99H_2O$.

Occurrence: A rare secondary mineral in hydrothermal base-metal deposits.

Association: Lithiophorite, goethite, halloysite (Salisbury, Connecticut, USA).

Distribution: Occurs in the Scovill mine, Salisbury, Litchfield Co., Connecticut, USA. From the Fowey Consols mine, Tywardreath, Cornwall, England. At the Clara mine, near Oberwolfach, and in the Silberbrünnle mine, near Gengenbach, Black Forest, Germany.

Name: For the dominant rare earth, *neodymium*, and relation to *rhabdophane*-(Ce).

Type Material: Yale University, New Haven, Connecticut, USA, 3.3135, 3.3137.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 774. (2) Hildebrand, F.A., M.H. Carron, and H.J. Rose, Jr. (1957) Re-examination of rhabdophane (scovillite) from Salisbury, Connecticut. Geol. Soc. Amer. Bull., 68, 1744–1745 (abs.). (3) Bowles, J.F.W. and D.J. Morgan (1984) The composition of rhabdophane. Mineral. Mag., 48, 146–148. (4) Muto, T., R. Meyrowitz, A.M. Pommer, and T. Murano (1959) Ningyoite, a new uranous phosphate mineral from Japan. Amer. Mineral., 44, 633–650.

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Rhabdophane-(Y) $YPO_4 \cdot H_2O$

Crystal Data: Hexagonal. *Point Group*: 622. Rod-like crystals to 3μm form divergent radial aggregates.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 4.54

Optical Properties: Translucent. *Color*: Yellowish white to yellowish brown. *Streak*: Yellowish white. *Luster*: Silky to dull.
Optical Class: n.d.

Cell Data: *Space Group*: $P6_222$. a = 6.959(2) c = 6.384(2) Z = 3

X-ray Powder Pattern: Higashimatsuura basalt, Hinodematsu, Genkai-cho, Saga Prefecture, Japan. 2.821 (100), 3.013 (77), 6.026 (76), 4.385 (47), 3.480 (44), 2.127 (28), 1.854 (26)

Chemistry:

	(1)	(2)
CaO	2.03	
∑ REE	[61.47]	
Y_2O_3	15.25	55.92
La_2O_3	20.76	
Ce_2O_3	1.10	
Pr_2O_3	5.28	
Nd_2O_3	14.73	
Sm_2O_3	0.33	
Gd_2O_3	4.02	
P_2O_5	27.98	35.16
H_2O	[8.52]	8.92
Total	100.00	100.00

(1) Higashimatsuura basalt, Japan; average of 9 electron microprobe analyses, H_2O calculated by difference; corresponding to $(Y_{0.33}La_{0.31}Nd_{0.21}Pr_{0.08}Gd_{0.05}Ce_{0.02}Sm_{0.00})_{\Sigma=1.01}Ca_{0.09}P_{0.96}O_4 \cdot 1.15\ H_2O$.
(2) $YPO_4 \cdot H_2O$.

Mineral Group: Rhabdophane group.

Occurrence: Forms druses on alkaline olivine basalt.

Association: Plagioclase, forsterite, augite, enstatite, magnetite, ilmenite.

Distribution: From the Higashimatsuura alkaline olivine basalt, Hinodematsu, Genkai-cho, Saga Prefecture, Japan.

Name: As the *Y*-dominant analog of *rhabdophane*-(Ce).

Type Material: Kitakyushu Museum of Natural History and Human History, Kitakyushuu, Japan (KMNHM000002).

References: (1) Takai, Y. and S. Uehara (2012) Rhabdophane-(Y), $YPO_4 \cdot H_2O$, a new mineral in alkali olivine basalt from Hinodematsu, Genkai-cho, Saga Prefecture. Journal of Mineralogical and Petrological Sciences, 107(2), 110-113. (2) (2014) Amer. Mineral., 99, 2442 (abs. ref. 1).

Rhenium Re

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Rhodesite $KHCa_2Si_8O_{19}\cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Matted silky fibers, some platy, to 2 mm. In flattened rosettes, irregular segregations, and crusts.

Physical Properties: *Cleavage:* Good, {100}. Hardness = ~4 D(meas.) = 2.27–2.36 D(calc.) = 2.26

Optical Properties: Translucent to transparent. *Color:* White. *Luster:* Silky. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. α = 1.501–1.504 β = 1.506–1.508 γ = 1.513–1.518 2V(meas.) = n.d. 2V(calc.) = 68.1°

Cell Data: *Space Group:* $Pmam$. a = 23.42–23.79 b = 6.55–6.59 c = 7.01–7.06 Z = 2

X-ray Powder Pattern: Trinity Co., California, USA.
6.548 (100), 4.386 (47), 5.901 (34), 6.302 (32), 5.032 (28), 2.864 (25), 2.762 (23)

Chemistry:

	(1)	(2)	(3)
SiO_2	61.83	66.27	63.50
Al_2O_3	0.29		
FeO	0.25		
MgO	0.08		
CaO	14.90	15.21	14.81
Na_2O	4.93	0.33	
K_2O	5.28	2.23	6.22
H_2O	12.50	[15.96]	15.47
Total	100.06	[100.00]	100.00

(1) Kimberley, South Africa, average of two analyses. (2) Do.; by electron microprobe, H_2O by difference. (3) $KHCa_2Si_8O_{19}\cdot 5H_2O$.

Occurrence: In a kimberlite pipe (Kimberley, South Africa); in a magadiite deposit localized in altered silicic lavas (Trinity Co., California, USA).

Association: Mountainite (Kimberley, South Africa); magadiite, montmorillonite (Trinity Co., California, USA).

Distribution: In South Africa, at the Bultfontein diamond mine, Kimberley, Cape Province. From near Redding, Trinity Co., California, USA. On the Zeilberg, near Maroldsweisach, Bavaria, Germany. From San Venanzo, near Terni, Lazio, Italy.

Name: For Cecil John Rhodes (1853–1902), British founder of the DeBeers Mining Company, also for Rhodes University, Grahamstown, South Africa, where the mineral was examined.

Type Material: The Natural History Museum, London, England, 1957,18; National Museum of Natural History, Washington, D.C., USA, 114793.

References: (1) Mountain, E.D. (1957) Rhodesite, a new mineral from the Bulfontein mine, Kimberley. Mineral. Mag., 31, 607–610. (2) Gard, J.A., H.F.W. Taylor, and R.A. Chalmers (1957) An investigation of two minerals: rhodesite and mountainite. Mineral. Mag., 31, 611–623. (3) (1958) Amer. Mineral., 43, 624 (abs. refs. 1 and 2). (4) Sheppard, R.A. and A.J. Gude, 3rd (1969) Rhodesite from Trinity County, California. Amer. Mineral., 54, 251–255. (5) Hesse, K.-F. (1979) Die Kristallstruktur von Rhodesit, $H_2K_2Ca_4Si_{16}O_{38}\cdot 10H_2O$ – ein Silikat mit verzweigten Doppelschichten. Zeits. Krist., 149, 155–156 (in German). (6) Hesse, K.-F., F. Liebau, and S. Merlino (1992) Crystal structure of rhodesite, $HK_{1-x}Na_{x+2y}Ca_{2-y}\{lB,3,2^2_\infty\}[Si_8O_{19}]\cdot(6-z)H_2O$, from three localities and its relation to other silicates with dreier double layers. Zeits. Krist., 199, 25–48.

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Rhodium (Rh, Pt)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$ (synthetic). As subhedral grains, to 200 μm.

Physical Properties: Hardness = n.d. VHN = 136–194, 165 average (30 g load). D(meas.) = n.d. D(calc.) = [16.5]

Optical Properties: Opaque. *Color:* In polished section, bright white. *Luster:* Metallic. R: (470) 75.2, (546) 72.6, (589) 73.3, (650) 75.7

Cell Data: *Space Group:* $Fm3m$ (synthetic). a = 3.856(1) Z = 4

X-ray Powder Pattern: Stillwater complex, Montana, USA. 0.7874 (100), 0.8623 (80), 0.8847 (70), 2.227 (60), 1.362 (50), 1.162 (50), 1.927 (30)

Chemistry:

	(1)
Pt	59.6
Rh	41.7
Total	101.3

(1) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $Rh_{0.57}Pt_{0.43}$.

Occurrence: A single grain was found in heavy mineral concentrates (Stillwater complex, Montana, USA).

Association: Platinum, Pt–Fe alloy, gold, moncheite, kotulskite, merenskyite, cooperite, braggite, vysotskite, sperrylite, pyrite, chalcopyrite, pyrrhotite, chromite, magnetite, marcasite, violarite, graphite (Stillwater complex, Montana, USA).

Distribution: In the USA, from the Stillwater complex, Montana [TL], and at Fox Gulch, Goodnews Bay, Alaska.

Name: From the Greek *rhodon*, *rose*.

Type Material: Royal Ontario Museum, Toronto, Canada, M33257.

References: (1) Cabri, L.J. and J.H.G. Laflamme (1974) Rhodium, platinum, and gold alloys from the Stillwater Complex. Can. Mineral., 12, 399–403. (2) (1976) Amer. Mineral., 61, 340 (abs. ref. 1). (3) Ewald, P.P. and C. Hermann, Eds. (1931) Rhodium, *Rh*. Strukturbereicht, 1, 69 (in German). (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 132–133.

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Rhodizite $(K, Cs)Al_4Be_4(B, Be)_{12}O_{28}$

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Crystal Data: Cubic. *Point Group:* $\overline{4}3m$. Typically as well-formed dodecahedra and tetrahedra, to 3.5 cm, modified by {001} and {$\overline{1}$11}. *Twinning:* On {111}, uncommon.

Physical Properties: *Cleavage:* {111} and {$\overline{1}$11}, indistinct. *Fracture:* Conchoidal. Hardness = 8–8.5 D(meas.) = 3.22–3.44 D(calc.) = 3.2–3.62 Strongly piezoelectric and pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless to white, may have a pale gray or pale yellow tinge; in transmitted light, colorless. *Luster:* Vitreous to slightly adamantine.
Optical Class: Isotropic, may display zoned anomalous birefringence. $n = 1.693(1)$

Cell Data: *Space Group:* $P\overline{4}3m$. a = 7.317–7.319 Z = 1

X-ray Powder Pattern: Manjaka, Madagascar; very similar to londonite.
2.983 (100), 2.440 (51), 3.274 (48), 2.111 (37), 1.775 (25), 1.956 (22), 2.205 (21)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2		0.08	CaO	0.18	0.04
CO_2	0.15		Li_2O	0.03	0.03
B_2O_3	50.2	[49.60]	Na_2O	0.06	0.19
Fe_2O_3		0.02	K_2O	2.77	5.03
Al_2O_3	25.8	26.35	Rb_2O	0.73	0.51
BeO	14.3	[16.21]	Cs_2O	6.4	1.70
MnO		0.03	H_2O^+	0.32	
MgO	0.01		Total	[101.0]	[99.79]

(1) Ambatofinandrahana, Madagascar; B_2O_3 by ICP, SiO_2 6.23% assumed as quartz; calculated neglecting impurities, corresponds to $(K_{0.46}Cs_{0.36}Rb_{0.06}Na_{0.02}Li_{0.02})_{\Sigma=0.92}Al_{3.99}Be_{4.00}(B_{11.35}Be_{0.55})_{\Sigma=11.90}O_{28.00}$. (2) Andasy, Madagascar; by electron microprobe, average of seven analyses, B_2O_3 and BeO calculated for stoichiometry; corresponds to $(K_{0.82}Cs_{0.09}Rb_{0.04}Na_{0.05}Li_{0.02}Ca_{0.01})_{\Sigma=1.03}(Al_{3.99}Si_{0.01})_{\Sigma=4.00}Be_{4.00}(B_{10.99}Be_{1.00})_{\Sigma=11.99}O_{28.00}$.

Occurrence: A rare late-stage accessory mineral in alkali-rich granite pegmatites.

Association: Londonite, elbaite, spodumene, beryl, béhierite, albite, microcline, quartz.

Distribution: Found near Sarapulka and Shaitanka, Mursinka district, Ural Mountains, Russia. In Madagascar, from Antandrokomby, near Mt. Bity, at Andasy, Besesitra, and Ifsina, Manandona Valley, Antsirabe district; from Fiakarandava, south of the Manandona Valley; from the Ambatofinandrahana district, in the Ankarata Mountains; at Antsongombato, 25 km southwest of Mahaiza, Betafo district; from Ampanivana, 15 km south of Antsongombato; at Ampakita and Sahanivotry, in the Sahatany Valley; and from Ambalalehifotsy. In England, from Meldon and Okehampton, Devon. In the USA, found in the Animikie Red Ace pegmatite, near Pine River, Florence Co., Wisconsin.

Name: From the Greek for *rose-colored*, for the rose-red color the mineral imparts to the blowpipe flame.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 329–330. (2) Pring, A., V.K. Din, D.A. Jefferson, D.A., and J.M. Thomas (1986) The crystal chemistry of rhodizite: a re-examination. Mineral. Mag., 50, 163–172.
(3) Simmons, W.B., F. Pezzotta, A.U. Falster, and K.L. Webber (2001) Londonite, a new mineral species: the Cs-dominant analogue of rhodizite from the Antandrokomby granitic pegmatite, Madagascar. Can. Mineral., 39, 747–755.

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Rhodochrosite $Mn^{2+}CO_3$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Crystals are rhombohedra $\{10\bar{1}1\}$ or scalenohedra $\{21\bar{3}1\}$, to 12 cm, modified by $\{0001\}$, $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, with several other forms, may be rounded or saddle-shaped. Commonly in bladed aggregates, columnar, stalactitic, botryoidal, compact granular, massive. *Twinning:* On $\{10\bar{1}2\}$, contact and lamellar, then flattened.

Physical Properties: *Cleavage:* $\{10\bar{1}1\}$, perfect; $\{01\bar{1}2\}$, a parting. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 3.70 D(calc.) = 3.70

Optical Properties: Transparent to translucent. *Color:* Pink, rose-red, cherry-red, yellow, yellowish gray, cinnamon-brown, may be banded; pale rose to colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, pearly in aggregates.
Optical Class: Uniaxial (–). *Pleochroism:* Faint. *Absorption:* $O > E$. $\omega = 1.810$ $\epsilon = 1.597$

Cell Data: *Space Group:* $R\bar{3}c$ (synthetic). $a = 4.777$ $c = 15.67$ Z = 6

X-ray Powder Pattern: Synthetic.
2.84 (100), 3.66 (35), 1.763 (35), 1.770 (30), 2.172 (25), 2.000 (25), 2.39 (20)

Chemistry:

	(1)	(2)
CO_2	38.26	38.29
FeO	0.77	
MnO	60.87	61.71
MgO	trace	
CaO	0.51	
Total	100.41	100.00

(1) Ljubija district, Bosnia-Herzegovina. (2) $MnCO_3$.

Polymorphism & Series: Forms two series, with calcite and with siderite.

Mineral Group: Calcite group.

Occurrence: A primary mineral in low- to moderate-temperature hydrothermal veins; in metamorphic deposits; common in carbonatites; authigenic and secondary in sediments; uncommon in granite pegmatites.

Association: Calcite, siderite, dolomite, fluorite, barite, quartz, pyrite, tetrahedrite, sphalerite, hübnerite (hydrothermal); rhodonite, garnet, alabandite, hausmannite (metamorphic).

Distribution: Numerous localities; only a few for fine specimens are listed. From Cavnic (Kapnikbánya) and Herja (Kisbánya), Baia Mare (Nagybánya) district, Romania. In the Wolf mine, near Herdorf, Westphalia, Germany. In Russia, from the Vuoriyarvi carbonatite complex and the Kovdor massif, Kola Peninsula. Large twinned crystals at Mont Saint-Hilaire, Quebec, Canada. In the USA, from the Emma mine, Butte, Silver Bow Co., Montana; in Colorado, at many localities, as fine large crystals in the Home Sweet Home mine, Alma, Park Co., from the Climax mine, Lake Co., in the Sunnyside mine, near Silverton, San Juan Co., and the Mountain Monarch mine, Ouray Co. In Mexico, from Cananea, Sonora, and Santa Eulalia, Chihuahua. Large crystals from the Huallapón mine, Pasto Bueno, Ancash Department, and in the Uchuc-Chacua deposit, Cajatambo Province, Peru. In Province, Peru. A large deposit of ornamental banded material at the Capillitas mine, San Luis, Catamarca Province, Argentina. Exceptional crystals from the Hotazel and N'Chwaning mines, near Kuruman, Cape Province, South Africa. From the Inakuraishi and Yakumo mines, Hokkaido, Japan.

Name: From the Greek *rhodon*, for *rose*, and *chrosis*, for *coloring*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 171–175. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 263–271; Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 150–162. (3) Effenberger, H., K. Mereiter, and J. Zemann (1981) Crystal structure refinements of magnesite, rhodochrosite, siderite, smithsonite, and dolomite, with discussion of some aspects of the stereochemistry of calcite type carbonates. Zeits. Krist., 156, 233–243. (4) (1957) NBS Circ. 539, 7, 32.

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Rhodonite $(Mn^{2+}, Fe^{2+}, Mg, Ca)SiO_3$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals rough, with rounded edges, typically tabular and elongated ‖ [001], to 20 cm; commonly massive, cleavable to compact. *Twinning:* Lamellar, with {010} as composition plane.

Physical Properties: *Cleavage:* Perfect on {110} and $\{1\bar{1}0\}$, $(110) \wedge (1\bar{1}0) = 92.5°$; good on {001}. *Fracture:* Conchoidal to uneven. Hardness = 5.5–6.5 D(meas.) = 3.57–3.76 D(calc.) = 3.726

Optical Properties: Transparent to translucent. *Color:* Rose-pink to brownish red, gray, or yellow, exterior commonly black from manganese oxides; in thin section, colorless to faint pink. *Streak:* White. *Luster:* Vitreous, somewhat pearly on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = yellowish red; Y = pinkish red; Z = pale yellowish red. *Orientation:* $X \wedge a \simeq 5°$; $Y \wedge b \simeq 20°$; $Z \wedge c \simeq 25°$. *Dispersion:* $r < v$. $\alpha = 1.711$–1.734 $\beta = 1.716$–1.739 $\gamma = 1.724$–1.748 2V(meas.) = 63°–87°

Cell Data: *Space Group:* $C\bar{1}$. $a = 9.758$ $b = 10.499$ $c = 12.205$ $\alpha = 108.58°$ $\beta = 102.92°$ $\gamma = 82.52°$ Z = 20

X-ray Powder Pattern: Franklin, New Jersey, USA. (ICDD 13-138).
2.772 (100), 2.980 (65), 2.924 (65), 3.14 (30), 3.34 (25), 3.10 (25), 2.651 (18)

Chemistry:

	(1)
SiO_2	45.46
Al_2O_3	0.27
Fe_2O_3	0.00
FeO	0.96
MnO	50.54
ZnO	trace
MgO	0.55
CaO	2.25
H_2O^+	0.00
H_2O^-	0.00
Total	100.03

(1) Chikla, Bhandara district, Maharashtra, India; corresponds to $(Mn^{2+}_{0.93}Ca_{0.05}Fe^{2+}_{0.02}Mg_{0.02})_{\Sigma=1.02}(Si_{0.99}Al_{0.01})_{\Sigma=1.00}O_3$.

Occurrence: In manganese-bearing deposits formed by hydrothermal, contact and regional metamorphic, and sedimentary processes.

Association: Calcite, willemite, franklinite (Franklin, New Jersey, USA); calcite, alleghanyite, tephroite, galaxite, grunerite, magnetite (Bald Knob, North Carolina, USA).

Distribution: A few localities for studied or fine material are: from around Yekaterinburg (Sverdlovsk), Ural Mountains, Russia. In the Harstigen mine, near Persberg, and at Långban, Värmland, Sweden. In the Meldon quarry, Okehampton, Devon, England. In Romania, at Băiţa (Rézbánya) and Cavnic (Kapnik). From near Viu and St. Marcel, Val d'Aosta, Italy. At Broken Hill, New South Wales, Australia, as gem crystals. In the Noda-Tamagawa mine, Iwate Prefecture, and many other places in Japan. In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; at Bald Knob, near Sparta, Alleghany Co., North Carolina; from Butte, Silver Bow Co., Montana. At Morro da Mina, Conselheiro Lafaiete, Minas Gerais, Brazil, as gem crystals. In the Chiurucu mine, Huanaco, Peru.

Name: From the Greek for *rose*, in reference to the mineral's color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 378–381. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 586–599. (3) Peacor, D.R. and N. Niizeki (1963) The redetermination and refinement of the crystal structure of rhodonite, $(Mn, Ca)SiO_3$. Zeits. Krist., 119, 98–116.

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Rhodostannite $Cu_2FeSn_3S_8$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Very fine-grained massive, slightly porous.

Physical Properties: Hardness = n.d. VHN = 243–266 (100 g load). D(meas.) = n.d. D(calc.) = 4.79

Optical Properties: Opaque. *Color:* Reddish. *Luster:* Metallic. *Anisotropism:* Distinct, from bluish gray to dark brown.

R_1–R_2: (400) 29.1–30.4, (420) 28.7–29.9, (440) 28.3–29.4, (460) 28.2–29.3, (480) 28.2–29.4, (500) 28.3–29.8, (520) 28.5–30.2, (540) 28.8–30.4, (560) 28.9–30.6, (580) 28.9–30.8, (600) 28.9–30.8, (620) 28.9–30.8, (640) 28.8–30.7, (660) 28.8–30.7, (680) 28.7–30.5, (700) 28.6–30.3

Cell Data: *Space Group:* $I4_1/a$ (synthetic). $a = 7.305(2)$ $c = 10.330(5)$ $Z = 2$

X-ray Powder Pattern: Vila Apacheta, Bolivia.
3.12 (100), 5.93 (60), 2.58 (50), 6.09 (40), 1.819 (30), 1.837 (20), 3.64 (16)

Chemistry:

	(1)	(2)	(3)
Cu	16.0	15.9	15.97
Fe	6.8	6.5	7.02
Sn	45.5	45.4	44.76
S	31.3	32.8	32.25
Total	99.6	100.6	100.00

(1) Vila Apacheta, Bolivia; by electron microprobe, corresponding to $Cu_{2.03}Fe_{0.98}Sn_{3.10}S_{7.89}$.
(2) Do.; by electron microprobe, corresponding to $Cu_{1.98}Fe_{0.92}Sn_{3.02}S_{8.08}$. (3) $Cu_2FeSn_3S_8$.

Occurrence: An alteration product of stannite (Vila Apacheta, Bolivia).

Association: Stannite, pyrite (Vila Apacheta, Bolivia).

Distribution: At Vila Apacheta, Bolivia [TL]. From the Pirquitas deposit, Rinconada Department, Jujuy Province, Argentina. In the Dean mine, southeast of Battle Mountain, Lander Co., Nevada, and in the Campbell mine, Bisbee, Cochise Co., Arizona, USA.

Name: From the Greek for *rose*, in allusion to its color, and for its affinity to stannite.

Type Material: n.d.

References: (1) Springer, G. (1968) Electronprobe analyses of stannite and related tin minerals. Mineral. Mag., 36, 1045–1051. (2) (1969) Amer. Mineral., 54, 1218 (abs. ref. 1). (3) Wang, N. (1975) Investigation of synthetic rhodostannite, $Cu_2FeSn_3S_8$. Neues Jahrb. Mineral., Monatsh., 166–171. (4) Jumas, J.C., E. Philippot, and M. Maurin (1979) Structure du rhodostannite synthétique. Acta Cryst., 35, 2195–2197 (in French with English abs.).

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Rhodplumsite $Pb_2Rh_3S_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As grains, to 40 μm, in a platinum nugget.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 9.74

Optical Properties: Opaque. *Color:* White in reflected light. *Pleochroism:* Notable; from cream-pink to grayish blue. *Anisotropism:* Strong.
R_1–R_2: (400) — , (420) — , (440) 38.6–44.5, (460) 39.2–45.2, (480) 39.5–46.3, (500) 39.5–47.1, (520) 39.2–48.2, (540) 38.6–49.4, (560) 37.8–50.6, (580) 36.8–51.7, (600) 36.2–52.7, (620) 35.9–53.4, (640) 36.2–54.6, (660) 36.8–55.7, (680) 37.7–56.6, (700) 38.5–57.3

Cell Data: *Space Group:* $R\overline{3}m$. $a = 5.73(1)$ $c = 14.00(1)$ $Z = 3$

X-ray Powder Pattern: Ural Mountains, Russia.
2.86 (10), 2.33 (6), 2.01 (6), 4.02 (3), 2.44 (3), 1.807 (3), 4.64 (2)

Chemistry:

	(1)	(2)
Rh	40.27	39.21
Ir	0.27	
Pt	0.24	
Pb	51.48	52.64
S	8.05	8.15
Total	100.31	100.00

(1) Ural Mountains, Russia; by electron microprobe; corresponds to $Pb_{1.95}(Rh_{3.06}Ir_{0.01}Pt_{0.01})_{\Sigma=3.08}S_{1.97}$. (2) $Pb_2Rh_3S_2$.

Occurrence: In a platinum nugget in a placer probably derived from the nearby Omutninskii gabbro-pyroxenite-dunite massif.

Association: Platinum, tulameenite, iridium–osmium, laurite, chromite.

Distribution: From the Omutninskaya platinum-bearing placer, Omutnaya River, 20 km south of Polevskoi, Sysert' district, Ural Mountains, Russia [TL].

Name: For rhodium and lead, *plumbum*, in the composition.

Type Material: Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

References: (1) Genkin, A.D., L.N. Vyal'sov, T.L. Evstigneeva, I.P. Laputina, and G.V. Basova (1983) Rhodplumsite, $Rh_3Pb_2S_2$, a new sulfide of rhodium and lead. Mineral. Zhurnal, 5(2), 87–91 (in Russian with English abs.). (2) (1984) Mineral. Abs., 35, 88 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 174.

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Rhomboclase $H_5Fe^{3+}O_2(SO_4)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As thin tabular crystals, {001}, {010}, {100}, {111}, {011}, with other modifying forms noted, giving a rhombic outline, to 2 cm; may be radially bladed in stalactites.

Physical Properties: *Cleavage:* Perfect on {001}, good on {110}. *Fracture:* Conchoidal to fibrous. *Tenacity:* Cleavage folia are flexible. Hardness = 2 D(meas.) = 2.23 D(calc.) = 2.210 Slowly soluble in H_2O.

Optical Properties: Transparent. *Color:* White, gray, pale yellow, may be pale green or pale blue if impure; colorless in transmitted light. *Luster:* Subvitreous to pearly.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.534$ $\beta = 1.553$–1.555 $\gamma = 1.634$–1.638 $2V(meas.) = 27°$

Cell Data: *Space Group: Pnma.* $a = 9.724(4)$ $b = 18.333(9)$ $c = 5.421(4)$ $Z = 4$

X-ray Powder Pattern: Cerro de Pasco, Peru.
9.18 (> 100), 3.29 (18), 4.05 (15), 3.33 (15), 3.11 (11), 3.05 (10), 4.75 (7)

Chemistry:

	(1)	(2)	(3)
SO_3	49.27	48.00	49.88
Fe_2O_3	24.54	25.72	24.87
FeO	0.35		
CuO	0.03		
CaO	0.10		
H_2O	[25.54]	26.6	25.25
rem.	0.15		
Total	[99.98]	100.3	100.00

(1) Szomolnok, Slovakia; remnant is $MgO+Na_2O$, H_2O stated determined by difference. (2) Cerro de Pasco, Peru, H_2O by TGA. (3) $H_5FeO_2(SO_4)_2 \cdot 2H_2O$.

Occurrence: An uncommon secondary mineral formed by alteration of pyrite, especially in an arid climate; typically of post-mining origin.

Association: Szomolnokite, copiapite, römerite, voltaite, epsomite, halotrichite, melanterite, chalcanthite, pyrite.

Distribution: From Smolník (Szomolnok), 16 km northeast of Rožňava, Slovakia. At Lesenceistvánd, Hungary. In the Nikitovka mercury deposit, Gorlovka, Ukraine. At the Esperanza mine, Cerro de Pasco, Peru. In Chile, from Alcaparrosa, near Cerritos Bayos, southwest of Calama, Antofagasta. Large crystals in the Socavon mine, Oruro, Bolivia. In the USA, from the Copper Queen mine, Bisbee, Cochise Co., and in the Magma mine, Superior district, Pinal Co., Arizona.

Name: From the Greek for *rhomb*, for the typical rhombic crystal outline, and for *to break*, for its perfect cleavage.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 436–437. (2) Mereiter, K. (1974) Die Kristallstruktur von Rhomboklas, $H_5O_2^+Fe[SO_4]_2 \cdot 2H_2O^-$. Tschermaks Mineral. Petrog. Mitt., 21, 216–232 (in German with English abs.). (3) Van Tassel, R. (1974) X-ray powder data of rhomboclase. Mineral. Mag.. 39, 611–612.

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Rhönite $\mathbf{Ca_2(Mg, Fe^{2+}, Fe^{3+}, Ti)_6(Si, Al)_6O_{20}}$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\bar{1}$. As prismatic or tabular crystals, to several cm; as skeletal grains with well-developed crystal faces; anhedral grains and aggregates. *Twinning:* Polysynthetic ∥ {010}, common.

Physical Properties: *Cleavage:* {010}, {001}, good. Hardness = 5–6 D(meas.) = 3.4–3.76 D(calc.) = [3.64]

Optical Properties: Translucent to opaque. *Color:* Dark brown to black.
Luster: Semimetallic.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = dark greenish brown, red-brown; Y = dark reddish to greenish brown; Z = dark reddish brown to black. *Dispersion:* $r < v$, extreme. *Absorption:* $Z > Y > X$. α = 1.795–1.810 β = 1.806–1.825 γ = 1.830–1.845 2V(meas.) = 50° to ∼90° 2V(calc.) = 65°

Cell Data: *Space Group:* $P\bar{1}$. a = 10.37–10.43 b = 10.76–11.21 c = 8.92–9.02 $\alpha = 102°-106°$ $\beta = 96°-101°$ $\gamma = 124°-127°$ Z = 2

X-ray Powder Pattern: Study Butte, Texas, USA.
2.947 (100), 2.550 (69), 2.691 (65), 2.092 (56), 1.498 (38), 2.783 (31), 1.991 (25)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	24.42	30.74	FeO	11.39	[0.37]	Na_2O	0.67	3.08
TiO_2	9.46	5.73	MnO	trace	0.26	K_2O	0.63	0.06
Al_2O_3	17.25	12.66	MgO	12.62	19.50	Total	100.56	[98.11]
Fe_2O_3	11.69	[17.37]	CaO	12.43	8.36			

(1) Scharnhausen, Germany; corresponds to $(Ca_{1.78}Na_{0.18}K_{0.11})_{\Sigma=2.07}(Mg_{2.52}Fe^{2+}_{1.28}Fe^{3+}_{1.17}Ti_{0.96})_{\Sigma=5.93}(Si_{3.27}Al_{2.72}Fe^{3+}_{0.01})_{\Sigma=6.00}O_{20}$. (2) Kalaheo, Hawaii, USA; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry, original total given as 98.12%; corresponds to $(Ca_{1.16}Na_{0.77}K_{0.01})_{\Sigma=1.94}(Mg_{3.78}Fe^{3+}_{1.65}Ti_{0.56}Fe^{2+}_{0.04}Mn_{0.03})_{\Sigma=6.06}(Si_{4.01}Al_{1.94}Fe^{3+}_{0.05})_{\Sigma=6.00}O_{20}$.

Mineral Group: Aenigmatite group.

Occurrence: In silica-undersaturated, alkalic, mafic to intermediate igneous rocks, as a primary mineral or an alteration product of amphiboles. Also developed at the contact of alkalic basalt and limestone.

Association: Titanian augite, kaersutite, alkalic feldspar, diopside, forsterite, spinel, perovskite, titanian magnetite, magnesioferrite.

Distribution: In Germany, in the Rhön Mountains, at Scharnhausen, near Stuttgart, Hesse; from Eichersattel, Sattelberg, and other volcanic cones in the Eifel district; at the Löbauer Berg, Saxony, and other places. From Skåne, Sweden. In France, from Puy de Saint-Sandoux, Auvergne; south of Bort-les-Orgues, Puy-de-Dôme; and at Monistrol-d'Allier, Haute Loire. From Hobbs Land, Greenland. In New Zealand, at Dunedin volcano, Otago Harbour, South Island. On Hut Point Peninsula, Ross Island, Antarctica. At Dogo, Oki Islands, Japan. Found near Study Butte, Brewster Co., Texas, and north of Kalaheo, Kauai, Hawaii, USA.

Name: For the Rhön district, Germany, from where it was first identified.

Type Material: n.d.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 88–89. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 655–658. (3) Cameron, K.L., M.F. Carman, and J.C. Butler (1970) Rhönite from Big Bend National Park, Texas. Amer. Mineral., 55, 864–874. (4) Johnston, A.D. and J.H. Stout (1985) Compositional variation of naturally occurring rhoenite [rhönite]. Amer. Mineral., 70, 1211–1216. (5) Bonaccorsi, E., S. Merlino, and M. Pasero (1990) Rhönite: structural and microstructural features, crystal chemistry and polysomatic relationships. Eur. J. Mineral., 2, 203–218.

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Ribbeite $(Mn^{2+},Mg)_5(SiO_4)_2(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals, up to 0.5 mm, in granular aggregates, to 20 cm.

Physical Properties: Hardness = ∼5 D(meas.) = 3.90(5) D(calc.) = 3.84

Optical Properties: Transparent. *Color:* Pink. *Streak:* Light pink. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; $X = Y$ = colorless; Z = light pink. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, moderate. *Absorption:* $Z > X = Y$. $\alpha = 1.780(3)$ $\beta = 1.792(3)$ $\gamma = 1.808(3)$ 2V(meas.) = 81.3(2)° 2V(calc.) = 82.5°

Cell Data: *Space Group:* $Pbnm$ or $Pbn2_1$. a = 4.799(1) $b = 10.742(6)$ $c = 15.70(1)$ Z = 4

X-ray Powder Pattern: Kombat mine, Namibia.
1.796 (100), 2.873 (80), 2.552 (80), 2.925 (70), 2.821 (70), 2.695 (60), 2.515 (40)

Chemistry:

	(1)
SiO_2	24.3
FeO	0.3
MnO	65.1
MgO	5.2
CaO	0.2
F	0.0
H_2O	[4.9]
Total	[100.0]

(1) Kombat mine, Namibia; by electron microprobe, H_2O by difference; corresponds to $(Mn^{2+}_{4.30}Mg_{0.60}Fe_{0.02}Ca_{0.02})_{\Sigma=4.94}Si_{1.90}O_{10}H_{2.54}$.

Polymorphism & Series: Dimorphous with alleghanyite.

Mineral Group: Leucophoenicite group.

Occurrence: In mineralogically distinct layers, in tectonically transported and boudinaged manganese-rich lenses within dolostones, apparently formed under prograde metamorphic conditions.

Association: Alleghanyite, manganoan calcite, pyrochroite, chlorite, galaxite, jacobsite.

Distribution: In the Kombat mine, 49 km south of Tsumeb, Namibia.

Name: To honor Dr. Paul H. Ribbe, Virginia Polytechnic Institute, Blacksburg, Virginia, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 163208.

References: (1) Peacor, D.R., P.J. Dunn, S.-C. Su, and J. Innes (1987) Ribbeite, a polymorph of alleghanyite and member of the leucophoenicite group from the Kombat mine, Namibia. Amer. Mineral., 72, 213–216.

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Richellite $(Ca, Fe^{2+})(Fe^{3+}, Al)_2(PO_4)_2(OH)_2$

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Crystal Data: Amorphous or nearly so; tetragonal after heating. *Point Group:* n.d. Radially fibrous globules, foliated or compact; typically massive, to 3 cm.

Physical Properties: Hardness = 2–3 D(meas.) = ∼2 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Reddish to yellowish brown. *Streak:* Reddish to yellowish brown. *Luster:* Greasy to hornlike, subvitreous.
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group:* n.d. $a = 5.18$ $c = 12.61$ Z = [1]

X-ray Powder Pattern: Richelle, Belgium; after heating to 500 °C for 30 minutes.
3.24(9), 1.590 (7), 3.58 (6), 3.15 (6), 5.99 (5), 4.35 (5), 4.14 (5)

Chemistry:

	(1)	(2)	(3)
P_2O_5	25.49	36.75	38.24
Al_2O_3	3.64	5.25	4.81
FeO			6.78
Fe_2O_3	29.67	42.78	35.50
CaO	7.19	10.37	9.82
HF	0.96		
H_2O^+	23.63		
H_2O^-	9.47		
H_2O		[4.85]	4.85
Total	100.05	[100.00]	100.00

(1) Richelle, Belgium. (2) Analysis (1) recalculated to 100%, with $(OH)^{1-}$ by analogy to the lipscombite structure. (3) $(Ca_{1.3}Fe^{2+}_{0.7})_{\Sigma=2.0}(Fe^{3+}_{3.3}Al_{0.7})_{\Sigma=4.0}(PO_4)_{4.0}(OH)_{2.0}$.

Occurrence: Presumably as a secondary mineral in phosphatic sedimentary rocks.

Association: Halloysite, allophane, koninckite (Richelle, Belgium).

Distribution: From Richelle, near Visé, Belgium. In the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada, USA.

Name: For the locality where first found, Richelle, Belgium.

Type Material: University of Liège, Liège, Belgium, 9361 and 9375.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 956–957. (2) McConnell, D. (1963) Thermocrystallization of richellite to produce a lazulite structure (calcium lipscombite). Amer. Mineral., 48, 300–307. (3) Jensen, M.C., J.C. Rota, and E.E. Foord (1995) The Gold Quarry mine, Carlin Trend, Eureka County, Nevada. Mineral. Record, 26, 449–469, esp. 463.

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Richelsdorfite $Ca_2Cu_5Sb^{5+}(AsO_4)_4(OH)_6Cl \cdot 6H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Rare crystals, to 1 mm, flattened on {001}, with {001}, {010}, {101}, {210}; typically in spherical aggregates and botryoidal crystalline crusts. *Twinning:* On {001}, common.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ∼2 D(meas.) = 3.20(3) D(calc.) = 3.27–3.33

Optical Properties: Translucent. *Color:* Turquoise-blue, sky-blue, greenish blue. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale blue to colorless; Y = greenish blue, blue; Z = light greenish blue, blue. *Orientation:* $Z = b$; $Y \simeq a$; X inclined to c. *Dispersion:* $r > v$. α = 1.640–1.698 β = 1.692–1.765 γ = 1.694–1.799 2V(meas.) = 10°–15°; 69(2)° 2V(calc.) = 21.6°; 68.7°

Cell Data: *Space Group:* $C2/m$. a = 14.078–14.079 b = 14.203–14.207 c = 13.470–13.49 β = 101.05°−101.06° Z = 4

X-ray Powder Pattern: Richelsdorf Mountains, Germany.
3.045 (100), 4.913 (70), 4.392 (60), 1.753 (60), 2.669 (50), 0.795 (50), 6.80 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
As_2O_5	31.18	35.23	34.80	CaO	8.97	8.36	8.49
Sb_2O_5	11.88	12.13	12.25	Cl	1.83	2.44	2.68
FeO	0.01			H_2O	[17.19]	[11.98]	12.27
CuO	28.71	30.41	30.11	$-O = Cl_2$	[0.41]	0.55	0.60
ZnO	0.23			Total	[99.59]	[100.00]	100.00

(1) Richelsdorf Mountains, Germany; by electron microprobe, H_2O by difference. (2) Triembach-au-Val, France; by electron microprobe, H_2O by difference. (3) $Ca_2Cu_5Sb(AsO_4)_4Cl(OH)_6 \cdot 6H_2O$.

Occurrence: In cavities in sandstone in the Kupferschiefer (Richelsdorf Mountains, Germany).

Association: Duftite, tyrolite, azurite, tetrahedrite–tennantite, calcite (Richelsdorf Mountains, Germany); tetrahedrite–tennantite, galena, brochantite, devilline, harmotome, calcite (Samson mine, Germany); erythrite, chalcophyllite, cornwallite, strashimirite, tetrahedrite–tennantite, barite (Triembach-au-Val, France).

Distribution: In Germany, from Iba, near Richelsdorf, Richelsdorf Mountains, and Reichenbach, near Bensheim, Hesse; at the Sauberg mine, Ehrenfriedersdorf, Saxony; in the Samson mine, St. Andreasberg, and on the dumps of the Glücksrad mine, Oberschulenberg, Harz Mountains; in the Alte Buntekuh mine, near Niederschelden, and at Ramsbeck, North Rhine-Westphalia; in the Clara mine, near Oberwolfach, Black Forest. From Triembach-au-Val, Haut-Rhin, France. Large crystals at the Burrus mine, Pyramid district, Washoe Co., Nevada, USA.

Name: For its first observed occurrence in the Richelsdorf Mountains, Germany.

Type Material: Göttingen University, Göttingen, Germany; National Museum of Natural History, Washington, D.C., USA, 150229.

References: (1) Süsse, P. and G. Schnorrer-Köhler (1983) Richelsdorfit, $Ca_2Cu_5Sb[Cl/(OH)_6/(AsO_4)]_4 \cdot 6H_2O$, ein neues Mineral. Neues Jahrb. Mineral., Monatsh., 145–150 (in German with English abs.). (2) (1984) Amer. Mineral., 69, 211 (abs. ref. 1). (3) Süsse, P. and B. Tillman (1987) The crystal structure of the new mineral richelsdorfite, $Ca_2Cu_5Sb(Cl/(OH)_6/(AsO_4)_4) \cdot 6H_2O$. Zeits. Krist., 179, 323–334. (4) Sarp, H., B. Dominik, and P.-J. Chiappero (1994) Nouveau gisement (Triembach-Le Val, Vosges, France): nouvelles propriétés optiques et diagramme de poudre de la richelsdorfite, $Ca_2Cu_5Sb[Cl(OH)_6(AsO_4)_4] \cdot 6H_2O$ (in French, with English abs.). Schweiz. Mineral. Petrog. Mitt., 74, 273–277.

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Richetite $PbU_4^{6+}O_{13}\cdot 4H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* 1 or $\overline{1}$. As platy crystals, flattened on {001}, bounded by {010}, {110}, and {1$\overline{1}$0}, to 0.1 mm, in lamellar aggregates ∥ {001}, on needles of uranophane. *Twinning:* Common on a plane or planes in the [001] zone, to give pseudohexagonal outlines.

Physical Properties: *Cleavage:* {001}, perfect; another ⊥ to first. Hardness = n.d. VHN = 113 D(meas.) = n.d. D(calc.) = 6.02 Radioactive.

Optical Properties: Opaque to translucent. *Color:* Black; brown in transmitted light. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = pale brown to colorless; $Y = Z$ = dull brown. *Orientation:* $X = c^*$; $Y \wedge [110] = 85°$; $Z \wedge [110] = 5°$. $\alpha = \sim 1.9$ $\beta = \sim 2.0$ $\gamma = \sim 2.0$ 2V(meas.) = Very large.

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 20.81(2)$ $b = 12.06(2)$ $c = 16.30(2)$ $\alpha = 103.8(2)°$ $\beta = 115.1(2)°$ $\gamma = 90.4(2)°$ Z = 9

X-ray Powder Pattern: Shinkolobwe, Congo.
3.122 (100), 7.12 (80), 3.55 (60), 3.47 (60), 2.486 (40), 1.961 (40), 2.008 (30)

Chemistry:

	(1)	(2)
UO_3	78.28	79.48
PbO	16.38	15.51
H_2O	[5.34]	5.01
Total	[100.00]	100.00

(1) Shinkolobwe, Congo; by electron microprobe, average of eight analyses, H_2O by difference; corresponding to $Pb_{1.07}U_{3.98}O_{13}\cdot 4.31H_2O$. (2) $PbU_4^{6+}O_{13}\cdot 4H_2O$.

Occurrence: A very rare secondary mineral in the oxidized zone of a hydrothermal uranium deposit (Shinkolobwe, Congo).

Association: Uraninite, uranophane, becquerelite, masuyite, torbernite, kasolite, rutherfordine, wölsendorfite (Shinkolobwe, Congo); metazeunerite, nováčekite, zeunerite, antlerite, langite (Jáchymov, Czech Republic).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Jáchymov (Joachimsthal), Czech Republic.

Name: To honor Emile Richet (1884–1939), Belgian geologist, formerly Chief Geologist, Union Minière du Haut-Katanga.

Type Material: University of Liège, Liège, Belgium, 1712.

References: (1) Vaes, J.F. (1947) Six nouveaux minéraux d'urane provenant de Shinkolobwe (Katanga). Ann. Soc. Géol. Belg., 70, B212–B229, esp. B221–B223 (in French). (2) (1948) Amer. Mineral., 33, 384 (abs. ref. 1). (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 91–92. (4) Piret, P. and M. Deliens (1984) Nouvelles données sur la richetite $PbO.4UO_3.4H_2O$. Bull. Minéral., 107, 581–585 (in French with English abs.).

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Richterite $Na[NaCa](Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly prismatic, flattened along [100], rarely doubly terminated, to 15 cm; acicular or asbestiform. *Twinning:* Simple or multiple twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.97–3.45 D(calc.) = [3.10]

Optical Properties: Transparent to translucent. *Color:* Brown, yellow, green, brownish red; colorless to pale yellow in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong, in pale yellows, orange, and red. *Orientation:* $Y = b$; $Z \wedge c = -54°$ to $-20°$. *Dispersion:* $r < v$, weak. *Absorption:* $Y > Z = X$.
$\alpha = 1.605–1.624$ $\beta = 1.618–1.64$ $\gamma = 1.627–1.641$ 2V(meas.) = 48°–68°

Cell Data: *Space Group:* $C2/m$. a = 9.783 (ICDD 20-484). $b = 17.943$ $c = 5.287$ $\beta = 104.070°$ Z = 2

X-ray Powder Pattern: Imerina, Madagascar. (ICDD 20-484).
8.29 (100), 3.09 (70), 3.33 (20), 2.695 (20), 2.78 (16), 4.47 (14), 8.85 (12)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	56.74	58.09	MnO	0.07	0.00	K_2O	1.80	0.47
TiO_2	0.28	0.18	NiO	0.23		F	1.30	3.91
Al_2O_3	0.71	0.17	MgO	21.95	24.34	Cl		0.03
Fe_2O_3	4.71		CaO	6.15	6.73	H_2O^+	0.87	
Cr_2O_3	0.06	0.06	SrO	0.02		$-O = F_2$	0.54	1.61
FeO	0.87	0.01	Na_2O	5.15	7.21	Total	100.37	99.59

(1) Libby, Lincoln Co., Montana, USA; corresponds to $(Na_{1.39}Ca_{0.92}K_{0.32})_{\Sigma=2.63}(Mg_{4.57}Fe^{3+}_{0.50}Fe^{2+}_{0.10}Al_{0.04}Ti_{0.03}Ni_{0.02}Mn_{0.01})_{\Sigma=5.27}(Si_{7.92}Al_{0.08})_{\Sigma=8.00}O_{22}[(OH)_{0.81}F_{0.57}]_{\Sigma=1.38}$. (2) Mayo Belwa meteorite; by electron microprobe, average of three analyses; corresponds to $(Na_{1.93}Ca_{1.00}K_{0.08})_{\Sigma=3.01}(Mg_{5.01}Al_{0.03}Ti_{0.02})_{\Sigma=5.06}Si_{8.03}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with ferrorichterite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.5$; $(Na + K)_A \geq 0.5$; 0.67 Na_B 1.33; $(Ca + Na)_B \geq 1.34$; $Si \geq 7.5$.

Occurrence: Commonly in contact metamorphosed limestones; in alkalic igneous rocks and carbonatites. Also in meteorites.

Association: Leucite, diopside, forsterite, calcite, apatite, natrolite, phlogopite, cristobalite, enstatite, plagioclase.

Distribution: A few historic localities or sources for good specimen material include: at Långban and Pajsberg, Värmland, Sweden. In the Praborna mine, near St. Marcel, Val d'Aosta, Italy. At the Kangerdlugssuaq Fjord, Greenland. In the Murun massif, southwest of Olekminsk, Yakutia, Russia. In the USA, at Iron Hill, Gunnison Co., Colorado and the Leucite Hills, Sweetwater Co., Wyoming. In Canada, from Gooderham, Wilberforce; on Tory Hill, Bancroft; and at Essenville, Ontario; from near Gatineau Park, Quebec. At the Jacupiranga mine, São Paulo, Brazil. In the Noda-Tamagawa mine, Iwate Prefecture, and the Taguchi mine, Aichi Prefecture, Japan. At Imerina, Madagascar.

Name: For Professor Theodor Richter (1824–1898), German mineralogist.

Type Material: Mining Academy, Freiberg, Germany, 28854.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 386, 391.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 352–358. (3) Bevan, A.W.R., J.C. Bevan, and J.G. Francis (1977) Amphibole in the Mayo Belwa meteorite: first occurrence in an enstatite achondrite. Mineral. Mag., 41, 531–534.

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Rickardite $Cu_{3-x}Te_2$ (x = 0 to 0.36)

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$ Massive, very fine grained, somewhat porous; may be botryoidal.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5 VHN = 72–85 (50 g load). D(meas.) = 7.54 D(calc.) = 7.467

Optical Properties: Opaque. *Color:* Purple-red on fresh surface, tarnishes rapidly. *Luster:* Metallic. *Pleochroism:* Strong; carmine to violet-gray. *Anisotropism:* Strong; exceptional, in fiery orange colors.
R_1–R_2: (400) 28.3–37.2, (420) 26.1–35.5, (440) 23.5–33.2, (460) 20.8–30.5, (480) 17.8–27.5, (500) 15.1–24.8, (520) 12.8–22.3, (540) 11.5–20.3, (560) 11.8–18.9, (580) 14.5–18.2, (600) 19.6–18.4, (620) 26.0–19.4, (640) 32.7–21.0, (660) 38.6–23.3, (680) 43.9–26.0, (700) 48.1–28.6

Cell Data: *Space Group: Pmmn* (synthetic). $a = 3.9727(4)$ $b = 4.0020(5)$ $c = 6.1066(3)$ Z = 2

X-ray Powder Pattern: Good Hope Mine, Colorado, USA.
2.07 (100), 3.36 (60), 2.55 (40), 1.988 (40), 1.158 (30), 2.82 (20), 1.706 (20)

Chemistry:

	(1)	(2)
Cu	40.74	40.0
Te	59.21	60.9
Total	99.95	100.9

(1) Good Hope mine, Colorado, USA; corresponds to $Cu_{2.76}Te_{2.00}$. (2) Do.; by electron microprobe, corresponds to $Cu_{2.64}Te_{2.00}$.

Occurrence: A late-stage mineral of low-temperature hydrothermal origin in some Te-bearing mineral deposits.

Association: Vulcanite, tellurium, cameronite, petzite, sylvanite, berthierite, pyrite, arsenopyrite, bornite.

Distribution: In the USA, in Colorado, at the Good Hope mine, Vulcan, Gunnison Co. [TL]; also at the Empress Josephine mine, Bonanza district, Saguache Co., at Buckeye Gulch, Lake Co., and elsewhere; in Arizona, from the Junction and Campbell mines, Bisbee, and the Little Joe shaft, Tombstone, Cochise Co. In the Horne mine, Noranda, Quebec, Canada. From the San Miguel prospect, 10 km southwest of Moctezuma, Sonora, Mexico. At the Lomo Hierro silver deposit, western Cuba. From the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. In Japan, from the Teine mine, Hokkaido, and the Kawazu mine, Shizuoka Prefecture. From Kalgoorlie, Western Australia. In South Africa, at Ookiep, Namaqualand. From the Byn'govsk Au–Te deposit, Ural Mountains, and the Koshmansaisk deposits, Chatkal Ridge, in the basin of the Arbulak River, Russia. At Zlata Bana, Slanske vrchy Mountains, Czech Republic. Other occurrences are known.

Name: In honor of Thomas Arthur Rickard (1864–1953), mining engineer and Editor of the Engineering and Mining Journal, New York and London.

Type Material: National Museum of Natural History, Washington, D.C., USA, 114590.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 198–199. (2) Mizota, T., K. Koto, and N. Morimoto (1973) Crystallography and composition of synthetic rickardite. Mineral. J. (Japan), 7, 252–261. (3) Schutte, W.J. and J.L de Boer (1993) Determination of the incommensurately modulated structure of $Cu_{3-x}Te_2$. Acta Cryst., 49, 398–403. (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 416–417. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 480.

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Rickturnerite $Pb_7O_4[Mg(OH)_4](OH)Cl_3$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As mats, to 16 mm, of flattened fibrous crystals.

Physical Properties: *Cleavage*: Indistinct. *Fracture*: Splintery. *Tenacity*: Brittle.
Hardness = ~ 3 VHN = 140 (100 g load). D(meas.) = n.d. D(calc.) = 6.886

Optical Properties: Translucent. *Color*: Pale emerald green, gray in reflected light with abundant greenish gray internal reflections. *Streak*: White. *Luster*: Vitreous.
Optical Class: n.d. n = 1.38 [calculated]
R_1-R_2: (470) 14.9-15.7, (546) 13.8-14.4, (589) 13.6-14.2, (650) 13.4-14

Cell Data: *Space Group*: *Pnma*. a = 5.8034(5) b = 11.3574(9) c = 12.9393(16) Z = 8

X-ray Powder Pattern: Torr Works (Merehead) quarry, England.
6.474 (100), 3.233 (73), 2.867 (57), 5.636 (44), 3.112 (31), 2.635 (25), 4.287 (20)

Chemistry:

	(1)	(2)
PbO	87.70	90.31
MgO	1.79	2.33
CuO	0.14	
Cl	6.62	6.15
H_2O	[2.27]	2.60
$-O=Cl_2$	1.50	1.39
Total	97.02	100.00

(1) Torr Works (Merehead) quarry, England; electron microprobe analyses, H_2O calculated from structure analysis; corresponding to $Pb_{7.16}Mg_{0.81}Cu_{0.03}Cl_{3.40}H_{4.60}O_{8.60}\cdot 1.15H_2O$.
(2) $Pb_7O_4[Mg(OH)_4](OH)Cl_3$.

Occurrence: Part of an assemblage of lead oxychloride minerals that occur in cavities in manganese oxide pods in limestone.

Association: Mereheadite, cerussite, calcite, aragonite, mimetite, hydrocerussite, "plumbonacrite," manganite, pyrolusite, and an uncharacterized lead oxychloride.

Distribution: From the Torr Works (Merehead) quarry, near the village of Cranmore, England.

Name: Honors Rick Turner, geologist and mineral collector, who collected the first specimens.

Type Material: Natural History Museum, London, England (BM 2008,100).

References: (1) Rumsey, M.S., S.V. Krivovichev, O.I. Siidra, C.A. Kirk, C.J. Stanley, and J. Spratt (2012) Rickturnerite, $Pb_7O_4[Mg(OH)_4](OH)Cl_3$, a complex new lead oxychloride mineral. Mineral. Mag., 76(1), 59-73. (2) (2015) Amer. Mineral., 100, 661-662 (abs. ref. 1).

Riebeckite $Na_2[(Fe^{2+},Mg)_3Fe^{3+}_2]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 20 cm. Commonly fibrous, asbestiform; earthy, massive. *Twinning:* Simple or multiple twinning ∥ {100}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; partings on {100}, {010}. *Fracture:* [Conchoidal to uneven.] *Tenacity:* Brittle. Hardness = 6
D(meas.) = 3.28–3.44 D(calc.) = 3.380

Optical Properties: Semitransparent. *Color:* Black, dark blue; dark blue to yellow-green in thin section. *Luster:* Vitreous to silky.
Optical Class: Biaxial (+) or (–). *Pleochroism:* X = blue, indigo; Y = yellowish green, yellow-brown; Z = dark blue. *Orientation:* $Y = b$; $X \wedge c = -8°$ to $-7°$; $Z \wedge c = 6°$–$7°$. *Dispersion:* Strong. $\alpha = 1.656$–1.697 $\beta = 1.670$–1.708 $\gamma = 1.665$–1.740 2V(meas.) = 50°–90°.

Cell Data: *Space Group:* $C2/m$. $a = 9.822$ $b = 18.07$ $c = 5.334$ $\beta = 103.52°$ Z = 2

X-ray Powder Pattern: Doubrutscha [Dobrudja], Romania. (ICDD 19-1061).
8.40 (100), 3.12 (55), 2.726 (40), 2.801 (18), 4.51 (16), 2.176 (16), 3.27 (14)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	52.90	50.45	CaO	0.12	0.08
TiO_2	0.57	0.14	Li_2O		0.54
Al_2O_3	0.12	1.96	Na_2O	6.85	6.80
Fe_2O_3	17.20	17.52	K_2O	0.03	1.48
Cr_2O_3	0.04		F		2.58
FeO	17.95	17.90	H_2O^+		0.87
MnO	0.00	1.40	$-O = F_2$		1.09
MgO	2.96	0.05	Total	98.74	100.68

(1) Dales Gorge Iron Formation, Western Australia; by electron microprobe, corresponds to $(Na_{2.00}Ca_{0.02}K_{0.01})_{\Sigma=2.03}(Fe^{2+}_{2.26}Mg_{0.66}Ti_{0.06})_{\Sigma=2.98}Fe^{3+}_{1.95}(Si_{7.98}Al_{0.02})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Pikes Peak area, Colorado, USA; corresponds to $(Na_{2.02}K_{0.29}Ca_{0.01})_{\Sigma=2.32}(Fe^{2+}_{2.30}Li_{0.33}Mn_{0.18}Al_{0.10}Ti_{0.02}Mg_{0.01})_{\Sigma=2.94}Fe^{3+}_{2.02}(Si_{7.75}Al_{0.25})_{\Sigma=8.00}O_{22}[F_{1.25}(OH)_{0.89}]_{\Sigma=2.14}$.

Polymorphism & Series: Forms a series with magnesioriebeckite.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) \geq 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) \geq 0.7$; $(Na + K)_A < 0.5$; $Na_B \geq 1.34$.

Occurrence: In alkalic granites and syenites; rarer in felsic volcanics and granite pegmatites; in some schists. In iron formations as asbestiform "crocidolite."

Association: Aegirine, nepheline, albite, arfvedsonite (igneous); tremolite, ferro-actinolite (metamorphic); grunerite, magnetite, hematite, stilpnomelane, ankerite, siderite, calcite, "chalcedony," quartz (iron formations).

Distribution: Numerous localities. On Socotra Island, Indian Ocean. In South Africa, north from Koegas, Cape Province, and east of Pietersburg, Transvaal. Exceptional crystals from Sultan Hamud, Kenya. In the USA, at Quincy, Norfolk Co., Massachusetts; at St. Peters Dome, near Pikes Peak, El Paso Co., Colorado; from Washington Pass, Okanogan Co., Washington. In Canada, at the Red Wine complex, Labrador, Newfoundland; and at Mont Saint-Hilaire, Quebec. Around Chapare, Cochabamba, Bolivia. At Wittenoom and elsewhere in the Hamersley Ranges, Western Australia.

Name: To honor Emil Riebeck (1853–1885), German explorer.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 400. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 333–351. (3) Hawthorne, F.C. (1978) The crystal structure of the amphiboles. VIII. The crystal structure and site chemistry of fluor-riebeckite. Can. Mineral., 16, 187–194. (4) Miyano, T. and C. Klein (1983) Conditions of riebeckite formation in the Iron-formation of the Dales Gorge Member, Hamersley Group, Western Australia. Amer. Mineral., 68, 517–529. (5) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 237–241.

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Rilandite $(Cr^{3+}, Al)_6SiO_{11} \cdot 5H_2O(?)$

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Crystal Data: n.d. *Point Group:* n.d. Subhedral, angular and platy; compact, massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2–3
D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Translucent (?). *Color:* Dark brownish black. *Streak:* Grayish brown.
Luster: Brilliant on fresh surface, otherwise dull, pitchy.
Optical Class: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SiO_2	9.98	11.05
Al_2O_3	18.58	23.45
Fe_2O_3	4.38	
Cr_2O_3	47.59	48.93
MgO	1.18	
CaO	1.32	
H_2O	16.64	16.57
Total	99.67	100.00

(1) Rio Blanco Co., Colorado, USA. (2) $(Cr, Al)_6SiO_{11} \cdot 5H_2O$ with Cr:Al = 3.5:2.5.

Occurrence: On the outer surface and in shallow recesses of a petrified log in sandstone.

Association: Carnotite, organic matter.

Distribution: From the Riland uranium claim, about 21 km east-northeast of Meeker, Rio Blanco Co., Colorado, USA.

Name: For James L. Riland, newspaper publisher from Meeker, Colorado, USA, owner of the mining claims on which the mineral was discovered.

Type Material: National Museum of Natural History, Washington, D.C., USA, 96808.

References: (1) Henderson, E.P. and F.L. Hess (1933) Corvusite and rilandite, new minerals from the Utah-Colorado carnotite region. Amer. Mineral., 18, 195–205.

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Rimkorolgite $(Mg, Mn^{2+})_5(Ba, Sr)(PO_4)_4 \cdot 8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals are short prismatic, elongated along [010], pseudohexagonal, to 0.07 mm, showing {001}, {010}, {101}; may be fibrous, and in crusts.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = 3
D(meas.) = 2.67(2) D(calc.) = [2.62]

Optical Properties: Transparent to translucent. *Color:* Yellow-brown, light pink, flesh-red to reddish brown. *Streak:* White. *Luster:* Vitreous, silky in aggregates.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.552(2)$ $\beta = 1.552(2)$ $\gamma = 1.558(2)$ 2V(meas.) = 23(5)°

Cell Data: *Space Group:* $Pcmm$, $Pcm2_1$, or $Pc2m$. $a = 12.829(4)$ $b = 8.335(2)$ $c = 18.312(3)$ Z = 4

X-ray Powder Pattern: Zheleznyi iron mine, Russia.
10.51 (100), 3.081 (78), 2.969 (44), 3.054 (41), 3.520 (34), 2.839 (34), 3.874 (32)

Chemistry:

	(1)
P_2O_5	36.25
MnO	1.55
MgO	26.55
CaO	0.1
SrO	1.8
BaO	16.95
H_2O	17.5
Total	100.70

(1) Zheleznyi iron mine, Russia; by electron microprobe, average of two analyses, total Mn as MnO, H_2O by the Penfield method; corresponds to $(Mg_{5.05}Mn_{0.17})_{\Sigma=5.22}(Ba_{0.85}Sr_{0.13}Ca_{0.01})_{\Sigma=0.99}(P_{0.98}O_4)_4 \cdot 7.45H_2O$.

Occurrence: In cavities in dolomitic carbonatites cutting jacupirangite and forsterite-magnetite iron ores in a differentiated alkalic massif.

Association: Collinsite, bobierrite, carbonate-fluorapatite, strontiowhitlockite, pyrite.

Distribution: From the Zheleznyi iron mine, Kovdor massif, Kola Peninsula, Russia.

Name: Honoring Professor Ol'ga Mikhailonova Rimskaya-Korsakova [RIMskaya-KORsakova, OLGa] (1914–1987), mineralogist, St. Petersburg University, St. Petersburg, Russia, who researched the Kovdor massif.

Type Material: St. Petersburg University, St. Petersburg; Mining Institute, St. Petersburg, Russia, 2035/1.

References: (1) Britvin, S.N., Y.A. Pakhomovskii, A.N. Bogdanova, A.P. Khomyakov, and N.I. Krasnova (1995) Rimkorolgite $(Mg, Mn)_5(Ba, Sr, Ca)(PO_4)_4 \cdot 8H_2O$ – a new mineral from the Kovdor iron deposit, Kola Peninsula. Zap. Vses. Mineral. Obshch., 124(1), 90–95 (in Russian). (2) (1996) Amer. Mineral., 81, 517–518 (abs. ref. 1).

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Ringwoodite $(Mg, Fe^{2+})_2SiO_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. As rounded grains, to 100 μm, or massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.90

Optical Properties: Semitransparent. *Color:* Purple, bluish to smoky gray, colorless. *Optical Class:* Isotropic. $n = 1.768(3)$

Cell Data: *Space Group: Ia3d.* $a = 8.113$–8.127 Z = 8

X-ray Powder Pattern: Tenham meteorite.
2.447 (100), 1.434 (60), 2.028 (40), 2.872 (20), 1.560 (20), 1.0559 (10), 0.8283 (10)

Chemistry:

	(1)	(2)
SiO_2	38.9	38.42
TiO_2		0.05
FeO	23.4	22.98
MnO		0.30
MgO	37.0	37.86
CaO		0.05
Total	99.3	[99.66]

(1) Tenham meteorite; by electron microprobe, corresponding to $(Mg_{1.48}Fe^{2+}_{0.52})_{\Sigma=2.00}SiO_4$.
(2) Pampa del Infierno meteorite; by electron microprobe, Al_2O_3, Cr_2O_3, NiO, Na_2O, K_2O all $< 0.01\%$, original total given as 99.64%; corresponds to $(Mg_{1.48}Fe^{2+}_{0.52})_{\Sigma=2.00}SiO_4$.

Polymorphism & Series: Trimorphous with forsterite and wadsleyite.

Occurrence: In veinlets cutting the matrix of meteorites and replacing olivine; probably produced during shock metamorphism.

Association: Majorite, magnesian silicate glass.

Distribution: In the Tenham, Pampa del Infierno, Catherwood, and Coorara chondrite meteorites.

Name: For Professor Alfred Edward Ringwood (1930–1993), noted geochemist of the Australian National University, Canberra, Australia.

Type Material: The Natural History Museum, London, England, 1935,792.

References: (1) Binns, R.A., R.J. Davis, and S.J.B. Reed (1969) Ringwoodite, natural $(Mg, Fe)_2SiO_4$ spinel in the Tenham meteorite. Nature, 221, 943–944. (2) (1969) Amer. Mineral., 54, 1219 (abs. ref. 1). (3) Coleman, L.C. (1977) Ringwoodite and majorite in the Catherwood meteorite. Can. Mineral., 15, 97–101. (4) Boctor, N.Z., P.M. Bell, and H.K. Mao (1982) Petrology and shock metamorphism of Pampa del Infierno chondrite. Geochim. Cosmochim. Acta, 46, 1903–1911.

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Rinkite $(Ca, Ce)_4Na(Na, Ca)_2Ti(Si_2O_7)_2F_2(O, F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Crystals prismatic along [001] and flattened on {100}, with {*hk*0} faces strongly striated, to 10 cm; massive. *Twinning:* Lamellar, polysynthetic on {100}.

Physical Properties: *Cleavage:* Distinct on {100}. *Fracture:* Uneven, conchoidal. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 3.18–3.44 D(calc.) = 3.36 Green cathodoluminescence.

Optical Properties: Opaque, translucent in thin fragments. *Color:* Reddish brown; alters to dull greenish or yellowish brown; bright red in transmitted light. *Streak:* Pale yellow, grayish brown, white. *Luster:* Vitreous on fractures, resinous to greasy on cleavages. *Optical Class:* Biaxial (+). *Pleochroism:* Slight, in yellow tints. *Orientation:* $X \wedge c = 3°$. *Absorption:* $Z > Y > X$. α = 1.643–1.662 β = 1.645–1.667 γ = 1.651–1.681 2V(meas.) = 43°–87°

Cell Data: *Space Group:* $P2_1/c$ or $P2_1$. $a = 5.679(3)$ $b = 7.412(3)$ $c = 18.835(6)$ $\beta = 101.26(3)°$ Z = 2

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
3.071 (100), 2.702 (70), 2.945 (40), 2.798 (40), 1.853 (30), 3.581 (25), 2.024 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	30.71	29.08	MnO	0.45	
TiO_2	5.33	13.36	MgO	0.63	
ZrO_2	7.43		CaO	22.53	23.26
ThO_2	0.34		Na_2O	2.44	8.98
Y_2O_3	3.52	0.92	K_2O	0.38	
ΣLa_2O_3	10.45		F	2.06	5.82
Ce_2O_3	6.04	21.25	H_2O^+	7.70	
Fe_2O_3	0.56	0.44	$-O = F_2$	0.86	2.45
			Total	99.71	100.66

(1) Langesundsfjord, Norway. (2) Julianehåb district, Greenland. (3) Khibiny massif, Kola Peninsula, USSR; by electron microprobe, analysis not given but stated to correspond to $(Ca_{3.7}Na_{2.4}Ce_{0.32}Nd_{0.19}La_{0.10}Y_{0.09}Pr_{0.05}Sm_{0.05}Sr_{0.15})_{\Sigma=7.05}(Ti_{0.92}Nb_{0.06}Zr_{0.03})_{\Sigma=1.01}$ $Si_{3.85}O_{14}F_{2.55}O_{1.3}$.

Occurrence: Characteristic of some nepheline syenites and related pegmatites.

Association: Arfvedsonite, aegirine, eudialyte, steenstrupine, leucophanite, wöhlerite, rosenbuschite, sodalite.

Distribution: From the Kangerdluarssuk Plateau, in the Ilímaussaq intrusion, southern Greenland. On the Islands of Låven and Stokkø, and at Barkevik, Langesundsfjord, Norway. In the Khibiny and Lovozero massifs, Kola Peninsula, Russia. At the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. From Mont Saint-Hilaire and near Saint-Amable, Quebec, and in the Red Wine complex, Labrador, Newfoundland, Canada.

Name: For Dr. H. Rink, at one time Director of Danish-Greenland commerce.

Type Material: University of Copenhagen, Copenhagen, Denmark, 2,3.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 722 (rinkite), 721–722 (mosandrite), 720–721 (johnstrupite). (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 312–316. (3) Sahama, G. and K. Hytönen (1957) Unit cell of mosandrite [rinkite], johnstrupite and rinkite. Geol. Fören. Förhandl. Stockholm, 79, 791–796. (4) Galli, E. and A. Alberti (1971) The crystal structure of rinkite. Acta Cryst., 27, 1277–1284. (5) Rastsvetaeva, R.K., B.E. Borutskii, and A.V. Shlyukova (1992) Crystal structure of Hibbing [Khibiny] rinkite. Kristallografiya (Sov. Phys. Crystal.), 36, 632–636 (in Russian).

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Rinmanite $Zn_2Sb_2Mg_2Fe_4^{3+}O_{14}(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals very rare, showing $\{11\overline{2}0\}$ and $\{01\overline{1}2\}$; commonly granular, massive.

Physical Properties: *Cleavage:* $\{11\overline{2}0\}$, good. *Fracture:* Splintery or conchoidal. Hardness = 3 D(meas.) = 2.347 D(calc.) = [2.37] Astringent taste.

Optical Properties: Semitransparent. *Color:* Colorless, rose-red, violet, yellow, becoming brown on exposure; colorless to yellowish in transmitted light. *Luster:* Adamantine, commonly silky.
Optical Class: Uniaxial (+). $\omega = 1.5886$ $\epsilon = 1.5894$

Cell Data: *Space Group:* $R\overline{3}c$. $a = 11.98$ $c = 13.84$ Z = 6

X-ray Powder Pattern: Vesuvius, Italy. (ICDD 20-925).
2.509 (100), 6.0 (55), 2.593 (45), 5.75 (40), 2.811 (35), 2.653 (35), 3.46 (30)

Chemistry:

	(1)	(2)
Na	5.61	5.62
K	28.90	28.69
Fe	13.94	13.66
Cl	51.87	52.03
Br	0.04	
Total	100.36	100.00

(1) Wolkramshausen, Germany; average of two analyses. (2) $K_3NaFeCl_6$.

Occurrence: A secondary mineral in marine saline evaporite deposits; as a volcanic sublimate.

Association: Halite, sylvite, kieserite, carnallite, langbeinite, anhydrite.

Distribution: In Germany, in Lower Saxony, at Wolkramshausen, near Nordhausen; from mines around Diekholzen and Salzdetfurth, near Hildesheim; at Wathlingen-Hänigsen, near Celle; and other mines around Hamelyn and Hannover. On Vesuvius, Campania, Italy. From Aislaby, near Whitby, Yorkshire, England. In the Gaudark salt deposit, Gissar Mountains, Uzbekistan. In salt beds under the Kansk-Taseev depression, Siberia, Russia.

Name: To honor Friedrich Wilhelm Berthold Rinne (1863–1933), German crystallographer and petrographer, University of Kiel, Kiel, Germany.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 107–108. (2) Beattie, J.K. and C.J. Moore (1982) Crystal and molecular structures of rinneite, sodium tripotassium hexachloroferrate(II), and hexaamminecobalt(III) hexachloroferrate(III). Comparison of iron-chloride distances in hexachloroferrates(II) and -(III). Inorg. Chem., 21, 1292–1295.

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Rinneite $K_3NaFe^{2+}Cl_6$

Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Crystals very rare, showing $\{11\bar{2}0\}$ and $\{01\bar{1}2\}$; commonly granular, massive.

Physical Properties: *Cleavage:* $\{11\bar{2}0\}$, good. *Fracture:* Splintery or conchoidal. Hardness = 3 D(meas.) = 2.347 D(calc.) = [2.37] Astringent taste.

Optical Properties: Semitransparent. *Color:* Colorless, rose-red, violet, yellow, becoming brown on exposure; colorless to yellowish in transmitted light. *Luster:* Adamantine, commonly silky.
Optical Class: Uniaxial (+). $\omega = 1.5886$ $\epsilon = 1.5894$

Cell Data: *Space Group:* $R\bar{3}c$. a = 11.98 $c = 13.84$ Z = 6

X-ray Powder Pattern: Vesuvius, Italy. (ICDD 20-925).
2.509 (100), 6.0 (55), 2.593 (45), 5.75 (40), 2.811 (35), 2.653 (35), 3.46 (30)

Chemistry:

	(1)	(2)
Na	5.61	5.62
K	28.90	28.69
Fe	13.94	13.66
Cl	51.87	52.03
Br	0.04	
Total	100.36	100.00

(1) Wolkramshausen, Germany; average of two analyses. (2) $K_3NaFeCl_6$.

Occurrence: A secondary mineral in marine saline evaporite deposits; as a volcanic sublimate.

Association: Halite, sylvite, kieserite, carnallite, langbeinite, anhydrite.

Distribution: In Germany, in Lower Saxony, at Wolkramshausen, near Nordhausen; from mines around Diekholzen and Salzdetfurth, near Hildesheim; at Wathlingen-Hänigsen, near Celle; and other mines around Hamelyn and Hannover. On Vesuvius, Campania, Italy. From Aislaby, Eskdale, Yorkshire, England. In the Gaudark salt deposit, Gissar Mountains, Uzbekistan. In salt beds under the Kansk-Taseev depression, Siberia, Russia.

Name: To honor Friedrich Wilhelm Berthold Rinne (1863–1933), German crystallographer and petrographer, University of Kiel, Kiel, Germany.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 107–108. (2) Beattie, J.K. and C.J. Moore (1982) Crystal and molecular structures of rinneite, sodium tripotassium hexachloroferrate(II), and hexaamminecobalt(III) hexachloroferrate(III). Comparison of iron-chloride distances in hexachloroferrates(II) and -(III). Inorg. Chem., 21, 1292–1295.

Riomarinaite $Bi(OH)SO_4 \cdot H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As acicular crystals elongated on [001], to 60 μm, as hollow masses and botryoidal crusts to several millimeters; rarely as globular aggregates composed of tufts and spherulites.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 2-3 D(meas.) = n.d. D(calc.) = 4.80(3)

Optical Properties: Transparent. *Color*: Whitish-beige to light gray. *Streak*: White to light gray. *Luster*: Vitreous.
Optical Class: n.d.

Cell Data: *Space Group: P*$2_1/n$. a = 6.0118(3) b = 13.3355(6) c = 6.4854(4) Z = 4
(for synthetic $Bi(OH)SO_4 \cdot H_2O$)

X-ray Powder Pattern: Falcacci stope, Rio Marina iron mine, Elba, Tuscany, Italy.
4.2598 (100), 5.4530 (42), 3.3350 (42), 5.1152 (37), 3.1127 (36), 5.1926 (32), 2.9151 (22)

Chemistry:

	(1)
Bi_2O_3	68.86
SO_3	24.28
H_2O	6.86
Total	100.00

(1) Falcacci stope, Rio Marina iron mine, Elba, Tuscany, Italy; wet chemical analysis, H_2O by difference; corresponding to $Bi_{1.02}H_{2.64}S_{1.05}O_6$.

Occurrence: A weathering product from the decomposition of bismuthinite and cosalite.

Association: Bismoclite, bismutite, cannonite, anglesite, hydroniumjarosite, plumbojarosite.

Distribution: Falcacci stope, Rio Marina iron mine, east coast of Elba Island, Tuscany, Italy.

Name: For the mine that produced the first specimens.

Type Material: Bavarian State Collection for Mineralogy, Munich, Germany (MSM 27074).

References: (1) Rögner, P. (2005) Riomarinaite, a new bismuth mineral from Falcacci stope, Rio Marina, Elba (Italy). Der Aufschluss, 56, 53-60 (in German with English abstract).
(2) (2005) Amer. Mineral., 90, 1948 (abs. ref. 1).

Rittmannite

$(Mn^{2+}, Ca)Mn^{2+}(Fe^{2+}, Mn^{2+}, Mg)_2$
$(Al, Fe^{3+})_2(PO_4)_4(OH)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, flattened on {001}, pseudohexagonal, to 1 mm, in subparallel aggregates.

Physical Properties: *Cleavage:* On {001}, indistinct. Hardness = 3.5 D(meas.) = 2.81(1) D(calc.) = 2.83

Optical Properties: Transparent. *Color:* Very pale yellow to lemon-yellow, brownish yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 7°$. $\alpha = 1.622$ $\beta = [1.626]$ $\gamma = [1.654]$ 2V(meas.) = 43(2)°

Cell Data: *Space Group:* $[P2/a]$ (by analogy to the whiteite group). $a = 15.01(4)$ $b = 6.89(3)$ $c = 10.16(3)$ $\beta = 112.82(25)°$ Z = 2

X-ray Powder Pattern: Mangualde pegmatite, Portugal.
9.38 (s), 2.802 (s), 4.69 (ms), 5.66 (m), 4.93 (m), 4.85 (m), 3.530 (m)

Chemistry:

	(1)
P_2O_5	35.9
Al_2O_3	11.3
Fe_2O_3	2.6
FeO	10.4
MnO	18.9
MgO	1.5
CaO	3.3
H_2O	[19.7]
Total	[103.6]

(1) Mangualde pegmatite, Portugal; by electron microprobe, average of two analyses, Fe^{2+}:Fe^{3+} from stoichiometry, total Mn as MnO, H_2O calculated; corresponds to $(Mn_{0.54}Ca_{0.47})_{\Sigma=1.01}$ $Mn_{1.01}(Fe^{2+}_{1.15}Mn_{0.56}Mg_{0.29})_{\Sigma=2.00}(Al_{1.75}Fe^{3+}_{0.25})_{\Sigma=2.00}(PO_4)_4(OH)_{2.02} \cdot 8H_2O$.

Mineral Group: Whiteite group.

Occurrence: A very rare mineral in phosphatic nodules in zoned granite pegmatite veins (Mangualde pegmatite, Portugal).

Association: Kryzhanovskite, frondelite, huréaulite, orthoclase (Mangualde pegmatite, Portugal).

Distribution: From the Mangualde pegmatite, near Mesquitela, and the Bendada pegmatite, near Guarda, Portugal.

Name: To honor Professor Alfred Rittmann (1893–1980), German petrologist and volcanologist, University of Catania, Catania, Italy.

Type Material: Natural History Museum, Pisa, 4760/89; Civic Museum of Natural History, Milan, Italy.

References: (1) Marzoni Fecia di Cossato, Y., P. Orlandi, and G. Vezzalini (1989) Rittmannite, a new mineral species of the whiteite group from the Mangualde granitic pegmatite, Portugal. Can. Mineral., 27, 447–449. (2) (1990) Amer. Mineral., 75, 932–933 (abs. ref. 1).

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Rivadavite $Na_6Mg[B_6O_7(OH)_6]_4 \cdot 10H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, elongated along [010], and flattened on {100}, showing large {100} modified by $\{\bar{1}02\}$, {012}, $\{\bar{1}12\}$, to 3 mm, in subparallel massive aggregates.

Physical Properties: *Cleavage:* Perfect on {100}, $\{\bar{1}02\}$; poor on {010}. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 1.905(2) D(calc.) = 1.91 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless, white *Luster:* Vitreous, silky in aggregates.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = -32°$. *Dispersion:* $r > v$.
$\alpha = 1.470(1)$ $\beta = 1.481(1)$ $\gamma = 1.497(1)$ 2V(meas.) = 80°

Cell Data: *Space Group:* $P2_1/m$. $a = 15.870$ $b = 8.010$ $c = 22.256$ $\beta = 116°26'$ Z = 1

X-ray Powder Pattern: Tincalayu deposit, Argentina.
14.2 (100), 7.59 (100), 2.950 (65), 3.246 (64), 6.23 (51), 4.740 (51), 5.340 (49)

Chemistry:

	(1)	(2)
B_2O_3	58.2	57.30
FeO	0.05	
MgO	2.70	2.76
Na_2O	12.7	12.76
K_2O	0.03	
H_2O^+	25.3	
H_2O^-	1.4	
H_2O		27.18
Total	100.38	100.00

(1) Tincalayu deposit, Argentina; corresponds to $Na_{5.90}Mg_{0.94}[B_{6.01}O_7(OH)_6]_4 \cdot 10.7H_2O$.
(2) $Na_6Mg[B_6O_7(OH)_6]_4 \cdot 10H_2O$.

Occurrence: In sedimentary borate deposits; deposited from borate-rich hot springs.

Association: Borax, tincalconite (Tincalayu deposit, Argentina).

Distribution: From the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. In the USA, from the Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., California. At the Tülüovasıdeposit, Bigadiç borate district, Balıkesir Province, Turkey.

Name: In honor of Bernardino Rivadavia (1780–1845), first President of the Argentine Republic.

Type Material: Harvard University, Cambridge, Massachusetts, 109055; National Museum of Natural History, Washington, D.C., USA, 137290, 137295.

References: (1) Hurlbut, C.S., Jr. and L.F. Aristarain (1967) Rivadavite, $Na_6MgB_{24}O_{40} \cdot 22H_2O$, a new borate from Argentina. Amer. Mineral., 52, 326–335. (2) Dal Negro, A. and L. Ungaretti (1973) Crystal structure of rivadavite. Naturwiss., 69(7), 350.

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Riversideite $Ca_5Si_6O_{16}(OH)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Cross-veinlet fibrous, to 1 cm; massive.

Physical Properties: *Cleavage:* {001}, perfect; {100}, secondary. Hardness = Soft. D(meas.) = n.d. D(calc.) = 2.6–2.7

Optical Properties: Translucent to nearly opaque. *Color:* White. *Luster:* Silky. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* Observed. $\alpha = 1.600(2)$ $\beta = 1.601(2)$ $\gamma = 1.605(2)$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 11.3$ $b = 7.30$ $c = 18.0$ Z = 4

X-ray Powder Pattern: Crestmore, California, USA; from 9.3 Å product of dehydrated tobermorite.
3.03 (vs), 2.33 (s), 1.83 (s), 9.3 (m), 3.59 (m), 2.78 (m), 1.66 (m)

Chemistry:

	(1)	(2)
SiO_2	35.3	51.87
TiO_2	< 0.1	
Al_2O_3	1.3	
Fe_2O_3	0.4	
MgO	1.4	
CaO	48.2	40.35
H_2O^+	13.3	7.78
Total	[100.0]	100.00

(1) Crestmore, California, USA; recalculated to 100.0% after deduction of CaO in calcite and P_2O_5 and SO_4 in apatite. (2) $Ca_5Si_6O_{16}(OH)_2 \cdot 2H_2O$.

Occurrence: As intimate intergrowths with apatite, in veinlets cutting contact metamorphosed limestone (Crestmore, California, USA).

Association: Apatite, vesuvianite, diopside, calcite, wollastonite (Crestmore, California, USA).

Distribution: From Crestmore, Riverside Co., California, USA. At Ballycraigy, near Larne, Co. Antrim, Ireland. In the Hatrurim Formation, Israel.

Name: For the first-noted occurrence in Riverside Co., California, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 93416.

References: (1) Eakle, A.S. (1917) Minerals associated with the crystalline limestone at Crestmore, Riverside County, California. Bull. Dept. Geol. Univ. Calif., 10(19), 327–360. (2) Taylor, H.F.W. (1953) Crestmoreite and riversideite. Mineral. Mag., 30, 155–165. (3) McConnell, J.D.C. (1954) The hydrated calcium silicates riversideite, tobermorite, and plombierite. Mineral. Mag., 30, 293–305. (4) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 30–45. (5) Taylor, H.F.W. (1957) The dehydration of tobermorite. Clays and Clay Minerals, 6, 101–109. (6) Mamedov, K.S. and N.V. Belov (1958) Crystal structure of tobermorite (tobermorites). Doklady Acad. Nauk SSSR, 123, 163–165 (in Russian). (7) (1959) Chem. Abs., 53, 5030 (abs. ref. 6).

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Roaldite Fe_4N

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$ (synthetic Fe_4N is $\overline{4}3m$). As planar foils, to 2 μm thick but many mm long, forming bursts embedded in kamacite.

Physical Properties: *Tenacity:* Ductile. Hardness = n.d. VHN = 600–900 (estimated). D(meas.) = n.d. D(calc.) = 7.21 (synthetic).

Optical Properties: Opaque. *Color:* White in reflected light.
Optical Class: Isotropic.
R: n.d.

Cell Data: *Space Group:* $Pm3m$ (synthetic Fe_4N is $P\overline{4}3m$). $a = 3.79(4)$ $Z = 1$

X-ray Powder Pattern: Synthetic Fe_4N.
2.191 (100), 1.144 (85), 1.897 (75), 1.342 (65), 0.949 (45), 1.095 (40), 2.684 (20)

Chemistry:

	(1)	(2)
Fe	89.8	88.6
Co	n.d.	0.53
Ni	5.58	6.35
N	6.3	7.6
Total	101.68	103.08

(1) Jerslev meteorite; by electron microprobe, trace Co assumed; corresponds to $(Fe_{3.76}Ni_{0.22}Co_{0.02})_{\Sigma=4.00}N$. (2) Youndegin meteorite; by electron microprobe, corresponds to $(Fe_{3.72}Ni_{0.26}Co_{0.02})_{\Sigma=4.00}N$.

Occurrence: A rare accessory mineral in iron-nickel meteorites, probably formed by diffusion of nitrogen.

Association: Kamacite, cohenite, schreibersite, carlsbergite, daubreelite.

Distribution: In the Jerslev, Youndegin, and Canyon Diablo iron meteorites.

Name: Honors Roald Norbach Nielsen (1928–), Danish electron microprobe analyst, of the Department of Metallurgy, Danish Technical Institute, Lyngby, Denmark.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1977,540.

References: (1) Buchwald, V.F. and H.P. Nielsen (1981) Roaldite, a new nitride in iron meteorites. Lunar and Planetary Science, 12, 112–114. (2) (1981) Amer. Mineral., 66, 1100 (abs. ref. 1). (3) Dvoriankina, G.G. and Z.G. Pinsker (1958) An investigation of the structure of Fe_4N. Kristallografiya (Sov. Phys. Crystal.), 3, 439–444.

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Robertsite $Ca_2Mn_3^{3+}O_2(PO_4)_3 \cdot 3H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Platy to wedge-shaped, pseudorhombohedral to barrel-shaped crystals, to 5 mm, showing {100}, {001}, {031}; fibrous, in botryoidal to feathery aggregates. *Twinning:* By rotation $\perp$ {100}, common.

Physical Properties: *Cleavage:* On {100}, good. Hardness = 3.5 D(meas.) = 3.13–3.17 D(calc.) = 3.22

Optical Properties: Semitransparent. *Color:* Black, deep red, bronzy; dark reddish brown to deep blood-red in thin slivers. *Streak:* Chocolate-brown. *Luster:* Vitreous to resinous or waxy, silky in fibrous material.
Optical Class: Biaxial (–). *Pleochroism:* X = pale reddish pink; $Y = Z$ = deep reddish brown. *Orientation:* $X \simeq \perp$ {100}. *Absorption:* $Y = Z \gg X$. $\alpha = 1.775(5)$ $\beta = 1.82(1)$ $\gamma = 1.82(1)$ 2V(meas.) = $\sim 8°$

Cell Data: *Space Group:* $A2/a$. $a = 17.36(2)$ $b = 19.53(5)$ $c = 11.30(3)$ $\beta = 96.0°$ Z = 12

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
8.63(10), 2.749 (6), 5.61 (5), 1.623 (5), 3.27 (4), 2.590 (4), 2.876 (3)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	35.6	34.57	CaO	17.9	18.21
Fe_2O_3	0.9		H_2O	8.1	8.77
Mn_2O_3	38.1	38.45	Total	100.6	100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, total Fe as Fe_2O_3, total Mn as Mn_2O_3, H_2O by the Penfield method on a separate sample; corresponds to $Ca_{1.93}(Mn_{2.92}Fe_{0.07})_{\Sigma=2.99}O_{1.84}(PO_4)_{3.04} \cdot 2.72H_2O$. (2) $Ca_2Mn_3O_2(PO_4)_3 \cdot 3H_2O$.

Polymorphism & Series: Dimorphous with pararobertsite.

Occurrence: A late secondary mineral in complex zoned granite pegmatites; in a phosphate deposit in limestone, derived from bat guano.

Association: Rockbridgeite, ferrisicklerite, leucophosphite, jahnsite, montgomeryite, collinsite, huréaulite (Tip Top mine, South Dakota, USA); carbonate-fluorapatite, calcite, dolomite, quartz, clay minerals (Khoa Rang Kai, Thailand).

Distribution: In the USA, from the Tip Top mine, 8.5 km southwest of Custer, and the White Elephant mine, near Pringle, Custer Co., and the Gap Lode pegmatite, Pennington Co., South Dakota; in the White Picacho district, Yavapai Co., Arizona; at the Stewart mine, Pala, San Diego Co., California; in the Emmons quarry, Greenwood, Oxford Co., Maine. At Hagendorf, Bavaria, Germany. From Jebilet, Morocco. At the Rubicon pegmatite, south of Karibib, Namibia. In the Khoa Rang Kai phosphate deposit, near Chiang Mai, northwestern Thailand.

Name: To honor Professor Willard Lincoln Roberts (1923–1987), mineralogist, South Dakota School of Mines and Technology, Rapid City, South Dakota, USA, researcher of Black Hills minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 127151.

References: (1) Moore, P.B. and J. Ito (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. II. Redefinition of overite, an isotype of segelerite. III. Isotypy of robertsite, mitridatite, and arseniosiderite. Amer. Mineral., 59, 48–59. (2) Moore, P.B. and T. Araki (1977) Mitridatite, $Ca_6(H_2O)_6[Fe_9^{III}O_6(PO_4)_9] \cdot 3H_2O$. A noteworthy octahedral sheet structure. Inorg. Chem., 16, 1096–1106. (3) Roberts, A.C., B.D. Sturman, P.J. Dunn, and W.L. Roberts (1988) Pararobertsite, $Ca_2Mn_3^{3+}(PO_4)_3O_2 \cdot 3H_2O$, a new mineral species from the Tip Top pegmatite, Custer Co., South Dakota, and its relationship to robertsite. Can. Mineral., 27, 451–455. (4) Van Kauwenbergh, S.J., M. Cooper-Fleck, and M.R. Williams (1988) The occurrence of robertsite in a sedimentary phosphate ore from Thailand. Mineral. Mag., 52, 505–508.

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Robinsonite $Pb_4Sb_6S_{13}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are slender, prismatic and striated ‖ [001], to 5 mm; fibrous to compact, intergrown with other sulfosalts; massive.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = n.d. D(meas.) = 5.64–5.75 D(calc.) = 5.743

Optical Properties: Opaque. *Color:* Bluish lead-gray. *Luster:* Metallic. *Anisotropism:* Strong; in blue-gray, cream-white, and brown-gray. R_1–R_2: n.d.

Cell Data: *Space Group:* $I2/m$. $a = 23.642(4)$ $b = 3.9761(6)$ $c = 24.420(4)$ $\beta = 93.808(3)^\circ$ Z = 4

X-ray Powder Pattern: Red Bird mine, Nevada, USA.
3.39 (100), 4.04 (80), 3.92 (80), 3.03 (80), 2.75 (80), 2.67 (80), 3.79 (60)

Chemistry:

	(1)	(2)	(3)
Pb	42.6	41.76	41.94
Fe		0.01	
Cu		0.01	
Ag		0.01	
Sb	35.5	36.05	36.97
Bi		0.02	
S	20.9	21.36	21.09
Total	99.0	[99.22]	100.00

(1) Red Bird mine, Nevada, USA; by electron microprobe, corresponding to $Pb_{4.10}Sb_{5.82}S_{13.00}$. (2) Malé Železné deposit, Slovakia; by electron microprobe, average of six analyses, original total given as 99.23%; corresponding to $Pb_{3.93}Sb_{5.77}S_{13.00}$. [??saved this spot for the chem analysis in 2004 ref??] (3) $Pb_4Sb_6S_{13}$.

Occurrence: A primary hydrothermal mineral with other lead sulfosalts.

Association: Zinkenite, boulangerite, semseyite, plagionite, stibnite, sphalerite, galena, pyrite, quartz, calcite.

Distribution: In the USA, in Nevada, from the Red Bird mercury mine, about 37 road km east of Lovelock, Antelope district, Pershing Co. [TL], and in the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co.; at the Cleary prospect, Fairbanks district, Alaska. From Madoc, Ontario, and in the Dodger tungsten mine, Salmo, British Columbia, Canada. At Vall de Ribes, eastern Pyrenees, Spain. Large crystals from the Malé Železné and Däbrava deposits, Low Tatra Mountains, Slovakia. At the Rujevac Sb–Zn–Pb deposit, western Serbia. From Săsar, Hondol, Romania. In the Bwlch mine, Deganwy, Gwynedd, Wales. At the Pitone quarry, near Seravezza, Tuscany, Italy. Several additional localities are known.

Name: To honor Dr. Stephen Clive Robinson (1911–1981), Geological Survey of Canada, who first synthesized the mineral at Queen's University, Kingston, Ontario, Canada.

Type Material: Canadian Geological Survey, Ottawa, Canada, 12132; National Museum of Natural History, Washington, D.C., USA, 106568.

References: (1) Berry, L.G., J.J. Fahey, and E.H. Bailey (1952) Robinsonite, a new lead antimony sulfide. Amer. Mineral., 37, 438–446. (2) Jambor, J.L. and A.G. Plant (1975) The composition of the lead sulphantimonide, robinsonite. Can. Mineral., 13, 415–417. (3) Makovicky, E., T. Balic-Žunic, L. Karanovic, D. Poleti, and J. Pršek (2004) Structure refinement of natural robinsonite, $Pb_4Sb_6S_{13}$: cation distribution and modular description. Neues Jahrb. Mineral., Monatsh., 49–67.

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Rockbridgeite $(Fe^{2+},Mn^{2+})Fe_4^{3+}(PO_4)_3(OH)_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral crystals rare; typically fibrous, elongated along [001], compact radiating, to 3 cm, in crusts, botryoidal and drusy masses.

Physical Properties: *Cleavage:* {100}, excellent; {010}, good; {001}, fair. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4.5 D(meas.) = 3.45 D(calc.) = 3.60

Optical Properties: Semitransparent. *Color:* Dark green, olive-green, greenish black, black, commonly color-banded; may be bronze-brown, reddish brown when oxidized. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+). *Pleochroism:* X = pale brown to pale yellow-brown; Y = bluish green; Z = dark bluish green. *Dispersion:* $r < v$, rarely $r > v$, strong. *Absorption:* $Z > Y > X$. $\alpha = 1.873$–1.875 $\beta = 1.880$ $\gamma = 1.895$–1.897 2V(meas.) = Moderate.

Cell Data: *Space Group: Bbmm.* a = 13.783(12) $b = 16.805(9)$ $c = 5.172(4)$ Z = 4

X-ray Powder Pattern: Irish Creek, Rockbridge Co., Virginia, USA.
3.196 (10), 4.842 (5), 3.573 (5), 2.409 (5), 1.5890 (5), 6.87 (4), 4.630 (4)

Chemistry:

	(1)	(2)
P_2O_5	31.76	32.82
Al_2O_3	0.21	
Fe_2O_3	50.84	49.23
FeO	6.14	5.54
MnO	0.40	5.47
MgO	0.76	
CaO	1.12	
H_2O	8.53	6.94
insol.	0.12	
Total	99.88	100.00

(1) Rockbridge Co., Virginia, USA. (2) $(Fe^{2+},Mn^{2+})Fe_4^{3+}(PO_4)_3(OH)_5$ with Fe^{2+}:Mn^{2+} = 1:1.

Polymorphism & Series: Forms a series with frondelite.

Occurrence: In "limonite" iron ore deposits; an alteration product of primary phosphates in complex granite pegmatites.

Association: Triphylite, huréaulite, barbosalite, roscherite, "limonite".

Distribution: Widespread; may be locally abundant. In the USA, in Virginia, on South Mountain, southeast of Midvale, Rockbridge Co.; at the Palermo #1 and Fletcher mines, North Groton, Grafton Co., New Hampshire; in the Tip Top, Bull Moose, and other mines, near Custer, Custer Co., and at the Big Chief, Etta, and other mines, near Keystone, Pennington Co., South Dakota. From the Énio pegmatite mine, northeast of Galiléia, and near São Jose da Safira, Agua Boa, Minas Gerais, Brazil. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina. At Sabugal, Mangualde, Bendada, and Moreira, Portugal. From the La Vilate quarry, near Chanteloube, Haute-Vienne, France. In Germany, at Hagendorf, and on the Kreuzberg, Pleystein, Bavaria; and from Ullersreuth, Saxony. In the Moculta phosphate quarry, northeast of Angaston, South Australia. From the Sandamap pegmatite, west of Usakos, Namibia. In the Pearl mine, Miami, Zimbabwe. At Tazenakht, Morocco.

Name: For the occurrence in Rockbridge Co., Virginia, USA, taken as the type locality.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 80600.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 867–869. (2) Moore, P.B. (1970) Crystal chemistry of the basic iron phosphates. Amer. Mineral., 55, 135–169.

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Rodalquilarite $H_3Fe_2^{3+}(Te^{4+}O_3)_4Cl$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Stout crystals, to 2.5 cm; commonly in crusts.

Physical Properties: *Cleavage:* One, good. *Tenacity:* Very brittle. Hardness = 2–3
D(meas.) = 4.97–5.15 D(calc.) = 5.08–5.14

Optical Properties: Semitransparent. *Color:* Grass-green, emerald-green, oil-green, pistachio-green, yellow-green; green in transmitted light. *Streak:* Greenish yellow.
Luster: Greasy.
Optical Class: Biaxial (–). $n = \sim 2.2$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = 38(5)°

Cell Data: *Space Group:* $P\overline{1}$. a = 8.89–9.00 b = 5.08–5.10 c = 6.63–6.64
$\alpha = 103°10'–103°22'$ $\beta = 106°38'–107°05'$ $\gamma = 77°52'–78°4'$ Z = 1

X-ray Powder Pattern: Rodalquilar, Spain.
4.24 (FFF), 2.62 (FF), 3.31 (F), 2.17 (F), 2.85 (mF), 2.97 (m), 1.873 (mf)

Chemistry:

	(1)	(2)	(3)
TeO_2	72.85	73.36	74.88
Fe_2O_3	18.45	18.59	18.73
Cl	4.80	3.98	4.16
H_2O	4.50	3.34	3.17
insol.	0.35		
$-O = Cl_2$	1.08	0.90	0.94
Total	99.87	98.37	100.00

(1) Rodalquilar, Spain; by microanalysis, corresponds to $H_{3.07}Fe_{2.00}(TeO_3)_{3.95}Cl_{1.17} \bullet 1.25H_2O$.
(2) Tombstone, Arizona, USA; by microanalysis. (3) $H_3Fe_2(TeO_3)_4Cl$.

Occurrence: A rare secondary mineral formed in the zone of oxidation of tellurium-bearing precious metal deposits.

Association: Emmonsite, gold, alunite, jarosite, quartz (Rodalquilar, Spain); tellurium, mackayite, emmonsite (near El Indio, Chile); emmonsite, sonoraite (Joe mine, Arizona, USA).

Distribution: From the Rodalquilar gold deposit, Almería Province, Spain. In the Wendy open pit, El Indio-Tambo district, east of La Serena, Coquimbo, Chile. At the Joe and Grand Central mines, Tombstone, Cochise Co., Arizona, USA.

Name: For its first-noted occurrence at Rodalquilar, Spain.

Type Material: Natural History Museum, Paris; National School of Mines, Paris, France.

References: (1) Sierra Lopez, J., G. Leal, R. Perriot, Y. Laurent, J. Protas, and Y. Dusausoy (1968) La rodalquilarite, chlorotellurite de fer, une nouvelle espèce minérale. Bull. Minéral., 91, 28–33 (in French with English abs.). (2) (1968) Amer. Mineral., 53, 2104–2105 (abs. ref. 1). (3) Dusausoy, Y. and J. Protas (1969) Determination et etude de la structure cristalline de la rodalquilarite, chlorotellurite acide de fer. Acta Cryst., 25, 1551–1558 (in French with English abs.). (4) Williams, S.A. (1980) The Tombstone District, Cochise County, Arizona. Mineral. Record, 11, 251–257.

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Rodolicoite $Fe^{3+}PO_4$

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Crystal Data: Hexagonal. *Point Group:* 32. In microcrystalline nodules, intimately mixed with grattarolaite, as crystallites to < 1000 Å.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.04

Optical Properties: Opaque. *Color:* Reddish brown. *Streak:* Brown. *Luster:* Greasy. *Optical Class:* Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P3_121$ (synthetic). $a = 5.048(3)$ $c = 11.215(8)$ Z = 3

X-ray Powder Pattern: Synthetic.
3.445 (100), 4.360 (19), 2.362 (14), 1.8846 (12), 2.180 (10), 1.4214 (10)

Chemistry: (1) Due to the tiny particle sizes (average about 260 Å) only bulk composition of the mixture could be determined; this is compatible with a composition of $Fe_{1.04}P_{0.96}O_{4.00}$; the identity of the mineral rests also on its X-ray powder pattern compared to synthetic material.

Occurrence: Very rare, in microcrystalline nodules in lignite beds which appear to have naturally burned.

Association: Grattarolaite, heterosite.

Distribution: From the Castelnuovo mine, Santa Barbara lignite district, 30 km southeast of Florence, Florence, Italy.

Name: Honoring Francesco Rodolico (1905–1988), Professor of Mineralogy, Florence University, Florence, Italy.

Type Material: Museum of Natural History, Florence University, Florence, Italy, 2087/RI.

References: (1) Cipriani, C., M. Mellini, G. Pratesi, and C. Viti (1997) Rodolicoite and grattarolaite, two new phosphate minerals from Santa Barbara mine, Italy. Eur. J. Mineral., 9, 1101–1106. (2) (1998) Amer. Mineral., 83, 654 (abs. ref. 1). (3) Arnold, H. (1986) Crystal structure of $FePO_4$ at 294 and 20 K. Zeits. Krist., 177, 139–142.

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Roeblingite $Pb_2Ca_6Mn^{2+}Si_6O_{18}(SO_4)_2(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As dense, compact masses of tiny lathlike crystals, which may be in parallel growth; as platy aggregates.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = < 3 D(meas.) = 3.433 D(calc.) = [3.44]

Optical Properties: Translucent. *Color:* White to pale pink; colorless in thin section. *Luster:* Dull to somewhat resinous.
Optical Class: Biaxial (+). *Dispersion:* $r < v$, slight. $\alpha = 1.654(1)$ $\beta = 1.660(1)$ $\gamma = 1.678(1)$ 2V(meas.) = 61(2)° 2V(calc.) = 61°

Cell Data: *Space Group:* $C2/m$. $a = 13.208(4)$ $b = 8.287(2)$ $c = 13.089(9)$ $\beta = 106.65(6)°$ Z = 2

X-ray Powder Pattern: Långban, Sweden. (ICDD 16-411).
3.15 (100), 4.20 (80), 3.04 (55), 2.102 (40), 6.47 (35), 6.29 (35), 2.947 (35)

Chemistry:

	(1)	(2)	(3)	(4)
SiO_2	23.58	23.57	24.6	24.62
MnO	2.48	2.49	4.4	4.84
PbO	31.03	30.04	30.7	30.48
CaO	25.95	23.12	22.6	22.98
SrO	1.40	2.79	0.7	
Na_2O	0.40			
K_2O	0.13			
H_2O^+	6.35	6.15	[6.13]	6.15
H_2O^-		0.45		
CO_2		0.61		
SO_2	9.0			
SO_3		10.81	10.6	10.93
Total	100.32	100.03	99.73	100.00

(1–2) Franklin, New Jersey, USA. (3) Långban, Sweden; by electron microprobe, H_2O calculated from stoichiometry. (4) $Pb_2Ca_6MnSi_6O_{18}(SO_4)_2(OH)_2 \cdot 4H_2O$.

Occurrence: As nodular masses in calcium silicate lenses containing abundant garnet (Franklin, New Jersey, USA); as fracture fillings in a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Garnet, titanite, zircon, phlogopite, axinite, willemite, datolite, barite, calcite, arsenopyrite, sphalerite, rhodonite, rhodochrosite.

Distribution: From Franklin, Sussex Co., New Jersey, USA. At Långban, Värmland, Sweden.

Name: For Colonel Washington Augustus Roebling (1837–1926), of Trenton, New Jersey, USA, distinguished American civil engineer, mineral collector, and benefactor of American geological sciences.

Type Material: National Museum of Natural History, Washington, D.C., USA, R8824, 124351; The Natural History Museum, London, England, 1925,69.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 60.
(2) Blix, R. (1931) The chemical composition of roeblingite. Amer. Mineral., 16, 455–469.
(3) Moore, P.B. and J. Shen (1984) Roeblingite, $Pb_2Ca_6(SO_4)_2(OH)_2(H_2O)_4[Mn(Si_3O_9)_2]$: its crystal structure and comments on the lone pair effect. Amer. Mineral., 69, 1173–1179.
(4) Dunn, P.J. (1985) The lead silicates from Franklin, New Jersey: occurrence and composition. Mineral. Mag., 49, 721–727. (5) Braithwaite, R.S.W. (1985) Roeblingite: a revised formula from infra-red and thermal analysis data. Mineral. Mag., 49, 756–758.

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Roedderite $(Na,K)_2(Mg,Fe^{2+})_5Si_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Platy to short prismatic hexagonal crystals, exhibiting dominant $\{10\bar{1}0\}$ and $\{0001\}$ with $\{11\bar{2}0\}$, $\{10\bar{1}2\}$, and $\{10\bar{1}4\}$, to 2 mm.

Physical Properties: Hardness = n.d. D(meas.) = ~2.6 D(calc.) = 2.63

Optical Properties: Transparent to translucent. *Color:* Colorless, yellowish to reddish brown. *Luster:* Vitreous.
Optical Class: Uniaxial (+) to slightly biaxial. ω = 1.537–1.543 ϵ = 1.536–1.547
2V(meas.) = 2°–5°

Cell Data: *Space Group:* $P\bar{6}2c$. a = 10.139(3) c = 14.269(4) Z = 2

X-ray Powder Pattern: Indarch meteorite; essentially identical with eifelite.
3.570 (100), 3.239 (77), 2.922 (67), 3.747 (66), 7.15 (64), 2.772 (44), 5.540 (36)

Chemistry:

	(1)	(2)
SiO_2	71.32	71.0
TiO_2	0.07	
Al_2O_3	0.36	0.4
FeO	0.49	2.0
MnO	0.31	
MgO	17.86	19.5
K_2O	4.16	3.3
Na_2O	5.29	4.0
Total	99.86	100.2

(1) Bellerberg volcano, Germany; by electron microprobe, corresponds to $(Na_{1.72}K_{0.89})_{\Sigma=2.61}(Mg_{4.48}Fe_{0.07}Al_{0.06}Mn_{0.04}Ti_{0.01})_{\Sigma=4.66}(Si_{11.99}Al_{0.01})_{\Sigma=12.00}O_{30}$. (2) Indarch meteorite; by electron microprobe, average of six analyses; corresponds to $(Na_{1.30}K_{0.69})_{\Sigma=1.99}(Mg_{4.86}Fe_{0.27})_{\Sigma=5.13}(Si_{11.88}Al_{0.07})_{\Sigma=11.95}O_{30}$.

Polymorphism & Series: Forms a series with eifelite.

Mineral Group: Milarite group.

Occurrence: In vesicles in contact metamorphosed basement gneiss xenoliths in leucite tephrite (Bellerberg volcano, Germany); an accessory mineral in an enstatite chondrite (Indarch meteorite).

Association: Hematite, tridymite, sanidine, spinel, pyroxene, quartz, sillimanite (Bellerberg volcano, Germany); enstatite, clinoenstatite, troilite, nickel-iron, schreibersite, plagioclase, carbon, tridymite, oldhamite, glass (Indarch meteorite).

Distribution: In the Indarch, Witchita County, and Canyon Diablo meteorites. From the Bellerberg volcano, two km north of Mayen, Eifel district, Germany.

Name: For Dr. Edwin Woods Roedder (1919–), mineralogist, U.S. Geological Survey, who noted the synthetic compound.

Type Material: n.d.

References: (1) Fuchs, L.H., C. Frondel, and C. Klein, Jr. (1966) Roedderite, a new mineral from the Indarch meteorite. Amer. Mineral., 51, 949–955. (2) Hentschel, G., K. Abraham, and W. Schreyer (1980) First terrestrial occurrence of roedderite in volcanic ejecta of the Eifel, Germany. Contr. Mineral. Petrol., 73, 127–130. (3) Abraham, K., W. Gebert, O. Medenbach, W. Schreyer, and G. Hentschel (1983) Eifelite, $KNa_3Mg_4Si_{12}O_{30}$, a new mineral of the osumilite group with octahedral sodium. Contr. Mineral. Petrol., 82, 252–258. (4) Armbruster, T. (1989) Crystal chemistry of double-ring silicates: structure of roedderite at 100 and 300 K. Eur. J. Mineral., 1, 715–718.

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Roggianite $Ca_2BeAl_2Si_4O_{13}(OH)_2 \cdot 2.5H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals prismatic, to 50 μm; in fibrous aggregates.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = n.d. D(meas.) = 2.02 D(calc.) = [2.34]

Optical Properties: Semitransparent. *Color:* Pale yellow.
Optical Class: Uniaxial (+). $\omega = 1.527(1)$ $\epsilon = 1.535(1)$

Cell Data: *Space Group:* $I4/mcm$. $a = 18.33(2)$ $c = 9.16(1)$ Z = 8

X-ray Powder Pattern: Alpe Rosso, Italy.
12.990 (100), 3.411 (68), 9.230 (49), 3.154 (43), 6.150 (42), 3.605 (41), 3.198 (34)

Chemistry:

	(1)	(2)
SiO_2	40.22	44.30
Al_2O_3	18.32	18.80
BeO	3.19	4.61
CaO	19.24	20.67
SrO	0.02	
Na_2O	0.28	
K_2O	0.63	
H_2O	[18.10]	11.62
Total	[100.00]	100.00

(1) Alpe Rosso, Italy; by electron microprobe, H_2O by difference.
(2) $Ca_2BeAl_2Si_4O_{13}(OH)_2 \cdot 2.5H_2O$.

Occurrence: Coating fractures in a sodic feldspar dike which cuts gneiss (Alpe Rosso, Italy).

Association: Thomsonite (Alpe Rosso, Italy); bertrandite, chrysoberyl, scheelite, molybdenite (Pizzo Marcio, Italy).

Distribution: At Alpe Rosso and Pizzo Marcio, Val Vigezzo, Piedmont, Italy.

Name: For Aldo G. Roggiani, Italian teacher of natural sciences, who first found the mineral.

Type Material: University of Modena, Modena, Italy; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 122280.

References: (1) Passaglia, E. (1969) Roggianite, a new silicate mineral. Clay Minerals, 8, 107–111. (2) Gard, J.A. (1969) An electron microscope and diffraction study of roggianite. Clay Minerals, 8, 112–113. (3) (1970) Amer. Mineral., 55, 322–323 (abs. refs. 1 and 2). (4) Passaglia, E. and G. Vezzalini (1988) Roggianite: revised chemical formula and zeolitic properties. Mineral. Mag., 52, 201–206. (5) Giuseppetti, G., F. Mazzi, C. Tadini, and E. Galli (1991) The revised crystal structure of roggianite: $Ca_2[Be(OH)_2Al_2Si_4O_{13}] < 2.5H_2O$. Neues Jahrb. Mineral., Monatsh., 307–314.

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Rohaite $TlCu_5SbS_2$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* 222, $mm2$, or $2/m\ 2/m\ 2/m$. Rarely as euhedral and subhedral crystals, to 0.5 mm; in patchy aggregates.

Physical Properties: *Tenacity:* Malleable. Hardness = n.d. VHN = 94 (25 g load). D(meas.) = n.d. D(calc.) = 7.752

Optical Properties: Opaque. *Color:* In reflected light, yellowish cream to dull bluish gray. *Luster:* Metallic. *Pleochroism:* Distinct to strong. *Anisotropism:* Very strong, from yellowish cream to black, with dark red-purple colors present near extinction.
R_1–R_2: (400) — , (420) 31.6–36.4, (440) 30.7–36.6, (460) 30.0–36.7, (480) 29.2–36.5, (500) 28.4–36.1, (520) 27.9–36.0, (540) 27.0–35.4, (560) 26.6–35.2, (580) 26.5–35.0, (600) 26.3–34.6, (620) 26.1–34.4, (640) 25.6–34.0, (660) 25.4–33.9, (680) 24.8–33.7, (700) 24.4–33.7

Cell Data: *Space Group:* $P222$, $Pmm2$, or $Pmmm$. $a = 7.602(2)$ $b = 3.801(2)$ $c = 20.986(8)$ $Z = 2$

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
3.078 (100), 2.393 (100), 3.800 (90), 1.902 (90), 2.623 (50), 2.605 (50), 2.577 (50)

Chemistry:

	(1)	(2)	(3)
Tl	26.6	27.7	28.87
Cu	18.6	17.8	17.20
Pb	2.0	1.6	
Fe	0.3	0.3	
Sb	41.0	43.5	44.87
S	9.3	9.6	9.06
Total	97.8	100.5	100.00

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, average of seven grains; corresponding to $Tl_{0.97}(Cu_{4.79}Fe_{0.07})_{\Sigma=4.86}Pb_{0.04}Sb_{1.13}S_{2.15}$. (2) Do.; by electron microprobe, average of eightgrains, corresponding to $Tl_{0.97}(Cu_{4.89}Fe_{0.06})_{\Sigma=4.95}Pb_{0.04}Sb_{1.05}S_{2.14}$.
(3) $TlCu_5SbS_2$.

Occurrence: In veins cutting an alkalic intrusive.

Association: Chalcocite, löllingite, cuprite, antimonian silver, analcime, sodalite.

Distribution: From the Ilímaussaq intrusion, southern Greenland [TL].

Name: In honor of Professor John ROse-HAnsen (1937–), Danish mineralogist, University of Copenhagen, Denmark.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1979,1211.

References: (1) Karup-Møller, S. (1978) Primary and secondary ore minerals associated with cuprostibite. Bull. Grønlands Geol. Undersøgelse, 126, 23–45. (2) (1980) Amer. Mineral., 65, 208–209 (abs. ref. 1). (3) Makovicky, E., Z. Johan, and S. Karup-Møeller (1980) New data on bukovite, thalcusite, chalcothallite and rohaite. Neues Jahrb. Mineral., Abh., 138, 122-146.
(4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 481.

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Rokühnite $Fe^{2+}Cl_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. Rarely in thin plates, dominated by {110}, with a number of other forms, to 300 μm; the plates are commonly composed of fibers. *Twinning:* On $\{\overline{2}01\}$, contact twins.

Physical Properties: *Cleavage:* Very good on {110}; good on {010}. *Tenacity:* Fibers are quite flexible. Hardness = n.d. D(meas.) = 2.35 D(calc.) = 2.35 Soluble in H_2O, hydrating topotactically and oxidizing rapidly on exposure to air.

Optical Properties: Semitransparent. *Color:* Light green, turning brown on oxidation; colorless in transmitted light.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = -49°$. *Dispersion:* $r \leq v$.
$\alpha = 1.605(2)$ $\beta = 1.633(1)$ $\gamma = 1.703(2)$ 2V(meas.) = 64(2)°

Cell Data: *Space Group:* $C2/m$, $C2$, or Cm. $a = 7.396(1)$ $b = 8.458(2)$ $c = 3.638(1)$ $\beta = 97.68(2)°$ Z = 2

X-ray Powder Pattern: Germany.
5.536 (100), 2.762 (74), 4.228 (62), 2.415 (55), 2.892 (54), 2.744 (30), 2.096 (30)

Chemistry:

	(1)	(2)
FeO	22.46	20.23
MgO	2.94	3.39
CaO	0.11	
Na_2O	13.89	14.56
K_2O	7.89	6.61
Cl	50.05	47.55
H_2O	14.58	17.25
$-O = Cl_2$	11.29	10.73
insol. HNO_3	0.06	0.04
Total	100.69	98.90

(1) Germany; analysis of a mixture, interpreted as: carnallite 8.89%, rinneite 18.47%, halite 23.55%, tachyhydrite 1.02%, and rokühnite 48.14%, of composition $(Fe_{0.88}Mg_{0.12})_{\Sigma=1.00}Cl_2 \cdot 1.95H_2O$. (2) Do.; carnallite 18.76%, rinneite 9.93%, halite 26.04%, and rokühnite 44.17%, of composition $(Fe_{0.94}Mg_{0.06})_{\Sigma=1.00}Cl_{1.98} \cdot 2.02H_2O$.

Occurrence: A secondary mineral in fissures in earlier potassium-rich salt beds.

Association: Carnallite, rinneite, halite, tachyhydrite, sylvite, langbeinite.

Distribution: In the Salzdetfurth potash mine, Hamelyn, and the Siegfried-Giesen and Hope potash mines, Sarstedt, Zechstein basin, south of Hannover, Lower Saxony, Germany.

Name: To honor Professor Dr. Robert Kühn (1911–), German mineralogist, Kaliforschungs-Institut der Kali und Salz AG, Hannover, Germany.

Type Material: Mineralogical Institute, University of Hannover, Hannover; Institute for Sedimentology, University of Heidelberg, Heidelberg, Germany.

References: (1) von Hodenberg, R. and G. von Struensee (1980) Rokühnite, $FeCl_2 \cdot 2H_2O$, a new mineral. Neues Jahrb. Mineral., Monatsh., 125–130. (2) (1981) Amer. Mineral., 66, 219 (abs. ref. 1). (3) von Hodenberg, R. and G. von Struensee (1980) Rokühnite – ein Sekundärmineral im hannoverschen Zechstein. Kali und Steinsalz, 8, 81–91 (in German with English abs.). (4) (1982) Mineral. Abs., 33, 430 (abs. ref. 3).

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Rollandite $Cu_3(AsO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Microcrystalline, to < 5 μm; in thin botryoidal crusts, and replacing emplectite crystals.

Physical Properties: *Fracture:* Conchoidal to irregular. *Tenacity:* Brittle. Hardness = 4–4.5 VHN = 513 (25 g load). D(meas.) = 6.86–7.01 D(calc.) = 7.21

Optical Properties: Semitransparent. *Color:* White to pale gray, pale green, yellow. *Luster:* Adamantine.
Optical Class: Biaxial (+). $\alpha = 2.09(4)$ $\beta =$ n.d. $\gamma = 2.27(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 6.879(1)$ $b = 7.159(1)$ $c = 6.732(1)$ $\beta = 104.84(1)^\circ$ Z = 4

X-ray Powder Pattern: Argentina.
3.15 (100), 2.97 (80), 3.33 (61), 2.98 (37), 4.82 (36), 2.70 (36), 2.50 (26)

Chemistry:

	(1)	(2)	(3)
As_2O_5	33.2	33.0	33.03
Bi_2O_3	67.2	67.9	66.97
Total	100.4	100.9	100.00

(1) Santiaguillo, Bolivia. (2) San Francisco de los Andes, Argentina; by electron microprobe. (3) $BiAsO_4$.

Polymorphism & Series: Dimorphous with tetrarooseveltite.

Mineral Group: Monazite group.

Occurrence: Vey rare in cassiterite veinlets in rhyolite-dacite lava flows (Santiaguillo, Bolivia); in the oxidized zone of a breccia pipe (San Francisco de los Andes, Argentina).

Association: Cassiterite (Santiaguillo, Bolivia); preisingerite, bismutite, mixite, zavaritskite, wulfenite (Moldava, Czech Republic); conichalcite, mixite (Uzbekistan).

Distribution: At Santiaguillo, west of Maragua, Potosí, Bolivia. From the San Francisco de los Andes and Cerro Negro de la Aguadita mines, San Juan Province, Argentina. In the Moldava fluorite mine, about 20 km northwest of Teplice, Krušné hory Mountains, Czech Republic. In the Ödsbach Valley, near Oberkirch, at the Clara mine, near Oberwolfach, and on the Schmiedestollen dump, Black Forest, Germany. From an undefined locality in the Chatkal Mountains, Uzbekistan.

Name: Honors Franklin Delano Roosevelt (1882–1945), 32nd President of the USA.

Type Material: Harvard University, Cambridge, Massachusetts, 101938; National Museum of Natural History, Washington, D.C., USA, 115317.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 697. (2) Bedlivy, D., E.J. Llambías, and J.F.H. Astarloa (1972) Rooseveltit von San Francisco de los Andes und Cerro Negro de la Aguadita, San Juan, Argentina. Tschermaks Mineral. Petrog. Mitt., 17, 65–75 (in German with English abs.). (3) Bedlivy, D. and K. Mereiter (1982) Structure of $\alpha-BiAsO_4$ (rooseveltite). Acta Cryst., 38, 1559–1561.

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Romanèchite $(Ba, H_2O)_2(Mn^{4+}, Mn^{3+})_5O_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Euhedral crystals very rare, flat, ridged, to 200 μm; acicular to fibrous, divergent; commonly reniform, botryoidal, stalactitic, colloform banded; very fine-grained massive.

Physical Properties: Hardness = 5–6 VHN = 514–715 (100 g load). D(meas.) = 4.70–4.74 D(calc.) = [4.90]

Optical Properties: Opaque. *Color:* Iron-black, dark steel-gray; gray-white in reflected light. *Streak:* Black, brownish black. *Luster:* Submetallic; dull when massive.
Optical Class: Biaxial. *Anisotropism:* Strong. *Bireflectance:* Strong; gray to white.
R_1–R_2: (400) 26.7–38.7, (420) 26.3–37.7, (440) 25.6–35.9, (460) 25.2–34.8, (480) 24.8–34.0, (500) 24.3–33.0, (520) 23.8–32.1, (540) 23.4–31.1, (560) 22.9–30.1, (580) 22.4–29.3, (600) 22.0–28.6, (620) 21.6–28.0, (640) 21.3–27.5, (660) 21.2–27.2, (680) 20.9–26.8, (700) 20.7–26.5

Cell Data: *Space Group:* $C2/m$. $a = 13.929(1)$ $b = 2.8459(4)$ $c = 9.678(1)$ $\beta = 92.39(1)^\circ$ $Z = 2$

X-ray Powder Pattern: Schneeberg, Germany.
2.190 (100), 3.465 (70), 2.875 (70), 2.415 (70), 1.820 (70), 1.560 (70), 1.399 (70)

Chemistry:

	(1)	(2)		(1)	(2)
WO_3		0.89	MgO	0.20	0.15
As_2O_5	1.50		CaO	0.40	0.19
SiO_2	0.40	0.52	BaO	16.20	17.46
MnO_2	66.87	66.62	K_2O	0.10	
Fe_2O_3	1.45	0.15	H_2O^+		4.38
MnO	8.23	7.09	H_2O^-		0.48
CoO		0.90	H_2O	4.65	
CuO	0.10	0.48	Total	100.10	99.68

(1) Romanèche, France. (2) Schneeberg, Germany. (3) Do.; by electron microprobe, analysis not given, H_2O by the Penfield method; corresponds to $(Ba_{0.66}Ca_{0.03}Na_{0.01})_{\Sigma=0.70}[(Mn^{4+}, Mn^{3+})_{4.83}Si_{0.06}Mg_{0.02}Al_{0.01}(W, Cu, Zn, Ni, Co)_{0.08}]_{\Sigma=5.00}O_{10} \bullet 1.2H_2O$.

Occurrence: A product of weathering of manganese-bearing oxides, carbonates, silicates; in sedimentary deposits; as replacement deposits in limestones and dolostones; a principal component of "psilomelane" and "desert varnish" (manganese oxide-rich coatings formed on rocks in arid regions); in some plume agates.

Association: Pyrolusite, hausmannite, chalcophanite, braunite, goethite, calcite, quartz.

Distribution: While of common occurrence, characterization by X-ray, chemical analysis, or both, is necessary. Authenticated from: Romanèche, Saône-et-Loire, France. In Germany, well-crystallized from Schneeberg, Saxony, and at the Clara Mine, near Oberwolfach, Black Forest. From the Restormel mine, Lostwithiel, Cornwall, England. In the USA, at Austinville, Wyeth Co., Virginia; from Sodaville, Mineral Co., Nevada; at the Hoggett mines, Hidalgo Co., New Mexico; at the Tolbard mine, Paymaster district, Imperial Co., California. In the Talmantes mine, near Parral, Chihuahua, Mexico. From Pilbara, Western Australia.

Name: For the occurrence at Romanèche, France.

Type Material: The Natural History Museum, London, England, 69160.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 668–671 [psilomelane = romanèchite, part]. (2) Fleischer, M. (1960) Studies of the manganese oxide minerals. III. Psilomelane [romanèchite]. Amer. Mineral., 45, 176–187. (3) Mukherjee, B. (1965) Crystallography of psilomelane [romanèchite], $A_3X_6Mn_8O_{16}$. Mineral. Mag., 35, 643–655. (4) Picot, P. and Z. Johan (1982) Atlas of ore minerals. B.R.G.M., Orléans, France, and Elsevier, Amsterdam, Holland, 328. (5) Turner, S. and J.E. Post (1988) Refinement of the substructure and superstructure of romanechite. Amer. Mineral., 73, 1155–1161.

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Romarchite SnO

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. In massive crusts.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [6.40]

Optical Properties: Semitransparent. *Color:* Black.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P4/mmm$ (synthetic). $a = 3.802$ $c = 4.836$ Z = 2

X-ray Powder Pattern: Boundary Falls, Canada.
2.98 (10), 1.601 (9), 1.799 (7), 2.679 (6), 1.491 (6b)

Chemistry: (1) Boundary Falls, Canada; X-ray spectrographic analysis detected only tin and a trace of iron.

Occurrence: As an alteration product on tin pannikins immersed in a river (Boundary Falls, Canada); replacing herzenbergite replacing cassiterite (Maria-Teresa mine, Bolivia); on tin ingots from the cargo of a ship wrecked in a Red Sea cove (Sharm Abhur, Saudi Arabia).

Association: Hydroromarchite (Boundary Falls, Canada); abhurite, kutnohorite, aragonite (Sharm Abhur, Saudi Arabia).

Distribution: At Boundary Falls, Winnipeg River, Ontario, Canada, where tin pannikins had been dropped by a voyageur between 1801 and 1821. From the Maria-Teresa mine, near Huari, between Oruro and Uyuni, Bolivia. In a cove of the Red Sea known as Sharm Abhur, about 30 km north of Jiddah, Saudi Arabia.

Name: For the Royal Ontario Museum ARCHeology Department.

Type Material: Royal Ontario Museum, Toronto, Canada, M28744.

References: (1) Organ, R.M. and J.A. Mandarino (1971) Romarchite and hydroromarchite, two new stannous minerals. Can. Mineral., 10, 916 (abs.). (2) (1972) Amer. Mineral., 57, 1555–1556 (abs. ref. 1).

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Roméite $(Ca, Fe^{2+}, Mn^{2+}, Na)_2(Sb, Ti)_2O_6(O, OH, F)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As octahedra, to 1 mm, with subordinate {001}, {110}, {112}, {113}, {133}; in crystalline aggregates; massive. *Twinning:* Uncommon on {111}.

Physical Properties: *Cleavage:* {111}, poor. *Fracture:* Splintery, uneven.
Hardness = 5.5–6.5 D(meas.) = 4.95–5.41 D(calc.) = [5.28–5.39]

Optical Properties: Transparent to translucent. *Color:* Pale yellow, yellowish to reddish brown, dark brown. *Streak:* Nearly white, pale yellow. *Luster:* Vitreous, greasy, subadamantine.
Optical Class: Isotropic; may be anomalously biaxial, zoned or sectored. n = 1.817–1.854

Cell Data: *Space Group:* $Fd3m$. a = 10.24–10.31 Z = 8

X-ray Powder Pattern: Långban, Sweden.
2.95 (10), 6.0 (8), 1.827 (8), 3.09 (7), 1.549 (7), 2.57 (6), 0.869 (6)

Chemistry:

	(1)	(2)	(3)
TiO_2		0.30	
Sb_2O_5	74.72	72.17	74.26
FeO	1.12	2.92	
MnO	6.27	0.43	
PbO		0.51	
MgO		0.35	
CaO	15.81	19.01	25.74
Na_2O	0.81	2.03	
K_2O		0.17	
F		3.50	
H_2O	1.39	0.66	
$-O = F_2$		[1.47]	
Total	100.12	[100.58]	100.00

(1) St. Marcel, Italy. (2) Långban, Sweden; after deduction of remnant 0.52%. (3) $Ca_2Sb_2O_7$.

Occurrence: A secondary mineral in some manganese-bearing hydrothermal mineral deposits which commonly have undergone metamorphism.

Mineral Group: Stibiconite group.

Association: Epidote, manganese oxides (St. Marcel, Italy); yeatmanite, sarkinite, willemite, diopside, andradite (Franklin, New Jersey, USA).

Distribution: In the Praborna mine, south of St. Marcel, Val d'Aosta, Piedmont, Italy. At the Radstädter Tauern-Pass, Salzburg, Austria. From Långban and Jakobsberg, Värmland, Sweden. In the USA, at Franklin, Sussex Co., New Jersey; from the Green prospect, Mopung Hills, Lake district, Churchill Co., Nevada. At the Tripuhy cinnabar mine, Ouro Prêto, Minas Gerais, Brazil. From the Tai Lee mine, Siput Utara, Perak, Malaysia. A few other localities are reported, but require modern authentication.

Name: To honor Jean Baptiste Louis Romé de l'Isle (1736–1790), early French crystallographer.

Type Material: Natural History Museum, Paris, France, 41.151 and 41.152.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1020–1022. (2) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Römerite $Fe^{2+}Fe_2^{3+}(SO_4)_4 \cdot 14H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are pseudocubic or thick tabular {010}, large {010}, {001}, with a well-developed [001] zone, many other forms, to 3 mm; in crystal aggregates, stalactitic, granular.

Physical Properties: *Cleavage:* On {010}, perfect; {001}, less perfect. *Fracture:* Uneven. Hardness = 3–3.5 D(meas.) = 2.174 D(calc.) = 2.173 Soluble in H_2O, taste saline, astringent.

Optical Properties: Translucent. *Color:* Rust-brown, clove-brown, honey-brown, yellow, may be violet-brown; yellow-brown in transmitted light. *Luster:* Oily, resinous, vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = reddish yellow; Y = pale yellow; Z = yellow-brown. *Dispersion:* $r > v$, very strong, may be crossed. α = 1.519–1.524 β = 1.570–1.571 γ = 1.580–1.583 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.463(8)$ $b = 15.309(18)$ $c = 6.341(8)$ $\alpha = 90°32(10)'$ $\beta = 101°05(10)'$ $\gamma = 85°44(10)'$ Z = 1

X-ray Powder Pattern: Island Mountain mine, California, USA.
4.79 (10), 4.03 (9), 5.05 (5), 2.38 (3), 3.16 (2), 2.62 (2), 1.907 (2)

Chemistry:

	(1)	(2)
SO_3	39.79	39.83
Fe_2O_3	20.11	19.86
FeO	8.71	8.94
H_2O	30.99	31.37
insol.	0.16	
Total	99.76	100.00

(1) Tierra Amarilla, Chile; corresponds to $Fe^{2+}_{0.97}Fe^{3+}_{2.02}(SO_4)_{3.98} \cdot 13.81H_2O$.
(2) $Fe^{2+}Fe^{3+}_2(SO_4)_4 \cdot 14H_2O$.

Occurrence: As an early alteration product of oxidizing pyrite or pyrrhotite; uncommonly a volcanic sublimate.

Association: Copiapite, melanterite, voltaite, halotrichite, szomolnokite, kornelite, rozenite, siderotil, alunite.

Distribution: In Germany, from the Rammelsberg mine, near Goslar, Harz Mountains; at Pfaffenreuth, near Waldsassen, Bavaria. At the Tmavýdůl coal mine, near Rtyně, and from Příbram, Czech Republic. In the Kamariza mine, Laurium, Greece. At Nagybörzsöny and Lesenceistvánd, Hungary. In Russia, in the Blyava sulfate deposits, Southern Ural Mountains, and on volcanoes on the Kamchatka Peninsula. From Madeni Zakh, Iran. In Chile, at Tierra Amarilla, southeast of Copiapó, Atacama; from Quetena, west of Calama, Alcaparrosa, near Cerritos Bayos, southwest of Calama, and Chuquicamata, Antofagasta. In the USA, at the United Verde mine, Jerome, Yavapai Co., and the Copper Queen mine, Bisbee, Cochise Co., Arizona; at the Island Mountain mine, Trinity Co., and the Leviathan mine, Alpine Co., California; in the Dexter mine group, Calf Mesa, San Rafael district, Emery Co., Utah. From Mt. Isa, Queensland, Australia. At Navarana Fjord, northeastern Freuchen Land, Greenland. Some additional minor localities are known.

Name: Honors Friedrich Adolph Römer (1809–1869), German geologist, Director of the School of Mines, Clausthal, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 520–522 [roemerite = römerite]. (2) Van Loan, P.R. and E.W. Nuffield (1959) An X-ray study of roemerite. Can. Mineral., 6, 348–356. (3) Fanfani, L., A. Nunzi, and P.F. Zanazzi (1970) The crystal structure of roemerite. Amer. Mineral., 55, 78–89.

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Röntgenite-(Ce) $Ca_2(Ce,La)_3(CO_3)_5F_3$

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Crystal Data: Hexagonal. *Point Group:* 3. Crystals are hexagonal, with $\{10\bar{1}1\}$, $\{01\bar{1}2\}$, $\{11\bar{2}0\}$, small (0001), striated horizontally, to 3 mm; commonly in syntaxic intergrowth with bastnäsite-(Ce), synchysite-(Ce), parisite-(Ce), cordylite-(Ce). *Twinning:* On (0001), twin and composition plane, rare.

Physical Properties: *Fracture:* Subconchoidal. Hardness = 4.5 (by analogy to related rare-earth carbonates). D(meas.) = n.d. D(calc.) = 4.19

Optical Properties: Transparent to translucent. *Color:* Wax-yellow, brown, green; pale yellow to colorless in transmitted light.
Optical Class: Uniaxial (+). $\omega = 1.658–1.662$ $\epsilon = 1.756$

Cell Data: *Space Group:* $R3$. $a = 7.13(3)$ $c = 69.4(2)$ $Z = 9$

X-ray Powder Pattern: n.d.

Chemistry: (1) Chemical composition has been inferred by interpolation in the bastnäsite–synchysite series.

Occurrence: A rare late-stage hydrothermal mineral in granite pegmatite (Narssârssuk, Greenland); in alkaline orthoclase pegmatite (Mianning deposit, China).

Association: Bastnäsite-(Ce), parisite-(Ce), synchysite-(Ce) as syntactic intergrowths.

Distribution: From Narssârssuk, Greenland. In the Mianning rare-earth deposit, Sichuan Province, China. At an undefined locality in the Chatkal Range, Tien-Shan Mountains, Uzbekistan. From Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Wilhelm Conrad Röntgen (1845–1923), German physicist, discoverer of X-rays, as the species was noted and confirmed by use of X-rays only.

Type Material: Harvard University, Cambridge, Massachusetts, 84233; National Museum of Natural History, Washington, D.C., USA, R2609, R2613, R2615.

References: (1) Donnay, G. (1953) Roentgenite [röntgenite], $3CeFCO_3 \bullet 2CaCO_3$, a new mineral from Greenland. Amer. Mineral., 38, 868–870. (2) Donnay, G. and J.D.H. Donnay (1953) The crystallography of bastnaesite, parisite, roentgenite, and synchisite. Amer. Mineral., 38, 932–963. (3) Van Landuyt, J. and S. Amelinckx (1975) Multiple beam direct lattice imaging of new mixed-layer compounds of the bastnaesite-synchisite series. Amer. Mineral., 60, 351–358. (4) Ni, Y., J.M. Hughes, and A.N. Mariano (1993) The atomic arrangement of bastnäsite-(Ce), $Ce(CO_3)F$, and structural elements of synchysite-(Ce), röntgenite-(Ce), and parisite-(Ce). Amer. Mineral., 78, 415–418.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Microcrystalline, to < 5 μm; in thin botryoidal crusts, and replacing emplectite crystals.

Physical Properties: *Fracture:* Conchoidal to irregular. *Tenacity:* Brittle. Hardness = 4–4.5 VHN = 513 (25 g load). D(meas.) = 6.86–7.01 D(calc.) = 7.21

Optical Properties: Semitransparent. *Color:* White to pale gray, pale green, yellow.
Luster: Adamantine.
Optical Class: Biaxial (+). $\alpha = 2.09(4)$ $\beta =$ n.d. $\gamma = 2.27(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 6.879(1)$ $b = 7.159(1)$ $c = 6.732(1)$ $\beta = 104.84(1)°$ Z = 4

X-ray Powder Pattern: Argentina.
3.15 (100), 2.97 (80), 3.33 (61), 2.98 (37), 4.82 (36), 2.70 (36), 2.50 (26)

Chemistry:

	(1)	(2)	(3)
As_2O_5	33.2	33.0	33.03
Bi_2O_3	67.2	67.9	66.97
Total	100.4	100.9	100.00

(1) Santiaguillo, Bolivia. (2) San Francisco de los Andes, Argentina; by electron microprobe. (3) $BiAsO_4$.

Polymorphism & Series: Dimorphous with tetrarooseveltite.

Mineral Group: Monazite group.

Occurrence: Vey rare in cassiterite veinlets in rhyolite-dacite lava flows (Santiaguillo, Bolivia); in the oxidized zone of a breccia pipe (San Francisco de los Andes, Argentina).

Association: Cassiterite (Santiaguillo, Bolivia); preisingerite, bismutite, mixite, zavaritskite, wulfenite (Moldava, Czech Republic); conichalcite, mixite (Uzbekistan).

Distribution: At Santiaguillo, west of Maragua, Potosí, Bolivia. From the San Francisco de los Andes and Cerro Negro de la Aguadita mines, San Juan Province, Argentina. At Moldava, about 20 km northwest of Teplice, Czech Republic. In the Ödsbach Valley, near Oberkirch, at the Clara mine, near Oberwolfach, and on the Schmiedestollen dump, Black Forest, Germany. From an undefined locality in the Chatkal Mountains, Uzbekistan.

Name: Honors Franklin Delano Roosevelt (1882–1945), 32nd President of the USA.

Type Material: Harvard University, Cambridge, Massachusetts, 101938; National Museum of Natural History, Washington, D.C., USA, 115317.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 697. (2) Bedlivy, D., E.J. Llambías, and J.F.H. Astarloa (1972) Rooseveltit von San Francisco de los Andes und Cerro Negro de la Aguadita, San Juan, Argentina. Tschermaks Mineral. Petrog. Mitt., 17, 65–75 (in German with English abs.). (3) Bedlivy, D. and K. Mereiter (1982) Structure of α–$BiAsO_4$ (rooseveltite). Acta Cryst., 38, 1559–1561.

Roquesite $CuInS_2$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Typically as inclusions in other sulfides, to 0.3 mm. *Twinning:* Polysynthetic.

Physical Properties: Hardness = n.d. VHN = 259–274 (25 g load). D(meas.) = n.d. D(calc.) = [4.78]

Optical Properties: Opaque. *Color:* In polished section, gray with a slight bluish tint. *Luster:* Metallic. *Anisotropism:* Very weak.
R_1–R_2: (400) 25.8–25.0, (420) 25.3–24.8, (440) 24.5–24.5, (460) 23.8–23.9, (480) 23.2–23.4, (500) 22.7–22.9, (520) 22.3–22.6, (540) 22.1–22.4, (560) 21.9–22.3, (580) 21.8–22.2, (600) 21.8–22.2, (620) 21.8–22.2, (640) 21.7–22.2, (660) 21.8–22.2, (680) 21.9–22.3, (700) 22.1–22.5

Cell Data: *Space Group:* $I\bar{4}2d$ (by analogy to chalcopyrite group). $a = 5.51$ $c = 11.05$ Z = 4

X-ray Powder Pattern: Charrier, France.
3.19 (vvs), 1.95 (vs), 1.66 (s), 2.76 (mw), 1.268 (vw), 1.127 (vvw), 3.08 (f)

Chemistry:

	(1)	(2)	(3)
Cu	26.8	28.4	26.20
Fe		0.6	
In	47.8	45.9	47.35
S	27.3	26.2	26.45
Total	101.9	101.1	100.00

(1) Charrier, France; by electron microprobe, corresponds to $Cu_{0.99}In_{0.98}S_{2.00}$. (2) Geevor mine, England; by electron microprobe, corresponds to $Cu_{1.09}Fe_{0.03}In_{0.98}S_{2.00}$. (3) $CuInS_2$.

Mineral Group: Chalcopyrite group.

Occurrence: In association with copper sulfides in high-temperature Sn–W–Bi–Mo hydrothermal veins in highly metamorphosed rocks (Charrier, France); a late-stage mineral in a skarn Fe–W ore pipe (Ulsan mine, South Korea); in magnetite-bearing massive chalcopyrite ore (Akenobe mine, Japan).

Association: Chalcopyrite, bornite, cubanite, covellite, sphalerite, tetrahedrite, emplectite, wittichenite, stannoidite, pyrite, löllingite, arsenopyrite, bismuth, cassiterite, ferberite, magnetite.

Distribution: In France, from Charrier, Allier [TL]; in Lautaret Pass, Hautes-Alpes; at La Telhaie, Morbihan; and from Vaultry, Haute-Vienne. In the Geevor mine, St. Just, Cornwall, England. At Listulli, Telemark, and Långban, Värmland, Sweden. From the Radka deposit, Pazardzhik, Bulgaria. At Cínovec (Zinnwald), Czech Republic From Syrymbet, Kazakhstan. In the Akenobe and Ikuno mines, Hyogo Prefecture, Japan. In the Ulsan mine, Kyongsang Province, South Korea. At the Tosham tin prospect, Bhiwani district, Haryana, India. In Canada, from Mount Pleasant, New Brunswick. At the Sure Fire mine, Pyramid district, Washoe Co., Nevada, USA. Found in the Mangabeira tin deposit, Goiás, Brazil. Additional localities are now known.

Name: Honors Professor Maurice Roques (1911–), French geologist, University of Clermont-Ferrand, Clermont-Ferrand, France.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1965,302.

References: (1) Picot, P. and R. Pierrot (1963) La roquésite, premier minéral d'indium: $CuInS_2$. Bull. Soc. fr. Minéral., 86, 7–14 (in French). (2) (1963) Amer. Mineral., 48, 1178–1179 (abs. ref. 1). (3) Imai, N. and S. Choi (1984) The first Korean occurrence of roquesite. Mineral. J. (Japan), 12, 162–172. (4) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 585–586. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 484.

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Rorisite CaFCl

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals rounded, tabular, flattened on {001}, showing {111}, {110}, rarely {100}, to 1 mm.

Physical Properties: *Cleavage:* {110}, perfect; {001}, excellent. *Fracture:* Conchoidal. *Tenacity:* Brittle, thin fragments slightly elastic. Hardness = 2 D(meas.) = 2.78(1) D(calc.) = 2.94 Hygroscopic, soluble in H_2O, altering to $CaCl_2$ and CaF_2; weak violet fluorescence under LW UV.

Optical Properties: Transparent, becoming turbid on exposure to moist air. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.668(2)$ $\epsilon = 1.635(2)$

Cell Data: *Space Group:* $[P4/nmm]$ (by analogy to matlockite). $a = 3.890(1)$ $c = 6.810(1)$ Z = 2

X-ray Powder Pattern: Kopeysk, Russia.
2.557 (100), 6.81 (45), 2.267 (35), 2.138 (32), 1.560 (32), 3.396 (30), 1.363 (25)

Chemistry:

	(1)	(2)
Mg	3.63	
Ca	38.94	42.40
F	23.29	20.10
Cl	34.24	37.50
Total	100.10	100.00

(1) Kopeysk, Russia; corresponds to $(Ca_{0.89}Mg_{0.13})_{\Sigma=1.02}F_{1.00}(Cl_{0.88}F_{0.12})_{\Sigma=1.00}$. (2) CaFCl.

Occurrence: Within carbonized wood in burnt coal dumps.

Association: Fluorite, periclase, troilite.

Distribution: From Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia.

Name: From the Latin for *dew*, in allusion to the transparent drops that cover the mineral in moist air.

Type Material: Mining Institute, St. Petersburg, 2073; Il'menskii Preserve Museum, Miass, 5880; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, r460/1.

References: (1) Chesnokov, B.V., T.P. Nishanbaev, and L.F. Bazhenova (1990) Rorisite CaFCl – a new mineral. Zap. Vses. Mineral. Obshch., 119(3), 73–76 (in Russian). (2) (1991) Amer. Mineral., 76, 1731 (abs. ref. 1).

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Rosasite $(Cu, Zn)_2(CO_3)(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are acicular, to 0.5 mm; in radial or divergent sprays or globular; compact mammillary to botryoidal crusts and masses, typically fibrous and with warty surfaces. *Twinning:* On {100}.

Physical Properties: *Cleavage:* In two directions. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 4.0–4.2 D(calc.) = 4.15

Optical Properties: Semitransparent. *Color:* Green, bluish green, sky-blue; pale blue to colorless in transmitted light.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = pale emerald-green; Z = dark emerald-green. *Orientation:* $X = c$; $Y \wedge a \simeq 10°$. *Absorption:* $X > Y > Z$. α = 1.672–1.688 β = 1.796–1.83 γ = 1.811–1.831 2V(meas.) = 33(5)° 2V(calc.) = 36.4°

Cell Data: *Space Group:* $P2_1/a$. a = 12.873(3) b = 9.354(3) c = 3.156(2) β = 110.36(3)° Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
2.600 (100), 6.05 (90), 5.07 (90), 3.69 (90), 2.962 (70), 2.534 (50), 2.144 (50)

Chemistry:

	(1)	(2)
CO_2	19.54	19.74
CuO	47.53	35.68
ZnO	24.60	36.50
H_2O	8.33	8.08
Total	[100.00]	100.00

(1) Sardinia; recalculated to 100% from an original total of 100.37% after deduction of MgO 0.15%, Fe_2O_3 0.39%, insoluble 0.33%. (2) $(Cu, Zn)_2(CO_3)(OH)_2$ with Cu:Zn = 1:1.

Mineral Group: Rosasite group.

Occurrence: An uncommon secondary mineral in the oxidized zone of Cu–Zn-bearing deposits, typically formed by zinc-bearing solutions on primary copper minerals; may be of post-mine origin.

Association: Malachite, aurichalcite, smithsonite, cerussite, hydrozincite, hemimorphite.

Distribution: From the Rosas mine, Sulcis, Sardinia, Italy. At a number of places in England, as Caldbeck Fells, Cumbria, and mines in Cornwall. Fine examples from Tsumeb, Namibia. In the USA, from the Kelly mine, Magdalena, Socorro Co., New Mexico; fine specimens from the Silver Bill mine, Gleeson, and at Bisbee, Cochise Co., in the 79 mine, Gila Co., and a number of other places in Arizona; from the Mohawk mine, San Bernardino Co., California; at Leadville, Lake Co., Colorado; from Majuba Hill, Pershing Co., Nevada; in the Hidden Treasure mine, Ophir district, Tooele Co., Utah. Abundant specimens from the Ojuela mine, Mapimí, Durango, Mexico. In small amounts from additional localities.

Name: For its occurrence in the Rosas mine, Sardinia, Italy.

Type Material: Natural History Museum, Paris, France, 109.327, 109.328, 139.61.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 251–252. (2) Roberts, A.C., J.L. Jambor, and J.D. Grice (1986) The X-ray crystallography of rosasite from Tsumeb, Namibia. Powder Diffraction, 1, 56–57.

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Roscherite

$Ca(Mn^{2+},Fe^{2+})_2Be_3(PO_4)_3(OH)_3 \cdot 2H_2O$ to $Ca(Mn^{2+},Fe^{2+})_3Be_2(PO_4)_3(OH)_3 \cdot 2H_2O$

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Crystal Data: Monoclinic or triclinic. *Point Group:* $2/m$ or $\bar{1}$. Crystals, to 2 cm, are short prismatic [001] or flattened on {100} or {010}, with {010}, {110}, {111}, with several other forms; in spherical to botryoidal aggregates and crusts, internally fibrous; powdery massive.

Physical Properties: *Cleavage:* On {001}, good; on {010}, distinct. Hardness = 4.5 D(meas.) = 2.90–2.97 D(calc.) = 2.77–2.94

Optical Properties: Semitransparent. *Color:* Greenish gray, olive-green, sage-green, dark brown, reddish brown, orange; yellowish green to brown in transmitted light, may show abnormal interference colors.
Optical Class: Biaxial (–). *Pleochroism:* X = yellow to olive-green; Y = yellow-brown, greenish brown; Z = chestnut-brown. *Orientation:* $X = b$; $Y \wedge c = -15°$ to 24°. *Dispersion:* $r > v$, very strong, crossed. $\alpha = 1.624–1.628$ $\beta = 1.639–1.644$ $\gamma = 1.643–1.650$ 2V(meas.) = Large.

Cell Data: *Space Group:* $C2/c$ with $a = 15.88–15.95$ $b = 11.90–11.95$ $c = 6.62–6.66$ $\beta = 94°42'–94°50'$ Z = 4, or *Space Group:* $C\bar{1}$ with $a = 15.921(5)$ $b = 11.965(4)$ $c = 6.741(1)$ $\alpha = 91°04(5)'$ $\beta = 94°21(5)'$ $\gamma = 89°59.5(5.0)'$ Z = 4

X-ray Powder Pattern: Greifensteine, Germany; close to zanazziite.
5.95 (10), 9.51 (9), 3.17 (8), 2.788 (6), 4.84 (4), 2.644 (4), 3.08 (2b)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	38.01	37.60	34.12	BeO	[13.74]	12.58	10.05
Fe_2O_3		13.36		CaO	11.48	7.60	10.76
FeO	10.13	6.26	30.40	H_2O	12.17	11.56	11.80
MnO	14.47	10.04	0.50	insol.		0.80	0.70
				Total	[100.00]	99.80	98.33

(1) Greifensteine, Germany; BeO originally determined as Al_2O_3. (2) Sapucaia mine, Brazil. (3) Gunnislake Clitters mine, England; BeO may include some Al_2O_3; corresponds to $Ca_{1.20}(Fe_{2.64}Mn_{0.04})_{\Sigma=2.68}Be_{2.51}(PO_4)_3(OH)_3 \cdot 2.58H_2O$.

Occurrence: In cavities in granite or complex zoned granite pegmatites.

Association: Morinite, lacroixite, eosphorite, apatite, tourmaline (Greifensteine, Germany); frondelite, faheyite, beryl, muscovite, quartz (Sapucaia mine, Brazil).

Distribution: On the Greifensteine, near Ehrenfriedersdorf, Saxony, Germany. In the Gunnislake Clitters mine, Calstock, Cornwall, England. In Brazil, from the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, and in the Énio pegmatite mine, northeast of Galiléia, Minas Gerais. In the USA, at the Davis mine, North Groton, Grafton Co., New Hampshire; from the Dunton quarry, Newry and the Black Mountain quarry, Rumford, Oxford Co., and elsewhere in Maine; at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; from the Foote mine, Kings Mountain, Cleveland Co., North Carolina.

Name: Honoring Walter Roscher, mineral collector, Ehrenfriedersdorf, Germany.

Type Material: Charles University, Prague, Czech Republic, 6472; The Natural History Museum, London, England, 1914,1381; National Museum of Natural History, Washington, D.C., USA, R6219.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 968–969. (2) Lindberg, M.L. (1958) The beryllium content of roscherite from the Sapucaia pegmatite mine, Minas Gerais, Brazil, and from other localities. Amer. Mineral., 43, 824–838. (3) Fanfani, L., P.F. Zanazzi, and A.R. Zanzari (1977) The crystal structure of a triclinic roscherite. Tschermaks Mineral. Petrog. Mitt., 24, 169–178. (4) Clark, A.M., E.E. Fejer, A.G. Couper, O. von Knorring, R.W. Turner, and R.W. Barstow (1983) Iron-rich roscherite from Gunnislake, Cornwall. Mineral. Mag., 47, 81–83. (5) Leavens, P.B., J.S. White, and J.A. Nelen (1990) Zanazziite, a new mineral from Minas Gerais, Brazil. Mineral. Record, 21, 413–417.

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Roscoelite $K(V^{3+}, Al, Mg)_2AlSi_3O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As minute scales, in druses, rosettes, or fan-shaped groups; fibrous and in felted aggregates; as impregnations, massive.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = Soft. D(meas.) = 2.92–2.94 D(calc.) = [2.89]

Optical Properties: Transparent to translucent. *Color:* Dark clove-brown, greenish brown to dark greenish brown. *Luster:* Pearly.
Optical Class: Biaxial (–). *Pleochroism:* X = green-brown; $Y = Z$ = olive-green.
α = 1.59–1.610 β = 1.63–1.685 γ = 1.64–1.704 2V(meas.) = 24.5°–39.5°

Cell Data: *Space Group:* $C2/c$. $a = 5.26$ $b = 9.09$ $c = 10.25$ $\beta = 101.0°$ Z = 2

X-ray Powder Pattern: Paradox Valley, Colorado, USA.
10.0 (100), 4.54 (80), 3.35 (80), 2.60 (80), 1.52 (60), 3.66 (50), 3.11 (50)

Chemistry:

	(1)
SiO_2	47.82
Al_2O_3	12.60
V_2O_5	19.94
FeO	3.30
MgO	2.43
CaO	trace
Na_2O	0.33
K_2O	8.03
H_2O^+	5.13
Total	99.58

(1) Stuckslager mine, California, USA.

Polymorphism & Series: Forms a series with muscovite; 1M polytype.

Mineral Group: Mica group.

Occurrence: An early-stage gangue mineral in low-temperature epithermal Au-Ag-Te deposits; from the oxidized portions of low-temperature sedimentary U-V ores.

Association: Quartz, pyrite, carbonates, fluorite, gold (Au-Ag-Te mineral association); corvusite, hewettite, carnotite, tyuyamunite (U-V mineral association).

Distribution: In the USA, from the Stuckslager mine, Lotus, El Dorado Co., California; in Colorado, from Cripple Creek, Teller Co., La Plata district, La Plata Co., Magnolia district, Boulder Co., the Gateway district, Mesa Co., in the Uravan and Paradox, Bull Canyon, and Slick Rock districts, in Montrose, San Miguel, and Dolores Cos. From the Spotted Horse mine, Maiden, Fergus Co., Montana; the Baker, Mammoth, and North Pole mines, Baker Co., Oregon; in the Monument No. 2 mine, Apache Co., and Monument No. 1 and Mitten No. 2 mines, Navajo Co., Arizona; from the Goldstrike mine, Lynn district, Eureka Co., Nevada. At the Yamato mine, Amamioshima Island, Kagoshima Prefecture, Japan. From Kalgoorlie, Western Australia and Radium Hill, Olary, South Australia. In the Emperor mine, Vatukoula, Viti Levu, Fiji Islands. At Horní Kalná, Czech Republic. From the Mounana mine, Gabon.

Name: For British scientist Henry Enfield Roscoe (1833–1915), of Manchester, England, who first prepared pure vanadium.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 635.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 11–30. (3) Wells, R.C. and W.W. Brannock (1946) The composition of roscoelite. U.S. Geol. Sur. Bull. 950, 121–127. (4) Heinrich, E.W. and A.A. Levinson (1955) Studies in the mica group; X-ray data on roscoelite and barium-muscovite. Amer. J. Sci., 253, 39–43. (5) Kurtz, J.P. and P.L. Hauff (1988) Roscoelite in Colorado telluride ores. In: Modreski, P.J., Ed., Mineralogy of precious metal deposits. Friends of Mineralogy, Golden, Colorado.

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Roselite $Ca_2(Co,Mg)(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [100], showing {011}, {$\bar{1}$11}, {010}, {110}, to 1.3 cm; commonly in spherical aggregates and druses. *Twinning:* Very common on {100} with {100} as composition plane, contact twins and fourlings.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 3.5 D(meas.) = 3.46–3.74 D(calc.) = 3.65

Optical Properties: Transparent to translucent. *Color:* Pale rose-pink to dark rose-pink; rose-pink in transmitted light, may be color zoned. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = pale rose-pink to dark rose-pink; Y = paler rose-pink; Z = palest rose-pink. *Orientation:* $X = b$ to $X \wedge c \sim 0°$–$4°$; $Y = b$ to $Y \wedge c = 12°$–$20°$; $Z \wedge c$ –70° to 91°. *Dispersion:* $r < v$, weak to strong. $\alpha = 1.694$–1.725 $\beta = 1.704$–1.730 $\gamma = 1.719$–1.735 2V(meas.) = 60°–75°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.801(1)$ $b = 12.898(3)$ $c = 5.617(1)$ $\beta = 107.42(2)°$ Z = 2

X-ray Powder Pattern: Schneeberg, Germany.
2.993 (100), 3.222 (75), 3.354 (60), 2.763 (50), 3.395 (35), 6.444 (20), 5.089 (20)

Chemistry:

	(1)	(2)
As_2O_5	49.96	52.76
CoO	12.45	8.60
MgO	4.67	4.63
CaO	23.72	25.74
H_2O	9.69	8.27
Total	100.49	100.00

(1) Schneeberg, Germany. (2) $Ca_2(Co,Mg)(AsO_4)_2 \cdot 2H_2O$ with Co:Mg = 1:1.

Polymorphism & Series: Dimorphous with roselite-beta; forms a series with wendwilsonite.

Mineral Group: Roselite group.

Occurrence: A rare secondary mineral in cobalt-bearing hydrothermal mineral deposits.

Association: Talmessite (Bou Azzer, Morocco).

Distribution: In Germany, from the Rappold and Daniel mines, Schneeberg, Saxony; at the Friedrich Christian mine, Wildschapbachtal, and the Anton mine, Heubachtal, near Schiltach, Black Forest. From Bou Azzer, Morocco. In the Talmessi mine, 35 km west of Anarak, Iran. From Huercal Overa, Almería Province, and at Molvizar, Granada Province, Spain.

Name: To honor Gustav Rose (1798–1873), Professor of Mineralogy, University of Berlin, Berlin, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 723–725. (2) Hawthorne, F.C. and R.B. Ferguson (1977) The crystal structure of roselite. Can. Mineral., 15, 36–42. (3) Dunn, P.J., B.D. Sturman, and J.A. Nelen (1987) Wendwilsonite, the Mg analogue of roselite, from Morocco, New Jersey, and Mexico, and new data on roselite. Amer. Mineral., 72, 217–221.

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Roselite-beta $Ca_2Co(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As granular aggregates.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 3.5–4 D(meas.) = 3.71 D(calc.) = 3.77

Optical Properties: Semitransparent. *Color:* Dark rose-red. *Luster:* Vitreous. *Optical Class:* Biaxial (–) [*sic*]. *Pleochroism:* X = pink; Y = pale pink; Z = nearly colorless. *Dispersion:* $r < v$, strong, crossed. $\alpha = 1.723$ $\beta = 1.737$ $\gamma = 1.756$ 2V(meas.) = 80°–90°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.88$ $b = 7.67$ $c = 5.58$ $\alpha = 112°19'$ $\beta = 71°21'$ $\gamma = 119°41'$ Z = 1

X-ray Powder Pattern: Schneeberg, Germany; nearly identical to talmessite. 2.75 (10), 3.08 (9), 3.59 (6), 3.98 (4), 3.22 (4), 1.894 (4), 1.719 (4)

Chemistry:

	(1)	(2)
As_2O_5	49.66	50.74
FeO	0.32	
CoO	13.28	16.54
NiO	1.43	
MgO	0.92	
CaO	26.29	24.76
H_2O	8.41	7.96
Total	100.31	100.00

(1) Schneeberg, Germany. (2) $Ca_2Co(AsO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with roselite.

Mineral Group: Fairfieldite group.

Occurrence: A rare secondary mineral in cobalt-bearing hydrothermal mineral deposits.

Association: Roselite, calcite, pyrite, quartz (Schneeberg, Germany); erythrite, arthurite, conichalcite, chenevixite, scorodite, cobaltaustinite, heterogenite (Dome Rock mine, Australia).

Distribution: From Schneeberg, Saxony, and at the Bauhaus district, Richelsdorf Mountains, Hesse, Germany. At Bou Azzer, Morocco. From Tsumeb, Namibia. In the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia. From the San Jose del Carmen mine, Copiapó, Atacama, Chile.

Name: As a monoclinic dimorph of *roselite*.

Type Material: The Natural History Museum, London, England, 1956,196; Harvard University, Cambridge, Massachusetts, USA, 105301.

References: (1) Frondel, C. (1955) Neomesselite and beta-roselite: two new members of the fairfieldite group. Amer. Mineral., 40, 828–833. (2) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésiens naturels. Bull. Soc. fr. Minéral., 87, 169–211 (in French).

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Rosemaryite $(Na, Ca, Mn^{2+})(Mn^{2+}, Fe^{2+})(Fe^{3+}, Fe^{2+}, Mg)Al(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Granular, massive, to 1 cm.

Physical Properties: *Cleavage:* Observed. Hardness = [> 4] (by analogy to ferrowyllieite). D(meas.) = n.d. D(calc.) = [3.63]

Optical Properties: Semitransparent. *Color:* Dark green, deep brown to reddish brown. *Luster:* Resinous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = pale brownish yellow; Z = pale greenish yellow. $\alpha = 1.723(2)$ $\beta = 1.742(2)$ $\gamma = 1.758(2)$ 2V(meas.) = –80°

Cell Data: *Space Group:* $P2_1/n$. a = 11.977(2) $b = 12.388(2)$ $c = 6.320(1)$ $\beta = 114°27(1)'$ Z = 4

X-ray Powder Pattern: Buranga, Rwanda.
3.024 (100), 2.693 (100), 2.726 (85), 3.487 (70), 2.842 (60), 2.062 (55), 5.451 (50)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	43.84	43.27	Li_2O	0.04	
Al_2O_3	6.90	8.13	Na_2O	3.40	3.69
Fe_2O_3	14.58	16.81	K_2O	0.00	0.03
FeO	11.64	2.13	H_2O^+		2.31
MnO	13.62	19.79	H_2O^-		0.19
ZnO	0.02		H_2O	1.73	
MgO	0.47	0.68	insol.	1.78	1.84
CaO	1.81	1.10	Total	99.83	99.97

(1) Rock Ridge pegmatite, South Dakota, USA; corresponds to $(Na_{0.47}Ca_{0.04})_{\Sigma=0.51}(Mn^{2+}_{0.20}Ca_{0.15}Na_{0.15})_{\Sigma=0.50}(Mn^{2+}_{0.69}Fe^{2+}_{0.31})_{\Sigma=1.00}(Fe^{3+}_{0.45}Mg_{0.06}Zn_{0.02}Li_{0.01})_{\Sigma=0.54}(Al_{0.63}Fe^{3+}_{0.37})_{\Sigma=1.00}(PO_4)_{3.00}$. (2) Buranga, Rwanda; corresponds to $(Na_{0.59}Ca_{0.02})_{\Sigma=0.61}(Mn^{2+}_{0.42}Ca_{0.08})_{\Sigma=0.50}(Mn^{2+}_{0.95}Fe^{2+}_{0.05})_{\Sigma=1.00}(Fe^{3+}_{0.82}Fe^{2+}_{0.10}Mg_{0.08})_{\Sigma=1.00}(Al_{0.78}Fe^{3+}_{0.22})_{\Sigma=1.00}(PO_4)_{3.00}$.

Polymorphism & Series: Forms two series, with ferrowyllieite, and with wyllieite; $Mn^{2+} > Fe^{2+}$ in M(1); Fe^{3+} dominant in M(2a).

Occurrence: In zoned complex granite pegmatites.

Association: Trolleite, alluaudite, montebrasite, scorzalite, strengite (Buranga, Rwanda).

Distribution: From the Rock Ridge pegmatite, near Custer, Custer Co., South Dakota, USA. At the Buranga pegmatite, near Gatumba, Rwanda.

Name: To honor Mrs. F. Rosemary Wyllie, wife of Professor Peter J. Wyllie, namesake of wyllieite, q.v.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162559.

References: (1) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (2) (1980) Amer. Mineral., 65, 810–811 (abs. ref. 1). (3) Fransolet, A.-M. (1995) Wyllieite et rosemaryite dans la pegmatite de Buranga, Rwanda. Eur. J. Mineral., 7, 567–575 (in French with English abs.).

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Rosenbergite $AlF_3 \cdot 3H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As slender tetragonal prismatic crystals, elongate along [001], to 0.25 mm, in radiating tufts.

Physical Properties: *Cleavage:* {001}, good. Hardness = n.d. VHN = 92–113, 103 average (15 g load). D(meas.) = 2.10(1) D(calc.) = 2.111

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.427$ $\epsilon = 1.403$

Cell Data: *Space Group:* $P4/n$. $a = 7.715(1)$ $c = 3.648(1)$ $Z = 2$

X-ray Powder Pattern: Cetine mine, Italy.
5.47 (100), 1.725 (85), 1.775 (78), 2.439 (72), 2.027 (70), 1.306 (70), 1.388 (65)

Chemistry:

	(1)
Al	19.94
F	41.05
H_2O	[39.01]
Total	[100.00]

(1) Cetine mine, Italy; by electron microprobe, H_2O by difference; corresponds to $Al_{1.02}F_{2.98} \cdot 2.99H_2O$.

Occurrence: Very rare in cavities in a silicified limestone from an antimony deposit in highly silicified evaporites (Cetine mine, Italy); in volcanic sublimates (Mt. Erebus, Antarctica).

Association: Gypsum, fluorite, elpasolite, ralstonite, onoratoite (Cetine mine, Italy).

Distribution: In the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. On Mt. Erebus, Antarctica.

Name: Honors Professor Philip E. Rosenberg, Washington State University, Pullman, Washington, USA, who first noted the mineral in Antarctica.

Type Material: University of Florence, Florence, Italy, 1934/RI.

References: (1) Olmi, F., C. Sabelli, and R. Trosti-Ferroni (1993) Rosenbergite, $AlF[F_{0.5}(H_2O)_{0.5}]_4 \cdot H_2O$, a new mineral from the Cetine mine (Tuscany, Italy): description and crystal structure. Eur. J. Mineral., 5, 1167–1174. (2) (1994) Amer. Mineral., 79, 765 (abs. ref. 1).

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Rosenbuschite $(Ca,Na)_3(Zr,Ti)Si_2O_7(O,F)_2$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals prismatic to acicular ‖ [010], to 5 mm; radial fibrous, feltlike, massive.

Physical Properties: *Cleavage:* Perfect on {100}, poor on $\{1\bar{2}0\}$, {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–6 VHN = 568–708 D(meas.) = 3.30–3.315 D(calc.) = [3.38]

Optical Properties: Transparent to translucent. *Color:* Orange, yellow-orange, gray. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak, in shades of yellow. *Orientation:* $X = c$; $Z \wedge \perp (001) = 28.5°$. *Absorption:* Weak; $Z > Y > X$. $\alpha = 1.678$ $\beta = 1.687$ $\gamma = 1.705$ 2V(meas.) = 78°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.12(5)$ $b = 11.39(5)$ $c = 7.27(3)$ $\alpha = 91°20(30)'$ $\beta = 99°40(30)'$ $\gamma = 111°50(30)'$ Z = 4

X-ray Powder Pattern: Langesundsfjord, Norway.
2.94 (100), 3.06 (80), 1.89 (60), 3.96 (40), 2.63 (40), 2.48 (40), 1.82 (40)

Chemistry:

	(1)
SiO_2	31.36
TiO_2	6.85
ZrO_2	20.10
Ce_2O_3	0.33
Fe_2O_3	1.00
MnO	1.39
CaO	24.87
Na_2O	9.93
F	5.83
$-O = F_2$	2.45
Total	99.21

(1) Langesundsfjord, Norway; corresponds to $(Ca_{1.71}Na_{1.23}Mn_{0.08}RE_{0.01})_{\Sigma=3.03}(Zr_{0.63}Ti_{0.33}Fe^{3+}_{0.05})_{\Sigma=1.01}Si_{2.01}O_8F_{1.18}$.

Occurrence: In some nepheline syenites and related pegmatites.

Association: Aegirine, natrolite, sodalite, zircon, låvenite, rinkite, eudialyte, leucophanite (Langesundsfjord, Norway).

Distribution: From Lille Arø Island and Skudesundskjaer, near Brevik, Langesundsfjord, and Bratthagen, north of Larvik, Norway. In the Norra Kärr complex, near Gränna, Sweden. From the Los Islands, Guinea. In the USA, from Red Hill, Moultonborough, Carroll Co., New Hampshire. At Mont Saint-Hilaire, Quebec, Canada. In Russia, from the Lovozero and Khibiny massifs, Kola Peninsula, and at Zaangar'ya, Yenisei Ridge, Siberia. In the Ilímaussaq intrusion, southern Greenland.

Name: For Professor Carl Harry F. Rosenbusch (1836–1914), German geologist and mineralogist, Heidelberg, Germany.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 374–375. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 343–347. (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 388–390. (4) Neumann, H. (1962) Contributions to the mineralogy of Norway. No. 13. Rosenbuschite and its relation to götzenite. Norsk. Geol. Tidsskr., 42, 179–186. (5) Shibaeva, R.P., V.I. Simonov, and N.V. Belov (1963) Crystal structure of the Ca, Na, Zr, Ti silicate rosenbuschite, $Ca_{3.5}Na_{2.5}Zr(Ti,Mn,Nb)[Si_2O_7]_2F_2O(F,O)$. Kristallografiya (Sov. Phys. Crystal.), 8, 505–516 (in Russian).

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Rosenhahnite $Ca_3Si_3O_8(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals flat tabular to lathlike, well modified, flattened on {010}, elongated along [001], to 5 mm; as irregular clusters of crystals.

Physical Properties: *Cleavage:* Perfect on {001}, good on {100} and {010}. Hardness = 4.5–5 D(meas.) = 2.89(2) D(calc.) = 2.895 Fluoresces light orangish pink under LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to buff or light yellow. *Optical Class:* Biaxial (–). α = 1.624–1.625 β = 1.640–1.641 γ = 1.646–1.647 2V(meas.) = 64(4)° 2V(calc.) = 64°

Cell Data: *Space Group:* $P\bar{1}$. a = 6.955(2) b = 9.484(2) c = 6.812(2) α = 108.64(2)° β = 94.84(2)° γ = 95.89(2)° Z = 2

X-ray Powder Pattern: Russian River, California, USA.
3.20 (100), 2.965 (90), 3.043 (60), 2.775 (40), 3.36 (30), 2.659 (30), 1.886 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.61	49.18	CaO	44.83	45.90
TiO_2	0.00		SrO	0.03	
B_2O_3	0.001		BaO	0.77	
Al_2O_3	0.06		Na_2O	0.21	
FeO	0.18		K_2O	0.00	
MnO	0.006		H_2O		4.92
MgO	0.1		LOI	5.2	
			Total	[100.00]	100.00

(1) Russian River, California, USA; by D-C arc emission spectroscopy, recalculated to 100.00% from an original total of 96.86%. (2) $Ca_3Si_3O_8(OH)_2$.

Occurrence: In veins in brecciated, fine-grained, garnet- and diopside-bearing metasediments (Russian River, California, USA).

Association: Pectolite, xonotlite, datolite (Russian River, California, USA); prehnite, gyrolite, okenite, apophyllite (Durham, North Carolina, USA); prehnite, xonotlite, pectolite (Staré Ransko, Czech Republic).

Distribution: In the USA, from the Russian River, in Mendocino Co., about eight km north of Cloverdale, California, and in the Durham quarry, near Durham, Wake Co., North Carolina. From Engyouji, Kochi Prefecture, Japan. At Wairere, south of Te Kuiti, New Zealand. From Staré Ransko, Czech Republic. In Russia, from Asbest, Ural Mountains.

Name: For Leo Rosenhahn (1906–1991), amateur mineralogist of San Anselmo, California, USA, who discovered the mineral.

Type Material: California Division of Mines & Geology, San Francisco, California; National Museum of Natural History, Washington, D.C., USA, 120124, 134562; The Natural History Museum, London, England, 1976,392–393.

References: (1) Pabst, A., E.B. Gross, and J.T. Alfors (1967) Rosenhahnite, a new hydrous calcium silicate from Mendocino County, California. Amer. Mineral., 52, 336–351. (2) Dunn, P.J. (1975) Rosenhahnite, a second occurrence with the zeolites of the Durham quarry, Durham, Wake County, North Carolina. Mineral. Record, 6, 300–301. (3) Wan, C., S. Ghose, and G.V. Gibbs (1977) Rosenhahnite, $C_3Si_3O_8(OH)_2$: crystal structure and the stereochemical configuration of the hydroxylated trisilicate group, $[Si_3O_8(OH)_2]$. Amer. Mineral., 62, 503–512.

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Roshchinite $Ag_{19}Pb_{10}Sb_{51}S_{96}$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Rosiaite $PbSb_2O_6$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. As flat tabular hexagonal crystals, with large {0001}, modified by {$10\bar{1}1$}, {$10\bar{1}0$}, and {$hk\bar{i}l$}, to 0.3 mm, in aggregates.

Physical Properties: *Cleavage:* {0001}, parting, possible. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.96

Optical Properties: Transparent. *Color:* Colorless to pale yellow. *Streak:* White. *Luster:* Resinous.
Optical Class: Uniaxial (–). $\omega = 2.092(2)$ $\epsilon = 1.920(10)$

Cell Data: *Space Group:* $P\bar{3}1m$. $a = 5.295(1)$ $c = 5.372(1)$ $Z = 1$

X-ray Powder Pattern: Cetine mine, Italy.
3.49 (vs), 2.648 (m), 2.110 (w), 1.887 (w), 1.651 (w), 1.531 (w), 2.688 (vw)

Chemistry:

	(1)	(2)
Sb_2O_5	58.67	59.17
PbO	40.88	40.83
Total	99.55	100.00

(1) Cetine mine, Italy; by electron microprobe, average of three analyses; corresponding to $Pb_{1.01}Sb_{2.00}O_6$. (2) $PbSb_2O_6$.

Occurrence: From an antimony deposit in highly silicified evaporites (Cetine mine, Italy).

Association: Valentinite, tripuhyite, bindheimite (Cetine mine, Italy).

Distribution: From the Cetine mine, 20 km southwest of Siena, and the Tafone mine, Grosseto, Tuscany, Italy.

Name: For the village of Rosia, near the Cetine mine, Italy.

Type Material: University of Genoa, Genoa, Italy.

References: (1) Basso, R., G. Lucchetti, L. Zefiro, and A. Palenzona (1996) Rosiaite, $PbSb_2O_6$, a new mineral from the Cetine mine, Siena, Italy. Eur. J. Mineral., 8, 487–492. (2) (1997) Amer. Mineral., 82, 208–209 (abs. ref. 1).

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Rosickýite S

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As equidimensional crystals; thick to very thin tabular on {010}, elongated along [010], to 1 mm; short prismatic on {110}, rarely acicular [001]; also dipyramidal with {111} and {$\overline{1}$11}; as crystalline efflorescences. *Twinning:* On {101}, the twinning lamellae parallel to the edge [010].

Physical Properties: Hardness = Low. VHN = n.d. D(meas.) = n.d. D(calc.) = 2.02–2.03

Optical Properties: Transparent to translucent. *Color:* Colorless to pale yellow with a greenish tinge. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = 1.25°$. *Dispersion:* Strong. α = High. β = High. γ = High. 2V(meas.) = Large.

Cell Data: *Space Group:* $P2/c$. $a = 8.476(2)$ $b = 13.088(3)$ $c = 9.270(2)$ $\beta = 124.92(2)°$ Z = 32

X-ray Powder Pattern: La Presta mine, Switzerland.
4.37 (100), 3.75 (100), 3.66 (80), 3.18 (80), 3.06 (60), 3.48 (40), 2.485 (40)

Chemistry: (1) La Presta mine, Switzerland; pure elemental sulfur by gas chromatography, enriched in ^{32}S, evidence of microbial activity.

Polymorphism & Series: Dimorphous with sulfur, to which it changes in time at room temperature.

Occurrence: In hollow "limonite" nodules in a thin clay stratum (Havírna, Czech Republic); in fumaroles (Vulcano, Italy); an alteration product of pyrite-rich asphalt (La Presta mine, Switzerland); formed from gypsum and stabilized due to microbial activity (Death Valley, California, USA).

Association: Pyrite, gypsum, rozenite, sulfur, calcite, "limonite", asphalt (La Presta mine, Switzerland).

Distribution: In the Czech Republic, from Havírna, near Letovice [TL], and at Visky. Well-crystallized in the La Presta asphalt mine, near Travers, Neuchâtel, Switzerland. From St. Andreasberg, Harz Mountains, and at Ronneburg, Thuringia, Germany. On Vulcano, Lipari Islands, Italy. In the USA, from Point Rincon, Ventura Co., and in the salt pan of Death Valley, California.

Name: Honors Professor Vojtěch Rosický (1880–1942), former Director of the Mineralogical and Petrological Institute of Masaryk University, Brno, Czech Republic.

Type Material: Moravian Museum, Brno, Czech Republic, A6111.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 145–146. (2) Sekanina, J. (1931) Rosickyit, die natürliche γ–Schwefelmodifikation. Zeits. Krist., 80, 174–189 (in German). (3) Douglas, S. and H. Yang (2002) Mineral biosignatures in evaporites: presence of rosickyite in an endoevaporitic microbial community from Death Valley, California. Geology, 30(12), 1075–1078. (4) Gallacher, A.C. and A.A. Pinkerton (1993) A redetermination of monoclinic α-sulfur. Acta Cryst., C49, 125–126. (5) Meisser, N., K.J. Schenk, and J.E. Spangenberg (2000) Rosickýite (monoclinic γ-sulphur) from La Presta asphalt mine, Neuchâtel, Switzerland: new X-ray powder diffraction data. Schweiz. Mineral. Petrogr. Mitt., 80, 299–303.

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Rosièresite $Pb_xCu_yAl_z(PO_4)_m \cdot nH_2O$

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Crystal Data: Amorphous (?). *Point Group:* n.d. Stalactitic, to 4 cm, concentric, massive.

Physical Properties: Hardness = n.d. D(meas.) = 2.2 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Greenish yellow, yellow, light brown.
Luster: Opaline.
Optical Class: Isotropic. $n = \sim 1.50$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
P_2O_5	25.5
As_2O_5	trace
Al_2O_3	23.0
CuO	3.0
PbO	10.0
H_2O	38.0
Total	99.5

(1) Rosières mine, France.

Occurrence: As post-mining incrustations.

Association: Tetrahedrite, cuprite, chrysocolla, malachite, azurite.

Distribution: From the Rosières copper mine, about one km east of Carmaux, Tarn, France.

Name: For the mineral's first occurrence at the Rosières mine, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 924. (2) Lacroix, A. (1910) Minéralogie de la France, IV, 532–533 (in French).

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Rossite $CaV_2^{5+}O_6 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. In small glassy lumps surrounded by alteration rims of metarossite.

Physical Properties: *Cleavage:* One direction, prominent. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 2.45 D(calc.) = 2.42 Slowly soluble in H_2O; transforms to metarossite in open air in a few weeks time, which is reversible.

Optical Properties: Transparent. *Color:* Pale yellow; yellow in transmitted light. *Luster:* Vitreous to somewhat pearly.
Optical Class: Biaxial (–) (recrystallized). *Orientation:* $Y \wedge b \simeq 45°$; $Z \simeq c$. *Dispersion:* Very strong. $\alpha = 1.710$ $\beta = 1.770$ $\gamma = 1.840$ 2V(meas.) = 60(15)°

Cell Data: *Space Group:* $P\overline{1}$ (recrystallized). $a = 8.552(2)$ $b = 8.576(2)$ $c = 7.028(2)$ $\alpha = 101.50(2)°$ $\beta = 114.96(2)°$ $\gamma = 103.39(2)°$ Z = 2

X-ray Powder Pattern: Yellow Cat Wash, Utah, USA; rehydrated from metarossite. 3.860 (100), 6.636 (95), 7.260 (90), 3.432 (60), 3.033 (55), 3.000 (50), 3.934 (25)

Chemistry:

	(1)	(2)
V_2O_5	58.00	58.67
MgO	0.14	
CaO	18.00	18.09
H_2O	22.90	23.24
insol.	1.60	
Total	100.64	100.00

(1) Bull Pen Canyon, Colorado, USA; corresponds to $Ca_{1.01}V_{1.98}O_6 \cdot 3.85H_2O$.
(2) $CaV_2O_6 \cdot 4H_2O$.

Occurrence: In veinlets in carnotite-bearing sandstone (Bull Pen Canyon, Colorado, USA).

Association: Metarossite, carnotite, gypsum (Bull Pen Canyon, Colorado, USA); huemulite, hummerite, thenardite, gypsum, epsomite (Malargüe district, Argentina).

Distribution: In the USA, on M.E. O'Neil's [Buckhorn] claim, Bull Pen Canyon, and at the Burro and Deremo-Snyder mines, Slick Rock district, San Miguel Co., Colorado; at Yellow Cat Wash, Thompsons district, Grand Co., Utah; and from the Mesa No. 1 mine, Lukachukai Mountains, Arizona. In the Malargüe district, Mendoza Province, Argentina.

Name: To honor Dr. Clarence Samuel Ross (1880–1975), American geologist and mineralogist, U.S. Geological Survey, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95331, R5707 (all type material has altered to metarossite).

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1053–1054. (2) Ahmed, F.R. and W.H. Barnes (1963) The crystal structure of rossite. Can. Mineral., 7, 713–726. (3) Bayliss, P. (1985) Powder X-ray diffraction data of rossite. Mineral. Mag., 49, 140–141.

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Rösslerite $MgHAsO_4 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare in small crystals, short prismatic; may be hairlike, to 4 cm, in radiating groups, and fine-grained crusts.

Physical Properties: *Cleavage:* {111}, imperfect. Hardness = 2–3 D(meas.) = 1.943 (synthetic). D(calc.) = 1.948 (synthetic). Dehydrates in air to brassite.

Optical Properties: Transparent. *Color:* Colorless to white, may be faintly tinted pink; colorless in transmitted light. *Luster:* Vitreous to dull.
Optical Class: Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = 14°$. $\alpha = 1.525(5)$ $\beta = 1.53(1)$ $\gamma = 1.550(5)$ 2V(meas.) = Small.

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 6.6918(5)$ $b = 25.744(2)$ $c = 11.538(1)$ $\beta = 95.15(1)°$ Z = 8

X-ray Powder Pattern: Synthetic.
4.08 (100), 6.43 (89), 4.49 (89), 4.67 (82), 4.29 (79), 12.90 (59), 2.863 (53)

Chemistry:

	(1)	(2)
As_2O_5	40.16	39.58
MgO	14.22	13.88
H_2O	45.62	46.54
Total	100.00	100.00

(1) Bieber, Germany. (2) $MgHAsO_4 \cdot 7H_2O$.

Occurrence: A secondary mineral in the oxidized zone of arsenic-bearing ore deposits.

Association: Pharmacolite, haidingerite, picropharmacolite, erythrite.

Distribution: In Germany, from Bieber, near Hanau, and from the Bauhaus district, Richelsdorf Mountains, Hesse; in the Sophia mine, near Wittichen, from the Anton mine, Heubachtal, near Schiltach, and in the Wolfgang mine, near Alpirsbach, Black Forest; at St. Andreasberg, Harz Mountains. Long fibers from Jáchymov (Joachimsthal), Czech Republic. At the White Caps mine, Manhattan district, Nye Co., Nevada, USA.

Name: Honoring Karl Rössler, Hanau, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 712–713. (2) Keller, P. (1971) Die Kristallchemie der Phosphat- und Arsenatminerale unter besonderer Berücksichtigung der Kationen-Koordinationspolyeder und des Kristallwassers. Neues Jahrb. Mineral., Monatsh., 491–510. (3) Ferraris, G. and M. Franchini-Angela (1973) Hydrogen bonding in the crystalline state. Crystal structure of $MgHAsO_4 \cdot 7H_2O$, roesslerite. Acta Cryst., 29, 286–292. (4) Street, R.L.T. and A. Whitaker (1973) The isostructurality of rösslerite and phosphorösslerite. Zeits. Krist., 137, 246–255.

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Rostite $Al(SO_4)(OH,F)\cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As flattened rhomboidal tablets, to 0.5 mm, in nodular aggregates and masses.

Physical Properties: Hardness = "Soft". D(meas.) = 1.892 D(calc.) = 1.92–1.96

Optical Properties: Semitransparent. *Color:* Chalky white.
Optical Class: Biaxial (+) or (–). *Orientation:* Y bisects the acute angle of the tablets; $Z \perp$ flattening. $\alpha = 1.440$–1.462 $\beta = 1.460$–1.470 $\gamma = 1.483$–1.487 2V(meas.) = 68°

Cell Data: *Space Group: Pcab.* $a = 11.169$–11.187 $b = 13.039$–13.060 $c = 10.871$–10.893 Z = 8

X-ray Powder Pattern: Libušín, Czech Republic.
4.248 (100), 4.183 (70), 3.901 (58), 3.403 (33), 2.730 (23), 3.269 (15), 3.347 (14)

Chemistry:

	(1)	(2)	(3)
SO_3	35.51	33.49	34.64
Al_2O_3	22.07	20.83	22.06
Fe_2O_3		0.53	
MgO	0.52	0.02	
CaO		0.36	
Na_2O	1.09	trace	
NH_3		0.48	
F		4.25	4.11
H_2O	40.69	41.51	40.92
insol.		0.39	
$-O = F_2$		1.79	1.73
Total	99.88	[100.07]	100.00

(1) Libušín, Czech Republic. (2) Do.; original total given as 100.09%; after deduction of gypsum and tschermigite, stated to correspond to $(Al_{1.06}Fe^{3+}_{0.02})_{\Sigma=1.08}(SO_4)_{0.99}[(OH)_{0.64}F_{0.62}]_{\Sigma=1.26}\cdot 5H_2O$. (3) $Al(SO_4)(OH,F)\cdot 5H_2O$ with OH:F = 1:1.

Polymorphism & Series: Dimorphous with jurbanite.

Occurrence: In burning waste heaps at a coal mine, formed by decomposition of aluminum-bearing rocks by gasses containing SO_2 and fluorine (Libušín, Czech Republic).

Association: Tschermigite, alunogen, copiapite (Libušín, Czech Republic).

Distribution: From the Nejedlý I (Schoeller) coal mine, Libušín, near Kladno, Czech Republic. At the Cetine mine, 20 km southwest of Siena, Tuscany, Italy.

Name: Honoring Professor Rudolph Rost (1902–?), Czech mineralogist, Charles University, Prague, Czech Republic, who first characterized the mineral.

Type Material: National Museum, Prague, Czech Republic, 29742.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 601 ["lapparentite" of Rost = rostite]. (2) Čech, F. (1979) Rostite, a new name for orthorhombic $Al(SO_4)(OH)\cdot 5H_2O$. Neues Jahrb. Mineral., Monatsh., 193–194. (3) Žáček, V. and P. Povondra (1988) New mineralogical data for rostite from Libušín, central Bohemia, Czechoslovakia. Neues Jahrb. Mineral., Monatsh., 476–480.

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Rouaite $Cu_2(NO_3)(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals flattened on {001}, may be elongated along [010] or equant, showing {001}, {100}, {101}, {110}, {011}, to 0.1 mm, isolated or in aggregates. *Twinning:* Rare on {001}.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.38(2) D(calc.) = 3.39

Optical Properties: Transparent. *Color:* Dark green, bluish green to emerald-green. *Streak:* Green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = dark blue-green; Y = blue-green; Z = pale green to colorless. *Orientation:* $Y = b$; $Z = c$; $X \wedge a = 5°$. *Dispersion:* $r < v$, strong. $\alpha = 1.700(2)$ $\beta = 1.715(2)$ $\gamma = 1.738(2)$ 2V(meas.) = 81.2° 2V(calc.) = 79(1)°

Cell Data: *Space Group:* $P2_1$. $a = 5.596(2)$ $b = 6.079(2)$ $c = 6.925(3)$ $\beta = 94.67(2)°$ Z = 2

X-ray Powder Pattern: Roua mines, France.
6.91 (100), 3.457 (90), 2.669 (80), 2.462 (80), 2.250 (50), 2.078 (50), 2.154 (40)

Chemistry:

	(1)	(2)
N_2O_5	21.64	22.49
CuO	65.5	66.26
H_2O	11.9	11.25
Total	99.04	100.00

(1) Roua mines, France; by electron microprobe, N_2O_5 and H_2O by CHN analyzer; corresponds to $Cu_{1.99}(NO_3)_{0.97}(OH)_{3.19}$. (2) $Cu_2(NO_3)(OH)_3$.

Polymorphism & Series: Dimorphous with gerhardtite.

Occurrence: Rare in cavities in cuprite from a hydrothermal copper deposit, the nitrate perhaps supplied from guano or organic matter in host-rock pelites (Roua mines, France).

Association: Cuprite, copper, silver, algodonite, domeykite, connellite, olivenite, malachite, theoparacelsite, gerhardtite (Roua mines, France).

Distribution: From the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, France. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For the Roua copper mines, France, from which the mineral was first described.

Type Material: Natural History Museum, Geneva, Switzerland.

References: (1) Sarp, H., R. Cerný, and L. Guenee (2001) Rouaite, $Cu_2(NO_3)(OH)_3$, un nouveau minéral: sa description et sa structure cristalline (Alpes-Maritimes, France). Riviéra Scientif., 85, 3–12 (in French with English abs.). (2) (2002) Amer. Mineral., 87, 998 (abs. ref. 1).

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Roubaultite $Cu_2(UO_2)_3(CO_3)_2O_2(OH)_2 \cdot 4H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are platy on {100}, in rosettes, to 3 mm.

Physical Properties: *Cleavage:* Perfect on {100}; good on {010}. Hardness = ∼3
D(meas.) = n.d. D(calc.) = 4.71 Radioactive.

Optical Properties: Semitransparent. *Color:* Grass-green to apple-green. *Luster:* Vitreous to slightly greasy.
Optical Class: Biaxial (+) *sic.* *Pleochroism:* $X = Y$ = colorless; Z = yellow-green.
$\alpha = 1.700(2)$ $\beta = 1.800(4)$ $\gamma = 1.83(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.767(3)$ $b = 6.924(3)$ $c = 7.850(3)$ $\alpha = 92.16(4)°$ $\beta = 90.89(4)°$ $\gamma = 93.48(4)°$ Z = 1

X-ray Powder Pattern: Shinkolobwe, Congo.
5.55 (10), 7.74 (9), 6.88 (8), 3.448 (8), 3.226 (8), 3.175 (8), 3.500 (7)

Chemistry:

	(1)	(2)
UO_3	71.6	71.79
CO_2	n.d.	7.36
SeO_2	0.3	
CuO	13.5	13.31
H_2O	14.8	7.54
Total	100.2	100.00

(1) Shinkolobwe, Congo; by electron microprobe, H_2O determined on a separate sample.
(2) $Cu_2(UO_2)_3(CO_3)_2O_2(OH)_2 \cdot 4H_2O$.

Occurrence: A rare mineral in the zone of oxidation of copper-bearing uranium deposits, formed by alteration of uraninite.

Association: Vandenbrandeite, soddyite, becquerelite, cuprosklodowskite, uranophane, heterogenite, uraninite (Shinkolobwe, Congo).

Distribution: From Shinkolobwe, near Kolwezi, at the Musonoi mine, and in the Kamoto mine, Katanga Province, Congo (Shaba Province, Zaire). In the Komsomol ore field, eastern Siberia, Russia.

Name: Honors Marcel Edouard Roubault (1905–1974), Professor of Geology, University of Nancy, Nancy, France.

Type Material: National School of Mines, Paris, France.

References: (1) Cesbron, F., R. Pierrot, and T. Verbeek (1970) La roubaultite $Cu_2(UO_2)_3(OH)_{10} \cdot 5H_2O$, une nouvelle espèce minérale. Bull. Minéral., 93, 550–554 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1912 (abs. ref. 1). (3) Ginderow, D. and F. Cesbron (1985) Structure de la roubaultite, $Cu_2(UO_2)_3(CO_3)_2O_2(OH)_2.4H_2O$. Acta Cryst., C41, 654–657 (in French with English abs.).

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Rouseite $Pb_2Mn^{2+}(As^{3+}O_3)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. As crystals, to 0.2 mm, elongated along [001], with large {010} and subordinate {110} and {102}.

Physical Properties: *Cleavage:* Perfect on {010} and {110}. *Tenacity:* Moderately brittle. Hardness = ∼3 D(meas.) = > 4.2 D(calc.) = 5.73

Optical Properties: Transparent to translucent. *Color:* Yellow-orange; colorless in transmitted light. *Streak:* Pale yellow. *Luster:* Dull, vitreous on cleavage surfaces.
Optical Class: Biaxial (–); maximum birefringence 0.070(10). *Dispersion:* $r > v$, strong.
α = 1.8–1.9 β = n.d. γ = n.d. 2V(meas.) = 46(2)°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. $a = 6.36(2)$ $b = 7.29(2)$ $c = 5.54(2)$ $\alpha = 97.3(3)°$ $\beta = 114.2(2)°$ $\gamma = 106.0(2)°$ Z = 1

X-ray Powder Pattern: Långban, Sweden.
6.81 (100), 2.849 (90), 2.983 (80), 3.06 (70), 3.38 (60), 3.25 (60), 2.016 (60)

Chemistry:

	(1)
As_2O_3	27.0
MnO	10.0
PbO	59.6
H_2O	4.8
Total	101.4

(1) Långban, Sweden; by electron microprobe, H_2O by TGA; corresponds to $Pb_{1.97}Mn_{1.04}(AsO_3)_{2.01} \cdot 1.96H_2O$.

Occurrence: A very rare species found on a museum specimen, in a fracture cutting calcite-hausmannite ore, from a metamorphosed Fe–Mn orebody.

Association: Trigonite, finnemanite, hausmannite, calcite.

Distribution: From Långban, Värmland, Sweden.

Name: For Dr. Roland C. Rouse (1943–), American mineralogist, University of Michigan, Ann Arbor, Michigan, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 94942.

References: (1) Dunn, P.J., D.R. Peacor, B.D. Sturman, and F.J. Wicks (1986) Rouseite, a new lead manganese arsenite from Långban, Sweden. Amer. Mineral., 71, 1034–1036.

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Routhierite $Tl(Cu, Ag)(Hg, Zn)_2(As, Sb)_2S_6$

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Crystal Data: Tetragonal. *Point Group:* $\overline{4}2m$. As anhedral grains, to 300 μm, and as veinlets. *Twinning:* Fine polysynthetic lamellae seen in polished section.

Physical Properties: *Cleavage:* Two perpendicular. Hardness = n.d. VHN = 148 (25 g load). D(meas.) = n.d. D(calc.) = 5.83

Optical Properties: Opaque. *Color:* Violet-red; in polished section, bluish white, with strong internal reflections. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak. R_1–R_2: (400) 31.7–34.0, (420) 31.3–33.2, (440) 30.9–32.4, (460) 30.5–31.7, (480) 30.0–31.2, (500) 29.5–30.9, (520) 28.9–30.5, (540) 28.1–30.0, (560) 27.1–29.1, (580) 26.3–28.1, (600) 25.5–27.3, (620) 25.0–26.6, (640) 24.5–26.1, (660) 24.1–25.7, (680) 23.8–25.2, (700) 23.5–24.8

Cell Data: *Space Group:* $I\overline{4}2m$ (by analogy to stalderite). a = 9.977–9.986 c = 11.290–11.348 Z = 4

X-ray Powder Pattern: Jas Roux, France.
4.146 (100), 2.989 (100), 2.495 (90), 3.525 (80), 1.870 (70), 1.763 (70), 1.827 (60)

Chemistry:

	(1)	(2)	(3)
Tl	20.4	19.7	20.21
Cu	3.9	3.8	6.28
Ag	3.8	4.2	
Hg	34.7	34.4	39.67
Zn	2.0	2.1	
As	13.2	13.2	14.82
Sb	2.6	2.9	
S	19.6	19.6	19.02
Total	100.2	99.9	100.00

(1) Jas Roux, France; by electron microprobe, corresponding to $Tl_{0.98}(Cu_{0.60}Ag_{0.35})_{\Sigma=0.95}(Hg_{1.70}Zn_{0.30})_{\Sigma=2.00}(As_{1.73}Sb_{0.21})_{\Sigma=1.94}S_{6.00}$. (2) Do.; by electron microprobe, corresponding to $Tl_{0.95}(Cu_{0.59}Ag_{0.38})_{\Sigma=0.97}(Hg_{1.68}Zn_{0.32})_{\Sigma=2.00}(As_{1.73}Sb_{0.23})_{\Sigma=1.96}S_{6.00}$. (3) $TlCuHg_2As_2S_6$.

Occurrence: In hydrothermal deposits in dolostone (Jas Roux, France).

Association: Realgar, stibnite, pierrotite, sphalerite, pyrite, smithite (Jas Roux, France); pyrite, stibnite, realgar, cinnabar, parapierrotite, molybdenite, sphalerite, tetrahedrite–tennantite (Hemlo deposit, Canada).

Distribution: From the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France [TL]. At the Vorontsovskoye gold deposit, Serov district, Northern Ural Mountains, Russia. In the Hemlo gold deposit, Thunder Bay district, Ontario, Canada.

Name: For Pierre Routhier (1916–), Professor of Economic Geology, University of Paris, Paris, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., J. Mantienne, and P. Picot (1974) La routhiérite, $TlHgAsS_3$, et la laffittite, $AgHgAsS_3$, deux nouvelles espèces minérales. Bull. Soc. fr. Minéral., 97, 48–53 (in French with English abs.). (2) (1975) Amer. Mineral., 60, 947 (abs. ref. 1). (3) Harris, D.C. (1989) The mineralogy and geochemistry of the Hemlo gold deposit, Ontario. Geol. Surv. Canada, Econ. Geol. Report 38. [??pages??] (4) Graeser, S., H. Schwander, R. Wulf, and A. Edenharter (1995) Stalderite $TlCu(Zn, Fe, Hg)_2As_2S_6$ – a new mineral related to routhierite: description and crystal structure determination. Schweiz. Mineral. Petrogr. Mitt., 75, 337–345. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 486.

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Rouvilleite $Na_3(Ca, Mn^{2+})_2(CO_3)_3F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As crystals, prismatic, elongated along [001], showing {100}, {010},{110}, {001}, {10$\overline{1}$}, {023}, {03$\overline{2}$}, to 1 mm; commonly in granular masses.

Physical Properties: *Cleavage:* Good on {001}; imperfect on {010}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.67–2.73 D(calc.) = 2.69

Optical Properties: Transparent to translucent. *Color:* Pale tan, pale pink, yellow, colorless, may be reddish brown from inclusions. *Streak:* White. *Luster:* Vitreous to waxy. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 6°$–$20°$. *Dispersion:* $r > v$, weak. $\alpha = 1.472$–1.473 $\beta = 1.562$–1.564 $\gamma = 1.569$–1.570 2V(meas.) = 25°–27° 2V(calc.) = 27.5°–30°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 8.012$–8.043 $b = 15.79$–15.812 $c = 7.019$–7.030 $\beta = 100.78°-101.16(3)°$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.895 (100), 2.711 (90), 7.081 (80), 1.869 (75), 2.937 (70), 2.039 (70), 2.637 (60)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	[37.21]	36.85	37.92	MnO	6.83	8.63	
Y_2O_3		1.06		MgO	0.01		
Gd_2O_3		0.03		CaO	26.47	21.16	32.22
Dy_2O_3		1.03		Na_2O	25.95	26.14	26.70
Er_2O_3		0.06		F	5.65	5.20	5.46
Yb_2O_3		0.08		$-O = F_2$	2.38	2.19	2.30
FeO	0.52	1.20		Total	[100.26]	99.25	100.00

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of three analyses, total Fe as FeO, total Mn as MnO, CO_2 calculated from stoichiometry, confirmed by IR; corresponds to $Na_{2.96}(Ca_{1.66}Mn_{0.34}Fe_{0.02})_{\Sigma=2.02}(CO_3)_3F_{1.06}$. (2) Mt. Alluaiv, Kola Peninsula, Russia; by electron microprobe, total Fe as FeO, total Mn as MnO, corresponds to $Na_{3.08}(Ca_{1.36}Mn_{0.44}Fe_{0.06}Y_{0.03}Dy_{0.02})_{\Sigma=1.91}(CO_3)_{3.02}F_{0.99}$. (3) $Na_3Ca_2(CO_3)_3F$.

Occurrence: In a sodalite xenolith in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in a differentiated alkalic massif (Lovozero massif, Kola Peninsula, Russia).

Association: Kupletskite, villiaumite, aegirine, microcline, cancrinite, analcime, shortite, vuonnemite, cryolite, kogarkoite (Mont Saint-Hilaire, Canada); manganotychite, mineevite, nahcolite, trona, pirssonite, sidorenkite, rhodochrosite (Lovozero massif, Kola Peninsula, Russia).

Distribution: From Mont Saint-Hilaire, Quebec, Canada. On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: For Rouville Co., within which the Mont Saint-Hilaire, Canada, locality is located.

Type Material: Canadian Museum of Nature, Ottawa, 54542; Royal Ontario Museum, Toronto, Canada, M44157, M44233.

References: (1) McDonald, A.M., G.Y. Chao, and R.A. Ramik (1991) Rouvilleite, a new sodium calcium fluorocarbonate mineral from Mont Saint-Hilaire, Quebec. Can. Mineral., 29, 107–111. (2) (1991) Amer. Mineral., 76, 2023 (abs. ref. 1). (3) Khomyakov, A.P., L.I. Polezhaeva, D.L. Rogachev, N.A. Yamnova, and D.Y. Pushcharovskiy (1991) A new natural fluorocarbonate, $Na_3Ca(Mn, Ca)(CO_3)_3F$, from the Lovozero alkaline massif. Vestnik Moscow University, Series 4, Geology, 1, 85–88 (in Russian). (4) Yamnova, N.A., D.Y. Pushcharovskiy, A.P. Khomyakov, and S.V. Vyatkin (1991) Crystal structure of a new natural fluorocarbonate, $Na_3Ca(Mn, Ca)(CO_3)_3F$. Kristallografiya (Sov. Phys. Crystal.), 36, 30–33.

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Roweite $\mathbf{Ca_2(Mn^{2+},Mg)_2B_4O_7(OH)_6}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Lathlike crystals, to 5 mm, flattened on {100}, elongated and striated along [010], showing {001}, {100}, {021}, {201}, {401}, with rough {010}, {021} as terminations; compact massive.

Physical Properties: *Cleavage:* On {100}, fair; on {001}, {021}, poor. *Fracture:* Even to conchoidal. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 2.935(5) D(calc.) = 2.939

Optical Properties: Transparent. *Color:* Pale brown; colorless in transmitted light. *Optical Class:* Biaxial (–). *Pleochroism:* Moderate; X = very pale brown to colorless; Y = pale amber; Z = yellowish brown. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, strong. *Absorption:* $X > Y > Z$. α = 1.631–1.648 β = 1.640–1.660 γ = 1.641–1.663 2V(meas.) = 15°–28°

Cell Data: *Space Group: Pbam.* a = 8.27–8.289 b = 13.25–13.357 c = 9.01–9.057 Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
3.974 (100), 2.600 (72), 2.184 (49), 2.128 (37), 2.264 (32), 1.708 (32), 1.641 (29)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
B_2O_3	32.40	30.2	34.15	ZnO	3.13		
SiO_2			1.37	MgO	1.66		7.59
Fe_2O_3			0.13	CaO	25.40		23.96
FeO			1.20	H_2O	8.51	11.9	13.40
MnO	28.30		17.87	insol.	0.84		
				Total	100.24		99.67

(1) Franklin, New Jersey, USA; corresponding to $Ca_2(Mn_{1.67}Mg_{0.16}Zn_{0.06})_{\Sigma=1.89}B_4O_7(OH)_6$. (2) Do.; partial analysis; by electron microprobe, B_2O_3 on a separate sample, H_2O by DTA–TGA; with cations stated to correspond to $Ca_{1.91}(Mn_{1.89}Mg_{0.16}Zn_{0.04})_{\Sigma=2.09}B_4O_7(OH)_6$. (3) Solongo deposit, Russia; corresponding to $Ca_{1.76}(Mn_{1.04}Mg_{0.78}Fe^{2+}_{0.06})_{\Sigma=1.88}B_{4.04}O_{6.67}(OH)_{6.06}$.

Polymorphism & Series: Forms a series with fedorovskite.

Occurrence: Very rare in hydrothermal veins in a metamorphosed stratiform zinc orebody (Franklin, New Jersey, USA).

Association: Clinochrysotile, calcite, franklinite, willemite, zincite (Franklin, New Jersey, USA).

Distribution: From Franklin, Sussex Co., New Jersey, USA. At the Solongo boron deposit, Buryatia, Russia.

Name: To honor George Rowe (1868–1947), Mine Captain at Franklin, New Jersey, USA, and long-time collector of Franklin minerals.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 96252; National Museum of Natural History, Washington, D.C., USA, 105493, C6291.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 377–378. (2) Aristarain, L.F., R.C. Erd, and G.D. Eberlein (1974) Roweite from Franklin, New Jersey: a restudy. Amer. Mineral., 59, 66–70. (3) Moore, P.B. and T. Araki (1974) Roweite, $Ca_2Mn_2^{2+}(OH)_4[B_4O_7(OH)_2]$: its atomic arrangement. Amer. Mineral., 59, 60–65. (4) Malinko, S.V., T.I. Stolyarova, and D.P. Shashkin (1972) The first finding of magnesium roweite, its paragenesis and products of replacement. Zap. Vses. Mineral. Obshch., 101, 465–473 (in Russian). (5) Yamnova, N.A., M.A. Simonov, and N.V. Belov (1975) Crystallochemical structure of roweite, $Ca_2(Mn,Mg)_2[B_4O_7(OH)_2](OH)_4$. Doklady Acad. Nauk SSSR, 221, 1326–1329 (in Russian). (6) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 641–642.

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Rowlandite-(Y) $Y_4Fe^{2+}Si_4O_{14}F_2(?)$

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Crystal Data: Triclinic; commonly metamict. *Point Group:* 1 or $\bar{1}$. As small irregular masses.

Physical Properties: Hardness = 5.5–6.5 D(meas.) = 4.39 when metamict; 4.55 when heated at 900 °C for one hour; 4.85 when crystalline. D(calc.) = [4.33]

Optical Properties: Transparent in thin fragments. *Color:* Pale dull green, grayish white; alters to brick-red material. *Luster:* Vitreous; waxy when altered.
Optical Class: Biaxial (+); isotropic when metamict. $n = 1.704$, metamict; 1.76 when heated at 900 °C for one hour. $\alpha = 1.763$ $\beta =$ n.d. $\gamma = 1.769$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P1$ or $P\bar{1}$. $a = 6.59$ $b = 8.65$ $c = 5.53$ $\alpha = 99°2'$ $\beta = 104°8'$ $\gamma = 91°28'$ Z = 1

X-ray Powder Pattern: Baringer Hill, Texas, USA; pattern from metamict material heated one hour in nitrogen at 900 °C; matches crystalline material.
3.06 (100), 4.87 (60), 3.51 (55), 3.59 (50), 2.076 (45), 1.720 (40), 2.608 (35)

Chemistry:

	(1)	(2)
SiO_2	25.98	30.59
UO_2	0.40	
Y_2O_3	61.91	57.47
FeO	4.69	9.14
CaO	0.19	
F		4.84
LOI	2.01	
$-O = F_2$		2.04
Total		100.00

(1) Baringer Hill, Texas, USA; partial analysis. (2) $Y_4FeSi_4O_{14}F_2$.

Occurrence: In some rare-earth-rich pegmatites.

Association: Gadolinite, yttrialite (Baringer Hill, Texas, USA).

Distribution: In the Baringer Hill pegmatite, 26 km west of Burnet, Llano Co., and from Clear Creek, Burnet Co., Texas, USA. In the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada. From an unspecified locality in Kazakhstan.

Name: For Henry Augustus Rowland (1848–1901), American physicist and spectroscopist, of Johns Hopkins University, Baltimore, Maryland, USA, student of the spectra of the rare earth elements, and for its *yttrium* content.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 134649.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 1047.
(2) Frondel, C. (1961) Two yttrium minerals: spencite and rowlandite. Can. Mineral., 6, 576–581.
(3) Shipovalov, Y.V. and A.V. Stepanov (1971) X-ray structural study of rowlandite. Issled. Oblast. Khim. Fiz. Metod. Anal. Min. Syr'ya, 189–192 (in Russian). (4) (1976) Mineral. Abs., 27, 67 (abs. ref. 3).

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Roxbyite Cu_9S_5

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$, m, or 2. As single crystals, to 0.01 mm, epitaxially intergrown with djurleite; in powdery mixtures with djurleite.

Physical Properties: *Cleavage:* Poor on {100}. Hardness = n.d. VHN = 83 (50 g load). D(meas.) = n.d. D(calc.) = 5.49

Optical Properties: Opaque. *Color:* Blue-black; in reflected light, white to off-white with a blue tinge. *Anisotropism:* Very weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 53.79$ $b = 30.90$ $c = 13.36$ $\beta = 90.0°$ Z = 512

X-ray Powder Pattern: Olympic Dam, Australia.
1.933 (100), 2.375 (90), 1.857 (80), 2.86 (70), 2.630 (50), 1.673 (25), 1.626 (20)

Chemistry:

	(1)	(2)	(3)
Cu	77.25	79.47	78.10
Fe	0.77	0.07	
S	22.19	21.94	21.90
Total	100.21	101.48	100.00

(1) Olympic Dam, Australia; by electron microprobe, corresponding to $(Cu_{8.80}Fe_{0.10})_{\Sigma=8.90}S_{5.00}$. (2) Do.; by electron microprobe, corresponding to $Cu_{9.15}S_{5.00}$. (3) Cu_9S_5.

Occurrence: A low-temperature alteration product of djurleite, in a complex polymetallic hydrothermal deposit (Olympic Dam, Australia); in a porphyry copper deposit (El Teniente mine, Chile).

Association: Djurleite, bornite, pyrite, chalcopyrite, hematite (Olympic Dam, Australia); djurleite (El Teniente mine, Chile).

Distribution: From the Olympic Dam Cu–Au–U deposit, Roxby Downs Station, near Woomera, South Australia [TL]. In the El Teniente mine, 67 km west of Rancagua, O'Higgins Province, Chile.

Name: For its occurrence at Roxby Downs, South Australia.

Type Material: Museum Victoria, Melbourne, Australia, M37924; The Natural History Museum, London, England, 1988,28.

References: (1) Mumme, W.G., G.J. Sparrow, and G.S. Walker (1988) Roxbyite, a new copper sulphide mineral from the Olympic Dam deposit, Roxby Downs, South Australia. Mineral. Mag., 52, 323-330. (2) (1989) Amer. Mineral., 74, 947 (abs. ref. 1).

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Rozenite $Fe^{2+}SO_4 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As cottonball-like concretions and nodules; most commonly as powdery efflorescences or coatings on melanterite.

Physical Properties: Hardness = [2–3] (by analogy to rozenite group members). D(meas.) = 2.293 (synthetic). D(calc.) = 2.29 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless, white, pale green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.527$ $\beta = 1.536$ $\gamma = 1.541$–1.543 (γ') 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 5.979(4)$ $b = 13.648(4)$ $c = 7.977(3)$ $\beta = 90°26(10)'$ Z = 4

X-ray Powder Pattern: Manitoba, Canada.
4.47 (10), 5.46 (9), 4.47 (7), 3.40 (6), 6.85 (5), 3.22 (5), 2.953 (5)

Chemistry:

	(1)	(2)	(3)
SO_3	36.29	35.91	35.75
Fe_2O_3		0.80	
FeO	31.13	30.65	32.08
MnO	0.06		
MgO	0.97		
H_2O	32.98	31.90	32.17
Total	[101.43]	99.26	100.00

(1) Staszic mine, Poland; original total given as 100.43%, corresponds to $Fe_{1.01}S_{0.99}O_4 \cdot 3.97H_2O$. (2) Manitoba, Canada; corresponds to $Fe_{0.98}S_{1.02}O_4 \cdot 4.02H_2O$. (3) $FeSO_4 \cdot 4H_2O$.

Mineral Group: Rozenite group.

Occurrence: An uncommon secondary mineral, formed at or below 21 °C and under low humidity directly from copper-free melanterite, in turn an alteration product of pyrite or marcasite; commonly a post-mining product, in lake-bed sediments, or coal seams.

Association: Melanterite, epsomite, jarosite, gypsum, sulfur, pyrite, marcasite, "limonite".

Distribution: In Poland, from Mt. Ornak, Tatra Mountains, and in the Staszic pyrite mine, Rudki. From the Voras Mountains, 17 km north-northwest of Ardéa, Greece. At Alšar (Allchar), near Rošden, Macedonia. In the Cetine mine, near Rosia, Tuscany, Italy. From Bleiberg, Carinthia, Austria. At Ramsbeck, North Rhine-Westphalia, Germany. In England, from the Oughterside coal mine, near Aspatria, Cumbria. In Scotland, at Slateford, near Edinburgh, from the West Mains coal mine, West Calder; and in the Howcommon limestone mine, Kilmarnock. In Canada, in Twp. 24, R28, west of 1st meridian, Manitoba; at the Spatsum claim, south of Ashcroft Manor, British Columbia; in the Dundas quarry, Dundas, Ontario. In the USA, from Bisbee, Cochise Co., Arizona; in the Kalkar quarry, Santa Cruz, Santa Cruz Co., California; at the Goldstrike mine, Lynn district, Humboldt Co., and other localities in Nevada. At Navarana fjord, Freuchen Land, Greenland. From Paddy's River mine, Australian Capital Territory. Additional localities are known.

Name: To honor Zygmunt Rozen (1874–1936), mineralogist and petrographer, Academy of Mining and Metallurgy, Kraców, Poland.

Type Material: Academy of Mining and Metallurgy, Kraców, Poland.

References: (1) Kubisz, J. (1960) Rozenite, $FeSO_4 \cdot 4H_2O$, a new mineral. Bull. acad. polonaise sci., Ser. sci. geol. geogr., 8, 97–113 (in English). (2) (1961) Amer. Mineral., 46, 242–243 (abs. ref. 1). (3) Jambor, J.L. and R.J. Traill (1963) On rozenite and siderotil. Can. Mineral., 7, 751–763. (4) Baur, W.H. (1962) Zur Kristallchemie der Salzhydrate. Die Kristallstrukturen von $MgSO_4.4H_2O$ (Leonhardtit) und $FeSO_4.4H_2O$. Acta Cryst., 15, 815–826 (in German with English abs.).

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Ruarsite RuAsS

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Crystal Data: Monoclinic. *Point Group:* n.d. As irregular grains or as aggregates, to 100–150 μm, having rough textured surfaces.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 893 (50 g load) low % Os grains; 734 (50 g load) for 14% Os. D(meas.) = n.d. D(calc.) = 7.08

Optical Properties: Opaque. *Color:* Lead-gray to dark lead-gray; grayish white in polished section. *Streak:* Grayish black. *Luster:* Metallic. *Pleochroism:* Pale yellowish white to pale grayish yellow-white. *Anisotropism:* Distinct, bluish gray to light reddish.
R_1–R_2: (480) 43.4, (546) 44.1, (589) 43.8, (656) 45.1

Cell Data: *Space Group:* n.d. $a = 5.931$ $b = 5.915$ $c = 6.003$ $\beta = 112°27'$ $Z = 4$

X-ray Powder Pattern: Anduo, Tibet, China.
2.77 (100), 1.870 (90), 1.695 (90), 1.890 (70), 1.660 (60), 3.79 (50), 1.580 (50)

Chemistry:

	(1)	(2)
Ru	42.45	48.58
Os	5.94	
Ir	1.67	
Pt	0.07	
Cu	0.00	
As	36.25	36.01
Sb	0.00	
S	14.08	15.41
Total	100.36	100.00

(1) Anduo, Tibet, China; by electron microprobe, average of eight analyses of seven grains; corresponding to $(Ru_{0.91}Os_{0.05}Ir_{0.02})_{\Sigma=0.98}As_{1.05}S_{0.94}$. (2) RuAsS.

Mineral Group: Arsenopyrite group.

Occurrence: In heavy mineral concentrates and in chromium ore derived from an Alpine-type ultramafic (Anduo, Tibet, China).

Association: Iridosmine, rutheniridosmine, ruthenosmiridium, Pt–Ir alloy, Ru–Fe alloy, osmium, sperrylite, laurite, chromian spinel, pyrite, pyrrhotite, löllingite, magnetite, chalcopyrite, molybdenite, galena, millerite (Anduo, Tibet, China).

Distribution: From the Anduo chromite deposit, northern Tibet, China [TL]. At the Neozhidannyy Creek placers, Tuva, Russia. In the Kapitanov chromite deposit, near Zvenyhorodka, Ukraine. From the Kraubath ultramafic massif, Styria, Austria. At the Kelly Lake Ni–Cu sulfide deposit, Sudbury, Ontario, Canada.

Name: For the chemical composition RUthenium, ARsenic, and Sulfur.

Type Material: Museum of Geology, (Beijing?), China.

References: (1) Yu Tsu-hsiang [Yu Zuxiang] and Hsueh-tsi Chou (1979) Ruarsite, a new mineral. K'o Hsueh T'ung Pao, 24, 310–316 (in Chinese). (2) (1980) Amer. Mineral., 65, 1068–1069 (abs. ref. 1). (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 133.

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Rucklidgeite $(Bi, Pb)_3Te_4$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As foliated aggregates, to 13 mm, and as smaller grains.

Physical Properties: *Cleavage:* Perfect on {0001}; "average" on rhombohedron. *Tenacity:* Flexible; brittle. Hardness = n.d. VHN = 51.6–62.9 (10 g load). D(meas.) = 7.739 D(calc.) = 8.06

Optical Properties: Opaque. *Color:* Silver-white; in polished section, white with very weak rose tint. *Streak:* Lead-gray. *Luster:* Metallic. *Pleochroism:* Very weak in air, noticeable in oil. *Anisotropism:* Distinct, reddish brown to bluish gray.
R_1–R_2: (400) 62.9–62.1, (420) 62.9–62.0, (440) 63.0–61.8, (460) 63.2–61.8, (480) 63.7–61.8, (500) 64.4–61.9, (520) 65.0–62.0, (540) 65.3–62.1, (560) 65.5–62.2, (580) 65.8–62.2, (600) 66.1–62.3, (620) 66.4–62.4, (640) 66.5–62.6, (660) 66.6–62.8, (680) 66.7–63.0, (700) 66.6–63.2

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.422$ $c = 41.49$ $Z = 3$

X-ray Powder Pattern: Kochkar deposit, Russia.
3.22 (100), 2.34 (90), 1.473 (60), 1.976 (50), 2.21 (40), 1.822 (40), 1.607 (40)

Chemistry:

	(1)	(2)		(1)	(2)
Bi	37.4	38.1	Sb	1.0	2.9
Pb	15.4	13.6	Te	43.9	44.2
Ag	1.2	1.1	Total	98.9	99.9

(1) Kochkar deposit, Russia; by electron microprobe, corresponding to $(Bi_{2.08}Pb_{0.88}Ag_{0.13})_{\Sigma=3.09}Te_{4.00}$. (2) Zod deposit, Armenia; by electron microprobe, corresponding to $(Bi_{2.11}Pb_{0.78}Ag_{0.12}Sb_{0.10})_{\Sigma=3.11}Te_{4.00}$.

Occurrence: Of hydrothermal origin.

Association: Gold, arsenopyrite, boulangerite, dolomite (Kochkar deposit, Russia); tellurobismuthite, volynskite, calaverite, hessite (Ashley deposit, Canada); altaite, galena, volynskite, hessite, melonite, chalcopyrite, michenerite, hawleyite (Kambalda, Australia).

Distribution: In Russia, from the Kochkar gold deposit, Plast, Southern Ural Mountains [TL]; at the Alekseevskoye mine, Sutam district, Stanovoi Range, southeast Yakutia; in the Mount General'skaya massif, Kola Peninsula. From the Zod gold deposit, 14 km east of Vardenis, Armenia [TL]. In the Aidarly porphyry copper deposit, Kazakhstan. At Oldřichov, near Tachov, Czech Republic. From the Dragset deposit, south Trondelag, Norway. In the USA, at the Campbell mine, Bisbee, Cochise Co., Arizona; from the Hesperus mine, La Plata Co., Colorado; in the Olinghouse mine, Olinghouse district, Washoe Co., Nevada. In Canada, from the Ashley deposit, Bannockburn Township, Ontario; in the Robb-Montbray mine, Montbray Township, Quebec; at the ABO prospect, Harrison Hot Springs, British Columbia. From the Lunnon Shoot, Kambalda, 56 km south of Kalgoorlie, Western Australia, and at Crown Reef, Norseman, Western Australia. From the Yanahara mine, Okayama Prefecture, Japan. In the Bulawan Au–Ag–Te deposit, Negros Occidental, Phillipines.

Name: Honors Dr. John Christopher Rucklidge (1938–), Canadian mineralogist, University of Toronto, Toronto, Canada, who first noted a mineral of analogous composition in the Robb-Montbray deposit, Ontario, Canada.

Type Material: Vernadsky Geological Museum, Moscow, 50743; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 83005, 87446, vis 245, vis247.

References: (1) Zav'yalov, E.N. and V.D. Begizov (1977) Rucklidgeite, $(Bi, Pb)_3Te_4$, a new mineral from the Zod and Kochkar gold ore deposits. Zap. Vses. Mineral. Obshch., 106, 62–68 (in Russian). (2) (1978) Amer. Mineral., 63, 599 (abs. ref. 1). (3) Harris, D.C., W.D. Sinclair, and R.I. Thorpe (1983) Telluride minerals from the Ashley deposit, Bannockburn Township, Ontario. Can. Mineral., 21, 137–143. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 488.

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Rudenkoite $Sr_3Al_{3.5}Si_{3.5}O_{10}(OH_{7.5},O_{0.5})Cl_2•H_2O$

Crystal Data: Monoclinic. *Point Group: m*, 2 or 2/*m*. As spheroidal aggregates of radiating fibers, to 7 mm, elongated on [100].

Physical Properties: *Cleavage:* None. *Fracture:* n.d. *Tenacity*: Flexible. Hardness = 1.5 (for aggregates). D(meas.) = 3.17(1) D(calc.) = 3.18

Optical Properties: Translucent. *Color:* White. *Luster:* n.d.
Optical Class: Biaxial (+). α = 1.639(2) β = 1.648(2) γ = 1.665(2) 2V(meas.) = 75(10)°
2V(calc.) = 72.71° *Dispersion:* Average, $r > v$. *Orientation:* $X = a$. *Pleochroism*: None.

Cell Data: *Space Group: P2/m*, *P*2, or *Pm*. a = 5.893(5) b = 7.262(5) c = 10.288(8)
β = 97.23(3)° Z = 1

X-ray Powder Pattern: Emel'dzhaksky deposit, Aldan province, southern Yakutsk, Russia.
10.13 (100), 2.96 (100), 2.90 (100), 2.505 (100), 3.23 (80), 2.182 (80), 1.855 (70)

Chemistry:

	(1)
CaO	0.86
SrO	34.61
BaO	0.54
Al_2O_3	21.01
SiO_2	24.73
Cl	9.06
H_2O	10.10
-O = Cl	2.04
Total	98.87

(1) Emel'dzhaksky deposit, Aldan province, southern Yakutsk, Russia; electron microprobe analysis, H_2O by Penfield method, OH^- and H_2O confirmed by IR; corresponding to $(Sr_{2.83}Ba_{0.33}Ca_{0.13})_{\Sigma=2.99}(Al_{3.49}Si_{3.48})_{\Sigma=6.97}O_{10.16}(OH)_{7.88}Cl_{2.16}•0.8H_2O$.

Occurrence: Formed in the last stages of (metasomatic) prehnitization, in garnet-wollastonite metamorphic rock (skarn) at the contact between pegmatite and calcite marble.

Association: Prehnite, calcite, spinel, diopside, fluorapatite.

Distribution: At the Emel'dzhaksky phlogopite deposit, Aldan province, Aldan Shield, southern Yakutsk, Russia.

Name: Honors Professor Sergey Alexandrovich Rudenko (1917-1992), a specialist in minerals of alkaline pegmatites, St. Petersburg (Leningrad) Mining Institute, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Science, Moscow, Russia; 3121/1.

References: (1) Chukanov, N.V., V.T. Dubinchuk, M.N. Murashko, A.E. Zadov, and V.Yu. Karpenko, (2004) Rudenkoite, $Sr_3Al_{3.5}Si_{3.5}O_{10}(OH_{7.5},O_{0.5})Cl_2•H_2O$, a new mineral from phlogopite deposits of southern Yakutsk. Zapiski Vseross. Mineral. Obshch. 133(3), 37-41 (in Russian, English abstract). (2) (2005) Amer. Mineral., 90, 770-771 (abs. ref. 1).

Ruitenbergite $Ca_9B_{26}O_{34}Cl_4(OH)_{24}\cdot 13H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Anhedral granular, to 7 mm.

Physical Properties: *Cleavage:* On {100}, good. *Fracture:* Even to slightly conchoidal. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = n.d. D(calc.) = 2.13

Optical Properties: Transparent to translucent. *Color:* Colorless to very pale yellow; colorless in transmitted light; blue-gray in reflected light. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z = c$; $Y \wedge a = 25°$. $\alpha = 1.542(1)$ $\beta = 1.545(1)$ $\gamma = 1.565(1)$ 2V(meas.) = 47(1)° 2V(calc.) = 42.5°

Cell Data: *Space Group:* $P2_1$. $a = 19.857(7)$ $b = 9.708(4)$ $c = 17.522(6)$ $\beta = 115.68(3)°$ Z = 2

X-ray Powder Pattern: Potash Corporation of America mine, Penobsquis, Canada. 8.56 (100), 6.62 (70), 9.03 (60), 6.14 (30b), 5.12 (30), 4.09 (30), 3.786 (30)

Chemistry:

	(1)	(2)
B_2O_3	46.72	45.94
CaO	26.33	25.62
Cl	6.28	7.20
H_2O	[22.09]	22.86
$-O = Cl_2$	1.42	1.62
Total	[100.00]	100.00

(1) Potash Corporation of America mine, Penobsquis, Canada; by electron microprobe, average of two analyses, H_2O by difference; corresponds to $Ca_{9.27}B_{26.51}O_{34.97}Cl_{3.50}(OH)_{24.63}\cdot 11.90H_2O$. (2) $Ca_9B_{26}O_{34}Cl_4(OH)_{24}\cdot 13H_2O$.

Polymorphism & Series: Dimorphous with pringleite.

Occurrence: Very rare, in an evaporite deposit.

Association: Halite, pringleite, hilgardite-1A, sylvite, anhydrite, quartz, clays.

Distribution: From the Potash Corporation of America mine, Penobsquis evaporite deposit, near Sussex, New Brunswick, Canada.

Name: To honor Dr. Arie A. Ruitenberg (1929–), geologist, Geological Surveys Branch, New Brunswick Department of Natural Resources, Sussex, Canada, for his contributions to the mineral industry in New Brunswick.

Type Material: Geological Survey of Canada, Ottawa, 66920; Canadian Museum of Nature, Ottawa, Canada, 82047.

References: (1) Roberts, A.C., J.A.R. Sterling, J.D. Grice, P.C. Burns, B.V. Roulston, J.D. Curtis, and J.L. Jambor (1993) Pringleite and ruitenbergite, polymorphs of $Ca_9B_{26}O_{34}(OH)_{24}Cl_4\cdot 13H_2O$, two new mineral species from Sussex, New Brunswick. Can. Mineral., 31, 795–800. (2) (1995) Amer. Mineral., 80, 1011–1012 (abs. ref. 1). (3) Grice, J.D., P.C. Burns, and F.C. Hawthorne (1994) Determination of the megastructures of the borate polymorphs pringleite and ruitenbergite. Can. Mineral., 32, 1–14.

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Ruizite $Ca_2Mn_2^{3+}Si_4O_{11}(OH)_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Euhedral prismatic crystals, to 1 mm, elongated ‖ [010] and somewhat flattened on {100}; as spherules of radial acicular crystals. *Twinning:* Common on {100}, always involving only two individuals.

Physical Properties: Hardness = ∼5 D(meas.) = 2.9(1) D(calc.) = 2.997

Optical Properties: Translucent. *Color:* Orange, inclining to brown. *Streak:* Pale apricot. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 44°$. *Dispersion:* $r > v$, strong, inclined. *Absorption:* $Y > Z \gg X$. $\alpha = 1.663$ $\beta = 1.715$ $\gamma = 1.734$ 2V(meas.) = 60.2° 2V(calc.) = 60.7°

Cell Data: *Space Group:* $C2/m$. $a = 11.95$–11.976 $b = 6.17$–6.175 $c = 9.03$–9.064 $\beta = 91.375°$ Z = 4

X-ray Powder Pattern: Christmas, Arizona, USA.
11.95 (100), 4.19 (70), 3.12 (60), 5.09 (50), 3.64 (40), 2.951 (40), 2.591 (40)

Chemistry:

	(1)	(2)
SiO_2	39.14	41.26
Mn_2O_3	23.42	27.11
CaO	20.57	19.26
H_2O	16.0	12.37
Total	99.13	100.00

(1) Christmas, Arizona, USA; SiO_2 by solvent extraction, Mn and Ca by AA, H_2O by the Penfield method. (2) $Ca_2Mn_2Si_4O_{11}(OH)_4 \cdot 2H_2O$.

Occurrence: In veinlets and on fracture surfaces in metalimestones, formed during cooling of a high-temperature calc-silicate assemblage under oxidizing conditions (Christmas, Arizona, USA).

Association: Apophyllite, kinoite, junitoite, wollastonite, grossular, diopside, vesuvianite, calcite, chalcopyrite, bornite, sphalerite, smectite (Christmas, Arizona, USA); apophyllite, pectolite, datolite, inesite, orientite, quartz (Wessels mine, South Africa).

Distribution: In the Christmas copper mine, Christmas, Gila Co., Arizona, USA. From the N'Chwaning and Wessels mines, near Kuruman, Cape Province, South Africa.

Name: For Joe Ana Ruiz, of Mammoth, Arizona, USA, collector of microscopic minerals, who discovered the mineral.

Type Material: University of Arizona, Tucson, Arizona; Harvard University, Cambridge, Massachusetts, 119096; National Museum of Natural History, Washington, D.C., USA, 136689; The Natural History Museum, London, England, 1980,534.

References: (1) Williams, S.A. and M. Duggan (1977) Ruizite, a new silicate mineral from Christmas, Arizona. Mineral. Mag., 41, 429–432. (2) (1978) Amer. Mineral., 63, 794–795 (abs. ref. 1). (3) Wilson, W.E. and P.J. Dunn (1978) The Kalahari manganese field. Mineral. Record, 9, 137–153. (4) Hawthorne, F.C. (1984) The crystal structure of ruizite, a sorosilicate with an $[Si_4Ø_{13}]$ cluster. Tschermaks Mineral. Petrog. Mitt., 33, 135–146. (5) Moore, P.B., J. Shen, and T. Araki (1985) Crystal chemistry of the $^2_\infty[M_2^{3+}\Phi_2(TO_4)_2]$ sheet: structural principles and crystal structures of ruizite, macfallite and orientite. Amer. Mineral., 70, 171–181.

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Rumseyite $[Pb_2OF]Cl$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As aggregates of minute tabular to prismatic crystals with pyramidal terminations.

Physical Properties: *Cleavage*: Perfect on {100}. *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = ~ 3 VHN = 140 (100 g load). D(meas.) = n.d. D(calc.) = 7.72

Optical Properties: Translucent. *Color*: Pale orange-brown, gray in reflected light with abundant pale-yellow internal reflections. *Streak*: White. *Luster*: Vitreous.
Optical Class: n.d. n = 2.15 [calculated]
R: (470) 14.6, (546) 13.6, (589) 13.4, (650) 13.2

Cell Data: *Space Group*: *I*4/*mmm*. a = 4.065(1) c = 12.631(7) Z = 2

X-ray Powder Pattern: Torr Works (Merehead) quarry, England.
2.923 (100), 2.875 (68), 3.848 (41), 6.306 (17), 1.680 (14), 2.110 (12), 2.049 (10)

Chemistry:

	(1)	(2)
PbO	90.63	92.07
F	3.53	3.92
Cl	7.15	7.31
$-O=(F+Cl)_2$	3.23	3.30
Total	99.08	100.00

(1) Torr Works (Merehead) quarry, England; average of 25 electron microprobe analyses, O calculated by difference, absence of OH^- determined by structure analysis; corresponding to $Pb_{2.039}O_{1.00}F_{0.992}Cl_{1.001}$. (2) $[Pb_2OF]Cl$.

Occurrence: Part of an assemblage of lead oxychloride minerals that occur in cavities in manganese oxide pods in limestone.

Association: Calcite, cerussite, diaboleite, hydrocerussite, pyrolusite, manganite.

Distribution: From the Torr Works (Merehead) quarry, near the village of Cranmore, Somerset, England.

Name: Honors Michael Scott (Mike) Rumsey (b. 1980), Curator and Collections Manager, the Natural History Museum, London, England.

Type Material: Natural History Museum, London, England (BM 1970,110).

References: (1) Turner, M.S., O.I. Siidra, S.V. Krivovichev, C.J. Stanley, and J. Spratt (2012) Rumseyite, $[Pb_2OF]Cl$, the first naturally occurring fluoroxychloride mineral with the parent crystal structure for layered lead oxychlorides. Mineral. Mag., 76(5), 1247-1255. (2) (2015) Amer. Mineral., 100, 662 (abs. ref. 1).

Rusakovite $(Fe^{3+}, Al)_5(VO_4, PO_4)_2(OH)_9 \cdot 3H_2O$

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Crystal Data: n.d. *Point Group:* n.d. In splinterlike lamellae, to several μm, veinlets, reniform concretions, and in crusts.

Physical Properties: Hardness = 1.5–2 D(meas.) = 2.73–2.80 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Gold-yellow, yellow-orange, yellowish red. *Streak:* Ocher-yellow. *Luster:* Dull.
Optical Class: Isotropic, or nearly so; weakly birefringent. $n = 1.833(4)$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Balasauskandyk deposit, Kazakhstan.
3.21 (10), 2.945 (9), 2.441 (8), 2.140 (7), 1.569 (6), 4.20 (5), 5.17 (4)

Chemistry:

	(1)	(2)
P_2O_5	6.50	5.80
V_2O_5	16.60	16.13
V_2O_4	5.00	5.10
SO_2	1.00	1.70
SiO_2	1.80	2.50
Al_2O_3	5.00	5.50
Fe_2O_3	45.00	43.70
MgO	1.40	trace
CaO	0.30	0.40
H_2O^+	13.30	14.60
H_2O^-	5.00	4.80
Total	100.90	100.23

(1–2) Balasauskandyk deposit, Kazakhstan.

Occurrence: In the oxidized zone of a vanadium-rich carbonaceous shale.

Association: Apatite, collophane, ferric allophane, vanadian mica, iron hydroxides, sulfides of Cu, Zn, Pb, V.

Distribution: From the Balasauskandyk vanadium deposit, northwest Kara-Tau Mountains, southern Kazakhstan.

Name: To honor Mikhail Petrovich Rusakov (1892–1963), Kazakh geologist, Institute of Geosciences, Alma-Ata, Kazakhstan.

Type Material: Mining Institute, St. Petersburg, 1250/2–3; Vernadsky Geological Museum, Moscow, 49848; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 62758.

References: (1) Ankinovich, E.A. (1960) A new vanadium mineral – rusakovite. Zap. Vses. Mineral. Obshch., 89, 440–447 (in Russian). (2) (1960) Amer. Mineral., 45, 1316 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 176–177.

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Rusinovite $Ca_{10}(Si_2O_7)_3Cl_2$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As fine-needles in fibrous sheaf-like aggregates and spherulites.

Physical Properties: *Cleavage*: Good on (010). *Fracture*: Conchoidal. *Tenacity*: Brittle. Hardness = 4-5 VHN = 320 (20 g load). D(meas.) = 2.93(1) D(calc.) = 2.931

Optical Properties: Transparent. *Color*: White, colorless in thin section. *Streak*: White. *Luster*: Vitreous to silky.
Optical Class: Biaxial (–). α = 1.645(2) β = 1.664(2) γ = 1.675(3) 2V(meas.) = 75(10)° 2V(calc.) = 75° *Orientation*: *X* = *a* (or *b*), *Y* = c, *Z* = *b* (or *a*).

Cell Data: *Space Group: Cmcm.* *a* = 3.7617(2) *b* = 16.9385(8) *c* = 17.3196(9) *Z* = 2

X-ray Powder Pattern: Upper Chegem caldera, near Mt. Lakargi, Northern Caucasus, Russia. 3.081 (100), 3.030 (79), 2.889 (74), 2.537 (74), 2.946 (43), 8.47 (39), 3.209 (33)

Chemistry:

	(1)
SiO_2	37.16
CaO	57.66
Cl	6.78
H_2O	[0.13]
–O=Cl	1.53
Total	100.20

(1) Upper Chegem caldera, near Mt. Lakargi, Northern Caucasus, Russia; average of 45 electron microprobe analyses, H_2O calculated for charge balance, corresponding to $Ca_{9.99}Si_{6.01}O_{21}(Cl_{1.86}OH_{0.14})$.

Occurrence: In a thermally altered (sanidinite facies) carbonate-silicate xenolith about 10 m in size enclosed in ignimbrite.

Association: Wadalite, wollastonite, trabzonite, rankinite, larnite.

Distribution: Upper Chegem caldera, near Mt. Lakargi, Kabardino-Balkaria, Northern Caucasus, Russia.

Name: Honors Vladimir L. Rusinov (1935-2007), a Russian petrologist who studied the thermodynamics of non-equilibrium mineral systems.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (4022/1).

References: (1) Galuskin, E.V., I.O. Galuskina, B. Lazic, T. Armbruster, A.E. Zadov, T. Krzykawski, K. Banasik, V.M. Gazeev, and N.N. Pertsev (2011) Rusinovite, $Ca_{10}(Si_2O_7)_3Cl_2$: a new skarn mineral from the Upper Chegem caldera, Kabardino-Balkaria, Northern Caucasus, Russia. European Journal of Mineralogy, 23, 837-844. (2) (2014) Amer. Mineral., 99, 873 (abs. ref. 1).

Russellite Bi_2WO_6

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Fine-grained, compact, massive, commonly intimately intermixed with other species.

Physical Properties: Hardness = 3.5 D(meas.) = 7.35(2) D(calc.) = [9.50]

Optical Properties: Semitransparent. *Color:* Pale yellow, greenish.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pca2_1$ (synthetic). $a = 5.43726(2)$ $b = 16.43018(5)$ $c = 5.45842(20)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.151 (100), 2.738 (29), 2.729 (22), 2.719 (22), 1.646 (21), 1.575 (21), 1.650 (20)

Chemistry:

	(1)	(2)	(3)
WO_3	25.50	31.30	33.22
Fe_2O_3	trace	1.92	
As_2O_3	0.26		
Bi_2O_3	68.26	59.04	66.78
PbO		1.89	
LOI	4.86		
insol.	1.60		
Total	100.48	94.15	100.00

(1) Castle-an-Dinas mine, England. (2) Flo property, Canada; by electron microprobe, total Fe as Fe_2O_3; corresponding to $(Bi_{1.59}Pb_{0.05})_{\Sigma=1.64}(W_{0.85}Fe_{0.15})_{\Sigma=1.00}O_6$. (3) Bi_2WO_6.

Occurrence: An alteration product of earlier bismuth minerals in Sn–W-bearing high-temperature hydrothermal mineral deposits, greisens, or granite pegmatites.

Association: Bismuth, bismuthinite, bismite, wolframite, ferberite, scheelite, ferritungstite, anthoinite, mpororoite, koechlinite, cassiterite, topaz, muscovite, tourmaline, quartz.

Distribution: In England, at the Castle-an-Dinas mine, St. Columb Major, and the Hingston Down quarry, Calstock, Cornwall; and from Buckbarrow Beck, Corney Fell, Cumbria. In Germany, at the Himmelsfürst mine, Erbisdorf, near Freiberg, and at Altenberg, Saxony, and in the Clara Mine, near Oberwolfach, Black Forest. From Krupka, Krušné hory Mountains, Czech Republic. In Canada, on the Nug-4 claim, Nahani River area, Northwest Territories, and the Flo property, Kalzas Mountain, 67 km southeast of Mayo, Yukon Territory. At Sylvanite, Hidalgo Co., New Mexico, USA. From near Poona, Western Australia. At Bugaya, Uganda. In the Kara-Oba Mo–W deposit, the Bom-Gorkhon deposit, and the Spokoynoye deposit, Kazakhstan.

Name: To honor Sir Arthur Edward Ian Montagu Russell (1878–1964), British mineralogist and mineral collector, of Swallowfield Park, Berkshire, England.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1934,615.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 604–605. (2) Hodge, L.C. (1970) Russellite: a second occurrence. Mineral. Mag., 37, 705–707. (3) Knight, K.S. (1992) The crystal structure of russellite; a re-determination using neutron powder diffraction of synthetic Bi_2WO_6. Mineral. Mag., 56, 399–409. (4) Ercit, T.S. and G.W. Robinson (1994) A refinement of the structure of ferritungstite from Kalzas Mountain, Yukon, and observations on the tungsten pyrochlores. Can. Mineral., 32, 567–574.

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Rustenburgite $(Pt,Pd)_3Sn$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As grains, rarely showing {001}, to 100 μm, and as droplike inclusions.

Physical Properties: Hardness = n.d. VHN = 365 (25 g load). D(meas.) = n.d. D(calc.) = 15.08

Optical Properties: Opaque. *Color:* In polished section, pale cream. *Luster:* Metallic. *Anisotropism:* Slight, due to strain.
R_1–R_2: (480) 56.2, (546) 59.8, (589) 60.4, (656) 61.65

Cell Data: *Space Group:* $Fm3m$ (probable) or $Pm3m$. a = 3.991 Z = 4

X-ray Powder Pattern: Merensky Reef, South Africa.
2.295 (100), 1.202 (100), 1.408 (90), 0.9153 (90), 0.8145 (90), 1.992 (80), 0.8922 (80)

Chemistry:

	(1)
Pt	53.44
Pd	28.28
Sn	17.70
Total	99.42

(1) Merensky Reef, South Africa; by electron microprobe, corresponding to $(Pt_{1.52}Pd_{1.48})_{\Sigma=3.00}Sn_{0.83}$.

Polymorphism & Series: Forms a series with atokite.

Occurrence: As very sparse grains in concentrates (Merensky Reef, South Africa).

Association: Atokite, unspecified platinum tellurides (Merensky Reef, South Africa); moncheite, pyrrhotite, pentlandite (Stillwater complex, Montana, USA).

Distribution: In the Rustenburg [TL], Atok, and Onverwacht mines, on the Merensky Reef, Bushveld complex, Transvaal, South Africa. From the Upper Banded Zone of the Stillwater complex, Montana, USA. In Russia, at Noril'sk, western Siberia; from the Ioko-Dovyren ultramafic pluton, northern Baikal district, eastern Siberia.

Name: For its occurrence in the Rustenburg mine, South Africa.

Type Material: n.d.

References: (1) Mihálik, S.A., S.A. Hiemstra, and J.P.R. de Villiers (1975) Rustenburgite and atokite, two new platinum-group minerals from the Merensky Reef, Bushveld Igneous Complex. Can. Mineral., 13, 146–150. (2) (1976) Amer. Mineral., 61, 340 (abs. ref. 1).

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Rustumite $Ca_{10}(SiO_4)(Si_2O_7)_2Cl_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals crudely tabular on {100}, to 1 cm. *Twinning:* Lamellar on {100}, twin axis [001], common.

Physical Properties: *Cleavage:* Poor on {100}, very poor on {010} and {001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.94]

Optical Properties: Translucent. *Color:* Colorless. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 4°–6°$. $\alpha = 1.640$ β = n.d. $\gamma = 1.651$ 2V(meas.) = 80°

Cell Data: *Space Group:* $C2/c$. $a = 7.62(5)$ $b = 18.55(5)$ $c = 15.51(5)$ $\beta = 104°20(10)'$ $Z = 4$

X-ray Powder Pattern: Kilchoan, Scotland.
3.03 (s1), 2.89 (s2), 3.19 (s3), 2.52 (ms), 1.907 (ms), 1.752 (ms), 2.75 (m)

Chemistry:

	(1)	(2)
SiO_2	33.8	32.16
CaO	61.6	60.03
Cl		7.59
H_2O		1.93
$-O = Cl_2$		1.71
Total	95.4	100.00

(1) Kilchoan, Scotland; by electron microprobe, partial analysis; contains less than 0.2% Fe_2O_3, Al_2O_3, MgO, no CO_2; Cl not determined (later inferred during crystal structure determination, and independently confirmed). (2) $Ca_{10}(SiO_4)(Si_2O_7)_2Cl_2(OH)_2$.

Occurrence: In limestones between two ring dikes, formed during a metamorphic period in which H_2O:CO_2 in the vapor phase was relatively high (Kilchoan, Scotland).

Association: Åkermanite, merwinite, larnite, spurrite, rankinite, kilchoanite (Kilchoan, Scotland).

Distribution: In Scotland, from near Kilchoan, Ardnamurchan, Argyllshire. From Carlingford, Co. Louth, Ireland. In the Igeltjärn mine, near Persberg, Värmland, Sweden. From the Güneyce-İkizdere area, Trabzon Province, Turkey. In the La Negra mine, Maconi, Querétaro, Mexico.

Name: For Rustum Roy (1924–), experimental petrologist and materials scientist, Pennsylvania State University, University Park, Pennsylvania, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119428, 119429.

References: (1) Agrell, S.O. (1965) Polythermal metamorphism of limestones at Kilchoan, Ardnamurchan. Mineral. Mag., 34, 1–15. (2) (1965) Amer. Mineral., 50, 2104 (abs. ref. 1). (3) Howie, R.A. and V.V. Ilyukhin (1977) Crystal structure of rustumite. Nature, 269, 231.

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Ruthenarsenite (Ru, Ni)As

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As irregular inclusions, to 100 μm, in a matrix of rutheniridosmine.

Physical Properties: Hardness = n.d. VHN = 743–933 (100 g load). D(meas.) = n.d. D(calc.) = 10.0 for $Ru_{0.89}Ni_{0.11}As$.

Optical Properties: Opaque. *Color:* In polished section, pale orange-brown to brownish gray. *Pleochroism:* Distinct. *Anisotropism:* Strong, orange-brown to pale steel-gray.
R_1–R_2: (470) 46.1–48.8, (546) 47.5–49.5, (589) 49.3–50.9, (650) 51.1–52.4

Cell Data: *Space Group: Pnma* (synthetic RuAs). $a = 5.628$ $b = 3.239$ $c = 6.184$
$Z = 4$

X-ray Powder Pattern: Papua New Guinea.
2.061 (100), 2.696 (70), 2.124 (50), 1.780 (40), 1.750 (40), 1.343 (40), 1.302 (40)

Chemistry:

	(1)	(2)
Ru	44.6	29.1
Ir	4.0	
Os	2.1	
Pt		1.5
Rh	2.3	27.4
Pd	1.8	0.59
Ni	4.4	0.69
As	39.4	41.1
Sb		1.4
Total	98.6	101.78

(1) Papua New Guinea; by electron microprobe, corresponding to $(Ru_{0.79}Ni_{0.13}Ir_{0.04}Rh_{0.04}Pd_{0.03}Os_{0.02})_{\Sigma=1.05}As_{0.95}$. (2) Onverwacht mine, South Africa; by electron microprobe, corresponding to $(Ru_{0.51}Rh_{0.47}Ni_{0.02}Pt_{0.01}Pd_{0.01})_{\Sigma=1.02}(As_{0.96}Sb_{0.02})_{\Sigma=0.98}$.

Occurrence: As inclusions in Os–Ir–Ru alloys (Papua New Guinea), and in Alpine-type ultramafics.

Association: Rutheniridosmine, irarsite, iridarsenite.

Distribution: From an unspecified locality [probably the Waria River, Bowutu Mountains, or the Yodda Goldfield] in Papua New Guinea [TL]. At Anduo, Tibet, China. In the Onverwacht mine, on the Merensky Reef, Bushveld complex, Transvaal, South Africa.

Name: For RUTHENium and ARSENic in the composition.

Type Material: Canadian Museum of Nature, Ottawa, Canada.

References: (1) Harris, D.C. (1974) Ruthenarsenite and iridarsenite, two new minerals from the Territory of Papua and New Guinea and associated irarsite, laurite and cubic iron-bearing platinum. Can. Mineral., 12, 280–284. (2) (1976) Amer. Mineral., 61, 177 (abs. ref. 1). (3) Harris, D.C. and L.J. Cabri (1973) The nomenclature of the natural alloys of osmium, iridium and ruthenium based on new compositional data of alloys from world-wide occurrences. Can. Mineral., 12, 104–112. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 134, 154.

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Ruthenirídosmine (Ir, Os, Ru)

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Euhedral laths and grains, and as inclusions in Pt–Fe alloys. *Twinning:* Very fine lamellar twinning, but nearly isotropic.

Physical Properties: Hardness = n.d. VHN = 960–1004 (100 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* In polished section, white with a bluish gray tinge. ?? *Luster:* Metallic. *Pleochroism:* Weak to absent. ?? *Anisotropism:* Weak to moderate; may show wavy extinction, colors tinged with orange. ??
R_1–R_2: (400) 66.6, (420) 66.7, (440) 67.0, (460) 67.4, (480) 67.6, (500) 67.7, (520) 67.5, (540) 67.1, (560) 66.6, (580) 65.9, (600) 65.2, (620) 64.6, (640) 64.1, (660) 63.6, (680) 63.3, (700) 63.0

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.726(2)$ $c = 4.326(3)$ Z = [2]

X-ray Powder Pattern: Papua New Guinea. ??
2.071 (100), 2.363 (80), 1.364 (60), 1.153 (50), 0.8737 (50B), 1.139 (40), 1.594 (40)

Chemistry:

	(1)	(2)
Os	37.5	
Ir	47.0	
Ru	12.4	
Pt	2.2	
Pd	0.5	
Rh	0.6	
Fe	0.2	
Cu	0.5	
Total	99.9	

(1) Rio Pilpe, Guapi Co., Colombia; by electron microprobe, corresponds to (2)

Occurrence: In placer sands, generally derived from ultramafic rocks.

Association: Other Os–Ir–Ru alloys, sperrylite, hollingworthite, iridarsenite, ruthenarsenite, michenerite, laurite, geversite, moncheite, chromite. ??

Distribution: In Canada, from several properties around Atlin, and from the Spruce Creek and Tulameen River areas, British Columbia. Around Zlatoust, Ural Mountains; in the Konder massif, Aldan Shield, Sakha; and from several other less well-defined localities, Russia. From Vourinos, Greece. In South Africa, on the Witwatersrand. From the Heazlewood and Adamsfield districts, Tasmania, Australia. At Ironstone Creek, Parapara, New Zealand. In the Massif du Sud, New Caledonia. From an unspecified locality in Papua New Guinea. ?? all suspect ??

Name: For RUTHENium, IRIDium, and OSMium in the composition; the name applied to hexagonal alloys with Ir dominant.

Type Material: n.d.

References: (1) Harris, D.C. and L.J. Cabri (1973) The nomenclature of the natural alloys of osmium, iridium and ruthenium based on new compositional data of alloys from world-wide occurrences. Can. Mineral., 12, 104–112. (2) (1975) Amer. Mineral., 60, 946 (abs. ref. 1). (??) Harris, D.C. and L.J. Cabri (1991) Nomenclature of platinum-group element alloys: review and revision. Can. Mineral., 29, 231–237. [all localities are suspect - analyses must be dropped??] TL Japan?? not even listed; (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 134–135. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 489.

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Ruthenium Ru

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As a tabular crystal, to 35 μm, partly included in platinum; granular.

Physical Properties: Hardness = n.d. VHN = 841–907, 872 average (100 g load). D(meas.) = n.d. D(calc.) = 12.438

Optical Properties: Opaque. *Color:* White with pale creamy tint in reflected light. *Anisotropism:* Weak.
R_1–R_2: (400) 68.8, (420) 69.1, (440) 69.5, (460) 70.0, (480) 70.3, (500) 70.6, (520) 70.7, (540) 70.5, (560) 70.1, (580) 69.5, (600) 68.8, (620) 67.9, (640) 67.0, (660) 66.0, (680) 65.2, (700) 64.7

Cell Data: *Space Group:* $P6_3/mmc$ (synthetic). $a = 2.7058$ $c = 4.2819$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.056 (100), 2.343 (40), 2.142 (35), 1.5808 (25), 1.3530 (25), 1.2189 (25), 1.1434 (25)

Chemistry:

	(1)
Ru	64.43
Ir	14.62
Pt	9.14
Rh	7.05
Os	5.29
Pd	0.49
Fe	0.21
Ni	trace
Cu	trace
Total	101.23

(1) Uryu River, Japan; by electron microprobe, corresponding to $(Ru_{0.74}Ir_{0.09}Rh_{0.08}Pt_{0.05}Os_{0.03}Pd_{0.01})_{\Sigma=1.00}$.

Occurrence: In a platinum grain (Uryu River, Japan).

Association: Platinum, other PGE minerals.

Distribution: In gravels of the Uryu River, near Horokanai, Hokkaido, Japan [TL]. In Russia, from Nizhni Tagil, Ural Mountains, and in a placer on the Upper Miass River, Southern Ural Mountains. In the Waiau River, western Southland, New Zealand. From the Kraubath ultramafic massif, Styria, Austria. In the USA, in the Yuba River, Nevada Co., California; at Tennessee Pass, Josephine Co, Oregon. In concentrates from the Wellgreen Cu–Ni–Pt–Pd deposit, Yukon Territory, Canada. At Rio Pilpe, Guapi Co., Colombia. Additional poorly specified localities are recorded.

Name: From the Latin *Ruthenia*, for *Ukraine* or *Russia*, as the element was found associated with platinum in the Ural Mountain placers, Russia; the name applied to hexagonal alloys with dominant Ru.

Type Material: University of Kagoshima, Kagoshima, Japan.

References: (1) Urashima, Y., T. Wakabayashi, T. Masaki, and Y. Terasaki (1974) Ruthenium, a new mineral from Horokanai, Hokkaido, Japan. Mineral. J. (Japan), 7, 438–444. (2) (1976) Amer. Mineral., 61, 177 (abs. ref. 1). (3) Ewald, P.P. and C. Hermann, Eds. (1931) Ruthenium, *Ru*. Strukturbereicht, 1, 69 (in German). (4) (1955) NBS Circ. 539, 4, 5. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 491.

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Rutherfordine $U^{6+}O_2(CO_3)$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are lathlike, elongated along [001], with large {100}, {010}, {001}, to 3 mm; commonly radiating, fibrous, matted, in pulverulent, earthy to very fine-grained dense masses.

Physical Properties: *Cleavage:* On {010}, perfect; on {001}, less perfect. Hardness = n.d. D(meas.) = 5.7 D(calc.) = 5.682 Radioactive.

Optical Properties: Semitransparent. *Color:* Pale yellow, straw-yellow, greenish yellow, orange, amber-brown, may be zoned. *Luster:* Dull to earthy, silky if fibrous. *Optical Class:* Biaxial (+). *Pleochroism:* Slight; X = colorless; Y = pale yellow; Z = pale greenish yellow. *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.715$–1.723 $\beta = 1.728$–1.730 $\gamma = 1.755$–1.795 2V(meas.) = Large. 2V(calc.) = 53°

Cell Data: *Space Group:* $Imm2$. $a = 4.840(1)$ $b = 9.273(2)$ $c = 4.298(1)$ Z = 2

X-ray Powder Pattern: Uluguru Mountains, Tanzania.
4.61 (100), 4.30 (70), 3.23 (40), 3.92 (30), 2.64 (25), 2.309 (20), 2.062 (20)

Chemistry:

	(1)	(2)	(3)
CO_2	13.1	13.6	13.33
UO_3	86.7	86.6	86.67
H_2O^+	0.2		
Total	[100.0]	100.2	100.00

(1) Uluguru Mountains, Tanzania; recalculated to 100% from an original total of 100.3%, after deduction of Pb and Ca as kasolite and uranophane, and remaining FeO and CaO as impurities. (2) Katanga Province, Congo. (3) $UO_2(CO_3)$.

Occurrence: A secondary mineral formed as a weathering product of uraninite.

Association: Uraninite, becquerelite, masuyite, schoepite, kasolite, curite, boltwoodite, vandendriesscheite, billietite, metatorbernite, fourmarierite, studtite, sklodowskite.

Distribution: From the Uluguru Mountains, Morogoro district, Tanzania. At Shinkolobwe, from Kalongwe, and in the Musonoi mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). In the USA, from Beryl Mountain, Acworth, Sullivan Co., and in the Palermo mine, near North Groton, Grafton Co., New Hampshire; at Newry, Oxford Co., Maine. In Utah, from the Delta mine, Emery Co., and in the "C" group of claims and the Jomac mine, White Canyon district, San Juan Co.; from the Lucky Mc No. 20 mine, Wind River Basin, Fremont Co., Wyoming; near McCoy, Eagle Co., and in the Maybell area, Moffat Co., Colorado; from the Apex uranium mine, Reese River district, Lander Co., Nevada. In England, at Loe Warren zawn, 0.75 km west of Botallack, St. Just, and in the South Terras mine, St. Stephen-in-Brannel, Cornwall. At the Les Mares and Rabéjac uranium deposits, south of Lodève, Hérault, France. From the Krunkelbachtal mine, near Menzenschwand, Black Forest, Germany. In Australia, from the Nabarlek uranium deposit, Northern Territory, and at the Coppertop mine, Peake and Denison Ranges, South Australia.

Name: Honors Professor Ernest Rutherford (1871–1937), New Zealand–English atomic physicist.

Type Material: Natural History Museum, Paris, 109.1083; National Museum of Natural History, Washington, D.C., USA, 93291.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 274–275. (2) Frondel, C. and R. Meyerowitz (1956) Studies of uranium minerals (XIX): rutherfordine, diderichite, and clarkeite. Amer. Mineral., 41, 127–133. (3) Clark, J.R. and C.L. Christ (1956) Some observations on rutherfordine. Amer. Mineral., 41, 844–850. (4) Finch, R.J., M.A. Cooper, and F.C. Hawthorne (1999) Refinement of the crystal structure of rutherfordine. Can. Mineral., 37, 929–938.

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Rutile TiO_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals prismatic, elongated and striated ‖ [001], to 25 cm, showing {110}, {010}, terminated by {101} or {111}, many others; equant, rarely dipyramidal; massive. *Twinning:* On {011}, common, or {031}, geniculated, reticulated; as contact twins with two, six, or eight individuals, cyclic, polysynthetic.

Physical Properties: *Cleavage:* {110}, good; {100}, moderate; {111}, in traces. *Fracture:* Conchoidal, subconchoidal, uneven. *Tenacity:* Brittle. Hardness = 6–6.5 VHN = 894–974 (100 g load). D(meas.) = 4.23(2), increasing with Nb–Ta content. D(calc.) = 4.25 Photosensitive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Reddish brown, red, pale yellow, pale blue, violet, rarely grass-green; black if high in Nb–Ta; red to brownish red, pale yellow in transmitted light, deep brown to green with high Nb–Ta; in reflected light, gray with bluish tint, with white, yellow, or red internal reflections. *Streak:* Pale brown, yellowish brown; gray, greenish black with high Nb–Ta. *Luster:* Adamantine to submetallic. *Optical Class:* Uniaxial (+). *Pleochroism:* Distinct; red, brown, yellow, green. *Dispersion:* Strong. *Absorption:* $E > O$. $\omega = 2.605$–2.613 $\epsilon = 2.899$–2.901 *Anisotropism:* Strong. R_1–R_2: (400) 23.7–27.0, (420) 23.2–26.5, (440) 22.7–26.0, (460) 22.2–25.5, (480) 21.7–25.1, (500) 21.3–24.7, (520) 20.9–24.3, (540) 20.6–24.0, (560) 20.2–23.6, (580) 20.0–23.4, (600) 19.7–23.1, (620) 19.5–22.9, (640) 19.2–22.8, (660) 19.1–22.6, (680) 19.0–22.5, (700) 18.9–22.5

Cell Data: *Space Group:* $P4_2/mnm$ (synthetic). $a = 4.5937$ $c = 2.9587$ Z = 2

X-ray Powder Pattern: Synthetic.
3.247 (100), 1.6874 (60), 2.487 (50), 2.188 (25), 1.6237 (20), 1.3598 (20), 1.3465 (12)

Chemistry:

	(1)
TiO_2	97.46
Fe_2O_3	2.62
Total	100.08

(1) Graves Mountain, Georgia, USA.

Polymorphism & Series: Trimorphous with anatase and brookite.

Mineral Group: Rutile group.

Occurrence: A common high-temperature, high-pressure accessory mineral in igneous rocks, anorthosite, and granite pegmatite; in hydrothermally-altered rocks; in gneiss, schist, contact metamorphosed limestone; in clays, shales; a common detrital mineral.

Association: Anatase, brookite, hematite, ilmenite, apatite, adularia, albite, titanite, chlorite, pyrophyllite, calcite, quartz.

Distribution: Many localities; a few for fine crystals include: in Switzerland, at Cavradi, Tavetsch, Graübunden, and Lodrino, Tessin. From the Pfitschtal, Trentino-Alto Adige, Italy. On the Saualpe, and at Herzogberg, near Modriach, Styria, Austria. From Kassoi Brod, Ural Mountains, Russia. In the USA, at Magnet Cove, Hot Spring Co., Arkansas; on Graves Mountain, Washington, Lincoln Co., Georgia; at Stony Point, Alexander Co., North Carolina; from Parkesburg and elsewhere, Chester Co., Pennsylvania; in the Champion mine, White Mountains, Mono Co., California. In Brazil, large crystals from Conquista, and at Ibitiara, Bahia. At the Giftkuppe mine, Omaruru, Namibia.

Name: From the Latin *rutilus*, for *red*, a common color of the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 554–561. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 34–39. (3) Howard, C.J., T.M. Sabine, and F. Dickson (1992) Structural and thermal parameters for rutile and anatase. Acta Cryst., 47, 462–468. (4) (1969) NBS Mono. 25, 7, 83.

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Rynersonite $Ca(Ta,Nb)_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 0.5 mm, elongated along [100] and flattened on {010}, in fibrous, felted aggregates, to several cm.

Physical Properties: *Fracture:* Uneven. Hardness = ∼4.5 D(meas.) = 6.402 D(calc.) = 6.39–7.20

Optical Properties: Transparent. *Color:* Pale creamy white to pale reddish pink; pale yellowish brown to dark brown. *Streak:* White. *Luster:* Dull, earthy in aggregates. *Optical Class:* Biaxial (+); birefringence ∼0.14. *Pleochroism:* $X = Y$ = straw-yellow; Z = light straw-yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = > 2.05$ $\beta = > 2.05$ $\gamma = > 2.05$ 2V(meas.) = Moderate.

Cell Data: *Space Group: Pmnb.* $a = 7.505(1)$ $b = 11.063(2)$ $c = 5.370(1)$ Z = 4

X-ray Powder Pattern: San Diego mine, California, USA.
3.038 (100), 4.835 (90), 2.964 (90), 3.754 (70), 2.683 (50), 2.359 (50), 2.767 (35)

Chemistry:

	(1)	(2)
Nb_2O_5	14.2	10.23
Ta_2O_5	66.6	74.6
SiO_2	3.0	1.01
Sb_2O_3	0.5	0.07
Bi_2O_3	0.1	0.43
FeO	0.4	1.43
MnO	0.1	0.35
CaO	13.0	8.50
Total	97.9	96.62

(1) San Diego mine, California, USA; by electron microprobe, total Fe as FeO; corresponds to $Ca_{1.11}(Ta_{1.44}Nb_{0.51})_{\Sigma=1.95}O_6$. (2) Wampewo pegmatite, Uganda; by electron microprobe, total Fe as FeO; corresponds to $(Ca_{0.75}Fe_{0.10}Mn_{0.02})_{\Sigma=0.87}(Ta_{1.67}Nb_{0.38})_{\Sigma=2.05}O_6$.

Occurrence: A rare alteration product of earlier Nb–Ta minerals in some granite pegmatites.

Association: Fersmite, stibiotantalite, cassiterite, microlite, beyerite, tourmaline, albite, quartz (San Diego Co., California, USA); microlite, wodginite, zircon, lepidolite, quartz (Wampewo pegmatite, Uganda).

Distribution: In the USA, from the Himalaya and San Diego mines, Mesa Grande district, San Diego Co., California; at the Brown Derby No. 1 pegmatite, Quartz Creek district, Gunnison Co., Colorado. In the Wampewo pegmatite, Gamba Hill, near Kampala, southwest Uganda.

Name: To honor Frederick James Rynerson (1882–1960), and his two sons, Buel Frederick Rynerson (1905–) and Eugene Bonfoey Rynerson (1910–), long-time pegmatite miners in San Diego Co., California, USA.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1977,144; National Museum of Natural History, Washington, D.C., USA, 135832, 135833, 136719, 149524.

References: (1) Foord, E.E. and M.E. Mrose (1978) Rynersonite, $Ca(Ta,Nb)_2O_6$, a new mineral from San Diego County, California. Amer. Mineral., 63, 709–714. (2) von Knorring, O. and T.G. Sahama (1979) A note on rynersonite from Uganda. Schweiz. Mineral. Petrolog. Mitt., 59, 15–18.

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Sabatierite Cu_6TlSe_4

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Crystal Data: Orthorhombic. *Point Group:* n.d. As radiating polycrystalline aggregates, to 0.05 mm.

Physical Properties: Hardness = n.d. VHN = 54 (15 g load). D(meas.) = n.d. D(calc.) = 6.78

Optical Properties: Opaque. *Color:* In polished section, bluish gray with slight cream tint. *Luster:* Metallic. *Pleochroism:* Distinct, in pale brown to pale blue. *Anisotropism:* Strong, with undulatory extinction, colors in pale gray-blue to dark yellow-brown.
R_1–R_2: (400) —, (420) 31.0–33.2, (440) 30.9–34.3, (460) 30.6–33.8, (480) 30.1–33.0, (500) 29.5–32.2, (520) 28.7–31.5, (540) 27.9–30.6, (560) 27.0–29.6, (580) 26.1–28.4, (600) 25.3–27.2, (620) 24.5–26.0, (640) 23.8–24.8, (660) 23.0–23.8, (680) 22.2–22.7, (700) 21.3–21.6

Cell Data: *Space Group:* n.d. $a = 3.986(4)$ $b = 5.624(4)$ $c = 9.778(8)$ $Z = 1$

X-ray Powder Pattern: Bukov deposit, Czech Republic.
3.089 (100), 2.706 (70), 1.991 (70), 2.445 (60), 1.847 (60), 3.987 (50), 2.525 (50)

Chemistry:

	(1)	(2)
Cu	42.71	42.29
Tl	22.44	22.67
Se	34.57	35.04
Total	99.72	100.00

(1) Bukov deposit, Czech Republic; by electron microprobe, average of five analyses, corresponding to $Cu_{6.06}Tl_{0.99}Se_{3.95}$. (2) Cu_6TlSe_4.

Occurrence: In calcite veins.

Association: Crookesite, berzelianite, umangite, bukovite.

Distribution: In the Bukov deposit, Rožná district, Czech Republic [TL].

Name: To honor Germain Sabatier (1923–), former Director of Research, C.N.R.S., Orléans, France.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z., M. Kvaček, and P. Picot (1978) La sabatierite, un nouveau séléniure de cuivre et de thallium. Bull. Minéral., 101, 557–560 (in French with English abs.). (2) (1979) Amer. Mineral., 64, 1331–1332 (abs. ref. 1). (3) Berger, R.A. (1987) Crookesite and sabatierite in a new light – a crystallographer's comment. Zeits. Krist., 181, 241–249.

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Sabelliite $Cu_2Zn(AsO_4, SbO_4)(OH)_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Crystals are tabular on {001}, showing only {001} with a characteristic coinlike circular outline, to 200 μm; usually in aggregates of crystals.

Physical Properties: *Tenacity:* Brittle. Hardness = ∼4.5 VHN = 322–469, 386 average (15 g load). D(meas.) = n.d. D(calc.) = 4.65

Optical Properties: Transparent. *Color:* Emerald-green. *Streak:* Pale green.
Luster: Adamantine.
Optical Class: Uniaxial (–). $\omega = 1.802(2)$ $\epsilon = 1.797(2)$

Cell Data: *Space Group:* $P\overline{3}$. $a = 8.197(2)$ $c = 7.312(1)$ $Z = 3$

X-ray Powder Pattern: Is Murvonis mine, Sardinia, Italy.
2.522 (100), 1.550 (100), 1.805 (92), 2.166 (88), 1.513 (85), 4.11 (55), 3.66 (52)

Chemistry:

	(1)
As_2O_5	23.07
Sb_2O_5	6.59
SiO_2	0.71
CuO	43.56
ZnO	19.48
H_2O	[6.05]
Total	[99.46]

(1) Is Murvonis mine, Sardinia, Italy; by electron microprobe, average of 20 spots on four crystals, H_2O calculated from direct determination of O content, structural H_2O absent by IR; corresponds to $Cu_{2.19}Zn_{0.96}(As_{0.80}Sb_{0.16}Si_{0.05})_{\Sigma=1.01}O_{4.31}(OH)_{2.69}$.

Occurrence: A rare mineral in the oxidized zone of a hydrothermal copper deposit, formed by weathering of sulfides and sulfosalts.

Association: Theisite, malachite, azurite, tetrahedrite.

Distribution: From the Is Murvonis mine, Domusnovas, Iglesias district, Sardinia, Italy.

Name: To honor Dr. Cesare Sabelli (1934–), Consiglio Nazionale della Ricerche, Florence, Italy, who has worked with the copper-bearing alteration minerals of Sardinia, Italy.

Type Material: Museum of Natural History, University of Florence, Florence, Italy, 2053/RI.

References: (1) Olmi, F., A. Santucci, and R. Trosti-Ferroni (1995) Sabelliite, a new copper-zinc arsenate-antimonate mineral from Sardinia, Italy. Eur. J. Mineral., 7, 1325–1330. (2) Olmi, F., C. Sabelli, and R. Trosti-Ferroni (1995) The crystal structure of sabelliite. Eur. J. Mineral., 7, 1331–1337. (3) (1996) Amer. Mineral., 81, 1014–1015 (abs. refs. 1–2).

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Sabieite $(NH_4)Fe^{3+}(SO_4)_2$

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Crystal Data: Hexagonal. *Point Group:* 32. Thin platelets, hexagonal, to 10 μm, constituting a powder.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.36] Slowly soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* [$P321$] (by analogy to synthetic). $a = 4.822$ $c = 8.1696$ Z = 1

X-ray Powder Pattern: Lone Creek Fall Cave, South Africa.
8.19 (100), 2.409 (30), 3.72 (20), 1.392 (20), 1.556 (15), 2.910 (10), 2.718 (10)

Chemistry:

	(1)	(2)
SO_3	61.80	60.19
Al_2O_3	0.68	
Fe_2O_3	28.64	30.02
K_2O	0.70	
$(NH_4)_2O$	8.18	9.79
Total	100.80	[100.00]

(1) Lone Creek Fall Cave, South Africa; recalculated to 100% from an original total of 100.80% after deduction of 12.77% insoluble; then corresponds to $[(NH_4)_{0.84}K_{0.04}]_{\Sigma=0.88}(Fe_{0.94}Al_{0.04})_{\Sigma=0.98}(S_{1.02}O_4)_2$. (2) $(NH_4)Fe(SO_4)_2$.

Occurrence: Formed by dehydration of lonecreekite.

Association: Lonecreekite, tschermigite.

Distribution: On the ceiling of Lone Creek Fall Cave, near Sabie, Eastern Transvaal, South Africa.

Name: For its occurrence near Sabie, South Africa.

Type Material: South African Geological Survey Museum, Pretoria, South Africa.

References: (1) Martini, J.E.J. (1983) Lonecreekite, sabieite, and clairite, new secondary ammonium ferric-iron sulphates from Lone Creek Fall Cave, near Sabie, Eastern Transvaal. Ann. Geol. Surv. S. Africa, 17, 29–34. (2) (1986) Amer. Mineral., 71, 229 (abs. ref. 1).

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Sabinaite $Na_4Zr_2TiO_4(CO_3)_4$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Flaky to blocky crystals, {001}, {010}, {100}, {110}, to 0.4 mm, with irregular pseudohexagonal outlines, in compact chalky aggregates and powdery coatings.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {100}. Hardness = n.d. D(meas.) = 3.36 D(calc.) = 3.44–3.48

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous, silky in aggregates *Optical Class:* Biaxial (–) or (+). *Orientation:* $Y = b$; $X \wedge c = 13°$. *Dispersion:* $r > v$, moderate. $\alpha = 1.72$–1.74 $\beta = 1.79$–1.80 $\gamma = 1.85$–[1.90] 2V(meas.) = 82°–85°

Cell Data: *Space Group:* $C2/c$. $a = 10.196(1)$ $b = 6.616(1)$ $c = 17.958(3)$ $\beta = 94.14(1)°$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
8.96 (100), 3.251 (50), 2.990 (50), 2.017 (45), 2.239 (40), 1.795 (35), 4.48 (25)

Chemistry:

	(1)	(2)	(3)
CO_2	27.1	[27.56]	28.11
TiO_2	12.0	10.91	12.75
ZrO_2	39.1	40.64	39.35
HfO_2	0.47	0.45	
CaO	0.2	0.02	
Na_2O	20.7	19.53	19.79
Total	99.57	[99.11]	100.00

(1) Francon quarry, Canada; by electron microprobe, TiO_2, ZrO_2, HfO_2 by neutron activation, CO_2 determined by wet methods and confirmed by IR; corresponds to $(Na_{4.18}Ca_{0.02})_{\Sigma=4.20}(Zr_{1.99}Hf_{0.01})_{\Sigma=2.00}Ti_{0.94}O_{4.14}(CO_3)_{3.86}$. (2) Mont Saint-Hilaire, Canada; by electron microprobe, average of five analyses of one crystal, CO_2 calculated for stoichiometry; corresponds to $Na_{4.02}(Zr_{1.99}Hf_{0.01})_{\Sigma=2.00}(Ti_{0.87}Zr_{0.12})_{\Sigma=0.99}O_4(CO_3)_4$. (3) $Na_4Zr_2TiO_4(CO_3)_4$.

Occurrence: A rare mineral in vugs in a silicocarbonatite sill (Francon quarry, Canada); in cavities in sodalite syenite associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Calcite, dawsonite, weloganite, cryolite, pyrite, galena, barite, ilmenorutile, ankerite, siderite, quartz (Francon quarry, Canada); albite, microcline, dawsonite, analcime, sodalite, pectolite, dolomite, aegirine (Mont Saint-Hilaire, Canada).

Distribution: From the Francon quarry, Montreal Island, Montreal, and at Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Ann Phyllis Sabina Stenson (1930–), mineralogist, Geological Survey of Canada, who collected sufficient of the mineral to allow its characterization.

Type Material: National School of Mines, Paris, France; Canadian Geological Survey, Ottawa, 61017–61024; Royal Ontario Museum, Toronto, Canada, M35902; National Museum of Natural History, Washington, D.C., USA, 145916.

References: (1) Jambor, J.L., B.D. Sturman, and G.C. Weatherly (1980) Sabinaite, a new anhydrous zirconium-bearing carbonate mineral from Montreal Island, Quebec. Can. Mineral., 18, 25–29. (2) (1981) Amer. Mineral., 66, 1277 (abs. ref. 1). (3) Chao, G.Y. and G. Jiexiang (1985) Sabinaite: a new occurrence and new data. Can. Mineral., 23, 17–19. (4) McDonald, A.M. (1996) The crystal structure of sabinaite, $Na_4Zr_2TiO_4(CO_3)_4$. Can. Mineral., 34, 811–815.

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Sabugalite $HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Crystals, to 1 mm, very thin on {001}, square to lathlike outlines, typically warped, in composite subparallel growths; typically in thick crusts.

Physical Properties: *Cleavage:* On {001}, perfect. *Tenacity:* Somewhat flexible. Hardness = 2.5 D(meas.) = ∼3.20 D(calc.) = 3.150 Radioactive; fluoresces bright lemon-yellow under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Bright yellow to lemon-yellow. *Luster:* Weakly vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = pale yellow. *Orientation:* Z = elongation. α = 1.564–1.565 β = 1.581–1.583 γ = 1.582–1.584 2V(meas.) = Moderately large, may be 0°.

Cell Data: *Space Group:* $C2/m$ (synthetic). a = 19.426 b = 9.483 c = 9.850 β = 96.161° Z = 2

X-ray Powder Pattern: Sabugal, Portugal.
9.69 (10), 4.86 (9), 3.47 (8), 2.188 (6), 4.39 (4), 2.452 (2), 2.389 (2)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3	65.22	65.01	64.41	Al_2O_3	2.65	3.20	2.87
P_2O_5	16.08	14.02	15.98	CaO		0.36	
As_2O_5		2.70		H_2O	15.93	[14.71]	16.74
				Total	99.88	[100.00]	100.00

(1) Quarta Feira mine, Portugal; corresponds to $H_{1.00}Al_{0.94}(UO_2)_{4.12}(PO_4)_{4.08} \cdot 15.96H_2O$. (2) Kariz, Portugal; H_2O by difference; corresponds to $H_{1.00}Al_{1.12}(UO_2)_{4.08}[(PO_4)_{3.56}(AsO_4)_{0.42}]_{\Sigma=3.98} \cdot 15.96H_2O$. (3) $HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$.

Mineral Group: Autunite group.

Occurrence: A secondary mineral formed in the oxidized zone of uranium veins.

Association: Meta-autunite, saléeite, phosphuranylite.

Distribution: In Portugal, in Beira Alta, from the Quarta Feira and Coitos mines, Sabugal Co.; at Kariz, Minho Province; and elsewhere. From the Pedro Alvaro and Cuidad Rodrigo vanadium mines, Salamanca Province, Spain. In the Margnac mine, Compreignac, and the La Crouzille mine, Haute-Vienne, France. At Arcu su Linnarbu, near Capoterra, Sardinia, Italy. In the USA, from the Black Water mine, Black Mesa Basin, Apache Co., and at the Huskon and Arrowhead claims, Huskon district, near Cameron, Coconino Co., Arizona; in the Union Carbide mine, Maybell district, Moffat Co., at the Pitch mine, Marshall Pass district, Saguache Co., and the High Park claims, Teller Co., Colorado; from the Happy Jack mine, White Canyon, San Juan Co., Utah; at the Lucky Mc No. 20 mine, the Blue Buck claim and Blarco group, Fremont Co., the Poison Creek claim, Crook Co., and the Del Linch claim, Johnson Co., Wyoming. In the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. From the El Sharana mine, South Alligator Valley, Northern Territory, Australia.

Name: For Sabugal Co., Portugal, in which the mineral was first found.

Type Material: The Natural History Museum, London, England, 1958,733; Harvard University, Cambridge, Massachusetts, 102192, 102193; National Museum of Natural History, Washington, D.C., USA, 106335–106337.

References: (1) Frondel, C. (1951) Studies of uranium minerals (VIII): sabugalite, an aluminum-autunite. Amer. Mineral., 36. 671–679. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 196–200. (3) Vochten, R. and J. Pelsmaekers (1983) Synthesis, solubility, electrokinetic properties and refined crystallographic data of sabugalite. Phys. Chem. Minerals, 9, 23–29.

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Sacrofanite

$(Na, Ca, K)_9(Si, Al)_{12}O_{24}$
$[(OH)_2, (SO_4), (CO_3), Cl_2]_3 \cdot nH_2O$

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Crystal Data: Hexagonal. *Point Group:* $6mm$, $\bar{6}m2$, or $6/m\ 2/m\ 2/m$. As hexagonal prisms, flattened on {0001}, to 2 cm.

Physical Properties: *Cleavage:* Perfect on {0001}, $\{01\bar{1}0\}$. Hardness = 5.5–6
D(meas.) = 2.423(5) D(calc.) = 2.446

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Pearly.
Optical Class: Uniaxial (–). $\omega = 1.505(1)$ $\epsilon = 1.486(1)$

Cell Data: *Space Group:* $P6_3mc$, $P\bar{6}2c$, or $P6_3/mmc$. $a = 12.865(4)$ $c = 74.240(10)$
Z = 14

X-ray Powder Pattern: Sabatini Mountains, Italy.
3.73 (100), 3.483 (43), 2.648 (30), 3.685 (26), 3.74 (25), 2.149 (18), 11.12 (12)

Chemistry:

	(1)
SiO_2	33.06
Al_2O_3	24.94
Fe_2O_3	0.35
CaO	8.76
Na_2O	16.50
K_2O	5.56
Cl	0.59
H_2O^+	2.47
SO_3	7.77
CO_2	1.00
$-O = Cl_2$	0.13
Total	[100.87]

(1) Sabatini Mountains, Italy; by XRF, Na by AA, Ca and H by microanalyser, H_2O by TGA, original total given as 99.87%; corresponds to $(Na_{6.25}Ca_{1.83}K_{1.39})_{\Sigma=9.47}(Si_{6.26}Al_{5.74})_{\Sigma=12.00}O_{24}[(OH)_{2.69}(SO_4)_{1.14}(CO_3)_{0.27}Cl_{0.20}]_{\Sigma=4.30} \cdot 0.27H_2O$.

Mineral Group: Cancrinite group.

Occurrence: As crystals lining a cavity in an ejected block of volcanic rock.

Association: Sanidine, andradite, fassaite, leucite, haüyne.

Distribution: From Valle Biachella, 3.2 km north-northwest of Sacrofano, in the Sacrofano caldera, Lazio, Italy.

Name: For the type locality in the Sacrofano volcanic area, Italy.

Type Material: University of Rome, Rome, Italy, 24332; Natural History Museum, Paris, France.

References: (1) Burragato, F., G.C. Parodi, and P.F. Zanazzi (1980) Sacrofanite – a new mineral of the cancrinite group. Neues Jahrb. Mineral., Abh., 140, 102–110. (2) (1981) Amer. Mineral., 66, 1100 (abs. ref. 1).

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Sadanagaite

$KCa_2[(Fe^{2+}, Mg)_3(Al, Fe^{3+})_2](Si_5Al_3)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* m, 2, or $2/m$. Prismatic crystals, to 1 mm; as polycrystalline aggregates.

Physical Properties: *Cleavage:* Perfect on {110}. *Tenacity:* [Brittle.] Hardness = ~6 D(meas.) = n.d. D(calc.) = 3.30

Optical Properties: Semitransparent. *Color:* Dark brown to black; in thin section, paler with greater silicon content. *Streak:* Very light brown. *Luster:* Vitreous.
Optical Class: Biaxial (+) or (–). *Pleochroism:* Strong; X = pale brown, grayish, or greenish yellow; Y = yellowish orange to light olive-brown; Z = greenish brown, light olive-brown to dark yellowish orange. *Orientation:* $Z \wedge c = 28°$. $\alpha = 1.673(2)$ $\beta = 1.684(2)$ $\gamma = 1.697(2)$ 2V(meas.) = 70°–90° 2V(calc.) = 86°

Cell Data: *Space Group:* $C2$, Cm, or $C2/m$. $a = 9.922(10)$ $b = 18.03(2)$ $c = 5.352(9)$ $\beta = 105.30(10)°$ Z = 2

X-ray Powder Pattern: [Myojin Island, Japan; identical to magnesio-sadanagaite.]
3.28 (100), 8.48 (80), 3.15 (70), 2.707 (60), 2.162 (55), 2.951 (50), 2.766 (45)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	29.9	34.4	MgO	6.1	6.11
TiO_2	4.3	3.15	CaO	11.9	11.9
Al_2O_3	22.6	18.4	Na_2O	0.6	0.73
FeO	17.4	18.4	K_2O	3.7	4.21
MnO	0.3	0.24	Total	96.8	97.5

(1) Yuge Island, Japan; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(K_{0.74}Na_{0.17})_{\Sigma=0.91}Ca_{1.99}(Fe^{2+}_{1.63}Mg_{1.41}Al_{0.81}Fe^{3+}_{0.63}Ti_{0.50})_{\Sigma=4.98}(Si_{4.66}Al_{3.34})_{\Sigma=8.00}O_{22}(OH)_2$. (2) Nogo-Hakusan area, Japan; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(K_{0.84}Na_{0.22})_{\Sigma=1.06}Ca_{1.99}(Fe^{2+}_{2.17}Mg_{1.42}Al_{0.74}Ti_{0.37}Fe^{3+}_{0.23}Mn_{0.03})_{\Sigma=4.96}(Si_{5.36}Al_{2.64})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with magnesio-sadanagaite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+})$ 0.5; $Fe^{3+}/(Fe^{3+} + Al^{vi})$ 0.50; $(Na + K)_A \geq 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si < 5.5$; $Ti < 0.5$.

Occurrence: By contact metamorphism, producing banded skarns, under amphibolite to pyroxene hornfels facies conditions; from eclogites.

Association: Vesuvianite, hercynite, sphene, ilmenite, apatite (Yuge Island, Japan); biotite, orthoclase, subsilicic ferroan pargasite (Nogo-Hakusan area, Japan).

Distribution: On Yuge Island, Ehime Prefecture, and in the Nogo-Hakusan area, Fukui Prefecture, Japan. At the Botallack mine, St. Just, Cornwall, England. In the Oetztal, Austria.

Name: To honor Professor Ryoichi Sadanaga of the Mineralogical Institute, University of Tokyo, Tokyo, Japan.

Type Material: University of Tokyo, Tokyo; National Science Museum, Tokyo, Japan, M23378.

References: (1) Shimazaki, H., M. Bunno, and T. Ozawa (1984) Sadanagaite and magnesio-sadanagaite, new silica-poor members of calcic amphibole from Japan. Amer. Mineral., 69, 465–471. (2) Rock, N.M.S. and B.E. Leake (1984) The International Mineralogical Association amphibole nomenclature scheme: computerization and its consequences. Mineral. Mag., 48, 211–227. (3) Sawaki, T. (1989) Sadanagaite and subsilicic ferroan pargasite from thermally metamorphosed rocks in the Nogo-Hakusan area, central Japan. Mineral. Mag., 53, 99–106. (4) Mogessie, A., F. Purtscheller, and R. Tessadri (1986) High alumina calcic amphiboles (alumino pargasite-magnesio sadanagaite) from metabasites and metacarbonates of Central Oetztal, Eastern Alps (Northern Tyrol, Austria). Neues Jahrb. Mineral., Abh., 154, 21–39.

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Saddlebackite $Pb_2Bi_2Te_2S_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic [010], also with prominent {101} and {310}, to 0.1 mm; commonly massive with a radiated fibrous structure, finely zoned with other arsenides. *Twinning:* As fivelings with {011} as twin plane; also forming cruciform penetration twins, as with arsenopyrite, with twin plane {101}.

Physical Properties: *Cleavage:* Distinct on {100}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 VHN = 792–882 (100 g load). D(meas.) = 7.2 D(calc.) = 7.471

Optical Properties: Opaque. *Color:* Tin-white, readily tarnishes to dark gray; in polished section, white. *Streak:* Grayish black. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: (400) 55.8–52.6, (420) 55.8–53.0, (440) 55.8–53.4, (460) 55.6–53.8, (480) 55.2–54.1, (500) 54.7–54.3, (520) 54.2–54.4, (540) 53.5–54.5, (560) 52.8–54.5, (580) 52.2–54.5, (600) 51.8–54.4, (620) 51.3–54.3, (640) 51.0–54.2, (660) 50.7–54.1, (680) 50.5–53.9, (700) 50.3–53.8

Cell Data: *Space Group: Pnnm.* $a = 5.173$ $b = 5.954$ $c = 2.999$ $Z = 2$

X-ray Powder Pattern: Cobalt, Canada. (ICDD 23-88).
2.379 (100), 2.572 (80), 2.597 (55), 1.862 (45), 1.849 (20), 1.650 (20), 1.636 (20)

Chemistry:

	(1)	(2)	(3)
Co	18.58	20.9	28.23
Fe	9.51	6.9	
Ni	0.00	0.3	
Cu	0.62		
As	70.36	69.3	71.77
S	0.90	2.6	
Total	99.97	100.0	100.00

(1) Schneeberg, Germany; corresponds to $(Co_{0.65}Fe_{0.35}Cu_{0.02})_{\Sigma=1.02}(As_{1.94}S_{0.06})_{\Sigma=2.00}$.
(2) Locality not specified; by electron microprobe, corresponds to $(Co_{0.70}Fe_{0.25}Ni_{0.01})_{\Sigma=0.96}$ $(As_{1.84}S_{0.16})_{\Sigma=2.00}$. (3) $CoAs_2$.

Polymorphism & Series: Dimorphous with clinosafflorite; forms a series with löllingite.

Mineral Group: Löllingite group.

Occurrence: In hydrothermal Co–Ni veins formed at medium temperature and pressure.

Association: Skutterudite, rammelsbergite, nickeline, silver, bismuth, löllingite.

Distribution: In Sweden, from Nordmark, Värmland [TL]; and at Tunaberg, Södermanland. In Germany, from Schneeberg and Annaberg, Saxony; at Bieber and Mackenheim, Hesse; from St. Andreasberg, Harz Mountains; and at Wittichen, Black Forest. From Burguillos de Cerro, Badajoz Province, Spain. In the Tynebottom mine, Garrigill, near Alston, Cumbria, England. At Sarrabus and Gonnosfanadiga, Sardinia, Italy. From Bou Azzer, Morocco. At the Talmessi and Meskani deposits, Anarak, Iran. In the USA, from the Quartzburg district, Grant Co., Oregon. At Cobalt and South Lorrain Township, Ontario; and from Great Bear Lake, Saskatchewan, Canada. In Australia, at Broken Hill, New South Wales. A number of other less prominent localities are known.

Name: From German *Safflor or Zaffer*, for *safflower*, in allusion to its use as a cobalt-blue pigment.

Type Material: Mining Academy, Freiberg, Germany, 3863.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 307–309. (2) Radcliffe, D. and L.G. Berry (1968) The safflorite–loellingite solid solution series. Amer. Mineral., 53, 1856–1881.

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic [010], also with prominent {101} and {310}; commonly massive with a radiated fibrous structure. *Twinning:* As fivelings with {011} as twin plane; also forming cruciform penetration twins, as with arsenopyrite, with twin plane {101}.

Physical Properties: *Cleavage:* Distinct on {100}. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 VHN = 792–882 (100 g load). D(meas.) = 7.2 D(calc.) = 7.471

Optical Properties: Opaque. *Color:* Tin-white, readily tarnishes to dark gray; in polished section, white. *Streak:* Grayish black. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: (400) 55.8–52.6, (420) 55.8–53.0, (440) 55.8–53.4, (460) 55.6–53.8, (480) 55.2–54.1, (500) 54.7–54.3, (520) 54.2–54.4, (540) 53.5–54.5, (560) 52.8–54.5, (580) 52.2–54.5, (600) 51.8–54.4, (620) 51.3–54.3, (640) 51.0–54.2, (660) 50.7–54.1, (680) 50.5–53.9, (700) 50.3–53.8

Cell Data: *Space Group: Pnnm.* $a = 5.173$ $b = 5.954$ $c = 2.999$ $Z = 2$

X-ray Powder Pattern: Cobalt, Canada. (JCPDS 23-88).
2.379 (100), 2.572 (80), 2.597 (55), 1.862 (45), 1.849 (20), 1.650 (20), 1.636 (20)

Chemistry:

	(1)	(2)	(3)
Co	18.58	12.99	28.23
Fe	9.51	15.28	
Ni	0.00	0.20	
Cu	0.62	0.33	
As	70.36	71.13	71.77
S	0.90	0.68	
Total	99.97	100.61	100.00

(1) Schneeberg, Germany. (2) Nordmarken, Sweden. (3) $CoAs_2$.

Polymorphism & Series: Dimorphous with clinosafflorite.

Occurrence: In hydrothermal veins of moderate temperature and pressure.

Association: Skutterudite, rammelsbergite, nickeline, silver, bismuth, löllingite.

Distribution: In the USA, from the Quartzburg district, Grant Co., Oregon. At Cobalt and South Lorrain, Ontario; and at Great Bear Lake, Saskatchewan, Canada. In Germany, at Schneeberg and Annaberg, Saxony; Bieber and Mackenheim, Hesse; St. Andreasberg, in the Harz Mountains; and at Wittichen, Black Forest. From Sweden, at Tunaberg, Södermanland; and at Nordmark, Wermland. From Burguillos de Cerro, Badajoz Province, Spain. At Sarrabus and Gonnosfanadiga, Sardinia, Italy. In Australia, at Broken Hill, New South Wales. A number of other less prominent localities are known.

Name: From *safflower*, in allusion to its use as a pigment.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 307–309. (2) Radcliffe, D. and L.G. Berry (1968) The safflorite–loellingite solid solution series. Amer. Mineral., 53, 1856–1881.

Sahamalite-(Ce) $(Mg, Fe^{2+})(Ce, La, Nd)_2(CO_3)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic euhedral crystals, to 0.2 mm, flattened on $\{\overline{2}01\}$, complexly developed with {110}, {120}, {010}, $\{\overline{1}31\}$, {011}, {012}, $\{\overline{1}42\}$, in subparallel radiating aggregates.

Physical Properties: *Cleavage:* Poor on {010}; traces on $\{\overline{2}01\}$. Hardness = n.d.
D(meas.) = 4.30 D(calc.) = 4.30

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 29°$. *Dispersion:* $r < v$, perceptible.
$\alpha = 1.679(2)$ $\beta = 1.776(2)$ $\gamma = 1.807(2)$ 2V(meas.) = 57° 2V(calc.) = 57°

Cell Data: *Space Group:* $P2_1/a$. $a = 5.894(1)$ $b = 16.116(3)$ $c = 4.612(1)$
$\beta = 106.54(1)°$ Z = 2

X-ray Powder Pattern: Mountain Pass, California, USA.
3.90 (10), 3.65 (10), 2.87 (10), 5.33 (7), 4.26 (7), 3.03 (7), 2.12 (7b)

Chemistry:

	(1)
CO_2	31.7
Ce_2O_3	31.4
$(La, Nd)_2O_3$	[27.8]
FeO	2.0
MgO	6.1
insol.	0.5
Total	[99.5]

(1) Mountain Pass, California, USA; $(La, Nd)_2O_3$ calculated as the difference from R_2O_3 less Fe_2O_3 and CeO_2; R_2O_3 determined by spectrographic analysis as La_2O_3 17.4%, Nd_2O_3 7.3%, Pr_2O_3 2.3%, Sm_2O_3 0.7%, total 27.7%; corresponds to $(Mg_{0.85}Fe_{0.15})_{\Sigma=1.00}[Ce_{1.06}(La, Nd)_{0.93}]_{\Sigma=1.99}(CO_3)_{4.00}$.

Occurrence: A rare accessory mineral in a rare-earth-bearing barite-dolomite carbonatite (Mountain Pass, California, USA).

Association: Parisite, bastnäsite, barite, dolomite, ankerite, quartz, hematite (Mountain Pass, California, USA); dorrite, esseneite, titanian andradite, magnetite–magnesioferrite–spinel, plagioclase, gehlenite–åkermanite, wollastonite, ulvöspinel, nepheline, apatite (Durham Ranch, Wyoming, USA); synchysite, monazite, strontianite, quartz (Kangankunde, Malawi).

Distribution: In the USA, from Mountain Pass, San Bernardino Co., California, and on the Durham Ranch, Powder River Basin, 13 km northeast of Reno Junction and 25 km south of Gillette, Campbell Co., Wyoming. At Kangankunde, Malawi.

Name: Honors Professor Thure Georg Sahama (1910–1983), Finnish geochemist and petrologist, University of Helsinki, Helsinki, Finland, who studied abundances of rare-earth elements.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106901.

References: (1) Jaffe, H.W., R. Meyerowitz, and H.T. Evans, Jr. (1953) Sahamalite, a new rare earth carbonate mineral. Amer. Mineral., 38, 741–754. (2) Pertlik, F. and A. Preisinger (1983) Crystal structure of sahamalite $(Mg, Fe)RE_2(CO_3)_4$. Tschermaks Mineral. Petrog. Mitt., 31, 39–46.

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Sahlinite $Pb_{14}O_9(AsO_4)_2Cl_4$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$ or m. Crystals are thin, scaly, to 2 mm, in seams and aggregates.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 2–3 D(meas.) = 7.38–8.00 D(calc.) = 8.096

Optical Properties: Semitransparent. *Color:* Pale sulfur-yellow, pale greenish yellow, bright yellow, to orange.
Optical Class: Biaxial (–). *Orientation:* $X = b$. n = Very high. 2V(meas.) = 96.5°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 12.710(13)$ $b = 22.498(8)$ $c = 11.360(9)$ $\beta = 118.99(3)°$ Z = 4

X-ray Powder Pattern: Långban, Sweden; close to kombatite.
3.011 (10), 2.946 (10), 2.814 (9), 1.754 (8), 2.249 (7), 1.985 (5), 2.021 (4)

Chemistry:

	(1)	(2)	(3)
As_2O_5	6.57	5.3	6.63
CO_2	0.43		
PbO	89.33	91.1	90.20
CaO	0.46		
Cl	4.05	4.0	4.09
H_2O	0.10		
$-O = Cl_2$	0.91	0.9	0.92
Total	100.03	99.5	100.00

(1) Långban, Sweden, average of two analyses; after deduction of Ca and CO_2 as calcite, corresponds to $Pb_{13.70}O_{8.85}(AsO_4)_{1.95}Cl_{3.92}$. (2) Do.; by electron microprobe. (3) $Pb_{14}O_9(AsO_4)_2Cl_4$.

Occurrence: In a metamorphosed Fe–Mn orebody (Långban, Sweden); in layered hausmannite-barite ore (Kombat mine, Namibia).

Association: Hausmannite, manganhumite, forsterite, dolomite (Långban, Sweden); copper, jacobsite, hausmannite, barite (Kombat mine, Namibia).

Distribution: From Långban, Värmland, Sweden. At the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia.

Name: To honor Dr. Carl Sahlin (1861–1943), General Manager of the iron works at Laxå, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; National Museum of Natural History, Washington, D.C., USA, B13892.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 775. (2) Rouse, R.C. and P.J. Dunn (1985) A re-examination of sahlinite from Långban, Sweden. Neues Jahrb. Mineral., Monatsh., 127–131.

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Sainfeldite $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongate along [001], flattened on {100}, showing {100}, {010}, {110}, {011}, {001}; in radiating groups and flattened rosettes, to 3 mm.

Physical Properties: Hardness = n.d. D(meas.) = 3.04(2) D(calc.) = 3.00(4)

Optical Properties: Transparent. *Color:* Colorless to light pink.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y \wedge c = \sim 20°$. $\alpha = 1.600(2)$ $\beta = 1.610(2)$ $\gamma = 1.616(2)$ 2V(meas.) = 80(2)°

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 18.781(7)$ $b = 9.820(4)$ $c = 10.191(4)$ $\beta = 97°1(3)'$ Z = 4

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France.
3.37 (FFF), 3.18 (FF), 8.7 (F), 4.64 (F), 3.06 (F), 4.86 (mF), 4.45 (mF)

Chemistry:

	(1)	(2)
As_2O_5	54.7	55.37
CaO	33.4	33.78
H_2O	11.5	10.85
Total	99.6	100.00

(1) Sainte-Marie-aux-Mines, France. (2) $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 4H_2O$.

Occurrence: A post-mine low-temperature reaction product of carbonate gangue with arsenical solutions derived from arsenic (Sainte-Marie-aux-Mines, France).

Association: Picropharmacolite, pharmacolite, ferrarisite, rauenthalite, fluckite, phaunouxite, calcite, löllingite (Sainte-Marie-aux-Mines, France); irhtemite (Bou Azzer, Morocco).

Distribution: In France, from the Gabe Gottes and Glückauf mines, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin; in the Salsigne mine, 15 km north of Carcassone, Aude; and at Duranus, Alpes Maritimes. From Jáchymov (Joachimsthal), Czech Republic. In the Anton mine, Heubachtal, near Schiltach, and the Sophia mine, near Wittichen, Black Forest, Germany. At Bou Azzer, Morocco.

Name: Honoring Paul Sainfeld (1916–), Honorary Curator, National School of Mines, Paris, France, who collected the type material.

Type Material: National School of Mines, Paris, France.

References: (1) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésiens naturels. Bull. Minéral., 87, 169–211 (in French). (2) (1965) Amer. Mineral., 50, 806 (abs. ref. 1). (3) Ferraris, G. and F. Abbona (1972) The crystal structure of $Ca_5(HAsO_4)_2(AsO_4)_2 \cdot 4H_2O$ (sainfeldite). Bull. Soc. fr. Minéral., 95, 33–41.

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Sakhaite $Ca_{12}Mg_4(BO_3)_7(CO_3)_4Cl(OH)_2 \cdot H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, in veinlets.

Physical Properties: Hardness = 5 D(meas.) = 2.78–2.83 D(calc.) = 2.79

Optical Properties: Transparent. *Color:* Gray to grayish white; colorless in transmitted light.
Luster: Vitreous to slightly greasy.
Optical Class: Isotropic. $n = 1.638$–1.641

Cell Data: *Space Group:* $Fd3m$. a = 14.685(3) Z = 4

X-ray Powder Pattern: Titovskoye deposit, Russia.
2.58 (100), 2.108 (56), 5.16 (22), 1.827 (21), 1.951 (14), 2.81 (13), 1.491 (12)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	14.33	13.36	MgO	12.54	12.24
SiO_2	0.25		CaO	50.18	51.09
B_2O_3	17.65	18.50	F	0.00	
Al_2O_3	0.24		Cl	2.63	2.68
Fe_2O_3	0.00		H_2O	2.75	2.74
FeO	0.31		$-O = (F, Cl)_2$	0.58	0.61
			Total	100.30	100.00

(1) Titovskoye deposit, Russia; CO_2 and BO_3 confirmed by IR; with $(OH)^{1-}$ calculated for charge balance, corresponds to $Ca_{11.71}Mg_{4.07}Fe_{0.06}Al_{0.06}Si_{0.05}(BO_3)_{6.64}(CO_3)_{4.26}Cl_{0.97}(OH)_{2.65} \cdot 0.68H_2O$.
(2) $Ca_{12}Mg_4(BO_3)_7(CO_3)_4Cl(OH)_2 \cdot H_2O$.

Occurrence: In lenses replacing marble at the contact of a granitic massif with dolostone (Titovskoye deposit, Russia).

Association: Kotoite, clinohumite, forsterite, suanite, spinel, ludwigite, borcarite, szaibélyite, sphalerite (Titovskoye deposit, Russia); szaibélyite, kotoite, fluoborite, stannian ludwigite, forsterite (Daiy Mountain, China).

Distribution: From the Titovskoye boron deposit, Tas-Khayakhtakh Mountains, Sakha, and at the Solongo boron deposit, Buryatia, Russia. In the Sayak-IV boron deposit, northeast Balkhash region, Kazakhstan. From Daiy Mountain, Qiliping, Hunan Province, China. At Fuka, near Bicchu, Okayama Prefecture, Japan. In the Kombat Cu–Pb–Ag mine, 49 km south of Tsumeb, Namibia.

Name: From *Sakha*, the Yakutian word for Yakutia [now Sakha].

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67237.

References: (1) Ostrovskaya, I.V., N.N. Pertsev, and I.B. Nikitina (1966) Sakhaite, a new carbonate-borate of calcium and magnesium. Zap. Vses. Mineral. Obshch., 95, 193–202 (in Russian). (2) (1966) Amer. Mineral., 51, 1816 (abs. ref. 1). (3) Giuseppetti, G, F. Mazzi, and C. Tadini (1977) The crystal structure of harkerite. Amer. Mineral., 62, 263–272. (4) Yakuovich, O.V., Y.K. Yegorov-Tismenko, M.A. Simonov, and N.V. Belov (1978) Crystal structure determination of sakhaite $Ca_3Mg[BO_3]_2[CO_3] \cdot 0.36H_2O$. Doklady Acad. Nauk SSSR, 239, 1103–1106 (in Russian). (5) Dunn, P.J., D.R. Peacor, J.A. Nelen, R.A. Ramik, and J. Innes (1990) A sakhaite-like mineral from the Kombat mine in Namibia. Mineral. Mag., 54, 105–108.

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Sakharovaite $Pb_4Fe(Bi,Sb)_6S_{14}$

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Crystal Data: Monoclinic (?) [by analogy to jamesonite]. *Point Group:* n.d. As radiating aggregates of fine capillary crystals, to 1 cm.

Physical Properties: *Cleavage:* Perfect in one direction. Hardness = Low. VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, pure white. *Luster:* Metallic. *Pleochroism:* Birefringent. *Anisotropism:* Strong; reddish internal reflections seen only in oil.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Ustarasai deposit, Uzbekistan.
3.412 (100), 2.721 (60), 2.031 (60b), 3.093 (40), 2.811 (40), 2.299 (40), 2.244 (40)

Chemistry:

	(1)
Pb	32.25
Fe	1.39
Cu	0.30
Bi	30.50
Sb	16.50
S	17.62
insol.	1.59
Total	100.15

(1) Ustarasai deposit, Uzbekistan; by analogy to jamesonite, corresponds to $Pb_{3.97}Fe_{0.63}Cu_{0.12}(Bi_{3.72}Sb_{3.45})_{\Sigma=7.17}S_{14.00}$.

Occurrence: In carbonate veinlets cutting arsenopyrite ore (Ustarasai deposit, Uzbekistan); as inclusions in and myrmeketic intergrowths with tetrahedrite (Rudňay, Slovakia).

Association: Antimony, realgar, cinnabar (Ustarasai deposit, Uzbekistan); tetrahedrite (Rudňay, Slovakia).

Distribution: From the Ustarasai bismuth deposit, near Brichmulla village, Pskem Range, southern Tien Shan, northeastern Uzbekistan [TL]. Found at Rudňay, Spišsko-Gemerské Rudohorie Mountains, Slovakia. In the Dachang district, Guangxi Autonomous Region, China.

Name: In honor of Professor Marina Sergeevna Sakharova (1917–), Soviet mineralogist specializing in gold and silver deposits, Moscow University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72022.

References: (1) Sakharova, M.S. (1955) Bismuth sulfosalts of the Ustarasaisk deposits. Trudy Mineral. Muzeya Akad. Nauk SSSR, 7, 112–116 (in Russian). (2) (1956) Amer. Mineral., 41, 814 (abs. ref. 1). (3) Kostov, I. (1959) Bismuth jamesonite or sakharovaite — a new mineral species. Trudy Mineral. Muzeya Akad. Nauk SSSR, 10, 148–149 (in Russian). (4) (1960) Amer. Mineral., 45, 1134 (abs. ref. 3). (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 177.

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Sakuraiite $(Cu, Zn, In, Fe, Sn)S$

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Crystal Data: Cubic. *Point Group:* 432, $\overline{4}3m$, or $4/m\ \overline{3}\ 2/m$. Forms in exsolution texture with stannite, to 0.5 mm.

Physical Properties: Hardness = 4 VHN = 243–282, 265 average (100 g load).
D(meas.) = n.d. D(calc.) = 4.45

Optical Properties: Opaque. *Color:* Greenish steel-gray; in polished section, purplish olive-gray with a red tint. *Streak:* Lead-gray with olive tint. *Luster:* Metallic. *Anisotropism:* Nearly isotropic.
R_1–R_2: (400) 22.5, (420) 22.5, (440) 22.5, (460) 22.6, (480) 22.6, (500) 22.6, (520) 22.6, (540) 22.7, (560) 22.6, (580) 22.5, (600) 22.5, (620) 22.6, (640) 22.6, (660) 22.6, (680) 22.6, (700) 22.4

Cell Data: *Space Group:* $P432$, $P\overline{4}3m$, or $Pm3m$. $a = 5.4563(24)$ $Z = 1$

X-ray Powder Pattern: Ikuno mine, Japan.
3.15 (100), 1.927 (40), 1.650 (20), 2.73 (10), 5.47 (6), 3.85 (6), 2.44 (6)

Chemistry:

	(1)	(2)	(3)
Cu	21	19.6	18.9
Zn	14	13.7	18.0
Cd		0.6	0.7
Fe	5	6.9	4.5
Ag	3.5	0.2	0.1
In	23	22.0	23.8
Sn	4	7.2	4.9
S	30	29.1	29.0
Total	100.5	99.3	99.9

(1) Ikuno mine, Japan; by electron microprobe, corresponding to $(Cu_{1.41}Zn_{0.92}In_{0.86}Fe_{0.38}Sn_{0.14}Ag_{0.14})_{\Sigma=3.85}S_{4.00}$. (2) Do.; by electron microprobe, corresponds to $(Cu_{1.36}Zn_{0.92}In_{0.84}Fe_{0.54}Sn_{0.27}Cd_{0.02}Ag_{0.01})_{\Sigma=3.96}S_{4.00}$. (3) Do.; by electron microprobe, corresponds to $(Cu_{1.32}Zn_{1.22}In_{0.92}Fe_{0.36}Sn_{0.18}Cd_{0.03})_{\Sigma=4.03}S_{4.00}$.

Occurrence: In a banded hydrothermal vein.

Association: Stannite, sphalerite, chalcopyrite, cassiterite, matildite, cobaltian arsenopyrite, quartz, calcite.

Distribution: From the Ikuno mine, Hyogo Prefecture, Japan [TL].

Name: Honors Dr. Kin-ichi Sakurai (1912–1993), Japanese mineral collector.

Type Material: National Science Museum, Tokyo, Japan, M15843; National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 108788; National Museum of Natural History, Washington, D.C., USA, 120592.

References: (1) Kato, A. (1965) Sakuraiite, a new mineral. Chigaku Kenkyu [Earth Science Studies], Sakurai volume, 1–5 (in Japanese). (2) (1968) Amer. Mineral., 53, 1421 (abs. ref. 1). (3) Shimizu, M., A. Kato, and T. Shiozawa (1986) Sakuraiite: chemical composition and extent of (Zn, Fe)In–for–CuSn substitution. Can. Mineral., 24, 405–409. (4) Kissin, S.A. and D.R. Owens (1986) The crystallography of sakuraiite. Can. Mineral., 24, 679–683.

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Sal ammoniac NH_4Cl

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals show {112}, {113}, {011}, rarely {001}; commonly with stepped or curved faces, skeletal or dendritic, to 5 cm; stalactitic, or in crusts, fibrous, earthy. *Twinning:* On {111}, may be cyclic.

Physical Properties: *Cleavage:* {111}, imperfect. *Fracture:* Conchoidal. *Tenacity:* Between brittle and sectile; very plastic. Hardness = 1–2 D(meas.) = 1.532 D(calc.) = 1.535 Soluble in H_2O; stinging salty taste.

Optical Properties: Transparent. *Color:* Colorless, white, pale gray, may be pale yellow to brown if impure; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic; may be weakly anisotropic. $n = 1.639(1)$

Cell Data: *Space Group:* $Pm3m$ (synthetic). $a = 3.8756$ $Z = 1$

X-ray Powder Pattern: Synthetic.
2.740 (100), 3.87 (25), 1.582 (25), 1.939 (8), 1.733 (6), 1.370 (6), 1.225 (6)

Chemistry: Identification relies on correspondence of properties with synthetic material.

Occurrence: A sublimation product around volcanic fumaroles; in burning coal seams and waste piles; in guano deposits. The ammonia usually is derived from organic matter.

Association: Sulfur (fumaroles); realgar, orpiment, sulfur, mascagnite, tschermigite (burning coal).

Distribution: Fumarolic on: Vesuvius, Campania; Etna, Sicily; Stromboli and Vulcano, Lipari Islands, Italy. From Mount Pelée, Martinique, West Indies. At Hekla, Iceland. On Parícutin, Michoacán, Mexico. At Kilauea, Hawaii, USA. From the Kukhi-Malik area, near Rarat, Tajikistan. With burning coal at: Duttweiler, near Saarbrücken, Saarland, Germany. At Saint-Etienne, Loire, France. From Newcastle, Northumberland, England. On Mt. Pyramide, Spitsbergen, Norway. In the USA, at the Hope Ranch, Santa Barbara Co., California. In guano on: Cincha and Guañape Islands, Peru. At [??ck-a Province??] Tarapacá, Chile.

Name: From the Greek, *sal ammoniac*, applied in antiquity to the synthetic compound.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 15–18. (2) (1953) NBS Circ. 539, 1, 59.

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Saléeite $Mg(UO_2)_2(PO_4)_2 \cdot 10H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Crystals are square plates, composite, flattened on {001}, with {001}, {100}, {120}, {012} (pseudotetragonal indices), to 2.5 cm; commonly in subparallel lamellar aggregates.

Physical Properties: *Cleavage:* On {001}, perfect; on {010}, {110}, indistinct (pseudotetragonal indices). Hardness = 2–3 D(meas.) = 3.27 D(calc.) = 3.21 Radioactive; fluoresces bright lemon-yellow under LW UV, pale yellow under SW UV.

Optical Properties: Transparent to opaque. *Color:* Lemon-yellow, straw-yellow, greenish yellow. *Luster:* Adamantine to waxy.
Optical Class: Biaxial (–), typically nearly uniaxial (–), sectored. *Pleochroism:* X = colorless; Z = pale greenish yellow. *Dispersion:* $r > v$, marked. α = 1.554–1.559 β = 1.570–1.582 γ = 1.571–1.585 2V(meas.) = 0°–61°

Cell Data: *Space Group:* $P2_1/c$. a = 6.951(3) b = 19.947(8) c = 9.896(4) β = 135.17(2)° Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
9.97 (10), 3.48 (8), 4.94 (7), 4.45 (4), 2.20 (3), 1.739 (3), 6.54 (2)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	61.72	61.23	MgO	4.43	4.31
P_2O_5	14.87	15.19	H_2O	19.39	19.27
			Total	100.41	100.00

(1) Cunha Baixa mine, Portugal; corresponds to $Mg_{1.03}(UO_2)_{2.02}(PO_4)_{1.96} \cdot 10.05H_2O$.
(2) $Mg(UO_2)_2(PO_4)_2 \cdot 10H_2O$.

Mineral Group: Autunite group.

Occurrence: In the oxidized zone of uranium-bearing polymetallic hydrothermal and sedimentary mineral deposits.

Association: Torbernite, autunite, zeunerite, bassetite, dewindtite, sabugalite, phosphuranylite, dumontite.

Distribution: Many localities. A few for good examples or studied material include: from Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Schneeberg, Saxony, Germany. In Spain, from the Caridid mine, Villavieja de Yeltes, Salamanca Province. From the Cunha Baixa and Quarta Feira mines, Sabugal, Portugal. From Arcu su Linnarbu, near Capoterra, Sardinia, Italy. In England, in Cornwall, from the South Terras mine, St. Stephen-in-Brannel; in Wheals Edward and Owles, St. Just; from Wheal Basset, Illogan; and at Roughton Great Consols, St. Clether. In the Plessis deposit, near Mortagne, Deux-Sèvres, France. In Australia, large crystals from the Ranger mine, Jabiru, and at Rum Jungle, Alligator River district, Northern Territory; in the Lake Boga granite quarry, near Swan Hill, and at Wycheproof, Victoria. From the Énio pegmatite mine, and at the Córrego do Urucum pegmatite, near Galiléia, Minas Gerais, Brazil. In the USA, from the Sue mine, Cherry Creek area, Gila Co., Arizona; on the High Park claims, Teller Co., Colorado.

Name: In honor of Achille Salée (1883–1932), Professor of Geology, Catholic University of Louvain, Louvain, Belgium.

Type Material: Catholic University of Louvain, Louvain, Belgium, K1812.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 988–989. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 177–183. (3) Piret, P. and M. Deliens (1980) Nouvelles données sur la saléeite holotype de Shinkolobwe. Bull. Minéral., 103, 630–632 (in French with English abs.). (4) Vochten, R. and M. Van Doorselaer (1984) Secondary uranium minerals of the Cunha Baixa mine. Mineral. Record, 15, 293–297. (5) Miller, S.A. and J.C. Taylor (1986) The crystal structure of saleeite, $Mg[UO_2PO_4]_2 \cdot 10H_2O$. Zeits. Krist., 177, 247–253.

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Salesite $Cu(IO_3)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Short prismatic crystals, to 2 mm, with large {101}, {111}, modified by {301}, {100}, {110}, {230}, {010}.

Physical Properties: *Cleavage:* Perfect on {101}. Hardness = 3 D(meas.) = 4.77(5) D(calc.) = 4.887

Optical Properties: Transparent. *Color:* Bluish green, deep green; bluish green in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale bluish green; Z = bluish green. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, extreme. $\alpha = 1.786(5)$ $\beta = 2.070(10)$ $\gamma = 2.075(10)$ 2V(meas.) = 0°–5°

Cell Data: *Space Group: Pnma.* $a = 10.794(2)$ $b = 6.708(1)$ $c = 4.781(1)$ Z = 4

X-ray Powder Pattern: Chuquicamata, Chile. (ICDD 22-236).
4.37 (100), 3.66 (65), 2.394 (60), 1.788 (55), 2.698 (50), 5.38 (40), 2.636 (30)

Chemistry:

	(1)	(2)
I_2O_5	64.79	65.33
CuO	30.62	31.14
Na_2O	0.59	
H_2O	3.68	3.53
Total	99.68	100.00

(1) Chuquicamata, Chile; $H_2O + I_2$ by the Penfield method, then I_2 dissolved by KI and titrated, H_2O taken by difference; corresponds to $(Cu_{0.99}Na_{0.04})_{\Sigma=1.03}(IO_3)_{1.00}(OH)_{1.05}$. (2) $Cu(IO_3)(OH)$.

Occurrence: A rare mineral in the oxidized zone of a copper porphyry deposit.

Association: Kaolin, quartz.

Distribution: From Chuquicamata, Antofagasta, Chile.

Name: To honor Reno H. Sales (1876–1969), Chief Geologist of the Anaconda Company, responsible for initial development of the mine at Chuquicamata, Chile.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 95027.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 315–316. (2) Ghose, S. and C. Wan (1978) Salesite, $CuIO_3(OH)$, and $Cu(IO_3)_2 \cdot 2H_2O$: a comparison of the crystal structures and their magnetic behavior. Amer. Mineral., 63, 172–179.

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Samaniite $Cu_2Fe_5Ni_2S_8$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As grains, to 0.1 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 3 VHN = 130 (50 g load). D(meas.) = n.d. D(calc.) = 4.89

Optical Properties: Opaque. *Color*: Yellowish white macroscopically and in reflected light.
Streak: n.d. *Luster*: Metallic.
Optical Class: n.d. *Pleochroism*: Weak, yellowish white to pale yellowish white.
Anisotropism: Weak, dark-gray to light-gray.
R_1-R_2: (436) 27.1-29.6, (497) 34.4-37.9, (543) 38.9-43.6, (586) 44.9-49.8, (648) 42.2-46.9

Cell Data: *Space Group*: $P4_2/mmm$. a = 10.089(1) c = 10.402(8) Z = 4

X-ray Powder Pattern: Horoman massif, Samani-cho, Samani-gun, Hokkaido, Japan.
3.118 (100), 1.844 (50), 1.595 (45), 1.873 (25), 3.050 (20), 5.88 (15), 2.703 (5)

Chemistry:

	(1)
Cu	16.90
Fe	34.60
Ni	15.48
Co	0.16
S	32.87
Total	100.01

(1) Horoman massif, Samani-cho, Samani-gun, Hokkaido, Japan; average of 10 electron microprobe analyses, corresponding to $Cu_{2.08}(Fe_{4.84}Ni_{2.06}Co_{0.02})_{\Sigma=6.92}S_8$.

Occurrence: Filling space between silicate minerals in lherzolites of a peridotite massif.

Association: Horomanite and sugakiite as intergrowths; bornite, talnakhite, copper, troilite, heazlewoodite, pentlandite, magnetite, olivine, clino- and orthopyroxenes.

Distribution: Horoman peridotite massif, Samani-cho, Samani-gun, Hokkaido, Japan.

Name: For the region of Japan (*Samani*-cho) from which the first specimens were collected.

Type Material: Tohoku University Museum, Japan.

References: (1) Kitakaze, A., H. Itoh, and R. Komatsu (2011) Horomanite, $(Fe,Ni,Co,Cu)_9S_8$, and samaniite, $Cu_2(Fe,Ni)_7S_8$, new mineral species from the Horoman peridotite massif, Hokkaido, Japan. Journal of Mineralogical and Petrological Sciences, 106, 204-210. (2) (2014) Amer. Mineral., 99, 552-553 (abs. ref. 1).

Samarskite-(Y) $(Y, Fe^{3+}, U)(Nb, Ta)O_4$

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Crystal Data: Orthorhombic; metamict. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, typically rough, elongated ‖ [001], to 12 cm, pyramidal terminations, cross-sections rectangular, flattened on {100} or {010}; commonly granular, massive.

Physical Properties: *Cleavage:* {010}, indistinct. *Fracture:* Conchoidal to small conchoidal. *Tenacity:* Brittle. Hardness = 5–6 VHN = 736–897 D(meas.) = 5.0–5.69 D(calc.) = [6.28] Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Velvet-black, may have a brownish tint, brown to yellowish brown due to alteration; light to dark brown in transmitted light. *Streak:* Dark reddish brown to black, yellow-brown; gray when altered. *Luster:* Vitreous to resinous, may be submetallic, splendent; externally dull.
Optical Class: Isotropic. n = 2.1–2.2

Cell Data: *Space Group: Pbcn*, probable; heated at 550 °C in H_2 atmosphere for 16 hours. $a = 5.687$ $b = 4.925$ $c = 5.210$ Z = [2]

X-ray Powder Pattern: Kawabe, Japan; after heating at 550 °C in hydrogen for 16 hours. 3.030 (100), 3.728 (15), 2.843 (15), 2.603 (15), 2.495 (10), 1.920 (10), 1.863 (10)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
UO_3	11.23		SnO_2	0.79		FeO	11.15	10.0
WO_3	1.41	2.1	Al_2O_3	0.19	0.3	MnO	0.69	1.5
U_3O_8		29.6	Y_2O_3	7.83	3.9	ZnO	0.17	
Nb_2O_5	32.02	38.3	La_2O_3	0.37		PbO	0.15	0.0
Ta_2O_5	11.18	10.2	Ce_2O_3	0.25		MgO	0.41	0.1
SiO_2	0.12		Dy_2O_3	1.56		CaO	0.51	0.3
TiO_2	0.68	0.2	Er_2O_3	13.37		Na_2O	0.28	0.1
ZrO_2	1.03	0.6	Fe_2O_3	2.13		K_2O	0.21	0.1
ThO_2	1.73	1.3	Sb_2O_3		0.2	H_2O	1.22	
						rem.	0.07	
						Total	100.75	98.8

(1) Miass, Russia. (2) Kawabe, Japan; by ICP, corresponds to $A_{0.99}B_{1.01}O_4$.

Occurrence: An accessory mineral in RE-rich granite pegmatites, common but not abundant; rarely as a detrital mineral.

Association: Columbite, zircon, monazite, uraninite, aeschynite, magnetite, albite, topaz, beryl, garnet, muscovite, biotite.

Distribution: A few localities for analyzed material include: at Miass, Ilmen Mountains, Southern Ural Mountains, Russia. From the Ånneröd, Iveland, and Setesdal districts, Norway. In the USA, at Glastonbury, Hartford Co., Connecticut; in the Mitchell pegmatite, Bedford Co., Virginia; around Spruce Pine, Mitchell Co., North Carolina; near Nuevo, Riverside Co., California; at the Addey claims, along Texas Creek, Fremont Co., Colorado; and in the New Year's Eve mine, Sierrita Mountains, Pima Co., Arizona. At Divina de Uba, near Belo Horizonte, Minas Gerais, Brazil. In Madagascar, from Ambatofotsikely, Antsirabe, Ampangabé, and elsewhere. At Kivu, Kivu Province, Congo (Zaire). In Japan, especially in the Ishikawa district, Fukushima Prefecture. Many other localities are known.

Name: To honor Colonel Vasilii Evgrafovich von Samarskii-Bykhovets (1803–1870), Chief of Staff of the Russian Corps of Mining Engineers.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 797–801, 806–807 [ampangabéite]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 526–533, 542–545 [ampangabéite]. (3) Sugitani, Y., Y. Suzuki, and K. Nagashima (1985) Polymorphism of samarskite and its relationship to other structurally related Nb–Ta oxides with the $\alpha-PbO_2$ structure. Amer. Mineral., 70, 856–866.

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Samfowlerite $Ca_{14}Mn_3Zn_2(Be,Zn)_2Be_6(SiO_4)_6(Si_2O_7)_4(OH,F)_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to 0.05 mm, and in groups.

Physical Properties: Hardness = <3. D(meas.) = 3.28(5) D(calc.) = 3.29–3.31 Weakly fluoresces red under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $X \wedge a = 44°$; $Z \wedge c = 29°$. $\alpha = 1.674(3)$ $\beta = 1.680(3)$ $\gamma = 1.681(3)$ 2V(meas.) = 29.0(1)°

Cell Data: *Space Group:* $P2_1/c$. $a = 9.068(2)$ $b = 17.992(2)$ $c = 14.586(2)$ $\beta = 104.86(1)°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.863 (100), 2.653 (50), 2.388 (50), 2.771 (40), 2.272 (30), 1.832 (30), 2.329 (20)

Chemistry:

	(1)
SiO_2	36.9
MnO	9.3
ZnO	9.5
BeO	5.6
MgO	0.2
CaO	34.1
F	1.0
H_2O	[3.8]
$-O = F_2$	0.4
Total	[100.0]

(1) Franklin, New Jersey, USA; by electron microprobe, Be and F by ion microprobe, H_2O by difference; crystal structure analysis indicates that Be is lower and H_2O is higher than reported; corresponding to $(Ca_{13.9}Mg_{0.1})_{\Sigma=14.0}Mn_{3.0}Zn_{2.6}Be_{5.1}Si_{14.0}O_{56.5}H_{9.6}F_{1.2}$.

Occurrence: In vugs in granular willemite-franklinite-andradite ore from a metamorphosed stratiform Zn–Mn deposit.

Association: Andradite-grossular, cahnite, clinochlore, leucophoenicite, johnbaumite, barite, franklinite, willemite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: For Samuel Fowler, M.D. (1779–1844), who early encouraged study of the Franklin deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, M04254.

References: (1) Rouse, R.C., D.R. Peacor, P.J. Dunn, S.-C. Su, P.H. Chi, and H. Yeates (1994) Samfowlerite, a new Ca Mn Zn beryllosilicate mineral from Franklin, New Jersey: its characterization and crystal structure. Can. Mineral., 32, 43–53.

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Sampleite $NaCaCu_5(PO_4)_4Cl \cdot 5H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are very thin, lathlike, flattened on {010}, elongated along [001], to 1 cm; in rosettes, usually aggregated into crusts.

Physical Properties: *Cleavage:* {010}, perfect; {100}, {001}, good. Hardness = ∼4
D(meas.) = 3.20 D(calc.) = 3.26

Optical Properties: Transparent. *Color:* Light blue to blue-green; blue in transmitted light. *Luster:* Pearly on {010}.
Optical Class: Biaxial (–). *Pleochroism:* X = deep blue, blue-green; Y = light blue, turquoise-blue; Z = turquoise-blue, colorless. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$. *Absorption:* $Z = Y > X$. $\alpha = 1.629(1)$ $\beta = 1.677(1)$ $\gamma = 1.679(1)$ 2V(meas.) = 5°–23°

Cell Data: *Space Group:* n.d. $a = 9.70$ $b = 38.40$ $c = 9.65$ Z = 8

X-ray Powder Pattern: Chuquicamata, Chile.
9.60 (10), 3.04 (10), 4.30 (8), 1.71 (8), 6.85 (7), 3.89 (7), 1.79 (7)

Chemistry:

	(1)	(2)
P_2O_5	32.10	32.03
CuO	44.12	44.88
MgO	0.52	
CaO	5.83	6.33
Na_2O	3.11	3.50
K_2O	1.49	
Cl	4.00	4.00
H_2O	9.74	10.16
$-O = Cl_2$	0.91	0.90
Total	100.00	100.00

(1) Chuquicamata, Chile; recalculated to 100% after deduction of insoluble 1.48%; corresponds to $(Na_{0.88}K_{0.27})_{\Sigma=1.15}(Ca_{0.91}Mg_{0.10})_{\Sigma=1.01}Cu_{4.83}(PO_4)_{3.94}Cl_{0.98} \cdot 4.71H_2O$.
(2) $NaCaCu_5(PO_4)_4Cl \cdot 5H_2O$.

Occurrence: A rare mineral in the oxidized zone of copper deposits in arid climates; in caves, derived from copper sulfides in the cave walls and phosphate from bat guano.

Association: Atacamite, libethenite, pseudomalachite, torbernite, chrysocolla, gypsum, calcite, jarosite.

Distribution: In Chile, in Antofagasta, from Chuquicamata; at the Fortuna mine, east of Baquedano; as large crystals from Mantos Blancos; at the Santa Catalina mine, Sierra Gorda district; and from the El Guanaco mine, near Taltal. In Australia, from the Lake Boga granite quarry, near Swan Hill, Victoria, at the Spring Creek mine, near Wilmington, South Australia, from Mooloo Station, 12 km east of the homestead, Murchison, and in the Jingemia Cave, 6 km northwest of Watheroo, Western Australia. From the Tsaobismund pegmatite, 60 km south of Karibib, Namibia. In the Mbobo Mkulu Cave, near Ngodwana, eastern Transvaal, South Africa.

Name: In honor of Mat Sample, Mine Superintendent, Chuquicamata, Chile.

Type Material: Harvard University, Cambridge, Massachusetts, 95023, 95024; National Museum of Natural History, Washington, D.C., USA, 137298.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 945–946. (2) Hurlbut, C.S, Jr. (1942) Sampleite, a new mineral from Chuquicamata, Chile. Amer. Mineral., 27, 586–589. (3) Guillemin, C. (1956) Contribution a la minéralogie des arséniates, phosphates et vanadates de cuivre: phosphates et vanadates de cuivre. II. Phosphates et vanadates de cuivre. Bull. Soc. fr. Minéral., 79, 219–275, esp. 226–229 (in French).

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Samsonite $Ag_4MnSb_2S_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic and striated ‖ [001], to 3 cm, in radiating groups.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 VHN = 187–212 (100 g load). D(meas.) = 5.51 D(calc.) = 5.50

Optical Properties: Nearly opaque; translucent in thin fragments. *Color:* Steel-black, deep red to brown in transmitted light; in polished section, bluish white with deep red internal reflections. *Streak:* Dark red. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak. R_1–R_2: (400) 33.8–38.5, (420) 33.6–34.9, (440) 33.2–34.5, (460) 32.6–33.8, (480) 31.6–33.0, (500) 30.6–32.2, (520) 29.6–31.1, (540) 28.8–30.0, (560) 28.1–29.0, (580) 27.5–28.1, (600) 26.8–27.5, (620) 26.3–26.9, (640) 25.9–26.5, (660) 25.4–26.1, (680) 25.1–25.8, (700) 24.8–25.6

Cell Data: *Space Group:* $P2_1/n$. $a = 10.362(4)$ $b = 8.101(3)$ $c = 6.647(3)$ $\beta = 92°38(4)'$ Z = 2

X-ray Powder Pattern: St. Andreasberg, Germany. (ICDD 11-74).
3.20 (100), 3.01 (90), 2.59 (60), 2.86 (50), 2.43 (50), 2.51 (40), 6.4 (30)

Chemistry:

	(1)	(2)
Ag	45.95	46.78
Mn	5.86	5.96
Cu	0.18	
Fe	0.22	
Sb	26.33	26.40
S	20.55	20.86
rem.	0.87	
Total	99.96	100.00

(1) St. Andreasberg, Germany; remainder is $CaCO_3$ 0.41%, $MgCO_3$ 0.46%, original total given as 99.86%; corresponds to $Ag_{3.99}Mn_{1.00}Fe_{0.04}Cu_{0.03}Sb_{2.02}S_{6.00}$. (2) $Ag_4MnSb_2S_6$.

Occurrence: Very rare in a hydrothermal vein (St. Andreasberg, Germany).

Association: Pyrargyrite, galena, dyscrasite, tetrahedrite, pyrolusite, quartz, calcite, apophyllite (St. Andreasberg, Germany).

Distribution: From the Samson vein, St. Andreasberg, Harz Mountains, Germany [TL]. At the Garpenberg Norra mine, Dalarna, Sweden. From the Brady Lake property of the Silver Miller mine, near Cobalt, Ontario, Canada.

Name: For the occurrence in the Samson vein, St. Andreasberg, Germany.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 393–395. (2) Werner and Fraatz (1910) Samsonit, ein manganhaltiges Silbermineral von St. Andreasberg im Harz. Centralblatt. Min., 331–336 (in German). (3) Edenharter, A. and W. Nowacki (1974) Verfeinerung der Kristallstruktur von Samsonit, $(SbS_3)_2Ag_2^{III}Ag_2^{IV}Mn^{VI}$. Zeits. Krist., 140, 87–99 (in German with English abs.). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 128–129. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 498.

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Samuelsonite $(Ca, Ba)Ca_8(Fe^{2+}, Mn^{2+})_4Al_2(PO_4)_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, elongated and striated ‖ [010], to 4 cm, flattened on {001}, showing large {100}, {001}, {101}, {$\bar{1}$01}, terminated by {012}, {$\bar{1}$12}, {$\bar{2}$11}, a few others, terminations may be ragged.

Physical Properties: *Cleavage:* On {001}, fair. Hardness = > 5 D(meas.) = 3.24–3.35 D(calc.) = 3.355

Optical Properties: Transparent to translucent. *Color:* Colorless, white.
Luster: Subadamantine, may be vitreous to resinous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; OAP $\sim\perp$ {001} cleavage, extinction inclined 22°. *Dispersion:* $r < v$, weak. $\alpha = 1.645$–1.648 $\beta = 1.650$–1.655 $\gamma = 1.655$–1.667 2V(meas.) = 70°–85° 2V(calc.) = 75°

Cell Data: *Space Group:* $C2/m$. $a = 18.495(5)$ $b = 6.805(2)$ $c = 14.000(5)$ $\beta = 112.75(6)°$ Z = 2

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
3.058 (10), 2.657 (7b), 3.032 (6), 1.706 (6), 3.389 (5), 2.734 (5), 3.245 (4)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	43.10	43.79	SrO	0.44	
Al_2O_3	4.80	6.18	BaO	2.04	2.31
Fe_2O_3		0.07	Li_2O		0.43
FeO	11.30	7.92	Na_2O	0.21	0.35
MnO	7.20	8.91	K_2O	0.02	
MgO	0.12	0.07	H_2O^+	3.00	1.85
CaO	28.30	28.41	Total	100.53	100.29

(1) Palermo #1 mine, New Hampshire, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(Ba_{0.21}Ca_{0.10}Sr_{0.07})_{\Sigma=0.38}Ca_{8.00}(Fe_{2.52}Mn_{1.63}Na_{0.11}Mg_{0.04})_{\Sigma=4.30}Al_{1.52}(PO_4)_{9.76}(OH)_{5.35}$. (2) Buranga pegmatite, Rwanda; corresponds to $(Ba_{0.24}Ca_{0.21})_{\Sigma=0.45}Ca_{8.00}(Mn_{2.04}Fe^{2+}_{1.78}Li_{0.46}Na_{0.18}Mg_{0.03})_{\Sigma=4.49}(Al_{1.97}Fe^{3+}_{0.02})_{\Sigma=1.99}(PO_4)_{10.00}(OH)_{2.00}\bullet 0.68H_2O$.

Occurrence: A secondary mineral in complex zoned granite pegmatites.

Association: Childrenite, hydroxylapatite, arrojadite, whitlockite, carbonate-apatite, laueite, Fe–Mn oxides (Palermo #1 mine, New Hampshire, USA); trolleite, bertossaite, scorzalite, apatite, burangaite, gatumbaite (Buranga pegmatite, Rwanda).

Distribution: From the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, USA. In the Buranga pegmatite, near Gatumba, Rwanda.

Name: Honoring Peter B. Samuelson (1941–), Rumney, New Hampshire, USA, for his efforts in field collecting of pegmatite minerals.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 128071.

References: (1) Moore, P.B., A.J. Irving, and A.R. Kampf (1975) Foggite, $CaAl(OH)_2(H_2O)[PO_4]$; goedkenite, $(Sr, Ca)_2Al(OH)[PO_4]_2$; and samuelsonite, $(Ca, Ba)Fe^{2+}_2Mn^{2+}_2Ca_8Al_2(OH)_2[PO_4]_{10}$: three new species from the Palermo No. 1 pegmatite, North Groton, New Hampshire. Amer. Mineral., 60, 957–964. (2) Moore, P.B. and T. Araki (1977) Samuelsonite: its crystal structure and relation to apatite and octacalcium phosphate. Amer. Mineral., 62, 229–245. (3) Fransolet, A.-M., O. von Knorring, and F. Fontan (1992) A new occurrence of samuelsonite in the Buranga pegmatite, Rwanda. Bull. Geol. Surv. Finland, 64(1), 13–21.

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Sanbornite $BaSi_2O_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As anhedral plates, up to 3 cm. *Twinning:* Polysynthetic on {100}.

Physical Properties: *Cleavage:* Perfect on {001}; imperfect on {100} and {010}. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.70(2) D(calc.) = 3.77

Optical Properties: Semitransparent. *Color:* White to colorless; in thin section, colorless. *Luster:* Pearly.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.598(1)$ $\beta = 1.617(2)$ $\gamma = 1.625(2)$ 2V(meas.) = 67° 2V(calc.) = 65°

Cell Data: *Space Group: Pcmn.* $a = 4.629(1)$ $b = 7.688(1)$ $c = 13.523(1)$ Z = 4

X-ray Powder Pattern: Trumbull Peak, California, USA.
3.97 (100), 3.092 (75), 3.342 (70), 2.720 (55), 3.422 (50), 2.130 (40), 6.79 (30)

Chemistry:

	(1)
SiO_2	44.16
Al_2O_3	0.41
Fe_2O_3	0.23
MgO	0.28
CaO	0.20
SrO	0.08
BaO	54.04
H_2O^+	0.54
H_2O^-	0.15
Total	100.09

(1) Trumbull Peak, California, USA; average of two analyses, corresponds to $(Ba_{0.95}Mg_{0.02}Fe^{3+}_{0.01}Ca_{0.01})_{\Sigma=0.99}(Si_{1.98}Al_{0.02})_{\Sigma=2.00}O_{4.98}\cdot 0.10H_2O$.

Occurrence: In veins in metamorphosed sediments, largely quartzites and hornfels (Trumbull Peak, California, USA).

Association: Quartz, gillespite, diopside, schorl, celsian, pyrrhotite, witherite (Trumbull Peak, California, USA); gillespite, pellyite, taramellite, fresnoite, muirite, barite (Gunn claim, Canada).

Distribution: From Trumbull Peak, near Incline, Mariposa Co., California, USA. On the Gunn claim, Itsy Mountains, near Macmillan Pass, Yukon Territory, Canada.

Name: For Frank Sanborn (1862–1936), mineralogist with the California Division of Mines, San Francisco, California, USA.

Type Material: n.d.

References: (1) Rogers, A.F. (1932) Sanbornite, a new barium silicate mineral from Mariposa County, California. Amer. Mineral., 17, 161–172. (2) Douglass, R.M. (1958) The crystal structure of sanbornite, $BaSi_2O_5$. Amer. Mineral., 43, 517–536. (3) Hesse, K.-F. (1980) Crystal chemistry of silica-rich barium silicates. III: refinement of the crystal structures of the layer silicates $Ba_2[Si_4O_{10}]$ (I), (sanbornite), and $Ba_2[Si_4O_{10}]$ (h). Zeits. Krist., 153, 33–41.

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Saneroite $\mathbf{Na_2(Mn^{2+},Mn^{3+})_{10}(Si_{11},V^{5+})O_{34}(OH)_4}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Tabular crystals, rarely prismatic to stocky, to 1 cm, in compact aggregates. *Twinning:* Present.

Physical Properties: *Cleavage:* Perfect in two perpendicular directions. Hardness = n.d. D(meas.) = 3.47 D(calc.) = 3.51

Optical Properties: Transparent to translucent. *Color:* Bright orange. *Luster:* Resinous to greasy.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = deep orange; Y = lemon-yellow; Z = yellow-orange. $\alpha = 1.715–1.725$ $\beta = 1.740–1.745$ $\gamma = 1.745–1.750$ 2V(meas.) = 40°–48°

Cell Data: *Space Group:* $P\bar{1}$. $a = 9.741(5)$ $b = 9.974(7)$ $c = 9.108(5)$ $\alpha = 92.70(4)°$ $\beta = 117.11(4)°$ $\gamma = 105.30(4)°$ Z = 1

X-ray Powder Pattern: Val Graveglia, Italy.
3.06 (s), 2.83 (s), 2.70 (s), 3.01 (m), 2.98 (m), 2.62 (m), 2.20 (m)

Chemistry:

	(1)
SiO_2	39.33
Fe_2O_3	0.36
As_2O_5	0.29
V_2O_5	6.60
MnO	40.13
CaO	0.25
Na_2O	4.53
H_2O^+	5.00
Total	96.49

(1) Val Graveglia, Italy; by electron microprobe, average of data collected on two zones of differing color, H_2O by TGA, valences from crystal structure analysis; corresponds to $Na_{2.40}(Mn^{2+}_{9.32}Fe^{3+}_{0.07}Ca_{0.07})_{\Sigma=9.46}(Si_{10.77}V^{5+}_{1.19}As^{5+}_{0.04})_{\Sigma=12.00}O_{35.30}\bullet 4.57H_2O$.

Occurrence: In veins in manganese ores associated with low-grade prehnite-pumpellyite facies metamorphic recrystallization of siliceous-hematitic sediments (Val Graveglia, Italy).

Association: Quartz, barite, caryopilite, ganophyllite (Val Graveglia, Italy); medaite, palenzonaite, pyrobelonite, fianelite, parsettensite, rhodochrosite, kutahorite, aegirine, quartz (Fianel mine, Switzerland).

Distribution: In Italy, at the Gambatesa and Molinello manganese mines, near Chiavari, Val Graveglia, Liguria, Italy. From the Fianel mine, Val Ferrera, Graubünden, Switzerland.

Name: For Edoardo Sanero, formerly Professor of Mineralogy at the University of Genoa, Genoa, Italy.

Type Material: University of Genoa, Genoa; Municipal Museum of Natural History, Genoa, Italy.

References: (1) Lucchetti, G., A.M. Penco, and R. Rinaldi (1981) Saneroite, a new natural hydrated Mn-silicate. Neues Jahrb. Mineral., Monatsh., 4, 161–168. (2) Basso, R. and A. Della Guista (1980) The crystal structure of a new manganese silicate. Neues Jahrb. Mineral., Abh., 138, 333–342. (3) (1981) Amer. Mineral., 66, 1277–1278 (abs. refs. 1 and 2).

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Sanidine $(K,Na)(Al,Si)_4O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly tabular on {010}, with a square cross section, to 50 cm. Acicular in spherulites. *Twinning:* Carlsbad twins are common, Baveno and Manebach twins rarer.

Physical Properties: *Cleavage:* Perfect on {001}, distinct on {010}; parting on {100}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 2.56–2.62 D(calc.) = [2.56]

Optical Properties: Transparent. *Color:* Colorless to white; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on cleavage.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c \simeq -20°$ (low); $Z = b$; $Y \wedge c \simeq -21°$ (high). *Dispersion:* $r < v$ or $r > v$, weak. $\alpha = 1.518$–1.524 $\beta = 1.522$–1.529 $\gamma = 1.522$–1.530 2V(meas.) = 18°–42° (low); 15°–63° (high)

Cell Data: *Space Group:* $C2/m$ (high). $a = 8.603(2)$ $b = 13.036(4)$ $c = 7.174(2)$ $\beta = 116.03(2)°$ Z = 4

X-ray Powder Pattern: Locality unknown.
3.326 (100), 3.284 (60), 3.788 (57), 4.235 (53), 3.225 (52), 2.584 (35), 3.458 (31)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	64.79	67.27	Na_2O		6.45
Al_2O_3	18.50	18.35	K_2O	16.79	7.05
$FeO + Fe_2O_3$		0.92	H_2O^+		0.08
CaO		0.15	H_2O^-		0.08
			Total	100.08	100.35

(1) Buck claims, Bernic Lake, Canada; by electron microprobe, average of analyses on six crystals; corresponds to $K_{0.99}Al_{1.01}Si_{3.00}O_8$. (2) Mitchell Mesa rhyolite, Texas, USA; corresponds to $(Na_{0.56}K_{0.40}Ca_{0.01})_{\Sigma=0.97}(Al_{0.97}Fe^{3+}_{0.03})_{\Sigma=1.00}Si_{3.01}O_8$.

Polymorphism & Series: High sanidine forms a series with high albite.

Mineral Group: Feldspar (alkali) group; (Al,Si) completely disordered.

Occurrence: Most common in felsic volcanic and hypabyssal rocks as rhyolites, phonolites, trachytes; as spherulites in volcanic glass. Also from ultrapotassic mafic, high-temperature contact metamorphic (sanidinite facies), and hydrothermally altered rocks. From eclogite nodules in kimberlite.

Association: Quartz, sodic plagioclase, muscovite, biotite, "hornblende," magnetite.

Distribution: Not uncommon, but rare in crystals of any size. In Germany, from Drachenfels, Siebengebirge, Rhine; and at Hohenfels, Mendig, Mayen, and elsewhere around the Laacher See, Eifel district. In France, at Mt. Dore, Auvergne, and Puy Gros du Laney, Puy-de-Dôme. From Vesuvius and Monte Somma, Campania, and Monte Cimine, Lazio, Italy. At Daichi, Wakayama Prefecture, Japan. From Kanchin-do, Meisem-gun, northeast Korea. In the USA, at Tooele, Tooele Co., Utah; Cottonwood Canyon, Peloncillo Mountains, Cochise Co., Arizona; as large crystals in Rabb Canyon and near the crest of the Black Range, Grant Co., New Mexico. From Bernic Lake, Manitoba, and Mont Saint-Hilaire, Quebec, Canada. In the Sierra de San Francisco, Durango, Mexico.

Name: From the Greek for *tablet* or *board*, in allusion to the mineral's common habit.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 318.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 6–93. (3) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 342–344.
(4) Ferguson, R.B., N.A. Ball, and P. Černý (1991) Structure refinement of an adularian end-member high sanidine from the Buck Claim pegmatite, Bernic Lake, Manitoba. Can. Mineral., 29, 543–552. (5) Scheel, H.J. (1971) Lead feldspar. Zeits. Krist., 133, 264–272.

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Sanjuanite $Al_2(PO_4)(SO_4)(OH)\cdot 9H_2O$

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Crystal Data: Triclinic (?). *Point Group:* n.d. Microscopic laths, parallel to divergent, fibrous, in chalklike aggregates.

Physical Properties: *Fracture:* Uneven to earthy. Hardness = 3 D(meas.) = 1.94 D(calc.) = 1.96

Optical Properties: Semitransparent. *Color:* White; colorless in transmitted light. *Luster:* Dull to silky.
Optical Class: Biaxial. *Orientation:* Positive elongation, extinction ∼25°–30°. $\alpha = 1.484$ (α') ⊥ length. β = n.d. $\gamma = 1.499$ (γ') ∥ length. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 11.314(11)$ $b = 9.018(9)$ $c = 7.376(7)$ $\alpha = 93°4.17(6.01)'$ $\beta = 95°46.49(4.17)'$ $\gamma = 105°39.77(4.42)'$ Z = 2

X-ray Powder Pattern: Sierra Chica de Zonda, Argentina.
10.77 (100), 4.13 (55), 5.28 (38), 4.32 (36), 3.450 (35), 8.66 (30), 4.27 (30)

Chemistry:

	(1)	(2)
SO_3	18.62	18.88
P_2O_5	16.39	16.73
Al_2O_3	23.48	24.04
Fe_2O_3	1.72	
H_2O	40.20	40.35
Total	100.41	100.00

(1) Sierra Chica de Zonda, Argentina; corresponds to $Al_{2.00}Fe_{0.10}(PO_4)_{1.00}(SO_4)_{1.01}(OH)\cdot 8.71H_2O$. (2) $Al_2(PO_4)(SO_4)(OH)\cdot 9H_2O$.

Occurrence: In mineralized joint fractures cutting slate.

Association: Gypsum, natrojarosite, iron oxides.

Distribution: On a ridge of the eastern slope of Sierra Chica de Zonda, about 45 km south-southwest from San Juan, San Juan Province, Argentina.

Name: For San Juan Province, Argentina, in which the mineral was first found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149522.

References: (1) de Abeledo, M.E.J., V. Angelelli, M.A.R. de Benyacar, and C. Gordillo (1968) Sanjuanite, a new hydrated basic sulfate-phosphate of aluminum. Amer. Mineral., 53, 1–8.
(2) de Bruiyn, H., G.J. Beukes, W.A. Van der Westhuizen, and E.A.W. Tordiffe (1989) Unit cell dimensions of the hydrated aluminum phosphate-sulphate minerals sanjuanite, kribergite, and hotsonite. Mineral. Mag., 53, 385–386.

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Sanmartinite $(Zn, Fe^{2+})WO_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare as crystals, to 60 μm, tabular on {001}, with {001}, {010}, {110}, {112}, {102}; typically in reticulated aggregates and fine-grained massive.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = n.d. D(meas.) = 6.70 D(calc.) = 7.87 (synthetic $ZnWO_4$).

Optical Properties: Translucent. *Color:* Reddish brown, with dark red internal reflections, dark brown to brownish black if massive. *Luster:* Resinous.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 4.702$ $b = 5.726$ $c = 4.948$ $\beta = 90°28'$ Z = 2

X-ray Powder Pattern: Synthetic $ZnWO_4$.
2.931 (100), 2.908 (90), 3.73 (40), 4.69 (35), 3.62 (35), 2.472 (35), 2.464 (35)

Chemistry:

	(1)	(2)	(3)
WO_3	72.62	73.41	74.02
FeO	7.24	4.67	
MnO	1.73	0.22	
ZnO	18.18	23.00	25.98
CaO	1.48		
insol.	0.24		
Total	[101.49]	101.30	100.00

(1) Los Cerrillos, Argentina; original total given as 101.25%; corresponds to $(Zn_{0.68}Fe_{0.31}Ca_{0.08}Mn_{0.07})_{\Sigma=1.14}(W_{0.95}O_4)$. (2) Do.; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponds to $(Zn_{0.81}Fe_{0.18})_{\Sigma=0.99}WO_4$. (3) $ZnWO_4$.

Occurrence: A rare alteration product of scheelite in a quartz vein between granite and granite pegmatite intruding Precambrian crystalline schists.

Association: Willemite, scheelite, tourmaline, quartz.

Distribution: From Los Cerrillos, seven km southwest of San Martín, San Luis Province, Argentina.

Name: For its occurrence near San Martín, Argentina.

Type Material: The Natural History Museum, London, England, 1978,353; Academy of Natural Sciences, Philadelphia, 25575; Harvard University, Cambridge, Massachusetts, 134566; National Museum of Natural History, Washington, D.C., USA, 105681, 137479.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1072–1073. (2) Dunn, P.J. (1978) Sanmartinite: new data. Mineral. Mag., 42, 281. (3) Redfern, S.A.T., A.M.T. Bell, C.M.B. Henderson, and P.F. Schofield (1995) Rietveld study of the structural phase transition in the sanmartinite ($ZnWO_4$)–cuproscheelite ($CuWO_4$) solid solution. Eur. J. Mineral., 7, 1019–1028. (4) (1963) NBS Mono. 25, 2, 40.

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Santaclaraite $CaMn_4^{2+}Si_5O_{14}(OH)_2 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Rarely as thick prismatic crystals, to 1 cm. As radiating lamellar aggregates of thin prismatic to tabular subhedral crystals, flattened on {100}. In rough spherules, also as cross-vein prismatic to nearly fibrous crystals. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Good on {100} and {010}. Hardness = 6.5
D(meas.) = 3.31 D(calc.) = 3.379

Optical Properties: Transparent. *Color:* Pale pink or moderate reddish orange. *Streak:* Pale pink. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* In thick sections, weak; X = very pale red; Y = pale red; Z = pale reddish brown. *Orientation:* $Z \wedge c = -2°$; $X \wedge b = -21°$ in {100} sections; $Y \wedge a = -14.5°$ in {010} sections; $Z \wedge c = 16°$. *Absorption:* $Y > Z > X$. $\alpha = 1.681(2)$ $\beta = 1.696(2)$ $\gamma = 1.708(2)$ 2V(meas.) = 81(1)°

Cell Data: *Space Group:* $P\bar{1}$. $a = 9.738(2)$ $b = 9.970(1)$ $c = 7.603(1)$ $\alpha = 109.77(1)°$ $\beta = 93.95(1)°$ $\gamma = 104.97(2)°$ Z = 2

X-ray Powder Pattern: Santa Clara Co., California, USA.
7.04 (100), 3.003 (84), 3.152 (80), 7.69 (63), 3.847 (57), 3.524 (39), 4.797 (38)

Chemistry:

	(1)
SiO_2	44.74
Al_2O_3	0.12
FeO	0.09
MnO	41.26
CoO	0.06
NiO	0.06
MgO	0.31
CaO	7.24
Na_2O	0.12
H_2O	5.28
Total	99.28

(1) Santa Clara Co., California, USA; H_2O by microcoulometric methods; corresponds to $(Ca_{0.87}Na_{0.03})_{\Sigma=0.90}(Mn^{2+}_{3.94}Mg_{0.05}Fe^{2+}_{0.01}Ni_{0.01}Co_{0.01})_{\Sigma=4.02}(Si_{5.04}Al_{0.02})_{\Sigma=5.06}O_{14.03}(OH)_{1.97} \cdot H_2O$.

Occurrence: As cross-fiber veins and irregular masses in manganese-oxide-stained chert and quartz.

Association: Calcite, quartz, barite, harmotome, chalcopyrite, copper, howieite, kutnohorite, rhodochrosite, braunite.

Distribution: From an unspecified manganese mine in the Diablo Range, Santa Clara Co., and the Buckeye mine, Stanislaus Co., California, USA.

Name: For the occurrence in Santa Clara Co., California, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA.

References: (1) Erd, R.C. and Y. Ohashi (1984) Santaclaraite, a new calcium-manganese silicate hydrate from California. Amer. Mineral., 69, 200–206. (2) Ohashi, Y. and L.W. Finger (1981) The crystal structure of santaclaraite, $CaMn_4[Si_5O_{14}(OH)](OH) \cdot H_2O$: the role of hydrogen atoms in the pyroxenoid structure. Amer. Mineral., 66, 154–168.

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Santafeite $(Na, Ca, Sr)_3(Mn^{2+}, Fe^{3+})_2Mn_2^{4+}(VO_4)_4(OH, O)_5 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Acicular crystals, to 4 mm, in radial spherulitic aggregates.

Physical Properties: *Cleavage:* {010}, perfect; {110}, distinct. *Tenacity:* Very brittle. Hardness = n.d. D(meas.) = 3.379 D(calc.) = [3.39]

Optical Properties: Opaque, translucent in thin fragments. *Color:* Black. *Streak:* Brown. *Luster:* Subadamantine.
Optical Class: Biaxial. *Pleochroism:* Pronounced; dark reddish brown to yellowish brown. *Orientation:* $X = c$; parallel extinction. *Dispersion:* Distinct. *Absorption:* $X > Y > Z$. $\alpha = 2.01$ $\beta =$ n.d. $\gamma =$ n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $B22_12$. $a = 9.25(2)$ $b = 30.00(2)$ $c = 6.33(2)$ Z = 4

X-ray Powder Pattern: Grants district, New Mexico, USA.
14.88 (10), 7.47 (5), 2.702 (5), 2.788 (4), 1.667 (4), 3.66 (3), 3.39 (3)

Chemistry:

	(1)	(2)
As_2O_5	2.2	3.2
V_2O_5	35.6	36.5
Al_2O_3		1.1
Fe_2O_3	0.9	1.1
MnO_2	16.6	16.5
MnO	13.7	13.3
MgO		0.9
CaO	6.2	5.2
SrO	6.0	8.5
Na_2O	4.1	5.0
H_2O	8.8	[8.8]
rem.	2.1	
Total	96.2	[100.1]

(1) Grants district, New Mexico, USA; remnant includes CuO 0.5%, CoO 0.1%, NiO 0.1%, UO_3 0.3%, SiO_2 + insoluble 0.8%, [cuprosklodowskite], CO_3 0.3% [limestone]. (2) Do.; by electron microprobe, Mn^{2+}:Mn^4 from (1); corresponds to $(Na_{1.44}Ca_{0.83}Sr_{0.73})_{\Sigma=3.00}(Mn^{2+}_{1.37}Mg_{0.20}Al_{0.19}Fe^{3+}_{0.12})_{\Sigma=1.88}(Mn^{4+}_{1.70}Mn^{2+}_{0.30})_{\Sigma=2.00}[(VO_4)_{3.59}(AsO_4)_{0.25}]_{\Sigma=3.84}[(OH), O]_{4.53} \cdot 2.10H_2O$.

Occurrence: Rarely incrusting fractures in limestone (Grants district, New Mexico, USA) and in sandstone (Monument No. 1 mine, Arizona, USA) in Colorado Plateau-type U–V deposits.

Association: Calcite, cuprosklodowskite (Grants district, New Mexico, USA); carnotite (Monument No. 1 mine, Arizona, USA).

Distribution: In the USA, from an unnamed uranium prospect about 20 km north of Grants, McKinley Co., New Mexico; at the Monument No. 1 mine, Monument Valley, Navajo Co., Arizona.

Name: For the Atchison, Topeka, and Santa Fe Railroad, on whose property the mineral was first found to occur, for their pioneering work in developing the uranium resources of the district.

Type Material: National Museum of Natural History, Washington, D.C., USA, 115882, 121957.

References: (1) Sun, M.-S. and R.H. Weber (1958) Santafeite, a new hydrated vanadate from New Mexico. Amer. Mineral., 43, 677–687. (2) Dunn, P.J. and D.R. Peacor (1986) Santafeite, a re-examination and new empirical formula. Mineral. Mag., 50, 299–300.

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Santanaite $9PbO \cdot 2PbO_2 \cdot CrO_3$

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Crystal Data: Hexagonal. *Point Group:* 622. Platy hexagonal crystals, flattened on {0001}, to 0.5 mm, in aggregates.

Physical Properties: *Cleavage:* {0001} and $\{11\bar{2}0\}$, very good; $\{10\bar{1}0\}$, rare. Hardness = ∼4 D(meas.) = n.d. D(calc.) = 9.155

Optical Properties: Semitransparent. *Color:* Straw-yellow; gray-brown in reflected light, with light yellow internal reflections. *Luster:* Adamantine.
Optical Class: Uniaxial (–). $\omega = 2.32$ $\epsilon = 2.12$

Cell Data: *Space Group:* $P6_322$. a = 9.03(1) $c = 39.84(8)$ Z = 6

X-ray Powder Pattern: Santa Ana mine, Chile.
3.539 (10), 2.606 (8), 2.080 (5), 1.701 (5), 2.948 (4), 2.846 (4), 2.243 (4)

Chemistry:

	(1)	(2)
Pb	88.0	88.10
Cr	1.9	2.01
O	[10.1]	9.89
Total	[100.0]	100.00

(1) Santa Ana mine, Chile; by electron microprobe, O by difference. (2) $Pb_{11}CrO_{16}$.

Occurrence: An alteration product of galena with other chromium-bearing minerals in an oxidized hydrothermal lead deposit.

Association: Galena, phoenicochroite, chromatian wulfenite, diaboleite, quartz.

Distribution: At the Santa Ana mine, near Caracoles, Sierra Gorda district, Antofagasta, Chile.

Name: For the occurrence at the Santa Ana mine, Chile.

Type Material: n.d.

References: (1) Mücke, A. (1972) Santanait, ein neues Bleichromat-Mineral. Neues Jahrb. Mineral., Monatsh., 455–458 (in German with English abs.). (2) (1973) Amer. Mineral., 58, 966 (abs. ref. 1).

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Santarosaite CuB_2O_4

Crystal Data: Tetragonal. *Point Group*: $\bar{4}\,2m$. As globules of leaf-like crystals, to 0.06 mm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 3.96

Optical Properties: Translucent. *Color*: Vivid blue. *Streak*: Pale blue.
Luster: Vitreous.
Optical Class: n.d. n = 1.75 (calculated from reflectance data).

Cell Data: *Space Group*: $I\bar{4}\,2d$. a = 11.517(8) c = 5.632(6) Z = 12

X-ray Powder Pattern: Santa Rosa mine, Northern Chile.
3.797 (100), 3.638 (47), 2.775 (35), 2.572 (26), 2.501 (26), 1.822 (21), 1.793 (20)

Chemistry:

	(1)	(2)
CuO	43.24	53.33
PbO	4.48	
CaO	0.97	
B_2O_3	45.44	46.67
Total	94.13	100.00

(1) Santa Rosa mine, Northern Chile; average of 17 electron microprobe and EELS analyses, BO_4 and absence of other anionic groups confirmed by IR and Raman spectroscopy, corresponding to $(Cu_{0.86}Pb_{0.03}Ca_{0.03})B_{2.06}O_4$. (2) CuB_2O_4.

Occurrence: In the oxidation zone of a hydrothermal polymetallic vein deposit.

Association: Atacamite, malachite, wulfenite, anhydrite.

Distribution: Santa Rosa mine, 15 km SE of Iquique, Atacama desert, Northern Chile.

Name: Named for the mine that produced the first specimens.

Type Material: Mineralogical Museum, University of Hamburg, Germany.

References: (1) Schlüter, J., D. Pohl, and U. Golla-Schindler (2008) Santarosaite, CuB_2O_4, a new mineral with disordered structure from the Santa Rosa mine, Atacama desert, Chile. Neues Jahrb. Mineral. Abh., 185, 27–32. (2) (2009) Amer. Mineral., 94, 402-403 (abs. ref. 1).

Santite $KB_5O_8 \cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Anhedral crystals, to 0.06 mm, typically in aggregates; as an efflorescent crust.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.74 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.422(2)$ $\beta = 1.435(2)$ $\gamma = 1.480(1)$ 2V(meas.) = 70°

Cell Data: *Space Group:* $Aba2$. $a = 11.10(2)$ $b = 11.18(2)$ $c = 9.08(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.36 (100), 3.52 (84), 5.60 (71), 2.767 (50), 2.181 (21), 3.28 (18), 5.93 (15)

Chemistry: (1) Larderello, Italy; partial analysis of a mixture was estimated to contain larderellite 66%, santite 25%, sassolite 9%; identification depends on agreement of optics, X-ray powder pattern, and unit cell size with synthetic material.

Occurrence: Very rare, formed in fumaroles, probably a product of reaction between potassium-rich solutions and larderellite (Larderello, Italy); as a deposit around a thermal spring (Eagle Borax Spring, California, USA).

Association: Larderellite, sassolite (Larderello, Italy); aristarainite, hydroboracite, kaliborite, mcallisterite, pinnoite, rivadavite (Eagle Borax Spring, California, USA).

Distribution: From Larderello, Val di Cecina, Tuscany, Italy. In the USA, at the Eagle Borax Spring, Furnace Creek district, Death Valley, Inyo Co., California.

Name: Honors Giorgio Santi (1746–1822), Italian chemist and Director, Museum of Natural History, University of Pisa, Pisa, Italy.

Type Material: Mineralogical Museum, University of Pisa, Pisa, Italy.

References: (1) Merlino, S. and F. Sartori (1970) Santite, a new mineral phase from Larderello, Tuscany. Can. Mineral., 27, 159–165. (2) (1971) Amer. Mineral., 56, 636 (abs. ref. 1). (3) Cook, W.R., Jr. and H. Jaffe (1957) The crystallographic, elastic, and piezoelectric properties of ammonium pentaborate and potassium pentaborate. Acta Cryst., 10, 705–707. (4) Clark, J.R. and C.L. Christ (1959) Studies of borate minerals (VII): X-ray studies of ammonioborite, larderellite, and the potassium and ammonium pentaborate tetrahydrates. Amer. Mineral., 44, 1150–1158.

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Saponite $(Ca_{0.5}, Na)_{0.3}(Mg, Fe^{2+})_3(Si, Al)_4O_{10}(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals minute, pseudohexagonal, tabular ‖ {001}; bladed, fibrous, flaky, or subparallel aggregates; nodular, fine-grained, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Plastic when hydrated, brittle when dry. Hardness = < 1–2 D(meas.) = 2.24–2.30 D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* White, yellow, gray, blue, green, reddish, brown. *Luster:* Greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless, light yellow to green-brown; Y = Z = colorless, greenish brown to dark brown. *Orientation:* $X \perp \{001\}$; $Z \parallel$ elongation. *Absorption:* $Y \simeq Z > X$. $\alpha = 1.48$–1.54 $\beta = 1.50$–1.58 $\gamma = 1.50$–1.58 2V(meas.) = 0°–40°

Cell Data: *Space Group:* n.d. $a = 5.3$ $b = 9.14$ $c = 16.9$ $\beta = \sim 97°$ Z = n.d.

X-ray Powder Pattern: Synthetic $Na_{0.33}Mg_{3.00}(Si_{0.67}Al_{3.67})_{\Sigma=4.00}O_{10}(OH)_2$, glycolated; very close to stevensite.
17.0 (100), 3.37 (80), 1.535 (70), 8.5 (50), 4.58 (50), 5.69 (40), 2.58 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.46	51.26	MgO	20.71	23.54
TiO_2		0.09	CaO	1.94	1.25
Al_2O_3	10.15	4.42	Na_2O	0.25	1.14
Fe_2O_3	3.56	1.14	K_2O	0.32	0.18
FeO	4.89		H_2O^+	4.24	6.58
MnO	0.24	0.03	H_2O^-	13.33	10.08
NiO		0.04	P_2O_5	0.14	
			Total	100.23	99.75

(1) Čáslav, Czech Republic; corresponds to $(Ca_{0.16}Mg_{0.05}Na_{0.04}K_{0.03})_{\Sigma=0.28}(Mg_{2.37}Fe^{2+}_{0.32}Fe^{3+}_{0.21}Al_{0.10})_{\Sigma=3.00}(Si_{3.16}Al_{0.84})_{\Sigma=4.00}O_{10}(OH)_2 \cdot 0.98H_2O$. (2) Ballarat, California, USA; by XRF, Na by AA, H_2O by TGA; corresponds to $(Ca_{0.19}Na_{0.16}K_{0.02})_{\Sigma=0.37}(Mg_{2.61}Al_{0.15}Fe^{2+}_{0.06})_{\Sigma=2.82}(Si_{3.77}Al_{0.23})_{\Sigma=4.00}O_{10}(OH)_2 \cdot nH_2O$.

Mineral Group: Smectite group.

Occurrence: Hydrothermally deposited in mineralized veins and in vesicles in basalt. Formed in fissures cutting calc-silicates, iron-rich skarns, amphibolites, and serpentinites.

Association: Celadonite, chlorite, copper, epidote, orthoclase, dolomite, calcite, quartz.

Distribution: Many localities; a few for well-studied material follow. At The Lizard, Cornwall, England. From Allt Ribhein, Fiskavaig Bay, Isle of Skye, Scotland. At Svärdsjö, Kopparberg, Sweden. From Čáslav, Czech Republic. In Poland, at Frankenstein, Silesia. At Krugersdorp, Transvaal, South Africa. In the USA, in the Kearsarge and Ahmeek mines, Keweenaw Peninsula, Houghton Co., Michigan; between Pigeon Point and Fond du Lac, north shore of Lake Superior, Cook Co., Minnesota; from near Milford, Beaver Co., Utah; at Ballarat, Inyo Co., California; in the Toughnut mine, Tombstone, Cochise Co., Arizona. From Thunder Bay, Ontario, Canada.

Name: From the Latin for *soap*, which it resembles.

Type Material: Mining Academy, Freiberg, Germany, 44591.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 682–683. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 226–245. (3) Ames, L.L. and L.B. Sands (1958) Factors affecting maximum hydrothermal stability in montmorillonites. Amer. Mineral., 43, 641–648. (4) Post, J.L. (1984) Saponite from Ballarat, California. Clays and Clay Minerals, 32, 147–153.

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Sapphirine $(Al,Mg)_8(Al,Si)_6O_{20}$

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Crystal Data: Monoclinic or triclinic. *Point Group:* $2/m$ or $\bar{1}$. Crystals indistinct, tabular on {010}, to 3 cm. Commonly as disseminated grains or aggregates. *Twinning:* Repeated on {010}; uncommon.

Physical Properties: *Cleavage:* Fair on {010}, poor on {001}, {100}. *Fracture:* Subconchoidal. Hardness = 7.5 D(meas.) = 3.40–3.58 D(calc.) = 3.486

Optical Properties: Transparent to translucent. *Color:* Light to dark blue or green, white, gray, pale red, yellow; in thin section, colorless to blue or pink. *Luster:* Vitreous. *Optical Class:* Biaxial (+) or (–). *Pleochroism:* X = colorless, pale reddish, yellowish green, pale yellow; Y = sky-blue, lavender-blue, bluish green; Z = blue, sapphire-blue, dark blue. *Orientation:* $Y = b$; $Z \wedge c = 6°$–$9°$. *Dispersion:* $r < v$, moderate to very strong. $\alpha = 1.701$–1.726 $\beta = 1.703$–1.728 $\gamma = 1.705$–1.734 2V(meas.) = 47°–114°

Cell Data: *Space Group:* $P2_1/a$ (2M) $a = 11.266(12)$ $b = 14.401(7)$ $c = 9.929(10)$ $\beta = 125.46(5)°$ Z = 4, or *Space Group:* $P\bar{1}$ (1A) $a = 9.97(1)$ $b = 10.34(1)$ $c = 8.62(1)$ $\alpha = 107.4(1)°$ $\beta = 95.2(1)°$ $\gamma = 123.8(1)°$ Z = 4

X-ray Powder Pattern: Fiskenæsset, Greenland; closely resembles surinamite. 2.447 (100), 2.015 (90), 2.990 (65), 1.4353 (65), 1.4192 (65), 2.023 (60), 2.844 (50)

Chemistry:

	(1)
SiO_2	12.83
Al_2O_3	65.29
Fe_2O_3	0.93
FeO	0.65
MgO	19.78
LOI	0.31
Total	99.79

(1) Fiskenæsset, Greenland; corresponds to $(Al_{4.43}Mg_{3.42}Fe^{3+}_{0.08}Fe^{2+}_{0.06})_{\Sigma=7.99}$ $(Al_{4.51}Si_{1.49})_{\Sigma=6.00}O_{20}$.

Polymorphism & Series: 1A, 2A, 2M, 3A, 4M, 5A polytypes.

Occurrence: In high-temperature metamorphic rocks or xenoliths with abundant aluminum and magnesium and low silicon. May occur as a primary magmatic mineral in subsilicic rocks.

Association: Sillimanite, kyanite, cordierite, kornerupine, corundum, surinamite, phlogopite, chrysoberyl, pyroxenes, spinel, garnet, calcite, quartz.

Distribution: Only a few localities are given, which have provided especially large or fine crystals, or rich material. Around Fiskenæsset, Greenland. In the USA, in the Cortland complex, Westchester Co., New York. In Canada, at Wilson Lake, Labrador, Newfoundland. At Sakena, Vorokafotra, Bekily, Anjamiary, and Betroka, Madagascar. Large crystals from Blinkwater, near Messina, Transvaal, South Africa. In Tanzania, at Mautia Hill. From Waldheim, Saxony, Germany. At Naxos, Greece. From Finero, Val Viggezo, Piedmont, Italy. In the Harts Range, Northern Territory, Australia. From the Napier complex, Casey Bay, Enderby Land, Antarctica.

Name: For its typical *sapphire*-blue color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 724–726. (2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 614–639. (3) Moore, P.B. (1969) The crystal structure of sapphirine. Amer. Mineral., 54, 31–49. (4) Merlino, S. (1980) Crystal structure of sapphirine-1*Tc*. Zeits. Krist., 151, 91–100. (5) Barbier, J. and B.G. Hyde (1988) Structure of sapphirine: its relation to the spinel, clinopyroxene, and β-gallia structures. Acta Cryst., 44, 373–377. (6) Christy, A.G. and A. Putnis (1988) Planar and line defects in the sapphirine polytypes. Phys. Chem. Minerals, 15, 548–558.

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Sarabauite $CaSb_{10}O_{10}S_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular and prismatic ‖ [010], to 1 mm.

Physical Properties: *Tenacity:* Somewhat sectile. Hardness = n.d. VHN = 272 (20 g load). D(meas.) = 4.8 D(calc.) = 4.99

Optical Properties: Translucent. *Color:* Carmine-red; gray-white in polished section with remarkable reddish orange internal reflections. *Streak:* Orange. *Luster:* Resinous. *Optical Class:* Biaxial (–) (synthetic). *Pleochroism:* Discernible in reflected light, from brownish to purplish tint; in transmitted light, reddish yellow ‖ Y; brownish red ‖ Z'. 2V(meas.) = ∼90° R_1–R_2: (486) 20.1–25.8, (546) 19.7–24.7, (589) 19.1–23.5, (656) 14.0–20.0

Cell Data: *Space Group:* $C2/c$. $a = 25.37(2)$ $b = 5.654(1)$ $c = 16.87(1)$ $\beta = 117.58(4)°$ Z = 4

X-ray Powder Pattern: Sarabau mine, Malaysia.
3.215 (100), 2.817 (88), 3.466 (78), 3.182 (60), 3.164 (50), 4.227 (42), 2.583 (40)

Chemistry:

	(1)	(2)
Ca	2.43	2.49
Sb	74.89	75.62
S	11.91	11.95
O	9.61	9.94
Total	98.84	100.00

(1) Sarabau mine, Malaysia; by electron microprobe, corresponds to $Ca_{0.99}Sb_{10.00}O_{9.76}S_{6.04}$.
(2) $CaSb_{10}O_{10}S_6$.

Occurrence: In hydrothermal mineral deposits, deposited at high temperature.

Association: Stibnite, sénarmontite, wollastonite, calcite, quartz (Sarabau mine, Malaysia).

Distribution: From the Sarabau mine [TL] and the Lucky Hill mine, Bau district, about 40 km southwest of Kuching, Sarawak, Malaysia.

Name: For its occurrence in the Sarabau mine, Malaysia.

Type Material: National Science Museum, Tokyo, Japan, MA7055; The Natural History Museum, London, England; National Museum of Natural History, Washington, D.C., USA, 146210.

References: (1) Nakai, I., H. Adachi, S. Matsubara, A. Kato, K. Masutomi, T. Fujiwara, and K. Nagashima (1978) Sarabauite, a new oxide sulfide mineral from the Sarabau mine, Sarawak, Malaysia. Amer. Mineral., 63, 715–719. (2) Nakai, I., K. Nagashima, K. Koto, and N. Morimoto (1978) Crystal chemistry of oxide-chalcogenide. I. The crystal structure of sarabauite $CaSb_{10}O_{10}S_6$. Acta Cryst., 34, 3569–3572.

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Sarcolite $NaCa_6Al_4Si_6O_{24}F(?)$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As equant pseudocubic hemihedral crystals, to 2.5 cm; in irregular masses.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6
D(meas.) = 2.91–2.96 D(calc.) = 2.82–2.90

Optical Properties: Transparent. *Color:* Flesh-pink, colorless. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.604(1)$ $\epsilon = 1.613(2)$

Cell Data: *Space Group:* $I4/m$. $a = 12.343(5)$ $c = 15.463(5)$ Z = 4

X-ray Powder Pattern: Monte Somma, Italy.
2.747 (100), 3.343 (90), 2.853 (87), 2.762 (69), 2.941 (64), 3.215 (51), 2.998 (51)

Chemistry:

	(1)	(2)	(3)
SiO_2	36.2	35.6	38.23
TiO_2	0.09	0.14	
Al_2O_3	19.2	18.6	21.63
FeO	0.32	0.43	
MnO	0.09	0.07	
MgO	0.29	0.38	
CaO	34.4	34.4	35.68
SrO	0.1	0.37	
Na_2O	3.79	2.58	3.29
K_2O	0.36	0.36	
F	1.19	1.01	2.02
Cl	0.01	0.01	
P_2O_5	1.44	1.60	
SO_3	0.13	3.14	
$-O = Cl_2$	0.50	0.43	0.85
Total	97.11	98.26	100.00

(1) Monte Somma, Italy; by electron microprobe. (2) Anguillara Sabazia, Italy; by electron microprobe. (3) $NaCa_6Al_4Si_6O_{24}F$.

Occurrence: In contact metamorphosed limestone-bearing volcanic ejecta.

Association: Augite, gehlenite, garnet (Monte Somma, Italy); augite, haüyne, fluorite (Anguillara Sabazia, Italy).

Distribution: In Italy, at Monte Somma and Vesuvius, Campania, and Anguillara Sabazia, Lazio.

Name: From the Greek for *flesh*, alluding to the color.

Type Material: The Natural History Museum, London, England, 1960,629.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 474.
(2) Livingstone, A. (1984) Fluorine in sarcolite: additional history and new chemical data. Mineral. Mag., 48, 107–112. (3) (1985) Amer. Mineral., 70, 441 (abs. ref. 2). (4) Giuseppetti, G., F. Mazzi, and C. Tadini (1977) The crystal structure of sarcolite. Tschermaks Mineral. Petrog. Mitt., 24, 1–21. (5) Maras, A. and E. Paris (1987) The crystal chemistry of sarcolite. Can. Mineral., 25, 731–737.

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Sarcopside $(Fe^{2+}, Mn^{2+}, Mg)_3(PO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous, to 1 mm, more commonly platy or lamellar, in veinlets in oriented intergrowth with graftonite or triphylite. *Twinning:* Polysynthetic on {001}, common.

Physical Properties: *Cleavage:* {100}, {001}, good; {010}, poor. *Fracture:* Splintery to fibrous. Hardness = 4 D(meas.) = 3.79 D(calc.) = 3.80; 3.94

Optical Properties: Translucent. *Color:* Pink, brown to gray, colorless. *Luster:* Silky to waxy.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 45°$. *Dispersion:* $r > v$, perceptible. $\alpha = 1.670–1.676$ $\beta = 1.728–1.730$ $\gamma = 1.730–1.734$ 2V(meas.) = 26°–28°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.437(22)$ $b = 4.768(9)$ $c = 6.026(8)$ $\beta = 90.00(15)°$ Z = 2

X-ray Powder Pattern: East Alstead, New Hampshire, USA.
3.03 (100), 3.54 (80), 6.06 (50), 2.819 (50), 3.95 (40), 4.37 (30), 2.558 (30)

Chemistry:

	(1)
P_2O_5	39.8
FeO	50.2
MnO	6.9
MgO	3.5
Total	100.4

(1) East Alstead, New Hampshire, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponding to $(Fe_{2.42}Mn_{0.34}Mg_{0.30})_{\Sigma=3.06}(PO_4)_{1.94}$. (2) Bull Moose mine, South Dakota, USA; by electron microprobe, analysis not given; stated to correspond to $(Fe_{2.34}Mn_{0.63}Mg_{0.03})_{\Sigma=3.00}(PO_4)_2$.

Occurrence: Formed along with graftonite, probably by exsolution from triphylite, in complex zoned granite pegmatites.

Association: Graftonite, vivianite, huréaulite, triphylite.

Distribution: From Góry Sowie (Michelsdorf), in the Eulengebirge, Silesia, Poland. At Otov and Domažlice, Czech Republic. From the Norrö pegmatite, on Rånö Island, and in the Berg quarry, near Sollefteå, Västerbotten, Sweden. At Hagendorf, Bavaria, Germany. In the USA, in New Hampshire, at the Gingrass Farm, near Deering, Hillsboro Co., in the G.E. Smith mine, Newport, Sullivan Co., and from the DeMott and French King No. 2 mines, East Alstead, Cheshire Co.; in South Dakota, at the Bull Moose and Victory mines, and the Lofton prospect, near Custer, Custer Co. From the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. In the Tsaobismund pegmatite, 60 km south of Karibib, Namibia.

Name: From the Greek for *flesh* and *view*, in allusion to its supposed flesh-red color [due to intimate intergrowth with graftonite].

Type Material: Wroclaw University, Wroclaw, Poland, IV-4247.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 858–859. (2) Hurlbut, C.S., Jr. (1965) Detailed description of sarcopside from East Alstead, New Hampshire. Amer. Mineral., 50, 1698–1707. (3) Moore, P.B. (1972) Sarcopside: its atomic arrangement. Amer. Mineral., 57, 24–35.

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Sarkinite $Mn_2^{2+}(AsO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals typically thick tabular {100}, elongated, to 4 mm, short prismatic, or tabular along [010]. May be crudely spherical, granular massive.

Physical Properties: *Cleavage:* On {100}, distinct. *Fracture:* Subconchoidal to uneven. Hardness = 4–5 D(meas.) = 4.08–4.18 D(calc.) = 4.20

Optical Properties: Semitransparent. *Color:* Flesh-red to dark blood-red, rose-red, orange, orange-brown, brown, reddish yellow to yellow; pale rose to yellow in transmitted light. *Streak:* Rose-red to yellow. *Luster:* Greasy.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Orientation:* $Y = b$; $X \wedge c = -54°$. *Dispersion:* $r < v$. *Absorption:* $X > Z > Y$. $\alpha = 1.790–1.793$ $\beta = 1.794–1.807$ $\gamma = 1.798–1.809$ 2V(meas.) = 83°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.779(2)$ $b = 13.596(2)$ $c = 10.208(2)$ $\beta = 108°53'$ Z = 16

X-ray Powder Pattern: Pajsberg [Harstigen mine, near Persberg], Sweden.
3.18 (10), 3.04 (10), 3.29 (9), 3.48 (8), 2.90 (7), 2.65 (6), 6.0 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	0.21			ZnO		0.15	
As_2O_5	41.60	44.09	43.23	PbO	0.25		
CO_2	0.76			MgO	0.98	0.19	
FeO	0.13	0.02		CaO	1.40	0.29	
MnO	51.60	51.77	53.38	H_2O	3.06	[3.40]	3.39
CuO		0.01		insol.	0.38		
				Total	100.37	[99.92]	100.00

(1) Pajsberg [Harstigen mine, near Persberg], Sweden. (2) Långban, Sweden; by electron microprobe, total Mn as MnO, original total given as 99.93%; corresponds to $(Mn_{1.93}Ca_{0.01}Mg_{0.01})_{\Sigma=1.95}(AsO_4)_{1.02}(OH)$. (3) $Mn_2(AsO_4)(OH)$.

Polymorphism & Series: Dimorphous with eveite.

Occurrence: Rare in metamorphosed Fe–Mn orebodies (Sweden); in manganese-rich lenses in quartzitic chlorite schists probably of marine origin (Ködnitz Valley, Austria); in metamorphosed stratiform zinc orebodies (New Jersey, USA).

Association: Lead, bementite, brandtite, calcite, barite (Harstigen mine, Sweden); katoptrite, magnetite, jacobsite, tephroite (Sjö mine, Sweden); tephroite, pyroxmangite, rhodonite, spessartine, rhodochrosite, tiragalloite (Ködnitz Valley, Austria); grischunite, brandtite, manganoan berzeliite, tilasite, rhodochrosite, braunite (Falotta mine, Switzerland); eveite, adamite, willemite, allactite, brandtite, parabrandtite, kraisslite, copper, euchroite, serpierite, rhodochrosite, barite, manganese oxides (Sterling Hill, New Jersey, USA).

Distribution: In Sweden, from the Harstigen mine, near Persberg, at the Brattfors mine, and from Långban, Värmland; in the Sjö mine, near Grythyttan, Örebro. In the Ködnitz Valley, Tirol, Austria. At the Falotta mine, Oberhalbstein, Graubünden, Switzerland. From Sterling Hill, Ogdensburg, and at Franklin, Sussex Co., New Jersey, USA.

Name: From the Greek for *made of flesh*, an allusion to the blood-red color and greasy luster.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 855–857. (2) Dal Negro, A., G. Giuseppetti, and J.M. Martin Pozas (1974) The crystal structure of sarkinite. Tschermaks Mineral. Petrog. Mitt., 21, 246–260. (3) Hålenius, U. and E. Westlund (1998) Manganese valency and the color of the $Mn_2AsO_4(OH)$ polymorphs eveite and sarkinite. Mineral. Mag., 62, 113–119. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 680–682. (5) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541, esp. 533.

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Sarmientite $Fe_2^{3+}(AsO_4)(SO_4)(OH)\cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, prismatic [001] and flattened on {010}, showing {010}, {110}, {011}, to 20 μm, aggregated into nodular masses.

Physical Properties: Hardness = n.d. D(meas.) = 2.58 D(calc.) = 2.58

Optical Properties: Semitransparent. *Color:* Pale yellow-orange.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 12°$. $\alpha = 1.628$ $\beta = 1.635$ $\gamma = 1.698$ 2V(meas.) = n.d. 2V(calc.) = 38°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.55$ $b = 18.55$ $c = 9.70$ $\beta = 97°39'$ Z = 4

X-ray Powder Pattern: Santa Elena mine, Argentina.
9.29 (100), 4.64 (90), 4.26 (80), 3.06 (70), 2.60 (48), 3.43 (40), 4.87 (38)

Chemistry:

	(1)	(2)
SO_3	18.28	17.64
As_2O_5	22.68	25.33
Fe_2O_3	36.57	35.19
CaO	0.27	
H_2O	22.86	21.84
Total	100.66	100.00

(1) Santa Elena mine, Argentina. (2) $Fe_2(AsO_4)(SO_4)(OH)\cdot 5H_2O$.

Occurrence: A rare mineral in oxidized pyritic veins in diabase.

Association: Fibroferrite, copiapite, botryogen, szomolnokite, zincian melanterite, slavíkite, epsomite, gypsum.

Distribution: From the Santa Elena mine, Quebrada de La Alcaparrosa, between San Juan and Calingasta, San Juan Province, Argentina.

Name: To honor Domingo Faustino Sarmiento (1811-1888), former President of Argentina.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1013–1014. (2) de Abeledo, M.E.J. and M.A.R. de Benyacar (1968) New data on sarmientite. Amer. Mineral., 53, 2077–2082.

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Sarrabusite $Pb_5CuCl_4(SeO_3)_4$

Crystal Data: Monoclinic. *Point Group*: *m* or 2/*m*. As spherical aggregates (<100 mm) of tabular crystals (<10 mm).

Physical Properties: *Cleavage*: Distinct. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.011

Optical Properties: Translucent. *Color*: Lemon-yellow. *Streak*: White. *Luster*: Vitreous. *Optical Class*: n.d.

Cell Data: *Space Group*: *Cc* or *C*2/*c*. a = 24.917(3) b = 5.506(1) c = 14.242(2) β = 101.77(1)° Z = 4

X-ray Powder Pattern: Baccu Locci mine, near Villaputzu, Sardinia, Italy. 3.034 (100), 3.685 (60), 2.728 (38), 2.043 (28), 3.314 (20), 2.079 (18), 2.106 (15)

Chemistry:

	(1)	(2)
PbO	61.26	63.80
SO_2	0.14	
CdO	1.44	
CuO	4.29	4.55
SeO_2	24.84	25.37
Cl	8.41	8.11
$- O = Cl_2$	1.90	1.83
Total	98.48	100.00

(1) Baccu Locci mine, near Villaputzu, Sardinia, Italy; average of 7 electron microprobe analyses, corresponding to $(Pb_{4.83}Cd_{0.20})_{\Sigma=5.03}Cu_{0.95}(Se_{3.94}S_{0.04})_{\Sigma=3.98}O_{11.83}Cl_{4.17}$. (2) $Pb_5CuCl_4(SeO_3)_4$.

Occurrence: A secondary mineral in a hydrothermal lead arsenic mineral deposit.

Association: Orlandiite, chalcomenite, anglesite.

Distribution: From the Baccu Locci mine, near Villaputzu, Sardinia, Italy.

Name: For *Sarrabus*, the region in Sardinia, from which the first specimens were obtained.

Type Material: Department of Structural Chemistry and Inorganic Stereochemistry, University of Milan, Italy (2010-02).

References: (1) Gemmi, M., I. Campostrini, F. Demartin, T. Gorelik, and C.M. Gramaccioli (2012) Structure of the new mineral sarrabusite, $Pb_5CuCl_4(SeO_3)_4$, solved by manual electron-diffraction tomography. Acta Cryst., B68, 15-23. (2) (2012) Amer. Mineral., 97, 1265 (abs. ref. 1).

Sartorite $PbAs_2S_4$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Prismatic, deeply striated ‖ [010] with rounded cavernous crystal terminations, to 10 cm; parallel and subparallel groupings common due in part to twinning. *Twinning:* Commonly repeated on {100} to produce lamination of crystals; lamellae seen in polished section may be bent.

Physical Properties: *Cleavage:* Fair on {100}. *Fracture:* Conchoidal. *Tenacity:* Extremely brittle. Hardness = 3 VHN = 196 D(meas.) = 5.10 D(calc.) = [5.13]

Optical Properties: Opaque. *Color:* Dark lead-gray; in polished section, pure white, rarely with deep red internal reflections. *Streak:* Chocolate-brown. *Luster:* Metallic. *Pleochroism:* Rarely visible, only in oil. *Anisotropism:* Weak.
R_1–R_2: (400) 37.5–40.4, (420) 37.1–40.0, (440) 36.7–39.6, (460) 36.1–39.2, (480) 35.7–38.8, (500) 35.1–38.3, (520) 34.5–37.8, (540) 33.9–37.2, (560) 33.3–36.6, (580) 32.6–35.9, (600) 31.9–35.2, (620) 31.1–34.4, (640) 30.4–33.4, (660) 29.8–32.6, (680) 29.1–32.0, (700) 28.6–31.5

Cell Data: *Space Group:* $P2_1/n$ (pseudocell; supercells exist). $a = 19.62$ $b = 7.89$ $c = 4.19$ $\beta = 90°$ Z = 4

X-ray Powder Pattern: Binntal, Switzerland.
3.49 (100), 2.76 (90), 2.96 (80), 2.33 (60), 3.87 (50), 2.64 (50), 4.15 (40)

Chemistry:

	(1)	(2)
Pb	43.63	42.70
As	30.46	30.87
S	25.51	26.43
Total	99.60	100.00

(1) Binntal, Switzerland; average of three analyses. (2) $PbAs_2S_4$.

Occurrence: In a hydrothermal deposit in dolostone (Binntal, Switzerland).

Association: Tennantite, pyrite, dufrénoysite, rathite, realgar (Binntal, Switzerland).

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL]. In the Pitone marble quarry, near Seravezza, Tuscany, Italy. At the Zuni mine, San Juan Co., Colorado, USA. From the Julcani district, Peru.

Name: Honors Professor Wolfgang Sartorius von Waltershausen (1809–1876), University of Göttingen, Göttingen, Germany, who first announced the species.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 478–481. (2) Pring, A., T. Williams, and R. Withers (1993) Structural modulation in sartorite: an electron microscope study. Amer. Mineral., 78, 619–626. (3) Pring, A. (2001) The crystal chemistry of the sartorite group minerals from Lengenbach, Binntal, Switzerland – a HRTEM study. Schweiz. Mineral. Petrog. Mitt., 81, 69–87. (4) Berlepsch, P., T. Armbruster, E. Makovicky, and D. Topa (2003) Another step toward understanding the true nature of sartorite: determination and refinement of a ninefold superstructure. Amer. Mineral., 88, 450–461. (5) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 166–167. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 499.

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Saryarkite-(Y) $Ca(Y,Th)Al_5(SiO_4)_2(PO_4,SO_4)_2(OH)_7 \cdot 6H_2O$

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Crystal Data: Tetragonal. *Point Group:* 422. Crystals needlelike, minute; massive.

Physical Properties: Hardness = 3.5–4 D(meas.) = 3.07–3.15 D(calc.) = 3.35 Slightly magnetic.

Optical Properties: Semitransparent. *Color:* White. *Luster:* Dull to greasy. *Optical Class:* Uniaxial (+). $\omega = 1.606$ $\epsilon = 1.620$

Cell Data: *Space Group:* $P42_12$ or $P4_22_12$. a = 8.213(2) c = 6.55(1) Z = 4

X-ray Powder Pattern: [Sary-Arka, Kazakhstan].
3.01 (100), 2.827 (100), 1.854 (100), 3.45 (90), 2.143 (90), 1.312 (80), 2.564 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	14.80	14.24	K_2O	0.44	0.32
ZrO_2	trace	trace	F	0.00	0.00
ThO_2	7.78	9.07	Cl	0.00	0.00
Al_2O_3	28.72	26.61	H_2O^-	2.39	1.72
RE_2O_3	11.02	10.79	CO_2	0.00	0.00
Fe_2O_3	1.40	2.21	P_2O_5	11.88	12.18
MgO	0.00		SO_3	2.88	3.41
CaO	6.02	6.59	LOI	12.36	12.30
Na_2O	0.79	0.75	Total	100.48	100.19

(1–2) [Sary-Arka, Kazakhstan]; average of two spectrographic determinations of RE_2O_3 = Y_2O_3 53.5%; La_2O_5 5.35%, Ce_2O_3 7.95%, Nd_2O_3 14.6%, Sm_2O_3 0.00%, Gd_2O_3 4.76%, Tb_2O_3 0.52%, Dy_2O_3 0.81%, Ho_2O_3 1.34%, Er_2O_3 4.23%, Tm_2O_3 0.52%, Yb_2O_3 5.35%, Lu_2O_3 1.15%; after deduction of Fe_2O_3, the average corresponds to $Al_5(Ca_{0.96}Y_{0.40}RE_{0.36}Th_{0.28})_{\Sigma=2.00}[(SiO_4)_{2.16}(PO_4)_{1.52}(SO_4)_{0.32}]_{\Sigma=4.00}(OH)_{6.6} \cdot 5.6H_2O$.

Occurrence: In Devonian propylitized felsic effusives and in altered granitic rocks associated with quartzites.

Association: Mica, alunite, andalusite, huttonite, barite, molybdenite, pyrite, hematite, hydrous iron oxides.

Distribution: From the Akkuduk rare-metal deposit, near the Mointy railway station,central Kazakhstan.

Name: From *Saryarka*, Kazakh name for the steppes area of central Kazakhstan, and for its high *yttrium* content.

Type Material: Mining Institute, St. Petersburg, 978/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72018, 72019.

References: (1) Krol, O.F., V.I. Chernov, Y.V. Shipovalov, and G.A. Khan (1964) Saryarkite, a new mineral. Zap. Vses. Mineral. Obshch., 93, 147–155 (in Russian). (2) (1964) Amer. Mineral., 49, 1775–1776 (abs. ref. 1).

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Sasaite $(Al, Fe^{3+})_6(PO_4, SO_4)_5(OH)_3 \cdot 35{-}36H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Crystals with rhombic outline, {110}, small {100}, {010}, to 20 μm, stacked in twisted vermiform aggregates; in veinlets, nodules, and efflorescences.

Physical Properties: *Cleavage:* On {001}, perfect. *Tenacity:* Chalky. Hardness = Soft. D(meas.) = 1.75 D(calc.) = 1.78 H_2O content variable with humidity.

Optical Properties: Transparent. *Color:* White; colorless in transmitted light. *Optical Class:* Biaxial (–). *Orientation:* $X \simeq c$; $Y \simeq b$; $Z \simeq a$. $\alpha = 1.465(1)$ $\beta = 1.473(1)$ $\gamma = 1.477(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 10.75$ $b = 15.02$ $c = 46.03$ Z = 6

X-ray Powder Pattern: West Driefontein Cave, South Africa; fully hydrated. 11.52 (100), 2.901 (42), 6.99 (23), 7.51 (22), 6.30 (21), 4.214 (18), 3.262 (18)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	2.77	3.72	CaO	0.12	0.08
P_2O_5	24.16	32.79	SrO	0.02	
Al_2O_3	21.65	29.81	K_2O		0.11
Fe_2O_3	1.05	0.13	F	0.03	
MnO	0.01		H_2O	49.50	[32.98]
MgO	0.07		$-O = F_2$	0.01	
CuO		0.38	insol.	0.07	
			Total	99.44	[100.00]

(1) West Driefontein Cave, South Africa; corresponds to $(Al_{5.77}Fe_{0.18}Ca_{0.03}Mg_{0.02})_{\Sigma=6.00}[(PO_4)_{4.62}(SO_4)_{0.47}]_{\Sigma=5.09}(OH)_{3.13} \cdot 35.79H_2O$. (2) Cheshunt, Australia; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference, $(OH)^{1-}$ for charge balance; corresponds to $(Al_{5.97}Fe_{0.02}Ca_{0.01})_{\Sigma=6.00}[(PO_4)_{4.72}(SO_4)_{0.47}]_{\Sigma=5.19}(OH)_{2.89} \cdot 17.33H_2O$.

Occurrence: Rarely formed from acidic phosphate-sulfate-rich solutions derived from bat guano reacting with clay minerals in cave soil (West Driefontein Cave, South Africa; Skipton lava tube caves, Australia); in veinlets in slate (Cheshunt, Australia).

Association: Variscite, strengite, phosphosiderite, leucophosphite, apatite.

Distribution: In West Driefontein Cave, Carlstonville, west Transvaal, South Africa. In Australia, in the Skipton lava tube caves, 40 km southwest of Ballarat, and near Cheshunt, Victoria. At Rapid Creek, Yukon Territory, Canada. In the Feengrotten (Cave), near Saalfeld, Thuringia, Germany.

Name: For the South African Speleological Association (SASA), whose members collected the first specimens.

Type Material: Geological Survey, Pretoria, South Africa; National Museum of Natural History, Washington, D.C., USA, 146835.

References: (1) Martini, J. (1978) Sasaite, a new phosphate mineral from West Driefontein Cave, Transvaal, South Africa. Mineral. Mag., 42, 401–404. (2) (1979) Amer. Mineral., 64, 464–465 (abs. ref. 1). (3) Johan, Z., E. Slansky, and P. Povondra (1983) Vashegyite, a sheet aluminum phosphate: new data. Can. Mineral., 21, 489–498, esp. 497. (4) Birch, W.D. and D.A. Henry (1993) Phosphate minerals of Victoria, 87–88, 130–131.

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Sassolite H_3BO_3

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Crystal Data: Triclinic. *Point Group:* 1. As scaly pseudohexagonal crystals, flattened on {001}, showing prominent {001}, additional minor complex forms, to 5 mm; may be stalactitic. *Twinning:* Around [001] as twin axis, common.

Physical Properties: *Cleavage:* Perfect on {001}, micaceous. *Tenacity:* Flexible. Hardness = 1 D(meas.) = 1.46–1.50 D(calc.) = 1.562 Soluble in H_2O, taste acid, slightly saline and bitter.

Optical Properties: Transparent. *Color:* White to gray, may be pale yellow from included sulfur or pale brown from included iron oxides; colorless in transmitted light. *Luster:* Pearly. *Optical Class:* Biaxial (–). *Orientation:* X almost $\perp$ {001}; OAP nearly $\parallel$ b and $\perp$ {001}. $\alpha = 1.337$–1.347 $\beta = 1.456$–1.457 $\gamma = 1.459$–1.468 2V(meas.) = 14°–17°

Cell Data: *Space Group:* $P1$ (synthetic). $a = 7.0187(14)$ $b = 7.035(2)$ $c = 6.3472(12)$ $\alpha = 92.49(12)°$ $\beta = 101°46(2)°$ $\gamma = 119.76(2)°$ Z = 4

X-ray Powder Pattern: Furnace Creek district, California, USA.
3.18 (10), 6.02 (1), 1.590 (1), 5.89 (< 1), 4.59 (< 1), 4.20 (< 1), 4.04 (< 1)

Chemistry:

	(1)	(2)
B_2O_3	57.19	56.30
H_2O	[42.81]	43.70
Total	[100.00]	100.00

(1) Furnace Creek district, California, USA; H_2O by difference. (2) H_3BO_3.

Occurrence: An evaporite or sublimate around hot spring lagoons and volcanic fumaroles; in bedded sedimentary borate deposits.

Association: Larderellite, santite, ginorite, probertite, searlesite, mirabilite, hieratite, glauberite, sulfur, realgar, sal ammoniac, alums.

Distribution: In Italy, from Tuscany, around the lagoons at Sasso, eight km from Castelnuovo, Val di Cecina, also at Larderello and other reduction works nearby; from Campi Flegrei, near Naples, and on Vesuvius, Campania; on Vulcano, Lipari Islands. In the USA, in California, from the Kramer borate deposit, Boron, Kern Co., in Death Valley, near the head of Furnace Creek, and in the Upper Biddy mine, near Ryan, Inyo Co., and at The Geysers, Sonoma Co.; from Norris geyser basin, Yellowstone National Park, Wyoming; at Steamboat Hot Springs, Steamboat Springs district, Washoe Co., Nevada. At the Copahue geothermal field, Neuquén Province, Argentina. In Japan, on Showa-shinzan, in the dome of Usu volcano, Hokkaido; at the Asamayama volcano, Nagano Prefecture; from the Iwodake volcano, Kagoshima Prefecture; at the Yunotani geothermal field, in the Aso caldera, Kyushu. From the Bezymyanni volcano, Kamchatka Peninsula, Russia.

Name: For its initially-noted occurrence at Sasso, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 662–663. (2) Allen, R.D. and H. Kramer (1957) Ginorite and sassolite from Death Valley, California. Amer. Mineral., 42, 56–61. (3) Taguchi, S., P.P. Parmentier, and T. Yamasaki (1981) Sassolite sublimated in a steam well at the Yunotani geothermal field, Aso caldera, Kyushu. Mineral. J. (Japan), 10, 338–343. (4) Gajhede, M., S. Larsen, and S. Ruttrup (1986) Electron density of orthoboric acid determined by X-ray diffraction at 105 K and *ab initio* calculations. Acta Cryst., 42, 545–552.

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Satimolite **$KNa_2Al_4B_6O_{15}Cl_3 \cdot 13H_2O$**

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystals are tabular rhombic, to 0.02 mm; commonly anhedral granular, in dense chalklike aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 1.70, after correction for boracite 31%. D(calc.) = [1.70]

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Biaxial (–). $\alpha = 1.535(2)$ $\beta = 1.552(2)$ $\gamma = 1.552(2)$ 2V(meas.) = Very small.

Cell Data: *Space Group:* n.d. $a = 12.62$ $b = 18.64$ $c = 6.97$ Z = 2

X-ray Powder Pattern: Satimola salt dome, Kazakhstan.
3.20 (10), 9.5 (9), 6.3 (9), 4.01 (9), 3.51 (8), 2.441 (8), 1.966 (8)

Chemistry:

	(1)	(2)	(3)
B_2O_3	35.80	24.76	24.91
Al_2O_3	16.62	24.10	24.32
Fe_2O_3	1.78		
MgO	8.39		
Na_2O	4.97	7.21	7.39
K_2O	4.18	6.06	5.62
Cl	11.48	12.70	12.69
H_2O^+	19.33		
H_2O^-	0.00		
H_2O		28.02	27.93
$-O = Cl_2$	2.59	2.85	2.86
Total	99.96	[100.00]	100.00

(1) Satimola salt dome, Kazakhstan. (2) Do.; after deduction of boracite and Fe_2O_3, and recalculating to 100%, then corresponds to $K_{1.00}Na_{2.00}Al_{4.00}B_{6.01}O_{15}Cl_{3.00} \cdot 13.02H_2O$. (3) $KNa_2Al_4B_6O_{15}Cl_3 \cdot 13H_2O$.

Occurrence: In halite–polyhalite–boracite–kieserite–clay rocks.

Association: Kaliborite, boracite, kieserite, magnesite.

Distribution: From the Satimola salt dome, north Caspian region, Kazakhstan.

Name: For its occurrence in the Satimola salt dome, Kazakhstan.

Type Material: Mining Institute, St. Petersburg, 1023/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69941.

References: (1) Bocharov, V.M., I.I. Khalturina, N.P. Avrova,, and Y.V. Shipovalov (1969) The new mineral satimolite, a hydrous chlorine-containing borate of aluminum and alkalies. Trudy Mineral. Muzeya Akad. Nauk SSSR, 19, 121–125 (in Russian). (2) Ostrovskaya, I.V. (1969) The formula for the new borate satimolite. Trudy Mineral. Muzeya Akad. Nauk SSSR, 19, 202–205 (in Russian). (3) (1970) Amer. Mineral., 55, 1069–1070 (abs. ref. 1–2).

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Satpaevite $Al_{12}V_2^{4+}V_6^{5+}O_{37}\cdot 30H_2O$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Crystals, to 0.1 mm, platy with hexagonal to rounded outlines, in fine granular aggregates, may be foliated.

Physical Properties: *Cleavage:* One direction, perfect, pinacoidal. Hardness = 1.5 in aggregates. D(meas.) = 2.4 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Canary-yellow to saffron-yellow; in transmitted light, greenish yellow to pale olive. *Luster:* Pearly on the cleavage; dull when fine-grained. *Optical Class:* Isotropic to biaxial (+). *Pleochroism:* Weak. *Orientation:* Extinction parallel. *Absorption:* $Z > X$. $\alpha = 1.676$ (α') β = n.d. $\gamma = 1.690$ (γ') 2V(meas.) = $\sim 70°$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kara-Tau Mountains, Kazakhstan.
1.918 (10), 2.330 (9), 1.471 (8), 3.905 (7), 5.86 (6), 1.554 (5), 4.425 (4)

Chemistry:

	(1)	(2)	(3)
V_2O_5	27.70	27.66	29.28
V_2O_4	7.40	7.30	8.90
SiO_2	1.40		
Al_2O_3	32.00	30.80	32.82
Fe_2O_3	0.25		
MgO	1.20		
CaO	1.70		
H_2O^+	22.80		
H_2O^-	4.10		
H_2O			29.00
Total	98.55		100.00

(1) Kara-Tau Mountains, Kazakhstan; spectrographic analysis shows Zn 0.5%, Cu 0.2%, Ni 0.1%, Cr 0.03%, Ba 0.01%. (2) Do.; partial reanalysis. (3) $Al_{12}V_2^{4+}V_6^{5+}O_{37}\cdot 30H_2O$.

Occurrence: In the oxidation zone of a vanadiferous clay-anthraxolite horizon.

Association: Steigerite, vanalite, hewettite, delvauxite, gypsum.

Distribution: In the Kurumsak and Balasauskandyk vanadium deposits, northwest Kara-Tau Mountains, southern Kazakhstan. northwestern Kara-Tau Mountains, Kazakhstan.

Name: Honors Kanysh Imantaevich Satpaev (1899–1964), Kazakhstani geologist, Institute of Geosciences, Alma-Ata, Kazakhstan.

Type Material: Mning Institute, St. Petersburg, 1251/1; Vernadsky Geological Museum, Moscow, 49850; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 62760.

References: (1) Ankinovich, E.A. (1959) New vanadium minerals – satpaevite and al'vanite [alvanite]. Zap. Vses. Mineral. Obshch., 88, 157–164 (in Russian). (2) (1959) Amer. Mineral., 44, 1325–1326 (abs. ref. 1).

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Satterlyite $(Fe^{2+}, Mg, Fe^{3+})_2(PO_4)(OH)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. Grains, to 4 cm, elongated along [0001], in radiating aggregates in nodules.

Physical Properties: Hardness = 4.5–5 D(meas.) = 3.68(5) D(calc.) = 3.60

Optical Properties: Translucent. *Color:* Pale yellow to pale brown. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Uniaxial (–), may be biaxial. *Pleochroism:* O = pale yellow; E = brownish yellow, in thick grains. *Absorption:* $E > O$. ω = 1.718–1.721 ϵ = 1.716–1.719
2V(meas.) = 10°–20°

Cell Data: *Space Group:* $P\overline{3}1m$, $P31m$, or $P312$. a = 11.361 c = 5.041 Z = 6

X-ray Powder Pattern: Big Fish River, Canada.
2.473 (100), 2.840 (80), 3.520 (70), 1.447 (60), 4.49 (50), 2.990 (40), 1.886 (40)

Chemistry:

	(1)
P_2O_5	34.8
SiO_2	0.2
Fe_2O_3	7.5
FeO	43.1
MnO	1.3
MgO	7.1
Na_2O	1.5
H_2O	5.2
Total	100.7

(1) Big Fish River, Canada; by electron microprobe, average of five grains, Fe^{2+}:Fe^{3+} from wet chemical determination, H_2O by the Penfield method; corresponding to $(Fe^{2+}_{1.21}Mg_{0.36}Fe^{3+}_{0.19}H_{0.16}Na_{0.10}Mn_{0.04})_{\Sigma=2.06}[(P_{0.99}Si_{0.01})_{\Sigma=1.00}O_4](OH)_{1.00}$.

Occurrence: In nodules in shales.

Association: Quartz, pyrite, wolfeite, marićite.

Distribution: From the Big Fish River area, Yukon Territory, Canada.

Name: To honor Dr. Jack Satterly (1906–1993), geologist, Ontario Department of Mines and Royal Ontario Museum, Toronto, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M34649; National Museum of Natural History, Washington, D.C., USA, 145743.

References: (1) Mandarino, J.A., B.D. Sturman, and M.I. Corlett (1978) Satterlyite, a new hydroxyl-bearing ferrous phosphate from the Big Fish River area, Yukon Territory. Can. Mineral., 16, 411–413. (2) (1979) Amer. Mineral., 64, 657–658 (abs. ref. 1).

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Sauconite $Na_{0.3}Zn_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Clayey, massive; as small micaceous plates in laminated to compact masses.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 1–2 D(meas.) = n.d. D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* Reddish brown, brown, brownish yellow, mottled. *Luster:* Dull.
Optical Class: Biaxial (–). *Orientation:* $Y = b$. $\alpha = 1.55$–1.58 $\beta = 1.59$–1.62 $\gamma = 1.59$–1.62 2V(meas.) = 0°–20°

Cell Data: *Space Group:* n.d. $a = 5.2$ $b = 9.1$ $c = 15.4$ $\beta =$ n.d. Z = n.d.

X-ray Powder Pattern: Coon Hollow mine, Arkansas, USA; air dried sample.
15.4 (100), 2.67 (100), 1.544 (100), 7.77 (90), 4.60 (90), 1.334 (75), 5.58 (50b)

Chemistry:

	(1)	(2)
SiO_2	34.46	33.40
TiO_2	0.24	0.15
Al_2O_3	16.95	7.45
Fe_2O_3	6.21	1.73
MnO		trace
CuO		0.13
ZnO	23.10	36.73
MgO	1.11	0.78
CaO		1.92
Na_2O		0.22
K_2O	0.49	0.27
H_2O^+	10.67	7.14
H_2O^-	6.72	9.78
Total	99.95	99.70

(1) Friedensville, Pennsylvania, USA. (2) Coon Hollow mine, Arkansas, USA.

Mineral Group: Smectite group.

Occurrence: Fills vugs and seams in oxidized zinc and copper deposits; may be redeposited at the water table.

Association: Hemimorphite, smithsonite, chrysocolla, coronadite, iron oxides.

Distribution: In the USA, from the Ueberroth mine, Saucon Valley, near Friedensville, Lehigh Co., Pennsylvania; the Coon Hollow mine, north of Zinc, Boone Co., Arkansas; and the Liberty mine, Meekers Grove, Lafayette Co., Wisconsin. In Arizona, at Castle Dome, Globe-Miami district, and the 79 mine, Gila Co., and from the Magma mine, Superior, Pinal Co.; and in Colorado, from the New Discovery and Yankee Doodle mines, Leadville, Lake Co. At Moresnet, Liège, Belgium. From the Lovozero massif, Kola Peninsula, and a number of other poorly defined Russian localities.

Name: For its occurrence in the Saucon Valley, Pennsylvania, USA.

References: (1) Dana, E.S. (1868) Dana's system of mineralogy (5th edition), 409. (2) Ross, C.S. (1946) Sauconite – a clay mineral of the montmorillonite group. Amer. Mineral., 31, 411–424. (3) Faust, G.T. (1951) Thermal analysis and X-ray studies of sauconite and of some zinc minerals of the same paragenetic association. Amer. Mineral., 36, 795–822. (4) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 226–245.

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Sayrite $Pb_2(UO_2)_5O_6(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As isolated prismatic crystals, to 0.6 mm, elongated along [010], showing $\{\bar{1}02\}$, {001}, {100}, terminated by {110}.

Physical Properties: *Cleavage:* $\{\bar{1}02\}$, distinct. Hardness = n.d. VHN = 150
D(meas.) = n.d. D(calc.) = 6.76 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow-orange to red-orange.
Luster: Vitreous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Pale yellow to amber-yellow. *Orientation:* $X \simeq c$; $Y = b$; $Z \simeq a$. α = n.d. $\beta = \sim 1.94$ $\gamma = \sim 1.95$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_1/c$. $a = 10.704(3)$ $b = 6.960(2)$ $c = 14.533(3)$
$\beta = 116.81(2)^\circ$ Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
3.113 (100), 3.512 (90), 7.01 (80), 3.052 (70), 5.63 (50), 1.955 (50), 1.916 (50)

Chemistry:

	(1)	(2)
UO_3	73.58	72.72
PbO	21.82	22.70
H_2O	[4.60]	4.58
Total	[100.00]	100.00

(1) Shinkolobwe, Congo; by electron microprobe, average of ten analyses; corresponding to $1.91PbO \cdot 5.03(UO_3) \cdot 4.99H_2O$. (2) $Pb_2(UO_2)_5O_6(OH)_2 \cdot 4H_2O$.

Occurrence: An alteration product of uraninite in the oxidized zone of a uranium orebody.

Association: Uraninite, becquerelite, uranophane, richetite, masuyite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Dr. David Sayre (1924–), American crystallographer, State University of New York, Stony Brook, New York, USA.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM13944.

References: (1) Piret, P., M. Deliens, J. Piret-Meunier, and G. Germain (1983) La sayrite, $Pb_2[(UO_2)_5O_6(OH)_2] \cdot 4H_2O$, nouveau minéral; propriétés et structure cristalline. Bull. Minéral., 106, 299–304 (in French with English abs.). (2) (1984) Amer. Mineral., 69, 568 (abs. ref. 1).

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Sazhinite-(Ce) **$Na_2CeSi_6O_{14}(OH)\cdot nH_2O$**

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals tabular to thick tabular, striated along their length, to 1.5 cm. As irregular grains and dense, fine-grained aggregates.

Physical Properties: *Cleavage:* Perfect on {100}, {010}, {001}. Hardness = 2–3 VHN = 153–258 (10–30 g load). D(meas.) = 2.61 D(calc.) = 2.80

Optical Properties: Transparent to opaque. *Color:* White, gray, cream. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.525(2)$ $\beta = 1.528(2)$ $\gamma = 1.544(2)$ 2V(meas.) = 47°

Cell Data: *Space Group:* $Pmm2$. $a = 7.50(3)$ $b = 15.62(6)$ $c = 7.35(3)$ Z = 2

X-ray Powder Pattern: Lovozero massif, Russia.
3.23 (100), 3.37 (75), 5.23 (55), 7.25 (40), 2.003 (40), 3.30 (35), 2.552 (35)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	46.28	52.58	CaO	0.50	
TiO_2	1.06		Na_2O	11.20	9.04
ThO_2	1.30		K_2O	1.21	
Al_2O_3	0.80		H_2O^+	9.58	
Fe_2O_3	0.26		H_2O^-	4.46	
RE_2O_3	21.15	23.93	H_2O		14.45
Nb_2O_5	0.65		P_2O_5	1.05	
MnO	0.06		Total	99.56	100.00

(1) Lovozero massif, Russia; RE = La 21.1%–22.2%, Ce 54.0%–56.0%, Pr 5.2%–5.5%, Nd 15.7%–16.8%, Sm 1.1%–1.4%, Eu 0.1%–0.2%, Gd 0.4%. (2) $Na_2CeSi_6O_{14}(OH)\cdot 5.5H_2O$.

Occurrence: As disseminations in natrolite and rims around altered steenstrupine in an alkalic pegmatite in a differentiated alkalic massif (Lovozero massif, Russia); in sodalite xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Natrolite, steenstrupine, neptunite (Lovozero massif, Russia); vuonnemite, sérandite, ussingite, sodalite, eudialyte (Mont Saint-Hilaire, Canada).

Distribution: In the Jubilee pegmatite, on Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For Academician Nikolai Petrovich Sazhin (1898–1969), a founder of the Soviet rare-earth industry, Mendeleeev Chemical Technology Institute, Moscow, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3386; Mining Institute, St. Petersburg, 1082/1; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75511, 75838, 76105; The Natural History Museum, London, England, 1994,28.

References: (1) Es'kova, E.M., E.I. Semenov, A.P. Khomyakov, M.E. Kazakova, and N.G. Shumyatskaya (1974) Sazhinite, a new silicate of sodium and rare earths. Zap. Vses. Mineral. Obshch., 103, 338–341 (in Russian). (2) (1975) Amer. Mineral., 60, 162 (abs. ref. 1). (3) Shumyatskaya, N.G., A.A. Voronkov, and Y.A. Pyatenko (1980) Sazhinite, $Na_2Ce[Si_6O_{14}(OH)]\cdot nH_2O$: a new representative of the dalyite family in crystal chemistry. Kristallografiya (Sov. Phys. Crystal.), 25, 728–734 (in Russian). (4) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec, Canada. Mineral. Record, 21, 283–359, esp 334.

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Sborgite $NaB_5O_6(OH)_4 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ (synthetic). As euhedral to anhedral crystals, to 1 mm, in sugary-textured to fine-grained aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 1.713 (synthetic). D(calc.) = 1.711 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* [White.]
Optical Class: Biaxial (+). $\alpha = 1.432$–1.435 β = n.d. $\gamma = 1.450$–1.488 2V(meas.) = Small.

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 11.189(8)$ $b = 16.474(14)$ $c = 13.576(9)$ $\beta = 112°50(2)'$ Z = 8

X-ray Powder Pattern: Furnace Creek district, California, USA.
4.60 (10), 3.30 (8), 3.20 (7), 3.74 (5), 3.18 (5), 4.29 (3), 3.56 (3)

Chemistry: (1) Identification depends on identity of X-ray powder pattern and optical data with synthetic material.

Occurrence: Formed in pipes at a reduction works for borates from hot spring lagoons, between 32° C and 60° C (Larderello, Italy); deposited in an arid climate in surficial debris above weathering borate-bearing veins and in beds of saline tuffaceous siltstone (Furnace Creek district, California, USA).

Association: Borax, thénardite (Larderello, Italy); halite, thénardite (Furnace Creek district, California, USA).

Distribution: From Larderello, Val di Cecina, Tuscany, Italy. At several localities in the Furnace Creek district, Death Valley, Inyo Co., California, USA.

Name: Honors Professor Umberto Sborgi (1883–1955), Italian chemist, University of Milan, Milan, Italy, a worker in the system Na_2O–B_2O_3–H_2O.

Type Material: University of Florence, Florence, Italy, 16801/702.

References: (1) Cipriani, C. (1957) Un nuovo minerale fra i prodotti boriferi di Larderello. Atti Rend. Accad. Lincei, 22, 519–525 (in Italian). (2) (1958) Amer. Mineral., 43, 378 (abs. ref. 1). (3) McAllister, J.F. (1961) Sborgite in the Furnace Creek area, California. U.S. Geol. Surv. Prof. Paper 424, B299–B301. (4) Merlino, S. and F. Sartori (1972) The crystal structure of sborgite, $NaB_5O_6(OH)_4.3H_2O$. Acta Cryst., 28, 3559–3567.

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Scacchite $MnCl_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As incrustations on rock, intermixed with other salts.

Physical Properties: *Cleavage:* {0001}, perfect, inferred from crystal structure. Hardness = Soft. D(meas.) = 2.98 D(calc.) = 3.04 Deliquescent; soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless when fresh, turning rose-red, then brown on exposure.
Optical Class: Uniaxial (–). $\epsilon = 1.708$ $\alpha = 1.622$

Cell Data: *Space Group:* $R\overline{3}m$ (synthetic). $a = 3.711(2)$ $c = 17.59(7)$ $Z = 3$

X-ray Powder Pattern: Synthetic.
5.85 (100), 2.592 (80), 3.161 (25), 1.8529 (25), 1.8118 (25), 1.7663 (13), 1.977 (11)

Chemistry: Analyses are lacking.

Occurrence: A product of fumarolic activity.

Association: Halite, sylvite, other chlorides.

Distribution: On Vesuvius, Campania, Italy.

Name: To honor Professor Arcangelo Scacchi (1810–1893), Italian mineralogist, University of Naples, Naples, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 40–41. (2) Tornero, J.D. and J. Fayos (1990) Single crystal structure refinement of $MnCl_2$. Zeits. Krist., 192, 147–148. (3) (1970) NBS Mono. 25, 8, 43.

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Scainiite $Pb_{14}Sb_{30}O_5S_{54}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As crystals, to 1 cm.

Physical Properties: Hardness = Low. VHN = 142–151, 148 average (100 g load). D(meas.) = n.d. D(calc.) = 13.52

Optical Properties: Opaque. *Color:* In polished section, gray. *Luster:* Metallic. *Anisotropism:* Very weak.
R_1–R_2: (400) 59.7–60.6, (420) 61.4–62.8, (440) 63.3–65.0, (460) 65.0–66.6, (480) 66.8–68.4, (500) 68.7–70.1, (520) 70.5–71.7, (540) 72.1–73.4, (560) 73.6–74.9, (580) 74.9–76.1, (600) 76.1–77.2, (620) 77.2–78.2, (640) 78.1–79.0, (660) 79.1–79.8, (680) 79.8–80.5, (700) 80.5–81.1

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.978$ $c = 4.842$ $Z = 2$

X-ray Powder Pattern: Landsberg, Germany.
2.273 (100), 0.8595 (60), 2.420 (50), 1.268 (50), 0.9538 (50), 1.489 (40), 0.9373 (40)

Chemistry:

	(1)	(2)
Ag	37.8	39.66
Hg	61.6	60.34
Total	99.4	100.00

(1) Landsberg, Germany; by electron microprobe, corresponding to $Ag_{1.07}Hg_{0.93}$; microprobe analyses give low totals because of high absorption; results cluster about $Ag_{1.12}Hg_{0.98}$.
(2) $Ag_{1.10}Hg_{0.90}$.

Occurrence: In the zone of oxidation, formed by the alteration of moschellandsbergite.

Association: Paraschachnerite, mercurian silver, acanthite, cinnabar, ankerite, "limonite" (Landsberg, Germany); paraschachnerite, mercurian silver, sphalerite, pyrite (Sala, Sweden).

Distribution: From the Vertrauen auf Gott mercury mine, Landsberg, near Obermoschel, Rhineland-Palatinate, Germany [TL]. At Sala, Västmanland, Sweden.

Name: Honors Professor Doris Schachner-Korn (1904–1989), ore mineralogist, Institute for Mineralogy and Ore Deposits, Rhine Westphalian Technical School, Aachen, Germany.

Type Material: Technical University, Berlin, Germany; National Museum of Natural History, Washington, D.C., USA, 145618, 150256.

References: (1) Seeliger, E. and A. Mücke (1972) Para-schachnerite, $Ag_{1.2}Hg_{0.8}$, und Schachnerite, $Ag_{1.1}Hg_{0.9}$, vom Landsberg bei Obermoschel, Pfalz. Neues Jahrb. Mineral., Abh., 117, 1–18 (in German with English abs.). (2) (1973) Amer. Mineral., 58, 347 (abs. ref. 1). (3) Zakrzewski, M.A. and E.A.J. Burke (1987) Schachnerite, paraschachnerite and silver amalgam from the Sala mine, Sweden. Mineral. Mag., 51, 318–321. (4) Cipriani, C., V. Moggi, G.P. Bernardini, M. Corazza, and G. Mazzetti (1993) Reinvestigation of natural and synthetic silver amalgams. Eur. J. Mineral., 5, 903–914. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 500.

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Scarbroite $Al_5(CO_3)(OH)_{13}\cdot 5H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $\overline{1}$ or 1. Crystals, to 1 μm, platy; in nodules and aggregates, very fine-grained, compact, massive.

Physical Properties: *Tenacity:* Friable, clayey. Hardness = "Soft". D(meas.) = 2.01(1) D(calc.) = 2.00

Optical Properties: Semitransparent. *Color:* White, may be discolored gray to brown. *Luster:* Dull.
Optical Class: Biaxial. $n = 1.509$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.94$ $b = 14.88$ $c = 26.47$ $\alpha = 98.7°$ $\beta = 96.5°$ $\gamma = 89.0°$ Z = 8

X-ray Powder Pattern: Scarborough, England.
8.66 (vvs), 3.724 (s), 5.99 (ms), 4.331 (ms), 8.34 (m), 5.63 (m), 4.906 (m)

Chemistry:

	(1)	(2)
SiO_2	3.2	
SO_3	1.8	
CO_2	7.9	8.70
Al_2O_3	45.7	50.37
MgO	0.1	
Na_2O	1.7	
K_2O	0.2	
H_2O	37.9	40.93
Total	98.5	100.00

(1) Scarborough, England; corresponding to $Al_{5.0}(CO_3)(OH)_{12.9}\cdot 5.2H_2O$.
(2) $Al_5(CO_3)(OH)_{13}\cdot 5H_2O$.

Occurrence: In vertical fissures in sandstone (Scarborough, England); authigenic, probably formed by dessication of near-shore bottom sediments of a hypersaline lake (Muskiki Lake, Canada).

Association: Hydroscarbroite, gibbsite, kaolinite, calcite, quartz (Scarborough, England); illite, kaolinite, smectite, "chlorite", huntite, feldspar, quartz (Muskiki Lake, Canada).

Distribution: In England, from South Bay, near Scarborough, North Yorkshire, and at Weston Favell, Northampton. From near Nikšić, Yugoslavia. In Canada, from Muskiki Lake, Saskatchewan.

Name: For its first-noted occurrence near Scarborough [contracted to Scarbro, the common local pronunciation], England.

Type Material: The Natural History Museum, London, England, 1984,898.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 694.
(2) Duffin, W.J. and J. Goodyear (1960) A thermal and X-ray investigation of scarbroite. Mineral. Mag., 32, 353–362. (3) Brindley, G.W. and J.J. Comer (1960) Electron-optical data for crystals of scarbroite. Mineral. Mag., 32, 363–365. (4) Brindley, G.W. (1980) Scarbroite, $Al_5(OH)_{13}CO_3\cdot 5H_2O$, compared with gibbsite and hydrotalcite. Mineral. Mag., 43, 615–618. (5) King, R.J. (1982) A new occurrence of scarbroite in Britain. J. Russell Soc., 1(1), 9–18.

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Scawtite **$Ca_7Si_6O_{18}(CO_3)\cdot 2H_2O$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thin crystals, tabular on {100}, forming parallel to slightly divergent aggregates.

Physical Properties: *Cleavage:* {010}, fair; {100}, poor. Hardness = 4.5–5
D(meas.) = 2.71 D(calc.) = 2.74

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 30°$. $\alpha = 1.595(1)$ $\beta = 1.605(1)$ $\gamma = 1.622(1)$ 2V(meas.) = 75°5′ 2V(calc.) = 74°

Cell Data: *Space Group:* $I2/m$. $a = 10.118(3)$ $b = 15.187(4)$ $c = 6.626(1)$ $\beta = 100°40(1)'$ Z = 2

X-ray Powder Pattern: Crestmore, California, USA.
3.04 (10), 1.898 (6), 2.495 (5), 2.24 (5), 4.56 (4), 2.79 (4), 6.05 (3)

Chemistry:

	(1)	(2)	(3)
SiO_2	41.95	43.5	43.27
TiO_2	0.01		
Al_2O_3	0.14		
Fe_2O_3	0.07		
MnO	0.01		
MgO	0.16		
CaO	46.93	46.1	47.12
H_2O^+	0.06	0.1	
H_2O^-	4.90	4.3	4.33
CO_2	5.6	4.4	5.28
rem.		1.2	
Total	99.83	99.6	100.00

(1) Crestmore, California, USA; total Fe as Fe_2O_3. (2) Ballycraigy, Ireland; remainder is trivalent metal oxides. (3) $Ca_7Si_6O_{18}(CO_3)\cdot 2H_2O$.

Occurrence: A late-stage hydrothermal mineral veining skarns formed from contact metamorphism of limestone.

Association: Melilite, spurrite, tobermorite, thomsonite, larnite, grossular, bultfonteinite, calcite, analcime, foshagite, hillebrandite.

Distribution: At Scawt Hill and Ballycraigy, near Larne, Co. Antrim, Ireland. On the Zeilberg, near Maroldsweisach, Bavaria, Germany. In the USA, at Crestmore, Riverside Co., California, and near Neihart, Cascade Co., Montana. From Kushiro, Hiroshima Prefecture, and in the Mihara mine and at Fuka, near Bicchu, Okayama Prefecture, Japan. From near Rehia, Tokatoka district, about 150 km north of Auckland, New Zealand.

Name: For the locality where first found, Scawt Hill, Ireland.

Type Material: The Natural History Museum, London, England, 1956,384.

References: (1) Tilley, C.E. (1930) Scawtite, a new mineral from Scawt Hill, Co. Antrim. Mineral. Mag., 22, 222–224. (2) (1935) Amer. Mineral., 20, 403 (abs. ref. 1). (3) Murdoch, J. (1955) Scawtite from Crestmore, California. Amer. Mineral., 40, 505–509. (4) McConnell, J.D.C. (1955) A chemical, optical and X-ray study of scawtite from Ballycraigy, Larne, N. Ireland. Amer. Mineral., 40, 510–514. (5) McConnell, D. and J. Murdoch (1958) The crystal chemistry of scawtite. Amer. Mineral., 43, 498–502. (6) Pluth, J.J. and J.V. Smith (1973) The crystal structure of scawtite, $Ca_7(Si_6O_{18})(CO_3)\cdot 2H_2O$. Acta Cryst., 29, 73–80.

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As crystals up to 1 cm in length, but most much smaller.

Physical Properties: Hardness = Low. VHN = n.d. D(meas.) = n.d. D(calc.) = 13.52

Optical Properties: Opaque. *Color:* In polished section, gray. *Luster:* Metallic. *Anisotropism:* Very weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.978$ $c = 4.842$ Z = 2

X-ray Powder Pattern: Landsberg, Germany.
2.273 (100), 0.8595 (60), 2.420 (50), 1.268 (50), 0.9538 (50), 1.489 (40), 0.9373 (40)

Chemistry: Microprobe analyses give low totals because of high absorption; results cluster about $Ag_{1.12}Hg_{0.98}$.

Occurrence: Found in the zone of oxidation, formed by the alteration of moschellandsbergite.

Association: Paraschachnerite, mercurian silver, acanthite, cinnabar, ankerite, "limonite" (Landsberg, Germany); paraschachnerite, mercurian silver, sphalerite, pyrite (Sala, Sweden).

Distribution: In the Vertraun Gott mercury mine at Landsberg, near Obermoschel, Rhineland-Palatinate, Germany. At Sala, Västmanland, Sweden.

Name: For Professor Doris Schachner, ore mineralogist, Institute for Mineralogy and Ore Deposits, Rhine Westphalian Technical School, Aachen, Germany.

Type Material: Technical University, Berlin, Germany; National Museum of Natural History, Washington, D.C., USA, 150256.

References: (1) Seeliger, E. and A. Mücke (1972) Para-schachnerite, $Ag_{1.2}Hg_{0.8}$, und Schachnerite, $Ag_{1.1}Hg_{0.9}$, vom Landsberg bei Obermoschel, Pfalz. Neues Jahrb. Mineral., Abh., 117, 1–18 (in German with English abs.). (2) (1973) Amer. Mineral., 58, 347 (abs. ref. 1). (3) Zakrzewski, M.A. and E.A.J. Burke (1987) Schachnerite, paraschachnerite and silver amalgam from the Sala mine, Sweden. Mineral. Mag., 51, 318–321.

Schafarzikite $Fe^{2+}Sb_2^{3+}O_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals, prismatic and striated ‖ [001], showing {100}, {110}, {111}, {132}, {012}, and several other forms, to 1 mm.

Physical Properties: *Cleavage:* {110}, perfect; {100}, very good; {001}, trace.
Hardness = 3.5 D(meas.) = 4.3 D(calc.) = [5.24]

Optical Properties: Opaque, translucent in thin fragments. *Color:* Red to red-brown; yellow in transmitted light. *Streak:* Brown. *Luster:* Metallic.
Optical Class: Uniaxial (+); weak birefringence. *Pleochroism:* E = brownish yellow; O = straw-yellow. $\omega = > 1.74$ ϵ = n.d.

Cell Data: *Space Group:* $P4_2/mbc$. $a = 8.590(5)$ $c = 5.913(5)$ Z = 4

X-ray Powder Pattern: Pernek, Slovakia.
1.050 (125), 1.014 (125), 1.670 (100), 1.309 (60), 1.158 (60), 3.22 (50), 3.04 (50)

Chemistry:

	(1)	(2)
As_2O_3	9.72	
Sb_2O_3	67.95	80.23
FeO	17.58	19.77
ZnO	1.10	
Total	96.35	100.00

(1) Buca della Vena mine, Italy; by electron microprobe, total Fe as FeO, Sb as Sb_2O_3, As as As_2O_3; corresponds to $(Fe_{0.88}Zn_{0.05})_{\Sigma=0.93}(Sb_{1.69}As_{0.36})_{\Sigma=2.05}O_4$. (2) $FeSb_2O_4$.

Occurrence: In oxidized antimony-bearing hydrothermal mineral deposits.

Association: Kermesite, valentinite, sénarmontite, stibnite, calcite (Pernek, Slovakia); apuanite, versiliaite, derbylite, bournonite, pyrite, sphalerite (Buca della Vena mine, Italy).

Distribution: From Pernek, near Pezinok, Slovakia. In the Buca della Vena iron mine, north of Stazzema, Apuan Alps, Tuscany, Italy. From Canada, in the Lac Nicolet mine, South Ham, Quebec.

Name: To honor Professor Ferenc Schafarzik (1854–1927), Hungarian mineralogist, of the Polytechnic, Budapest, Hungary.

Type Material: University of Vienna, Vienna, Austria.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1035–1036. (2) Zemann, J. (1951) Formel und Kristallstruktur des Schafarzikits. Tschermaks Mineral. Petrog. Mitt., 2, 166–175 (in German). (3) Fischer, R. and F. Pertlik (1975) Verfeinerung der Kristallstruktur des Schafarzikits, $FeSb_2O_4$. Tschermaks Mineral. Petrog. Mitt., 22, 236–241 (in German with English abs.). (4) Mellini, M., M. Amouric, A. Baronnet, and G. Mercuriot (1981) Microstructures and nonstoichiometry in schafarzikite-like minerals. Amer. Mineral., 66, 1073–1079.

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Schairerite $Na_{21}(SO_4)_7F_6Cl$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Steep trigonal rhombohedra $\{03\bar{3}2\}$, modified by $\{10\bar{1}0\}$, $\{10\bar{1}1\}$, $\{01\bar{1}2\}$, $\{0001\}$, to 2 mm; may form polycrystals with galeite.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5
D(meas.) = 2.612–2.616 D(calc.) = 2.619 Slowly soluble in H_2O.

Optical Properties: Transparent to translucent with clay inclusions. *Color:* Colorless; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.440$ $\epsilon = 1.445$

Cell Data: *Space Group:* $P31m$. $a = 12.197(4)$ $c = 19.259(11)$ $Z = 3$

X-ray Powder Pattern: Searles Lake, California, USA.
2.76 (10), 3.52 (8), 3.79 (7), 1.760 (7), 3.01 (6), 2.58 (6), 4.44 (2)

Chemistry:

	(1)	(2)	(3)
SO_3	42.79	42.96	42.95
Na_2O	49.51	49.54	49.88
K_2O	0.16		
F	8.30	8.55	8.74
Cl	3.53	2.76	2.72
$-O = (F, Cl)_2$	4.29	4.22	4.29
Total	[100.00]	99.59	100.00

(1) Searles Lake, California, USA; recalculated to oxides from an original total of 98.95%, after deduction of $(Fe, Al)_2O_3$ 0.15%, CaO 0.30%, loss on ignition 0.90%, insoluble 0.20%. (2) Do.; by electron microprobe, average of two sets of analyses, recalculated to oxides from an original total of 99.61%. (3) $Na_{21}(SO_4)_7F_6Cl$.

Occurrence: In a playa lake deposit (Searles Lake, California, USA); associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Galeite, gaylussite, tychite, pirssonite, thénardite, northupite, trona, hanksite, calcite (Searles Lake, California, USA); pectolite, shortite, kogarkoite, phlogopite, arfvedsonite, leucophanite, leucosphenite (Mont Saint-Hilaire, Canada).

Distribution: In the USA, from Searles Lake, San Bernardino Co., California. At Mont Saint-Hilare, Quebec, Canada. From the Nagyvisnyó evaporite deposit, Bükk Mountains, Hungary.

Name: To honor Dr. John Frank Schairer (1904–1970), American physical chemist, Carnegie Geophysical Laboratory, Washington, D.C., USA, who studied the system Na_2SO_4–NaF–NaCl–H_2O.

Type Material: National Museum of Natural History, Washington, D.C., USA, 96437, 96439, 112736.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 547–548. (2) Brown, F.H. and A. Pabst (1971) New data on galeite and schairerite. Amer. Mineral., 56, 174–178. (3) Pabst, A., D.L. Sawyer, and G. Switzer (1963) Galeite and related phases in the system Na_2SO_4–NaF–NaCl. Amer. Mineral., 48, 485–510. (4) Fanfani, L., A. Nunzi, P.F. Zanazzi, A.R. Zanzari, and C. Sabelli (1975) The crystal structure of schairerite and its relationship to sulphohalite. Mineral. Mag., 40, 131–139.

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Schallerite $(Mn^{2+}, Fe^{2+})_{16}As_3^{3+}Si_{12}O_{36}(OH)_{17}$

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Crystal Data: Hexagonal. *Point Group:* n.d. As markedly hemimorphic crystals, to 2 mm, having steep pyramids and terminated by dull {0001} and {000$\bar{1}$} pedions. As slightly rectangular aggregates resembling augen; also granular to massive.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ~5 D(meas.) = 3.339–3.368 D(calc.) = [3.48]

Optical Properties: Transparent to translucent. *Color:* Red-brown. *Luster:* Waxy; pearly on the basal cleavage.
Optical Class: Uniaxial (–). ω = 1.681–1.704 ϵ = 1.643–1.679

Cell Data: *Space Group:* n.d. a = 13.36–13.43 c = 14.24–14.31 Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
1.688 (100), 2.673 (60), 1.511 (60), 2.466 (50), 2.022 (50), 3.55 (40), 1.975 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	32.0	31.51	31.27	MnO	42.5	48.90	49.22
TiO_2		0.03		ZnO	1.6		
Al_2O_3		0.01		MgO	2.3	0.06	
Fe_2O_3	2.6			CaO		0.02	
As_2O_3	12.81	11.41	12.87	Cl	0.0	0.11	
FeO		0.14		H_2O	6.82	[6.73]	6.64
				Total	100.6	[98.92]	100.00

(1) Franklin, New Jersey, USA; by electron microprobe, As_2O_3 by wet chemical analysis, H_2O by the Penfield method. (2) Ködnitz Valley, Austria; by electron microprobe, average of 13 analyses; H_2O calculated from stoichiometry; original total given as 99.83%. (3) $Mn_{16}As_3Si_{12}O_{36}(OH)_{17}$.

Polymorphism & Series: Dimorphous with nelenite.

Occurrence: In banded willemite-franklinite ore or rhodonite, from a metamorphosed stratiform zinc deposit (Franklin, New Jersey, USA); in manganese-rich lenses in quartzitic chlorite schists probably of marine origin (Ködnitz Valley, Austria).

Association: Willemite, franklinite, calcite, rhodonite (Franklin, New Jersey, USA); tephroite, pyroxmangite, rhodonite, spessartine, rhodochrosite (Ködnitz Valley, Austria).

Distribution: From Franklin, Sussex Co., New Jersey, USA. In the Ködnitz Valley, Tirol, Austria.

Name: For Dr. Waldemar Theodore Schaller (1882–1967), mineralogist, U.S. Geological Survey.

Type Material: Harvard University, Cambridge, Massachusetts, 87106; National Museum of Natural History, Washington, D.C., USA, R6610.

References: (1) Gage, R.B., E.S. Larsen, and H.E. Vasser (1925) Schallerite, a new arseno-silicate mineral from Franklin Furnace, New Jersey. Amer. Mineral., 10, 9–11. (2) Bauer, L.H. and H. Berman (1928) Friedelite, schallerite, and related minerals. Amer. Mineral., 13, 341–348. (3) McConnell, D. (1954) Crystal chemistry of schallerite. Amer. Mineral., 39, 929–936. (4) Dunn, P.J., D.R. Peacor, J.A. Nelen, and J.A. Norberg (1981) Crystal-chemical data for schallerite, caryopilite and friedelite from Franklin and Sterling Hill, New Jersey. Amer. Mineral., 66, 1054–1062. (5) Albrecht, J. (1990) An As-rich manganiferous mineral assemblage from the Ködnitz Valley (Eastern Alps, Austria): geology, mineralogy, genetic considerations, and implications for metamorphic Mn deposits. Neues Jahrb. Mineral., Monatsh., 363–375.

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Schaurteite $Ca_3Ge^{4+}(SO_4)_2(OH)_6 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\overline{6}m2$, or $6mm$. Needlelike crystals, to 1 cm, in fibrous aggregates.

Physical Properties: Hardness = n.d. D(meas.) = ∼2.65 D(calc.) = 2.64

Optical Properties: Semitransparent. *Color:* White. *Luster:* Silky.
Optical Class: Uniaxial (+). $\omega = 1.569$ $\epsilon = 1.581$

Cell Data: *Space Group:* $P6_3/mmc$, $P\overline{6}2c$, or $P6_3mc$. a = 8.525 $c = 10.803$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.34 (10), 4.26 (7), 2.129 (6), 7.40 (5), 3.49 (5), 2.579 (5), 2.239 (5)

Chemistry:

	(1)	(2)
SO_3	29.5	29.60
GeO_2	[21.5]	19.33
CaO	31.7	31.09
$H_2O^{800°C}$	19.9	
$H_2O^{105°C}$	0.2	
H_2O		19.98
Total	[102.8]	100.00

(1) Tsumeb, Namibia; original analysis presented as GeO 18.2%, DTG shows Ge^{4+}, corrected to GeO_2 above. (2) $Ca_3Ge(SO_4)_2(OH)_6 \cdot 3H_2O$.

Occurrence: A rare secondary mineral formed in the oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Germanite.

Distribution: From Tsumeb, Namibia.

Name: Honors Dr. Werner T. Schaurte (1893–1978), German chemist, Johannesburg, South Africa.

Type Material: The holotype is missing from the Technical University, Berlin, Germany; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 144520.

References: (1) Strunz, H. and C. Tennyson (1967) Schaurteit, ein neues Germanium-Mineral von Tsumeb/SW-Afrika und seine Paragenese. In: *Festschrift Dr. Werner T. Schaurte*, Bauer & Schaurte, Neuss/Rhein, Germany (BRD), 33-47 (in German). (2) (1968) Amer. Mineral., 53, 507 (abs. ref. 1).

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Scheelite $CaWO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals are typically pseudo-octahedral {011} or {112}, with modifying forms {001}, {013}, {121}, several others, to 32 cm; commonly granular, massive. *Twinning:* {110}, common, penetration and contact twins, composition plane {110} or {001}.

Physical Properties: *Cleavage:* On {101}, distinct; on {112}, interrupted; on {001}, indistinct. Hardness = 4.5–5 D(meas.) = 6.10(2) D(calc.) = 6.09 Bright bluish white cathodoluminescence and fluorescence under SW UV and X-rays.

Optical Properties: Transparent to opaque; transparent in transmitted light. *Color:* Colorless, white, gray, brown, pale yellow, yellow-orange, pale shades of orange, red, green; may be compositionally color zoned. *Streak:* White. *Luster:* Vitreous to adamantine.
Optical Class: Uniaxial (+). $\epsilon = 1.935$–1.938 $\omega = 1.918$–1.921

Cell Data: *Space Group:* $I4_1/a$ (synthetic). $a = 5.2429(3)$ $c = 11.3737(6)$ $Z = 4$

X-ray Powder Pattern: Kernville, California, USA.
3.10 (100), 4.76 (55), 3.072 (30), 1.928 (30), 1.592 (30), 2.622 (25), 2.296 (20)

Chemistry:

	(1)	(2)
WO_3	80.17	80.52
MoO_3	0.07	
MgO	trace	
CaO	19.49	19.48
Total	99.73	100.00

(1) Schwarzenberg, Germany. (2) $CaWO_4$.

Polymorphism & Series: Forms a series with powellite.

Occurrence: Typically a component of contact-metamorphic tactite; in high-temperature hydrothermal veins and greisen; less common in granite pegmatites and medium-temperature hydrothermal veins; alluvial.

Association: Cassiterite, wolframite, topaz, fluorite, apatite, tourmaline, quartz (greisen); grossular–andradite, diopside, vesuvianite, tremolite (tactite).

Distribution: An important ore of tungsten, with many localities. Some for fine and large crystals include: from Sweden, at the Bispberg iron mine, near Säter, Dalarne. In Germany, from Altenberg and Schwarzenberg, Saxony. At Cínovec (Zinnwald) and Horní Slavkov (Schlaggenwald), Czech Republic. From Traversella, Piedmont, Italy. At Tenkergin, Chukotka, Siberia, Russia. In the Natas mine, about 80 km south of Windhoek, Namibia. Large crystals from the Tae wha mine, Chungju, North Chungchong Province, South Korea. At Pia Oac, Tonkin, North Vietnam. In China, from near Pingwu, Xuebao Ding Mountains, Sichuan Province, China. A large deposit in the Flat River Valley, Northwest Territories, Canada. In the USA, in Arizona, large crystals from the Cohen mine, Dragoon Mountains, Cochise Co.; commercially mined at the Pine Creek mine, near Bishop, Inyo Co., California. At Mitopilas, Sonora, Mexico. In the Morro Velho gold mine, Nova Lima, Minas Gerais, Brazil.

Name: Honors Karl Wilhelm Scheele (1742–1786), who determined the mineral contained tungsten.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1075–1077. (2) Hazen, R.M., L.W. Finger, and J.W.E. Mariathasan (1985) High-pressure crystal chemistry of scheelite-type tungstates and molybdates. J. Phys. Chem. Solids, 46, 253–263. (3) (1956) NBS Circ. 539, 6, 23.

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Crystal Data: Orthorhombic (synthetic). *Point Group:* $2/m\ 2/m\ 2/m$. Small indistinct flat crystals.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.83 Soluble in H_2O, forming a struvite residue.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (+) (synthetic). *Orientation:* $Z = a$; OAP = {001}. $\alpha = 1.508(2)$ $\beta = 1.515(2)$ $\gamma = 1.523(2)$ 2V(meas.) = ~90° 2V(calc.) = 86°

Cell Data: *Space Group:* *Pbca* (probable; synthetic). $a = 11.47$ $b = 23.63$ $c = 8.62$ $Z = 8$

X-ray Powder Pattern: Synthetic.
5.94 (100), 2.97 (43), 5.21 (37), 2.80 (29), 3.02 (22), 3.46 (21), 4.31 (19)

Chemistry:

	(1)	(2)
P_2O_5	43.88	43.76
FeO	0.20	
MnO	0.05	
MgO	12.17	12.42
$(NH_4)_2O$	16.15	16.05
H_2O	27.55	27.77
Total	100.00	100.00

(1) Skipton lava tube caves, Australia. (2) $(NH_4)_2Mg(PO_3OH)_2 \cdot 4H_2O$.

Occurrence: Rarely formed in drier portions of bat guano, by the reaction of NH_4 from guano with Mg in surrounding rocks.

Association: Struvite, newberyite (Skipton lava tube caves, Australia).

Distribution: In the Skipton lava tube caves, 40 km southwest of Ballarat, Victoria, Australia. From Chaos Cave, Transvaal, South Africa.

Name: To honor Professor Arnulf Schertel (1841–1902), mineralogist, Freiberg Mining Academy, Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 699. (2) Frazier, A.W., J.R. Lehr, and J.P. Smith (1963) The magnesium phosphates hannayite, schertelite and bobierrite. Amer. Mineral., 48, 635–641. (3) Catti, M. and M. Franchini-Angela (1976) Hydrogen bonding in the crystalline state. Structure of $Mg_3(NH_4)_2(HPO_4)_4 \cdot 4H_2O$ (hannayite), and crystal-chemical relationships with schertelite and struvite. Acta Cryst., 32, 2842–2848.

Schiavinatoite $(Nb, Ta)BO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As portions of prismatic tetragonal dipyramidal crystals, intergrown with béhierite, to 2 cm.

Physical Properties: Hardness = ∼8 D(meas.) = n.d. D(calc.) = 6.548

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $n = 2.30(5)$, birefringent. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $I4_1/amd$. $a = 6.219(5)$ $c = 5.487(5)$ Z = 4

X-ray Powder Pattern: Antsongombato, Madagascar; calculated pattern, very close to béhierite.
4.115 (100), 3.110 (84), 2.328 (49), 1.598 (42), 2.481 (36), 1.939 (29), 1.646 (25)

Chemistry:

	(1)	(2)
B_2O_3	[16.60]	16.44
Nb_2O_5	33.08	31.38
Ta_2O_5	50.37	52.18
Total	[100.05]	100.00

(1) Antsongombato, Madagascar; by electron microprobe, average of 16 analyses, B_2O_3 calculated from stoichiometry; corresponds to $(Nb_{0.52}Ta_{0.48})_{\Sigma=1.00}BO_4$. (2) $(Nb, Ta)BO_4$ with Nb:Ta = 1:1.

Occurrence: Very rare in miarolitic cavities in a pegmatite dike.

Association: Béhierite, rhodizite, elbaite–liddicoatite, spodumene, pollucite, danburite, apatite, quartz, feldspar.

Distribution: From Antsongombato, south of Betafo, Madagascar.

Name: To honor Professor Guiseppe Schiavinato (1915–1996), Italian mineralogist, who supported the advancement of mineralogy in Italy.

Type Material: City Museum of Natural History, Milan, Italy, M31137.

References: (1) Demartin, F., V. Diella, C.M. Gramaccioli, and F. Pezzotta (2001) Schiavinatoite, $(Nb, Tb)BO_4$, the Nb analogue of behierite. Eur. J. Mineral., 13, 159–165.

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Schieffelinite $\mathbf{Pb(Te^{6+}O_4, SO_4)\cdot H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are very rare, flattened on {010}, modified by {001}, {320}, {133}; typically platy or scaly, to 1 mm, in random aggregates.

Physical Properties: *Cleavage:* On {010}, easy. Hardness = 2 D(meas.) = 4.98(12) D(calc.) = 5.15

Optical Properties: Transparent to translucent. *Color:* Colorless, milky white. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak.
$\alpha = 1.897$ $\beta = 1.940$ $\gamma = 1.942$ 2V(meas.) = 24°

Cell Data: *Space Group: Cmcm.* $a = 9.67$ $b = 19.56$ $c = 10.47$ Z = 16

X-ray Powder Pattern: Joe shaft, Tombstone, Arizona, USA.
9.778 (10), 3.426 (6), 3.250 (6b), 3.560 (5b), 3.338 (5), 3.033 (5), 2.934 (5)

Chemistry:

	(1)
SO_3	6.8
TeO_3	28.6
PbO	58.2
H_2O	4.7
Total	98.3

(1) Joe shaft, Tombstone, Arizona, USA; average of two analyses, H_2O by the Penfield method; corresponds to $Pb_{1.05}(Te_{0.66}S_{0.34})_{\Sigma=1.00}O_4 \cdot 1.06H_2O$.

Occurrence: In the oxidized zone of tellurium-bearing hydrothermal precious metal deposits.

Association: Rodalquilarite, girdite, bromargyrite, gold, pyrite, empressite, goethite, quartz.

Distribution: On the dumps of the Joe shaft and at the Grand Central mine, Tombstone, Cochise Co., Arizona, USA.

Name: To honor Edward Schieffelin (1847–1897), a discoverer of the mines at Tombstone, Arizona, USA.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,539; University of Arizona Mineral Museum, Tucson, Arizona; National Museum of Natural History, Washington, D.C., USA, R18474.

References: (1) Williams, S.A. (1980) Schieffelinite, a new lead tellurate-sulphate from Tombstone, Arizona. Mineral. Mag., 43, 771–773. (2) (1981) Amer. Mineral., 66, 219 (abs. ref. 1).

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Schirmerite $Ag_3Pb_3Bi_9S_{18}$ to $Ag_3Pb_6Bi_7S_{18}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As lath-shaped grains, to several mm; also massive and fine-granular.

Physical Properties: *Cleavage:* Noticeable along grain length; transverse and longitudinal partings. Hardness = ∼2 VHN = 150–206 D(meas.) = n.d. D(calc.) = 7.58

Optical Properties: Opaque. *Color:* Lead-gray to iron-black; in polished section, white. *Luster:* Metallic. *Pleochroism:* Weak in air, weak to distinct in oil. *Anisotropism:* Weak in air, distinct to strong in oil, in gray to black.

R_1–R_2: (400) 42.6–46.6, (420) 43.0–47.3, (440) 43.4–48.0, (460) 43.6–48.2, (480) 43.5–48.2, (500) 43.2–48.0, (520) 42.9–47.7, (540) 42.4–47.2, (560) 42.0–46.7, (580) 41.7–46.2, (600) 41.4–46.0, (620) 41.2–45.7, (640) 41.1–45.6, (660) 41.0–45.5, (680) 40.9–45.3, (700) 40.9–45.1

Cell Data: *Space Group:* $Bbmm$, $Bb2_1m$, or $Bbm2$. $a = 13.448(2)$ $b = 44.386(1)$ $c = 4.022(12)$ $Z = 8$

X-ray Powder Pattern: Treasure Vault mine, Colorado, USA.
2.035 (100), 3.207 (90), 2.923 (90), 2.878 (70), 2.873 (70), 2.786 (70), 2.382 (70)

Chemistry:

	(1)	(2)	(3)
Ag	9.1	9.51	8.97
Cu	0.1		
Pb	29.0	18.27	34.47
Bi	45.9	55.26	40.56
S	16.7	16.96	16.00
Total	100.8	100.00	100.00

(1) Treasure Vault mine, Colorado, USA; by electron microprobe. (2) $Ag_3Pb_3Bi_9S_{18}$. (3) $Ag_3Pb_6Bi_7S_{18}$.

Occurrence: Disseminated through quartz.

Association: Galena, matildite, hessite, aikinite, clausthalite, bismuthinite, lillianite.

Distribution: In the USA, in Colorado, from several mines on the Treasure Vault and parallel lodes, Geneva district [TL], Clear Creek, Park, and Summit Cos.; in the Lake City district, Hinsdale Co.; from Darwin, Inyo Co., California. In Scotland, from Corrie Buie, Meal nan Oighreag, Perthshire. At the Monteneme W–Sn deposit, Galice?? which Prov. or delete??, Spain. In the Toroiaga mine, Baia Borşa district, Romania. From the Zambarak Pb–Zn deposit, eastern Karamazar, Tajikistan. At the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In China, at the Shanhu W–Sn deposit, Guangxi Zhuangzu Autonomous Region, and in the Huangshaping Pb–Zn deposit, Guiyang, Hunan Province. Additional localities are known, but the species may be confused with other homologous sulfosalts.

Name: In honor of Dr. J.F.L. Schirmer, former Superintendent of the U.S. Mint, Denver, Colorado, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 424. (2) Karup-Møller, S. (1973) New data on schirmerite. Can. Mineral., 11, 952–957. (3) Makovicky, E. and S. Karup-Møller (1977) Chemistry and crystallography of the lillianite homologous series. Neues Jahrb. Mineral., Abh., 131, 56–82. (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 736–737.

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Schlemaite $Cu_6(Pb,Bi)Se_4$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Schlossmacherite $(H_3O, Ca)Al_3(SO_4, AsO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As polycrystalline aggregates and crusts.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.00

Optical Properties: Semitransparent. *Color:* Pale green to gray-green; colorless in thin section. *Luster:* Waxy.
Optical Class: Uniaxial. $n = 1.597$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.998(2)$ $c = 16.67(1)$ Z = [3]

X-ray Powder Pattern: Emma Luisa mine, Chile.
2.962 (100), 4.918 (70), 2.979 (50), 3.510 (35), 1.900 (35), 2.218 (30), 1.752 (25)

Chemistry:

	(1)
SO_3	29.32
As_2O_5	13.44
Al_2O_3	36.33
Fe_2O_3	0.55
CuO	1.19
CaO	3.51
SrO	0.26
BaO	0.33
Na_2O	0.47
K_2O	0.54
H_2O	[14.06]
Total	[100.00]

(1) Emma Luisa mine, Chile; by electron microprobe, H_2O by difference, $(OH)^{1-}$ calculated for charge balance; corresponds to $[(H_3O)_{0.54}Ca_{0.26}Na_{0.07}Cu_{0.06}K_{0.05}Sr_{0.01}Ba_{0.01}]_{\Sigma=1.00}(Al_{2.97}Fe_{0.03})_{\Sigma=3.00}[(SO_4)_{1.53}(AsO_4)_{0.49}]_{\Sigma=2.02}(OH)_{6.19}$.

Mineral Group: Beudantite group.

Occurrence: A rare secondary mineral in the oxidized zone of a copper-bearing gold deposit.

Association: Ceruleite, chenevixite, olivenite, alumopharmacosiderite, mansfieldite, barite, quartz, goethite.

Distribution: From the Emma Luisa gold mine, Guanaco district, about 100 km east-northeast of Taltal, Antofagasta, Chile.

Name: To honor Professor Emeritus Karl Schlossmacher (1887–1980), Institute for Mineralogy and Petrography, Johannes Gutenberg University, Mainz, Germany, Honorary President of the German Gemmological Society.

Type Material: University of Heidelberg, Heidelberg, Germany, 10'11'13.

References: (1) Schmetzer, K. and H. Bank (1979) Schlossmacherit, ein neues Mineral, benannt nach Prof. Dr. Karl Schlossmacher, dem Ehrenvorsitzenden der Deutschen Gemmologischen Gesellschaft. Z. deutsch gemm. Ges., 28, 131–133 (in German). (2) (1980) Amer. Mineral., 65, 1069 (abs. ref. 1). (3) Schmetzer, K., J. Ottemann, and H. Bank (1980) Schlossmacherit, $(H_3O, Ca)Al_3[(OH)_6|(S, As)O_4)_2]$, ein neues Mineral der Alunit-Jarosit-Reihe. Neues Jahrb. Mineral., Monatsh., 215–220 (in German with English abs.).

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Schmiederite $Pb_2Cu_2(Se^{4+}O_3)(Se^{6+}O_4)(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous crystals, to 1 mm, in spherical, radial, or irregular aggregates, may be in crusts; powdery.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.62

Optical Properties: Transparent. *Color:* Pale to deep Prussian blue. *Luster:* Subadamantine, satiny in aggregates.
Optical Class: Biaxial (+). $\alpha = 1.85$–1.9 $\beta = 1.9$–1.95 $\gamma = 1.95$–2.1 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$ (synthetic). $a = 9.922(3)$ $b = 5.712(2)$ $c = 9.396(3)$ $\beta = 101.96(3)°$ Z = 2

X-ray Powder Pattern: Cóndor mine, Argentina.
3.23 (100), 3.19 (90), 3.13 (90), 3.57 (60), 4.85 (50), 4.52 (50), 2.74 (40)

Chemistry:

	(1)	(2)
SeO_3	14.72	14.43
SeO_2	12.86	12.62
CuO	18.09	18.09
PbO	51.25	50.76
H_2O	[3.08]	4.10
Total	[100.00]	100.00

(1) Cóndor mine, Argentina; partial elemental analysis here recalculated to oxides assuming Se^{4+}:Se^{6+} = 1:1; corresponds to $Pb_{2.00}Cu_{2.00}(SeO_3)_{1.01}(SeO_4)_{1.01}(OH)_{3.99}$.
(2) $Pb_2Cu_2(SeO_3)(SeO_4)(OH)_4$.

Occurrence: A rare secondary mineral in the oxidized zone of selenium-bearing hydrothermal base metal deposits.

Association: Chalcomenite, molybdomenite, umangite, clausthalite (Cóndor mine, Argentina).

Distribution: From the Cóndor mine, Los Llantenes district, Sierra de Cacheuta, La Rioja Province, Argentina. In the El Dragón mine, 30 km southwest of Cerro Rico de Potosí, Potosí, Bolivia. In Wales, from the Llechwedd Helyg mine, Tir-y-Mynach, and at the Nantycagl (Eaglebrook) mine, Ceulanymaesmawr, Dyfed; in the Dyfngwm mine, Penegoes, Powis; from Machen. In the Greystone quarry, Levant, Cornwall, England. From the Baccu Locci mine, near Villaputzu, Sarrabus district, Sardinia, Italy. In the Tonopah-Belmont mine, Osborne district, Maricopa Co., Arizona, USA.

Name: To honor Oscar Schmieder (1891–1980), German geographer, a Director of the Museum of Mineralogy and Geology, National University, Córdoba, Argentina.

Type Material: The Natural History Museum, London, England, 1962,217; National Museum of Natural History, Washington, D.C., USA, 160487.

References: (1) Sarp, H. and G. Burri (1987) Étude de la schmiederite de la mine Condor, La Rioja (Sierra de Cacheuta) Argentine, un séléniate et sélénite hydraté de plomb et de cuivre. Schweiz. Mineral. Petrog. Mitt., 67, 219–223 (in French with English abs.). (2) Effenberger, H. (1987) Crystal structure and chemical formula of schmiederite, $Pb_2Cu_2(OH)_4(SeO_3)(SeO_4)$, with a comparison to linarite, $PbCu(OH)_2(SO_4)$. Mineral. Petrol., 36, 2–12.

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Schmitterite $(UO_2)Te^{4+}O_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Individual crystals are bladelike, elongated along [100] and flattened on [010], in rosettes, to 2 mm, and in scales and tufts; may be aggregated into nodules and crusts.

Physical Properties: *Cleavage:* On {100}. *Tenacity:* Plastic. Hardness = ∼1
D(meas.) = 6.878 (synthetic). D(calc.) = 6.916 Radioactive.

Optical Properties: Semitransparent. *Color:* Colorless, pale straw-yellow, pale yellow.
Luster: Pearly.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. α = n.d. $\beta = 2.05$ $\gamma = > 2.11$
2V(meas.) = ∼75°

Cell Data: *Space Group:* $P2_1ab$ (synthetic). $a = 7.860(4)$ $b = 10.089(2)$ $c = 5.363(2)$
Z = 4

X-ray Powder Pattern: Synthetic.
3.682 (10), 5.35 (9), 3.099 (9), 4.73 (8), 3.170 (8), 1.971 (7), 1.549 (6)

Chemistry: (1) Identification depends on coincidence of the X-ray powder pattern with synthetic material, and the presence of uranium and tellurium.

Occurrence: In the oxidized zone of a hydrothermal Au–Te deposit (Moctezuma mine, Mexico); in the oxidized zone of a uranium deposit (Shinkolobwe, Congo).

Association: Emmonsite, mackayite, cuzticite, eztlite, "limonite" (Moctezuma mine, Mexico); uraninite, siegenite, vaesite (Shinkolobwe, Congo).

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, and at the San Miguel prospect, 10 km northwest of the Moctezuma mine, Sonora, Mexico. From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Eduardo Schmitter Villada (1904–1982), Professor of Mineralogy and Petrology, National University of Mexico, Mexico City, Mexico.

Type Material: Mexican Institute of Geology, National University of Mexico, Mexico City, Mexico; Natural History Museum, Paris, France, 175.80; National Museum of Natural History, Washington, D.C., USA, 120247, 122475, 164351.

References: (1) Gaines, R.V. (1971) Schmitterite – a new uranyl tellurite from Moctezuma, Sonora. Amer. Mineral., 56, 411–415. (2) Meunier, G. and J. Galy (1973) Structure cristalline de la schmitterite synthétique $UTeO_5$. Acta Cryst., 29, 1251–1255 (in French with English abs.).

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Schneebergite $BiCo_2(AsO_4)_2[(H_2O)(OH)]$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As crystals, to 0.1 mm, bladed to scaly, elongated ‖ [001] or tabular {010}, composed of {100}, {010}, {001}, {101}, {$\bar{1}$01}, in rosettes and microcrystalline coatings.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = ∼2 D(meas.) = 1.92(2) D(calc.) = 1.931 May dehydrate to metaschoderite in a dry atmosphere.

Optical Properties: Semitransparent. *Color:* Yellowish orange.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; Y = deep yellow; Z = yellow.
Orientation: $X = b$; $Y \wedge c = 26(5)°$. $\alpha = 1.560(1)$ $\beta = 1.563(1)$ $\gamma = 1.565(1)$
2V(meas.) = 42(3)°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 16.26(1)$ $b = 30.60(4)$ $c = 12.55(1)$ $\beta = 91.77(8)°$ Z = 18

X-ray Powder Pattern: Wilson Springs mine, Arkansas, USA.
16.3 (100), 15.3 (70), 7.64 (35), 2.893 (35), 5.686 (25), 5.410 (25), 2.843 (25)

Chemistry:

	(1)	(2)	(3)
P_2O_5	17.4	21.08	17.40
V_2O_5	24.6	22.37	22.29
Al_2O_3	23.8	25.67	24.99
Fe_2O_3	0.27	0.47	
H_2O^+	7.5		
H_2O^-	26.6		
H_2O		[30.41]	35.32
Total	[100.17]	[100.00]	100.00

(1) Fish Creek Range, Nevada, USA; original total given as 100.27%, corresponds to $Al_{1.92}(PO_4)_{1.00}(VO_4)_{1.10}\bullet 7.94H_2O$. (2) Wilson Springs mine, Arkansas, USA; by electron microprobe, H_2O by difference. (3) $Al_2(PO_4)(VO_4)\bullet 8H_2O$.

Occurrence: A rare mineral formed from amorphous phosphatic gels or by crystallization from meteoric solution in fractures in phosphatic chert (Fish Creek Range, Nevada, USA).

Association: Vashegyite, wavellite (Fish Creek Range, Nevada, USA); metahewettite, metaschoderite, bokite, minyulite, leucophosphite (Cockalorum Wash, Nevada, USA); hewettite, duttonite, fervanite, metaschoderite, straczekite, apatite, quartz (Wilson Springs mine, Arkansas, USA).

Distribution: In the USA, from the Van-Nav-Sand claim group, Fish Creek Range, about 48 km south of Eureka, Eureka Co., and near Cockalorum Wash, Nye Co., Nevada; in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas.

Name: To honor William Paul Schoder (1900–1977), research chemist, Union Carbide Corporation, for his work on the metallurgy of vanadium.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145791, 144479.

References: (1) Hausen, D.M. (1962) Schoderite, a new phosphovanadate mineral from Nevada. Amer. Mineral., 47, 637–648. (2) Pabst, A. (1979) Schoderite, a new locality and a redescription. Amer. Mineral., 64, 713–720.

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Schneiderhöhnite $Fe^{2+}Fe_3^{3+}As_5^{3+}O_{13}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As flattened curved crystals, to 3 cm; also spindle-shaped, in aggregates.

Physical Properties: *Cleavage:* {100}, perfect; two others observed. Hardness = ∼3
D(meas.) = 4.3 D(calc.) = 4.40

Optical Properties: Opaque, transparent in thin flakes. *Color:* Dark brown, nearly black; yellow-brown to yellow-orange; in reflected light, red-brown with brownish red internal reflections. *Streak:* Coffee-brown. *Luster:* Metallic to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* Red-brown to pale yellow. *Absorption:* $X > Y < Z$.
$\alpha = > 2.11$ $\beta =$ n.d. $\gamma = < 2.13$ 2V(meas.) = n.d. *Anisotropism:* Weak; greenish to brownish.

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.924(2)$ $b = 10.016(3)$ $c = 9.103(3)$ $\alpha = 59.91(2)°$
$\beta = 112.41(2)°$ $\gamma = 81.69(2)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
7.25 (10), 3.583 (10), 2.891 (10), 2.598 (10), 2.399 (9), 3.320 (8), 2.255 (8)

Chemistry:

	(1)	(2)
As	47.03	46.48
Fe	27.90	27.72
Zn	0.93	
Ge	0.37	
O	[23.77]	25.80
Total	[100.00]	100.00

(1) Tsumeb, Namibia; by electron microprobe, average of three analyses, O by difference.
(2) $Fe^{2+}Fe_3^{3+}As_5O_{13}$.

Occurrence: A rare secondary mineral in an oxidation zone in a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Zincian stottite, chalcocite, tennantite, leiteite (Tsumeb, Namibia); löllingite, karibibite, eosphorite, arseniosiderite, scorodite, quartz (Bou Azzer, Morocco).

Distribution: From Tsumeb, Namibia. At Bou Azzer, Morocco. From the Córrego do Urucum pegmatite, near Galiléia, Minas Gerais, Brazil. At the Veta Negra mine, Pampa Larga district, Tierra Amarilla, southeast of Copiapó, Chile. In the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA. At the Belaj-Gora pegmatite in Kazakhstan.

Name: To honor Hans Schneiderhöhn (1887–1962), Professor of Mineralogy, University of Freiburg, Freiburg im Breisgau, Germany.

Type Material: Royal Ontario Museum, Toronto, Canada, M33238; Harvard University, Cambridge, Massachusetts, USA, 111932.

References: (1) Ottemann, J., B. Nuber, and B.H. Geier (1973) Schneiderhöhnit, ein natürliches Eisen-Arsen-Oxid aus der tiefen Oxidationszone von Tsumeb. Neues Jahrb. Mineral., Monatsh., 517–523. (2) (1974) Amer. Mineral., 59, 1139 (abs. ref. 1). (3) Hawthorne, F.C. (1985) Schneiderhöhnite, $Fe^{2+}Fe_3^{3+}As_5^{3+}O_{13}$, a densely packed arsenite structure. Can. Mineral., 23, 675–679.

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As crystals, to 0.1 mm, bladed to scaly, elongated $\parallel$ [001] or tabular {010}, composed of {100}, {010}, {001}, {101}, {$\bar{1}$01}, in rosettes and microcrystalline coatings.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = ~2 D(meas.) = 1.92(2) D(calc.) = 1.931 May dehydrate to metaschoderite in a dry atmosphere.

Optical Properties: Semitransparent. *Color:* Yellowish orange.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; Y = deep yellow; Z = yellow.
Orientation: $X = b$; $Y \wedge c = 26(5)°$. $\alpha = 1.560(1)$ $\beta = 1.563(1)$ $\gamma = 1.565(1)$
2V(meas.) = 42(3)°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 16.26(1)$ $b = 30.60(4)$ $c = 12.55(1)$
$\beta = 91.77(8)°$ Z = 18

X-ray Powder Pattern: Wilson Springs mine, Arkansas, USA.
16.3 (100), 15.3 (70), 7.64 (35), 2.893 (35), 5.686 (25), 5.410 (25), 2.843 (25)

Chemistry:

	(1)	(2)	(3)
P_2O_5	17.4	21.08	17.40
V_2O_5	24.6	22.37	22.29
Al_2O_3	23.8	25.67	24.99
Fe_2O_3	0.27	0.47	
H_2O^+	7.5		
H_2O^-	26.6		
H_2O		[30.41]	35.32
Total	[100.17]	[100.00]	100.00

(1) Fish Creek Range, Nevada, USA; original total given as 100.27%, corresponds to $Al_{1.92}(PO_4)_{1.00}(VO_4)_{1.10}\cdot 7.94H_2O$. (2) Wilson Springs mine, Arkansas, USA; by electron microprobe, H_2O by difference. (3) $Al_2(PO_4)(VO_4)\cdot 8H_2O$.

Occurrence: A rare mineral formed from amorphous phosphatic gels or by crystallization from meteoric solution in fractures in phosphatic chert (Fish Creek Range, Nevada, USA).

Association: Vashegyite, wavellite (Fish Creek Range, Nevada, USA); metahewettite, metaschoderite, bokite, minyulite, leucophosphite (Cockalorum Wash, Nevada, USA); hewettite, duttonite, fervanite, metaschoderite, straczekite, apatite, quartz (Wilson Springs mine, Arkansas, USA).

Distribution: In the USA, from the Van-Nav-Sand claim group, Fish Creek Range, about 48 km south of Eureka, Eureka Co., and near Cockalorum Wash, Nye Co., Nevada; in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas.

Name: To honor William Paul Schoder (1900–1977), research chemist, Union Carbide Corporation, for his work on the metallurgy of vanadium.

Type Material: National Museum of Natural History, Washington, D.C., USA, 145791, 144479.

References: (1) Hausen, D.M. (1962) Schoderite, a new phosphovanadate mineral from Nevada. Amer. Mineral., 47, 637–648. (2) Pabst, A. (1979) Schoderite, a new locality and a redescription. Amer. Mineral., 64, 713–720.

Schoenfliesite $MgSn^{4+}(OH)_6$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Very fine-grained, to about 0.5 μm; as fibrous crusts on cassiterite.

Physical Properties: Hardness = ∼4 D(meas.) = > 3.32 D(calc.) = 3.49

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Isotropic. $n = 1.667(10)$

Cell Data: *Space Group:* $Pn\overline{3}$ (synthetic). $a = 7.759(6)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.88 (100), 4.48 (50), 2.74 (25), 1.733 (25), 2.34 (20), 1.938 (20), 1.582 (20)

Chemistry:

	(1)	(2)	(3)	(4)
TiO_2	0.37			
SnO_2	12.36	61.5	58.7	61.50
Al_2O_3	0.98			
B_2O_3	0.65			
Fe_2O_3	72.24			
FeO	0.76		0.0	
MnO	0.97		3.6	
MgO	4.27	16.5	15.3	16.45
CaO	0.43		0.0	
H_2O^+	6.07	22.0	21.8	
H_2O^-	0.06			
H_2O				22.05
insol.	1.04			
Total	100.20	[100.0]	99.4	100.00

(1) Brooks Range, Alaska; averages of varying numbers of determinations on the same sample; calculated to be a mixture of maghemite 57.38%, goethite 17.45%, hulsite 4.33%, fluorite 0.60%, and schoenfliesite 19.51%. (2) Schoenfliesite from (1) recalculated to 100%. (3) Pitkäranta district, Russia; by electron microprobe, average of 7 points; corresponds to $(Mg_{0.94}Mn_{0.13})_{\Sigma=0.1.07}Sn_{0.97}(OH)_{6.00}$. (4) $MgSn(OH)_6$.

Mineral Group: Schoenfliesite group.

Occurrence: A late-stage hydrothermal alteration product of hulsite in a boron-metasomatized limestone near the contact with a granite intrusive (Brooks Range, Alaska, USA); a late-stage low-temperature mineral in serpentinized dolostone associated with W, Sr, B, Be-bearing skarns (Pitkäranta district, Russia).

Association: Hulsite, goethite, maghemite (Brooks Range, Alaska, USA); cassiterite, berborite, calcite, fluorite, dolomite, magnetite, chondrodite, diopside (Pitkäranta district, Russia).

Distribution: On the northwest flank of Brooks Mountain, Seward Peninsula, Alaska, USA. From the Pitkäranta district, Lake Ladoga, Karelia, Russia. At the Damoshan deposit, Gejiu tin district, Yunnan Province, China. From Sungai Gow, Pahang, Malaysia.

Name: To honor Arthur Moritz Schoenflies (1853–1928), Professor of Mathematics, University of Frankfurt-am-Main, Frankfurt, Germany, for his derivation of the 230 space groups.

Type Material: n.d.

References: (1) Faust, G.T. and W.T. Schaller (1971) Schoenfliesite, $MgSn(OH)_6$. Zeits. Krist., 134, 116–141. (2) (1972) Amer. Mineral., 57, 1557–1558 (abs. ref. 1). (3) Nefedov, E.I., W.L. Griffin, and R. Kristiansen (1977) Minerals of the schoenfliesite–wickmanite series from Pitkäranta, Karelia, U.S.S.R. Can. Mineral., 15, 437–445.

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Schoepite $(UO_2)_4O(OH)_6 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Commonly in crystals, tabular ∥ {001}, equant, may be short prismatic along {001}, to 1.5 mm; highly developed, with over 20 forms noted; rarely in microcrystalline aggregates.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 4.8–4.96 D(calc.) = 4.87 Radioactive; fluoresces green under UV.

Optical Properties: Transparent. *Color:* Sulfur-yellow to citron-yellow; brownish yellow to amber-yellow, as a surficial alteration towards metaschoepite and paraschoepite; yellow in transmitted light. *Streak:* Yellow. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = almost colorless; $Y = Z$ = lemon-yellow to golden yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong. $\alpha = 1.690(3)$ $\beta = 1.714(3)$ $\gamma = 1.735(3)$ 2V(meas.) = 75°–85°

Cell Data: *Space Group:* $P2_1ca$. $a = 14.337(3)$ $b = 16.813(5)$ $c = 14.731(4)$ Z = 8

X-ray Powder Pattern: Shaba Province, Congo.
7.35 (100), 3.66 (50), 3.24 (9), 2.446 (9), 2.571 (4), 3.21 (3), 3.162 (3)

Chemistry:

	(1)	(2)
UO_3	87.73	87.59
H_2O	12.32	12.41
Total		100.00

(1) Shaba Province, Congo; UO_3 average of four partial determinations, H_2O average of two partial determinations. (2) $(UO_2)_4O(OH)_6 \cdot 6H_2O$.

Occurrence: A rare alteration product of uraninite in hydrothermal uranium deposits; may form directly from ianthinite.

Association: Uraninite, becquerelite, billietite, vandendriesscheite, fourmarierite, ianthinite, curite, soddyite, rutherfordine, uranophane (Shinkolobwe, Congo); paraschoepite, arsenuranylite, metazeunerite, uranospinite, nováčekite (Cherkasar deposit, Uzbekistan).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In the USA, at Beryl Mountain, Acworth, Sullivan Co., and in the Ruggles mine, Grafton, and the Palermo mine, near North Groton, Grafton Co., New Hampshire; in Utah, at the Consolidated mine, Green Vein Mesa, Emery Co., the Happy Jack mine, White Canyon, and the Frey No. 4 mine, Red Canyon, San Juan Co., and the Oyler Tunnel claim, near Fruita, Wayne Co.; at the Lookout No. 22 claim, Marshall Pass district, Saguache Co., Colorado; from the Monument No. 2 mine, Apache Co., the Abe Lincoln mine, northeast of Wickenburg, Yavapai Co., and the Black Point-Murphy mine, near Cameron, Coconino Co., Arizona; from Paguate, Valencia Co., New Mexico; in the Lucky Mc mine, Gas Hills district, Fremont Co., Wyoming. From Wölsendorf, Bavaria, Germany. In the Margnac mine, Compreignac, Haute-Vienne, and at the Mas-d'Alary and Rabéjac uranium deposits, south of Lodève, Hérault, France. In Japan, at Akura, Okayama Prefecture, and in the Tarumi mine, Kagoshima Prefecture. From the Cherkasar uranium deposit, Chaktal Mountains, Uzbekistan. Several additional localities are known.

Name: Honors Alfred Schoep (1881–1966), Professor of Mineralogy, University of Ghent, Ghent, Belgium, for his contributions to uranium mineralogy.

Type Material: Royal Ontario Museum, Toronto, Canada, M13072.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 627–628. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 72–78. (3) Toussaint, J. and H. Brasseur (1959) Sur la structure de quelques composés uranifères hydratés. Bull. Cl. Sci. Acad. Roy. Belg., 45, 501–506 (in French). (4) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates [schoepite-I]. Amer. Mineral., 45, 1026–1061. (5) Finch, R.J., M.A. Cooper, F.C. Hawthorne, and R.C. Ewing (1996) The crystal structure of schoepite, $[(UO_2)_8O_2(OH)_{12}](H_2O)_{12}$. Can. Mineral., 34, 1071–1088.

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Schöllhornite $Na_{0.3}CrS_2 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$, or 32. As thin bands a few μm wide in caswellsilverite, also as individual grains, to 250 μm.

Physical Properties: *Cleavage:* Basal, perfect (synthetic); distinct parting on {*h*0*l*}. Hardness = n.d. VHN = 41.8–90.8 on {0001} (15 g load) (synthetic). D(meas.) = 2.70 (synthetic). D(calc.) = 2.74

Optical Properties: Opaque. *Color:* In reflected light, gray in air, bluish gray in oil. *Luster:* Submetallic (synthetic).
Optical Class: Uniaxial (–). *Pleochroism:* Distinct; white with yellowish tint to light gray with bluish or greenish tint. *Anisotropism:* Strong.
R_1–R_2: (400) — , (420) 15.4–17.0, (440) 16.0–17.4, (460) 16.6–19.3, (480) 16.5–19.3, (500) 16.4–19.4, (520) 16.2–19.3, (540) 16.0–19.3, (560) 15.8–19.3, (580) 15.5–19.3, (600) 15.2–19.2, (620) 15.2–19.1, (640) 15.0–19.0, (660) 15.1–19.1, (680) 15.1–19.4, (700) 14.8–19.0

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. $a = 3.32(1)$ $c = 26.6(1)$ $Z = 3$

X-ray Powder Pattern: Synthetic.
8.85 (vsb), 2.81 (mb), 2.53 (mb), 1.66 (mb), 4.43 (wb), 2.21 (vvwb)

Chemistry:

	(1)	(2)	(3)
Na	5.10	4.95	4.89
Cr	36.3	36.2	36.87
Ti	0.17		
Mn	0.17		
S	45.5	44.9	45.47
H_2O	14.3	13.9	12.77
Total	101.5	100.0	100.00

(1) Norton County meteorite; by electron microprobe, average values; corresponds to $Na_{0.31}Cr_{0.98}S_{2.00} \cdot 1.20H_2O$. (2) Synthetic schöllhornite; by electron microprobe, corresponds to $Na_{0.31}Cr_{0.99}S_{2.00} \cdot 1.10H_2O$. (3) $Na_{0.3}CrS_2 \cdot H_2O$.

Occurrence: In an enstatite achondrite meteorite with other chromium-rich minerals, probably formed by terrestrial weathering of caswellsilverite.

Association: Caswellsilverite, daubréelite, titanoan troilite, ferromagnesian alabandite, oldhamite, kamacite, perryite.

Distribution: Found in the Norton County enstatite achondrite meteorite [TL].

Name: Honors Professor Robert Schöllhorn, Inorganic Chemical Institute, Münster University, Münster, Germany.

Type Material: Institute of Meteoritics and Department of Geology, University of New Mexico, Albuquerque, New Mexico, USA.

References: (1) Okada, A., K. Keil, B.F. Leonard, and I.D. Hutcheon (1985) Schöllhornite, $Na_{0.3}(H_2O)_1[CrS_2]$, a new mineral in the Norton County enstatite achondrite. Amer. Mineral., 70, 638–643.

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Scholzite $CaZn_2(PO_4)_2 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals elongated ‖ [001], may be platy, pseudohexagonal, showing {100}, {110}, {130}, {231}, {061}, to 2.5 cm; typically syntactically intergrown with parascholzite on {100}; in radial aggregates.

Physical Properties: *Cleavage:* On {100}, fair, a parting with parascholzite lamellae. Hardness = 3–4 D(meas.) = 3.11–3.13 D(calc.) = 3.10

Optical Properties: Semitransparent. *Color:* Colorless to white, pale gray; rarely lime-green, reddish brown, yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$.
$\alpha = 1.581–1.585$ $\beta = 1.586–1.587$ $\gamma = 1.596–1.599$ 2V(meas.) = 33°–70° 2V(calc.) = 34°–71°

Cell Data: *Space Group:* $Pbcm$ or $Pbc2_1$. $a = 17.149–17.178$ $b = 22.236–22.28$ $c = 6.667–6.691$ Z = 12

X-ray Powder Pattern: Reaphook Hill, Australia.
8.55 (100), 2.805 (70), 4.300 (60), 3.404 (40), 1.909 (40), 4.53 (30), 3.182 (30)

Chemistry:

	(1)	(2)
P_2O_5	35.99	35.77
FeO	0.38	
MnO	1.36	
ZnO	35.70	41.02
MgO	0.94	
CaO	14.29	14.13
H_2O	10.36	9.08
insol.	0.88	
Total	99.90	100.00

(1) Hagendorf, Germany; corresponds to $Ca_{1.00}(Zn_{1.72}Mg_{0.09}Mn_{0.08}Fe_{0.02})_{\Sigma=1.91}(PO_4)_{1.99} \cdot 2.26H_2O$. (2) $CaZn_2(PO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with parascholzite.

Occurrence: May be a primary mineral, but more commonly a secondary mineral in Zn phosphate-bearing granite pegmatites and sediments.

Association: Parascholzite, sphalerite, triplite (Hagendorf, Germany); parahopeite, collinsite (Reaphook Hill, Australia); tarbuttite (Kabwe, Zambia).

Distribution: From Hagendorf, Bavaria, Germany. At Otov, near Domažlice, Czech Republic. In the Baccu Locci mine, Cagliari, Sardinia, Italy. From Richelle, near Visé, Belgium. At Kabwe (Broken Hill), Zambia. In Australia, fine examples on Reaphook Hill, near Blinman, Flinders Ranges, South Australia; from Broken Hill, New South Wales. In the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; from the Snowstorm mine, North Battle Mountain district, Lander Co., Nevada, USA. In China, at an undefined locality in Guangdong Province.

Name: Honoring Dr. Adolph Scholz (1894–1950), chemist and mineral collector, Regensburg, Germany.

Type Material: The Natural History Museum, London, England, 1961,14; Harvard University, Cambridge, Massachusetts, 102210; National Museum of Natural History, Washington, D.C., USA, 106411.

References: (1) Strunz, H. (1948) Scholzit, eine neue Mineralart. Fortschr. Mineral. (1950) 27, 31 (in German). (2) (1951) Amer. Mineral., 36, 382 (abs. ref. 1). (3) Strunz, H. and C. Tennyson (1956) Kristallographie von Scholzit, $CaZn_2[PO_4]_2 \cdot 2H_2O$. Zeits. Krist., 107, 318–330 (in German). (4) Taxer, K. (1975) Structural investigations on scholzite. Amer. Mineral., 60, 1019–1022. (5) Sturman, B.D., R.C. Rouse, and P.J. Dunn (1981) Parascholzite, a new mineral from Hagendorf, Bavaria, and its relationship to scholzite. Amer. Mineral., 66, 843–851.

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Schoonerite $Fe_2^{2+}ZnMn^{2+}Fe^{3+}(PO_4)_3(OH)_2 \cdot 9H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Lathlike and strawlike crystals, elongated along [100], flattened on {010}, showing {001}, {010}, {100}, to 2 mm, typically curved and crinkled, as rosettes, scales, in sprays and mats.

Physical Properties: *Cleavage:* {010}, perfect; {001}, good. Hardness = ∼4
D(meas.) = 2.87–2.92 D(calc.) = 2.79

Optical Properties: Transparent to translucent. *Color:* Pale tan to brown, greenish brown, yellowish brown; copper-red to bronzy on exposure. *Streak:* Pale brown. *Luster:* Subvitreous to waxy.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = pale yellow; Y = pale brown; Z = brown. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Absorption:* $Z > Y > X$. $\alpha = 1.618(5)$ $\beta = 1.652(3)$ $\gamma = 1.682(3)$ 2V(meas.) = 70°–80°

Cell Data: *Space Group: Pmab.* $a = 11.119(4)$ $b = 25.546(11)$ $c = 6.437(3)$ Z = 4

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
12.77 (10), 2.768 (9), 8.356 (7), 6.43 (4), 3.761 (4), 3.182 (4), 1.600 (4)

Chemistry:

	(1)	(2)
P_2O_5	29.45	27.69
Al_2O_3	0.73	
Fe_2O_3		10.38
FeO	29.84	18.69
MnO	7.32	9.23
ZnO	7.95	10.58
MgO	1.74	
CaO	1.38	
K_2O	0.47	
H_2O	[23.43]	23.43
Total	[102.31]	100.00

(1) Palermo #1 mine, New Hampshire, USA; by electron microprobe, total Fe as FeO, H_2O from theory. (2) $Fe_2^{2+}ZnMn^{2+}Fe^{3+}(PO_4)_3(OH)_2 \cdot 9H_2O$.

Occurrence: A rare late-stage low-temperature hydrothermal alteration and weathering product formed from earlier more reduced phases.

Association: Mitridatite, laueite, strunzite, whitmoreite, siderite, ludlamite, messelite, vivianite, whitlockite, hydroxylapatite, childrenite, jahnsite, arrojadite, Fe–Mn oxyhydroxides (Palermo #1 mine, New Hampshire, USA).

Distribution: From the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, and at Newry, Oxford Co., Maine, USA. At Hagendorf, Bavaria, Germany.

Name: To honor Richard Schooner (1925–), Woodstock, Connecticut, USA, student and collector of New England minerals.

Type Material: National Museum of Natural History, Washington, D.C., USA, 135934, 137019.

References: (1) Moore, P.B. and A.R. Kampf (1977) Schoonerite, a new zinc-manganese-iron phosphate mineral. Amer. Mineral., 62, 246–249. (2) Kampf, A.R. (1977) Schoonerite: its atomic arrangement. Amer. Mineral., 62, 250–255.

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Schorl $NaFe^{2+}_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals prismatic to acicular, or may be flattened along [0001], with prominent trigonal prism and pyramid, to 1.5 m. Commonly hemimorphic, and striated ‖ [0001]. Also radial, fibrous, and massive. *Twinning:* Rarely on $\{10\bar{1}0\}$, $\{40\bar{4}1\}$.

Physical Properties: *Cleavage:* $\{11\bar{2}0\}$, $\{10\bar{1}1\}$, very poor. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 7 D(meas.) = 3.18–3.22 D(calc.) = 3.244 Pyroelectric and piezoelectric.

Optical Properties: Transparent to nearly opaque. *Color:* Black, brownish black, bluish black; in thin section, bluish yellow. *Streak:* White. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–); under strain may show slight biaxiality. *Pleochroism:* Very strong; O = yellow-brown; E = pale yellow, pale brown. ω = 1.660–1.671 ϵ = 1.635–1.650

Cell Data: *Space Group:* $R3m$. a = 15.93–16.03 c = 7.12–7.19 Z = 3

X-ray Powder Pattern: Brazil.
3.48 (100), 2.587 (100), 2.96 (93), 6.39 (62), 4.01 (56), 4.23 (55), 2.046 (48)

Chemistry:

	(1)		(1)
SiO_2	36.04	MgO	0.42
TiO_2	0.54	CaO	1.01
B_2O_3	[10.43]	Li_2O	[n.d.]
Al_2O_3	30.83	Na_2O	2.72
$Fe_2O_3 + FeO$	17.59	K_2O	0.05
MnO	0.11	Total	[99.74]

(1) St. Andreasberg, Germany; by electron microprobe, B_2O_3 calculated from stoichiometry, Fe^{2+}:Fe^{3+} from Mössbauer spectroscopy; stated to correspond to $(Na_{0.88}Ca_{0.11}K_{0.01})_{\Sigma=1.00}(Fe^{2+}_{1.64}Al_{0.44}Fe^{3+}_{0.42}Mg_{0.11}Ca_{0.07}[Li_{0.07}]Ti_{0.07}Mn_{0.02})_{\Sigma=2.84}(Al_{5.61}Fe^{2+}_{0.39})_{\Sigma=6.00}(BO_3)_3Si_6O_{18}[(OH)_{3.70}O_{0.30}]_{\Sigma=4.00}$.

Polymorphism & Series: Forms a series with dravite.

Mineral Group: Tourmaline group.

Occurrence: In granites and granite pegmatites, high-temperature hydrothermal veins, and some metamorphic rocks; also detrital.

Association: Quartz, albite, microcline, orthoclase, epidote, garnet, muscovite, topaz, cassiterite, scheelite, fluorite, beryl.

Distribution: Many localities, but few for fine crystals. From Sonnenberg, near St. Andreasberg, Harz Mountains, Germany. At Bovey Tracey, Devon, England. From San Piero in Campo, Elba, Italy. Around Alabashka and Mursinka, Ural Mountains, Russia. In the USA, from Haddam, Middlesex Co., Connecticut; at Pierrepont and elsewhere in St. Lawrence Co., New York; from Stony Point, Alexander Co., and near Statesville, Iredell Co., North Carolina; in the Little Three mine, Ramona, San Diego Co., California. At Santa Cruz, Sonora, Mexico. Around Bom Jesus de Lapa and Mendes Pimental, Minas Gerais, Brazil. At Anibib and Farm Etemba, Namibia. From the Nuristan district, Laghman Province, Afghanistan.

Name: From the Old German *Schürl*, of uncertain derivation, perhaps meaning *impurities*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 551–558 [tourmaline]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 559–602. (3) Fortier, S. and G. Donnay (1975) Schorl refinement showing composition dependence of the tourmaline structure. Can. Mineral., 13, 173–177. (4) Dietrich, R.V. (1985) The tourmaline group. Van Nostrand, New York, 64.

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Schorlomite $\mathbf{Ca_3(Ti^{4+},Fe^{3+})_2(Si,Fe^{3+})_3O_{12}}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As trapezohedra and dodecahedra, up to 2 cm; more commonly massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7–7.5
D(meas.) = 3.69–3.88 D(calc.) = 3.77

Optical Properties: Translucent to nearly opaque. *Color:* Grayish black, black, may be tarnished blue; deep reddish brown. *Streak:* Grayish black to red-orange or orange-brown. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.94$–1.98; increases with Ti content.

Cell Data: *Space Group: Ia3d.* a = 12.09–12.145 Z = 8

X-ray Powder Pattern: Magnet Cove, Arkansas, USA.
1.614 (100), 2.702 (80), 1.679 (70), 2.468 (60), 3.026 (50), 1.351 (50), 1.319 (50)

Chemistry:

	(1)	(2)
SiO_2	25.66	26.08
TiO_2	22.10	15.34
Al_2O_3		4.52
Fe_2O_3	21.58	17.24
FeO		2.54
MnO		0.29
MgO		1.19
CaO	29.78	31.03
Na_2O		0.17
K_2O		0.08
H_2O^+		0.25
P_2O_5		0.28
Total	99.12	99.01

(1) Magnet Cove, Arkansas, USA. (2) Fanshan complex, China; corresponds approximately to $(Ca_{2.80}Fe^{2+}_{0.18}Mg_{0.15}Na_{0.03}Mn_{0.02}K_{0.01})_{\Sigma=3.19}(Ti^{4+}_{0.69}Fe^{3+}_{0.66}Al_{0.46})_{\Sigma=1.81}(Si_{2.24}Fe^{3+}_{0.46}Ti^{4+}_{0.30})_{\Sigma=3.00}O_{12}$.

Polymorphism & Series: Forms a series with andradite.

Mineral Group: Garnet group.

Occurrence: In carbonatites, syenites, and phonolites; also in skarns.

Association: Leucite, brookite, nepheline, potassic feldspar (Magnet Cove, Arkansas, USA).

Distribution: From Magnet Cove, Hot Spring Co., Arkansas, and near the Gem mine, San Benito Co., California, USA. In the Jacupiranga mine, São Paulo, Brazil. At Camphouse, Ardnamurchan, Argyllshire, Scotland. On Alnö Island, Sweden. From Iivaara, Kuusamo, Finland. In the Tokatoka district, about 150 km north of Auckland, New Zealand. From Fuka, near Bicchu, Okayama Prefecture, Japan. At Morotu, Sakhalin, Russia. In the Fanshan ultramafic complex, Hebei Province, China.

Name: For its resemblance to schorl.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128705.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 447–448. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 622–628, 639–641. (3) Wu Gongbao and Mu Baolei (1986) The crystal chemistry and Mössbauer study of schorlomite. Phys. Chem. Minerals, 13, 198–205. (4) McConnell, D. (1942) Griphite, a hydrophosphate garnet. Amer. Mineral., 27, 452–461.

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Schreibersite $(Fe, Ni)_3P$

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Crystal Data: Tetragonal. *Point Group:* $\overline{4}$. Rarely in crystals, rounded, may be hoppered; commonly in plates or tablets, or rods and needles, embedded in or along grain boundaries of kamacite in iron meteorites.

Physical Properties: *Cleavage:* Perfect on {001}; another, prismatic, on {010} or {110}, imperfect. *Tenacity:* Very brittle. Hardness = 6.5–7 D(meas.) = 7.0–7.3 D(calc.) = 7.12–7.44 Strongly magnetic.

Optical Properties: Opaque. *Color:* Silver-white to tin-white, tarnishing brass-yellow or brown. *Luster:* Brilliant metallic.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* $I\overline{4}$. $a = 9.013$–9.106 $c = 4.424$–4.464 $Z = 8$

X-ray Powder Pattern: Synthetic Fe_3P.
2.20 (100), 1.978 (100), 2.03 (80), 1.115 (80), 1.281 (65), 1.127 (65), 1.762 (55)

Chemistry:

	(1)	(2)	(3)	(4)
Fe	41.54	66.92	81.7	84.40
Co	0.80	0.62		
Ni	42.61	18.16		
P	15.05	14.88	18.1	15.60
Total	100.00	100.58	99.8	100.00

(1–2) Beaconsfield meteorite. (3) Red Sea; average of four analyses. (4) Fe_3P.

Occurrence: In nearly all iron meteorites, but lacking in those which are nickel deficient; rare in stony meteorites. Terrestrial occurrences are in reduced differentiated lenses in basalt (Disko Island, Greenland); as a hydrothermal metasomatic replacement of mineralized wood at a depth of 1400 m (Red Sea).

Association: Kamacite, tetrataenite (meteorites); iron, cohenite, troilite, wüstite (Disko Island, Greenland).

Distribution: Common in iron meteorites, as Magura, Bohumilitz, Beaconsfield, Canyon Diablo, Coahuila, many others. In Greenland, on Disko Island, near Kitdlît. At an unspecified location in the Red Sea.

Name: To honor Karl Franz Anton von Schreibers (1775–1852), of Vienna, Austria.

Type Material: Natural History Museum, Vienna, Austria (Magura meteorite).

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 124–126. (2) Borodaev, Y.S., Y.A. Bogdanov, and L.N. Vyal'sov (1982) New nickel-free variety of schreibersite Fe_2P. Zap. Vses. Mineral. Obshch., 111, 682–687 (in Russian). (3) Ulff-Møller, F. (1985) Solidification history of the Kitdlît lens: immiscible metal and sulphide liquids from a basaltic dyke on Disko, central west Greenland. J. Petrol., 26, 64–91. (4) Fasiska, E.J. and L. Zweil (1967) Thermal expansion of Fe_3P. Trans. A.I.M.E., 239, 924–925. (5) Doenitz, F.-D. (1970) Die Kristallstruktur des meteoritischen Rhabdits $(Fe, Ni)_3P$. Zeits. Krist., 131, 222–236 (in German with English abs.).

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Schreyerite $V_2^{3+}Ti_3O_9$

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Crystal Data: Monoclinic. *Point Group:* n.d. As lamellae and grains, to 30 μm, exsolved within rutile crystals. *Twinning:* Polysynthetic, universal.

Physical Properties: Hardness = n.d. VHN = 1100–1200 D(meas.) = n.d. D(calc.) = [4.46]

Optical Properties: Opaque. *Color:* Reddish brown; gray in reflected light. *Optical Class:* Biaxial. $n = 2.7$ *Pleochroism:* Weak; yellow-brown to reddish brown. *Anisotropism:* Moderate. *Bireflectance:* White to brownish. R: (546) 21

Cell Data: *Space Group:* n.d. $a = 7.06(1)$ $b = 5.024(3)$ $c = 18.84(3)$ $\beta = 119.68(7)°$ Z = [4]

X-ray Powder Pattern: Lasamba Hill, Kenya. 2.737 (vs), 2.874 (s), 4.075 (m), 3.381 (m), 2.432 (w), 2.518 (vvw), 2.310 (vvw)

Chemistry:

	(1)	(2)	(3)
TiO_2	61.07	60.95	61.52
Al_2O_3	0.43	0.30	
V_2O_3	35.93	33.80	38.48
Cr_2O_3	2.23	2.45	
FeO	0.10	1.25	
MnO		0.18	
MgO	0.11		
Total	99.87	98.93	100.00

(1) Lasamba Hill, Kenya; by electron microprobe, average of six analyses, total Fe as FeO; corresponds to $(V_{1.86}Cr_{0.12}Al_{0.02})_{\Sigma=2.00}Ti_3O_9$. (2) Sätra, Sweden; by electron microprobe, average of four analyses, total Fe as FeO; corresponds to $(V_{1.8}Cr_{0.2})_{\Sigma=2.0}Ti_3O_9$. (3) $V_2Ti_3O_9$.

Polymorphism & Series: Dimorphous with kyzylkumite.

Occurrence: In quartz-biotite-sillimanite-diopside-epidote gneiss in contact with quartzite, formed above 600 °C and 5 kbar (Lasamba Hill, Kenya); in quartzitic schists (Ol'khon Gate Straits, Lake Baikal, Russia).

Association: Vanadian rutile, kornerupine, kyanite, sillimanite, muscovite, apatite, tourmaline, graphite, pyrrhotite, chalcopyrite, pentlandite (Lasamba Hill, Kenya); rutile, eskolaite, karelianite, vuorelainenite, olkhonskite (Ol'khon Gate Straits, Lake Baikal, Russia).

Distribution: From six km southeast of Lasamba Hill, Kwale district, south of Voi, Kenya. At Komolo, Tanzania. In Sweden, from the Sätra mine, Doverstorp, Bergslagen metallic province. Found 4.5 km south of the Ol'khon Gate Strait, on the western shore of Lake Baikal, Siberia, Russia.

Name: To honor Dr. Werner Schreyer (1930–), Professor of Mineralogy, Ruhr University, Bochum, Germany.

Type Material: University of Heidelberg, Heidelberg, Germany; National Museum of Natural History, Washington, D.C., USA, 136230.

References: (1) Medenbach, O. and K. Schmetzer (1976) Schreyerit ($V_2Ti_3O_9$), ein neues Vanadium-Mineral aus Kenya. Naturwiss., 63, 293–294 (in German). (2) (1977) Amer. Mineral., 62, 395 (abs. ref. 1). (3) Medenbach, O. and K. Schmetzer (1978) Schreyerite, $V_2Ti_3O_9$, a new mineral. Amer. Mineral., 63, 1182–1186. (4) Zakrzewski, M.A., E.A.J. Burke, and W.J. Lustenhouwer (1982) Vuorelainenite, a new spinel, and associated minerals from the Sätra (Doverstorp) pyrite deposit, central Sweden. Can. Mineral., 20, 281–290. (5) Bernhardt, H.-J., K. Schmetzer, and O. Medenbach (1983) Berdesinskiite, V_2TiO_5, a new mineral from Kenya and additional data for schreyerite, $V_2Ti_3O_9$. Neues Jahrb. Mineral., Monatsh., 110–118.

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Schröckingerite $NaCa_3(UO_2)(SO_4)(CO_3)_3F \cdot 10H_2O$

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* $\overline{1}$. Rare pseudohexagonal crystals, to 6 mm, with prominent {001}, very narrow {100}, {101}, {201}, {102}, {104}, {108}; micaceous, scaly, rosettes, globular aggregates, in crusts and efflorescences.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible. Hardness = 2.5 D(meas.) = 2.544–2.550 D(calc.) = 2.547 Radioactive; strong yellowish green fluorescence under UV.

Optical Properties: Transparent. *Color:* Greenish yellow. *Luster:* Subvitreous, pearly on {001}.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless, pale yellow; $Y = Z$ = greenish yellow. *Orientation:* $X \simeq c$; $Y \simeq b$; $Z \simeq a$. α = 1.489–1.496 β = 1.537–1.545 γ = 1.538–1.545 2V(meas.) = 0°–22.5°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.634(1)$ $b = 9.635(1)$ $c = 14.391(2)$ $\alpha = 91.41(1)°$ $\beta = 92.33(1)°$ $\gamma = 120.26(1)°$ Z = 2

X-ray Powder Pattern: Synthetic.
7.26 (10), 4.796 (8), 8.48 (7), 2.876 (7), 14.28 (3), 5.421 (2), 4.167 (2)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	31.44	32.19	F	2.15	2.14
SO_3	9.17	9.01	H_2O	20.15	20.28
CO_2	14.20	14.86	insol.	1.03	
CaO	18.14	18.93	$-O = F_2$	0.90	0.90
Na_2O	3.63	3.49	Total	99.01	100.00

(1) Wamsutter, Wyoming, USA; insoluble SiO_2 0.08%, R_2O_3 0.95%; corresponds to $Na_{1.06}Ca_{2.92}(UO_2)_{0.98}(CO_3)_{2.91}(SO_4)_{1.03}F_{1.02} \cdot 10.10H_2O$. (2) $NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$.

Occurrence: An uncommon alteration product of uraninite in the oxidized zone of uranium deposits; may be of post-mine origin.

Association: Gypsum, andersonite, bayleyite, swartzite, albrechtschraufite, liebigite, uraninite, dolomite.

Distribution: May be an ore of uranium. From the Evangelista vein, Jáchymov (Joachimsthal), and the Rozna uranium deposit, Czech Republic. On the Radhausberg, near Bad Gastein, Austria. At the Geevor mine, St. Just, Cornwall, England. In the Gerstenegg-Sommerloch cable tunnel, north of the Grimsel Pass, Bern, Switzerland. In the USA, from Lost Creek, about 60 km north-northwest of Wamsutter, Sweetwater Co., Wyoming; in Arizona, in the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co., and the Jack Daniels No. 1 and Foley Bros. No. 5 mines, Cameron area, Coconino Co.; large crystals in the Grants district, McKinley Co., New Mexico. In Utah, from the Shinarump No. 1 and 3 mines, Seven Mile Canyon, on the Crabapple claim, Green River district, near Moab, from the McCoy group, and at the Parco No. 25 mine, Yellow Cat group, Thompsons district, Grand Co., at the Hideout mine, White Canyon district, San Juan Co., and elsewhere; in the Troublesome Formation, Middle Park, Grand Co., and at a number of other places in Colorado. Large crystals from the Soberanía mine, 15 km east of Mendoza, Mendoza Province, and elsewhere in Argentina. A number of additional localities are more poorly characterized.

Name: To honor Julius Schröckinger von Neudenberg (1813–1882), Austrian geologist who originally found the mineral at Jáchymov, Czech Republic.

Type Material: Natural History Museum, Vienna, Austria, A.a.6740.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 236. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 121–126. (3) Mereiter, K. (1986) Crystal structure and crystallographic properties of a schröckingerite from Joachimsthal. Tschermaks Mineral. Petrog. Mitt., 35, 1–18.

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Schubnelite $Fe^{3+}VO_4 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As crystals, elongated along [001], showing {100}, {010}, and tiny {001}, to 0.5 mm. *Twinning:* On $\{2\overline{1}2\}$, cruciform, common.

Physical Properties: Hardness = n.d. D(meas.) = 3.28–3.29 D(calc.) = 3.29 Magnetic.

Optical Properties: Semitransparent. *Color:* Black; yellowish brown, orangish brown, or greenish brown when transparent. *Luster:* Brilliant.
Optical Class: Biaxial. *Pleochroism:* Observable.
R_1–R_2: (400) — , (420) 19.5–17.3, (440) 18.4–15.8, (460) 17.7–15.1, (480) 17.3–14.7, (500) 16.3–14.3, (520) 16.3–13.8, (540) 15.8–13.4, (560) 15.6–13.2, (580) 15.5–13.2, (600) 15.6–13.0, (620) 15.0–12.6, (640) 14.9–12.6, (660) — , (680) — , (700) —

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.466(1)$ $b = 5.675(2)$ $c = 6.610(1)$ $\alpha = 101.02(1)^\circ$ $\beta = 95.10(1)^\circ$ $\gamma = 107.32(1)^\circ$ Z = 1

X-ray Powder Pattern: Mounana mine, Gabon.
4.47 (FFF), 3.21 (FFF), 5.15 (FF), 3.19 (FF), 6.41 (F), 3.07 (F), 2.68 (mF)

Chemistry:

	(1)	(2)
V_2O_5	31.40	48.17
V_2O_4	16.95	
Fe_2O_3	41.05	38.61
H_2O	10.	9.54
Total	99.40	100.00

(1) Mounana mine, Gabon; by microchemical analysis, H_2O by TGA. (2) $FeVO_4 \cdot H_2O$.

Occurrence: At the base of the oxidized zone of a uranium deposit (Mounana mine, Gabon); in a hydrothermal gold deposit (Gold Quarry mine, Nevada, USA).

Association: Fervanite, goethite (Mounana mine, Gabon); kazakhstanite, fervanite, tyuyamunite (Gold Quarry mine, Nevada, USA).

Distribution: From the Mounana uranium mine, Franceville, Gabon. In the USA, at the Monument No. 2 mine, Monument Valley, Apache Co., Arizona; in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada.

Name: To honor Henri-Jean Schubnel (1935–), mineralogist and gemologist, Bureau de Recherches Géologiques et Minières, Paris, France.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1970,149; National Museum of Natural History, Washington, D.C., USA, 137457.

References: (1) Cesbron, F. (1970) La schubnélite, nouveau vanadate de fer hydraté. Bull. Soc. fr. Minéral., 93, 470–475 (in French with English abs.). (2) (1972) Amer. Mineral., 57, 1556–1557 (abs. ref. 1). (3) Evans, H.T., Jr. and L.W. Finger (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 518–519. (4) Jensen, M.C., J.C. Rota, and E.E. Foord (1995) The Gold Quarry mine, Carlin-Trend, Eureka, Nevada. Mineral. Record, 26, 449–469, esp. 463. (5) Schindler, M. and F.C. Hawthorne (1999) Schubnelite. $[Fe^{3+}(V^{5+}O_4)(H_2O)]$, a novel heteropolyhedral framework mineral. Amer. Mineral., 665–668.

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Schuetteite $Hg_3O_2(SO_4)$

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Crystal Data: Hexagonal. *Point Group:* n.d. Very rare microcrystals, hexagonal plates or prisms; typically as thin earthy films.

Physical Properties: Hardness = ∼3 D(meas.) = 8.18 D(calc.) = 8.36

Optical Properties: Semitransparent. *Color:* Canary-yellow, greenish yellow, yellowish orange.
Optical Class: Uniaxial (–), moderate to high birefringence. *Pleochroism:* Slight; O = greenish yellow; E = yellow-orange. $\omega = > 2.10$ $\epsilon = > 2.10$

Cell Data: *Space Group:* n.d. $a = 7.07(1)$ $c = 10.05(1)$ Z = 3

X-ray Powder Pattern: Synthetic.
2.91 (100), 3.34 (70), 2.60 (55), 1.933 (25), 5.19 (20), 1.556 (18), 2.30 (16)

Chemistry:

	(1)	(2)
SO_3	12.3	10.97
HgO	87.7	89.03
Total	[100.0]	100.00

(1) Oceanic mine, California, USA; recalculated to 100.0% after deduction of opal as SiO_2 12.74%, other impurities 2.10%, and H_2O 3.73% [by difference]; identification depends primarily on the correspondence of an X-ray powder pattern with synthetic material. (2) $Hg_3O_2(SO_4)$.

Occurrence: A recently formed secondary mineral in opalite [chalcedonic] mercury deposits, typically formed on cinnabar exposed to sunlight.

Association: Cinnabar.

Distribution: In the USA, in California, from a calcined dump at the Oceanic mine, San Luis Obispo Co., at the Mt. Diablo mine, Contra Costa Co., in the Sulphur Bank mine, Lake Co., and near the Clear Creek mercury mine, New Idria district, San Benito Co. In Nevada, from the B & B mine, east slope of the White Mountains, Fish Lake Valley district, Esmeralda Co., at the Silver Cloud mine, north of Battle Mountain, Ivanhoe district, Lander Co., from the Red Bird mercury mine, Antelope Springs district, and the Goldbanks mercury mine, Goldbanks district, Pershing Co.; at the Opalite mine, Malheur Co., Oregon.

Name: Honors Curt Nicolaus Schuette (1895–1975), American mining engineer and geologist, who studied many mercury deposits.

Type Material: National Museum of Natural History, Washington, D.C., USA, 117725.

References: (1) Bailey, E.H., F.A. Hildebrand, C.L. Christ, and J.J. Fahey (1959) Schuetteite, a new supergene mercury mineral. Amer. Mineral., 44, 1026–1038.

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Schuilingite-(Nd) $PbCu(Nd,Gd,Sm,Y,Dy)(CO_3)_3(OH)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are acicular, to 1.5 mm, with large {110}, minor {010}, terminated by {0*kl*}, isolated, in subparallel aggregates, or in crusts.

Physical Properties: *Cleavage:* Perfect on {110}; poor on {100}. Hardness = 3.5
D(meas.) = n.d. D(calc.) = 4.74

Optical Properties: Transparent. *Color:* Azure-blue, deep blue. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = colorless to pale blue; Y = azure-blue; Z = blue. *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.730$ $\beta = 1.770$ $\gamma = 1.795$
2V(meas.) = ∼60°–75° 2V(calc.) = 56°–63°

Cell Data: *Space Group:* $P2_1cn$. $a = 7.419(2)$ $b = 18.859(3)$ $c = 6.395(1)$ Z = 4

X-ray Powder Pattern: [Kasompi mine,] Congo.
3.827 (100), 2.928 (100), 4.46 (90), 3.162 (90), 4.77 (80), 4.67 (80), 2.634 (80)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	20.74	[20.54]	Dy_2O_3	3.05	3.74
Y_2O_3	2.04	2.90	Er_2O_3		0.89
La_2O_3	1.00	0.94	Yb_2O_3	trace	0.30
Pr_2O_3	1.14	0.80	Lu_2O_3	trace	
Nd_2O_3	8.51	6.31	CuO	11.89	11.35
Sm_2O_3	3.44	3.16	PbO	36.03	36.85
Eu_2O_3	2.44	1.63	H_2O	5.10	[4.20]
Gd_2O_3	3.95	5.12	Total	99.33	[99.39]
Tb_2O_3	trace	0.66			

(1) [Kasompi mine,] Congo; by electron microprobe, CO_2 by chromatography, CO_2+H_2O by TGA; corresponds to $Pb_{1.04}Cu_{0.96}(Nd_{0.32}Gd_{0.14}Sm_{0.13}Y_{0.12}Dy_{0.11}Eu_{0.09}La_{0.04}Pr_{0.04})_{\Sigma=0.99}(CO_3)_{3.01}(OH)_{0.95}\cdot 0.85H_2O$. (2) Do.; by electron microprobe, average of five analyses, CO_2 and H_2O calculated for stoichiometry, original total given as 98.91%; corresponds to $Pb_{1.05}Cu_{0.92}(Nd_{0.24}Gd_{0.18}Y_{0.16}Dy_{0.13}Sm_{0.12}Eu_{0.06}La_{0.04}Pr_{0.03}Er_{0.03}Tb_{0.02}Yb_{0.01})_{\Sigma=1.02}(CO_3)_3(OH)\cdot H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal base metal deposits.

Association: Gysinite-(Nd), malachite, cerussite, wulfenite, kasolite, schoepite, uranophane, curite, françoisite-(Nd), kamotoite-(Y), astrocyanite-(Ce), masuyite, uraninite.

Distribution: From the Kasompi, Menda, and Kamoto East mines, Katanga Province, Congo (Shaba Province, Zaire).

Name: To honor Hendrik Jan Schuiling (1892–1966), Chief Geologist, Union Minière du Haut-Katanga, Congo.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG11.418.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 252. (2) Piret, P. and M. Deliens (1982) Nouvelles données sur la schuilingite, carbonate hydraté de terres rares, de plomb et de cuivre. Bull. Minéral., 105, 225–228 (in French with English abs.). (3) Sarp, H., J. Bertrand, and J. Deferne (1983) Données nouvelles sur la schuilingite de Shinkolobwe (Shaba, Zaïre), carbonate hydraté de plomb, cuivre et de terres rares. Schweiz. Mineral. Petrog. Mitt., 63, 1–6 (in French with English abs.). (4) Schindler, M. and F.C. Hawthorne (1999) The crystal structure of schuilingite-(Nd). Can. Mineral., 37, 1463–1470.

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Schulenbergite $(Cu, Zn)_7(SO_4)_2(OH)_{10} \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ or 3. Crystals are hexagonal or rhombic, very thin tabular, to 4 mm, in spherules, sheaves, and rosettes.

Physical Properties: *Cleavage:* Perfect on {0001}; poor on $\{11\overline{2}0\}$. Hardness = ∼2
D(meas.) = 3.28–3.42 D(calc.) = 3.38–3.45

Optical Properties: Transparent. *Color:* Pale blue-green, emerald-green. *Streak:* Blue-green, pale green. *Luster:* Vitreous, pearly on {0001}.
Optical Class: Uniaxial (–). *Pleochroism:* Faint to strong; O = colorless, emerald-green to green; E = colorless to pale green. $\omega = 1.640–1.707$ $\epsilon = 1.623–1.666$

Cell Data: *Space Group:* $P\overline{3}$ or $P3$. $a = 8.211–8.249$ $c = 7.106–7.183$ Z = 1

X-ray Powder Pattern: [Glücksrad mine,] Germany.
7.186 (100), 2.700 (80), 2.527 (80), 3.581 (40), 3.209 (30), 2.157 (30), 1.559 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	17.4	15.13	CuO	36.7	53.18
CO_2	0.8		ZnO	28.1	11.39
CoO		0.84	H_2O	17.4	[18.68]
NiO		0.78	Total	100.4	[100.00]

(1) [Glücksrad mine,] Germany; CO_2 by gas chromatograph, H_2O by TGA; corresponds to $(Cu_{4.00}Zn_{3.00})_{\Sigma=7.00}[(SO_4)_{1.89}(CO_3)_{0.16})]_{\Sigma=2.05}(OH)_{9.90} \cdot 3.43H_2O$. (2) Cap Garonne mine, France; by electron microprobe, average of nine analyses, H_2O by difference; corresponds to $(Cu_{5.77}Zn_{1.21}Ni_{0.10}Co_{0.09})_{\Sigma=7.17}(SO_4)_{1.63}(OH)_{11.08} \cdot 3.40H_2O$.

Occurrence: A rare secondary mineral formed in the oxidized zone of Cu–Zn-bearing hydrothermal mineral deposits, commonly post-mine; in Cu–Zn slags.

Association: Namuwite, brochantite, posnjakite, ktenasite, serpierite, linarite, malachite, cerussite, hemimorphite, smithsonite, gypsum, chalcopyrite, sphalerite, quartz.

Distribution: In Germany, in the Harz Mountains, from dumps at the Glücksrad mine, near Oberschulenberg, and in slag at the Ochsenhütte, Granetal, and at Juliushütte, Astfeld, near Goslar; from the Marie mine, southeast of Wilnsdorf, near Siegen, and in the Wilder Mann mine, near Müsen, Siegerland; from the Bastenberg mine, near Ramsbeck, North Rhine-Westphalia; in the Richelsdorfer Mountains, Hesse; on dumps of the Friedrichssegen mine, near Bad Ems, at the Virneberg mine, near Rheinbreitbach, Rhineland-Palatinate, and elsewhere. From the Cap Garonne mine, near le Pradet, Var, France. In England, from the Smallcleugh mine, Nenthead, Cumbria; large crystals in the Waterbank mine, Ecton Hill, Staffordshire, at the Prince of Wales mine, Calstock, and in the Penberthy Croft mine, St. Hilary, Cornwall. In Wales, from the Dyfngwm mine, Penegoes, Powis; in Dyfed, at the Penrhiw mine, Ystumtuen, from the Ystrad Einion mine, at the Nantycagl (Eaglebrook) mine, Ceulanymaesmawr, and in the Frongoch mine. From the Kamariza mine, and in slag, at Laurium, Greece. At Broken Hill, New South Wales, Australia.

Name: For its occurrence at the Glücksrad mine, near Oberschulenberg, Germany.

Type Material: Institute of Crystallography and Petrography, University of Hannover, Hannover, Germany; National School of Mines, Paris, France.

References: (1) Hodenberg, R.v., W. Krause, and H. Täuber (1984) Schulenbergit, $(Cu, Zn)_7(SO_4, CO_3)_2(OH)_{10} \cdot 3H_2O$, ein neues Mineral. Neues Jahrb. Mineral., Monatsh., 17–24 (in German with English abs.). (2) (1985) Amer. Mineral., 70, 438 (abs. ref. 1). (3) Mumme, W.G., H. Sarp, and P.J. Chiappero (1994) A note on the crystal structure of schulenbergite. Archs Sci. Genève, 47(2), 117–124.

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Schulténite $Pb(AsO_3OH)$

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Crystal Data: Monoclinic. *Point Group: m.* Crystals are flattened {010}, with large {010} striated ‖ [001], {130}, {140}, {111}, {121}, {001}, {011}, many other forms, rarely to 17.5 cm. *Twinning:* Rare "fishtail" twins according to an unknown law.

Physical Properties: *Cleavage:* On {010}, good. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 5.943–6.07 D(calc.) = 6.079 May fluoresce dull yellow under LW UV.

Optical Properties: Transparent. *Color:* Colorless to white; in transmitted light, colorless. *Streak:* White. *Luster:* Vitreous to nearly adamantine.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = -24°$; $Z \wedge c = 66°$. *Dispersion:* Strong. $\alpha = [1.890]$ $\beta = 1.910$ $\gamma = 1.976$ 2V(meas.) = 58°14′

Cell Data: *Space Group: Pa.* $a = 5.946(6)$ $b = 6.783(6)$ $c = 4.873(5)$ $\beta = 95.53(6)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.35 (vvs), 3.13 (vs), 1.950 (vsb), 1.778 (sb), 2.19 (ms), 1.683 (ms), 1.546 (ms)

Chemistry:

	(1)	(2)
As_2O_5	32.18	33.11
PbO	63.97	64.30
H_2O	2.88	2.59
Total	99.03	100.00

(1) Tsumeb, Namibia. (2) $Pb(AsO_3OH)$.

Occurrence: A rare secondary mineral in the oxidized zone of Pb–As-rich hydrothermal deposits.

Association: Anglesite, bayldonite, cuprian adamite, keyite, olivenite, duftite, carminite, beudantite, scorodite, stranskiite, pharmacosiderite, mimetite, cerussite, tennantite, galena, arsenopyrite.

Distribution: From Tsumeb, Namibia. On a ridge between Granite Lake and Gifford Lake, 13 km east of North Bend, King Co., Washington, USA. In the Deer Hills vein, Caldbeck Fells, Cumbria, England. In Germany, from the Michael mine, Weiler, near Lahr, and on the Geiges mine dump, near Schramberg, Black Forest; at St. Andreasberg, Harz Mountains; from Ramsbeck, North Rhein-Westphalia. At Grabanz, near Finkenstein, Austria.

Name: Honoring Professor August Benjamin Friherre af Schultén (1856–1912), chemist, University of Helsinki, Helsinki, Finland, who studied synthetic arsenates.

Type Material: The Natural History Museum, London, England, 1926,205; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 106356.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 661–663. (2) Claringbull, G.F. (1950) An X-ray study of schultenite. Mineral. Mag., 29, 287–290. (3) Falls, R., B. Cannon, and J.A. Mandarino (1985) Schultenite from King County, Washington, USA: a second occurrence, and review. Mineral. Mag., 49, 65–69. (4) Wilson, C.C. (1994) Structural studies of schultenite in the temperature range 125–324 K by pulsed single crystal neutron diffraction – hydrogen ordering and structural distortions. Mineral. Mag., 58, 629–634.

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Schumacherite $Bi_3O(VO_4, AsO_4, PO_4)_2(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are tabular ∥ {010}, with $\{\overline{1}10\}$, and $\{10\overline{1}\}$, to 0.1 mm, in crusts.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼3 D(meas.) = n.d. D(calc.) = 6.90

Optical Properties: Translucent. *Color:* Yellow, yellow-brown, red-brown. *Luster:* Adamantine. *Optical Class:* Biaxial (+), probable. *Orientation:* $X' \wedge c \simeq 22°$; OAP $\simeq \{11\overline{1}\}$. $\alpha = > 2.20(2)$ β = n.d. $\gamma = 2.42(2)$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.05(3)$ $b = 7.46(3)$ $c = 6.90(3)$ $\alpha = 87.7(3)°$ $\beta = 115.3(3)°$ $\gamma = 111.5(3)°$ Z = 2

X-ray Powder Pattern: Schneeberg, Germany; very similar to preisingerite and petitjeanite. 3.28 (10), 3.19 (8), 3.09 (8), 4.57 (6), 1.976 (5), 6.21 (4), 4.13 (4)

Chemistry:

	(1)
P_2O_5	3.6
As_2O_5	5.8
V_2O_5	10.9
Bi_2O_3	79.0
H_2O	[1.0]
Total	[100.3]

(1) Schneeberg, Germany; by electron microprobe, H_2O calculated; corresponds to $Bi_{3.03}O_{0.97}[(V_{0.54}As_{0.22}P_{0.22})_{\Sigma=0.98}O_4]_2(OH)_{1.00}$.

Polymorphism & Series: Forms series with petitjeanite and preisingerite.

Occurrence: Very rare, in the oxidized zone of Bi-rich hydrothermal deposits.

Association: Pucherite, namibite, quartz (Schneeberg, Germany); bismutite, bismutoferrite, bismutostibiconite, koechlinite, namibite (Lodi #4 mine, California, USA); beyerite, namibite (Mica Lode mine, Colorado, USA); mrázekite, pucherite (Morass Creek, Australia).

Distribution: From the Pucher shaft, Wolfgang Maassen mine, and on the Sauschwart mine dump, Schneeberg, Saxony, Germany. In the USA, at the Lodi #4 mine, Spring Creek district, Plumas Co., California; from the Mica Lode mine, Eight Mile Park, Fremont Co., Colorado; from Manhattan, Nye Co., Nevada. At Morass Creek, north of Benambra, Victoria, Australia.

Name: To honor Professor Friedrich Schumacher (1884–1975), Universities of Freiberg and Bonn, Germany.

Type Material: University of Stuttgart, Stuttgart, Germany; National Museum of Natural History, Washington, D.C., USA, 149596.

References: (1) Walenta, K., P.J. Dunn, G. Hentschel, and K. Mereiter (1983) Schumacherit, ein neues Wismutmineral von Schneeberg in Sachsen. Tschermaks Mineral. Petrog. Mitt., 31, 165–173 (in German with English abs.). (2) (1985) Amer. Mineral., 70, 438 (abs. ref. 1). (3) Krause, W., K. Belendorff, and H.-J. Bernhardt (1993) Petitjeanite, $Bi_3O(OH)(PO_4)_2$, a new mineral, and additional data for the corresponding arsenate and vanadate, preisingerite and schumacherite. Neues Jahrb. Mineral., Monatsh., 487–503.

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Schwartzembergite $H_2Pb_5I^{3+}O_6Cl_3$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are flat pyramidal, rounded, to 5 mm; in earthy to compact masses and crusts.

Physical Properties: *Cleavage:* Distinct on {001}. Hardness = 2–2.5 D(meas.) = 5.7–7.09 D(calc.) = 5.72

Optical Properties: Semitransparent. *Color:* Honey-yellow, straw-yellow, lemon-yellow, yellowish brown, reddish brown. *Streak:* Straw-yellow. *Luster:* Adamantine.
Optical Class: Uniaxial (–), anomalously biaxial (–). $\omega = 2.36$ (Li) $\epsilon = 2.25$ $\alpha = 2.25(2)$ (Li) $\beta = 2.35(2)$ $\gamma = 2.36(2)$ 2V(meas.) = 12°

Cell Data: *Space Group:* $I4/mmm$. $a = 3.997(1)$ $c = 12.566(4)$ Z = 1

X-ray Powder Pattern: Santa Ana mine, Chile.
2.880 (10), 1.633 (9), 2.806 (8), 2.091 (7), 3.782 (6), 1.986 (6), 1.262 (6)

Chemistry:

	(1)	(2)	(3)	(4)
SO_3	0.47			
I_2O_3	10.27	15.99	11.20	11.04
PbO	80.90	76.34	81.13	81.62
CaO	0.67			
Cl	7.95	8.05	7.95	7.78
H_2O	n.d.	2.44	1.20	1.32
$-O = Cl_2$	1.79	1.82	1.79	1.76
Total	98.47	101.00	99.69	100.00

(1) San Rafael mine, Chile; here converted to oxides, original total 99.95%. (2) Santa Ana mine, Chile; here converted to oxides, original total 101.48%. (3) San Rafael mine, Chile; by electron microprobe, average of 24 analyses, H_2O by hydrogen line extraction; corresponds to $H_{1.86}Pb_{4.86}I_{1.04}O_6Cl_{3.13}$. (4) $H_2Pb_5IO_6Cl_3$.

Occurrence: A rare secondary mineral formed in the oxidized zone of hydrothermal polymetallic deposits in an arid climate.

Association: Cerussite, anglesite, paralaurionite, boleite, seeligerite.

Distribution: In Chile, in Antofagasta, from Cachinal, between Paposa and Taltal; at the San Rafael, Santa Ana, and San Francisco (Beatriz) mines, near Caracoles, Sierra Gorda district, southwest of Calama; from Challacollo, Tarapacá.

Name: Honors Dr. Schwartzemberg [probably Dr. Adolf Emilio Schwarzenberg (1826–1907)], assayer, Copiapó, Chile, who first called attention to the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 317–318. (2) Mücke, A. (1970) Schwartzembergit von der Mina Sta. Ana. Neues Jahrb. Mineral., Monatsh., 467–472 (in German with English abs.). (3) Welch, M.D., F.C Hawthorne, M.A. Cooper, and T.K. Kyser (2001) Trivalent iodine in the crystal structure of schwartzembergite, $Pb_5^{2+}I^{3+}O_6H_2Cl_3$. Can. Mineral., 39, 785–795.

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Schwertmannite $\mathbf{Fe^{3+}_{16}O_{16}(SO_4)_2(OH)_{12}\cdot nH_2O}$ (n ~ 10 to 12)

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Crystal Data: Tetragonal. *Point Group:* $4/m$ (probable). As fibrous aggregates of poorly-crystalline needles, to 100 μm, in films and thin to thick crusts.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.77–3.99

Optical Properties: Semitransparent. *Color:* Brownish yellow. *Streak:* Ocher-yellow. *Optical Class:* Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P4/m$ (probable). a = 10.66(4) c = 6.04(1) Z = 1

X-ray Powder Pattern: Pyhäsalmi mine, Finland; consists of broad bands.
2.55 (100), 3.39 (46), 4.86 (37), 1.51 (24), 2.28 (23), 1.66 (21), 1.46 (18)

Chemistry:

	(1)	(2)	(3)
Fe_2O_3	62.6	71.0	74.01
H_2O^+	12.9		
H_2O^-	10.2		
H_2O		14.6	16.71
CO_2	1.5		
SO_3	12.7	14.4	9.28
Total	99.9	[100.0]	100.00

(1) Pyhäsalmi mine, Finland; Fe and S by ICP, CO_2 by gas analyzer, H_2O by TGA. (2) Analysis (1) after deduction of CO_2 and adsorbed H_2O^-, recalculated to 100.0%; corresponds to $Fe_{16}O_{16}(OH)_{9.6}(SO_4)_{3.2}\cdot 10H_2O$. (3) $Fe_{16}O_{16}(SO_4)_2(OH)_{12}\cdot 10H_2O$.

Occurrence: A secondary mineral precipitated by waters of pH 3–4.5 and high in iron sulfate content from the surface oxidation of metal sulfides.

Association: Goethite, jarosite, natrojarosite, ferrihydrite, sulfides.

Distribution: From the Pyhäsalmi mine, Oulu, Finland. At over 40 unspecified localities in Europe, North America, and Australia.

Name: For Udo Schwertmann (1927–), Professor of Soil Science, Technical University of Munich, Munich, Germany, who has worked on poorly crystalline products of weathering.

Type Material: Museum of Natural History, University of Helsinki, Helsinki, Finland, B8659.

References: (1) Bigham, J.M., L. Carlson, and E. Murad (1994) Schwertmannite, a new iron oxyhydroxysulphate from Pyhäsalmi, Finland, and other localities. Mineral. Mag., 58, 641–648. (2) (1995) Amer. Mineral., 80, 847 (abs. ref. 1).

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Schüllerite $Ba_2Na(Mn,Ca)(Fe^{3+},Mg,Fe^{2+})_2Ti_2(Si_2O_7)_2(O,F)_4$

Crystal Data: Triclinic. *Point Group:* 1. As flattened crystals to 2 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* n.d. *Tenacity:* Brittle. Hardness = 3-4 D(meas.) = n.d. D(calc.) = 3.974

Optical Properties: Translucent. *Color:* Brown. *Streak:* White. *Luster:* n.d. *Optical Class:* Biaxial (-). α = 1.756(3) β= 1.773(4) γ = 1.780(4) 2V = 40(20)° *Dispersion*: Weak, *r* < *v*. *Pleochroism*: Medium, brown to dark brown. *Absorption*: *X* > *Y* > *Z*. *Orientation:* Z ^ c = 20°.

Cell Data: *Space Group: P1*. *a* = 5.4027(1) *b* = 7.066(4) *c* = 10.2178(1) α = 99.816(1)° β = 99.624(1)° γ = 90.084(1)° *Z* = 1

X-ray Powder Pattern: Löhley quarry, Eifel region, Rheinland-Pfalz, Germany. 2.791 (100), 2.144 (52), 2.664 (46), 3.308 (45), 2.609 (36), 9.96 (29), 3.203 (29)

Chemistry:

	(1)		(1)
Na_2O	3.55	SiO_2	26.12
K_2O	0.55	TiO_2	11.17
MgO	3.89	Al_2O_3	1.33
CaO	2.62	F	2.12
SrO	1.99	$-O = F_2$	0.89
BaO	28.09	Total	98.98
FeO	3.43		
Fe_2O_3	8.89		
Nb_2O_5	2.45		

(1) Löhley quarry, Eifel region, Rheinland-Pfalz, Germany; average of 5 electron microprobe analyses, Fe^{3+}:Fe^{2+} calculated from X-ray emission spectra; corresponding to $(Ba_{1.68}Sr_{0.18}K_{0.11}Na_{1.05}Ca_{0.43}Mn_{0.47}Mg_{0.88}Fe^{2+}_{0.44}Fe^{3+}_{1.02}Ti_{1.28}Nb_{0.17}Al_{0.24})_{\Sigma=7.95}Si_{3.98}O_{16.98}F_{1.02}$.

Occurrence: A late pneumatolitic mineral in miarolitic cavities in alkaline basalt.

Association: Nepheline, leucite, augite, phlogopite, magnetite, titanite, fresnoite, barytolamprophyllite, fluorapatite, perovskite, pyrochlore.

Distribution: At the Löhley quarry, Eifel volcanic region, near Üdersdorf, Rheinland-Pfalz (Rhineland-Palatinate), Germany.

Name: Honors Willi Schüller (b 1953), prominent mineral collector, specialist in the mineralogy of Eifel, and collector of the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia; 3995/2 and 3995/1.

References: (1) Chukanov, N.V., R.K. Rastsvetaeva, S.N. Britvin, A.A. Viryus, D.I. Belakovskiy, I.V. Pekov, S.M. Aksenov, and B. Ternes (2011) Schüllerite, $Ba_2Na(Mn,Ca)(Fe^{3+},Mg,Fe^{2+})_2Ti_2(Si_2O_7)_2(O,F)_4$, a new mineral from Eifel volcanic region, Germany. Zap. Ross. Mineral. Obshch., 140(1), 67-75 (in Russian, English abstract). English translation: Geol. Ore Deposits, (2011), 53(8), 767-774. (2) Rastsvetaeva, R.K., S.M. Aksenov, and N.V. Chukanov (2011) Crystal structure of schüllerite, a new mineral of the heterophyllosilicate family. Doklady Akademii Nauk, 437(4), 499-503 (in Russian). English translation: Doklady Chemistry (2011), 437, 90-94. (3) (2013) Amer. Mineral., 98, 813 (abs. refs. 1 & 2).

Sclarite $(Zn, Mg, Mn^{2+})_4Zn_3(CO_3)_2(OH)_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 0.2 mm, platy on {001}, elongated along [010], in roughly spherulitic aggregates.

Physical Properties: *Tenacity:* Moderately brittle. Hardness = 3–4 D(meas.) = 3.51(5) D(calc.) = 3.547

Optical Properties: Transparent to translucent. *Color:* Colorless to grayish white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 49°$. *Dispersion:* $r \gg v$, strong.
$\alpha = 1.648(1)$ $\beta = 1.664(1)$ $\gamma = 1.702(2)$ 2V(meas.) = 63.4(6)° 2V(calc.) = 67°

Cell Data: *Space Group:* $A2/a$. $a = 16.110(7)$ $b = 5.432(1)$ $c = 15.041(10)$ $\beta = 95.490(4)°$ Z = 4

X-ray Powder Pattern: Franklin, New Jersey, USA.
7.50 (10), 3.63 (5), 2.621 (5), 3.75 (4), 3.53 (4), 2.500 (4), 2.281 (3)

Chemistry:

	(1)
CO_2	[12.67]
FeO	0.1
MnO	4.2
ZnO	62.0
MgO	6.7
H_2O	[12.97]
Total	[98.64]

(1) Franklin, New Jersey, USA; by electron microprobe, total Mn as MnO, CO_2 and H_2O calculated from crystal-structure analysis; corresponds to $(Zn_{2.39}Mg_{1.18}Mn_{0.42})_{\Sigma=3.99}Zn_{3.00}(CO_3)_2(OH)_{10}$.

Occurrence: Very rare on a museum specimen, in a veinlet possibly of hydrothermal origin, from a metamorphosed stratiform zinc orebody.

Association: Gageite, leucophoenicite, chlorophoenicite, rhodochrosite, willemite, zincite, franklinite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: To honor Professor Charles Bertram Sclar (1925–2001), Geology Department, Lehigh University, Bethlehem, Pennsylvania, USA, who long studied the genesis of the Franklin deposit.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 53777; National Museum of Natural History, Washington, D.C., USA, B13671.

References: (1) Grice, J.D. and P.J. Dunn (1989) Sclarite, a new mineral from Franklin, New Jersey, with essential octahedrally and tetrahedrally coordinated zinc: description and structure refinement. Amer. Mineral., 74, 1355–1359.

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Scolecite $CaAl_2Si_3O_{10}\cdot 3H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* m. Crystals are slender prismatic, may be square in cross section, elongated and striated ‖ [001], to 30 cm. Characteristically in radiating sprays, fibrous masses; nodular, massive. *Twinning:* On {100}, twin axis [001], common, as contact or penetration twins.

Physical Properties: *Cleavage:* {110} and $\{1\bar{1}0\}$, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.25–2.29 D(calc.) = 2.275 Pyroelectric; piezoelectric; may fluoresce yellow to brown under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in thin section. *Luster:* Vitreous, silky when fibrous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 15°–18°$; $Y \wedge a = -14°$ to $-17°$. *Dispersion:* $r < v$, strong. $\alpha = 1.507–1.513$ $\beta = 1.516–1.520$ $\gamma = 1.517–1.521$ 2V(meas.) = 36°–56°

Cell Data: *Space Group:* Cc. $a = 18.508(5)$ $b = 18.981(5)$ $c = 6.527(2)$ $\beta = 90.64(1)°$ Z = 8

X-ray Powder Pattern: Near Surat Thani, Thailand.
5.848 (100), 2.882 (100), 6.590 (90), 4.387 (90), 2.851 (70), 4.722 (60), 2.929 (60)

Chemistry:

	(1)
SiO_2	45.16
Al_2O_3	25.90
CaO	14.86
Na_2O	0.16
K_2O	0.06
H_2O	13.66
Total	99.80

(1) Syhadree Mountains, Bombay, India; corresponds to $(Ca_{1.05}Na_{0.02})_{\Sigma=1.07}$ $Al_{2.00}Si_{2.97}O_{10}\cdot 2.99H_2O$.

Mineral Group: Zeolite group.

Occurrence: Primarily in cavities in basalts; in gneisses and amphibolites, and in laccoliths and dikes derived from syenitic and gabbroic magmas.

Association: Zeolites, prehnite, calcite.

Distribution: Many localities for good crystals are known; exceptional crystals from the Teigarhorn, Berufjord, Iceland. At Ben More, Isle of Mull, and Talisker Bay, Isle of Skye, Scotland. From Pflüglhof, Malta Valley, Carinthia, Austria. In Switzerland, from the Shattig Wichel, Fallital-Giuv area, Graübunden. Exceptional crystals in the Poona, Nasik, and Bombay districts, Maharashtra, India. In the USA, on the south fork of the Toutle River, Cowlitz Co., in the Pioneer quarry, Bremerton, Kitsap Co., and other localities in Washington. At Charcas, San Luis Potosí, Mexico. Large crystals from near Bento Gonçalves, Rio Grande do Sul, Brazil.

Name: From the Greek for *worm*, alluding to its curling action when heated.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 604–605. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 358–376. (3) Smith, G.W. and R. Walls (1971) A redetermination of the unit-cell geometry of scolecite. Mineral. Mag., 38, 72–75. (4) Joswig, W., H. Bartl, and H. Fuess (1984) Structure refinement of scolecite by neutron diffraction. Zeits. Krist., 166, 219–223.

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Scorodite $Fe^{3+}AsO_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals pyramidal {111}, tabular [001], or prismatic [010], with large {111}, {101}, {201}, {001}, many other modifying forms, to 5 cm. Commonly as crystalline crusts; may be porous, sinterlike, earthy, massive.

Physical Properties: *Cleavage:* {201}, imperfect; {001}, {100}, in traces.
Fracture: Subconchoidal. Hardness = 3.5–4 D(meas.) = 3.27 D(calc.) = 3.276

Optical Properties: Semitransparent. *Color:* Pale leek-green, grayish green, liver-brown, pale blue, violet, yellow, pale grayish, colorless; may be blue-green in daylight but bluish purple to grayish blue in incandescent light; in transmitted light, colorless to pale shades of green or brown. *Luster:* Vitreous to subadamantine, subresinous.
Optical Class: Biaxial (+). *Pleochroism:* Typically faint; blue-violet to blue-green. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > X = Y$. $\alpha = 1.741$–1.784 $\beta = 1.744$–1.805 $\gamma = 1.768$–1.820 2V(meas.) = 40°–∼75°

Cell Data: *Space Group: Pcab.* $a = 8.937$–8.953 $b = 10.278$–10.325 $c = 9.996$–10.038
Z = 8

X-ray Powder Pattern: Bhilivara [Bhilwara] district, Rajasthan, India.
4.50 (100), 5.65(80), 3.20 (80), 3.07 (60), 3.01 (60), 2.601 (60), 5.05 (40)

Chemistry:

	(1)	(2)
As_2O_5	49.79	49.79
Fe_2O_3	34.60	34.60
H_2O	15.61	15.61
Total	100.00	100.00

(1) Kiura mine, Japan. (2) $FeAsO_4 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with parascorodite; forms a series with mansfieldite.

Mineral Group: Variscite group.

Occurrence: A secondary mineral formed by oxidation of As-bearing sulfides.

Association: Pharmacosiderite, beudantite, carminite, dussertite, arseniosiderite, adamite, austinite, vivianite, iron oxides.

Distribution: Numerous occurrences, typically in small amounts; some localities for well-crystallized material are: in Germany, from Schwarzenberg, Saxony, and in the Clara mine, near Oberwolfach, Black Forest. At Horní Slavkov (Schlaggenwald), Czech Republic. From Lölling, Carinthia, Austria. Found at a number of places in Gwennap, Calstock, and elsewhere in Cornwall, England. Occurs at Djebel Debar, Qacentina (Constantine), Algeria. Very large crystals from Tsumeb, Namibia. Large crystals from Antonio Pereira, Minas Gerais, Brazil. In Mexico, large crystals from the El Cobre mine, Aranzazú, Concepción del Oro, Zacatecas, and in the Ojuela mine, Mapimí, Durango. In the USA, in Utah, an ore mineral at Gold Hill, Tooele Co., and in the Tintic district, Juab Co.; and from the Majuba Hill mine, Antelope district, Pershing Co., Nevada. At the Kiura mine, Oita Prefecture, Japan, large crystals. From Broken Hill, New South Wales, Australia.

Name: From the Greek for *garlic*, in allusion to its odor when heated.

Type Material: Mining Academy, Freiberg, Germany, 21245.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 763–767. (2) Kitahama, K., R. Kiriyama, and Y. Baba (1975) Refinement of the crystal structure of scorodite. Acta Cryst., 31, 322–324. (3) Hawthorne, F.C. (1976) The hydrogen positions in scorodite. Acta Cryst., 32, 2891–2892. (4) Dasgupta, D.R., A.K. Datta, and N.R. Sen Gupta (1966) Occurrence of scorodite in a pegmatite in Bhilwara district, Rajasthan, India. Mineral. Mag., 35, 776–777.

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Scorzalite $(Fe^{2+},Mg)Al_2(PO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive, to 7 cm. *Twinning:* Multiple, lamellar.

Physical Properties: *Cleavage:* On {110}, good; on {101}, indistinct. Hardness = 6 D(meas.) = 3.33 D(calc.) = 3.32

Optical Properties: Semitransparent. *Color:* Dark blue. *Streak:* White to pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = blue. *Orientation:* $Y = b$; $X \simeq c$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.626$–1.645 $\beta = 1.654$–1.674 $\gamma = 1.663$–1.680 2V(meas.) = n.d. 2V(calc.) = 58°–62°

Cell Data: *Space Group:* $P2_1/c$. $a = 7.15$ $b = 7.31$ $c = 7.25$ $\beta = 120°35'$ Z = 2

X-ray Powder Pattern: Corrego Frio mine, Brazil; nearly identical to lazulite.
3.24 (vs), 3.20 (vs), 3.14 (s), 6.17 (m), 4.72 (m), 3.08 (m), 2.55 (m)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
P_2O_5	42.90	44.64	FeO	14.74	11.30	CaO	0.02	
TiO_2	0.10		MnO	0.11		H_2O	5.86	5.66
Al_2O_3	30.87	32.06	ZnO	0.17		Total	99.54	100.00
Fe_2O_3	0.54		MgO	4.23	6.34			

(1) Corrego Frio mine, Brazil; corresponds to $(Fe^{2+}_{0.66}Mg_{0.34}Zn_{0.01})_{\Sigma=1.01}(Al_{1.93}Fe^{3+}_{0.02})_{\Sigma=1.95}(PO_4)_{1.94}(OH)_{2.08}$. (2) $(Fe,Mg)Al_2(PO_4)_2(OH)_2$ with Fe:Mg = 1:1.

Polymorphism & Series: Forms a series with lazulite.

Mineral Group: Lazulite group.

Occurrence: Typically a secondary mineral in complex zoned granite pegmatites; may occur in kyanite-rich quartzite.

Association: Souzalite, triphylite, wyllieite, trolleite, apatite, lacroixite, berlinite, tourmaline, muscovite, feldspar, quartz.

Distribution: From the Corrego Frio pegmatite mine, Divino das Laranjeiras, near Linópolis, Minas Gerais, Brazil. In the USA, at the Victory mine, four km northeast of Custer, Custer Co., and the White Cap mine, three km south of Keystone, Pennington Co., South Dakota; in the Palermo #1 mine, near North Groton, Grafton Co., and the G.E. Smith mine, Newport, New Hampshire; at the Champion mine, Mono Co., California; from McIntyre Creek, about four km west of Glendevey, Larimer Co., Colorado. In the Buranga and Rusororo pegmatites, Gatumba district, Rwanda. At Jebilet, Morocco. From Hålsjöberget, Värmland, and in the Norrö pegmatite, on Rånö Island, Sweden. At Hagendorf, Bavaria, Germany. Other localities are reported, but chemical analyses would be desirable.

Name: To honor Dr. Evaristo Pena Scorza (1899–?), Chief Mineralogist, Mineral Survey of Brazil, Rio de Janeiro, Brazil.

Type Material: The Natural History Museum, London, England, 1965,207; Harvard University, Cambridge, Massachusetts, 100679; National Museum of Natural History, Washington, D.C., USA, C5862.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 908–911. (2) Pecora, W.T. and J.J. Fahey (1949) The Corrego Frio pegmatite, Minas Gerais: scorzalite and souzalite, two new phosphate minerals. Amer. Mineral., 34, 83–93. (3) Pecora, W.T. and J.J. Fahey (1950) The lazulite-scorzalite isomorphous series. Amer. Mineral., 35, 1–18. (4) Lindberg, M.L. and C.L. Christ (1959) Crystal structures of the isostructural minerals lazulite, scorzalite and barbosalite. Acta Cryst., 12, 695–697. (5) Abernathy, S.A. and F.N. Blanchard (1982) Variations in unit cell parameters and in the X-ray diffraction intensity ratio $I(200)/I(100)$ in the lazulite-scorzalite series. Amer. Mineral., 67, 610–614.

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Scotlandite $PbS^{4+}O_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are elongated along [001], spear- or chisel-shaped, with {021}, {031}, {100}, {010}, rare {011}, {032}, to 3 mm, in radial and fanlike aggregates.

Physical Properties: *Cleavage:* Perfect on {100}; good on {010}. Hardness = ∼2 D(meas.) = 6.37(2) D(calc.) = 6.396–6.44 May fluoresce yellow under LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, grayish white, brown, pale yellow if included with pyromorphite. *Luster:* Adamantine to resinous, pearly on cleavages. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge a = 15°$–$20°$; $Z \wedge a = 4°$. *Dispersion:* $r \ll v$, strong. $\alpha = 1.95$–2.035 $\beta = 2.00$–2.040 $\gamma = 2.085$–2.10 2V(meas.) = ∼35° 2V(calc.) = 37°40′

Cell Data: *Space Group:* $P2_1/m$. $a = 4.505(2)$ $b = 5.333(2)$ $c = 6.405(2)$ $\beta = 106.24(3)°$ Z = 2

X-ray Powder Pattern: Leadhills, Scotland.
3.99 (10), 3.25 (8), 3.38 (7), 2.66 (7), 2.56 (5), 2.24 (5), 2.01 (5)

Chemistry:

	(1)	(2)	(3)
SO_2	19.88	17.89	22.30
PbO	77.85	79.03	77.70
Total	97.73	96.92	100.00

(1) Leadhills, Scotland; by electron microprobe, sulfite confirmed by IR and secondary ion mass spectrometry; corresponds to $Pb_{1.06}S_{0.94}O_{2.94}$. (2) Argentolle mine, France; by electron microprobe, corresponds to $Pb_{1.16}S_{0.91}O_3$. (3) $PbSO_3$.

Occurrence: A very rare secondary mineral, formed in the oxidized zone of hydrothermal lead deposits.

Association: Pyromorphite, anglesite, lanarkite, leadhillite, susannite, barite (Leadhills, Scotland); leadhillite, susannite, macphersonite, cerussite, pyromorphite, galena, quartz (Argentolle mine, France); mattheddleite, lanarkite, leadhillite, caledonite, galena (Roughton Gill, England).

Distribution: Found on a museum specimen labelled as coming from the Susanna mine, Leadhills, Lanarkshire, Scotland. At Roughton Gill, Caldbeck Fells, Cumbria, England. From the Argentolle mine, near Saint-Prix, Saône-et-Loire, France. In the Haus Baden mine, near Badenweiler, Black Forest, Germany. At Tsumeb, Namibia.

Name: For Scotland, within which the first specimen was found.

Type Material: University of Salzburg, Salzburg, Austria; University of Stuttgart, Stuttgart, Germany, NM13; Royal Scottish Museum, Edinburgh, Scotland; The Natural History Museum, London, England, 1982,451; Royal Ontario Museum, Toronto, Canada, M39907.

References: (1) Paar, W.H., R.S.W. Braithwaite, T.T. Chen, and P. Keller (1984) A new mineral, scotlandite ($PbSO_3$) from Leadhills, Scotland: the first naturally occurring sulphite. Mineral. Mag., 48, 283–288. (2) (1985) Amer. Mineral., 70, 876 (abs. ref. 1). (3) Sarp, H. and G. Burri (1984) Seconde occurrence du nouveau minéral scotlandite $PbSO_3$. Schweiz. Mineral. Petrog. Mitt., 64, 317–321 (in French with English abs.). (4) Pertlik, F. and J. Zemann (1985) The crystal structure of scotlandite. Tschermaks Mineral. Petrog. Mitt., 34, 289–295.

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Scrutinyite α–PbO_2

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals, to 30 μm.

Physical Properties: *Cleavage:* [{100}, perfect; {010}, imperfect] (forms by analogy to columbite). Hardness = n.d. D(meas.) = n.d. D(calc.) = 9.867

Optical Properties: Translucent in thin flakes. *Color:* Dark reddish brown, clove-brown, red on thin edges; in reflected light, gray-white with reddish brown internal reflections. *Streak:* Dark brown. *Luster:* Submetallic.
Optical Class: Biaxial. *Anisotropism:* Weak; pale blue. *Bireflectance:* Very weak; gray-white to bluish gray.
R_1–R_2: (546) 17.9–18.8, (589) 17.0–17.9

Cell Data: *Space Group: Pbcn.* $a = 4.971(2)$ $b = 5.956(2)$ $c = 5.438(2)$ $Z = 4$

X-ray Powder Pattern: Sunshine #1 mine, New Mexico, USA.
3.117 (100), 1.840 (80), 2.722 (50), 1.527 (50), 3.816 (40), 1.635 (40), 3.497 (30)

Chemistry: (1) Sunshine #1 mine, New Mexico, USA; by electron microprobe, average of ten analyses gave PbO 98.2%; the remainder is probably $(OH)^{1-}$ to balance Pb^{2+} replacing Pb^{4+} in the structure.

Polymorphism & Series: Dimorphous with plattnerite.

Occurrence: In the oxidized zone of hydrothermal lead-bearing ore deposits.

Association: Murdochite, plattnerite, fluorite, quartz (Sunshine #1 mine, New Mexico, USA); plattnerite, rosasite, "limonite" (Mapimí, Mexico).

Distribution: In the Sunshine #1 and Mex-Tex mines, near Bingham, Hansonburg district, Socorro Co., New Mexico, and at the Grand Deposit mine, Muncy Creek district, White Pine Co., Nevada, USA. From the Ojuela mine, Mapimí, Durango, Mexico.

Name: From *scrutiny*, in allusion to the close examination necessary to recognize and characterize the species.

Type Material: National Museum of Natural History, Washington, D.C., USA, 165479.

References: (1) Taggart, J.E., Jr., E.E. Foord, A. Rosenzweig, and T. Hanson (1988) Scrutinyite, natural occurrences of αPbO_2 from Bingham, New Mexico, U.S.A., and Mapimi, Mexico. Can. Mineral., 26, 905–910. (2) (1990) Amer. Mineral., 75, 709–710 (abs. ref. 1). (3) Zaslavskij, A.I. and S.S. Tolkačev (1952) [The structure of α modification of lead dioxide.] Ž. Fiz. Khim, SSSR, 26, 743–752. (4) (1952) Structure Reports, 16, 224–225 (abs. ref. 3).

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Seamanite $Mn_3^{2+}B(PO_4)(OH)_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Acicular, elongated along [001], showing {110} and {111}, to 1 cm.

Physical Properties: *Cleavage:* On {001}, distinct. *Tenacity:* Brittle. Hardness = 4
D(meas.) = 3.08–3.128 D(calc.) = 3.132

Optical Properties: Transparent. *Color:* Pale yellow to wine-yellow, pale pink; colorless in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$. $\alpha = 1.640(3)$ $\beta = 1.663(3)$ $\gamma = 1.665(3)$ 2V(meas.) = 40°

Cell Data: *Space Group:* *Pbnm*. $a = 7.811(5)$ $b = 15.114(10)$ $c = 6.691(5)$ Z = 4

X-ray Powder Pattern: Chicagoan mine, Michigan, USA.
6.917 (10), 2.843 (8), 3.777 (7), 2.502 (7), 7.551 (6), 4.204 (6), 3.467 (6)

Chemistry:

	(1)	(2)
P_2O_5	15.94	19.05
B_2O_3	9.94	9.34
FeO	0.11	
MnO	56.42	57.11
(Mg, Ca)O	1.33	
H_2O	14.57	14.50
Total	98.31	100.00

(1) Chicagoan mine, Michigan, USA; average of four analyses. (2) $Mn_3B(PO_4)(OH)_6$.

Occurrence: In fractures cutting siliceous rock.

Association: Sussexite, calcite, manganese oxide.

Distribution: In the Chicagoan mine, near Iron River, Iron Co., Michigan, USA.

Name: To honor Professor Arthur Edmund Seaman (1858–1937), American mineralogist, Michigan College of Mining and Technology, Houghton, Michigan, USA, who first noted the mineral.

Type Material: Michigan Technical University, Houghton, Michigan; National Museum of Natural History, Washington, D.C., USA, 96282.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 388–389. (2) Kurkutova, E.N., B.G. Rau, and I.M. Rumanova (1971) Crystal structure of seamanite $Mn_3[PO_4/BO_3]\cdot 3H_2O = Mn_3[PO_3OH][BO(OH)_3](OH)_2$. Doklady Acad. Nauk SSSR, 197, 1070–1073 (in Russian). (3) Moore, P.B. and S. Ghose (1971) A novel face-sharing octahedral trimer in the crystal structure of seamanite. Amer. Mineral., 56, 1527–1538.

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Searlesite $NaBSi_2O_5(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* 2. Flat crystals, to 17 cm, occur along bedding planes. Commonly as spherulitic aggregates of radiating acicular to prismatic crystals; as massive granular aggregates.

Physical Properties: *Cleavage:* Perfect on {100}; imperfect on $\{\bar{1}02\}$, {010}. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.44–2.46 D(calc.) = 2.46 Piezoelectric; may fluoresce green under SW UV.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous, slightly pearly on cleavage surfaces.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 34°$. $\alpha = 1.515$ $\beta = 1.533$ $\gamma = 1.535$ 2V(meas.) = 55°

Cell Data: *Space Group:* $P2_1$. $a = 7.9814(12)$ $b = 7.0657(8)$ $c = 4.9054(4)$ $\beta = 93.95(1)°$ Z = 2

X-ray Powder Pattern: Green River Formation, Wyoming, USA.
8.01 (100), 4.06 (50), 3.48 (40), 3.24 (40), 4.31 (30), 3.54 (30), 3.21 (30)

Chemistry:

	(1)	(2)
SiO_2	58.88	58.91
B_2O_3	16.95	17.07
Al_2O_3	0.04	
Fe_2O_3	0.04	
MgO	0.03	
Na_2O	15.31	15.19
H_2O^+	8.90	8.83
Total	100.15	100.00

(1) Green River Formation, Wyoming, USA. (2) $NaBSi_2O_5(OH)_2$.

Occurrence: Commonly interbedded with oil shales or marls (Green River Formation, USA); in boron-bearing evaporite deposits (California, USA); rarely in vugs in phonolite (Point of Rocks, New Mexico, USA).

Association: Shortite, trona, pyrite (Green River Formation, USA); "opal" (Cave Springs Wash, Nevada, USA).

Distribution: In the USA, at Searles Lake, San Bernardino Co., in the Kramer borate deposit, Kern Co., and at Lake Tecopa, Inyo Co., California; widespread in the Green River Formation of Utah and Wyoming; from Cave Springs Wash, Silver Peak Range, Esmeralda Co., Nevada; and at Point of Rocks, Colfax Co., New Mexico. In Canada, at Mont Saint-Hilaire, Quebec. From Kremna, near Tito Uzice; Lopare; and near Bela Stena, Yugoslavia.

Name: Honors John W. Searles, who put down the deep well from which type material was extracted.

Type Material: Harvard University, Cambridge, Massachusetts, 81274; National Museum of Natural History, Washington, D.C., USA, R6457, 93270, 94734, 96080, 124352.

References: (1) Larsen, E.S. and W.B. Hicks (1914) Searlesite, a new mineral. Amer. J. Sci., 38, 437–440. (2) Fahey, J.J. and J.M. Axelrod (1950) Searlesite from the Green River Formation of Wyoming. Amer. Mineral., 35, 1014–1020. (3) Ghose, S. and C. Wan (1976) Structural chemistry of borosilicates, part II: searlesite, $NaBSi_2O_5(OH)$: absolute configuration, hydrogen locations, and refinement of the structure. Amer. Mineral., 61, 123–129.

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Sederholmite β–NiSe

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As grains in clausthalite.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 7.06

Optical Properties: Opaque. *Color:* In polished section, yellow to orange-yellow. *Optical Class:* Uniaxial. *Pleochroism:* Distinct, in shades of yellow. *Anisotropism:* Strong to distinct, in pinkish to greenish colors.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 3.624$ $c = 5.288$ $Z = 2$

X-ray Powder Pattern: Kuusamo, Finland.
2.70 (100), 2.015 (80), 1.806 (60), 1.535 (40), 1.50 (40), 1.348 (30), 1.155 (30)

Chemistry:

	(1)	(2)
Ni	36.8	42.65
Co	1.9	
Se	61.3	57.35
Total	100.0	100.00

(1) Kuusamo, Finland; by X-ray fluorescence. (2) NiSe.

Mineral Group: Nickeline group.

Occurrence: In calcite veins, in sills of albite diabase in schist, associated with low-grade uranium mineralization.

Association: Wilkmanite, penroseite, clausthalite, calcite.

Distribution: From Kuusamo, northeastern Finland [TL].

Name: In honor of Jakob Johannes Sederholm (1863–1934), former Director of the Geological Survey of Finland.

Type Material: n.d.

References: (1) Vuorelainen, Y., A. Huhma, and A. Häkli (1964) Sederholmite, wilkmanite, kullerudite, mäkinenite, and trüstedtite, five new nickel selenide minerals. Compt. Rendus Soc. Géol. Finlande, 36, 113–125. (2) (1965) Amer. Mineral., 50, 519–520 (abs. ref. 1).

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Sedovite $U^{4+}(MoO_4)_2$

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Acicular crystals, to 0.5 mm, radiating, fibrous, powdery, in thin crusts and imbedded in gypsum.

Physical Properties: *Cleavage:* One, ‖ elongation. Hardness = n.d. D(meas.) = 4.2 D(calc.) = n.d. Radioactive.

Optical Properties: Translucent, nearly opaque. *Color:* Brown to reddish brown; gray with brownish tint in reflected light, with bright red internal reflections.
Optical Class: Biaxial. *Pleochroism:* Slight; $X = Y$ = pale reddish brown; Z = reddish brown. *Orientation:* $Y \wedge$ elongation = 38°; positive elongation. $\alpha = > 1.789$ $\beta = > 1.789$ $\gamma = > 1.789$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 3.36(6)$ $b = 11.08(3)$ $c = 6.42(5)$ Z = n.d.

X-ray Powder Pattern: Kyzylsai deposit, Kazakhstan.
3.193 (10), 11.04 (9), 3.370 (9), 3.064 (9), 5.530 (8), 3.702 (8), 2.775 (6)

Chemistry:

	(1)	(2)
SO_3	41.51	
MoO_3	5.50	51.60
UO_3	0.00	
SiO_2	0.60	
UO_2	4.16	48.40
Fe_2O_3	0.17	
CaO	27.89	
H_2O	19.72	
Total	99.55	100.00

(1) Kyzylsai deposit, Kazakhstan; deducting SO_3, CaO, H_2O as gypsum and 20% of MoO_3 as due to molybdenite, the remainder corresponds to $U_{1.00}(MoO_4)_{2.00}$. (2) $U(MoO_4)_2$.

Occurrence: A rare secondary mineral formed in the oxidized zone of a U–Mo deposit.

Association: Uraninite, gypsum, iriginite, calcurmolite, mourite, autunite, phosphuranylite, wulfenite, powellite, molybdenite, barite.

Distribution: From the Kyzylsai Mo–U deposit, Chu-Ili Mountains, southwestern Balkhash region, Kazakhstan.

Name: To honor Georgii Yakovlevich Sedov (1877–1914), Russian Arctic explorer.

Type Material: Mining Institute, St. Petersburg, 1000/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67300, 72032.

References: (1) Skvortsova, K.V. and G.A. Sidorenko (1965) Sedovite – a new supergene mineral of uranium and molybdenum. Zap. Vses. Mineral. Obshch., 94, 548–554 (in Russian). (2) (1966) Amer. Mineral., 51, 530 (abs. ref. 1).

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Seeligerite $Pb_3O(IO_3)Cl_3$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* 222. Crystals are thin square platelets, to 1 mm.

Physical Properties: *Cleavage:* Good on {001}, {110}; poor on {100}, {010}. Hardness = n.d. D(meas.) = 6.83 (synthetic). D(calc.) = 7.052

Optical Properties: Semitransparent. *Color:* Bright yellow. *Optical Class:* Biaxial (–). *Dispersion:* $r > v$. $\alpha = 2.12$ $\beta = \sim 2.32$ $\gamma = \sim 2.32$ 2V(meas.) = 4°

Cell Data: *Space Group:* $C222_1$. a = 7.964(3) $b = 7.964(3)$ $c = 27.288(7)$ Z = 8

X-ray Powder Pattern: Synthetic. 3.219 (10), 3.649 (9), 2.785 (8), 1.991 (8), 1.693 (8), 1.619 (8), 2.816 (7)

Chemistry: (1) Santa Ana mine, Chile; no analysis could be performed due to admixtures; identification depends on coincidence of the X-ray powder pattern with that of synthetic material.

Occurrence: A rare secondary mineral formed in the oxidized zone of hydrothermal polymetallic mineral deposits.

Association: Boleite, paralaurionite, schwartzembergite (Santa Ana mine, Chile).

Distribution: From the Santa Ana, Casucha, and San Francisco (Beatriz) mines, near Caracoles, Sierra Gorda district, Antofagasta, Chile.

Name: To honor Erich Seeliger, Professor of Mineralogy, Technical University, Berlin, Germany.

Type Material: Type material is missing from the Technical University, Berlin, Germany.

References: (1) Mücke, A. (1971) Seeligerit, ein natürliches Blei-Jodat. Neues Jahrb. Mineral., Monatsh., 210–217 (in German with English abs.). (2) (1972) Amer. Mineral., 57, 327–328 (abs. ref. 1).

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Seelite $\mathbf{Mg(UO_2)_2(As^{3+}O_3)_{2-x}(As^{5+}O_4)_x \cdot 7H_2O}$ **(x**= 0.6)

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are tabular, flattened on {100} or {001}, or elongated [010], showing {100}, {001}, {010}, {011}, {$01\overline{1}$}, to 1 mm; typically in spherules, rosettes, and divergent needles.

Physical Properties: *Fracture:* Irregular. Hardness = ∼3 D(meas.) = 3.70 D(calc.) = 3.60–3.71 Radioactive.

Optical Properties: Semitransparent. *Color:* Canary-yellow, apple-green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X = Y$ = yellow; Z = colorless. *Orientation:* $Z \wedge c = 5(1)°$. *Dispersion:* $r \gg v$, inclined. α = 1.602–1.610 β = 1.730–1.737 γ = 1.740–1.753 2V(meas.) = 30°–41° 2V(calc.) = 34°–37.5°

Cell Data: *Space Group:* $C2/m$. a = 18.194–18.207 b = 7.062–7.071 c = 6.661–6.670 β = 99.65°−99.70° Z = 2

X-ray Powder Pattern: Rabéjac deposit, France.
9.02 (100), 4.48 (80), 3.01 (60), 2.849 (60), 3.28 (50), 4.90 (40), 4.00 (40)

Chemistry:

	(1)	(2)
UO_3	62.43	62.75
As_2O_5	6.67	25.52
As_2O_3	13.41	
MgO	4.09	4.39
H_2O	13.40	[7.34]
Total	[100.00]	[100.00]

(1) Rabéjac deposit, France; by electron microprobe, original total 104.03%, As^{3+}:As^{5+} from crystal-structure analysis, H_2O by CHN analyzer; corresponds to $Mg_{0.97}(UO_2)_{2.08}(As^{3+}O_3)_{1.30}(As^{5+}O_4)_{0.56} \cdot 7.08H_2O$. (2) Talmessi mine, Iran; by electron microprobe, H_2O by difference, corresponds to $Mg_{1.00}(UO_2)_{2.01}(AsO_4)_{2.03} \cdot 4H_2O$.

Occurrence: A rare mineral in the oxidation zone of uranium-bearing hydrothermal deposits.

Association: Annabergite, talmessite, zaratite, uranospinite (Talmessi mine, Iran); zeunerite (Rabéjac deposit, France).

Distribution: In the Talmessi mine, 35 km west of Anarak, Iran. From the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France.

Name: To honor Paul Seel (1904–1982) and Hilde Seel (1902–1987), American collectors of microscopic minerals, Philadelphia, Pennsylvania, USA.

Type Material: Royal Institute of Natural Sciences, Brussels, Belgium, RC4191; University of Pierre and Marie Curie, Paris, France.

References: (1) Bariand, P., B. Bachet, C. Brassy, O. Medenbach, M. Deliens, and P. Piret (1993) Seelite, a new uranium mineral from the Talmessi mine, Iran, and Rabejac, France. Mineral. Record, 24, 463–467. (2) (1994) Amer. Mineral., 79, 1012 (abs. ref. 1). (3) Piret, P. and J. Piret-Meunier (1994) Structure de la seelite de Rabejac (France). Eur. J. Mineral., 6, 673–677 (in French with English abs.).

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Segelerite $CaMgFe^{3+}(PO_4)_2(OH)\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are long prismatic and striated ‖ [001], to 1 mm, showing {100}, {010}, {110}, {121}, with a nearly square cross-section.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 4 D(meas.) = 2.67 D(calc.) = 2.610

Optical Properties: Semitransparent. *Color:* Pale green, yellow-green, brownish yellow, chartreuse, may be colorless. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = colorless; Z = yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Absorption:* $Z > X = Y$. $\alpha = 1.618(3)$ $\beta = 1.635(3)$ $\gamma = 1.650(3)$ 2V(meas.) = Large.

Cell Data: *Space Group: Pbca.* $a = 14.826(5)$ $b = 18.751(4)$ $c = 7.307(1)$ Z = 8

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
2.868 (10), 9.31 (9), 5.34 (6), 3.729 (5), 3.421 (5), 4.97 (4), 4.65 (4)

Chemistry:

	(1)	(2)
P_2O_5	33.1	35.55
Al_2O_3	0.4	
Fe_2O_3	16.4	20.00
MnO	0.0	
MgO	9.5	10.10
CaO	13.6	14.05
H_2O	19.1	20.30
Total	92.1	100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, total Fe as Fe_2O_3, H_2O by loss on ignition; corresponds to $Ca_{1.04}Mg_{1.00}(Fe_{0.89}Al_{0.05})_{\Sigma=0.94}(PO_4)_{2.00}(OH)_{0.89}\cdot 3.84H_2O$.
(2) $CaMgFe(PO_4)_2(OH)\cdot 4H_2O$.

Mineral Group: Overite group.

Occurrence: A rare alteration product of triphylite in zoned complex granite pegmatites.

Association: Ferrisicklerite-rockbridgeite, collinsite, hydroxylapatite, robertsite (Tip Top mine, South Dakota, USA).

Distribution: From the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA. On Milgun Station, Western Australia. In the Mangualde pegmatite, near Mesquitela, and at Belmonte, south of Guarda, Portugal. From Hagendorf, Bavaria, Germany.

Name: Honoring Curt George Segeler (1901–1989), American engineer and amateur mineralogist, Brooklyn, New York, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 127154.

References: (1) Moore, P.B. (1974) I. Jahnsite, segelerite, and robertsite, three new transition metal phosphate species. II. Redefinition of overite, an isotype of segelerite. III. Isotypy of robertsite, mitridatite, and arseniosiderite. Amer. Mineral., 59, 48–59. (2) Moore, P.B. and T. Araki (1977) Overite, segelerite, and jahnsite; a study in combinatorial polymorphism. Amer. Mineral., 62, 692–702.

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Segnitite $HPbFe_3^{3+}(AsO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ (probable). Rhombohedral or pseudo-octahedral crystals, to 5 mm, showing {$11\overline{2}2$} and {0001}; typically as spherical clusters, or in drusy crusts and spongy aggregates.

Physical Properties: *Cleavage:* On {0001}, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼4 D(meas.) = > 4.2 D(calc.) = 4.77(1)

Optical Properties: Transparent to translucent. *Color:* Greenish brown to yellowish brown, dark brown. *Streak:* Pale yellow. *Luster:* Vitreous to adamantine.
Optical Class: Uniaxial (–). *Pleochroism:* Pale to medium yellow. $\omega = 1.975(5)$ $\epsilon = 1.955(5)$

Cell Data: *Space Group:* [$R\overline{3}m$] (probable, by analogy to beudantite). $a = 7.359(3)$ $c = 17.113(8)$ Z = 3

X-ray Powder Pattern: Broken Hill, Australia.
3.092 (100), 5.966 (50), 3.678 (40), 2.283 (30), 1.992 (30), 1.840 (25), 2.849 (20)

Chemistry:

	(1)	(2)
SO_3	0.57	
P_2O_5	0.37	
As_2O_5	27.89	30.42
Al_2O_3	1.13	
Fe_2O_3	28.91	31.70
CuO	0.14	
ZnO	1.87	
PbO	30.58	29.54
BaO	0.49	
H_2O	8.01	8.34
Total	99.96	100.00

(1) Broken Hill, Australia; by electron microprobe, average of ten analyses, total Fe as Fe_2O_3, H_2O by CHN analyzer; corresponds to $(Pb_{1.05}Ba_{0.03})_{\Sigma=1.08}(Fe_{2.76}Zn_{0.22}Al_{0.17}Cu_{0.01})_{\Sigma=3.16}[(AsO_4)_{1.85}(PO_4)_{0.05}(SO_4)_{0.04}]_{\Sigma=1.94}(OH, H_2O)_{6.24}$. (2) $HPbFe_3(AsO_4)_2(OH)_6$.

Occurrence: Of rare occurrence in the oxidized zone of a Pb–Zn orebody (Broken Hill, Australia); in a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Beudantite–corkite, adamite–olivenite, duftite, bayldonite, carminite, mimetite, hidalgoite, pharmacosiderite, mawbyite, agardite-(Y), spessartine, quartz, coronadite, goethite (Broken Hill, Australia); olivenite, duftite (Tsumeb, Namibia).

Distribution: In Australia, from Broken Hill, New South Wales, and at Coppin Pool, about 41 km east-southeast of Mt. Tom Price, Western Australia. Large crystals from Tsumeb, Namibia. In the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA. From the Penberthy Croft mine, St. Hilary, Cornwall, England.

Name: Honoring Dr. E. Ralph Segnit (1923–1999), mineralogist and petrologist, University of Adelaide, Adelaide, Australia, for his contributions to Australian mineralogy.

Type Material: Museum Victoria, Melbourne, Australia, M30044.

References: (1) Birch, W.D., A. Pring, and B.M. Gatehouse (1992) Segnitite, $PbFe_3H(AsO_4)_2(OH)_6$, a new mineral in the lusungite group from Broken Hill, New South Wales, Australia. Amer. Mineral., 77, 656–659.

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Seidozerite $(Na,Ca)_2(Zr,Ti,Mn)_2Si_2O_7(O,F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As radiating crystals, elongated along [010], to 5 cm, showing {001}, {100}, {010}, {011}, {111}, and {203}.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = 4–5
D(meas.) = 3.472 D(calc.) = 3.87

Optical Properties: Opaque, translucent in thin fragments. *Color:* Brownish red to reddish yellow; red where translucent. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Intense; X = dark red; Y = red; Z = light yellow. *Orientation:* $X = b$; $Z = a$; $Y \wedge c = 13°$. *Dispersion:* $r > v$, strong. *Absorption:* $X > Y > Z$.
$\alpha = 1.725$ $\beta = 1.758$ $\gamma = 1.830$ 2V(meas.) = 68°

Cell Data: *Space Group:* $P2/c$ or Pc. $a = 5.53(3)$ $b = 7.10(4)$ $c = 18.30(10)$
$\beta = 102°43'$ Z = 4

X-ray Powder Pattern: Lovozero massif, Russia.
2.97 (10), 2.87 (7), 1.830 (7), 2.58 (4), 1.633 (4), 2.43 (3), 2.25 (3)

Chemistry:

	(1)		(1)
SiO_2	31.40	MnO	4.22
TiO_2	13.16	MgO	1.79
ZrO_2	23.14	CaO	2.80
Al_2O_3	1.38	Na_2O	14.55
Fe_2O_3	2.85	F	3.56
Nb_2O_5	0.60	H_2O	0.60
FeO	1.06	$-O = F_2$	1.49
		Total	99.62

(1) Lovozero massif, Russia; corresponds to $(Na_{1.79}Ca_{0.19})_{\Sigma=1.98}(Zr_{0.72}Ti_{0.63}Mn_{0.23}Mg_{0.17}Fe^{3+}_{0.13}Al_{0.10}Fe^{2+}_{0.06}Nb_{0.02})_{\Sigma=2.06}Si_{2.00}O_7(O_{1.28}F_{0.72})_{\Sigma=2.00}$.

Occurrence: In thin veins in nepheline syenite pegmatites in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Microcline, aegirine, nepheline, apatite, pyrochlore, magnetite, ilmenite, titanian låvenite, eudialyte (Lovozero massif, Russia).

Distribution: In Russia, in the Lovozero massif, near the Muruai and Uel'kuai Rivers, Seidozero region, Kola Peninsula, and in the Burpala massif, 120 km north of Lake Baikal, eastern Siberia. From Val Giuv, Graübunden, Switzerland.

Name: For the Lake Seidozero region, Kola Peninsula, Russia, near which the mineral occurs.

Type Material: Vernadsky Geological Museum, 45148; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 59965, vis4318, vis4319.

References: (1) Semenov, E.I., M.E. Kazakova, and V.I. Simonov (1958) A new zirconium mineral, seidozerite, and other minerals of the wöhlerite group in alkalic pegmatites. Zap. Vses. Mineral. Obshch., 87, 590–597 (in Russian). (2) (1959) Amer. Mineral., 44, 467–468 (abs. ref. 1); 910 (errata ref. 2). (3) Simonov, V.I. and N.V. Belov (1959) The determination of the structure of seidozerite. Kristallografiya (Sov. Phys. Crystal.), 4, 1463–175 (in Russian). (4) Skszat, S.M. and V.I. Simonov (1966) The structure of calcium seidozerite. Kristallografiya (Sov. Phys. Crystal.), 10, 591–595 (in Russian).

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Seifertite SiO_2

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m* or *mm*2. As lamellae to 0.2 mm.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d.
D(meas.) = n.d. D(calc.) = 4.294

Optical Properties: Transparent. *Color*: n.d. *Streak*: n.d. *Luster*: n.d.
Optical Class: n.d.

Cell Data: *Space Group*: *Pbcn* or *Pb*2*n*. a = 4.097(1) b = 5.0462(9) c = 4.4946(8) Z = 4

X-ray Powder Pattern: Shergotty meteorite. (Quickly amorphizes under electron, laser or ion beams) 2.596 (100), 3.181 (72), 1.938 (64), 1.4199 (44), 1.514 (31), 1.970 (25), 1.288 (19)

Chemistry: Electron-microprobe analyses with a defocused beam showed almost pure SiO_2 with minor concentrations in Na_2O (0.2 to 0.50 wt.%) and Al_2O_3 (0.8 to 1.60 wt.%).

Occurrence: Formed by shock-induced solid-state transformation (> 35 GPa) of either tridymite or cristobalite in basaltic achondrite meteorites, presumably of Martian origin.

Association: Stishovite, silica glass, unnamed monoclinic silica polymorph.

Distribution: In the Martian meteorite Shergotty that fell on August 25, 1865 in Bihar State, India and the Zagami meteorite that fell in Katsina Province**,** Nigeria on October 3, 1962.

Name: Honors Friedrich A. Seifert (b. 1941), founding Director of the Bayerisches Geoinstitut, Universität Bayreuth, Germany, for his important contributions to high-pressure geoscience.

Type Material: Museum of the Geological Survey in Calcutta, India.

References: (1) El Goresy, A., P. Dera, T.G. Sharp, C.T. Prewitt, M. Chen, L. Dubrovinsky, B. Wopenka, N.Z. Boctor, and R.J. Hemley (2008) Seifertite, a dense orthorhombic polymorph of silica from the Martian meteorites Shergotty and Zagami. Eur. J. Mineral., 20, 523–528. (2) (2009) Amer. Mineral., 94, 403 (abs. ref. 1). (3) Dera, P., C.T. Prewitt, N.Z. Boctor, and R.J. Hemley (2002) Characterization of a high-pressure phase of silica from the Martian meteorite Shergotty. Amer. Mineral., 87, 1018-1023.

Seinäjokite $(Fe, Ni)(Sb, As)_2$

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Crystal Data: Orthorhombic or pseudo-orthorhombic. *Point Group:* n.d. Massive.

Physical Properties: Hardness = n.d. VHN = 332 D(meas.) = n.d. D(calc.) = 7.938

Optical Properties: Opaque. *Color:* In polished section, pale gray with a rose tint.
Luster: Metallic.
Optical Class: Biaxial. *Anisotropism:* Distinct, brown to blue.
R_1–R_2: (400) —, (420) —, (440) 63.8, (460) 62.4, (480) 61.4, (500) 60.8, (520) 60.8, (540) 60.8, (560) 60.8, (580) 61.0, (600) 61.4, (620) 61.9, (640) 62.7, (660) 63.4, (680) 64.3, (700) 65.3

Cell Data: *Space Group:* n.d. $a = 3.190(1)$ $b = 5.81(1)$ $c = 6.490(15)$ Z = 2

X-ray Powder Pattern: Seinäjoki deposit, Finland.
2.81 (100), 2.59 (90), 2.03 (80), 1.790 (60), 1.212 (5), 1.174 (30), 1.626 (20)

Chemistry:

	(1)
Fe	15.4
Ni	4.0
Co	0.6
Sb	73.5
As	6.9
Te	1.2
Total	101.6

(1) Seinäjoki deposit, Finland; by electron microprobe, average of six analyses; corresponding to $(Fe_{0.78}Ni_{0.19}Co_{0.03})_{\Sigma=1.00}(Sb_{1.71}As_{0.26}Te_{0.03})_{\Sigma=2.00}$.

Mineral Group: Löllingite group.

Occurrence: In an antimony deposit, replacing antimony (Seinäjoki deposit, Finland).

Association: Antimony, antimonian westerveldite, breithauptite, altaite (Seinäjoki deposit, Finland).

Distribution: From the Seinäjoki antimony deposit, Vaasa, Finland [TL]. In the Ilímaussaq intrusion, southern Greenland. At Zolotaya Gora, Ural Mountains, Russia.

Name: For the occurrence at Seinäjoki, Finland.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Mozgova, N.N., Y.S. Borodaev, N.A. Ozerova, V. Paakkonen, O.L. Sveshnikova, V.S. Balitskii, and B.A. Dorogovin (1976) Seinäjokite, $(Fe_{0.8}Ni_{0.2})(Sb_{1.7}As_{0.3})$ and antimonian westerveldite from Seinäjoki, Finland. Zap. Vses. Mineral. Obshch., 105, 617–630 (in Russian). (2) (1977) Amer. Mineral., 62, 1059–1060 (abs. ref. 1). (3) Mozgova, N.N., Y.S. Borodaev, N.A. Ozerova, and V. Paakkonen (1977) New minerals of the group of iron antimonides and arsenides from the Seinäjoki deposit, Finland. Bull. Geol. Soc. Finland, 49, 47–52 (in English).

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Sekaninaite $(Fe^{2+},Mg)_2Al_4Si_5O_{18}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As poorly developed crystals, to 70 cm. *Twinning:* Commonly twinned on {110} and {310}, simulating hexagonal symmetry.

Physical Properties: *Cleavage:* {100}, imperfect; parting on {001}. Hardness = 7–7.5 D(meas.) = 2.76–2.77 D(calc.) = 2.78

Optical Properties: Transparent to translucent. *Color:* Blue to blue-violet.
Luster: Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = blue; Z = pale blue. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, moderate. *Absorption:* $Y > Z > X$. $\alpha = 1.561$ $\beta = 1.572$ $\gamma = 1.576$ 2V(meas.) = 66°

Cell Data: *Space Group: Cccm.* $a = 17.230(5)$ $b = 9.835(3)$ $c = 9.314(3)$ Z = 4

X-ray Powder Pattern: Dolní Bory, Czech Republic.
8.583 (100), 3.386 (100), 3.376 (100), 4.081 (83), 3.076 (74), 3.143 (64), 3.043 (57)

Chemistry:

	(1)
SiO_2	45.10
TiO_2	0.04
Al_2O_3	30.63
Fe_2O_3	0.91
FeO	17.85
MnO	0.92
MgO	1.69
CaO	0.39
Na_2O	0.68
K_2O	0.03
H_2O^+	1.84
H_2O^-	0.12
Total	100.20

(1) Dolní Bory, Czech Republic; corresponding to $(Fe^{2+}_{1.63}Mg_{0.28}Na_{0.14}Mn_{0.09}Ca_{0.05})_{\Sigma=2.19}(Al_{3.94}Fe^{3+}_{0.08})_{\Sigma=4.02}Si_{4.93}O_{18}\cdot 0.67H_2O$.

Polymorphism & Series: Forms a series with cordierite.

Occurrence: In the albite zone of pegmatites in granulites and gneisses (Dolní Bory, Czech Republic); in bauxitic lithomarge intensely altered by a diabase plug (Brockley, Ireland).

Association: Albite, quartz (Dolní Bory, Czech Republic).

Distribution: From Dolní Bory, near Velké Meziříčí, Czech Republic. At Brockley, Rathlin Island, Co. Antrim, Ireland. From Gåsborn, Bergslagen, Sweden. At Filone Rosina, Elba, Italy. In Japan, from Kitasugama, Fukushima Prefecture; Sasago and Doshi, Yamanashi Prefecture; Ide, Kyoto Prefecture; Ishii, Yamaguchi Prefecture; and in the Hanoka mine, Kagoshima Prefecture.

Name: For Professor Josef Sekanina (1901–), Czech mineralogist who first discovered the mineral.

Type Material: Moravian Museum, Brno, Czech Republic, A6108.

References: (1) Stanek, J. and J. Miskovsky (1975) Sekaninaite, a new mineral of the cordierite series, from Dolni Bory, Czechoslovakia. Scr. Fac. Sci. Nat. Ujep Brun., Geol. 1(5), 21–30. (2) (1977) Amer. Mineral., 62, 395 (abs. ref. 1). (3) Hochella, M.F., Jr., G.E. Brown, Jr., F.K. Ross, and G.V. Gibbs (1979) High-temperature crystal chemistry of hydrous Mg- and Fe-cordierites. Amer. Mineral., 64, 337–351. (4) Ryback, G., R. Nawaz, and E. Farley (1988) Seventh supplementary list of British Isles minerals (Irish). Mineral. Mag., 52, 267–274.

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Selenium Se

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Crystal Data: Hexagonal. *Point Group:* 32. Forms acicular crystals, to 2 cm, commonly hollow and tubular; as sheetlike clusters and felted masses; also as glassy droplets.

Physical Properties: *Cleavage:* Good on $\{01\bar{1}2\}$. *Tenacity:* Flexible. Hardness = 2 VHN = n.d. D(meas.) = 4.80 D(calc.) = 4.809

Optical Properties: Opaque, transparent in very thin fragments. *Color:* Gray to purple-gray, red in transmitted light; in polished section, white in air, darker white to grayish brown in oil. *Streak:* Red. *Luster:* Metallic.
Optical Class: Uniaxial (+). *Pleochroism:* Distinct, cream-white toward brown. $\omega = 3.0$ $\epsilon = 4.04$ *Anisotropism:* Very strong.
R_1–R_2: (400) 29.9–50.9, (420) 28.3–48.6, (440) 27.0–46.5, (460) 26.1–44.6, (480) 25.5–43.1, (500) 25.5–42.3, (520) 25.9–41.6, (540) 26.8–41.4, (560) 27.9–41.3, (580) 28.8–41.0, (600) 29.8–40.4, (620) 30.1–39.7, (640) 29.9–38.7, (660) 28.8–37.6, (680) 27.9–37.0, (700) 27.5–36.8

Cell Data: *Space Group:* $P3_121$ or $P3_221$. $a = 4.3662$ $c = 4.9536$ $Z = 3$

X-ray Powder Pattern: Synthetic.
3.00 (100), 3.78 (55), 2.072 (35), 1.998(20), 1.766 (20), 2.184 (16), 1.650 (10)

Chemistry: Very pure selenium, with a trace of S.

Occurrence: Formed at relatively low temperatures by sublimation of fumarolic vapors, and from oxidation of selenium-bearing organic compounds in sandstone U–V deposits; from burning coal and pyritic ores.

Association: Pyrite, ferroselite, zippeite, metatyuyamunite, metarossite, montroseite, corvusite.

Distribution: In the USA, from the United Verde mine, Jerome, Yavapai Co., Arizona; at a number of localities in U–V deposits of the Colorado Plateau, as in the Peanut mine, Bull Canyon, Uravan district, Montrose Co., Colorado, and the Parco No. 23 mine, Thompsons district, Grand Co., Utah. From the Road Hog No. 1A mine, Black Hills, Fall River Co., South Dakota; in the Mopung Hills, Churchill Co., and the Gold Quarry mine, near Carlin, Eureka Co., Nevada; in uranium mines around Grants, McKinley Co., New Mexico; from Darwin, Inyo Co., California. At the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. From the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, Potosí, Bolivia. On Vesuvius, Campania, Italy. In the Czech Republic, at Kladno. In Russia, from the Kul'Yurt Tau pyrite deposit, and in the Zhivetski horizon, Tuva. From the Yutangba district, near Enshi, Hubei Province, China.

Name: From the Greek, *selene*, *the moon*, in allusion to its similarity to tellurium, named for *the earth*, Latin *tellus*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 136–137. (2) Thompson, M.E., C. Roach, and W. Braddock (1956) New occurrences of native selenium. Amer. Mineral., 41, 156–157. (3) (1955) NBS Circ. 539, 5, 54. (4) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 42–44. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 382–383. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 504 (synthetic).

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Selenopolybasite $[(Ag, Cu)_6(Sb, As)_2(S, Se)_7][Ag_9Cu(S, Se)_2Se_2]$

Crystal Data: Hexagonal. *Point Group*: 3*m*. As subhedral to anhedral grains, to 400 μm.

Physical Properties: *Cleavage*: None detected. *Tenacity*: Brittle.
Hardness = 3-3.5 VHN = 125-141 (100 g load). D(meas.) = n.d. D(calc.) = 6.548

Optical Properties: Opaque. *Color*: Light gray in reflected light. *Streak*: Black.
Luster: Metallic. *Bireflectance:* Weak to moderate. Anisotropic. *Pleochroism:* Weak; gray to violet-blue gray.
Optical Class: n.d.
(R_{min}-R_{max}): (471.1) 32.8-34.1, (548.3) 31.0-32.9, (586.6) 30.2-31.8, (652.3) 29.3-30

Cell Data: *Space Group*: *P*3*m*1. *a* = 7.5950(4) *c* = 12.0731(6) *Z* = 1

X-ray Powder Pattern: De Lamar Mine, Idaho, USA.
2.8880 (100), 3.0183 (84), 3.1731 (48), 2.8880 (48), 2.3629 (34), 1.8987 (31), 2.2237 (28)

Chemistry:

	(1)
Ag	66.17
Cu	3.19
Bi	0.09
Pb	0.09
Zn	0.03
Fe	0.07
Sb	9.47
As	0.60
S	11.36
Se	8.42
Total	99.49

(1) De Lamar Mine, Idaho, USA; average of 10 electron microprobe analyses, corresponding to $[(Ag_{5.67}Cu_{0.20}Bi_{0.01}Pb_{0.01}Zn_{0.01}Fe_{0.03})_{\Sigma=5.93}(Sb_{1.86}As_{0.19})_{\Sigma=2.05}(S_{6.68}Se_{0.34})_{\Sigma=7.02}]$ $[Ag_9Cu(S_{1.79}Se_{0.21})_{\Sigma=2.00}Se_2]$.

Mineral Group: Member of the pearceite-polybasite group.

Occurrence: In silicious veins through rhyolite porphyry altered at shallow depth by heated brines.

Association: Naumannite, covellite, pyrite, calcite.

Distribution: In a museum sample collected at the De Lamar Mine, Owyhee County, Idaho, USA.

Name: The selenium dominant analogue of *polybasite*.

Type Material: Mineral Collection, Natural History Museum, University of Florence, Italy (2453/I).

References: (1) Bindi, L., M. Evain, and S. Menchetti (2007) Selenopolybasite, $[(Ag,Cu)_6(Sb,As)_2(S,Se)_7][Ag_9Cu(S,Se)_2Se_2]$, a new member of the pearceite–polybasite group from the De Lamar Mine, Owyhee County, Idaho, USA. Can. Mineral., 45, 1525-1528. (2) (2008) Amer. Mineral., 93, 1689 (abs. ref. 1).

Selenostephanite $Ag_5Sb(Se,S)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Platy crystals, in irregular aggregates to 0.08 mm, filling interstices.

Physical Properties: Hardness = 2.5–3 VHN = 95–116 (20 g load). D(meas.) = n.d. D(calc.) = 7.5

Optical Properties: Opaque. *Color:* In polished section, grayish white with olive tint. *Anisotropism:* Brownish gray to gray.
R_1–R_2: (420) 33.3–34.8, (520) 33.6–36.0, (580) 32.6–34.8, (640) 31.0–33.0, (700) 30.4–32.3

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.86$ $b = 11.84$ $c = 8.92$ Z = 4

X-ray Powder Pattern: Rudnaya Sopka deposit, Russia.
2.96 (10), 2.64 (9), 2.28 (9), 2.23 (9), 1.918 (9b), 1.888 (9b)

Chemistry:

	(1)
Ag	55.80
Sb	12.63
Se	29.04
S	1.44
Total	98.91

(1) Rudnaya Sopka deposit, Russia; by electron microprobe, corresponding to $Ag_{5.00}Sb_{1.00}(Se_{3.56}S_{0.44})_{\Sigma=4.00}$.

Occurrence: In quartz and orthoclase-quartz veins with other silver minerals in a volcanogenic Au–Ag deposit.

Association: Miaragyrite, clausthalite, Au–Ag alloy, pyrargyrite, acanthite, clausthalite, naumannite, argyrodite, tetrahedrite–tennantite, pyrite, sphalerite, chalcopyrite, orthoclase, quartz.

Distribution: From the Rudnaya Sopka Au–Ag deposit, central Chukotka Peninsula, Russia [TL].

Name: For selenium in the composition, and similarity to stephanite.

Type Material: Central Institute for Geological Exploration for Base and Precious Metals, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82774.

References: (1) Botova, M.M., S.M. Sandomirskaya, and N.G. Tschuvikina (1985) Selenostephanite $Ag_5Sb(Se,S)_4$ – a new mineral. Zap. Vses. Mineral. Obshch., 114, 627–630 (in Russian). (2) (1987) Amer. Mineral., 72, 225 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 182.

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Seligmannite $PbCuAsS_3$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals equant, short prismatic [001], tabular on {001}, to 20 mm; multiple striations common on {110}. *Twinning:* On {110}, very common; polysynthetic twinning observed in polished section.

Physical Properties: *Cleavage:* Very poor on {001}, {100}, and {010}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 168–181 (100 g load). D(meas.) = 5.38 D(calc.) = 5.41

Optical Properties: Opaque. *Color:* Dark lead-gray to black; in polished section, rose-white. *Streak:* Chocolate-brown to purple-black. *Luster:* Metallic. *Anisotropism:* Strong.
R_1–R_2: (400) 34.8–36.0, (420) 34.6–35.6, (440) 34.2–35.3, (460) 33.9–35.1, (480) 33.5–35.0, (500) 33.0–34.7, (520) 32.6–34.4, (540) 32.3–34.0, (560) 32.1–33.7, (580) 31.8–33.3, (600) 31.4–32.8, (620) 31.0–32.4, (640) 30.5–32.0, (660) 29.9–31.4, (680) 29.4–31.0, (700) 29.0–30.6

Cell Data: *Space Group:* $Pn2_1m$. $a = 8.076(2)$ $b = 8.737(5)$ $c = 7.634(3)$ $Z = 4$

X-ray Powder Pattern: Binntal, Switzerland.
2.72 (100), 3.85 (80), 1.749 (70), 5.72 (60), 2.56 (50), 1.914 (50), 1.414 (50)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Pb	46.34	48.5	46.89	Fe	0.06		
Cu	13.09	15.2	14.38	As	16.88	13.5	16.96
Ag	0.11			Sb	0.64	1.6	
Zn	0.27			S	21.73	20.6	21.77
				Total	99.12	99.4	100.00

(1) Binntal, Switzerland; corresponds to $Pb_{0.99}Cu_{0.91}(As_{1.00}Sb_{0.02})_{\Sigma=1.02}S_{3.00}$. (2) Do.; by electron microprobe, corresponds to $Pb_{1.09}Cu_{1.12}(As_{0.84}Sb_{0.06})_{\Sigma=0.90}S_{3.00}$. (3) $PbCuAsS_3$.

Polymorphism & Series: Forms a series with bournonite.

Occurrence: In cavities in dolostone (Binntal, Switzerland).

Association: Tennantite, sphalerite, pyrite, dufrénoysite, rathite, baumhauerite (Binntal, Switzerland); tennantite, jordanite, dufrénoysite (Bleikvassli deposit, Norway).

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL]. At Mooseck, near Golling, Salzburg, Austria. From Sulitjelma and in the Bleikvassli Zn–Pb–Cu deposit, northern Norway. At the Aghios Philippos Pb–Zn deposit, near Kirki, Greece. In the USA, from Bingham, Tooele Co., Utah; at Butte, Silver Bow Co., Montana; and in the Balmat-Edwards mine, Balmat, St. Lawrence Co., New York. From the Whisky Creek group of mines, near Woodcock, British Columbia, and in the Hemlo gold deposit, Thunder Bay district, Ontario, Canada. At the Noche Buena mine, Mazapil, Zacatecas, Mexico. From Cerro de Pasco, Peru. In the Desierto mine, near Iquique, Tarapacá, Chile. From Tsumeb, Namibia. At the Pb–Zn deposit, Yanbian, Sichuan Province, China. From Broken Hill, New South Wales, Australia. A few additional localities are known.

Name: Honors Gustav Seligmann (1849–1920), a mineral collector of Koblenz, Germany.

Type Material: Museum of Natural History, Fribourg, Switzerland, B618.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 411–412. (2) Edenharter, A., W. Nowacki, and Y. Takéuchi (1970) I. Verfeinerung der Kristallstruktur von Bournonit $[(SbS_3)_2|Cu_2^{IV}Pb^{VII}Pb^{VIII}]$ und von Seligmannit $[(AsS_3)_2|Cu_2^{IV}Pb^{VII}Pb^{VIII}]$. Zeits. Krist., 131, 397–417 (in German with English abs.).
(3) Bakakin, V.V. and A.A. Godovikov (1980) Crystal structure and twinning of seligmannite and bournonite. Doklady Acad. Nauk SSSR, 215, 345–347 (in Russian). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 172.
(5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 505.

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Sellaite MgF_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Short prismatic crystals, to 5 cm, with prominent {010}, {011}, {110}, may be flattened, pyramidal; fibrous, radial, spherulitic, in aggregates. *Twinning:* On {011}.

Physical Properties: *Cleavage:* Perfect on {010} and {110}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 3.15 D(calc.) = 3.08 Very slightly soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.378$ $\epsilon = 1.390$

Cell Data: *Space Group:* $P4_2/mnm$ (synthetic). $a = 4.6213(1)$ $c = 3.0519(1)$ Z = 2

X-ray Powder Pattern: Synthetic.
3.275 (100), 2.231 (95), 1.711 (75), 2.067 (35), 1.375 (35), 1.635 (30), 2.545 (20)

Chemistry:

	(1)	(2)
Mg	38.37	39.01
F	[61.63]	60.99
Total	[100.00]	100.00

(1) Gebroulaz glacier, France; F by difference. (2) MgF_2.

Occurrence: In a bituminous dolomite-anhydrite rock (Gebroulaz glacier, France); in evaporites (Bleicherode, Germany); in volcanic ejecta and fumarolic deposits (Vesuvius, Italy); in marble (Carrara, Italy); in a metamorphic magnesite deposit (Brumado mine, Brazil); in an alkalic granite (Lake Gjerdingen, Norway).

Association: Fluorite, sulfur, celestine, anhydrite, gypsum, magnesite, quartz.

Distribution: In France, in the moraine of the Gebroulaz glacier, near Moûtiers, Savoy, and in the Font Sante mine, Estrel, Var. In Germany, from Bleicherode, Harz, in the Clara mine, near Oberwolfach, Black Forest, and at Emmelberg, Eifel district. In Italy, from Carrara, Tuscany; on Vesuvius, Campania, and on Mt. Etna, Sicily. From near Lake Gjerdingen, Nordmarka, Norway. Large crystals in the Brumado mine, Bahia, Brazil. At the Huanzala mine, Huanuco, Peru. In the Rico-Argentine mine group, Rico district, Dolores Co., Colorado, USA. A few other localities have been reported but modern verification is desirable.

Name: Honors Quintino Sella (1827–1884), Italian mining engineer and mineralogist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 37–39. (2) Bauer, W.H. (1976) Rutile-type compounds. V. Refinement of MnO_2 and MgF_2. Acta Cryst., 32, 2200–2204. (3) Vidal-Valat, G., J.-P. Vidal, C.M.E. Zeyen, and K. Kurki-Suonio (1979) Neutron diffraction study of magnesium fluoride single crystals. Acta Cryst., 35, 1584–1590. (4) Raade, G. and J. Haug (1981) Morphology and twinning of sellaite from Gjerdingen, Norway. Mineral. Record, 12, 231–232. (5) (1955) NBS Circ. 539, 4, 33–34.

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Selwynite **$NaK(Be,Al)Zr_2(PO_4)_4 \cdot 2H_2O$**

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are anhedral, indistinct, in radiating groups.

Physical Properties: *Fracture:* Semiconchoidal. Hardness = 4 D(meas.) = 2.94 D(calc.) = 3.08

Optical Properties: Transparent. *Color:* Deep purplish blue, may be pale lavender if weathered. *Streak:* Pale lavender. *Luster:* Vitreous.
Optical Class: Uniaxial (+). *Pleochroism:* Distinct; O = medium bluish lavender; E = very pale bluish lavender. $\omega = 1.624(2)$ $\epsilon = 1.636(2)$

Cell Data: *Space Group:* $[I4_1/amd]$ (by analogy to gainesite). $a = 6.570(3)$ $c = 17.142(6)$ Z = 2

X-ray Powder Pattern: Wycheproof, Australia.
6.161 (100), 3.286 (50), 3.039 (30), 4.291 (25), 2.895 (20), 2.609 (5), 2.431 (5)

Chemistry:

	(1)		(1)
P_2O_5	40.90	CaO	0.98
SiO_2	0.49	SrO	0.16
ZrO_2	33.76	BaO	0.16
HfO_2	1.17	Na_2O	4.77
Al_2O_3	1.04	K_2O	6.26
Ce_2O_3	0.03	Rb_2O	0.20
FeO	0.49	Cs_2O	0.70
MnO	0.99	F	0.37
BeO	1.43	H_2O	5.4
MgO	0.15	$-O = F_2$	0.16
		Total	99.29

(1) Wycheproof, Australia; by electron microprobe, average of nine analyses, Rb and Be by ICP, H_2O determined by CHN analyzer; corresponds to $Na_{1.00}(K_{0.92}Na_{0.06}Cs_{0.03}Rb_{0.02})_{\Sigma=1.03}(Be_{0.40}Al_{0.14}Ca_{0.12}Mn_{0.10}Fe_{0.05}Mg_{0.03}Sr_{0.01}Ba_{0.01})_{\Sigma=0.86}(Zr_{1.89}Hf_{0.04})_{\Sigma=1.93}[(P_{1.00}Si_{0.02})_{\Sigma=1.02}O_{3.95}]_4F_{0.13} \cdot 2.07H_2O$.

Occurrence: Very rare, a cavity filling in veins, formed under reducing conditions during late-stage cooling in granite pegmatite.

Association: Wardite, eosphorite, montmorillonite, "limonite".

Distribution: In a quarry 0.5 km east of Wycheproof, Victoria, Australia.

Name: To honor Alfred Richard Cecil Selwyn (1824–1902), founding Director of the Geological Survey of Victoria, Australia, and later, the Geological Survey of Canada.

Type Material: Museum Victoria, Melbourne, Australia, M42492, M42590.

References: (1) Birch, W.D., A. Pring, and E.E. Foord (1995) Selwynite, $NaK(Be,Al)Zr_2(PO_4)_4 \cdot 2H_2O$, a new gainesite-like mineral from Wycheproof, Victoria, Australia. Can. Mineral., 33, 55–58. (2) (1995) Amer. Mineral., 80, 1075 (abs. ref. 1).

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Semenovite-(Ce) $(Na,Ca)_9(Ce,La)_2(Fe^{2+},Mn)(Si,Be)_{20}(O,OH,F)_{48}$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$.
As pseudotetragonal dipyramidal crystals, to 1 cm, and coarsely crystalline aggregates.
Twinning: Multiple interpenetration twinning on {110} with composition plane {120}, produces a pseudotetragonal habit; viewed in thin section, two sets of parallel twin boundaries produce rhombic-shaped intersections.

Physical Properties: *Fracture:* Uneven. Hardness = 3.5–4 D(meas.) = 3.140(2) D(calc.) = 3.17

Optical Properties: Transparent, to translucent when altered. *Color:* Brown or orange-brown to grey or reddish brown when altered; colorless to greyish brown in thin section.
Luster: Vitreous, to dull when altered.
Optical Class: Uniaxial (–) to biaxial (–). *Orientation:* $X = c$. $\alpha = 1.595(2)$ $\beta = 1.614(2)$ $\gamma = 1.614(2)$ $2V(meas.) = 55°$

Cell Data: *Space Group: Pmnn.* $a = 13.879(5)$ $b = 13.835(5)$ $c = 9.942(6)$ $Z = 2$

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
3.282 (100), 2.841 (100), 2.727 (100), 8.082 (70), 6.949 (40), 5.250 (40), 3.182 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	42.8	45.1	46.2	ZnO	0.5	0.4	0.4
TiO_2		0.2	0.2	PbO	0.5		
Al_2O_3	0.7	0.1		BeO	8.2		8.3
CeO_2	6.8			CaO	6.0	7.8	8.0
La_2O_3	6.8			Na_2O	11.0	11.5	11.6
Y_2O_3	2.3			K_2O	0.1	0.1	
RE_2O_3	3.1	18.0	18.1	F	4.5		4.2
Fe_2O_3	2.4			H_2O	1.9		1.5
FeO	0.8	1.9	2.1	$-O = F_2$	1.9		1.8
MnO	1.8	1.1	1.2	Total	98.3		100.0

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, wet chemical analysis, spectrography, AA, and TGA; $RE_2O_3 = Nd_2O_3$ 2.2%, Gd_2O_3 0.6%, $(Sm,Eu)_2O_3$ 0.3%; corresponds to $(Na_{6.74}Ca_{2.04}K_{0.04})_{\Sigma=8.82}(La_{0.80}Ce_{0.74}Y_{0.32}RE_{0.44})_{\Sigma=2.30}(Mn_{0.48}Fe^{2+}_{0.21}Zn_{0.12}Pb_{0.04})_{\Sigma=0.85}Fe^{3+}_{0.57}(Si_{13.55}Be_{6.24}Al_{0.26})_{\Sigma=20.05}[O_{40.40}F_{4.51}(OH)_{4.04}]_{\Sigma=48.95}$. (2) Do.; by electron microprobe, partial analysis, average of analysis in (1) and two additional analyses; Ce > La indicated. (3) Analysis calculated from stoichiometry of the crystal structure.

Occurrence: A late-stage hydrothermal mineral developed in cavities within albitite veins cutting alkalic igneous rocks.

Association: Epididymite, eudidymite, "lithium-mica," albite.

Distribution: North of the westernmost end of Lake Taseq, in the Ilímaussaq intrusion, southern Greenland.

Name: Honors Professor E.I. Semenov, Russian mineralogist, Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia.

Type Material: University of Copenhagen, Copenhagen, Denmark; National Museum of Natural History, Washington, D.C., USA, 145810.

References: (1) Petersen, O.V. and J.G. Rønsbo (1972) Semenovite – a new mineral from the Ilímaussaq alkaline intrusion, South Greenland. Lithos, 5, 163–173. (2) (1973) Amer. Mineral., 58, 1114 (abs. ref. 1). (3) Mazzi, F., L. Ungaretti, A. Dal Negro, O.V. Petersen, and J.G. Rönsbo [Rønsbo] (1979) The crystal structure of semenovite. Amer. Mineral., 64, 202–210.

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Semseyite $Pb_9Sb_8S_{21}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular {001}, to 2 cm, or prismatic [010]; elongated along $[\bar{4}01]$ and $[\bar{2}01]$; commonly twisted and composite; also rosettelike groups.

Physical Properties: *Cleavage:* Perfect on {112}. *Tenacity:* Brittle. Hardness = 2.5 VHN = n.d. D(meas.) = 6.03 D(calc.) = 6.12

Optical Properties: Opaque. *Color:* Gray to black; in polished section, white with a pale green tint. *Streak:* Black. *Luster:* Metallic, tarnishes to dull.
Optical Class: Biaxial. *Pleochroism:* Very weak, in yellow green to darker, grayish green.
Anisotropism: Strong.
R_1–R_2: (400) 38.6–44.5, (420) 38.3–44.2, (440) 38.0–43.9, (460) 37.7–43.6, (480) 37.4–43.3, (500) 37.2–43.1, (520) 37.0–42.8, (540) 36.7–42.5, (560) 36.4–42.2, (580) 36.0–41.7, (600) 35.4–41.1, (620) 34.9–40.4, (640) 34.3–39.8, (660) 33.6–39.1, (680) 32.9–38.4, (700) 32.2–37.6

Cell Data: *Space Group:* $C2/c$. $a = 13.603(3)$ $b = 11.936(8)$ $c = 24.435(7)$ $\beta = 106.047(10)°$ Z = 4

X-ray Powder Pattern: Herja, Romania.
3.260 (100), 3.81 (90), 2.949 (90), 2.857 (80), 3.351 (70), 3.88 (60), 2.152 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pb	51.88	52.24	53.10	Fe	trace	0.02	
Sn		0.17		Mn		0.01	
Ag	0.56	0.07		Sb	27.20	27.99	27.73
Cu	0.11	0.01		Bi		0.09	
Zn		0.01		S	19.73	19.92	19.17
Cd		0.10		insol.	1.15		
				Total	100.63	100.63	100.00

(1) Herja, Romania; corresponds to $(Pb_{8.55}Ag_{0.18}Cu_{0.06})_{\Sigma=8.79}Sb_{7.62}S_{21.00}$. (2) Chichibu mine, Japan; by electron microprobe, average of 23 analyses; corresponds to $(Pb_{8.52}Sn_{0.05}Cd_{0.03}Ag_{0.02}Cu_{0.01}Zn_{0.01}Fe_{0.01}Mn_{0.01})_{\Sigma=8.66}(Sb_{7.77}Bi_{0.02})_{\Sigma=7.79}S_{21.00}$. (3) $Pb_9Sb_8S_{21}$.

Occurrence: In hydrothermal veins formed at medium temperature.

Association: Sorbyite, jamesonite, bournonite, zinkenite, guettardite, jordanite, diaphorite, sphalerite, galena, pyrite, chalcopyrite, tetrahedrite, bournonite, arsenopyrite, siderite.

Distribution: In Romania, from Baia Sprie (Felsőbánya) [TL], at Herja (Kisbánya), in the Baia Mare (Nagybánya) district, and from Rodna. In Germany, at Wolfsberg, Harz Mountains, and from the Caspari mine, Arnsberg, North Rhine-Westphalia. From the Les Anglais mine, Massaic, Cantal; Montlucan and Bournac, Montagne Noire, Finistère; Saint-Pons, Alpes-de-Haute-Provence; and elsewhere in France. In Scotland, at the Louisa mine, Glendinning, Eskdale, Dumfries. In Bolivia, at the San José mine, Oruro. From Herminia, in the Julcani district, Peru. At the Brobdignag prospect, near Silverton, San Juan Co., the Argentine Pass area, Clear Creek Co., and near the Maid of Orleans mine, Montezuma district, Summit Co., Colorado, USA. From near Madoc, Ontario, Canada. In the Chichibu mine, Saitama Prefecture, Japan. In small amounts from other occurrences.

Name: In honor of Andor von Semsey (1833–1923), a Hungarian nobleman much interested in minerals.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 466–468. (2) Jambor, J.L. (1969) Sulphosalts of the plagionite group. Mineral. Mag., 37, 442–446. (3) Kohatsu, J.J. and B.J. Wuensch (1974) Prediction of structures in the homologous series $Pb_{3+2n}Sb_8S_{15+2n}$ (the plagionite group). Acta Cryst., 30, 2935–2937. (4) Kato, A., S. Masaaki, and Y. Okada (1997) Re-study of semseyite from the Chichibu mine, Saitama Prefecture, Japan. Bull. Natl. Sci. Mus., Tokyo, Ser. C, 23(3-4), 79–86. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 753–754. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 506.

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Senaite $\mathbf{Pb(Ti,Fe,Mn)_{21}O_{38}}$

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Crystal Data: Hexagonal; may be metamict. *Point Group:* $\overline{3}$. Rough crystals, tabular or acute rhombohedra; in rounded fragments, to several cm. *Twinning:* By rotation around [0001], forming cyclic interpenetrant trillings; on $\{52\overline{7}0\}$.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* [Brittle.] Hardness = > 6 D(meas.) = 5.204–5.301 D(calc.) = [5.23] May be radioactive.

Optical Properties: Opaque, may be transparent in very thin fragments. *Color:* Black; oil-green to greenish black in transmitted light. *Streak:* Brownish black. *Luster:* Submetallic. *Optical Class:* Uniaxial (–); low birefringence. $\omega = 2.50$ (Li). ϵ = n.d. R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.393(2)$ $c = 20.811(5)$ Z = 3

X-ray Powder Pattern: Dattas, Brazil.
2.894 (100), 3.43 (90), 1.981 (75), 1.603 (70), 1.447 (70), 2.468 (50), 2.265 (50)

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5		0.22	FeO	21.99	
TiO_2	50.32	54.88	MnO	17.58	3.33
ThO_2	0.84	0.3	ZnO		0.53
Y_2O_3		3.55	PbO	9.62	9.08
La_2O_3		0.65	MgO		0.15
Ce_2O_3		0.60	BaO		0.3
Fe_2O_3		25.48	SrO		1.1
Cr_2O_3		0.10	Total	100.35	100.27

(1) Curralinho, Brazil. (2) Dattas, Brazil; by electron microprobe, average of four analyses, total Fe as Fe_2O_3, total Mn as MnO; corresponding to $(Pb_{0.76}Sr_{0.20}La_{0.08}Ce_{0.07}Ba_{0.04})_{\Sigma=1.15}$ $(Ti_{12.89}Fe^{3+}_{5.99}Mn_{0.88}Y_{0.59}Zn_{0.12}Mg_{0.07}Nb_{0.03}Cr_{0.02}Th_{0.02})_{\Sigma=20.61}O_{38}$.

Mineral Group: Crichtonite group.

Occurrence: In granite or syenite pegmatites; in a hydrothermal deposit; a detrital mineral.

Association: Ilmenite, rutile, magnetite, hematite.

Distribution: In Brazil, from a number of occurrences in the Diamantina district, as at Datas; Curralinho; Santa Quitéria; Imbiruçu; Vargeas; Rio Cipó; Riacho das Varas; and elsewhere in Minas Gerais [some may be crichtonite]. From Wannigletscher, Binntal, and near Collonges, Valais, Switzerland. On Pizzo Cervandone, Alpe Devero, Val d'Aosta, and at Cuneo, Piedmont, Italy. At Alinci and Nezilovo, Macedonia. From near Tvedalen, Norway. In the Mangruvan Fe–Mn deposit, near Guldsmedshyttan, Örebro, Sweden. In the USA, from St. Peters Dome, near Pikes Peak, El Paso Co., Colorado. At Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Joachim Candido de Costa Sena (1852–1919), Professor of Mineralogy, School of Mines, Ouro Preto, Brazil.

Type Material: The Natural History Museum, London, England, 83656, 86037; National Museum of Natural History, Washington, D.C., USA, R7241.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 541–542. (2) Rouse, R.C. and D.R. Peacor (1968) The relationship between senaite, magnetoplumbite, and davidite. Amer. Mineral., 53, 869–879. (3) Grey, I.E. and D.J. Lloyd (1976) The crystal structure of senaite. Acta Cryst., 32, 1509–1513. (4) Foord, E.E., W.N. Sharp, and J.W. Adams (1984) Zinc- and Y-group-bearing senaite from St Peters Dome, and new data on senaite from Dattas, Minas Gerais, Brazil. Mineral. Mag., 48, 97–106.

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Sénarmontite Sb_2O_3

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly as octahedra, to 3 cm, which may be modified by the cube or dodecahedron; in crusts, granular massive.

Physical Properties: *Cleavage:* {111}, interrupted. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 5.50 D(calc.) = 5.584

Optical Properties: Transparent to translucent. *Color:* Colorless, grayish white; colorless in transmitted light. *Streak:* White. *Luster:* Resinous to subadamantine.
Optical Class: Isotropic; strong anomalous anisotropism, zoned or sectored. $n = 2.087$

Cell Data: *Space Group:* $Fd3m$ (synthetic). $a = 11.1519(2)$ $Z = 16$

X-ray Powder Pattern: Synthetic.
3.218 (100), 1.972 (42), 2.788 (40), 1.681 (35), 6.44 (12), 1.279 (12), 2.559 (11)

Chemistry: Modern analyses are unavailable.

Polymorphism & Series: Dimorphous with valentinite.

Occurrence: Formed by oxidation of antimony, stibnite, and other antimony minerals in hydrothermal antimony-bearing deposits.

Association: Valentinite, kermesite, stibiconite, cetineite, mopungite, sulfur.

Distribution: In large crystals at Sensa (Haminate mine), Aïn-el-Bebbouch, Qacentina (Constantine), Algeria. From the Globe and Phoenix mine, Kwekwe (Que Que), Zimbabwe. At Pernek, near Pezinok, and Dubrava, Slovakia. From Arnsberg, Westphalia, and St. Ulrich, Black Forest, Germany. At Anzat-le-Luguet, Puy-de-Dôme, France. In several mines around St. Endellion and elsewhere in Cornwall, England. From the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. In Canada, from the Lac Nicolet mine, South Ham, Quebec; at Red Lake, Ontario; and in Lake George antimony deposit, 40 km west of Fredricton, New Brunswick. In the Green prospect, Mopung Hills, Churchill Co., Nevada, USA. A few other localities are known.

Name: To honor Henri Hureau de Sénarmont (1808–1862), French physicist and mineralogist, School of Mines, Paris, France, who first noted the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 544–545. (2) Svensson, C. (1975) Refinement of the crystal structure of cubic antimony trioxide, Sb_2O_3. Acta Cryst., 31, 2016–2018. (3) (1954) NBS Circ. 539, 3, 31.

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Senegalite $Al_2(PO_4)(OH)_3 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals, to 1.5 mm, are flattened on [010], showing large {001}, {010}, {101}, {111}, small {100}, {011}, {021}.

Physical Properties: *Cleavage:* On {010}, poor. Hardness = 5.5 D(meas.) = 2.552(7) D(calc.) = 2.551

Optical Properties: Transparent. *Color:* Colorless to pale yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, weak.
$\alpha = 1.562(2)$ $\beta = 1.566(2)$ $\gamma = 1.587(2)$ 2V(meas.) = 53(4)° 2V(calc.) = 48°

Cell Data: *Space Group:* $P2_1nb$. $a = 7.675(4)$ $b = 9.711(4)$ $c = 7.635(4)$ Z = 4

X-ray Powder Pattern: Kouroudiako deposit, Senegal.
3.834 (10), 2.990 (9), 3.610 (8), 2.348 (8), 5.41 (7), 2.070 (7), 1.929 (7)

Chemistry:

	(1)	(2)
P_2O_5	31.83	32.56
Al_2O_3	46.23	46.78
Fe_2O_3	0.28	
H_2O	21.00	20.66
Total	99.34	100.00

(1) Kouroudiako deposit, Senegal; by electron microprobe, total Fe as Fe_2O_3, H_2O by TGA, $(OH)^{1-}$ and H_2O confirmed by IR; corresponds to $Al_{1.98}(PO_4)_{0.98}(OH)_{3.08} \cdot H_2O$.
(2) $Al_2(PO_4)(OH)_3 \cdot H_2O$.

Occurrence: In the oxidized zone of a magnetite iron ore deposit.

Association: Turquoise, augelite, wavellite, crandallite.

Distribution: From the Kouroudiako iron deposit, Falémé river basin, Senegal.

Name: For Senegal, the country in which it was first found to occur.

Type Material: National School of Mines, Paris, France.

References: (1) Johan, Z. (1976) La sénégalite, $Al_2(PO_4)(OH)_3 \cdot H_2O$, un nouveau minéral. Lithos, 9, 165–171 (in French with English abs.). (2) (1977) Amer. Mineral., 62, 595–596 (abs. ref. 1). (3) Keegan, T.D., T. Araki, and P.B. Moore (1979) Senegalite, $Al_2(OH)_3(H_2O)(PO_4)$, a novel structure type. Amer. Mineral., 64, 1243–1247.

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Sengierite $Cu_2(UO_2)_2(V_2O_8)(OH)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are six-sided thin plates, flattened on {001}, to 2 mm, showing {001}, {110}, {100}, {201}, {111}; as flaky coatings.

Physical Properties: *Cleavage:* On {001}, perfect. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 4.05 D(calc.) = 4.10 Radioactive.

Optical Properties: Transparent. *Color:* Yellowish green to greenish yellow. *Streak:* Pale green. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = bluish green to colorless; Y = olive-green to greenish yellow; Z = yellowish green to colorless. *Orientation:* $Y = b$; $X \wedge c = 13°40'$. *Dispersion:* $r < v$, strong. *Absorption:* $Z = Y > X$. α = 1.76–1.77 β = 1.92–1.94 γ = 1.94–1.97 2V(meas.) = 37°–39°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.599(5)$ $b = 8.093(4)$ $c = 10.085(9)$ $\beta = 103.42(6)°$ Z = 2

X-ray Powder Pattern: Luiswishi mine, Congo.
9.82 (vvs), 4.91 (vs), 3.735 (s), 3.197 (s), 3.179 (s), 3.144 (s), 3.094 (s)

Chemistry:

	(1)	(2)
UO_3	47.45	55.05
V_2O_5	15.96	17.50
$(Fe, Al)_2O_3$	1.43	
CuO	14.82	15.31
H_2O	15.77	12.14
Total	95.43	100.00

(1) Luiswishi mine, Congo. (2) $Cu_2(UO_2)_2(V_2O_8)(OH)_2 \cdot 6H_2O$.

Occurrence: A rare secondary mineral, deposited from solutions derived from primary uraninite.

Association: Volborthite, vandenbrandeite, malachite, chrysocolla, cobalt oxides (Luiswishi mine, Congo); chalcocite, covellite, malachite, tyuyamunite, chlorargyrite (Cole shaft, Arizona, USA).

Distribution: From the Luiswishi copper mine, Lubumbashi; at Shinkolobwe and in the Ruiwe, Musonoi, and Mutoshi mines, Katanga Province, Congo (Shaba Province, Zaire). From the Cole shaft, Bisbee, Cochise Co., Arizona, and the Section 33 mine, Grants district, McKinley Co., New Mexico, USA. In the Malargüe district, Mendoza Province, Argentina. At the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France. From the Argana Bigoudine area, Amelal, Morocco.

Name: To honor Edgard Sengier (1879–1963), Director, Union Minière du Haut Katanga, principal mining company in the former Belgian Congo.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 103963.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1047–1048. (2) Hutton, C.O. (1957) Sengierite from Bisbee, Arizona. Amer. Mineral., 42, 408–411. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 258–260. (4) Piret, P., J.-P. Declercq, and D. Wauters-Stoop (1980) Structure cristalline de la sengiérite. Bull. Minéral., 103, 176–178 (in French with English abs.).

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Sepiolite $Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, possible. Compact nodular, earthy, clayey, massive. Rarely fine fibrous along [001], to 2 cm.

Physical Properties: Hardness = 2–2.5 D(meas.) = > 2; dry porous masses float on water. D(calc.) = [2.26]

Optical Properties: Opaque or nearly so. *Color:* Grayish white, white, white with a yellowish or reddish tinge; bluish green. *Luster:* Dull.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless to very pale yellow; $Y = Z$ = golden yellow. α = 1.515–1.520 β = n.d. γ = 1.525–1.529 2V(meas.) = 0°–50°

Cell Data: *Space Group:* *Pncn* or *Pnan*, possible. $a = 5.21$ $b = 26.73$ $c = 13.50$
Z = 4

X-ray Powder Pattern: Eskişehir, Turkey.
12.8 (100), 2.58 (45), 4.53 (35), 4.29 (35), 3.35 (30vb), 3.77 (20), 2.26 (16b)

Chemistry:

	(1)	(2)
SiO_2	52.50	55.65
Al_2O_3	0.60	
Fe_2O_3	2.99	
FeO	0.70	
MgO	21.31	24.89
CaO	0.47	
H_2O^+	21.27	19.46
Total	99.84	100.00

(1) Ampandrandava, Madagascar. (2) $Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$.

Occurrence: A sedimentary clay mineral; also in serpentine.

Association: "Opal," dolomite.

Distribution: Known from many localities, but not in large amounts. A few localities affording good material include: from antiquity, at Eskişehir, Turkey. From Vallecas, near Madrid, and Cabañas, near Toledo, Spain. At Nugssuaq, western Greenland. In the USA, from Middletown, Delaware Co., Pennsylvania; at Gouverneur, St. Lawrence Co., New York; in Little Cottonwood Canyon, Salt Lake Co., Utah; from Crestmore, Riverside Co., California; on the southern High Plains, from Amarillo, Texas to Hobbs, New Mexico; at Ash Meadows, Nye Co., Nevada. From Cerro Mercado, Durango, Mexico. From near Lake Amboseli, Kenya. At Lake Natron, Tanzania. From Ampandrandava, Madagascar. At Kuzuu, Tochigi Prefecture, Japan.

Name: From the Greek for *cuttle-fish*, the bone of which resembles the mineral in being light and porous.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 680–681.
(2) Brauner, K. and A. Preisinger (1956) Structur und Entstehung des Sepioliths. Tschermaks Mineral. Petrog. Mitt., 6, 120–140 (in German). (3) Brindley, G.W. (1959) X-ray and electron diffraction data for sepiolite. Amer. Mineral., 44, 495–500. (4) McLean, S.A., B.L. Allen, and J.R. Craig (1972) The occurrence of sepiolite and attapulgite on the southern High Plains. Clays and Clay Minerals, 20, 143–149. (5) Nagata, H., S. Shimoda, and T. Sudo (1974) On dehydration of bound water of sepiolite. Clays and Clay Minerals, 22, 285–293.

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Sérandite $Na(Mn^{2+},Ca)_2Si_3O_8(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Prismatic to acicular crystals, elongated along [010]; bladed, blocky, or tabular crystals, flattened on {100}, to 20 cm. As radiating crystal aggregates; massive. *Twinning:* Around [010], with composition plane {100}; less commonly contact twinned by reflection on {110}.

Physical Properties: *Cleavage:* Perfect on {001}, {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 3.34 D(calc.) = 3.42

Optical Properties: Transparent to translucent. *Color:* Rose-red, orange, salmon-pink, light pink, colorless, brown, black; colorless in thin section. *Streak:* White. *Luster:* Vitreous to greasy; fibrous aggregates are dull to silky.
Optical Class: Biaxial (+). *Dispersion:* $r < v$, moderate. $\alpha = 1.668$ $\beta = 1.671$ $\gamma = 1.703$ 2V(meas.) = 39° 2V(calc.) = 39°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.683(1)$ $b = 6.889(1)$ $c = 6.747(1)$ $\alpha = 90.53(5)°$ $\beta = 94.12(2)°$ $\gamma = 102.75(2)°$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada. (ICDD 25-723).
2.983 (100), 3.158 (90), 2.838 (65), 2.192 (60), 2.495 (45), 2.602 (35), 7.51 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	48.72	49.88	CaO	10.42	2.62
Al_2O_3	0.29		Na_2O	7.38	8.63
Fe_2O_3	0.03		K_2O	0.26	0.01
FeO	1.33	0.13	H_2O^+	2.67	
MnO	28.99	37.33	H_2O^-	0.11	
MgO	0.06	0.13	H_2O		[1.27]
			Total	[100.26]	[100.00]

(1) Rouma Isle, Guinea; original total given as 100.46%. (2) Tanohata mine, Japan; by electron microprobe, H_2O by difference; corresponds to $Na_{1.00}(Mn^{2+}_{1.88}Ca_{0.17}Mg_{0.01})_{\Sigma=2.06}Si_{2.97}O_8(OH)$.

Polymorphism & Series: Forms a series with pectolite.

Occurrence: In sodalite xenoliths and pegmatites cutting syenites and nepheline syenites in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in vugs in phonolite (Point of Rocks, New Mexico, USA); in a contact metamorphosed terrigenous volcanogenic manganese deposit (Tumannoe deposit, Russia).

Association: Sodalite, nepheline, aegirine, astrophyllite, arfvedsonite, eudialyte, leucophanite, analcime, villiaumite, fluorite (Rouma Isle, Guinea); analcime, aegirine, mangan-neptunite, microcline (Mont Saint-Hilaire, Canada).

Distribution: From Rouma Isle, Los Islands, Guinea. In the USA, at Point of Rocks, Colfax Co., New Mexico; from the Gem mine, San Benito Co., California; on Granite Mountain, near Little Rock, Pulaski Co., Arkansas. Large crystals from Mont Saint-Hilaire, and from near Saint-Amable, Quebec, Canada. In the Tanohata mine, Iwate Prefecture, Japan. At the Tumannoe deposit, Bol'shoi Santar Island, Okhotsk Sea, and on Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: Honors J.M. Sérand, who aided the collection of type material.

Type Material: National Museum of Natural History, Washington, D.C., USA, 96515.

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References: (1) Lacroix, A. (1931) Les pegmatites de la syénite sodalitique de l'île Rouma (Archipel de Los, Guinée française). Description d'un nouveau minéral (sérandite) qu'elles renferment. Compt. Rendus Acad. Sci. Paris, 192, 187–194 (in French). (2) (1931) Amer. Mineral., 16, 344 (abs. ref. 1). (3) Takéuchi, Y., Y. Kudoh, and T. Yamanaka (1976) Crystal chemistry of the serandite-pectolite series and related minerals. Amer. Mineral., 61, 229–237. (4) Mandarino, J.A. and V. Anderson (1989) Monteregian treasures. Cambridge Univ. Press, 183. (5) Richards, R.P. (1991) Twin laws for serandite from Mont Saint-Hilaire, Quebec. Rocks & Minerals, 66, 44 (abs.).

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Serendibite $Ca_2(Mg,Al)_6(Si,Al,B)_6O_{20}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Rarely in small tabular crystals; as anhedral grains, to 2 cm, and aggregates. *Twinning:* Polysynthetic on $\{0\bar{1}1\}$, common.

Physical Properties: *Cleavage:* Good on {010}, {001}; (010) ∧ (001) ∼66°. Hardness = 6.5–7 D(meas.) = 3.42–3.52 D(calc.) = 3.47

Optical Properties: Transparent. *Color:* Grayish blue-green to deep blue, green, or brown; in transmitted light, nearly colorless to pale yellow-green or blue. *Luster:* Vitreous. *Optical Class:* Biaxial (+) or (–). *Pleochroism:* Strong; X = pale yellow, yellow-green to blue-green; Y = almost colorless, pale yellow, blue, blue-green; Z = light to dark blue. *Orientation:* $Z \wedge c = 26°–40°$. *Dispersion:* $r > v$, strong to extremely strong; may produce abnormal interference colors. α = 1.700–1.738 β = 1.703–1.741 γ = 1.706–1.743 2V(meas.) = 78°–90°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.019$ $b = 10.393$ $c = 8.630$ $\alpha = 106.36°$ $\beta = 96.06°$ $\gamma = 124.36°$ Z = 2

X-ray Powder Pattern: Melville Peninsula, Canada.
2.846 (100), 2.595 (80), 2.461 (80), 2.038 (70), 2.032 (70), 2.018 (50), 3.320 (40)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	25.33	22.54	MnO		0.13	F		0.02
TiO_2		0.09	MgO	14.91	13.63	H_2O^+	0.69	
B_2O_3	[4.17]	7.80	CaO	14.56	15.76	P_2O_5	0.48	
Al_2O_3	34.96	34.18	Na_2O	0.51	0.05	Total	[100.00]	[100.08]
FeO	4.17	5.88	K_2O	0.22				

(1) Gangapitiya, Sri Lanka; B_2O_3 by difference; corresponds to $(Ca_{1.89}Na_{0.12}K_{0.02})_{\Sigma=2.03}(Al_{2.92}Mg_{2.69}Fe^{2+}_{0.42})_{\Sigma=6.03}(Si_{3.04}Al_{1.57}B_{1.39})_{\Sigma=6.00}O_{20}$. (2) Tayozhnoye deposit, Russia; by electron microprobe, B by ion microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry, original total given as 100.07%; corresponds to $(Ca_{1.99}Na_{0.01})_{\Sigma=2.00}(Al_{3.00}Mg_{2.40}Fe^{3+}_{0.34}Fe^{2+}_{0.24}Ti_{0.01}Mn_{0.01})_{\Sigma=6.00}(Si_{2.66}Al_{1.75}B_{1.59})_{\Sigma=6.00}O_{20}$.

Mineral Group: Aenigmatite group.

Occurrence: In skarns, affected by boron metasomatism, along the contact between carbonate rocks and granite, tonalite, or granulite.

Association: Diopside, spinel, phlogopite, scapolite, calcite, tremolite, apatite, grandidierite, sinhalite, hyalophane, uvite, pargasite, clinozoisite, forsterite, warwickite, graphite.

Distribution: At Gangapitiya, near Ambakotte, Sri Lanka. In the USA, from near Johnsburg, Warren Co., Amity, near Warwick, Orange Co., and Russell, St. Lawrence Co., New York; and in the New City quarry, three km south of Riverside, Riverside Co., California, USA. On the Melville Peninsula, Northwest Territories, Canada. In Russia, in the Tayozhnoye iron deposit, 550 km south of Yakutsk, Yakutia. From the Handeni district, Tanzania. At Ianapera and Ihosy, Madagascar.

Name: From the old Arabic name, *Serendib*, for Sri Lanka (Ceylon).

Type Material: n.d.

References: (1) Prior, G.T. and A.K. Coomáraswámy (1903) Serendibite, a new borosilicate from Ceylon. Mineral. Mag., 13, 224–227. (2) Machin, M.P. and P. Süsse (1974) Serendibite: a new member of the aenigmatite structure group. Neues Jahrb. Mineral., Monatsh., 435–441. (3) Hutcheon, I., A.E. Gunter, and A.N. Lecheminant (1977) Serendibite from Penrhyn group marble, Melville Peninsula, District of Franklin. Can. Mineral., 15, 108–112. (4) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 659–661. (5) Grew, E.S., N.N. Pertsev, V.A. Boronikhin, S.Y. Borisovskiy, M.G. Yates, and N. Marquez (1991) Serendibite in the Tayozhnoye deposit of the Aldan Shield, eastern Siberia, U.S.S.R. Amer. Mineral., 76, 1061–1080.

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Sergeevite $Ca_2Mg_{11}(CO_3)_9(HCO_3)_4(OH)_4 \cdot 6H_2O(?)$

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Crystal Data: Hexagonal (?). *Point Group:* n.d. Rhombohedral crystals, to 0.5 μm, in globular concretions and irregular veinlets.

Physical Properties: *Fracture:* Uneven to conchoidal. Hardness = ∼3.5 D(meas.) = 2.55–2.87 D(calc.) = 2.64

Optical Properties: Semitransparent. *Color:* White. *Luster:* Dull.
Optical Class: Uniaxial, birefringence 0.010–0.012. $n = 1.581$ ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* n.d. $a = 19.01$ $c = 7.82$ Z = 3

X-ray Powder Pattern: Malyi Mukulan deposit, Russia.
2.821 (100), 7.14 (30), 3.58 (30), 2.87 (30), 1.965 (27), 1.755 (20), 3.37 (15)

Chemistry:

	(1)	(2)
SiO_2	0.73	
CO_2	43.17	43.75
Al_2O_3	0.21	
FeO	1.08	
CuO	0.64	
MgO	33.20	33.90
CaO	7.80	8.58
H_2O	12.88	13.77
Total	99.71	100.00

(1) Malyi Mukulan deposit, Russia; $(CO_3)^{2-}$, $(HCO_3)^{1-}$, $(OH)^{1-}$ confirmed by IR, chrysocolla impurity estimated about 1.3%. (2) $Ca_2Mg_{11}(CO_3)_9(HCO_3)_4(OH)_4 \cdot 6H_2O$.

Occurrence: A weathering product of pyroxene–garnet skarn.

Association: Huntite, chrysocolla, chalcanthite, brochantite, malachite, gypsum, epsomite, "limonite".

Distribution: From the Malyi Mukulan tin deposit, Tyrnyauz district, Baksan River Valley, northern Caucasus Mountains, Russia.

Name: To honor Professor Yevgenii Mikhailovich Sergeev (1924–1997), geological engineer, Moscow University, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1262/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80181, 82947.

References: (1) Yakhontova, L.K., I.I. Ilyusnina, T.I. Stolyarova, Y.K. Yegorov-Tismenko, and L.V. Kuleshevich (1980) Sergeevit – a new hydrous carbonate of magnesium and calcium. Zap. Vses. Mineral. Obshch., 109, 217–223 (in Russian). (2) (1981) Amer. Mineral., 66, 1100 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 182.

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Serpierite $Ca(Cu,Zn)_4(SO_4)_2(OH)_6 \cdot 3H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are lathlike, elongated along [010], flattened on {100}, with $\{10\overline{1}\}$, $\{31\overline{1}\}$, $\{\overline{3}11\}$, other minor forms, to 5 mm, in tufted aggregates and botryoidal fibrous masses.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = n.d. D(meas.) = 3.07 D(calc.) = 3.08

Optical Properties: Transparent. *Color:* Sky-blue; greenish blue in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Pleochroism:* X = nearly colorless, pale green; Y = bluish green; Z = deep greenish blue, blue-green. *Orientation:* $Y = b$; $X \wedge a = 24°$, $Z \simeq c$. *Dispersion:* $r > v$, strong. $\alpha = 1.584(3)$ $\beta = 1.642(3)$ $\gamma = 1.647(3)$ 2V(meas.) = 35(2)° 2V(calc.) = 37°

Cell Data: *Space Group:* $C2/c$. $a = 22.186(2)$ $b = 6.250(2)$ $c = 21.853(2)$ $\beta = 113.36(1)°$ Z = 8

X-ray Powder Pattern: Laurium, Greece; similar to devilline.
10.22 (vs), 5.09 (s), 3.386 (s), 2.708 (ms), 2.650 (ms), 2.440 (ms), 4.744 (m)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	24.29	24.78	CaO	8.00	8.68
CuO	36.12	24.62	H_2O	16.75	16.73
ZnO	13.95	25.19	Total	99.11	100.00

(1) Laurium, Greece; corresponds to $Ca_{0.93}(Cu_{2.96}Zn_{1.12})_{\Sigma=4.08}(SO_4)_{1.98}(OH)_{6.06} \cdot 3.03H_2O$.
(2) $Ca(Cu,Zn)_4(SO_4)_2(OH)_6 \cdot 3H_2O$ with Cu:Zn = 1:1.

Polymorphism & Series: Dimorphous with orthoserpierite.

Occurrence: A secondary mineral in the oxidized zone of hydrothermal Cu–Zn-bearing hydrothermal mineral deposits; commonly a post-mine product.

Association: Smithsonite, devilline, posnjakite, ktenasite, linarite, langite, brochantite, wroewolfeite, namuwite, schulenbergite, hydrozincite, malachite, gypsum.

Distribution: From the Kamariza mine, Laurium, Greece. On Ross Island, Lough Leane, Co. Kerry, Ireland. In England, in the Waterbank mine, Ecton, Staffordshire; from the Potts Gill and other mines, Caldbeck Fells, Cumbria; at the Smallcleugh mine, Nenthead, Northumberland. From the West Blackcraig mine, near Newton Stewart, Kirkcudbrightshire, Scotland. At the Friedrichssegen mine, near Bad Ems, Rhineland-Palatinate, Germany. Rich masses from the Prince Leopold mine, Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). At Tsumeb, Namibia. In the USA, in Colorado, large crystals from the Bulldog Mountain mine, Creede district, Mineral Co., at the Titusville mine, San Juan Co., and a number of other places; from the Bay Horse mine, Challis, Custer Co., Idaho; in the Linchburg mine, nine km south of Magdalena, Socorro Co., New Mexico. From the Otoño mine, Caborca, Sonora, Mexico. At Broken Hill, New South Wales, Australia. A number of additional minor localities are now known.

Name: Honors Giovanni Battista Serpieri (1832–1897), Italian engineer, who helped to reopen the ancient mines at Laurium, Greece.

Type Material: Natural History Museum, Paris, France, 73.38, 78.226.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 592–593. (2) Faraone, D., C. Sabelli, and P.F. Zanazzi (1967) Su du solfati basici idrati: serpierite e devillite. Atti Rend. Accad. Lincei, 43, 369–382 (in Italian with English abs.). (3) Sabelli, C. and P.F. Zanazzi (1968) The structure of serpierite. Acta Cryst., 24, 1214–1221. (4) Krause, W. and H. Täuber (1992) Zum Kenntnisstand der Minerale Serpierit, Orthoserpierit und Devillin. Aufschluss, 43(1), 1–25 (in German).

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Shabaite-(Nd) $Ca(Nd,Y,Sm)_2(UO_2)(CO_3)_4(OH)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m or 2. Crystals are rounded micaceous plates, flattened on {010} and elongated along [100], in rosettes, to 5 mm. *Twinning:* On {001}.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 2.5 D(meas.) = 3.13(10) D(calc.) = 3.23 Radioactive.

Optical Properties: Translucent to opaque. *Color:* Pale greenish yellow, pale green; very pale yellow in transmitted light. *Luster:* Pearly.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = 3°–4°$. $\alpha = 1.534(2)$ $\beta = [1.590(4)]$ $\gamma = 1.600(2)$ 2V(meas.) = 44°

Cell Data: *Space Group:* $P2/m$, Pm, or $P2$. $a = 9.208(5)$ $b = 32.09(3)$ $c = 8.335(4)$ $\beta = 90.3(1)°$ Z = 5

X-ray Powder Pattern: Kamoto-East mine, Congo.
15.9 (100), 7.31 (70), 4.17 (70), 3.072 (60b), 4.58 (50), 4.01 (30), 9.20 (20)

Chemistry:

	(1)
UO_3	30.32
CO_2	18.92
Y_2O_3	4.91
La_2O_3	1.50
Ce_2O_3	0.50
Pr_2O_3	2.36
Nd_2O_3	13.58
Sm_2O_3	5.54
Dy_2O_3	2.96
CaO	5.99
H_2O	13.49
Total	100.07

(1) Kamoto-East mine, Congo; by electron microprobe, average of ten analyses, CO_2, H_2O by gas chromatography; corresponds to $Ca_{1.01}(Nd_{0.76}Y_{0.42}Sm_{0.30}Dy_{0.14}Pr_{0.14}La_{0.08}Ce_{0.04})_{\Sigma=1.88}(UO_2)_{1.00}(CO_3)_{4.08}(OH)_{1.50} \cdot 5.57H_2O$.

Occurrence: A very rare secondary mineral in the oxidized zone of a uranium-bearing Cu–Co deposit.

Association: Uraninite, uranophane, kamotoite-(Y), astrocyanite-(Ce), françoisite-(Nd), schuilingite-(Nd), masuyite.

Distribution: From the Kamoto-East Cu–Co mine, five km west of Kolwezi, Katanga Province, Congo (Shaba Province, Zaire).

Name: For Shaba, a former name of Katanga Province, Congo.

Type Material: Royal Belgian Institute of Natural Sciences, Brussels, Belgium, RC3511.

References: (1) Deliens, M. and P. Piret (1989) La shabaïte-(Nd), $Ca(TR)_2(UO_2)(CO_3)_4(OH)_2.6H_2O$, nouvelle espèce minérale de Kamoto, Shaba, Zaïre. Eur. J. Mineral., 1, 85–88 (in French with English abs.). (2) (1990) Amer. Mineral., 75, 433–434 (abs. ref. 1).

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Shabynite $Mg_5(BO_3)(Cl,OH)_2(OH)_5 \cdot 4H_2O$

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Crystal Data: Monoclinic (?). *Point Group:* n.d. Fine fibrous, in veinlets, to 1 cm thick.

Physical Properties: *Tenacity:* Elastic. Hardness = 3 D(meas.) = 2.32 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Snow-white.
Optical Class: Biaxial (–). *Orientation:* $X \parallel$ elongation, parallel extinction. $\alpha = 1.543(2)$ $\beta = 1.571(3)$ $\gamma = 1.577(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Korshunovskoye deposit, Russia.
9.27 (10), 2.439 (8), 3.69 (7b), 5.47 (6), 2.377 (6), 4.21 (5), 1.798 (5)

Chemistry:

	(1)		(1)
SiO_2	0.05	Na_2O	0.29
TiO_2	0.01	K_2O	0.03
B_2O_3	8.08	F	0.06
Al_2O_3	0.00	Cl	13.06
Fe_2O_3	0.18	H_2O^+	27.18
MnO	0.34	H_2O^-	3.00
MgO	50.20	$-O = (F,Cl)_2$	2.95
CaO	0.40	Total	99.93

(1) Korshunovskoye deposit, Russia; $(BO_3)^{3-}$, $(OH)^{1-}$, H_2O confirmed by IR; corresponds to $Mg_{5.05}(BO_3)_{0.94}[Cl_{1.49}(OH)_{0.79}]_{\Sigma=2.28}(OH)_5 \cdot 3.90H_2O$.

Occurrence: As veinlets in a brecciated dolomitic marble in a skarn magnetite deposit.

Association: Dolomite, korshunovskite, ekaterinite, dashkovaite, iowaite, halite.

Distribution: From the Korshunovskoye iron–boron skarn deposit, Irkutsk district, Siberia, Russia.

Name: Honors Leonid Ivanovich Shabynin (1909–), Russian geologist, specialist in skarn deposits, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1225/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 80672; National Museum of Natural History, Washington, D.C., USA, 160483.

References: (1) Pertsev, N.N., S.V. Malinko, V.A. Vakhrushev, B.P. Fitsev, E.V. Sokolova, and I.B. Nikitina (1980) Shabynite – a new hydrated borate-chloride of magnesium. Zap. Vses. Mineral. Obshch., 109, 569–573 (in Russian). (2) (1981) Amer. Mineral., 66, 1101 (abs. ref. 1).

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Shadlunite $(Pb, Cd)(Fe, Cu)_8S_8$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, as irregular grains, to 0.4 mm; also in veinlets, mainly in cubanite. *Twinning:* Polysynthetic, seen in polished section.

Physical Properties: Hardness = n.d. VHN = 210 (20 g load). D(meas.) = n.d. D(calc.) = 4.72

Optical Properties: Opaque. *Color:* In polished section, grayish yellow. *Luster:* Metallic. *Optical Class:* Isotropic. *Pleochroism:* Weak. *Anisotropism:* Weak.
R: (400) — , (420) — , (440) 18.0, (460) 19.5, (480) 20.8, (500) 22.0, (520) 23.4, (540) 24.5, (560) 25.8, (580) 26.9, (600) 27.7, (620) 28.7, (640) 29.3, (660) 30.2, (680) 30.8, (700) 31.2

Cell Data: *Space Group: Fm3m.* a = 10.91 Z = 4

X-ray Powder Pattern: Majak mine, Russia.
3.29 (10), 1.925 (9), 3.84 (4), 2.11 (4), 5.42 (3), 3.16 (2), 1.666 (2)

Chemistry:

	(1)
Cu	27.5
Fe	24.1
Pb	16.6
Cd	3.9
S	27.4
Total	99.5

(1) Majak mine, Russia; by electron microprobe, corresponding to $(Pb_{0.75}Cd_{0.32})_{\Sigma=1.07}(Fe_{4.04}Cu_{4.05})_{\Sigma=8.09}S_{8.00}$.

Mineral Group: Pentlandite group.

Occurrence: As tiny grains and veinlets cutting Cu–Ni sulfide ores.

Association: Manganese-shadlunite, cubanite, talnakhite.

Distribution: In Russia, from the Majak [TL] and Oktyabr mines, Talnakh area, Noril'sk region, western Siberia, and at the Ust'-Khann'ya intrusive, lower Khann'ya River, Vilyui River basin, eastern Siberia. In the USA, in the Minnamax Cu–Ni sulfide deposit, Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota, and from the Cove mine, McCoy district, Lander Co. Nevada.

Name: In honor of Soviet mineralogist Tat'yana Nikolaevna Shadlun (1912–1996), researcher on ore minerals, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75510.

References: (1) Evstigneeva, T.L., A.D. Genkin, N.V. Troneva, A.A. Filimonova, and A.I. Tsepin (1973) Shadlunite, a new sulfide of copper, iron, lead, manganese and cadmium from copper–nickel ores. Zap. Vses. Mineral. Obshch., 102, 63–74 (in Russian). (2) (1973) Amer. Mineral., 58, 1114 (abs. ref. 1).

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Shafranovskite $(Na,K)_6(Mn^{2+},Fe^{2+})_3Si_9O_{24}\cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As granular aggregates, to 5 mm.

Physical Properties: *Cleavage:* Well developed on {0001}. *Fracture:* Conchoidal. Hardness = 2–3 in aggregate. D(meas.) = 2.76–2.78 D(calc.) = 2.78 Strongly electromagnetic.

Optical Properties: Translucent. *Color:* Dark green to olive-green or yellow-green; pale yellow-green in thin section. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.587(2)$ $\epsilon = 1.570(2)$

Cell Data: *Space Group:* $P31m$ or $P3m1$. $a = 14.58$ $c = 21.01$ Z = 6

X-ray Powder Pattern: Kola Peninsula, Russia.
10.54 (100), 3.51 (70), 2.787 (60), 2.975 (50b), 3.60 (45b), 10.77 (35)

Chemistry:

	(1)
SiO_2	47.52
TiO_2	0.12
Al_2O_3	0.39
Fe_2O_3	1.85
FeO	6.10
MnO	14.50
MgO	0.34
CaO	0.61
Na_2O	10.24
K_2O	7.82
H_2O	9.78
Total	99.27

(1) Kola Peninsula, Russia; corresponds to $(Na_{3.63}K_{1.82}Mn^{2+}_{0.29}Ca_{0.12})_{\Sigma=5.86}(Mn^{2+}_{1.95}Fe^{2+}_{0.93}Mg_{0.09}Ti_{0.02}Fe^{3+}_{0.01})_{\Sigma=3.00}(Si_{8.68}Fe^{3+}_{0.24}Al_{0.01})_{\Sigma=8.93}O_{24}\cdot 5.96H_2O$.

Occurrence: Produced by late-stage crystallization of alkalic nepheline syenite magmas in pegmatites in differentiated alkalic massifs.

Association: Thermonatrite, natrophosphate, nacaphite, olympite, sidorenkite, aegirine, villiaumite, phosinaite, rasvumite.

Distribution: On Mts. Rasvumchorr, Niorkpakhk, Koashkar, and Koashva, Khibiny massif, and at the Jubilee pegmatite, Mt. Karnasurt, and several other localities in the Lovozero massif, Kola Peninsula, Russia.

Name: Honors Professor Ilarion Ilarionovich Shafranovskii (1907–1994), mineralogist and crystallographer at the Mining Institute, St. Petersburg, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5713/1; Mining Institute, St. Petersburg, 1202/1; Vernasdsky Geological Institute, 57772; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81593.

References: (1) Khomyakov, A.P., Z.V. Vrubelevskaya, B.B. Zvyagin, N.A. Mateeva, and G.O. Piloyan (1982) Shafranovskite $(Na,K)_6(Mn,Fe)_3Si_9O_{24}\cdot 6H_2O$, a new mineral. Zap. Vses. Mineral. Obshch., 111, 475–480 (in Russian). (2) (1983) Amer. Mineral., 68, 644 (abs. ref. 1). (3) (1983) Chem. Abs., 98, 19574 (abs. ref. 1). (4) (1983) Mineral. Abs., 34, 1961 (abs. ref. 1).

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Shakhovite $Hg_4^{1+}Sb^{5+}O_3(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* m. Platy crystals, to about 2 mm, slightly elongated.

Physical Properties: *Cleavage:* In two directions, parallel elongation. *Tenacity:* Brittle. Hardness = 3–3.5 VHN = 285–362, 317 average (20 g load). D(meas.) = 8.34–8.51, 8.38 average. D(calc.) = 8.60

Optical Properties: Semitransparent. *Color:* Bright lettuce-green, olive-green, yellowish green, darkening on exposure; grayish white in reflected light. *Streak:* Yellowish white. *Luster:* Adamantine.
Optical Class: Biaxial; high birefringence. *Pleochroism:* Weak; olive-green to colorless.
$\alpha = > 2.03$ $\beta = > 2.03$ $\gamma = > 2.03$ 2V(meas.) = n.d.
R_1–R_2: (434) 24.5–19.0, (460) 22.5–17.6, (486) 21.5–16.4, (500) 21.5–16.2, (546) 20.2–15.8, (590) 20.3–15.6, (656) 18.2–13.4

Cell Data: *Space Group:* Im. $a = 4.871(1)$ $b = 15.098(3)$ $c = 5.433(1)$ $\beta = 98.86(2)^\circ$
$Z = 2$

X-ray Powder Pattern: Kelyana mine, Russia.
3.88 (10), 3.33 (8), 2.69 (6), 2.63 (5), 2.552 (5), 1.931 (3.5), 3.47 (3b)

Chemistry:

	(1)	(2)	(3)	(4)
Hg	77.25	77.57	77.3	78.42
Sb	11.53	11.93	12.1	11.90
O	9.88	9.67		9.38
H				0.30
Total	98.66	99.17		100.00

(1) Kelyana mine, Russia; by electron microprobe, Hg average of 24 analyses, Sb average of 13 analyses, O average of five analyses; Cu, As, Cl, S absent; corresponding to $Hg_{4.03}Sb_{1.00}O_{6.47}$. (2) Khaydarkan, Kyrgyzstan; by electron microprobe, Hg average of 15 analyses, Sb average of 10 analyses, O average of seven analyses; corresponding to $Hg_{4.09}Sb_{1.04}O_{6.38}$. (3) Landsberg, Germany; by electron microprobe, presence of $(OH)^{1-}$ confirmed by IR. (4) $Hg_4SbO_3(OH)_3$.

Occurrence: A late-stage secondary mineral in the oxidation zone of cinnabar-stibnite ore (Kelyana mine, Russia); in the oxidation zone of cinnabar-livingstonite ore (Khaydarkan, Kyrgyzstan); in oxidized Hg–Sb-bearing tetrahedrite ore (Landsberg, Germany).

Association: Calomel, eglestonite, mercury, montroydite, terlinguaite, corderoite, kelyanite, kuznetsovite, antimony oxides (Kelyana mine, Russia); calomel, cinnabar, mercury, malachite, goethite (Landsberg, Germany).

Distribution: In the Kelyana Sb–Hg mine, North Muya Mountains, Buryatia, Transbaikal, Siberia, Russia. From the Khaydarkan deposit, Fergana Valley, Alai Range, south Kyrgyzstan. At Landsberg, near Obermoschel, and Stahlberg, Rhineland-Palatinate, Germany.

Name: To honor Feliks Nikolaevich Shakhov (1894–1971), Head of the Division of Geochemistry of the Russian Academy of Sciences, Novosibirsk, Russia.

Type Material: Central Siberian Geological Museum, Siberian Division, Academy of Sciences, Novosibirsk, BII-30/1; Mining Institute, St. Petersburg, 1212/1–2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81603.

References: (1) Vasil'ev, V.I., Y.G. Lavrent'ev, and N.A. Pal'chik (1980) Shakhovite – $Hg_8Sb_2O_{13}$ – a new supergene mineral. Geol. i Geofiz., 128–132 (in Russian with English abs.). (2) (1981) Amer. Mineral., 66, 1101 (abs. ref. 1). (3) Tillmanns, E., R. Krupp, and K. Abraham (1982) New data on the mercury antimony mineral shakhovite: chemical composition, unit cell and crystal structure. Tschermaks Mineral. Petrog. Mitt., 30, 227–235. (4) Baur, W.H. and E. Tillmanns (1986) How to avoid unnecessarily low symmetry in crystal structure determinations. Acta Cryst., 42, 95–111.

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Shandite $Pb_2Ni_3S_2$

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Crystal Data: Hexagonal, pseudocubic. *Point Group:* $\overline{3}\,2/m$. As minute grains embedded in serpentine; oriented within and as thin rims on other sulfides.

Physical Properties: *Cleavage:* Rhombohedral. Hardness = 4 VHN = n.d.
D(meas.) = 8.72 D(calc.) = 8.87

Optical Properties: Opaque. *Color:* In polished section, cream-white. *Luster:* Metallic. *Pleochroism:* Distinct. *Anisotropism:* Strong; in gray-blue and yellow-brown.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 5.591(1)$ $c = 13.579(1)$ Z = 3

X-ray Powder Pattern: Synthetic.
2.794 (100), 2.779 (98), 1.971 (86), 3.943 (84), 2.281 (81), 1.610 (42), 1.759 (31)

Chemistry:

	(1)	(2)
Pb	61.64	63.30
Cu	0.00	
Zn	0.01	
Ni	28.40	26.90
Fe	0.43	
Co	0.14	
Mn	0.08	
Bi	0.00	
S	9.58	9.80
Total	[100.28]	100.00

(1) Isua Belt, Greenland; by electron microprobe, original total given as 100.29%; corresponds to $Pb_{1.91}Fe_{0.05}Mn_{0.01}Ni_{3.10}Co_{0.02}S_{1.91}$. (2) $Pb_2Ni_3S_2$.

Occurrence: In serpentine (Trial Harbour, Australia and Isua Belt, Greenland); in segregations in an iron-rich lens in basalt (Kitdlît, Greenland).

Association: Heazlewoodite, pentlandite, sphalerite, chromite, magnetite (Trial Harbour, Australia); galena, altaite, lead, iron, troilite (Kitdlît, Greenland); heazlewoodite, pentlandite (Isua Belt, Greenland).

Distribution: In Australia, from Trial Harbour, Tasmania [TL], and at Nullagine, Western Australia. From near Kitdlît, Disko Island, and in the Isua Belt, about 150 km northeast of Godthåb, western Greenland. In the Jeffrey mine, Asbestos, Quebec, Canada. From the Itoigawa district, Niigata Prefecture, Japan.

Name: To honor the Scottish petrologist, Professor Samuel James Shand (1882–1957), of Columbia University, New York, USA.

Type Material: n.d.

References: (1) Ramdohr, P. (1950) Über das Vorkommen von Heazlewoodit Ni_3S_2 und über ein neues ihn begleitendes Mineral: Shandit $Ni_3Pb_2S_2$. Sitzungsbarichte der Deutchen Akademie der Wissenschaften zu Berlin (Matematischnaturwissenschaftlische Klasse, Jahrgang 1949) 6, 1–29 (in German). (2) Peacock, M.A. and J. McAndrew (1950) On parkerite and shandite and the crystal structure of $Ni_3Pb_2S_2$. Amer. Mineral., 35, 425–439. (3) Brower, W.S., H.S. Parker, and R.S. Roth (1974) Reexamination of synthetic parkerite and shandite. Amer. Mineral., 59, 296–301. (4) Clauss, A., M. Warasteh, and K. Weber (1978) Kristallchemische Untersuchung der Mischungsreihe $Ni_3Pb_2S_2$–$Ni_3Pb_2Se_2$ sowie eine Bemerkung zur Shandit-Struktur. Neues Jahrb. Mineral., Monatsh., 256–268 (in German with English abs.). (5) Dymek, R.F. (1987) Shandite, $Ni_3Pb_2S_2$, in a serpentinized metadunite from the Isua Supracrustal Belt, west Greenland. Can. Mineral., 25, 245–249. (6) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 404–405.

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Shannonite $Pb_2O(CO_3)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Anhedral to platy crystals, to 400 μm, aggregated into porcelaneous crusts.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3–3.5
D(meas.) = n.d. D(calc.) = 7.31–7.59

Optical Properties: Opaque. *Color:* White; white in reflected light, due to white internal reflections. *Streak:* White. *Luster:* Waxy.
Optical Class: Biaxial. n = [2.09] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_12_12_1$ (synthetic). $a = 9.014(1)$ $b = 9.315(1)$ $c = 5.1465(7)$
Z = 4

X-ray Powder Pattern: Grand Reef mine, Arizona, USA.
3.215 (100), 3.181 (90), 4.02 (40), 2.858 (40), 2.564 (35), 6.49 (30), 4.14 (30)

Chemistry:

	(1)	(2)
CO_2	9.70	8.97
PbO	89.9	91.03
Total	99.6	100.00

(1) Grand Reef mine, Arizona, USA; by electron microprobe, CO_2 by CHN analyzer; corresponding to $Pb_{1.91}O(C_{1.05}O_3)$. (2) $Pb_2O(CO_3)$.

Occurrence: A rare secondary mineral formed in the oxidation zone, probably by acidic groundwater reacting with cerussite, in a lead ore deposit (Grand Reef mine, Arizona, USA).

Association: Cerussite, litharge, massicot, minium, hydrocerussite, fluorite, plumbojarosite, hematite, manganese oxides, quartz, muscovite (Grand Reef mine, Arizona, USA).

Distribution: From the Grand Reef mine, about six km northeast of Klondyke, Aravaipa district, Graham Co., Arizona, USA.

Name: Honors David Michael Shannon (1942–2003?2002??ck??), mineral dealer and collector, Mesa, Arizona, USA, who provided the original material.

Type Material: Canadian Geological Survey, Ottawa, Canada, 67216; The Natural History Museum, London, England, 1993,487.

References: (1) Roberts, A.C., J.A.R. Sterling, G.J.C. Carpenter, A.J. Criddle, G.C. Jones, T.C. Birkett, and W.D. Birch (1995) Shannonite, Pb_2OCO_3, a new mineral from the Grand Reef mine, Graham County, Arizona, USA. Mineral. Mag., 59, 305–310. (2) (1996) Amer. Mineral., 81, 252 (abs. ref. 1). (3) Krivovichev, S.V. and P.C. Burns (2000) Crystal chemistry of basic lead carbonates. II. Crystal structure of synthetic shannonite. Mineral. Mag., 64, 1063–1068.

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Sharpite $Ca(UO_2)_6(CO_3)_5(OH)_4 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Very fine needlelike crystals, to 5 mm, in subparallel aggregates, typically flat radial fibrous; may be in crusts.

Physical Properties: Hardness = 2.5–3 D(meas.) = > 4.45 D(calc.) = 4.61 Radioactive.

Optical Properties: Semitransparent. *Color:* Greenish yellow, olive-green, pale green, pale gray; pale yellow in transmited light.
Optical Class: Biaxial (+). *Pleochroism:* Slight; $X = Y$ = pale brown, very pale yellow-green; Z = pale yellow-green. *Orientation:* $Y \perp$ laths; $Z \parallel$ elongation; positive elongation, parallel extinction. $\alpha = 1.632–1.638$ $\beta =$ close to α $\gamma = 1.720–1.722$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 21.99(2)$ $b = 15.63(2)$ $c = 4.487(4)$ Z = 2

X-ray Powder Pattern: Shinkolobwe, Congo.
4.497 (100), 3.910 (48), 7.82 (40), 5.34 (35), 2.996 (33), 11.02 (30), 6.37 (28)

Chemistry:

	(1)	(2)
UO_3	81.04	80.33
CO_2	10.30	10.30
CaO	2.70	2.62
H_2O	6.81	6.75
Total	100.85	100.00

(1) Shinkolobwe, Congo; contained insoluble cobalt oxide 1.6%; $(CO_3)^{2-}$, H_2O confirmed by IR, TGA; corresponds to $Ca_{1.02}(UO_2)_{6.01}(CO_3)_{4.96}(OH)_{4.14} \cdot 5.95H_2O$. (2) $Ca(UO_2)_6(CO_3)_5(OH)_4 \cdot 6H_2O$.

Occurrence: A very rare secondary mineral formed in the oxide zone of hydrothermal uranium deposits.

Association: Uranophane, becquerelite, schoepite, curite, masuyite, vandenbrandeite, ianthinite, uraninite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In France, at Kruth, Haut-Rhin, and in the Brugeaud mine, near Bessines, Haute-Vienne.

Name: To honor Major Robert Richard Sharp (1881–1956), English engineer and prospector who discovered the Shinkolobwe deposit, Congo.

Type Material: University of Liège, Liège, Belgium, 6280, 16905.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 275. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 106–107. (3) Chervet, J. (1960) Les minerais uranifères français. University Presses of France, Paris, vol. I, part II, 235–237 (in French). (4) Čejka, J., Z. Mrázek, and Z. Urbanec (1984) New data on sharpite, a calcium uranyl carbonate. Neues Jahrb. Mineral., Monatsh., 109–117.

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Shattuckite $Cu_5(SiO_3)_4(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely as well-formed prismatic crystals elongated on {001}, to 2 mm. Typically forms aggregates of spherulitic masses composed of acicular crystals.

Physical Properties: *Cleavage:* {010} and {100}, perfect. Hardness = ~3.5
D(meas.) = 4.11 D(calc.) = 4.128

Optical Properties: Semitransparent. *Color:* Deep to medium blue. *Luster:* Silky. *Optical Class:* Biaxial (+). *Pleochroism:* X = very pale blue; Y = pale blue; Z = deep blue. *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.753(3)$ $\beta = 1.782(3)$ $\gamma = 1.815(3)$
2V(meas.) = n.d. 2V(calc.) = 88°

Cell Data: *Space Group: Pcab.* $a = 9.885(1)$ $b = 19.832(2)$ $c = 5.3825(8)$ $Z = 4$

X-ray Powder Pattern: Ajo, Arizona, USA.
4.42 (100), 4.96 (90), 3.50 (80), 3.30 (80), 2.745 (70), 1.627 (70), 2.400 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	36.68	37.2	36.63
FeO	0.19		
MnO	0.03	1.6	
CuO	60.41	59.0	60.62
MgO	0.02	0.17	
CaO	0.01		
H_2O^+	2.66	[2.03]	2.75
Total	[100.00]	[100.00]	100.00

(1) Ajo, Arizona, USA; recalculated to 100.00% after deduction of 0.58% quartz; corresponds to $Cu_{5.02}(SiO_3)_{4.01}(OH)_{1.94}$. (2) Mili, Evvia Island, Greece; by electron microprobe, H_2O by difference; corresponding to $(Cu_{4.80}Mn_{0.15}Mg_{0.03})_{\Sigma=4.98}(SiO_3)_{4.01}(OH)_2$. (3) $Cu_5(SiO_3)_4(OH)_2$.

Occurrence: A secondary mineral in oxidized copper deposits.

Association: Chrysocolla, ajoite, malachite, quartz, hematite.

Distribution: In the USA, in Arizona, in the Shattuck mine, Bisbee, Cochise Co., the New Cornelia mine, Ajo, Pima Co., the San Manuel and Mammoth-St. Anthony mines, Tiger, Pinal Co., the Clifton-Morenci district, Greenlee Co., and at several localities south of Wickenburg, Maricopa Co.; in the Santa Fe district, Mineral Co., Nevada; from the Buckhorn mine, Red Cloud district, Lincoln Co., New Mexico. From Munihuaza, near Alamos, Sonora, Mexico. At Tsumeb, Namibia. From Tantara and M'Sesa, near Kambove, Katanga Province, Congo (Shaba Province, Zaire). At Mili, Evvia Island, and Apikia, Andros Island, Cyclades Islands, Greece.

Name: For the type locality, the Shattuck mine, Bisbee, Arizona, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R4871–R4874, 87447, 93891, 95727.

References: (1) Ford, W.E. (1915) Dana's system of mineralogy, (6th edition), app. III, 72. (2) Newberg, D.W. (1964) X-ray study of shattuckite. Amer. Mineral., 49, 1234–1239. (3) Vlisidis, A.C. and W.T. Schaller (1967) The formula of shattuckite. Amer. Mineral., 52, 782–786. (4) Evans, H.T., Jr. and M.E. Mrose (1977) The crystal chemistry of the hydrous copper silicates, shattuckite and plancheite. Amer. Mineral., 62, 491–502. (5) Reinecke, T., E. Tillmanns, and H.-J. Bernhardt (1991) Abswurmbachite, $Cu^{2+}Mn^{3+}_6[O_8/SiO_4]$, a new mineral of the braunite group: natural occurrence, synthesis, and crystal structure. Neues Jahrb. Mineral., Abh., 163, 117–143.

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Shcherbakovite $K_2NaTi^{4+}{}_2O(OH)[Si_4O_{12}]$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. Crystals are long prismatic, to 6 cm; terminated crystals are uncommon.

Physical Properties: *Cleavage:* Two directions, observed microscopically, may be parting. *Tenacity:* Brittle. *Fracture:* Uneven. Hardness = 6.5 VHN = 731-845 D(meas.) = 2.968 D(calc.) = 3.194

Optical Properties: Opaque, translucent on thin edges. *Color:* Dark brown to blue-green. *Luster:* Vitreous, greasy on fracture surfaces.
Optical Class: Biaxial (-). *Pleochroism:* Distinct; *X* = pale yellow; *Y* = yellow; *Z* = brownish yellow. *Dispersion: r* < *v*, strong. *Absorption: Z* > *Y* ≥ *X*. α = 1.707 β = 1.745 γ = 1.776 2V(meas.) = 82°

Cell Data: Space Group: *Imma*. *a* = 8.1538(4) *b* = 10.5569(5) *c* = 13.9882(6) Z = 4

X-ray Powder Pattern: Wolgidee Hills, Western Australia; nearly identical to batisite. 2.911 (100), 3.201 (80), 3.399 (75), 2.634 (70), 2.191 (60), 2.102 (60), 1.680 (60)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.61	40.57	MnO	0.04	
TiO_2	17.91	18.87	$(Nb,Ta)_2O_5$	10.44	10.49
ZrO_2	1.23		MgO	0.26	
Na_2O	5.82	5.59	CaO	0.82	0.20
K_2O	12.29	13.22	BaO	6.22	6.07
ZrO_2		0.84	H_2O		0.73
Al_2O_3	0.76		H_2O^+	0.54	
Fe_2O_3	1.80	1.05	H_2O^-	0.10	
FeO	0.47		Total	99.61	97.63

(1) Khibiny massif, Russia; corresponds to $(K_{1.23}Na_{1.10}Ba_{0.24}Ca_{0.08}Mg_{0.04})_{\Sigma=2.69}(Ti_{1.31}Nb_{0.44}Fe_{0.17}Zr_{0.06})_{\Sigma=1.98}Si_{3.96}[O_{13.6}(OH)_{0.4}]_{\Sigma=14.00}$. (2) Mount Rasvumchorr, Khibiny massif, Russia; electron microprobe analysis, H_2O from crystal structure analysis, Mn, Mg, Al, Ta, Sr, F, Cl not detected, corresponds to $(K_{0.66}Ba_{0.23}Na_{0.07}Ca_{0.02})_{\Sigma=0.98}K_{1.00}Na_{1.00}(Ti_{1.40}Nb_{0.47}Fe_{0.08}Zr_{0.04})_{\Sigma=1.99}(O_{1.52}OH_{0.48})_{\Sigma=2.00}[Si_4O_{12}]$.

Polymorphism & Series: Forms a series with batisite.

Occurrence: Very rare, in pegmatite in a differentiated alkalic massif as a hydrothermal pectolite–natrolite vein cutting leucite-normative kalsilite–nepheline rischorrite (Khibiny massif, Russia); in lamproite (Leucite Hills, Wyoming, USA).

Association: Natrolite, manganoan pectolite, albite, potassic feldspar, astrophyllite, strontian fluorapatite, titanite (Khibiny massif, Russia); priderite, jeppeite, wadeite, perovskite, phlogopite, richterite (Wolgidee Hills, Western Australia).

Distribution: From Mts. Rasvumchorr and Yukspor, Khibiny massif, Kola Peninsula, Russia. In the Wolgidee Hills, West Kimberley district, Western Australia. From Emmons Mesa, Zirkel Mesa, and Black Butte, Leucite Hills, Sweetwater Co., Wyoming, USA.

Name: For Academician Demitrii Ivanovich Shcherbakov (1893-1966), Russian mineralogist and geochemist, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; 57256.

References: (1) Es'kova, E.M. and M.E. Kazakova (1954) Shcherbakovite - a new mineral. Doklady Acad. Nauk SSSR, 99, 837-841 (in Russian). (2) (1955) Amer. Mineral., 40, 788 (abs.

ref. 1). (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 550-553. (4) Prider, R.T. (1965) Noonkanbahite, a potassic batisite from the lamproites of Western Australia. Mineral. Mag., 34, 403-405. (5) Mitchell, R.H. (1990) Shcherbakovite in leucite phlogopite lamproites from the Leucite Hills, Wyoming. Mineral. Mag., 54, 645-646. (6) Y. A. Uvarova, E. Sokolava, F. C. Hawthorne, R. P. Lifeovich and R. H. Mitchell (2004) The crystal chemistry of shcherbakovite from the Khibina massif, Kola peninsula, Russia. Can. Mineral., 41, 1193-1201. (7) Krivovichev, S.V., V.N. Yakovenchuk, and Ya.A. Pakhomovskiy (2004) Topology and symmetry of the titanosilicate framework in the crystal structure of shcherbakovite, $Na(K,Ba)_2(Ti,Nb)_2O_2[Si_4O_{12}]$. Zapiski Vseross. Mineral. Obshch. 133(3), 55-63 (in Russian, English abstract). (8) (2005) Amer. Mineral., 90, 773 (abs. ref. 7).

Shcherbinaite V_2O_5

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Acicular crystals, to 1 cm, may be lathlike, elongated along [001] and flattened on [100], in finely fibrous aggregates. *Twinning:* By rotation about [100], with {031} composition plane probable, as simple and geniculated contact twins.

Physical Properties: *Cleavage:* {010} and {001}, perfect. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.38 D(calc.) = [3.37]

Optical Properties: Translucent. *Color:* Yellow-green, golden yellow; straw-yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial. *Orientation:* X or $Y = c$. $n = 2.42$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Pnmm$. $a = 4.364(8)$ $b = 11.50(2)$ $c = 3.561(4)$ Z = 2

X-ray Powder Pattern: Bezymianny volcano, Russia.
4.339 (100), 2.883 (50), 4.067 (28), 3.411 (28), 2.176 (24), 5.726 (22), 2.760 (22)

Chemistry:

	(1)	(2)
V_2O_5	39.	97.55
Na_2O	3.9	
LOI	12.5	
insol.	42.	
Total	97.4	97.55

(1) Bezymianny volcano, Russia; acid insoluble = SiO_2 24%, Fe_2O_3 3.3%, CaO 7%, Mg and Al $> 1\%$. (2) Izalco volcano, El Salvador; by electron microprobe, maximum of 15 analyses, with no elements other than V detected.

Occurrence: Deposited from fumarolic gasses, rich in halogens, at 500–550 °C, on the walls of volcanic fissures (Bezymianny volcano, Russia); in vanadium-bearing sublimates in fumaroles on a basaltic volcanic cone (Izalco volcano, El Salvador).

Association: Bannermanite, stoiberite, ziesite, fingerite, chalcocyanite, chalcanthite (Izalco volcano, El Salvador).

Distribution: From the Bezymyanniy volcano and the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. In El Salvador, on the Izalco volcano.

Name: Honors Vladimira Vital'evich Shcherbina (1907–1978), Russian geochemist of the Vernadsky Institute of Geochemistry and Analytical Chemistry, Academy of Sciences, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis6272.

References: (1) Borisenko, L.F. (1972) The new mineral – shcherbinaite. Zap. Vses. Mineral. Obshch., 101, 464 (in Russian). (2) Borisenko, L.F., Y.K. Serafimova, M.Y. Kazakova, and N.G. Shumyatskaya (1970) First find of crystalline V_2O_5 in the products of volcanic eruption in Kamchatka. Doklady Acad. Nauk SSSR, 193, 683–686 (in Russian). (3) (1973) Amer. Mineral., 58, 560 (abs. refs. 1 and 2). (4) Hughes, J.M. and L.W. Finger (1983) The crystal chemistry of shcherbinaite, naturally occurring V_2O_5. Amer. Mineral., 68, 1220–1222. (5) Enjalbert, R. and J. Galy (1986) A refinement of the structure of V_2O_5. Acta Cryst., C42, 1467–1469.

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Sheldrickite $NaCa_3(CO_3)_2F_3 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 3. Blocky crystals, to 0.1 mm; in fibrous aggregates and thin flakes. *Twinning:* By reflection on {001}.

Physical Properties: *Cleavage:* Parting on {001}, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.86(4) D(calc.) = 2.86

Optical Properties: Semitransparent. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous to silky.
Optical Class: Uniaxial (+). $\omega = 1.538(2)$ $\epsilon = 1.563(4)$

Cell Data: *Space Group:* $P3_2$. $a = 6.726(2)$ $c = 15.044(4)$ Z = 3

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
2.010 (100), 2.791 (50), 2.508 (40), 1.939 (40), 5.809 (30), 5.010 (30), 3.358 (30)

Chemistry:

	(1)	(2)
CO_2	[25.81]	26.02
CaO	48.84	49.73
SrO	0.36	
Na_2O	9.16	9.16
F	16.17	16.85
H_2O	5.61	5.33
$-O = F_2$	6.81	7.09
Total	[99.14]	100.00

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of three analyses, H_2O by TGA, CO_2 calculated from structure analysis, $(CO_3)^{2-}$ and H_2O confirmed by IR; corresponds to $Na_{1.01}(Ca_{2.97}Sr_{0.01})_{\Sigma=2.98}(CO_3)_2[F_{2.90}(OH)_{0.07}]_{\Sigma=2.97} \cdot H_2O$. (2) $NaCa_3(CO_3)_2F_3 \cdot H_2O$.

Occurrence: A very rare late-stage hydrothermal mineral in a marble xenolith in nepheline syenite associated with an intrusive alkalic gabbro-syenite complex.

Association: Shortite, pectolite, microcline, polylithionite, arfvedsonite, molybdenite.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Professor George M. Sheldrick (1942–), Institute for Organic Chemistry, University of Göttingen, Göttingen, Germany, author of widely-used crystal structural refinement computer programs.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81530, 81537–81539.

References: (1) Grice, J.D., R.A. Gault, and J. Van Velthuizen (1997) Sheldrickite, a new sodium-calcium-fluorocarbonate mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 35, 181–187. (2) (1997) Amer. Mineral., 82, 1262 (abs. ref. 1).

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Sherwoodite $\mathbf{Ca_9(AlV_2^{4+}V_{12}^{5+}O_{40})_2 \cdot 56H_2O}$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As euhedal crystals, showing {110} and {011}, equant or flattened along [001], to 1 mm; in polycrystalline aggregates.

Physical Properties: *Fracture:* Subconchoidal to uneven. Hardness = ∼2 D(meas.) = 2.8(1) D(calc.) = 2.56 H_2O varies zeolitically.

Optical Properties: Semitransparent. *Color:* Dark blue-black, with progressive alteration becoming blue-green and yellow-green. *Streak:* Pale blue. *Luster:* Vitreous to earthy. *Optical Class:* Uniaxial (–). *Pleochroism:* O = green to yellow-brown; E = blue to deep blue-green. $\omega = 1.765$ $\epsilon = 1.735$–1.738

Cell Data: *Space Group:* $I4/amd$. $a = 28.06(3)$ $c = 13.56(2)$ $Z = 4$

X-ray Powder Pattern: Colorado Plateau, USA.
12.3 (s), 10.0 (s), 9.3 (ms), 2.61 (m), 2.10 (mb), 7.8 (w), 7.1 (w)

Chemistry:

	(1)	(2)
V_2O_5	52.1	52.85
V_2O_4	[6.2]	8.03
Al_2O_3	2.7	2.47
Fe_2O_3	0.8	
MgO	0.5	
CaO	13.7	12.22
H_2O	24.0	24.43
Total	[100.0]	100.00

(1) Peanut mine, Colorado, USA; total V and V_2O_4 determined directly, V_2O_5 by difference, recalculated to 100% after deduction of insoluble 3.8%; corresponds to $(Ca_{8.7}Mg_{0.5})_{\Sigma=9.2}Al_{2.0}Fe^{3+}_{0.4}V^{4+}_{4.0}V^{5+}_{23.6}O_{80} \cdot 56H_2O$. (2) $Ca_9Al_2V^{4+}_4V^{5+}_{24}O_{80} \cdot 56H_2O$.

Occurrence: An oxidation product of lower valent vanadium minerals, on fracture surfaces and replacing fossil wood in Colorado Plateau-type U–V deposits; likely widely distributed.

Association: Selenium, metatyuyamunite, melanovanadite (Colorado Plateau, USA); pascoite, pyrite, copper, gypsum, patrónite, melanovanadite (Minasragra, Peru).

Distribution: In the USA, in Colorado, from the Peanut and Jo Dandy mines, Bull Canyon district, Uravan district, Montrose Co., at the Fall Creek mine, Placerville, San Miguel Co., and the Matchless mine, Calamity Mesa, Mesa Co.; on Wilson Mesa, Grand Co., Utah; in the Shadyside mine, east Carrizo Mountains, San Juan Co., New Mexico; and in the Joleo mine, Apache Co., Arizona. From Minasragra, 46 km from Cerro de Pasco, Peru.

Name: To honor Alexander M. Sherwood (1888–?), American analytical chemist, U.S. Geological Survey.

Type Material: National Museum of Natural History, Washington, D.C., USA, 115883, 121951.

References: (1) Thompson, M.E., C.H. Roach, and R. Meyrowitz (1958) Sherwoodite, a mixed vanadium(IV)-vanadium(V) mineral from the Colorado Plateau. Amer. Mineral., 43, 749–755. (2) Evans, H.T., Jr. and J.A. Konnert (1978) The crystal chemistry of sherwoodite, a calcium 14-vanadoaluminate heteropoly complex. Amer. Mineral., 63, 863–868.

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Shigaite $NaMn_6^{2+}Al_3(SO_4)_2(OH)_{18}\cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Hexagonal tabular crystals, to 2 cm, may be in groups; as thin films and fracture coatings. *Twinning:* On {0001}.

Physical Properties: *Cleavage:* On {0001}, perfect. *Tenacity:* Moderately flexible. Hardness = ∼2 D(meas.) = 2.32 D(calc.) = 2.35

Optical Properties: Semitransparent. *Color:* Pale yellow, bright yellow, golden yellow, burnt orange; brownish yellow if included, brown to black if altered. *Streak:* Very pale yellow to white. *Luster:* Vitreous to dull.
Optical Class: Uniaxial (–). *Pleochroism:* Distinct; O = yellow; E = very pale yellow. *Absorption:* $O > E$. $\omega = 1.546$ ϵ = n.d.

Cell Data: *Space Group:* $R\overline{3}$. $a = 9.51$–9.52 $c = 32.83$–33.074 Z = 3

X-ray Powder Pattern: Ioi mine, Japan.
10.89 (100), 5.47 (90), 2.457 (90), 3.664 (80), 2.198 (60), 1.944 (60), 4.36 (40)

Chemistry:

	(1)	(2)	(3)
SO_3	13.6	12.75	13.95
Al_2O_3	15.3	11.8	13.32
Fe_2O_3	0.9	2.6	
MnO	41.7	42.1	37.08
MgO		0.25	
Na_2O	n.d.	n.d.	2.70
H_2O	28.0	[30.5]	32.95
Total	99.5	[100.0]	100.00

(1) Ioi mine,Japan; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, H_2O by TGA-EGA. (2) Iron Monarch quarry, Australia; by electron microprobe, average of two analyses, total Fe as Fe_2O_3, total Mn as MnO, H_2O by difference. (3) $NaMn_6Al_3(SO_4)_2(OH)_{18}\cdot 12H_2O$.

Occurrence: A rare secondary mineral in metamorphosed manganese ore deposits.

Association: Rhodochrosite, sonolite, manganosite, pyrochroite, jacobsite, hausmannite, galaxite (Ioi mine, Japan); rhodochrosite, leucophoenicite, gageite, caryopilite (Wessels mine, South Africa); arsenoclasite, gatehouseite, hematite, hausmannite, manganoan ferroan calcite, barite, gypsum (Iron Monarch quarry, Australia).

Distribution: From the Ioi mine, about 25 km east of Kyoto, Shiga Prefecture, Japan. In South Africa, at the N'Chwaning mine, and large crystals from the Wessels mine, near Kuruman, Cape Province. In the Iron Monarch quarry, Iron Knob, South Australia. Large crystals from the Bengal Cannon mine, Iron Co., Michigan, USA.

Name: For Shiga Prefecture, Japan, within which the original locality, the Ioi mine, is located.

Type Material: National Museum of Natural History, Washington, D.C., USA, 122089.

References: (1) Peacor, D.R., P.J. Dunn, A. Kato, and F.J. Wicks (1985) Shigaite, a new manganese aluminum sulfate mineral from the Ioi mine, Shiga, Japan. Neues Jahrb. Mineral., Monatsh., 453–457. (2) (1986) Amer. Mineral., 71, 1546 (abs. ref. 1). (3) Pring, A., P.G. Slade, and W.D. Birch (1992) Shigaite from Iron Monarch, South Australia. Mineral. Mag., 56, 417–419. (4) Cooper, M.A. and F.C. Hawthorne (1996) The crystal structure of shigaite, $[AlMn_2^{2+}(OH)_6]_3(SO_4)_2Na(H_2O)_6H_2O_6$, a hydrotalcite-group mineral. Can. Mineral., 34, 91–97.

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Shlykovite $KCa[Si_4O_9(OH)]\cdot 3H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As distorted lamellae, to 1 mm, flattened along {001}; as fibers to 0.5 mm and as fibrous aggregates to 2 cm. Rarely as pinacoidal crystals to 0.4 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: Lamellae pliable. Hardness = 2.5-3 D(meas.) = n.d. D(calc.) = 2.244

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous; aggregates, pearly to silky.
Optical Class: Biaxial (-). α = 1.500(3) β = 1.509(2) γ = 1.515(2) 2V(meas.) = 60(20)° 2V(calc.) = 78° *Orientation*: *X* = *c*. *Dispersion:* Medium, *r* < *v*.

Cell Data: *Space Group*: $P2_1/c$. *a* = 6.4897(4) *b* = 6.9969(5), *c* = 26.714(2) β = 94.597(8)° Z = 4

X-ray Powder Pattern: Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.
13.33 (100), 6.67 (76), 2.945 (62), 3.068 (57), 6.47 (55), 3.469 (45), 3.042 (45)

Chemistry:

	(1)
Na_2O	0.68
K_2O	11.03
CaO	13.70
SiO_2	59.86
H_2O	[14.73]
Total	100.00

(1) Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia; average of 7 electron microprobe analyses, H_2O by difference, OH/H_2O calculated for charge balance; corresponding to $(K_{0.96}Na_{0.09})_{\Sigma=1.05}Ca_{1.00}Si_{4.07}O_{9.932}(OH)_{0.68}\cdot 3H_2O$.

Occurrence: A late-stage hydrothermal mineral along fractures in a high-potassium peralkaline pegmatite in urtite rocks near the contact with nepheline-apatite rock.

Association: Cryptophyllite.

Distribution: At the Central mine, Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: Honors geologist, Valeriy Georgievich Shlykov (1941-2007), Moscow State University, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (3753/1).

References: (1) Pekov, I.V., N.V. Zubkova, Ya.E. Filinchuk, N.V. Chukanov, A.E. Zadov, D.Yu. Pushcharovsky, and E.R. Gobechiya (2010) Shlykovite $KCa[Si_4O_9(OH)]\cdot 3H_2O$ and Cryptophyllite $K_2Ca[Si_4O_{10}]\cdot 5H_2O$ - new mineral species from the Khibiny alkaline pluton, Kola Peninsula, Russia. Zap. Ross. Mineral. Obshch., 139(1), 37-50 (in Russian with English abstract); and Geology of Ore Deposits, 52, 767-777. (2) Zubkova, N.V., Ya.E. Filinchuk, I.V. Pekov, D.Yu. Pushcharovsky, and E.R. Gobechiya (2010) Crystal structures of shlykovite and cryptophyllite: comparative crystal chemistry of phyllosilicate minerals of the mountainite family. Eur. J. Mineral., 22, 547-555. (3) (2012) Amer. Mineral., 97, 1526-1527 (abs. refs. 1 and 2).

Shomiokite-(Y) $Na_3(Y,Dy)(CO_3)_3 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Short prismatic pseudohexagonal crystals, to 2 mm, showing {010}, {110}, {111}, {011}, in rosettelike aggregates; massive granular, to 30 cm.

Physical Properties: *Cleavage:* On {110}, perfect; a parting on {001}. Hardness = 2–3 D(meas.) = 2.52(5) D(calc.) = 2.59

Optical Properties: Translucent, transparent in small pieces. *Color:* Colorless, pink, pale yellow. *Luster:* Dull, waxy to silky.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$.
$\alpha = 1.528(2)$ $\beta = 1.529(2)$ $\gamma = 1.531(2)$ 2V(meas.) = 45°

Cell Data: *Space Group:* $Pbn2_1$. $a = 10.034$–10.136 $b = 17.348$–17.358 $c = 5.946$–5.970 Z = 4

X-ray Powder Pattern: Mt. Alluaiv, Kola Peninsula, Russia.
2.076 (100), 2.858 (70), 4.85 (65), 6.53 (55), 5.05 (50), 2.597 (50), 2.229 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
CO_2	32.10	[33.36]	33.68	Ho_2O_3	0.63	0.73	
Y_2O_3	21.52	19.05	28.81	Er_2O_3	1.24	2.13	
La_2O_3		0.20		Eu_2O_3		0.00	
Ce_2O_3	0.09	1.81		Yb_2O_3		1.55	
Pr_2O_3		0.52		Lu_2O_3		0.26	
Nd_2O_3		2.79		CaO	0.01		
Sm_2O_3		0.95		Na_2O	21.93	23.25	23.72
Gd_2O_3	1.80	1.05		H_2O	14.20	[13.66]	13.79
Tb_2O_3	0.46	0.36		Total	[99.01]	[104.88]	100.00
Dy_2O_3	5.03	2.81					

(1) Mt. Alluaiv, Kola Peninsula, Russia; H_2O by coulometry, original total given as 99.10%; corresponds to $(Na_{2.93}Ca_{0.01})_{\Sigma=2.94}(Y_{0.79}Dy_{0.11}Gd_{0.04}Er_{0.03}Ho_{0.01}Tb_{0.01})_{\Sigma=0.99}(C_{1.06}O_3)_3 \cdot 3.26H_2O$. (2) Mont Saint-Hilaire, Canada; by electron microprobe, CO_2, H_2O calculated from stoichiometry; corresponds to $(Na_{2.97}(Y_{0.67}Nd_{0.07}Dy_{0.06}Ce_{0.04}Er_{0.04}Yb_{0.03}Sm_{0.02}Gd_{0.02}Ho_{0.02}La_{0.01}Tb_{0.01}Pr_{0.01}Tm_{0.01}Lu_{0.01})_{\Sigma=1.02}(CO_3)_3 \cdot 3H_2O$. (3) $Na_3Y(CO_3)_3 \cdot 3H_2O$.

Occurrence: In interstices and as large segregations in potassic feldspar in pegmatites (Mt. Alluaiv, Kola Peninsula, Russia); associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Albite, cancrinite, aegirine, elpidite, natron, natroxalate, kogarkoite, villiaumite, neighborite, trona, sidorenkite, siderite, sphalerite (Mt. Alluaiv, Kola Peninsula, Russia); microcline, albite, aegirine, analcime, rhodochrosite, eudialyte, catapleiite, sphalerite, petersenite-(Ce) (Mont Saint-Hilaire, Canada).

Distribution: From Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For the Shomiok River, in the Lovozero massif, flowing near Mt. Alluaiv, where the mineral was first found.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, r545/1; The Natural History Museum, London, England, 1994,030.

References: (1) Khomyakov, A.P., N.G. Shumyatskaya, and L.T. Polezhaeva (1994) Shomiokite-(Y) – $Na_3Y(CO_3)_3 \cdot 3H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 121, 129–132 (in Russian). (2) (1994) Amer. Mineral., 79, 765–766 (abs. ref. 1). (3) Rastsvetaeva, R.K., D.Y. Pushcharovskiy, and I.G. Pekov (1996) Crystal structure of shomiokite-(Y), $Na_3Y(CO_3)_3$ $3H_2O$. Eur. J. Mineral., 8, 1249–1255. (4) Grice, J. (1996) The crystal structure of shomiokite-(Y). Can. Mineral., 34, 649–655. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 185–186.

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Shortite $Na_2Ca_2(CO_3)_3$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are typically wedge-shaped, tabular to short prismatic on [100], to 3 cm, showing (100), $(\bar{1}00)$, (011), $(0\bar{1}1)$, $(00\bar{1})$, with {011} striated by $\{00\bar{1}\} \parallel [100]$.

Physical Properties: *Cleavage:* Distinct on {010}. *Fracture:* Conchoidal. Hardness = 3–4.5 D(meas.) = 2.629 D(calc.) = 2.620 Slowly decomposes in H_2O, with $CaCO_3$ residue; strongly pyroelectric; pale amber fluorescence under SW UV.

Optical Properties: Transparent. *Color:* Colorless, pale yellow, dark yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$, moderate.
$\alpha = 1.531$–1.532 $\beta = 1.555$–1.556 $\gamma = 1.570$ 2V(meas.) = 69.0(5)° 2V(calc.) = 73.9°–75°

Cell Data: *Space Group:* $Amm2$. $a = 4.947(1)$ $b = 11.032(2)$ $c = 7.108(1)$ Z = 2

X-ray Powder Pattern: John Hay, Jr. Well No. 1, Wyoming, USA.
2.562 (100), 5.515 (71), 4.957 (71), 2.179 (71), 1.996 (60), 5.985 (50), 3.818 (50)

Chemistry:

	(1)	(2)	(3)
CO_2	42.90	[43.37]	43.12
MgO	0.04		
CaO	36.34	36.57	36.63
Na_2O	19.91	20.06	20.25
insol.	0.66		
Total	99.85	[100.00]	100.00

(1) John Hay, Jr. Well No. 1, Wyoming, USA. (2) Upper Canada mine, Canada; by electron microprobe, CO_2 by difference. (3) $Na_2Ca_2(CO_3)_3$.

Occurrence: In saline dolomitic marl (Green River Formation, Wyoming and Utah, USA); in kimberlite dikes (Upper Canada mine, Canada); in carbonatite (Vuoriyarvi massif, Kola Peninsula, Russia); in differentiated alkalic massifs (Kovdor and Khibiny massifs, Kola Peninsula, Russia); associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Trona, nahcolite, pyrite (Green River Formation, Wyoming and Utah, USA); phlogopite, magnetite, apatite, perovskite, calcite, olivine (Upper Canada mine, Canada); barentsite, villiaumite, natrite, natrolite, albite (Khibiny massif, Kola Peninsula, Russia).

Distribution: In the USA, from the Green River Formation, Wyoming and Utah, with indicated reserves of billions of tons; found in the John Hay, Jr. Well No. 1, about 30 km west Green River, Sweetwater Co., Wyoming; and in the Uintah Basin, northeastern Utah. In Canada, in the Upper Canada gold mine, Kirkland Lake district, Ontario, and at Mont Saint-Hilaire, Quebec. In Russia, on the Kola Peninsula, in the Vuoriyarvi carbonatite complex, from the Kovdor massif, and on Mt. Restin'yun, Khibiny massif; from the Udachnaya pipe, Daldyn kimberlite field, Sakha.

Name: To honor Dr. Maxwell Naylor Short (1889–1952), Professor of Mineralogy, University of Arizona, Tucson, Arizona, USA.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 98093.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 222–223. (2) Fahey, J.J. (1962) Saline minerals of the Green River Formation. U.S. Geol. Surv. Prof. Paper 405, 22–28, 46. (3) Dickens, B., A. Hyman, and W.E. Brown (1971) Crystal structure of $Ca_2Na_2(CO_3)_3$ (shortite). J. Res. Natl. Bur. Stnd., A. Physics and chemistry, 75(2), 129–135. (4) Watkinson, D.H. and G.Y. Chao (1973) Shortite in kimberlite from the Upper Canada Gold mine, Ontario. J. Geology, 81, 229–233.

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Shuangfengite $IrTe_2$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Crystal Data: Orthorhombic (?). *Point Group:* n.d. Platy lamellar crystals, to 1 mm, in aggregates.

Physical Properties: Hardness = 2 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Light blue.
Optical Class: Biaxial (–). *Pleochroism:* X = light blue; $Y = Z$ = greenish blue.
Dispersion: $r < v$. $\alpha = 1.640$ $\beta = 1.690$ $\gamma = 1.690$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
As_2O_5	41.43	43.08
CuO	37.32	39.76
CaO	7.33	7.01
Cl	2.7	2.21
H_2O		8.44
$-O = Cl_2$	[0.6]	0.50
insol.	1.66	
Total	[89.84]	100.00

(1) Khovu-Aksy deposit, Russia. (2) $Ca_2Cu_8(AsO_4)_6Cl(OH)\cdot 7H_2O$.

Occurrence: Found in the zone of oxidation of copper bearing ores.

Association: n.d.

Distribution: From the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, Russia.

Name: To honor Aleksei Vasil'evich Shubnikov (1887–1970), Director of the Crystallographic Institute, Russian Academy of Sciences, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 456/1–3; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 57262.

References: (1) Nefedov, Y.I. (1953) [Report on new minerals] in: V.A. Mokievsky, The scientific session of the Federov Institute together with the All-Union Mineralogical Society. Zap. Vses. Mineral. Obshch., 82, 311–317 (in Russian). (2) (1955) Amer. Mineral., 40, 551–552 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 186.

Shuiskite $Ca_2(Mg,Al)(Cr,Al)_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As radiating aggregates of fibrous prismatic crystals, to 1 cm.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 6 D(meas.) = 3.24 D(calc.) = [3.35]

Optical Properties: Semitransparent. *Color:* Dark brown, with a violet tint. *Streak:* Light greenish brown. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = blue-violet; Y = yellowish green; Z = dark violet. *Dispersion:* $r < v$, strong. α = 1.725–1.733 β = 1.762–1.772 γ = 1.769–1.775 2V(meas.) = 40°–50°

Cell Data: *Space Group:* $A2/m$. $a = 8.897$ $b = 5.843$ $c = 19.41$ $\beta = 98°$ Z = 4

X-ray Powder Pattern: Saranovskii mine, Russia.
1.593 (10), 2.90 (9), 1.487 (8), 2.73 (7), 2.64 (5), 2.52 (5b), 2.46 (5)

Chemistry:

	(1)
SiO_2	31.42
TiO_2	0.65
Al_2O_3	12.75
Fe_2O_3	1.65
Cr_2O_3	19.34
FeO	0.00
MnO	trace
MgO	5.07
CaO	21.00
Na_2O	0.19
K_2O	0.22
H_2O^+	7.03
H_2O^-	0.50
Total	99.82

(1) Saranovskii mine, Russia; corresponding to $(Ca_{1.91}K_{0.03}Na_{0.02})_{\Sigma=1.96}(Mg_{0.64}Al_{0.25}Fe_{0.10})_{\Sigma=0.99}(Cr_{1.30}Al_{0.69}Ti_{0.04})_{\Sigma=2.03}(Si_{2.67}Al_{0.30})_{\Sigma=2.97}O_{11}(OH)_{2.00} \cdot 0.99H_2O$.

Mineral Group: Pumpellyite group.

Occurrence: On the walls of fractures in chromitite.

Association: Uvarovite, chlorite, titanite.

Distribution: From the Biserskoye deposit and Saranovskii chromium mine, five km north of the Laki railway station, Gorozavod district, Northern Ural Mountains, Russia.

Name: For Vadim Prokof'evich Shuiskii (1936–), petrologist of the Ural Scientific Center, Yekaterinburg (Sverdlovsk), Russia.

Type Material: Ural Geological Museum, Mining Institute, Yekaterinburg (Sverdlovsk); Mining Institute, St. Petersburg, 1227/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81684.

References: (1) Ivanov, O.K., V.A. Arkhangel'skaya, L.O. Miroshnikova, and T.A. Shilova (1981) Shuiskite, the chromium analog of pumpellyite, from the Bisersk deposit, Urals. Zap. Vses. Mineral. Obshch., 110, 508–512 (in Russian). (2) (1982) Amer. Mineral., 67, 860 (abs. ref. 1).

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Sibirskite $CaH(BO_3)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rhombic to prismatic crystals, to 1.5 mm, and as irregular grains, in aggregates. *Twinning:* On {100}, polysynthetic.

Physical Properties: Hardness = n.d. VHN = 298–383, 339 average (25 g load).
D(meas.) = 2.58 D(calc.) = 2.59

Optical Properties: Semitransparent. *Color:* Colorless, white, pale gray; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* OAP $\simeq$ {100}. α = 1.554–1.555 β = 1.638–1.643 γ = 1.652–1.658 2V(meas.) = 43° 2V(calc.) = 42.6°

Cell Data: *Space Group:* $P2_1/a$. a = 8.643(6) b = 9.523(2) c = 3.567(3) β = 119.23(3)° Z = 4

X-ray Powder Pattern: Fuka, Japan.
2.955 (100), 2.603 (94), 4.77 (33), 3.329 (32), 2.927 (21), 1.891 (20), 5.92 (16)

Chemistry:

	(1)	(2)
B_2O_3	33.83	34.85
CaO	56.21	56.13
H_2O	9.62	9.02
Total	99.66	100.00

(1) Fuka, Japan; by electron microprobe, B_2O_3 by wet chemistry, H_2O by LOI; corresponds to $Ca_{1.00}H_{1.07}B_{0.97}O_3$. (2) $CaH(BO_3)$.

Polymorphism & Series: Dimorphous with parasibirskite.

Occurrence: In veinlets and aggregates in skarns.

Association: Calcite, "chlorite", pyrite, garnet, vesuvianite, datolite, tourmaline, axinite (Yuliya Svintsovaya deposit, Russia); takedaite, nifontovite, olshanskyite, pentahydroborite, frolovite, parasibirskite, uralborite, borcarite, fluorite, calcite (Fuka, Japan).

Distribution: In Russia, from the Yuliya Svintsovaya Pb–Zn deposit, 20 km east-northeast of the Son railway station, Khakassia district, Siberia; at the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains; and on the Chersk and Selenyakhsk Ridges, Transbaikal. From Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For its first-noted occurrence in Siberia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64709.

References: (1) Vasilkova, N.N. (1962) A new calcium borate – sibirskite. Zap. Vses. Mineral. Obshch., 91, 455–464 (in Russian). (2) (1963) Amer. Mineral., 48, 433 (abs. ref. 1). (3) Kusachi, I., C. Henmi, and S. Kobayashi (1997) Sibirskite from Fuka, Okayama Prefecture, Japan. Mineral. J. (Japan), 19, 109–114.

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Sicklerite $Li(Mn^{2+},Fe^{3+})PO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Massive, as rims around and in crystals and masses of triphylite-lithiophilite.

Physical Properties: *Cleavage:* {100}, good. Hardness = ∼4 D(meas.) = 3.45 D(calc.) = [3.54]

Optical Properties: Subtranslucent to opaque. *Color:* Yellow to red-brown, black; yellow-brown in thin section. *Streak:* Pale yellowish brown, brown, reddish brown. *Optical Class:* Biaxial (–). *Pleochroism:* X = deep reddish, or deep yellow; Y = paler reddish or paler yellow; Z = very pale reddish or very pale yellow. *Orientation:* $X = a$. *Dispersion:* $r \gg v$, very strong. $\alpha = 1.710–1.720$ $\beta = 1.730–1.738$ $\gamma = 1.745$ 2V(meas.) = $> 60°$

Cell Data: *Space Group: Pmnb.* $a = 6.030(15)$ $b = 10.082(9)$ $c = 4.750(5)$ Z = 4

X-ray Powder Pattern: Tanco pegmatite, Canada. (ICDD 33-802).
2.971 (100), 2.495 (75), 3.497 (40), 2.448 (35), 5.037 (30), 4.327 (30), 1.6081 (25)

Chemistry:

	(1)	(2)
P_2O_5	43.10	46.68
Fe_2O_3	11.26	8.06
Mn_2O_3	2.10	
MnO	33.60	37.12
CaO	0.20	0.12
$(Li,H)_2O$	3.80	[7.85]
Na_2O		0.13
K_2O		0.04
H_2O	1.71	n.d.
insol.	4.18	
Total	99.95	[100.00]

(1) Pala, California, USA. (2) Stewart mine, California, USA; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, $(Li,H)_2O$ by difference; corresponds to $(Li_{0.94}Na_{0.01})_{\Sigma=0.95}(Mn^{2+}_{0.80}Fe^{3+}_{0.15})_{\Sigma=0.95}(PO_4)_{1.00}$.

Polymorphism & Series: Forms a series with ferrisicklerite.

Occurrence: Formed by late hydrothermal alteration or weathering of triphylite-lithiophilite in complex zoned granite pegmatites.

Association: Huréaulite, stewartite, jahnsite, phosphosiderite (Pala, California, USA).

Distribution: In the USA, in the Vanderburg mine, Hiriart Mountain, and the Stewart mine, Pala district, San Diego Co., California; from the White Picacho district, Yavapai Co., Arizona; in the Custer Mountain mine, 2.5 km east-southeast of Custer, Custer Co., South Dakota. From the Tanco pegmatite, Bernic Lake, Manitoba, Canada. At Tammela, and in the Viitaniemi pegmatite, near Eräjärvi, Finland. From Varuträsk, at the Norrö pegmatite, on Rånö Island, and on Utö Island, Sweden. From Sidi-bou-Othmane, Morocco. Occurs at Wodgina, Western Australia. Probably present in many other pegmatites; chemical analyses are desirable for certainty that the material fits the present definition.

Name: Honoring the Sickler family, mineral collectors, formerly of Pala, California, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 101195; National Museum of Natural History, Washington, D.C., USA, 93653.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 672–673. (2) Shigley, J.E. and G.E. Brown, Jr. (1985) Occurrence and alteration of phosphate minerals at the Stewart pegmatite, Pala district, San Diego Co., California. Amer. Mineral., 70, 395–408.

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Siderazot Fe_5N_2

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Crystal Data: Hexagonal. *Point Group:* 622. A very thin coating on lava.

Physical Properties: Hardness = n.d. D(meas.) = 3.147 D(calc.) = 3.08

Optical Properties: Opaque. *Color:* Silvery white. *Luster:* Metallic.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_322$ (synthetic). $a = 4.678$ $c = 4.369$ Z = 0.5

X-ray Powder Pattern: Synthetic.
2.346 (100), 2.196 (100), 2.061 (100), 1.596 (100), 1.349 (100), 1.2355 (100), 1.1484 (100)

Chemistry:

	(1)	(2)
Fe	90.86	90.88
N	9.14	9.12
Total	100.00	100.00

(1) Etna, Sicily, Italy. (2) Fe_5N_2.

Occurrence: A volcanic sublimate on lava.

Association: n.d.

Distribution: On Etna, Sicily, and Vesuvius, Campania, Italy.

Name: From the Greek for *iron*, *sideros*, and *nitrogen*, *azote*, for its composition.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 126. (2) Hendricks, S.B. and P.R. Kosting (1930) XXXV. The crystal structure of Fe_2P, Fe_2N, Fe_3N, and FeB. Zeits. Krist., 74, 511–533.

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Siderite $Fe^{2+}CO_3$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\,2/m$. Commonly crystallized, typically rhombohedral $\{10\bar{1}1\}$ to steep scalenohedral $\{21\bar{3}1\}$, prismatic $\{10\bar{1}0\}$, $\{0001\}$, with additional minor forms, to 25 cm; fibrous, stalactitic, spherulitic, cleavable, fine-grained massive. *Twinning:* Uncommon on $\{01\bar{1}2\}$, lamellar; rare on $\{0001\}$.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}1\}$. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 3.75–4.25 D(meas.) = 3.96(1) D(calc.) = 3.932

Optical Properties: Translucent. *Color:* Yellowish brown, brown; white, ash-gray, yellowish gray, pale green; colorless, yellow, yellow-brown in transmitted light. *Streak:* White. *Luster:* Vitreous, may be pearly or silky.
Optical Class: Uniaxial (–). *Dispersion:* Strong. $\omega = 1.875$ $\epsilon = 1.633$

Cell Data: *Space Group:* $R\bar{3}c$. $a = 4.6916$–4.6935 $c = 15.3796$–15.3860 Z = 6

X-ray Powder Pattern: Ivigtut, Greenland.
2.795 (100), 1.7315 (35), 1.7382 (30), 3.593 (25), 2.346 (20), 2.134 (20), 1.9650 (20)

Chemistry:

	(1)	(2)
CO_2	38.19	37.99
FeO	61.08	62.01
MnO	1.12	
MgO	0.13	
CaO	0.10	
Total	100.62	100.00

(1) Camborne, England. (2) $FeCO_3$.

Polymorphism & Series: Forms three series, with magnesite, with rhodochrosite, and with smithsonite.

Mineral Group: Calcite group.

Occurrence: A common component of bedded sedimentary iron ores and metamorphic iron formations; in hydrothermal metallic veins; rarely in granite and nepheline syenite pegmatites; in carbonatites; authigenic, and in concretions.

Association: Quartz, barite, fluorite, pyrite.

Distribution: Many noted localities worldwide, including: in Germany, from Freiberg and Neudorf, Harz Mountains, and in the Siegerland district, Westphalia. In Austria, on the Erzberg, near Eisenerz, Styria, and Hüttenberg-Lölling, Carinthia. From Allevard, Isère, France. In England, from many mines in Cornwall, as at the Great Onslow Consols mine, St. Breward, Wheal Maudlin, Lanlivrey, Dolcoath mine, Camborne; from the Virtuous Lady mine, Tavistock, Devon. At Panasqueira, Portugal. From Ivigtut, Greenland. Very large crystals at Mont Saint-Hilaire, Quebec, Canada. In the USA, from Bisbee, Cochise Co., and in the Antler mine, Mohave Co., Arizona; at Leadville, Lake Co., Colorado. From Mosojllacta, Colavi, Bolivia, large crystals. In Brazil, in the Morro Velho gold mine, Nova Lima, Minas Gerais, and at Pedreira Ataleia, Governador Valadares.

Name: From the Greek *sideros*, for *iron* in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 167–171. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 272–277; Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 163–177. (3) Effenberger, H., K. Mereiter, and J. Zemann (1981) Crystal structure refinements of magnesite, rhodochrosite, siderite, smithsonite, and dolomite, with discussion of some aspects of the stereochemistry of calcite type carbonates. Zeits. Krist., 156, 233–243. (4) (1978) NBS Mono. 25, 15.

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Sideronatrite $Na_2Fe^{3+}(SO_4)_2(OH)\cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely in good crystals, lathlike to acicular, to 3 cm; commonly fibrous, earthy, pulverulent, in efflorescences and crusts, nodular, massive.

Physical Properties: *Cleavage:* On {010}, perfect; on {100}, fair. *Tenacity:* Slightly flexible. Hardness = 1.5–2.5 D(meas.) = 2.22–2.35 D(calc.) = 2.276 Soluble in boiling H_2O, with separation of Fe_2O_3; reversibly dehydrates to metasideronatrite depending on relative humidity and exposure to sunlight.

Optical Properties: Semitransparent. *Color:* Lemon-yellow, straw-yellow, pale orange, yellow-brown; in transmitted light, nearly colorless to pale yellow. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = nearly colorless; Y = very pale amber-yellow; Z = pale amber-yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, strong. $\alpha = 1.508(3)$ $\beta = 1.525(3)$ $\gamma = 1.586(3)$ 2V(meas.) = n.d. 2V(calc.) = 58(5)°

Cell Data: *Space Group:* *Pbnm*; may be *Pnn*2 or *Pnnm* if OD structure. $a = 7.27(2)$ $b = 20.50(3)$ $c = 7.15(2)$ Z = 4

X-ray Powder Pattern: Sierra Gorda [district], Chile.
10.15 (FFF), 3.01 (FF), 3.38 (F), 2.68 (F), 6.78 (mF), 3.58 (mF), 5.00 (f)

Chemistry:

	(1)	(2)
SO_3	42.98	43.87
Fe_2O_3	22.40	21.88
Na_2O	17.00	16.98
H_2O	17.75	17.27
Total	100.13	100.00

(1) Sierra Gorda [district], Chile; corresponds to $Na_{1.96}Fe_{1.00}(SO_4)_{1.92}(OH)_{1.12}\cdot 2.96H_2O$.
(2) $Na_2Fe(SO_4)_2(OH)\cdot 3H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized zone of iron-rich deposits in very arid climates, may be post-mine; also formed by alteration of pyrite by saline water in metallic veins, coal measures, and in a sea-spray environment.

Association: Metasideronatrite, ferrinatrite, copiapite, voltaite, melanterite, halotrichite, uklonskovite, jurbanite, jarosite, pyrite, marcasite.

Distribution: In Chile, from the San Simon mine, Huantajaya, Tarapacá; in the Compania mine, Sierra Gorda district, southwest of Calama, and at Chuquicamata, Antofagasta. From Potosí, Bolivia. At the Santa Bárbara sulfur mine, El Palmar district, Jujuy Province, Argentina. On the Urus Plateau, Cheleken Peninsula, Caspian Sea, Turkmenistan. From north of Ballybunion, Co. Kerry, Ireland. At Barton-on-Sea, Hampshire, on Trerubies Cliff, near Delabole, Cornwall, and in the Rising Sun colliery, Backworth, Northumberland, England. From Winterslag and Eisden, Belgium. In the Polish Turoszow brown coal mine, Turoszow, Poland. From the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. At the New Milo mine, Wadnaminga, South Australia. Large crystals in the Hot Springs Point sulfur mine, Crescent Valley, Eureka Co., Nevada, USA. A few additional localities are known.

Name: From the Greek for iron, *sideros* and sodium, *natrium*, in its chemical composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 604–605. (2) Cesbron, F. (1964) Contribution à la minéralogie des sulfates de fer hydratés. Bull. Soc. fr. Minéral., 87, 125–143 (in French). (3) Scordari, F. (1981) Sideronatrite: a mineral with a $\{Fe_2(SO_4)_4(OH)_2\}$ guildite type chain? Tschermaks Mineral. Petrog. Mitt., 28, 315–319.

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Siderophyllite $\mathbf{KFe_2^{2+}Al(Al_2Si_2)O_{10}(F,OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals sharp, pseudohexagonal, to 1 cm; in foliated aggregates.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 2.5–3 D(meas.) = 3.1 D(calc.) = [3.17]

Optical Properties: Semitransparent. *Color:* Black, dark brown, dark green. *Optical Class:* Biaxial (–). *Pleochroism:* X = brown; $Y = Z$ = dark brown. *Orientation:* $Y = b$. *Dispersion:* $r < v$. $\alpha = 1.590$ $\beta = 1.640$ $\gamma = 1.640$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. (synthetic $\sim KFe_2^{2+}Al(Al_2Si_2)O_{10}(OH)_2$). $a = 5.348(2)$ $b = 9.261(3)$ $c = 10.263(4)$ $\beta = 100.19(7)^\circ$ Z = 2

X-ray Powder Pattern: Altenberg, Germany; resembles zinnwaldite. (ICDD 25-1355). 9.99 (10b), 2.62 (10), 3.36 (9), 3.27 (9), 1.542 (9), 2.432 (8), 1.666 (8b)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	34.21	37.01	Na_2O	1.43	0.58
TiO_2		0.02	K_2O	6.50	9.02
Al_2O_3	16.53	15.89	Rb_2O		0.19
Fe_2O_3	20.15	trace	Cs_2O		0.12
FeO	14.17	30.16	F	0.08	3.88
MnO	0.91	1.01	Cl		0.24
MgO	1.34	0.22	H_2O		1.92
CaO	0.48	0.10	LOI	4.54	
Li_2O		1.01	$-O = (F,Cl)_2$	0.03	1.68
			Total	100.31	99.69

(1) Pikes Peak, Colorado, USA; loss on ignition taken as H_2O. (2) Brooks Mountain [*sic*], Alaska, USA; corresponds to $(K_{0.93}Na_{0.09}Rb_{0.01})_{\Sigma=1.03}Fe^{2+}_{2.02}(Al_{0.47}Li_{0.33}Mn_{0.07}Mg_{0.03})_{\Sigma=0.90}(Si_{2.97}Al_{1.03})_{\Sigma=4.00}O_{10}(F,OH)_2$.

Polymorphism & Series: 1M polytype.

Mineral Group: Mica group.

Occurrence: In pegmatites in nepheline syenite; in greisens in granite and aplite.

Association: Microcline, astrophyllite (Pikes Peak, Colorado, USA).

Distribution: On Pikes Peak, El Paso Co., Colorado, and in the Brooks Range, Alaska, USA. At Mont Saint-Hilaire, Quebec, Canada. From Altenberg, Saxony, Germany. In the Reschen Pass, Trentino-Alto Adige, Italy. At Badzhala, Ural Mountains, Russia. From Newcastle, Co. Down, Ireland. Probably additional localities exist.

Name: From the Greek for *iron* and *leaf*, for its composition and habit.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 627–632. (2) Foster, M.D. (1960) Interpretation of the composition of trioctahedral micas. U.S. Geol. Sur. Prof. Paper 354-B, 11–49. (3) Levillain, C., P. Maurel, and F. Menil (1981) Mössbauer studies of synthetic and natural micas on the polylithionite-siderophyllite join. Phys. Chem. Minerals, 7, 71–76.

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Siderotil $(Fe^{2+}, Cu)SO_4 \cdot 5H_2O$

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Crystal Data: Triclinic (synthetic). *Point Group:* $\overline{1}$ or 1. Rare acicular crystals, to 0.1 mm, typically fibrous to powdery.

Physical Properties: Hardness = n.d. D(meas.) = 2.1–2.2 D(calc.) = 2.212 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Pale green. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). α = 1.513–1.515 β = 1.526 γ = 1.534–1.535 2V(meas.) = 50°–60°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 6.292(5)$ $b = 10.632(8)$ $c = 6.072(5)$ $\alpha = 82.62(1)°$ $\beta = 110.01(1)°$ $\gamma = 105.18(1)°$ Z = 2

X-ray Powder Pattern: Yerington, Nevada, USA.
4.89 (10), 3.73 (8), 5.57 (6), 5.73 (5), 3.21(4), 2.92 (4), 2.68 (4)

Chemistry:

	(1)	(2)
SO_3	[32.99]	33.10
FeO	15.9	29.70
CoO	0.35	
CuO	14.1	
H_2O	36.66	37.20
Total	[100.00]	100.00

(1) Yerington, Nevada, USA; SO_3 by difference; corresponds to $(Fe_{0.55}Cu_{0.44}Co_{0.01})_{\Sigma=1.00}$ $SO_4 \cdot 5H_2O$. (2) $FeSO_4 \cdot 5H_2O$; some copper is required to stabilize the structure.

Mineral Group: Chalcanthite group.

Occurrence: Forms by dehydration of cuprian melanterite.

Association: Melanterite.

Distribution: Originally incompletely described from Idrija (Idria), Slovenia, where it may or may not occur. Some authenticated localities include: in the USA, in Nevada, from the Yerington district, Lyon Co., at the Watt mine, Reese River district, Lander Co., and from Steamboat Springs, Steamboat Springs district, Washoe Co.; at Bingham Canyon, Salt Lake Co., Utah; from the Mt. Diablo mercury mine, Contra Costa Co., California; in the Campbell shaft, Bisbee, Cochise Co., Arizona; at Ducktown, Polk Co., Tennessee. In the Capillitas mine, Catamarca Province, Argentina. At Grandola, near Lisbon, Portugal. In the Clara mine, near Oberwolfach, Black Forest, Germany. From Les Vallettes, Valais, Switzerland.

Name: From the Greek for iron, *sideros*, and for fiber, *tilos*, for its composition and structure.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 491–492. (2) Jambor, J.L. and R.J. Traill (1963) On rozenite and siderotil. Can. Mineral., 7, 751–763. (3) Peterson, R.C. and Y. Zhang (2002) The atomic structure of siderotil $(Fe, Cu)SO_4 \cdot 5H_2O$. IMA, 18th General Meeting, 118–119 (abs.).

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Sidorenkite $Na_3Mn^{2+}(PO_4)(CO_3)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$ or 2. Crystals, elongated along [001], are boxlike, showing {100}, {010}, rarely {001}, to 3 cm; granular.

Physical Properties: *Cleavage:* On {100} and {010}, perfect; on {001}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼2 D(meas.) = 2.90–3.03 D(calc.) = 2.98 Strongly electromagnetic.

Optical Properties: Transparent. *Color:* Colorless, pale rose-red to pale pink, with surficial brownish or yellowish tint. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.521(2)$ $\beta = 1.563(2)$ $\gamma = 1.585(2)$ 2V(meas.) = 68° 2V(calc.) = 70°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. a = 8.997(4) $b = 6.741(2)$ $c = 5.163(2)$ $\beta = 90.16(4)°$ Z = 2

X-ray Powder Pattern: Mt. Alluaiv, Kola Peninsula, Russia.
3.36 (100), 8.97 (20), 1.682 (20), 2.69 (15), 2.99 (12), 2.243 (12), 2.58 (8)

Chemistry:

	(1)	(2)
P_2O_5	25.77	25.45
CO_2	15.71	15.78
FeO	0.49	
MnO	22.40	25.44
MgO	0.00	
CaO	2.20	
Na_2O	32.36	33.33
K_2O	0.44	
Total	99.37	100.00

(1) Mt. Alluaiv, Kola Peninsula, Russia; corresponds to $(Na_{2.93}K_{0.03})_{\Sigma=2.96}(Mn_{0.89}Ca_{0.11}Fe_{0.02})_{\Sigma=1.02}(PO_4)_{1.02}(CO_3)_{1.00}$. (2) $Na_3Mn(PO_4)(CO_3)$.

Occurrence: A rare low-temperature hydrothermal mineral, formed very late in the crystallization of hyperagpaitic pegmatites in a differentiated alkalic massif (Mt. Alluaiv, Kola Peninsula, Russia); in sodalite syenite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Villiaumite, kogarkoite, thermonatrite, aegirine (Mt. Alluaiv, Kola Peninsula, Russia); rasvumite, ussingite, villiaumite (Mont Saint-Hilaire, Canada).

Distribution: From Mt. Alluaiv, Lovozero massif, and in the Khibiny massif, Kola Peninsula, Russia. On Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Academician Aleksandr Vasil'evich Sidorenko (1917–1982), noted Russian geologist, a founder of the Kola Branch of the Russian Academy of Sciences.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5198; Mining Institute, St. Petersburg, 1110/1–2; Vernadsky Geological Museum, Moscow, 51718; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79775.

References: (1) Khomyakov, A.P., E.I. Semenov, M.E. Kazakova, and N.G. Shumyatskaya (1979) Sidorenkite, $Na_3Mn(PO_4)(CO_3)$ – a new mineral. Zap. Vses. Mineral. Obshch., 108, 56–59 (in Russian). (2) (1979) Amer. Mineral., 64, 1332 (abs. ref. 1). (3) Kurova, T.A., N.G. Shumyatskaya, A.A. Voronkov, and Y.A. Pyatenko. (1980) Crystal structure of sidorenkite, $Na_3Mn(PO_4)(CO_3)$. Sov. Phys. Doklady Acad. Nauk SSSR, 25, 156–157 (in Russian).

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Sidpietersite $Pb_4(S_2O_3)O_2(OH)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Euhedral to subhedral crystals, to 0.3 mm, are bladed, elongated along [01$\overline{1}$], platy on {001}, showing {001}, {100}, {01$\overline{1}$}, in radiating aggregates; more typically in warty nodular to earthy masses.

Physical Properties: *Cleavage:* Perpendicular to [01$\overline{1}$]. *Fracture:* Uneven. *Tenacity:* Sectile. Hardness = 1–2 D(meas.) = n.d. D(calc.) = 6.765

Optical Properties: Transparent to opaque. *Color:* Colorless, white, cream-beige. *Streak:* White to cream-white. *Luster:* Vitreous to pearly. *Optical Class:* [Biaxial.] *Pleochroism:* Slight. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.455(2)$ $b = 6.496(2)$ $c = 11.207(4)$ $\alpha = 114.33(2)°$ $\beta = 89.65(2)°$ $\gamma = 88.68(2)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
10.13 (100), 3.414 (100), 3.198 (80), 5.93 (50), 2.622 (40), 4.401 (35), 2.889 (35)

Chemistry:

	(1)	(2)
SO_3	7.58	7.95
S	3.04	3.18
PbO	89.55	88.66
H_2O	[1.79]	1.79
$-O = S$	1.51	1.58
Total	[100.45]	100.00

(1) Tsumeb, Namibia; by electron microprobe, $(S_2O_3)^{2-}$ and $(OH)^{1-}$ confirmed by IR and crystal-structure analysis; after partitioning S 6.07% as S^{6+}:S^{2-} = 1:1 and calculating $(OH)^{1-}$ for stoichiometry, corresponds to $Pb_{4.09}(S^{6+}_{0.97}S^{2-}_{0.97}O_{2.90})O_{2.09}(OH)_{2.03}$.

Occurrence: A very rare late-stage alteration product of galena in the oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Smithsonite, zincite, greenockite, galena, sphalerite, quartz.

Distribution: From Tsumeb, Namibia.

Name: To honor Sidney Pieters (1920–2003), Windhoek, Namibia, prominent dealer in Tsumeb minerals.

Type Material: The Natural History Museum, London, England, 1998,36; Canadian Geological Survey, Ottawa, Canada, 68076.

References: (1) Roberts, A.C., M.A. Cooper, F.C. Hawthorne, A.J. Criddle, C.J. Stanley, C.L. Key, and J.L. Jambor (1999) Sidpietersite, $Pb^{2+}_4(S^{6+}O_3S^{2-})O_2(OH)_2$, a new thiosulfate-bearing mineral species from Tsumeb, Namibia. Can. Mineral., 37, 1269–1273. (2) Cooper, M.A. and F.C. Hawthorne (1999) The structure topology of sidpietersite, $Pb^{2+}_4(S^{6+}O_3S^{2-})O_2(OH)_2$, a novel thiosulfate structure. Can. Mineral., 37, 1275–1282. (3) (2000) Amer. Mineral., 85, 1323–1324 (abs. ref. 1–2).

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Sidwillite $MoO_3 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are pseudohexagonal, flattened on {010}, with {101}, {103}, {$\bar{1}$01}, {111}, and {11$\bar{1}$}, to 0.2 mm.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 2.5 D(meas.) = 3.12 D(calc.) = 3.11

Optical Properties: Semitransparent. *Color:* Canary-yellow. *Streak:* Pale yellow. *Luster:* Resinous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = colorless; $Y = Z$ = yellow. *Orientation:* $X = b$; $Z \wedge a = 47°$. $\alpha = 1.70(1)$ $\beta = 2.21(2)$ $\gamma = 2.38(2)$ 2V(meas.) = n.d. 2V(calc.) = 48°

Cell Data: *Space Group:* $P2_1/n$. $a = 10.618(5)$ $b = 13.825(7)$ $c = 10.482(5)$ $\beta = 91.61(4)°$ Z = 16

X-ray Powder Pattern: Lake Como, Colorado, USA.
3.322 (100), 3.248 (93), 6.94 (84), 3.680 (58), 3.79 (53), 2.656 (51), 2.620 (41)

Chemistry:

	(1)	(2)
MoO_3	78.60	79.98
Fe_2O_3	trace	
H_2O	[21.40]	20.02
Total	[100.00]	100.00

(1) Lake Como, Colorado, USA; by electron microprobe, average of 15 analyses, H_2O by difference. (2) $MoO_3 \cdot 2H_2O$.

Occurrence: An oxidation product of jordisite in a quartz vein.

Association: Jordisite, quartz.

Distribution: From near Lake Como, Hinsdale Co., Colorado, USA.

Name: To honor Dr. Sidney Arthur Williams (1933–), American mineralogist and petrologist of Douglas, Arizona, USA, for his contributions to the mineralogy of oxidation zones of ore deposits.

Type Material: National School of Mines, Paris, France.

References: (1) Cesbron, F. and D. Ginderow (1985) La sidwillite, $MoO_3.2H_2O$; une nouvelle espèce minérale de Lake Como, Colorado, USA. Bull. Minéral., 108, 813–823 (in French with English abs.). (2) (1986) Amer. Mineral., 71, 1546 (abs. ref. 1).

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Siegenite $(Ni, Co)_3S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals dominantly octahedral, to 1 cm; also massive, granular to compact. *Twinning:* On {111}; may be polysynthetic.

Physical Properties: *Cleavage:* Imperfect on {001}. *Fracture:* Subconchoidal to uneven. Hardness = 4.5–5.5 VHN = 459–548 (100 g load). D(meas.) = 4.5–4.8 D(calc.) = 4.83

Optical Properties: Opaque. *Color:* Pale gray to steel-gray; tarnishes easily to copper-red or violet-gray. *Luster:* Metallic, brilliant on fresh surface.
R: (400) 42.8, (420) 43.2, (440) 43.7, (460) 44.3, (480) 44.8, (500) 45.4, (520) 45.9, (540) 46.6, (560) 47.2, (580) 48.1, (600) 49.0, (620) 50.0, (640) 50.8, (660) 51.6, (680) 52.4, (700) 53.2

Cell Data: *Space Group:* $Fd3m$. a = 9.41 Z = 8

X-ray Powder Pattern: Mine la Motte, Missouri, USA.
2.86 (100), 1.670 (80), 2.36 (70), 1.815 (60), 0.988 (50), 3.34 (40), 1.228 (40)

Chemistry:

	(1)	(2)	(3)	(4)
Co	26.08	20.36	13.7	19.35
Ni	31.18	31.24	41.5	38.54
Fe	0.62	3.22	2.8	
Cu		3.16		
S	42.63	42.43	42.1	42.11
insol.	0.16			
Total	100.67	100.41	100.1	100.00

(1) Littfeld, Germany; corresponds to $(Co_{1.33}Ni_{1.60}Fe_{0.03})_{\Sigma=2.96}S_{4.00}$. (2) Mine la Motte, Missouri, USA; corresponds to $(Co_{1.04}Ni_{1.61}Fe_{0.17}Cu_{0.15})_{\Sigma=2.97}S_{4.00}$. (3) Schönbrunn deposit, near Ölsnitz, [Vogtland=Saxony or Thuringia ck??, not in Rand-McNally, mindat.org??] Germany; by electron microprobe, corresponds to $(Co_{0.71}Ni_{2.14}Fe_{0.15})_{\Sigma=3.00}S_{4.00}$. (4) $CoNi_2S_4$.

Mineral Group: Linnaeite group.

Occurrence: In hydrothermal veins with other Cu–Ni–Fe sulfides.

Association: Chalcopyrite, pyrrhotite, galena, sphalerite, pyrite, millerite, gersdorffite, ullmannite.

Distribution: In Germany, from the Siegen district, North Rhine-Westphalia [TL], as at Müsen and Littfeld. From near Brestovsko, central Bosnian Mountains, Serbia. At Kladno, Czech Republic. From Blackcraig, Kirkcudbrightshire, Scotland. In the USA, in the Mine la Motte, Madison Co.; fine crystals from the Buick mine, Bixby, Iron Co., and in the Miliken (Sweetwater) mine, Reynolds Co., Missouri. In Canada, from the Langis mine, Cobalt-Gowganda area, Ontario. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From Kilembe, Uganda. In the Kamaishi mine, Iwate Prefecture, and the Yokozuru mine, north Kyushu, Japan. From Kalgoorlie, Western Australia. Known from many other minor localities.

Name: For the occurrence in the Siegen district, Germany.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 262–265. (2) Pietzsch, C. and H. Kämpf (1993) Moessbauer investigations of siegenite – an attempt at structural analysis. Neues Jahrb. Mineral., Monatsh., 265–277. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 76–77. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 509.

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Sieleckiite **$Cu_3Al_4(PO_4)_2(OH)_{12}\cdot 2H_2O$**

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals, to 100 μm, in smooth spherical aggregates, to 0.5 mm, with a finely fibrous radiating structure.

Physical Properties: *Fracture:* Subconchoidal. Hardness = ∼3 D(meas.) = 3.02(2) D(calc.) = 2.94

Optical Properties: Translucent. *Color:* Deep sky-blue to Royal blue. *Streak:* Pale blue. *Luster:* Pearly.
Optical Class: Biaxial. *Pleochroism:* Weak; colorless to very pale blue. *Orientation:* Length-slow. $\alpha = 1.63$ $\beta =$ n.d. $\gamma = 1.66$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.41(8)$ $b = 7.56(5)$ $c = 5.95(6)$ $\alpha = 90.25(12)°$ $\beta = 91.27(12)°$ $\gamma = 104.02(7)°$ Z = 1

X-ray Powder Pattern: Mt. Oxide, Australia.
5.036 (100), 3.852 (100), 9.120 (50), 2.827 (50), 2.460 (50), 3.276 (30), 2.570 (20)

Chemistry:

	(1)	(2)
P_2O_5	19.42	19.48
CO_2	1.6	
Al_2O_3	26.57	27.99
CuO	32.39	32.75
H_2O	18.1	19.78
Total	98.1	100.00

(1) Mt. Oxide, Australia; by electron microprobe, H_2O by CHN analyzer; corresponds to $Cu_{3.11}Al_{3.98}(PO_4)_{2.09}(OH)_{12}\cdot 1.7H_2O$. (2) $Cu_3Al_4(PO_4)_2(OH)_{12}\cdot 2H_2O$.

Occurrence: A rare secondary mineral found in a fracture in a boulder from the oxidized zone of a copper deposit.

Association: Variscite, turquoise, libethenite, pseudomalachite.

Distribution: From the Mt. Oxide copper mine, 150 km north of Mt. Isa, Queensland, Australia.

Name: To honor Robert Sielecki (1958–), Australian geologist, who collected the first specimens.

Type Material: Museum Victoria, Melbourne, M38238, M38538; South Australian Museum, Adelaide, Australia, G14180.

References: (1) Birch, W.D. and A. Pring (1988) Sieleckiite, a new copper aluminium phosphate from Mt Oxide, Queensland, Australia. Mineral. Mag., 52, 515–518. (2) (1989) Amer. Mineral., 74, 1401 (abs. ref. 1).

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Sigismundite

$\mathbf{Na_3(Ba,K,Pb)(Ca,Sr)(Fe^{2+},Mg,Mn^{2+})_{14}Al(PO_4)_{12}(OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Imperfect and shattered elongated crystals, to 1 cm, in massive lumps.

Physical Properties: *Cleavage:* Two, imperfect, at ∼110°. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.544

Optical Properties: Translucent. *Color:* Grayish green; greenish yellow in transmitted light. *Streak:* White. *Luster:* Greasy.
Optical Class: Biaxial. *Orientation:* Extinction ∼25° to elongation. $n = 1.65(1)$
2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$. $a = 16.406(5)$ $b = 9.945(3)$ $c = 24.470(5)$
$\beta = 105.73(2)°$ Z = 4

X-ray Powder Pattern: Near Madésimo, Italy.
3.010 (100), 3.178 (51), 2.678 (42), 2.523 (27), 2.805 (25), 4.519 (23), 2.775 (21)

Chemistry:

	(1)		(1)
P_2O_5	40.50	CaO	2.09
SiO_2	0.02	SrO	1.09
Al_2O_3	2.45	BaO	5.68
FeO	27.64	Na_2O	4.44
MnO	0.70	K_2O	0.26
PbO	0.76	H_2O	[0.86]
MgO	10.85	Total	[97.34]

(1) Near Madésimo, Italy; average of ten analyses, total Fe as FeO, total Mn as MnO, H_2O from crystal-structure analysis; corresponds to $Na_{3.02}(Ba_{0.78}K_{0.12}Pb_{0.07}Sr_{0.02})_{\Sigma=0.99}(Ca_{0.79}Sr_{0.20})_{\Sigma=0.99}(Fe_{8.12}Mg_{5.68}Mn_{0.21})_{\Sigma=14.01}Al_{1.01}(PO_4)_{12}(OH)_2$.

Occurrence: A very rare mineral in phengitic quartzite, formed probably by metamorphism of phosphatic organic matter.

Association: Quartz, apatite, iron carbonates, potassic feldspar, rutile, schorl, barite, celestine, lazulite, woodhouseite, crandallite, kaolinite, mitridatite, diaspore, svanbergite, vanadinite, albite, iron oxides.

Distribution: From near Madésimo, Spluga Valley, Lombardy, Italy.

Name: In honor of Pietro Sigismund (1874–1962), mineral collector specializing in minerals from Val Malenco, Italy.

Type Material: Civic Museum of Natural History, Morbegno, Italy.

References: (1) Demartin, F., C.M. Gramaccioli, T. Pilati, and E. Sciesa (1996) Sigismundite, $(Ba,K,Pb)Na_3(Ca,Sr)(Fe,Mg,Mn)_{14}Al(OH)_2(PO_4)_{12}$, a new Ba-rich member of the arrojadite group from Spluga Valley, Italy. Can. Mineral., 34, 827–834. (2) (1997) Amer. Mineral., 82, 432–433 (abs. ref. 1).

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Sigloite $Fe^{3+}Al_2(PO_4)_2(OH)_3 \cdot 7H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are pseudomorphic after paravauxite crystals, distorted and curved, showing {010}, {001}, {100}, {110}, several other forms, to about 1 cm, in intergrowths.

Physical Properties: *Cleavage:* On {010}, perfect; on {001}, good. Hardness = 3
D(meas.) = 2.35 D(calc.) = [2.40]

Optical Properties: Semitransparent. *Color:* Pale straw-yellow, pale brownish orange, light brown.
Optical Class: Biaxial (+). *Orientation:* X (90°,32°); Y (–144°,70°); Z (–46°,66°) [using (ϕ,ρ)].
Dispersion: $r < v$, strong. $\alpha = 1.563$ $\beta = 1.586(1)$ $\gamma = 1.619$ 2V(meas.) = 76°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.190(2)$ $b = 10.419(4)$ $c = 7.033(3)$ $\alpha = 105.00(3)°$ $\beta = 111.31(3)°$ $\gamma = 70.87(3)°$ Z = 1

X-ray Powder Pattern: Siglo XX mine, Bolivia.
9.69 (10), 6.46 (9), 4.86 (9), 3.23 (7), 2.82 (6), 2.56 (5), 4.68 (4b)

Chemistry:

	(1)	(2)
P_2O_5	27.47	29.77
SiO_2	0.11	
Al_2O_3	21.09	21.38
Fe_2O_3	13.53	16.74
FeO	2.76	
MnO	0.24	
MgO	0.87	
Na_2O	0.44	
K_2O	0.26	
H_2O	33.55	32.11
Total	100.32	100.00

(1) Siglo XX mine, Bolivia. (2) $FeAl_2(PO_4)_2(OH)_3 \cdot 7H_2O$.

Mineral Group: Paravauxite group.

Occurrence: A rare late-stage secondary mineral, formed by oxidation of vauxite, in open fractures cutting cassiterite veins in a hydrothermal tin deposit.

Association: Wavellite, metavauxite, crandallite, childrenite, vauxite, quartz.

Distribution: Found in the Siglo XX mine, Llallagua, Potosí, Bolivia.

Name: For its occurrence in the Siglo XX mine, Llallagua, Bolivia.

Type Material: Harvard University, Cambridge, Massachusetts, 107443; National Museum of Natural History, Washington, D.C., USA, 115320.

References: (1) Hurlbut, C.S., Jr. and R. Honea (1962) Sigloite, a new mineral from Llallagua, Bolivia. Amer. Mineral., 47, 1–8. (2) Hawthorne, F.C. (1988) Sigloite: the oxidation mechanism in $[M_2^{3+}(PO_4)_2(OH)_2(H_2O)_2]^{2-}$ structures. Mineral. Petrol., 38, 201–211.

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Silhydrite $3SiO_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Microcrystalline grains, to 4 μm, in porous punky masses.

Physical Properties: *Fracture:* Subconchoidal to irregular. Hardness = 1, in aggregate. D(meas.) = 2.141(3) D(calc.) = 2.116 by the rule of Gladstone and Dale.

Optical Properties: Transparent. *Color:* White; in transmitted light, colorless. *Optical Class:* Biaxial. $n = 1.466$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 14.519(5)$ $b = 18.80(1)$ $c = 15.938(4)$ Z = [28]

X-ray Powder Pattern: Trinity Center, California, USA.
14.50 (100), 3.424 (82), 3.143 (35), 3.627 (27), 3.540 (25), 7.31 (22), 7.07 (21)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	88.93	90.91	K_2O	0.01	
TiO_2	0.01		F	0.00	
Al_2O_3	0.01		Cl	0.01	
Fe_2O_3	0.04		H_2O^+	3.13	
FeO	0.02		H_2O^-	6.65	
MnO	0.00		H_2O		9.09
MgO	0.71		CO_2	0.07	
CaO	0.11		P_2O_5	0.00	
Na_2O	0.05		Total	99.75	100.00

(1) Trinity Center, California, USA. (2) $3SiO_2 \cdot H_2O$.

Occurrence: Formed by the leaching of sodium from magadiite by near-surface water.

Association: Magadiite.

Distribution: About 10 km east of Trinity Center, Trinity Co., California, USA.

Name: For the SILica and water of HYDRation in its composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 125042.

References: (1) Gude, A.J., 3rd and R.A. Sheppard (1972) Silhydrite, $3SiO_2 \cdot H_2O$, a new mineral from Trinity County, California. Amer. Mineral., 57, 1053–1065.

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Silinaite $NaLiSi_2O_5 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular to prismatic, to 2 mm; in fibrous clusters; earthy to chalky massive. *Twinning:* About [110], with composition plane {001}.

Physical Properties: *Cleavage:* {001}, perfect; {010}, good; {110}, distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼4.5 D(meas.) = 2.24(1) D(calc.) = 2.23

Optical Properties: Transparent to translucent, opaque. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous to earthy. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Y \wedge c = 16°$. *Dispersion:* $r > v$, strong, inclined. $\alpha = 1.515(1)$ $\beta = 1.516(1)$ $\gamma = 1.518(1)$ 2V(meas.) = 64(1)° 2V(calc.) = 71°

Cell Data: *Space Group:* $A2/n$. $a = 5.061(1)$ $b = 8.334(2)$ $c = 14.383(3)$ $\beta = 96.67(2)°$ Z = 4

X-ray Powder Pattern: Mont Saint-Hilaire, Canada. 7.14 (100), 4.14 (100), 2.847 (100), 4.24 (80), 4.02 (80), 2.698 (50), 1.610 (40)

Chemistry:

	(1)
SiO_2	58.54
Al_2O_3	0.01
CaO	0.14
Li_2O	[7.28]
Na_2O	14.96
H_2O	[17.56]
Total	[98.49]

(1) Mont Saint-Hilaire, Canada; by electron microprobe, Li_2O and H_2O calculated from stoichiometry of crystal structure; corresponds to $(Na_{0.99}Ca_{0.01})_{\Sigma=1.00}LiSi_{2.00}O_5 \cdot 2H_2O$.

Occurrence: In sodalite syenite xenoliths in nepheline syenite in an intrusive alkalic gabbro-syenite complex.

Association: Ussingite, terskite-(Ce), sérandite, vuonnemite, halite, villiaumite, thermonatrite, aegirine.

Distribution: At Mont Saint-Hilaire, Quebec, Canada.

Name: For SIlicon, LIthium, and sodium, NAtrium, in the composition.

Type Material: Canadian Museum of Nature, Ottawa, 56467, 56468; Royal Ontario Museum, Toronto, Canada, M44516, M44517.

References: (1) Chao, G.Y., J.D. Grice, and R.A. Gault (1991) Silinaite, a new sodium lithium silicate hydrate mineral from Mont Saint-Hilaire, Quebec. Can. Mineral., 29, 359–362. (2) Grice, J.D. (1991) The crystal structure of silinaite, $NaLiSi_2O_5 \cdot 2H_2O$: a monophyllosilicate. Can. Mineral., 29, 363–367. (3) (1991) Amer. Mineral., 76, 2023–2024 (abs. refs. 1 and 2).

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Sillénite $Bi_{12}SiO_{20}$

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Crystal Data: Cubic. *Point Group:* 23. Crystals are cubes, up to 5 mm; fine-grained granular to massive.

Physical Properties: *Tenacity:* Waxy in part. Hardness = Soft. VHN = 345–386 (50 g load). D(meas.) = 9.16 D(calc.) = 9.18

Optical Properties: Translucent. *Color:* Olive-green, gray-green, yellow-green, yellow, reddish brown; in transmitted light, deep golden brown to yellow. *Streak:* Light yellowish to brownish white. *Luster:* Adamantine.
Optical Class: Isotropic. $n = > 2.50$

Cell Data: *Space Group: I*23. $a = 10.110(2)$ $Z = 2$

X-ray Powder Pattern: Durango, Mexico.
3.216 (10), 1.743 (9), 2.730 (8), 2.939 (7), 1.651 (6), 1.499 (6), 1.216 (5)

Chemistry:

	(1)	(2)
SiO_2	2.22	1.85
Bi_2O_3	97.74	96.48
Total	99.96	98.33

(1) Fuka, Japan; corresponds to $Bi_{11.93}Si_{1.05}O_{20}$. (2) Do.; by electron microprobe, corresponds to $Bi_{12.13}Si_{0.90}O_{20}$.

Occurrence: A secondary mineral formed by the oxidation of bismuth-bearing minerals (Durango, Mexico); in a hydrothermal vein in skarns (Fuka, Japan).

Association: Bismutite (Durango, Mexico); shattuckite, ajoite, duhamelite (Munihuaza, Mexico); calcite (Fuka, Japan).

Distribution: In Mexico, from an unspecified locality in Durango, and at Munihuaza, near Alamos, Sonora. In the Monapo pegmatite, Mocambique district, Mozambique. From Fujikawachi, Oita Prefecture; Fuka, near Bicchu, Okayama Prefecture; and Ishikawa, Fukushima Prefecture, Japan. In the Czech Republic, from near Smrkovec, Slavkovský Les Mountains, about 10 km north-northeast of Mariánské Lázně.

Name: In honor of Dr. Lars Gunnar Sillén (1916–), Swedish chemist of Stockholm, Sweden.

Type Material: Harvard University, Cambridge, Massachusetts, 83256; National Museum of Natural History, Washington, D.C., USA, C1926.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 601. (2) Aurivillius, B. and L.G. Sillén (1945) Polymorphy of bismuth trioxide. Nature, 155, 305–306. (3) Kusachi, I. and C. Henmi (1991) Sillenite from Fuka, Okayama Prefecture, Japan. Mineral. J. (Japan), 15, 343–348. (4) Radaev, S.F., V.I. Simonov, and Y.F. Kargin (1992) Structural features of γ-phase Bi_2O_3 and its place in the sillenite family. Acta Cryst., 48, 604–609.

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Sillimanite Al_2SiO_5

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, may be acicular, with square cross sections, rounded and striated, poorly terminated, to 2 cm; as fibrous mats; rarely radiating.

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Uneven. *Tenacity:* Tough in aggregate. Hardness = 6.5–7.5 D(meas.) = 3.23–3.24 D(calc.) = [3.24]

Optical Properties: Transparent to translucent. *Color:* Colorless or white to gray, also brown, yellow, yellow-green, gray-green, blue-green, blue; colorless in thin section. *Streak:* White. *Luster:* Vitreous to subadamantine.
Optical Class: Biaxial (+). *Pleochroism:* If colored, X = pale brown or pale yellow; Y = brown or green; Z = dark brown or blue. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$, strong. $\alpha = 1.653–1.661$ $\beta = 1.657–1.662$ $\gamma = 1.672–1.683$ 2V(meas.) = 21°–30°

Cell Data: *Space Group: Pbnm.* a = 7.4883(7) b = 7.6808(7) c = 5.7774(5) Z = 4

X-ray Powder Pattern: Custer, Custer Co., South Dakota, USA.
3.42 (100), 3.37 (65), 2.204 (60), 2.541 (40), 2.679 (30), 2.111 (20), 5.36 (16)

Chemistry:

	(1)
SiO_2	37.08
Al_2O_3	63.11
Fe_2O_3	0.09
Total	100.28

(1) Delaware Co., Pennsylvania, USA; corresponds to $Al_{2.00}Si_{1.00}O_5$.

Polymorphism & Series: Trimorphous with kyanite and andalusite.

Occurrence: In high-grade metamorphic schists, gneisses, and hornfels; more rarely in pegmatites. Also as a detrital mineral.

Association: Andalusite, kyanite, potassic feldspar, almandine, cordierite, biotite, quartz.

Distribution: Of widespread occurrence, but fine examples are uncommon. From the Lisens Alp, Selraintal, Tirol, Austria. At Maršová (Marschendorf), Czech Republic. From Bodenmais, Bavaria, Germany. At Pontgibaud, Auvergne, France. In the USA, from Chester, near Saybrook, Middlesex Co., and near Norwich, New London Co., Connecticut; from Chester, Delaware Co., Pennsylvania; at Monroe, Orange Co., New York. In the Okkampitiya, Ratnapura, Deniyaya, and Balangoda districts, Sri Lanka, as gem crystals. At Christmas Point, Enderby Land, Antarctica.

Name: For Professor Benjamin Silliman (1779–1864), Professor of Chemistry and Mineralogy, Yale University, New Haven, Connecticut, USA.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 498–499. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 719–741. (3) Althaus, E. (1969) Das System Al_2O_3–SiO_2–H_2O. Experimentelle Untersuchungen und Folgerungen für die Petrogenese der metamorphen Gesteine. Neues Jahrb. Mineral., Abh., 111, 74–110 (in German). (4) Winter, J.K. and S. Ghose (1979) Thermal expansion and high-temperature crystal chemistry of the Al_2SiO_5 polymorphs. Amer. Mineral., 64, 573–586.

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Silver Ag

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals commonly cubic, octahedral, or dodecahedral, to 2 cm; in parallel groups; more commonly as elongated, wiry, arborescent, or reticulated forms. Massive, in scales, sheets, and as coatings. *Twinning:* On {111} as simple pairs and repeated in aggregates radiating along [111] axes.

Physical Properties: *Fracture:* Hackly. *Tenacity:* Ductile, malleable. Hardness = 2.5–3 VHN = 60–65 (100 g load). D(meas.) = 10.1–11.1 (10.5 when pure). D(calc.) = 10.497

Optical Properties: Opaque. *Color:* Silver-white, tarnishes gray to black; in polished section, brilliant silver-white. *Streak:* Silver-white. *Luster:* Metallic.
R: (400) 83.4, (420) 84.5, (440) 86.0, (460) 87.7, (480) 89.1, (500) 90.5, (520) 91.8, (540) 93.0, (560) 93.5, (580) 93.7, (600) 94.0, (620) 94.4, (640) 94.7, (660) 95.2, (680) 95.6, (700) 96.0

Cell Data: *Space Group:* $Fm3m$. $a = 4.0862$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.359 (100), 2.044 (40), 1.231 (26), 1.445 (25), 0.9375 (15), 1.8341 (13), 0.9137 (12)

Chemistry:

	(1)
Ag	98.450
Au	0.004
Cu	0.011
Fe	0.024
Hg	1.130
Sb	0.581
Total	100.200

(1) Kongsberg, Norway.

Polymorphism & Series: Forms a series with gold; the cubic form is 3C; hexagonal stacking polytypes 2H and 4H are known.

Occurrence: A primary hydrothermal mineral, also formed by secondary processes, especially in the oxidized portions of mineral deposits.

Association: Acanthite, chlorargyrite, embolite, silver sulfosalts, gold, copper.

Distribution: Numerous localities even for fine specimens. Well-crystallized examples from: in Germany, near Freiberg and Marienberg, Saxony, and at St. Andreasberg, Harz Mountains. Exceptionally developed at Kongsberg, Norway. From Příbram and Jáchymov (Joachimsthal), Czech Republic. In Italy, from Monte Narba, Sarrabus, Sardinia. In the USA, on the Keweenaw Peninsula, Houghton and Keweenaw Cos., Michigan; at Aspen, Pitkin Co., and from Creede, Mineral Co., Colorado; and in Arizona, in the Silver King mine, Pinal Co. In Canada, in large amounts from Cobalt; and in the Thunder Bay district, at Silver Islet, on the north shore of Lake Superior, Ontario. Important production from Mexico, in many states; finely crystallized from Batopilas, Chihuahua; masses over 1500 kg from Arizonac, Sonora. At Chañarcillo, south of Copiapó, Atacama, Chile. In Australia, at Broken Hill, New South Wales.

Name: From an Old English word for the metal *soelfer*, related to the German *silber* and the Dutch *zilver*; the chemical symbol from the Latin *argentum*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 96–99. (2) Ewald, P.P. and C. Hermann, Eds. (1931) Silber, *Ag*. Strukturbereicht, 1, 36–38 (in German). (3) Novgorodova, M.I., A.I. Gorshkov, and A.V. Mokhov (1979) Native silver and its new structural modifications. Zap. Vses. Mineral. Obshch., 108, 552–563 (in Russian). (4) (1953) NBS Circ. 539, 1, 23. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 511.

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Simferite $Li(Mg, Fe^{3+}, Mn^{3+})_2(PO_4)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Rare crystals, to 0.1 mm, are tabular, with {001}, {010}, {110}, {120}, in aggregates. *Twinning:* Commonly observable, on an unknown law.

Physical Properties: *Fracture:* Uneven. Hardness = n.d. VHN = 457(30) (100 g load). D(meas.) = 3.22–3.27 D(calc.) = 3.25

Optical Properties: Semitransparent. *Color:* Dark red to nearly black. *Streak:* Brown. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (+). *Pleochroism:* X = light brown to red; Y = brownish yellow to brown; Z = yellow to reddish yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, strong. $\alpha = 1.690$–1.704 $\beta = 1.702$–1.716 $\gamma = 1.712$–1.726 2V(meas.) = 54°–60°

Cell Data: *Space Group:* $Pbnm$ or $Pbn2_1$. a = 4.7468(7) b = 10.101(2) c = 5.8992(7) Z = 4

X-ray Powder Pattern: Radionovskoye pegmatite field, Ukraine.
2.48 (10), 4.30 (9), 2.93(8), 3.85 (6), 3.45 (6), 2.42(6), 2.23 (6)

Chemistry:

	(1)	(2)
P_2O_5	51.90	51.00
Fe_2O_3	16.87	17.39
Mn_2O_3	9.84	14.83
MgO	15.78	12.36
CaO	0.00	0.08
Li_2O	5.45	5.35
Total	99.84	101.01

(1) Radionovskoye pegmatite field, Ukraine; corresponds to $Li_{1.00}(Mg_{1.09}Fe^{3+}_{0.57}Mn^{3+}_{0.34})_{\Sigma=2.00}(P_{1.01}O_4)_2$. (2) Do.; corresponds to $Li_{0.98}(Mg_{0.85}Fe^{3+}_{0.60}Mn^{3+}_{0.52})_{\Sigma=1.97}(P_{1.00}O_4)_2$.

Occurrence: At the contact of a rare-earth-bearing granite pegmatite and phlogopitized ultramafic tremolite rock.

Association: Muscovite, quartz, oligoclase, albite, phlogopite, tourmaline, apatite.

Distribution: In the Radionovskoye pegmatite field, middle Berda River, Zaporozhe district, Ukraine.

Name: For the city of Simferopol, Crimea, Ukraine, where the mineral was studied.

Type Material: n.d.

References: (1) Yakubovich, O.V., V.V. Bairakov, and M.A. Simonov (1989) Crystal structure of simferite $Li(Mg, Fe^{3+}, Mn^{3+})_2[PO_4]_2$. Doklady Acad. Nauk SSSR, 307, 1119–1122 (in Russian). (2) (1993) Amer. Mineral., 78, 452 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 187–188.

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Simmonsite Na_2LiAlF_6

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals are hexagonal, commonly flattened on {0001}, or prismatic, may be in parallel, to 1 mm.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ∼1.5 D(meas.) = 3.292 D(calc.) = 3.341

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.657(1)$ $\epsilon = 1.700(1)$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.334(2)$ $c = 23.58(1)$ Z = 3

X-ray Powder Pattern: Richelsdorf, Germany.
7.87 (100), 2.672 (60), 2.725 (50), 3.58 (40), 3.16 (40), 2.372 (40), 5.33 (30)

Chemistry:

	(1)	(2)
FeO	1.25	
ZnO	73.63	71.40
Cl	11.73	12.44
H_2O	16.21	18.96
$-O = Cl_2$	2.65	2.80
Total	100.17	100.00

(1) Richelsdorf, Germany; by electron microprobe, average of several determinations; H_2O by Karl Fischer titration, presence established by IR. (2) $Zn_5Cl_2(OH)_8 \cdot H_2O$.

Occurrence: A rare secondary mineral formed by weathering of zinc-bearing slag.

Association: Wülfingite, hydrocerussite, diaboleite, zincite, hydrozincite, zinc.

Distribution: On slag heaps from the foundry at Richelsdorf, Hesse, Germany.

Name: Honors Werner Simon and Kurt Kolle, mineral collectors of Cornberg, near Richelsdorf, Germany.

Type Material: Göttingen University, Göttingen; Heidelberg University, Heidelberg, Germany.

References: (1) Schmetzer, K., G. Schnorrer-Köhler, and O. Medenbach (1985) Wülfingite, $\epsilon-Zn(OH)_2$, and simonkolleite, $Zn_5(OH)_8Cl_2 \cdot H_2O$, two new minerals from Richelsdorf, Hesse, F.R.G. Neues Jahrb. Mineral., Monatsh., 145–154. (2) (1988) Amer. Mineral., 73, 194–195 (abs. ref. 1). (3) Allmann, R. (1968) Verfeinerung der Struktur des Zinkhydrochlorids II, $Zn_5(OH)_8Cl_2 \cdot 1H_2O$. Zeits. Krist., 126, 417–426 (in German with English abs.).

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Simonellite $C_{19}H_{24}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. A crystalline incrustation.

Physical Properties: Hardness = n.d. D(meas.) = 1.08 D(calc.) = 1.10

Optical Properties: Semitransparent. *Color:* White.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* *Pnna* (studied on material recrystallized from benzene).
$a = 9.231(3)$ $b = 9.134(3)$ $c = 36.01(1)$ Z = 8

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
C	89.84	90.42
H	10.15	9.58
Total	99.99	100.00

(1) Fognano, Italy. (2) $C_{19}H_{24}$; 1,1-dimethyl-7-isopropyl-1,2,3,4-tetrahydrophenanthrene, MP 59° C–60° C, BP 314° C–316° C.

Occurrence: In lignite, apparently derived from coniferous forests.

Association: n.d.

Distribution: From a coal mine at Fognano, near Montepulciano, Tuscany, Italy. A component of other brown coals and volcanic ashes, but noted in organic extractions.

Name: Honors Professor Vittorio Simonelli (1860–1929), Italian geologist, University of Bologna, Bologna, Italy, who discovered the mineral.

Type Material: n.d.

References: (1) Ciusa, R. and A. Galizzi (1921) Ricerche su alcuni costituenti delle lignite. Gazetta Chimica Italiana, 51(1), 55–60 (in Italian). (2) (1922) Amer. Mineral., 7, 178 (abs. ref. 1). (3) Foresti, E. and L. Riva di Sanseverino (1969) The X-ray crystal and molecular structure of an organic mineral: simonellite, $C_{19}H_{24}$. Atti Rend. Accad. Lincei, 47, 41–54.

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Simonite $TlHgAs_3S_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As irregular crystals, to 0.2 mm across.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 5.036

Optical Properties: Opaque. *Color:* Red.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/n$. $a = 5.948(2)$ $b = 11.404(6)$ $c = 15.979(5)$ $\beta = 90.15(1)^\circ$ $Z = 4$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
Tl	24.00	24.86
Hg	23.80	24.40
As	25.55	27.34
Sb	1.68	0.00
S	24.97	23.40
Total	100.00	100.00

(1) Alšar, Macedonia; by electron microprobe, corresponds to $Tl_{0.90}Hg_{0.91}(As_{2.63}Sb_{0.11})_{\Sigma=2.74}S_{6.00}$. (2) $TlHgAs_3S_6$.

Occurrence: As inclusions in rebulite.

Association: Rebulite, christite or routhierite, parapierrotite.

Distribution: From Alšar (Allchar), near Rošden, Macedonia [TL].

Name: Apparently to honor Simon Engel, son of Peter Engel, Swiss crystallographer, the principal describer.

Type Material: Natural History Museum, Bern, Switzerland, B2920.

References: (1) Engel, P., W. Nowacki, T. Balić-Žunić, and S. Šćavnićar (1982) The crystal structure of simonite, $TlHgAs_3S_6$. Zeits. Krist., 161, 159–166. (2) (1984) Amer. Mineral., 69, 211 (abs. ref. 1).

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Crystals are hexagonal, commonly flattened on {0001}, or prismatic, may be in parallel, to 1 mm.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = ~1.5 D(meas.) = 3.292 D(calc.) = 3.341

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.657(1)$ $\epsilon = 1.700(1)$

Cell Data: *Space Group:* $R\bar{3}m$. $a = 6.334(2)$ $c = 23.58(1)$ $Z = 3$

X-ray Powder Pattern: Richelsdorf, Germany.
7.87 (100), 2.672 (60), 2.725 (50), 3.58 (40), 3.16 (40), 2.372 (40), 5.33 (30)

Chemistry:

	(1)	(2)
FeO	1.25	
ZnO	73.63	71.40
Cl	11.73	12.44
H_2O	16.21	18.96
$-O = Cl_2$	2.65	2.80
Total	100.17	100.00

(1) Richelsdorf, Germany; by electron microprobe, average of several determinations; H_2O by Karl Fischer titration, presence established by IR. (2) $Zn_5(OH)_8Cl_2 \cdot H_2O$.

Occurrence: A rare secondary mineral formed by weathering of zinc-bearing slag.

Association: Wülfingite, hydrocerussite, diaboleite, zincite, hydrozincite, zinc.

Distribution: On slag heaps from the foundry at Richelsdorf, Hesse, Germany.

Name: Honors Werner Simon and Kurt Kolle, mineral collectors of Cornberg, near Richelsdorf, Germany.

Type Material: Göttingen University, Göttingen; Heidelberg University, Heidelberg, Germany.

References: (1) Schmetzer, K., G. Schnorrer-Köhler, and O. Medenbach (1985) Wülfingite, ϵ–$Zn(OH)_2$, and simonkolleite, $Zn_5(OH)_8Cl_2 \cdot H_2O$, two new minerals from Richelsdorf, Hesse, F.R.G. Neues Jahrb. Mineral., Monatsh., 145–154. (2) (1988) Amer. Mineral., 73, 194–195 (abs. ref. 1). (3) Allmann, R. (1968) Verfeinerung der Struktur des Zinkhydrochlorids II, $Zn_5(OH)_8Cl_2 \cdot 1H_2O$. Zeits. Krist., 126, 417–426 (in German with English abs.).

Simplotite $CaV_4^{4+}O_9 \cdot 5H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$, m, or 2. Radiating books of pseudotetragonal plates, showing {101}, to 1 mm; in micaceous plates and hemispherical aggregates.

Physical Properties: *Cleavage:* {010}, perfect, micaceous. Hardness = ∼1
D(meas.) = 2.64(2) D(calc.) = 2.65

Optical Properties: Semitransparent. *Color:* Black, greenish black; yellow-green in thin flakes. *Streak:* Brownish black. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = yellow; $Y = Z$ = green. *Orientation:* $X = b$; $Z \wedge c \simeq -58°$. *Dispersion:* $r > v$, weak, crossed. $\alpha = 1.705(2)$ $\beta = 1.767(2)$ $\gamma = 1.769(2)$
2V(meas.) = ∼25°; after several years dehydration $\alpha = 1.730(5)$ $\beta = 1.781(3)$ $\gamma = 1.807(3)$
2V(meas.) = 40°

Cell Data: *Space Group:* $A2/m$, Am, or $A2$. $a = 8.39(3)$ $b = 17.02(5)$ $c = 8.37(3)$
$\beta = 90°25(5)'$ Z = 4

X-ray Powder Pattern: Colorado Plateau, USA; strong preferred orientation.
8.51 (100), 2.62 (25), 3.14 (18), 4.26 (9), 2.84 (9), 3.42 (6), 2.52 (5)

Chemistry:

	(1)	(2)
V_2O_4	69.0	69.42
V_2O_5	0.5	
CaO	11.8	11.73
H_2O^+	4.0	
H_2O^-	14.7	
H_2O		18.85
Total	[100.0]	100.00

(1) Peanut mine, Colorado, USA; total V and V^{4+} determined directly, V^{5+} by difference, recalculated to 100% after deduction of insoluble 0.5%, mainly SiO_2. (2) $CaV_4O_9 \cdot 5H_2O$.

Occurrence: A secondary mineral on fracture surfaces and replacing fossil wood in Colorado Plateau-type U–V deposits.

Association: Montroseite, duttonite, melanovanadite, selenium, uraninite, coffinite, vanadiferous silicates.

Distribution: In the USA, in Colorado, from the Peanut mine, Bull Canyon, in the J.J. and Hummer mines, Paradox Valley, and at the Shattuck-Denn mine, Club Mesa, Uravan district, Montrose Co., and on the Sundown claim, Gypsum Valley, and the Burro mine, Slick Rock district, San Miguel Co.; from the Vanadium Queen mine, La Sal Creek, San Juan Co., Utah.

Name: For John Richard Simplot (1909–), Boise, Idaho, of the J.R. Simplot Mining Co., which owned the Peanut mine.

Type Material: National Museum of Natural History, Washington, D.C., USA, 115881.

References: (1) Thompson, M.E., C.H. Roach, and R. Meyrowitz (1958) Simplotite, a new quadrivalent vanadium mineral from the Colorado Plateau. Amer. Mineral., 43, 16–24.

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Simpsonite $Al_4(Ta,Nb)_3O_{13}(OH)$

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Crystal Data: Hexagonal. *Point Group:* 3. Euhedral to subhedral crystals, tabular to short prismatic, with $\{10\bar{1}0\}$ and {0001}, and rarely a few other forms, striated ‖ [0001], to 2.4 cm; commonly in subparallel groups.

Physical Properties: *Fracture:* Conchoidal. Hardness = 7.5 D(meas.) = 6.68–6.82 D(calc.) = [6.82–6.86] Blue-white cathodoluminescence and fluorescence in SW UV, rarely fluoresces yellow.

Optical Properties: Semitransparent. *Color:* White to cream, yellow to yellow-brown when altered; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (–). $\omega = 2.045(5)$ $\epsilon = 2.025(5)$

Cell Data: *Space Group:* $P3$. $a = 7.385$–7.387 $c = 4.515$–4.516 $Z = 1$

X-ray Powder Pattern: Alto do Giz pegmatite, Brazil.
1.651 (100), 2.859 (67), 3.69 (62), 2.131 (59), 1.395 (54), 2.417 (40), 2.609 (37)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	1.82	0.0	8.6
Ta_2O_5	71.54	76.4	64.6
SiO_2	1.00		
TiO_2	0.02	0.0	0.0
SnO_2	0.10	0.0	0.9
Al_2O_3	25.20	22.8	24.3
FeO	0.16		
CaO	0.12		
H_2O		1.0	1.1
Total	99.96	100.2	99.5

(1) Alto do Giz pegmatite, Brazil. (2) Do.; by electron microprobe, H_2O calculated for O:OH = 13:1; corresponding to $Al_{3.93}Ta_{3.04}O_{13}(OH)$. (3) Mumba, Congo; by electron microprobe, H_2O calculated for O:OH = 13:1, corresponding to $Al_{3.97}Sn_{0.05}(Ta_{2.44}Nb_{0.54})_{\Sigma=2.98}O_{13}(OH)$.

Occurrence: An uncommon accessory mineral in some tantalum-rich granite pegmatites.

Association: Tantalite, manganotantalite, microlite, tapiolite, beryl, spodumene, montebrasite, pollucite, petalite, eucryptite, tourmaline, muscovite, quartz.

Distribution: From Tabba Tabba, Western Australia. At the Alto do Giz pegmatite, near Parelhas, and the Onça mine, about 25 km distant, Rio Grande do Norte, Brazil. In the Al Hayat and Mdara mines, Bikita, and at the Benson No. 3 pegmatite, Mtoko, Zimbabwe. In Congo (Zaire), from Mumba, near Lake Kivu, Kivu Province, and in the Manono pegmatite, Katanga (Shaba) Province. At the Leshaia pegmatite, Vuoriyarvi carbonatite complex, Kola Peninsula, Russia. In Canada, from the Tanco pegmatite, Bernic Lake, Manitoba.

Name: To honor Dr. Edward Sydney Simpson (1875–1939), Western Australian government mineralogist and mineral analyst.

Type Material: Western Australian Museum, Perth, MDC1006, MDC1007; The Natural History Museum, London, England, 1938,122.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 771. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 446–449. (3) Pough, F.H. (1945) Simpsonite and the northern Brazilian pegmatite region. Bull. Geol. Soc. Amer., 56, 505–514. (4) Kerr, P.F. and R.J. Holmes (1945) X-ray study of the tantalum mineral simpsonite. Bull. Geol. Soc. Amer., 56, 479–504. (5) Ercit, T.S., P. Černý, and F.C. Hawthorne (1992) The crystal chemistry of simpsonite. Can. Mineral., 30, 663–671.

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Sincosite $\mathbf{CaV_2^{4+}(PO_4)_2(OH)_4 \cdot 3H_2O}$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Thin tabular, square to rectangular crystals, with {001}, {010}, and {110}, striated on {001} ‖ [100] and [110], to 1 cm, may be composite; in rosettes, crudely radial and in scaly aggregates; botryoidal to nodular massive. *Twinning:* On {110}, rare.

Physical Properties: *Cleavage:* Perfect on {001}; good on {110}; poor on {010}. *Tenacity:* Brittle. Hardness = Soft. D(meas.) = ∼2.84–2.98 D(calc.) = 2.970

Optical Properties: Translucent to transparent in small grains. *Color:* Leek-green, olive-green, pale green, blue-green, brownish green; in transmitted light, light green, olive-green, brownish green, yellowish green, bluish green, typically zoned parallel {001}. *Streak:* Green. *Luster:* Vitreous, submetallic if partially dehydrated.
Optical Class: Uniaxial (–), partially biaxial (–) if dehydrated. *Pleochroism:* Strong; $O = Z =$ gray-green; $E = X =$ nearly colorless to pale yellow. *Dispersion:* $r > v$, faint. $\omega = \sim 1.680$ $\epsilon = \sim 1.655$ $\alpha = 1.670$–1.675 $\beta = 1.690$ $\gamma = 1.693$–1.694 2V(meas.) = 10°–83°

Cell Data: *Space Group:* $P4_2/n$. a = 8.895–9.08 $c = 12.727$–12.86 Z = [4]

X-ray Powder Pattern: Black Hills, South Dakota, USA.
6.35 (100), 3.190 (80), 3.511 (60), 2.682 (50), 2.907 (40), 2.100 (40), 3.841 (25)

Chemistry:

	(1)	(2)	(3)
P_2O_5	31.7	31.37	31.27
V_2O_5	0.0		
V_2O_4	36.3	36.44	36.54
CaO	12.1	12.51	12.35
H_2O	19.9	[19.68]	19.84
insol.	0.3		
Total	100.3	[100.00]	100.00

(1) Sincos, Peru. (2) Black Hills, South Dakota, USA; by electron microprobe, average of three analyses, total V as V_2O_4, H_2O by difference. (3) $CaV_2(PO_4)_2(OH)_4 \cdot 3H_2O$.

Occurrence: In veinlets in black carbonaceous shale (Sincos, Peru).

Association: Gypsum (Sincos, Peru); minyulite (Ross Hannibal mine, South Dakota, USA).

Distribution: From Sincos, Junin Province, Peru. In the USA, large crystals in the Ross Hannibal mine, about four km southwest of Lead, Lawrence Co., South Dakota; from Bloomington, Bear Lake Co., and in the Enoch Valley phosphate mine, Soda Springs, Caribou Co., Idaho; in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas; from the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada. At an unspecified locality in Kazakhstan.

Name: For its originally noted occurrence near Sincos, Peru.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 99139, 101699; National Museum of Natural History, Washington, D.C., USA, 95096.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1057–1058. (2) Zolensky, M.E. (1985) New data on sincosite. Amer. Mineral., 70, 409–410. (3) Shitov, V.A., E.V. Prozorovskaya, I.G. Smyslova, and L.G. Kuznetsova (1984) Sincosite – rare vanadium phosphate. Zap. Vses. Mineral. Obshch., 113, 56–59 (in Russian).

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Sinhalite $MgAlBO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rare euhedral crystals, equant to prismatic [001], showing {110}, {120}, {130}, {140}, {111}, {121}, {112}, {132}, {101}, {011}, {021}, {001}, to 2 cm; anhedral grains.

Physical Properties: *Fracture:* Conchoidal. Hardness = 6.5–7 D(meas.) = 3.47–3.50 D(calc.) = 3.446

Optical Properties: Transparent. *Color:* Colorless, pale yellow, yellow, greenish brown, dark brown; brownish pink, pale pink if chromian; colorless in transmitted light. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = brown, pale yellow; Y = green, pale brown, bluish gray; Z = paler brown, pale greenish brown, pale pinkish gray. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Absorption:* $X > Y > Z$. $\alpha = 1.667$–1.676 $\beta = 1.697$–1.704 $\gamma = 1.705$–1.712 2V(meas.) = 55° 2V(calc.) = 55.6(8)°

Cell Data: *Space Group: Pbnm.* $a = 4.3320(4)$ $b = 9.8819(5)$ $c = 5.6813(4)$ Z = 4

X-ray Powder Pattern: Sri Lanka.
2.14 (vvs), 1.621 (vs), 3.24 (s), 2.62 (s), 4.93 (ms), 2.38 (ms), 2.30 (ms)

Chemistry:

	(1)	(2)	(3)
B_2O_3	24.2	[27.70]	27.61
Al_2O_3	41.0	41.91	40.43
Fe_2O_3	2.0		
FeO		2.10	
MgO	32.3	29.24	31.96
H_2O	0.3		
Total	99.8	[100.95]	100.00

(1) Sri Lanka; corresponds to $Mg_{1.02}(Al_{1.03}Fe^{3+}_{0.03})_{\Sigma=1.06}B_{0.89}O_{3.94}$. (2) Do.; by electron microprobe, average of ten analyses, total Fe as FeO, B_2O_3 calculated from stoichiometry; corresponds to $(Mg_{0.91}Fe^{2+}_{0.04}Al_{0.04})_{\Sigma=0.99}Al_{1.00}BO_4$. (3) $MgAlBO_4$.

Occurrence: A rare accessory mineral formed in boron-rich skarns at the contact of limestones with granite or gneiss.

Association: Spinel, serendibite, ludwigite, warwickite.

Distribution: From Sri Lanka, in gem gravels, in the Ratnapura district, at Nivitigala, Balangoda, Nirialla; around Elahera and Eheliyagoda; and elsewhere. From Mogok, Myanmar, in gem gravels. In the USA, at Johnsburg, Warren Co., New York, and in the Bodnar quarry, near Hamburg, Sussex Co., New Jersey. Found near Bancroft, Ontario, Canada. From the Kwakonje area, Handeni district, Tanzania. In the Tayozhnoye iron deposit, 550 km south of Yakutsk, and the Taiga boron–iron deposit, Sakha, Russia. From the Huayuangou boron deposit, Liaoning Province, China.

Name: From *Sinhala*, the Sanskrit name for Ceylon.

Type Material: The Natural History Museum, London, England, 1952,36–1952,37 and other earlier museum specimens.

References: (1) Claringbull, F.A. and M.H. Hey (1952) Sinhalite ($MgAlBO_4$), a new mineral. Mineral. Mag., 29, 841–849. (2) Payne, C.J. (1958) A crystal of sinhalite from Mogok, Burma. Mineral. Mag., 31, 978–978. (3) Hayward, C.L., R.J. Angel, and N.L. Ross (1994) The structural redetermination and crystal chemistry of sinhalite, $MgAlBO_4$. Eur. J. Mineral., 6, 313–321. (4) Pitman, L.C., C.S. Hurlbut, Jr., and C.A. Francis (1995) Euhedral sinhalite crystals from Sri Lanka. Mineral. Record, 26, 91–94.

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Sinjarite $CaCl_2 \cdot 2H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. As elongated to rhombic crystals, in granular massive aggregates.

Physical Properties: *Cleavage:* Prismatic, good. Hardness = 1.5 D(meas.) = 1.66 D(calc.) = [1.60] Very hygroscopic.

Optical Properties: Semitransparent. *Color:* Pale pink. *Streak:* White. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial. $n = 1.54$

Cell Data: *Space Group:* n.d. (synthetic). $a = 7.21$ $c = 5.86$ Z = [2]

X-ray Powder Pattern: Sinjar, Iraq.
2.82 (100), 3.04 (99), 6.09 (86), 2.96 (71), 2.73 (71), 3.06 (66), 2.36 (51)

Chemistry:

	(1)	(2)
Na	0.85	
Ca	25.84	27.26
Cl	46.64	48.23
H_2O	26.55	24.51
Total	99.88	100.00

(1) Sinjar, Iraq; averages of several determinations, Na by flame photometer, H_2O taken as loss on ignition. (2) $CaCl_2 \cdot 2H_2O$.

Occurrence: In a dry stream bed, apparently precipitated from groundwater.

Association: n.d.

Distribution: From near Sinjar, west of Mosul, Iraq.

Name: For a town near the occurrence, Sinjar, Iraq.

Type Material: Museum of Natural History, University of Mosul, Mosul, Iraq.

References: (1) Aljubouri, Z.A. and S.M. Aldabbagh (1980) Sinjarite, a new mineral from Iraq. Mineral. Mag., 43, 643–645. (2) (1980) Amer. Mineral., 65, 1069 (abs. ref. 1).

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Sinkankasite $Mn^{2+}Al(PO_3OH)_2(OH)\cdot 6H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals are bladed prismatic to acicular, elongated along [001], tabular on {100}, showing {100}, {010}, {001}, to 4 mm, typically parallel to divergent, and in spherical aggregates. *Twinning:* On {100}, common.

Physical Properties: *Cleavage:* On {100}, perfect; also a parting along {100} twin boundaries. *Tenacity:* Very brittle. Hardness = ∼4 D(meas.) = 2.27 D(calc.) = 2.25

Optical Properties: Transparent. *Color:* Colorless to white. *Luster:* Vitreous to dull, vitreous on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Y \wedge c \simeq 11°$. *Dispersion:* $r < v$, moderate.
$\alpha = 1.511(2)$ $\beta = 1.529(2)$ $\gamma = 1.544(2)$ 2V(meas.) = n.d. 2V(calc.) = 84°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.590(2)$ $b = 9.818(2)$ $c = 6.860(1)$ $\alpha = 108.04(3)°$ $\beta = 99.63(3)°$ $\gamma = 98.87(3)°$ Z = 2

X-ray Powder Pattern: Barker mine, South Dakota, USA.
9.2 (100), 5.06 (60), 5.41 (50), 4.58 (40), 2.834 (40), 2.701 (40), 2.943 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	35.30	36.5	35.58	Na_2O	0.09		
Al_2O_3	9.35	12.6	12.78	F	n.d.	2.0	
FeO	7.4	6.9		H_2O^+	14.6		
MnO	12.5	11.3	17.78	H_2O^-	16.7		
ZnO	0.03			H_2O		31.3	33.86
MgO	0.25	0.2		$-O = F_2$		0.8	
CaO	3.31			Total	99.53	[100.0]	100.00

(1) Barker mine, South Dakota, USA; corresponds to $(Mn_{0.71}Ca_{0.24}Fe_{0.15}Mg_{0.02}Na_{0.01})_{\Sigma=1.13}(Al_{0.74}Fe^{3+}_{0.26})_{\Sigma=1.00}(PO_3OH)_{2.00}(OH)_{1.26}\cdot 6.35H_2O$. (2) Do.; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by the Penfield method, normalized to 100.0% with H_2O as determined, from an original total of 106.5%, thought high due to loss of H_2O in the electron beam; then corresponds to $(Mn_{0.64}Fe_{0.38}Mg_{0.02})_{\Sigma=1.04}Al_{1.00}(PO_3OH)_{2.08}[(OH)_{0.44}F_{0.42}]_{\Sigma=0.86}\cdot 5.56H_2O$. (3) $MnAl(PO_3OH)_2(OH)\cdot 6H_2O$.

Occurrence: A late-stage hydrothermal alteration product of triphylite in complex zoned granite pegmatites.

Association: Vivianite, huréaulite, carbonate-apatite, strengite, barbosalite, fluellite (Barker pegmatite, South Dakota, USA).

Distribution: In the USA, from the Barker (Ferguson) mine, five km southeast of Keystone, Pennington Co., South Dakota; and in the Palermo #3 mine, near North Groton, Grafton Co., New Hampshire.

Name: To honor Dr. John Sinkankas (1915–2002), American author and bibliographer on mineralogical and gemological subjects.

Type Material: The Natural History Museum, London, England; National Museum of Natural History, Washington, D.C., USA, 149597.

References: (1) Peacor, D.R., P.J. Dunn, W.L. Roberts, T.J. Campbell, and W.B. Simmons (1984) Sinkankasite, a new phosphate from the Barker pegmatite, South Dakota. Amer. Mineral., 69, 380–382. (2) Burns, P.C. and F.C. Hawthorne (1995) The crystal structure of sinkankasite, a complex heteropolyhedral sheet mineral. Amer. Mineral., 80, 620–627.

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Sinnerite $Cu_6As_4S_9$

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Crystal Data: Triclinic, pseudocubic. *Point Group:* 1. Flattened to columnar crystals, typically corroded, to about 1.2 cm. *Twinning:* Crystals are twinned complexly; principal laws are twin planes {010} and {110}.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ∼4 VHN = 373 D(meas.) = 5.2(3) D(calc.) = [4.46] (synthetic).

Optical Properties: Opaque. *Color:* Steel-gray. *Streak:* Gray-black. *Luster:* Metallic. R_1–R_2: n.d.

Cell Data: *Space Group:* $P1$. $a = 9.064(8)$ $b = 9.830(8)$ $c = 9.078(8)$ $\alpha = 90°00(20)'$ $\beta = 109°30(20)'$ $\gamma = 107°48(20)'$ Z = 2

X-ray Powder Pattern: Binntal, Switzerland.
3.02 (100), 1.852 (80), 1.581 (70), 1.205 (30), 3.34 (20), 1.556 (20), 1.312 (20)

Chemistry:

	(1)	(2)	(3)
Cu	41.3	39.1	39.32
As	29.2	29.7	30.91
S	29.8	28.7	29.77
Total	100.3	97.5	100.00

(1) Binntal, Switzerland; by electron microprobe, corresponding to $Cu_{6.29}As_{3.77}S_{9.00}$. (2) Do.; by electron microprobe, corresponding to $Cu_{6.19}As_{3.99}S_{9.00}$. (3) $Cu_6As_4S_9$.

Occurrence: On sulfides in crystalline dolostone.

Association: Tennantite, galena, sphalerite.

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL].

Name: Honors Rudolph von Sinner (1890–1960), President of the Commission of the Natural History Museum, Bern, Switzerland.

Type Material: Mineralogical-Petrographical Institute, University of Bern, Bern, Switzerland, L2120-62; University of Copenhagen, Copenhagen, Denmark.

References: (1) Nowacki, W., F. Marumo, and Y. Takéuchi (1964) Untersuchungen an Sulfiden aus dem Binnatal (Kt. Wallis, Schweiz). Schweiz. Mineral. Petrog. Mitt., 44, 5–9 (in German). (2) (1975) Mineral. Abs., 17, 74 (abs. ref. 1). (3) Marumo, F. and W. Nowacki (1964) The crystal structure of lautite and of sinnerite, a new mineral from the Lengenbach Quarry. Schweiz. Mineral. Petrog. Mitt., 44, 439–454. (4) (1965) Amer. Mineral., 50, 1504 (abs. ref. 3). (5) Makovicky, E. and B.J. Skinner (1972) Studies of the sulfosalts of copper. II. The crystallography and composition of sinnerite, $Cu_6As_4S_9$. Amer. Mineral., 57, 824–834. (6) Makovicky, E. and B.J. Skinner (1975) Studies of the sulfosalts of copper. IV. Structure and twinning of sinnerite, $Cu_6As_4S_9$. Amer. Mineral., 60, 998–1012.

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Sinoite Si_2N_2O

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Rarely in lathlike crystals, to 200 μm, and in granular aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.80–2.85 D(calc.) = 2.84 Bright greenish yellow cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless in thin section; light gray in reflected light.
Optical Class: Biaxial (–) (probable). *Orientation:* $Z = c$. $\alpha = 1.740$ β = n.d. , close to γ. $\gamma = 1.855$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Cmc2_1$ (synthetic). $a = 8.843(5)$ $b = 5.473(5)$ $c = 4.835(5)$ Z = 4

X-ray Powder Pattern: Synthetic.
4.43 (10), 3.36 (10), 4.66 (8), 2.61 (5), 2.42 (5), 2.39 (4), 4.13 (3)

Chemistry:

	(1)	(2)	(3)
Si	56.6	56.7	56.07
N	31.5	31.7	27.96
O	13.1	13.0	15.97
Total	101.2	101.4	100.00

(1) Jajh deh Kot Lalu meteorite; by electron microprobe, average of several hundred determinations; corresponds to $Si_{2.00}N_{2.23}O_{0.81}$. (2) Hvittis meteorite; by electron microprobe. (3) Si_2N_2O.

Occurrence: A rare mineral embedded in enstatite in chondritic meteorites.

Association: Enstatite, nickel-iron, plagioclase, troilite, pigeonite, daubreelite, oldhamite, ferroan alabandite, graphite, tridymite (Jajh deh Kot Lalu meteorite).

Distribution: In the Jajh deh Kot Lalu, Hvittis, Ufana, Yilmia, and Pillistfer enstatite chondrite meteorites.

Name: For SIlicon, Nitrogen, and Oxygen in the composition.

Type Material: American Museum of Natural History, New York, New York, USA, 3954.

References: (1) Andersen, C.A., K. Keil, and B. Mason (1964) Silicon oxynitride: a meteoric mineral. Science, 146, 256–257. (2) (1965) Amer. Mineral., 50, 521 (abs. ref. 1). (3) Keil, K. and C.A. Andersen (1965) Occurrences of sinoite, Si_2N_2O, in meteorites. Nature, 203, 745. (4) Idrestedt, I. and C. Brosset (1964) Structure of Si_2N_2O. Acta Chem. Scand., 18, 1879–1886.

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Sitinakite $KNa_2Ti_4Si_2O_{13}(OH)\cdot 4H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals equant to stubby prismatic, to 4 mm; in aggregates.

Physical Properties: *Cleavage:* {100} and {001}, perfect. Hardness = 4.5
D(meas.) = 2.86(6) D(calc.) = 2.89

Optical Properties: Semitransparent. *Color:* Colorless, light brown, pale rose.
Streak: White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.780(3)$ $\epsilon = 1.988(3)$

Cell Data: *Space Group:* $P4_2/mcm$. $a = 7.819(2)$ $c = 12.099(4)$ $Z = 2$

X-ray Powder Pattern: Khibiny massif, Russia.
7.84 (100), 6.02 (100), 3.25 (80), 2.003 (70), 2.608 (60), 3.36 (50), 2.805 (50)

Chemistry:

	(1)		(1)
SiO_2	17.80	CaO	0.05
TiO_2	46.68	SrO	0.96
ZrO_2	0.08	BaO	0.58
Ce_2O_3	0.12	Na_2O	10.79
Fe_2O_3	0.16	K_2O	4.93
Nb_2O_5	5.05	H_2O	11.7
Ta_2O_5	0.05	Total	98.95

(1) Khibiny massif, Russia; by electron microprobe, average of three analyses, H_2O by TGA; corresponds to $K_{0.68}Na_{2.28}Sr_{0.06}Ba_{0.02}Ca_{0.01}(Ti_{3.82}Nb_{0.25}Fe_{0.01})_{\Sigma=4.08}Si_{1.94}O_{13}[(OH)_{0.54}O_{0.46}]_{\Sigma=1.00}\cdot 3.98H_2O$.

Occurrence: In hydrothermally altered portions of alkalic pegmatites in a differentiated alkalic massif.

Association: Nepheline, natrolite, aegirine, microcline, apatite, vinogradovite.

Distribution: On Mts. Kukisvumchorr and Yukspor, Khibiny massif, Kola Peninsula, Russia.

Name: For SIlicon; TItanium; sodium, NAtrium; and potassium, Kalium, in its composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, ining Institute, St. Petersburg, Russia, 2021/1; The Natural History Museum, London, England, 1994,31.

References: (1) Menshikov, Y.P., E.V. Sokolova, Y.K. Yegorov-Tismenko, A.P. Khomyakov, and L.I. Polezhaeva (1992) Sitinakite $Na_2KTi_4Si_2O_{13}(OH)\cdot 4H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 121(1), 94–99. (2) (1994) Mineral. Abs., 45, 241 (abs. ref. 1).

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Sjögrenite $Mg_6Fe^{3+}_2(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As broad basal plates bounded by rough pyramid and prism faces; commonly intergrown with pyroaurite.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Laminae flexible, not elastic. Hardness = 2.5 D(meas.) = 2.11(3) D(calc.) = 2.11

Optical Properties: Transparent to nearly opaque. *Color:* Cream-white, pale yellow, orange, pale brown, nearly colorless; colorless in transmitted light. *Luster:* Waxy to vitreous, pearly on cleavages.
Optical Class: Uniaxial (–). *Pleochroism:* O = pale yellow to brown; E = colorless.
$\omega = 1.573(3)$ $\epsilon = 1.550(3)$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 3.113(3)$ $c = 15.61(1)$ Z = 1/4

X-ray Powder Pattern: Långban, Sweden.
7.78 (10), 3.90 (6), 2.54 (5), 2.21 (5), 1.87 (5), 2.65 (4), 2.39 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.41			MgO	35.44	35.9 – 43.1	36.55
Al_2O_3	0.11			H_2O	33.62		32.67
Fe_2O_3	23.19	24.3 – 26.5	24.13	CO_2	7.01		6.65
FeO	0.10			LOI		40.6	
MnO	0.28			Total	100.16		100.00

(1) Långban, Sweden; mixture of pyroaurite and sjögrenite. (2) Zlatogor intrusive, Kazakhstan; by electron microprobe, five partial elemental analyses, here converted to oxides. (3) $Mg_6Fe_2(CO_3)(OH)_{16}\cdot 4H_2O$.

Polymorphism & Series: Dimorphous with pyroaurite.

Mineral Group: Manasseite group.

Occurrence: In low-temperature hydrothermal veins in a metamorphosed Fe–Mn orebody (Långban, Sweden); in a vein in serpentinized dunite (Zlatogor intrusive, Kazakhstan); in a vein in a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA).

Association: Pyroaurite, calcite (Långban, Sweden); pokrovskite, magnesite (Zlatogor intrusive, Kazakhstan); pyroaurite, willemite, chlorophoenicite, barite, sphalerite (Sterling Hill, New Jersey, USA).

Distribution: From Långban and Nordmark, Värmland, Sweden. In the Phlogopite mine, Kovdor massif, Kola Peninsula, Russia. From the Zlatogor layered intrusive, northern Kazakhstan. Found at Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For Stens Anders Hjalmar Sjögren (1856–1922), Swedish mineralogist, Professor of Mineralogy, University of Stockholm, Stockholm, Sweden.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 83907.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 659–660. (2) Mumpton, F.A., H.W. Jaffe, and C.S. Thompson (1965) Coalingite, a new mineral from the New Idria serpentine, Fresno and San Benito Counties, California. Amer. Mineral., 50, 1893–1913. (3) Allmann, R. and H.-H. Lohse (1966) Die Kristallstruktur des Sjögrenits und eines Umwandlungsproduktes des Koenenits (= Chlor-Manasseits) Neues Jahrb. Mineral., Monatsh., 161–181 (in German with English abs.). (4) Ingram, L. and H.F.W. Taylor (1967) The crystal structures of sjögrenite and pyroaurite. Mineral. Mag., 36, 465–479. (5) Ivanov, O.K., Y.V. Mozzherin, and V.I. Vilisov (1986) New data on sjögrenite. Izvestiya Akad. Nauk Kazakh. SSR, Geol. Ser. 1, 40–45 (in Russian). (6) (1988) Amer. Mineral., 73, 199 (abs. ref. 5).

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Skinnerite Cu_3SbS_3

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As irregular grains, to 0.1 mm. *Twinning:* Microscopic to submicroscopic about {001}.

Physical Properties: Hardness = n.d. VHN = 148–166 (50 g load). D(meas.) = n.d. D(calc.) = 5.10

Optical Properties: Opaque, transparent in very thin sections. *Color:* In polished section, pale bluish gray, with deep red internal reflections; very deep red in transmitted light. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Distinct; pale purple to grayish yellow. R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 7.814(1)$ $b = 10.242(1)$ $c = 13.273(1)$ $\beta = 90.29(1)^\circ$ Z = 8

X-ray Powder Pattern: Synthetic.
2.830 (100), 2.628 (90), 2.619 (90), 3.911 (80), 3.208 (70), 3.192 (70), 3.048 (70)

Chemistry:

	(1)	(2)
Cu	46.08	46.66
Ag	2.01	
Sb	29.06	29.80
S	22.79	23.54
Total	99.94	100.00

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, average of 15 analyses; corresponding to $Cu_{3.06}Ag_{0.08}Sb_{1.01}S_{3.00}$. (2) Cu_3SbS_3.

Occurrence: In a complex of analcime-natrolite veins cutting naujaites (Ilímaussaq intrusion, Greenland).

Association: Sénarmontite, valentinite, tetrahedrite, antimony, chalcostibite, löllingite, galena, natrolite, analcime, ussingite, sodalite, feldspars, acmite, arfvedsonite, steenstrupine-(Ce) (Ilímaussaq intrusion, Greenland).

Distribution: From the Ilímaussaq intrusion, southern Greenland [TL]. In the Clara mine, near Oberwolfach, Black Forest, Germany. At Košice, Czech Republic. From near Belmont, Belmont district, Nye Co., Nevada, USA.

Name: In honor of Professor Brian John Skinner (1928–), Australian-American economic geologist, Yale University, New Haven, Connecticut, USA.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1979.1121; Mineralogical-Petrographical Institute, University of Bern, Bern, Switzerland.

References: (1) Karup-Møller, S. and E. Makovicky (1974) Skinnerite, Cu_3SbS_3, a new sulfosalt from the Ilímaussaq alkaline intrusion, South Greenland. Amer. Mineral., 59, 889–895. (2) Makovicky, E. (1994) Polymorphism in Cu_3SbS_3 and Cu_3BiS_3: the ordering schemes for copper atoms and electron microscope observations. Neues Jahrb. Mineral., Abh., 168, 185–212. (3) Makovicky, E. and T. Balić-Žunić (195) The crystal structure of skinnerite, $P2_1/c$–Cu_3SbS_3, from powder data. Can. Mineral., 33, 655–663.

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Skippenite Bi_2Se_2Te

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ $2/m$, $3m$ or 32. Crystals flattened ∥ {0001}, to 1 mm, strongly deformed to produce lamellae, in massive aggregates.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. VHN = 52–74, 63 average (25 g load). D(meas.) = n.d. D(calc.) = 7.94

Optical Properties: Opaque. *Color:* Steel-gray; white with a yellow tint in polished section. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Moderate, blue to bluish gray.
R_1–R_2: (400) — , (420) 41.0–43.0, (440) 44.6–46.1, (460) 46.5–47.8, (480) 47.7–48.8, (500) 48.3–49.5, (520) 48.7–50.0, (540) 49.0–50.3, (560) 49.1–50.4, (580) 49.1–50.4, (600) 49.2–50.5, (620) 49.3–50.6, (640) 49.4–50.8, (660) 49.4–50.8, (680) 49.4–50.8, (700) 49.4–50.8

Cell Data: *Space Group:* $R\overline{3}m$, $R3m$, or $R32$. $a = 4.183(4)$ $c = 29.12(8)$ $Z = 3$

X-ray Powder Pattern: Otish Mountains deposit, Canada.
3.074 (10), 2.090 (8), 2.267 (7), 4.85 (6), 3.584 (6), 9.71 (5), 2.133 (5)

Chemistry:

	(1)	(2)
Bi	60.85	59.41
Cu	0.19	
Pb	0.14	
Se	22.46	22.45
Te	15.68	18.14
S	0.58	
Total	99.90	100.00

(1) Otish Mountains deposit, Canada; by electron microprobe, average of six analyses; corresponding to $(Bi_{2.07}Cu_{0.02}Pb_{0.01})_{\Sigma=2.10}Se_{2.02}(Te_{0.87}S_{0.13})_{\Sigma=1.00}$. (2) Bi_2Se_2Te.

Mineral Group: Tetradymite group.

Occurrence: In a vein-type uranium deposit with other tellurides and selenides.

Association: Watkinsonite, součekite, clausthalite, chalcopyrite, Au–Ag alloy.

Distribution: From the Otish Mountains uranium deposit, Quebec, Canada [TL].

Name: To honor Professor George Skippen (1936–), Canadian geologist, Carleton University, Ottawa, Canada.

Type Material: n.d.

References: (1) Johan, Z., P. Picot, and F. Ruhlmann (1987) The ore mineralogy of the Otish Mountains uranium deposit, Quebec: skippenite, Bi_2Se_2Te, and watkinsonite, $Cu_2PbBi_4(Se,S)_8$, two new mineral species. Can. Mineral., 25, 625–637. (2) (1989) Amer. Mineral., 74, 947 (abs. ref. 1). (3) Nakajima, S. (1963) The crystal structure of $Bi_2Te_{3-x}Se_x$. J. Phys. Chem. Solids, 24, 479–485. [str??must]

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Sklodowskite $(H_3O)_2Mg(UO_2)_2(SiO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals acicular along [010], to 4 mm, in tightly compacted parallel aggregates. Commonly reticulated, radiating divergent, stellate; as velvety coatings; earthy, massive. *Twinning:* With {001} or {100} as the twin plane, probable.

Physical Properties: *Cleavage:* Perfect on {100}. Hardness = ~2–3 D(meas.) = 3.54 D(calc.) = [3.51] Radioactive.

Optical Properties: Transparent to translucent. *Color:* Citron-yellow to pale lemon-yellow. *Streak:* Yellow. *Luster:* Adamantine to vitreous and silky, earthy when massive. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; Y = yellow; Z = pale yellow. *Orientation:* $Y = b$. *Dispersion:* $r > v$, strong. α = 1.613–1.615 β = 1.635–1.642 γ = 1.656–1.657 2V(meas.) = Very large.

Cell Data: *Space Group:* $C2/m$. a = 17.382(6) b = 7.047(1) c = 6.610(2) $\beta = 105°54(12)'$ Z = 2

X-ray Powder Pattern: Shaba Province, Congo.
8.42 (10), 4.19 (8), 3.27 (7), 3.52 (6), 3.00 (6), 5.91 (5), 4.00 (5)

Chemistry:

	(1)	(2)
SiO_2	14.28	14.61
TeO_3	1.08	
UO_3	64.72	69.54
NiO	0.20	
MgO	3.74	4.90
$(Na,K)_2O$	1.97	
H_2O	13.41	10.95
Total	99.40	100.00

(1) Shinkolobwe, Congo. (2) $(H_3O)_2Mg(UO_2)_2(SiO_4)_2 \cdot 2H_2O$.

Occurrence: A rare secondary mineral formed by the action of silica-bearing waters on uraninite or earlier-formed secondary uranium minerals.

Association: Kasolite, soddyite, torbernite, uranophane, uranophane-beta, nováčekite, metazeunerite, curite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In the USA, from the Grants district, McKinley Co., New Mexico; at the Oyler Tunnel claim, near Fruita, Wayne Co., and from the Honeycomb Hills, Juab Co., Utah; in the New Haven mine, Crook Co., Wyoming; and in the Ross-Adams mine, Bokan Mountain, Prince of Wales Island, Alaska. From the Santo Domingo mine, Santa Eulalia, Chihuahua, Mexico. In the Pedra Preta mine, Brumado district, Bahia, Brazil. In the Nabarlek and Koongara uranium deposits and at Rum Jungle, Northern Territory, Australia. In the Rabéjac uranium deposit, seven km south-southwest of Lodève, Hérault, France.

Name: For Marie Sklodowska-Curie (1867–1934), Polish-French physicist and chemist, pioneer worker on radioactivity.

Type Material: n.d.

References: (1) Schoep, A. (1924) La sklodowskite, nouveau minéral radioactif. Compt. Rendus Acad. Sci. Paris, 179, 413–415 (in French). (2) (1925) Amer. Mineral., 10, 132 (abs. ref. 1). (3) Gorman, D.H. (1957) Studies of radioactive compounds: IX - sklodowskite. Can. Mineral., 6, 52–60. (4) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 300–304. (5) Stohl, F.V. and D.K. Smith (1981) The crystal chemistry of the uranyl silicate minerals. Amer. Mineral., 66, 610–625.

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Skorpionite $Ca_3Zn_2(PO_4)_2CO_3(OH)_2 \cdot H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As needle-like crystals, to 0.5 mm, elongated parallel to [001] with dominant {100} and {110}; additional forms {111}, {221}, {131}, {$\bar{1}$ 01}.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3.5 D(meas.) = 3.15(3) D(calc.) = 3.17

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White.
Luster: Vitreous.
Optical Class: Biaxial (-). α = 1.5884(10) β =1.6445 (calc.) γ = 1.6455(10) 2V = 15.0(5)°
Orientation: $Y \wedge c = 26°$ (in acute β); $Z = b$.

Cell Data: *Space Group*: *C*2/*c*. a = 19.045(3) b = 9.320(2) c = 6.525(1) β = 92.73(2)° Z = 4

X-ray Powder Pattern: Skorpion mine, Lüderitz district, Karas region, south-western Namibia. Intensities corrected to remove effects of preferred orientation.
3.170 (100), 2.788 (67), 3.014 (54), 9.501 (53), 3.063 (42), 5.238 (30), 2.582 (21)

Chemistry:

	(1)	(2)
CaO	30.89	30.42
ZnO	28.83	29.43
P_2O_5	25.49	25.67
CO_2 (calc)	7.96	7.96
H_2O (calc)	6.52	6.52
Total	99.69	100.00

1) Skorpion mine, Lüderitz district, Karas region, south-western Namibia; average of 17 electron microprobe analyses, anionic groups confirmed by IR, H_2O and CO_2 calculated, corresponding to $Ca_{3.05}Zn_{1.96}(PO_4)_{1.99}(CO_3)_{1.00}(OH)_{2.06} \cdot 0.98H_2O$. (2) $Ca_3Zn_2(PO_4)_2CO_3(OH)_2 \cdot H_2O$.

Occurrence: A secondary mineral in an oxidized non-sulfide zinc deposit formed by weathering of sediment- and volcanic-hosted disseminated sulfide minerals.

Association: Tarbuttite, hydrozincite, gypsum.

Distribution: Skorpion zinc mine, Lüderitz district, Karas region, south-western Namibia.

Name: For the locality that produced the first specimens.

Type Material: Mineralogical Institute, University of Bochum, Germany, IMA 2005-010.

References: (1) Krause, W., H. Effenberger, H.-J. Bernhardt, and O. Medenbach (2008) Skorpionite, $Ca_3Zn_2(PO_4)_2CO_3(OH)_2 \cdot H_2O$, a new mineral from Namibia: description and crystal structure. Eur. J. Mineral., 20, 271–280. (2) (2009) Amer. Mineral., 94, 403 (abs. ref. 1).

Skutterudite $CoAs_{2-3}$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Crystals are cubes, octahedra, dodecahedra, to 9 cm; rarely prismatic; in skeletal growth forms, distorted aggregates; also massive, granular and dense. *Twinning:* On {112} as sixlings and complex shapes; also reported on {011}.

Physical Properties: *Cleavage:* Distinct on {001} and {111}; in traces on {011}. *Fracture:* Conchoidal to uneven. Hardness = 5.5–6 VHN = 606–824; 810–915 (100 g load). D(meas.) = 6.5 D(calc.) = 6.821

Optical Properties: Opaque. *Color:* Tin-white to silver-gray, tarnishes gray or iridescent; in polished section, gray, creamy or golden white. *Streak:* Black. *Luster:* Metallic.
R: (400) 55.3, (420) 56.0, (440) 56.4, (460) 56.6, (480) 56.4, (500) 56.1, (520) 55.7, (540) 55.3, (560) 55.0, (580) 54.7, (600) 54.4, (620) 54.1, (640) 53.8, (660) 53.5, (680) 53.1, (700) 52.7

Cell Data: *Space Group:* $Im3$. $a = 8.195(3)$ $Z = 8$

X-ray Powder Pattern: Synthetic $CoAs_3$.
2.592 (100), 2.193 (35), 1.835 (35), 1.609 (30), 1.675 (20), 0.9537 (20), 3.35 (18)

Chemistry:

	(1)	(2)	(3)	(4)
Co	19.70	19.0	28.23	20.77
Fe	2.80	2.0		
Ni		1.8		
As	76.41	75.7	71.77	79.23
S	1.03	2.1		
Total	[99.94]	100.6	100.00	100.00

(1) Skutterud, Norway; recalculated after deduction of SiO_2 5.63%; corresponding to $(Co_{0.87}Fe_{0.13})_{\Sigma=1.00}(As_{2.65}S_{0.08})_{\Sigma=2.73}$. (2) Cobalt, Canada; by electron microprobe, corresponding to $(Co_{0.83}Fe_{0.09}Ni_{0.08})_{\Sigma=1.00}(As_{2.60}S_{0.17})_{\Sigma=2.77}$. (3) $CoAs_2$. (4) $CoAs_3$.

Polymorphism & Series: Forms a series with nickel-skutterudite.

Occurrence: Typically in medium- to high-temperature hydrothermal veins with other Ni–Co sulfide minerals.

Association: Nickeline, cobaltite, arsenopyrite, silver, silver sulfosalts, bismuth, calcite, siderite, barite, quartz.

Distribution: From many localities as an accessory mineral, only rarely as an important ore or in fine specimens. In Norway, from Skutterud, Modum [TL]. At Schneeberg, Annaberg, and Freiberg, Saxony, Germany. From Austria, at Lölling, Carinthia. In Spain, in the valley of Gistain, Huesca Province. From France, at Riomanou, Hautes-Pyrénées, and on Mount Chalanches, Isère. At Talnotry, Kirkcudbrightshire, Scotland. From a number of mines in Cornwall, England. At Khovu-Akay, Tuva, Russia. Well-crystallized from the Aghbar (Arhbar) and Irhtem (Ightem) mines, Bou Azzer district, Morocco. In the USA, in Connecticut, at Chatham, Middlesex Co.; and from Mine la Motte, Madison Co., Missouri. In Canada, in large amounts at Cobalt; in South Lorrain Township; at Sudbury; and Gowganda, Ontario.

Name: For the Norwegian locality at Skutterud.

Type Material: Mining Academy, Freiberg, Germany, 3910.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 342–346. (2) Roseboom, E.H., Jr. (1962) Skutterudites $(Co, Ni, Fe)As_{3-x}$: composition and cell dimensions. Amer. Mineral., 47, 310–327. (3) Radcliffe, D. (1971) Structural formula and composition of skutterudite. Can. Mineral., 9, 559–563. (4) Mandel, N. and J. Donohue (1971) The refinement of the crystal structure of skutterudite, $CoAs_3$. Acta Cryst., 27, 2288–2289. (5) Pauling, L. (1978) Covalent chemical bonding of transition metals in pyrite, cobaltite, skutterudite, millerite and related minerals. Can. Mineral., 16, 447–452. (6) (1960) NBS Circ. 539, 10, 21. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 515, 516.

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Slavíkite $NaMg_2Fe_5^{3+}(SO_4)_7(OH)_6 \cdot 33H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Crystals, to 0.3 mm, with large $\{10\overline{1}1\}$, $\{0001\}$, modified by $\{02\overline{2}1\}$, $\{05\overline{5}2\}$, $\{50\overline{5}2\}$; scaly, as incrustations and efflorescences, fine granular massive.

Physical Properties: *Cleavage:* On $\{0001\}$, a parting. Hardness = n.d. D(meas.) = 1.905–1.99 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Yellow, pale yellow-green. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* O = lemon-yellow; E = nearly colorless. $\omega = 1.530–1.537$ $\epsilon = 1.494–1.506$

Cell Data: *Space Group:* $R\overline{3}$. $a = 12.20$ $c = 35.13$ Z = 3

X-ray Powder Pattern: Medzev, Czech Republic.
5.47 (vs), 4.20 (vs), 2.93 (vs), 5.85 (s), 3.48 (s), 3.13 (s), 5.05 (m)

Chemistry:

	(1)	(2)
SO_3	34.62	32.59
Fe_2O_3	23.93	23.21
MgO	4.40	4.69
Na_2O	0.29	1.80
H_2O	37.21	37.71
Total	100.45	100.00

(1) Quebrada de La Alcaparrosa, Argentina. (2) $NaMg_2Fe_5(SO_4)_7(OH)_6 \cdot 33H_2O$.

Occurrence: An uncommon secondary oxidation product of pyrite in shales and slates.

Association: Halotrichite, pickeringite, fibroferrite, copiapite, melanterite, epsomite, jarosite, gypsum.

Distribution: In the Czech Republic, on Valachov Hill, near Skřivaň; from Troja, near Prague; and at Mandát. From Medzev, 26 km west of Košice, Slovakia. At Rudabánya, Hungary. From Pöham, near Radstadt, Austria. At Franquenies, Belgium. From Le Kaymar, Aveyron, France. At Wiescoszowice, Poland. In the Servette mine, Saint Marcel, Val d'Aosta, Piedmont, Italy. From the Santa Elena mine, Quebrada de La Alcaparrosa, San Juan Province, Argentina. At Alum Cave Bluff, Sevier Co., Tennessee, USA.

Name: In honor of František Slavík (1876–1957), Professor of Mineralogy, Charles University, Prague, Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 8877.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 621–622. (2) Süsse, P. (1975) Struktur und Kristallchemie des Slavikits, $NaMg_2Fe_5(SO_4)_7(OH)_7 \cdot 33H_2O$. Neues Jahrb. Mineral., Monatsh., 27–40. (in German with English abs.). (3) Makovický, E. and V. Streško (1967) Slavikite from Medzev near Košice, Czechoslovakia. Tschermaks Mineral. Petrog. Mitt., 12, 100–107.

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Slawsonite $(Sr,Ca)Al_2Si_2O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular crystals, elongated along [110], with {110} and {001}, to 7 cm; in radial aggregates.

Physical Properties: *Cleavage:* Good on {001}, fair to good on {100}.
Fracture: Subconchoidal. Hardness = 5.5–6.5 D(meas.) = 3.05(1) D(calc.) = 3.044
May fluoresce intense pinkish red-purple under SW UV.

Optical Properties: Semitransparent. *Color:* Light gray to colorless; colorless in thin section.
Streak: White.
Optical Class: Biaxial (–). *Orientation:* $Y \wedge c = 5°$–$11°$. *Dispersion:* $r < v$, medium, or $r > v$, very weak. $\alpha = 1.570$–1.573 $\beta = 1.581$–1.582 $\gamma = 1.585$–1.586 2V(meas.) = 55°–82°

Cell Data: *Space Group:* $P2_1/a$. $a = 8.888(2)$ $b = 9.344(2)$ $c = 8.326(3)$ $\beta = 90.33(2)°$
Z = [4]

X-ray Powder Pattern: Sarusaka, Japan.
3.231 (100), 3.938 (80), 2.930 (50), 2.087 (40), 3.720 (35), 2.949 (35), 2.679 (35)

Chemistry:

	(1)	(2)
SiO_2	38.68	37.78
TiO_2	0.36	
Al_2O_3	29.32	30.26
Fe_2O_3	1.14	
FeO	0.02	
MgO	0.25	
CaO	2.26	0.33
SrO	26.60	31.22
Na_2O	0.13	
K_2O	0.07	
H_2O^+	0.17	
H_2O^-	0.09	
Total	99.09	99.59

(1) Wallowa Mountains, Oregon, USA; corresponds to $(Sr_{0.82}Ca_{0.13}Mg_{0.02})_{\Sigma=0.97}(Al_{1.84}Fe^{3+}_{0.05})_{\Sigma=1.89}(Si_{2.06}Ti_{0.01})_{\Sigma=2.07}O_8$. (2) Rendai, Japan; by electron microprobe, corresponds to $(Sr_{0.98}Ca_{0.02})_{\Sigma=1.00}Al_{1.93}Si_{2.04}O_8$.

Mineral Group: Feldspar group.

Occurrence: In pectolite veinlets in metamorphosed xenoliths (Rendai, Japan); in a xenolith in ultramafic rock (Sarusaka, Japan).

Association: Calcite, phlogopite, albite, pyrite (Wallowa Mountains, Oregon, USA); celsian, cymrite, xonotlite, prehnite, grossular, diopside (Sarusaka, Japan).

Distribution: From the Wallowa Mountains, Wallowa Co., Oregon, USA. In Japan, in Kochi Prefecture, from Sarusaka, Kamagi; Rendai, Kochi City; and Miyanotani, Hidaka.

Name: For Professor Chester Baker Slawson (1898–1964), mineralogist at the University of Michigan, Ann Arbor, Michigan, USA.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 122831–122833.

References: (1) Griffen, D.T., P.H. Ribbe, and G.V. Gibbs (1977) The structure of slawsonite, a strontium analog of paracelsian. Amer. Mineral., 62, 31–35. (2) Matsubara, S. (1985) The mineralogical implication of barium and strontium silicates. Bull. Nat. Sci. Mus., Tokyo, ser. C, 11, 37–95. (3) (1987) Amer. Mineral., 72, 225–226 (abs. ref. 2).

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Smirnite $Bi_2Te^{4+}O_5$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals tabular, to 2 mm, in aggregates, and as incrustations.

Physical Properties: *Cleavage:* Perfect on {001}; distinct in some other directions. *Tenacity:* Brittle. Hardness = n.d. VHN = 142–227 (20–30 g load), with great anisotropy. D(meas.) = 7.78 D(calc.) = 7.72

Optical Properties: Transparent to translucent. *Color:* Colorless, pale gray, or pale yellow; pale gray in reflected light; darkens on exposure to sunlight.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 2.35$ $\beta = 2.36$ $\gamma = 2.46$ 2V(meas.) = 35°–40° *Anisotropism:* Strong.
R_1–R_2: (400) 20.7–19.1, (420) 20.5–18.8, (440) 20.0–18.1, (460) 19.7–17.8, (480) 19.4–17.5, (500) 19.3–17.5, (520) 19.3–17.4, (540) 19.2–17.4, (560) 19.1–17.3, (580) 19.0–17.2, (600) 18.8–17.0, (620) 18.7–16.8, (640) 18.5–16.7, (660) 18.3–16.5, (680) 18.2–16.3, (700) 18.0–16.3

Cell Data: *Space Group:* $Cm2a$. $a = 16.447(19)$ $b = 5.513(3)$ $c = 11.579(15)$ Z = 8

X-ray Powder Pattern: Zod deposit, Armenia.
3.226 (100), 2.890 (60), 1.996 (30), 1.992 (28), 1.727 (27), 2.743 (24), 2.750 (23)

Chemistry:

	(1)	(2)
Bi	60.9	66.81
Pb	2.3	
Sb	1.9	
Fe	0.3	
Cu	0.1	
Ag	0.1	
Te	20.7	20.40
O	12.5	12.79
Total	98.8	100.00

(1) Zod deposit, Armenia; by electron microprobe, average of four analyses; corresponding to $(Bi_{1.84}Sb_{0.10}Pb_{0.07}Fe_{0.03}Cu_{0.01}Ag_{0.01})_{\Sigma=2.06}Te_{1.02}O_{4.92}$. (2) Bi_2TeO_5.

Occurrence: A secondary mineral in tellurium-bearing hydrothermal ore deposits.

Association: Tellurobismuthite, tetradymite, volynskite, galena, quartz.

Distribution: From the Zod gold deposit, 14 km east of Vardenis, Armenia. In the Northern Aksu gold deposit, Kazakhstan. From near Il'kovtsy, Vygorlat-Gutinsk Mountains, Transcarpathian region, western Ukraine.

Name: Honors Vladimir Ivanovich Smirnov (1910–1988), Russian investigator of ore deposits, Moscow University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82767.

References: (1) Spiridonov, E.M., L.A. Demina, V.A. Dolgikh, G.M. Antonina, A.D. Rakcheev, L.V. Bulgak, S.I. Lebedeva, and T.N. Chvileva (1984) Smirnite Bi_2TeO_5 – a new mineral. Doklady Acad. Nauk SSSR, 278, 199–202 (in Russian). (2) (1985) Amer. Mineral., 70, 876–877 (abs. ref. 1).

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Smithite $AgAsS_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly equant, {100}, {001}, {111}, {$11\bar{1}$}, and a dozen other forms; also tabular on {100}, to 3 mm; pseudohexagonal.

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5–2 VHN = n.d. D(meas.) = 4.88 D(calc.) = 4.926

Optical Properties: Transparent; becoming opaque on exposure to light, then translucent in thin splinters. *Color:* Scarlet, vermilion, pink; becoming red-orange on exposure to light. *Streak:* Vermilion. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Slight in transmitted light. *Orientation:* $Y = b$; $Z \wedge c = 6.5°$. *Dispersion:* Strong. $n = 3.27(9)$ 2V(meas.) = ∼65°
R_1–R_2: (400) 40.7–44.0, (420) 40.0–43.2, (440) 39.3–42.4, (460) 38.7–41.5, (480) 37.9–40.4, (500) 37.0–39.2, (520) 36.0–38.0, (540) 35.0–36.6, (560) 33.8–35.4, (580) 32.7–34.7, (600) 32.0–34.0, (620) 31.4–33.4, (640) 31.0–32.9, (660) 30.6–32.4, (680) 30.4–31.8, (700) 30.1–31.4

Cell Data: *Space Group:* $A2/a$. $a = 17.23$ $b = 7.78$ $c = 15.19$ $\beta = 101°12'$ Z = 24

X-ray Powder Pattern: Synthetic.
2.82 (100), 3.21 (80), 2.72 (60), 1.953 (50), 1.701 (40), 1.661 (40), 1.608 (40)

Chemistry:

	(1)	(2)
Ag	43.9	43.69
As	28.9	30.34
Sb	0.4	
S	26.0	25.97
Total	99.2	100.00

(1) Binntal, Switzerland. (2) $AgAsS_2$.

Polymorphism & Series: Dimorphous with trechmannite.

Occurrence: Of hydrothermal origin with other Ag–As sulfides.

Association: Sphalerite, pyrite, realgar, orpiment, hutchinsonite, sartorite, rathite (Binntal, Switzerland); chabournéite, pierrotite, parapierrotite, stibnite, pyrite, sphalerite, twinnite, zinkenite, madocite, andorite, laffittite, routhierite, aktashite, wakabayashilite, realgar, orpiment (Jas Roux, France); proustite, gersdorffite, argentian miargyrite (Silvermines, Ireland).

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL]. At the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France. From Wiesloch, Black Forest, Germany. At Silvermines, Co. Tipperary, Ireland.

Name: In honor of George Frederick Herbert Smith (1872–1953), crystallographer of the British Museum (Natural History), London, England.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 430–432. (2) Hellner, E. and H. Burzlaff (1964) Die Struktur des Smithits $AgAsS_2$. Naturwiss., 51, 35–36 (in German). (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 142–143.

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Smithsonite $ZnCO_3$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. Uncommon as crystals, to 10 cm, rhombohedral $\{10\bar{1}1\}$ and scalenohedral $\{21\bar{3}1\}$, with $\{10\bar{1}0\}$, $\{0001\}$, additional modifying forms, with curved faces; typically botryoidal, reniform, spherulitic; stalactitic, and as cave pearls; earthy, friable, granular to porous or compact massive.

Physical Properties: *Cleavage:* On $\{10\bar{1}1\}$, nearly perfect. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 4.43(1) D(calc.) = 4.43 May fluoresce pale green or pale blue under UV.

Optical Properties: Translucent to transparent. *Color:* White, pale gray, dark gray, pale brown, brown, more rarely pale shades of red, pink, orange, yellow, green, apple-green, emerald-green, blue, bluish gray; colorless to faintly tinted in transmitted light. *Streak:* White. *Luster:* Vitreous, may be pearly.
Optical Class: Uniaxial (–). $\omega = 1.842–1.850$ $\epsilon = 1.619–1.623$

Cell Data: *Space Group:* $R\bar{3}c$. $a = 4.6526(7)$ $c = 15.0257(22)$ $Z = 6$

X-ray Powder Pattern: Kabwe, Zambia.
2.760 (100), 3.55 (50), 1.703 (45), 2.327 (25), 1.946 (25), 2.110 (18), 1.515 (14)

Chemistry:

	(1)	(2)
CO_2	35.25	35.10
ZnO	64.55	64.90
MgO	0.04	
CaO	0.35	
insol.	0.07	
Total	100.26	100.00

(1) Aachen district, Germany. (2) $ZnCO_3$.

Polymorphism & Series: Forms two series, with rhodochrosite and with siderite.

Mineral Group: Calcite group.

Occurrence: A secondary mineral formed in the oxidized zone of zinc-bearing deposits and replacing adjacent carbonate rocks, where it may constitute an ore.

Association: Hemimorphite, willemite, hydrozincite, cerussite, malachite, azurite, aurichalcite, anglesite.

Distribution: Many localities, even for fine specimens, including: abundant at Laurium, Greece. In major ore deposits at Tarnowitz and Beuthen, Poland. From Moresnet, Belgium. At Altenberg, near Aachen, North Rhine-Westphalia, Germany. Good crystals from Chessy, near Lyon, Rhône, France. At Bleiberg, Carinthia, Austria. From Iglesias, Sardinia, Italy. Large crystals at Kabwe (Broken Hill), Zambia. Abundant in fine specimens with large crystals, from Tsumeb, Namibia. In the USA, at Friedensville, Lehigh Co., Pennsylvania; in the Joplin district, Jasper Co., Missouri; from the Rush Creek district, Marion Co., Arkansas; an ore at Leadville, Lake Co., Colorado; in the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona; fine examples from the Kelly mine, Magdalena, Socorro Co., New Mexico. In Mexico, abundant at Santa Eulalia, Chihuahua, and from Choix, Sinaloa. At Trang da, Tonkin, North Vietnam. From Broken Hill, New South Wales, Australia.

Name: To honor James Lewis (Macie) Smithson (1754–1829), British chemist and mineralogist, whose bequest founded the Smithsonian Institution, Washington, D.C., USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 176–180. (2) Effenberger, H., K. Mereiter, and J. Zemann (1981) Crystal structure refinements of magnesite, rhodochrosite, siderite, smithsonite, and dolomite, with discussion of some aspects of the stereochemistry of calcite type carbonates. Zeits. Krist., 156, 233–243. (3) (1958) NBS Circ. 539, 8.

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Smolianinovite $(Co, Ni, Mg, Ca)_3(Fe^{3+}, Al)_2(AsO_4)_4 \cdot 11H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Finely fibrous, to 200μm, in earthy to dense aggregates and incrustations.

Physical Properties: Hardness = ∼2 D(meas.) = 2.05–2.15; 2.43–2.49 D(calc.) = 2.2

Optical Properties: Transparent. *Color:* Yellow to yellow-brown. *Luster:* Silky. *Optical Class:* Biaxial; birefringence 0.003–0.004. *Orientation:* Parallel extinction, positive elongation. $n = 1.625(5)$

Cell Data: *Space Group:* n.d. $a = 6.40$ $b = 11.72$ $c = 21.9$ Z = 2

X-ray Powder Pattern: [Khovu-Aksy deposit, Russia or Bou Azzer, Morocco]; all lines diffuse.
21.94 (10), 11.58 (8), 3.20 (6), 2.92 (5), 1.642 (5), 1.486 (2), 2.59 (1)

Chemistry:

	(1)	(2)
As_2O_5	41.88	43.96
SiO_2	0.75	0.00
Al_2O_3	1.5	2.36
Fe_2O_3	11.8	12.01
CoO	8.01	14.88
NiO	8.18	0.42
MgO	2.10	1.31
CaO	3.69	5.10
H_2O^+	15.38	20.83
H_2O^-	6.41	
Total	99.7	100.87

(1) [Khovu-Aksy deposit, Russia or Bou Azzer, Morocco]; IR confirms $(AsO_4)^{3-}$, H_2O, and lack of $(OH)^{1-}$; with $(OH)^{1-}$ for charge balance, corresponds to $(Co_{1.21}Ni_{1.08}Mg_{0.87}Ca_{0.74})_{\Sigma=3.90}(Fe_{1.67}Al_{0.33})_{\Sigma=2.00}(AsO_4)_{4.11}(OH)_{1.47} \cdot 11H_2O$. (2) Mt. Cobalt, Australia; Fe^{3+} confirmed by Mössbauer spectra, H_2O by a microgravimetric technique; with $(OH)^{1-}$ for charge balance, corresponds to $(Co_{2.02}Ca_{0.93}Mg_{0.33}Ni_{0.06})_{\Sigma=3.34}(Fe_{1.53}Al_{0.47})_{\Sigma=2.00}(AsO_4)_{3.89}(OH)_{1.01} \cdot 11H_2O$.

Occurrence: An oxidation product of Ni–Co arsenides.

Association: Erythrite, pharmacolite, quartz.

Distribution: From the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, Russia. At the Bastnäs mine, near Riddarhyttan, Västmanland, Sweden. From Bou Azzer, Morocco. On Mt. Cobalt, 110 km south of Cloncurry, Queensland, and in the Dome Rock copper mine, about 40 km northwest of Mingary, South Australia. At the Sara Alicia mine, near Alamos, Sonora, Mexico. From Schneeberg, Saxony, Germany. At the Muckross mine, Co. Kerry, Ireland.

Name: To honor Professor Nikolai Alekseevich Smol'yaninov (1885–1957), Russian mineralogist, Moscow University, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1286/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64823.

References: (1) Yakhontova, L.K. (1956) A new mineral – smolianinovite. Doklady Acad. Nauk SSSR, 109, 849–850 (in Russian). (2) (1957) Amer. Mineral., 42, 307–308 (abs. ref. 1). (3) Yakhontova, L.K., G.A. Sidorenko, N.E. Sergeeva, and L.I. Ryabakova (1973) New data on smolianinovite. Konst. Svoistva Mineral., 7, 120–123 (in Russian). (4) (1974) Amer. Mineral., 59, 1141 (abs. ref. 3). (5) Smith, L.K., K.N. Han, and F. Lawson (1977) On the occurrence of smolyaninovite in the Mount Cobalt deposit, in north-western Queensland, Australia. Mineral. Mag., 41, 385–388. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 189–190.

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Smrkovecite $Bi_2O(PO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to 0.1 mm, in spherical and mammillary aggregates and crusts. *Twinning:* According to an unknown law, common.

Physical Properties: *Cleavage:* On {010}, indistinct. *Fracture:* Subconchoidal. Hardness = 4–5 D(meas.) = n.d. D(calc.) = [6.69]

Optical Properties: Transparent to translucent. *Color:* White to pale yellow, may be zoned. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, distinct. $\alpha = 2.05(6)$ $\beta = 2.06(7)$ $\gamma = 2.09(6)$ 2V(meas.) = 58.0(6)° 2V(calc.) = 61°

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy to atelestite). $a = 6.954(2)$ $b = 7.494(4)$ $c = 10.869(6)$ $\beta = 107.00(6)°$ Z = 4

X-ray Powder Pattern: Smrkovec, Czech Republic.
3.254 (100), 3.271 (51), 3.145 (34), 2.727 (29), 4.268 (17), 1.885 (16), 2.544 (14)

Chemistry:

	(1)	(2)
P_2O_5	12.74	13.00
As_2O_5	0.17	
V_2O_5	0.03	
SiO_2	0.02	
Bi_2O_3	85.16	85.35
H_2O	[1.65]	1.65
Total	[99.77]	100.00

(1) Smrkovec, Czech Republic; by electron microprobe, average of five analyses, H_2O calculated for stoichiometry; corresponds to $Bi_{2.01}O_{1.00}[(PO_4)_{0.98}(AsO_4)_{0.01}]_{\Sigma=0.99}(OH)_{1.00}$.
(2) $Bi_2O(PO_4)(OH)$.

Occurrence: A rare secondary mineral formed by weathering, found in old mine dumps at an Ag–Bi–As–U deposit.

Association: Quartz, atelestite, bismutite, bismutoferrite, eulytite, metatorbernite, petitjeanite, preisingerite, pucherite, retgersite, sillénite.

Distribution: From near Smrkovec, Slavkovský Les Mountains, about 10 km north-northeast of Mariánské Lázně (Marienbad), Czech Republic.

Name: For its first-noted occurrence near Smrkovec, Czech Republic.

Type Material: National Museum, Prague, Czech Republic, P1N84596.

References: (1) Řídkošil, T., J. Sejkora, and V. Šrein (1996) Smrkovecite, monoclinic $Bi_2O(OH)(PO_4)$, a new mineral of the atelestite group. Neues Jahrb. Mineral., Monatsh., 97–102.
(2) (1996) Amer. Mineral., 81, 1283–1284 (abs. ref. 1).

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Smythite **$Fe_{3+x}S_4$** (x = 0 to 0.3)

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As very thin hexagonal flakes, to 2 mm.

Physical Properties: *Cleavage:* Perfect basal. *Fracture:* Subconchoidal. *Tenacity:* Flexible and elastic lamellae. Hardness = n.d. VHN = 388 D(meas.) = ∼4.32 D(calc.) = ∼4.32 Strongly ferromagnetic, crystals attracted edge-on.

Optical Properties: Opaque. *Color:* Jet-black with a brown tinge against a white background, pale bronze-yellow viewed on the mirrorlike base; in polished section, pinkish cream. *Streak:* Dark gray. *Luster:* Metallic; splendent on basal section. *Pleochroism:* Strong; grayish yellow to reddish brown. *Anisotropism:* Strong; yellow and blue-gray.
R_1–R_2: n.d.

Cell Data: *Space Group:* $R\overline{3}m$. a = 3.4651(5) c = 34.34(2) Z = 3

X-ray Powder Pattern: Bloomington, Indiana, USA.
1.732 (100), 1.897 (80), 1.979 (70), 11.5 (60), 3.00 (60), 2.56 (60), 2.26 (60)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Fe	56.98	57.81	56.64	Co		0.03	
Ni	1.04	0.07		S	40.92	41.33	43.36
Cu		0.03		Total	98.94	99.27	100.00

(1) Bloomington, Indiana, USA; by electron microprobe, average of seven analyses; corresponds to $(Fe_{3.20}Ni_{0.06})_{\Sigma=3.26}S_{4.00}$. (2) Landsberg, Germany; by electron microprobe, corresponds to $Fe_{3.21}S_{4.00}$. (3) Fe_3S_4.

Occurrence: Formed as a low-temperature oxidation product of the strongly magnetic monoclinic phase of pyrrhotite, as inclusions in calcite crystals in quartz geodes; also in hydrothermal veins.

Association: Pyrite, greigite, mackinawite, pyrrhotite, marcasite, magnetite, sphalerite, galena, chalcopyrite, calcite.

Distribution: In the USA, in Monroe Co., Indiana, from a road cut about 3 km north of Bloomington [TL], and near Unionville; at the Kramer borate deposit, Boron, Kern Co., California; and from near Helena, Lewis and Clark Co., Montana. In Canada, from the Silverfields mine, at Cobalt, and the Nicopor mine, north of Schreiber, Ontario; in the Bird River mines, Lac du Bonnet area, Manitoba; and elsewhere. In Ukraine, from the Kimmerian sedimentary iron ores of the Kerch Peninsula. In the Kamaishi mine, Iwate Prefecture, Japan. In the Lengenbach quarry, Binntal, Valais, and Trimbach, near Olten, Switzerland. In Germany, from Hartenstein, Saxony; in the Clara mine, near Oberwolfach, Black Forest; and at Landsberg, near Obermoschel, Rhineland-Palatinate. From the Ceragiola quarry, near Seravezza, Tuscany, Italy. At Wadi Kamal, Saudi Arabia.

Name: Honors Professor Charles Henry Smyth, Jr. (1866–1937), economic geologist and petrologist, Princeton University, Princeton, New Jersey, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 106149; National Museum of Natural History, Washington, D.C., USA, 112704.

References: (1) Erd, R.C. and H.T. Evans, Jr. (1956) The compound Fe_3S_4 (smythite) found in nature. J. Amer. Chem. Soc., 78, 2017. (2) (1956) Amer. Mineral., 41, 815–816 (abs. ref. 1). (3) Erd, R.C., H.T. Evans, Jr., and D.H. Richter (1957) Smythite, a new iron sulfide and associated pyrrhotite from Indiana. Amer. Mineral., 42, 309–333. (4) Taylor, L.A. (1970) Smythite, $Fe_{3+x}S_4$, and associated minerals from the Silverfields mine, Cobalt, Ontario. Amer. Mineral., 55, 1650–1658. (5) Taylor, L.A. and K.L. Williams (1972) Smythite, $(Fe,Ni)_9S_{11}$ — a redefinition. Amer. Mineral., 57, 1571–1577. (6) Fleet, M.E. (1982) Synthetic smythite and monoclinic Fe_3S_4. Phys. Chem. Minerals, 8, 241–246. (7) Krupp, R.E. (1994) Phase relations and phase transformations between the low-temperature iron sulfides mackinawite, greigite, and smythite. Eur. J. Mineral., 6, 265–278.

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Sobolevite $\mathbf{Na_{11}(Na,Ca)_4(Mg,Mn^{2+})Ti_4(Si_2O_7)_2(PO_4)_4O_3F_3}$

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Crystal Data: Triclinic. *Point Group:* 1. As platy masses to 5 mm, flattened on {001}.

Physical Properties: *Cleavage:* Perfect on {001}, distinct on {110}. Hardness = ~4.5–5 VHN = 342–712 D(meas.) = 3.03 D(calc.) = 3.03

Optical Properties: Semitransparent. *Color:* Brown. *Luster:* Metallic, resinous, or pearly on (001).
Optical Class: Biaxial (–). *Pleochroism:* X = nearly colorless; $Y = Z$ = yellowish brown. *Orientation:* $X = b$; $Y = a$; $X \wedge c = 32°$. *Dispersion:* $r < v$, strong. *Absorption:* $Z = Y > X$. $\alpha = 1.627(2)$ $\beta = 1.686(2)$ $\gamma = 1.690(2)$ 2V(meas.) = 25°–33°

Cell Data: *Space Group:* $P1$. $a = 7.078(1)$ $b = 5.4115(7)$ $c = 40.618(10)$ $\alpha = 90.01(2)°$ $\beta = 93.19(2)°$ $\gamma = 90.00(1)°$ Z = 2

X-ray Powder Pattern: Mt. Alluaiv, Russia.
2.896 (100), 2.691 (70), 2.913 (50), 1.771 (50), 1.671 (50), 3.18 (40), 1.717 (35)

Chemistry:

	(1)
SiO_2	17.1
TiO_2	15.2
Fe_2O_3	0.6
Nb_2O_5	4.4
MnO	4.0
MgO	0.6
CaO	6.4
Na_2O	29.7
F	0.7
P_2O_5	19.9
$-O = F_2$	0.3
Total	98.3

(1) Mt. Alluaiv, Russia; by electron microprobe, average of four samples; corresponds to $(Na_{13.47}(Ca_{1.60})_{\Sigma=15.07}(Mn_{0.79}Mg_{0.21}Fe_{0.11})_{\Sigma=1.11}(Ti_{2.67}Nb_{0.46})_{\Sigma=3.13}P_{3.94}Si_{4.00}O_{33.19}F_{0.52}$.

Occurrence: In alkalic pegmatite, cutting sodalite-cancrinite syenite, in a differentiated alkalic massif.

Association: Lamprophyllite, lomonosovite.

Distribution: On Mt. Alluaiv, Lovozero massif, Kola Peninsula, Russia.

Name: For Academician Vladimir Stepanovich Sobolev (1908–1982), Russian mineralogist, petrologist, and former President of the International Mineralogical Association, Institute of Geology and Geophysics, Novosibirsk, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5778/2; Mining Institute, St. Petersburg, 1303/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82754.

References: (1) Khomyakov, A.P., T.A. Kurova, and N.I. Chistyakova (1983) Sobolevite, $Na_{14}Ca_2MnTi_3P_4Si_4O_{34}$, a new mineral. Zap. Vses. Mineral. Obshch., 112, 456–461 (in Russian). (2) (1984) Amer. Mineral., 69, 813 (abs. ref. 1). (3) (1987) Amer. Mineral., 72, 1279 (errata ref. 2). (4) (1988) Sokolova, E.V., Y.K. Yegorov-Tismenko, and A.P. Khomyakov (1988) Crystal structure of sobolevite. Doklady Acad. Nauk SSSR, 302, 1112–1118 (in Russian). (5) (1991) Amer. Mineral., 76, 305 (abs. ref. 4).

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Sobolevskite PdBi

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Crystal Data: Hexagonal, probable. *Point Group:* n.d. As grains, to 0.1 mm; may be in myrmeketic intergrowthswith other species.

Physical Properties: Hardness = n.d. VHN = 236 (50 g load). D(meas.) = n.d. D(calc.) = 11.88

Optical Properties: Opaque. *Color:* Pale pinkish orange; in polished section, grayish white with creamy tint. *Anisotropism:* Strong; in reddish lilac, brown, and pale cream shades. R_1–R_2: (400) — , (420) — , (440) — , (460) — , (480) 46.7–52.2, (500) 48.3–53.6, (520) 50.4–56.1, (540) 52.4–57.7, (560) 54.3–59.7, (580) 55.5–61.0, (600) 56.5–62.0, (620) 57.8–63.5, (640) 59.3–65.0, (660) 60.2–66.2, (680) 60.5–67.5, (700) 60.8–68.3

Cell Data: *Space Group:* n.d. $a = 4.23$ $c = 5.69$ Z = 2

X-ray Powder Pattern: Oktyabr mine, Russia.
3.07 (100), 2.26 (100), 2.11 (90), 1.690 (50), 1.182 (50), 1.74 (40), 1.342 (40)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Pd	34.4	35.47	33.74	Pb		2.10	
Pt		0.11		Sb		0.09	
Sn		0.11		Bi	66.2	54.14	66.26
Cu		0.12		Te		7.65	
				Total	100.6	99.79	100.00

(1) Oktyabr mine, Russia; by electron microprobe, corresponding to $Pd_{1.01}Bi_{1.00}$. (2) Do.; by electron microprobe, corresponding to $(Pd_{1.00}Cu_{0.01})_{\Sigma=1.01}(Bi_{0.78}Te_{0.18}Pb_{0.03})_{\Sigma=0.99}$. (3) PdBi.

Polymorphism & Series: Forms a series with kotulskite.

Mineral Group: Nickeline group.

Occurrence: In massive and disseminated Cu–Ni–PGE minerals; in copper deposits in organic-rich limestones; along grain boundaries in silicates in layered intrusives.

Association: Paolovite, sperrylite, altaite, taimyrite, silver, polarite, talnakhite, chalcopyrite, cubanite, mooihoekite, troilite, pyrrhotite, galena (Oktyabr mine, Russia); platinian gold, palladium (Lubin mine, Poland).

Distribution: In Russia, from the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia [TL]; in the Federov Pansky layered mafic intrusion, Kola Peninsula; at the Vostok deposit, Lukkulaisvaara layered intrusion, and the Burakovsky complex, Karelia; in the Kingash massif, eastern Sayan. From the Keivitsansarvi Ni–Cu–PGE deposit, Keivitsa intrusion, northern Finland. In the Lubin and Polkovice copper mines, near Legnica, Zechstein copper district, Lower Silesia, Poland. From the Onverwacht mine, in the Merensky Reef, Bushveld complex, Transvaal, South Africa. At the Wellgreen Ni–Cu–PGE deposit, Yukon Territory; from Blue Lake, Quebec; in footwall and deposits of the Sudbury igneous complex, Ontario, Canada. From the Bacuri complex, Amapá, Brazil. Additional localities are now known.

Name: Honors Petr Grigorevich Sobolevski (1781–1841), Russian metallurgist, who studied the platinum deposits of the Ural Mountains.

Type Material: Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Evstigneeva, T.L., A.D. Genkin, and V.A. Kovalenker (1975) A new bismuthide of palladium, sobolevskite, and the nomenclature of minerals of the system PdBi–PdTe–PdSb. Zap. Vses. Mineral. Obshch., 104, 568–579 (in Russian). (2) (1976) Amer. Mineral., 61, 1054 (abs. ref. 1). (3) Cook, N.J., C.L. Ciobanu, R.K.W. Merkle, and H.-J. Bernhardt (2002) Sobolevskite, taimyrite, and Pt_2CuFe (tulameenite?) in complex talnakhite ore, Noril'sk orefield, Russia. Can. Mineral., 40, 329–340.

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Sodalite $Na_8Al_6Si_6O_{24}Cl_2$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals rare, typically dodecahedra, to 10 cm; as embedded grains or massive. *Twinning:* On {111}, common, forming pseudohexagonal prisms by elongation along [111].

Physical Properties: *Cleavage:* {110}, poor. *Fracture:* Uneven to conchoidal.
Tenacity: Brittle. Hardness = 5.5–6 D(meas.) = 2.27–2.33 D(calc.) = 2.31 Bright red-orange cathodoluminescence and fluorescence under LW and SW UV, with yellowish phosphorescence; may be photochromic in magentas; may give off the odor of H_2S on fracture.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, yellowish, greenish, light to dark blue, reddish; in thin section, colorless to gray. *Streak:* White. *Luster:* Vitreous to greasy.
Optical Class: Isotropic. $n = 1.483–1.487$

Cell Data: *Space Group:* $P\bar{4}3n$. $a = 8.870–8.882$ $Z = 1$

X-ray Powder Pattern: Ice River, Canada. (ICDD 20-1070).
3.63 (100), 6.30 (80), 2.10 (80), 2.57 (70), 2.38 (70), 1.569 (60), 1.480 (60)

Chemistry:

	(1)
SiO_2	37.95
Al_2O_3	31.42
FeO	0.39
MnO	0.08
Na_2O	24.16
K_2O	0.05
Cl	7.33
SO_3	0.09
$-O = Cl_2$	1.65
Total	99.82

(1) Mont Saint-Hilaire, Canada; by electron microprobe, corresponds to $Na_{7.50}Fe_{0.05}Al_{5.93}Si_{6.07}O_{23.83}[Cl_{1.99}(SO_4)_{0.01}]_{\Sigma=2.00}$.

Mineral Group: Sodalite group.

Occurrence: Formed in nepheline syenites, phonolites, and related rock types. In metasomatized calcareous rocks, and in cavities in ejected volcanic blocks.

Association: Nepheline, cancrinite, titanian andradite, aegirine, microcline, sanidine, albite, calcite, fluorite, ankerite, barite.

Distribution: Widespread; some prominent localities include: on the Kangerdluarssuk Plateau and around the Tunugdliarfik Fjord, in the Ilímaussaq intrusion, southern Greenland. From the Langesundsfjord, Norway. In the Khibiny and Lovozero massifs, Kola Peninsula, Russia. From Monte Somma and Vesuvius, Campania, Italy. At the Bellerberg volcano, two km north of Mayen, and elsewhere in the Eifel district, Germany. From Litchfield, Kennebec Co., Maine, and at Magnet Cove, Hot Spring Co., Arkansas, USA. In Canada, from Bancroft, Ontario; at Mont Saint-Hilaire, Quebec; and along the Ice River, at Kicking Horse Pass, British Columbia. From Cerro Sapo, Cochabamba, Bolivia.

Name: In allusion to its *sodium* content.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 429–431. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 289–302. (3) Peterson, R.C. (1983) The structure of hackmanite, a variety of sodalite, from Mont St-Hilaire, Quebec. Can. Mineral., 21, 549–552. (4) Hassan, I. and H.D. Grundy (1984) The crystal structures of sodalite-group minerals. Acta Cryst., 40, 6–13.

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Soddyite $(UO_2)_2SiO_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As crystals of pyramidal to platy habit, to 3 mm. As subparallel to divergent crystal clusters; in cross-fiber veinlets; also massive to earthy.

Physical Properties: *Cleavage:* Perfect on {001}, good on {111}. Hardness = 3.5 D(meas.) = 4.63–4.70 D(calc.) = [5.09] Radioactive.

Optical Properties: Translucent to transparent. *Color:* Amber to yellow or greenish yellow. *Streak:* Pale yellow. *Luster:* Vitreous to adamantine, dull when earthy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = very pale yellow; Z = pale yellow-green. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, negligible to strong.
$\alpha = 1.650$–1.654 $\beta = 1.680$–1.685 $\gamma = 1.699$–1.715 2V(meas.) = 70°–84°

Cell Data: *Space Group: Fddd.* $a = 8.32$ $b = 11.21$ $c = 18.71$ Z = [8]

X-ray Powder Pattern: Ruggles mine, New Hampshire, USA.
3.32 (100), 4.48 (90), 6.14 (80), 2.69 (70), 2.47 (60), 1.855 (50), 2.09 (40)

Chemistry:

	(1)	(2)
SiO_2	7.61	8.99
UO_3	85.79	85.62
H_2O	6.16	5.39
Total	99.56	100.00

(1) Kasolo, Congo. (2) $(UO_2)_2SiO_4 \cdot 2H_2O$.

Occurrence: A secondary mineral formed by oxidation of uraninite.

Association: Kasolite, sklodowskite, uranophane, torbernite, curite.

Distribution: From Kasolo, Swambo, and in the Musonoi mine, Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). At the Norrabees pegmatite, Namaqualand, Cape Province, South Africa. In the Krunkelbachtal mine, near Menzenschwand, Black Forest, Germany. In the USA, in the Ruggles pegmatite, Grafton, Grafton Co., New Hampshire; at the Steel City mine, Yavapai Co., Arizona; from the Jackpile mine, Laguna, Valencia Co., New Mexico; in the Lucky Mc mine, Fremont Co., Wyoming; from the Honeycomb Hills, Juab Co., Utah; and at the Lookout No. 22 claim, Marshall Pass, Saguache Co., Colorado. On Mt. Painter, Flinders Ranges, South Australia, and from South Alligator Valley, Northern Territory, Australia.

Name: For Frederick Soddy (1877–1956), British radiochemist.

Type Material: Natural History Museum, Paris, France, 122.122/3

References: (1) Schoep, A. (1922) La soddite [soddyite], nouveau minéral radioactif. Compt. Rendus Acad. Sci. Paris, 174, 1066–1067 (in French). (2) (1922) Amer. Mineral., 7, 179–180 (abs. ref. 1). (3) Gorman, D.H. (1952) Studies of radioactive compounds: V - soddyite. Amer. Mineral., 37, 386–396. (4) Stohl, F.V. and D.K. Smith (1981) The crystal chemistry of the uranyl silicate minerals. Amer. Mineral., 66, 610–625.

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Sodium alum $NaAl(SO_4)_2 \cdot 12H_2O$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As octahedral crystals, to 1 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼3 D(meas.) = 1.64 (synthetic). D(calc.) = 1.670 (synthetic). Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless; colorless in transmitted light.
Luster: Vitreous.
Optical Class: Isotropic. $n = 1.4388$

Cell Data: *Space Group:* $Pa3$. $a = 12.214(1)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
4.314 (100), 2.962 (35), 3.526 (14), 7.05(7), 1.9077 (7), 3.263 (6), 2.493 (6)

Chemistry: (1) There are apparently no analyses of natural material.

Occurrence: A sublimate on burning coal heaps (Bátonyterenye, Hungary); a recent precipitate (Recsk mine, Hungary).

Association: Blödite, kröhnkite (Recsk mine, Hungary).

Distribution: Earlier reported localities require confirmation by modern methods. Recently identified in Hungary, from the Recsk copper mine, Mátra Mountains, and at Bátonyterenye.

Name: For its *sodium* content, and as a hydrated aluminum sulfate.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 474 [soda alum]. (2) Szakáll, S., Ed. (2002) Minerals of the Carpathians. Granit, Prague, 278. (3) Cromer, D.T., M.I. Kay, and A.C. Larson (1967) Refinement of the alum structures. II. X-ray and neutron diffraction of $NaAl(SO_4)_2.12H_2O$, γ alum. Acta Cryst., 22, 182–187. (4) (1978) NBS Mono. 25, 15.

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Sodium betpakdalite $(Na, Ca)_3Fe_2^{3+}Mo_6^{6+}As_2^{5+}O_{28}\cdot 15H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. Crystals are pseudohexagonal, very thin, platy, to several μm; as powdery aggregates, crusts, and films.

Physical Properties: Hardness = n.d. D(meas.) = 2.02 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Lemon-yellow. *Luster:* Dull in aggregates. *Optical Class:* Biaxial. *Pleochroism:* Distinct; X = pale yellow; Z = yellow. *Orientation:* $Z \wedge$ elongation = 38°. *Absorption:* $Z > X$. $\alpha = 1.792$ β = n.d. $\gamma = 1.810$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: [Kyzylsai deposit, Kazakhstan].
8.73 (10), 3.629 (9), 1.836 (8), 3.243 (7), 2.940 (7), 2.752 (7), 2.071 (7)

Chemistry:

	(1)
MoO_3	50.22
SO_3	0.00
As_2O_5	13.93
SiO_2	0.20
Al_2O_3	0.40
Fe_2O_3	11.25
MgO	0.22
CaO	4.23
Na_2O	3.14
K_2O	0.20
H_2O^+	16.65
Total	[100.44]

(1) [Kyzylsai deposit, Kazakhstan]; original total given as 100.48%, H_2O confirmed by IR; corresponds to $(Na_{1.71}Ca_{1.28})_{\Sigma=2.99}Fe^{3+}_{2.05}Mo^{6+}_{5.90}As^{5+}_{2.05}O_{28}\cdot 15.27H_2O$.

Occurrence: A rare secondary mineral formed in the oxidation zone of a Mo–U deposit.

Association: Natrojarosite, goethite, arsenian pyrite, calcite.

Distribution: From an unspecified locality [Kyzylsai deposit, Chu-Ili Mountains, southwestern Balkhash Lake region, Kazakhstan].

Name: For a *sodium*-bearing mineral showing some relation to *betpakdalite*.

Type Material: Mining Institute, St. Petersburg, 1883/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74275, 74276.

References: (1) Skvortsova, K.V., G.A. Sidorenko, Y.S. Nesterova, G.A. Arapova, A.D. Dara, and L.I. Rybakova (1971) Sodium betpakdalite and conditions of its formation. Zap. Vses. Mineral. Obshch., 100, 603–611 (in Russian). (2) (1972) Amer. Mineral., 57, 1312–1313 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 191.

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Sodium boltwoodite $(H_3O)(Na,K)(UO_2)SiO_4 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As flaky, radiating-fibrous aggregates and fine-grained coatings.

Physical Properties: *Cleavage:* Perfect on {010}, imperfect on {001}. Hardness = n.d. D(meas.) = 4.1 D(calc.) = 4.4 Radioactive.

Optical Properties: Translucent. *Color:* Pale yellow to white; in transmitted light, pale yellow to colorless.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Z = pale yellow. α = 1.613–1.645 β = [1.63–1.66] γ = 1.645–1.672 2V(meas.) = Large.

Cell Data: *Space Group:* $P2_12_12_1$. $a = 27.40(5)$ $b = 7.02(2)$ $c = 6.65(2)$ Z = 8

X-ray Powder Pattern: Kyzylsai district, Kazakhstan.
6.71 (10), 2.92 (10), 4.70 (8), 3.49 (8), 3.37 (8), 3.10 (8), 6.92 (7)

Chemistry:

	(1)
SiO_2	14.70
UO_3	59.57
Al_2O_3	0.1
Fe_2O_3	0.45
PbO	0.00
MgO	0.00
CaO	4.35
Na_2O	4.21
K_2O	3.10
H_2O	8.70
LOI	14.23
Total	[109.41]

(1) Kyzylsai district, Kazakhstan; contained quartz and calcite, original total given as 100.71%; after subtracting impurities, corresponds to $(H_3O)(Na_{0.7}K_{0.3})_{\Sigma=1.0}(UO_2)(SiO_4) \cdot H_2O$.

Occurrence: A minor secondary mineral formed from subalkaline groundwater in the near-surface parts of uranium deposits in arid regions.

Association: Kaolinite, calcite, feldspar, quartz, gypsum, Fe-Mn oxides and hydroxides.

Distribution: Found at an unnamed uranium deposit, Kyzylsai district, Chu-Ili Mountains, Balkhash Lake region, Kazakhstan.

Name: For *sodium* in its composition and its relation to *boltwoodite*.

Type Material: n.d.

References: (1) Chernikov, A.A., D.P. Shashkin, and I.N. Gavrilova (1975) Sodium boltwoodite. Doklady Acad. Nauk SSSR, 221, 195–197 (in Russian). (2) (1976) Amer. Mineral., 61, 1054–1055 (abs. ref. 1). (3) Stohl, F.V. and D.K. Smith (1981) The crystal chemistry of the uranyl silicate minerals. Amer. Mineral., 66, 610–625.

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Sodium meta-autunite $Na_2(UO_2)_2(PO_4)_2 \cdot (6-8)H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Platy crystals, to 5 mm, may be in radiating and foliated masses.

Physical Properties: *Cleavage:* {001}, perfect; {100}, less perfect. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = n.d. D(calc.) = [3.62] Yellow-green fluorescence under UV. Radioactive.

Optical Properties: Semitransparent. *Color:* Lemon-yellow, lettuce-yellow, greenish yellow. *Luster:* Vitreous, pearly on {001}.
Optical Class: Uniaxial (–). *Pleochroism:* Weak; O = light yellow; E = pale yellow. $\omega = 1.578$ $\epsilon = 1.559$

Cell Data: *Space Group:* $P4/nmm$. $a = 6.97$ $c = 8.69$ Z = 1

X-ray Powder Pattern: Kuruk deposit, Tajikistan.
3.67 (10), 2.675 (8), 1.566 (8b), 1.540 (8b), 3.23 (7), 1.639 (7), 1.364 (7)

Chemistry:

	(1)	(2)	(3)
UO_3	61.9	62.53	62.17
P_2O_5	15.56	14.69	15.43
CO_2	0.24		
SiO_2	1.6		
Al_2O_3	0.32		
Fe_2O_3	0.97		
MgO	0.43		
CaO	1.2	0.14	
Na_2O	5.62	6.88	6.74
H_2O^+	4.05		
H_2O^-	9.02		
H_2O		14.84	15.66
Total	100.91	99.08	100.00

(1) Kuruk deposit, Tajikistan; after deduction of impurities, stated to correspond to $(Na, Ca)_{\Sigma=2.04}(UO_2)_{1.91}(PO_4)_{2.00} \cdot 6.66H_2O$. (2) Do.; corresponds to $(Na, Ca)_{\Sigma=2.12}(UO_2)_{2.1}(PO_4)_{2.00} \cdot 7.9H_2O$. (3) $Na_2(UO_2)_2(PO_4)_2 \cdot 8H_2O$.

Mineral Group: Autunite group.

Occurrence: In the oxidized zone of a uranium deposit in a granodiorite massif.

Association: Schoepite, gypsum, kaolinite, "limonite".

Distribution: Found in the Kuruk uranium deposit, 15 km northeast of Khodzhent, Samgar Steppe, northern Tajikistan.

Name: The prefix *meta* indicates the dehydration product of *"sodium autunite"*, the transitory sodium analog of *meta-autunite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67809–67812.

References: (1) Chernikov, A.A., O.V. Krutetskaya, and N.I. Organova (1957) Sodium-autunite [sodium meta-autunite]. Atomnaya Energiya, 3, 133–140 (in Russian). (2) (1958) Amer. Mineral., 43, 383 (abs. ref. 1). (3) Chernikov, A.A. and N.I. Organova (1994) Sodium autunite and sodium meta-autunite. Doklady Acad. Nauk SSSR, 338, 368–371 (in Russian). (4) (1995) Amer. Mineral., 80, 1329–1330 (abs. ref. 3 with discussion of nomenclature). (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 190–191.

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Sodium pharmacosiderite $(Na,K)_2Fe_4^{3+}(AsO_4)_3(OH)_5 \cdot 7H_2O$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Cubic crystals, to 1 mm, in aggregates.

Physical Properties: *Cleavage:* On {001}, imperfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 2.79(4) D(calc.) = 2.90 for $Na_2Fe_4(AsO_4)_3(OH)_5 \cdot 7H_2O$.

Optical Properties: Transparent to translucent. *Color:* Pale green to dull orange; pale green to colorless in thin section. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.705(4)$

Cell Data: *Space Group:* $[P\bar{4}3m]$ (by analogy to pharmacosiderite). $a = 8.012(1)$ $Z = 1$

X-ray Powder Pattern: Marda, Australia.
7.99 (100), 3.27 (80), 2.831 (60), 2.416 (60), 4.61 (50), 2.532 (50), 4.00 (40)

Chemistry:

	(1)
As_2O_5	36.7
Fe_2O_3	35.5
Na_2O	5.8
K_2O	2.7
H_2O	19.3
Total	[100.0]

(1) Marda, Australia; by electron microprobe, total Fe as Fe_2O_3, H_2O by the Penfield method; normalized to 100.0% from an original total of 106.2%, keeping H_2O constant; then corresponding to $(Na_{1.68}K_{0.52})_{\Sigma=2.20}Fe_{4.00}(AsO_4)_{2.87}(OH)_{5.59} \cdot 6.84H_2O$.

Occurrence: Initially found on a museum specimen, presumably an alteration product of arsenopyrite (Marda, Australia).

Association: Pharmacosiderite, scorodite, arseniosiderite, "jarosite", arsenopyrite, quartz (Marda, Australia).

Distribution: In Australia, from Marda, Western Australia, and at Mafeking, Victoria. From the Gold Hill mine, Tooele Co., Utah, USA.

Name: In allusion to *sodium* in the composition and its relation to *pharmacosiderite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 146392.

References: (1) Peacor, D.R. and P.J. Dunn (1985) Sodium-pharmacosiderite, a new analog of pharmacosiderite from Australia and new occurrences of barium-pharmacosiderite [= barian pharmacosiderite]. Mineral. Record, 16, 121–124. (2) (1986) Amer. Mineral., 71, 230 (abs. ref. 1) (3) Kokinos, M. and W.S. Wise (1993) The Gold Hill mine, Tooele County, Utah. Mineral. Record, 24, 11–22.

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Sodium uranospinite $(Na_2, Ca)(UO_2)_2(AsO_4)_2 \cdot 5H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Imperfect lathlike to fibrous elongated crystals, to 2 cm, in divergent or irregular aggregates, and as incrustations.

Physical Properties: *Cleavage:* On {001}, perfect; on {010}, distinct. Hardness = 2.5 D(meas.) = 3.846 D(calc.) = [3.66] Fluoresces bright yellowish green under UV. Radioactive.

Optical Properties: Semitransparent. *Color:* Yellow-green, lemon-yellow, straw-yellow. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Uniaxial (–), commonly anomalously biaxial (–). *Pleochroism:* Faint; X = colorless; $Y = Z$ = yellow. $\omega = 1.612$ $\epsilon = 1.585$ 2V(meas.) = Small.

Cell Data: *Space Group:* $[P4/nmm]$ (by analogy to meta-autunite). $a = 7.12$ $c = 8.61$ Z = 1

X-ray Powder Pattern: Bota-Burum deposit, Kazakhstan.
8.48 (10), 3.68 (10), 3.292 (9), 1.837 (9), 1.987 (8), 1.634 (8), 5.45 (7)

Chemistry:

	(1)
UO_3	58.29
P_2O_5	1.65
As_2O_5	20.84
SiO_2	2.39
Al_2O_3	0.91
Fe_2O_3	0.57
MgO	trace
CaO	1.87
Na_2O	3.91
K_2O	0.00
H_2O^+	3.49
H_2O^-	6.00
Total	99.92

(1) Bota-Burum deposit, Kazakhstan; neglecting Si, Al, Fe as impurities, corresponds to $(Na_{1.26}Ca_{0.34})_{\Sigma=1.60}(UO_2)_{2.04}[(AsO_4)_{1.82}(PO_4)_{0.22}]_{\Sigma=2.04} \cdot 5.27H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: In the oxidized zone of a uranium–sulfide deposit in felsite porphyry and sodium-bearing tuffaceous breccias (Bota-Burum deposit, Kazakhstan).

Association: Realgar, orpiment, scorodite, mansfieldite, trögerite, arseniosiderite, metatorbernite, metazeunerite, uranophane, uraninite, arsenopyrite, pyrite, galena (Bota-Burum deposit, Kazakhstan).

Distribution: In the Bota-Burum uranium deposit, 15 km southwest of Alakol Lake, Chu-Ili Mountains, southwestern Balkhash district, Kazakhstan. At the Buhlskopf mine, near Ellweiler, Rhineland-Palatinate, Germany. On the Clyde Long property, Elk Park, San Juan Co., Colorado, USA.

Name: For its dominant *sodium* content and relation to *uranospinite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72124–74126.

References: (1) Kopchenova, E.V. and K.V. Skvortsova (1957) Sodium uranospinite. Doklady Acad. Nauk SSSR, 114, 634–636 (in Russian). (2) (1958) Amer. Mineral., 43, 383–384 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 191.

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Sodium-zippeite $Na_4(UO_2)_6(SO_4)_3(OH)_{10}\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Rare in crystals, to 100 μm, rhomboidal to slightly elongated plates, extremely thin, may be petallike, lathlike, spindle-shaped, in vermiform aggregates; as cross-fiber veinlets, warty crusts, very fine-grained powdery to massive; commonly in efflorescences. *Twinning:* Common on {*h*0*l*}, contact twins, with another law, polysynthetic.

Physical Properties: *Cleavage:* Perfect on {010}; perhaps another perpendicular. Hardness = ∼2 D(meas.) = > 3.3 D(calc.) = n.d. Radioactive; fluoresces bright yellow under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Yellow, lemon-yellow, yellow-orange. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless to pale yellow; Z = dark yellow to golden yellow. *Orientation:* $X \perp$ plane of flattening; $Z = c$. α = 1.630–1.637 β = 1.685–1.689 γ = 1.732–1.739 2V(meas.) = Moderate to large.

Cell Data: *Space Group:* n.d. $a = 8.82$ $b = 17.12$ $c = 7.32$ Z = n.d.

X-ray Powder Pattern: Synthetic.
7.34 (100), 3.663 (54), 3.490 (44), 3.153 (35), 2.858 (15), 3.754 (14), 2.118 (11)

Chemistry:

	(1)	(2)
SO_3	10.43	10.71
UO_3	75.86	76.53
Na_2O	5.25	5.53
K_2O	0.47	
H_2O	7.99	7.23
Total	[100.00]	100.00

(1) Delta mine, Utah, USA; recalculated to 100% after deduction of gypsum 0.1% and insoluble $SiO_2 + Al_2O_3 + Fe_2O_3$ 4.39%. (2) $Na_4(UO_2)_6(SO_4)_3(OH)_{10}\cdot 4H_2O$.

Occurrence: A secondary alteration product of uraninite and base-metal sulfides in the oxidized zone of uranium-rich deposits, typically in sandstone-type uranium deposits; of post-mine origin, where the sodium may be supplied by percolating saline water.

Association: Andersonite, uranopilite, johannite, schröckingerite, uranopilite, other "zippeite-group" minerals.

Distribution: In the USA, in Utah, from the Happy Jack mine, White Canyon, and the W.N. mine, Deer Flat, San Juan Co.; in the Delta and Lucky Strike No. 2 mines, San Rafael district, and at the Sodaroll mine, Green River district, Emery Co.; from the Parco No. 23 mine, Thompsons district, Grand Co.; at the Atomic King mine, Cane Springs, Moab Co.; in the Oyler mine, Henry Mountains district, Wayne Co.; in Arizona, from the Sue mine, Cherry Creek district, Gila Co., and in the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co.; at the Jackpile mine, Grants district, Socorro Co., New Mexico. From Jáchymov (Joachimsthal), Czech Republic. In the Geevor mine, St. Just, Cornwall, England.

Name: For its content of *sodium* and relation to the other *zippeite* group species.

Type Material: n.d.

References: (1) Frondel, C., J. Ito, R.M. Honea, and A.M. Weeks (1976) Mineralogy of the zippeite group. Can. Mineral., 14, 429–436.

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Sogdianite $(K,Na)_2(Li,Fe^{2+})_3(Zr,Fe^{3+},Ti)_2Si_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Tabular crystals, to 1 cm; in platy aggregates, to 15 cm.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = 5–7 D(meas.) = 2.76–2.90 D(calc.) = [2.75] Fluoresces dark violet under LW UV and very dark red under SW UV.

Optical Properties: Transparent to translucent. *Color:* Violet. *Luster:* Vitreous. *Optical Class:* Uniaxial (–) [*sic*]. $\omega = 1.606$ $\epsilon = 1.608$

Cell Data: *Space Group:* $P6/mcc$. $a = 10.083(5)$ $c = 14.24(1)$ $Z = 2$

X-ray Powder Pattern: Dara-i-Pioz massif, Tajikistan; similar to sugilite.
3.20 (10), 2.90 (10), 4.09 (9), 1.838 (8), 1.326 (8), 1.517 (7), 4.51 (6)

Chemistry:

	(1)		(1)
SiO_2	68.83	CaO	0.00
TiO_2	2.88	BaO	0.32
ZrO_2	9.78	Li_2O	3.73
Al_2O_3	1.04	Na_2O	2.81
Fe_2O_3	4.61	K_2O	4.84
FeO	1.22	F	0.00
MnO	trace	H_2O	0.00
MgO	trace	Total	100.06

(1) Dara-i-Pioz massif, Tajikistan; corresponding to $(K_{1.05}Na_{0.95})_{\Sigma=2.00}(Li_{2.55}Al_{0.15})_{\Sigma=2.70}(Zr_{0.8}Fe^{3+}_{0.6}Ti_{0.4}Fe^{2+}_{0.2})_{\Sigma=2.0}Si_{12}O_{30}$.

Mineral Group: Milarite group.

Occurrence: In a pegmatite vein with a composition about that of an alkalic granite.

Association: Thorite, stillwellite, pyrochlore, tienshanite, thorite, cesium kupletskite, microcline, quartz, aegirine (Dara-i-Pioz massif, Tajikistan); aegirine, polylithionite (Washington Pass, Washington, USA).

Distribution: From the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. In the Wessels mine, near Kuruman, Cape Province, South Africa. At Washington Pass, Okanogan Co., Washington, USA.

Name: For *Sogdiana*, an ancient Central Asian state.

Type Material: Mineralogy Museum, St. Petersburg University, St. Petersburg, 16246; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72028, 74962, vis3595.

References: (1) Dusmatov, V.D., A.F. Efimov, Z.T. Kataeva, L.A. Khoroshilova, and K.P. Yanulov (1968) Sogdianite, a new mineral. Doklady Acad. Nauk SSSR, 182, 1176–1177 (in Russian). (2) (1969) Amer. Mineral., 54, 1221–1222 (abs. ref. 1). (3) Bakakin, V.V., V.P. Balko, and L.P. Solov'eva (1974) Crystal structures of milarite, armenite, and sogdianite. Kristallografiya (Sov. Phys. Crystal.), 19, 741–745 (in Russian). (4) Dillmann, R. (1978) Sogdianit. Z. Deutsch. Gemmol. Gesell., 27, 214 (in German). (5) (1979) Mineral. Abs., 30, 250 (abs. ref. 4).

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Söhngeite $Ga(OH)_3$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$. In crystalline twinned groups and aggregates, to 1 cm; very rarely as single crystals. *Twinning:* As trillings of composite flattened and curved crystals, interpenetrant at right angles, according to an unknown law.

Physical Properties: Hardness = 4–4.5 D(meas.) = 3.84 D(calc.) = 3.847

Optical Properties: Semitransparent. *Color:* White, pale yellow, pale brown, pale greenish yellow.
Optical Class: Isotropic. $n = 1.736$

Cell Data: *Space Group:* $Pmn2_1$. $a = 7.4865$ $b = 7.4379$ $c = 7.4963$ Z = [8]

X-ray Powder Pattern: Tsumeb, Namibia.
3.74 (10), 1.669 (7), 2.63 (6), 1.525 (6), 1.867 (4), 2.15 (3.5), 2.36 (3)

Chemistry:

	(1)	(2)
SiO_2	1.8	
Al_2O_3	4.7	
Ga_2O_3	66.8	77.62
Fe_2O_3	2.3	
H_2O^+	19.6	
H_2O^-	4.2	
H_2O		22.38
Total	99.4	100.00

(1) Tsumeb, Namibia. (2) $Ga(OH)_3$.

Occurrence: An alteration product of gallite-bearing germanite in an oxidation zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Germanite, gallite.

Distribution: From Tsumeb, Namibia.

Name: Honors Dr. A.P.G. Söhnge, formerly Chief Geologist, Tsumeb Corporation, Tsumeb, Namibia.

Type Material: n.d.

References: (1) Strunz, H. (1965) Söhngeit, $Ga(OH)_3$, ein neues Mineral. Naturwissenschaften, 52, 493 (in German). (2) (1966) Amer. Mineral., 51, 1815 (abs. ref. 1). (3) Scott, J.D. (1970) Crystal structure of a new mineral, söhngeite. Amer. Crystallogr. Assoc., Prog. and Abs., 76. (4) Pinch, W.W. and W.E. Wilson (1977) [Tsumeb] Minerals: a descriptive list. Mineral. Record, 8(3), 32.

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Solongoite $Ca_2B_3O_4Cl(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Subhedral crystals, tabular, vertically striated, to 0.2 mm.

Physical Properties: *Cleavage:* One, imperfect, parallel elongation. Hardness = 3.5 D(meas.) = 2.514 D(calc.) = 2.58

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z \wedge c = 25°$, positive elongation. *Dispersion:* $r > v$, very weak. $\alpha = 1.510(1)$ $\beta = 1.510(1)$ $\gamma = 1.545(1)$ 2V(meas.) = Very small.

Cell Data: *Space Group:* $P2_1/b$. $a = 7.975(2)$ $b = 12.571(5)$ $c = 7.237(2)$ $\beta = 86.14(3)°$ Z = 4

X-ray Powder Pattern: Solongo deposit, Russia.
2.196 (10), 7.84 (9), 1.734 (9), 2.61 (8), 2.54 (8), 1.911 (8), 2.74 (7)

Chemistry:

	(1)	(2)
B_2O_3	38.54	37.29
MgO	0.50	
CaO	39.54	40.05
Cl	7.62	12.66
H_2O^+	15.40	
H_2O^-	0.00	
H_2O		12.86
$-O = Cl_2$	1.74	2.86
Total	99.86	100.00

(1) Solongo deposit, Russia; H_2O absent by IR; corresponds to $(Ca_{1.92}Mg_{0.03})_{\Sigma=1.95}$ $B_{3.02}O_4Cl_{0.58}(OH)_{4.66}$. (2) $Ca_2B_3O_4Cl(OH)_4$.

Occurrence: From a drillhole into a contact metamorphic boron deposit at a depth of 400 m.

Association: Szaibélyite, andradite–grossular, kurchatovite, calcite, "chlorite", vesuvianite, svabite, magnetite, hematite, sphalerite, quartz.

Distribution: From the Solongo boron deposit, Buryatia, Russia.

Name: For the Solongo (Buryat for *rainbow*, for the variety of boron minerals contained) deposit, Russia, from which it was first noted.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74785.

References: (1) Malinko, S.V. (1974) The new boron mineral – solongoite. Zap. Vses. Mineral. Obshch., 103, 117–121 (in Russian). (2) (1975) Amer. Mineral., 60, 162–163 (abs. ref. 1). (3) Yamnova, N.A., M.A. Simonov, and N.V. Belov (1977) Refined crystal structure of solongoite $Ca_2[B_3O_4(OH)_4]Cl$. Kristallografiya (Sov. Phys. Crystal.), 22, 624–626 (in Russian).

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Sonolite $Mn_9^{2+}(SiO_4)_4(OH,F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic to anhedral, to 2.5 cm; granular. *Twinning:* Singular or lamellar on {101}, common.

Physical Properties: Hardness = 5.5 D(meas.) = 3.82–4.00 D(calc.) = 3.97

Optical Properties: Transparent. *Color:* Brown, dark brown, reddish brown to reddish orange; colorless in thin section. *Luster:* Dull to vitreous.
Optical Class: Biaxial (–). *Orientation:* $X \wedge \{001\} = 9°–10°$. *Dispersion:* $r > v$. $\alpha = 1.763$ $\beta = 1.779$ $\gamma = 1.793$ 2V(meas.) = 75.5°–82°

Cell Data: *Space Group:* $P2_1/b$. $a = 4.872(5)$ $b = 10.669(12)$ $c = 14.287(7)$ $\alpha = 100.30(10)°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.869 (10), 1.743 (10), 2.651 (7), 2.608 (7), 2.699 (5.5), 2.458 (5), 2.504 (4.5)

Chemistry:

	(1)
SiO_2	22.37
TiO_2	0.09
Al_2O_3	2.56
FeO	0.93
MnO	62.01
MgO	3.45
CaO	0.73
F	0.21
H_2O^+	3.08
H_2O^-	0.30
CO_2	4.53
$-O = F_2$	0.09
Total	100.17

(1) Hanawa mine, Japan; corresponds to $(Mn_{7.80}Mg_{1.05}Fe_{0.16}Ca_{0.16})_{\Sigma=9.17}(Si_{3.45}Al_{0.62}Ti_{0.01})_{\Sigma=4.08}O_{15.91}[(OH)_{1.95}F_{0.14}]_{\Sigma=2.09}$.

Polymorphism & Series: Dimorphous with jerrygibbsite.

Mineral Group: Humite group.

Occurrence: In metamorphosed manganese-rich deposits.

Association: Rhodochrosite, galaxite, pyrochroite (Japan); franklinite, willemite, zincite, manganosite, chlorite, calcite, tephroite (Franklin, New Jersey, USA).

Distribution: In the Sono mine, Kyoto Prefecture; the Hanawa mine, Iwate Prefecture; the Hokkejino mine, Kyoto Prefecture; the Kuratomi mine, Oita Prefecture; and a number of other places in Japan. In the USA, at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and at Bald Knob, near Sparta, Alleghany Co., North Carolina. From Bonneval-sur-Arc, Savoie, France. In Kyrgyzstan, on Inyl'chek Ridge, Tien Shan.

Name: For the Sono mine, Japan, where it was originally found.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 114576.

References: (1) Yoshinaga, M. (1963) Sonolite, a new manganese silicate mineral. Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol., 14, 1–21. (2) (1963) Amer. Mineral., 48, 1413 (abs. ref. 1). (3) Cook, D. (1969) Sonolite, alleghanyite and leucophoenicite from New Jersey. Amer. Mineral., 54, 1392–1398. (4) Ribbe, R.H. and G.V. Gibbs (1971) Crystal structures of the humite minerals: III. Mg/Fe ordering in humite and its relation to other ferromagnesian silicates. Amer. Mineral., 56, 1155–1173. (5) Kato, T., Y. Ito, and N. Hashimoto (1989) The crystal structures of sonolite and jerrygibbsite. Neues Jahrb. Mineral., Monatsh., 410–430.

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Sonoraite $Fe^{3+}Te^{4+}O_3(OH)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Bladelike crystals, to 2 mm, flattened on {100}, in subparallel sheaves and rosettes.

Physical Properties: Hardness = ∼3 D(meas.) = 3.95(1) D(calc.) = 4.18

Optical Properties: Transparent. *Color:* Dark yellowish green. *Luster:* Vitreous. *Optical Class:* Biaxial (–). $\alpha = 2.018(3)$ $\beta = 2.023(3)$ $\gamma = 2.025(3)$ 2V(meas.) = 20°–25°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.984(2)$ $b = 10.268(1)$ $c = 7.917(2)$ $\beta = 108.49(2)°$ Z = 8

X-ray Powder Pattern: Moctezuma mine, Mexico.
10.4 (10), 4.66 (8), 3.110 (8), 3.290 (7), 3.66 (6), 5.18 (5), 3.035 (5)

Chemistry:

	(1)	(2)
TeO_2	52.5	59.90
Fe_2O_3	27.9	29.96
H_2O	18.2	10.14
Total	98.6	100.00

(1) Moctezuma mine, Mexico; H_2O taken as loss on ignition. (2) $FeTeO_3(OH)\cdot H_2O$.

Occurrence: A very rare mineral in the oxide zone of a hydrothermal Au–Te ore deposit (Moctezuma mine, Mexico).

Association: Emmonsite, anglesite, "limonite", quartz (Moctezuma mine, Mexico); emmonsite (Mohawk mine, Nevada, USA); rodalquilarite, emmonsite, jarosite, limonite (Tombstone, Arizona, USA).

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the USA, in the Mohawk mine, Goldfield, Esmeralda Co., Nevada; from the Joe shaft, near Tombstone, Cochise Co., Arizona; in the Wilcox district, Catron Co., New Mexico; in Colorado, at the Good Hope mine, Vulcan district, Gunnison Co., and the Hoosier mine, Cripple Creek district, Teller Co.

Name: For the state of Sonora, Mexico, in which the mineral was first found.

Type Material: The Natural History Museum, London, England, 1967,390; National Museum of Natural History, Washington, D.C., USA, 119271, 164343, 164344.

References: (1) Gaines, R.V., G. Donnay, and M.H. Hey (1968) Sonoraite. Amer. Mineral., 53, 1828–1832. (2) Donnay, G., J.M. Stewart, and H. Preston (1970) The crystal structure of sonoraite, $Fe^{3+}Te^{4+}O_3(OH)\cdot H_2O$. Tschermaks Mineral. Petrog. Mitt., 14, 27–44.

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Sopcheite $Ag_4Pd_3Te_4$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Massive.

Physical Properties: Hardness = n.d. VHN = 134–209 (10 g load). D(meas.) = n.d. D(calc.) = 9.948

Optical Properties: Opaque. *Color:* Pale gray with a brownish tint in reflected light. *Luster:* Metallic. *Anisotropism:* Weak; yellowish red to bluish.

R_1–R_2: (400) 36.2–38.3, (420) 37.0–39.0, (440) 38.8–39.9, (460) 41.2–40.8, (480) 43.3–41.7, (500) 44.6–42.6, (520) 45.0–43.5, (540) 44.8–44.4, (560) 44.8–45.6, (580) 45.2–47.0, (600) 45.5–48.3, (620) 45.7–49.2, (640) 45.9–49.8, (660) 46.2–50.2, (680) 46.5–50.5, (700) 47.0–50.8

Cell Data: *Space Group:* n.d. $a = 9.645$ $b = 7.906$ $c = 11.040$ Z = 4

X-ray Powder Pattern: Monchegorsk deposits, Russia.
3.33 (100), 1.805 (70b), 2.56 (60), 2.70 (50), 2.30 (50b), 4.12 (40), 2.15 (40)

Chemistry:

	(1)	(2)	(3)
Ag	32.62	34.3	34.22
Pd	25.26	25.8	25.31
Fe	0.80		
Cu	0.09		
Ni	0.03		
Bi	0.17	0.5	
Te	41.32	39.7	40.47
Total	100.29	100.3	100.00

(1) Monchegorsk deposits, Russia; by electron microprobe, corresponding to $(Ag_{3.78}Fe_{0.18}Cu_{0.02}Ni_{0.01})_{\Sigma=3.99}Pd_{2.96}(Te_{4.04}Bi_{0.01})_{\Sigma=4.05}$. (2) Lac des Iles complex, Canada; by electron microprobe, average of three analyses; corresponding to $Ag_{4.00}Pd_{3.05}(Te_{3.92}Bi_{0.03})_{\Sigma=3.95}$.
(3) $Ag_4Pd_3Te_4$.

Occurrence: In veinlets cutting chalcopyrite (Monchegorsk deposits, Russia).

Association: Merenskyite, kotulskite, chalcopyrite, mackinawite (Monchegorsk deposits, Russia).

Distribution: From the Monchegorsk group of Cu–Ni deposits, in the Sopcha massif, Monchegorsk pluton, Kola Peninsula, Russia [TL]. In Canada, in Ontario, in the Roby zone, Lac des Iles complex; at the Levack West mine, Sudbury; at the Geordie Lake intrusion, Coldwell complex. From the Santo Tomas II porphyry copper deposit, Benguet, Philippines.

Name: For the type locality, Sopcha Mountain, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, Russia, 5709/1.

References: (1) Orsoev, D.A., S.A. Rezhenova, and A.N. Bodanova (1982) Sopcheite, $Ag_4Pd_3Te_4$, a new mineral from copper–nickel ores of the Monchegorsk pluton. Zap. Vses. Mineral. Obshch., 111, 114–117 (in Russian). (2) (1983) Amer. Mineral., 68, 472 (abs. ref. 1). (3) Dunning, G.R., J.H.G. Laflamme, and A.J. Criddle (1984) Sopcheite: a second Canadian occurrence, from the Lac-des-Iles Complex, Ontario. Can. Mineral., 22, 233–237.

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Sofiite $Zn_2(Se^{4+}O_3)Cl_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are thin platy to micalike, pseudohexagonal, may be elongated along [001], with {010}, {100}, to 5 mm. *Twinning:* On {100}, contact, to give "swallow-tail" forms.

Physical Properties: *Cleavage:* On {010}, perfect; on {201}, less perfect. *Tenacity:* Brittle. Hardness = n.d. VHN = 38–61, average 49 (10 g load). D(meas.) = n.d. D(calc.) = 3.64(1) Soluble with difficulty in H_2O.

Optical Properties: Transparent. *Color:* Colorless, becomes sky-blue on long exposure to air. *Streak:* White. *Luster:* Vitreous to greasy or silky.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.709(3)$ $\beta = 1.726(2)$ $\gamma = 1.750(2)$ 2V(meas.) = n.d. 2V(calc.) = 91°

Cell Data: *Space Group: Pccn.* $a = 10.251(4)$ $b = 15.223(2)$ $c = 7.666(5)$ $Z = 8$

X-ray Powder Pattern: Tolbachik volcano, Russia; preferred orientation due to {010} cleavage.
7.61 (100), 3.807 (23), 2.918 (12), 3.055 (8), 3.237 (6), 2.538 (6), 2.727 (4)

Chemistry:

	(1)	(2)
SeO_2	34.48	33.76
CuO	0.19	
ZnO	47.83	49.53
PbO	0.35	
Cl	22.26	21.58
$-O = Cl_2$	5.02	4.87
Total	100.09	100.00

(1) Tolbachik volcano, Russia; by electron microprobe, average of 38 analyses; corresponds to $(Zn_{1.92}Cu_{0.01}Pb_{0.01})_{\Sigma=1.94}(Se_{1.02}O_{2.94})Cl_{2.06}$. (2) $Zn_2(SeO_3)Cl_2$.

Occurrence: In fractures in volcanic fumaroles, formed at 180 °C–230 °C.

Association: Tenorite, cotunnite, piypite, ponomarevite, chalcocyanite, chloromenite, burnsite, ilinskite, georgbokiite, dolerophanite, halite, sylvite, gold.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: To honor Sof'ya Ivanovna Naboko (1909–), Institute of Volcanology, Petropavlovsk-Kamchatskii, Russia, leading investigator of the Kamchatka volcanoes.

Type Material: Mining Institute, St. Petersburg, Russia, 1550/1.

References: (1) Vergasova, L.P., S.K. Filatov, T.F. Semenova, and T.M. Filosofva (1989) Sofiite $Zn_2(SeO_3)Cl_2$ – a new mineral from volcanic sublimates. Zap. Vses. Mineral. Obshch., 118(1), 65–69 (in Russian). (2) (1990) Amer. Mineral., 75, 1211–1212 (abs. ref. 1). (3) Semenova, T.F., I.V. Rozhdestvenskaya, S.K. Filatov, and L.P. Vergasova (1992) Crystal structure and physical properties of sophiite [sofiite], $Zn_2(SeO_3)Cl_2$, a new mineral. Mineral. Mag., 56, 241–245.

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Sorbyite $Pb_{19}(Sb, As)_{20}S_{49}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are equant to thin tabular, elongated [010], and commonly heavily striated ‖ [010], to 1 mm. *Twinning:* Irregular lamellae seen in polished section.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. VHN = 175 (50 g load). D(meas.) = n.d. D(calc.) = 5.52

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Strong. *Anisotropism:* Strong.
R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/m$. $a = 45.15$ $b = 8.28$ $c = 26.53$ $\beta = 113.4°$ Z = 4

X-ray Powder Pattern: Madoc, Canada.
3.44 (100), 3.38 (90), 4.13 (60), 2.96 (60), 2.099 (50), 4.02 (40), 3.04 (40)

Chemistry:

	(1)	(2)
Pb	46.6	46.9
Cu	1.2	
Ag	0.17	
Sb	26.3	25.8
As	3.5	5.7
S	20.7	22.1
Total	98.47	100.5

(1) Madoc, Canada; by electron microprobe, corresponds to $(Pb_{17.07}Cu_{1.43}Ag_{0.15})_{\Sigma=18.65}(Sb_{16.40}As_{3.55})_{\Sigma=19.95}S_{49.00}$. (3) Novoye, Kyrgyzstan; by electron microprobe; corresponds to $(Pb_{16.09}(Sb_{15.07}As_{5.41})_{\Sigma=20.48}S_{49.00}$.

Occurrence: Of hydrothermal origin, in a deposit in marble (Madoc, Canada); in a hydrothermal deposit in limestone, replacing pyrite and sphalerite, with other Pb–As–Sb sulfides (Novoye, Kyrgyzstan).

Association: Boulangerite, jamesonite, antimonian baumhauerite, zinkenite, semseyite, geocronite, robinsonite (Madoc, Canada); sphalerite, pyrite, galena, playfairite, twinnite, guettardite, baumhauerite, realgar, orpiment, cinnabar, fluorite, quartz (Novoye, Kyrgyzstan).

Distribution: In Canada, from near Madoc, Ontario [TL]. In the USA, from the Northern Belle and Lucky Strike mines, Candelaria district, Mineral Co., Nevada. From Novoye, Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan.

Name: To honor Henry Clifton Sorby (1826–1908), English chemist and the founder of metallography.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, 35802.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Ontario, Part 2, mineral descriptions. Can. Mineral., 9, 191–207. (2) (1968) Amer. Mineral., 53, 1425 (abs. ref. 1). (3) Mozgova, N.N., N.S. Bortnikov, Y.S. Borodaev, and A.I. Tzépine (1982) Sur la non-stoechiométrie des sulfosels antimonieux arséniques de plomb. Bull. Minéral., 105, 3–10 (in French with English abs.). (4) Jambor, J.L., J.H.G. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 93–100.

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Sørensenite **$Na_4SnBe_2Si_6O_{18}\cdot 2H_2O$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As lath-shaped to acicular crystals ‖ [010], branching or splitting from the base upwards, forming bladed fans and bowties, to 15 cm. *Twinning:* Complex, twin axis ⊥ [011] in {100}, uncommon.

Physical Properties: *Cleavage:* $\{10\bar{1}\}$ and {100}, distinct, $(10\bar{1}) \wedge (100) = 63°$. *Tenacity:* Brittle. Hardness = 5–5.5 VHN = 572–658, 616 average. D(meas.) = 2.9 D(calc.) = 2.92

Optical Properties: Transparent. *Color:* Colorless to pale pink, altering to milky white; in transmitted light, colorless; anomalous yellow-brown and blue interference colors. *Luster:* Silky. *Optical Class:* Biaxial (–). *Dispersion:* Strong, inclined. α = 1.576–1.579 β = 1.581–1.585 γ = 1.584–1.586 2V(meas.) = Small to 75°. 2V(calc.) = 76(5)°

Cell Data: *Space Group:* $C2/c$. a = 20.698(17) b = 7.442(5) c = 12.037(11) β = 117.28(6)° Z = 4

X-ray Powder Pattern: Nákâlâq, Greenland.
2.918 (100), 3.41 (85), 2.960 (85), 3.06 (75), 6.31 (60), 2.837 (50), 2.676 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	49.73	50.41	49.98
SnO_2	20.07	18.40	20.89
Fe_2O_3	0.04	trace	
Nb_2O_5	0.75	1.36	
BeO	8.02	7.43	6.94
Na_2O	15.95	17.21	17.19
K_2O	0.34	0.08	
H_2O	5.24	5.01	5.00
Total	100.14	99.90	100.00

(1) Nákâlâq, Greenland. (2) Kvanefjeld, Greenland. (3) $Na_4SnBe_2Si_6O_{18}\cdot 2H_2O$.

Occurrence: On the floor of miarolitic cavities in hydrothermal veins cutting coarse-grained nepheline syenites.

Association: Analcime, microcline, neptunite, sodalite, aegirine, arfvedsonite, beryllite, chkalovite, apatite, sphalerite.

Distribution: Found at Nákâlâq and Kvanefjeld, in the Ilímaussaq intrusion, southern Greenland.

Name: For Professor Henning Sørensen, Danish mineralogist and petrographer, University of Copenhagen, Copenhagen, Denmark.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1965.222; The Natural History Museum, London, England.

References: (1) Semenov, E.I., V.I. Gerasimovskii, N.V. Maksimova, S. Andersen, and O.V. Petersen (1965) Sorensenite [*sic*], a new sodium-beryllium-tin-silicate from the Ilímaussaq intrusion, South Greenland. Medd. Grønland, 181(1), 1–19. (2) (1966) Amer. Mineral., 51, 1547–1548 (abs. ref. 1). (3) Metcalf-Johansen, J. and R.G. Hazell (1976) The crystal structure of sorensenite, $Na_4SnBe_2(Si_3O_9)_2\cdot 2H_2O$. Acta Cryst., 32, 2553–2556.

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Sorosite $Cu(Sn, Sb)$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As hexagonal to anhedral inclusions in tin, to 0.4 mm.

Physical Properties: *Fracture:* Very brittle. Hardness = n.d. VHN = 381–498, 444 average (40–50 g load). D(meas.) = n.d. D(calc.) = 7.6

Optical Properties: Opaque. *Color:* Nearly white with pinkish tint in reflected light. *Anisotropism:* Distinct to moderate; brownish gray to bluish gray. *Bireflectance:* Weak to distinct.

R_1–R_2: (400) —, (420) —, (440) 62.9–70.5, (460) 64.2–72.0, (480) 65.3–73.8, (500) 66.4–75.2, (520) 67.2–76.3, (540) 67.9–77.1, (560) 68.4–77.9, (580) 68.8–78.3, (600) 69.0–78.7, (620) 69.0–78.9, (640) 69.0–79.0, (660) 69.1–79.0, (680) 69.1–79.0, (700) 69.1–79.1

Cell Data: *Space Group:* $P6_3/mmc$ (probable). $a = 4.217(4)$ $c = 5.120(6)$ $Z = 2$

X-ray Powder Pattern: Baimka placer, Russia.
2.970 (10), 2.094 (9), 2.112 (8), 1.487 (5), 1.218 (5), 1.212 (5), 1.333 (4)

Chemistry:

	(1)	(2)
Cu	35.33	35.99
Fe	1.18	trace
Sn	58.18	56.12
Sb	4.77	7.89
Total	99.46	[100.00]

(1) Baimka placer, Russia; by electron microprobe, average of nine analyses; corresponding to $(Cu_{1.00}Fe_{0.04})_{\Sigma=1.04}(Sn_{0.89}Sb_{0.07})_{\Sigma=0.96}$. (2) Rio Tamaná, Colombia; by electron microprobe, average of nine analyses, recalculated to 100% from an original total of 92.75%; corresponding to $Cu_{1.05}(Sn_{0.88}Sb_{0.12})_{\Sigma=1.00}$.

Occurrence: Very rare, in a gold-PGE placer probably derived from Alaskan-type complexes, formed under low-sulfur reducing conditions (Baimka placer, Russia); in concentrates from precious metal placers (Rio Tamaná, Colombia); in sediments (Mid-Atlantic Ridge).

Association: Tin, stistaite, herzenbergite, cassiterite, lead (Baimka placer, Russia); tin, stistaite (Rio Tamaná, Colombia).

Distribution: From the Baimka gold-PGE placer deposit, in the Bol'shoy Anyuy River area, western Chukotka, Russian Far East, Russia [TL]. In the Rio Tamaná, the Department of Chocó, Cauca, Colombia. From the Mir zone, Mid-Atlantic Ridge (26°N).

Name: To honor George Soros (1930–), American financier, for his support of science in the former Russian republics.

Type Material: St. Petersburg Mining University, St. Petersburg, Russia, 2083/1.

References: (1) Barkov, A.Y., Laajoki, K.V.O., S.S. Gornostayev, Y.A. Pakhomoovskii, and Y.P. Men'shikov (1998) Sorosite, Cu(Sn, Sb), a new mineral from the Baimka placer deposit, western Chukotka, Russian Far East. Amer. Mineral., 83, 901–906. (2) Rose, D. (1981) New data for stistaite and antimony-bearing ??ν–Cu_6Sn_5 from Rio Tamaná, Colombia. Neues Jahrb. Mineral., Monatsh., 117–126.

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Sosedkoite $(K, Na)_5Al_2(Ta, Nb)_{22}O_{60}$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As acicular, slightly elongated crystals, to 0.1 mm, included in microlite and cesstibtantite.

Physical Properties: Hardness = n.d. VHN = 800–860 (20 g load). D(meas.) = n.d. D(calc.) = 6.90 Faint blue cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Adamantine.
Optical Class: Biaxial; strong birefringence. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.
Anisotropism: Strong.
R_1–R_2: (486) 13.5–12.8, (551) 12.8–12.0, (589) 13.3–12.3, (656) 11.3–11.3

Cell Data: *Space Group:* n.d. $a = 17.25(3)$ $b = 17.73(3)$ $c = 3.95(2)$ $Z = 1$

X-ray Powder Pattern: Mt. Vasin-Myl'k, Russia.
3.95 (10), 3.03 (9), 1.974 (6), 6.1 (5), 3.47 (5), 2.79 (5), 2.376 (5)

Chemistry:

	(1)
Nb_2O_5	2.71
Ta_2O_5	91.25
Sb_2O_5	0.47
Al_2O_3	1.96
CaO	0.10
Na_2O	1.15
K_2O	2.79
Li_2O	< 0.1
Total	100.43

(1) Mt. Vasin-Myl'k, Russia; by electron microprobe, Li estimated by AA; corresponds to $(K_{3.06}Na_{1.85}Ca_{0.09})_{\Sigma=5.00}Al_{1.92}(Ta_{20.65}Nb_{1.03}Sb_{0.14})_{\Sigma=21.82}O_{60}$.

Occurrence: In a granite pegmatite.

Association: Microlite, simpsonite, cesstibtantite, stibiotantalite, alumotantite, natrotantite.

Distribution: From Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia.

Name: Honors Aleksandr Federovich Sosedko (1901–1957), Russian mineralogist, Institute of Geological Sciences, Academy of Sciences, Moscow, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5518; Mining Museum, St. Petersburg, 2099/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Voloshin, A.V., Y.P. Men'shikov, and Y.A. Pakhomovskii (1982) Sosedkoite, $(K, Na)_5Al_2(Ta, Nb, Sb)_{22}O_{60}$ – a new mineral from granite pegmatite. Doklady Acad. Nauk SSSR, 264, 442–445 (in Russian). (2) (1983) Amer. Mineral., 68, 644 (abs. ref. 1).

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Součekite $PbCuBi(S,Se)_3$

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Crystal Data: Orthorhombic, probable. *Point Group:* [$mm2$] (by analogy to bournonite). As anhedral grains, to 0.01 mm, typically filling interstices between lath-shaped crystals of poubaite; also in veinlets. *Twinning:* Very fine polysynthetic.

Physical Properties: Hardness = n.d. VHN = 166–188, 179 average (25 g load). D(meas.) = n.d. D(calc.) = 7.60

Optical Properties: Opaque. *Color:* Lead-gray; in polished section, creamy with a brownish tint. *Luster:* Metallic. *Pleochroism:* Distinct in oil, in creamy brown to pale gray with a bluish tint. *Anisotropism:* Medium strong; pale brown to dark blue-gray.
R_1–R_2: (400) —, (420) 44.3–48.2, (440) 44.2–47.9, (460) 44.1–47.5, (480) 43.7–47.1, (500) 43.9–47.1, (520) 43.8–47.2, (540) 43.7–47.2, (560) 43.6–47.3, (580) 43.5–47.3, (600) 43.5–47.4, (620) 43.5–47.5, (640) 43.4–47.6, (660) 43.6–47.7, (680) 43.4–47.4, (700) 43.4–47.7

Cell Data: *Space Group:* [$Pn2_1m$] (by analogy to bournonite). $a = 8.153(3)$ $b = 8.498(4)$ $c = 8.080(3)$ Z = 4

X-ray Powder Pattern: Oldřichov, Czech Republic.
2.757 (100), 2.717 (100), 4.040 (80), 4.249 (60), 2.019 (60), 3.774 (50), 1.833 (50)

Chemistry:

	(1)	(2)	(3)
Pb	33.86	32.68	31.74
Cu	9.76	9.93	9.97
Bi	31.71	32.41	33.32
Se	14.55	14.55	16.30
Te	0.79	0.51	1.05
S	8.83	9.25	7.83
Total	99.50	99.33	100.21

(1) Oldřichov, Czech Republic; by electron microprobe, corresponds to $Pb_{1.05}Cu_{0.99}Bi_{0.97}(S_{1.77}Se_{1.19}Te_{0.04})_{\Sigma=3.00}$. (2) Do.; by electron microprobe; corresponds to $Pb_{0.99}Cu_{0.98}Bi_{0.98}(S_{1.82}Se_{1.16}Te_{0.02})_{\Sigma=3.00}$. (3) Otish Mountains deposit, Canada; by electron microprobe, average of seven analyses; corresponds to $Pb_{1.00}Cu_{1.03}Bi_{1.04}(S_{1.60}Se_{1.35}Te_{0.05})_{\Sigma=3.00}$.

Occurrence: In hydrothermal quartz-carbonate veins (Oldřichov, Czech Republic); in a vein-type uranium deposit with other tellurides and selenides (Otish Mountains deposit, Canada).

Association: Poubaite, galena, clausthalite, selenian–sulfurian rucklidgeite, uraninite (Oldřichov, Czech Republic); watkinsonite, poubaite, wittichenite (Otish Mountains deposit, Canada).

Distribution: From Oldřichov, near Tachov, Czech Republic [TL]. At the Beregove and Muzhieve deposits, Ukraine. In the Otish Mountains uranium deposit, Quebec, Canada.

Name: In honor of Frantisek Souček (1911–1989), Department of Mineralogy, Charles University, Prague, Czech Republic, and a devoted mineral collector.

Type Material: Charles University, Prague, Czech Republic, 21241; National School of Mines, Paris, France.

References: (1) Čech, F. and I. Vavřín (1979) Součekte, $CuPbBi(S,Se)_3$, a new mineral of the bournonite group. Neues Jahrb. Mineral., Monatsh., 289–295. (2) (1980) Amer. Mineral., 65, 209 (abs. ref. 1). (3) Johan, Z., P. Picot, and F. Ruhlmann (1987) The ore mineralogy of the Otish Mountains uranium deposit, Quebec: skippenite, Bi_2Se_2Te, and watkinsonite, $Cu_2PbBi_4(Se,S)_8$, two new mineral species. Can. Mineral., 25, 625–638.

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Souzalite $(Mg,Fe^{2+})_3(Al,Fe^{3+})_4(PO_4)_4(OH)_6 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals are bladed, to 1 cm, in aggregates; as coarse fibrous masses. *Twinning:* Commonly exhibits polysynthetic twinning, with twin axis [010] and composition plane {001}.

Physical Properties: *Cleavage:* On {001}, good; a second ⊥ {001}, poor. Hardness = 5.5–6 D(meas.) = 3.087 D(calc.) = 3.07

Optical Properties: Semitransparent. *Color:* Green, blue-green, emerald-green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = green to colorless; Y = blue; Z = colorless to yellow. *Orientation:* $X \perp$ a cleavage; Z = elongation. *Dispersion:* $r > v$, extreme. $\alpha = 1.617$–1.618 $\beta = 1.642$ $\gamma = 1.652$–1.653 2V(meas.) = n.d. 2V(calc.) = 66°–68°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 11.74(1)$ $b = 5.11(1)$ $c = 13.58(1)$ $\alpha = 90°55(5)'$ $\beta = 99°05(5)'$ $\gamma = 90°20(5)'$ Z = 2

X-ray Powder Pattern: Corrego Frio mine, Brazil.
3.386 (100), 2.553 (90d), 2.921 (80d), 4.760 (60), 3.152 (60), 3.06 (40), 6.72 (30)

Chemistry:

	(1)
P_2O_5	37.70
TiO_2	0.07
Al_2O_3	26.07
Fe_2O_3	2.65
FeO	11.49
MnO	0.31
SnO	0.04
MgO	9.62
CaO	0.02
H_2O^+	12.04
Total	100.01

(1) Corrego Frio mine, Brazil; corresponding to $(Mg_{1.78}Fe^{2+}_{1.19}Mn_{0.03})_{\Sigma=3.00}(Al_{3.82}Fe^{3+}_{0.25})_{\Sigma=4.07}(PO_4)_{3.96}(OH)_{6.33} \cdot 1.82H_2O$.

Polymorphism & Series: Forms a series with gormanite.

Occurrence: A rare hydrothermal alteration product of scorzalite in complex zoned granite pegmatites, in sedimentary phosphate nodules, and in a high-pressure kyanite deposit.

Association: Scorzalite.

Distribution: From the Corrego Frio pegmatite mine, Divino das Laranjeiras, near Linópolis, Minas Gerais, Brazil. Along Rapid Creek, Yukon Territory, Canada. In the Bell Pit, Newry, Oxford Co., Maine, USA.

Name: To honor Dr. Antonio José Alves de Souza (1896–1961), Director, Mineral Survey of Brazil, Rio de Janeiro, Brazil.

Type Material: Royal Ontario Museum, Toronto, Canada, M34010; Harvard University, Cambridge, Massachusetts, 100680; National Museum of Natural History, Washington, D.C., USA, C5863, 159981, 160114.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 911–912. (2) Moore, P.B. (1970) Crystal chemistry of the basic iron phosphates. Amer. Mineral., 55, 135–169. (3) Sturman, B.D., J.A. Mandarino, M.E. Mrose, and P.J. Dunn (1981) Gormanite, $Fe^{2+}_3Al_4(PO_4)_4(OH)_6 \cdot 2H_2O$, the ferrous analogue of souzalite, and new data for souzalite. Can. Mineral., 19, 381–387.

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Spadaite $MgSiO_2(OH)_2 \cdot H_2O(?)$

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Crystal Data: n.d. *Point Group:* n.d. As dense porcelaneous or felted shreddy masses.

Physical Properties: *Fracture:* Conchoidal or splintery, imperfect, interrupted.
Hardness = 2.5 D(meas.) = ~2.2 D(calc.) = n.d.

Optical Properties: Translucent. *Color:* Cream or pink; colorless in thin section.
Luster: Pearly or greasy.
Optical Class: Biaxial (+). $\alpha = 1.521(3)$ $\beta = 1.525(3)$ $\gamma = 1.545(3)$ 2V(meas.) = Small to medium.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
SiO_2	56.00	53.96	44.04
Al_2O_3	0.66		
FeO	0.66	0.35	
MgO	30.67	32.08	29.55
H_2O	11.34	[13.64]	26.41
Total	99.33	[100.03]	100.00

(1) Capo di Bove, Italy; material probably dried at 100° before analysis thereby driving off some H_2O. (2) Gold Hill, Utah, USA; recalculated to the same total after insoluble impurities (taken as diopside, garnet, and wollastonite) 12.58% and H_2O^- 10.36% deducted from original total of 100.03%. (3) $MgSiO_2(OH)_2 \cdot H_2O$.

Occurrence: In leucite-bearing lava (Capo di Bove, Italy); in amygdular diabase (Sasbach, Germany); replacing tactite minerals near gold ore shoots (Gold Hill, Utah, USA).

Association: Wollastonite, diopside, garnet.

Distribution: At Capo di Bove, near Rome, Lazio, Italy. At Sasbach, Baden-Württemberg, Germany. In the Cane Springs, Alvarado, and Midas mines, near Gold Hill, Tooele Co., Utah, and in the Livingston quarry, Palos Verdes Hills, Los Angeles Co., California, USA.

Name: For Lavino Spada de Medici (1801–1863), Italian political figure interested in mineralogy.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 682. (2) Schaller, W.T. and T.B. Nolan (1931) An occurrence of spadaite at Gold Hill, Utah. Amer. Mineral., 16, 231–236.

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Spangolite $Cu_6Al(SO_4)Cl(OH)_{12}\cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Crystals equant, flattened, or elongated along [0001], to 2 cm, with prominent $\{000\overline{1}\}$, equally developed $\{10\overline{1}0\}$, $\{01\overline{1}0\}$, $\{10\overline{1}1\}$, $\{01\overline{1}1\}$, deeply striated parallel $\{0001\}$, with additional $\{h0\overline{h}l\}$ forms, small $\{0001\}$, in parallel aggregates; may exhibit hemimorphic pyramidal development; cleavable massive. *Twinning:* On $\{0001\}$, the acute forms about opposite antilogous poles joined to give an hourglasslike shape.

Physical Properties: *Cleavage:* On $\{0001\}$, perfect; distinct on $\{10\overline{1}1\}$, $\{01\overline{1}1\}$. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2 on $\{0001\}$, 3 on inclined faces. D(meas.) = 3.135–3.141 D(calc.) = 3.14 Pyroelectric.

Optical Properties: Transparent. *Color:* Dark green, emerald-green, bluish green; pale green in transmitted light. *Streak:* Pale green. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* Weak; O = green; E = bluish green. ω = 1.680–1.687 ϵ = 1.627–1.641

Cell Data: *Space Group:* $P31c$. a = 8.245–8.278 c = 14.32–14.54 Z = 2

X-ray Powder Pattern: Tintic district, Utah, USA. 7.07 (10), 3.59 (8), 2.54 (7), 1.80 (7), 1.98 (6), 2.36 (5), 2.66 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	10.11	10.03	H_2O	20.41	20.32
Al_2O_3	6.60	6.39	$-O=Cl_2$	0.92	1.00
CuO	59.51	59.82	Total	99.82	100.00
Cl	4.11	4.44			

(1) Region of Tombstone, Arizona, USA; average of four analyses, three partial; corresponds to $Cu_{5.97}Al_{1.04}(SO_4)_{1.00}Cl_{0.92}(OH)_{12.14}\cdot 2.97H_2O$. (2) $Cu_6Al(SO_4)Cl(OH)_{12}\cdot 3H_2O$.

Occurrence: A rare secondary mineral in the oxidization zone of hydrothermal copper deposits.

Association: Cuprite, connellite, brochantite, chalcophyllite, cyanotrichite, linarite, caledonite, clinoclase, azurite, malachite, aurichalcite, chrysocolla.

Distribution: Found in many localities in minor amounts. In the USA, in Arizona, the original specimen found "within a radius of 200 miles of Tombstone" [almost certainly from Bisbee]; large crystals in the Copper Queen, Czar, and Southwest mines, Bisbee; in the Maid of Sunshine mine, Courtland, Turquoise district, Cochise Co.; at Metcalf, Clifton-Morenci district, Greenlee Co.; from the Mex-Tex, Blanchard, and Portales mines, near Bingham, Hansonburg district, Socorro Co., and elsewhere in New Mexico; at the Grand Central mine, Tintic district, Juab Co., Utah; in the Majuba Hill mine, Antelope district, Pershing Co., and elsewhere in Nevada. From Wheal Gorland, Gwennap, and the West Caradon mine, St. Cleer, Cornwall, England. At Trébas, Tarn, and Fontana Rossa, Corsica, France. From the Arenas mine, south of Iglesias, Sardinia, Italy. In the Kamariza mine, Laurium, Greece. From Brixlegg, Tirol, Austria. At the Kabasaka and Nyukaku mines, Kyogo Prefecture, Japan. Additional localities are known.

Name: Honors Norman Spang (1842–1922), Etna, Pennsylvania, USA, American mineral collector, who provided the original specimen.

Type Material: The Natural History Museum, London, England, 74198; Yale University, New Haven, Connecticut, 3.3482; National Museum of Natural History, Washington, D.C., USA, 83512.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 556–558. (2) Merlino, S., M. Pasero, C. Sabelli, R. Trosti-Ferroni (1992) Crystal structure refinements of spangolite, a hydrated basic sulphate of copper and aluminum, from three different occurrences. Neues Jahrb. Mineral., Monatsh., 349–357. (3) Hawthorne, F.C., M. Kimata, and R.K. Erby (1993) The crystal structure of spangolite, a complex copper sulfate sheet mineral. Amer. Mineral., 78, 649–652. (4) Frondel, C. (1949) Crystallography of spangolite. Amer. Mineral., 34, 181–187.

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Spencerite $Zn_4(PO_4)_2(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals elongated along [001], tabular on {100}, bluntly terminated or lancelike, with many other forms, to 2 cm. Typically with a columnar to platy structure, stalactitic, massive. *Twinning:* Polysynthetic, twin plane and composition plane {100}.

Physical Properties: *Cleavage:* On {100}, perfect; on {010}, good; on {001}, distinct. Hardness = ∼3 D(meas.) = 3.123–3.145 D(calc.) = 3.282

Optical Properties: Transparent to translucent. *Color:* White, pale green; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \simeq a$. *Dispersion:* $r > v$, moderate.
$\alpha = 1.586$ $\beta = 1.602$ $\gamma = 1.606$ 2V(meas.) = 49°

Cell Data: *Space Group:* $P2/c$. $a = 10.448(3)$ $b = 5.282(1)$ $c = 11.208(3)$ $\beta = 116°44(2)'$ Z = 2

X-ray Powder Pattern: Hudson Bay mine, Canada. (ICDD 35-631).
9.34 (100), 3.491 (50), 2.3292 (25), 4.590 (19), 3.861 (7), 3.4211 (6), 3.1055 (6)

Chemistry:

	(1)	(2)
P_2O_5	26.13	26.31
ZnO	60.39	60.34
H_2O	13.44	13.35
Total	99.96	100.00

(1) Hudson Bay mine, Canada. (2) $Zn_4(PO_4)_2(OH)_2 \cdot 3H_2O$.

Occurrence: A rare secondary mineral in some zinc-bearing hydrothermal deposits.

Association: Hemimorphite, hopeite, smithsonite, cerussite.

Distribution: Found in the Hudson Bay mine, about eight km southeast of Salmo, near Nelson, Kootenay district, British Columbia, Canada. At Kabwe (Broken Hill), Zambia. In the Turf Pits mine, Grassington Moor, Yorkshire, England.

Name: To honor Leonard James Spencer (1870–1959), British mineralogist, formerly Keeper of Minerals, British Museum (Natural History), London, England.

Type Material: Royal Ontario Museum, Toronto, Canada, M9602, M9610, M9691, M9726; The Natural History Museum, London, England; Natural History Museum, Paris, France, 120.22; Harvard University, Cambridge, Massachusetts, 98956; National Museum of Natural History, Washington, D.C., USA, 121566.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 931–933. (2) Fanfani, L., A. Nunzi, and P.F. Zanazzi (1972) Structure and twinning in spencerite. Mineral. Mag., 38, 687–692.

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Sperrylite $PtAs_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Commonly well crystallized as cubes and cubo-octahedrons, to 5 cm; may be highly modified with rounded edges and corners; as intergrowths with Pt–Fe alloys.

Physical Properties: *Cleavage:* Indistinct on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6–7 VHN = 960–1277 ⊥ (100); 960–1277 ⊥ (111) (100 g load). D(meas.) = 10.58 D(calc.) = 10.78

Optical Properties: Opaque. *Color:* Tin-white. *Streak:* Black. *Luster:* Metallic. R: (400) 53.6, (420) 53.6, (440) 53.9, (460) 53.9, (480) 53.9, (500) 53.9, (520) 54.0, (540) 53.9, (560) 53.8, (580) 53.7, (600) 53.5, (620) 53.1, (640) 52.7, (660) 52.3, (680) 51.9, (700) 51.4

Cell Data: *Space Group: Pa*3. $a = 5.967$ $Z = 4$

X-ray Powder Pattern: Vermilion mine, Sudbury, Canada.
1.801 (100), 0.777 (90), 1.148 (70), 2.98 (60), 0.798 (60), 2.11 (50), 3.43 (40)

Chemistry:

	(1)	(2)		(1)	(2)
Pt	56.8	56.56	As	42.8	43.44
Sb	0.08		Total	99.68	100.00

(1) Vermilion mine, Sudbury, Canada; by electron microprobe, corresponding to $Pt_{1.01}As_{1.96}$.
(2) $PtAs_2$.

Mineral Group: Pyrite group.

Occurrence: The most widespread platinum mineral, occurring in every type of deposit.

Association: Pyrrhotite, pentlandite, chalcopyrite, violarite, cubanite, bornite, sphalerite, galena, linnaeite, magnetite, testibiopalladite, sudburyite, omeiite, gold, argentian gold (Danba, China); leadamalgam, chromite, ilmenite, magnetite, gersdorffite, pyrite, chalcopyrite, violarite, millerite, galena, stibnite, argentian gold, niggliite, iridosmine, platinum, merenskyite, kotulskite (Shiaonanshan, China); also cooperite, laurite.

Distribution: In Canada, at the Vermilion [TL], Victoria, and Frood mines, Algoma district, near Sudbury, Ontario. In the USA, at the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming; in the Key West mine, east of Moapa, Bunkerville district, Clark Co., Nevada; and from the Stillwater complex, Montana. In the Bushveld complex, on the Merensky reef, Transvaal, South Africa, fine crystals from the Tweefontein Farm, near Potgietersrus; also at the Atok, Onverwacht, and Rustenburg mines. From Antamponbato, Madagascar. In China, from Danba, Sichuan Province; and Shiaonanshan, Inner Mongolia. In Australia, at several deposits east of Broken Hill, New South Wales, and at Kambalda, 56 km south of Kalgoorlie, Western Australia. In Russia, large crystals from the Talnakh area, Noril'sk region, and at Nikolaevsky, Amur, Siberia; in the Konder massif, Aldan Shield, Sakha; and elsewhere. In Finland, at Rometölväs Hill, in the Koillismaa complex; from the Hitura Cu–Ni deposit; and in the Siikakama intrusion.

Name: Honors Francis Lewis Sperry (1861–1906), chemist of Sudbury, Ontario, Canada, who first found the mineral.

Type Material: Royal Ontario Museum, Toronto, Canada; Yale University, New Haven, Connecticut, USA, 1.2950, 1.5895.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 292–293. (2) Szymański, J.T. (1979) The crystal structure of plararsite, Pt(As, S), and a comparison with sperrylite, $PtAs_2$. Can. Mineral., 17, 117–123. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 89. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 136–138. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 809–811. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 521.

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Spertiniite $Cu(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Flat tabular to lathlike crystals, to 10 μm, in radial and botryoidal aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = Soft. D(meas.) = 3.93(2) D(calc.) = 3.94 Synthetic material decomposes in hot H_2O.

Optical Properties: Transparent. *Color:* Blue to blue-green. *Luster:* Vitreous. *Optical Class:* Biaxial. *Pleochroism:* Strong; X = colorless; Z = dark blue. *Orientation:* Extinction parallel; elongation positive. $\alpha = 1.720(2)$ β = n.d. $\gamma = > 1.800(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Cmc2_1$. $a = 2.951(1)$ $b = 10.592(3)$ $c = 5.257(3)$ Z = 4

X-ray Powder Pattern: Jeffrey mine, Canada.
2.63 (100), 3.73 (90), 5.29 (80), 2.266 (70), 1.718 (70), 2.50 (60), 2.361 (50)

Chemistry:

	(1)	(2)
Cu	66.9	65.14
Cl	0.1	
OH		34.86
Total		100.00

(1) Jeffrey mine, Canada; by electron microprobe. (2) $Cu(OH)_2$.

Occurrence: A very rare mineral, altering from chalcocite in alkaline groundwater, in a rodingite dike near the contact with a serpentinized dunite (Jeffrey mine, Quebec, Canada).

Association: Chalcocite, atacamite, copper, diopside, grossular, vesuvianite (Jeffrey mine, Quebec, Canada).

Distribution: In Canada, in Quebec, from the Jeffrey mine, Asbestos, and at Mont Saint-Hilaire. In the USA, at Ely, White Pine Co., Nevada, and from Bisbee, Cochise Co., Arizona. At Dzhezkazgan, Kazakhstan. In Germany, from Juliüshutte, Astfeld, Harz Mountains, in slag. At Tsumeb, Namibia.

Name: Honors Francesco Spertini (1937–), Chief Geologist, Jeffrey mine, Asbestos, Canada, who submitted the first sample.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 44696–44699; Harvard University, Cambridge, Massachusetts, USA, 126504.

References: (1) Grice, J.D. and E. Gasparrini (1981) Spertiniite, $Cu(OH)_2$, a new mineral from the Jeffrey mine, Quebec. Can. Mineral., 19, 337–340. (2) (1982) Amer. Mineral., 67, 860 (abs. ref. 1). (3) Oswald, H.R., A. Reller, H.W. Schmalle, and E. Dubler (1990) Structure of copper(II) hydroxide, $Cu(OH)_2$. Acta Cryst., C46, 2279–2284.

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Spessartine $Mn_3^{2+}Al_2(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Commonly as euhedral crystals, dodecahedra or trapezohedra, or in combination with other cubic forms, to 10 cm. Fine or coarse granular, compact, massive.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 7–7.5 D(meas.) = 4.190 D(calc.) = 4.179

Optical Properties: Transparent to translucent. *Color:* Red, reddish orange, yellow, yellowish brown, reddish brown, brown, black; pale pink to pale brown in thin section, may be sectored. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic; may show weak anisotropism. *Dispersion:* Weak. $n = 1.800$

Cell Data: *Space Group: Ia3d.* a = 11.621 Z = 8

X-ray Powder Pattern: Synthetic.
2.60 (100), 1.557 (40), 1.614 (30), 2.91 (25), 1.886 (20), 1.681 (20), 2.37 (16)

Chemistry:

	(1)	(2)
SiO_2	35.33	36.41
TiO_2	trace	
Al_2O_3	21.50	20.60
FeO	trace	
MnO	41.06	42.99
MgO	trace	
CaO	1.02	
H_2O	0.86	
Total	99.77	100.00

(1) Kinko mine, Yamaguchi Prefecture, Japan; corresponds to $(Mn_{2.82}Ca_{0.09})_{\Sigma=2.91}$ $Al_{1.92}(Si_{2.86}Al_{0.14})_{\Sigma=3.00}O_{12}$. (2) $Mn_3Al_2(SiO_4)_3$.

Polymorphism & Series: Forms a series with almandine.

Mineral Group: Garnet group.

Occurrence: Common in granite pegmatites, granites, and rhyolites. Formed in some skarns and metasomatic manganese-rich rocks adjacent to igneous intrusions or in regionally metasomatized areas.

Association: Quartz, potassic feldspar, tourmaline, rhodonite, pyroxmangite, tephroite, alleghanyite, galaxite, muscovite, topaz, apatite, beryl, albite, bixbyite, pseudobrookite.

Distribution: While a less-common garnet, nevertheless many localities. From Aschaffenburg, Spessart Mountains, Bavaria, Germany. On Seriphos, Cyclades Islands, Greece. In the USA, in Leiper's quarry, Avondale, Delaware Co., Pennsylvania; the Rutherford mine, Amelia, Amelia Co., Virginia; in the Ramona and Pala districts, San Diego Co., California; from the Thomas Range, Juab Co., Utah; at Ely, White Pine Co., Nevada; from near Nathrop, Chaffee Co., Colorado. In Brazil, from Nangue and Urucum, Minas Gerais, and at Carnaúba, near Picui, Rio Grande do Norte. From Marienflüss, Namibia. At Tsilaizina and Anjanabonoina, Madagascar. In the Gilgit district, and at Dusso, Baltistan, Pakistan. From Broken Hill, New South Wales, Australia. At Wada-toge Pass, Nagano Prefecture, Japan.

Name: For the locality near Spessart, Germany.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 437–447. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 468–698, esp. 590–602. (3) Yoder, H.S. and M.L. Keith (1951) Complete substitution of aluminum for silicon: the system $3MnO \cdot Al_2O_3 \cdot 3SiO_2$ – $3Y_2O_3 \cdot 5Al_2O_3$. Amer. Mineral., 36, 519–533. (4) Novak, G.A. and G.V Gibbs (1971) The crystal chemistry of the silicate garnets. Amer. Mineral., 56, 791–825.

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Sphaerobismoite Bi_2O_3

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Crystal Data: Tetragonal. *Point Group:* n.d. Crystals tabular, to 20 μm, may show a tetragonal outline, in spherulitic aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4 D(meas.) = n.d. D(calc.) = 7.17

Optical Properties: Semitransparent. *Color:* Green, pale yellow, or gray. *Streak:* White. *Luster:* Adamantine to dull.
Optical Class: Uniaxial (+). $\omega = 2.13(2)$ $\epsilon = 2.18(2)$

Cell Data: *Space Group:* n.d. $a = 8.08(2)$ $c = 6.46(2)$ $Z = 4$

X-ray Powder Pattern: Black Forest, Germany.
3.16 (100), 5.73 (70), 1.902 (60), 3.44 (50), 2.02 (50)

Chemistry:

	(1)
Bi_2O_3	98.40
As_2O_3	1.78
Total	100.18

(1) Black Forest, Germany; by electron microprobe, corresponding to $(Bi_{1.92}As_{0.08})_{\Sigma=2.00}O_3$.

Polymorphism & Series: Dimorphous with bismite.

Occurrence: An oxidation product of wittichenite and emplectite.

Association: Bismutite, mixite, malachite, barite, quartz, "limonite".

Distribution: From Neubulach, and at Schmiedestollen-Holde, near Wittichen, Black Forest, Germany.

Name: In allusion to the spherical aggregates, and *bismuth* in its composition.

Type Material: n.d.

References: (1) Walenta, K. (1995) Sphaerobismoite, a new mineral of the composition Bi_2O_3 from the Black Forest. Aufschluss, 46, 245–248 (in German). (2) (1996) Amer. Mineral., 81, 1514–1515 (abs. ref. 1).

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Sphalerite (Zn, Fe)S

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals tetrahedral, dodecahedral, typically complex and distorted, curved and conical faces common, to 30 cm. Also fibrous, botryoidal, stalactitic, cleavable, coarse to fine granular, massive. *Twinning:* Twin axis [111], twin plane {111}, simple contact twins or complex lamellar forms.

Physical Properties: *Cleavage:* Perfect on {011}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 VHN = 208–224 (100 g load). D(meas.) = 3.9–4.1 D(calc.) = 4.096 Pyroelectric, may be triboluminescent, fluorescent.

Optical Properties: Transparent to translucent, opaque when iron-rich. *Color:* Highly variable, ranging from colorless to dark brown, gray, black, commonly brown, yellow, red, green. *Streak:* Pale brown to pale yellow and white. *Luster:* Resinous to adamantine.
Optical Class: Isotropic. $n = 2.369$ (Na) (ZnS). *Anisotropism:* May show strain-induced birefringence.
R: (400) 19.6, (420) 19.0, (440) 18.3, (460) 17.9, (480) 17.5, (500) 17.2, (520) 16.9, (540) 16.7, (560) 16.5, (580) 16.4, (600) 16.3, (620) 16.2, (640) 16.1, (660) 16.0, (680) 15.9, (700) 15.8

Cell Data: *Space Group:* $F\bar{4}3m$. a = 5.4060 Z = 4

X-ray Powder Pattern: Synthetic ZnS.
3.123 (100), 1.912 (51), 1.561 (30), 2.705 (10), 1.240 (9), 1.1034 (9), 1.351 (6)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Zn	66.98	44.67	67.10	Mn		2.66	
Fe	0.15	18.25		S	32.78	33.57	32.90
Cd		0.28		Total	99.91	99.43	100.00

(1) Sonora, Mexico; corresponds to $Zn_{1.00}S_{1.00}$. (2) St. Christoph mine, Isère, France; corresponds to $(Zn_{0.65}Fe_{0.31}Mn_{0.05})_{\Sigma=1.01}S_{1.00}$. (3) ZnS.

Polymorphism & Series: Trimorphous with matraite and wurtzite.

Mineral Group: Sphalerite group.

Occurrence: Formed under a wide range of low- to high-temperature hydrothermal conditions; in coal, limestone, and other sedimentary deposits.

Association: Galena, chalcopyrite, marcasite, pyrite, fluorite, barite, quartz, many other hydrothermal minerals.

Distribution: The most important ore of zinc. Only a few localities for the finest crystallized examples can be given. In Germany, from Freiberg, Saxony, and Neudorf, Harz Mountains. Colorless crystals in the Lengenbach quarry, Binntal, Valais, Switzerland. At Horní Slavkov (Schlaggenwald) and Příbram, Czech Republic. From Rodna, Romania. Transparent crystals in the Aliva mine, Picos de Europa Mountains, Cantabria [Santander] Province, Spain. In England, from Alston Moor, Cumbria. At Dal'negorsk, Primorskiy Kray, Russia. From Watson Lake, Yukon Territory, Canada. In the USA, in the Tri-State district of the Mississippi Valley; near Baxter Springs, Cherokee Co., Kansas; Joplin, Jasper Co., Missouri and Picher, Ottawa Co., Oklahoma. From the Elmwood mine, near Carthage, Smith Co., Tennessee; in the Eagle mine, Gilman district, Eagle Co., Colorado. In Mexico, from Santa Eulalia and Naica, Chihuahua, and Cananea, Sonora. At Huaron, Casapalca, and Huancavelica, Peru.

Name: From the Greek for *treacherous*, the mineral sometimes being mistaken for galena, but yielding no lead.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 210–215. (??) Ewald, ?? (1916) ??title?? Ann. Phys.,??, 257–??. str?? or (1980) Acta Cryst., A36, 482 ?? (2) (1953) NBS Circ. 539, 2, 16. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 523.

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Spheniscidite $(NH_4,K)(Fe^{3+},Al)_2(PO_4)_2(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rimming soil particles and in fine grained aggregates, in the 75–2000 μm size range.

Physical Properties: Hardness = Very soft. D(meas.) = n.d. D(calc.) = [3.08] Magnetic.

Optical Properties: Translucent. *Color:* Colorless, brownish. *Luster:* Dull, earthy. *Optical Class:* Biaxial; moderate birefringence. $n = \sim 1.7$

Cell Data: *Space Group:* $[P2_1/n]$ (by analogy to leucophosphite). $a = 9.75(1)$ $b = 9.63(2)$ $c = 9.70(1)$ $\beta = 102°34(7)'$ Z = 4

X-ray Powder Pattern: Elephant Island.
6.79 (100), 5.99 (90), 3.053 (45), 7.62 (40), 4.75 (35), 4.26 (35), 3.358 (35)

Chemistry:

	(1)
P_2O_5	32.42
Al_2O_3	9.33
Fe_2O_3	30.10
MgO	0.30
CaO	0.50
K_2O	4.45
$(NH_4)_2O$	3.27
H_2O^+	13.79
H_2O^-	5.84
Total	[100.00]

(1) Elephant Island; by X-ray fluorescence, presence of NH_4 confirmed by IR, recalculated after deduction of SiO_2 9.93%, TiO_2 0.91%, with $(OH)^{1-}$ calculated for charge balance; then corresponding to $[(NH_4)_{0.55}K_{0.41}Ca_{0.04}Mg_{0.03}]_{\Sigma=1.03}(Fe^{3+}_{1.65}Al_{0.80})_{\Sigma=2.45}(PO4)_{2.00}(OH)_{2.45}\cdot 2.12H_2O$.

Occurrence: Formed by interaction of phosphate solutions derived from guano with micaceous and chloritic minerals in soil under a penguin rookery.

Association: Micas, chlorites.

Distribution: On Elephant Island, South Shetland Islands, about 800 km southeast of Cape Horn, British Antarctic Territory, Antarctica.

Name: For *Sphenisciformes*, the Latin order name for penguins.

Type Material: Macaulay Institute for Soil Research, Aberdeen, Scotland; The Natural History Museum, London, England.

References: (1) Wilson, M.J. and D.C. Bain (1986) Spheniscidite, a new phosphate mineral from Elephant Island, British Antarctic Territory. Mineral. Mag., 50, 291–293. (2) (1987) Amer. Mineral., 72, 1027 (abs. ref. 1).

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Sphaerocobaltite $CoCO_3$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals uncommon, rhombohedral $\{10\overline{1}1\}$, flat discoidal {0001}, modified by $\{10\overline{1}0\}$, to 5 mm; commonly compact radiated, concentric, spherical, massive, and in crusts. *Twinning:* Observed.

Physical Properties: *Cleavage:* [On $\{10\overline{1}1\}$] (by analogy to the calcite group). Hardness = 4 D(meas.) = 4.13 D(calc.) = 4.214

Optical Properties: Translucent. *Color:* Deep rose-red, red, may be surficially altered to gray, brown, or velvet-black. *Streak:* Peach-blossom-red. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = red-violet; E = rose-red. $\omega = 1.855(5)$ $\epsilon = 1.60(1)$

Cell Data: *Space Group:* $R\overline{3}c$. $a = 4.659$ $c = 14.957$ Z = 6

X-ray Powder Pattern: Synthetic.
2.743 (100), 3.551 (40), 1.702 (30), 1.697 (25), 2.330 (20), 2.112 (20), 1.948 (20)

Chemistry:

	(1)	(2)
CO_2	36.36	37.00
CoO	61.75	63.00
CaO	1.89	
Total	[100.00]	100.00

(1) Schneeberg, Germany; recalculated to 100% from an original total of 99.94% after deduction of Fe_2O_3 3.41%, H_2O 1.22%. (2) $CoCO_3$.

Mineral Group: Calcite group.

Occurrence: A rare accessory mineral in hydrothermal cobalt-bearing mineral deposits.

Association: Roselite, erythrite, annabergite (Schneeberg, Germany); cobaltian calcite, cobaltian dolomite (Congo).

Distribution: From Schneeberg, Saxony, Germany. At Libiola, near Casarza, and in the Valle del Neva, Liguria, Italy. From Zemo-Svanetia, Georgia. Found in a number of mines in Katanga Province, Congo (Shaba Province, Zaire), including Kambove; in the Musonoi and Kamoto mines, near Kolwezi; from Kabolela; Mupine; at the Kirilabomwe mine; from Konkola; very large crystals from the Kakanda mine. At the Aghbar (Arhbar) mine, Bou Azzer district, Morocco. In the Cameron area, Coconino Co., Arizona, USA. From Boleo, Baja California, Mexico. At the Mt. Cobalt mine, 140 km south of Cloncurry, Queensland, Australia.

Name: From the Greek for *sphere* and *cobalt* in its composition.

Type Material: Mining Academy, Freiberg, Germany, 15177.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 175–176. (2) Pertlik, F. (1986) Structures of hydrothermally synthesized cobalt(II) carbonate and nickel(II) carbonate. Acta Cryst., C42, 4–5. (3) (1960) NBS Circ. 539, 10, 24.

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Spinel $MgAl_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly as octahedra, to 30 cm, may show dodecahedron or cube faces, rarely as dodecahedra; coarse granular, rounded, massive. *Twinning:* On {111} as both twin and composition plane, the spinel law, penetration or contact, may be repeated as sixlings.

Physical Properties: *Cleavage:* Parting on {111}. *Fracture:* Conchoidal, uneven to splintery. *Tenacity:* Brittle. Hardness = 7.5–8 D(meas.) = 3.6–4.1, increasing with Fe and Zn content. D(calc.) = 3.578

Optical Properties: Transparent to nearly opaque. *Color:* Colorless, brown, black; red, orange, yellow, green, blue, indigo, violet. *Streak:* White. *Luster:* Vitreous, splendent to dull. *Optical Class:* Isotropic. $n = 1.719$

Cell Data: *Space Group:* $Fd3m$ (synthetic). $a = 8.0898(9)$ $Z = 8$

X-ray Powder Pattern: Synthetic.
2.437 (100), 2.020 (65), 1.4289 (55), 1.5554 (45), 2.858 (40), 4.66 (35), 1.0524 (12)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	0.02	0.56		MnO		0.68	
TiO_2	0.05			ZnO	0.33	16.47	
Al_2O_3	70.08	57.99	71.67	MgO	28.77	14.08	28.33
Fe_2O_3		6.94		CaO		0.33	
FeO	0.33	3.23		Total	99.58	100.28	100.00

(1) "South East Asia"; corresponds to $Mg_{1.00}(Al_{1.97}Mg_{0.02}Fe_{0.01}Zn_{0.01})_{\Sigma=2.01}O_4$. (2) Kaveltorp, Sweden; corresponds to $(Mg_{0.57}Zn_{0.33}Fe^{2+}_{0.07}Mn^{2+}_{0.02}Ca_{0.01})_{\Sigma=1.00}(Al_{1.84}Fe^{3+}_{0.14}Si_{0.02})_{\Sigma=2.00}O_4$. (3) $MgAl_2O_4$.

Polymorphism & Series: Forms three series, with magnesiochromite, with gahnite, and with hercynite.

Mineral Group: Spinel group.

Occurrence: A common mineral, formed at high-temperatures as an accessory in igneous rocks, principally basalts, kimberlites, peridotites, and in xenoliths; in regionally metamorphosed aluminum-rich schists; in regionally and contact metamorphosed limestones; a detrital mineral.

Association: Forsterite, chondrodite, scapolite, phlogopite, corundum, sillimanite, andalusite.

Distribution: Many localities. Some for good specimens include: gem crystals from around Mogok, Myanmar (Burma). In Sri Lanka, in the Ratnapura and Elahera districts, and elsewhere. In the USA, at many places from Amity and Edenville, Orange Co., New York to Andover, Allegany Co., New Jersey; fine crystals from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey. From near Midland, and at the Crestmore quarry, Riverside Co., California. In Canada, at Burgess, Ontario, and Wakefield, Quebec. In the Eifel district, and at Bodenmais, Bavaria, Germany. On Monte Somma and Vesuvius, Campania, Italy. From Andrahomana, Ambinda, Besakoa, and many other places in Madagascar. Large crystals from the Emeldjak and Katalakhu deposits, in the Aldan Shield, Sakha, Russia. At Gorondarinskoye, Pamir Mountains, Tajikistan.

Name: Perhaps from the Latin *spinella*, for *little thorn*, in allusion to the spine-shaped octahedral crystals.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 689–697. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 56–88, esp. 62–67. (3) Finger, L.W., R.M. Hazen, and A.M. Hofmeister (1986) High-pressure crystal chemistry of spinel ($MgAl_2O_4$) and magnetite (Fe_3O_4): comparisons with silicate spinels. Phys. Chem. Minerals, 13, 215–220. (4) (1971) NBS Mono. 25, 9, 25.

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Spionkopite $Cu_{39}S_{28}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$, $3m$, or 32. Massive.

Physical Properties: *Cleavage:* {0001}. Hardness = n.d. VHN = 63–93 (15 g load); 120–162 (10 g load). D(meas.) = n.d. D(calc.) = 5.13

Optical Properties: Opaque. *Color:* Blue. *Luster:* Metallic. *Pleochroism:* Blue to pale blue; formerly called "blaubleibender Covellit" (blue-remaining covellite) for this reason. *Anisotropism:* Orange.
R_1–R_2: (400) 26.1–33.4, (420) 25.8–32.9, (440) 25.1–32.3, (460) 24.2–31.4, (480) 23.0–30.5, (500) 21.8–29.5, (520) 20.5–28.5, (540) 19.0–27.4, (560) 17.6–26.4, (580) 16.3–25.4, (600) 14.9–24.4, (620) 13.6–23.8, (640) 12.4–23.8, (660) 11.2–24.3, (680) 10.0–24.6, (700) 9.06–24.3

Cell Data: *Space Group:* $P\overline{3}m1$, $P3m1$, $P31m$, or $P321$. $a = 22.962$ $c = 41.429$ $Z = 18$

X-ray Powder Pattern: Spionkop Creek, Canada.
1.910 (100), 3.076 (85), 2.777 (30), 1.820 (30), 2.297 (25), 3.681 (20), 2.849 (20)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	67.1	70.8	67.2	73.41
Fe			7.8	
Zn			0.7	
S	25.8	27.2	24.5	26.59
Total	92.9	98.0	100.2	100.00

(1–2) Yarrow and Spionkop Creeks, Canada; by electron microprobe. (3) Eretria, Greece; by electron microprobe. (4) $Cu_{39}S_{28}$.

Occurrence: As weathering-produced lamellar replacements of anilite and djurleite in stratabound red-bed copper deposits (Spionkop Creek, Canada); in a serpentine-hosted magnetite-chromite deposit (Eretria, Greece).

Association: Anilite, djurleite, yarrowite, tennantite (Yarrow and Spionkop Creeks, Canada); geerite, chalcopyrite, cobalt pentlandite, magnetite, chromite, andradite, chlorite, diopside (Eretria, Greece).

Distribution: From the Upper Grinnell Formation, Spionkop Creek and Yarrow Creek areas of southwestern Alberta, Canada [TL]. In the USA, at the Campbell mine, Bisbee, Cochise Co., Arizona; in the Lone Tree mine, Buffalo Mountain district, Humboldt Co., Nevada; from Dekalb Township, St. Lawrence Co., New York; and at Washington Pass, Okanogan Co., Washington. From near Eretria, Greece. At Schulenberg, near Clausthal, Harz Mountains, and in the Clara mine, near Oberwolfach, Black Forest, Germany. From the Lubin and Rudna copper mines, near Legnica, Zechstein copper district, Lower Silesia, Poland. In the West Carbery district, Co. Cork, Ireland.

Name: For the locality at Spionkop Creek, Canada.

Type Material: Canadian Geological Survey, Ottawa; Queen's University, Kingston, Ontario, Canada; Harvard University, Cambridge, Massachusetts, 122290; National Museum of Natural History, Washington, D.C., USA, 149430, 149431.

References: (1) Goble, R.J. (1980) Copper sulfides from Alberta: yarrowite, Cu_9S_8, and spionkopite, $Cu_{39}S_{28}$. Can. Mineral., 18, 511–518. (2) (1981) Amer. Mineral., 66, 1279 (abs. ref. 1). (3) Economou, M.I. (1981) A second occurrence of the copper sulfides geerite and spionkopite in Eretria area, central Greece. Neues Jahrb. Mineral., Monatsh., 489–494. (4) Goble, R.J. (1985) The relationship between crystal structure, bonding and cell dimensions in the copper sulfides. Can. Mineral., 23, 61–76. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 529.

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Spiroffite $(Mn^{2+},Zn)_2Te_3^{4+}O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral crystals, to 1 cm, commonly cleavable massive.

Physical Properties: *Cleavage:* Observed in at least two directions. *Fracture:* Conchoidal. Hardness = ∼3.5 D(meas.) = 5.01(2) D(calc.) = 5.059

Optical Properties: Transparent to translucent. *Color:* Purple, red, pale pink. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (+). $\alpha = 1.85(1)$ $\beta = 1.91(1)$ $\gamma = [2.20]$ 2V(meas.) = 55(5)°

Cell Data: *Space Group:* $C2/c$. $a = 12.870(2)$ $b = 5.3813(5)$ $c = 11.888(2)$ $\beta = 98.22(1)°$ Z = 4

X-ray Powder Pattern: Moctezuma mine, Mexico.
4.98 (vs), 3.00 (vs), 4.06 (s), 3.31 (s), 2.77 (w), 2.69 (w), 2.60 (w)

Chemistry:

	(1)
TeO_2	76.29
MnO	14.20
ZnO	9.36
CaO	0.15
Total	[100.00]

(1) Moctezuma mine, Mexico; recalculated to 100% from an original total of 100.06% after deduction of H_2O 0.03%, insoluble 0.22%, remnant = Bi_2O_3 0.08%, Sb_2O_3 0.02%, Al_2O_3 0.02%, PbO 0.05%, CdO 0.07%, CoO 0.02%, MgO 0.02%; corresponds to $(Mn_{1.26}Zn_{0.72}Ca_{0.02})_{\Sigma=2.00}Te_{3.01}O_{8.02}$.

Occurrence: Very rare in the oxidized zone of an Au–Te deposit (Moctezuma mine, Mexico); very rare in intensely silicified pyritic shales (Joe mine, Arizona, USA).

Association: Tellurium, tellurite, paratellurite, denningite, mroseite, zemannite (Moctezuma mine, Mexico).

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. Large crystals at the Joe mine, Tombstone, Cochise Co., Arizona, USA. From the Kawazu mine, Shizuoka Prefecture, Japan.

Name: To honor Professor Kiril Spiroff (1901–1981), Bulgarian–American mineralogist, Michigan College of Mining and Technology, Houghton, Michigan, USA.

Type Material: Natural History Museum, Paris, France, 175.79; Royal Ontario Museum, Toronto, Canada, M24879; Harvard University, Cambridge, Massachusetts, USA, 108109.

References: (1) Mandarino, J.A., S.J. Williams, and R.S. Mitchell (1963) Spiroffite, a new tellurite mineral from Moctezuma, Sonora, Mexico. Mineral. Soc. Amer. Special Paper 1, 305–309. (2) Cooper, M.A. and F.C. Hawthorne (1996) The crystal structure of spiroffite. Can. Mineral., 34, 821–826.

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Spodumene $LiAlSi_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, typically flattened and striated ‖ {100}, with {100}, {010}, and {110}, to 12.5 m and 54 t. Commonly massive. *Twinning:* Common on {100}.

Physical Properties: *Cleavage:* Good on {110}, (110) ∧ $(1\bar{1}0)$ ∼87°; {100}, {010} partings. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 3.03–3.23 D(calc.) = 3.184 Yellow, orange, or pink fluorescence under LW and SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, greenish white, grayish white, yellowish green, emerald-green, yellow, pink, violet, may be bicolored; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on cleavage.
Optical Class: Biaxial (+). *Pleochroism:* X = purple to green; Z = colorless. *Orientation:* $Y = b$; $Z \wedge c = 20°–26°$. *Dispersion:* $r < v$. $\alpha = 1.648–1.663$ $\beta = 1.655–1.669$ $\gamma = 1.662–1.679$ 2V(meas.) = 58°–68°

Cell Data: *Space Group:* $C2/c$. $a = 9.45$ $b = 8.39$ $c = 5.215$ $\beta = 110°$ Z = 4

X-ray Powder Pattern: Pala, California, USA (?). (ICDD 33-786).
2.921 (100), 2.793 (90), 4.205 (75), 6.12 (40), 4.36 (35), 3.444 (35), 3.190 (35)

Chemistry:

	(1)
SiO_2	63.60
Al_2O_3	27.48
Fe_2O_3	0.04
MnO	0.14
MgO	< 0.02
CaO	< 0.02
Li_2O	7.79
Na_2O	0.22
H_2O^+	0.17
Total	99.44

(1) Pala, California, USA; corresponds to $(Li_{0.98}Na_{0.01})_{\Sigma=0.99}Al_{1.00}(Si_{1.99}Al_{0.01})_{\Sigma=2.00}O_6$.

Mineral Group: Pyroxene group.

Occurrence: A common constituent of lithium-rich granite pegmatites; in aplites and gneisses.

Association: Quartz, albite, petalite, eucryptite, lepidolite, beryl.

Distribution: From Utö, Södermanland, and in the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. In Finland, from near Kuortane, and in the Tammela district. In the USA, giant crystals in the Etta mine, near Keystone, Pennington Co., and elsewhere in the Black Hills, South Dakota; at Hiddenite, Alexander Co. and in the Foote mine, Kings Mountain, Cleveland Co., North Carolina; from the Pala district, San Diego Co., California; and in the Harding mine, Dixon, Taos Co., New Mexico. From the Tanco mine, Bernic Lake, Manitoba, Canada. At the Urupuca mine, Itambacari, and at Resplendor, Minas Gerais, Brazil. From Mawi and Kantiva, Nuristan district, Laghman Province, Afghanistan. At Maharitra, Mt. Bity, and at Anjanabonoina, Madagascar. From Bikita, Zimbabwe. Many other minor localities are known.

Name: From the Greek for *ash-colored*, in allusion to its color.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 366–369.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition), v. 2A, single-chain silicates, 527–544.

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Spurrite $Ca_5(SiO_4)_2(CO_3)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Anhedral crystalline, granular or massive. *Twinning:* Polysynthetic twins on {001} and {101}, composition planes {001} or $\{20\bar{5}\}$.

Physical Properties: *Cleavage:* Perfect on {001}, poor on {100}, (001) ∧ (100) = 79°. *Fracture:* Uneven to splintery. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.02 D(calc.) = 3.025 Green cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* White to gray or lavender-gray; colorless in thin section. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y \wedge a \simeq 45°$; $Z \wedge c = 33°$. *Dispersion:* $r > v$, weak, crossed, distinct. α = 1.637–1.641 β = 1.672–1.676 γ = 1.676–1.681
2V(meas.) = 35°–41°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.49$ $b = 6.705$ $c = 14.16$ $\beta = 101°19'$ Z = 4

X-ray Powder Pattern: Luna Co., New Mexico, USA. (ICDD 13-496).
2.701 (100), 2.635 (70), 3.019 (65), 2.663 (50), 2.170 (40), 3.81 (30), 2.609 (30)

Chemistry:

	(1)		(1)
SiO_2	26.96	CaO	62.34
TiO_2	0.01	Na_2O	0.05
Al_2O_3	0.39	K_2O	trace
Fe_2O_3	0.11	H_2O^+	0.00
MnO	0.03	CO_2	9.73
MgO	0.23	Total	99.85

(1) Velardeña, Mexico; corresponds to $(Ca_{4.95}Mg_{0.02}Na_{0.01})_{\Sigma=4.98}(Si_{2.00}Al_{0.03}Fe^{3+}_{0.01})_{\Sigma=2.04}O_8(C_{0.98}O_3)$.

Polymorphism & Series: Dimorphous with paraspurrite.

Occurrence: A product of high-temperature thermal metamorphism along the contact between carbonate rock and mafic magma.

Association: Gehlenite, merwinite, tilleyite, hillebrandite, scawtite, kilchoanite, rankinite, larnite, foshagite, wollastonite.

Distribution: From the Santa Juana mine, Velardeña, Durango, and in the Encantada district, Coahuila, Mexico. In the USA, at Crestmore, Riverside Co., California; in the Tres Hermanas district, Luna Co., New Mexico; and from the Little Belt Mountains, Lewis and Clark and Meagher Co., Montana. In Ireland, from Scawt Hill, near Larne, and at Carneal, Co. Antrim, and at Carlingford, Co. Louth. From Camas Mòr, Isle of Muck, and at Camphouse, Ardnamurchan, Argyllshire, Scotland. At Golden Gully, Tokatoka district, about 150 km north of Auckland, New Zealand. From the Güneyce-İkizdere area, Trabzon Province, Turkey. In the Hatrurim Formation, Israel. At Kushiro and Hirata, Hiroshima Prefecture, and at Fuka, near Bicchu, Okayama Prefecture, Japan. Found near Anakit Creek, at the mouth of the Lower Tunguska River, central Siberia, and elsewhere in Russia.

Name: For Josiah Edward Spurr (1870–1950), American geologist.

Type Material: National Museum of Natural History, Washington, D.C., USA, 86532; The Natural History Museum, London, England, 1923,1032.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 97. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 263–271. (3) Smith, J.V., I.L. Karle, H. Hauptman, and J. Karle (1960) The crystal structure of spurrite, $Ca_5(SiO_4)_2CO_3$. II. Description of structure. Acta Cryst., 13, 454–458.

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Srebrodolskite $Ca_2Fe_2^{3+}O_5$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals platy on {010}; granular, less than 0.1 mm, in aggregates.

Physical Properties: *Cleavage:* {*h0l*}, distinct. Hardness = 5.5 D(meas.) = 4.04(1) D(calc.) = 4.03 Weakly magnetic.

Optical Properties: Opaque, transparent in thin slivers. *Color:* Black; red-brown in transmitted light. *Streak:* Grayish brown. *Luster:* Adamantine, metallic in aggregates. *Optical Class:* Biaxial (–) (?). *Pleochroism:* Weak; in brownish reds. *Orientation:* X = [010]. $\alpha = \sim 2.24$ $\beta = \sim 2.25$ $\gamma = \sim 2.27$ 2V(meas.) = n.d. 2V(calc.) = 71° (synthetic).

Cell Data: *Space Group: Pnma.* $a = 5.420(3)$ $b = 14.752(3)$ $c = 5.594(3)$ Z = 4

X-ray Powder Pattern: Kopeysk, Russia.
7.381 (10), 3.690 (10), 2.676 (10), 1.844 (10), 1.946 (7), 2.797 (6), 2.710 (6)

Chemistry:

	(1)	(2)
Al_2O_3	0.00	
Fe_2O_3	56.50	58.74
MnO	0.90	
MgO	1.19	
CaO	41.69	41.26
Total	100.28	100.00

(1) Kopeysk, Russia; corresponds to $Ca_{2.01}(Fe^{3+}_{1.91}Mg_{0.08}Mn_{0.03})_{\Sigma=2.02}O_5$. (2) $Ca_2Fe^{3+}_2O_5$.

Occurrence: Formed from calcined ankerite in petrified wood baked by burning coal heaps (Kopeysk, Russia); in leucite tephrite lava at contacts between lava and calcium-rich xenoliths (Bellerberg volcano, Germany).

Association: Portlandite, fluorellestadite, lime, periclase, spurrite, larnite, magnesioferrite, hematite, anhydrite (Kopeysk, Russia); sanidine, clinopyroxene, pyrrhotite, thompsonite, ettringite, willhendersonite, gismondine, jasmundite, mayenite, bellbergite, calcic olivine, portlandite (Bellerberg volcano, Germany).

Distribution: From mines around Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany.

Name: Honors Dr. Boris Ivanovich Srebrodol'skii (1927–), Russian-Ukrainian mineralogist, Institute of Geology and Geochemistry, Lvov, Ukraine.

Type Material: Mining Institute, St. Petersburg, 1943/1; Il'menskii Preserve Museum, Miass; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84277, vis6221.

References: (1) Chesnokov, B.V. and L.F. Bazhenova (1985) Srebrodolskite $Ca_2Fe_2O_5$ – a new mineral. Zap. Vses. Mineral. Obshch., 114, 195–199 (in Russian). (2) (1986) Amer. Mineral., 71, 1279–1280 (abs. ref. 1). (3) (1986) Mineral. Abs., 37, 531 (abs. ref. 1). (4) Smith, D.K. (1962) Crystallographic changes with the substitution of aluminum for iron in dicalcium ferrite. Acta Cryst., 15, 1146–1152.

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Srilankite $(Ti, Zr)O_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As idiomorphic inclusions, less than 1 mm, intergrown with associated minerals.

Physical Properties: *Cleavage:* One direction, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼6.5 VHN = 900–1000 D(meas.) = ∼4.6 D(calc.) = 4.77 Commonly radioactive.

Optical Properties: Opaque, translucent in thin fragments. *Color:* Black, brownish black; dark blue in transmitted light; gray-white in reflected light. *Luster:* Submetallic to adamantine. *Optical Class:* Biaxial (–); high birefringence. n = [2.38] 2V(meas.) = 16(1)° *Anisotropism:* Observed.
R_1–R_2: (480) 19.4–18.6, (546) 18.4–16.0, (589) 18.5–16.4, (649) 18.7–17.0

Cell Data: *Space Group: Pbcn.* a = 4.706(5) b = 5.553(5) c = 5.024(4) Z = 4

X-ray Powder Pattern: Rakwana, Sri Lanka.
2.92 (100), 1.516 (35), 1.721 (30), 3.61 (25), 1.692 (25), 1.864 (15), 1.793 (15)

Chemistry:

	(1)
TiO_2	56.30
$(Zr, Hf)O_2$	43.97
Total	100.27

(1) Rakwana, Sri Lanka; by electron microprobe, average of 50 analyses of four grains, UO_2 0.15(5)% in three grains; corresponds to $[Ti_{0.66}(Zr, Hf)_{0.34}]_{\Sigma=1.00}O_2$.

Occurrence: In pebbles found in concentrates from a placer gemstone mine.

Association: Zirconolite, baddeleyite, geikielite, spinel, perovskite.

Distribution: From Rakwana, Sri Lanka.

Name: For Sri Lanka, the country where the mineral was first collected.

Type Material: National Museum of Natural History, Washington, D.C., USA, 165370.

References: (1) Willgallis, A., E. Siegmann, and T. Hettiaratchi (1983) Srilankite, a new Zr–Ti-oxide mineral. Neues Jahrb. Mineral., Monatsh., 151–157. (2) (1984) Amer. Mineral., 69, 212 (abs. ref. 1). (3) Willgallis, A. and H. Hartl (1983) $(Zr_{0.33}Ti_{0.67})O_2$ – ein natürliches Zirkonium-Titanoxid mit $\alpha-PbO_2-$Struktur. Zeits. Krist., 164, 59–66 (in German with English abs.).

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Stalderite $TlCu(Zn,Fe,Hg)_2As_2S_6$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

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Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Staněkite $\mathbf{Fe^{3+}(Mn, Fe^{2+}, Mg)O(PO_4)}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. May be anhedral, showing rough {120} faces, elongated along [001], to 2 cm, in subparallel aggregates; granular.

Physical Properties: *Cleavage:* Parting ⊥ [001]. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 3.80 D(calc.) = 4.09

Optical Properties: Nearly opaque. *Color:* Black; pale gray in reflected light, with reddish yellow to brownish red internal reflections. *Streak:* Dark brown. *Luster:* Weakly submetallic. *Optical Class:* Biaxial. *Pleochroism:* Weak. *Anisotropism:* Distinct, pale brownish gray. *Bireflectance:* Weak.
R_1–R_2: (400) 12.86–15.20, (420) 11.90–14.00, (440) 11.15–13.05, (460) 10.90–12.75, (480) 10.75–12.46, (500) 10.57–12.33, (520) 10.41–12.33, (540) 10.48–12.26, (560) 10.52–12.25, (580) 10.68–12.29, (600) 10.69–12.31, (620) 10.75–12.30, (640) 10.77–12.35, (660) 10.80–12.42, (680) 10.72–12.33, (700) 10.54–12.15

Cell Data: *Space Group:* $P2_1/a$. $a = 11.844(3)$ $b = 12.662(3)$ $c = 9.989(3)$ $\beta = 105.93(2)°$ Z = 16

X-ray Powder Pattern: Clementine II pegmatite, Namibia.
2.971 (100), 2.810 (85), 2.857 (58), 3.259 (50), 3.412 (38), 5.54 (37), 3.621 (35)

Chemistry:

	(1)
P_2O_5	31.16
TiO_2	0.02
Al_2O_3	0.01
Fe_2O_3	41.56
FeO	1.56
MnO	23.12
ZnO	0.22
MgO	0.50
CaO	0.13
Na_2O	0.13
K_2O	0.05
Total	[98.46]

(1) Clementine II pegmatite, Namibia; by electron microprobe, original total given as 98.42%, FeO:Fe_2O_3 by Mössbauer spectroscopy; corresponds to $Fe^{3+}_{1.00}(Mn_{0.73}Fe^{3+}_{0.16}Fe^{2+}_{0.05}Mg_{0.03}Na_{0.01})_{\Sigma=0.98}O(P_{0.98}O_4)$.

Occurrence: An uncommon alteration product of earlier phosphates in zoned complex granite pegmatites.

Association: Eosphorite, arrojadite, kryzhanovskite, ferrisicklerite, alluaudite, quartz (Clementine II pegmatite, Namibia); ferrisicklerite, heterosite (Albères, France).

Distribution: In Namibia, near Karibib, from the Clementine II pegmatite, Okatjimukuju Farm, and at the Helikon pegmatite; from the Cameroon pegmatite, Usakos. In the Albères massif, Pyrénées-Orientales, France. From Cap Creus, east of Figueras, Gerona Province, Spain.

Name: To honor Professor Josef Staněk (1928–), Masarykov University, Brno, Czech Republic, specialist in pegmatite phosphate mineralogy.

Type Material: University of Stuttgart, Stuttgart, Germany; National School of Mines, Paris, France, 45634.

References: (1) Keller, P., F. Fontan, F. Velasco Roldan, and J.C. Melgarejo (1997) Staněkite, $Fe^{3+}(Mn, Fe^{2+}, Mg)(PO_4)O$: a new phosphate mineral in pegmatites at Karibib (Namibia) and French Pyrénées (France). Eur. J. Mineral., 9, 475–482. (2) (1998) Amer. Mineral., 83, 187 (abs. ref. 1).

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As subhedral to irregular grains, to 1 mm, in veinlets and rimming olivine.

Physical Properties: Hardness = 4.5–5 D(meas.) = 3.15(1) D(calc.) = 3.15

Optical Properties: Transparent. *Color:* Reddish to amber, pale bluish if weathered; colorless in transmitted light.
Optical Class: Biaxial (+). α = 1.594–1.619 β = [1.596]–1.622 γ = 1.604–1.631
2V(meas.) = 50°–60°

Cell Data: *Space Group:* $P2/c$ or Pc. a = 17.16(3) b = 10.00(2) c = 22.88(4)
$\beta = 100°15(10)'$ Z = 8

X-ray Powder Pattern: Estherville meteorite.
2.817 (10), 3.747 (8), 2.505 (8), 3.845 (6), 8.31 (5), 6.01 (5), 1.870 (4)

Chemistry:

	(1)
P_2O_5	46.6
FeO	13.8
MnO	1.4
MgO	12.9
CaO	24.6
Total	99.3

(1) Estherville meteorite; by electron microprobe, total Fe as FeO, total Mn as MnO; corresponding to $Ca_{4.02}(Mg_{2.91}Fe_{1.74}Mn_{0.18})_{\Sigma=4.83}(PO_4)_6$.

Occurrence: A rare component of some meteorites.

Association: Olivine, whitlockite, farringtonite, troilite.

Distribution: In the Estherville mesosiderite meteorite, and the pallasite meteorites Albin, Finmarken, Imilac, Newport, Mount Vernon, Santa Rosalia, and Zaisho.

Name: To honor Stanley Field (1875–1964), former Chairman of the Board of Trustees of the Field Museum of Natural History, Chicago, Illinois, USA, during whose tenure the Museum's meteorite collection reached major proportions.

Type Material: Masses of the Estherville meteorite are at: The Natural History Museum, London, England; Natural History Museum, Paris, France; Natural History Museum, Vienna, Austria; Field Museum of Natural History, Chicago, Illinois; Harvard University, Cambridge, Massachusetts; National Museum of Natural History, Washington, D.C., USA.

References: (1) Fuchs, L.H. (1967) Stanfieldite: a new phosphate mineral from stony-iron meteorites. Science, 158, 910–911. (2) (1968) Amer. Mineral., 53, 508 (abs. ref. 1).

Stanleyite $V^{4+}O(SO_4)\cdot 6H_2O$

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Crystal Data: Orthorhombic, possibly monoclinic or triclinic. *Point Group:* n.d. As aggregates of minute plates, to 1.5 mm, which may be in parallel to subparallel stacks, and as efflorescences.

Physical Properties: Hardness = 1–1.5 D(meas.) = 1.95 D(calc.) = 2.01 Easily soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Aquamarine-blue to deep cobalt-blue.
Streak: White.
Optical Class: Biaxial (+). *Pleochroism:* Moderate; $X = Y$ = blue; Z = very pale blue to colorless. *Orientation:* Extinction at up to 15° to the length. *Absorption:* $X = Y > Z$.
$\alpha = 1.505$ $\beta = 1.519$ $\gamma = 1.533$ 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. $a = 12.12$ $b = 9.71$ $c = 14.92$ $Z = 8$

X-ray Powder Pattern: Minasragra, Peru; shows some preferred orientation.
4.20 (100), 4.98 (90), 4.69 (80), 4.41 (60), 3.81 (60), 3.73 (60), 3.09 (20)

Chemistry:

	(1)	(2)
SO_3	29.0	29.53
V_2O_4	30.6	30.60
H_2O	38.0	39.87
rem.	1.8	
Total	99.4	100.00

(1) Minasragra, Peru; by electron microprobe, average of nine analyses, SO_3 and H_2O by TGA, remnant = SiO_2 0.3%, TiO_2 0.1%, Al_2O_3 0.2%, FeO 0.2%, NiO 0.3%, MgO 0.1%, CaO 0.1%, K_2O 0.4%, Cl 0.1%; corresponds to $V_{1.01}O_{1.01}S_{0.99}O_{3.99}\cdot 5.78H_2O$. (2) $VO(SO_4)\cdot 6H_2O$.

Occurrence: Initially found on a museum specimen of patronite from a rich vanadium deposit.

Association: Patronite, pyrite, potassium alum, quartz.

Distribution: From Minasragra, 46 km from Cerro de Pasco, Peru.

Name: To honor Henry Morton Stanley (1841–1904), noted Welsh–American journalist-explorer.

Type Material: Royal Scottish Museum, Edinburgh, Scotland, 1922.11.6; National Museum of Natural History, Washington, D.C., USA, 160386.

References: (1) Livingstone, A. (1982) Stanleyite, a new vanadium sulphate mineral from Peru. Mineral. Mag., 45, 163–166. (2) (1983) Amer. Mineral., 68, 644–645 (abs. ref. 1).

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Stannite Cu_2FeSnS_4

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Rarely as crystals, to 6 cm, with a pseudo-octahedral habit due to twinning; also massive, granular, and disseminated. *Twinning:* As penetration twins on {102} and with [112] as twin axis and {112} as composition plane. Polysynthetic lamellae seen in polished section.

Physical Properties: *Cleavage:* Indistinct on {110} and {001}. *Fracture:* Uneven. Hardness = 4 VHN = 216–265 (25 g load). D(meas.) = 4.3–4.5 D(calc.) = 4.490

Optical Properties: Opaque. *Color:* Steel-gray to iron-black, may tarnish blue; in polished section gray with olive-green tinge. *Streak:* Blackish. *Luster:* Metallic. *Pleochroism:* Indistinct in air, distinct in oil. *Anisotropism:* Distinct; violet and slate-green.
R_1–R_2: (400) 21.4–22.2, (420) 22.1–23.4, (440) 23.5–24.7, (460) 24.9–26.0, (480) 26.2–27.0, (500) 27.1–27.8, (520) 27.7–28.3, (540) 27.8–28.4, (560) 27.6–28.3, (580) 27.3–28.0, (600) 27.0–27.6, (620) 26.7–27.3, (640) 26.6–27.1, (660) 26.5–27.0, (680) 26.5–27.0, (700) 26.7–27.1

Cell Data: *Space Group:* $I\bar{4}2m$. $a = 5.4432(11)$ $c = 10.7299(51)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
3.11 (100), 1.908 (80), 1.640 (60), 1.623 (60), 2.427 (50), 1.784 (50), 1.240 (50)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Cu	29.24	29.6	29.58	Sn	27.14	27.7	27.61
Fe	13.95	10.8	12.99	In		0.03	
Zn	0.08	2.2		S	28.88	29.7	29.82
Cd		0.11		insol.	0.51		
				Total	99.80	100.1	100.00

(1) Chocaya, Bolivia; corresponds to $Cu_{2.04}Fe_{1.11}Sn_{1.02}S_{4.00}$. (2) Oruro, Bolivia; by electron microprobe, corresponding to $Cu_{2.01}(Fe_{0.84}Zn_{0.14})_{\Sigma=0.98}Sn_{1.01}S_{4.00}$. (3) Cu_2FeSnS_4.

Polymorphism & Series: Dimorphous with ferrokesterite.

Mineral Group: Stannite group.

Occurrence: In tin-bearing vein deposits of hydrothermal origin.

Association: Chalcopyrite, sphalerite, tetrahedrite, arsenopyrite, pyrite, cassiterite, wolframite.

Distribution: In Cornwall, England, from Wheal Rock, near St. Agnes [TL], and at a number of other mines, where it may constitute an ore mineral. In the Czech Republic, from Cínovec (Zinnwald). In Australia, at Broken Hill, New South Wales, and from Zeehan, Tasmania. In Bolivia, in the Itos and San José mines, Oruro; at Llallagua, Chocaya, and Cerro Rico, Potosí; and from Uncia. In the USA, at the Peerless and Etta mines, near Keystone, Pennington Co., South Dakota. From the Brunswick tin mines, 56 km southwest of Fredericton, New Brunswick, Canada. As large crystals from the Yaogangxian mine, 45 km northeast of Yizhang, Hunan Province, China. Noted in small amounts from a number of other localities world-wide.

Name: From the Latin *stannum*, *tin*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 224–226. (2) Kissin, S.A. and D.R. Owens (1979) New data on stannite and related tin sulfide minerals. Can. Mineral., 17, 125–135. (3) Bonazzi, P., L. Bindi, G.P. Bernardini, and S. Menchetti (2003) A model for the mechanism of incorporation of Cu, Fe and Zn in the stannite-kësterite series, Cu_2FeSnS_4–Cu_2ZnSnS_4. Can. Mineral., 41, 639–649. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 51–52. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 542–553. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 531.

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Stannoidite $Cu_8(Fe,Zn)_3Sn_2S_{12}$

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Crystal Data: Orthorhombic. *Point Group:* 222. Massive, in veinlets, to 1 mm.

Physical Properties: *Fracture:* Uneven to subconchoidal. Hardness = ∼4 VHN = 181–274 (100 g load). D(meas.) = n.d. D(calc.) = [4.68]

Optical Properties: Opaque. *Color:* Brass-brown; in polished section, pinkish brown. *Streak:* Dark brown-gray. *Luster:* Metallic. *Pleochroism:* Distinct, pale salmon-brown to brown. *Anisotropism:* Strong; dark orange-red to yellow-gray.
R_1–R_2: (400) 17.5–18.9, (420) 17.4–19.2, (440) 18.2–20.3, (460) 19.5–21.7, (480) 20.8–23.0, (500) 21.8–24.2, (520) 22.8–25.3, (540) 23.7–26.3, (560) 24.6–27.1, (580) 25.4–27.8, (600) 26.2–28.4, (620) 27.1–29.1, (640) 27.8–29.5, (660) 28.7–30.0, (680) 29.6–30.5, (700) 30.3–30.8

Cell Data: *Space Group: I*222. $a = 10.767$ $b = 5.411$ $c = 16.118$ Z = [2]

X-ray Powder Pattern: Konjo mine, Japan.
3.11 (100), 1.906 (70), 1.621 (20b), 2.70 (16), 4.83 (10), 5.40 (5), 4.13 (4)

Chemistry:

	(1)	(2)		(1)	(2)
Cu	37.2	38.2	Zn	1.2	0.8
Ag	0.1		Sn	16.5	18.7
Fe	12.5	11.9	S	31.2	29.9
			Total	98.7	99.5

(1) Konjo mine, Japan; by electron microprobe, corresponding to $(Cu_{7.22}Ag_{0.01})_{\Sigma=7.23}(Fe_{2.76}Zn_{0.23})_{\Sigma=2.99}Sn_{1.71}S_{12.00}$. (2) Vila Apacheta, Bolivia; by electron microprobe, corresponding to $Cu_{7.74}(Fe_{2.74}Zn_{0.16})_{\Sigma=2.90}Sn_{2.03}S_{12.00}$.

Occurrence: In hydrothermal Sn–Cu sulfide deposits.

Association: Chalcopyrite, galena, tetrahedrite, stannite, cassiterite, siderite, quartz (Konjo mine, Japan); hemusite, enargite, luzonite, colusite, reniérite, tennantite, chalcopyrite, pyrite (Chelopech, Bulgaria).

Distribution: In Japan, at the Konjo mine, Okayama Prefecture [TL]; the Fukoku mine, Kyoto Prefecture; and in Hyogo Prefecture, at the Ikuno mine, Kanagase; Akenobe mine, Yabu; and elsewhere. In Australia, at Tingha, New South Wales. From St. Michael's Mount, Marazion, Cornwall, England. At the Chelopech deposit, Sofia, Bulgaria. From Vaultry, Haute-Vienne; Montebras, Creuse; and Chizeuil, Saône-et-Loire, France. In the Barquilla deposit, Salamanca Province, Spain. From Långban, Värmland, Sweden. In Russia, at the Tyrnyauz W–Mo deposit, left bank of the Baksan River Valley, northern Caucasus Mountains, and from the Nevskoye W–Sn deposit, 25 km northwest of Omsukchan, Magadan region. In the Campbell mine, Bisbee, Cochise Co., Arizona, and at Butte, Silver Bow Co., Montana, USA. From the Maggie porphyry copper deposit, 15 km north of Ashcroft, British Columbia, Canada. From Bolivia, at Vila Apacheta. In Peru, from the Colquijirca mine, Junín.

Name: For its physical and chemical similarity to stannite.

Type Material: Geological Institute, University of Tokyo, Tokyo; National Science Museum, Tokyo, Japan, M16183; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 121005.

References: (1) Kato, A. (1969) Stannoidite, $Cu_5(Fe,Zn)_2SnS_8$, a new stannite-like mineral from the Konjo mine, Okayama Prefecture, Japan. Bull. Nat. Sci. Mus. Tokyo, 12, 165–172. (2) (1969) Amer. Mineral., 54, 1495 (abs. ref. 1). (3) Springer, G. (1968) Electronprobe analyses of stannite and related tin minerals. Mineral. Mag., 36, 1045–1051. (4) Yamanaka, T. and A. Kato (1976) Mössbauer effect study of ^{57}Fe and ^{119}Sn in stannite, stannoidite, and mawsonite. Amer. Mineral., 61, 260–265. (5) Kudoh, Y. and Y. Takéuchi (1976) The superstructure of stannoidite. Zeits. Krist., 144, 145–160. (6) Shimizu, M. and N. Shikazono (1987) Stannoidite-bearing tin ore: mineralogy, texture and physicochemical environment of formation. Can. Mineral., 25, 229–236. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 533.

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Stannomicrolite $(Sn^{2+}, Fe^{2+}, Mn^{2+})(Ta, Sn^{4+}, Nb)_2(O, OH)_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As rims, to 20 μm, surrounding ferrowodginite crystals, which may be almost completely replaced when small.

Physical Properties: *Fracture:* [Uneven] (by analogy to pyrochlore group).
Tenacity: [Brittle.] Hardness = > 7 D(meas.) = 8.34 (synthetic $Sn_2Ta_2O_7$). D(calc.) = 8.21 (synthetic $Sn_2Ta_2O_7$).

Optical Properties: Translucent. *Color:* Yellowish brown; in reflected light, light gray with a reddish or lilac tint, with strong reddish brown internal reflections.
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group:* $Fd3m$. a = 10.57 Z = [8]

X-ray Powder Pattern: Near Sukula, Finland.
3.046 (vs), 1.866 (s), 1.589 (s), 2.640 (ms), 1.524 (m), 1.2105 (m), 1.1796 (m)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	7.40	7.40	7.40
Ta_2O_3	41.86	41.86	41.86
TiO_2	0.99	0.99	0.99
SnO_2	48.35		8.49
SnO		43.22	35.63
FeO	2.09	2.09	2.09
MnO	1.42	1.42	1.42
H_2O			0.61
Total	102.10	96.97	98.49

(1) Near Sukula, Finland; by electron microprobe, total Sn as SnO_2. (2) Do.; analysis (1) with total Sn as SnO. (3) Do.; analysis (1) with Sn^{2+}, Sn^{4+} and $(OH)^{1-}$ calculated to fill all sites; then corresponding to $(Sn^{2+}_{1.69}Fe^{2+}_{0.18}Mn^{2+}_{0.13})_{\Sigma=2.00}(Ta_{1.21}Sn^{4+}_{0.36}Nb_{0.35}Ti_{0.08})_{\Sigma=2.00}[O_{6.57}(OH)_{0.43}]_{\Sigma=7.00}$.

Mineral Group: Pyrochlore group, microlite subgroup; $Sn_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Ta_B \geq Nb_B$.

Occurrence: A very rare mineral, replacing ferrowodginite inclusions in tantalian cassiterite, in a museum specimen from a granite pegmatite.

Association: Ferrowodginite, tantalian cassiterite, bismuth.

Distribution: From near Sukula, Tammela, Finland, the exact locality now lost.

Name: For tin, STANNum, in the composition, and membership in the *microlite* subgroup of the pyrochlore group.

Type Material: n.d.

References: (1) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410 [sukulaite = stannomicrolite]. (2) Vorma, A. and J. Siivola (1967) Sukulaite – $Ta_2Sn_2O_7$ – and wodginite as inclusions in cassiterite in the granite pegmatite in Sukula, Tammela in SW Finland. Compt. Rendus Soc. géol. Finlande [Bull. Geol. Finland No. 229], 39, 173–187. (3) (1968) Amer. Mineral., 53, 2103–2104 (abs. ref. 2). (4) Ercit, T.S., P. Černý, and J. Siivola (1987) The composition of stannomicrolite. Neues Jahrb. Mineral., Monatsh., 249–252.

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Stannopalladinite $(Pd, Cu)_3Sn_2(?)$

Crystal Data: Hexagonal. *Point Group:* n.d. As elongated and rounded cubic crystals up to 0.1 mm, intergrown with niggliite. *Twinning:* Occasionally exhibited polysynthetically.

Physical Properties: Hardness = n.d. VHN = 220–228; 387–452. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Brown-rose, pale pink. *Anisotropism:* Strong, from lilac-red to gray-blue.
R_1–R_2: (460) 46.2–48.5, (500) 50.3–51.5, (540) 53.0–54.0, (580) 54.0–55.5, (620) 56.0–57.8, (660) 57.0–60.0, (700) 57.0–61.0

Cell Data: *Space Group:* n.d. $a = 4.40$ $c = 5.66$ Z = [1]

X-ray Powder Pattern: Synthetic Pd_3Sn_2. (JCPDS 4-801).
2.27 (100), 2.20 (100), 1.58 (70), 1.28 (70), 1.19 (70), 0.834 (70), 0.830 (70)

Chemistry:

	(1)	(2)
Pd	40. – 45.	58
Pt	15. – 20.	2
Fe	0.3 – 2.3	
Sn	28. – 33.	38
Cu	5. – 12.	
Ni	0.1 – 0.7	
insol.	0.25 – 2.5	
Total		98

(1) Noril'sk region (?), USSR; by electron microprobe, ranges of analyses. (2) Monchegorsk, USSR; by electron microprobe, average of analyses.

Occurrence: In sulfide Cu-Ni ores (Noril'sk region (?), USSR).

Association: Chalcopyrite, Pt–Fe alloy (Noril'sk region (?), USSR); niggliite, hessite, tellurides of Pt and Pd (Monchegorsk, USSR).

Distribution: Originally described from a locality thought to be in the Noril'sk region, and since described from the Taimyr mine, Talnakh area, of that region in western Siberia; the species later redefined from Monchegorsk, Kola Peninsula; also at the Ugol'nri Ruch' placer, all in the USSR.

Name: For the composition.

Type Material: n.d.

References: (1) Maslenitzky, I.N., P.V. Faleev, and E.V. Iskyul (1947) Tin-bearing minerals of the platinum group in sulfide copper–nickel ores. Doklady Acad. Nauk SSSR, 58, 1137–1140 (in Russian). (2) (1949) Mineral. Abs., 10, 453 (abs. ref. 1). (3) Chernyaev, I.A. and O.E. Yushko-Zakharova (1970) Diagnosis of micro-inclusions of minerals of the platinum group by means of the JXA-3A X-ray spectroscopic analyzer. In: Physical properties of rare-metal minerals and methods for their study. Izdat. "Nauka", 80–81 (in Russian). (4) (1971) Amer. Mineral., 56, 360–361 (abs. ref. 3). (5) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 139.

Starkeyite $MgSO_4 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibrous aggregates, to 4 cm; commonly as powdery efflorescences.

Physical Properties: Hardness = [2–3] (by analogy to rozenite group members). D(meas.) = 2.01 (synthetic). D(calc.) = 2.007(3) Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* White to pale yellow. *Luster:* Dull. *Optical Class:* Biaxial (–). $\alpha = 1.460$ $\beta = 1.471$ $\gamma = 1.474$ 2V(meas.) = 55(18)°

Cell Data: *Space Group:* $P2_1/n$ (synthetic). $a = 5.922(6)$ $b = 13.604(4)$ $c = 7.905(5)$ $\beta = 90°51(10)'$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 24-720).
4.46 (100), 5.43 (75), 3.951 (65), 2.946 (55), 6.83 (45), 3.398 (45), 3.216 (40)

Chemistry:

	(1)	(2)
SO_3	41.0	41.61
FeO	4.5	
MgO	17.5	20.94
H_2O	36.0	37.45
Total	99.0	100.00

(1) Alta mine, California, USA; by electron microprobe and gravimetric methods, total Fe as FeO; corresponds to $(Mg_{0.86}Fe_{0.12})_{\Sigma=0.98}(SO_4)_{1.02} \cdot 4.00H_2O$. (2) $MgSO_4 \cdot 4H_2O$.

Mineral Group: Rozenite group.

Occurrence: An uncommon secondary mineral formed in the presence of iron sulfides; as efflorescences from evaporation of surface and ground waters.

Association: Pyrite, marcasite (Starkey mine, Missouri, USA); konyaite, blödite, gypsum, halite (Great Konya Basin, Turkey); szomolnokite, gunningite (Goldstrike mine, Nevada, USA).

Distribution: In the USA, from the Starkey mine, Madison Co., Missouri; at the Alta troilite mine, Del Norte Co., California; in the Green River Formation, northern Piceance Creek Basin, Garfield and Rio Blanco Cos., and at Garden Park, Fremont Co., Colorado; from the Goldstrike mine, Lynn district, Eureka Co., Nevada; near the Fuemerol mine area, Emery Co., Utah. In the Hansa I mine, Empelde, and the Niedersachsen mine, near Wathlingen, Lower Saxony, Germany. In the Nižná Mysl'a mine, Vel'ky Milic massif, Slovakia. Long fibers from Felsőpetény, also at Rudabánya, Szarvaskő, and Radostyán, Hungary. From the Cantiere Macei, Capo Calamita, Elba, Italy. In Turkey, in the Great Konya Basin, near Çakmak, Konya Province.

Name: For its originally-noted occurrence at the Starkey mine, Missouri, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 105610.

References: (1) Grawe, O.R. (1956) Starkeyite, a correction. Amer. Mineral., 41, 662. (2) Baur, W.H. (1964) On the crystal chemistry of salt hydrates. II. A neutron diffraction study of $MgSO_4.4H_2O$. Acta Cryst., 17, 863–869. (3) Snetsinger, K.G. (1973) Ferroan starkeyite from Del Norte Co., California. Can. Mineral., 12, 229.

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Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As prismatic, lath or bar-like crystals to 70 μm, or in sprays, sheaf-like aggregates or crusts to 0.5 mm.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 3.5-4 VHN = 182 (20 g load). D(meas.) = n.d. D(calc.) = 4.54

Optical Properties: Opaque. *Color*: Golden brown to reddish brown, gray with a brownish hue and distinct red-brown internal reflections in reflected light. *Streak*: Yellowish brown. *Luster*: Semi-metallic. *Anistropism*: Weak. *Bireflectance*: Weak.
Optical Class: n.d.
R_1-R_2: (470) 14.2–12.45, (546) 13.2–11.6, (589) 13.0–11.4, (650) 12.6–11.35

Cell Data: *Space Group*: $P\bar{1}$. a = 6.08(4) b = 8.26(5) c = 10.71(6) α = 97.8(1)° β = 92.4(1)° γ = 90.4(1)° Z = 2

X-ray Powder Pattern: Yadovitaya fumarole, Tolbachik volcano, Kamchatka, Russia.
2.526 (100), 2.322 (98), 2.745 (47), 8.18 (46), 3.047 (41), 10.65 (32), 1.867 (23)

Chemistry:

	(1)	(2)
K_2O	4.90	6.56
CaO	0.04	
PbO	1.29	
CuO	48.20	55.43
ZnO	5.59	
Al_2O_3	0.08	
Fe_2O_3	0.10	
P_2O_5	0.05	
As_2O_5	4.49	
V_2O_5	31.89	38.01
SO_3	0.19	
MoO_3	2.34	.
Total	99.16	100.00

(1) Yadovitaya fumarole, Tolbachik volcano, Kamchatka, Russia; average of 8 electron microprobe analyses; corresponding to $(K_{0.76}Pb_{0.04}Ca_{0.01})_{\Sigma=0.81}(Cu_{4.45}Zn_{0.51}Al_{0.01}Fe_{0.01})_{\Sigma=4.98}$ $(V_{2.58}As_{0.29}Mo_{0.12}S_{0.02}P_{0.01})_{\Sigma=3.02}O_{13}$. (2) $KCu_5O(VO_4)_3$.

Occurrence: In sublimates around a volcanic fumarole.

Association: Lammerite, hematite, palmierite, tenorite, piypite, rutile, orthoclase, lyonsite, pseudolyonsite, lammerite-β, langbeinite, calciolangbeinite, cupromolybdite.

Distribution: From the Yadovitaya (poisonous) fumarole, Second scoria cone of the Northern Breach, Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia.

Name: Honors Russian crystallographer and crystal chemist Galina L. Starova (b. 1946) for her contributions to the crystal chemistry of minerals from the Tolbachik fumaroles.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia (4196/1).

References: (1) Pekov, I.V., M.E. Zelenski, V.O. Yapaskurt, Y.S. Polekhovsky, and M.N. Murashko (2013) Starovaite, $KCu_5O(VO_4)_3$, a new mineral from fumarole sublimates of the Tolbachik volcano, Kamchatka, Russia. European Jour. Mineral., 25, 91-96. (2) (2014) Amer. Mineral., 99, 1517-1518 (abs. ref. 1).

Staurolite $(Fe^{2+}, Mg)_2Al_9(Si, Al)_4O_{20}(O, OH)_4$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Commonly in prismatic crystals exhibiting {110}, {010}, {001}, and {101}, typically rough, to 12 cm. *Twinning:* Commonly as 60° twins with {231} as twin plane, may be cyclic; less commonly as 90° cruciform twins with {031} as twin plane.

Physical Properties: *Cleavage:* Distinct on {010}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 7–7.5 D(meas.) = 3.74–3.83 D(calc.) = 3.686

Optical Properties: Transparent to opaque. *Color:* Dark reddish brown to blackish brown, yellowish brown, rarely blue; pale golden yellow in thin section. *Streak:* White to grayish. *Luster:* Subvitreous to resinous.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Y = pale yellow; Z = golden yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, weak. *Absorption:* $Z > Y > X$.
$\alpha = 1.736–1.747$ $\beta = 1.742–1.753$ $\gamma = 1.748–1.761$ 2V(meas.) = 80°–90°

Cell Data: *Space Group:* $C2/m$. $a = 7.863–7.871$ $b = 16.534–16.613$ $c = 5.632–5.663$ $\beta = 90.00°–90.45°$ Z = 2

X-ray Powder Pattern: Pizzo Forno, Switzerland. (ICDD 15-397).
3.012 (100), 2.693 (100), 2.372 (80), 3.559 (60), 2.400 (60), 1.515 (60), 1.511 (60)

Chemistry:

	(1)		(1)
SiO_2	27.82	MnO	0.22
TiO_2	0.32	CoO	0.02
Al_2O_3	54.91	ZnO	0.19
Fe_2O_3	0.43	MgO	0.62
Cr_2O_3	0.01	Li_2O	0.36
FeO	12.39	H_2O	[2.26]
		Total	[99.55]

(1) Black Mountain, Grafton Co., New Hampshire, USA; by electron and ion microprobe, average of 23 analyses, H_2O determined on a separate sample; corresponds to $(Fe^{2+}_{1.43}Li_{0.20}Mg_{0.13}Mn_{0.03}Zn_{0.02})_{\Sigma=1.81}(Al_{8.64}Fe^{3+}_{0.04}Ti_{0.03})_{\Sigma=8.71}(Si_{3.85}Al_{0.15})_{\Sigma=4.00}O_{24}H_{2.08}$.

Occurrence: Common in pelitic schists, gneisses, and argillaceous rocks regionally metamorphosed to amphibolite grade; also a detrital mineral.

Association: Almandine, sillimanite, kyanite, tourmaline, muscovite, quartz, chloritoid.

Distribution: Widespread, with fine crystals from, for example: at Pizzo Forno and Alpe Piona, Ticino, Switzerland. On Mt. Greiner, Zillertal, Tirol, Austria. From the Keivy massif, Kola Peninsula, Russia. Large twins, in the old Provinces of Finistère and Morbihan, in "Brittany," France. From Fanzeres, Portugal. In the USA, at Franconia, Grafton Co., New Hampshire; Chesterfield, Hampshire Co., Massachusetts; near Blue Ridge, Fannin Co., Georgia; near Picures, Taos Co., New Mexico. In Brazil, in Minas Gerais, from Rubellita and Ardenella; Agua Quente, Rio Pardo de Minas; and Fazenda Graniais.

Name: Derived from the Greek for a *cross*, describing the common twins.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 558–560. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 816–866. (3) Hawthorne, F.C., L. Ungaretti, R. Oberti, F. Caucia, and A. Callegari (1993) The crystal chemistry of staurolite. I. Crystal structure and site populations. Can. Mineral., 31, 551–582. (4) Hawthorne, F.C., L. Ungaretti, R. Oberti, F. Caucia, and A. Callegari (1993) II. Order-disorder and the monoclinic → orthorhombic phase transition. Can. Mineral., 31, 583–595. (5) Hawthorne, F.C., L. Ungaretti, R. Oberti, F. Caucia, and A. Callegari (1993) III. Local order and chemical composition. Can. Mineral., 31, 597–616.

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Steacyite $\mathbf{K_{1-x}(Na,Ca)_2ThSi_8O_{20}}$ (x = 0.2 to 0.4)

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As crystals elongated ‖ [001], terminated by {100} and {001}, to 2 mm; radiating crystalline; massive. *Twinning:* Cruciform, by 90° rotation about [010].

Physical Properties: *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.95, on porous material. D(calc.) = 3.32 Radioactive, emitting α and β particles, but not γ radiation.

Optical Properties: Translucent to transparent in thin section. *Color:* Dark brown, green, yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.573(1)$ $\epsilon = 1.572(1)$

Cell Data: *Space Group:* $P4/mcc$. $a = 7.58(1)$ $c = 14.77(2)$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
3.38 (100), 3.32 (55), 5.30 (45), 2.64 (41), 2.00 (26), 1.82 (20), 2.16 (19)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	57.92	52.12	MgO	0.17	
ThO_2	28.03	30.08	CaO	4.92	4.38
UO_2	0.00	0.14	Na_2O	3.36	3.96
RE_2O_3	0.47	1.81	K_2O	3.42	4.42
Fe_2O_3	0.00		F		0.23
As_2O_3		0.45	H_2O	0.00	
MnO	1.64		P_2O_5		0.02
PbO	0.07		$-O = F_2$		0.10
			Total	100.00	[97.51]

(1) Mont Saint-Hilaire, Canada; corresponds to $K_{0.61}(Na_{0.73}Ca_{0.72}Mn_{0.19}Mg_{0.03})_{\Sigma=1.67}(Th_{0.88}Pb_{0.01})_{\Sigma=0.89}Si_8O_{19.56}$. (2) Rouma Isle, Guinea; $RE_2O_3 = La_2O_3$ 0.37%, Ce_2O_3 0.95%, Pr_2O_3 0.02%, Nd_2O_3 0.38%, Sm_2O_3 0.09%, original total given as 97.61%; corresponds to $K_{0.86}(Na_{1.17}Ca_{0.72}RE_{0.10})_{\Sigma=1.99}(Th_{1.04}U_{0.05})_{\Sigma=1.09}(Si_{7.92}As_{0.04})_{\Sigma=7.96}O_{20}$.

Occurrence: In cavities in pegmatite veins in nepheline syenite in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in a miarolitic cavity in nepheline syenite (Rouma Isle, Guinea); in quartz-albite-aegirine veinlets and in albitites in syenites (Dara-i-Pioz massif, Tajikistan).

Association: Nenadkevichite, analcime, aegirine (Mont Saint-Hilaire, Canada); arfvedsonite, astrophyllite, catapleiite, eudialyte, sérandite, villiaumite (Rouma Isle, Guinea); baratovite, miserite, titanite (Dara-i-Pioz massif, Tajikistan).

Distribution: From Mont Saint-Hilaire, Quebec, Canada. On Rouma Isle, Los Islands, Guinea. In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan.

Name: For Harold R. Steacy, formerly Curator of the National Mineral Collection, Geological Survey of Canada, Ottawa, Canada.

Type Material: École Polytechnique, Montreal, 12480; Canadian Geological Survey, Ottawa, 61529; Canadian Museum of Nature, Ottawa, Canada; National Museum of Natural History, Washington, D.C., USA, 149820; The Natural History Museum, London, England, 1970,168.

References: (1) Perrault, G. and J.T. Szymański (1982) Steacyite, a new name, and a re-evaluation of the nomenclature of "ekanite"-group minerals. Can. Mineral., 20, 59–63. (2) (1983) Amer. Mineral., 68, 472 (abs. ref. 1). (3) Richard, P. and G. Perrault (1972) Structure cristalline de l'ekanite [steacyite] de St-Hilaire, P.Q. Acta Cryst., 28, 1994–1999 (in French). (4) Parodi, G.C. and G. Della Ventura (1987) Steacyite from the Rouma Isle (Los Islands, Republic of Guinea). Neues Jahrb. Mineral., Monatsh., 233–239. (5) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 188–189.

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Steedeite $NaMn_2[Si_3BO_9](OH)_2$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Crystals are acicular and elongated along [001] to 0.5 mm, and exhibiting dominant {100} with minor {010} and {001}; also as nest-like aggregates. Weak pale green to pale yellow fluorescence under medium-wave radiation.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.106

Optical Properties: Transparent to translucent. *Color*: Colorless to pale pink. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (n.d.). Positive elongation. n = 1.636(2) to 1.656(2) *Pleochroism*: None.

Cell Data: *Space Group*: $P\bar{1}$. a = 6.837(1) b = 7.575(2) c = 8.841(2) α = 99.91(3)° β = 102.19° γ = 102.78(3)° Z = 2

X-ray Powder Pattern: Poudrette quarry, Mont Saint-Hilaire, Québec, Canada.
8.454 (100), 3.331 (83), 2.823 (80), 2.859 (52), 7.234 (39), 3.081 (38), 2.169 (25)

Chemistry:

	(1)	(2)
Na_2O	7.51	7.63
CaO	0.17	
MnO	31.02	34.95
FeO	0.86	
SiO_2	46.34	44.40
S	0.39	
B_2O_3	[8.73]	8.58
H_2O	[4.52]	4.44
Total	99.53	100.00

(1) Poudrette quarry, Mont Saint-Hilaire, Québec, Canada; average of 14 electron microprobe analyses, B and H_2O calculated and their presence confirmed by crystal structure refinement and Raman spectroscopy; corresponding to $Na_{0.97}(Mn_{1.75}Fe_{0.05}Ca_{0.01})_{\Sigma=1.81}(Si_{3.07}S_{0.02})_{\Sigma=3.09}BO_9(OH)_2$.
(2) $NaMn_2[Si_3BO_9](OH)_2$.

Occurrence: Precipitated in vugs in altered sodalite syenite by late-stage aqueous fluids, presumably highly alkaline due to the presence of natrite.

Association: Microcline, analcime, nepheline, aegirine, pyrrhotite, sodalite, eudialyte-group minerals, natron, catapleiite.

Distribution: From the Poudrette quarry, Mont Saint-Hilaire, La Vallée-du-Richelieu, Montérégie (formerly Rouville County), Québec, Canada.

Name: Honors Anthony Hosford Steede (b. 1940) in recognition of his contributions to the understanding of the mineralogy of Mont Saint-Hilaire.

Type Material: Department of Natural History, Royal Ontario Museum, Toronto, Ontario, Canada (M56489).

References: (1) Haring, M.M.M. and A.M. McDonald (2014) Steedeite, $NaMn_2[Si_3BO_9](OH)_2$: Characterization, crystal-structure determination, and origin. Can. Mineral., 52, 47-60. (2) (2014) Amer. Mineral., 99, 2442-2443 (abs. ref. 1).

Steenstrupine-(Ce)

$Na_{14}Ce_6Mn^{2+}Mn^{3+}Fe_2^{3+}(Zr,Th)(Si_6O_{18})_2(PO_4)_7(OH)_2 \cdot 3H_2O$

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Crystal Data: Hexagonal; commonly metamict. *Point Group:* $\bar{3}\,2/m$. Rhombohedral crystals, rounded and rough, to 10 cm; massive.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4–5 D(meas.) = 3.38–3.47. D(calc.) = [3.63] Radioactive.

Optical Properties: Opaque. *Color:* Brownish red to black. *Streak:* Brownish, nearly white. *Luster:* Dull.
Optical Class: Uniaxial (–). *Pleochroism:* Weak, in brown and yellow tints. $\omega = 1.665–1.667$ $\epsilon = 1.662–1.663$

Cell Data: *Space Group:* $R\bar{3}m$. $a = 10.460(4)$ $c = 45.479(15)$ $Z = 3$

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
3.27 (10), 2.60 (9), 3.17 (8), 2.74 (8), 15.14 (6), 3.04 (5), 2.88 (5)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	26.72	22.95	MnO	6.60	2.26
ZrO_2		3.92	MgO	0.31	
ThO_2	2.13		CaO	2.33	
Y_2O_3	0.36		Na_2O	11.23	13.81
$(Ce,La)_2O_3$	29.60	31.36	H_2O	3.45	2.29
Fe_2O_3	2.67	5.08	P_2O_5	8.19	15.82
Mn_2O_3		2.51	F	1.24	
Nb_2O_5	4.37		$-O = F_2$	0.52	
			Total	98.68	100.00

(1) Julianehåb, Greenland. (2) $Na_{14}Ce_6Mn^{2+}Mn^{3+}Fe_2^{3+}Zr(Si_6O_{18})_2(PO_4)_7(OH)_2 \cdot 3H_2O$.

Occurrence: In ultra-agpaitic pegmatites of nepheline-sodalite syenites and syenites.

Association: Lepidolite, aegirine, murmanite, ussingite, natrolite, nordite, nepheline, sodalite.

Distribution: From the Kangerdluarssuk Plateau and elsewhere in the Ilímaussaq intrusion, southern Greenland. In the Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For Knud Johannes Vogelius Steenstrup (1842–1913), Danish geologist of Copenhagen, Denmark.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1881.1070.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 415.
(2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 321–324. (3) Makovicky, E. and S. Karup-Møller (1981) Crystalline steenstrupine from Tunugdliarfik in the Ilímaussaq alkaline intrusion, South Greenland. Neues Jahrb. Mineral., Abh., 140, 300–330. (4) Moore, P.B. and J. Shen (1983) Crystal structure of steenstrupine: a rod structure of unusual complexity. Tschermaks Mineral. Petrog. Mitt., 31, 47–67.

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Steigerite $AlVO_4 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. Cryptocrystalline fibrous, may be flat platy {010}, to < 1 μm; gumlike to compact massive, typically as coatings.

Physical Properties: *Cleavage:* Perfect on {010}; fair on {100} and {100}.
Tenacity: Pulverulent. Hardness = 2.5–3 D(meas.) = 2.52–2.58 D(calc.) = 2.58

Optical Properties: Semitransparent. *Color:* Canary-yellow, greenish yellow, olive-green.
Luster: Waxy in compact aggregates.
Optical Class: Biaxial (+). α = 1.720–1.730 β = 1.730–1.734 γ = 1.748–1.752
2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 11.840$ $b = 25.00$ $c = 11.040$
$\beta = 111°10'$ Z = 24

X-ray Powder Pattern: Kara-Tau Mountains, Kazakhstan.
2.93 (10), 12.52 (5), 2.18 (5), 1.897 (5), 1.758 (5), 3.09 (4), 2.21 (4)

Chemistry:

	(1)	(2)	(3)
SO_3		0.66	
P_2O_5		4.91	
V_2O_5	44.44	39.00	46.41
SiO_2		0.28	
Al_2O_3	25.14	26.00	26.01
Fe_2O_3	1.50	0.90	
Cr_2O_3		0.95	
CaO		1.20	
H_2O^+	21.04	19.30	
H_2O^-	8.08	6.90	
H_2O			27.58
Total	100.20	100.10	100.00

(1) Gypsum Valley, Colorado, USA. (2) Kara-Tau Mountains, Kazakhstan. (3) $Al(VO_4) \cdot 3H_2O$.

Occurrence: In U–V deposits impregnating sandstone (Gypsum Valley, Colorado, USA); a weathering product in vanadium-rich schists (Kara-Tau Mountains, Kazakhstan).

Association: Fervanite, corvusite, gypsum (Gypsum Valley, Colorado, USA); navajoite, tyuyamunite, rauvite, hewettite (Monument No. 2 mine, Arizona, USA); vanalite, hewettite, delvauxite, satpaevite, gypsum, vashegyite, variscite, halloysite, alunite (Kara-Tau Mountains, Kazakhstan).

Distribution: In the USA, from the Sullivan Brothers and adjacent Ponto No. 3 claims, Gypsum Valley, San Miguel Co.; in the Fox mine, Atkinson Mesa, Uravan district, Montrose Co., Colorado; on the Cactus Rat claims, Thompsons district, Grand Co., Utah; at the Monument No. 2 mine, Monument Valley, Apache Co., Arizona. In several mines of the Kurumsak and Balasauskandyk districts, northwestern Kara-Tau Mountains, Kazakhstan.

Name: Honoring Dr. George Steiger (1869–1944), Chief Chemist, U.S. Geological Survey, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, C5108.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1049–1050. (2) Ankinovich, E.A., F.A. Kurmakaeva, and I.S. Zazubina (1987) Steigerite and vanalite from carbonaceous-siliceous vanadium-bearing formations of northwestern Kara-Tau (southern Kazakhstan). Zap. Vses. Mineral. Obshch., 116, 100–113 (in Russian with English abs.).

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Steklite $KAl(SO_4)_2$

Crystal Data: Hexagonal. *Point Group*: 32. As hexagonal or irregularly shaped crystals, platy on (001), to 1 mm. Crystals often split and combined in open aggregates or thin crusts.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. *Fracture:* n.d.
Hardness = 2.5 D(meas.) = n.d. D(calc.) = 2.797

Optical Properties: Transparent. *Color:* Colorless, white to grayish-white in aggregates.
Streak: White. *Luster:* Vitreous.
Optical Class: Uniaxial (-). ω = 1.546(2) ε = 1.533(3) *Pleochroism:* None.

Cell Data: Space Group: *P*321. a = 4.7281(3) c = 7.9936(5) Z = 1

X-ray Powder Pattern: Tolbachik volcano, Kamchatka, Russia.
3.649 (100), 2.861 (51), 8.02 (34), 2.364 (25), 2.660 (19), 2.267 (14), 1.822 (12), 4.085 (11)

Chemistry:

	(1)
Na_2O	0.09
K_2O	18.12
CaO	0.08
MnO	0.03
Fe_2O_3	2.02
Al_2O_3	18.18
SO_3	61.80
Total	100.37

(1) Tolbachik volcano, Kamchatka, Russia; average of 5 electron microprobe analyses, corresponds to $(K_{0.997}Na_{0.008}Ca_{0.004})_{\Sigma=1.009}(Al_{0.925}\ Fe^{3+}_{0.066}Mg_{0.003}Mn_{0.001})_{\Sigma=0\ 995}S_{2.001}O_8$.

Occurrence: A volcanic sublimate formed at 150-170 °C as part of sulfate crusts around an active fumarole. Also described as a sublimate near burning coal deposits.

Association: Alumoklyuchevskite, langbeinite, euchlorine, fedotovite, chalcocyanite, hematite, kamchatkite, atlasovite, melanothallite, tenorite, avdoninite, belloite, ziesite, Cu-lyonsite (Tolbackhik, Russia).

Distribution: From the Second scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption (1975–1976), Tolbachik volcano, Kamchatka, and the dumps of coal mine N 47 near Kopeisk, South Urals, Russia. At Showashinzan volcano, Hokkaido, Japan. From Izalco volcano, El Salvador and Santiaguit volcano, Guatemala. From burning anthracite coal deposits Eastern Pennsylvania, USA.

Name: From the Russian word *стекло* (*steklo*) for *glass* as an allusion to the visual appearance of aggregates of the mineral formed around vents of a burning coal heap (coal mine N 47 near Kopeisk, South Urals, Russia).

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; 4109/1.

References: (1) Murashko, M.N., I.V. Pekov, S.V. Krivovichev, A.P. Chern-yatyeva, V.O. Yapaskurt, A.E. Zadov, and M.E. Zelensky (2012) Steklite, $KAl(SO_4)_2$: the find at Tolbachik volcano (Kamchatka, Russia), validation as a mineral species and crystal structure. Zap. Ross. Mineral. Obshch., 141(4), 36-44 (in Russian, English abstract). (2) (2013) Amer. Mineral., 98, 2203-2204 (abs. ref. 1 and additional references).

Stellerite **$CaAl_2Si_7O_{18}\cdot 7H_2O$**

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Single crystals show the forms {100}, {010}, {001}, and {111}. Commonly in spheres, to 12 cm, of radiating crystals; as crystal aggregates.

Physical Properties: *Cleavage:* {010}, perfect. Hardness = n.d. D(meas.) = 2.13(1) D(calc.) = 2.12

Optical Properties: Transparent. *Color:* Colorless to white; in transmitted light, colorless. *Optical Class:* Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.4848(5)$ $\beta = 1.4964(5)$ $\gamma = 1.4979(5)$ $2V(meas.) = 47(2)^\circ$ $2V(calc.) = 39(8)^\circ$

Cell Data: *Space Group: Fmmm.* $a = 13.599(4)$ $b = 18.222(4)$ $c = 17.863(3)$ $Z = [8]$

X-ray Powder Pattern: Villanova Monteleone, Sardinia, Italy; cannot be distinguished from barrerite.
9.03 (100), 4.057 (45), 3.028 (23), 4.655 (15), 3.003 (10), 2.771 (8), 3.397 (7)

Chemistry:

	(1)		(1)
SiO_2	59.15	SrO	0.05
Al_2O_3	14.21	BaO	0.02
Fe_2O_3	0.17	Na_2O	0.19
MnO	trace	K_2O	0.23
MgO	0.04	H_2O	17.79
CaO	7.45	Total	99.30

(1) Villanova Monteleone, Sardinia, Italy; corresponds to $(Ca_{0.94}Na_{0.04}K_{0.04}Mg_{0.01})_{\Sigma=1.03}(Al_{1.98}Fe_{0.02})_{\Sigma=2.00}Si_{7.00}O_{18}\cdot 7.02H_2O$.

Mineral Group: Zeolite group.

Occurrence: Lines cavities and fracture surfaces in volcanic rocks altered by hydrothermal solutions.

Association: Zeolites, prehnite, tridymite.

Distribution: Increasingly recognized from localities worldwide; only a few of the best confirmed of these can be given. On Copper Island, Komandorskiye (Commander) Islands, Bering Sea, and at Klichka, Chita region, Siberia, Russia. Fine examples in the Sarbayskaya quarry, near Rudniy, Kazakhstan. From Villanova Monteleone, Alghero, Sardinia, Italy. At Kongsberg, Norway. In the USA, at Ritter Hot Springs, Grant Co., Oregon; on Hook Mountain, Rockland Co., New York; and at Fanwood, Somerset Co., New Jersey. In Australia, large crystals from around Gunnedah, New South Wales, and at Harcourt, Dookie, and Corop, Victoria. Exceptional examples from Cinchwad, Poona, and in the Nasik district, Maharashtra, India.

Name: For Georg Wilhelm Steller (1709–1746), discoverer of the Komandorskiye (Commander) Islands, Russia.

Type Material: The Natural History Museum, London, England, 1934,650.

References: (1) Morozewicz, J.A. (1909) Über Stellerit, ein neues Zeolithmineral. Bull. Intern. Acad. Sci. Cracovie, part 2, 344–359 (in German). (2) Erd, R.C., G.D. Eberlein, and A. Pabst (1967) Stellerite: a valid orthorhombic end member of a continuous series with monoclinic stilbite. Geol. Soc. Amer. Annual Meeting Abs. with Prog., 58–59 (abs.). (3) (1968) Amer. Mineral., 53, 511 (abs. ref. 2). (4) Galli, E. and E. Passaglia (1973) Stellerite from Villanova Monteleone, Sardinia. Lithos, 6, 83–90. (5) Galli, E. and A. Alberti (1975) The crystal structure of stellerite. Bull. Minéral., 98, 11–18. (6) Passaglia, E., E. Galli, L. Leonardo, and G. Rossi (1978) The crystal chemistry of stilbites and stellerites. Bull. Minéral., 101, 368–375.

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Stenhuggarite $CaFe^{3+}Sb^{3+}As_2^{3+}O_7$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As equant pseudo-octahedral crystals, to 3 mm, showing {100}, {211}, and {301}.

Physical Properties: *Fracture:* Conchoidal. Hardness = > 4 D(meas.) = 4.63(5) D(calc.) = 4.56

Optical Properties: Transparent to translucent. *Color:* Bright reddish orange. *Streak:* Bright yellow.
Optical Class: Uniaxial, nearly isotropic. *Absorption:* Strong. $n = > 2.0$, low birefringence.

Cell Data: *Space Group:* $I4_1/amd$. $a = 16.144(3)$ $c = 10.706(2)$ $Z = 16$

X-ray Powder Pattern: Långban, Sweden.
2.985 (10), 1.8450 (4), 2.548 (3.5), 1.5440 (3.5), 5.92 (3), 1.1963 (2.5), 8.00 (2)

Chemistry:

	(1)
As	31.3
Sb	24.5
Fe	11.0
Ca	8.1
O	[25.1]
Total	[100.0]

(1) Långban, Sweden; by electron microprobe, O by difference; corresponds to $Ca_{1.00}Fe_{0.98}Sb_{1.00}As_{2.06}O_{7.76}$.

Occurrence: Very rare in hematite ore from a metamorphosed Fe–Mn orebody.

Association: Hematite.

Distribution: From Långban, Värmland, Sweden.

Name: From the Swedish for *stonemason*, in honor of Dr. Brian Harold Mason (1917–), U.S. National Museum, Washington, D.C., USA, for his contributions to the mineralogy of the Långban deposit.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; The Natural History Museum, London, England, 1969,117; National Museum of Natural History, Washington, D.C., USA, 120066.

References: (1) Moore, P.B. (1970) Stenhuggarite, a new mineral from Långban and new data on magnussonite. Arkiv Mineral. Geol., 5(6), 55–62. (2) (1971) Amer. Mineral., 56, 636–637 (abs. ref. 1). (3) Coda, A., A. Dal Negro, C. Sabelli, and V. Tazzoli (1977) The crystal structure of stenhuggarite. Acta Cryst., 33, 1807–1811.

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Stenonite $(Sr, Ba, Na)_2Al(CO_3)F_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Cleavable, massive, to 4 cm.

Physical Properties: *Cleavage:* On {001}, {120}, good. Hardness = ∼3.5
D(meas.) = 3.86(7) D(calc.) = 3.847

Optical Properties: Transparent to translucent. *Color:* White, colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = -32°$. $\alpha = 1.452$ $\beta = 1.527$ $\gamma = 1.538$ 2V(meas.) = 43°

Cell Data: *Space Group:* $P2_1/n$. $a = 5.450(2)$ $b = 8.704(2)$ $c = 13.050(3)$ $\beta = 98.72(2)°$ Z = 4

X-ray Powder Pattern: Ivigtut, Greenland.
6.97 (s), 1.706 (s), 2.158 (ms), 2.291 (m), 1.747 (m), 1.645 (m), 1.590 (m)

Chemistry:

	(1)	(2)
CO_2	16.00	16.80
Al	7.73	7.55
Ca	0.01	
Sr	47.08	49.06
Ba	1.09	
Na	0.58	
F	27.13	26.59
H_2O	n.d.	
Total	99.62	100.00

(1) Ivigtut, Greenland; estimated to contain jarlite 3%. (2) $(Sr, Ba, Na)_2Al(CO_3)F_5$.

Occurrence: A rare mineral in the contact zone between siderite–cryolite and fluorite-rich rocks.

Association: Jarlite, weberite, jørgensonite, thomsenolite, gearksutite, topaz, muscovite, barite, pyrite, siderite, quartz.

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland.

Name: Honors Nicholaus Stenonis (Steno) (1638–1686), Danish scientist, who determined the constancy of interfacial angles of crystals.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1965.16–1965.22, 1981.1016–1981.1018, 1981.1021, 1981.1060. Natural History Museum, Paris, France,; The Natural History Museum, London, England, 1966,536.

References: (1) Pauly, H. (1962) Stenonite, a new carbonate-fluoride from Ivigtut, South Greenland. Medd. Grønland, 169(9), 1–24. (2) (1963) Amer. Mineral., 48, 1178 (abs. ref. 1). (3) Hawthorne, F.C. (1984) The crystal structure of stenonite and the classification of the aluminofluoride minerals. Can. Mineral., 22, 245–251.

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Stepanovite **$NaMgFe^{3+}(C_2O_4)_3 \cdot 8-9H_2O$**

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Crystal Data: Hexagonal. *Point Group:* n.d. Forms exhibited are {0001}, {11$\bar{2}$0}, {01$\bar{1}$2}, {10$\bar{1}$4}, {5$\bar{1}$42} [*sic*]; xenomorphic granular.

Physical Properties: *Fracture:* Irregular. Hardness = 2 D(meas.) = 1.69 D(calc.) = 1.69 Easily soluble in H_2O.

Optical Properties: Transparent. *Color:* Green. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellow-green; E = colorless. $\omega = 1.515$ $\epsilon = 1.417$

Cell Data: *Space Group:* n.d. $a = 9.28$ $c = 36.67$ Z = 6

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
C_2O_4	50.36	50.75
Al	0.00	
Fe^{3+}	10.78	10.73
Fe^{2+}	0.00	
Mg	4.68	4.67
Na	4.48	4.42
K	0.00	
H_2O	29.73	29.43
Total	100.03	100.00

(1) Tyllakh deposit, Russia. (2) $NaMgFe^{3+}(C_2O_4)_3 \cdot 8.5H_2O$.

Occurrence: In thin veinlets in coal.

Association: Calcite, dolomite, whewellite, weddellite.

Distribution: From the Tyllakh brown coal deposit, left bank of the Olenhinskii channel near its mouth, estuary of the Lena River, Bulun district, polar Sakha, Russia.

Name: To honor Pavel Ivanovich Stepanov (1880–1947), Russian specialist in coal geology.

Type Material: Mining Institute, St. Petersburg, Russia, 1659/1.

References: (1) Nefedov, Y.I. (1953) [Report on new minerals] in: V.A. Mokievsky, The scientific session of the Federov Institute together with the All-Union Mineralogical Society. Zap. Vses. Mineral. Obshch., 82, 311–317 (in Russian). (2) (1955) Amer. Mineral., 40, 551 (abs. ref. 1). (3) Knipovich, Y.N., A.I. Komkov, and E.I. Nefedov (1963) On stepanovite and the new mineral zhemchuzhnikovite. Trudy. Vses. Nauchno-Issled. Geol. Inst. 96, 131–135 (in Russian). (4) (1964) Amer. Mineral., 49, 442 (abs. ref. 3). (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 194.

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals short prismatic to tabular [001], to 6 cm, also elongated along [100], with {110} striated parallel to $[1\bar{1}4]$; massive, compact and disseminated. *Twinning:* On {110}, commonly repeated to form pseudohexagonal groups; less common on {130}, {100} and {010}, with composition plane {001}.

Physical Properties: *Cleavage:* Imperfect on {010} and {021}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 2–2.5 VHN = n.d. D(meas.) = 6.26 D(calc.) = 6.28–6.32

Optical Properties: Opaque. *Color:* Iron-black; in polished section, pale gray. *Streak:* Iron-black. *Luster:* Metallic. *Pleochroism:* Very weak; white to pale pink. *Anisotropism:* Strong, in vivid colors.
R_1–R_2: (400) 32.0–33.0, (420) 32.1–33.2, (440) 32.2–33.4, (460) 31.5–33.2, (480) 30.7–32.6, (500) 30.0–32.0, (520) 29.0–31.3, (540) 28.4–30.6, (560) 28.0–30.2, (580) 27.6–29.8, (600) 27.5–29.6, (620) 27.6–29.6, (640) 27.8–29.5, (660) 28.0–29.2, (680) 28.5–28.7, (700) 28.2–28.2

Cell Data: *Space Group:* $Cmc2_1$. a = 7.830–7.837 b = 12.450–12.467 c = 8.538
Z = 4

X-ray Powder Pattern: Freiberg, Germany.
3.08 (100), 2.58 (90), 2.89 (60), 2.13 (50), 2.19 (40), 1.834 (40), 3.56 (30)

Chemistry:

	(1)	(2)	(3)
Ag	68.65	68.21	68.33
Sb	15.22	15.86	15.42
S	16.02	15.95	16.25
Total	99.89	100.02	100.00

(1) Copiapó, Chile; traces of As and Cu. (2) Cornwall, England; trace of Fe. (3) Ag_5SbS_4.

Occurrence: A late-stage mineral in hydrothermal silver deposits.

Association: Proustite, acanthite, silver, tetrahedrite, galena, sphalerite, pyrite.

Distribution: From many silver mining localities, typically in small amounts, and only rarely in fine specimens. In Germany, at Freiberg [TL], Schneeberg, and Marienberg, Saxony; and as exceptional crystals from St. Andreasberg, Harz Mountains. In Slovakia, at Banská Hodruša and from Banská Štiavnica (Schemnitz). In the Czech Republic, at Jáchymov (Joachimsthal), Příbram, and Třebsko. In Italy, fine twins from Monte Narba, near Sarrabus, Sardinia. In England, as twinned crystals from Wheal Boys, St. Endellion, Cornwall. At Espedalen, Norway. From Azegour, Morocco. At Altyn-Topkan, Tadjikistan. In Canada, in the Cobalt district, Ontario; at United Keno Hill Mines, and fine examples from the Husky mine, Elsa, Yukon Territory. In the USA, in Nevada, as an important ore mineral in the Comstock Lode, Virginia City, Storey Co. In Mexico, large crystals from Arizpe, Sonora; at Guanajuato; from Fresnillo, Zacatecas. At Chañarcillo, south of Copiapó, Atacama, Chile. In Bolivia, from Colquechaca, Potosí. At San Cristobal, Peru. From Broken Hill, New South Wales, Australia.

Name: In honor of the Archduke Victor Stephan (1817–1867), former Mining Director of Austria.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 358–361. (2) Petrunina, A.A., B.A. Maksimov, V.V. Ilyukhin, and N.V. Belov (1969) Crystal structure of stephanite. Doklady Acad. Nauk SSSR, 188, 342–344 (in Russian). (3) Ribár, B. and W. Nowacki (1970) Die Kristallstruktur von Stephanit, $[SbS_3|S|Ag_5^{III}]$. Acta Cryst., 26, 201–207 (in German). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 122–123. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 535.
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Stercorite $(NH_4)Na(PO_3OH)\cdot 4H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. Crystalline, nodular and massive. *Twinning:* Common on {010}.

Physical Properties: Hardness = 2 D(meas.) = 1.574 (synthetic). D(calc.) = 1.570 Soluble in H_2O.

Optical Properties: Transparent. *Color:* White to yellowish and brownish; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* Z $\simeq \perp$ {001}; OAP $\simeq \perp$ {010}. *Dispersion:* $r > v$, rather strong. $\alpha = 1.439$ $\beta = 1.442$ $\gamma = 1.469$ 2V(meas.) = 35°34′

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.636(2)$ $b = 6.9187(14)$ $c = 6.4359(13)$ $\alpha = 90.46(3)°$ $\beta = 97.87(3)°$ $\gamma = 109.20(3)°$ Z = 2

X-ray Powder Pattern: Synthetic. (ICDD 24-1048).
6.53 (100), 9.93 (95), 4.24 (55), 2.911 (50), 2.884 (50), 4.77 (40), 3.658 (40)

Chemistry:

	(1)	(2)	(3)
P_2O_5	34.33	34.54	33.95
Na_2O	15.75	14.50	14.82
$(NH_4)_2O$	7.68	8.48	12.45
H_2O	42.24	42.48	38.78
Total	100.00	100.00	100.00

(1) Ichaboe Island, Namibia. (2) Guañape Island, Peru. (3) $(NH_4)Na(PO_3OH)\cdot 4H_2O$.

Occurrence: In bird and bat guano deposits.

Association: Struvite (Ichaboe Island, Namibia); archerite, biphosphammite (Petrogale Cave, Western Australia).

Distribution: On Ichaboe Island, northwest of Lüderitz, Namibia. From Guañape Island, south of Trujillo, Peru. In Petrogale Cave, near Madura, Western Australia.

Name: From the Latin for *dung*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 698–699. (2) Ferraris, G. and M. Franchini-Angela (1974) Hydrogen bonding in the crystalline state: crystal structure and twinning of $NaNH_4HPO_4\cdot 4H_2O$ (stercorite). Acta Cryst., 30, 504–510.

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Sterlinghillite $Mn_3^{2+}(AsO_4)_2 \cdot 4H_2O$

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Crystal Data: n.d. *Point Group:* n.d. As bundles and hemispherical clusters of lathlike to platy crystals, to 0.1 mm.

Physical Properties: *Cleavage:* One, perfect, parallel to elongation. Hardness = 3
D(meas.) = 2.95 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White to light pink. *Streak:* White.
Luster: Dull to silky.
Optical Class: Biaxial. *Orientation:* Inclined extinction, wavy. $\alpha = 1.656(3)$ β = n.d.
$\gamma = 1.671(3)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
11.12 (100), 3.209 (100), 2.751 (60), 2.880 (40), 2.848 (40), 6.39 (30), 3.692 (30)

Chemistry:

	(1)	(2)
As_2O_5	44.7	44.65
FeO	0.2	
MnO	39.5	41.35
ZnO	2.9	
MgO	0.1	
H_2O	[12.6]	14.00
Total	[100.0]	100.00

(1) Sterling Hill, New Jersey, USA; by electron microprobe, total Mn as MnO, H_2O by difference.
(2) $Mn_3(AsO_4)_2 \cdot 4H_2O$.

Occurrence: A very rare mineral in seams in franklinite ore from a metamorphosed stratiform zinc orebody.

Association: Franklinite, sphalerite, löllingite, calcite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For the Sterling Hill mine, New Jersey, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 147269.

References: (1) Dunn, P.J. (1981) Sterlinghillite, a new hydrated manganese arsenate mineral from Ogdensburg, New Jersey. Amer. Mineral., 66, 182–184.

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Sternbergite $AgFe_2S_3$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are thin pseudohexagonal basal plates, to 0.6 cm, striated on {001} ‖ [100], also ‖ [010]; forming rosettes and fanlike aggregates. *Twinning:* On {130}, lamellar.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Thin lamellae are flexible, foil-like. Hardness = 1–1.5 VHN = 31–44 (50 g load). D(meas.) = 4.101–4.215 D(calc.) = 4.275

Optical Properties: Opaque. *Color:* Pinchbeck-brown, may tarnish blue-violet on selected faces; in reflected light, pale brown. *Streak:* Black. *Luster:* Metallic, brilliant on {001}. *Pleochroism:* Distinct, in browns. *Anisotropism:* Strong; bluish and reddish to lilac, reddish brown to pale green with purplish pink shades.

R_1–R_2: (400) 18.2–30.1, (420) 19.0–31.0, (440) 19.8–32.0, (460) 20.6–33.1, (480) 21.6–34.0, (500) 22.4–34.9, (520) 23.2–35.7, (540) 23.9–36.4, (560) 24.5–37.0, (580) 25.2–37.5, (600) 26.0–38.0, (620) 26.7–38.2, (640) 27.3–38.3, (660) 27.7–38.2, (680) 28.0–38.1, (700) 28.1–37.9

Cell Data: *Space Group: Ccmb.* $a = 6.615(2)$ $b = 11.639(4)$ $c = 12.693(4)$ Z = 8

X-ray Powder Pattern: Měděnec, Czech Republic.
5.780 (10), 2.785 (7), 3.226 (6), 2.616 (5), 4.281 (3), 1.938 (3), 1.893 (3)

Chemistry:

	(1)	(2)
Ag	35.27	34.17
Fe	35.97	35.37
S	29.10	30.46
Total	100.34	100.00

(1) Jáchymov, Czech Republic. (2) $AgFe_2S_3$.

Polymorphism & Series: Dimorphous with argentopyrite.

Occurrence: In hydrothermal veins with other silver sulfosalt minerals and in Co–Ni–Ag sulfide assemblages.

Association: Stephanite, acanthite, proustite, pyrargyrite, argentopyrite, xanthoconite, pyrite, galena, sphalerite, dolomite, calcite, quartz.

Distribution: In the Czech Republic, from Jáchymov (Joachimsthal) [TL], at Příbram, and in the Krušné hory Mountains, at Měděnec. In Germany, from Johanngeorgenstadt, Freiberg, Marienberg, and Schneeberg, Saxony, and at St. Andreasberg, Harz Mountains. From the Ruen Pb–Zn deposit, Osogovo region, Bulgaria. At Hiendelaencina, Guadalajara Province, Spain. From the Akersberg mine, Oslo, Norway. In the USA, in Arizona, in the Leroy mine, Dos Cabezas Mountains, Cochise Co. At the Highland Bell mine, Beaverdell, British Columbia, Canada. From the Kamikita mine, Aomori Prefecture, Japan.

Name: To honor Caspar Maria Sternberg (1761–1838), Czech botanist, of the National Museum in Prague, Czech Republic.

Type Material: National Museum, Prague, Czech Republic.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 246–248. (2) Czamanske, G.K. and R.R. Larsen (1969) The chemical

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identity and formula of artgentopyrite and sternbergite. Amer. Mineral., 54, 1198–1201. (3) Šrein, V., T. Řídkošil, P. Kašpar, and J. Šourek (1986) Argentopyrite and sternbergite from polymetallic veins of the skarn deposit Měděnec, Krušné hory Mts., Czechoslovakia. Neues Jahrb. Mineral., Abh., 154, 207–222. (4) Pertlik, F. (1987) Crystal structure of sternbergite. Neues Jahrb. Mineral., Monatsh., 458–464. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 628–630. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 536.

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Sterryite $Ag_2Pb_{10}(Sb, As)_{12}S_{29}$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ or $2/m\ 2/m\ 2/m$. Plumose and as bundles of fibers elongate ‖ [001], to 1 mm, also as anhedral grains. *Twinning:* Very fine twin lamellae rarely seen in polished section.

Physical Properties: *Cleavage:* Perfect on {$hk0$}. Hardness = ∼3.5 VHN = n.d. D(meas.) = n.d. D(calc.) = 5.91

Optical Properties: Opaque. *Color:* Black; in polished section, white. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Strong, from gray to white.

R_1–R_2: (470) 37.6–40.4, (546) 36.0–38.7, (589) 35.1–37.7, (650) 33.9–36.3

Cell Data: *Space Group:* *Pba*2 or *Pbam* (pseudocell). $a = 28.4(5)$ $b = 42.6(6)$ $c = 8.20(5)$ $Z = 4$

X-ray Powder Pattern: Madoc, Canada.
3.26 (100), 3.68 (90), 2.836 (70), 3.54 (60), 2.965 (60), 4.14 (50), 3.94 (50)

Chemistry:

	(1)
Ag	3.39
Cu	0.86
Pb	45.43
Sb	22.63
As	6.18
S	20.76
Total	99.25

(1) Madoc, Canada; by electron microprobe, average of 14 analyses; corresponding to $(Ag_{1.41}Cu_{0.61})_{\Sigma=2.02}Pb_{9.82}(Sb_{8.33}As_{3.70})_{\Sigma=12.03}S_{29.00}$.

Occurrence: Of hydrothermal origin, in marble.

Association: Veenite, guettardite.

Distribution: From near Madoc, Ontario, Canada [TL].

Name: To honor Thomas Sterry Hunt (1826–1892), first mineralogist with the Geological Survey of Canada, Ottawa, Canada.

Type Material: Canadian Geological Survey, Ottawa, 12169; Royal Ontario Museum, Toronto, Canada; National Museum of Natural History, Washington, D.C., USA, 160258.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Ontario. Part 2 – mineral descriptions. Can. Mineral., 9, 191–213. (2) (1968) Amer. Mineral., 53, 1423 (abs. ref. 1). (3) Jambor, J.L., J.H.G. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100.

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Stetefeldtite $Ag_2Sb_2(O,OH)_7(?)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Powdery, massive.

Physical Properties: Hardness = 3.5–4.5 D(meas.) = 4.6 D(calc.) = [4.58]

Optical Properties: Semitransparent. *Color:* Yellow, black to brown when admixed with impurities; pale yellow in transmitted light. *Streak:* Pale yellow, shining.
Optical Class: Isotropic. $n = 1.95$

Cell Data: *Space Group:* $Fd3m$. a = 10.46 Z = 8

X-ray Powder Pattern: Belmont, Nevada, USA.
3.02 (100), 2.61 (70), 1.85 (70), 1.58 (70), 1.20 (50), 0.884 (50), 1.17 (40)

Chemistry:

	(1)
Sb_2O_4	43.77
Ag	23.74
Cu	12.78
Fe	1.82
S	4.7
H_2O	7.9
Total	94.71

(1) Belmont, Nevada, USA; average of two analyses; assuming Cu, Fe, and S are contained in admixed chalcocite and pyrite, then corresponds to $Ag_{1.1}Sb_{1.4}(O,OH,H_2O)_{6.3}$.

Mineral Group: Stibiconite group.

Occurrence: Apparently an alteration product in the oxidized zone of some hydrothermal Ag–Sb-bearing mineral deposits, where it may constitute an ore of silver.

Association: Chalcocite, pyrite, quartz (Belmont, Nevada, USA).

Distribution: In the USA, in Nevada, in the Empire and Philadelphia districts, Belmont, 80 km northeast of Tonopah, Nye Co., and in the Black Warrior mine, near Silver Peak, Esmeralda Co.; in Arizona, at the Snyder Hill mine, Tucson Mountains, Pima Co., in the Johnny Lyon Hills, Cochise Co., and from the Red Cloud mine, Silver District, La Paz Co.

Name: To honor Carl August Stetefeldt (1838–1896), German-American mining engineer and metallurgist.

Type Material: Location of original type material is unknown; restudied on Harvard University, Cambridge, Massachusetts, 80285; National Museum of Natural History, Washington, D.C., USA, 104763.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 598 [stetefeldite]. (2) Mason, B. and C.J. Vitaliano (1953) The mineralogy of the antimony oxides and antimonates. Mineral. Mag., 30, 100–112.

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Stevensite $(Ca_{0.5}, Na)_{0.3}Mg_3Si_4O_{10}(OH)_2$

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Crystal Data: [Monoclinic] (by analogy to the smectite group). *Point Group:* n.d. Aggregates of plates, to 1 μm; massive.

Physical Properties: Hardness = 2.5 D(meas.) = 2.15–2.56 D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* Pink, buff, amber, white, gray, brown. *Luster:* Dull to resinous.
Optical Class: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Springfield, New Jersey, USA; very close to saponite.
12.5–13.0 (10), 2.55 (10), 4.54 (6), 1.520 (4), 3.17–3.20 (3), 26.5 (2)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	57.30	51.38	61.99	CaO	0.97	0.73	2.17
TiO_2		0.02		Na_2O	0.03	0.59	
Al_2O_3	0.00	0.04		K_2O	0.03	0.18	
Fe_2O_3	0.32	1.29		F	0.00		
FeO	0.00			H_2O^+	7.17	[21.85]	4.65
MnO	0.21			H_2O^-	6.69		
MgO	27.47	23.92	31.19	Total	100.19	[100.00]	100.00

(1) Springfield, New Jersey, USA. (2) Prócida Island, Italy; by electron microprobe, H_2O by difference; corresponds to $(Na_{0.09}Ca_{0.06}K_{0.02})_{\Sigma=0.17}(Mg_{2.77}Fe^{3+}_{0.08})_{\Sigma=2.85}Si_4O_{10}(OH)_2$.
(3) $(Ca/2)_{0.3}Mg_3Si_4O_{10}(OH)_2$.

Mineral Group: Smectite group.

Occurrence: In cavities in basalt, formed by late-stage hydrothermal replacement of pectolite. A hydrothermal alteration product of igneous rocks, as dunite and tuff. May form authigenically, interstratified with other species.

Association: Quartz, talc, pectolite.

Distribution: In the USA, in New Jersey, from Bergen Hill, Hudson Co., Springfield, Essex Co., Paterson, Passaic Co., and elsewhere; at Mine Creek, Bakersville, Mitchell Co., North Carolina. On Prócida Island, Italy. From Corstorphine Hill, Edinburgh, Scotland. In the Ohiri mine, Yamagata Prefecture, and the Akatani mine, Niigata Prefecture, Japan. Probably occurs at additional localities but modern confirmation required.

Name: For E.A. Stevens, founder, Stevens Institute of Technology, Hoboken, New Jersey, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R4719.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 64, 66 [talc]. (2) Faust, G.T. and K.J. Murata (1953) Stevensite, redefined as a member of the montmorillonite group. Amer. Mineral., 38, 973–987. (3) Faust G.T., J.C. Hathaway, and G. Millot (1959). A restudy of stevensite and allied minerals. Amer. Mineral., 44, 342–370. (4) Leoni, L. and F. Sartori (1983) Stevensite pseudomorphous after periclase. Neues Jahrb. Mineral., Monatsh., 556–562.

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Stewartite $Mn^{2+}Fe_2^{3+}(PO_4)_2(OH)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As acicular to thin tabular bladed crystals, with inclined terminations, to 4 mm, in bundles and tufts.

Physical Properties: Hardness = n.d. D(meas.) = 2.94 D(calc.) = 2.48

Optical Properties: Semitransparent. *Color:* Lemon-yellow, yellow to brownish yellow. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; Y = pale yellow; Z = yellow. *Orientation:* Extinction inclined on all crystal edges. *Dispersion:* $r < v$, strong. $\alpha = 1.63$ $\beta = 1.658$ $\gamma = 1.66$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.398(2)$ $b = 10.672(3)$ $c = 7.223(3)$ $\alpha = 90.10(3)^\circ$ $\beta = 109.10(2)^\circ$ $\gamma = 71.83(2)^\circ$ Z = 2

X-ray Powder Pattern: Stewart mine, California, USA.
10.04 (10), 6.73 (7), 5.035 (5), 3.925 (5), 3.03 (4), 2.60 (4), 2.489 (4)

Chemistry: (1) No analysis has been made; composition established as a polymorph of laueite.

Polymorphism & Series: Trimorphous with laueite and pseudolaueite.

Occurrence: A rare oxidation product formed by the leaching of primary phosphates in complex zoned granite pegmatites.

Association: Lithiophilite, triphylite, huréaulite, strunzite, laueite, pseudolaueite, eosphorite, rockbridgeite, strengite, diadochite, phosphosiderite, Fe–Mn oxides.

Distribution: In the USA, at the Stewart mine, Pala, San Diego Co., California; in the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., New Hampshire; at Newry, Oxford Co., Maine; from the Hesnard mine, three km southwest of Keystone, Pennington Co., and the Linwood, Tip Top, and White Elephant mines, near Custer, Custer Co., South Dakota; in the White Picacho district, Maricopa and Yavapai Cos., Arizona. At the Boqueirão pegmatite, three km southeast of Parelhas, Rio Grande do Norte, Brazil. In the Okatjimukuju pegmatite, near Karibib, Namibia. From Vilate, near Chanteloube, Haute-Vienne, France. At Sabugal, in the Mangualde pegmatite, near Mesquitela, and the Bendada pegmatite, near Guarda, Portugal. From Hagendorf, Bavaria, Germany. Other localities will undoubtedly be noted.

Name: For its originally noted occurrence at the Stewart mine, Pala, California, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 93656.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 730. (2) Murdoch, J. (1958) Phosphate minerals of the Borborema pegmatites: II–Boqueirão. Amer. Mineral., 43, 1148–1156. (3) Moore, P.B. and T. Araki (1974) Stewartite, $Mn^{2+}Fe_2^{3+}(OH)_2(H_2O)_6[PO_4]_2 \cdot 2H_2O$: its atomic arrangement. Amer. Mineral., 59, 1272–1276. (4) Moore, P.B. (1975) Laueite, pseudolaueite, stewartite and metavauxite: a study in combinatorial polymorphism. Neues Jahrb. Mineral., Abh., 123, 148–159.

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Stibarsen SbAs

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As indistinct crystals; more commonly reniform or mammillary, to 3 cm; also curved lamellar, fine granular. Typically graphically intergrown with arsenic or antimony in exsolution texture.

Physical Properties: *Cleavage:* Perfect in one direction. Hardness = 3–4 VHN = n.d. D(meas.) = 5.8–6.2 D(calc.) = 6.44

Optical Properties: Opaque. *Color:* Tin-white or reddish gray, tarnishes gray. *Streak:* Gray. *Luster:* Metallic, may be splendent, but not uncommonly dull.
R_1–R_2: (400) 64.8–67.8, (420) 65.0–68.0, (440) 65.2–68.2, (460) 64.8–67.9, (480) 64.0–67.2, (500) 63.0–66.8, (520) 62.3–66.6, (540) 61.6–66.3, (560) 61.2–66.0, (580) 60.8–65.9, (600) 60.5–65.8, (620) 60.3–65.7, (640) 60.1–65.8, (660) 60.0–66.2, (680) 59.8–66.3, (700) 59.6–66.4

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.0255(11)$ $c = 10.837(9)$ $Z = 3$

X-ray Powder Pattern: Varuträsk, Sweden. (ICDD 31-80).
2.92 (100), 2.01 (70), 2.13 (60), 1.661 (40), 1.282 (40), 3.60 (30), 1.467 (20)

Chemistry:

	(1)	(2)
Sb	61.5	61.90
As	35.0	38.10
Bi	0.02	
Fe	0.85	
S	0.20	
insol.	2.20	
Total	99.77	100.00

(1) Varuträsk, Sweden. (2) SbAs.

Mineral Group: Arsenic group.

Occurrence: Most commonly in hydrothermal veins, but also in pegmatites.

Association: Arsenic, arsenolite, antimony, kermesite, stibnite, stibiconite, cervantite, sphalerite, siderite, calcite, quartz.

Distribution: From the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden [TL]. At Marienberg, Saxony, and from St. Andreasberg, Harz Mountains, Germany. In France, in the Chalanches mine, near Allemont, Isère. At Cavnic (Kapnikbánya) and Baia Mare (Nagybánya), Romania. In the Czech Republic, from Příbram. At Hüttenberg, Carinthia, Austria. From Valtellina, Italy. In the USA, in the Ophir mine, Comstock Lode, Virginia City, Storey Co., Nevada. In Canada, at Atlin, Alder Island, and in the Engineer mine, Tagish Lake, British Columbia; from Bernic Lake, Manitoba. At the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. From Broken Hill, New South Wales, Australia. A few additional localities are known.

Name: For the composition, intermediate between antimony, STIBium, and ARSENic.

References: (1) Wretblad, P.E. (1941) Minerals of the Varuträsk pegmatite, XX. Die allemontite und das system As–Sb. Geol. Fören. Förhandl. Stockholm, 63, 19–48 (in German). (2) (1941) Amer. Mineral., 26, 456 (abs. ref. 1). (3) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 130–132 ("allemontite", part). (4) Bayliss, P. (1991) Crystal chemistry and crystallography of some minerals in the tetradymite group, Amer. Mineral., 76, 257–265.

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Stibiconite $Sb^{3+}Sb_2^{5+}O_6(OH)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Massive, botryoidal, as incrustations, may be concentrically zoned, to several cm thick; typically powdery, compact.

Physical Properties: Hardness = 5.5–7, when compact. D(meas.) = 3.3–5.5
D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Pale yellow to yellowish white, reddish white, orange; gray, brown, black when impure. *Luster:* Pearly, opaline, glassy to earthy.
Optical Class: Isotropic. n = 1.621–2.047, often in admixtures.

Cell Data: *Space Group: Fd3m.* a = 10.255–10.282 Z = 8

X-ray Powder Pattern: Locality not stated.
2.96 (100), 5.93 (90), 1.81 (80), 3.09 (70), 1.55 (60), 2.57 (40), 1.18 (40)

Chemistry:

	(1)	(2)
SiO_2	1.03	
Al_2O_3	0.05	
Fe_2O_3	0.10	
Sb	73.4	76.37
MgO	0.05	
CaO	1.79	
O	21.3	21.75
H_2O^+	1.98	1.88
H_2O^-	0.61	
Total	100.3	100.00

(1) Yucunani mine, Tejocotes, Oaxaca, Mexico; Sb^{3+}:Sb^{5+} calculated from stoichiometry; corresponds to $(Sb^{3+}_{0.52}Ca_{0.16})_{\Sigma=0.68}Sb^{5+}_{2.19}O_6(OH)_{0.83}$. (2) $Sb^{3+}Sb^{5+}_2O_6(OH)$.

Mineral Group: Stibiconite group.

Occurrence: A secondary mineral in hydrothermal mineral deposits, formed by the oxidation of other antimony-bearing minerals, commonly stibnite, which it may entirely replace.

Association: Cervantite, valentinite, kermesite, antimony, stibnite.

Distribution: Probably very common, but modern confirmation is required for many earlier localities. From Losacio, Zamora Province, Spain. At Ramsbeck, North Rhein-Westphalia, and in the Clara Mine, near Oberwolfach, Black Forest, Germany. At Szalonack, Hungary. An important ore from Catorce and Tierras Prietas, San Luis Potosi, and at El Antimonio, Sonora, Mexico. In Canada, in the Lac Nicolet mine, South Ham Township, Wolfe Co., Quebec. In the USA, at the Black Warrior mine, near Unionville, Pershing Co., Nevada; from Antimony, Garfield Co., Utah; in the Stanley stibnite mine, Shoshone Co., Idaho; along Erskine Creek, Kern Co., California. In Kyrgyzstan, in the Kadamdzhai antimony deposit.

Name: From the Latin for antimony, STIBIum, and the Greek for *powder* or *dust*, a common habit.

Type Material: Neither an analysis nor a type locality was given on introduction of the name by Beudant in 1832.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 597–598. (2) Vitaliano, C.J. and B. Mason (1952) Stibiconite and cervantite. Amer. Mineral., 37, 982–999.

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Stibiobetafite $(Ca, Sb^{3+})_2(Ti, Nb, Ta)_2(O, OH)_7$

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Crystal Data: Cubic; may be metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rare rounded octahedra with small cube modifications, to 8 mm; commonly anhedral, granular, in veinlets and aggregates.

Physical Properties: *Fracture:* [Conchoidal to uneven] (by analogy to betafite).
Tenacity: Brittle. Hardness = ∼5 D(meas.) = 5.30 (on impure material). D(calc.) = 5.19

Optical Properties: Semitransparent. *Color:* Dark brown to brown-black; brown in transmitted light; medium gray in reflected light. *Streak:* Pale brown to cream.
Luster: Vitreous.
Optical Class: Isotropic. $n = > 1.78$

Cell Data: *Space Group:* $Fd3m$. a = 10.351 Z = 8

X-ray Powder Pattern: Věžná, Czech Republic; after heating at 700 °C for one hour.
2.988 (10), 1.829 (6), 1.561 (5), 2.581 (4), 5.94 (3), 1.495 (3), 1.187 (3)

Chemistry:

	(1)		(1)
Nb_2O_5	21.6	PbO	0.13
Ta_2O_5	19.3	SnO	2.9
TiO_2	16.5	CaO	14.5
Al_2O_3	0.49	Na_2O	0.30
Sb_2O_3	23.2	F	0.15
FeO	0.6	H_2O	0.44
MnO	0.6	$-O = F_2$	0.06
		Total	100.65

(1) Věžná, Czech Republic; by electron and ion microprobe on a selected grain; total Sb as Sb_2O_3, Fe as FeO, Mn as MnO, Sn as SnO; corresponds to $(Ca_{1.11}Sb^{3+}_{0.69}Sn_{0.09}Fe_{0.04}Mn_{0.04}Na_{0.04})_{\Sigma=2.01}(Ti_{0.89}Nb_{0.70}Ta_{0.38}Al_{0.04})_{\Sigma=2.01}O_6[O_{0.76}(OH)_{0.21}F_{0.03}]_{\Sigma=1.00}$.

Mineral Group: Pyrochlore group, betafite subgroup; $Sb_A > 20\%$; $2Ti_B \geq (Nb + Ta)_B$.

Occurrence: As replacement masses and in veinlets, in a granite pegmatite in a serpentinite.

Association: Columbite, niobian rutile, antimony, stokesite, cassiterite, zircon, albite.

Distribution: From Věžná, Czech Republic.

Name: From the Latin for antimony, STIBium, in its composition, and as a member of the *betafite* subgroup of the pyrochlore group.

Type Material: University of Manitoba, Winnipeg, M5233; Royal Ontario Museum, Toronto, Canada, M35630.

References: (1) Černý, P., F.C. Hawthorne, J.H.G. Laflamme, and J.R. Hinthorne (1979) Stibiobetafite, a new member of the pyrochlore group from Vezná, Czechoslovakia. Can. Mineral., 17, 583–588. (2) (1981) Amer. Mineral., 66, 1278 (abs. ref. 1).

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Stibiocolumbite $Sb(Nb, Ta)O_4$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals prismatic ‖ [010]; {001} and {101} striated ‖ [010]. *Twinning:* About [010] with composition plane {001}, commonly an irregular junction, or polysynthetic.

Physical Properties: *Cleavage:* {001}, distinct; {100}, indistinct. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 5.68 (synthetic $SbNbO_4$). D(calc.) = [5.72] Strongly pyroelectric.

Optical Properties: Semitransparent. *Color:* Dark brown to light yellowish brown; reddish yellow, reddish brown, greenish yellow; in transmitted light, pale yellow-brown to brown, may be zoned. *Streak:* Pale yellow to yellow-brown. *Luster:* Resinous to adamantine.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, strong.
$\alpha = 2.398$ $\beta = 2.419$ $\gamma = 2.459$ 2V(meas.) = n.d. 2V(calc.) = 73°25′

Cell Data: *Space Group:* $Pc2_1n$ (synthetic $SbNbO_4$). $a = 4.929$ $b = 11.797$ $c = 5.559$ Z = 4

X-ray Powder Pattern: Synthetic $SbNbO_4$; nearly identical to stibiocolumbite.
3.125 (100), 2.947 (28), 1.735 (21), 3.517 (18), 1.891 (12), 2.779 (10), 2.023 (10)

Chemistry:

	(1)	(2)	(3)
WO_3		12.34	
Nb_2O_5	37.30	29.82	47.70
Ta_2O_5	13.00	8.64	
TiO_2		0.10	
SnO_2		1.05	
Bi_2O_3	0.53		
Sb_2O_3	49.28	43.99	52.30
PbO		3.54	
Total	100.11	99.48	100.00

(1) Mesa Grande district, California, USA. (2) Pamir Mountains, Tajikistan; by electron microprobe, corresponding to $(Sb_{0.93}Pb_{0.05})_{\Sigma=0.98}(Nb_{0.69}W_{0.16}Ta_{0.12}Sn_{0.02})_{\Sigma=0.99}O_4$.
(3) $SbNbO_4$.

Mineral Group: Forms a series with stibiotantalite. [As stibiocolumbite was originally defined from its analysis only, some properties given here are likely for stibiotantalite].

Occurrence: A rare accessory mineral in complex granite pegmatites.

Association: Tourmaline, beryl, lepidolite (Mesa Grande district, California, USA).

Distribution: From the Mesa Grande district, San Diego Co., California, USA. At Emd, Mattertal, Valais, Switzerland. From an undisclosed locality in the Pamir Mountains, Tajikistan.

Name: From the Latin for antimony, STIBium, in its composition, and relation to *columbite*.

Type Material: The type crystal was totally consumed during analysis before realization it was of a new species.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 767–769. (2) Roth, R.S. and J.L. Waring (1963) Synthesis and stability of bismutotantalite, stibiotantalite and chemically similar ABO_4 compounds. Amer. Mineral., 48, 1348–1356. (3) Konovalenko, S.I., A.V. Voloshin, Y.A. Pakhomovskii, L.N. Rossovskii, and A.N. Anan'yev (1982) Tungsten varieties of tantaloniobates in granitic miarolitic pegmatites of southwestern Pamirs. Mineral. Zhurnal, 4(1), 65–74 (in Russian with English abs.).

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Stibiocolusite $Cu_{13}V_4(Sb,Sn,As)_3S_{16}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $6mm$, or $\overline{6}m2$. As hexagonal thin to thick tabular crystals, to 200 μm; as inclusions in chromite, massive sulfides, and silicates; as inclusions in Pt–Fe alloys. *Twinning:* Ubiquitous.

Physical Properties: Hardness = n.d. VHN = 610(7) (100 g load). D(meas.) = n.d. D(calc.) = 10.8

Optical Properties: Opaque. *Color:* In polished section, yellowish white. *Pleochroism:* Weak; pale yellow to yellowish white, also faint greenish, pinkish, or lavender. *Anisotropism:* Distinct; colors may be lacking but some grains are purplish gray to greenish gray.

R_1–R_2: (400) 41.8–42.3, (420) 43.3–44.7, (440) 44.9–46.8, (460) 46.8–49.0, (480) 48.6–50.7, (500) 50.2–52.3, (520) 51.7–53.6, (540) 53.0–54.8, (560) 54.1–55.6, (580) 55.2–56.4, (600) 56.3–57.0, (620) 57.3–57.6, (640) 58.3–58.0, (660) 59.1–58.3, (680) 60.1–58.6, (700) 61.0–59.0

Cell Data: *Space Group:* $P6_3/mmc$, $P6_3mc$, or $P\overline{6}2c$. $a = 7.598(2)$ $c = 28.112(9)$ $Z = 12$

X-ray Powder Pattern: Tweefontein Farm, South Africa.
2.236 (100), 2.194 (100), 1.279 (50), 1.228 (50), 1.183 (50), 1.576 (40), 1.267 (30)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Pd	68.0	67.8	68.60	Sb	30.5	31.2	31.40
Cu	1.6	1.9		As	0.2		
Sn	0.2			Total	100.5	100.9	100.00

(1) Tweefontein Farm, South Africa; by electron microprobe, corresponding to $(Pd_{4.87}Cu_{0.19}Sn_{0.01})_{\Sigma=5.07}(Sb_{1.91}As_{0.02})_{\Sigma=1.93}$. (2) Goodnews Bay, Alaska, USA; by electron microprobe, average of analyses of seven grains; corresponding to $(Pd_{4.83}Cu_{0.23})_{\Sigma=5.06}Sb_{1.94}$. (3) Pd_5Sb_2.

Occurrence: An uncommon constituent of PGE deposits in layered intrusives and ophiolites, nevertheless a major carrier of palladium; in placers.

Association: Braggite, cooperite, mertieite-II, sperrylite, Pt–Fe–Cu–Ni alloys, genkinite, platarsite, chromite, chalcopyrite, pentlandite, pyrrhotite, geversite, gold, violarite.

Distribution: In Transvaal, South Africa, from Tweefontein Farm, Potgietersrus district [TL], and from the Elephant Winze, near Rietfontein; at the Onverwacht and Driekop mines, all on the Merensky Reef, Bushveld complex. In Russia, from the Morozova mine, Noril'sk region, western Siberia; at Zlatoust, Ural Mountains; from the Pustaya River placers, Kamchatka. At Tilkerode, Harz Mountains, Germany. In the Pirogues River, New Caledonia. In the USA, at Goodnews Bay, Alaska. From the Lac des Iles complex, Ontario, Canada. In the Department of Chocó, Cauca, Colombia. At Kambalda, 56 km south of Kalgoorlie, Western Australia. From the Santo Tomas II porphyry copper deposit, Benguet, Philippines. A number of other localities are known.

Name: For the composition.

Type Material: The Natural History Museum, London, England, 1930,950–952; Royal Ontario Museum, Toronto, Canada, M34229; National Museum of Natural History, Washington, D.C., USA, 135408.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 175. (2) Cabri, L.J. and T.T. Chen (1976) Stibiopalladinite from the type

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locality. Amer. Mineral., 61, 1249–1254. (3) Desborough, G.A., J.J. Finney, and B.F. Leonard (1973) Mertieite, a new palladium mineral from Goodnews Bay, Alaska. Amer. Mineral., 58, 1–10. (4) El-Boragy, M., S. Bhan, and K. Schubert (1970) Kristallstruktur von Pd_5Sb_2 und Ni_5As_2 und einigen Varianten. J. Less-Common Metals, 22, 445–458 (in German with English abs.). (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 413–416. (6) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 139–140. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 537.

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Stibiomicrolite $(Sb, Ca, Na)_2(Ta, Nb)_2O_7$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Extremely fine grained.

Physical Properties: *Fracture:* [Uneven] (by analogy to the pyrochlore group).
Tenacity: [Brittle.] Hardness = < 5.5 D(meas.) = n.d. D(calc.) = 5.84–6.22

Optical Properties: Semitransparent. *Color:* Greenish white to white; gray in reflected light.
Streak: White.
Optical Class: Isotropic. $n = > 1.9$

Cell Data: *Space Group:* $Fd3m$. a = 10.455(2) Z = 8

X-ray Powder Pattern: Varuträsk pegmatite, Sweden.
3.01 (10), 3.14 (9), 6.03 (8), 1.575 (8), 2.61 (7), 1.846 (7), 2.010 (5)

Chemistry:

	(1)
Nb_2O_5	17.54
Ta_2O_5	52.65
Sb_2O_3	19.24
CaO	6.78
Na_2O	2.58
Total	[98.79]

(1) Varuträsk pegmatite, Sweden; by electron microprobe, total Sb as Sb_2O_3, original total given as 98.80%; corresponds to $(Sb_{0.71}Ca_{0.65}Na_{0.45})_{\Sigma=1.81}(Ta_{1.29}Nb_{0.71})_{\Sigma=2.00}O_7$. (2) Odd West pegmatite, Canada; analysis not given, corresponds to $(Ca_{0.71}Sb_{0.46}Na_{0.22}Fe_{0.04}Sn_{0.03})_{\Sigma=1.46}(Ta, Nb)_2O_7$.

Mineral Group: Pyrochlore group, microlite subgroup; $Sb_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Ta_B \geq Nb_B$.

Occurrence: A very rare mineral, replacing stibiotantalite, in the lithium-rich albite unit of a complex granite pegmatite (Varuträsk pegmatite, Sweden).

Association: Stibiotantalite, antimony, allemontite, lithiophilite, alkalic beryl, cassiterite, columbite–tantalite, microlite (Varuträsk pegmatite, Sweden); cassiterite (Odd West pegmatite, Canada).

Distribution: In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. In the Odd West pegmatite, southeastern Manitoba, Canada.

Name: From the Latin for antimony, STIBIum, in its composition, and membership in the *microlite* subgroup of the pyrochlore group.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 600200; University of Manitoba, Winnipeg, Canada, M6134.

References: (1) Groat, L.A., P Černý, and T.S. Ercit (1987) Reinstatement of stibiomicrolite as a valid species. Geol. Fören. Förhandl. Stockholm, 109, 105–109. (2) (1988) Amer. Mineral., 73, 1499 (abs. ref. 1). (3) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 757 [hypothetical mineral].

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $6mm$, or $\bar{6}m2$. As hexagonal thin to thick tabular crystals, up to about 200 μm. *Twinning:* Ubiquitous.

Physical Properties: Hardness = n.d. VHN = 610(7) (100 g load). D(meas.) = n.d. D(calc.) = 10.8

Optical Properties: Opaque. *Color:* In polished section, yellowish white. *Pleochroism:* Weak, in pale yellow to yellowish white, also sometimes faint greenish, pinkish, or lavender. *Anisotropism:* Distinct, colors usually lacking but some grains are purplish gray to greenish gray. R_1–R_2: (400) 39.9–40.6, (420) 42.2–43.4, (440) 44.5–46.2, (460) 46.6–48.5, (480) 48.4–50.4, (500) 50.0–52.0, (520) 51.4–53.2, (540) 52.5–54.2, (560) 53.5–54.8, (580) 54.4–55.2, (600) 55.4–55.6, (620) 56.4–56.0, (640) 57.4–56.6, (660) 58.6–57.1, (680) 59.7–57.6, (700) 61.0–58.3

Cell Data: *Space Group:* $P6_3/mmc$, $P6_3mc$, or $P\bar{6}2c$. $a = 7.598(2)$ $c = 28.112(9)$ Z = 12

X-ray Powder Pattern: Tweefontein Farm, South Africa.
2.236 (100), 2.194 (100), 1.279 (50), 1.228 (50), 1.183 (50), 1.576 (40), 1.267 (30)

Chemistry:

	(1)	(2)	(3)
Pd	68.0	67.8	68.60
Cu	1.6	1.9	
Sn	0.2		
Sb	30.5	31.2	31.40
As	0.2		
Total	100.5	100.9	100.00

(1) Tweefontein Farm, South Africa; by electron microprobe, corresponding to $(Pd_{4.87}Cu_{0.19})_{\Sigma=5.06}Sb_{1.91}$. (2) Goodnews Bay, Alaska, USA; by electron microprobe, average of analyses of seven grains, corresponding to $(Pd_{4.83}Cu_{0.23})_{\Sigma=5.06}Sb_{1.94}$. (3) Pd_5Sb_2.

Occurrence: An uncommon constituent of platinum deposits.

Association: Braggite, cooperite, mertieite-II, sperrylite, Pt–Fe–Cu–Ni alloys, genkinite, platarsite, chromite, chalcopyrite, pentlandite, pyrrhotite, geversite, gold, violarite.

Distribution: In the USA, at Goodnews Bay, Alaska. In Transvaal, South Africa, from Tweefontein Farm, Potgietersrust district, and from the Elephant Winze, near Rietfontein; at the Onverwacht and Driekop mines. From the Department of Chocó, Cauca, Colombia. In the USSR, from the Morozova mine, Noril'sk region, western Siberia, and at Zlatoust, Ural Mountains. From the Lac des Iles Complex, Ontario, Canada.

Name: For the composition.

Type Material: British Museum (Natural History), London, England, 1930,950-2; Royal Ontario Museum, Toronto, Canada, M34229; National Museum of Natural History, Washington, D.C., USA, 135408; all probably topotypic.

References: (1) Cabri, L.J. and T.T. Chen (1976) Stibiopalladinite from the type locality. Amer. Mineral., 61, 1249–1254. (2) Desborough, G.A., J.J. Finney, and B.F. Leonard (1973) Mertieite, a new palladium mineral from Goodnews Bay, Alaska. Amer. Mineral., 58, 1–10. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 413–416. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 139–140.

Stibiotantalite $Sb(Ta,Nb)O_4$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals prismatic ‖ [010], flattened ‖ to [001], may be equant, to 12 cm; {001} and {101} striated ‖ [010]. *Twinning:* About [010] with composition plane {001}; polysynthetic.

Physical Properties: *Cleavage:* {001}, distinct; {100} indistinct. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 7.53 (synthetic $SbTaO_4$). D(calc.) = [7.58] Strongly pyroelectric.

Optical Properties: Semitransparent. *Color:* Dark brown to light yellowish brown; reddish yellow, reddish brown, greenish yellow; in transmitted light, pale yellow-brown to brown, may be zoned. *Streak:* Pale yellow to yellow-brown. *Luster:* Resinous to adamantine.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, strong.
$\alpha = 2.374$ $\beta = 2.404$ $\gamma = 2.457$ 2V(meas.) = n.d. 2V(calc.) = $75°5'$

Cell Data: *Space Group:* $Pc2_1n$ (synthetic $SbTaO_4$). $a = 4.911$ $b = 11.814$ $c = 5.535$
Z = 4

X-ray Powder Pattern: Synthetic $SbTaO_4$; nearly identical to stibiotantalite.
3.121 (100), 3.506 (38), 2.950 (34), 2.687 (22), 2.692 (21), 1.735 (19), 1.888 (17)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	1.79	11.3	
Ta_2O_5	57.29	43.3	60.25
SiO_2		0.1	
Sb_2O_3	40.64	40.3	39.75
Bi_2O_3	0.30	3.8	
CaO		0.1	
Total	100.02	98.9	100.00

(1) Greenbushes, Western Australia. (2) Mesa Grande district, California, USA; by electron microprobe, corresponding to $Sb_{1.00}(Ta_{0.71}Nb_{0.30})_{\Sigma=1.01}O_4$. (3) $SbTaO_4$.

Mineral Group: Forms a series with stibiocolumbite.

Occurrence: An uncommon accessory mineral in complex granite pegmatites.

Association: Tantalite (Greenbushes, Western Australia); antimony, allemontite, microlite, stibiomicrolite, lithiophilite, alkalic beryl, cassiterite, columbite–tantalite (Varuträsk, Sweden).

Distribution: From the Greenbushes tin placers, Wodgina district, Western Australia. Large crystals at the Muiâne and other mines, Alto Ligonha, Mozambique. From the Benson mine, Mtoko, Zimbabwe. In the USA, from Topsham, Sagadahoc Co., Maine; in California, in San Diego Co., fine crystals from the Himalaya mine, Mesa Grande district; at the Katerina, Stewart, and Vandenburg mines, Pala district; and in the Little Three mine, Ramona district; in the Brown Derby pegmatite, Gunnison Co., Colorado. In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. From the Voronya massif, Kola Peninsula, Russia. Found near Stak Nala, Gilgit district, Pakistan.

Name: From the Latin for antimony, STIBIum, in the composition, and relation to *tantalite*.

Type Material: Western Australian Museum, Perth, Astralia, MDC550; Harvard University, Cambridge, Massachusetts, USA, 111954.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 767–769. (2) Roth, R.S. and J.L. Waring (1963) Synthesis and stability of bismutotantalite, stibiotantalite and chemically similar ABO_4 compounds. Amer. Mineral., 48, 1348–1356. (3) Foord, E.E. and M.E. Mrose (1978) Rynersonite, $Ca(Ta,Nb)_2O_6$, a new mineral from San Diego County, California. Amer. Mineral., 63, 709–714.

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Stibivanite $Sb_2^{3+}V^{4+}O_5$

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Crystal Data: Monoclinic or orthorhombic. *Point Group:* $2/m$; $2/m$ $2/m$ $2/m$ or $mm2$. Lathlike fibrous crystals, to 3 mm, may be cylindrical, in incrustations of radiating aggregates.

Physical Properties: *Tenacity:* Flexible and elastic. Hardness = ∼4 VHN = 148–256, 232 average (50 g load). D(meas.) = n.d. D(calc.) = 5.26–5.267

Optical Properties: Translucent. *Color:* Bright yellow-green; light to dark gray in reflected light, with green to yellowish internal reflections. *Streak:* White. *Luster:* Adamantine. *Optical Class:* Biaxial (–) or (+). *Pleochroism:* Strong; X = emerald-green with olive tint; Y = emerald-green; Z = olive-green. *Orientation:* $X = b$; $Z \wedge c \simeq 0°$ [2M]; $X = a$; $Y = b$; $Z = c$ [2O]. *Dispersion:* $r \gg v$, very strong. $\alpha = > 1.87$ β = n.d. $\gamma = < 1.89$ 2V(meas.) = 85(1)° *Anisotropism:* Moderate.

Cell Data: *Space Group:* $P2/c$ (2M), with $a = 17.989(6)$ $b = 4.792(1)$ $c = 5.500(2)$ $\beta = 95.15(3)°$ Z = 4, or *Space Group:* $Pmcn$ or $P2_1cn$ (2O), with $a = 17.916(3)$ $b = 4.790(1)$ $c = 5.509(1)$ Z = 4

X-ray Powder Pattern: Lake George deposit, Canada (2M).
2.996 (10), 3.502 (7), 3.173 (7), 4.646 (6), 2.114 (4), 1.870 (4), 1.787 (4)

Chemistry:

	(1)	(2)
VO_2	22.01	22.15
Sb_2O_3	79.31	77.85
Total	101.32	100.00

(1) Lake George deposit, Canada; by electron microprobe, Sb^{3+} and V^{4+} confirmed by crystal-structure analysis, H_2O and $(OH)^{1-}$ absent by IR; corresponds to $Sb^{3+}_{2.01}V^{4+}_{0.98}O_5$.
(2) Sb_2VO_5.

Polymorphism & Series: 2M and 2O polytypes.

Occurrence: In late veins in a hydrothermal antimony deposit (Lake George deposit, Canada); in a metasomatized hydrothermal iron deposit (Buca della Vena mine, Italy).

Association: Antimony, stibnite, sénarmontite, pyrite, arsenopyrite, sphalerite, quartz (Lake George deposit, Canada); anatase, apuanite, barite, beryl, derbylite, dolomite, hematite, magnetite, pyrite, tourmaline, versiliaite (Buca della Vena mine, Italy).

Distribution: From the Lake George antimony deposit, 40 km west of Fredricton, New Brunswick, Canada. In the Buca della Vena mine, northeast of Stazzema, Apuan Alps, Tuscany, Italy.

Name: From the Latin for antimony, STIBIum, and VANadium in the composition.

Type Material: Canadian Geological Survey, Ottawa, 61523–61525; National Museum of Natural Science, Ottawa, 44654–44658; Royal Ontario Museum, Toronto, Canada, M36642; The Natural History Museum, London, England, 1984,369–370; Harvard University, Cambridge, Massachusetts, 117335; National Museum of Natural History, Washington, D.C., USA, 148697; University of Pisa, Pisa, Italy, 4880 (2O polytype).

References: (1) Kaiman, S., D.C. Harris, and J.E. Dutrizac (1980) Stibivanite, a new mineral from the Lake George antimony deposit, New Brunswick. Can. Mineral., 18, 329–332. (2) Szymański, J.T. (1980) A redetermination of the structure of Sb_2VO_5, stibivanite, a new mineral. Can. Mineral., 18, 333–337. (3) (1981) Amer. Mineral., 66, 1278 (abs. refs. 1 and 2). (4) Merlino, S., P. Orlandi, N. Perchiazzi, R. Basso, and A. Palenzona (1989) Polytypism in stibivanite. Can. Mineral., 27, 625–632.

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Stibnite Sb_2S_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Slender to stout, complexly terminated crystals, elongated along [001], to 0.65 m; bent crystals not uncommon, rarely twisted. In radiating and confused groups of acicular crystals; also columnar, granular, or very fine masses. *Twinning:* Rare; twin planes {130}, {120}, and perhaps {310}.

Physical Properties: *Cleavage:* Perfect and easy on {010}; imperfect on {100} and {110}. *Fracture:* Subconchoidal. *Tenacity:* Highly flexible but not elastic; slightly sectile. Hardness = 2 VHN = 71–86, {010} section (100 g load). D(meas.) = 4.63 D(calc.) = 4.625

Optical Properties: Opaque. *Color:* Lead-gray, tarnishing blackish or iridescent; in polished section, white. *Streak:* Lead-gray. *Luster:* Metallic, splendent on cleavage surfaces. *Anisotropism:* Strong.

R_1–R_2: (400) 31.1–53,3, (420) 30.8–53.2, (440) 30.6–53.0, (460) 30.7–52.8, (480) 31.0–52.2, (500) 31.2–51.1, (520) 31.4–49.7, (540) 31.2–48.5, (560) 30.8–47.2, (580) 30.3–45.8, (600) 29.7–44.5, (620) 29.3–43.5, (640) 29.2–42.6, (660) 29.4–41.8, (680) 29.6–41.1, (700) 29.4–40.3

Cell Data: *Space Group: Pbnm.* $a = 11.234(3)$ $b = 11.314(2)$ $c = 3.837(2)$ Z = 4

X-ray Powder Pattern: Synthetic.
2.764 (100), 3.053 (95), 3.556 (70), 3.573 (65), 5.052 (55), 2.680 (50), 2.525 (45)

Chemistry:

	(1)	(2)
Sb	71.45	71.69
S	28.42	28.31
Total	99.87	100.00

(1) Wolfsberg, Germany. (2) Sb_2S_3.

Polymorphism & Series: Dimorphous with metastibnite.

Mineral Group: Forms a series with bismuthinite.

Occurrence: Of hydrothermal origin, formed in veins through a wide range of temperatures.

Association: Realgar, orpiment, cinnabar, galena, lead sulfantimonides, pyrite, marcasite, arsenopyrite, cervantite, stibiconite, calcite, ankerite, barite, chalcedonic quartz.

Distribution: The most important ore of antimony, although large deposits are rare. The following localities have produced outstanding crystallized material. In the USA, at the White Caps mine, Manhattan district, Nye Co., and the Murray mine, Independence Mountains district, Elko Co., Nevada. From the San José and other mines, Oruro, Bolivia. In Germany, at Wolfsberg, Harz Mountains, and near Arnsberg, North Rhine-Westphalia. At Kremnica (Kremnitz) and Banská Štiavnica (Schemnitz), Slovakia. From Příbram, Czech Republic. At Baia Sprie (Felsőbánya) and Herja (Kisbánya), Baia Mare (Nagybánya) district, Romania. In France, at Massaic, Cantal; and at La Lucette, Mayenne. At the Kusa mine, near Bau, Sarawak, Malaysia. From Thames, New Zealand. At Bahar-Lou, near Hamadan, Iran. From Kadamzhay, Kyrgyzstan. Magnificent groups of crystals in the Ichinokawa mine, near Saijo, Ehime Prefecture (Iyo Province), Japan. In China, from the Xikuangshan mine, northeast of Lengshuijiang, Hunan Province, economically very important; fine crystals from the [?? verify in MR as spelling seems off, not in mindat.org ?? and Lushi is a Co.??] Lijai Valligy mine, Lushi, Henan Province.

Name: From the Greek *stibi*, then Latin *stibium*, an old name for the mineral.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 270–275. (2) Kyono, A., M. Kimata, M. Matsuhisa, Y. Miyashita, and K. Okamoto (2002) Low-temperature crystal structures of stibnite implying orbital overlap of Sb $5s^2$ inert pair electrons. Phys. Chem. Minerals, 29, 254–260. (3) Kuze, S., D. Du Boulay, N. Ishizawa, A. Saiki, and A. Pring (2004) X-ray diffraction evidence for a monoclinic form of stibnite, Sb_2S_3, below 290 K. Amer. Mineral., 89, 1022–1025. (4) (1955) NBS Circ. 539, 5, 6. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 692–697. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 538.

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Stichtite $Mg_6Cr_2(CO_3)(OH)_{16}\cdot 4H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As aggregates of fibers or plates, commonly matted, contorted; as cross-fiber veinlets and micaceous scales.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Laminae flexible, not elastic; greasy feel. Hardness = 1.5–2 D(meas.) = 2.16 D(calc.) = 2.11

Optical Properties: Transparent. *Color:* Lilac to rose-pink; lilac to rose-pink in transmitted light. *Streak:* Very pale lilac to white. *Luster:* Waxy to resinous, somewhat pearly. *Optical Class:* Uniaxial (–); may be anomalously biaxial. *Pleochroism:* Weak; O = dark rose-pink to lilac; E = light rose-pink to lilac. $\omega = 1.545(3)$ $\epsilon = 1.518(3)$ 2V(meas.) = Small.

Cell Data: *Space Group:* $R\overline{3}m$. $a = 3.09$ $c = 23.19$ Z = 3/8

X-ray Powder Pattern: Dundas, Tasmania, Australia. (ICDD 14-330).
7.8 (100), 3.91 (90), 2.60 (40), 2.32 (30), 1.97 (30), 1.54 (20), 1.51 (20)

Chemistry:

	(1)	(2)
Al_2O_3	2.30	
Fe_2O_3	4.18	
Cr_2O_3	14.15	23.24
MgO	37.72	36.98
H_2O	34.14	33.05
CO_2	7.15	6.73
Total	[100.00]	100.00

(1) Dundas, Tasmania, Australia; probably intermixed with barbertonite, original total given as 99.27%, recalculated to 100% after deduction of SiO_2 2.09%, FeO 0.28% as chromite.
(2) $Mg_6Cr_2(CO_3)(OH)_{16}\cdot 4H_2O$.

Polymorphism & Series: Dimorphous with barbertonite.

Mineral Group: Hydrotalcite group.

Occurrence: An alteration product of chromite in serpentinite.

Association: Barbertonite, chromite, antigorite.

Distribution: From Stichtite Hill, near the Adelaide mine, Dundas, Tasmania, Australia. In the Kaapsehoop asbestos mine, Kaapse Hoop, and the New Amianthus asbestos mine, Stolzburg, Barberton district, Transvaal, and several other places in South Africa. On the Darwendale Farm, Darwendale, Zimbabwe. At Bou Offroich, near Bou Azzer, Morocco. In Scotland, at Cunningsburgh, Shetland Islands. From Långban, Värmland, Sweden. In Russia, from near Tyungur, Kaznakhty Range, and in the Terektinskogo Range, Altai Mountains. In Canada, from Langmuir Township, Ontario, and in the Megantic mine, Black Lake, Quebec. From Campo Formosa, Bahia, Brazil. In the Keonjhar district, Orissa, India.

Name: To honor Robert C. Sticht (1857–1922), formerly General Manager of the Mount Lyell Mining and Railway Company, Tasmania, Australia.

Type Material: National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 655–656. (2) Frondel, C. (1941) Constitution and polymorphism of the pyroaurite and sjögrenite groups. Amer. Mineral., 26, 295–315. (3) Taylor, H.W.F. (1973) Crystal structures of some double hydroxide minerals. Mineral. Mag., 39, 377–389. (4) Bookin, A.S., V.I. Cherkashin, and V.A. Drits (1993) Polytype diversity of the hydrotalcite-like minerals. II. Determination of the polytypes of experimentally studied varieties. Clays and Clay Minerals, 41, 558–564.

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Stilbite **$NaCa_2Al_5Si_{13}O_{36}\cdot 14H_2O$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals typically thin tabular, flattened on [010], to 14 cm; in fasicled, sheaflike, or globular aggregates. *Twinning:* Ubiquitous on {001}, cruciform and penetration twins.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.19(1) D(calc.) = 2.23

Optical Properties: Transparent to translucent. *Color:* White, yellowish, gray, pink, reddish, orange, light brown to dark brown; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on cleavage.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 5°$. *Dispersion:* $r < v$.
$\alpha = 1.484–1.500$ $\beta = 1.492–1.507$ $\gamma = 1.494–1.513$ 2V(meas.) = 30°–49°

Cell Data: *Space Group:* $F2/m$. $a = 13.595–13.657$ $b = 18.197–18.309$ $c = 17.775–17.842$ $\beta = 90.05°–90.91°$ Z = [4]

X-ray Powder Pattern: Montresta, Sardinia, Italy.
9.13 (100), 4.065 (58), 3.028 (36), 2.780 (21), 4.679 (16), 4.627 (15), 3.199 (13)

Chemistry:

	(1)
SiO_2	52.70
Al_2O_3	17.71
CaO	7.76
Na_2O	2.39
K_2O	1.09
H_2O^+	16.32
H_2O^-	2.08
Total	100.05

(1) Pedemonte, Bellinzona, Tessin, Switzerland; corresponds to $(Na_{1.12}K_{0.34})_{\Sigma=1.46}Ca_{2.02}Al_{5.08}Si_{12.82}O_{36}\cdot 13.24H_2O$.

Mineral Group: Zeolite group.

Occurrence: A low-temperature hydrothermal mineral, in amygdules and cavities in basalts, andesites, and various metamorphic rocks. Formed in hot springs deposits, and as a cementing agent in some sandstones and conglomerates.

Association: Zeolites, prehnite, calcite, quartz.

Distribution: A common zeolite, with many occurrences of large and fine crystals. In Iceland, at the Helgustadir mine, Reydarfjord, and the Teigarhorn, Berufjord. On several of the Faeroe Islands. In the Glasgow district, Dumbartonshire, Scotland. At Strzegom (Striegau), Poland. In the USA, at Great Notch and Paterson, Passaic Co., New Jersey; on the south fork of the Toutle River, Cowlitz Co., and at Skookumchuck Dam, near Bucoda, Thurston Co., Washington; from Goble, Columbia Co., and near Dollar, Lynn Co., Oregon. Along the Bay of Fundy, Nova Scotia, Canada. From Guanajuato, Mexico. At Rio das Antas, Bento Gonçalves, Rio Grande do Sul, Brazil. From around Gunnedah and Tambar Springs, New South Wales, and Arkaroola, South Australia. Exceptional crystals from the Bombay, Poona, and Nasik districts, Maharashtra, India.

Name: From the Greek for *luster*, in reference to its pearly luster.

Type Material: Natural History Museum, Paris, France, Haüy 4059.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 583–585. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 377–385. (3) Galli, E. (1971) Refinement of the crystal structure of stilbite. Acta Cryst., 27, 833–841. (4) Passaglia, E., E. Galli, L. Leonardo, and G. Rossi (1978) The crystal chemistry of stilbites and stellerites. Bull. Minéral., 101, 368–375.

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Stilleite ZnSe

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As microscopic angular inclusions. *Twinning:* Twin lamellae noted in polished section.

Physical Properties: Hardness = ∼5 VHN = n.d. D(meas.) = 5.42 D(calc.) = 5.267

Optical Properties: Opaque to translucent. *Color:* Gray; in polished section, resembles tetrahedrite without the olive-brown or greenish blue hues.
Optical Class: Isotropic. $n = \sim 2.5$
R: n.d.

Cell Data: *Space Group:* $F\bar{4}3m$. $a = 5.667$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.273 (100), 2.003 (70), 1.707 (44), 1.1561 (15), 1.299 (13), 1.416 (9), 1.0901 (8)

Chemistry:

	(1)	(2)
Zn	40.30	45.29
Hg	7.04	
Se	54.95	54.71
Total	102.29	100.00

(1) Santa Brigida mine, Argentina; by electron microprobe, corresponds to $(Zn_{0.92}Hg_{0.05})_{\Sigma=0.97}Se_{1.03}$. (2) ZnSe.

Mineral Group: Sphalerite group.

Occurrence: Included in linnaeite (Shinkolobwe, Congo); intermixed with other selenides (Santa Brigida mine, Argentina).

Association: Pyrite, linnaeite, clausthalite, selenian vaesite, molybdenite, dolomite (Shinkolobwe, Congo); tiemannite, clausthalite, eucairite, umangite, klockmannite (Santa Brigida mine, Argentina).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire) [TL]. In the Santa Brigida mine, La Rioja Province, Argentina. From Tilkerode, Harz Mountains, Germany.

Name: Honors Hans Stille (1876–1966), German geologist.

Type Material: n.d.

References: (1) Ramdohr, P. (1956) Stilleit, ein neues Mineral, natürliches Zinkselenid, von Shinkolobwe. Geotektonisches Symposium zu Ehren von Hans Stille, 481–483 (in German). (2) (1957) Amer. Mineral., 42, 584 (abs. ref. 1). (3) DeMontreuil, L.A. (1974) Occurrence of mercurian stilleite. Bol. Soc. Geol. Peru, 44, 28–41 (in Spanish). (4) (1975) Chem. Abs., 82, 61925 (abs. ref. 4). (5) McIntyre, G.J., G. Moss, and Z. Barnea (1980) Anharmonic temperature factors of zinc selenide determined by X-ray diffraction from an extended-face crystal. Acta Cryst., A36, 482–490. (6) (1954) NBS Circ. 539, 3, 23.

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Stillwaterite Pd_8As_3

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$ or 3. As anhedral grains, to 265 μm. *Twinning:* Rarely observed in polished section.

Physical Properties: Hardness = n.d. VHN = 384 (50 g load). D(meas.) = n.d. D(calc.) = 10.96

Optical Properties: Opaque. *Color:* In polished section, pale creamy gray with faint pinkish tint.. *Luster:* Metallic. *Anisotropism:* Weak in air, dark gray to brownish gray; in oil, distinct in brownish black with a blue to yellow-brown tinge.

R_1–R_2: (470) 51.6–52.7, (546) 52.5–53.2, (589) 53.1–53.7, (650) 54.4–55.0

Cell Data: *Space Group:* $P\overline{3}$ or $P3$. $a = 7.392$–7.399 $c = 10.311$ Z = 3

X-ray Powder Pattern: Stillwater complex, Montana, USA.
2.115 (100), 2.355 (80), 1.351 (50), 0.8858 (40), 2.700 (30), 1.991 (30b), 2.521 (20)

Chemistry:

	(1)	(2)	(3)
Pd	79.0	79.13	79.11
Pt		0.40	
Au		0.07	
Ni		0.01	
As	21.2	20.83	20.89
Sb		0.05	
Bi		0.04	
S		0.03	
Total	100.2	[100.56]	100.00

(1) Stillwater complex, Montana, USA; by electron microprobe; corresponds to $Pd_{7.87}As_{3.00}$. (2) Siikakämä intrusion, Finland; by electron microprobe, average of three grains, original total given as 100.58%; corresponds to $(Pd_{7.97}Pt_{0.02})_{\Sigma=7.99}(As_{2.98}S_{0.01})_{\Sigma=2.99}$. (3) Pd_8As_3.

Occurrence: In layered ultramafic igneous bodies.

Association: Gold, palladoarsenide, sperrylite, braggite, hollingworthite, chalcopyrite, digenite, pentlandite, pyrrhotite.

Distribution: From the Banded and Upper zones of the Stillwater complex, Montana, USA [TL]. In the Roby zone, Lac des Iles complex, Ontario, Canada. At the Siikakämä intrusion, about 50 km southeast of Rovaniemi, northern Finland. From the Lukkulaisvaara layered intrusion, Karelia, Russia.

Name: For the Stillwater mafic complex, Montana, USA.

Type Material: Royal Ontario Museum, Toronto, Canada, M33559; The Natural History Museum, London, England, 1979,129; National Museum of Natural History, Washington, D.C., USA, 132500.

References: (1) Cabri, L.J., J.L.G. Laflamme, J.M. Stewart, J.F. Rowland, and Tzong R. Chen (1975) New data on some palladium arsenides and antimonides. Can. Mineral., 13, 321–335. (2) (1977) Amer. Mineral., 62, 1060 (abs. ref. 1). (3) Hänninen, E., R. Törnroos, and S.I. Lahti (1986) Stillwaterite and associated platinum group minerals from the Siikakämä layered mafic intrusion, northern Finland. Lithos, 19, 87–93.

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Stillwellite-(Ce) $(Ce, La, Ca)BSiO_5$

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Crystal Data: Hexagonal. *Point Group:* 3. As flat rhombohedral crystals, to 4 cm, and massive. *Twinning:* Observed about [100].

Physical Properties: *Cleavage:* One imperfect. *Fracture:* Conchoidal. Hardness = ~6.5 D(meas.) = 4.57–4.60 D(calc.) = 4.67

Optical Properties: Transparent to translucent. *Color:* Red-brown to pale pink; colorless in thin section. *Streak:* White.
Optical Class: Uniaxial (+) to biaxial (+). ω = 1.765–1.784 ϵ = 1.780–1.787
2V(meas.) = 0°–6°

Cell Data: *Space Group:* $P3_1$. a = 6.841–6.844 c = 6.700–6.702 Z = 3

X-ray Powder Pattern: Mary Kathleen mine, Australia.
3.43 (s), 2.96 (s), 2.13 (ms), 4.44 (m), 1.864 (m), 2.71 (mw), 2.24 (mw)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	22.40	22.06	La_2O_3	27.95	19.12	MgO	0.06	
UO_2		0.22	Ce_2O_3	33.15	30.82	CaO	0.95	0.34
ThO_2		5.41	Pr_2O_3		1.82	F	0.30	
B_2O_3	12.23	[13.46]	Nd_2O_3		5.36	H_2O^+	0.85	
Al_2O_3	0.42		Sm_2O_3		0.34	H_2O^-	0.10	
Y_2O_3	0.74	0.28	Fe_2O_3	0.18		P_2O_5	0.67	
						Total	[100.00]	[99.26]

(1) Mary Kathleen mine, Australia; recalculated to 100.00% after removal of very small amounts of uraninite and apatite determined by separate analysis. (2) Vico volcano, near Vetralla, Italy; by electron microprobe, B_2O_3 calculated from stoichiometry, original total given as 99.23%; corresponds to $(Ce_{0.50}La_{0.31}Nd_{0.08}Th_{0.05}Pr_{0.03}Ca_{0.02}Sm_{0.01})_{\Sigma=1.00}B_{1.02}Si_{0.97}O_5$.

Occurrence: Locally abundant as a metasomatic replacement of metamorphosed calcareous sediments (Mary Kathleen mine, Australia); in alkalic pegmatites in syenite in an alkalic massif (Dara-i-Pioz massif, Tajikistan).

Association: Allanite, garnet, uraninite (Mary Kathleen mine, Australia); calcite, monazite, bastnäsite, thorite, uranothorite, thorianite (Desmont mine, Canada); pyrochlore, tienshanite, sogdianite, thorite, cesium kupletskite, reedmergnerite, steacyite, pectolite, quartz (Dara-i-Pioz massif, Tajikistan).

Distribution: In the Mary Kathleen mine, about 55 km east of Mt. Isa, Queensland, Australia. At the Desmont mine, near Wilberforce, Ontario, and at Mont Saint-Hilaire, Quebec, Canada. From Mineville, Essex Co., New York, USA. Large crystals in the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. From the Inagli massif, 30 km west of Aldan, Yakutia, Russia. Found around the Langesundsfjord, Norway. In the Ilímaussaq intrusion, southern Greenland. At Bassano Romano and on the Vico volcano, near Vetralla, Lazio, Italy.

Name: For Dr. Frank Leslie Stillwell (1888–1963), Australian ore mineralogist, and its predominant *cerium* content.

Type Material: National Museum of Natural History, Washington, D.C., USA, 113038.

References: (1) McAndrew, J. and T.R. Scott (1955) Stillwellite, a new rare-earth mineral from Queensland. Nature, 176, 509–510. (2) (1956) Amer. Mineral., 41, 370 (abs. ref. 1). (3) Gay, P. (1957) An X-ray investigation of some rare-earth silicates: cerite, lessingite, beckelite, britholite, and stillwellite. Mineral. Mag., 31, 455–468. (4) Dusmatov, V.D., A.F. Efimov, and Y.I. Semenov (1963) First discoveries of stillwellite in the USSR. Doklady Acad. Nauk SSSR, 153, 913–915 (in Russian). (5) Dusmatov, V.D. (1964) First discovery of stillwellite in USSR. Dokl. Akad. Nauk Tadzh. SSR, 7, 33–35. (6) Callegari, A., G. Giuseppetti, F. Mazzi, and C. Tadini (1992) The refinement of the crystal structure of stillwellite: RE[$BSiO_5$]. Neues Jahrb. Mineral., Monatsh., 49–57. (7) Burns, P.C., F.C. Hawthorne, D.J. MacDonald, G.D. Ventura, and G.C. Parodi (1993) The crystal structure of stillwellite. Can. Mineral., 31, 147–152.

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Stilpnomelane $K(Fe^{2+}, Mg, Fe^{3+})_8(Si, Al)_{12}(O, OH)_{27}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As plates or scales and fibers with comb structures; as plumose or radiating groups, to 1 cm; as a velvety coating.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {010}. Hardness = 3–4 D(meas.) = 2.59–2.96 D(calc.) = 2.667

Optical Properties: Semitransparent. *Color:* Black, greenish black, yellowish bronze, greenish bronze; in thin section, golden brown, dark brown, green. *Luster:* Pearly to vitreous on cleavage surface, may be submetallic.
Optical Class: Biaxial (–). *Pleochroism:* X = bright golden yellow to pale yellow; Y = Z = deep reddish brown to deep green to nearly black. *Orientation:* $Y = b$; $X \simeq \perp$ (001). $\alpha = 1.543–1.634$ $\beta = 1.576–1.745$ $\gamma = 1.576–1.745$ 2V(meas.) = $\sim 0°$

Cell Data: *Space Group:* $P\bar{1}$. $a = 21.86–22.05$ $b = 21.86–22.05$ $c = 17.62–17.74$ $\alpha = 124.14°–125.65°$ $\beta = 95.86°–95.93°$ $\gamma = 120.00°$ Z = 6

X-ray Powder Pattern: Crystal Falls, Iron Co., Michigan, USA.
12.3 (100), 4.16 (100), 2.55 (100), 2.69 (70), 3.12 (60), 1.568 (60), 6.26 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	44.45	48.03	MgO	2.77	4.94
TiO_2		0.23	CaO	0.53	0.83
Al_2O_3	7.26	6.48	Na_2O	0.03	
Fe_2O_3	20.82	4.12	K_2O	2.06	0.83
FeO	14.04	22.88	H_2O^+	6.41	6.90
MnO	0.05	2.67	H_2O^-	1.35	2.64
			Total	99.77	100.55

(1) Zuckmantel, Poland. (2) Western Otago, New Zealand.

Occurrence: In banded iron formations and enclosing slates and schists. In metamorphic rocks of the blueschist and greenschist facies, and in some metamorphosed massive sulfide deposits.

Association: Quartz, siderite, apatite, hematite, minnesotaite, greenalite, chamosite, grunerite (iron formations); magnetite, chlorite, quartz, pyrrhotite, chalcopyrite (massive sulfides); quartz, glaucophane, manganoan garnet, albite, epidote, actinolite, chlorite (greenschists).

Distribution: From Obergrund, near Zuckmantel, Silesia, Poland. At Beroun na Morave, Czech Republic. From Prägraten, Tirol, Austria. In Sweden, at the Brunsjö mine, near Grythyttan, Örebro. From Mullion Island, The Lizrd, Cornwall, England. In the USA, at the Sterling mine, Antwerp, Jefferson Co., New York; from Franklin, Sussex Co., New Jersey; in the Laytonville quarry, Mendocino Co., and a number of other places in California; at Bald Knob, near Sparta, Alleghany Co., North Carolina; in the Animikian Iron Formations of Minnesota. From Poplar Creek, British Columbia, Canada. At the Great Cobar mine, New South Wales, and in the Hamersley Ranges, Western Australia. From French Ridge and Queenstown, West Otago, New Zealand.

Name: From the Greek for *shining* and *black*, in allusion to its luster and color.

Type Material: Wroclaw University, Wroclaw, Poland, II–11434, II–11437.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 658.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 103–114. (3) Eggleton, R.A. and S.W. Bailey (1965) The crystal structure of stilpnomelane. Part I. The sub cell. Clays and Clay Minerals, 13, 49–63. (4) Eggleton, R.A. (1972) The crystal structure of stilpnomelane. Part II. The full cell. Mineral. Mag., 38, 693–711. (5) Eggleton, R.A. and B.W. Chappell (1976) The crystal structure of stilpnomelane. Part III. Chemistry and physical properties. Mineral. Mag., 42, 361–368. (6) Crawford, E.S., D.A. Jefferson, and J.M. Thomas (1977) Electron-microscope and diffraction studies of polytypism in stilpnomelane. Acta Cryst., A33, 548–553.

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Stishovite SiO_2

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As aggregates of submicron-size crystals.

Physical Properties: Hardness = n.d. VHN = 2080 ∥ [001]; 1700 ⊥ [001] (100 g load, synthetic). D(meas.) = 4.35 (synthetic). D(calc.) = 4.29 Resonance at –191.3 ppm by ^{29}Si magic-angle spinning nuclear magnetic resonance spectroscopy.

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (+). $\omega = 1.799–1.800$ $\epsilon = 1.826–1.845$

Cell Data: *Space Group:* $P4_2/mnm$ (synthetic). $a = 4.1772(7)$ $c = 2.6651(4)$ $Z = 2$

X-ray Powder Pattern: Meteor Crater, Arizona, USA.
2.959 (100), 1.530 (50), 1.981 (35), 1.235 (25), 2.246 (18), 1.478 (18), 1.870 (13)

Chemistry: Qualitative spectrographic analysis of the mineral from Meteor Crater, Arizona, USA indicates essentially pure SiO_2.

Polymorphism & Series: Quartz, tridymite, cristobalite, and coesite are polymorphs.

Mineral Group: Rutile group.

Occurrence: At sites of meteorite impact, formed by shock metamorphism of quartz at temperatures ≥ 1200 °C and pressures ∼100 kbar; then metastable, alters to glass or cristobalite at ≥ 300 °C.

Association: Coesite, quartz, silica glass.

Distribution: From Meteor Crater, Coconino Co., Arizona, and at the Cretaceous-Tertiary boundary, Raton, Colfax Co., New Mexico, USA. In Germany, at the Nördlinger Ries crater, Bavaria. From the Vredefort Ring crater, Orange Free State, South Africa. At the Ternovska crater, Krivoi Rog, Ukraine. From the Lonar Lake crater, Maharashtra, India.

Name: In honor of the Russian crystallographer Sergei Mikhailovich Stishov, who, with S.V. Popova, first synthesized the compound.

Type Material: n.d.

References: (1) Frondel, C. (1962) Dana's system of mineralogy, (7th edition), v. III, silica minerals, 317–318. (2) Sinclair, W. and A.E. Ringwood (1978) Single crystal analysis of the structure of stishovite. Nature, 272, 714–715. (3) McHone, J.F., R.A. Nieman, C.F. Lewis, and A.M. Yates (1989) Stishovite at Cretaceous-Tertiary boundary, Raton, New Mexico. Science, 243, 1182–1184. (4) Ross, N.L., J.-F. Shu, R.M. Hazen, and T. Gasparik (1990) High-pressure crystal chemistry of stishovite. Amer. Mineral., 75, 739–747.

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Stistaite SnSb

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Crystal Data: Cubic. *Point Group:* n.d. As well-formed cubic crystals, to 0.15 mm, and as aggregates in tin.

Physical Properties: *Tenacity:* Malleable. Hardness = > 2 VHN = 103–127, 115 average. D(meas.) = n.d. D(calc.) = 5.59

Optical Properties: Opaque. *Color:* Pale gray; in polished section, creamy white.

R: (400) —, (420) —, (440) —, (460) 78.0, (480) 79.3, (500) 80.5, (520) 81.2, (540) 81.6, (560) 81.5, (580) 81.3, (600) 81.5, (620) 81.8, (640) 82.0, (660) 82.5, (680) —, (700) —

Cell Data: *Space Group:* n.d. $a = 4.15$ $Z = 1$

X-ray Powder Pattern: Elkiaidai River, Uzbekistan.
3.09 (10), 2.19(10), 1.374 (8), 1.253(7), 1.022 (6), 1.779 (4), 1.537 (4)

Chemistry:

	(1)	(2)	(3)	
Sn	56.9	55.55	56.38	49.36
Cu		0.12		
Sb	43.1	44.33	44.13	50.64
Total	100.0	[100.00]	100.51	100.00

(1) Elkiaidai River, Uzbekistan; by electron microprobe; corresponds to $Sn_{1.15}Sb_{0.85}$. (2) Rio Tamaná, Colombia; by electron microprobe, recalculated to 100% from an original total of 93.84%; corresponds to $Sn_{1.12}Sb_{0.87}$. (3) Baimka placer, Russia; by electron microprobe, corresponds to $Sn_{1.13}Sb_{0.87}$. (4) SnSb.

Occurrence: In concentrates from placer deposits from a region of Silurian shaly-sandy sediments (Elkiaidai River, Uzbekistan); in concentrates from precious metal placers (Rio Tamaná, Colombia).

Association: Tin, zircon, "leucoxene", rutile, apatite, barite, celestine, scheelite, cinnabar (Elkiaidai River, Uzbekistan); tin, sorosite, herzenbergite, cassiterite, lead (Baimka placer, Russia)

Distribution: From the Elkiaidai River, eastern margin of the Northern Nuratau Range, western Uzbekistan [TL]. At the Baimka gold-PGE placer, western Chukotka, Russian Far East, Russia. In the Rio Tamaná, the Department of Chocó, Cauca, Colombia.

Name: For the composition, from Greek STIbium, *antimony*, and STAnnum, *tin*.

Type Material: n.d.

References: (1) Nikolaeva, E.P., V.A. Grigorenko, S.D. Gagarkina, and P.E. Tsypkina (1970) New natural intermetallic compounds of tin, antimony and copper. Zap. Vses. Mineral. Obshch., 99, 68–70 (in Russian). (2) (1971) Amer. Mineral., 56, 358 (abs. ref. 1). (3) Rose, D. (1981) New data for stistaite and antimony-bearing ν–Cu_6Sn_5 from Rio Tamaná, Colombia. Neues Jahrb. Mineral., Monatsh., 117–126. (4) Barkov, A.Y., Laajoki, K.V.O., S.S. Gornostayev, Y.A. Pakhomoovskii, and Y.P. Men'shikov (1998) Sorosite, Cu(Sn, Sb), a new mineral from the Baimka placer deposit, western Chukotka, Russian Far East. Amer. Mineral., 83, 901–906. (5) Hägg, R. and A.G. Hybinette (1935) X-ray studies on the systems tin-antimony and tin-arsenic. Phil. Mag., ser. 7, 20, 913–929. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 195.

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Stoiberite $Cu_5V_2^{5+}O_{10}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As incrustations of polycrystalline aggregates, with crystals, less than 100 μm, platy on {100}.

Physical Properties: Hardness = n.d. D(meas.) = 5.0 (synthetic). D(calc.) = 4.96

Optical Properties: Opaque, transparent only on thin edges. *Color:* Black; reddish brown in transmitted light; very light gray in reflected light. *Streak:* Reddish brown. *Luster:* Metallic. *Optical Class:* Biaxial. *Pleochroism:* Slight; bluish white. *Absorption:* Very weak. *Anisotropism:* Weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P2_1/n$. $a = 15.654(15)$ $b = 6.054(4)$ $c = 8.385(11)$ $\beta = 102.29(12)^\circ$ Z = 4

X-ray Powder Pattern: Izalco volcano, El Salvador.
7.92 (10), 2.095 (8), 4.797 (7), 2.687 (7), 2.603 (7), 1.956 (7), 2.536 (6)

Chemistry:

	(1)	(2)
V_2O_5	30.3	31.38
CrO_3	1.0	
CuO	68.1	68.62
Total	99.4	100.00

(1) Izalco volcano, El Salvador; by electron microprobe, average of 20 analyses of 10 crystals, total V as V_2O_5, Cr as Cr_2O_3; corresponding to $Cu_{4.98}(V_{1.94}Cr_{0.06})_{\Sigma=2.00}O_{10}$. (2) $Cu_5V_2O_{10}$.

Occurrence: A very rare mineral, deposited in vanadium-bearing sublimates in fumaroles on a basaltic volcanic cone.

Association: Shcherbinaite, ziesite, fingerite, bannermanite, chalcocyanite, chalcanthite.

Distribution: On Izalco volcano, El Salvador.

Name: To honor Dr. Richard Edwin Stoiber (1911–2001), Emeritus Professor of Geology, Dartmouth College, Hanover, New Hampshire, USA, who has studied Central American volcanoes and their mineralogy.

Type Material: Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire; National Museum of Natural History, Washington, D.C., USA, 144942.

References: (1) Birnie, R.W. and J.M. Hughes (1979) Stoiberite, $Cu_5V_2O_{10}$, a new copper vanadate from Izalco volcano, El Salvador, Central America. Amer. Mineral., 64, 941–944.
(2) Shannon, R.D. and C. Calvo (1973) Crystal structure of $Cu_5V_2O_{10}$. Acta Cryst., 29, 1338–1345.

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Stokesite **$CaSnSi_3O_9 \cdot 2H_2O$**

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic crystals with {100} and {211} dominant; also spherical and radial fibrous aggregates, to 3 cm.

Physical Properties: *Cleavage:* Perfect on {101}, imperfect on {100}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ~6 D(meas.) = 3.185 D(calc.) = 3.211

Optical Properties: Transparent. *Color:* Colorless to white; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on {100}.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$. $\alpha = 1.609$–1.618 $\beta = 1.612$–1.619 $\gamma = 1.619$–1.628 2V(meas.) = 69.5° 2V(calc.) = 66°40′–70°23′

Cell Data: *Space Group: Pnna.* $a = 14.465$ $b = 11.625$ $c = 5.235$ Z = 4

X-ray Powder Pattern: Roscommon Cliff, England.
3.99 (100), 2.89 (100b), 7.25 (80), 1.556 (70), 5.82 (60), 4.54 (60), 3.55 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	43.1	42.89	42.61
SnO_2	33.3	35.79	35.62
FeO		0.00	
MnO		0.00	
CaO	13.45	12.86	13.25
H_2O	8.6	[8.46]	[8.52]
Total	98.45	[100.00]	[100.00]

(1) Roscommon Cliff, England. (2) Do.; by electron microprobe, H_2O by difference; corresponding to $Ca_{0.97}Sn_{1.00}Si_{3.01}O_9 \cdot 2.03H_2O$. (3) Corrégo do Urucum, Brazil; by electron microprobe, H_2O by difference; corresponding to $Ca_{1.00}Sn_{1.00}Si_{3.00}O_9 \cdot 2.0H_2O$.

Occurrence: On axinite (Roscommon Cliff, England); in miarolitic cavities in a quartz-albite pegmatite (Věžná, Czech Republic).

Association: Axinite, cassiterite (Roscommon Cliff, England); albite, titanite, beryl, microlite, quartz (Corrégo do Urucum, Brazil).

Distribution: On Roscommon Cliff, St. Just, and in the Halvosso quarry, Longdowns, Cornwall, England. From Ctidružice and Věžná, Czech Republic. In the Pitkäranta district, Lake Lagoda, Karelia. Large spherical masses of crystals from Corrégo do Urucum, near Galiléia, Minas Gerais, Brazil. In the USA, in the Himalaya mine, Mesa Grande district, San Diego Co., California. From the Iwaguro Sekizai quarry, Tahara, Gifu Prefecture, Japan.

Name: For Sir George Gabriel Stokes (1819–1903), Professor of Mathematics, Cambridge University, Cambridge, England.

Type Material: Mineralogical Museum, Cambridge University, Cambridge, England.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 100. (2) Gay, P. and Rickson, K.O. (1960) X-ray data on stokesite. Mineral. Mag., 32, 433–435. (3) Vorma, A. (1963) Crystal structure of stokesite, $CaSnSi_3O_9 \cdot 2H_2O$. Mineral. Mag., 33, 615–616. (4) Couper, A.G. and A.M. Clark (1977) Stokesite crystals from two localities. Mineral. Mag., 41, 411–414.

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Stolzite $PbWO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Crystals are commonly dipyramidal {111}, {101}, with {011}, {112}, {001}, complex development with over 30 other forms recorded; may be flat tabular {001}, {101}, to 6 cm.

Physical Properties: *Cleavage:* Imperfect on {001}; indistinct on {011}. *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 8.34 D(calc.) = 8.408 May fluoresce bright red to red-orange under LW UV and lemon-yellow under SW UV.

Optical Properties: Translucent, transparent in thin pieces. *Color:* Reddish brown, brown, yellowish gray, smoky gray, straw-yellow, lemon-yellow; may be green, orange, red. *Streak:* White. *Luster:* Resinous, subadamantine.
Optical Class: Uniaxial (–). $\omega = 2.27$ $\epsilon = 2.18$–2.19

Cell Data: *Space Group:* $I4_1/a$ (synthetic). $a = 5.4695(3)$ $c = 12.0432(3)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.25 (100), 2.024 (35), 1.6606 (35), 2.732 (30), 3.01 (20), 1.7820 (20), 1.931 (16)

Chemistry:

	(1)	(2)
WO_3	51.34	50.95
MnO	0.78	
PbO	47.44	49.05
Total	99.56	100.00

(1) Broken Hill, Australia. (2) $PbWO_4$.

Polymorphism & Series: Dimorphous with raspite.

Occurrence: An uncommon mineral in the oxidized zone of hydrothermal tungsten-bearing lead deposits.

Association: Raspite, cerussite, anglesite, pyromorphite, mimetite.

Distribution: At many localities in small amounts. From Cínovec (Zinnwald), Czech Republic. At Bleiberg, Carinthia, Austria. Large crystals in the Sainte-Lucie mine, Saint-Léger de Peyre, Lozère, France. From La Tala, Salamanca Province, Spain. At several mines in Caldbeck Fells, Cumbria, England. Fine examples from Broken Hill, New South Wales, Australia. At Yaogangxian, Hunan Province, China. From the Kramat Pulai mine, Kinta district, Perak, Malaysia. In the Sumidoro gold placers, Minas Gerais, Brazil. At Diko Ajuba, Nigeria. From Djebel Aouam, Morocco. Large crystals from Tsumeb, Namibia. In the USA, in Arizona, at the Reef mine, Huachuca Mountains, the Primos mine, Little Dragoon Mountains, and the Cohen mine, Dragoon Mountains, Cochise Co.; large crystals at the Fat Jack mine, Bradshaw Mountains, Yavapai Co.; from the Thompson mine, Darwin district, Inyo Co., California; in the Emma mine, Little Cottonwood Canyon district, Salt Lake Co., Utah; at the Black Pine mine, Phillipsburg, Granite Co., Montana.

Name: To honor Dr. Joseph Alexis Stolz (1803–1896), Teplice, Czech Republic, who provided the first specimen.

Type Material: Mining Academy, Freiberg, Germany, 17596.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1087–1089. (2) Hazen, R.M., L.W. Finger, and J.W.E. Mariathasan (1985) High-pressure crystal chemistry of scheelite-type tungstates and molybdates. J. Phys. Chem. Solids, 46, 253–263. (3) Xu Keqin, Xue Jiyue, Ding Yang, and Lu Guanglie (1994) Discovery of stolzite in China and refinement of its crystal structure. Acta Geologica Sinica, 68(3), 287–292 (in Chinese with English abs.). (4) (1967) NBS Mono. 25, 5, 34.

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Stottite $\mathbf{Fe^{2+}Ge^{4+}(OH)_6}$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m$. Crystals are tetragonal dipyramidal, pseudo-octahedral, with dominant {111}, modified by {100}, {110}, {101}, {102}, {001}, and others, to 1 cm.

Physical Properties: *Cleavage:* {100}, {010}, good; {001}, poor. Hardness = 4.5
D(meas.) = 3.596 D(calc.) = [3.54]

Optical Properties: Transparent to translucent. *Color:* Brown, green, orange, red; in transmitted light, orange-brown, may be zoned with light olive-gray to nearly colorless centers. *Streak:* Grayish white. *Luster:* Resinous to adamantine, greasy on cleavages.
Optical Class: Uniaxial (–); anomalously biaxial. *Dispersion:* $r > v$. $\omega = 1.737$–1.738 $\epsilon = 1.728$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P4_2/n$. $a = 7.594(4)$ $c = 7.488(6)$ $Z = 4$

X-ray Powder Pattern: Tsumeb, Namibia.
3.767 (vs), 2.655 (s), 1.687 (ms), 2.171 (m), 1.886 (m), 1.672 (m), 1.538 (m)

Chemistry:

	(1)	(2)
GeO_2	41.75	45.38
FeO	34.81	31.17
MnO	0.88	
MgO	0.46	
CaO	0.34	
H_2O	21.84	23.45
Total	100.08	100.00

(1) Tsumeb, Namibia; corresponds to $(Fe^{2+}_{1.15}Mg_{0.03}Mn_{0.03}Ca_{0.01})_{\Sigma=1.22}Ge^{4+}_{0.95}(OH)_6$.
(2) $FeGe(OH)_6$.

Mineral Group: Stottite group.

Occurrence: A rare secondary mineral formed in an oxidized zone of a germanium-rich dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tennantite, germanite, reniérite, chalcocite, leiteite, schneiderhöhnite, brunogeierite, siderite.

Distribution: From Tsumeb, Namibia.

Name: To honor Charles E. Stott (1896–1978), geologist and formerly General Director of the Tsumeb mine, Tsumeb, Namibia.

Type Material: Technical University, Berlin, Germany; National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, USA, 111460.

References: (1) Strunz, H., G. Söhnge, and B.H. Geier (1958) Stottit, ein neues Germanium-Mineral, und seine Paragenese in Tsumeb. Neues Jahrb. Mineral., Monatsh., 85–96 (in German). (2) (1958) Amer. Mineral., 43, 1006 (abs. ref. 1). (3) Ross, C.R., II, L.R. Bernstein, and G.A. Waychunas (1988) Crystal-structure refinement of stottite, $FeGe(OH)_6$. Amer. Mineral., 73, 657–661.

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Straczekite $\mathbf{(Ca,K,Ba)(V^{5+},V^{4+})_8O_{20}\cdot 3H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. Lathlike fibers, elongated along [010], to 0.5 mm, in radiating groups and foliated masses. *Twinning:* On {00*l*}, possible, observed by X-ray diffraction.

Physical Properties: *Cleavage:* {100}, perfect. Hardness = Very soft. D(meas.) = 3.09–3.29 D(calc.) = 3.21

Optical Properties: Opaque, thin flakes are translucent. *Color:* Greenish black; yellowish green in transmitted light. *Streak:* Greenish black. *Luster:* Greasy.
Optical Class: Biaxial (–) (probable). *Pleochroism:* Slight; apple-green to olive-green.
Orientation: Extinction parallel to length. n = [1.99] (by the rule of Gladstone and Dale).
2V(meas.) = Large.

Cell Data: *Space Group:* $C2/m$, $C2$, or Cm. $a = 11.679(2)$ $b = 3.6608(4)$ $c = 10.636(2)$ $\beta = 100.53(4)^\circ$ Z = [1]

X-ray Powder Pattern: Wilson Springs, Arkansas, USA.
3.486 (100), 10.449 (50), 1.8306 (50), 1.9437 (15), 3.255 (10), 2.492 (10), 1.8030 (10)

Chemistry:

	(1)
V_2O_5	66.4
V_2O_4	15.3
Fe_2O_3	0.9
CaO	2.5
BaO	5.5
Na_2O	0.4
K_2O	1.8
H_2O	7.2
Total	100.0

(1) Wilson Springs, Arkansas, USA; corresponds to $(Ca_{0.39}K_{0.33}Ba_{0.31}Na_{0.11})_{\Sigma=1.14}(V^{5+}_{6.31}V^{4+}_{1.59}Fe^{3+}_{0.10})_{\Sigma=8.00}O_{20.02}\cdot 2.9H_2O$. (2) Monument No. 2 mine, Arizona, USA; analysis not given, corresponds to $(Ca_{0.58}K_{0.11}Na_{0.06}Fe_{0.04})_{\Sigma=0.79}(V_{7.87}Fe_{0.13})_{\Sigma=8.00}O_{20}\cdot 3.17H_2O$.

Occurrence: An uncommon secondary mineral, in seams in argillaceous gangue, in vanadium-rich alkalic igneous and metamorphosed sedimentary rocks (Wilson Springs, Arkansas, USA).

Association: Hewettite, duttonite, fervanite, schoderite, metaschoderite (Wilson Springs, Arkansas, USA).

Distribution: In the USA, in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas, and from the Monument No. 2 mine, Monument Valley, Apache Co., Arizona.

Name: To honor John A. Straczek, Chief Geologist, Union Carbide Corporation.

Type Material: n.d.

References: (1) Evans, H.T., Jr., G. Nord, J. Marinenko, and C. Milton (1984) Straczekite, a new calcium barium potassium vanadate mineral from Wilson Springs, Arkansas. Mineral. Mag., 48, 289–293. (2) (1985) Amer. Mineral., 70, 877 (abs. ref. 1). (3) Evans, H.T., Jr. and J.M. Hughes (1990) Crystal chemistry of the natural vanadium bronzes. Amer. Mineral., 75, 508–521, esp. 515–516.

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Stranskiite $Zn_2Cu(AsO_4)_2$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Tabular crystals in radiating aggregates and massive, to 1 cm.

Physical Properties: *Cleavage:* On {010}, good; on {100}, {001}, {$\overline{1}$01}, indistinct. Hardness = 4 D(meas.) = 5.23–5.3 D(calc.) = 5.00–5.1

Optical Properties: Semitransparent. *Color:* Cyan-blue. *Luster:* Vitreous. *Optical Class:* Biaxial (–). $\alpha = 1.795$ $\beta = 1.842$ $\gamma = 1.874$ 2V(meas.) = 80° 2V(calc.) = 76°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.073$–5.092 $b = 6.669$–6.695 $c = 5.268$–5.304 $\alpha = 109.85°-110.16°$ $\beta = 112.09°-112.14°$ $\gamma = 86.74°-86.88°$ Z = 1

X-ray Powder Pattern: Tsumeb, Namibia.
3.134 (100), 2.788 (80), 2.506 (60), 4.154 (30), 2.601 (30), 6.250 (20), 4.690 (20)

Chemistry:

	(1)	(2)	(3)	(4)
SO_3		trace		
As_2O_5	47.1	50.3	49.0	48.68
SiO_2	1.3			
FeO	0.8	trace		
CuO	18.4	21.1	17.4	16.85
ZnO	30.4	28.0	34.4	34.47
MgO	0.8			
CaO	1.2			
Total	100.0	99.4	100.8	100.00

(1) Tsumeb, Namibia; analysis calculated from empirical $(Zn_{1.73}Ca_{0.10}Mg_{0.09}Fe_{0.05})_{\Sigma=1.97}$ $Cu_{1.07}[(As_{0.95}Si_{0.05})_{\Sigma=1.00}O_4]_2$. (2) Do.; by XRF, corresponding to $Zn_{1.69}Cu_{1.28}(AsO_4)_{2.00}$. (3) Do.; by electron microprobe. (4) $Zn_2Cu(AsO_4)_2$.

Occurrence: A very rare secondary mineral in the oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Chalcocite, tennantite, galena, schulténite, anglesite, bayldonite, cuprian adamite, keyite, olivenite, claudetite, ludlockite, tsumcorite, koritnigite, warikahnite, duftite, carminite, beudantite, scorodite, o'danielite, zincroselite, leiteite.

Distribution: From Tsumeb, Namibia.

Name: Honoring Professor Iwan N. Stranski (1897–1979), German chemist and physicist, Berlin, Germany.

Type Material: n.d.

References: (1) Strunz, H. (1960) Stranskiit, ein neues Mineral. Naturwiss., 47, 376 (in German). (2) (1960) Amer. Mineral., 45, 1315 (abs. ref. 1). (3) Hänni, H.A., W.B. Stern, and M. Glor (1978) New data on stranskiite from Tsumeb, Namibia. Amer. Mineral., 63, 213–215. (4) Keller, P., H. Hess, and P.J. Dunn (1979) Die Ladungsbilanz für eine verfeinerte Kristallstruktur von Stranskiit, $Zn_2Cu(AsO_4)_2$. Tschermaks Mineral. Petrog. Mitt., 26, 167–174 (in German with English abs.).

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Strashimirite $Cu_8(AsO_4)_4(OH)_4 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. Thin tabular, elongated to fibrous crystals, to 4 mm, typically in radiating spherulitic aggregates, to 1 cm, and in crusts.

Physical Properties: *Cleavage:* May exhibit parting $\perp$ elongation. Hardness = n.d. D(meas.) = n.d. D(calc.) = [3.67]

Optical Properties: Semitransparent. *Color:* White to pale green. *Luster:* Pearly to greasy. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; Y = very pale yellowish green; Z = yellowish green. *Orientation:* $Z \wedge$ elongation $\simeq 5°$. $\alpha = 1.726(1)$ $\beta =$ n.d. $\gamma = 1.747(2)$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P2/m$, Pm, or $P2$. $a = 9.70$ $b = 18.90$ $c = 9.127$ $\beta = 97°15'$ Z = 3

X-ray Powder Pattern: Zapachitsa deposit, Bulgaria.
18.74 (10), 2.86 (10), 8.97 (9), 3.13 (9), 9.46 (8), 4.79 (8), 4.21 (8)

Chemistry:

	(1)	(2)
As_2O_5	38.3	37.61
CuO	49.8	52.07
ZnO	2.0	
H_2O	[9.9]	10.32
Total	[100.0]	100.00

(1) Zapachitsa deposit, Bulgaria; H_2O by difference, corresponds to $(Cu_{7.70}Zn_{0.30})_{\Sigma=8.00}(AsO_4)_{4.08}(OH)_{3.52} \cdot 5H_2O$. (2) $Cu_8(AsO_4)_4(OH)_4 \cdot 5H_2O$.

Occurrence: A secondary mineral in the oxidation zone of Cu–As-bearing mineral deposits.

Association: Tyrolite, cornwallite, clinoclase, euchroite, olivenite, parnauite, goudeyite, arthurite, metazeunerite, chalcophyllite, cyanotrichite, scorodite, pharmacosiderite, brochantite, azurite, malachite, chrysocolla.

Distribution: At the Zapachitsa copper deposit, Ismerez, Stara-Planina, Bulgaria. From Novoveská Huta, Czech Republic. On the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais, Switzerland. In Germany, from Kamsdorf and Saalfeld, Thuringia; at the Clara mine, near Oberwolfach, Black Forest; in the Richelsdorf Mountains, Hesse; and elsewhere. From the Cap Garonne mine, near le Pradet, Var, and Triembach-au-Val, Haut-Rhin, France. At Wheals Gorland and Unity, Gwennap, Cornwall, England. In the Tynagh mine, near Loughrea, Co. Galway, Ireland. In the USA, in Nevada, at the Majuba Hill mine, Antelope district, Pershing Co., in the Nickel mine, Table Mountain district, Churchill Co., from the San Rafael mine, Lodi district, Nye Co., and the Burrus mine, Pyramid district, Washoe Co.; from Gold Hill, Tooele Co., and in the Centennial Eureka mine, Tintic district, Juab Co., Utah.

Name: To honor Strashimir Dimitrov, Bulgarian petrographer.

Type Material: Natural History Museum, Sofia; University of Sofia, Sofia, Bulgaria.

References: (1) Mincheva-Stefanova, I. (1968) Strashimirite, a new hydrous copper arsenate. Zap. Vses. Mineral. Obshch., 97, 470–477 (in Russian). (2) (1969) Amer. Mineral., 54, 1221 (abs. ref. 1). (3) Minčeva-Stefanova, J. (1986) Parageneses of strashimirite. Geohimija, Mineralogija i Petrologija, 20–21, 49–57 (in Bulgarian with English abs.). (4) (1988) Mineral. Abs., 39, 116 (abs. ref. 3).

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Strätlingite $Ca_2Al_2SiO_2(OH)_{10}\cdot 2.25H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\,2/m$. Platy crystals, to 0.5 mm, and in rosettes.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.96–1.98

Optical Properties: Transparent. *Color:* Colorless to light green.
Optical Class: Uniaxial (–). $\omega = 1.534$ ϵ = n.d.

Cell Data: *Space Group:* $R\bar{3}m$. a = 5.745(7) c = 37.77(1) Z = 3

X-ray Powder Pattern: Bellerberg volcano, Germany.
12.5 (100), 4.16 (100), 6.2 (70), 2.87 (70), 2.61 (40), 2.49 (40), 2.12 (40)

Chemistry:

	(1)	(2)
SiO_2	17.55	15.97
Al_2O_3	23.22	24.15
CaO	25.13	25.60
SrO	1.09	0.74
BaO	0.90	0.81
Na_2O	0.13	0.04
K_2O	0.18	0.01
H_2O^+		28.00
H_2O^-		4.5
H_2O	[31.80]	
Total	[100.00]	99.82

(1) Bellerberg volcano, Germany; by electron microprobe, H_2O by difference; corresponding to $(Ca_{1.90}Sr_{0.04}Ba_{0.03}Na_{0.02}K_{0.01})_{\Sigma=2.00}Al_{1.93}Si_{1.24}O_{2.13}(OH)_{10.44}\cdot 2.25H_2O$. (2) Montalto di Castro, Italy; by electron microprobe, H_2O by TGA; corresponding to $(Ca_{1.94}Sr_{0.03}Ba_{0.02}Na_{0.01})_{\Sigma=2.00}$ $Al_{2.02}Si_{1.13}O_{1.85}(OH)_{10.85}\cdot 2.25H_2O$.

Occurrence: In a metamorphosed limestone xenolith in basalt (Bellerberg volcano, Germany); within metamorphosed clay xenoliths in phonolite (Montalto di Castro, Italy).

Association: Nepheline, melilite, garnet, thomsonite, gismondine, ettringite, hydrocalumite (Bellerberg volcano, Germany); tobermorite, ettringite, calcite, vertumnite (Montalto di Castro, Italy).

Distribution: At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. In a quarry at Campomorto, Montalto di Castro, Lazio, Italy.

Name: For W. Strätling, who synthesized the mineral.

Type Material: University of Erlangen, Nürnberg, Germany; National Museum of Natural History, Washington, D.C., USA, 137064.

References: (1) Hentschel, G. and H.-J. Kuzel (1976) Strätlingit, $2CaO\cdot Al_2O_3\cdot SiO_2\cdot 8H_2O$, ein neues Mineral. Neues Jahrb. Mineral., Monatsh., 326–330 (in German with English abs.). (2) Kuzel, H.-J. (1976) Crystallographic data and thermal decomposition of synthetic gehlenite hydrate $2CaO\cdot Al_2O_3\cdot SiO_2\cdot 8H_2O$. Neues Jahrb. Mineral., Monatsh., 319–325. (3) (1977) Amer. Mineral., 62, 395 (abs. refs. 1 and 2). (4) Rinaldi, R., M. Sacerdoti, and E. Passaglia (1990) Strätlingite: crystal structure, chemistry, and a reexamination of its polytype vertumnite. Eur. J. Mineral., 2, 841–849.

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Strelkinite $Na_2(UO_2)_2(V_2O_8)\cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Rare in platy to equant crystals, to 1.5 mm, which may be in fanlike aggregates; usually in powdery crusts.

Physical Properties: *Cleavage:* One, $\perp$ {001}, perfect. Hardness = 2–2.5 D(meas.) = 4.0–4.2 (corrected for impurities). D(calc.) = 4.22 Radioactive; fluoresces pale tobacco-green under UV.

Optical Properties: Semitransparent. *Color:* Gold-yellow to canary-yellow. *Luster:* Silky to pearly.
Optical Class: Biaxial (–). *Pleochroism:* Weak; Y = yellow; Z = pale yellow. *Orientation:* X = c; $Y = b$; $Z = a$. $\alpha = 1.674$–1.770 $\beta = 1.855$–1.907 $\gamma = 1.880$–1.915 2V(meas.) = Medium.

Cell Data: *Space Group:* $Pnmm$ or $Pnm2$. $a = 10.64(2)$ $b = 8.36(2)$ $c = 32.72(2)$
Z = 8

X-ray Powder Pattern: n.d.
7.68 (10), 3.95 (8), 4.08 (6), 3.20 (5), 8.18 (4), 2.007 (4), 3.55 (3)

Chemistry:

	(1)	(2)	(3)
UO_3	61.48	56.95	61.91
V_2O_5	21.30	18.50	19.68
SiO_2		4.40	
Al_2O_3		0.22	
CaO	0.40	1.44	
Na_2O	8.35	6.20	6.71
K_2O	0.00	0.20	
H_2O^+	8.12	10.27	11.70
LOI		2.23	
Total	99.65	100.41	100.00

(1) Basaral, Kazakhstan; CaO due to calcite impurity; corresponds to $Na_{2.28}(UO_2)_{1.84}(V_2O_8)\cdot 3.85H_2O$. (2) Do.; original LOI given as 12.50%, partitioned as H_2O 10.27%, CO_2 1.15%, reduction of U^{6+} and V^{5+} 1.08%, then deducting SiO_2, Al_2O_3, CaO, K_2O as due to calcite and clay impurities, corresponds to $Na_{2.00}(UO_2)_{2.00}(V_2O_8)\cdot 5.70H_2O$. (3) $Na_2(UO_2)_2(V_2O_8)\cdot 6H_2O$.

Occurrence: Along seams and fractures in carbonaceous-siliceous shales.

Association: Calcite, quartz, iron hydroxides, clay minerals.

Distribution: From Basaral, ten km north of the Bota-Burum uranium deposit, Chi-Ili Mountains, Kazakhstan. In the Kendyktas Mountains, Kyzylkum district, Uzbekistan.

Name: To honor Professor Mikhail Fedorovich Strelkin (1905–1965), Russian mineralogist, Institute of Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry, Moscow, Russia, who studied uranium ores.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74783, 74784.

References: (1) Alekseeva, M.A., A.A. Chernikov, D.P. Shashkin, E.A. Kon'kova, and I.N. Gavrilova (1974) Strelkinite – a new uranyl vanadate. Zap. Vses. Mineral. Obshch., 103, 576–580 (in Russian). (2) (1975) Amer. Mineral., 60, 488–489 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 195–196.

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Strengite $Fe^{3+}PO_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are variable in habit, may be dominated by {111}, lathlike along [001], or elongated along [100] or [010], to 5 cm, with many forms. Generally radial fibrous, as botryoidal or spherical aggregates and crusts. *Twinning:* Rarely on {201}.

Physical Properties: *Cleavage:* On {010}, good; on {001}, poor. Hardness = 3.5 D(meas.) = 2.84–2.87 D(calc.) = 2.84

Optical Properties: Transparent to translucent. *Color:* Purple, violet, pink, peach-blossom-red, carmine, greenish white; may be nearly colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, strong. $\alpha = 1.697$–1.708 $\beta = 1.708$–1.719 $\gamma = 1.741$–1.745 2V(meas.) = Moderate to small.

Cell Data: *Space Group: Pcab.* $a = 10.122(1)$ $b = 9.886(1)$ $c = 8.7233(7)$ Z = 8

X-ray Powder Pattern: The Kreuzberg, Germany. (ICDD 33–667).
3.114 (100), 4.383 (85), 5.509 (60), 2.546 (50), 3.996 (45), 3.002 (45), 2.949 (45)

Chemistry:

	(1)	(2)
P_2O_5	38.24	37.99
Fe_2O_3	43.40	42.73
H_2O	18.89	19.28
Total	100.53	100.00

(1) Pleystein, Germany. (2) $FePO_4 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with phosphosiderite, forms a series with variscite.

Mineral Group: Variscite group.

Occurrence: A late secondary mineral in complex granite pegmatites; in "limonite" iron ores and gossans; with magnetite iron ores; rarely a cave mineral.

Association: Beraunite, huréaulite, dufrénite, bermanite, stewartite, cacoxenite, rockbridgeite, vivianite, apatite, leucophosphite, phosphosiderite.

Distribution: In Germany, in the Eleonore and Rotläufchen iron mines, near Giessen, Hesse; at Hagendorf, and on the Kreuzberg, Pleystein, Bavaria. At Cyrilov, Czech Republic. In Sweden, from the Leveäniemi mine, Svappavaara, and in the Kiruna iron mines. At Iglesias, Sardinia, Italy. From the Mangualde pegmatite, near Mesquitela, Portugal. In the Bomi Hill Caves, Liberia. In the USA, from the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., New Hampshire; at Midvale, Rockbridge Co., Virginia; large crystals from Indian Mountain, Cherokee Co., Alabama; at Three Oak Gap and the Coon Creek mine, Polk Co., Arkansas; in the Wood mine, Cooke Co., Tennessee; from the Bull Moose mine, five km southeast of Custer, Custer Co., South Dakota; at Pala, San Diego Co., California. In the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina. At the Iron Monarch quarry, Iron Knob, South Australia. A number of other minor localities are known.

Name: To honor Johan August Streng (1830–1897), German mineralogist, University of Giessen, Giessen, Germany.

Type Material: Wroclaw University, Wroclaw, Poland, II–18166.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 756–761.

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Stringhamite $CaCuSiO_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals well-formed, but smaller than 0.1 mm, dominated by {011} and {101}; also as botryoidal fracture fillings. *Twinning:* Common, perhaps pervasive, on an undetermined law.

Physical Properties: Hardness = n.d. D(meas.) = 3.16–3.18 D(calc.) = 3.67

Optical Properties: Transparent to translucent. *Color:* Deep azure.
Optical Class: Biaxial (+). *Pleochroism:* X = light blue-gray; Y = light blue; Z = dark blue.
Orientation: $X = b$; $Y \wedge c = 2.5°$. $\alpha = 1.709$ $\beta = 1.717$ $\gamma = 1.729$ 2V(meas.) = n.d.
2V(calc.) = 80°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.030(2)$ $b = 16.135(3)$ $c = 5.343(1)$
$\beta = 102.96(1)°$ Z = 4

X-ray Powder Pattern: Bawana mine, Utah, USA.
2.768 (100), 2.523 (40), 3.236 (39), 8.049 (35), 3.928 (34), 1.614 (23), 4.884 (21)

Chemistry:

	(1)	(2)
SiO_2	26.95	28.11
Al_2O_3	0.07	
FeO	0.77	
CuO	33.41	37.22
MgO	0.01	
CaO	25.40	26.24
H_2O	[13.39]	8.43
Total	[100.00]	100.00

(1) Bawana mine, Utah, USA; by electron microprobe, H_2O by difference. (2) $CaCuSiO_4 \cdot H_2O$.

Occurrence: A retrograde reaction product between copper-bearing solutions and diopside in diopside-magnetite tactites (Bawana mine, Utah, USA).

Association: Thaumasite, tenorite, kinoite, calcite (Bawana mine, Utah, USA); kinoite, apophyllite (Christmas, Arizona, USA).

Distribution: In the USA, in the Bawana mine, about six km northwest of Milford, Beaver Co., Utah; at Crestmore, Riverside Co., California; and from the Christmas copper mine, Gila Co., Arizona. In the El Bronce mine, Tierra Amarilla, Copiapó, Chile.

Name: In honor of Bronson Ferrin Stringham (1907–1968), Professor of Mineralogy, University of Utah, Salt Lake City, Utah, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128031; The Natural History Museum, London, England, 1976,421.

References: (1) Hindman, J.R. (1976) Stringhamite, a new hydrous copper calcium silicate from Utah. Amer. Mineral., 61, 189–192. (2) Hawthorne, F.C. (1985) The crystal structure of stringhamite. Tschermaks Mineral. Petrog. Mitt., 34, 15–24.

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Stromeyerite AgCuS

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are prismatic, pseudohexagonal about [010], to 5 mm; commonly massive, compact. *Twinning:* Common on {101}.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 VHN = 70–72 (25 g load). D(meas.) = 6.2–6.3 D(calc.) = 6.33

Optical Properties: Opaque. *Color:* Dark steel-gray, tarnishes bluish; in polished section, dull grayish white. *Streak:* Steel-gray. *Luster:* Metallic. *Pleochroism:* Weak in air, strong in oil, grayish brown to whitish gray, with a faint bluish gray tinge or creamy with a pink tint. *Anisotropism:* Strong, vivid blue and deep violet.

R_1–R_2: (400) 30.5–36.0, (420) 30.4–39.7, (440) 29.8–41.6, (460) 28.9–39.8, (480) 28.0–36.5, (500) 27.4–34.0, (520) 27.0–32.3, (540) 26.7–31.2, (560) 26.5–30.3, (580) 26.4–29.7, (600) 26.3–29.3, (620) 26.3–29.1, (640) 26.3–28.8, (660) 26.3–28.9, (680) 26.4–28.9, (700) 26.6–29.2

Cell Data: *Space Group: Bbmm.* $a = 6.62$ $b = 7.94$ $c = 4.06$ Z = 4

X-ray Powder Pattern: Silver King mine, Arizona, USA.
2.61 (100), 3.30 (60), 2.02 (50), 1.985 (50), 1.884 (50), 1.740 (40), 1.421 (40)

Chemistry:

	(1)	(2)	(3)
Ag	53.31	52.10	53.01
Cu	31.00	32.14	31.24
Fe	trace		
S	16.02	15.26	15.75
Total	100.33	99.50	100.00

(1) Foster mine, Cobalt, Canada. (2) Guarisamey, Mexico; average of three analyses. (3) AgCuS.

Occurrence: In hydrothermal veins, formed most commonly by secondary processes, although it also forms as a primary mineral.

Association: Freibergite, bornite, chalcopyrite, galena, other sulfides.

Distribution: An accessory mineral in a number of deposits, although only rarely in good crystals. From Zmeyewskaja-Goro, near Zmeinogorsk (Schlangenberg), Altai Mountains, Siberia, Russia [TL]. In Kazakhstan, at Dzhezkazgan. From Godejord, Norway. At Rudelstadt and Kupferberg, Silesia, Poland. From Příbram and Vrančice, Czech Republic. In Australia, at Mt. Lyell, Tasmania, and from Broken Hill, New South Wales. In Chile, at Santiago, at San Lorenzo in Aconcagua, and at Copiapó and Tarapacá. In the USA, in Arizona, an important ore mineral at the Silver King and Magma mines, Superior, Pinal Co. In Colorado, at many mines in the state; crystallized from the Red Mountain district, San Juan Co.; the American Sisters mine, Clear Creek Co., and elsewhere. From Butte, Silver Bow Co., Montana. In Canada, from Cobalt and Gowganda, Timiskaming district, Ontario; and at the Silver King mine, south of Nelson, British Columbia.

Name: In honor of Professor Friedrich Stromeyer (1776–1835), chemist and mineralogist, University of Göttingen, Göttingen, Germany, who first analyzed the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 190–191. (2) Frueh, A.J., Jr. (1955) The crystal structure of stromeyerite, AgCuS: a possible defect structure. Zeits. Krist., 106, 299–307. (3) Suhr, N. (1955) The

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Ag_2S–Cu_2S system. Econ. Geol., 50, 347–350. ??data used?? (??) Baker, ??, ?? (1991) ??title?? Acta Cryst., ??, 891–??. str, Strunz?? (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 36–37. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 477–480. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 539. (7) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 196.

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Stronalsite $Na_2SrAl_4Si_4O_{16}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. In short prisms, to 1 mm, forming blocky aggregates.

Physical Properties: *Cleavage:* Rectangular parting suspected. Hardness = 6.5
D(meas.) = 2.95 D(calc.) = 2.95

Optical Properties: Semitransparent. *Color:* White; in thin section, colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. $\alpha = 1.563(2)$ $\beta = [1.564]$ $\gamma = 1.574(2)$ 2V(meas.) = 32°

Cell Data: *Space Group:* *Ibam* or *Iba*2. $a = 8.415(4)$ $b = 9.901(4)$ $c = 16.729(9)$
Z = 4

X-ray Powder Pattern: Rendai, Japan; very similar to banalsite.
3.204 (100), 3.502 (80), 2.881 (70), 3.183 (50), 2.067 (50), 3.765 (40), 3.069 (40)

Chemistry:

	(1)	(2)
SiO_2	39.09	38.87
Al_2O_3	32.70	32.30
CaO	0.17	0.41
SrO	15.71	17.11
BaO	2.29	0.80
Na_2O	9.98	10.12
Total	[99.94]	99.61

(1) Rendai, Japan; by electron microprobe, average of five analyses, original total given as 99.91%; corresponds to $Na_{1.99}(Sr_{0.94}Ba_{0.09}Ca_{0.02})_{\Sigma=1.05}Al_{3.95}Si_{4.01}O_{16}$. (2) Mt. Ohsa, Japan; by electron microprobe; corresponds to $Na_{2.02}(Sr_{1.03}Ca_{0.05}Ba_{0.03})_{\Sigma=1.11}Al_{3.92}Si_{4.00}O_{16}$.

Mineral Group: Feldspar group.

Occurrence: A secondary alteration mineral in veins cutting mafic metatuff xenoliths (Rendai, Japan); in veinlets and grains in jadeitic aggregates within serpentinite (Mt. Ohsa, Japan).

Association: Pectolite, slawsonite, albite, calcite, aragonite, natrolite, thomsonite, prehnite, datolite, rosenhahnite, vuagnatite.

Distribution: From a quarry near Rendai, Kochi City, Kochi Prefecture, and on Mt. Ohsa, Okayama Prefecture, Japan.

Name: For STRONtium and ALuminum in its composition.

Type Material: National Science Museum, Tokyo, Japan; National Museum of Natural History, Washington, D.C., USA, 160484.

References: (1) Hori, H., I. Nakai, K. Nagashima, S. Matsubara, and A. Kato (1987) Stronalsite, $SrNa_2Al_4Si_4O_{16}$, a new mineral from Rendai, Kochi City, Japan. Mineral. J. (Japan), 13, 368–375. (2) (1988) Amer. Mineral., 73, 195 (abs. ref. 1).

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Strontianite $SrCO_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals typically short to long prismatic, may be acicular, elongated along [001], pseudohexagonal, to 8 cm; columnar, fibrous, rounded, granular, powdery, massive. *Twinning:* On {110}, contact or less commonly penetration twins, repeated to give trillings, fourlings; may be polysynthetic.

Physical Properties: *Cleavage:* On {110}, nearly perfect; on {021}, poor; on {010}, interrupted. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 3.76(2) D(calc.) = 3.780 May be thermoluminescent; fluorescent under UV, cathodoluminescent under X-rays and electron beams.

Optical Properties: Transparent to translucent. *Color:* Colorless, gray, pale yellow, pale green, yellowish brown, pale red, may be longitudinally zoned; colorless in transmitted light. *Luster:* Vitreous, resinous on breaks.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, weak.
$\alpha = 1.517$ $\beta = 1.663$ $\gamma = 1.667$ 2V(meas.) = n.d. 2V(calc.) = 7°07′

Cell Data: *Space Group: Pmcn.* $a = 5.1059(7)$ $b = 8.4207(13)$ $c = 6.0319(11)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.535 (100), 3.450 (70), 2.0526 (50), 2.458 (40), 1.9053 (35), 2.481 (34), 2.4511 (33)

Chemistry:

	(1)	(2)
CO_2	30.35	29.81
CaO	2.70	
SrO	66.31	70.19
BaO	0.17	
Total	99.53	100.00

(1) Strontian, Scotland. (2) $SrCO_3$.

Mineral Group: Aragonite group.

Occurrence: An uncommon low-temperature hydrothermal mineral formed in veins in limestone, marl, and chalk; in geodes and concretions; rarely occurs in hydrothermal metallic veins; common in carbonatites.

Association: Barite, calcite, celestine, harmotome, sulfur.

Distribution: Dozens of known localities, nearly all in minor amounts. From Strontian, Argyll, Scotland. In Germany, from Clausthal and Bad Grund, Harz Mountains; at Bräunsdorf, near Freiberg, Saxony; in the Lützow mine, Könitz, Thuringia; commercial deposits at Drensteinfurt, near Hamm, Westphalia; in the Dreislar mine, near Medebach, with fine crystals from Aschberg, Beckum, North Rhine-Westphalia. In Austria, large crystals from Oberdorf, Styria, and at Leogang, Salzburg; from Brixlegg, Tirol. From Nepean Township, Ontario, Canada. In the USA, from the Strontium Hills, 16 km north of Barstow, San Bernardino Co., California; in the Homestake mine, Lead, Lawrence Co., South Dakota; in Illinois, at a number of mines around Rosiclare, as the Minerva #1 mine, Cave-in-Rock, Hardin Co., Illinois; in the Winfield quarry, Union Co., Pennsylvania. From the Sierra Mojada district, Coahuila, Mexico. In the Kovdor, Sallanlatvi, and Vouriyärvi carbonatites, and the Khibiny and Lovozero massifs, Kola Peninsula, Russia.

Name: For Strontian, Scotland, source of the first specimens.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 196–200. (2) Speer, J.A. and M.L. Hensley-Dunn (1976) Strontianite composition and physical properties. Amer. Mineral., 61, 1001–1004. (3) Jarosch, D. and G. Heger (1988) Neutron diffraction investigation of strontianite, $SrCO_3$. Bull. Minéral., 111, 139–142. (4) (1953) NBS Circ, 539, v. 3.

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Strontioborite $SrB_8O_{11}(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* 2. Micalike crystals, to 2 mm.

Physical Properties: *Tenacity:* Very brittle. Hardness = n.d. D(meas.) = 2.40 D(calc.) = 2.38

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Biaxial (+) or (–). *Orientation:* Positive or negative elongation, inclined extinction. $\alpha = 1.470(2)$ $\beta = 1.510(2)$ $\gamma = 1.579(2)$ 2V(meas.) = ∼85° 2V(calc.) = 78°

Cell Data: *Space Group:* $P2_1$. $a = 9.909(5)$ $b = 8.130(10)$ $c = 7.623(1)$ $\beta = 108.4(2)°$ Z = 2

X-ray Powder Pattern: Chelkar salt dome, Kazakhstan.
7.33 (10), 4.09 (8), 3.50 (7), 3.32 (7), 3.06 (6), 2.033 (6), 7.77 (4)

Chemistry:

	(1)	(2)
B_2O_3	57.85	66.60
MgO	5.75	
CaO	4.15	
SrO	21.66	24.78
H_2O	11.52	8.62
Total	100.93	100.00

(1) Chelkar salt dome, Kazakhstan. (2) $SrB_8O_{11}(OH)_4$.

Occurrence: In the insoluble residue from a salt dome.

Association: Ginorite, boracite, halurgite, kieserite, anhydrite, preobrazhenskite, boracite, aksaite, metaborite (Chelkar salt dome, Kazakhstan).

Distribution: From the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, and in the Inder borate deposit, Kazakhstan.

Name: For STRONTIum and BORate in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69851.

References: (1) Lobanova, V.V. (1960) A new borate – strontioborite. Doklady Acad. Nauk SSSR, 135, 173–175 (in Russian). (2) (1961) Amer. Mineral., 46, 768 (abs. ref. 1).
(3) Brovkin, A.A., N.V. Zayakina, and V.S. Brovkina (1976) Crystal structure of strontioborite $Sr[B_8O_{11}(OH)_4]$. Kristallografiya (Sov. Phys. Crystal.), 20, 911–916 (in Russian).

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Strontiochevkinite $(Sr, La, Ce, Ca)_4(Fe^{2+}, Fe^{3+})(Ti, Zr)_4Si_4O_{22}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As rounded grains, up to 1.5 mm. *Twinning:* Thick parallel or interpenetrating twins seen in polished section.

Physical Properties: Hardness = ∼5 D(meas.) = n.d. D(calc.) = 5.44

Optical Properties: Opaque. *Color:* Flesh-pink; dark gray in reflected light, may show deep red internal reflections. *Luster:* Submetallic. *Anisotropism:* Strong, in shades of gray.

Cell Data: *Space Group:* $P2_1/a$. $a = 13.56$ $b = 5.70$ $c = 11.10$ $\beta = 100.32°$ $Z = 2$

X-ray Powder Pattern: Near Sarambi, Paraguay.
3.01 (100), 1.97 (75), 2.19 (70), 2.51 (40), 2.73 (30), 2.85 (25), 3.21 (10)

Chemistry:

	(1)		(1)
SiO_2	20.45	Cr_2O_3	0.04
TiO_2	23.16	FeO	6.02
ZrO_2	10.30	MnO	0.08
Al_2O_3	0.11	CaO	2.05
Y_2O_3	0.05	SrO	19.60
La_2O_3	9.18	BaO	0.38
Ce_2O_3	9.35	Na_2O	0.02
RE_2O_3	0.05	Total	100.84

(1) Near Sarambi, Paraguay; UO_2, ThO_2, Nb_2O_5, PbO, MgO, K_2O, all $< 0.01\%$; corresponds to $(Sr_{2.17}Ce_{0.66}La_{0.65}Ca_{0.42}Ba_{0.03}Na_{0.01})_{\Sigma=3.94}(Fe^{2+}_{0.96}Mn_{0.01})_{\Sigma=0.97}(Ti_{3.26}Zr_{0.96}Al_{0.03}Cr_{0.01})_{\Sigma=4.26}Si_{3.91}O_{22}$.

Occurrence: In the more mafic bands of fenite dikes formed radially around carbonatite plugs.

Association: Sanidine, aegirine, nepheline, hematite, zeolites, strontian loparite, lamprophyllite.

Distribution: In the Sarambi carbonatite complex, about 27 km northeast of Sarambi, Paraguay.

Name: For the *strontium* content and relation to *chevkinite*.

Type Material: The Natural History Museum, London, England, 1984,482; National Museum of Natural History, Washington, D.C., USA, 161154.

References: (1) Haggerty, S.E. and A.N. Mariano (1983) Strontian-loparite and strontio-chevkinite: two new minerals in rheomorphic fenites from the Paraná basin carbonatites, South America. Contr. Mineral. Petrol., 84, 365–381. (2) (1984) Amer. Mineral., 69, 1192–1193 (abs. ref. 1).

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Strontiodresserite $(Sr, Ca)Al_2(CO_3)_2(OH)_4 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As lathlike crystals, to 0.2 mm, typically in radially divergent aggregates forming atoll-shaped rings or smooth spheres.

Physical Properties: Hardness = n.d. D(meas.) = 2.71 D(calc.) = 2.73

Optical Properties: Transparent to translucent. *Color:* White. *Luster:* Vitreous to silky. *Optical Class:* Biaxial (–). *Orientation:* $Y \parallel$ elongation; $X \perp$ elongation and in the plane of flattening. $\alpha = 1.510(4)$ $\beta = 1.583(2)$ $\gamma = [1.595(4)]$ 2V(meas.) = 42.5(1)°

Cell Data: *Space Group:* [*Pbnm*] (by analogy to dundasite). $a = 9.168(4)$ $b = 16.037(6)$ $c = 5.598(3)$ Z = 4

X-ray Powder Pattern: Francon quarry, Canada.
7.97 (10), 3.021 (8), 6.04 (7), 2.648 (6), 2.052 (6), 1.738 (6), 4.41 (5)

Chemistry:

	(1)
Al_2O_3	29.13
CaO	2.78
SrO	24.36
Total	

(1) Francon quarry, Canada; by electron microprobe, averages of three partial analyses; presence of H_2O and $(OH)^{1-}$ confirmed by IR; corresponds to $(Sr, Ca)_{1.00}Al_{2.00}(CO_3)_2(OH)_4 \cdot H_2O$.

Occurrence: As a rare crystalline coating in vugs in a silicocarbonatite sill.

Association: Quartz, weloganite, dawsonite, montroyalite.

Distribution: From the Francon quarry, Montreal Island, Montreal, Quebec, Canada.

Name: As the *strontium* analog of *dresserite*.

Type Material: Canadian Geological Survey, Ottawa, 13704; Royal Ontario Museum, Toronto, Canada, M34626, M34627.

References: (1) Jambor, J.L., A.P. Sabina, A.C. Roberts, and B.D. Sturman (1977) Strontiodresserite, a new Sr-Al carbonate from Montreal Island, Quebec. Can. Mineral., 15, 405–407. (2) Roberts, A.C. (1978) The space group of strontiodresserite. Geol. Surv. Canada Paper 78–1B, 180.

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Strontiofluorite SrF_2

Crystal Data: Isometric. *Point Group:* 4/*m* $\bar{3}$ 2/*m*. As cubo-octahedral crystals to 0.3 mm, as spherical grains to1 mm, or as fine-grained compact massive aggregates; as pseudomorphs after prismatic lamprophyllite.

Physical Properties: *Cleavage:* Perfect {111}. *Fracture:* Stepped. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 4.05 D(calc.) = 4.11

Optical Properties: Translucent. *Color:* Pale gray; colorless in transmitted light. *Streak:* White. *Luster:* Greasy.
Optical Class: Isotropic. n = 1.438(2)

Cell Data: *Space Group: Fm*$\bar{3}$ *m*. *a* = 5.713(8) *Z* = 4

X-ray Powder Pattern: Khibiny massif, Kola Peninsula, Russia.
3.324 (100), 2.029 (90), 1.731 (60), 1.172 (50), 1.317 (30), 2.886 (20), 1.434 (20)

Chemistry:

	(1)
Na	1.79
Ca	9.57
Sr	42.81
Ba	7.06
La	2.14
Ce	2.78
Nd	0.64
F	33.15
Total	99.94

(1) Mt. Koashva, Khibiy massif, Kola Peninsula, Russia; average of several electron microprobe analyses; corresponding to $(Sr_{0.56}Ca_{0.27}Na_{0.09}Ba_{0.06}Ce_{0.02}La_{0.02}Nd_{0.01})_{\Sigma=1.03}F_2$.

Mineral Group: Fluorite group.

Occurrence: In lenses of sodalite-microcline-aegirine rock within an apatite-rich urtite; produced by intense alteration of primary Sr-bearing minerals by F-rich hydrothermal fluids in a peralkaline parageneses.

Association: Astrophyllite, burbankite, chlorobartonite, fluorite, fluorapatite, polezhaevite-(Ce).

Distribution: Mt. Koashva and Mt. Kitchepakhk, Khibiny alkaline massif, Kola Peninsula, Russia.

Name: As a Sr-dominant analogue of fluorite.

Type Material: Mineralogical Museum, St. Petersburg State University, Russia; Geological and Mineralogical Museum of the Geological Institute, Kola Science Center, Russian Academy of Sciences, Apatity, Russia (6455).

References: (1) Yakovenchuk, V.N., G.Y. Ivanyuk, Y.A. Pakhomovsky, E.A. Selivanova, J.A. Korchak, and A.P. Nikolaev (2010) Strontiofluorite, SrF_2, a new mineral species from the Khibiny Massif, Kola Peninsula, Russia. Can. Mineral., 48, 1487-1492. (2) (2013) Amer. Mineral., 98, 281-282 (abs. ref. 1).

Strontioginorite $SrCaB_{14}O_{20}(OH)_6 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thick tabular {010} crystals, prismatic along [001], to 3 mm, with dominant {110}, {010}, {111}, and six other forms. *Twinning:* On (010) twin plane with $[\bar{1}01]$ twin axis.

Physical Properties: *Cleavage:* On {010}, perfect; on {001}, very good. *Tenacity:* Easily deformed. Hardness = 2–3 D(meas.) = 2.25(1) D(calc.) = 2.265

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Silky.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = 38°–42°$; $Z \wedge [\bar{1}01] = –49°$ to $–54°$.
$\alpha = 1.512–1.515$ $\beta = 1.524–1.526$ $\gamma = 1.573–1.577$ 2V(meas.) = 49°–53°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.817(8)$ $b = 14.448(8)$ $c = 12.783(8)$
$\beta = 101°25(5)'$ Z = 4

X-ray Powder Pattern: Königshall-Hindenburg mine, Germany.
7.25 (vs), 2.10 (s), 5.40 (m), 3.92 (m), 3.34 (m), 1.19 (m), 4.75 (mw)

Chemistry: (1) Stoichiometry established by analogy to ginorite, and validated by close similarity of X-ray powder patterns, optical properties and densities; formula from crystal structure analysis; SrO 10%–20% by X-ray fluorescence analysis, corresponding to as much as $Sr(Ca_{0.66}Sr_{0.34})_{\Sigma=1.00}B_{14}O_{20}(OH)_6 \cdot 5H_2O$.

Occurrence: A rare insoluble residue in salt beds (Königshall-Hindenburg mine, Germany).

Association: Halite, anhydrite (Königshall-Hindenburg mine, Germany).

Distribution: From the Königshall-Hindenburg potash mine, Reyershausen, near Göttingen, Lower Saxony, Germany. At the Inder borate deposit, Kazakhstan. From the Furnace Creek district, Death Valley, Inyo Co., California, USA. In the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina.

Name: As the *strontium* analog of *ginorite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 114168.

References: (1) Braitsch, O. (1959) Über Strontioginorit, eine neue Ginorit-Varietät aus dem Zechsteinsalz. Beitr. Mineral. u. Petrog., 6, 366–370 (in German). (2) (1960) Amer. Mineral., 45, 478 (abs. ref. 1). (3) Konnert, J.A., J.R. Clark, and C.L. Christ (1970) Crystal structure of strontioginorite, $(Sr, Ca)_2B_{14}O_{20}(OH)_6 \cdot 5H_2O$. Amer. Mineral., 55, 1911–1931. (4) Christian, R.P., G.D. Eberlein, and J.A. Konnert (1974) Optical and X-ray crystallographic investigations of strontioginorites. J. Res. U.S. Geol. Surv., 2(6), 699–700.

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Strontiojoaquinite $Sr_2Ba_2(Na,Fe^{2+})_2Ti_2Si_8O_{24}(O,OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* 2, m, or $2/m$. Crystals pseudotetragonal, steeply dipyramidal, to 0.5 mm, overgrown on joaquinite-(Ce) cores.

Physical Properties: *Cleavage:* Good on {001}. Hardness = 5.5 D(meas.) = n.d. D(calc.) = 3.68

Optical Properties: Semitransparent. *Color:* Green, yellow-green, yellow-brown. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; $X = Y$ = colorless; Z = yellow. *Orientation:* $Y = b$; $Z = c$; $X \wedge a = 19°$. *Dispersion:* $r > v$, strong. *Absorption:* $Z > X = Y$. $\alpha = 1.710(2)$ $\beta = 1.718(2)$ $\gamma = 1.780(3)$ 2V(meas.) = 35°–45°

Cell Data: *Space Group:* $P2$, Pm, or $P2/m$. $a = 10.516(6)$ $b = 9.764(5)$ $c = 11.87(1)$ $\beta = 109°17(4)'$ Z = 2

X-ray Powder Pattern: San Benito Co., California, USA.
2.801 (100), 2.967 (72), 3.011 (48), 2.923 (45), 2.611 (42), 4.47 (40), 2.432 (40)

Chemistry:

	(1)
SiO_2	37.54
TiO_2	12.48
Al_2O_3	0.00
RE_2O_3	0.20
FeO	4.03
MnO	0.00
CaO	0.00
SrO	16.23
BaO	24.52
Li_2O	0.03
Na_2O	2.76
H_2O	2.1
Total	[99.89]

(1) Mina Numero Uno, California, USA; by electron microprobe, Li, RE, and H_2O determined using ion microprobe; $RE_2O_3 = Y_2O_3$ 0.00%, La_2O_3 0.14%, Ce_2O_3 0.003%, Pr_2O_3 0.003%, Nd_2O_3 0.05%, Sm_2O_3 0.00%, Gd_2O_3 0.00%, Dy_2O_3 0.00%, original total given as 99.85%; corresponds to $(Sr_{2.00}Ba_{0.04})_{\Sigma=2.04}Ba_{2.00}(Na_{1.14}Fe_{0.72}Li_{0.06})_{\Sigma=1.92}Ti_{2.00}Si_8O_{24}[(OH)_{1.36}O_{0.64}]_{\Sigma=2.00} \cdot 0.81H_2O$.

Polymorphism & Series: Dimorphous with strontio-orthojoaquinite.

Mineral Group: Joaquinite group.

Occurrence: In a metamorphosed and metasomatized basalt lens in serpentinite (Mina Numero Uno, California, USA); in veins cutting metagraywacke (prospect, San Benito Co., California, USA).

Association: Joaquinite-(Ce), neptunite, natrolite, albite, actinolite, crossite, benitoite, analcime.

Distribution: From Mina Numero Uno, south side of Clear Creek; at the Gem mine; and at a prospect about three km southwest of San Benito Mountain, San Benito Co., California, USA.

Name: For its *strontium* content and its relation to *joaquinite* in contrast to strontio-orthojoaquinite.

Type Material: University of California, Santa Barbara, California; Harvard University, Cambridge, Massachusetts, 119526; National Museum of Natural History, Washington, D.C., USA, 149429.

References: (1) Wise, W.S. (1982) Strontiojoaquinite and bario-orthojoaquinite: two new members of the joaquinite group. Amer. Mineral., 67, 809–816.

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Strontiomelane $SrMn_2^{3+}Mn_6^{4+}O_{16}$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are octahedra, to 0.5 mm.

Physical Properties: *Cleavage:* Noted, may be a parting. *Tenacity:* Friable. Hardness = n.d. VHN = 245 D(meas.) = 3.8 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Light yellow, white in the interior, may have a pale blue cast. *Luster:* [Vitreous to resinous] (by analogy to the pyrochlore group). *Optical Class:* Isotropic. $n = 2.08$

Cell Data: *Space Group:* $Fd3m$. a = 10.53 Z = 8

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	71.72	67.1	MnO	0.00	
Ta_2O_5	0.31		MgO	0.00	
SiO_2	0.00		CaO	0.42	4.6
TiO_2	0.03	3.5	SrO	16.08	14.0
ThO_2	0.00		BaO	0.37	
Al_2O_3	0.21		Na_2O	0.11	2.6
RE_2O_3	1.86	0.0	K_2O	0.28	
Fe_2O_3	1.53	0.5	H_2O	7.56	[7.7]
			Total	100.48	[100.0]

(1) Tatarkskoye deposit, Russia; RE = La 30.5%, Ce 59%, Pr 2%, Nd 2.3%, Sm 2.2%, Eu 0.54%, Gd 0.18%, Dy 0.9%, Ho 0.18%, Er 0.72%, Yb 1.3%, Lu 0.18%; corresponding to $(Sr_{0.55}RE_{0.04}Ca_{0.03}K_{0.02}Ba_{0.01}Na_{0.01})_{\Sigma=0.66}(Nb_{1.91}Fe_{0.07}Al_{0.01}Ta_{0.01})_{\Sigma=2.00}[O_{4.09}(OH)_{2.97}]_{\Sigma=7.06}$. (2) Mt. Weld, Australia; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponding to $(Sr_{0.50}Na_{0.31}Ca_{0.30})_{\Sigma=1.11}(Nb_{1.87}Ti_{0.16}Fe_{0.02})_{\Sigma=2.05}O_6(OH)$.

Mineral Group: Pyrochlore group and subgroup; $Sr_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: Replacing pyrochlore in laterites above a weathered complex dolomitic carbonatite cutting metasedimentary clastic-carbonate rocks (Tatarkskoye deposit, Russia); a weathering product of pyrochlore in a carbonatite (Mt. Weld, Australia).

Association: Bariopyrochlore, pyrochlore, goethite, crandallite, ilmenorutile, manganese oxides, quartz (Tatarkskoye deposit, Russia); pyrochlore, plumbopyrochlore, ceriopyrochlore (Mt. Weld, Australia).

Distribution: From Mt. Vavnbed, Lovozero massif, Kola Peninsula, and in the Tatarkskoye deposit, Yenisei Ridge, Siberia, Russia. In the Mt. Weld carbonatite, 35 km south of Laverton, Western Australia. In the USA, in the Wilson Springs (Potash Sulphur Springs) mine, Garland Co., Arkansas. At St. Andre, near Oka, Quebec, Canada. From the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire).

Name: For STRONTIum in the composition, and membership in the *pyrochlore* group.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, Russia, 5536.

References: (1) Lapin, A.V., A.A. Malyshev, V.V. Ploshko, and G.Y. Cherepivskaya (1986) Strontiopyrochlore from lateritic weathered mantle of carbonatite. Doklady Acad. Nauk SSSR, 290, 1212–1217 (in Russian). (2) (1988) Amer. Mineral., 73, 930 (abs. ref. 1). (3) Lottermoser, B.G. and B.M. England (1988) Compositional variation in pyrochlores from the Mt Weld carbonatite laterite, Western Australia. Mineral. Petrol., 38, 37–51.

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Strontio-orthojoaquinite $Sr_2Ba_2(Na,Fe^{2+})_2Ti_2Si_8O_{24}(O,OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Angular anhedral crystals, up to 2 mm, in spotty aggregates and lenses.

Physical Properties: *Cleavage:* {001} perfect. Hardness = 5.5 D(meas.) = 3.62 D(calc.) = 3.87

Optical Properties: Semitransparent. *Color:* Yellow.
Optical Class: Biaxial (–). *Pleochroism:* Weak; $X = Y$ = colorless; Z = light yellow.
$\alpha = 1.707(3)$ β = n.d. $\gamma = 1.778(3)$ 2V(meas.) = 42°–48°

Cell Data: *Space Group:* $Pcam$ or $Pca2_1$. $a = 10.517(6)$ $b = 9.777(5)$ $c = 22.392(12)$
Z = [4]

X-ray Powder Pattern: Ohmi, Japan.
2.799 (100), 2.611 (41), 2.966 (36), 4.47 (33), 2.441 (32), 2.239 (31), 5.60 (30)

Chemistry:

	(1)		(1)
SiO_2	35.12	MgO	0.03
TiO_2	12.48	CaO	trace
ZrO[*sic*]	0.19	SrO	5.85
Al_2O_3	0.27	BaO	31.31
RE_2O_3	1.12	Na_2O	2.74
Nb_2O_5	1.42	K_2O	0.94
FeO	4.75	H_2O^+	2.59
MnO	trace	H_2O^-	0.47
		Total	[99.28]

(1) Ohmi, Japan; method of analysis not given, original total given as 99.36%; corresponds to $(Ba_{2.76}Sr_{0.76}RE_{0.12}Mg_{0.01})_{\Sigma=3.65}(Na_{1.20}Fe^{3+}_{0.91}Nb_{0.13}K_{0.03}Zr_{0.02})_{\Sigma=2.29}Ti_{2.13}(Si_{7.98}Al_{0.06})_{\Sigma=8.04}O_{24.66}(OH)_{3.02}$.

Polymorphism & Series: Dimorphous with strontiojoaquinite.

Mineral Group: Joaquinite group.

Occurrence: In an amphibolite-quartz-albitite dike cutting serpentinite.

Association: Benitoite, leucosphenite.

Distribution: At Ohmi, Niigata Prefecture, Japan.

Name: For its *strontium* content, ORTHOgonal crystal system, and relation to *joaquinite*.

Type Material: n.d.

References: (1) Chihara, K., M. Komatsu, and T. Mizota (1974) A joaquinite-like mineral from Ohmi, Niigata Prefecture, Central Japan. Mineral. J. (Japan), 7, 395–399. (2) Wise, W.S. (1982) Strontiojoaquinite and bario-orthojoaquinite: two new members of the joaquinite group. Amer. Mineral., 67, 809–816.

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Strontiopiemontite $CaSr(Al,Mn^{3+},Fe^{3+})_3(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic, elongated along [010], to 1 mm; in radial aggregates. *Twinning:* On {001}.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 6 D(meas.) = 3.65–3.73 D(calc.) = 3.73

Optical Properties: Transparent. *Color:* Deep red. *Streak:* Purple-brown.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = yellow-orange; Y = violet; Z = reddish violet. *Orientation:* $Y = b$. $n = 1.763$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$. $a = 8.862(2)$ $b = 5.682(1)$ $c = 10.191(4)$ $\beta = 114.70(1)^\circ$ Z = [2]

X-ray Powder Pattern: Val Graveglia, Italy.
2.916 (100), 3.493 (50), 2.836 (50), 2.601 (50), 1.590 (50), 2.678 (40), 2.117 (40)

Chemistry:

	(1)
SiO_2	34.27
TiO_2	< 0.10
Al_2O_3	17.56
Fe_2O_3	4.89
Mn_2O_3	12.93
MnO	2.87
MgO	< 0.10
CaO	11.69
SrO	13.45
H_2O	[1.72]
Total	[99.38]

(1) Val Graveglia, Italy; by electron microprobe, Mn^{2+}:Mn^{3+} calculated from stoichiometry, H_2O calculated to give one H per formula unit; corresponds to $(Ca_{0.79}Mn^{2+}_{0.21})_{\Sigma=1.00}(Sr_{0.68}Ca_{0.31})_{\Sigma=0.99}(Al_{1.81}Mn^{3+}_{0.86}Fe^{3+}_{0.32})_{\Sigma=2.99}Si_{3.00}O_{12}(OH)$.

Mineral Group: Epidote group.

Occurrence: As veinlets in a low-temperature metamorphosed manganese ore deposit (Val Graveglia, Italy).

Association: Calcite, rhodonite, rhodochrosite, ganophyllite, braunite, quartz (Val Graveglia, Italy); xonotolite, vuagnatite (Wessels mine, South Africa).

Distribution: From the Molinello and Cassagna manganese mines, near Chiavari, Val Graveglia, Liguria, Italy. In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: From its *strontium* content and similarity to *piemontite*.

Type Material: University of Florence, Florence, Italy, 1266/l.

References: (1) Bonazzi, P., S. Menchetti, and A. Palenzona (1990) Strontiopiemontite, a new member of the epidote group, from Val Graveglia, Liguria, Italy. Eur. J. Mineral., 2, 519–523. (2) (1991) Amer. Mineral., 76, 668 (abs. ref. 1).

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Strontiowhitlockite $Sr_9Mg(PO_4)_6(PO_3OH)$

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Crystal Data: Hexagonal. *Point Group:* 3*m*. Pipelike tubes, to 3 mm, of radial fibers, and rosettes of rounded tabular crystals, flattened on {0001}; fine granular.

Physical Properties: *Cleavage:* On {0001}, fair, may be a parting. Hardness = n.d. D(meas.) = 3.64(2) D(calc.) = 3.60

Optical Properties: Semitransparent. *Color:* White, pale gray, pale brown; colorless in transmitted light. *Streak:* White. *Luster:* Dull.
Optical Class: Uniaxial (–). *Orientation:* $X = c$; parallel extinction. $\omega = 1.601(2)$ $\epsilon = 1.598(2)$

Cell Data: *Space Group:* [*R*3*c*] (by analogy to whitlockite). $a = 10.644(9)$ $c = 39.54(6)$ Z = 6

X-ray Powder Pattern: Kovdor massif, Kola Peninsula, Russia.
3.004 (100), 2.661 (80), 3.288 (37), 1.783 (36), 3.071 (29), 1.940 (29), 2.246 (26)

Chemistry:

	(1)	(2)
P_2O_5	35.2	33.60
FeO	0.2	
MnO	0.2	
MgO	4.6	2.73
CaO	5.5	
SrO	51.4	63.06
BaO	2.3	
Na_2O	0.0	
H_2O	0.5	0.61
Total	99.9	100.00

(1) Kovdor massif, Kola Peninsula, Russia; by electron microprobe, H_2O by microcoulometric methods, PO_3OH confirmed by IR; corresponds to $(Sr_{6.96}Ca_{1.38}Mg_{0.60}Ba_{0.21}Mn_{0.04}Fe_{0.04})_{\Sigma=9.23}$ $Mg_{1.00}(PO_4)_6(P_{0.96}O_3OH_{0.78})$. (2) $Sr_9Mg(PO_4)_6(PO_3OH)$.

Occurrence: Very rare, in cavities in a dolomite carbonatite vein cutting pyroxenites in an alkalic massif.

Association: Strontian collinsite, bobierrite, carbonate-fluorapatite, rimkorolgite, pyrite, dolomite, unnamed Sr–Mg phosphate.

Distribution: From the Zheleznyi iron ore deposit, Kovdor alkalic massif, Kola Peninsula, Russia.

Name: As the *strontium* analog of *whitlockite*.

Type Material: Mining Institute, St. Petersburg, 2022/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, r558.

References: (1) Britvin, S.N., Y.A. Pakhomovskii, A.N. Bogdanova, and V.I. Skiba (1991) Strontiowhitlockite, $Sr_9Mg(PO_3OH)(PO_4)_6$, a new mineral from the Kovdor deposit, Kola Peninsula, U.S.S.R. Can. Mineral., 29, 87–93. (2) (1991) Amer. Mineral., 76, 2024 (abs. ref. 1).

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Strontium-apatite $(Sr,Ca)_5(PO_4)_3(OH,F)$

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Crystal Data: Hexagonal. *Point Group:* $6/m$ or 6. As poorly-formed prismatic crystals, exhibiting $\{10\overline{1}0\}$, $\{10\overline{1}1\}$, $\{0001\}$, to 4 cm.

Physical Properties: *Cleavage:* Imperfect on $\{10\overline{1}0\}$. Hardness = 5 D(meas.) = 3.84 D(calc.) = 3.95

Optical Properties: Transparent. *Color:* Colorless, pale green to yellowish green.
Luster: Vitreous, greasy on fracture surfaces.
Optical Class: Uniaxial (–). $\omega = 1.651$ $\epsilon = 1.637$

Cell Data: *Space Group:* $P6_3/m$ or $P6_3$. $a = 9.565(8)$ $c = 7.115(3)$ Z = 2

X-ray Powder Pattern: Inagli massif, Russia.
2.89 (10), 3.167 (7), 2.78 (7), 2.005 (7), 1.909 (7), 1.467 (6), 2.32 (5)

Chemistry:

	(1)		(1)
SiO_2	0.90	CaO	10.80
ThO_2	0.60	SrO	46.06
P_2O_5	30.44	BaO	2.70
Al_2O_3	0.40	Na_2O	0.64
RE_2O_3	3.73	K_2O	0.10
Fe_2O_3	0.15	F	1.67
MnO	0.00	H_2O	0.61
MgO	1.64	$-O = F_2$	0.70
		Total	99.74

(1) Inagli massif, Russia; $RE_2O_3 = La_2O_3$ 26.15%, Ce_2O_3 53.9%, Pr_2O_3 5.0%, Nd_2O_3 13.8%, Sm_2O_3 0.63%, Eu_2O_3 0.1%, Gd_2O_3 0.31%, Dy_2O_3 0.06%, Er_2O_3 0.06%, Yb_2O_3 0.13%; corresponding to $(Sr_{2.96}Ca_{1.28}Mg_{0.27}RE_{0.15}Na_{0.15}Ba_{0.12}Th_{0.01}Fe_{0.01})_{\Sigma=4.95}[(P_{0.95}Si_{0.03}Al_{0.02})_{\Sigma=1.00}O_4]_{3.00}[(OH)_{0.58}F_{0.45}]_{\Sigma=1.03}$.

Mineral Group: Apatite group.

Occurrence: In alkalic pegmatite veins in a zoned ultramafic intrusion (Inagli massif, Russia).

Association: Batisite, innelite, lorenzenite, eudialyte, aegirine, eckermannite, microcline, magnesioarfvedsonite, albite (Inagli massif, Russia).

Distribution: In Russia, from the Inagli massif, 30 km west of Aldan, Sakha, and on Mt. Rasvumchorr, Khibiny massif, Kola Peninsula.

Name: As a *strontium*-dominant member of the *apatite* group; see fluorapatite.

Type Material: Vernadsky Geological Museum, Moscow, 48010; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 63197, 66210.

References: (1) Yefimov, A.S., S.M. Kravchenko, and Z.V. Vasil'yeva (1962) Strontium-apatite, a new mineral. Doklady Acad. Nauk SSSR, 142, 439–442 (in Russian). (2) (1962) Amer. Mineral., 47, 808 (abs. ref. 1). (3) Pushcharovskiy, D.Y., T.N. Nadezhina, and A.P. Khomyakov (1987) Crystal structure of strontium apatite from Khibiny. Kristallografiya (Sov. Phys. Crystal.), 32, 891–895 (in Russian). (4) Hughes, J.M., M. Cameron, and K.D. Crowley (1991) Ordering of divalent cations in the apatite structure: crystal structure refinements of natural Mn- and Sr-bearing apatite. Amer. Mineral., 76, 1857–1862.

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Strunzite $Mn^{2+}Fe_2^{3+}(PO_4)_2(OH)_2 \cdot 6H_2O$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\overline{1}$. Crystals are flattened on {100}, typically needlelike to hairlike, to 2 cm; in radiating sprays, tufts, and coatings. *Twinning:* On $\{1\overline{2}0\}$, common.

Physical Properties: Hardness = n.d. D(meas.) = 2.52(5) D(calc.) = 2.49

Optical Properties: Semitransparent. *Color:* White, pale yellow, straw-yellow, brownish yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Faint; X = nearly colorless; Y = yellow-brown; Z = darker yellow-brown. *Orientation:* $Z \wedge c = 10°–19°$. *Absorption:* $Z > X = Y$. $\alpha = 1.619–1.625$ $\beta = 1.640–1.670$ $\gamma = 1.696–1.720$ 2V(meas.) = Medium. 2V(calc.) = 56°–93°

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.228(5)$ $b = 9.837(5)$ $c = 7.284(5)$ $\alpha = 90.17(5)°$ $\beta = 98.44(5)°$ $\gamma = 117.44(5)°$ Z = 2

X-ray Powder Pattern: Hagendorf, Germany; nearly identical to ferrostrunzite.
9.02 (10), 5.32 (8), 4.35 (6), 4.27 (6), 3.29 (6), 3.23 (6), 4.50 (5)

Chemistry:

	(1)	(2)
P_2O_5	33.0	28.46
Fe_2O_3	36.0	32.02
MnO	9.1	14.23
H_2O^+	22.5	25.29
Total	100.6	100.00

(1) Hagendorf, Germany. (2) $Mn^{2+}Fe_2^{3+}(PO_4)_2(OH)_2 \cdot 6H_2O$.

Occurrence: A secondary mineral, typically altered from triphylite, in zoned complex granite pegmatites.

Association: Triphylite, laueite, rockbridgeite, many other Mn–Fe phosphates.

Distribution: From Hagendorf, Waidhaus, and Hühnerkobel, near Zwiesel, Bavaria, Germany. At Blaton, Belgium. In Portugal, from Sabugal, in the Mangualde pegmatite, near Mesquitela, and the Bendada pegmatite, near Guarda. In the Gravel Hill mine, Perranzabuloe, Cornwall, England. At the Norrö pegmatite, on Rånö Island, and from near Kapelludden, Utö Island, Sweden. From Morašice, Czech Republic. In the USA, from the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., the G.E. Smith mine, Newport, Sullivan Co., and the Fitzgibbon mine, Alstead, Cheshire Co., New Hampshire; in Maine, at the Red Hill quarry, Rumford, and the BB quarry, Norway, Oxford Co., and elsewhere; in the Big Chief mine, one km south of Glendale, and the Hesnard and Etta mines, near Keystone, Pennington Co., from the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; from the Foote mine, Kings Mountain, Cleveland Co., North Carolina. At several mines around Linópolis, Minas Gerais, Brazil.

Name: To honor Dr. Hugo Strunz (1910–), Professor of Mineralogy, Technical University, Berlin, Germany, for his work on pegmatite phosphate minerals, especially those of Hagendorf, Germany.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 106288–106301.

References: (1) Frondel, C. (1957) Strunzit, ein neues Mineral. Naturwiss., 45, 37–38 (in German). (2) (1958) Amer. Mineral., 43, 793–794. (3) Frondel, C. (1957) Strunzit, ein neues Eisen-Mangan-Phosphat. Neues Jahrb. Mineral., Monatsh., 222–226 (in German). (4) Fanfani, L., M. Tomassini, P.F. Zanazzi, and A.R. Zanzari (1978) The crystal structure of strunzite, a contribution to the crystal chemistry of basic ferric-manganous hydrated phosphates. Tschermaks Mineral. Petrog. Mitt., 25, 77–87.

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Strüverite $(Ti, Ta, Fe^{2+})O_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As dipyramidal, prismatic crystals, to several cm, with striated prism faces. *Twinning:* Common on {101}.

Physical Properties: *Cleavage:* {110}, distinct. *Fracture:* Conchoidal. Hardness = 6–6.5 VHN = 911–998 D(meas.) = 4.2–5.8 D(calc.) = [5.68–5.77]

Optical Properties: Opaque, translucent through thin edges. *Color:* Black; red or reddish brown in transmitted light; light gray in reflected light. *Streak:* Grayish black. *Luster:* Adamantine, resinous.
Optical Class: Uniaxial (+). *Pleochroism:* Strong; E = brown; O = dark bluish green or greenish blue. *Absorption:* $E > O$. $n = > 2.6$ *Anisotropism:* Strong. *Bireflectance:* Weak. R_1–R_2: n.d.

Cell Data: *Space Group:* $P4_2/mnm$. a = 4.62–4.64 c = 2.98–3.00 Z = 2

X-ray Powder Pattern: Altai Mountains, Mongolia; almost identical to ilmenorutile.
3.25 (10), 1.699 (10), 2.495 (9), 1.641 (7), 1.375 (7), 1.183 (7), 1.054 (7)

Chemistry:

	(1)	(2)
Nb_2O_5	6.5	9.30
Ta_2O_5	35.5	33.12
SiO_2		0.41
TiO_2	47.8	47.0
SnO_2	0.3	
Al_2O_3		0.60
FeO	9.2	9.70
MnO	0.1	0.09
MgO		0.03
CaO		0.05
Total	99.4	100.30

(1) Craveggia, Italy; by electron microprobe, total Fe as FeO, total Mn as MnO. (2) Altai Mountains, Mongolia; corresponds to $(Ti_{0.63}Ta_{0.16}Fe_{0.15}Nb_{0.07})_{\Sigma=1.01}O_2$.

Polymorphism & Series: Forms a series with ilmenorutile; Ta:Nb > 1.

Occurrence: A late primary mineral in granite pegmatites; rarely detrital.

Association: Columbite, ilmenite, beryl, cassiterite, zircon, monazite, albite, microcline.

Distribution: From Craveggia, Val Vigezzo, Piedmont, Italy. At Věžná, near Rožná, and Písek, Czech Republic. In the Etta mine, near Keystone, Pennington Co., South Dakota, USA. At Tongafeno, Fefana, Mananjary, Ampangabé, and elsewhere in Madagascar. From near Salak North, Kuala Kangsar, Perak, Malaya. At Globe Hill, Western Australia. Other localities are reported, either undefined, or the material requiring modern confirmation.

Name: Honors Professor Giovanni Strüver (1842–1915), mineralogist, University of Rome, Rome, Italy.

Type Material: The Natural History Museum, London, England, 1906,123; Natural History Museum, Paris, France, 108.371.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 554–561 [rutile, part]. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 412–414. (3) Černý, P., F. Čech, and P. Povondra (1964) Review of ilmenorutile-strüverite minerals. Neues Jahrb. Mineral., Abh., 101, 142–172. (4) Clark, A.M. (1974) A tantalum-rich variety of sphene. Mineral. Mag., 39, 605–607. (5) Černý, P., B.J. Paul, F.C. Hawthorne, and R. Chapman (1981) A niobian rutile–disordered columbite intergrowth from the Huron claim pegmatite, southeastern Manitoba. Can. Mineral., 19, 541–548.

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Struvite-(K) $KMgPO_4 \cdot 6H_2O$

Crystal Data: Orthorhombic. *Point Group*: *mm*2. As acicular prismatic crystals, to 0.7 mm; elongated on [010] with wedge-shaped terminations, displaying {001}, {010}, {101}, {012}, {110}, {111}, $\{01\bar{2}\}$. *Twinning:* Contact twins on (101) common.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.864

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Biaxial (+). α = 1.490(2) β = 1.493(2) γ = n.d. $2V_Z$ = large (> 70°). *Dispersion*: $r < v$, weak. *Orientation*: (OAP) $\perp$ [010]; β parallel a.

Cell Data: *Space Group*: $Pmn2_1$ (by analogy to struvite). a = 6.903(3) b = 6.174(2) c = 11.146(3) Z = 2

X-ray Powder Pattern: Lengenbach, Binntal, Switzerland.
4.255 (100), 3.271 (90), 4.136 (80), 2.650 (70), 2.905 (70), 2.699 (50), 1.9541 (50)

Chemistry: Lengenbach, Binntal, Switzerland; Qualitative EDS analyses confirmed major K, Mg, P, and traces of Sb, Fe, and Cu. Structure refinement confirmed the pure K end-member.

Occurrence: Of either late hydrothermal or secondary origin (Switzerland); an alteration product of animal bones and circulating fluids (Austria).

Association: Rathite, dolomite (Switzerland); newberyite (Austria).

Distribution: Lengenbach, Binntal, Switzerland; Rossblei, Schladminger Tauern, Styria, Austria.

Name: As the potassium equivalent of struvite.

Type Material: Natural History Museum, Basel, Switzerland, S176.

References: (1) Graeser, S., W. Postl, H.-P. Bojar, P. Berlepsch, T. Armbruster, T. Raber, K. Ettinger, and F. Walter (2008) Struvite-(K), $KMgPO_4 \cdot 6H_2O$, the potassium equivalent of struvite—a new mineral. Eur. J. Mineral., 20, 629–633. (2) (2009) Amer. Mineral., 94, 403-404 (abs. ref. 1).

Struvite $(NH_4)Mg(PO_4)\cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Crystals are equant, wedgelike, short prismatic, or tabular, hemimorphic, with large {011}, {100}, {001}, {101}, {$\overline{1}$01}, {102}, several other forms, to 3 cm. *Twinning:* On {001} as twin and composition plane, with deep re-entrants.

Physical Properties: *Cleavage:* {001}, good; {010}, poor. *Fracture:* Subconchoidal to uneven. Hardness = 2 D(meas.) = 1.711 D(calc.) = 1.706 Slightly soluble in H_2O, dehydrates in dry, warm air. Pyroelectric and piezoelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, may be tinted yellow or brown from impurities, and becomes surficially white on dehydration; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, strong.
$\alpha = 1.495$ $\beta = 1.496$ $\gamma = 1.504$ 2V(meas.) = 37°22′

Cell Data: *Space Group:* $Pmn2_1$ (synthetic). $a = 6.955(1)$ $b = 6.142(1)$ $c = 11.218(2)$
Z = 2

X-ray Powder Pattern: Synthetic.
4.257 (100), 5.601 (60), 2.919 (55), 2.690 (50), 2.660 (45), 5.905 (40), 4.139 (40)

Chemistry:

	(1)	(2)
P_2O_5	28.82	28.92
FeO	0.81	
MnO	0.16	
MgO	16.07	16.42
$(NH_4)_2O$	10.57	10.61
H_2O	43.57	44.05
Total	100.00	100.00

(1) Skipton lava tube caves, Australia. (2) $(NH_4)Mg(PO_4)\cdot 6H_2O$.

Occurrence: In peaty earth intermixed with cattle dung (Hamburg, Germany); typically formed in bird or bat guano in caves and surface deposits.

Association: Newberyite, hannayite, brushite, stercorite.

Distribution: Found under St. Nikolai Church, Hamburg, Germany. From an archaeological excavation at High Street and Fishamble Street, Dublin, Ireland. At the Limfjord, Denmark. In the Niah Great Cave, Sarawak, Malaysia. From Saldanha Bay, Cape Province, and Ficus and Boon's Caves, Transvaal, South Africa. On Ichaboe Island, northwest of Lüderitz, Namibia. From Gcwihaba Cave, 280 km west of Maun, northwestern Botswana. On Réunion Island, Indian Ocean; the Bounty Islands, South Pacific Ocean; King Georges Island, Maritime Antarctic. In the Skipton lava tube caves, 40 km south of Ballarat, Victoria, Australia. In the USA, on Paoha Island, Mono Lake, Mono Co., California.

Name: To honor Heinrich Christoph Gottfried Struve (1772–1851), German mineral collector, serving as Russian Consul at Hamburg, Germany when the mineral was discovered.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 715–717. (2) Ferraris, G., H. Fuess, and W. Joswig (1986) Neutron diffraction study of $MgNH_4PO_4\cdot 6H_2O$ (struvite) and survey of water molecules donating short hydrogen bonds. Acta Cryst., 42, 253–258. (3) (1964) NBS Mono. 25, 3, 41.

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Studenitsite $NaCa_2B_9O_{14}(OH)_4 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As flattened wedge-shaped crystals, to 5 mm, dominated by {001}, {011}, {111}, with poorly developed {100}, {110}, {012}, in aggregates.

Physical Properties: *Tenacity:* "Fragile". Hardness = 5.5–6 VHN = 527–550
D(meas.) = 2.29 D(calc.) = 2.34

Optical Properties: Translucent to transparent in thin pieces. *Color:* Colorless, pale gray, yellowish gray. *Streak:* White.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z = a$; $Y \wedge c = 10°$. *Dispersion:* $r > v$, medium. $\alpha = 1.532(2)$ $\beta = 1.538(2)$ $\gamma = 1.564(2)$ 2V(meas.) = 54(2)°

Cell Data: *Space Group:* $P2_1/c$. $a = 11.4994(8)$ $b = 12.5878(9)$ $c = 10.5297(7)$
$\beta = 99.423(6)°$ Z = 4

X-ray Powder Pattern: Piskaya deposit, Yugoslavia.
3.04 (100), 3.35 (89), 5.41 (66), 3.27 (59), 2.210 (59), 5.20 (57), 4.20 (56)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.09		CaO	20.84	21.22
CO_2	0.00		SrO	0.09	
B_2O_3	59.64	59.28	Na_2O	5.96	5.86
Al_2O_3	0.05		K_2O	0.08	
Fe_2O_3	0.05		H_2O^+	13.64	
MnO	0.01		H_2O^-	0.00	
MgO	0.02		H_2O		13.64
			Total	100.47	100.00

(1) Piskaya deposit, Yugoslavia; $(OH)^{1-}$ and H_2O confirmed by IR.
(2) $NaCa_2B_9O_{14}(OH)_4 \cdot 2H_2O$.

Occurrence: As lenses in clay and carbonate-bearing volcanogenic-sedimentary borate deposits.

Association: Colemanite, howlite, ulexite, pentahydroborite.

Distribution: From the Piskaya deposit, Yarondolskii Basin, on the Ibar River, 280 km south of Belgrade, Yugoslavia.

Name: For the Studenitsa Cloister near the first occurrence.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Malinko, S.V., S. Anichich, D. Yoksimovich, A.E. Lisitsyn, G.I. Dorokhova, M.A. Yamnova, V.V. Vlasov, and A.A. Ozol (1995) Studenitsite $NaCa_2[B_9O_{14}(OH)_4] \cdot 2H_2O$ – a new borate from Serbia, Yugoslavia. Zap. Vses. Mineral. Obshch., 124(3), 57–64 (in Russian with English abs.). (2) (1996) Amer. Mineral., 81, 1284 (abs. ref. 1).

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Studtite $UO_4 \cdot 4H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$, m, or 2. Needlelike crystals, elongated along [001], to 1 mm, in radial fibrous aggregates and crusts.

Physical Properties: *Tenacity:* Flexible. Hardness = Soft. D(meas.) = 3.58 (synthetic). D(calc.) = 3.64 Radioactive.

Optical Properties: Translucent to transparent. *Color:* Yellow to pale yellow; nearly colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* Z = elongation. α = 1.537–1.551 β = 1.555–1.686 γ = 1.680–1.690 2V(meas.) = Small.

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. a = 11.85(2) b = 6.80(1) c = 4.25(1) $\beta = 93°51(20)'$ Z = 2

X-ray Powder Pattern: Menzenschwand, Germany.
5.93 (10), 3.40 (8), 2.96 (6), 2.23 (6), 2.02 (5), 1.970 (5b), 4.27 (4)

Chemistry: Qualitative microchemical and electron microprobe analyses typically show major U with traces of Pb, H_2O, CO_3 attributed to impurities. Characterization of naturally-occurring material thus rests on equivalence of the X-ray pattern and optical properties with the synthetic compound, and chemical behavior as a peroxide.

Occurrence: A very rare mineral in the oxidized zone of some uranium-bearing mineral deposits.

Association: Uranophane, rutherfordine, lepersonnite (Shinkolobwe, Congo); billietite, uranophane, rutherfordine, barite, quartz, hematite, "limonite" (Menzenschwand, Germany); tengchongite, calcurmolite, kivuite (Tengchong Co., China).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Menzenschwand, Black Forest, Germany. From Mitterberg, Salzburg, Austria. In France, at Davignac, Corrèze, and from the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault. In Tengchong Co., and at Tongbiguan village, Yingjiang Co., Yunnan Province, China.

Name: To honor Franz Edward Studt, geologist, who published a geological map of Shaba (Katanga) Province in 1913.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 275. (2) Walenta, K. (1974) On studtite and its composition. Amer. Mineral., 59, 166–171. (3) Zhi-Xiong Wang,Tian-Zhu Zeng, and Jin-Shiu Yin (1979) Discovery of studtite in China. K'o Hsueh T'ung Pao, 24(10), 453–454 (in Chinese). (4) (1979) Chem. Abs., 91, 164 (abs. ref. 3). (5) Deliens, M. and P. Piret (1983) Metastudtite, $UO_4 \cdot 2H_2O$, a new mineral from Shinkolobwe, Shaba, Zaire. Amer. Mineral., 68, 456–458.

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Stumpflite $Pt(Sb, Bi)$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Massive grains, to a few tenths of a mm, intergrown with geversite.

Physical Properties: Hardness = n.d. VHN = 385 (50 g load). D(meas.) = n.d. D(calc.) = 13.52

Optical Properties: Opaque. *Color:* In polished section, cream. *Luster:* Metallic. *Pleochroism:* Perceptible. *Anisotropism:* Strong, in brownish yellow.

R_1–R_2: (400) —, (420) 45.9–49.3, (440) 49.1–52.2, (460) 52.0–54.7, (480) 54.6–57.3, (500) 56.6–59.5, (520) 58.2–61.5, (540) 59.3–63.0, (560) 60.2–64.5, (580) 61.1–65.7, (600) 62.1–66.7, (620) 62.9–67.6, (640) 63.7–68.5, (660) 64.5–69.3, (680) 65.0–70.0, (700) 65.1–70.7

Cell Data: *Space Group:* $P6_3/mmc$ (probable). $a = 4.175(2)$ $c = 5.504(2)$ $Z = 2$

X-ray Powder Pattern: Driekop mine, South Africa.
3.027 (10), 2.192 (10), 2.088 (8), 3.618 (6), 1.512 (5), 1.720 (4), 1.224 (4)

Chemistry:

	(1)
Pt	57.0
Sb	26.1
Bi	16.3
Total	99.4

(1) Driekop mine, South Africa; by electron microprobe, corresponding to $Pt_{1.00}(Sb_{0.73}Bi_{0.27})_{\Sigma=1.00}$.

Mineral Group: Nickeline group.

Occurrence: In platinum concentrates from an ultramafic pipe deposit (Driekop mine, South Africa).

Association: Geversite, Pt–Fe alloys (Driekop mine, South Africa).

Distribution: From the Driekop mine, on the Merensky Reef, Bushveld complex, Transvaal, South Africa [TL]. From near Nizhni Tagil, Ural Mountains, Russia. In the Kelvon Grove prospect, near Fifield, New South Wales, Australia.

Name: Honors Professor Eugen Friedrich Stumpfl (1931–), University of Hamburg, Hamburg, Germany, who first described the mineral.

Type Material: Bureau de Recherches Géologiques et Minières (B.R.G.M.), Orléans; National School of Mines, Paris, France.

References: (1) Johan, Z. and P. Picot (1972) La stumpflite, Pt(Sb, Bi), un nouveau minéral. Bull. Soc. fr. Minéral., 95, 610–613 (in French with English abs.). (2) (1974) Amer. Mineral., 59, 211 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 540.

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Sturmanite $\mathbf{Ca_6(Fe^{3+}, Al, Mn^{2+})_2(SO_4)_2[B(OH)_4](OH)_{12}\cdot 25H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As dipyramidal tabular to elongated hexagonal crystals, to 40 cm, showing $\{10\bar{1}0\}$, $\{10\bar{1}4\}$, $\{11\bar{2}4\}$, typically in groups, may be in stacked parallel aggregates. *Twinning:* Probably twinned (by analogy to ettringite).

Physical Properties: *Cleavage:* On $\{10\bar{1}0\}$, perfect. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 1.847 D(calc.) = 1.855

Optical Properties: Transparent to translucent. *Color:* Bright yellow. *Streak:* Pale yellow, greenish yellow, brownish orange if altered. *Luster:* Vitreous, slightly greasy on fracture surfaces.
Optical Class: Uniaxial (+) or (–). *Pleochroism:* Weak; O = pale green; E = pale yellowish green. *Absorption:* $O < E$. $\omega = 1.499$–1.500 $\epsilon = 1.497$–1.505

Cell Data: *Space Group:* $[P31c]$ (by analogy to ettringite). $a = 11.16(3)$ $c = 21.79(9)$ Z = 2

X-ray Powder Pattern: Kuruman district, South Africa.
9.67 (100), 5.58 (70), 3.89 (70), 2.582 (60), 2.774 (50), 2.215 (50), 2.161 (40)

Chemistry:

	(1)
SO_3	14.2
B_2O_3	3.2
Al_2O_3	1.13
Fe_2O_3	8.84
MnO	1.30
CaO	25.6
H_2O	46.7
Total	101.0

(1) Kuruman district, South Africa; by AA, B_2O_3 spectrophotometrically, H_2O by the Penfield method; corresponds to $Ca_{6.0}(Fe^{3+}_{1.5}Al_{0.3}Mn^{2+}_{0.2})_{\Sigma=2.0}(SO_4)_{2.3}[B(OH)_4]_{1.2}(OH)_{12.0}\cdot 25.7H_2O$.

Mineral Group: Ettringite group.

Occurrence: An uncommon secondary mineral in cavities in metamorphosed bedded manganese deposits.

Association: Barite, manganite, hausmannite, hematite.

Distribution: From the Kuruman district, with large crystals in the Wessels and N'Chwaning II mines, Cape Province, South Africa.

Name: Honors Bozidar Darko Sturman (1937–), Canadian mineralogist, Royal Ontario Museum, Toronto, Ontario, Canada.

Type Material: National Museum of Natural History, Washington, D.C., USA, 148261.

References: (1) Peacor, D.R., P.J. Dunn, and M. Duggan (1983) Sturmanite, a ferric iron, boron analogue of ettringite. Can. Mineral., 21, 705–709. (2) (1988) Amer. Mineral., 73, 195 (abs. ref. 1).

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Stützite $\mathbf{Ag_{5-x}Te_3}$ (x = 0.24 to 0.36)

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. The only crystal known is the type, 2 cm, hexagonal, equant, and highly modified, with 14 forms; commonly massive, compact, granular.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 3.5 VHN = 73–90 (25 g load). D(meas.) = 8.00 D(calc.) = 8.18

Optical Properties: Opaque. *Color:* Dark lead-gray, tarnishes rapidly to a dark bronze to iridescence; in polished section, pale gray. *Luster:* Metallic. *Anisotropism:* Moderate, in gray reddish brown-blue.
R_1–R_2: (400) 41.2–42.9, (420) 41.2–42.5, (440) 41.2–42.0, (460) 41.2–41.6, (480) 41.2–41.3, (500) 41.1–41.1, (520) 41.0–40.8, (540) 40.8–40.4, (560) 40.7–40.0, (580) 40.6–39.5, (600) 40.6–39.0, (620) 40.6–38.7, (640) 40.7–38.3, (660) 40.8–37.9, (680) 40.9–37.4, (700) 41.1–37.0

Cell Data: *Space Group:* $C6/mmm$. $a = 13.38$ $c = 8.45$ $Z = 7$

X-ray Powder Pattern: May Day mine, Colorado, USA.
2.16 (100b), 2.55 (80b), 3.03 (70), 2.62 (70), 3.56 (60), 3.52 (60), 2.11 (60)

Chemistry:

	(1)	(2)	(3)
Ag	57.1	59.8	58.49
Cu		0.1	
Te	42.6	39.2	41.51
Total	99.7	99.1	100.00

(1) Red Cloud mine, Colorado, USA; by electron microprobe, corresponding to $Ag_{4.76}Te_{3.00}$.
(2) Bisbee, Arizona, USA; by electron microprobe, correspnding to $(Ag_{5.41}Cu_{0.02})_{\Sigma=5.43}Te_{3.00}$.
(3) Ag_5Te_3.

Occurrence: As replacement masses in hydrothermal deposits associated with other tellurides and sulfides.

Association: Sylvanite, hessite, altaite, petzite, empressite, tellurium, gold, galena, sphalerite, colusite, tetrahedrite–tennantite, pyrite.

Distribution: A museum specimen, probably from Săcărîmb (Nagyág), Romania [TL]. At Kremnica (Kremnitz) and Byšta, Slovakia. From Glava, Värmland, Sweden. In the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. On Temagami Island, Lake Temagami, Ontario; and at Lindquist Lake, Quebec, Canada. In the USA, in Colorado, at the May Day mine, La Plata district, La Plata Co.; from the Golden Fleece mines, Lake City, Hinsdale Co.; at the Empress Josephine mine, Bonanza district, Saguache Co.; from Buckeye Gulch, near Leadville, Lake Co.; and at the Red Cloud and other mines, Jamestown and Gold Hill districts, Boulder Co. In the Mayflower mine, Tobacco Root Mountains, Madison Co., Montana; from the Campbell mine, Bisbee, Cochise Co., Arizona. At the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the Kawazu mine, Shizuoka Prefecture, Japan.

Name: To honor Andreas Xavier Stütz (1747–1806), mineralogist of Vienna, Austria.

Type Material: Vienna University, Vienna, Austria, 5808; Harvard University, Cambridge, Massachusetts, USA, 108098.

References: (1) Thompson, R.M., M.A. Peacock, J.F. Rowland, and L.G. Berry (1951) Empressite and "stuetzite". Amer. Mineral., 36, 458–469. (2) Honea, R. (1964) Empressite and stuetzite redefined. Amer. Mineral., 49, 325–338. (3) Cabri, L.J. (1965) Discussion of "empressite and stuetzite redefined" by R.M. Honea. Amer. Mineral., 50, 795–801. (4) Stumpfl, E.F. and J. Rucklidge (1968) New data on natural phases in the system Ag–Te. Amer. Mineral., 53, 1513–1522. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 540.

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Suanite $Mg_2B_2O_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As aggregates of slender prismatic to fibrous crystals, elongated along [010].

Physical Properties: *Cleavage:* In one direction ∥ [010], perfect. Hardness = 5.5
D(meas.) = 2.91 D(calc.) = 2.91

Optical Properties: Translucent. *Color:* White, pale gray; colorless in transmitted light.
Luster: Silky to pearly.
Optical Class: Biaxial (–). *Orientation:* $X = b$. *Dispersion:* $r > v$, weak. $\alpha = 1.596$
$\beta = 1.639$ $\gamma = 1.670$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 12.303(4)$ $b = 3.1228(9)$ $c = 9.917(4)$
$\beta = 104.26(3)°$ Z = 4

X-ray Powder Pattern: Hol Kol mine, North Korea.
2.557 (100), 2.010 (60), 2.823 (50), 1.916 (30), 4.47 (25), 1.562 (21), 2.983 (18)

Chemistry:

	(1)	(2)
SiO_2	0.80	
B_2O_3	42.28	46.34
$(Al + Fe)_2O_3$	0.63	
MgO	50.64	53.66
CaO	1.52	
H_2O^+	3.87	
H_2O^-	0.19	
Total	99.93	100.00

(1) Hol Kol mine, North Korea; after deduction of szaibélite, corresponds to $Mg_{1.96}B_2O_5$.
(2) $Mg_2B_2O_5$.

Occurrence: In a contact metasomatic hydrothermal boron deposit in diopside–clinohumite–dolomite–calcite skarn (Hol Kol mine, North Korea).

Association: Kotoite, sakhaite, ludwigite, szaibélyite, clinohumite, forsterite, apatite, spinel, calcite.

Distribution: From the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea. At the Zhuanmiao and Houxianyu boron deposits, Liaoning Province, China. In Russia, in Sakha, from the Titovskoye boron–iron deposit, Tas-Khayakhtakh Mountains, in the Taiga boron–iron deposit, and from the Tayozhnoye iron deposit, 550 km south of Yakutsk. From Băiţa (Rézbánya), Băişoara, Cacova Ierii, Gilău Mountains, and elsewhere in Romania. At Kami-neichi, Miyako, Iwate Prefecture, Japan.

Name: For Suan Co., the North Korean region from which the first specimens were collected.

Type Material: n.d.

References: (1) Watanabe, T. (1953) Suanite, a new magnesium borate mineral from Hol Kol, Suan, North Korea. Mineral. J. (Japan), 1, 54–62. (2) (1955) Amer. Mineral., 40, 941 (abs. ref. 1). (3) Guo, G.-C., W.-D. Cheng, J.-T. Chen, H.-H. Zhuang, J.-S. Huang, and Q.-E. Zhang (1995) Monoclinic $Mg_2B_2O_5$. Acta Cryst., C51, 2469–2471. (4) Mrose, M.E. and M. Fleischer (1963) The probable identity of magnioborite with suanite. Amer. Mineral., 48, 915–924.

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Sudburyite (Pd, Ni)Sb

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As small inclusions, typically elongated, to 100 μm, commonly in cobaltite or maucherite.

Physical Properties: Hardness = n.d. VHN = 281–311 (25 g load). D(meas.) = 9.37 (PdSb) D(calc.) = 9.41 (PdSb)

Optical Properties: Opaque. *Color:* In polished section, white with a yellow tint. *Luster:* Metallic. *Anisotropism:* Weak to moderate, in pale grayish yellow and dark grayish brown.
R_1–R_2: (400) 49.1–45.0, (420) 50.9–46.9, (440) 52.9–49.2, (460) 54.7–51.5, (480) 56.6–53.8, (500) 58.6–55.8, (520) 60.7–57.7, (540) 62.8–59.3, (560) 64.4–60.4, (580) 65.7–61.4, (600) 66.9–62.2, (620) 67.8–62.8, (640) 68.6–63.4, (660) 69.3–63.6, (680) 70.0–63.9, (700) 70.5–64.2

Cell Data: *Space Group:* $P6_3/mmc$. $a = 4.083$ $c = 5.602$ $Z = 2$

X-ray Powder Pattern: Synthetic PdSb.
2.18 (100), 0.7790 (100), 0.8237 (90), 1.202 (80), 2.03 (70), 0.9006 (70), 1.489 (60)

Chemistry:

	(1)	(2)	(3)
Pd	36.1	40.8	46.0
Ni	7.6	3.2	
Sb	55.5	51.3	53.3
Bi	0.77	4.5	
As	0.71	0.5	< 0.01
Te	0.79	0.1	
Total	101.47	100.4	99.3

(1) Copper Cliff South mine, Sudbury, Canada; by electron microprobe, corresponding to $(Pd_{0.71}Ni_{0.27})_{\Sigma=0.98}(Sb_{0.96}Bi_{0.01}As_{0.02}Te_{0.01})_{\Sigma=1.00}$. (2) Do.; by electron microprobe corresponding to $(Pd_{0.85}Ni_{0.12})_{\Sigma=0.97}(Sb_{0.93}Bi_{0.05}As_{0.02})_{\Sigma=1.00}$. (3) Witwatersrand, South Africa; by electron microprobe, corresponding to $Pd_{0.99}Sb_{1.01}$.

Mineral Group: Nickeline group.

Occurrence: As tiny inclusions, commonly in cobaltite or maucherite, in mechanical concentrates of platinum-group minerals (Sudbury, Canada).

Association: Cobaltite, maucherite, gersdorffite, breithauptite, chalcopyrite, nickeline, galena (Sudbury, Canada); pyrrhotite, pentlandite, chalcopyrite, violarite, cubanite, bornite, sphalerite, galena, linnaeite, magnetite, testibiopalladite, sperrylite, omeiite, gold (Danba, China).

Distribution: In Canada, from the Copper Cliff South [TL] and Frood mines, Sudbury, Ontario; and in the Wellgreen Cu–Ni–Pt–Pd deposit, Yukon Territory. At Danba, Sichuan Province, China. From the Baula complex, Orissa, India. From Kambalda, 56 km south of Kalgoorlie, Western Australia. In the Onverwacht and Tweefontein pipes, on the Merensky Reef, Bushveldt complex, and from the Witwatersrand, Transvaal, South Africa.

Name: For the localities at Sudbury, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M32841.

References: (1) Cabri, L.J. and J.H.G. Laflamme (1974) Sudburyite, a new palladium–antimony mineral from Sudbury, Ontario. Can. Mineral., 12, 275–279. (2) (1976) Amer. Mineral., 61, 178 (abs. ref. 1). (3) Ping-Chiu Fu, Yu-Hua Kung, and Liu Chang (1979) Crystal structure of sudburyite. Ti Ch'iu Hua Hseuh, 72–75 (in Chinese). (4) (1979) Chem. Abs., 90, 213618 (abs. ref. 3). (5) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 141, 158. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 542.

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Sudoite $\mathbf{Mg_2(Al,Fe^{3+})_3Si_3AlO_{10}(OH)_8}$

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Crystal Data: Monoclinic. *Point Group:* 2/*m*. Fine-grained.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = n.d. D(meas.) = 2.63–2.68 D(calc.) = 2.653

Optical Properties: Translucent. *Color:* Whitish.
Optical Class: Biaxial (+). α = 1.581–1.583 β = 1.584–1.589 γ = [1.591–1.601] 2V(meas.) = 64°–70°

Cell Data: *Space Group:* *C*2/*m*. *a* = 5.237(3) *b* = 9.070(5) *c* = 14.285(13) β = 97°02(5)′ Z = 2

X-ray Powder Pattern: Negaunee, Michigan, USA.
2.501 (100), 4.52 (85), 14.2 (80), 4.74 (80), 3.55 (65), 1.511 (60), 2.409 (50)

Chemistry:

	(1)		(1)
SiO_2	32.81	MnO	0.29
TiO_2	0.18	MgO	13.54
Al_2O_3	35.71	CaO	0.03
Fe_2O_3	2.66	K_2O	0.03
FeO	1.07	H_2O	12.95
		Total	99.27

(1) Ottré, Belgium; by XRF, Fe^{2+}:Fe^{3+} determined separately, H_2O by titration with Karl Fischer reagent; corresponds to $(Mg_{1.85}Fe^{2+}_{0.08}Mn_{0.02})_{\Sigma=1.95}(Al_{2.86}Fe^{3+}_{0.18}Ti_{0.01})_{\Sigma=3.05}$ $Si_{3.00}Al_{1.00}O_{10}(OH)_{7.91}$.

Mineral Group: Chlorite group.

Occurrence: Disseminated in hematite ore, probably of hydrothermal origin (Negaunee, Michigan, USA); an authigenic mineral in aeolian sandstones (Kesselberg, Germany); in low-grade metamorphic assemblages (Ottré, Belgium).

Association: Hematite (Negaunee, Michigan, USA); quartz, carpholite, manganoan garnet, hematite (Biesenrode, Germany); pyrophyllite, diaspore, mica, böhmite (Itaya, Japan).

Distribution: From Lützelbach, near Plochingen, Baden-Württemberg; in the Kesselberg area, Black Forest; and from near Biesenrode, Harz Mountains, Germany. At Ottré, near Salmchâteau, Ardennes Mountains, Belgium. From Beresov, Ural Mountains, Russia. In the USA, from the Tracy mine, Negaunee, Marquette Co., Michigan. Around the Cigar Lake uranium deposit, Athabasca basin, Saskatchewan, Canada. From the Hanaoka and Kamakita mines, Aomori Prefecture; the Ehara mine, Mitsuishi, and at Itaya, Hyogo Prefecture; in the Furutobe mine, Akita Prefecture; the Kamagamine mine, Hiroshima Prefecture; the Shinyo mine, Nagano Prefecture, and elsewhere in Japan.

Name: For Professor Toshio Sudo (1911–), University of Tokyo, Tokyo, Japan.

Type Material: n.d.

References: (1) von Engelhardt, W., G. Müller, and H. Kromer (1962) Dioktaedrischer Chlorit ("Sudoit") in Sedimenten des Mittleren Keupers von Plochingen (Württ.). Naturwiss., 49, 205–206 (in German). (2) (1963) Amer. Mineral., 48, 213–214 (abs. ref. 1). (3) Eggleton, R.A. and S.W. Bailey (1967) Structural aspects of dioctahedral chlorite. Amer. Mineral., 52, 673–689. (4) Shirozu, H. and S. Higashi (1976) Structural investigations of sudoite and regularly interstratified sericite/sudoite. Mineral. J. (Japan), 8, 158–170. (5) Kramm, U. (1980) Sudoite in low-grade metamorphic manganese rich assemblages. Neues Jahrb. Mineral., Abh., 138, 1–13. (6) Bailey, S.W. and J.S. Lister (1989) Structures, compositions, and X-ray diffraction identification of dioctahedral chlorites. Clays and Clay Minerals, 37, 193–202.

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Suessite $(Fe, Ni)_3Si$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As anhedral interstitial vein fillings, to about 150 μm long; as cubic crystals, skeletal, to 0.3 mm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.08 Strongly ferromagnetic.

Optical Properties: Opaque. *Color:* Cream-white in reflected light.
Optical Class: Isotropic.
R: (470) 48.5, (546) 51.6, (589) 53.5, (650) 50.0

Cell Data: *Space Group:* $Im3m$. $a = 2.841(2)$ $Z = [0.5]$

X-ray Powder Pattern: North Haig meteorite.
2.005 (10), 1.160 (3), 1.42 (1)

Chemistry:

	(1)	(2)
Fe	84.7	83.1
Cr	0.10	0.04
Co	0.21	0.27
Ni	1.6	4.5
Si	15.3	13.7
P	0.06	0.17
Total	101.97	101.78

(1) North Haig meteorite; by electron microprobe, corresponds to $(Fe_{2.78}Ni_{0.05}Co_{0.01})_{\Sigma=2.84}(Si, P)_{1.00}$. (2) Do.; by electron microprobe, corresponds to $(Fe_{2.98}Ni_{0.15}Co_{0.01})_{\Sigma=3.14}(Si, P)_{1.00}$.

Occurrence: In a highly reduced brecciated meteorite (North Haig meteorite); in amygdaloidal basaltic porphyrite (Chatkal Range, Russia).

Association: Olivine, pigeonite, kamacite, troilite, carbonaceous material (North Haig meteorite); khamrabaevite (Chatkal Range, Russia).

Distribution: In the North Haig olivine-pigeonite achondrite (ureilite) meteorite. From the Ir-Tash stream basin, Arashan Mountains, Chatkal Range, Uzbekistan.

Name: To honor Dr. Hans E. Suess (1909–1993), Austrian-American geochemist, Professor of Chemistry, University of California at San Diego, La Jolla, California, USA, for his work in cosmochemistry and meteoritics.

Type Material: Institute of Meteoritics, University of New Mexico, Albuquerque, New Mexico, USA.

References: (1) Keil, K., J.L. Berkley, and L.H. Fuchs (1982) Suessite, Fe_3Si: a new mineral in the North Haig ureilite. Amer. Mineral., 67, 126–131. (2) Novgorodova, M.I., R.G. Yusupov, M.T. Dmitrieva, A.I. Tsepin, A.V. Sivtsov, and A.I. Gorshkov (1984) Khamrabaevite, (Ti,V,Fe)C, a new mineral. Zap. Vses. Mineral. Obshch., 113, 697–703 (in Russian).

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Sugakiite $Cu(Fe, Ni)_8S_8$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As irregular grains, to 0.1 mm; as lamellae.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = n.d. VHN = 145 (50 g load). D(meas.) = n.d. D(calc.) = 4.71

Optical Properties: Opaque. *Color*: Reddish yellow; creamy white with reddish tint in reflected light. *Streak*: n.d. *Luster*: Metallic. Tarnishes brownish gray on exposure to air.
Optical Class: n.d. *Anisotropism:* Weak, dark to light gray.
R_1-R_2: (436) 25.6–31.9, (497) 29.9–36.1, (543) 33.2-39.1, (586) 36.1–41.5, (648) 39.3–44.3

Cell Data: *Space Group*: $P4_2/mnm$. $a = 10.566(5)$ $c = 9.749(8)$ $Z = 4$

X-ray Powder Pattern: Horoman massif, Samanicho, Samani-gun, Hokkaido, Japan.
2.072 (100), 1.793 (85), 1.804 (83), 3.061 (74), 1.954 (42), 1.962 (38), 2.641 (33)

Chemistry:

	(1)
Cu	6.99
Fe	43.27
Ni	16.10
Co	0.17
S	33.04
Total	99.57

(1) Horoman massif, Hokkaido, Japan; average of 8 electron microprobe analyses, corresponding to $Cu_{0.85}(Fe_{6.01}Ni_{2.13}Co_{0.02})_{\Sigma=8.16}S_{7.99}$.

Occurrence: An intergranular exsolved phase in sulfide aggregates in lherzolite in a peridotite massif.

Association: Bornite, talnakhite, copper, $(Fe,Ni,Co,Cu)_9S_8$, $Cu_2(Fe,Ni)_7S_8$.

Distribution: Horoman peridotite massif, Samanicho, Samani-gun, Hokkaido, Japan.

Name: Honors emeritus professor Asahiko Sugaki (b 1923), Tohoku University, Sendai, Japan, for his studies on sulfide phase equilibria.

Type Material: Tohoku University Museum, Sendai, Japan.

References: (1) Kitakaze, A. (2008) Sugakiite, $Cu(Fe,Ni)_8S_8$, A new mineral species from Hokkaido, Japan. Can. Mineral., 46, 263–267. (2) (2008) Amer. Mineral., 93, 1944 (abs. ref. 1).

Sugilite $KNa_2(Fe^{3+},Mn^{3+},Al)_2Li_3Si_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals prismatic, to 2 cm, rare. Commonly in interlocking aggregates of subhedral grains, compact to massive.

Physical Properties: *Cleavage:* {0001}, poor. Hardness = 5.5–6.5 D(meas.) = 2.74–2.79 D(calc.) = 2.80

Optical Properties: Transparent to translucent. *Color:* Light brownish yellow to bright magenta; nearly colorless in thin section. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* Weak. ω = 1.595–1.611 ϵ = 1.590–1.607

Cell Data: *Space Group:* $P6/mcc$. $a = 10.007$ $c = 14.000$ Z = 2

X-ray Powder Pattern: Iwagi Islet, Japan; similar to sogdianite.
4.32 (100), 3.19 (80), 4.06 (55), 2.876 (50b), 3.50 (25), 2.499 (18), 6.98 (13)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	71.38	72.38	CaO	0.00	
TiO_2	0.51	0.00	Li_2O	3.14	[4.5]
Al_2O_3	2.97	5.88	Na_2O	4.37	5.65
Fe_2O_3	12.76	5.62	K_2O	3.76	4.71
Mn_2O_3		0.89	H_2O^+	0.81	
FeO	0.19		H_2O^-	0.12	
			Total	[100.01]	[99.63]

(1) Iwagi Islet, Japan; by XRF and spectrographic methods, recalculated after deduction of admixed pectolite; corresponds to $(K_{0.81}Na_{0.19})_{\Sigma=1.00}[(H_2O)_{0.91}Na_{0.64}]_{\Sigma=1.55}(Fe^{3+}_{1.32}Na_{0.59}Ti_{0.06}Fe^{2+}_{0.03})_{\Sigma=2.00}(Li_{2.12}Al_{0.59}Fe^{3+}_{0.29})_{\Sigma=3.00}Si_{12}O_{30}$. (2) Wessels mine, South Africa; by electron microprobe, Li_2O from stoichiometry; corresponding to $K_{1.00}Na_{1.82}(Al_{1.16}Fe^{3+}_{0.70}Mn^{3+}_{0.12})_{\Sigma=1.98}Li_{3.02}Si_{12}O_{30}$.

Mineral Group: Milarite group.

Occurrence: In an aegirine-bearing syenite stock in biotite granite (Iwagi Islet, Japan); in bedded manganese deposits (near Kuruman, South Africa).

Association: Albite, aegirine, pectolite, titanite, allanite, andradite, zircon, apatite (Iwagi Islet, Japan).

Distribution: On Iwagi Islet, Ehime Prefecture, Japan. In the Wessels and N'Chwaning mines, near Kuruman, Cape Province, South Africa. At Mont Saint-Hilaire, Quebec, Canada. In the Cerchiara mine, near Faggiona, Liguria, Italy. From an undetermined locality in Madhya Pradesh, India. In the Woods mine, 30 km north-northeast of Tamworth, New South Wales, Australia.

Name: For Professor Ken-ichi Sugi (1901–1948), Japanese petrologist, who discovered the mineral.

Type Material: Yamaguchi University, Yamaguchi; Sakurai Museum, Tokyo; National Science Museum, Tokyo, Japan; The Natural History Museum, London, England, 1975,342; National Museum of Natural History, Washington, D.C., USA, 133982.

References: (1) Murakami, N., T. Kato, Y. Miura, and F. Hirowatari (1977) Sugilite, a new silicate mineral from Iwagi Islet, southwest Japan. Mineral. J. (Japan), 8, 110–121. (2) (1977) Amer. Mineral., 62, 596 (abs. ref. 1). (3) Dunn, P.J., J.J. Brummer, and H. Belsky (1980) Sugilite, a second occurrence: Wessels mine, Kalahari manganese field, Republic of South Africa. Can. Mineral., 18, 37–39. (4) Clark, A.M., E.E. Fejer, A.G. Couper, G.S. Bearne, and V.K. Din (1980) Additional data on sugilite. Mineral. Mag., 43, 947–949. (5) Armbruster, T. and R. Oberhänsli (1988) Crystal chemistry of double-ring silicates: structures of sugilite and brannockite. Amer. Mineral., 73, 595–600.

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Sulfoborite $Mg_3B_2(SO_4)(OH)_9F$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tabular to prismatic crystals, elongated along [001], showing {001}, {010}, {110}, {101}, {111}, to 5 cm.

Physical Properties: *Cleavage:* {110}, good; {001}, fair. *Tenacity:* Brittle. Hardness = 4–4.5 D(meas.) = 2.38–2.45 D(calc.) = [2.44] Decomposed by H_2O.

Optical Properties: Transparent. *Color:* Colorless, may be pale red from included iron oxide; colorless in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. α = 1.522–1.527 β = 1.536–1.540 γ = 1.544–1.552 2V(meas.) = 70°–88°

Cell Data: *Space Group: Pnma.* a = 10.132(1) b = 12.537(1) c = 7.775(1) Z = 4

X-ray Powder Pattern: Inder deposit, Kazakhstan. (ICDD 14-639).
3.47 (100), 3.09 (100), 2.050 (100), 3.13 (80), 2.973 (70), 5.55 (40), 4.40 (40)

Chemistry:

	(1)	(2)
SO_3	22.46	22.08
B_2O_3	19.79	19.20
Fe_2O_3	0.11	
MgO	33.48	33.34
F	n.d.	5.24
H_2O	23.53	22.35
insol.	0.32	
$-O = F_2$		2.21
Total	99.69	100.00

(1) Westeregeln, Germany. (2) $Mg_3B_2(SO_4)(OH)_9F$.

Occurrence: An uncommon mineral in marine salt deposits.

Association: Carnallite, anhydrite, boracite, celestine, kieserite (Westeregeln, Germany); polyhalite, kaliborite, aphthitalite, carnallite, preobrazhenskite (Inder deposit, Kazakhstan).

Distribution: In Germany, from near Westeregeln, Saxony-Anhalt, and at the Wittmar potash mine, Asse, southwest of Braunschweig, Lower Saxony. At Forden, near Scarborough, Yorkshire, England. From the Inder borate deposit, Kazakhstan.

Name: In allusion to *sulfur* and *boron* in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 387–388. (2) Giese, R.F., Jr., and G. Penna (1983) The crystal structure of sulfoborite, $Mg_3SO_4(B(OH)_4)_2(OH)F$. Amer. Mineral., 68, 255–261.

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Sulphohalite $Na_6(SO_4)_2FCl$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Octahedral, dodecahedral, cubic, or in combinations thereof, to 3 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼3.5 D(meas.) = 2.489–2.500 D(calc.) = 2.505 Slowly soluble in H_2O, with a mildly saline taste.

Optical Properties: Transparent. *Color:* Colorless, pale greenish yellow or gray; colorless in transmitted light. *Luster:* Vitreous to greasy.
Optical Class: Isotropic. $n = 1.455(1)$

Cell Data: *Space Group:* $Fm3m$. a = 10.068(3) Z = 4

X-ray Powder Pattern: Searles Lake, California, USA.
3.56 (10), 2.91 (8), 1.779 (6.5), 2.51 (6), 1.939 (5), 3.03 (4), 2.249 (2.5)

Chemistry:

	(1)	(2)
SO_3	41.79	41.64
Na_2O	32.37	48.36
Na	11.60	
K_2O	0.10	
F	4.71	4.94
Cl	9.10	9.22
LOI	0.15	
$-O = (F, Cl)_2$		4.16
Total	99.82	100.00

(1) Searles Lake, California, USA. (2) $Na_6(SO_4)_2FCl$.

Occurrence: In evaporite deposits (Searles Lake, California, USA; Otjiwalundo salt pan, Namibia); a volcanic sublimate (Kamchatka Peninsula, Russia).

Association: Hanksite, halite (Searles Lake, California, USA); trona, thénardite, pirssonite (Otjiwalundo salt pan, Namibia).

Distribution: In the USA, from Searles Lake, San Bernardino Co., California. In the Otjiwalundo salt pan, about 400 km west-northwest of Otavi, Namibia. From volcanoes on the Kamchatka Peninsula, Russia.

Name: In allusion to *sulfur* and sodium chloride, (*halite*), in the composition, neglecting fluorine, the presence of which was unnoticed in the original analysis of type material.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 548–549. (2) Pabst, A., D.L. Sawyer, and G. Switzer (1963) Galeite and related phases in the system Na_2SO_4−NaF−NaCl. Amer. Mineral., 48, 485–510. (3) Sakamoto, Y. (1968) The size, atomic charges, and motion of the sulfate radical of symmetry $\overline{4}3m$ in the crystal of sulfohalite, $Na_6ClF(SO_4)_2$. J. Sci. Hiroshima Univ., Ser. A-II, 32(1), 101–108 (in English).

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Sulphotsumoite Bi_3Te_2S

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As a rim, to 1 mm, around tsumoite; massive and as aggregates.

Physical Properties: *Cleavage:* Very perfect in one direction. *Tenacity:* Brittle. Hardness = Very soft. VHN = 64–66 (5 g load). D(meas.) = n.d. D(calc.) = 8.13

Optical Properties: Opaque. *Color:* Grayish white. *Luster:* Metallic.

R_1–R_2: (400) — , (420) 51.8–53.8, (440) 51.8–54.1, (460) 52.0–54.7, (480) 52.3–55.3, (500) 52.7–56.0, (520) 53.2–56.7, (540) 53.6–57.3, (560) 53.8–57.8, (580) 53.9–58.0, (600) 53.8–58.0, (620) 53.7–58.0, (640) 53.6–58.0, (660) 53.6–57.9, (680) 53.6–57.9, (700) 53.6–57.8

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 4.316$ $c = 23.43$ $Z = 2$

X-ray Powder Pattern: Burgagylkan deposit or Egerlyakh deposit, Russia. 3.16 (100), 2.32 (60), 2.16 (50), 1.779 (40) 1.367 (40), 4.67 (30), 1.960 (30)

Chemistry:

	(1)	(2)	(3)
Bi	70.1	67.7	68.58
Te	27.0	28.6	27.91
Se	0.5		
S	3.2	3.4	3.51
Total	100.8	99.7	100.00

(1) Burgagylkan deposit or Egerlyakh deposit, Russia; by electron microprobe, corresponding to $Bi_{3.08}Te_{1.94}(S_{0.92}Se_{0.06})_{\Sigma=0.98}$. (2) Do.; by electron microprobe, corresponding to $Bi_{2.97}Te_{2.06}S_{0.97}$. (3) Bi_3Te_2S.

Occurrence: Of hydrothermal origin, with other bismuth tellurides.

Association: Tsumoite, joséite-B.

Distribution: In Russia, from the Burgagylkan Au–Ag deposit, upper Chelomzha River, Magadan district [TL], and the Egerlyakh deposit, Indigirka River basin, northeastern Sakha [TL]. At the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In the Pogo Au–As–Bi–Te deposit, 145 km east of Fairbanks, Alaska, USA.

Name: In allusion to the chemical relation to tsumoite.

Type Material: Mining Institute, St. Petersburg, 1369/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87246.

References: (1) Zav'yalov, E.N. and V.D. Begizov (1982) Sulphotsumoite, Bi_3Te_2S, a new bismuth mineral. Zap. Vses. Mineral. Obshch., 111, 316–320 (in Russian). (2) (1983) Amer. Mineral., 68, 1250 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 198.

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals dipyramidal on {111}, thick tabular and disphenoidal, to 20 cm; also massive, reniform, and forming stalactites; as a powder. *Twinning:* On {101}, {011}, {110}, rare.

Physical Properties: *Cleavage:* Imperfect on {001}, {110}, {111}; parting on {111}. *Fracture:* Conchoidal to uneven. *Tenacity:* Rather brittle to somewhat sectile. Hardness = 1.5–2.5 VHN = n.d. D(meas.) = 2.07 D(calc.) = 2.076

Optical Properties: Transparent to translucent. *Color:* Sulfur-yellow to honey-yellow, yellowish brown, greenish, reddish or yellowish gray; may be black from included organic matter. *Streak:* White. *Luster:* Resinous to greasy.

Optical Class: Biaxial positive (+). *Pleochroism:* Distinct. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$. $\alpha = 1.9579$ (Na). $\beta = 2.0377$ (Na). $\gamma = 2.2452$ (Na). 2V(meas.) = 68°58′ 2V(calc.) = n.d.

R_1–R_2: n.d.

Cell Data: *Space Group: Fddd.* $a = 10.468$ $b = 12.870$ $c = 24.49$ Z = 128

X-ray Powder Pattern: Synthetic.
3.90 (100), 3.24 (60), 5.75 (50), 7.76 (40), 3.48 (40), 3.12 (40), 2.12 (40)

Chemistry: Sulfur, sometimes with Se and Te.

Polymorphism & Series: Dimorphous with rosickýite.

Occurrence: A sublimation product at volcanic fumaroles; a product of the activity of biological micro-organisms; as a result of low oxidation potential and highly acidic chemical reactions in mineral deposits; formed by the decomposition of sulfides, especially pyrite, during mine fires; found in sedimentary rocks.

Association: Gypsum, anhydrite, halite, aragonite, calcite, celestine.

Distribution: In the USA, large deposits occur in salt domes, as in Louisiana, especially in the area of Lake Charles, Chalcasieu Parish, and in Texas near Freeport, Brazoria Co. At Sulfur Mountain, in Yellowstone Park, Wyoming. In California, at the Sulfur Bank mercury mine, on Clear Creek, Lake Co. Crystals from quarries at Maybee and Scofield, Monroe Co., Michigan. On Sicily, at Cianciana, Agrigento, and Racalmuto, the source of exceptionally large and fine crystals; from many other places in Italy, notably at Solfatara di Pozzuoli, near Naples; at Perticara, near Rimini, Marche; and at Carrara, Tuscany. Large crystals from Spain, at Conil, near Cádiz, Cádiz Province. In Baja California, Mexico, at San Felipe. Numerous other localities are known, the occurrence often inconspicuous.

Name: From the Latin *sulfur*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 140–144. (2) (1960) NBS Circ. 539, 9, 54.

Sulvanite Cu_3VS_4

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals cubic, to 2.5 cm, but most commonly massive.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 3.5 VHN = 135–157 (100 g load). D(meas.) = 3.86–4.00 D(calc.) = 3.94

Optical Properties: Opaque. *Color:* Bronze-gold; pale yellow in polished section. *Streak:* Black. *Luster:* Metallic, tarnishes to dull. *Anisotropism:* Weak, rarely.
R: (400) 28.1, (420) 26.4, (440) 24.4, (460) 24.1, (480) 27.6, (500) 31.4, (520) 30.6, (540) 28.4, (560) 27.7, (580) 29.4, (600) 30.0, (620) 30.8, (640) 29.5, (660) 27.9, (680) 26.7, (700) 25.9

Cell Data: *Space Group:* $P\bar{4}3m$. $a = 5.3912(7)$ $Z = 1$

X-ray Powder Pattern: Mercur district, Utah, USA.
5.44 (100), 1.910 (80), 3.12 (50), 2.40 (40), 1.634 (40), 1.101 (40), 1.804 (30)

Chemistry:

	(1)	(2)	(3)
Cu	47.97	51.6	51.55
V	12.15	14.3	13.77
S	31.66	34.4	34.68
rem.	7.49		
Total	99.27	100.3	100.00

(1) Burra-Burra, South Australia; average of two analyses, remainder $(Fe, Al)_2O_3$ 1.04% and gangue 6.45%; corresponds to $Cu_{3.06}V_{0.97}S_{4.00}$. (2) Mercur, Utah, USA; by electron microprobe, corresponds to $Cu_{3.03}V_{1.05}S_{4.00}$. (3) Cu_3VS_4.

Polymorphism & Series: Forms a series with arsenosulvanite.

Occurrence: In hydrothermal copper deposits which contain vanadium as a primary sulfide.

Association: Chalcopyrite, chalcocite, digenite, covellite, chrysocolla, malachite, azurite, atacamite, vésigniéite, mottramite, gypsum (Burra-Burra, Australia); yushkinite, cadmian sphalerite, fluorite (Pay-Khoy, Russia).

Distribution: From the Edelweiss mine, Burra district, South Australia [TL]. At Tsumeb, Namibia. From Kipushi, Katanga Province, Congo (Shaba Province, Zaire). At the Oyu Tolgoi porphyry Cu–Au deposit, Gobi Desert, Mongolia. In the USA, in the Thorpe Hills, and near Mercur, Tooele Co., Utah; in the Redhouse Barite mine, near Golconda, Humboldt Co., Nevada. On the Rough claims, north of Sifton Pass, British Columbia, Canada. At Pay-Khoy, in the middle stream of the Silova-Yakha River, Russia. From the Ceragiola quarry, near Carrara, Tuscany, Italy. At Bor, Serbia. In the Assarel and Medet deposits, Bulgaria. From Ponte Castiola, Corsica, France. On Koksín Hill, near Mítov, Czech Republic.

Name: For the composition: SULfur and VANadium.

Type Material: Natural History Museum, Paris, France, 101.112, 101.370.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 384–385. (2) Trojer, F.J. (1966) Refinement of the structure of sulvanite. Amer. Mineral., 51, 890–894. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 57. (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 566–567. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 546.

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Sundiusite $Pb_{10}O_8(SO_4)Cl_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. Platy crystals, in plumose aggregates, to 8 mm.

Physical Properties: *Cleavage:* {100}, perfect; {001}, possible. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 7.0(2) D(calc.) = 7.20

Optical Properties: Semitransparent. *Color:* White to colorless. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (+); birefringence 0.070. *Orientation:* Length-slow. $\alpha = > 2.1$ $\beta = > 2.1$ $\gamma = > 2.1$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$, Cm, or $C2$. $a = 24.67(1)$ $b = 3.781(1)$ $c = 11.881(5)$ $\beta = 100.07(4)°$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
2.981 (10), 2.737 (8), 3.101 (6), 3.044 (6), 6.10 (3), 3.744 (3), 3.914 (2)

Chemistry:

	(1)	(2)
FeO	0.5	
PbO	93.1	94.30
Cl	3.0	3.00
SO_3	3.5	3.38
$-O = Cl_2$	0.7	0.68
Total	99.4	100.00

(1) Långban, Sweden; by electron microprobe, corresponding to $(Pb_{9.65}Fe_{0.15})_{\Sigma=9.80}(SO_4)O_{7.8}Cl_{1.95}$. (2) $Pb_{10}O_8(SO_4)Cl_2$.

Occurrence: On fracture surfaces in a museum specimen of manganese ore from a metamorphosed Fe–Mn orebody.

Association: Blixite, braunite, hausmannite, manganoan biotite, calcite.

Distribution: From Långban, Värmland, Sweden.

Name: To honor Nils Sundius (1886–1976), Swedish mineralogist, who made numerous contributions to Långban mineralogy.

Type Material: The Natural History Museum, London, England, 1980,580; Royal Ontario Museum, Toronto, Canada, M36619; Harvard University, 117086; National Museum of Natural History, Washington, D.C., USA, 134984.

References: (1) Dunn, P.J. and R.C. Rouse (1980) Sundiusite, a new lead sulfate oxychloride from Långban, Sweden. Amer. Mineral., 65, 506–508.

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Suolunite $Ca_2Si_2O_5(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As coarse-bladed crystals, to 3 mm, in stellate aggregates; fine-granular massive.

Physical Properties: Hardness = 3.5 D(meas.) = 2.63–2.68 D(calc.) = 2.673 Distinctly piezoelectric.

Optical Properties: Transparent to translucent. *Color:* White to cream. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. $\alpha = 1.610$–1.612 $\beta = 1.620$ $\gamma = 1.623$ 2V(meas.) = 30°–35°

Cell Data: *Space Group:* $Fdd2$. $a = 11.02$–11.15 $b = 19.67$–19.82 $c = 6.00$–6.08 Z = 16

X-ray Powder Pattern: Al Khawd, Oman.
4.133 (100), 2.687 (85), 3.173 (81), 2.849 (62), 2.647 (51), 2.558 (37), 2.331 (26)

Chemistry:

	(1)	(2)	(3)
SiO_2	43.38	43.35	44.78
CaO	42.95	42.22	41.79
SrO	trace		
Na_2O	trace		
K_2O	trace		
H_2O^+	13.17	14.05	13.43
Total	99.50	99.62	100.00

(1) Suolun, China. (2) Kulaski, Bosnia-Herzegovina. (3) $Ca_2Si_2O_5(OH)_2 \cdot H_2O$.

Occurrence: In veins cutting harzburgites in an ultramafic intrusive (Suolun, China); as a precipitate from an alkaline spring in a fault zone in basalts overlying an ultramafic intrusive (Al Khawd, Oman).

Association: Tobermorite.

Distribution: From Suolun, Inner Mongolia, China. At Kulaski, near Doboj, Bosnia-Herzegovina. From Al Khawd, near Masqat, Oman.

Name: For the original locality, Suolun, China.

Type Material: n.d.

References: (1) Yung-Hwei Huang (1965) Suolunite, a new mineral. Geol. Review, 23(1), 7 (in Chinese). (2) (1968) Amer. Mineral., 53, 349 (abs. ref. 1). (3) Jo-Ku Ts'Eng, Chi-Yueh Hsieh, and Chih-Chung P'eng (1966) The crystal structure of suolunite. Kexue Tongbao, 17(1), 45–48 (in English). (4) (1967) Amer. Mineral., 52, 560–561 (abs. ref. 3). (5) Stojanovic, D., D. Dordevic, and B. Derkovic (1974) Suolunite and tobermorite in the diabase rocks of Kulaski, near Doboj, Bosnia, Yugoslavia. Glas. Prir. Muz. Beogradu, Ser. A, 5–15 (in Serbian). (6) (1975) Chem. Abs., 83, 13427 (abs. ref. 5). (7) Stanger, G. and C. Neal (1984) A new occurrence of suolunite, from Oman. Mineral. Mag., 48, 143–146.

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Surinamite $(Mg, Fe^{2+})_3Al_4BeSi_3O_{16}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As small crystals, platy ∥ {010}, to 0.2 mm.

Physical Properties: *Cleavage:* One well-developed ⊥ {010}. Hardness = n.d.
D(meas.) = > 3.3 D(calc.) = 3.58

Optical Properties: Transparent. *Color:* Dark blue, blue-green.
Optical Class: Biaxial (–). *Pleochroism:* Y = violet; ∥ to cleavage = bright blue-green; ⊥ to cleavage = very light greenish brown to colorless. *Orientation:* $Y = b$. *Dispersion:* Very strong.
$\alpha = 1.738$ $\beta = 1.743$ $\gamma = 1.746$ 2V(meas.) = 67°–68°

Cell Data: *Space Group:* $P2/n$. $a = 9.916(1)$ $b = 11.384(1)$ $c = 9.631(1)$
$\beta = 109.30(1)°$ Z = 4

X-ray Powder Pattern: Bakhuis Mountains, Surinam; closely resembles sapphirine.
2.435 (100), 1.99 (100), 1.420 (80), 7.05 (60), 2.91 (60), 1.432 (60), 1.411 (60)

Chemistry:

	(1)	(2)
SiO_2	33.1	32.3
TiO_2	0.05	
Al_2O_3	34.9	34.3
FeO	12.25	10.8
MnO	1.05	0.7
ZnO	0.05	
BeO	n.d.	[4.5]
MgO	16.45	17.3
CaO	0.05	0.0
F	0.05	
Total	[97.95]	[99.9]

(1) Bakhuis Mountains, Surinam; by electron microprobe, original total given as 97.85%; BeO ∼4% inferred from later analyses. (2) Chimwala area, Zambia; BeO assumed, then corresponding to $(Mg_{2.39}Fe_{0.55}Mn_{0.06})_{\Sigma=3.00}(Al_{3.74}Fe_{0.28})_{\Sigma=4.02}Be_{1.00}Si_{2.99}O_{16}$.

Occurrence: In mylonitic mesoperthite gneiss, probably formed during high-pressure granulite facies metamorphism of aluminous rocks (Bakhuis Mountains, Surinam); in sillimanite-rich segregations in pegmatites (Casey Bay, Antarctica); as pseudomorphs after cordierite (Chimwala area, Zambia).

Association: Biotite, kyanite, sillimanite, spinel (Bakhuis Mountains, Surinam); quartz, sillimanite, sapphirine, taaffeite (Casey Bay, Antarctica); cordierite (Chimwala area, Zambia).

Distribution: From the Bakhuis Mountains, Surinam. In the Woolanga Bore area, Strangways Range, Northern Territory, Australia. From Casey Bay, Enderby Land, Antarctica. In the Chimwala area, Eastern Province, Zambia.

Name: For Surinam, the country of first occurrence.

Type Material: Geological & Mining Service, Paramaribo, Surinam, EW 1115.

References: (1) de Roever, E.W.F., C. Kieft, E. Murray, E. Klein, and W.H. Drucker (1976) Surinamite, a new Mg-Al silicate from the Bakhuis Mountains, western Surinam. I. Description, occurrence, and conditions of formation. Amer. Mineral., 61, 193–199. (2) de Roever, E.W.F., D. Lattard, and W. Schreyer (1981) Surinamite: a beryllium-bearing mineral. Contr. Mineral. Petrol., 76, 472–473. (3) Moore, P.B. and T. Araki (1983) Surinamite, *ca.* $Mg_3Al_4Si_3BeO_{16}$: its crystal structure and relation to sapphirine, *ca.* $Mg_{2.8}Al_{7.2}Si_{1.2}O_{16}$. Amer. Mineral., 68, 804–810. (4) de Roever, E.W.F. and S. Vrána (1985) Surinamite in pseudomorphs after cordierite in polymetamorphic granulites from Zambia. Amer. Mineral., 70, 710–713.

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Surite

$(Pb,Ca)_{2-3}(CO_3)_{1.5-2}(OH,F)_{0.5-1}\cdot (Al,Fe^{3+})_2(Si,Al)_4O_{10}(OH)_2\cdot nH_2O$

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Crystal Data: Monoclinic. *Point Group:* 2 (possible). As aggregates of tabular lath-shaped crystals, to ~5 μm.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2–3 D(meas.) = 4.0 D(calc.) = [4.00]

Optical Properties: Semitransparent. *Color:* White to pale green; colorless in thin section. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial. $\alpha = 1.693(2)$ β = n.d. $\gamma = 1.738(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1$ (possible). $a = 5.22$ $b = 8.97$ $c = 16.3$ $\beta = 96.1°$ Z = 2

X-ray Powder Pattern: Cruz del Sur mine, Argentina; basal spacing does not expand with ethylene glycol treatment.
4.05 (100), 5.4 (71), 16.2 (68), 3.24 (60), 2.313 (50), 2.700 (35), 4.48 (20)

Chemistry:

	(1)
SiO_2	23.58
Al_2O_3	11.27
Fe_2O_3	0.41
CuO	0.07
PbO	45.32
MgO	1.29
CaO	4.75
Na_2O	0.77
H_2O	3.72
CO_2	9.45
Total	100.63

(1) Cruz del Sur mine, Argentina; corresponds to $(Pb_{1.84}Ca_{0.77}Na_{0.23}Cu_{0.01})_{\Sigma=2.85}(CO_3)_{1.95}(OH)_{0.59}\cdot(Al_{1.58}Mg_{0.29}Fe^{3+}_{0.05})_{\Sigma=1.92}(Si_{3.57}Al_{0.43})_{\Sigma=4.00}O_{10}(OH)_2\cdot 0.58H_2O$.

Occurrence: As fissure fillings in the oxidized zone of a Pb-Zn deposit.

Association: Kaolinite, cerussite, quartz.

Distribution: In the Cruz del Sur mine, 42 km east-southeast of Los Menucos, Rio Negro Province, Argentina.

Name: For the type locality, the Cruz del Sur mine, Argentina.

Type Material: Institute of Earth Science, Waseda University, Tokyo, Japan; National Museum of Natural History, Washington, D.C., USA, 147202.

References: (1) Hayase, K., J.A. Dristas, S. Tsutsumi, R. Otsuka, S. Tanabe, T. Sudo, and T. Nishiyama (1978) Surite, a new Pb-rich layer silicate mineral. Amer. Mineral., 63, 1175–1181.
(2) Kampf, A.R., L.L. Jackson, G.B. Sidder, E.E. Foord, and P.M. Adams (1992) Ferrisurite, the Fe^{3+} analogue of surite, from Inyo County, California. Amer. Mineral., 77, 1107–1111.

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Surkhobite $(Ba, K)_2CaNa(Mn, Fe^{2+}, Fe^{3+})_8Ti_4(Si_2O_7)_4O_4(F, OH, O)_6$

Crystal Data: Monoclinic. *Point Group*: 2. As poorly formed platy crystals, to 1 mm, dominated by {001} and as grains, to 2 cm. *Twinning*: Microscopic twins on (001).

Physical Properties: *Cleavage*: Perfect {001}. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 4.5 VHN = 482 on {001}, 250 perpendicular to {001} (20-30 g load).
D(meas.) = 3.84(10) D(calc.) = 3.98

Optical Properties: Translucent. *Color*: Brownish red. *Streak*: White. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.790$ (calculated from 2V) $\beta = 1.858(10)$ $\gamma = 1.888(10)$
2V = 65(5)° *Orientation*: $X = b$; $Z \wedge a = 34°$. *Dispersion:* $r < v$, strong.
Pleochroism: Y = orange; Z = bright yellow; X = yellow. Absorption: $Y > Z \geq X$.

Cell Data: *Space Group*: $C2$. $a = 10.723(1)$ $b = 13.826(2)$ $c = 20.791(4)$ $\beta = 95.00(1)°$
Z = 4

X-ray Powder Pattern: Dara-i-Pioz massif, Tajikistan.
3.454 (100), 2.592 (70), 2.074 (40), 10.39 (20), 3.186 (15), 2.862 (15), 1.728 (15)

Chemistry:

	(1)
Na_2O	2.27
K_2O	1.87
CaO	2.53
SrO	0.26
BaO	11.16
MgO	0.13
MnO	16.32
FeO	13.92
Fe_2O_3	2.11
Al_2O_3	0.02
SiO_2	27.17
TiO_2	16.14
Nb_2O_5	2.14
ZrO_2	0.34
F	2.94
H_2O	1.17
$-O = F_2$	1.24
Total	99.25

(1) Dara-i-Pioz massif, Tajikistan; electron microprobe and Mössbauer analysis, water by Penfield method, corresponding to $Na_{2.60}K_{1.41}Ca_{1.60}Sr_{0.09}Ba_{2.58}(Mn_{8.17}Fe^{2+}_{6.88}Fe^{3+}_{0.94}Mg_{0.115}Al_{0.01})_{\Sigma=16.115}(Ti_{7.17}Nb_{0.57}Zr_{0.10})_{\Sigma=7.84}Si_{16.06}H_{4.61}F_{5.49}O_{70.51}$.

Occurrence: In a zoned alkaline syenite pegmatite replacing astrophyllite and bafertisite.

Association: Aegirine, microcline, albite, quartz, amphibole, annite, bafertisite, astrophyllite, zircon, fluorite, polylithionite, stillwelite, sogdianite, tadjikite.

Distribution: Dara-i-Pioz massif, central Tajikistan.

Name: For the Surkhob river, in the basin of which the first specimens were collected.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Rastsvetaeva, R.K., E.M. Eskova, V. D. Dusmatov, N.V. Chukanov, and F. Schneider (2008) Surkhobite: revalidation and redefinition with the new formula, $(Ba,K)_2CaNa(Mn,Fe^{2+},Fe^{3+})_8Ti_4(Si_2O_7)_4O_4(F,OH,O)_6$. Eur. J. Mineral., 20, 289–295. (2) (2009) Amer. Mineral., 94, 404 (abs. ref. 1). (3) (2004) Amer. Mineral., 89, 469-470.

Sursassite $\mathbf{Mn_2^{2+}Al_3(SiO_4)(Si_2O_7)(OH)_3}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As fibers, up to 2.5 cm, in veinlets and as radiated botryoidal masses.

Physical Properties: *Cleavage:* On {001} and {101}. Hardness = n.d. D(meas.) = 3.256 D(calc.) = 3.57

Optical Properties: Semitransparent. *Color:* Copper-red.
Optical Class: Biaxial (–). *Pleochroism:* Strong; $X = Z$ = colorless to pale yellow; Y = deep golden brown. *Dispersion:* $r > v$, strong. $\alpha = 1.735$–1.736 $\beta = 1.753$–1.755 $\gamma = 1.766$–1.767 2V(meas.) = 65°

Cell Data: *Space Group:* $P2_1/m$. a = 8.70(1) $b = 5.79(1)$ $c = 9.78(1)$ $\beta = 108.9(1)°$ Z = 2

X-ray Powder Pattern: Val d'Err, Switzerland. (ICDD 18-1286).
2.82 (100), 2.88 (70), 2.57 (70), 2.66 (60), 2.14 (60), 4.56 (50), 3.72 (50)

Chemistry:

	(1)	(2)	(3)
SiO_2	34.70	39.39	35.90
TiO_2	0.14	0.05	
Al_2O_3	22.90	18.72	30.46
FeO	1.67	3.47	
MnO	29.42	26.64	28.26
MgO	2.79	2.68	
CaO	2.26	2.00	
Na_2O	0.12	0.18	
K_2O	0.23		
H_2O	5.81	6.70	5.38
Total	100.04	99.83	100.00

(1) Val d'Err, Switzerland. (2) Plymouth deposit, Canada. (3) $Mn_2Al_3(SiO_4)(Si_2O_7)(OH)_3$.

Occurrence: As vein fillings in manganese deposits in low-grade metasediments.

Association: Braunite, barite, calcite, quartz.

Distribution: From the Val d'Err, Oberhalbstein, Graubünden, Switzerland. In the Plymouth deposit, near Woodstock, New Brunswick, Canada. From the Palos Verdes Hills, Los Angeles Co., California, USA. In the Molinello manganese mine, near Chiavari, Val Graveglia, Liguria, Italy. On Andros Island, Cyclades Islands, Greece.

Name: From the Roman name for Oberhalbstein, *Sursass*, Switzerland.

Type Material: Federal Institute of Technology, Zurich, Switzerland, 194807; The Natural History Museum, London, England.

References: (1) Jakob, J. (1926) Sursassite, ein Mangansilikat aus dem Val d'Err (Graubünden). Schweiz. Mineral. Petrog. Mitt., 6, 376–380 (in German). (2) (1927) Amer. Mineral., 12, 380 (abs. ref. 1). (3) Heinrich, E.W. (1962) Sursassite from New Brunswick. Can. Mineral., 7, 291–300. (4) Mellini, M., S. Merlino, and M. Pasero (1984) X-ray and HRTEM study of sursassite: crystal structure, stacking disorder, and sursassite-pumpellyite intergrowth. Phys. Chem. Minerals, 10, 99–105. (5) Allmann, R. (1984) Die Struktur des Sursassits und ihre Beziehung zur Pumpellyit- und Ardennit-struktur. Fortschr. Mineral., Bieheft 1 (Suppl.), 62, 3–4 (in German).

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Susannite $Pb_4(SO_4)(CO_3)_2(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* 3. As equant to acute rhombohedral crystals, modified by a prism and basal pinacoid, to 8 cm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.52

Optical Properties: Translucent. *Color:* Colorless, white, pale green, pale yellow, brown. *Optical Class:* Uniaxial, may be anomalously biaxial. ω = n.d. ϵ = n.d. 2V(meas.) = 0°–3°

Cell Data: *Space Group:* $P3$. $a = 9.0718(7)$ $c = 11.570(1)$ Z = 3

X-ray Powder Pattern: Susanna mine, Scotland; nearly identical to leadhillite, from which it may be distinguished by presence of the (101) diffraction peak at 6.5 (1).
3.571 (vs), 2.937 (s), 2.622 (s), 4.538 (ms), 2.113 (ms), 2.316 (m), 2.066 (m)

Chemistry: (1) Composition established by crystal-structure analysis.

Polymorphism & Series: Trimorphous with leadhillite and macphersonite.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal lead-bearing deposits, formed at temperatures above 80 °C.

Association: Leadhillite, macphersonite, lanarkite, caledonite, cerussite (Leadhills, Scotland).

Distribution: From the Susanna mine, Leadhills, Lanarkshire, Scotland. At Caldbeck Fells, Cumbria, England. In Wales, in Dyfed, from the Esgair Hir mine, Bwlch-y-Esgair, Ceulanymaesmawr; in the Bwlch Glas mine; at the Llechweddhelyg mine, Tir-y-Mynach; from the Hendrefelen mine, Ysbyty Ystwyth; and at the Frongoch mine. In Germany, in the Richelsdorfer Mountains, Hesse; from Virneberg, near Rheinbreitbach, Rhineland-Palatinate; at Ramsbeck, North Rhine-Westphalia, Wilnsdorf. Siegerland; and in the Clara mine, near Oberwolfach, Black Forest. In the USA, from the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, and at the Ecton mine, Audubon, Montgomery Co., Pennsylvania. From Iporanga, Sao Paulo, Brazil. Very large crystals at Tsumeb, Namibia.

Name: For its first-noted occurrence in the Susanna mine, Leadhills, Scotland.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 298–299. (2) Mrose, M.E. and R.P. Christian (1969) The leadhillite-susannite relation. Can. Mineral., 10, 141 (abs.). (3) Livingstone, A. and J.D. Russell (1985) X-ray powder data for susannite and its distinction from leadhillite. Mineral. Mag., 49, 759–761. (4) Steele, I.M., J.J. Pluth, and A. Livingstone (1999) Crystal structure of susannite, $Pb_4SO_4(CO_3)_2(OH)_2$: a trimorph with macphersonite and leadhillite. Eur. J. Mineral., 11, 493–499.

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Sussexite $Mn^{2+}BO_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As bladed acicular crystals, to 7 mm; cross-vein or radial fibrous, in felted or matted aggregates, nodular. *Twinning:* Submicroscopic twinning on {100} which cannot be resolved optically.

Physical Properties: *Tenacity:* Inflexible. Hardness = 3–3.5 D(meas.) = 3.30 D(calc.) = 3.335

Optical Properties: Semitransparent. *Color:* White to buff, straw-yellow, pale pink; colorless in transmitted light. *Streak:* White. *Luster:* Silky, dull, earthy.
Optical Class: Biaxial (–). *Orientation:* Parallel extinction; X = elongation; $Z \perp$ flattening. *Dispersion:* $r > v$. $\alpha = 1.670$ $\beta = 1.728$ $\gamma = 1.732$ 2V(meas.) = ∼25°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.866(3)$ $b = 10.718(2)$ $c = 3.287(1)$ $\beta = 94.75(3)°$ Z = 8

X-ray Powder Pattern: N'chwaning II mine, South Africa.
6.43 (10), 2.773 (7), 3.34 (6), 2.632 (6), 2.494 (6), 2.741 (5), 2.694 (5)

Chemistry:

	(1)	(3)
B_2O_3	30.52	30.33
FeO	0.16	
MnO	49.40	61.82
MgO	9.56	
CaO	2.03	
H_2O	8.33	7.85
Total	[100.00]	100.00

(1) Franklin, New Jersey, USA; recalculated to 100% after deduction of willemite 4.5%.
(2) N'chwaning II mine, South Africa; by electron microprobe, analysis not given; stated to correspond to $(Mn_{0.95}Mg_{0.05})_{\Sigma=1.00}BO_2(OH)$. (3) $MnBO_2(OH)$.

Polymorphism & Series: Forms a series with szaibélyite.

Occurrence: A rare hydrothermal mineral typically in veinlets in boron-bearing metamorphosed Mn–Fe–Zn deposits.

Association: Pyrochroite, rhodochrosite, wiserite, hausmannite, sonolite, alabandite, seamanite, tephroite, alleghanyite, willemite, leucophoenicite, hauckite.

Distribution: In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; at the Chicagon and Bengal mines, Iron Co., Michigan; in the Mountain Lake mine, Big Cottonwood district, Salt Lake Co., Utah. Large crystals from the N'chwaning II and Hotazel mines, near Kuruman, Cape Province, South Africa. At the Gonzen iron–manganese mine, near Sargans, St. Gallen Canton, Switzerland. In the Kurihara mine, Mie Prefecture, the Yaei mine, Shiga Prefecture, the Hokkoji mine, Tochigi Prefecture, the Matsuo mine, Kochi Prefecture, and a number of other localities in Japan.

Name: For Sussex Co., New Jersey, USA, within which the first specimens were collected.

Type Material: Yale University, New Haven, Connecticut, 3.1072; National Museum of Natural History, Washington, D.C., USA, 124356.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 375–377. (2) Hoffmann, C. and T. Armbruster (1995) Crystal structure of a (001) twinned sussexite $Mn_2B_2O_4(OH)_2$ from the Kalahari manganese field South Africa. Schweiz. Mineral. Petrog. Mitt., 75, 123–133.

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Suzukiite $BaV^{4+}Si_2O_7$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As tiny flakes forming aggregates around other minerals.

Physical Properties: *Cleavage:* {010}, perfect; {100} and {001}, distinct. Hardness = 4–4.5 D(meas.) = 4.0 D(calc.) = 4.03

Optical Properties: Semitransparent. *Color:* Bright green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale green; Y = light yellow-green; Z = bluish green. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, very strong. *Absorption:* $Z > Y > X$. $\alpha = 1.730(5)$ $\beta = [1.739]$ $\gamma = 1.748(5)$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $Amam$ or $Ama2$. $a = 7.089(2)$ $b = 15.261(2)$ $c = 5.364(1)$ Z = 2

X-ray Powder Pattern: Mogurazawa mine, Japan.
7.63 (100), 3.818 (60), 3.353 (60), 2.394 (35), 3.276 (25), 2.653 (18), 1.526 (16)

Chemistry:

	(1)
SiO_2	33.59
TiO_2	0.20
VO_2	23.56
SrO	3.21
BaO	38.38
Total	98.94

(1) Mogurazawa mine, Japan; by electron microprobe, corresponding to $(Ba_{0.89}Sr_{0.11})_{\Sigma=1.00}(V^{4+}_{1.01}Ti_{0.01})_{\Sigma=1.02}Si_{1.98}O_7$.

Occurrence: In massive rhodonite-rhodochrosite ores of a bedded manganese deposit, formed in very weakly metamorphosed Triassic cherts.

Association: Quartz, barite, alabandite, nagashimalite, rhodonite, rhodochrosite, barian roscoelite.

Distribution: In the Mogurazawa mine, Gumma Prefecture, Japan.

Name: For Dr. Jun Suzuki (1896–1970), petrologist and mineralogist, Professor at Hokkaido University, Sapporo, Japan.

Type Material: National Science Museum, Tokyo, Japan, M-21385.

References: (1) Matsubara, S., A. Kato, and S. Yui (1982) Suzukiite, $Ba_2V^{4+}_2[O_2|(Si_4O_{12})]$, a new mineral from the Mogurazawa mine, Gumma Prefecture, Japan. Mineral. J. (Japan), 11, 15–20. (2) (1983) Amer. Mineral., 68, 282 (abs. ref. 1).

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Svabite $Ca_5(AsO_4)_3(F,OH)$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As stout prismatic hexagonal crystals, typically modified by several bipyramids, to 5 mm; massive.

Physical Properties: *Cleavage:* Indistinct on $\{10\bar{1}0\}$. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 3.5–3.8 D(calc.) = 3.67 Fluoresces reddish orange under LW UV and yellow under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless, yellowish white, gray, grayish green; colorless to pale lilac in transmitted light. *Luster:* Vitreous to subresinous. *Optical Class:* Uniaxial (–). $\omega = 1.706$ $\epsilon = 1.698$

Cell Data: *Space Group:* $P6_3/m$. $a = 9.75$ $c = 6.92$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
2.87 (10), 2.79 (9), 1.860 (6), 3.44 (5), 3.94 (4), 2.65 (4), 1.981 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	0.69		CaO	42.07	44.14
P_2O_5	0.38		Na_2O	0.56	
As_2O_5	51.05	54.28	K_2O	0.30	
FeO	0.08		F	1.99	1.50
MnO	0.26		Cl	0.12	
PbO	3.02		H_2O	0.25	0.71
MgO	0.52		$-O=(F,Cl)_2$	0.87	0.63
			Total	100.42	100.00

(1) Jakobsberg, Sweden. (2) $Ca_5(AsO_4)_3(F,OH)$ with F:OH = 1:1.

Mineral Group: Apatite group.

Occurrence: A rare accessory mineral in calcsilicate skarns.

Association: Manganoan diopside, brandtite, sarkinite, garnet (Harstigen mine, Sweden); hausmannite (Jakobsberg, Sweden); manganoan diopside, tilasite, manganberzeliite, bergslagite, hematite, calcite, barite (Långban, Sweden).

Distribution: In Sweden, found in the Harstigen mine, near Persberg, at Jakobsberg, and at Långban, Värmland; from Kesebol, Dalsland; in the Ultevis district, Jokkmokk, Swedish Lappland. In the Clara Mine, near Oberwolfach, Black Forest, Germany.

Name: Honors Anton Svab (1703–1768), Swedish mining official.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 113494.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 899–900. (2) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541, esp. 536.

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Svanbergite **$SrAl_3(PO_4)(SO_4)(OH)_6$**

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals typically rhombohedral $\{10\overline{1}1\}$, may be pseudocubic, with $\{10\overline{1}2\}$, $\{02\overline{2}1\}$, $\{0001\}$, to 5 mm; granular, massive.

Physical Properties: *Cleavage:* On $\{0001\}$, distinct. Hardness = 5 D(meas.) = 3.20–3.24 D(calc.) = 3.24

Optical Properties: Translucent. *Color:* Colorless, cream-yellow, rose, reddish brown; colorless in transmitted light. *Luster:* Vitreous to adamantine.
Optical Class: Uniaxial (+). $\omega = 1.631$–1.635 $\epsilon = 1.646$–1.649

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.970$–6.992 $c = 16.567$–16.75 Z = 3

X-ray Powder Pattern: Champion mine, California, USA. (ICDD 39-1361).
2.949 (100), 2.2069 (85), 1.8923 (45), 1.4543 (40), 2.766 (30), 1.7433 (30), 5.675 (25)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3	17.34	15.88	17.34	CaO	3.25	1.02	
P_2O_5	16.70	17.42	15.37	SrO	12.84	21.18	22.45
Al_2O_3	36.91	32.91	33.13	BaO		0.22	
Fe_2O_3	0.24	0.00		H_2O	12.51	[11.37]	11.71
				Total	99.79	[100.00]	100.00

(1) Near Hawthorne, Nevada, USA. (2) Champion mine, California, USA; by electron microprobe, H_2O by difference; corresponding to $(Sr_{0.94}Ca_{0.08}Ba_{0.01})_{\Sigma=1.03}Al_{2.96}(PO_4)_{1.12}(SO_4)_{0.91}(OH)_6$. (3) $SrAl_3(PO_4)(SO_4)(OH)_6$.

Mineral Group: Beudantite group.

Occurrence: In aluminous medium-grade metamorphic deposits; from bauxite deposits; a product of sulphatic argillic wall-rock alteration in hydrothermal vein and disseminated ore deposits, replacing apatite.

Association: Pyrophyllite, kyanite, andalusite, lazulite, augelite, alunite, kaolinite, quartz.

Distribution: From Hålsjöberg (Horrsjöberg), Värmland, and at the Västanå mine, near Näsum, Skåne, Sweden. In the Novodmitrievsk Pb–Zn deposit, Donets Basin, Ukraine. From Wheal Coates, St. Agnes, Cornwall, England. In France, at Chizeuil, near Chalmoux, Saône-et-Loire. From Andorinha-Cantahede, Portugal. In the Radjou iron deposit, Syria. From the Sallanlatvi carbonatite, Kola Peninsula, and in the Shakhtam deposit, not otherwise located in the Transbaikal, and at a number of less-well-defined localities in Russia. In the USA, in the Dover andalusite mine, about 20 km northeast of Hawthorne, Mineral Co., Nevada; at Ogilby, Imperial Co., and at the Champion mine, White Mountains, Mono Co., California; from Summitville, Rio Grande Co., and several other minor occurrences in Colorado; at Tyrone, Grant Co., New Mexico. In the Rio São Jose, near Paraguaçu, Bahia, Brazil. From La Granja, Peru. At La Escondida, about 150 km south-southeast of Antofagasta, Chile. Additional occurrences have been reported, but require modern confirmation or better location.

Name: Honoring Lars Fredrik Svanberg (1805–1878), Swedish chemist, Professor of Mineralogy, University of Uppsala, Uppsala, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1005–1006. (2) Wise, W.S. (1975) Solid solution between the alunite, woodhouseite, and crandallite mineral series. Neues Jahrb. Mineral., Monatsh., 540–545. (3) Kato, T. and Y. Miúra (1977) The crystal structures of jarosite and svanbergite. Mineral. J. (Japan), 8, 419–430. (4) Stoffregen, R.E. and C.N. Alpers (1987) Woodhouseite and svanbergite in hydrothermal ore deposits: products of apatite destruction during advanced argillic alteration. Can. Mineral., 25, 201–211.

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Sveinbergeite $Ca(Fe_6^{2+}Fe^{3+})Ti_2(Si_4O_{12})_2O_2(OH)_5(H_2O)_4$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. Crystals lamellar, to 10 mm, in rosette-like divergent groups and spherical aggregates, also as scaly, radiating masses.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Uneven. *Tenacity*: Flexible. Hardness = 3 D(meas.) = n.d. D(calc.) = 3.152

Optical Properties: Transparent. *Color*: Dark green. *Streak*: Pale green.
Luster: Vitreous to pearly.
Optical Class: Biaxial (+). α = 1.745(2) β = 1.746(2) γ = 1.753(2) 2V(meas.) = 20(3)° 2V(calc.) = 41.5° *Orientation*: $X \wedge (001)$, $Y \wedge b = 12°$, $Z = a$. *Pleochroism*: Medium, Z = deep green, $X = Y$ = brownish green. *Absorption*: $Z > X \sim Y$.

Cell Data: *Space Group: P*$\bar{1}$. a = 5.329(4) b = 11.803(8) c = 11.822(8) α = 101.140(8)° β = 98.224(8)° γ = 102.442(8)° Z = 1

X-ray Powder Pattern: Buer syenite pegmatite, Larvik plutonic complex, Oslo Region, Norway. 11.395 (100), 2.880 (38), 2.640 (31), 1.643 (24), 2.492 (20), 1.616 (15), 1.573 (14)

Chemistry:

	(1)	(2)		(1)	(2)
Nb_2O_5	0.55		CaO	3.87	4.23
TiO_2	10.76	12.06	MgO	0.52	
ZrO_2	0.48		K_2O	0.49	
SiO_2	34.41	36.29	Na_2O	0.27	
Al_2O_3	0.34		F	0.24	
Fe_2O_3	5.57	6.03	H_2O	[8.05]	8.84
FeO	29.39	32.54	-O=F	0.10	.
MnO	1.27		Total	96.11	100.00

(1) Buer syenite pegmatite, Larvik plutonic complex, Oslo Region, Norway; electron microprobe analysis, Fe^{2+}/Fe^{3+} ratio calculated from structure refinement and Mössbauer spectroscopic data, H_2O calculated from structure analysis and OH confirmed by IR, corresponding to $(Ca_{0.95}Na_{0.12}K_{0.14})_{\Sigma=1.21}Fe^{2+}_{5.65}Fe^{3+}_{0.93}Mn_{0.25}Mg_{0.18})_{\Sigma=7.01}(Ti_{1.86}Nb_{0.06}Zr_{0.05}Fe^{3+}_{0.03})_{\Sigma=2}(Si_{7.91}Al_{0.09})_{\Sigma=8}O_{34.61}H_{12.34}F_{0.17}$. (2) $Ca(Fe_6^{2+}Fe^{3+})Ti_2(Si_4O_{12})_2O_2(OH)_5(H_2O)_4$.

Mineral Group: Astrophyllite group.

Occurrence: A late forming mineral in cavities in syenite pegmatite in an alkaline plutonic complex.

Association: Microcline, magnesiokatophorite, aenigmatite, aegirine, albite, calcite, fluorapatite, molybdenite, galena, a hochelagaite-like mineral.

Distribution: Buer syenite pegmatite, Larvik plutonic complex, Vesterøya peninsula, Sandefjord, Oslo Region, Norway.

Name: Honors Svein Arne Berge (b. 1949), the Norwegian amateur mineralogist who observed and collected the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Science, Moscow, Russia (3966) and the Natural History Museum, Section of Geology, University of Oslo, Norway (42259 and 42260).

References: (1) Khomyakov, A.P., F. Cámara, E. Sokolova, Y. Abdu, and F.C. Hawthorne (2011) Sveinbergeite, $Ca(Fe_6^{2+}Fe^{3+})Ti_2(Si_4O_{12})_2O_2(OH)_5(H_2O)_4$, a new astrophyllite-group mineral from the Larvik Plutonic Complex, Oslo Region, Norway: Description and crystal structure. Mineralogical Magazine, 75, 2687-2702. (2) (2014) Amer. Mineral., 99, 873-874 (abs. ref. 1).

Sveite **$KAl_7(NO_3)_4Cl_2(OH)_{16}\cdot 8H_2O$**

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Crystal Data: Monoclinic (probable). *Point Group:* n.d. As lumpy aggregates of contorted submicroscopic flakes.

Physical Properties: *Cleavage:* Probably on {001}, perfect. Hardness = ∼1 D(meas.) = 2.0 D(calc.) = 2.185 Gelatinous when moist; highly hygroscopic, forming a residue of $Al(OH)_3$.

Optical Properties: Translucent. *Color:* White; colorless in transmitted light. *Optical Class:* Biaxial (+). $\alpha = 1.503(2)$ β = n.d. $\gamma = 1.535(2)$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. $a = 10.89$ $b = 13.04$ $c = 30.71$ $\beta = 92.10°$ Z = 6

X-ray Powder Pattern: Autana Cave, Venezuela.
10.20 (100), 2.443 (55), 3.692 (40), 5.995 (35), 6.174 (20), 4.209 (20), 2.752 (20)

Chemistry:

	(1)	(2)
SO_3	2.65	
P_2O_5	0.17	
N_2O_5	18.26	22.43
Al_2O_3	37.12	37.05
K_2O	5.18	4.89
$(NH_4)_2O$	< 0.02	
Cl	8.50	7.36
H_2O	29.25	29.93
$-O = Cl_2$	1.92	1.66
C	< 0.30	
insol.	0.10	
Total	99.31	100.00

(1) Autana Cave, Venezuela; K_2O by flame photometry, $(NH_4)_2O$ by distillation, and C, H, N, S by gas chromatography, insoluble is quartz; corresponds to $K_{1.07}Al_{7.07}(NO_3)_{3.28}(SO_4)_{0.32}(PO_4)_{0.02}Cl_{2.32}(OH)_{15.96}\cdot 7.77H_2O$. (2) $KAl_7(NO_3)_4Cl_2(OH)_{16}\cdot 8H_2O$.

Occurrence: As crusts and efflorescences precipitated from solutions trickling onto cave roofs and walls.

Association: Quartz.

Distribution: From the Autana Cave, Amazonas Territory, Venezuela. On a rock overhang at an unspecified locality in the northeastern San Joaquin Valley, California, USA.

Name: From the first letters of the Sociedad Venezolana de Espeleología, whose members collected the original material studied.

Type Material: University of Central Venezuela, Caracas, Venezuela; The Natural History Museum, London, England, 1985,348; National Museum of Natural History, Washington, D.C., USA, 162532.

References: (1) Martini, J.E.J. (1980) Sveite, a new mineral from Autana Cave, Territorio Federal Amazonas, Venezuela. Trans. Geol. Soc. S. Afr., 83, 239–241. (2) (1982) Amer. Mineral., 67, 1076 (abs. ref. 1). (3) Graham, R.C., J.O. Ervin, and W.M. Graham (1988) The occurrence and properties of sveite in the northeastern San Joaquin Valley, California. Program and Abstracts, Annual Clay Minerals Conference, 25, 50.

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Sverigeite $NaMn^{2+}MgSn^{4+}Be_2Si_3O_{12}(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In well-formed complex crystals, to 2 mm, elongated ‖ [001]; as irregular platy segregations.

Physical Properties: *Cleavage:* {010}, perfect; two other directions, distinct. Hardness = ∼6.5 D(meas.) = 3.60 D(calc.) = 3.61

Optical Properties: Translucent. *Color:* Yellow; in transmitted light, pale yellow to yellow. *Streak:* Light yellow. *Luster:* Vitreous on cleavages and fractures, dull on crystal faces. *Optical Class:* Biaxial (+). *Pleochroism:* Moderate; X = yellow; $Y \simeq Z$ = pale yellow. *Orientation:* $Z = b$. *Dispersion:* $r > v$, strong. *Absorption:* $X > Y \simeq Z$. $\alpha = 1.678(4)$ $\beta = 1.684(4)$ $\gamma = 1.699(4)$ 2V(meas.) = 67(4)°

Cell Data: *Space Group: Imma.* $a = 10.815(8)$ $b = 13.273(8)$ $c = 6.818(6)$ Z = 4

X-ray Powder Pattern: Långban mine, Sweden.
2.884 (100), 2.826 (90), 5.77 (70), 4.35 (70), 2.98 (60), 2.644 (60), 6.63 (50)

Chemistry:

	(1)
SiO_2	33.5
SnO_2	28.5
FeO	0.3
MnO	11.8
ZnO	1.2
BeO	9.7
MgO	8.1
Na_2O	6.1
H_2O	1.2
Total	100.4

(1) Långban mine, Sweden; by electron microprobe; Be by AA, H_2O by the Penfield method; corresponds to $Na_{1.04}(Mg_{1.06}Mn^{2+}_{0.88}Zn_{0.08}Fe^{2+}_{0.02})_{\Sigma=2.04}Sn_{1.00}Be_{2.06}Si_{2.96}O_{12.19}H_{0.71}$.

Occurrence: Found on a mine dump; possibly part of a vein assemblage.

Association: Mimetite, jacobsite, manganoan calcite, amphibole.

Distribution: From Långban, Värmland, Sweden.

Name: For the country where the mineral was found, Sweden, *Sverige* in Swedish.

Type Material: National Museum of Natural History, Washington, D.C., USA, 160023, 160341.

References: (1) Dunn, P.J., D.R. Peacor, W.B. Simmons, and R.V. Gaines (1984) Sverigeite, a new tin beryllium silicate mineral from Långban, Värmland, Sweden. Geol. Fören. Förhandl. Stockholm, 106, 175–177. (2) (1985) Amer. Mineral., 70, 1332 (abs. ref. 1). (3) Rouse, R.C., D.R. Peacor, and G.W. Metz (1989) Sverigeite, a structure containing planar NaO_4 groups and chains of 3- and 4-membered beryllosilicate rings. Amer. Mineral., 74, 1343–1350.

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Svyatoslavite $CaAl_2Si_2O_8$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic ‖ [100], with {011}, {100}, and {110}, to 0.8 mm.

Physical Properties: *Cleavage:* Poor on {100}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼6 D(meas.) = 2.695(5) D(calc.) = 2.687 Fluoresces weak yellowish in SW UV.

Optical Properties: Semitransparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.552(2)$ $\beta = 1.578(2)$ $\gamma = 1.581(2)$ 2V(meas.) = n.d. 2V(calc.) = 37.08°

Cell Data: *Space Group:* $P2_12_12$. $a = 8.232(5)$ $b = 8.606(10)$ $c = 4.852(5)$ Z = 2

X-ray Powder Pattern: Kopeysk, Russia.
3.22 (100), 4.16 (80), 2.09 (80), 2.71 (70), 1.967 (70), 1.670 (70), 3.75 (60)

Chemistry:

	(1)
SiO_2	43.62
Al_2O_3	35.37
FeO	0.02
MnO	0.00
MgO	0.03
CaO	19.33
Na_2O	0.41
K_2O	0.01
Total	98.79

(1) Kopeysk, Russia; by electron microprobe, average of two analyses; corresponds to $(Ca_{0.96}Na_{0.04})_{\Sigma=1.00}Al_{1.95}Si_{2.04}O_8$.

Polymorphism & Series: Trimorphous with anorthite and dmisteinbergite.

Mineral Group: Feldspar group.

Occurrence: In burning dumps, as a sublimate on fracture walls in coal, formed at about 700 °C–900 °C.

Association: Anorthite, troilite, cohenite, fayalite, titanite, graphite.

Distribution: From Kopeysk, Chelyabinsk coal basin, Southern Ural Mountains, Russia.

Name: For Svyatoslav Nestorovich Ivanov (1911–), Soviet geologist, Ural Scientific Center, Yekaterinburg (Sverdlovsk), Russia.

Type Material: Il'menskii Preserve Museum, Miass, 16243vr; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Chesnokov, B.V., E.V. Lotova, V.S. Pavlyuchenko, L.V. Usova, A.F. Bushmakin, and T.P. Nishanbayev (1989) Svyatoslavite $CaAl_2Si_2O_8$ (orthorhombic) – a new mineral. Zap. Vses. Mineral. Obshch., 118(2), 111–114 (in Russian). (2) (1991) Amer. Mineral., 76, 300–301 (abs. ref. 1).

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Svyazhinite $(Mg, Mn^{2+})(Al, Fe^{3+})(SO_4)_2F \cdot 14H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As tabular crystals, elongated along $\{0\overline{1}4\}$, with wedgelike terminations, to 0.5 mm, showing dominant forms $\{0\overline{1}4\}$, $\{4\overline{1}0\}$, {110}, {210}, six other forms; forms nodular aggregates, which may be hollow. *Twinning:* On $\{0\overline{1}4\}$.

Physical Properties: *Cleavage:* {010}. Hardness = 2 D(meas.) = 1.67 D(calc.) = 1.69 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Yellow; colorless in transmitted light.
Luster: Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y \wedge c \simeq 40°$; $Z \wedge a \simeq 25°$. $\alpha = 1.423(2)$ $\beta = 1.439(2)$ $\gamma = 1.444(2)$ 2V(meas.) = Small. 2V(calc.) = 57°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 6.217$ $b = 13.306$ $c = 6.255$ $\alpha = 90.09°$ $\beta = 93.50°$ $\gamma = 82.05°$ Z = 1

X-ray Powder Pattern: Ilmen Mountains, Russia.
4.91 (10), 5.68 (7), 4.40 (5), 4.15 (5), 2.824 (5), 2.84 (4.5), 3.39 (4)

Chemistry:

	(1)
SO_3	29.37
Al_2O_3	8.65
Fe_2O_3	1.90
MnO	3.07
MgO	4.18
CaO	0.38
F	3.42
Cl	0.17
H_2O	49.40
$-O = (F, Cl)_2$	1.48
Total	99.06

(1) Ilmen Mountains, Russia; by laser microprobe, corresponds to $(Mg_{0.57}Mn_{0.24}Ca_{0.04})_{\Sigma=0.85}(Al_{0.93}Fe_{0.13})_{\Sigma=1.06}(SO_4)_{2.00}(F_{0.98}Cl_{0.03})_{\Sigma=1.01} \cdot 14.96H_2O$.

Occurrence: A weathering product in fractures cutting pyrite–fluorite-bearing pyroxene–amphibole fenites.

Association: Gypsum, pickeringite, melanterite, copiapite, epsomite, jarosite, pyrite, fluorite.

Distribution: From near Miass, Ilmen Mountains, Southern Ural Mountains, Russia.

Name: Honors Nikolai Vasil'evich Svyazhin (1927–1967), Russian mineralogist, Ural Mining Institute, Sverdlovsk, Russia.

Type Material: Sverdlovsk Mining Institute, Sverdlovsk; Il'menskii Preserve Museum, Miass, iz4524; Mining Institute, St. Petersburg, 1509/1; Vernadsky Geological Museum, Moscow, 53493; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82772.

References: (1) Chesnokov, B.V., L.F. Bazhenova, I.E. Kamentsev, V.O. Polyakov, and A.F. Bushmakin (1984) Svyazhinite, $(Mg, Mn, Ca)(Al, Fe^{3+})(SO_4)_2F \cdot 14H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 113, 347–351 (in Russian). (2) (1985) Amer. Mineral., 70, 877 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 199.

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Swaknoite $(NH_4)_2Ca(PO_3OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystals are needlelike, elongate along [001], with {110}, {100}, {111}, {001}, to 1 mm, in rosettes; as coatings.

Physical Properties: *Tenacity:* Brittle. Hardness = Soft. D(meas.) = 1.91 D(calc.) = 1.89 Soluble on H_2O.

Optical Properties: Semitransparent. *Color:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.506$ $\beta = 1.510$ $\gamma = 1.512$ 2V(meas.) = 65(10)° 2V(calc.) = 70°

Cell Data: *Space Group:* n.d. $a = 20.959$ $b = 7.403$ $c = 6.478$ Z = 4

X-ray Powder Pattern: Arnhem Cave, Namibia.
6.99 (100), 3.705 (89), 10.5 (57), 3.177 (55), 3.651 (39), 4.739 (36), 5.24 (21)

Chemistry:

	(1)	(2)
P_2O_5	48.93	49.61
CaO	21.46	19.60
$(NH_4)_2O$	16.06	18.20
H_2O	12.78	12.59
Total	99.23	100.00

(1) Arnhem Cave, Namibia; by electron microprobe, NH_4 and H_2O by CHN analyzer; corresponds to $(NH_4)_{1.78}Ca_{1.10}(PO_3OH)_{1.99} \cdot 1.05H_2O$. (2) $(NH_4)_2Ca(PO_3OH)_2 \cdot H_2O$.

Polymorphism & Series: Dimorphous with mundrabillaite.

Occurrence: Formed from bat guano and urine by reaction with cave walls.

Association: Mundrabillaite, dittmarite, arcanite, dolomite.

Distribution: Found in Arnhem Cave, 150 km east of Windhoek, Namibia.

Name: From Suid Wes Africa Karst Navorsing Organisasie (SWAKNO), a speleological exploration organization, the members of which noted the species.

Type Material: State Museum, Windhoek, Namibia; Transvaal Museum, Pretoria, South Africa.

References: (1) Martini, J.E.J. (1991) Swaknoite [$Ca(NH_4)_2 \cdot (HPO_4)_2 \cdot H_2O$, orthorhombic]: a new mineral from Arnhem cave, Namibia. Bull. South African Speleological Assoc., 32, 72–74. (2) (1993) Amer. Mineral., 78, 1110 (abs. ref. 1).

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Swamboite $U^{6+}H_6(UO_2)_6(SiO_4)_6 \cdot 30H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals elongated ‖ [010], to ~1 mm, showing {001} and $\{\bar{2}01\}$; in nodular fibrous aggregates.

Physical Properties: *Cleavage:* $\{\bar{2}01\}$, good. Hardness = n.d. D(meas.) = 4.0 D(calc.) = 4.064 Radioactive.

Optical Properties: Transparent. *Color:* Deep to very pale yellow; in transmitted light, colorless to yellow.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = light yellow. *Orientation:* $X \simeq a$; $Y \simeq b$; $Z \wedge c = 13°$. *Dispersion:* $r > v$, strong. $\alpha = 1.640$ $\beta = 1.661$ $\gamma = 1.663$ 2V(meas.) = 30° 2V(calc.) = 34°

Cell Data: *Space Group:* $P2_1/a$. $a = 17.64(3)$ $b = 21.00(5)$ $c = 20.12(4)$ $\beta = 103.4(2)°$ Z = 18

X-ray Powder Pattern: Swambo, Congo.
8.67 (100), 4.75 (80), 4.32 (80), 3.51 (60), 2.979 (60b), 5.85 (50), 4.49 (50)

Chemistry:

	(1)	(2)
SiO_2	12.73	13.42
UO_3	67.43	74.51
H_2O^+	19.93	12.07
Total	100.09	100.00

(1) Swambo, Congo; by electron microprobe, average of six analyses, H_2O by TGA.
(2) $UH_6(UO_2)_6(SiO_4)_6 \cdot 30H_2O$.

Occurrence: A secondary mineral formed during the weathering of uranium deposits.

Association: Soddyite, gypsum, curite (Swambo, Congo).

Distribution: From the uranium deposit of Swambo, about 36 km west of Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In the USA, at the Jomac mine, White Canyon district, San Juan Co., Utah.

Name: For the occurrence at Swambo, Congo (Zaire).

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM13690.

References: (1) Deliens, M. and P. Piret (1981) La swamboïte, nouveau silicate d'uranium hydraté du Shaba, Zaïre. Can. Mineral., 19, 553–557 (in French with English abs.). (2) (1983) Amer. Mineral., 68, 1250 (abs. ref. 1).

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Swartzite $CaMg(UO_2)(CO_3)_3 \cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to about 0.3 mm, prismatic along [001], in efflorescent crusts.

Physical Properties: Hardness = n.d. D(meas.) = 2.3 D(calc.) = 2.32 Radioactive; soluble in H_2O; fluoresces bright yellow-green under SW UV.

Optical Properties: Transparent. *Color:* Green; turns dull pale yellow on dehydration. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = yellow. *Dispersion:* $r > v$. $\alpha = 1.465$ $\beta = 1.51$ $\gamma = 1.540$ 2V(meas.) = n.d. 2V(calc.) = 40°

Cell Data: *Space Group:* $P2_1/m$ (synthetic). $a = 11.080(2)$ $b = 14.634(2)$ $c = 6.439(1)$ $\beta = 99.43(1)°$ Z = 2

X-ray Powder Pattern: Hillside mine, Arizona, USA.
8.76 (10), 5.50 (10), 7.31 (9), 4.82 (8), 2.91 (8), 2.06 (8), 1.707 (8)

Chemistry:

	(1)	(2)
UO_3	38.85	39.15
CO_2	17.92	18.07
MgO	5.47	5.52
CaO	7.32	7.67
Na_2O	0.26	
K_2O	0.49	
H_2O	29.69	29.59
Total	[100.00]	100.00

(1) Hillside mine, Arizona, USA; recalculated to 100% after deduction of gypsum 4.38% and insoluble 0.30%. (2) $CaMg(UO_2)(CO_3)_3 \cdot 12H_2O$.

Occurrence: A secondary mineral in oxidized portions of a polymetallic sulfide deposit, the source of uranium undetermined.

Association: Gypsum, schröckingerite, andersonite, bayleyite (Hillside mine, Arizona, USA).

Distribution: In the USA, from the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co., Arizona; in Colorado, in the Rifle mine, Garfield Co., and the Schwartzwalder mine, Jefferson Co.; at the Coral prospect, Elk Ridge, San Juan Co., Utah.

Name: Honors Charles K. Swartz (1861–1949), Professor of Geology and Mineralogy, Johns Hopkins University, Baltimore, Maryland, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 106107, 106108.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 238–239. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Survey Bull. 1064, 117–119. (3) Mereiter, K. (1986) Synthetic swartzite, $CaMg[UO_2(CO_3)_3] \cdot 12H_2O$, and its strontium analogue, $SrMg[UO_2(CO_3)_3] \cdot 12H_2O$: crystallography and crystal structure. Neues Jahrb. Mineral., Monatsh., 481–492.

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Swedenborgite $NaBe_4SbO_7$

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Crystal Data: Hexagonal. *Point Group:* $6mm$. Short prismatic crystals, $\{10\bar{1}0\}$, $\{10\bar{1}1\}$, and {0001} prominent, to 8 mm, may be morphologically hemihedral. *Twinning:* Observed.

Physical Properties: *Cleavage:* {0001}, distinct. *Fracture:* Subconchoidal. Hardness = ∼8 D(meas.) = 4.285 D(calc.) = 4.28

Optical Properties: Transparent. *Color:* Colorless, pale wine-yellow to honey-yellow; colorless in transmitted light.
Optical Class: Uniaxial (–). *Dispersion:* Strong. $\omega = 1.7724$ $\epsilon = 1.7700$

Cell Data: *Space Group:* $P6_3mc$. $a = 5.442$ $c = 8.848$ $Z = 2$

X-ray Powder Pattern: Långban, Sweden.
4.20 (10), 2.72 (9), 2.51 (9), 2.32 (9), 3.22 (8), 4.70 (7), 4.40 (7)

Chemistry:

	(1)	(2)
Sb_2O_5	54.17	55.25
BeO	34.72	34.17
MgO	0.52	
CaO	0.94	
Na_2O	8.50	10.58
K_2O	0.21	
H_2O	0.39	
P_2O_5	0.23	
Total	99.68	100.00

(1) Långban, Sweden; average of three partial analyses. (2) $NaBe_4SbO_7$.

Occurrence: In skarn from a metamorphosed Fe–Mn orebody.

Association: Bromellite, richterite, manganoan biotite, calcite, hematite.

Distribution: From Långban, Värmland, Sweden.

Name: Honors Emanuel Swedenborg (1688–1772), Swedish philosopher and theologian.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; The Natural History Museum, London, England, 1924,560.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1027–1029. (2) Pauling, L., H.P. Klug, and A.N. Winchell (1935) The crystal structure of swedenborgite, $NaBe_4SbO_7$. Amer. Mineral., 20, 492–501. (3) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Sweetite $Zn(OH)_2$

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Crystal Data: Tetragonal. *Point Group:* 422. Dipyramidal crystals, to 1 mm, showing possible {112}; rare {001}, may be tabular.

Physical Properties: Hardness = n.d. D(meas.) = ∼3.33 D(calc.) = 3.41

Optical Properties: Translucent to transparent. *Color:* Colorless to whitish.
Optical Class: Uniaxial (–). $\omega = 1.635$ $\epsilon = 1.628$

Cell Data: *Space Group:* $P4_12_12$ or $P4_32_12$ (probable). $a = 8.222(5)$ $c = 14.34(1)$
Z = 20

X-ray Powder Pattern: Near Ashover, England.
2.922 (100), 3.572 (60), 4.53 (37), 1.764 (24), 2.708 (18), 2.257 (17), 1.560 (14)

Chemistry:

	(1)	(2)	(3)
ZnO	84.3	87.33	81.88
PbO		0.35	
CdO		0.11	
CaO		0.29	
H_2O	17.0	[17.0]	18.12
Total	101.3	[105.08]	100.00

(1) Near Ashover, England; by AA, H_2O by CHN analyzer; high total thought due to ZnO in the core of the analyzed crystal. (2) Do.; by electron microprobe, H_2O from (1), high total thought due to dehydration in the electron beam; corresponds to $Zn_{1.26}Ca_{0.01}[O_{0.55}(OH)_{1.45}]_{\Sigma=2.00}$. (3) $Zn(OH)_2$.

Polymorphism & Series: Trimorphous with ashoverite and wülfingite.

Occurrence: In an oxidized vein in limestone.

Association: Galena, ashoverite, wülfingite, anglesite, cerussite, hydrocerussite, litharge, fluorite, palygorskite, calcite.

Distribution: From a limestone quarry 200–300 m northwest of Milltown, near Ashover, Derbyshire, England.

Name: To honor Jessie May Sweet (1901–1979), Curator of the mineral collections of the British Museum (Natural History), London, England.

Type Material: The Natural History Museum, London, England, 1982,4.

References: (1) Clark, A.M., E.E. Fejer, A.G. Couper, and G.C. Jones (1984) Sweetite, a new mineral from Derbyshire. Mineral. Mag., 48, 267–269. (2) (1985) Amer. Mineral., 70, 438 (abs. ref. 1). (3) Clark, A.M., E.E. Fejer, G. Cressey, and P.C. Tandy (1988) Ashoverite, a new mineral, and other polymorphs of $Zn(OH)_2$ from Milltown, Ashover, Derbyshire. Mineral. Mag., 52, 699–702.

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Swinefordite $\mathbf{Li_{0.5}(Al,Li,Mg)_2(Si,Al)_4O_{10}(OH,F)_2 \cdot nH_2O}$

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Crystal Data: Monoclinic. *Point Group:* n.d. Resembles petroleum jelly when hydrated; on dehydration, becomes fibrous, in thin ribbons, folded and twisted, and in curled sheets.

Physical Properties: *Tenacity:* Tough; greasy when hydrated. Hardness = ∼1 D(meas.) = n.d. D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* Greenish yellow to light olive when hydrated; light greenish gray to grayish olive after dehydration. *Streak:* White. *Luster:* Glistening when hydrated; dull when partially dehydrated.
Optical Class: Biaxial (–). *Pleochroism:* Y = almost colorless; Z = pale yellow-brown. *Orientation:* $X \simeq c$; $Y = a$. α = [1.492] β = 1.524(2) γ = 1.526(2) 2V(meas.) = 29°–45° 2V(calc.) = 37°

Cell Data: *Space Group:* $C2/m$. a = 5.2 b = 9.0 c = 13.0 β = n.d. Z = n.d.

X-ray Powder Pattern: Kings Mountain, North Carolina, USA; partly hydrated. (ICDD 29-809).
12.96 (vvs), 4.53 (vs), 1.508 (vs), 3.09 (s), 2.62 (m), 1.713 (m), 1.304 (m)

Chemistry:

	(1)
SiO_2	54.1
Al_2O_3	13.1
Fe_2O_3	1.9
MgO	6.8
CaO	0.8
Li_2O	4.7
Na_2O	0.63
H_2O	15.6
F	1.49
$-O = F_2$	[0.63]
Total	[98.49]

(1) Kings Mountain, North Carolina, USA; original total given as 99.12%, corresponding to $(Li_{0.38}Na_{0.08}Ca_{0.06}Mg_{0.02})_{\Sigma=0.54}(Li_{0.93}Al_{0.80}Mg_{0.68}Fe^{3+}_{0.10})_{\Sigma=2.51}(Si_{3.74}Al_{0.26})_{\Sigma=4.00}O_{10}[(OH)_{1.68}F_{0.32}]_{\Sigma=2.00} \cdot 2H_2O$.

Mineral Group: Smectite group.

Occurrence: Deposited from ground water, as coatings on the walls of fracture zones and fissures, or replacing spodumene, in a Li-Sn-rich pegmatite.

Association: Spodumene, switzerite, vivianite, quartz, albite, apatite.

Distribution: From the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA.

Name: For Dr. Ada Swineford (1917–1993), clay mineralogist and Professor of Geology at Western Washington State College, Bellingham, Washington, USA.

Type Material: National School of Mines, Paris, France; Department of Geology, East Carolina University, Greenville, North Carolina; University of Delaware, Newark, Delaware; Harvard University, Cambridge, Massachusetts, 125477; National Museum of Natural History, Washington, D.C., USA, 126826, 131848, 144722.

References: (1) Tien, P.-L., P.B. Leavens, and J.A. Nelen (1975) Swinefordite, a dioctahedral-trioctahedral Li-rich member of the smectite group from Kings Mountain, North Carolina. Amer. Mineral., 60, 540–547.

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Switzerite $\mathbf{(Mn^{2+},Fe^{2+})_3(PO_4)_2 \cdot 7H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Thin crystals, tabular on {001}, or bladed by elongation along [100], to 5 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle, somewhat flexible. Hardness = Soft. D(meas.) = 2.535 D(calc.) = 2.562 Rapidly and irreversibly topotactically transforms in air to metaswitzerite.

Optical Properties: Transparent to translucent. *Color:* Pink, becoming yellowish or brownish on dehydration. *Luster:* Vitreous, pearly on {001}.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \perp \{001\}$. $\alpha = 1.560(1)$ $\beta = 1.574(1)$ $\gamma = 1.580(1)$ 2V(meas.) = 70° 2V(calc.) = 66°

Cell Data: *Space Group:* $P2_1/a$. $a = 8.528(4)$ $b = 13.166(5)$ $c = 11.812(4)$ $\beta = 110.05(3)°$ Z = 4

X-ray Powder Pattern: Foote mine, North Carolina, USA.
11.12 (100), 3.37 (90), 8.47 (50), 2.137 (50), 2.353 (40), 2.94 (30), 1.612 (30)

Chemistry:

	(1)
P_2O_5	32.94
SiO_2	0.06
Al_2O_3	0.27
FeO	3.60
MnO	46.05
MgO	0.15
CaO	0.20
H_2O	n.d.
Total	83.27

(1) Foote mine, North Carolina, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; due to loss of H_2O in electron beam, all elements are high, H_2O in formula from crystal-structure analysis; corresponds to $(Mn_{2.79}Fe_{0.21})_{\Sigma=3.00}(PO_4)_2 \cdot 7H_2O$.

Occurrence: In complex zoned granite pegmatites.

Association: Metaswitzerite, vivianite (Foote mine, North Carolina, USA) huréaulite (Tip Top mine, South Dakota, USA); triplite, bermanite, phosphosiderite, leucophosphite, strengite, phosphosiderite, paulkerrite (7U7 Ranch, Arizona, USA); scholzite, parahopeite, phosphophyllite rockbridgeite; (Reaphook Hill, Australia).

Distribution: In the USA, from the Foote mine, Kings Mountain, Cleveland Co., North Carolina; at the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota; from the 7U7 Ranch, 40 km west of Hillside, Bagdad district, Yavapai Co., Arizona; in the Emmons quarry, Greenwood, and the Bell Pit, Newry, Oxford Co., Maine. From the Tanco pegmatite, Bernic Lake, Manitoba, Canada. At Hagendorf, Bavaria, Germany. In the Mangualde pegmatite, near Mesquitela, Portugal. From near Eräjärvi, Finland. At Reaphook Hill, near Blinman, Flinders Ranges, and in the Iron Monarch quarry, Iron Knob, South Australia.

Name: To honor Dr. George Shirly Switzer (1915–), Chairman Emeritus, Department of Mineral Sciences, United States National Museum, Smithsonian Institution, Washington, D.C., USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120871.

References: (1) White, J.S., Jr., P.B. Leavens, and P.F. Zanazzi (1986) Switzerite redefined as $Mn_3(PO_4)_2 \cdot 7H_2O$, and metaswitzerite, $Mn_3(PO_4)_2 \cdot 4H_2O$. Amer. Mineral., 71, 1221–1223.
(2) Zanazzi, P.F., P.B. Leavens, and J.S. White, Jr. (1986) Crystal structure of switzerite, $Mn_3(PO_4)_2 \cdot 7H_2O$, and its relationship to metaswitzerite, $Mn_3(PO_4)_2 \cdot 4H_2O$. Amer. Mineral., 71, 1224–1228.

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Sylvanite $(Au, Ag)_2Te_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 1 cm, short prismatic [001] or [010], thick tabular on {100} and {010}; may be skeletal, bladed, imperfectly columnar, granular. *Twinning:* Common on {100} as contact, lamellar, or penetration twins, resembling cuneiform characters.

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 1.5–2 VHN = 154–172 (100 g load). D(meas.) = 8.16 D(calc.) = 8.161

Optical Properties: Opaque. *Color:* Steel-gray to silver-white inclining to yellow; in polished section, creamy white. *Streak:* Steel-gray to silver-white. *Luster:* Metallic, brilliant. *Pleochroism:* Strong; cream-white to leather-brown. *Anisotropism:* Very strong; in grayish brown, grayish white, and yellowish and bluish tints.

R_1–R_2: (400) 43.2–53.6, (420) 45.4–55.9, (440) 47.7–57.9, (460) 49.7–59.6, (480) 50.9–60.8, (500) 51.8–61.8, (520) 52.3–62.6, (540) 52.5–62.9, (560) 52.5–63.0, (580) 52.5–63.0, (600) 52.6–62.9, (620) 52.8–62.7, (640) 53.0–62.4, (660) 53.3–62.2, (680) 53.6–62.2, (700) 54.1–62.4

Cell Data: *Space Group:* $P2/c$. $a = 8.95(1)$ $b = 4.478(5)$ $c = 14.62(2)$ $\beta = 145.35(5)^\circ$ Z = 2

X-ray Powder Pattern: Fiji Islands.
3.05 (100), 2.15 (50), 2.25 (30), 1.989 (30), 2.98 (20), 1.797 (20), 1.523 (20)

Chemistry:

	(1)	(2)	(3)
Au	25.45	29.85	24.19
Ag	13.94	9.18	13.22
Cu		0.15	

	(1)	(2)	(3)
Ni		0.10	
Te	60.61	60.45	62.59
Total	100.00	99.73	100.00

(1) Cripple Creek, Colorado, USA. (2) Kalgoorlie, Australia. (3) $(Au, Ag)_2Te_4$ with Au:Ag = 1:1.

Occurrence: Most commonly in low-temperature hydrothermal veins; also in medium- and high-temperature deposits, typically among the last minerals formed.

Association: Gold, calaverite, krennerite, altaite, hessite, petzite, acanthite, pyrite, galena, sphalerite, chalcopyrite, quartz, "chalcedony", fluorite.

Distribution: A mineral present in minor amounts in many Au–Ag deposits, but only rarely in rich specimens or of economic importance. In Romania, from Baia-de-Arieş (Offenbánya) [TL], Săcărîmb (Nagyág) [TL], and Facebánya. At Glava, Värmland, Sweden. In the Bereznyakov gold deposit and the Yaman-Kasy Cu–Zn–pyrite deposits, Southern Ural Mountains, Russia. In Canada, from the Dome mine, Porcupine, Ontario. In the USA, in California, at the Melones and Stanislaus mines, Carson Hill district, Calaveras Co.; in Colorado, in abundance at Cripple Creek, Teller Co., and important in the Magnolia, Gold Hill, and Sunshine districts, Boulder Co., and elsewhere; in the Cornucopia district, Baker Co., Oregon; from the Mayflower mine, Tobacco Root Mountains, Madison Co., and the at Gies mine, Judith Mountains, Fergus Co., Montana. From the San Francisco mine, 145 km north of Hermosillo, Sonora, Mexico. At the El Indio mine, east of La Serena, Coquimbo, Chile. From Kalgoorlie, Western Australia. In the Bulawan deposit, Negros Occidental, Phillipines. At the Arakara goldfields, Guyana. From the Emperor mine, Vatukoulu, and in the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands.

Name: From TranSYLVANia, Romania where it was first found, and in allusion to the element tellurium (*sylvanium*, a name early proposed for the element), which the mineral contains.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 338–341. (2) Van Tendeloo, G., P. Gregoriades, and S. Amelinckx (1983) Electron microscopic studies of modulated structures in $(Au, Ag)Te_2$: Part II. Sylvanite $AgAuTe_2$. J. Solid State Chem., 50, 335–361. (3) Pertlik, F. (1984) Kristallchemie natürlicher Telluride. I: Verfeinerung der Kristallstruktur des Sylvanites, $AuAgTe_4$. Tschermaks Mineral. Petrog. Mitt., 33, 203–212 (in German with English abs.). (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 148. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 424–426. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 547.

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Sylvite **KCl**

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As cubes, cubo-octahedra, and octahedra, to 15 cm; may be columnar, in crusts, coarse granular to compact, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle, ductile under low strain. Hardness = 2 D(meas.) = 1.993(5) D(calc.) = 1.987 Soluble in H_2O; salty taste, with bitter overtones.

Optical Properties: Transparent. *Color:* Colorless to white, pale gray, pale blue; yellowish red to red when included with hematite; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Isotropic; anomalously weakly anisotropic when strained. $n = 1.4903$

Cell Data: *Space Group:* $Fm3m$ (synthetic). $a = 6.2931$ $Z = 4$

X-ray Powder Pattern: Synthetic.
3.146 (100), 2.224 (59), 1.816 (23), 1.407 (20), 1.284 (13), 1.573 (8), 1.0490 (6)

Chemistry: Typically nearly pure KCl.

Occurrence: In sedimentary basins, forming thick bedded deposits with halite; as a sublimate in volcanic fumaroles; in nitrate beds and cave deposits; a product of burning coal; may be included in other minerals as a product of intermediate-grade metamorphism.

Association: Halite, kieserite, kainite, carnallite, polyhalite, gypsum, anhydrite.

Distribution: On Vesuvius, Campania, Italy. At Hallein, Salzburg, Austria. In Germany, from Westeregeln and Stassfurt, 34 km south of Magdeburg, Saxony-Anhalt, and at Bernburg, Lower Saxony. At Aislaby, near Whitby, Yorkshire, England. From Kalusz, Ukraine. In the Verkhnekamsk sylvite deposit, Solikamsk-Berezniki region, Ural Mountains, Russia. In the USA, in the Permian salt basin of southeastern New Mexico, in the Carlsbad potash district, Eddy Co. with large crystals in the Potash Corporation of America mine, and adjacent parts of Texas. From the Smoky Hills, Peace River area, Alberta, Canada. Other minor localities are known.

Name: From the alchemical *Sal digestivus Sylvii* or *Salt of Sylvius*, the digestive salt of François Sylvius de le Boë (1614–1672), Dutch physician and chemist of Leiden, Netherlands.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 7–9. (2) (1953) NBS Circ. 539, 1, 65.

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Symesite $Pb_{10}(SO_4)O_7Cl_4(H_2O)$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As blocky crystal 'blebs', to 2 mm; as crystalline aggregates to 1 cm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Uneven.
Tenacity: n.d. Hardness = 4 D(meas.) = 7.3(2) D(calc.) = 7.23

Optical Properties: Translucent. *Color*: Pink; gray in reflected light. *Streak*: White.
Luster: Vitreous.
Orientation: n.d. *Anistropism:* Weak.
Optical Class: n.d. n = > 2
R_1-R_2: (400) 17.20-17.95, (420) 16.50-17.40, (440) 15.90-16.90, (460) 15.50-16.50, (470) 15.20-16.30, (480) 15.10-16.10, (500) 14.90-15.80, (520) 14.50-15.50, (540) 14.30-15.30, (546) 14.20-15.30, (560) 14.10-15.20, (580) 14.00-15.00, (589) 13.90-15.00, (600) 13.90-14.90, (620) 13.80-14.80, (640) 13.80-14.80, (650) 13.70-14.70, (660) 13.70-14.70, (680) 13.60-14.65, (700) 13.60-14.60

Cell Data: *Space Group*: $B\bar{1}$. a = 19.727(2) b = 8.796(1) c = 13.631(2) α = 82.21(1)° β= 78.08(1)° γ= 100.04(1)° Z = 4

X-ray Powder Pattern: Merehead Quarry, Somerset, England.
2.911 (100), 3.286 (90), 2.955 (90), 2.793 (80), 6.573 (40), 3.768 (40), 3.805 (30)

Chemistry:

	(1)	(2)
PbO	90.66	91.48
SO_3	3.15	3.28
Cl	5.83	5.81
H_2O	-	0.74
-O=Cl	1.32	1.31
Total	98.32	100.00

(1) Merehead Quarry, Somerset, England; average of 17 electron microprobe analyses, H_2O from stoichiometry, corresponding to $(Na_{0.99}Sr_{0.03}K_{0.01})_{\Sigma=1.03}Ca_{2.01}Be_{2.99}Si_{3.98}O_{13}(OH)\cdot 2H_2O$.

Occurrence: A secondary low-temperature mineral formed from metalliferous brines moving along fractures through Mn and Fe-oxide mineral deposits in limestone.

Association: Cerussite, hydrocerussite, paralaurionite, blixite, chloroxiphite, pyrolusite, coronadite, hematite, parkinsonite, mereheadite.

Distribution: Merehead Quarry, near Cranmore, Somerset, England.

Name: Honors Robert Symes (1937–) of the Department of Mineralogy, the Natural History Museum (London, England), in recognition of his many contributions to the mineralogy of the ore deposits of South-West England.

Type Material: Natural History Museum, London, England (Specimen BM1998,37).

References: (1) Welch, M.D., M.A. Cooper, F.C. Hawthorne, and A.J. Criddle (2000) Symesite, $Pb_{10}(SO_4)O_7Cl_4(H_2O)$, a new PbO-related sheet mineral: Description and crystal structure. Amer. Mineral., 85, 1526-1533.

Symplesite $Fe_3^{2+}(AsO_4)_2 \cdot 8H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals elongated along [001], may be flattened $\{1\overline{1}0\}$, to 2 cm; in fibrous, radially spherical aggregates. *Twinning:* On $\{1\overline{1}0\}$; translation gliding observed.

Physical Properties: *Cleavage:* On {110}, perfect. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 2.96–3.01 D(calc.) = 3.02

Optical Properties: Transparent, becoming translucent on oxidation. *Color:* Leek-green, pale green; dark green, greenish black to dark Indigo-blue on oxidation. *Streak:* Pale bluish. *Luster:* Vitreous to oily, pearly on cleavages.
Optical Class: Biaxial (–). *Pleochroism:* X = deep blue; Y = nearly colorless; Z = yellowish. *Orientation:* $X \perp \{1\overline{1}0\}$; $Z \wedge c = 31.5°$, increasing to 50° on oxidation. *Dispersion:* $r > v$, strong. $\alpha = 1.635(5)$ $\beta = 1.668(3)$ $\gamma = 1.702(3)$ 2V(meas.) = 86.5°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.86$–7.86 $b = 9.35$–9.41 $c = 4.72$–4.75 $\alpha = 93.7°-99.9°$ $\beta = 97.4°-98.1°$ $\gamma = 106°-106.5°$ Z = 1

X-ray Powder Pattern: Baia Sprie, Romania; very similar to metaköttigite.
6.785 (100), 7.499 (16), 8.971 (15), 4.007 (8), 3.743 (8), 5.027 (7), 4.069 (7)

Chemistry:

	(1)	(2)
As_2O_5	34.73	38.99
FeO	37.84	36.56
H_2O	[27.43]	24.45
Total	[100.00]	100.00

(1) Hüttenberg, Austria; recalculated after deduction of quartz 7.7%, H_2O by difference.
(2) $Fe_3(AsO_4)_2 \cdot 8H_2O$.

Polymorphism & Series: Dimorphous with parasymplesite.

Occurrence: A rare secondary mineral in the oxidized zone of some arsenic-rich hydrothermal mineral deposits.

Association: Pharmacosiderite, scorodite, erythrite, roselite, annabergite, parasymplesite, "limonite".

Distribution: In Germany, from the Tännig, near Lobenstein, Thuringia, and at Neustädtel-Schneeberg, Saxony. From Baia Sprie (Felsőbánya), Romania. At Pisek, Czech Republic. From Hüttenberg and Lölling, Carinthia, Austria. From Laurium, Greece, in slag. In Italy, at Pizzo Cipolla, near Mandanici, Sicily. In the Wanthwaite mine, St. John's in the Vale, Cumbria, England. At Bou Azzer, Morocco. Large crystals from the Ojuela mine, Mapimí, Durango, Mexico. In the USA, in the Kalkar quarry, Santa Cruz, Santa Cruz Co., California; at the Getchell mine, about 32 km northeast of Golconda, Humboldt Co., Nevada; in the Custer Mountain quarry, Custer, Custer Co., North Dakota. In Australia, from the O'Donoghue Castle copper mine, 10 km west of Wooltana, Flinders Ranges, South Australia, and at the Magnet mine, Dundas, Tasmania.

Name: From the Greek for *with* and *to be associated*, in allusion to the other rare arsenates accompanying it in the original occurrence.

Type Material: Mining Academy, Freiberg, Germany, 21034.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 752–753. (2) Ito, T. and H. Mori (1954) The symplesite problem. Tokyo Univ. Fac. Sci. J., 9(2), 201–204. (3) Schmetzer, K., G. Tremmel, and W. Bartelke (1980) Eine Paragenese seltener Minerale aus Bou-Azzer, Marokko; Parasymplesit, Symplesit, Schneiderhöhnit, Karibibit. Neues Jahrb. Mineral., Abh., 138, 94–108 (in German).

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Synadelphite $(Mn^{2+}, Mg, Ca, Pb)_9(As^{3+}O_3)(As^{5+}O_4)_2(OH)_9 \cdot 2H_2O(?)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are short tabular to prismatic [001], with {110} striated ‖ [001], {011}, {121}, {010}, to 3 mm; in reniform crusts. *Twinning:* Observed optically.

Physical Properties: *Cleavage:* On {010}, imperfect. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.57–3.79 D(calc.) = 3.57 Oxidizes readily on exposure to air.

Optical Properties: Transparent if colorless, grading from translucent to opaque. *Color:* Colorless internally, externally garnet-red, red-brown, dark brown, nearly black; in transmitted light, colorless to pink, pale brown, may be sectored as well as zoned. *Luster:* Vitreous, adamantine to submetallic. *Optical Class:* Biaxial (+). *Pleochroism:* X = colorless to light brown; Y = colorless to brown; Z = light brown to dark red-brown. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.750$–1.87 $\beta = 1.751$–1.88 $\gamma = 1.761$–1.93 2V(meas.) = 37°–40° 2V(calc.) = 35°15′–67°37′

Cell Data: *Space Group: Pnma.* $a = 10.754(11)$ $b = 18.865(17)$ $c = 9.884(14)$ Z = 4

X-ray Powder Pattern: Nordmark, Sweden.
8.72 (10), 2.636 (9), 9.36 (7), 2.091 (7), 1.5996 (7), 5.27 (5), 3.080 (5)

Chemistry:

	(1)	(2)		(1)	(2)
As_2O_5	32.43	21.20	CaO	0.28	
As_2O_3	n.d.	9.12	H_2O	11.33	10.80
FeO	0.17		insol.	0.19	
MnO	56.43	58.88	Total	100.83	100.00

(1) Långban, Sweden. (2) $Mn_9(As^{3+}O_3)(As^{5+}O_4)_2(OH)_9 \cdot 2H_2O$.

Occurrence: A rare low-temperature hydrothermal mineral cutting hausmannite ores in dolomitic marble (Moss mine, Sweden).

Association: Pyrochroite, manganite, jacobsite, allactite, calcite (Moss mine, Sweden); manganon biotite, allactite, hausmannite (Långban, Sweden); kraisslite, allactite (Sterling Hill, New Jersey, USA).

Distribution: Found in the Moss mine, Nordmark, and at Långban, Värmland, Sweden. From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: From the Greek for *with* and *brother*, as it is commonly associated with several other chemically similar minerals.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 780–782, 919–920 [hemafibrite = synadelphite]. (2) Moore, P.B. (1970) Crystal chemistry of the basic manganese arsenates: IV. Mixed arsenic valences in the crystal structure of synadelphite. Amer. Mineral., 55, 2023–2037.

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Synchysite-(Ce) $Ca(Ce,La)(CO_3)_2F$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Crystals are commonly acute pyramidal [using pseudohexagonal indices] $\{10\bar{1}0\}$ to tabular and striated $\parallel \{0001\}$, but oscillatory and sceptered due to syntactic intergrowths $\parallel \{0001\}$ with bastnäsite-(Ce), parisite-(Ce), röntgenite-(Ce), cordylite, to 6 cm. *Twinning:* On $\{0001\}$, may be lamellar.

Physical Properties: *Fracture:* Subconchoidal to splintery. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.90 D(calc.) = 3.88

Optical Properties: Translucent. *Color:* Wax-yellow, brown, grayish yellow; colorless to pale yellow in transmitted light. *Luster:* Vitreous to subadamantine, may be greasy. *Optical Class:* Uniaxial (+). *Pleochroism:* Weak. *Absorption:* $O < E$. $\omega = 1.674$ $\epsilon = 1.770$

Cell Data: *Space Group:* $C2/c$. $a = 12.329(2)$ $b = 7.110(1)$ $c = 18.741(2)$ $\beta = 102.68(1)^\circ$ Z = 12

X-ray Powder Pattern: Predazzo, Italy.
3.55 (100), 2.80 (100), 9.1 (60), 4.53 (50), 2.06 (50), 1.934 (50), 3.32 (40)

Chemistry:

	(1)		(1)		(1)
CO_2	[27.95]	Ce_2O_3	22.34	Gd_2O_3	1.27
SiO_2	0.14	Pr_2O_3	2.27	CaO	18.14
Y_2O_3	0.45	Nd_2O_3	12.73	F	[5.73]
La_2O_3	9.96	Sm_2O_3	1.79	$-O = F_2$	2.41
				Total	[100.36]

(1) Trimouns talc deposit, France; by electron microprobe, average of ten points, CO_2 and F calculated from stoichiometry; corresponds to $Ca_{1.02}(Ce_{0.43}La_{0.24}Nd_{0.19}Pr_{0.05}Sm_{0.03}Gd_{0.02}Y_{0.01})_{\Sigma=0.97}(CO_3)_2F$. (2) Mont Saint-Hilaire, Canada; analysis not given, stated to correspond to $Ca_{0.94}(Ce_{0.62}La_{0.32}Y_{0.02}Th_{0.01}Eu_{0.01})_{\Sigma=0.98}(CO_3)_2F_{0.64}$.

Occurrence: An uncommon hydrothermal accessory mineral in granites and alkalic syenites.

Association: Astrophyllite, catapleiite, neptunite, epididymite, elpidite, cordylite, fluorite, rhodochrosite, polylithionite, aegirine, microcline, albite (Narssârssuk, Greenland); ewaldite, belovite-(Ce), fluorite, nenadkevichite, ancylite-(Ce), kukharenkoite-(Ce), mckelveyite-(Y), burbankite, calcite, barite, orthoclase (Khibiny massif, Russia).

Distribution: In Greenland, very large crystals from Narssârssuk, and in the Ilímaussaq intrusion. At Holmestrand, Norway. In the Valle de Arán, Lerida Province, Spain. In Italy, from Predazzo, Trentino-Alto Adige, and on the east flank of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont. In Switzerland, from Piz Blas, Val Nalps, and at La Bianca, Val Casatscha, Grisons; on the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais; with many other minor occurrences. In the Kaiserer and Lohningbruch quarries, Rauris Valley, Salzburg, Austria. In the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France. In Russia, rock-forming in the Khibiny massif, Kola Peninsula. From the Lueshe carbonatite, 150 km north of Goma, Kivu Province, Congo (Zaire). In Canada, from Mont Saint-Hilaire and at Saint-Amable, Quebec. From Mt. Weld, 34 km south of Laverton, Western Australia. Increasingly recognized from additional localities.

Name: From the Greek for *confounding*, as originally thought to be parisite, and dominant *cerium*.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 287–289. (2) Wang, L., Y. Ni, J.M. Hughes, P. Bayliss, and J.W. Drexler (1994) The atomic arrangement of synchysite-(Ce), $CeCaF(CO_3)_2$. Can. Mineral., 32, 865–871. (3) de Parseval, P., F. Fontan, and T. Aigouy (1997) Composition chimique des minéraux de terres rares de Trimouns (Ariège, France). Compt. Rendus Acad. Sci. Paris, 324, 625–630 (in French with English abs.).

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Synchysite-(Nd) $Ca(Nd,La)(CO_3)_2F$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* n.d. As bladed crystals, to 0.036 mm, in radial to platy aggregates.

Physical Properties: Hardness = ∼1, in aggregates. D(meas.) = n.d. D(calc.) = 4.14

Optical Properties: Transparent to translucent. *Color:* Pale grayish blue; pale brown, grayish brown, pale violet to colorless in transmitted light. *Streak:* White. *Luster:* Dull. *Optical Class:* Biaxial (+). *Orientation:* Negative elongation, parallel extinction. $\alpha = 1.61$ $\beta = 1.66$ $\gamma = 1.74$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 4.039(2)$ $b = 6.984(5)$ $c = 54.27(4)$ Z = 12

X-ray Powder Pattern: Holičky deposit, Czech Republic.
4.52 (100), 9.04 (60), 2.77 (36), 1.898 (33), 3.50 (19), 3.25 (16), 2.26 (16)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	[26.9]	[17.1]	Dy_2O_3	2.5	1.4
UO_2	0.9		Ho_2O_3	0.3	
La_2O_2	0.9	17.9	Lu_2O_3	0.2	
Ce_2O_3	0.7	3.0	Y_2O_3	9.0	5.8
Pr_2O_3	1.8	6.8	CaO	18.3	12.6
Nd_2O_3	17.6	23.2	F	6.8	7.0
Sm_2O_3	6.9	4.3	$-O = F_2$	2.9	2.9
Eu_2O_3	2.3		Total	[100.0]	[100.0]
Gd_2O_3	7.8	3.8			

(1) Holičky deposit, Czech Republic; by electron microprobe, CO_3 by difference, determined present by IR; corresponds to $(Ca_{1.03}U_{0.01})_{\Sigma=1.04}(Nd_{0.33}Y_{0.25}Gd_{0.14}Sm_{0.13}Eu_{0.04}Dy_{0.04}Pr_{0.03}La_{0.02}Ce_{0.01}Ho_{0.01})_{\Sigma=1.00}(CO_3)_{1.94}F_{1.13}$. (2) Grebnik deposit, Yugoslavia; by electron microprobe, average of three analyses, CO_2 calculated by difference; corresponds to $Ca_{1.10}(Nd_{0.34}La_{0.27}Y_{0.12}Pr_{0.10}Sm_{0.08}Gd_{0.05}Ce_{0.04}Dy_{0.02})_{\Sigma=1.02}(CO_3)_{1.90}F_{0.90}$.

Occurrence: An authigenic minerals in cement in sandstone (Holičky deposit, Czech Republic); filling cavities in the base of a bauxite deposit in contact with limestone (Grebnik deposit, Yugoslavia).

Association: Florencite-(La), sphalerite, manganoan siderite, pyrite, kaolinite, quartz (Holičky deposit, Czech Republic).

Distribution: From the Holičky deposit, near Česká Lípa, Czech Republic. In the Grebnik bauxite deposit, Serbia, Yugoslavia. At the Pyörönmaa pegmatite, Kangasala, Finland.

Name: For its relation to *synchysite*-(Ce) and dominant *neodymium*.

Type Material: Charles University, Prague, Czech Republic, 21242, National Museum of Natural History, Washington, D.C., USA, 161213.

References: (1) Scharm, B. and P. Kühn (1983) Synchisite-(Nd), $Ca(Nd,Y,Gd,...)F|(CO_3)_2$, a new mineral. Neues Jahrb. Mineral., Monatsh., 201–210. (2) Maksimović, Z. and G. Pantó (1978) Minerals of the rare-earth elements in karstic bauxites: synchisite-(Nd), a new mineral from the Grebnik deposit. Proc. 4th International Congress for the study of bauxites, alumina, and aluminum, Athens, 13 pp.

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Synchysite-(Y) $Ca(Y,Ce)(CO_3)_2F$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Crystals exhibit [using pseudohexagonal indices] $\{11\bar{2}1\}$ and $\{0001\}$, with smaller $\{10\bar{1}0\}$, $\{02\bar{2}1\}$, $\{33\bar{6}5\}$, $\{5.5.\bar{10}.3\}$, to 0.2 mm; typically in very fine-grained aggregates.

Physical Properties: Hardness = ∼4.5 D(meas.) = 3.9 D(calc.) = [3.88]

Optical Properties: Transparent to translucent. *Color:* Red-brown, pale yellow, pale pink, colorless. *Luster:* Greasy.
Optical Class: Uniaxial (+). $\omega = 1.643$–1.645 $\epsilon = 1.73$–1.74

Cell Data: *Space Group:* $C2/c$. $a = 12.039(3)$ $b = 6.950(1)$ $c = 18.436(6)$ $\beta = 102.45(2)^\circ$ Z = 12

X-ray Powder Pattern: Cotopaxi, Colorado, USA.
1.89 (10), 2.00 (9), 1.83 (9), 1.37 (9), 2.75 (8), 3.47 (7), 1.26 (7)

Chemistry:

	(1)	(2)
CO_2	31.4	29.98
Y_2O_3	24.	19.23
Ce_2O_3		27.95
RE_2O_3	[22.1]	
CaO	18.5	19.10
F	5.7	6.47
$-O = F_2$	2.4	2.73
Total	[99.3]	100.00

(1) Near Cotopaxi, Colorado, USA; RE_2O_3 by difference, after deduction of kainosite 10.8% and Fe_2O_3 1%, corresponds to $Ca_{1.0}(Y_{0.6}RE_{0.4})_{\Sigma=1.0}(CO_3)_{2.0}F_{0.9}$. (2) $Ca(Y,Ce)(CO_3)_2F$ with Y:Ce = 1:1.

Occurrence: A rare hydrothermal accessory mineral in alkalic granites and granite pegmatites.

Association: Kainosite, bastnäsite, xenotime, hematite, quartz (Dover, New Jersey, USA).

Distribution: In the USA, from the Scrub Oaks iron mine, Mine Hill, 4 km west of Dover, Morris Co., New Jersey; at the Henry pegmatite, near Cotopaxi, Fremont Co., and the Big Bertha and White Cloud pegmatites, South Platte district, Jefferson Co., Colorado; from Rib Mountain, Marathon Co., Wisconsin. In the Evans-Lou quarry, near Wakefield, Quebec, Canada. Around Gallt y Wenallt, Gwynedd, Wales. On the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais, Switzerland. At Bad Grund, Harz Mountains, Germany. Crystallized in the Bantyshevo salt stock, Dnieper-Donets Basin, Ukraine. From the Jabal Sa'id pegmatite, central Saudi Arabia. At Xiaocaidan, Qinghai Province, China.

Name: For its relation to *synchysite*-(Ce) and dominant *yttrium*.

Type Material: n.d.

References: (1) Smith, W.L., J. Stone, D.R. Ross, and H. Levine (1960) Doverite [= synchysite-(Y)], a possible new yttrium fluocarbonate from Dover, Morris Co., New Jersey. Amer. Mineral., 45, 92–98. (2) Levinson, A.A. and R.A. Borup (1962) Doverite [= synchysite-(Y)] from Cotopaxi, Colorado. Amer. Mineral., 47, 337–343. (3) Levinson, A.A. (1966) A system of nomenclature for rare-earth minerals. Amer. Mineral., 51, 152–158. (4) Kvasnitsa, V.B., N.B. Navaleva, V.A. Shumlyanskiy, and N.V. Zhikalyak (1990) New rare-earth carbonate and phosphate finds in the Ukraine. Doklady Acad. Nauk SSSR, 314, 455–458 (in Russian). (5) Liben Wang and Kangjing Zhou (1995) The crystal structure of synchysite-(Y), $YCa(CO_3)F$. Acta Petrologica Mineralogica, 14(4), 336–344 (in Chinese with English abs.).

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Syngenite $K_2Ca(SO_4)_2 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, tabular on {100} to prismatic along [001], with many forms recorded, to 14 cm; forms lamellar aggregates and crystalline crusts. *Twinning:* Contact twins on {100} common.

Physical Properties: *Cleavage:* On {110} and {100}, perfect; on {010}, distinct. *Fracture:* Conchoidal. Hardness = 2.5 D(meas.) = 2.579–2.603 D(calc.) = 2.575 Soluble in H_2O, with separation of gypsum.

Optical Properties: Transparent to translucent. *Color:* Colorless, milky white, faintly yellow due to inclusions; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = -2°17'$. *Dispersion:* $r < v$, very strong.
$\alpha = 1.501$ $\beta = 1.517$ $\gamma = 1.518$ 2V(meas.) = 28°

Cell Data: *Space Group:* $P2_1/m$. $a = 9.77$ $b = 7.15$ $c = 6.25$ $\beta = 104.0°$ Z = 2

X-ray Powder Pattern: Synthetic.
2.855 (100), 3.165 (75), 5.71 (55), 2.741 (55), 2.827 (50), 9.49 (40), 4.624 (40)

Chemistry:

	(1)	(2)
SO_3	49.04	48.75
MgO	0.64	
CaO	16.97	17.08
K_2O	28.03	28.68
H_2O	5.81	5.49
Total	100.49	100.00

(1) Kalush, Ukraine; corresponds to $K_{1.97}Ca_{1.00}(SO_4)_{2.03} \cdot 1.07H_2O$. (2) $K_2Ca(SO_4)_2 \cdot H_2O$.

Occurrence: An uncommon diagenetic component of marine salt deposits; a volcanic sublimate or pneumatolytic reaction product; a hydrothermal vein filling in a geothermal field; derived from bat guano in caves.

Association: Halite, arcanite (salt deposits); biphosphammite, aphthitalite, monetite, whitlockite, uricite, brushite, gypsum (caves).

Distribution: In Ukraine, large crystals from the Kalush salt deposit (Kalusz, Poland), and at Stebnyk. In Germany, from Thuringia, in the Glückauf mine, near Sondershausen, from Bischofferode, and at Volkenroda-Pöther, near Mühlhausen; from the Stassfurt salt district, Saxony-Anhalt; in the Sigmundshall mine, Bokeloh, and at the Kalkberg, near Lüneburg, Lower Saxony. On Vesuvius, Campania, and in the Cesano geothermal field, Latium, Italy. From Haleakala volcano, Maui, Hawaii, USA. In Murra-el-elevyn, Dingo Dongo, and Petrogale Caves, Western Australia. From Gcwihaba Cave, 280 km west of Maun, northwestern Botswana. On volcanoes on the Kamchatka Peninsula, Russia. Around Mt. Erebus, Victoria Land, Antarctica. From the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China.

Name: From the Greek for *related*, for the chemical resemblance to polyhalite.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 442–444. (2) Corazza, E. and C. Sabelli (1967) The crystal structure of syngenite, $K_2Ca(SO_4)_2 \cdot H_2O$. Zeits. Krist., 124, 398–408. (3) Bokiy, G.B., N.A. Pal'chik, and M.Y. Antipin (1978) Crystal structure of syngenite. Kristallografiya (Sov. Phys. Crystal.), 23, 257–260 (in Russian). (4) Cavarretta, G., A. Mottana, and F. Tecce (1983) Görgeyite and syngenite in the Cesano geothermal field (Latium, Italy). Neues Jahrb. Mineral., Abh., 147, 304–314. (5) (1977) NBS Mono. 25, 14.

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Szaibélyite $MgBO_2(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As flattened fibers or laths; in spheroidal aggregates, to 5 mm; typically as felted or matted fibrous aggregates. *Twinning:* On {100}.

Physical Properties: *Tenacity:* Inflexible. Hardness = 3–3.5 D(meas.) = 2.62 D(calc.) = 2.738

Optical Properties: Translucent. *Color:* White to buff, straw-yellow; colorless in transmitted light. *Streak:* White. *Luster:* Silky to dull.
Optical Class: Biaxial (–). *Orientation:* Parallel extinction; $X \parallel$ elongation; $Z \perp$ flattening. *Dispersion:* $r > v$. $\alpha = 1.575$ $\beta = 1.646$ $\gamma = 1.650$ 2V(meas.) = 25°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.577(2)$ $b = 10.393(2)$ $c = 3.139(1)$ $\beta = 95.88(2)°$ Z = 8

X-ray Powder Pattern: Taiga deposit, Sakha, Russia.
6.27 (100), 2.664 (70), 2.089 (65), 2.207 (58), 2.441 (50), 3.04 (41), 2.548 (37)

Chemistry:

	(1)	(2)		(1)	(2)
B_2O_3	40.17	41.38	H_2O	12.00	10.71
R_2O_3	0.29		insol.	0.10	
MgO	47.12	47.91	Total	99.68	100.00

(1) Schmidtmannshall, Germany. (2) $MgBO_2(OH)$.

Polymorphism & Series: Polytypes -O and -M are known; forms a series with sussexite.

Occurrence: Uncommon in marine evaporite deposits; in boron-bearing contact metasomatized dolomitic marbles and skarns, and metamorphosed banded iron formation.

Association: Ludwigite, hulsite, magnetite, fluoborite, vonsenite, sinhalite, nordenskiöldine, warwickite, brucite, aragonite, brugnatellite, clinohumite, dolomite (skarns); boracite, sylvite, halite, kainite (marine salt deposits).

Distribution: Numerous localities worldwide, typically in small amounts. In Romania, from Băiţa (Rézbánya) and at Ocna de Fier (Morávicza; Vaskő). In Germany, in the Stassfurt salt district, Saxony-Anhalt; from Pöhla, Erzgebirge, and at Vienenburg, north of Bad Harzburg. At Broadford, Isle of Skye, Inverness-shire, Scotland. In the Brosso mine, northwest of Ivrea, Torino, Italy. From Norberg, Västmanland, Sweden. In the USA, from Bolinas Bay, Marin Co., California; near Blind Mountain, west of Pinoche, Lincoln Co., and east of the Ludwig gypsum mine, Lyon Co., Nevada. In Canada, from the Potash Corporation of America mine, Penobsquis evaporite deposit, and the Salt Springs evaporite deposit, near Sussex, New Brunswick; near Bancroft, Ontario, and elsewhere. In the St. Dizier tin–boron deposit, 20 km northwest of Zeehan, Tasmania, Australia. From the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea. At Irazuyama, Ehime Prefecture, Japan. In the Taiga boron–iron deposit, and the Tayozhnoye iron deposit, 550 km south of Yakutsk, Sakha, Russia. In economic amounts in the Inder boron deposit, Kazakhstan. Mined for boron at Fengchen and elsewhere in Liaoning Province, China. Millions of tons are in the Gole Gohar iron deposit, Bafq district, Iran.

Name: Honors István Ádám Rudolf Szaibély (1777–1855), Rézbánya, Hungary [now Băiţa, Romania], mine surveyor, who collected the first specimens.

Type Material: Loránd Eötvös University, Budapest, Hungary, E555.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 375–377. (2) Takéuchi, Y. and Y. Kudoh (1975) Szaibelyite, $Mg_2(OH)[B_2O_4(OH)]$: Crystal structure, pseudosymmetry, and polymorphism. Amer. Mineral., 60, 273–279. (3) Lisitsyn, A.E., O.M. Dara, T.V. Tkacheva, V.V. Rudnev, A.L. Gaft, and N.V. Dobrovol'skaya (1985) New data on ludwigite and szaibelyite of the Taiga skarn-magnetite deposit (southern Yakutia [Sakha]). Zap. Vses. Mineral. Obshch., 114, 62–73 (in Russian).

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Szenicsite $Cu_3(MoO_4)(OH)_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As lamellar {100} crystals, elongated on [001], dominated by {100} with {110}, curved {010} common, {211} uncommon, to 3 cm; typically as jackstraw or booklike radial aggregates intergrown about [001].

Physical Properties: *Cleavage:* {100} and {010}, good. *Tenacity:* Brittle.
Hardness = 3.5–4 D(meas.) = 4.26(5) D(calc.) = 4.279

Optical Properties: Transparent to translucent. *Color:* Dark green. *Streak:* Malachite-green. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Pleochroism:* X = yellow-green; $Y = Z$ = green. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, strong. $\alpha = > 1.8$ $\beta = > 1.8$ $\gamma = > 1.8$
2V(meas.) = 74(3)°

Cell Data: *Space Group: Pnnm.* $a = 8.5201(8)$ $b = 12.545(1)$ $c = 6.0794(6)$ Z = 4

X-ray Powder Pattern: Jardinera No. 1 mine, Chile.
2.591 (vs), 5.471 (s), 3.754 (s), 3.043 (s), 1.519 (s), 4.599 (m), 2.759 (m), 2.415 (m)

Chemistry:

	(1)	(2)
MoO_3	34.00	34.38
Al_2O_3	0.14	
CuO	56.26	57.01
H_2O	8.79	8.61
Total	99.19	100.00

(1) Jardinera No. 1 mine, Chile; by electron microprobe, average of 20 analyses; H_2O by LOI, MoO_4^{2-} and OH^- confirmed by IR; corresponds to $Cu_{2.97}Al_{0.01}(MoO_4)_{0.99}(OH)_{4.09}$.
(2) $Cu_3(MoO_4)(OH)_4$.

Occurrence: A uncommon secondary mineral in the oxidized zone of a copper–molybdenum deposit in granite.

Association: Powellite, chrysocolla, brochantite, lindgrenite, gold, molybdenite, chalcopyrite, chalcocite, hematite, barite, quartz.

Distribution: From the Jardinera No. 1 mine, five km east of Inca de Oro, Atacama, Chile.

Name: Honors husband and wife Marissa Szenics (1950–) and Terry Szenics (1947–), mineral collectors and dealers who found the first specimens.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 133734, 133735, 133738, 133739.

References: (1) Francis, C.A., L.C. Pitman, and D.E. Lange (1997) Szenicsite, a new copper molybdate from Inca de Oro, Atacama, Chile. Mineral. Record, 28, 387–394. (2) (1998) Amer. Mineral., 83, 403 (abs. ref. 1). (3) Burns, P.C. (1998) The crystal structure of szenicsite, $Cu_3MoO_4(OH)_4$. Mineral. Mag., 62, 461–469.

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Szmikite $Mn^{2+}SO_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As botryoidal to stalactitic masses and efflorescences.

Physical Properties: *Fracture:* Splintery to granular. *Tenacity:* [Brittle.] Hardness = 1.5 D(meas.) = 3.15 D(calc.) = 2.946 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Grayish white, pale pink, pale red, rose-red. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$. $\alpha = 1.562(3)$ $\beta = 1.595(3)$ $\gamma = 1.632(3)$ 2V(meas.) = $\sim 90°$

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 7.116(1)$ $b = 7.667(1)$ $c = 7.920(2)$ $\beta = 118.11(1)°$ Z = 4

X-ray Powder Pattern: Synthetic.
3.507 (100), 4.916 (50), 3.139 (40), 4.855 (30), 3.361 (30), 2.580 (30), 3.445 (20)

Chemistry:

	(1)	(2)
MnO	41.70	41.97
SO_3	47.27	47.37
H_2O	11.05	10.66
Total	100.02	100.00

(1) Baia Sprie, Romania; average of two analyses. (2) $MnSO_4 \cdot H_2O$.

Mineral Group: Kieserite group.

Occurrence: A rare post-mining incrustation.

Association: Jokokuite (Jokoku mine, Japan).

Distribution: In Romania, from Baia Sprie (Felsőbánya) and in the Borzaş gold mine, Gutâi Mountains. In the Jokoku mine, southwest Hokkaido, Japan. At the Silver King mine, Galena Hill, Yukon Territory, Canada.

Name: Honors Ignaz Nathaniel Szmik (1815–1881), Hungarian mining official at Felsőbánya, Hungary (now Baia Sprie, Romania), who discovered the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 481. (2) Wildner, M. and G. Giester (1991) The crystal structures of kieserite-type compounds. I. Crystal structures of $Me(II)SO_4 \cdot H_2O$ (Me = Mn,Fe,Co,Ni,Zn). Neues Jahrb. Mineral., Monatsh., 296–306. (3) (1979) NBS Mono 25, 16, 49.

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Szomolnokite $Fe^{2+}SO_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Small crystals are typically distorted, dipyramidal $\{\overline{1}11\}$ and $\{110\}$, tabular on $\{\overline{1}11\}$, commonly in parallel growths; globular to stalactitic. *Twinning:* Common, according to an undetermined law.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 3.03–3.07 D(calc.) = 3.097 Slowly soluble in H_2O.

Optical Properties: Transparent when unoxidized. *Color:* Sulfur-yellow, yellowish brown to reddish brown; blue, colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = -26°$. *Dispersion:* $r > v$, strong.
$\alpha = 1.591$ $\beta = 1.623$ $\gamma = 1.663$ 2V(meas.) = 80°

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 7.078(3)$ $b = 7.549(3)$ $c = 7.773(3)$ $\beta = 118.65(2)°$ Z = 4

X-ray Powder Pattern: Synthetic.
3.444 (100), 3.116 (42), 2.521 (37), 4.85 (30), 2.579 (27), 3.373 (24), 3.282 (21)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	47.96	47.12	MgO	0.25	
Fe_2O_3	1.36		CaO	0.07	
FeO	39.42	42.28	$(Na,K)_2O$	0.31	
CuO	1.20		H_2O	10.36	10.60
ZnO	0.14		Total	101.07	100.00

(1) Smolník, Slovakia. (2) $FeSO_4 \cdot H_2O$.

Mineral Group: Kieserite group.

Occurrence: An uncommon secondary mineral formed in pyrite-rich oxidized sulfide deposits, typically under highly acid and arid conditions.

Association: Rhomboclase, halotrichite, fibroferrite, römerite, copiapite, voltaite, pyrite.

Distribution: Widespread in small amounts. Several localities for studied material include: from Smolník (Szomolnok), 16 km northeast of Rožňava, Slovakia. On Valachov Hill, near Skřivaň, and at Kladno, Czech Republic. From the Staszic mine, Rudki, Poland. In the Clara mine, near Oberwolfach, Black Forest, Germany. From the Crumlin colliery, Ebbw Vale, Gwent, Wales. At Quetena, west of Calama, and Alcaparrosa, near Cerritos Bayos, southwest of Calama, Antofagasta, Chile. From the Santa Elena mine, Quebrada de La Alcaparrosa, San Juan Province, Argentina. In the USA, from the Tintic Standard mine, near Dividend, East Tintic district, Utah Co., Utah; at Bisbee, Cochise Co. and in the Magma mine, Pinal Co., Arizona; from the Goldstrike mine, Lynn district, Eureka Co., Nevada; at the Island Mountain mine, Trinity Co., California. From Saghand, Yazd, Iran.

Name: For the first recognized occurrence at Szomolnok, Hungary (now Smolník, Slovakia).

Type Material: The type specimens were destroyed in 1956 at the Natural History Museum, Budapest, Hungary.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 479–480. (2) Pistorius, C.W.F.T. (1960) Lattice constants of $FeSO_4.H_2O$ (artificial szomolnokite) and $NiSiO_4.H_2O$. Bull. Soc. Chim. Belge., 69, 570–574. (3) Wildner, M. and G. Giester (1991) The crystal structures of kieserite-type compounds. I. Crystal structures of $Me(II)SO_4 \cdot H_2O$ (Me = Mn,Fe,Co,Ni,Zn). Neues Jahrb. Mineral., Monatsh., 296–306.

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Szymańskiite $(H_3O)_8^{1+}Hg_{16}^{1+}(Ni,Mg)_6(CO_3)_{12}(OH)_{12}\cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6. As sprays of euhedral to subhedral prismatic crystals, elongated along [0001], with dominant $\{10\overline{1}0\}$ striated ‖ [0001], and minor {0001}, to 0.4 mm.

Physical Properties: *Cleavage:* $\{10\overline{1}0\}$, poor. *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.86 Slowly darkens on exposure to light.

Optical Properties: Transparent. *Color:* Blue-gray to blue-green, darkening to black on exposure to air. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellowish green; E = bluish green.
Absorption: $O < E$. $\omega = 1.795(3)$ $\epsilon = 1.786(3)$

Cell Data: *Space Group:* $P6_3$. $a = 17.3984(7)$ $c = 6.0078(4)$ $Z = 1$

X-ray Powder Pattern: Clear Creek claim, California, USA.
14.9 (100), 5.60 (100), 3.299 (80), 2.704 (60), 2.665 (60), 3.201 (50), 2.476 (50)

Chemistry:

	(1)	(2)
NiO	7.9	6.59
Hg_2O	75.8	72.14
MgO	2.0	1.67
CO_2		11.42
H_2O		8.18
Total		100.00

(1) Clear Creek claim, California; by electron microprobe, average of three analyses, values high due to volatilization; IR confirms presence of CO_3^{2-}, $(OH)^{1-}$, H_2O. (2) Do.; with H_2O and CO_2^{2-} determined by crystal-structure analysis, corresponds to $(H_3O)_8Hg_{16}(Ni_{4.08}Mg_{1.92})_{\Sigma=6.00}(CO_3)_{12}(OH)_{12}\cdot 3H_2O$.

Occurrence: A very rare secondary mineral in the oxidized zone of a mercury–nickel-bearing sulfide deposit in silicate–carbonate rock hydrothermally altered from serpentinite.

Association: Cinnabar, montroydite, mercury, edgarbaileyite, millerite, cinnabar, quartz.

Distribution: From the Clear Creek claim, near the Clear Creek mercury mine, New Idria district, San Benito Co., California, USA.

Name: Honors Dr. Jan T. Szymański (1938–), X-ray crystallographer, Canadian Centre for Mineral and Energy Technology (CANMET), Ottawa, Canada.

Type Material: Canadian Geological Survey, Ottawa, Canada, 65743.

References: (1) Roberts, A.C., T.S. Ercit, R.C. Erd, and R.L. Oscarson (1990) Szymańskiite, $Hg_{16}^{1+}(Ni,Mg)_6(CO_3)_{12}(OH)_{12}(H_3O)_8^{1+}\cdot 3H_2O$, a new mineral species from the Clear Creek claim, San Benito County, California. Can. Mineral., 28, 703–707. (2) Szymanski, J.T. and A.C. Roberts (1990) The crystal structure of szymańskiite, a partly ordered $(Hg-Hg)^{2+}, (Ni,Mg)^{2+}$ hydronium-carbonate-hydroxide-hydrate. Can. Mineral., 28, 709–718. (3) (1991) Amer. Mineral., 76, 1731 (abs. refs. 1–2).

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Tacharanite $Ca_{12}Al_2Si_{18}O_{51}\cdot 18H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As aggregates of fibers, to several μm, in bundles or spherulites; porcelaneous cryptocrystalline masses.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Tough. Hardness = n.d. D(meas.) = 2.33–2.36 D(calc.) = [2.28]

Optical Properties: Semitransparent. *Color:* Milky white. *Luster:* Vitreous to dull. *Optical Class:* [Biaxial.] n = 1.518–1.537 2V(meas.) = n.d.

Cell Data: *Space Group:* A-centered monoclinic pseudocell. $a = 17.07$ $b = 3.65$ $c = 27.9$ $\beta = 114.1°$ Z = 1

X-ray Powder Pattern: Bramburg, Germany.
12.7 (vvs), 3.048 (vs), 2.775 (s), 1.822 (s), 5.19 (ms), 2.888 (ms), 2.853 (ms)

Chemistry:

	(1)	(2)
SiO_2	41.8	48.3
Al_2O_3	5.6	4.5
Fe_2O_3	0.3	0.0
MgO	3.2	0.4
CaO	33.6	30.8
Na_2O	0.6	0.5
K_2O	0.1	0.6
H_2O	15.2	14.9
Total	100.4	[100.0]

(1) Portree, Scotland. (2) Bramburg, Germany; H_2O by TGA, recalculated to 100.0%; corresponds to $(Ca_{12.2}Na_{0.4}Mg_{0.4}K_{0.3})_{\Sigma=13.3}Al_{2.0}Si_{17.9}O_{51}\cdot 18.4H_2O$.

Occurrence: In amygdules and fractures in metabasalts and basaltic breccias; in hydrothermally altered quartzite inclusions in basalt (Bramburg, Germany).

Association: Tobermorite, gyrolite, mesolite, thomsonite, xonotlite, calcite, saponite (Portree, Scotland); scawtite (Huntley, Scotland).

Distribution: In Scotland, from north of Portree, Isle of Skye; on the Isle of Mull; and in the Binbill quarry, Cairnie, Huntley, Aberdeenshire. From Carneal, Co. Antrim, Ireland. At Bramburg, near Göttingen, Lower Saxony, and at Arensberg, near Zilsdorf, Eifel district, Germany. At Espalion, Aveyron, France. Along the Olbirella, near Tiglieto, Liguria, Italy. From Australia, on Tasmania, in the Marrawah-Redpa area and Brittons Swamp; on Gads Hill, Mersey-Forth River valleys; and at Liawenee, Great Lake. From Noaki, near Yaizu, Shuzuoka Prefecture, Japan.

Name: From the Gaelic *tacharan* for *changeling*, as the mineral converts to others on exposure to air.

Type Material: The Natural History Museum, London, England, 1961,163; National School of Mines, Paris, France.

References: (1) Sweet, J.M., D.I. Bothwell, and D.L. Williams (1961) Tacharanite and other hydrated calcium silicates from Portree, Isle of Skye. Mineral. Mag., 32, 745–753. (2) (1962) Amer. Mineral., 47, 173 (abs. ref. 1). (3) Cliff, G., J.A. Gard, G.W. Lorimer, and H.W.F. Taylor (1975) Tacharanite. Mineral. Mag., 40, 113–126.

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Tachyhydrite $CaMg_2Cl_6 \cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. In rounded masses.

Physical Properties: *Cleavage:* $\{10\overline{1}1\}$, perfect. Hardness = 2 D(meas.) = 1.667 D(calc.) = 1.673 Very deliquescent; tastes sharp and bitter.

Optical Properties: Transparent. *Color:* Wax-yellow to honey-yellow, may be colorless; colorless to pale yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.520$ $\epsilon = 1.512$

Cell Data: *Space Group:* $R\overline{3}$ (synthetic). $a = 10.136(1)$ $c = 17.318(2)$ Z = 3

X-ray Powder Pattern: Synthetic.
2.884 (100), 5.77 (35), 2.609 (25), 1.443 (25), 1.983 (20), 5.07 (12), 3.097 (10)

Chemistry:

	(1)	(2)	(3)
Mg	9.97	9.71	9.39
Ca	7.16	7.72	7.74
Cl	40.85	40.89	41.10
H_2O	42.50	42.20	41.77
Total	100.48	100.52	100.00

(1) Stassfurt, Germany; average of two analyses. (2) Krügershall, Germany.
(3) $CaMg_2Cl_6 \cdot 12H_2O$.

Occurrence: A rare mineral in bedded salt deposits of oceanic origin.

Association: Kainite, carnallite, sylvite, halite, kieserite, bischofite, anhydrite.

Distribution: In Germany, from Stassfurt, 34 km south of Magdeburg, Saxony-Anhalt, at Krügershall-Teutschenthal, near Halle, and from Vienenburg, Lower Saxony. In the Santa Rosa de Lima and Taquari Basins, Sergipe, Brazil, with reserves estimated at 4 billion t. On the Khorat Plateau, Thailand, also massive reserves.

Name: From the Greek for *quick* and *water*, remarking on its deliquescence.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 95–96. (2) Erd, R.C., M.A. Clynne, J.R. Clark, and R.W. Potter II (1979) Crystal data for tachyhydrite, $CaMg_2Cl_6 \cdot 12H_2O$. J. Applied Crystallography, 12, 481–482.
(3) Clark, J.R., H.T. Evans, Jr., and R.C. Erd (1980) Tachyhydrite, dimagnesium calcium chloride 12-hydrate. Acta Cryst., 36, 2736–2739.

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Tadzhikite-(Y) $\mathbf{Ca_3(Y,Ce)_2(Ti,Al,Fe^{3+})B_4Si_4O_{22}}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, flattened on {010}, to several cm; in spherulites of curved flakes. *Twinning:* Polysynthetic Albite twinning at a fine scale visible under the microscope.

Physical Properties: *Cleavage:* Parting on {010}. Hardness = 6 D(meas.) = 3.73–3.86 D(calc.) = 3.77

Optical Properties: Translucent to opaque. *Color:* Pale, grayish brown, reddish to dark brown; colorless to dark brown in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z \wedge a = 7°$; $Z \wedge b = 4°$; $Z \wedge c = 23°$–$25°$.
$\alpha = 1.750$–1.761 $\beta = [1.767]$ $\gamma = 1.763$–1.772 2V(meas.) = 80°–92°

Cell Data: *Space Group:* $P2/a$. $a = 18.946(4)$ $b = 4.714(4)$ $c = 10.302(2)$ $\beta = 111.58(2)°$ Z = 2

X-ray Powder Pattern: Dara-i-Pioz massif, Tajikistan.
2.65 (100), 1.913 (55), 4.96 (30), 2.94 (30), 1.665 (30), 2.86 (25), 2.19 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	24.70	23.35	FeO		0.00
TiO_2	6.53	3.72	MnO	0.89	0.40
ThO_2	0.50	0.50	BeO		0.20
B_2O_3	12.70	14.47	MgO	0.42	0.00
Al_2O_3	0.00	2.30	CaO	18.31	18.06
RE_2O_3	32.43	34.07	SrO	0.04	0.04
Fe_2O_3	1.32	3.12	Na_2O	1.17	0.00
Nb_2O_5	0.75		Total	99.76	100.23

(1) Dara-i-Pioz massif, Tajikistan; RE = Y 40.1%, La 2.3%, Ce 11.5%, Pr 3.1%, Nd 13.0%, Sm 6.3%, Eu 0.7%, Gd 9.0%, Tb 0.8%, Dy 6.4%, Ho 0.9%, Er 3.6%, Tm 0.7%, Yb 1.6%; corresponds to $Na_{0.39}Ca_{3.36}RE_{2.23}(Ti_{0.98}Fe^{3+}_{0.20})_{\Sigma=1.18}B_{3.76}Si_{4.24}O_{22.54}$. (2) Do.; RE = Y 24.0Sm 3.8%, Gd 6.0%, Dy 6.6%, Ho 1.05%, Er 4.2%, Tm 0.22%, Yb 0.57%, Lu 0.09%; corresponds to $Ca_{3.18}RE_{2.20}(Ti_{0.43}Fe^{3+}_{0.37}Al_{0.31})_{\Sigma=1.11}B_{4.04}(Si_{3.80}Al_{0.20})_{\Sigma=4.00}O_{22.00}$.

Occurrence: In the replacement units of zoned pegmatite dikes (Dara-i-Pioz massif, Tajikistan).

Association: Quartz, microcline, aegirine, ekanite, titanite, eudialyte, polylithionite, arfvedsonite-riebeckite, pyrochlore, tienshanite, stillwellite.

Distribution: In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan. From Tvedalen, Langesundsfjord, Norway. In the Cimini Hills, near Rome, Lazio, Italy. From Mont Saint-Hilaire, Quebec, Canada.

Name: For the occurrence in Tajikistan (Tadzhikistan), and its *yttrium* content.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73374, 74575, 74965, vis3328.

References: (1) Efimov, A.F., V.D. Dusmatov, V.Y. Alkhazov, Z.G. Pudovkina, and M.Y. Kazakova (1970) Tadzhikite, a new borosilicate of the rare earths of the hellandite group. Doklady Acad. Nauk SSSR, 195, 1190–1193 (in Russian). (2) (1971) Amer. Mineral., 56, 1838–1839 (abs. ref. 1). (3) Chernitsova, N.M., Z.V. Pudovkina, and Y. Pyatenko (1982) Crystal structure of tadzhikite $(Ca,TR)_4(Y,Fe,Al)(O,OH)_2[Si_4B_4O_{22}]$. Doklady Acad. Nauk SSSR, 264, 342–344 (in Russian). (4) (1982) Chem. Abs., 97, 83068 (abs. ref. 3).

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Taenite γ–(Fe, Ni)

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As small plates and grains, fine scales, and large ellipsoidal masses, to 40 kg (terrestrial); in intergrowths with, or narrow selvages around, kamacite in meteorites.

Physical Properties: *Tenacity:* Malleable, flexible. Hardness = 5–5.5 VHN = n.d. D(meas.) = 7.8–8.22 D(calc.) = 8.29 (ordered). Strongly magnetic.

Optical Properties: Opaque. *Color:* Silver-white to grayish white. *Luster:* Metallic.
R: n.d.

Cell Data: *Space Group:* $Fm3m$. a = 7.146 Z = 32

X-ray Powder Pattern: Linville ataxite meteorite - ordered structure.
3.340 (100), 2.879 (80), 2.526 (80), 4.239 (60), 2.279 (10), 2.187 (10), 2.070 (10)

Chemistry:

	(1)	(2)	(3)
Fe	68.13	74.78	25.24
Ni	30.85	24.32	74.17
Co	0.69	0.33	0.46
Cu	0.33		
P			0.04
S			0.09
C		0.50	
Total	100.00	99.93	100.00

(1) Cañon Diablo meteorite. (2) Welland meteorite. (3) Josephine Co., Oregon, USA (terrestrial).

Occurrence: In massive serpentine bodies, as particles in placer sands, and as loose, detached masses which give few clues as to their ultimate origin, which was most likely hydrothermal, igneous, or metamorphic. Important in meteorites.

Association: Kamacite, graphite, cohenite, moissanite, schreibersite, troilite, daubréelite, oldhamite, other meteorite minerals.

Distribution: From Gorge River, South Island, New Zealand [TL]. In the USA, in Josephine and Jackson Cos., Oregon; and in California, near South Fork, Smith River, Del Norte Co. In Canada, on the Fraser River, Lillooet district, British Columbia. Taenite is found in all octahedrite meteorites which exhibit Widmannstätten structures as well as in some nickel-rich ataxites.

Name: From the Greek for *band* or *strip*, in allusion to its platy structure.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 117–119 ["nickel-iron"]. (2) Ramsden, A.R. and E.N. Cameron (1966) Kamacite and taenite superstructures and a metastable tetragonal phase in iron meteorites. Amer. Mineral., 51, 37–55. (3) Albertsen, J.F., G.B. Jensen, and J.M. Knudsen (1978) Structure of taenite in two iron meteorites. Nature, 273, 453–454. (3) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 360–361.

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Taikanite $BaSr_2Mn_2^{3+}O_2Si_4O_{12}$

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Crystal Data: Monoclinic. *Point Group:* 2. As equant grains, rarely elongated, to 1.6 mm; in aggregates of grains. *Twinning:* Observed in thin section.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ~6 VHN = 831–1059 (100 g load). D(meas.) = 4.72 D(calc.) = 4.81

Optical Properties: Semitransparent. *Color:* Greenish black. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = violet to black; $Y = Z$ = emerald-green. *Orientation:* $X = a$; $Y = b$; $Z \wedge c = 44°$; $X \wedge c = 46°$. *Dispersion:* $r > v$, strong. $\alpha = 1.775(3)$ $\beta = [1.792]$ $\gamma = 1.814(2)$ 2V(meas.) = 74°–80°

Cell Data: *Space Group:* $C2$. $a = 14.600(2)$ $b = 7.759(4)$ $c = 5.142(1)$ $\beta = 93.25(2)°$ Z = 1

X-ray Powder Pattern: Irnimi deposit, Russia.
2.912 (100), 2.832 (90), 2.569 (80), 3.270 (70), 1.946 (60), 3.440 (40), 1.718 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	27.17	32.50	MgO	0.14	0.00
Al_2O_3		0.09	CaO	0.46	0.29
Fe_2O_3		0.00	SrO	33.78	25.40
Mn_2O_3		20.59	BaO	18.43	18.90
MnO	19.42		Na_2O	0.18	0.06
PbO		2.10	K_2O		0.01
			Total	99.58	99.94

(1) Irnimi deposit, Russia; by electron microprobe, average of three analyses; corresponds to $Ba_{1.03}(Sr_{2.78}Ca_{0.07}Na_{0.05}Mg_{0.03})_{\Sigma=2.93}Mn_{2.34}Si_{3.86}O_{14}$. (2) Wessels mine, South Africa; by electron microprobe, corresponds to $(Ba_{0.93}Pb_{0.07})_{\Sigma=1.00}(Sr_{1.84}Ca_{0.04}Na_{0.02})_{\Sigma=1.90}Mn^{3+}_{1.96}(Si_{4.07}Al_{0.01})_{\Sigma=4.08}O_{14}$.

Occurrence: In hydrothermal manganese ores related to alkalic dikes intruding limestones and siliceous rocks (Irnimi deposit, Russia); in a bedded manganese deposit (Wessels mine, South Africa).

Association: Braunite, namansilite, strakhovite (Irnimi deposit, Russia); sérandite, pectolite, braunite, sugilite, hennomartinite, kornite (Wessels mine, South Africa).

Distribution: From the Irnimi manganese deposit, Taikan Mountains, Khabarovsk Territory, Russia. In the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For the occurrence in the Taikan Mountains, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84394.

References: (1) Kalinin, V.V., A.B. Dauletkulov, A.I. Gorshkov, and N.V. Troneva (1985) Taikanite – a new silicate of strontium, barium and manganese. Zap. Vses. Mineral. Obshch., 114, 635–641 (in Russian). (2) (1987) Amer. Mineral., 72, 226 (abs. ref. 1). (3) Yamnova, N.A., L.V. Kalacheva, D.Y. Pushcharovskii, and V.V. Kalinin (1992) Crystal structure of taikanite $Sr_2BaMn_2[Si_4O_{12}]O_2$. Kristallografiya (Sov. Phys. Crystal.), 37, 319–321. (4) Armbruster, T., R. Oberhänsli, and M. Kunz (1993) Taikanite, $BaSr_2Mn_2^{3+}O_2[Si_4O_{12}]$, from the Wessels mine, South Africa: a chain silicate related to synthetic $Ca_3Mn_2^{3+}O_2[Si_4O_{12}]$. Amer. Mineral., 78, 1088–1095.

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Taimyrite $(Pd, Cu, Pt)_3Sn$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As rounded grains, to 3 mm, and as veinlets; in zoned aggregates with other species. *Twinning:* Most grains show polysynthetic twinning.

Physical Properties: Hardness = n.d. VHN = 480(25) (50 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Bronze-gray; pale gray with a rose tint in reflected light. *Luster:* Metallic. *Pleochroism:* Distinct; from pale gray with a rose tint to a creamy tint. *Anisotropism:* Colors from dark gray with a blue tint to yellowish gray.
R_1–R_2: (400) 33.0–37.1, (430) 37.8–41.2, (460) 39.6–42.3, (490) 42.3–45.2, (520) 44.0–47.8, (550) 45.5–49.6, (580) 47.4–51.6, (610) 49.7–54.0, (640) 51.4–56.5, (670) 53.0–59.2, (700) 54.0–61.9

Cell Data: *Space Group:* n.d. a = 16.11(2) or 12.57(2) b = 11.27(1) or 13.40(2) c = 8.64(1) or 17.09(2) Z = n.d.

X-ray Powder Pattern: Majak mine, Russia.
2.155 (100), 2.29 (55), 2.365 (40), 1.44 (40)

Chemistry:

	(1)	(2)
Pd	46.9	46.02
Cu	10.3	11.85
Pt	15.4	14.44
Sn	23.8	24.77
Pb	0.0	1.01
Sb	2.5	1.86
Total	98.9	99.95

(1) Majak mine, Russia; by electron microprobe, corresponds to $(Pd_{1.95}Cu_{0.72}Pt_{0.35})_{\Sigma=3.02}(Sn_{0.89}Sb_{0.09})_{\Sigma=0.98}$. (2) Oktyabr mine, Russia; by electron microprobe, corresponding to $(Pd_{1.88}Cu_{0.81}Pt_{0.32})_{\Sigma=3.01}(Sn_{0.90}Sb_{0.07}Pb_{0.02})_{\Sigma=0.99}$.

Occurrence: As grains and veinlets near the contact between sulfide and rock-forming minerals in gabbro-diabase; in massive sulfide ores.

Association: Au–Ag alloys, polarite, sperrylite, froodite, sobolevskite, atokite, rustenburgite, tatyanite, mooihoekite, talnakhite, chalcopyrite, pentlandite, cubanite, pyrrhotite, galena, sphalerite (Talnakh area, Russia).

Distribution: In Russia, from the Majak [TL] and Oktyabr mines, Talnakh area, Noril'sk region, Taimyr Peninsula, western Siberia. In the Loolekop carbonatite, Phalaborwa, Transvaal, South Africa.

Name: For the type locality on the Taimyr Peninsula, Russia.

Type Material: Mineralogical Museum of the Moscow Geological Prospecting Institute; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81390.

References: (1) Begizov, V.D., E.N. Zav'yalov, and E.G. Palov (1982) New data on taimyrite, $(Pd, Cu, Pt)_3Sn$ from copper–nickel ores of the Talnakh deposit. Zap. Vses. Mineral. Obshch., 111, 78–83 (in Russian). (2) (1983) Amer. Mineral., 68, 1252 (abs. ref. 1). (3) Barkov, A.Y., R.F. Martin, G. Poirier, and Y.N. Takovlev (2000) The taimyrite–tatyanaite series and zoning in intermetallic compounds of Pt, Pd, Cu, and Sn from Noril'sk, Siberia, Russia. Can. Mineral., 38, 599–609. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 201.

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Taeniolite $KLiMg_2Si_4O_{10}F_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular crystals, pseudohexagonal, to 3.5 cm; as individual scales or lamellar, also in cryptocrystalline aggregates. *Twinning:* Penetration trillings rare.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Foliae flexible, somewhat elastic. Hardness = 2.5–3.5 D(meas.) = 2.83–2.90 D(calc.) = 2.80

Optical Properties: Transparent. *Color:* Colorless, brown to greenish brown, typically concentrically zoned. *Luster:* Vitreous, silky.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless to pale greenish brown; $Y = Z$ = yellowish to reddish brown. *Absorption:* $Y = Z > X$. α = 1.522–1.541 β = 1.553–1.570 γ = 1.553–1.570 2V(meas.) = 0°–5°

Cell Data: *Space Group:* $C2/m$. a = 5.254(2) b = 9.110(4) c = 10.187(2) β = 99.85(4)° Z = 2

X-ray Powder Pattern: Magnet Cove, Arkansas, USA; 1M.
3.34 (100), 10.04 (74), 5.01 (44), 1.999 (35), 3.12 (26), 2.88 (25), 3.60 (17)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	52.2	52.88	53.5	Na_2O	1.8	1.22	0.27
TiO_2		2.00	1.06	K_2O	11.5	11.38	11.3
Al_2O_3	2.7	trace	3.00	F		5.36	6.3
FeO	0.6	1.89	3.35	H_2O^+		4.24	[1.30]
MnO		1.38	0.21	H_2O^-		2.00	
MgO	19.1	17.42	18.3	LOI	8.7		
Li_2O	3.8	2.44	2.4	$-O = F_2$		2.25	
				Total	100.4	99.96	[100.99]

(1) Narssârssuk, Greenland. (2) Lovozero massif, Russia. (3) Coyote Peak, California, USA; by electron microprobe, H_2O calculated to give (F+OH) = 2; corresponding to $(K_{1.01}Na_{0.04})_{\Sigma=1.05}Li_{0.68}(Mg_{1.92}Fe^{2+}_{0.20}Ti_{0.06}Al_{0.01}Mn_{0.01})_{\Sigma=2.20}(Si_{3.76}Al_{0.24})_{\Sigma=4.00}O_{10}[F_{1.40}(OH)_{0.60}]_{\Sigma=2.00}$.

Polymorphism & Series: 1M, $2M_1$, 3A polytypes.

Mineral Group: Mica group.

Occurrence: A late-stage mineral in nepheline syenite pegmatites.

Association: Quartz, dickite (Narssârssuk, Greenland); natrolite, apatite, neptunite, polylithionite, manganoan pectolite (Lovozero massif, Russia); natrolite, pectolite, aegirine, barytolamprophyllite, rasvumite (Coyote Peak, California, USA).

Distribution: From Narssârssuk, Greenland. In the Lovozero and Khibiny massifs, Kola Peninsula, and at several poorly defined localities around Lake Baikal, Siberia, Russia. In the USA, at Magnet Cove, Hot Spring Co., Arkansas, and Coyote Peak, near Orick, Humboldt Co., California. From Mont Saint-Hilaire, Quebec, Canada.

Name: From the Greek for *ribbon* in reference to the mineral's tabular crystals.

Type Material: University of Copenhagen, Copenhagen, Denmark.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 102–103. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 29–31. (3) Miser, H.D. and R.E. Stevens (1938) Taeniolite from Magnet Cove, Arkansas. Amer. Mineral., 23, 104–110. (4) La Londe, R.E. (1963) X-ray diffraction data for taeniolite. Amer. Mineral., 48, 204–205. (5) Toraya, H., S. Iwai, F. Marumo, and M. Hirao (1977) The crystal structure of taeniolite, $KLiMg_2Si_4O_{10}F_2$. Zeits. Krist., 146, 73–83. (6) Erd, R.C., G.C. Czamanske, and C.E. Meyer (1983) Taeniolite, an uncommon lithium-mica from Coyote Peak, Humboldt Co., California. Mineral. Record, 14, 39–40.

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Takanelite $(Mn^{2+}, Ca)Mn_4^{4+}O_9 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. Intergrown on a fine scale with other minerals, colloform, banded, nodular massive.

Physical Properties: *Tenacity:* Friable. Hardness = 2.5–3 VHN = 480 (100 g load). D(meas.) = 3.43 D(calc.) = 3.436

Optical Properties: Opaque. *Color:* Steel-gray to black; yellowish gray in reflected light. *Streak:* Brownish black to dark brown. *Luster:* Submetallic to dull. *Optical Class:* Uniaxial. *Pleochroism:* Weak; yellowish white to yellowish light gray. *Anisotropism:* Moderate; yellowish gray to light brownish gray. R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 2.830$–2.843 $c = 7.240$–7.53 $Z = 1$

X-ray Powder Pattern: Nomura mine, Japan; close to ranciéite, variable with hydration. 7.57 (100), 3.765 (25), 2.349 (20), 4.43 (18b), 1.420 (17), 2.462 (15), 2.065 (10)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	3.61		CaO	2.66	3.64
TiO_2	trace		BaO	0.00	
MnO_2	70.39	74.01	Na_2O	0.05	
Al_2O_3	1.70		K_2O	0.05	0.33
Fe_2O_3	1.34	0.26	H_2O^+	4.92	
MnO	13.06	10.42	H_2O^-	2.22	
MgO	0.22	0.59	H_2O		11.50
			Total	100.22	100.75

(1) Nomura mine, Japan; after subtraction of impurity SiO_2, Al_2O_3, Fe_2O_3, H_2O^- and part of H_2O^+ as halloysite, goethite, and quartz, corresponds to $(Mn^{2+}_{0.89}Ca_{0.23}Mg_{0.03})_{\Sigma=1.15}Mn^{4+}_{3.94}O_9 \cdot 1.3H_2O$. (2) Janggun mine, South Korea; by electron microprobe, Mn and H_2O by wet methods; corresponds to $(Mn^{2+}_{0.68}Ca_{0.32}Mg_{0.09}K_{0.04})_{\Sigma=1.13}Mn^{4+}_{3.96}O_9 \cdot 2.97H_2O$.

Polymorphism & Series: Forms a series with ranciéite.

Occurrence: Formed in the oxide zone of a bedded manganese deposit in metamorphosed cherts (Nomura mine, Japan); a secondary mineral derived from alteration of rhodochrosite in a manganese deposit (Janggun mine, South Korea).

Association: Braunite, todorokite, halloysite, goethite, quartz (Nomura mine, Japan); nsutite, pyrolusite (Janggun mine, South Korea).

Distribution: In the Nomura mine, Ehime Prefecture, Japan. From the Janggun mine, Bonghwa district, South Korea. At the Anson Betts mine, Plainfield, Hampshire Co., Massachusetts, and from Marfa, Presidio Co., Texas, USA.

Name: To honor Dr. Katsutoshi Takane (1899–1945), Professor of Mineralogy, Tohoku University, Sendai, Japan.

Type Material: Tohoku University, Sendai, Japan.

References: (1) Nambu, M. and K. Tanida (1971) New mineral takanelite. J. Japan. Assoc. Mineral. Petrol. Econ. Geol., 65, 1–15 (in Japanese with English abs.). (2) (1971) Amer. Mineral., 56, 1487–1488 (abs. ref. 1). (3) Kim, S.J. (1991) New characterization of takanelite. Amer. Mineral., 76, 1426–1430. (4) Kim, S.J. (1993) Chemical and structural variations in rancieite–takanelite solid solution series. Neues Jahrb. Mineral., Monatsh., 233–240.

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Takedaite $Ca_3B_2O_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As granular crystals, to 0.8 mm.

Physical Properties: Hardness = 4.5 VHN = 429–503, 478 average (25 g load).
D(meas.) = 3.10(2) D(calc.) = 3.12

Optical Properties: Semitransparent. *Color:* White to pale gray; colorless in thin section.
Luster: Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.726$ $\epsilon = 1.630$

Cell Data: *Space Group:* $R\overline{3}c$. $a = 8.638(1)$ $c = 11.850(2)$ $Z = 6$

X-ray Powder Pattern: Fuka, Japan.
2.915 (100), 1.895 (75), 2.756 (61), 2.493 (44), 2.044 (21), 2.160 (19), 1.976 (18)

Chemistry:

	(1)	(2)
B_2O_3	28.41	29.27
CaO	71.13	70.73
LOI	0.14	
Total	99.68	100.00

(1) Fuka, Japan; corresponds to $Ca_{3.05}B_{1.96}O_6$. (2) $Ca_3B_2O_6$.

Occurrence: A rare mineral probably formed by boron-rich fluids reacting between crystalline limestone and gehlenite-spurrite skarns.

Association: Frolovite, nifontovite, olshanskyite, pentahydroborite, sibirskite, calcite.

Distribution: From Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: Honors Professor Hiroshi Takeda (1934–), mineralogist, University of Tokyo, Tokyo, Japan.

Type Material: National Science Museum, Tokyo, Japan; National Museum of Natural History, Washington, D.C., USA, 165482.

References: (1) Kusachi, I., C. Henmi, and S. Kobayashi (1995) Takedaite, a new mineral from Fuka, Okayama Prefecture, Japan. Mineral. Mag., 59, 549–552. (2) (1996) Amer. Mineral., 81, 518 (abs. ref. 1).

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Takéuchiite $(Mn^{2+},Mg)_2Mn^{3+}BO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As acicular crystals, to 1 cm, with rhomboidal cross section ⊥ to the dominant form {320}.

Physical Properties: *Fracture:* Uneven. Hardness = ∼6 D(meas.) = n.d. D(calc.) = 3.93

Optical Properties: Opaque. *Color:* Black. *Streak:* Brown. *Luster:* Metallic.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group: Pnnm.* a = 27.585(4) b = 12.561(3) c = 6.027(2) Z = 24

X-ray Powder Pattern: Långban, Sweden.
1.511 (100), 2.60 (90), 5.20 (85), 2.035 (80), 2.73 (70), 2.209 (70), 3.02 (65)

Chemistry:

	(1)
B_2O_3	17.10
Mn_2O_3	35.56
Fe_2O_3	7.43
MnO	8.99
MgO	30.84
TiO_2	0.50
Total	100.42

(1) Långban, Sweden; by electron microprobe, average of 12 analyses of 4 specimens; total Fe as Fe_2O_3, Mn^{3+}:Mn^{2+} derived from crystal-structure analysis; corresponds to $(Mn^{2+}_{1.56}Mg_{0.26}Fe^{3+}_{0.19}Ti^{4+}_{0.01})_{\Sigma=2.02}Mn^{3+}_{0.92}BO_5$.

Occurrence: Very rare in museum specimens from a metamorphosed Fe–Mn orebody.

Association: Dolomite, calcite.

Distribution: From Långban, Värmland, Sweden.

Name: Honors Professor Yoshio Takéuchi (1924–), University of Tokyo, Tokyo, Japan, who predicted the existence of the species and its crystal structure.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; National Museum of Natural History, Washington, D.C., USA, 138548.

References: (1) Bovin, J.-O. and M. O'Keeffe (1980) Takéuchiite, a new oxyborate mineral from Långban, Sweden. Amer. Mineral., 65, 1130–1133. (2) Norrestam, R. and J.-O. Bovin (1987) The crystal structure of takéuchiite, $Mg_{1.71}Mn_{1.29}BO_5$. Zeits. Krist., 181, 135–149. (3) Cooper, M.A. and F.C. Hawthorne (1998) The crystal structure of blatterite, $Sb^{5+}_3(Mn^{3+},Fe^{3+})_9(Mn^{2+},Mg)_{35}(BO_3)_{16}O_{32}$, and structural hierarchy in Mn^{3+}−bearing zigzag borates. Can. Mineral., 36, 1171–1193.

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Takovite $\mathbf{Ni_6Al_2(CO_3,OH)(OH)_{16}\cdot 4H_2O}$

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Crystal Data: Hexagonal. *Point Group:* [$\overline{3}$ 2/m or 3] (by analogy to the hydrotalcite group). Microcrystalline, platy, to 1 μm; commonly in veinlets and massive.

Physical Properties: Hardness = [∼2] D(meas.) = 2.80 D(calc.) = 2.95

Optical Properties: Translucent. *Color:* Bluish green, yellowish green.
Optical Class: Uniaxial (–). ω = 1.602–1.605 ϵ = 1.594–1.598 2V(meas.) = Small.

Cell Data: *Space Group:* [$R\overline{3}m$ or $R3$] (by analogy to the hydrotalcite group).
a = 3.025–3.028 c = 22.45–22.595 Z = 3/8

X-ray Powder Pattern: Takovo, Serbia; very close to comblainite.
7.566 (10), 3.767 (9), 2.552 (9), 1.917 (9), 2.264 (8), 1.510 (8), 1.481 (8)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	10.17	6.2		Na_2O	0.46		
Al_2O_3	20.16	16.0	12.58	K_2O	0.09		
Fe_2O_3	1.78	1.16		H_2O^+	26.60		
NiO	37.24	41.15	55.31	H_2O^-	3.48		
ZnO		0.03		H_2O		25.38	26.68
MgO		0.45		CO_2	n.d.	11.14	5.43
CaO	0.47	0.11		Total	100.45	101.62	100.00

(1) Takovo, Serbia; quartz 10.17%, goethite 2%, and calcite 0.8% considered as impurities. (2) Agnew, Australia; after deduction of SiO_2 impurity, corresponds to $(Ni_{4.94}Fe_{0.13}Mg_{0.10}Ca_{0.02}Al_{2.81})_{\Sigma=8.00}(OH)_{14.42}(CO_3)_{2.27}\cdot 5.42H_2O$. (3) $Ni_6Al_2(OH)_{16}CO_3\cdot 4H_2O$.

Mineral Group: Hydrotalcite group.

Occurrence: In a karstitic bauxite at the contact of limestone and metamorphosed serpentinite (Takovo, Serbia); an alteration product of nickel sulfides (Western Australia).

Association: Gibbsite, allophane (Takovo, Serbia); glaukosphaerite, népouite, gaspéite, paratacamite, nickeloan magnesite, gypsum, (Kambalda, Australia).

Distribution: From Takovo, Serbia. In the Blangvette West mine, Le Thoronet, Var, France. On Mueo, New Caledonia. In Western Australia, at the Carr Boyd Rocks nickel mine; the Agnew nickel deposit, north of Kalgoorlie; from Kambalda, 56 km south of Kalgoorlie; and the Dordie North nickel deposit. In the USA, at Wells Canyon, Oquirrh Mountains, Utah Co., Utah, and at the Alpine mine, Clear Creek, San Benito Co., California.

Name: For Takovo, Serbia, from which it was first described.

Type Material: National Museum of Natural History, Washington, D.C., USA, 136981.

References: (1) Maksimovíc, Z. (1957) Takovite, a new mineral from Takovo, Serbia. Compt. Rend. Soc. serbe Géol, ann. 1955, 219. (2) (1958) Mineral. Abs., 13, 624 (abs. ref. 1). (3) Maksimovic, Z. (1970) Features and genesis of takovite. Zap. Vses. Mineral. Obshch., 99, 595–600 (in Russian). (4) (1972) Amer. Mineral., 57, 1559 (abs. refs. 1 and 3). (5) Nickel, E.H., C.E.S. Davis, M. Bussell, P.J. Bridge, J.G. Dunn, and R.D. MacDonald (1977) Eardleyite [takovite] as a product of the supergene alteration of nickel sulfides in Western Australia. Amer. Mineral., 62, 449–457. (6) Bish, D.L. and G.W. Brindley (1977) A reinvestigation of takovite, a nickel aluminum hydroxy-carbonate of the pyroaurite group. Amer. Mineral., 62, 458–464. (7) Taylor, H.W.F. (1973) Crystal structures of some double hydroxide minerals. Mineral. Mag., 39, 377–389.

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Talc $Mg_3Si_4O_{10}(OH)_2$

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Crystal Data: Triclinic or monoclinic. *Point Group:* $\bar{1}$ or 1; $2/m$. Crystals platy, pseudotrigonal pyramids, to 1 cm; fibrous, fine-grained compact, massive.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Sectile; flexible but not elastic. Hardness = 1 D(meas.) = 2.58–2.83 D(calc.) = [2.78]

Optical Properties: Translucent. *Color:* Light to dark green, brown, white; colorless in thin section. *Streak:* White. *Luster:* Pearly, greasy, dull.
Optical Class: Biaxial (–). *Orientation:* $Y \simeq a$; $Z \simeq b$. *Dispersion:* $r > v$. $\alpha = 1.539$–1.550 $\beta = 1.589$–1.594 $\gamma = 1.589$–1.600 2V(meas.) = 0°–30°

Cell Data: *Space Group:* $P\bar{1}$. $a = 5.291(3)$ $b = 9.460(5)$ $c = 5.290(3)$ $\alpha = 98.68(5)°$ $\beta = 119.90(5)°$ $\gamma = 85.27(5)°$ Z = 2, or *Space Group:* $C2/c$. $a = 5.287$ $b = 9.158$ $c = 18.95$ $\beta = 99.30°$ Z = 4

X-ray Powder Pattern: "Manchuria", China.
9.34 (100), 3.116 (100), 4.66 (90), 2.476 (65), 1.870 (40), 1.527 (40), 4.55 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	60.06	62.16	63.37
Al_2O_3	1.60	0.88	
FeO	1.74	1.41	
MgO	30.83	30.86	31.88
CaO	0.40		
H_2O^+	5.02	4.92	4.75
Total	99.65	100.23	100.00

(1) Parma district, Apennines, Italy; corresponds to $(Mg_{2.94}Fe^{2+}_{0.09}Ca_{0.03})_{\Sigma=3.06}(Si_{3.84}Al_{0.12})_{\Sigma=4.00}O_{10}(OH)_{2.14}$. (2) Malangen, Norway; corresponds to $(Mg_{2.91}Fe^{2+}_{0.07})_{\Sigma=2.98}(Si_{3.94}Al_{0.07})_{\Sigma=4.01}O_{10}(OH)_{2.08}$. (3) $Mg_3Si_4O_{10}(OH)_2$.

Polymorphism & Series: 1A, $2M_1$ polytypes.

Occurrence: In talc-rich schists or steatite through hydrothermal alteration of mafic rocks (steatitization) subsequent to serpentinization during greenschist facies metamorphism. Also formed by thermal low-temperature metamorphism of siliceous dolostones.

Association: Actinolite, tremolite, chlorite, pyroxene, vermiculite, serpentine, anthophyllite, dolomite, calcite.

Distribution: Of widespread occurrence. Some localities for good crystals or pure material include: on Mt. Greiner, Zillertal, Tirol, Austria. At Zermatt, Valais, and St. Gotthard, Ticino, Switzerland. From the Pfitschtal, Trentino-Alto Adige, Italy. At the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France. From Goepfersgruen, Bavaria, Germany. At Snarum, Norway. In the Onotosk deposit, Irkutsk, Siberia, Russia. In the USA, near Fowler, St. Lawrence Co., New York; Delta, York Co., Pennsylvania; Smithfield, Providence Co., Rhode Island; Rochester, Windsor Co., Vermont; Holly Springs, Cherokee Co., Georgia; near San Andreas, Calaveras Co., California.

Name: Probably from the Arabic *talq*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 678–680. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 121–130. (3) Stemple, I.S. and G.W. Brindley (1960) A structural study of talc and talc-tremolite relations. J. Amer. Ceramic Soc., 43, 34–42. (4) Akizuki, M. and J. Zussman (1978) The unit cell of talc. Mineral. Mag., 42, 107–110. (5) Perdikatsis, B. and H. Burzlaff (1981) Strukturverfeinerung am Talk $Mg_3[(OH)_2Si_4O_{10}]$. Zeits. Krist., 156, 177–186 (in German with English abs.).

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Talmessite $Ca_2Mg(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As crystals, to 3 mm; radiating fibrous aggregates, may be stalactitic or in crusts.

Physical Properties: Hardness = [∼5] (by analogy to the fairfieldite group).
D(meas.) = 3.421 D(calc.) = [3.53]

Optical Properties: Semitransparent. *Color:* White, colorless, pale green (nickelian), brownish pink (cobaltian); colorless in transmitted light. *Luster:* [Vitreous].
Optical Class: Biaxial (–). $\alpha = 1.672$ $\beta = 1.685$ $\gamma = 1.698$ 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.874(7)$ $b = 6.943(11)$ $c = 5.537(6)$ $\alpha = 97.3(1)°$ $\beta = 108.7(1)°$ $\gamma = 108.1(2)°$ Z = 1

X-ray Powder Pattern: Talmessi mine, Iran; nearly identical to roselite-beta.
3.07 (100), 2.77 (100), 3.21 (80), 5.09 (60), 3.56 (60), 1.717 (60), 4.62 (40)

Chemistry:

	(1)	(2)
As_2O_5	47.7	54.94
NiO	0.8	
MgO	7.5	9.64
CaO	29.5	26.81
BaO	3.2	
H_2O	6.7	8.61
Total	95.4	100.00

(1) Talmessi mine, Iran; Ba and excess Ca [as carbonate?] probably impurities; after removal stated to correspond to $Ca_{2.00}(Mg_{0.97}Ni_{0.06})_{\Sigma=1.03}(AsO_4)_{2.06} \cdot 1.84H_2O$.
(2) $Ca_2Mg(AsO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Forms a series with gaitite.

Mineral Group: Fairfieldite group.

Occurrence: A rare secondary species formed typically in the oxidized zone of some hydrothermal mineral deposits, an alteration product of realgar, orpiment, or Cu–Ni arsenides.

Association: Gaitite, erythrite, annabergite, picropharmacolite, pharmacolite, austinite, fluorite, barite, aragonite, calcite, dolomite.

Distribution: From the Talmessi mine, 35 km west of Anarak, Iran. In the Arhbar (Aghbar) and Aït Ahmane mines, Bou Azzer district, Morocco. From Tsumeb, Namibia. In the USA, at the Gold Hill mine, Tooele Co., Utah: in a cave in Peach Springs Canyon, Mohave Co., Arizona. From Gomez Palacio, Durango, Mexico. At Cross Creek, near Savona, British Columbia, Canada. From Lucéram, Alpes-Maritimes, France. At Stelzing, Austria. In Russia, from the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, and several other undefined localities.

Name: For the Talmessi mine, Iran, in which the mineral was first found.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England.

References: (1) Bariand, P. and P. Herpin (1960) Un arséniate de calcium et de magnésium, isomorphe de la β rosélite. Bull. Minéral., 83, 118–121 (in French). (2) (1960) Amer. Mineral., 45, 1315 (abs. ref. 1). (3) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésiens naturels. Bull. Minéral., 87, 169–211 (in French). (4) Yakhontova, L.K. (1968) Magnesium-calcium and calcium arsenates from the oxidation zone of an arsenide deposit. Trudy Mineral. Muzeya, Akad. Nauk SSSR, 18, 154–167 (in Russian). (5) Catti, M., G. Ferraris, and G. Ivaldi (1977) Hydrogen bonding in the crystalline state. Structure of talmessite, $Ca_2(Mg,Co)(AsO_4)_2 \cdot 2H_2O$, and crystal chemistry of related minerals. Bull. Minéral., 100, 230–236.

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Talnakhite $Cu_9(Fe,Ni)_8S_{16}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As narrow laths, to 2 mm; typically in massive intergrowths with other Cu–Fe sulfides.

Physical Properties: Hardness = n.d. VHN = 261–277 (50 g load). D(meas.) = 4.29 D(calc.) = 4.36

Optical Properties: Opaque. *Color:* Chalcopyrite-yellow, tarnishes rapidly to hues of pink and brown.
R: (400) —, (420) —, (440) —, (460) 22.4, (480) 24.7, (500) 30.0, (520) 32.7, (540) 35.4, (560) 37.5, (580) 38.8, (600) 39.8, (620) 39.6, (640) 40.8, (660) 41.1, (680) 41.8, (700) 41.6

Cell Data: *Space Group:* $I\bar{4}3m$ (probable). $a = 10.59(1)$ $Z = 2$

X-ray Powder Pattern: Talnakh area, Russia.
3.06 (100), 1.873 (90), 1.599 (70), 1.079 (60), 2.64 (50), 1.213 (50), 1.019 (50)

Chemistry:

	(1)	(2)
Cu	37.15	36.8
Fe	29.1	29.8
Ni	0.75	0.7
S	33.31	34.0
Total	100.31	101.3

(1) Talnakh area, Russia; by electron microprobe, average of five analyses; corresponds to $Cu_{9.00}(Fe_{8.03}Ni_{0.20})_{\Sigma=8.20}S_{16.00}$. (2) Noril'sk, Russia; by electron microprobe, corresponds to $Cu_{8.74}(Fe_{8.05}Ni_{0.16})_{\Sigma=8.21}S_{16.00}$.

Occurrence: In concentrations of up to 70% in zones to 12 m thick, in hydrothermal ores (Talnakh area, Russia); in the layered ultramafic Stillwater complex (Nye, Montana, USA); a component of undersea black smokers.

Association: Chalcopyrite, cubanite, djerfisherite, pentlandite, valleriite or mackinawite, magnetite, Ag–Au alloy, Pd–Pb alloy (Talnakh area, Russia).

Distribution: In Russia, from the Norilsk-I [TL] and Talnakh deposits [TL], Talnakh area, Noril'sk region, western Siberia. At Strachimir, Bulgaria. From the Filizchai deposit, Azerbaijan. In the Axial Rift Valley, Red Sea. At Nye, Stillwater Co., Montana, USA. In the Horoman peridotite, Hokkaido, Japan. From the Zhilingtou Au–Ag deposit, Zhejiang Province, China.

Name: For the Talnakh area, Russia, where it occurs.

Type Material: Mining Institute, St. Petersburg, 103a/1–5; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69836–69839; Canadian Museum of Nature, Ottawa; Royal Ontario Museum, Toronto, Canada, M29419; National Museum of Natural History, Washington, D.C., USA, 121944.

References: (1) Bud'ko, I.A. and E.A. Kulagov (1968) The new mineral talnakhite, a cubic variety of chalcopyrite. Zap. Vses. Mineral. Obshch., 97, 63 (in Russian). (2) (1970) Amer. Mineral., 55, 2135 (abs. ref. 1). (3) Cabri, L.J. and D.C. Harris (1971) New compositional data for talnakhite, $Cu_{18}(Fe,Ni)_{16}S_{32}$. Econ. Geol., 66, 673–675. (4) Cabri, L.J. (1972) Mooihoekite and haycockite, two new copper–iron sulfides and their relationship to chalcopyrite and talnakhite. Amer. Mineral., 57, 689–708. (5) Hall, S.R. and E.J. Gabe (1972) The crystal structure of talnakhite, $Cu_{18}Fe_{16}S_{32}$. Amer. Mineral., 57, 368–380. (6) Putnis, A. (1978) Talnakhite and mooihoekite: The accessibility of ordered structures in the metal-rich region around chalcopyrite. Can. Mineral., 16, 23–30. (7) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 548. (8) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 201–202.

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Tamarugite $NaAl(SO_4)_2 \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tabular {010} or short prismatic [001] crystals, with a multiplicity of additional forms, to 1 mm; may be fibrous or fine granular. *Twinning:* Reportedly polysynthetic.

Physical Properties: *Cleavage:* {010}, perfect. Hardness = ∼3 D(meas.) = 2.06(1) D(calc.) = 2.066 Soluble in H_2O, sweet astringent taste.

Optical Properties: Transparent. *Color:* Colorless; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 4°–5°$. $\alpha = 1.484(1)$ $\beta = 1.486(1)$ $\gamma = 1.497(1)$ 2V(meas.) = ∼60°

Cell Data: *Space Group:* $P2_1/a$. $a = 7.353(2)$ $b = 25.225(5)$ $c = 6.097(2)$ $\beta = 95.2(1)°$ $Z = 4$

X-ray Powder Pattern: Cerro Pintados, Chile.
4.223 (100), 4.207 (80), 3.647 (59), 3.964 (32), 2.899 (23), 3.153 (21), 12.54 (16)

Chemistry:

	(1)	(2)
SO_3	45.66	45.72
Al_2O_3	14.48	14.56
CaO	0.20	
Na_2O	9.04	8.85
Cl	0.12	
H_2O	30.86	30.87
$-O = Cl_2$	[0.03]	
Total	[100.33]	100.00

(1) Cerro Pintados, Chile; original total 100.36% (2) $NaAl(SO_4)_2 \cdot 6H_2O$.

Occurrence: A secondary mineral in oxidized sulfide-bearing alkali-rich aluminous rocks, with sodium supplied from hydrothermal solutions or sea-spray; as efflorescences in active geothermal systems; may be formed by reaction between acid sulfate solutions or fumarolic gas and wall rock.

Association: Pickeringite, coquimbite, quenstedtite, sideronatrite, mendozite, kröhnkite, halite, alunogen, meta-alunogen, potassium alum, epsomite, halotrichite, halite, gypsum, anhydrite.

Distribution: In Chile, from Cerro Pintados, 80 km southeast of Iquique, Tarapacá; in Antofagasta, at the Compania mine, eight km south of Sierra Gorda; from Alcaparrosa, near Cerritos Bayos, southwest of Calama; at Chuquicamata, and Quetena, west of Calama; in Atacama, at Tierra Amarilla, southeast of Copiapó. In Italy, in the Alum Cave, Vulcano, Lipari Islands; at the Furtei gold mine, Sardinia; from the Cetine mine, near Rosia, Tuscany, and at the Grotta dello Zolfo, Cape Miseno, Campania. In the Skouriotissa mine, Cyprus. At Compton Chine, Isle of Wight. From Saghand, Yazd, Iran. At the Myoban hot spring, Beppu, Oita Prefecture, Japan. From Anglesea, Victoria, Australia. In the Te Kopia geothermal area, New Zealand. On St. Bartholomew Island, West Indies. In the USA, near Eureka, St. Louis Co., and at Fulton, Calloway Co., Missouri. A number of other occurrences are known.

Name: For the originally-noted occurrence at Cerro Pintados, in the Tamarugal Pampa, Chile.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 466–468. (2) Robinson, P.D., J.H. Fang, and F.D. Bloss (1966) Cell dimensions and space group of tamarugite. Amer. Mineral., 51, 1805–1807. (3) Robinson, P.D. and J.H. Fang (1969) Crystal structure and mineral chemistry of double-salt hydrates: I. Direct determination of the crystal structure of tamarugite. Amer. Mineral., 54, 19–30.

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Tancoite $HNa_2LiAl(PO_4)_2(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, typically equant to tabular {010}, elongated along [001], with {001}, {010} {100}, {021}, {111}, to 1 mm, and in subparallel [001] druses.

Physical Properties: *Cleavage:* On {010} and {100}, fair. *Fracture:* Conchoidal.
Hardness = 4–4.5 D(meas.) = 2.752 D(calc.) = 2.724

Optical Properties: Transparent. *Color:* Colorless to pale pink; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = z$; $Z =$ a. *Dispersion:* $r < v$, weak.
$\alpha = 1.541(2)$ $\beta = 1.563(2)$ $\gamma = 1.564(2)$ 2V(meas.) = 23(2)° 2V(calc.) = 24°

Cell Data: *Space Group: Pbcb.* $a = 6.948(2)$ $b = 14.089(4)$ $c = 14.065(3)$ Z = 8

X-ray Powder Pattern: Tanco mine, Canada.
4.672 (100), 3.150 (100), 3.413 (90), 2.479 (90), 1.760 (40), 1.438 (40), 1.429 (40)

Chemistry:

	(1)	(2)
P_2O_5	50.1	49.31
Al_2O_3	18.3	17.71
CaO	0.5	
Li_2O	5.2	5.19
Na_2O	20.0	21.53
H_2O	6.8	6.26
Total	100.9	100.00

(1) Tanco mine, Canada; Li by AA, H_2O by DTA-TGA-EGA analysis, presence of $(OH)^{1-}$ and absence of H_2O confirmed by IR; corresponds to $H_{1.13}Na_{1.82}Li_{0.98}Ca_{0.03}Al_{1.01}(P_{1.00}O_4)_2(OH)$.
(2) $HNa_2LiAl(PO_4)_2(OH)$.

Occurrence: In cavities in dump material from a complex granite pegmatite.

Association: Lithiophosphate, apatite, spodumene, cookeite, barite, calcite, quartz.

Distribution: From the Tanco mine, Bernic Lake, Manitoba, Canada.

Name: For the Tanco mine, Canada, its original locality.

Type Material: University of Manitoba, Winnipeg, Manitoba, M5533, M5534; Royal Ontario Museum, Toronto, M36416–8; Canadian Museum of Nature, Ottawa, Canada, 42900; The Natural History Museum, London, England, 1980,52; National School of Mines, Paris, France; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; 1980,52; Harvard University, Cambridge, Massachusetts, 117129; National Museum of Natural History, Washington, D.C., USA, 146284, 146893.

References: (1) Ramik, R.A., B.D. Sturman, P.J. Dunn, and A.S. Povarennykh (1980) Tancoite, a new lithium sodium aluminum phosphate from the Tanco pegmatite, Bernic Lake, Manitoba. Can. Mineral., 18, 185–190. (2) (1981) Amer. Mineral., 66, 1278 (abs. ref. 1).
(3) Hawthorne, F.C. (1983) The crystal structure of tancoite. Tschermaks Mineral. Petrog. Mitt., 31, 121–135.

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Taneyamalite $\mathbf{Na(Mn^{2+}, Mg, Fe^{2+})_{12}Si_{12}(O, OH)_{44}}$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. As needlelike crystals, elongated along [001], to 250 μm; in irregular crinkled flakes and subparallel aggregates.

Physical Properties: *Cleavage:* Perfect to good on (010), fair on (100). Hardness = 5–6
D(meas.) = 3.30 D(calc.) = 3.25–3.34.

Optical Properties: Translucent. *Color:* Greenish gray-yellow. *Streak:* Light yellow, brown. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = colorless to pale golden yellow; Y = colorless to yellowish brown; Z = pale yellow to dark brown. *Absorption:* $Z > Y \geq X$.
α = 1.646–1.697 β = 1.664–1.720 γ = 1.676–1.732 2V(meas.) = ∼70°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. a = 10.188–10.198 b = 9.754–9.820 c = 9.485–9.567
$\alpha = 90°30'–90.43°$ $\beta = 70°32'–71.02°$ $\gamma = 108°34'–109.17°$ Z = 1

X-ray Powder Pattern: Taneyama mine, Japan.
9.155 (100), 3.252 (37), 2.774 (24), 7.948 (22), 2.202 (21), 2.665 (18), 3.067 (17)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	43.42	40.32	CaO	0.02	0.53
TiO_2	0.75	0.05	Na_2O	1.80	1.63
Al_2O_3	1.25	2.08	K_2O	0.00	0.10
Fe_2O_3	6.39	8.68	H_2O^+		6.99
FeO		11.88	H_2O^-		0.73
MnO	30.97	23.83	H_2O	[7.61]	
MgO	6.25	2.50	Total	[98.46]	99.32

(1) Iwaizawa mine, Japan; by electron microprobe, total Fe as Fe_2O_3, H_2O calculated to give (O+OH) = 44; corresponds to $(Na_{0.96}Ca_{0.01})_{\Sigma=0.97}(Mn^{2+}_{7.20}Mg_{2.58}Fe^{3+}_{1.33}Al_{0.41}Ti_{0.16})_{\Sigma=11.68}Si_{12.00}[O_{29.98}(OH)_{14.02}]_{\Sigma=44.00}$. (2) Taneyama mine, Japan; corresponds to $(Na_{0.91}Ca_{0.16}K_{0.04})_{\Sigma=1.11}(Mn^{2+}_{5.78}Fe^{2+}_{2.85}Fe^{3+}_{1.87}Mg_{1.07}Al_{0.26})_{\Sigma=11.83}(Si_{11.55}Al_{0.44}Ti_{0.01})_{\Sigma=12.00}[O_{30.63}(OH)_{13.37}]_{\Sigma=44.00}$.

Occurrence: In cracks in ferruginous chert, mafic rocks, and limestone subjected to blueschist facies metamorphism (Taneyama mine, Japan); in bedded manganese ores in weakly metamorphosed chert and greenstone of the prehnite-pumpellyite metagraywacke facies (Iwaizawa mine, Japan).

Association: Quartz, hematite, chamosite (Taneyama mine, Japan); caryopilite, bannisterite, braunite, rhodochrosite, calcite, albite, cinnabar, pyrite (Iwaizawa mine, Japan).

Distribution: In the Taneyama mine, Kumamoto Prefecture, and the Iwaizawa mine, near Agano, Saitama Prefecture, Japan. From Brezovia, Yugoslavia. In the USA, from Ward Creek, near Cazadero, and along the Russian River, Sonoma Co., and Pacheco Pass, Santa Clara Co., California.

Name: For the Taneyama mine, Japan, where the mineral was first noted.

Type Material: Department of Geology, Kyushu University, Hakozaki; Sakurai Museum, Tokyo; National Science Museum, Tokyo, Japan; National Museum of Natural History, Washington, D.C., USA, 142945.

References: (1) Aoki, Y., H. Akasako, and K. Ishida (1981) Taneyamalite, a new manganese silicate mineral from the Taneyama mine, Kumamoto Prefecture, Japan. Mineral. J. (Japan), 10, 385–395. (2) Matsubara, S. (1981) Taneyamalite, $(Na, Ca)(Mn^{2+}, Mg, Fe^{3+}, Al)_{12}Si_{12}(O, OH)_{44}$, a new mineral from the Iwaizawa mine, Saitama Prefecture, Japan. Mineral. Mag., 44, 51–53. (3) (1981) Amer. Mineral., 66, 1101 (abs. ref. 2).

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Tangeite $CaCu(VO_4)(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Rare crystals are short prismatic, with acute terminations, to 3 mm; typically in scaly crystal rosettes and aggregates; botryoidal to spheroidal, fibrous, as crusts; massive.

Physical Properties: *Cleavage:* {010}, perfect; {001}, good. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 3.75 D(calc.) = [3.84]

Optical Properties: Transparent. *Color:* Greenish yellow, gray, siskin-green, dark green, olive-green; pale green in transmitted light. *Luster:* Vitreous, pearly on the cleavage. *Optical Class:* Biaxial (–). *Pleochroism:* $X = Y$ = brown; Z = green. *Orientation:* $X = a$; $Y = b$. *Dispersion:* $r > v$, strong. α = 2.00–2.01 β = 2.01–2.05 γ = 2.02–2.09 2V(meas.) = 83°–90°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.45$ $b = 9.26$ $c = 5.91$ Z = 4

X-ray Powder Pattern: Tyuya-Muyun, Kyrgyzstan.
2.88 (100), 2.61 (100), 4.15 (75), 3.14 (60), 1.61 (60), 5.86 (40), 3.73 (40)

Chemistry:

	(1)	(2)		(1)	(2)
U_3O_8	trace		CuO	33.29	33.77
V_2O_5	38.45	38.60	CaO	22.69	23.81
SiO_2	0.20		H_2O	3.90	3.82
Al_2O_3	0.50		Total	99.13	100.00
Fe_2O_3	0.10				

(1) Tyuya-Muyun, Kyrgyzstan. (2) $CaCu(VO_4)(OH)$.

Polymorphism & Series: Forms a series with conichalcite.

Mineral Group: Adelite group.

Occurrence: A rare secondary mineral in vanadium-bearing mineral deposits in sandstone.

Association: Calcite, barite, malachite (Tyuya-Muyun, Kyrgyzstan); rhodonite, quartz, pyrobelonite, chalcocite, neotocite, copper (Molinello mine, Italy); malachite, chrysocolla, tyuyamunite, chalcopyrite, pyrite, "limonite" (Garnet Ridge, Arizona, USA).

Distribution: From the Tyuya-Muyun Cave, Fergana Valley, Alai Range, Kyrgyzstan. Well-crystallized at the Molinello manganese mine, near Chiavari, Val Graveglia, Liguria, Italy. In the USA, from near Uranium, Roc Creek, Paradox Valley, at the Pluto mine, Bull Canyon, Uravan district, Montrose Co., and in the Shirley May mine, Garo district, Park Co., Colorado; from the Richardson district, Moab Valley, Grand Co., and in the Whirlwind mine, Monument Valley, San Juan Co., Utah; in Arizona, from Monument Valley, on Garnet Ridge, Apache Co., and at the Monument No. 1 mine, Navajo Co., and in the Copper Queen mine, New Water Mountains, Yuma Co.; from the Mammoth copper mine, Grindstone Creek, Glenn Co., California. At Menzies Bay, Vancouver Island, British Columbia, Canada. From the west side of Lake Torrens, Stuart Shelf, South Australia. From Luiswishi, Katanga Province, Congo (Shaba Province, Zaire). Large crystals from the Lueca vanadium mines, Angola. A few other minor localities are known, some requiring modern confirmation.

Name: For its initially noted occurrence in the Tange Gorge, Fergana Valley, Alai Range, Kyrgyzstan.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, m6065, m6066, m6068.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 817–818 [calciovolborthite = tangeite, part]. (2) Basso, R., A. Palenzona, and L. Zefiro (1989) Crystal structure refinement of a Sr-bearing term related to copper vanadates and arsenates of adelite and descloizite groups. Neues Jahrb. Mineral., Monatsh., 300–308. (3) Basso, R. and L. Zefiro (1994) Mineral nomenclature: status of calciovolborthite and tangeite. Neues Jahrb. Mineral., Monatsh., 205–208.

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Tantalaeschynite-(Y) $(Ca, Y, Ce)(Ta, Ti, Nb)_2O_6$

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Crystal Data: Orthorhombic; metamict. *Point Group:* [$2/m$ $2/m$ $2/m$] [by analogy to aeschynite-(Y)]. Crystals, prismatic ‖ [001], to 5.6 cm, showing {010}, {001}, {110}, {130}.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5.5–6 VHN = 657–673 (100 g load). D(meas.) = 5.75–6.13, on impure material. D(calc.) = 6.39 Radioactive.

Optical Properties: Transparent. *Color:* Brownish black to black; in thin section, yellow-orange; in reflected light, dark gray with abundant white to dark red internal reflections. *Streak:* Pale yellowish brown. *Luster:* Resinous.
Optical Class: Isotropic.
R: (470) 14.5, (546) 14.2, (589) 14.0, (650) 14.0

Cell Data: *Space Group:* [*Pmnb*.] $a = 7.38$ $b = 10.97$ $c = 5.34$ Z = [4]

X-ray Powder Pattern: Raposa pegmatite, Brazil; after heating in air at 1300 °C.
3.00 (10), 2.94 (10), 1.581 (7), 2.65 (5), 1.70 (5), 1.86 (4)

Chemistry:

	(1)		(1)
Nb_2O_5	18.7	Nd_2O_3	1.9
Ta_2O_5	39.3	Sm_2O_3	0.6
TiO_2	11.7	Gd_2O_3	0.6
ThO_2	6.5	Dy_2O_3	0.4
UO_2	0.4	Er_2O_3	0.4
Y_2O_3	4.6	Yb_2O_3	0.7
La_2O_3	1.3	Fe_2O_3	0.9
Ce_2O_3	3.7	CaO	6.2
Pr_2O_3	0.6	Total	98.5

(1) Raposa pegmatite, Brazil; by electron microprobe, corresponding to $(Ca_{0.47}Y_{0.17}Ce_{0.10}RE_{0.14}Th_{0.10}U_{0.01})_{\Sigma=0.99}(Ta_{0.75}Ti_{0.62}Nb_{0.60}Fe_{0.05})_{\Sigma=2.02}O_6$.

Polymorphism & Series: Forms a series with aeschynite-(Y).

Occurrence: In a pegmatite.

Association: Quartz, microcline, biotite, columbite, beryl.

Distribution: In the Raposa pegmatite, near São José do Sabugí, Paraíba, Brazil.

Name: For an *aeschynite* with TANTALum greater than titanium in the composition and with *yttrium* as the dominant rare-earth element.

Type Material: Department of Geosciences, University of Brasilia, Brasilia, Brazil, NT-52; Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands, NT-52.

References: (1) Adusumilli, M.S., C. Kieft, and E.A.J. Burke (1974) Tantal-aeschynite, a new mineral of the aeschynite group from the Borborema region, north-eastern Brazil. Mineral. Mag., 39, 571–576. (2) (1974) Amer. Mineral., 59, 1331–1332 (abs. ref. 1).

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Tantalcarbide $(Ta, Nb)C$

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Crystal Data: Orthorhombic; metamict. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals indistinct, tabular, to 5 cm, with {100} and {110} striated.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 5.77–5.87 D(calc.) = n.d. Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Brownish black to chestnut-brown; amber-yellow in thin fragments. *Luster:* Resinous.
Optical Class: Isotropic. n = n.d.
R: n.d.

Cell Data: *Space Group: Pbcn.* $a = 14.574(3)$ $b = 5.555(1)$ $c = 5.184(3)$ Z = 4

X-ray Powder Pattern: Craveggia, Italy; after heating at 1000 °C in air.
3.12 (10), 2.87 (7), 2.67 (3), 2.52 (3), 2.28 (1), 2.15 (1)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	3.35	4.16	Ce_2O_3	7.22	9.54
Nb_2O_5	3.83	15.27	Fe_2O_3	1.18	1.53
Ta_2O_5	47.31	22.95	Bi_2O_3		0.04
SiO_2	0.90	0.13	MnO	0.35	0.28
TiO_2	14.17	21.05	PbO	trace	1.71
SnO_2	0.14	0.44	CaO	2.22	0.97
ThO_2	trace	2.86	Na_2O	trace	
Al_2O_3		0.31	LOI	2.40	2.24
$(Y, Er)_2O_3$	17.48	16.36	Total	100.55	99.84

(1) Cooglegong, Australia. (2) Woodstock, Australia.

Occurrence: A detrital mineral in tin placers (Western Australia); in a granite pegmatite (Craveggia, Italy).

Association: Strüverite, columbite, ilmenite, tourmaline, spessartine, beryl, allanite, monazite, xenotime (Craveggia, Italy).

Distribution: From Eleys, 16 km south of Cooglegong, and at Woodstock, Pilbara district, Western Australia. From Piano del Lavonchio, near Craveggia, Val Vigezzo, Piedmont, Italy. At Ituri, Haut-Congo Province, Congo (Haut-Zaire Province, Zaire).

Name: For its relation to *euxenite*, with TANTalum greater than niobium.

Type Material: Western Australian Museum, Perth, Australia, S392A; Natural History Museum, Paris, France, 128.223; The Natural History Museum, London, England, 1928,340–341.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 787–792 [euxenite–polycrase, part], 808 [delorenzite]. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 341–343 [delorenzite = tanteuxenite-(Y)]. (3) De Pol, C. and L. Vescovi Minutti (1967) Ricerche roentgenografiche sulla tanteuxenite de Craveggia (delorenzite di Zambonini). Rend. Soc. Ital. Mineral. Petrol., 23, 31–45 (in Italian).

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Crystal Data: Orthorhombic; metamict. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals indistinct, tabular, to 5 cm, with {100} and {110} striated.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 5.77–5.87 D(calc.) = n.d. Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Brownish black to chestnut-brown; amber-yellow in thin fragments. *Luster:* Resinous.
Optical Class: Isotropic. n = n.d.
R: n.d.

Cell Data: *Space Group: Pbcn.* $a = 14.574(3)$ $b = 5.555(1)$ $c = 5.184(3)$ $Z = 4$

X-ray Powder Pattern: Craveggia, Italy; after heating at 1000 °C in air.
3.12 (10), 2.87 (7), 2.67 (3), 2.52 (3), 2.28 (1), 2.15 (1)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	3.35	4.16	Ce_2O_3	7.22	9.54
Nb_2O_5	3.83	15.27	Fe_2O_3	1.18	1.53
Ta_2O_5	47.31	22.95	Bi_2O_3		0.04
SiO_2	0.90	0.13	MnO	0.35	0.28
TiO_2	14.17	21.05	PbO	trace	1.71
SnO_2	0.14	0.44	CaO	2.22	0.97
ThO_2	trace	2.86	Na_2O	trace	
Al_2O_3		0.31	LOI	2.40	2.24
$(Y, Er)_2O_3$	17.48	16.36	Total	100.55	99.84

(1) Cooglegong, Australia. (2) Woodstock, Australia.

Occurrence: A detrital mineral in tin placers (Western Australia); in a granite pegmatite (Craveggia, Italy).

Association: Strüverite, columbite, ilmenite, tourmaline, spessartine, beryl, allanite, monazite, xenotime (Craveggia, Italy).

Distribution: From Eleys, 16 km south of Cooglegong, and at Woodstock, Pilbara district, Western Australia. From Piano del Lavonchio, near Craveggia, Val Vigezzo, Piedmont, Italy. At Ituri, Haut-Zaire Province, Congo (Zaire).

Name: For its relation to *euxenite*, with TANTalum greater than niobium.

Type Material: The Natural History Museum, London, England, 1928,340–341.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 787–792 [euxenite–polycrase, part], 808 [delorenzite]. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 341–343 [delorenzite = tanteuxenite-(Y)]. (3) De Pol, C. and L. Vescovi Minutti (1967) Ricerche roentgenografiche sulla tanteuxenite de Craveggia (delorenzite di Zambonini). Rend. Soc. Ital. Mineral. Petrol., 23, 31–45 (in Italian).

Tantite Ta_2O_5

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Crystal Data: Triclinic. *Point Group:* n.d. Massive, as veinlets and lenses in microlite, to 0.05 mm.

Physical Properties: Hardness = n.d. VHN = 1300 (20 g load). D(meas.) = n.d. D(calc.) = 8.45 Weak blue cathodoluminescence.

Optical Properties: Transparent. *Color:* Colorless; grayish white in reflected light.
Luster: Adamantine.
Optical Class: Biaxial. *Anisotropism:* Observed.
R_1–R_2: (486) 17.5–16.5, (551) 17.2–15.4, (589) 17.1–15.3, (656) 15.4–14.2

Cell Data: *Space Group:* n.d. $a = 3.80$ (2) $b = 3.79(2)$ $c = 35.74(4)$ $\alpha = 90.92°$ $\beta = 90.18°$ $\gamma = 90°$ Z = 6

X-ray Powder Pattern: Mt. Vasin-Myl'k, Russia.
3.01 (10b), 1.844 (9b), 1.573 (8), 2.429 (5), 1.004 (5), 1.360 (4), 3.98 (3)

Chemistry:

	(1)
Nb_2O_5	1.36
Ta_2O_5	98.28
TiO_2	0.08
Total	99.72

(1) Mt. Vasin-Myl'k, Russia; by electron microprobe, corresponding to $(Ta_{1.95}Nb_{0.04})_{\Sigma=1.99}O_5$.

Occurrence: In a granite pegmatite cutting amphibolites (Mt. Vasin-Myl'k, Russia); in a highly fractionated pegmatite (Animikie Red Ace pegmatite, Wisconsin, USA).

Association: Microlite, stibiotantalite, holtite (Mt. Vasin-Myl'k, Russia); manganotantalite, wodginite, tantalian manganotantalite, elbaite (Animikie Red Ace pegmatite, Wisconsin, USA).

Distribution: From Mt. Vasin-Myl'k, Voron'i massif, Kola Peninsula, Russia. In the Animikie Red Ace pegmatite, Pine River, Florence Co., Wisconsin, USA.

Name: For TANTalum in the composition.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5770; Mining Institute, St. Petersburg, 1683/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82545.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, and G.A. Perlina (1983) Tantite Ta_2O_5 – a new mineral from granitic pegmatites of the Kola Peninsula. Mineral. Zhurnal, 5(3), 90–93 (in Russian with English abs.). (2) (1984) Amer. Mineral., 69, 1193 (abs. ref. 1). (3) Falster, A.U., W.B. Simmons, and K.L. Webber (1993) Niobium-tantalum minerals from the Animikie Red Ace pegmatite, Florence County, Wisconsin. Geol. Soc. Amer., Abs. with Prog., 25, 216 (abs.).

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Taramellite $\mathbf{Ba_4(Fe^{3+},Ti,Fe^{2+},Mg)_4(B_2Si_8O_{27})O_2Cl_x}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Tabular to equidimensional crystals; as fibrous aggregates and massive.

Physical Properties: *Cleavage:* Perfect on {100}; parting $\perp$ {100}. Hardness = 5.5 D(meas.) = 3.92 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Reddish brown. *Luster:* Vitreous to silky. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; $X = Y$ = pale pinkish to flesh-red; Z = dark brown to nearly black. *Dispersion:* $r > v$, distinct. $\alpha = 1.770(3)$ $\beta = 1.774(3)$ $\gamma = 1.83(2)$ 2V(meas.) = 40(3)°

Cell Data: *Space Group: Pmmn.* $a = 12.05$–12.22 $b = 13.90$–14.00 $c = 7.12$–7.14 $Z = 2$

X-ray Powder Pattern: Candoglia, Italy. (ICDD 17-479).
3.01 (100), 2.584 (55), 3.83 (50), 2.480 (45), 3.30 (40), 3.16 (40), 2.783 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	33.9	30.29	CaO	1.1	0.15
TiO_2	7.7		BaO	37.5	33.93
B_2O_3	n.d.	5.03	Na_2O	0.8	
Fe_2O_3	12.2	20.19	K_2O	0.1	
FeO	3.7		Cl	n.d.	1.08
MnO		0.17	H_2O^+	2.1	
PbO		8.50	$-O = Cl_2$		0.24
MgO	0.8		Total	99.9	99.10

(1) Candoglia, Italy; B and Cl are known to be essential to the structure. (2) Långban, Sweden; by electron and ion microprobe, Al_2O_3 0.10%; corresponds to $(Ba_{3.43}Pb_{0.59})_{\Sigma=4.02}(Fe^{3+}_{3.92}Ca_{0.04}Mn_{0.04})_{\Sigma=4.00}B_{2.24}Si_{7.82}O_{29}Cl_{0.48}$.

Polymorphism & Series: Forms a series with titantaramellite.

Occurrence: In metamorphic rocks rich in barium silicates, in contact with granitic rocks (Candoglia, Italy); in a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Calcite, diopside, actinolite, celsian, magnetite, chalcopyrite, pyrite (Candoglia, Italy); quartz, calcite, hematite, barylite, barite, manganoan pectolite, potassic feldspar, manganoan garnet, melanotekite, barian hedyphane, rhodonite, manganoan aegirine (Långban, Sweden).

Distribution: From Candoglia, Valle de Toce, Piedmont, Italy. At Långban, Värmland, Sweden.

Name: For Torquato Taramelli (1845–1922), Italian geologist.

Type Material: Natural History Museum, Paris, France, 109.1005.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 103. (2) Mazzi, F. (1957) Riesame della taramellite. Atti. Soc. Toscana Sci. Nat., 64, 237–245 (in Italian). (3) (1959) Amer. Mineral., 44, 469–470 (abs. ref. 2). (4) Mazzi, F. and G. Rossi (1980) The crystal structure of taramellite. Amer. Mineral., 65, 123–128. (5) Alfors, J.T. and A. Pabst (1984) Titanian taramellites in western North America. Amer. Mineral., 69, 358–373. (6) Grew, E.S., M.G. Yates, D.I. Belakovskiy [Belakovskii], R.C. Rouse, S.-C. Su, and N. Marquez (1994) Hyalotekite from reedmergnerite-bearing peralkaline pegmatite, Dara-i-Pioz, Tajikistan, and from Mn skarn, Långban, Sweden: a new look at an old mineral. Mineral. Mag., 58, 285–297.

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Taramite $Na[NaCa][(Fe^{2+},Mg)_3Al_2](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 10 cm; as grains and rims on other amphiboles.

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 3.231–3.476 D(calc.) = 3.384

Optical Properties: Semitransparent. *Color:* Black, black with tinges of blue or green, deep blue-green; pale yellow or blue-green in thin section. *Luster:* [Vitreous.] *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = pale to light yellow, pale brown; Y = deep blue-green, greenish blue; Z = deep blue, green, black, deep gray-green. *Orientation:* $X \simeq a$; $Y \simeq c$; $Z = b$. *Absorption:* $Z > Y \gg X$. $\alpha = 1.705(3)$ $\beta = 1.713(4)$ $\gamma = 1.715(3)$ 2V(meas.) = ∼53.7°

Cell Data: *Space Group:* $C2/m$. $a = 9.923(1)$ $b = 18.134(2)$ $c = 5.352(1)$ $\beta = 104.84(1)°$ Z = 2

X-ray Powder Pattern: Mbozi complex, Tanzania.
3.15 (100), 8.53 (70), 2.732 (50), 2.605 (30), 2.347 (30), 1.447 (30), 3.29 (25)

Chemistry:

	(1)	(2)	(3)
SiO_2	37.51	38.56	39.05
TiO_2	0.73	0.96	1.56
Al_2O_3	8.50	10.31	9.98
Fe_2O_3	11.41	13.12	10.98
FeO	23.21	18.72	18.36
MnO	1.70	1.91	1.38
MgO	0.56	1.24	3.76
CaO	7.91	5.78	6.94
Na_2O	3.79	4.71	4.56
K_2O	2.10	2.73	1.88
F	0.14	0.30	
Cl		0.15	
H_2O^+	2.32	1.66	1.81
H_2O^-	0.33	0.00	
$-O = (F,Cl)_2$	0.06	0.16	
Total	100.15	99.99	100.26

(1) Vali-Tarama Valley, Ukraine. (2) Mbozi complex, Tanzania; corresponds to $(Na_{1.47}K_{0.56})_{\Sigma=2.03}Ca_{1.00}(Fe^{2+}_{2.52}Fe^{3+}_{1.59}Mg_{0.30}Mn_{0.26}Al_{0.15}Ti_{0.11})_{\Sigma=4.93}(Si_{6.20}Al_{1.80})_{\Sigma=8.00}O_{22.03}[(OH)_{1.78}F_{0.15}Cl_{0.04}]_{\Sigma=1.97}$. (3) Bancroft, Canada; corresponds to $(Na_{1.40}Ca_{1.18}K_{0.38})_{\Sigma=2.96}(Fe^{2+}_{2.43}Fe^{3+}_{1.31}Mg_{0.89}Ti_{0.19}Mn_{0.18}Al_{0.04})_{\Sigma=5.04}(Si_{6.18}Al_{1.82})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with magnesiotaramite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) < 0.5$; $(Na + K)_A \geq 0.5$; 0.67 Na_B 1.33; $(Ca + Na)_B \geq 1.34$; $Si < 6.5$.

Occurrence: In sodium-metasomatized alkalic gneisses and nepheline syenite dikes; in eclogite metamorphosed to the amphibolite facies.

Association: Nepheline, aegirine, oligoclase, microcline, nyböite.

Distribution: From the Vali-Tarama Valley, near Mariupol (Zhdanov), Ukraine. From near Miass, Ilmen Mountains, Southern Ural Mountains, Russia. In China, near Lanshantou, Jianchang, Jiangsu Province. At the Mbozi syenite gabbro complex, 80 km southwest of Mbeya, Tanzania. From the Darkainle complex, Borama district, northwest Hargeisa, Somali Republic. In Canada, in the York River area, Bancroft, Ontario.

Name: For the type locality, the Vali-Tarama Valley, Ukraine.

Type Material: National Museum of Natural History, Washington, D.C., USA, R3259, 95477.

References: (1) Morozewicz, J. (1925) Über einige Eisenalkali-amphibole. Tschermaks Mineral. Petrog. Mitt., 38, 210–222 (in German). (2) (1926) Amer. Mineral., 11, 219 (abs. ref. 1). (3) Brock, P.W.G., D.C. Gellatly, and O. von Knorring (1964) Mboziite, a new sodic amphibole end-member. Mineral. Mag., 33, 1057–1065. (4) Hawthorne, F.C. and H.D. Grundy (1978) The crystal chemistry of the amphiboles. VII. The crystal structure and site chemistry of potassian ferri-taramite. Can. Mineral., 16, 53–62.

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Taranakite $(K,Na)_3(Al,Fe^{3+})_5(PO_4)_2(PO_3OH)_6 \cdot 18H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Pseudohexagonal platy crystals, rarely to 0.5 mm; typically in compact nodular aggregates, pulverulent, powdery, flourlike to claylike, massive.

Physical Properties: *Tenacity:* Unctuous. Hardness = Very soft. D(meas.) = 2.12–2.15 D(calc.) = 2.12

Optical Properties: Transparent. *Color:* White, gray, yellowish white; colorless in transmitted light.
Optical Class: Uniaxial (–). $\omega = 1.506$–1.510 $\epsilon = 1.500$–1.503

Cell Data: *Space Group:* $R\overline{3}c$ (synthetic). $a = 8.7025(11)$ $c = 95.05(1)$ $Z = 6$

X-ray Powder Pattern: Apulian Cave PU 38, Italy.
15.82 (100), 3.82 (40), 3.14 (31), 3.36 (29), 7.47 (28), 3.59 (22), 7.92 (18)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	42.32	41.88	42.30	K_2O	7.09	8.43	10.53
Al_2O_3	19.03	17.48	18.99	H_2O	31.10	28.43	28.18
Fe_2O_3	0.42	1.67		insol.		0.37	
Na_2O		1.28		Total	99.96	99.54	100.00

(1) Onino-Iwaya Cave, Japan; by gravimetry and flame photometry; corresponds to $H_{7.09}K_{1.97}(Al,Fe)_{4.98}(PO_4)_8 \cdot 19.7H_2O$. (2) Castellana Cave, Italy. (3) $K_3Al_5(PO_4)_2(PO_3OH)_6 \cdot 18H_2O$.

Occurrence: Formed from phosphatic solutions derived from bird or bat guano reacting with clays or aluminous rocks under perenially damp conditions; the most common phosphate mineral in caves.

Association: Vashegyite, leucophosphite, minyulite, francoanellite, brushite, ardealite, strengite, variscite, vivianite.

Distribution: From the Sugarloaves, near New Plymouth, Taranaki Peninsula, New Zealand. On Réunion Island, Indian Ocean; Island Leones, Patagonia, Argentina; King George Island, Maritime Antarctic. In Australia, in the Russenden Cave, Queensland; the Skipton lava tube caves, 40 km southwest of Ballarat, Victoria; in caves at Mimegarra, Western Australia; and the Jenolan Caves, New South Wales. In the Yangsue Posayen Cave, 20 km south of Guilin, Guangxi Province, China. From the Niah Great Cave, Sarawak, Malaysia. In the Onino-Iwaya Cave, Hiroshima Prefecture, Japan. From the Tour Combes Cave, near Oran, Algeria. In Etienne's Cave, and well-crystallized in Christmas Cave, Transvaal, South Africa. From the Bacho Kuo Cave, Bulgaria. In the Minerva Grotto, Fauzan, Hérault, France. In Italy, in the Castellana Cave, south of Bari, Puglia; on Monte Alburno, near Controne, Salerno. In the USA, in the Pig Hole Cave, Giles Co., Virginia; and the Low Water Bridge Cave, Greene Co., Missouri. Additional localities are known.

Name: For its first recognized occurrence on the Taranaki Peninsula, New Zealand.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 999–1000. (2) Smith, J.P. and W.E. Brown (1959) X-ray studies of aluminum and iron phosphates containing potassium or ammonium. Amer. Mineral., 44, 138–142. (3) Balenzano, F., L. Dell'Anna, and M. Di Pierro (1974) Ricerche mineralogische su alcuni fosfati rinvenuti nelle grotte di Castellana (Bari): strengite alluminifera, vivianite, taranakite, brushite e idrossiapatite. Rend. Soc. Ital. Mineral. Petrol., 30, 543–573 (in Italian). (4) Sakae, T. and T. Sudo (1975) Taranakite from the Onino-Iwaya Limestone Cave at Hiroshima Prefecture, Japan: a new occurrence. Amer. Mineral., 60, 331–334. (5) Fiore, S. and R. Laviano (1991) Brushite, hydroxylapatite, and taranakite from Apulian caves (southern Italy): new mineralogical data. Amer. Mineral., 76, 1722–1727. (6) Dick, S., U. Gossner, A. Weiss, C. Robl, G. Grossman, G. Ohms, and T. Zeiske (1998) Taranakite – the mineral with the longest crystallographic axis. Inorg. Chi. Acta, 269, 47–57.

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Tarapacáite K_2CrO_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rarely as thick tabular {001} crystals; typically disseminated granular. *Twinning:* As pseudohexagonal trillings on {011}.

Physical Properties: *Cleavage:* On {010} and {100}, distinct. Hardness = n.d. D(meas.) = 2.74 (synthetic). D(calc.) = 2.735 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Bright canary-yellow.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r > v$, weak.
$\alpha = 1.687$ $\beta = 1.722$ $\gamma = 1.731$ 2V(meas.) = 52°

Cell Data: *Space Group:* *Pnam* (synthetic). $a = 7.662(1)$ $b = 10.391(1)$ $c = 5.919(1)$
Z = 4

X-ray Powder Pattern: Synthetic.
3.078 (100), 2.988 (75), 2.960 (40), 2.479 (25), 2.286 (25), 2.599 (22), 2.570 (21)

Chemistry: (1) Analyses of natural material are lacking; identification depends on coincidence of optical and X-ray data with synthetic material.

Occurrence: A minor accessory mineral in nitrate deposits.

Association: Lopezite, dietzeite.

Distribution: In Chile, in nitrate caliche deposits throughout the Atacama Desert, as at the Oficina Maria Elena, near Tocopilla, Antofagasta, and Zapiga, Tarapacá.

Name: For its first noted occurrence in the Tocopilla Pampa, 170 km north of Antofagasta, Tarapacá, Chile.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 644-645. (2) Pistorius, C.W.F.T. (1962) Phase relations of some potassium compounds to very high pressures. Z. Physik. Chem., 35, 109–121. (3) McGinnety, J.A. (1972) Redetermination of the structures of potassium sulphate and potassium chromate: the effect of electrostatic crystal forces upon observed bond lengths. Acta Cryst., 28, 2845–2858. (4) Toriumi, K. and Y. Saito (1978) Electron-density distribution in crystals of α−K_2CrO_4. Acta Cryst., 34, 3149–3156.

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Tarbagataite $(K,\square)_2(Ca,Na)(Fe^{2+},Mn)_7Ti_2(Si_4O_{12})_2O_2(OH)_4(OH,F)$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As lamellar intergrowths with astrophyllite to 0.2 mm.

Physical Properties: *Cleavage*: Perfect on {001}, moderate on {010}. *Fracture*: n.d. *Tenacity*: Elastic. Hardness = 3 D(meas.) = n.d. D(calc.) = 3.263

Optical Properties: Transparent. *Color*: Brown to pale golden brown. *Streak*: Colorless to pale yellow. *Luster*: Vitreous to pearly.
Optical Class: Biaxial (+). α = 1.710(3) β = 1.715(3) γ = 1.745(3) 2V(meas.) = 37(3)° 2V(calc.) = 45° *Pleochroism*: *X* = yellow-brown, *Y* = orange-red, *Z* = yellow-orange.
Absorption: *X* < *Z* < *Y*. *Orientation*:

	a	*b*	*c*
X	89.5°	165.6°	58.5°
Y	94.8°	95.4°	147.0°
Z	4.8°	103.3°	98.9°

Cell Data: *Space Group*: $P\bar{1}$. *a* = 5.3868(6) *b* = 11.9141(6) *c* = 11.7171(2) α = 112.978(2)° β = 94.641(2)° γ = 103.189(2)° Z = 1

X-ray Powder Pattern: Verkhnee Espe deposit, Tarbagatai mountain range, Kazakhstan.
3.258 (100), 4.095 (80), 2.858 (80), 2.761 (70), 3.497 (50), 2.560 (50), 3.735 (30)

Chemistry:

	(1)		(1)		(1)
Nb_2O_5	2.98	ZnO	0.12	Cs_2O	0.38
SnO_2	1.20	FeO	18.71	Rb_2O	1.28
ZrO_2	0.32	MnO	15.48	Na_2O	1.14
TiO_2	9.29	MgO	0.83	F	0.49
SiO_2	36.11	CaO	2.58	$-O=F_2$	0.21
Al_2O_3	0.12	K_2O	2.67	H_2O	3.11
				Total	96.60

(1) Verkhnee Espe deposit, Tarbagatai mountain range, Kazakhstan; average of multiple electron microprobe analyses, H_2O calculated from structure analysis; corresponding to $(K_{0.76}Rb_{0.18}Na_{0.12}Cs_{0.04}\square_{0.90})_{\Sigma=2}(Ca_{0.62}Na_{0.38})_{\Sigma=1}(Fe^{2+}_{3.51}Mn_{2.94}Mg_{0.28}Zr_{0.02}Zn_{0.02}\square_{0.23})_{\Sigma=7}(Ti_{1.57}Nb_{0.30}Sn_{0.11}Zr_{0.02})_{\Sigma=2}(Si_{8.09}Al_{0.03})_{\Sigma=8.12}O_{30.65}H_{4.65}F_{0.35}$.

Mineral Group: Astrophyllite group.

Occurrence: In pegmatite veins and fenite associated with alkaline granitic massifs.

Association: Astrophyllite, microcline, albite, quartz, aegirine, kupletskite, zircon, thorite, xenotime, fergusonite, fersmite, euxenite-(Y), ilmenite, columbite-(Mn), zinc pyrophanite, keiviite, thalenite-(Y), cappelenite-(Y), eudialyte, jinshajiangite, milarite, helvite, bertrandite, bavenite.

Distribution: From the Verkhnee Espe deposit, northern part of the Tarbagatai mountain range, Akjailyautas Mountains, Kazakhstan.

Name: For the Tarbagatai mountain range where the Verkhnee Espe deposit that produced the first specimens is located.

Type Material: Geological Museum, Satpaev Institute of Geological Sciences, Almaty, Kazakhstan (# 3009/2010).

References: (1) Stepanov, A.V., G.K. Bekenova, V.L. Levin, E. Sokolova, F.C. Hawthorne, and E.A. Dobrovol'skaya (2012) Tarbagataite, $(K,\square)_2(Ca,Na)(Fe^{2+},Mn)_7Ti_2(Si_4O_{12})_2O_2(OH)_4(OH,F)$, a new astrophyllite-group mineral species from the Verkhnee Espe deposit, Akjailyautas Mountains, Kazakhstan: Description and crystal structure. Can. Mineral., 50(1), 159-168. (2) (2014) Amer. Mineral., 99, 2156-2157 (abs. ref. 1).

Tarbuttite $Zn_2(PO_4)(OH)$

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Crystal Data: Triclinic, pseudocubic. *Point Group:* $\overline{1}$. Crystals typically equant to short prismatic, complex, with many forms, to 2 cm; in sheaflike or saddle-shaped aggregates; as crusts.

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* Uneven. Hardness = 3.5–4 D(meas.) = 4.19 D(calc.) = 4.21

Optical Properties: Transparent to translucent. *Color:* Colorless, pale yellow, may be brown, red, or green; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* X (7°,58°); Y (159°,25°); Z (−86°,80°) [using (ϕ,ρ)]. *Dispersion:* Strong. $\alpha = 1.659$–1.660 $\beta = 1.683$–1.705 $\gamma = 1.702$–1.713 2V(meas.) = 50°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.499$ $b = 5.654$ $c = 6.465$ $\alpha = 102°51'$ $\beta = 102°46'$ $\gamma = 86°50'$ Z = 2

X-ray Powder Pattern: Kabwe, Zambia. (ICDD 36-410).
6.17 (100), 2.058 (30), 2.782 (25), 3.697 (20), 2.882 (19), 2.980 (12), 2.971 (12)

Chemistry:

	(1)	(2)	(3)
SO_3		0.01	
P_2O_5	29.2	30.3	29.24
SiO_2		0.06	
FeO		0.02	
MnO		0.01	
ZnO	66.6	66.9	67.05
MgO		0.03	
CaO		0.04	
H_2O	3.8	[2.6]	3.71
Total	99.6	[100.0]	100.00

(1) Kabwe, Zambia; corresponds to $Zn_{1.98}(PO_4)_{0.99}(OH)_{1.02}$. (2) Reaphook Hill, Australia; by electron microprobe, average of ten analyses; corresponds to $Zn_{1.96}(PO_4)_{0.96}(OH)_{0.70}$. (3) $Zn_2(PO_4)(OH)$.

Occurrence: An uncommon secondary mineral in the oxidized zone of zinc-bearing deposits.

Association: Hopeite, hemimorphite, smithsonite, parahopeite, hydrozincite, scholzite, cerussite, pyromorphite, descloizite, vanadinite, "limonite".

Distribution: From Kabwe (Broken Hill), Zambia. In the Lueca vanadium mines, Angola. From the Kef Semmah mine, near Sétif, Algeria. In Australia, on Reaphook Hill, near Blinman, Flinders Ranges, South Australia; at Broken Hill, New South Wales. In the Hudson Bay mine, Salmo, British Columbia, Canada. At an undefined locality in Guangdong Province, China.

Name: Honoring Percy Coventry Tarbutt, Director of the Broken Hill Exploration Company, who early provided material for characterization.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 869–871. (2) Cocco, G., L. Fanfani, and P.F. Zanazzi (1966) The crystal structure of tarbuttite. Zeits. Krist., 123, 321–329. (3) Hill, R.J. and A.R. Milnes (1974) Phosphate minerals from Reaphook Hill, Flinders Ranges, South Australia. Mineral. Mag., 39, 684–695.

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Tarkianite $(Cu,Fe)(Re,Mo)_4S_8$

Crystal Data: Isometric. *Point Group:* $\bar{4}$ 3m. As equant grains to 0.5 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5.5-6 VHN = 537–584 (15 g load). D(meas.) = n.d. D(calc.) = 7.30

Optical Properties: Opaque. *Color:* Black; light gray in reflected light in air, brownish gray in oil. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.
R_{air}-R_{oil}: (470) 38.02- 20.91, (546) 38.87- 21.76, (589) 39.18- 21.84, (650) 39.30- 22.12

Cell Data: *Space Group: $F\bar{4}3m$.* a = 9.563(1) Z = 4

X-ray Powder Pattern: Hitura mine, Nivala, west-central Finland.
5.531 (100), 2.885 (90), 2.389 (90), 1.841 (90), 1.690 (80), 2.194 (70), 1.952 (60)

Chemistry:

	(1)
Fe	0.59
Ni	0.09
Co	0.08
Cu	5.48
Mo	12.32
Re	53.61
Os	0.84
S	26.77
Total	99.78

(1) Hitura mine, Nivala, west-central Finland; average of 34 electron microprobe analyses, corresponding to $(Cu_{0.83}Fe_{0.10}Ni_{0.02}Co_{0.01})_{\Sigma=0.96}(Re_{2.79}Mo_{1.22}Os_{0.04})_{\Sigma=4.03}S_{8.01}$.

Occurrence: In a heavy mineral concentrate derived from a serpentinized, disseminated sulfide and PGM-bearing, ultramafic intrusion.

Association: Pentlandite, chromite, pyrrhotite, valleriite, chalcopyrite, cubanite, mackinawite, sperrylite, michenerite, irarsite, froodite, hollingworthite.

Distribution: From the Hitura mine, 13 km south of Nivala, west-central Finland and the Stillwater complex, Montana, USA. Other reported occurrences are the Coldwell complex, Ontario, Canada; the Lukkulaisvaara complex, Karelia, and Monchegorsk, Kola Peninsula, Russia; Ekojoki, Finland, and two localities in Sweden.

Name: Honors Prof. Mahmud Tarkian (b. 1941) of the University of Hamburg, Germany, who earlier described an occurrence of the mineral.

Type Material: Finnish Museum of Natural History, Geological Museum, University of Helsinki, Finland; C4001.

References: (1) Kojonen, K.K., A.C. Roberts, O.-P. Isomäki, V.F. Knauf, B. Johanson, and L. Pakkanen (2004) Tarkianite, $(Cu,Fe)(Re,Mo)_4S_8$, a new mineral species from the Hitura mine, Nivala, Finland. Can. Mineral., 42, 539–544. (2) (2005) Amer. Mineral., 90, 273 (abs. ref. 1).

Tassieite $(Na,\square)Ca_2(Mg,Fe^{2+},Fe^{3+})_2(Fe^{3+},Mg)_2(Fe^{2+},Mg)_2(PO_4)_6\cdot 2H_2O$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As platy grains with irregular outline, to 1 mm.

Physical Properties: *Cleavage*: Perfect to good on {100} and on a second direction at 60° to the first. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.45

Optical Properties: Transparent. *Color*: Dark green. *Streak*: Light green. *Luster*: Vitreous. *Optical Class:* Biaxial (+). α = 1.712(2) β = 1.713(2) γ = 1.722(2) 2V(meas.) = 46(1)° 2V(calc.) = 37° *Dispersion*: Very weak. *Pleochroism*: Strong; *X* = dark blue, *Y* = blue, *Z* = light brown. *Absorption*: *X* > *Y* >> *Z*.

Cell Data: *Space Group*: *Pbca*. *a* = 12.4588(14) *b* = 11.5974(13) *c* = 12.7506(15) Z = 4

X-ray Powder Pattern: Stornes Peninsula, Larsemann Hills, Prydz Bay, East Antarctica.
2.735 (100), 3.000 (80), 2.895 (80), 3.497 (40), 2.091 (30), 2.545 (10), 6.40 (5)

Chemistry:

	(1)		(1)
SiO_2	0.01	CaO	11.56
P_2O_5	44.54	SrO	0.02
SO_3	0.06	Y_2O_3	0.26
MgO	10.95	Ce_2O_3	0.08
MnO	0.38	Yb_2O_3	0.13
FeO	25.40	UO_2	0.04
FeO	[14.93]	F	0.04
Fe_2O_3	[11.63]	H_2O	[3.78]
Na_2O	1.96	Total	100.34

(1) Stornes Peninsula, Larsemann Hills, Prydz Bay, East Antarctica; average of electron microprobe analyses, Fe^{2+}: Fe^{3+} and H_2O calculated from stoichiometry; corresponding to $Na_{0.60}Ca_{1.96}Mg_{2.59}Mn_{0.05}Fe^{2+}_{1.98}Fe^{3+}_{1.39}Y_{0.02}Yb_{0.01}S_{0.01}P_{5.98}O_{24}\cdot 2H_2O$.

Mineral Group: Wicksite group, with Mg-dominant in the M1 structural site.

Occurrence: A late-stage, low-temperature mineral formed by hydrothermal alteration of stornesite-(Y), wagnerite and fluorapatite in the core of a fluorapatite nodule in regionally metamorphosed and fractured gneissic rocks.

Association: Stornesite-(Y), wagnerite, fluorapatite, xenotime-(Y), mélonjosephite, monazite-(Ce).

Distribution: From between Johnston Fjord and Tassie Tarn, Stornes Peninsula, Larsemann Hills, Prydz Bay, East Antarctica.

Name: For a lake, Tassie Tarn, near the site from which the first specimens were collected.

Type Material: National Museum of Natural History, Washington, D.C., USA, (NMNH 174436).

References: (1) Grew, E.S., T. Armbruster, O. Medenbach, M.G. Yates, and C.J. Carson (2007) Tassieite, $(Na,\square)Ca_2(Mg,Fe^{2+},Fe^{3+})_2(Fe^{3+},Mg)_2(Fe^{2+},Mg)_2(PO_4)_6\cdot 2H_2O$, a new hydrothermal wicksite group mineral in fluorapatite nodules from granulite-facies paragneiss in the Larsemann Hills, Prydz Bay, East Antarctica. Can. Mineral., 45, 293-305. (2) (2007) Amer. Mineral., 92, 1778-1779 (abs. ref. 1).

Tatarskite $Ca_6Mg_2(SO_4)_2(CO_3)_2Cl_4(OH)_4 \cdot 7H_2O$

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Crystal Data: Orthorhombic (probable). *Point Group:* n.d. As coarsely crystalline masses, to 3 cm.

Physical Properties: *Cleavage:* Two sets of distinct pinacoidal cleavages. Hardness = 2.5 D(meas.) = 2.341 D(calc.) = n.d. Soluble in boiling H_2O.

Optical Properties: Transparent. *Color:* Colorless to very pale yellow. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* Positive elongation, parallel extinction. $\alpha = 1.567(2)$ $\beta = 1.654(2)$ $\gamma = 1.722(2)$ 2V(meas.) = n.d. 2V(calc.) = 83°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Chelkar salt dome, Kazakhstan.
2.967 (10), 2.625 (9), 5.34 (8), 2.004 (8), 2.917 (7), 1.585 (7), 2.522 (6)

Chemistry:

	(1)	(2)
SO_3	15.45	17.09
CO_2	9.60	9.39
SiO_2	0.23	
Al_2O_3	0.25	
MgO	6.78	8.60
CaO	36.32	35.90
Na_2O	1.22	
K_2O	0.78	
F	0.10	
Cl	14.84	15.13
H_2O	17.00	17.30
$-O = (F, Cl)_2$	3.35	3.41
Total	[99.22]	100.00

(1) Chelkar salt dome, Kazakhstan; original total given as 99.61%, stated to correspond to $Ca_{6.14}Mg_{1.60}(K, Na)_{0.26}(SO_4)_2(CO_3)_2Cl_4(OH)_4 \cdot 7H_2O$. (2) $Ca_6Mg_2(SO_4)_2(CO_3)_2Cl_4(OH)_4 \cdot 7H_2O$.

Occurrence: A rare secondary mineral found in drill core in a marine salt deposit.

Association: Anhydrite, halite, bischofite, magnesite, hilgardite.

Distribution: From the Chelkar salt dome, Ak-saĭ Valley, Uralsk district, Kazakhstan.

Name: Honors Professor Vitalii Borisovich Tatarskii (1907–1993), mineralogist, St. Petersburg University, St. Petersburg, Russia.

Type Material: Mining Institute, St. Petersburg, 948/1-2; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 79820.

References: (1) Lobanova, V.V. (1963) The new mineral tatarskite. Zap. Vses. Mineral. Obshch., 92, 697–702 (in Russian). (2) (1964) Amer. Mineral., 49, 1151–1152 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 206.

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Tatyanaite $(Pt, Pd, Cu)_9Cu_3Sn_4$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

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Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Tausonite $SrTiO_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Cubes and cubo-octahedra, to 2 mm, and granular, massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6–6.5
D(meas.) = 4.88 D(calc.) = 4.83–4.86

Optical Properties: Semitransparent. *Color:* Ruby-red, brownish red, dark reddish brown, gray; white in reflected light. *Luster:* Adamantine.
Optical Class: Isotropic; may be weakly anisotropic. $n = 2.40$

Cell Data: *Space Group:* $Pm3m$. a = 3.905–3.913 Z = 1

X-ray Powder Pattern: Murun massif, Russia.
2.761 (100), 1.952 (50), 1.5941 (30), 2.254 (18), 1.3805 (15), 1.2346 (10), 1.0436 (10)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5	trace	0.13		Fe_2O_3	1.80	1.22	
SiO_2	5.00	2.20		MnO	0.04	trace	
TiO_2	44.60	43.40	43.53	MgO	0.10	0.11	
ZrO_2	0.00	0.07		CaO	2.36	2.76	
Al_2O_3	0.70	trace		SrO	42.00	39.26	56.47
La_2O_3	trace	2.23		BaO	1.60	0.40	
Ce_2O_3	trace	4.10		Na_2O	1.22	2.16	
Nd_2O_3	trace	0.91		K_2O	0.82	0.22	
				Total	100.24	[99.17]	100.00

(1) Murun massif, Russia; after deducting impurities corresponds to $(Sr_{0.85}Ca_{0.02}Ba_{0.02}Na_{0.02}K_{0.02})_{\Sigma=0.93}TiO_3$. (2) Do.; original total given as 99.18%; corresponds to $(Sr_{0.70}Na_{0.10}Ce_{0.05}Ca_{0.03}La_{0.02}Nd_{0.01}K_{0.01})_{\Sigma=0.92}Ti_{1.00}O_3$. (3) $SrTiO_3$.

Mineral Group: Perovskite group.

Occurrence: In aegirine-kalsilite rock in an alkalic massif (Murun massif, Russia); in a rheomorphic fenite dike in a carbonatite complex (Sarambi, Paraguay).

Association: Aegirine, kalsilite, potassic feldspar, titanite, magnetite, lamprophyllite, barium lamprophyllite, wadeite, batisite, anatase (Murun massif, Russia).

Distribution: From the Murun massif, southwest of Olekminsk, Sakha, Russia. In the Sarambi carbonatite complex, about 27 km northeast of Sarambi, Paraguay.

Name: To honor Academician Lev Vladimirovich Tauson (1917–1989), Russian geochemist, Director of the Geochemical Institute, Irkutsk, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Vorob'ev, E.I., A.A. Konev, Y.V. Malyshonok, G.F. Afonina, and A.N. Sapozhnikov (1984) Tausonite, $SrTiO_3$, a new mineral of the perovskite group. Zap. Vses. Mineral. Obshch., 113, 86–89 (in Russian). (2) (1985) Amer. Mineral., 70, 218 (abs. ref. 1). (3) (1985) Mineral. Abs., 36, 94 (abs. ref. 1).

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Tavorite $LiFe^{3+}(PO_4)(OH)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals, {100}, {010}, {001}, to 5 mm; commonly very fine-grained, massive, in veinlets, disseminated, and thin films.

Physical Properties: Hardness = n.d. D(meas.) = 3.32 D(calc.) = 3.33

Optical Properties: Semitransparent. *Color:* Greenish yellow, grass-green, bright apple-green. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = yellow-green; Z = colorless. *Orientation:* $X \wedge a \simeq 15°$; $Y \wedge b \simeq 0°$; $Z \wedge c \simeq 38°$. *Dispersion:* $r > v$, strong. $\alpha = 1.795(5)$ $\beta = 1.81(1)$ $\gamma = 1.86(1)$ 2V(meas.) = 50(2)° 2V(calc.) = 59°

Cell Data: *Space Group:* $P\overline{1}$. $a = 5.340(2)$ $b = 7.283(2)$ $c = 5.110(2)$ $\alpha = 109.29(2)°$ $\beta = 97.86(3)°$ $\gamma = 106.32(3)°$ Z = 2

X-ray Powder Pattern: Sapucaia mine, Brazil.
3.045 (10), 3.285(9), 4.99 (5), 2.474 (4), 4.68 (3), 1.662 (3b), 3.95 (2)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	39.78	40.61	Li_2O	7.64	8.55
Fe_2O_3	42.57	45.69	H_2O^+	5.76	5.15
FeO	2.39		H_2O^-	0.40	
MnO	1.47		Total	100.01	100.00

(1) Sapucaia mine, Brazil; corresponds to $(Li_{0.90}Fe^{2+}_{0.06}Mn^{2+}_{0.04})_{\Sigma=1.00}Fe^{3+}_{0.94}(PO_4)_{0.99}(OH)_{1.13}$.
(2) $LiFe(PO_4)(OH)$.

Mineral Group: Amblygonite group.

Occurrence: A secondary oxidation product of earlier phosphates in complex zoned granite pegmatites.

Association: Barbosalite, heterosite, ferrisicklerite, triphylite, huréaulite, rockbridgeite, jahnsite, vivianite.

Distribution: In Brazil, in the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, and the Énio pegmatite mine, northeast of Galiléia, Minas Gerais; from near Pedra Lavrda, Paraíba. In the USA, in the Palermo #1 and Fletcher mines, near North Groton, Grafton Co., New Hampshire; in South Dakota, from the Custer Mountain, Hot Shot, Elkhorn, Bull Moose, Hesnard, Linwood, and White Elephant mines; good crystals from the Tip Top mine, 8.5 km southwest of Custer, Custer Co. At Hagendorf, Bavaria, Germany. In the Buranga pegmatite, Gatumba district, Rwanda. In Namibia, from the Tsaobismund pegmatite, 60 km south of Karibib, and at the Sandamap pegmatite, west of Usakos. From Jebilet, Morocco. In the Mangualde pegmatite, near Mesquitela, Portugal. Undoubtedly to be recognized at additional localities.

Name: To honor Dr. Elysiario Tavora (1911–), Professor of Mineralogy, University of Brazil, Rio de Janeiro, Brazil.

Type Material: National Museum, Rio de Janeiro, Brazil; The Natural History Museum, London, England, 1965,209; Harvard University, Cambridge, Massachusetts, 107298 and 107299; National Museum of Natural History, Washington, D.C., USA, 106842.

References: (1) Lindberg, M.L. and W.T. Pecora (1955) Tavorite, and barbosalite, two new phosphate minerals from Minas Gerais, Brazil. Amer. Mineral., 40, 952–966. (2) Roberts, A.C., P.J. Dunn, J.D. Grice, D.E. Newbury, and W.L. Roberts (1988) The X-ray crystallography of tavorite from the Tip Top pegmatite, Custer, South Dakota. Powder Diffraction, 3(2), 93–95. (3) Genkina, E.A., Y.K. Kabalov, B.A. Maksimov, and O.K. Mel'nikov (1984) The crystal structure of synthetic tavorite $LiFe[PO_4](OH, F)$. Kristallografiya (Sov. Phys. Crystal.), 29, 50–55 (in Russian).

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Tazheranite $(Zr, Ti, Ca)O_2$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$, $\bar{4}3m$, or 432. Anhedral crystals, thick tabular, may be rounded, to 1.5 mm, and as irregular grains.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7.5
D(meas.) = 5.01(2) D(calc.) = [5.03]

Optical Properties: Semitransparent. *Color:* Yellowish orange to reddish orange, rarely cherry-red, then zoned, brownish green; in thin section, pale yellow, zoned with a reddish tint.
Luster: Adamantine to greasy on fractures.
Optical Class: Isotropic; may exhibit weak to strong anisotropism, centrally zoned. $n = 2.25(2)$

Cell Data: *Space Group:* $Fm3m$, $F\bar{4}3c$, or $F432$. $a = 5.108(1)$ $Z = 4$

X-ray Powder Pattern: Tazheran massif, Russia.
2.94 (10), 1.804 (10), 1.539 (10), 2.55 (6), 1.171 (5), 1.044 (5), 0.9828 (5)

Chemistry:

	(1)
SiO_2	0.63
TiO_2	2.42
ZrO_2	67.67
Ti_2O_3	11.65
Al_2O_3	4.61
Fe_2O_3	0.92
MgO	2.38
CaO	9.97
Total	100.25

(1) Tazheran massif, Russia; after deduction of spinel 5.41% and forsterite 1.48%, corresponds to $(Zr_{0.59}Ca_{0.19}Ti^{3+}_{0.18}Ti^{4+}_{0.03}Al_{0.02}Fe_{0.02})_{\Sigma=1.03}O_{1.74}$.

Occurrence: In calciphyres banding periclase-brucite marble xenoliths in an alkalic massif (Tazheran massif, Russia).

Association: Spinel, forsterite, åkermanite–gehlenite, clinohumite, ludwigite, azoproite, magnesioferrite, calzirtite, baddeleyite, geikielite, perovskite, rutile, zircon, dolomite, calcite (Tazheran massif, Russia).

Distribution: In the Tazheran alkalic massif, west of Lake Baikal, eastern Siberia, Russia. On Alnö Island, Sweden. From the Jacupiranga carbonatite, São Paulo, Brazil.

Name: For the Tazheran massif, Russia, where it was first noted.

Type Material: Mining Institute, St. Petersburg, 1094/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72602, vis5748; National Museum of Natural History, Washington, D.C., USA, 145796.

References: (1) Konev, A.A., Z.F. Ushchapovskaya, A.A. Kashaev, and V.S. Lebedeva (1969) Tazheranite, a new calcium-titanium-zirconium mineral. Doklady Acad. Nauk SSSR, 186, 917–920 (in Russian). (2) (1970) Amer. Mineral., 55, 318 (abs. ref. 1). (3) Kashaev, A.A. and Z.F. Ushchapovskaya (1969) Tazheranite – a mineral with CaF_2−type structure. Kristallografiya (Sov. Phys. Crystal.), 14, 1064–1065 (in Russian). (4) Neder, R.B., F. Frey, and H. Schulz (1990) Defect structure of zirconia ($Zr_{0.85}Ca_{0.15}O_{1.85}$) at 290 and 1550 K. Acta Cryst., A46, 799–809.

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Teallite $PbSnS_2$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals thin tabular on {001} with nearly square section, to 1 cm; lateral faces striated ‖ their intersection with {001}, and with striations on {001} ‖ [110]. More commonly as massive aggregates of thin, graphitelike folia having irregular edges; warped or bent crystals typical. *Twinning:* Seen only in polished section.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Flexible, somewhat malleable. Hardness = 1.5 VHN = n.d. D(meas.) = 6.36 D(calc.) = 6.567

Optical Properties: Opaque. *Color:* Grayish black, may tarnish dull or iridescent; in polished section, white with slight yellow tint. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak; in white with pale golden tint, and pure white. *Anisotropism:* Distinct to rather high.
R_1–R_2: (400) 39.8–43.7, (420) 40.4–44.0, (440) 41.0–44.3, (460) 41.6–44.4, (480) 42.0–44.5, (500) 42.3–44.4, (520) 42.5–44.3, (540) 42.5–44.1, (560) 42.4–43.8, (580) 42.2–43.5, (600) 41.8–43.1, (620) 41.5–42.6, (640) 41.0–42.2, (660) 40.5–41.7, (680) 40.0–41.3, (700) 39.6–40.9

Cell Data: *Space Group: Pbnm.* $a = 4.266(3)$ $b = 11.419(7)$ $c = 4.090(2)$ Z = 2

X-ray Powder Pattern: Montserrat, Bolivia.
2.84 (100), 3.41 (60), 1.419 (50), 3.27 (40), 2.33 (40), 2.03 (40), 1.090 (40)

Chemistry:

	(1)	(2)
Pb	52.09	53.13
Fe	0.17	
Sn	30.55	30.43
S	16.91	16.44
Total	[99.72]	100.00

(1) Santa Rosa mine, Bolivia; recalculated after deduction of Zn 1.08% as ZnS. (2) $PbSnS_2$.

Occurrence: A hydrothermal mineral in tin veins; may be an important ore mineral.

Association: Cassiterite, stannite, franckeite, cylindrite, galena, sphalerite, wurtzite, pyrite.

Distribution: Found in many Bolivian tin veins, including those of the Santa Rosa [TL], Ichucollo, and El Salvador mines, Montserrat, and the Porvenir mine, Huanuni, Oruro; Mount Cerillos, near Carguaicollo, in the Cordillera de los Frailes, Potosí; the Lipey Huaico mine, Ocuri; the San Alfredo mine, Colquiri; and the Aliada mine, Colquechaca. In the Ivigtut cryolite deposit, southwestern Greenland. At Radvanice, near Trutnov, Czech Republic. From Sinantscha, Sichota-Alin, and Smirnowsk, Transbaikal, Russia. At the Wallah Wallah mine, Rye Park, New South Wales, Australia. From the Toyoha mine, Hokkaido, Japan. In the Changpo deposit, Dachang district, Guangxi Province, China.

Name: To honor Jethro Justinian Harris Teall (1849–1924), Director of the Geological Survey of Great Britain and Ireland.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 439–441. (2) Hofmann, W. (1935) Ergebnisse der Srukturbestimmung komplexer Sulfide. I. Die Struktur von Zinnsulfür SnS und Teallit $PbSnS_2$. Zeits. Krist., 92, 161–185 (in German). (3) Mosburg, S., D.R. Ross, P.M. Bethke, and P. Toulmin (1961) X-ray powder data for herzenbergite, teallite, and tin trisulfide. U.S. Geol. Sur. Prof. Paper 424-C, C347–C348. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 75. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 660–662. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 549.

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Teepleite $Na_2B(OH)_4Cl$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are tabular on {001}, in rounded lenslike shapes composed of {001} and {101}, to 5 cm; commonly forms aggregates of rosettes.

Physical Properties: *Fracture:* Irregular to subconchoidal. *Tenacity:* Very brittle. Hardness = 3–3.5 D(meas.) = 2.076 D(calc.) = 2.070 (synthetic). Soluble in H_2O; alters to tincalconite on exposure.

Optical Properties: Transparent. *Color:* Colorless to white, pale buff due to organic inclusions; colorless in transmitted light. *Luster:* Vitreous to greasy, dulled on exposure to air. *Optical Class:* Uniaxial (–). $\omega = 1.519$ $\epsilon = 1.503$

Cell Data: *Space Group:* $P4/nmm$. $a = 7.260(2)$ $c = 4.847(2)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.697 (10), 2.015 (9), 2.90 (8), 1.659 (8), 2.264 (7), 1.815 (7), 1.709 (7)

Chemistry:

	(1)	(2)
B_2O_4	22.05	26.71
CO_3	9.42	
Ca	0.08	
Na	28.93	28.69
Cl	18.72	22.12
H_2O	20.48	22.48
insol.	0.15	
Total	99.83	100.00

(1) Borax Lake, California, USA; after deduction of Ca as calcite and remaining CO_2 as trona, corresponds to $Na_{2.00}B_{1.00}(OH)_{3.69}Cl_{1.03}$. (2) $Na_2B(OH)_4Cl$.

Occurrence: Formed by reaction of boron-rich brines with halite in an extremely desiccated lake (Borax Lake, California, USA).

Association: Halite, trona, burkeite, hanksite.

Distribution: In the USA, in California, from Borax Lake, Lake Co., and in large crystals at Searles Lake, San Bernardino Co.

Name: Honors John Edgar Teeple (1874–1931), for his work on the chemistry of Searles Lake, California, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 95832; National Museum of Natural History, Washington, D.C., USA, 97449.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 372–373. (2) Ross, V. and J.O. Edwards (1959) Tetrahedral boron in teepleite and bandylite. Amer. Mineral., 44, 875–877. (3) Effenberger, H. (1982) Verfeinerung der Kristallstruktur von synthetischem Teepleit. Acta Cryst., 38, 82–85 (in German).

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Teineite **$CuTe^{4+}O_3 \cdot 2H_2O$**

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals are prismatic along [001], may be flattened on {010}, may be rough due to alteration; exhibiting forms {010}, {110}, {011}, rare {073}, to 2 cm; commonly as crusts and aggregates.

Physical Properties: *Cleavage:* On {010}, good; on {001} and {100}, poor.
Tenacity: Brittle. Hardness = 2.5 D(meas.) = 3.80 D(calc.) = 3.86

Optical Properties: Semitransparent. *Color:* Cerulean blue, Cobalt blue, bluish gray; in transmitted light, bright blue to greenish blue. *Streak:* Pale blue.
Optical Class: Biaxial (–). *Pleochroism:* X = greenish blue; Y = blue; Z = Indigo blue.
Orientation: $X = a$; $Y = b$; $Z = c$. *Absorption:* $Z > Y > X$. $\alpha = 1.767$ $\beta = 1.782$ $\gamma = 1.791$
2V(meas.) = 36°

Cell Data: *Space Group:* $P2_12_12_1$ (synthetic). $a = 6.634(4)$ $b = 9.597(5)$ $c = 7.428(4)$
Z = 4

X-ray Powder Pattern: Teine mine, Japan.
3.45 (10), 5.45 (9b), 3.06 (8), 2.94 (7), 2.880 (7), 2.392 (7), 5.87 (6)

Chemistry:

	(1)	(2)
SO_3	6.96	
TeO_3	50.63	58.00
CuO	29.54	28.91
H_2O	12.87	13.09
Total	[100.00]	100.00

(1) Teine mine, Japan; recalculated to 100% from an original total of 100.9% after deducting insoluble 6.1%. (2) $CuTeO_3 \cdot 2H_2O$.

Occurrence: A rare secondary mineral formed by oxidation of copper- and tellurium-bearing sulfides.

Association: Tellurite, tellurium, pyrite, tetrahedrite, sphalerite, azurite, malachite, quartz, barite (Teine mine, Japan); hessite, galena, bornite, cerussite, azurite, chlorargyrite, quetzalcoatlite, quartz, barite, clay (Moctezuma mine, Mexico); cuprite, malachite, graemite (Cole shaft, Arizona, USA).

Distribution: In Japan, from the Teine mine, Sapporo, Hokkaido, and in the Kawazu mine, three km north of Shimoda, Shizuoka Prefecture. At the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the USA, in Arizona, large crystals from the Cole shaft and in the Shattuck mine, Bisbee, Warren district, Cochise Co., and in the Dome Rock Mountains, La Paz Co.; from the Lone Pine mine, Wilcox district, Catron Co., New Mexico. At Salmchâteau, near Ottré, Belgium. From Åmotsdal, Norway. At the Aginsk gold telluride deposit, Kamchatka, Far Eastern Region, Russia.

Name: For the Teine mine, Japan, in which specimens were first found.

Type Material: University of Hokkaido, Sapporo, Japan; Harvard University, Cambridge, Massachusetts, USA, 94749.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 635–636. (2) Effenberger, H. (1977) Verfeinerung der Kristallstruktur von synthetischem Teineit, $CuTeO_3 \cdot 2H_2O$. Tschermaks Mineral. Petrog. Mitt., 24, 287–298 (in German with English abs.). (3) Mandarino, J.A. (1964) X-ray powder data for teineite and chalcomenite. Amer. Mineral., 49, 1481–1485. (4) Yosimura, T. (1939) Teineite, a new tellurate mineral from the Teine mine, Hokkaido, Japan. Jour. Fac. Sci., Hokkaido Imp. Univ., Series IV, no. 3–4, 465–470.

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Telargpalite $(Pd, Ag)_3(Te, Pb)$

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Crystal Data: Cubic. *Point Group:* n.d. As rounded, commonly elongate, grains, to 200 μm, dispersed and intergrown with sulfide minerals.

Physical Properties: Hardness = n.d. VHN = 62 (10 g load). D(meas.) = n.d. D(calc.) = 7.378

Optical Properties: Opaque. *Color:* In polished section, pale gray with lilac tint.

R: (400) — , (420) — , (440) 44.7, (460) 45.3, (480) 46.6, (500) 47.5, (520) 49.1, (540) 50.1, (560) 50.9, (580) 51.7, (600) 52.4, (620) 53.7, (640) 54.7, (660) 55.6, (680) 56.7, (700) 57.2

Cell Data: *Space Group:* n.d. $a = 12.60(2)$ $Z = 16$

X-ray Powder Pattern: Oktyabr mine, Russia.
2.42 (10), 2.10 (5), 3.05 (4), 2.74 (3), 1.475 (3), 2.22 (2), 1.822 (2)

Chemistry:

	(1)	(2)
Pd	39.0	42.73
Ag	30.8	29.82
Pb	6.7	0.46
Bi	3.7	1.46
Te	19.8	26.32
Se	0.6	
Total	100.6	100.79

(1) Oktyabr mine, Russia; by electron microprobe, average of analyses of nine samples; corresponding to $(Pd_{1.72}Ag_{1.34})_{\Sigma=3.06}(Te_{0.73}Pb_{0.15}Bi_{0.08}Se_{0.04})_{\Sigma=1.00}$. (2) Nadezhda deposit, Russia; by electron microprobe, average of 41 analyses; corresponding to $(Pd_{1.86}Ag_{1.28})_{\Sigma=3.14}$ $(Te_{0.96}Bi_{0.03}Pb_{0.01})_{\Sigma=1.00}$.

Occurrence: In metasomatically altered Cu–Ni sulfide ores (Talnakh area, Russia); in the layered ultramafic Stillwater complex (Nye, Montana, USA).

Association: Chalcopyrite, bornite, millerite, braggite, silver, kotulskite, clausthalite (Talnakh area, Russia).

Distribution: In Russia, from the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia [TL], and in the Nadezhda deposit, Lukkulaisvaara layered intrusion, Karelia. From Nye, Stillwater Co., Montana, USA.

Name: For the constituent chemical elements, TELlurium, ARGentum *silver*, and PALladium.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76575.

References: (1) Kovalenker, V.A., A.D. Genkin, T.L. Evstigneeva, and I.P. Laputina (1974) Telargpalite – new mineral of palladium, silver, and tellurium, from the copper-nickel ores of the Oktyabr deposit. Zap. Vses. Mineral. Obshch., 103, 595–600 (in Russian). (2) (1975) Amer. Mineral., 60, 489 (abs. ref. 1). (3) Barkov, A.Y., R.F. Martin, M. Tarkian, G. Poirier, and Y. Thibault (2001) Pd–Ag tellurides from a Cl-rich environment in the Lukkulaisvaara layered intrusion, northern Russian Karelia. Can. Mineral., 39, 639–653. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 142.

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Tellurantimony Sb_2Te_3

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As lath-shaped crystals, to 350 μm. *Twinning:* In polished section, twinning perpendicular to the elongation axis of the lath-shaped crystals is commonly seen.

Physical Properties: Hardness = n.d. VHN = 49.8 (25 g load). D(meas.) = n.d. D(calc.) = 6.511

Optical Properties: Opaque. *Color:* In polished section, pinkish cream. *Luster:* Metallic. *Pleochroism:* Weak; from pink to cream. *Anisotropism:* Moderate; in pink and dark gray.

R_1–R_2: (400) 57.7–60.9, (420) 58.9–62.4, (440) 60.1–63.5, (460) 60.9–64.5, (480) 61.7–65.3, (500) 62.2–65.9, (520) 62.7–66.5, (540) 63.0–67.0, (560) 63.3–67.4, (580) 63.5–67.7, (600) 63.6–67.9, (620) 63.6–68.0, (640) 63.5–67.9, (660) 63.3–67.8, (680) 63.0–67.6, (700) 62.8–67.6

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.258$ $c = 30.516$ $Z = 3$

X-ray Powder Pattern: Synthetic.
3.157 (100), 2.349 (35), 2.130 (25), 1.766 (10), 1.578 (8), 1.470 (8), 1.3597 (8)

Chemistry:

	(1)	(2)	(3)
Sb	37.5	37.1	38.88
Pb		1.3	
Bi	0.3		
Te	61.8	61.5	61.12
Total	99.6	99.9	100.00

(1) Mattagami mine, Canada; by electron microprobe, average of analyses of eight grains; corresponds to $Sb_{1.91}Te_{3.00}$. (2) Kobetsuzawa mine, Japan; by electron microprobe, corresponding to $(Sb_{1.96}Pb_{0.04})_{\Sigma=2.00}Te_{3.00}$. (3) Sb_2Te_3.

Polymorphism & Series: Forms a series with tellurobismuthite.

Mineral Group: Tetradymite group.

Occurrence: In a zinc-rich stratiform massive sulfide deposit of volcanogenic origin in Archean volcanics (Mattagami Lake mine, Canada).

Association: Altaite, pyrrhotite, chalcopyrite (Mattagami Lake mine, Canada); altaite, tellurium (Kobetsuzawa mine, Japan).

Distribution: In Canada, from the Mattagami Lake mine, about 8 km southwest of the town of Matagami, Quebec [TL]. At the Smuggler, Little Johnny, Washburn, and other mines, Boulder Co., Colorado, USA. From the Kobetsuzawa mine, near Sapporo, Hokkaido, Japan. In the Danba district, Sichuan Province, China. At Kalgoorlie, Western Australia. In Romania, from Săcărîmb (Nagyág), Stănija, and Măgura-Hondol. At Kremnica (Kremnitz), Slovakia. From Enasen, ??ck, Sweden.

Name: For the composition.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M31957.

References: (1) Thorpe, R.I. and D.C. Harris (1973) Mattagamite and tellurantimony, two new telluride minerals from Mattagami Lake mine, Matagami area, Quebec. Can. Mineral.,

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12, 55–60. (2) (1974) Amer. Mineral., 59, 383 (abs. ref. 1). (3) Nakata, M., J. Chung, H. Honma, and K. Sakurai (1985) On tellurantimony from the Kobetsuzawa mine, Sapporo, Japan. J. Mineral. Soc. Japan, 17, 79–83 (in Japanese with English abs.). (4) Effenberger, H. and F. Pertlik (1987) Hydrothermal und Kristallstruktur von stochiometrischen Tellurantimon, Sb_2Te_3, und Tellurobismutit, Bi_2Te_3. Mitt. Österreichen Mineral. Ges., 132, 157–161 (in German with English abs.??). (5) (1964) NBS Mono. 25, 3, 8. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 551.

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Tellurite TeO_2

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals acicular, elongated along [001], or lathlike, flattened on {100}, commonly striated ‖ [001], to 2 cm. In tufted to spherical radiating groups; powdery, massive.

Physical Properties: *Cleavage:* {100}, perfect. *Tenacity:* Flexible. Hardness = 2 D(meas.) = 5.90(2) D(calc.) = [5.75] Very slightly soluble in H_2O.

Optical Properties: Transparent. *Color:* White, yellowish white, straw-yellow, honey-yellow; nearly colorless in transmitted light. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r < v$, moderate. $\alpha = 2.00(5)$ $\beta = 2.18(2)$ $\gamma = 2.35(2)$ 2V(meas.) = ∼90°

Cell Data: *Space Group: Pbca.* $a = 12.035(6)$ $b = 5.464(3)$ $c = 5.607(3)$ Z = 8

X-ray Powder Pattern: "Cananea" [Moctezuma mine], Mexico.
3.280 (100), 3.723 (95), 3.008 (50), 2.730 (45), 2.800 (25), 2.298 (25), 1.930 (25)

Chemistry:

	(1)	(2)
Te	78.68	79.95
Bi	trace	
Fe_2O_3	0.70	
O	19.58	20.05
insol.	1.04	
Total	100.00	100.00

(1) Good Hope mine, Colorado, USA. (2) TeO_2.

Polymorphism & Series: Dimorphous with paratellurite.

Occurrence: An alteration product of tellurium and tellurides in the oxide zone of some hydrothermal mineral deposits.

Association: Tellurium, tetradymite, nagyagite, many secondary tellurates.

Distribution: In Romania, in Transylvania, from Faţa Băii (Faczebaja), Zalatna, and Săcărîmb (Nagyág). In Kazakhstan, from the Zavodinskii mine, near Ziryanovskii, Altai Mountains. In Japan, from the Teine mine, northwest of Sapporo, Hokkaido, and the Kawazu and Susaki mines, Shizuoka Prefecture. In the USA, in Colorado, from Cripple Creek, Teller Co., in the Good Hope mine, Gunnison Co., and the Keystone, Smuggler, and John Jay mines, Central district, Boulder Co.; from the Goldfield-Belmont, Clermont, and Mohawk mines, Goldfield district, Esmeralda Co., Nevada. Large crystals from the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: For its composition as a TELLURium dioxide.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 593–595. (2) Beyer, H. (1967) Verfeinerung der Kristallstruktur von Tellurit, dem rhombischen TeO_2. Zeits. Krist., 124, 228–238 (in German with English abs.). (3) (1960) NBS Circ. 539, 9, 57–58.

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Tellurium Te

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Crystal Data: Hexagonal. *Point Group:* 32. Crystals, to 3.5 cm, prismatic and acicular ‖ [0001] with (+) and (–) rhombohedra equally developed; also massive, columnar to fine granular.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}0\}$, imperfect on {0001}. *Tenacity:* Brittle, somewhat. Hardness = 2–2.5 VHN = 48–66 (10 g load). D(meas.) = 6.1–6.3 D(calc.) = 6.225

Optical Properties: Opaque. *Color:* Tin-white; in polished section, white. *Streak:* Gray. *Luster:* Metallic. *Pleochroism:* Feeble. *Anisotropism:* Fairly strong.

R_1–R_2: (400) 58.1–64.2, (420) 58.4–64.8, (440) 58.7–65.3, (460) 59.1–65.7, (480) 59.3–66.1, (500) 59.7–66.5, (520) 60.0–66.8, (540) 60.1–67.0, (560) 60.2–66.8, (580) 60.0–66.6, (600) 59.5–66.0, (620) 58.8–65.2, (640) 57.9–64.3, (660) 57.1–63.4, (680) 56.1–62.3, (700) 55.0–61.3

Cell Data: *Space Group:* $P3_121$ or $P3_221$. $a = 4.4572$ $c = 5.9290$ Z = 3

X-ray Powder Pattern: Synthetic.
3.230 (100), 2.351 (37), 2.228 (31), 3.86 (20), 1.835 (20), 1.479 (13), 1.616 (12)

Chemistry:

	(1)
Te	99.45
Se	0.40
Fe	0.11
Total	99.96

(1) Gunnison Co., Colorado, USA.

Occurrence: In hydrothermal veins; may be of both primary and secondary origin; a sublimate in volcanic fumaroles.

Association: Gold, sylvanite, empressite, altaite, pyrite, galena, alabandite, barite, quartz, carbonates.

Distribution: In Romania, from Faţa Băii (Zlatna, Faczebaj) [TL] and Baia-de-Arieş (Offenbánya). At the Fossa volcano, Vulcano, Lipari Islands, Italy. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. Large cleavages at the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In the USA, from many localities in Colorado, including Cripple Creek, Teller Co.; in the Magnolia, Gold Hill, Ballarat, and Central districts, Boulder Co.; and at the Vulcan mine, Gunnison Co.; in Nevada, at the Mohawk and Clermont mines, Goldfield district, Humboldt Co., and from Delamar, Lincoln Co. At the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. From the El Indio mine, east of La Serena, Coquimbo, Chile. At Kalgoorlie, Western Australia. In the Teine mine, northwest of Sapporo, Hokkaido, and in the Kawazu mine, near Sizewka, Shizuoka Prefecture, Japan. From the Emperor mine, Vatukoula, Viti Levu, Fiji Islands. At the Guilaizhuang gold deposit, Shandong Province, and in the Dashuigou tellurium deposit, Sichuan Province, China. Additional minor localities are known.

Name: Latin name for *the earth*, *tellus*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 138–139. (2) Chenin, P. and P. Unger (1967) ??title?? Acta Cryst., 23, 670–671. (3) (1953) NBS Circ. 539, 1, 26. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 552.

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Tellurobismuthite Bi_2Te_3

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As irregular plates and foliated masses.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Laminae flexible but not elastic; slightly sectile. Hardness = 1.5–2 VHN = 51 (25 g load). D(meas.) = 7.815 D(calc.) = 7.857

Optical Properties: Opaque. *Color:* Pale lead-gray; in polished section, white. *Streak:* Pale lead-gray. *Luster:* Metallic, splendent on fresh cleavages. *Anisotropism:* Weak.
R_1–R_2: (400) 62.3–62.9, (420) 62.4–63.4, (440) 62.4–63.8, (460) 62.6–64.0, (480) 62.6–64.3, (500) 62.5–64.7, (520) 62.4–65.3, (540) 62.4–65.8, (560) 62.6–66.2, (580) 62.9–66.5, (600) 63.2–66.8, (620) 63.5–67.1, (640) 63.9–67.5, (660) 64.5–67.9, (680) 65.0–68.3, (700) 65.3–68.4

Cell Data: *Space Group:* $R\overline{3}m$. a = 4.3852 c = 30.483 Z = 3

X-ray Powder Pattern: Synthetic.
3.222 (100), 2.376 (25), 2.192 (25), 5.078 (8), 1.812 (8), 1.4901 (8), 2.031 (6)

Chemistry:

	(1)	(2)	(3)
Bi	53.07	51.99	52.20
Te	48.19	47.89	47.80
S		0.12	
Total	101.26	100.00	100.00

(1) Tellurium mine, Virginia, USA. (2) Oya mine, Japan. (3) Bi_2Te_3.

Polymorphism & Series: Forms a series with tellurantimony.

Mineral Group: Tetradymite group.

Occurrence: Typically formed in hydrothermal gold-quartz veins of low sulfur content.

Association: Gold, bismuth, gold tellurides, tetradymite, altaite, chalcopyrite, pyrrhotite.

Distribution: In the USA, from Field's vein, Dahlonega, Lumpkin Co., Georgia [TL]; in the Tellurium mine, Fluvanna Co., Virginia; in New Mexico, from the Little Mildred mine, near Hachita, Grant Co.; at the Campbell mine, Bisbee, Cochise Co., Arizona; in Colorado, from near Whitehorn, Fremont Co. and at the Little Gerald and Hamilton mines, Sierra Blanca, Huerfano, Costilla, and Alamosa Cos. In Canada, a number of minor occurrences, as at the Hunter mine, Khutze Inlet, near Swanson Bay; from the Lucky Jim mine, Quadra Island, and at the Ashloo mine, near Squamish, Howe Sound, British Columbia; from the Robb-Montbray mine, Montbray Township, and at the Horne mine, Noranda, Quebec. From the Uzelga copper deposit, Ural Mountains, Russia. At the Zhanatyube deposit, Kazakhstan. In Japan, in the Oya mine, Miyagi Prefecture; the Ojiri mine, Iwate Prefecture; the Suwa mine, Ibaragi Prefecture; and the Kiura mine, Oita Prefecture. At the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea. From the Tuvatu Au–Ag–Te deposit, Viti Levu, Fiji Islands. At the Bulawan deposit, Negros Occidental, Phillipines. In Sweden, at Boliden, Västerbotten. In Wales, from the Clogau-St. Davids mine, Mangtall Mountains, Dollgelly, and the Vigra mine, Llanaker, Merionshire.

Name: For the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 160–161. (2) Effenberger, H. and F. Pertlik (1987) Hydrothermal und Kristallstruktur von stochiometrischen Tellurantimon, Sb_2Te_3, und Tellurobismutit, Bi_2Te_3. Mitt. Österreichen Mineral. Ges., 132, 157–161 (in German with English abs.??). (3) (1964) NBS Mono. 25, 3, 16. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 555.

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Tellurohauchecornite Ni_9BiTeS_8

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As irregular grains, to 150 μm.

Physical Properties: Hardness = n.d. VHN = 812–825 (50 g load). D(meas.) = n.d. D(calc.) = 6.50

Optical Properties: Opaque. *Color:* Bronze-yellow.

R_1–R_2: (470) 41.2–44.8, (546) 43.9–47.7, (589) 45.6–49.4, (650) 48.2–51.9

Cell Data: *Space Group:* $P4/mmm$. a = 14.64 $c = 10.87$ Z = 8

X-ray Powder Pattern: Strathcona mine, Sudbury, Canada.
2.80 (100), 2.314 (60), 2.405 (50), 4.35 (40), 3.66 (40), 3.28 (40), 1.868 (40)

Chemistry:

	(1)	(2)
Ni	44.1	47.12
Fe	0.9	
Co	0.9	
Bi	22.4	18.63
As	0.0	
Sb	0.0	
Te	8.5	11.38
S	21.9	22.87
Total	98.7	100.00

(1) Strathcona mine, Sudbury, Canada; by electron microprobe; corresponds to $(Ni_{8.80}Fe_{0.19}Co_{0.18})_{\Sigma=9.17}Bi_{1.26}Te_{0.78}S_{8.00}$. (2) Ni_9BiTeS_8.

Mineral Group: Hauchecornite group.

Occurrence: In hydrothermal Ni–Co–Cu sulfide veins.

Association: Millerite, chalcopyrite.

Distribution: From the Strathcona mine, Sudbury, Ontario, Canada [TL].

Name: Alludes to its chemical relation to the hauchecornite group.

Type Material: Royal Ontario Museum, Toronto, Canada, M30942.

References: (1) Gait, R.L. and D.C. Harris (1980) Arsenohauchecornite and tellurohauchecornite: new minerals in the hauchecornite group. Mineral. Mag., 43, 877–888. (2) (1981) Amer. Mineral., 66, 436 (abs. ref. 1). (3) Gait, R.L. and D.C. Harris (1972) Hauchecornite—antimonian, arsenian and tellurian varieties. Can. Mineral., 11, 819–825.

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Telluronevskite Bi_3TeS_2

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As grains, to 100 μm.

Physical Properties: Hardness = n.d. VHN = 376–399, 388 average, and 296–308, 302 average on two grains (15 g load). D(meas.) = 10.25 (synthetic). D(calc.) = 10.62

Optical Properties: Opaque. *Color:* In polished section, cream with a yellowish tint. *Luster:* Metallic. *Pleochroism:* None in air, very faintly discernible in oil. *Anisotropism:* Moderate to strong in air, strong in oil, in gray to light brownish gray.

R: (400) — , (420) 44.6, (440) 45.3, (460) 45.9, (480) 46.7, (500) 47.8, (520) 49.0, (540) 50.0, (560) 51.3, (580) 52.6, (600) 53.9, (620) 55.2, (640) 56.5, (660) 57.8, (680) 58.9, (700) 60.1

Cell Data: *Space Group:* $P2_1/c$ (synthetic). $a = 7.458(1)$ $b = 13.938(1)$ $c = 8.839(1)$ $\beta = 91.97(1)^\circ$ Z = 4

X-ray Powder Pattern: Stillwater complex, Montana, USA.
2.237 (100), 1.305 (80b), 2.543 (70), 2.134 (60), 2.094 (60), 1.961 (60), 2.196 (50b)

Chemistry:

	(1)	(2)
Pd	65.4	65.23
Sn	0.07	
As	0.33	
Bi	0.15	
Sb	0.12	
Te	34.1	34.77
Total	100.17	100.00

(1) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $Pd_{8.99}(Te_{3.91}As_{0.07}Bi_{0.01}Sn_{0.01}Sb_{0.01})_{\Sigma=4.01}$. (2) Pd_9Te_4.

Occurrence: As tiny grains in mineral concentrates.

Association: Keithconnite, magnetite, kotulskite, merenskyite, moncheite, braggite, vysotskite.

Distribution: From the Banded and Upper Zones of the Stillwater complex, Montana, USA [TL].

Name: For TELLURium and PALLADium in the composition.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M35867; National Museum of Natural History, Washington, D.C., USA, 144958.

References: (1) Cabri, L.J., J.R. Rowland, J.H.G. Laflamme, and J.M. Stewart (1979) Keithconnite, telluropalladinite and other Pd–Pt tellurides from the Stillwater Complex, Montana. Can. Mineral., 17, 589–594. (2) (1981) Amer. Mineral., 66, 1275 (abs. ref. 1). ??added??ck??need copy?? (3) Matković, P. and K. Schubert (1978) Kristallstruktur von Pd_9Te_4. J. Less Common Metals, 58, 39–46 (in German with English abs.). (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 142–143, 158.

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As tiny (27 x 27 to 55 x 100 μm) grains.

Physical Properties: Hardness = n.d. VHN = 376–399, 388 average, and 296–308, 302 average on two grains (15 g load). D(meas.) = 10.25 (synthetic). D(calc.) = 10.62

Optical Properties: Opaque. *Color:* In polished section, cream with a yellowish tint. *Luster:* Metallic. *Pleochroism:* None in air, very faintly discernible in oil. *Anisotropism:* Moderate to strong in air, strong in oil, in gray to light brownish gray.
R: (400) — , (420) 44.6, (440) 45.3, (460) 45.9, (480) 46.7, (500) 47.8, (520) 49.0, (540) 50.0, (560) 51.3, (580) 52.6, (600) 53.9, (620) 55.2, (640) 56.5, (660) 57.8, (680) 58.9, (700) 60.1

Cell Data: *Space Group:* $P2_1/c$. $a = 7.456(6)$ $b = 13.936(5)$ $c = 8.842(9)$ $\beta = 91.94°$ Z = 4

X-ray Powder Pattern: Stillwater Complex, Montana, USA.
2.237 (100), 1.305 (80b), 2.543 (70), 2.134 (60), 2.094 (60), 1.961 (60), 2.196 (50b)

Chemistry:

	(1)	(2)
Pd	65.4	65.23
Sn	0.07	
As	0.33	
Bi	0.15	
Sb	0.12	
Te	34.1	34.77
Total	100.17	100.00

(1) Stillwater Complex, Montana, USA; by electron microprobe, yielding $Pd_{8.99}(Te_{3.91}As_{0.07}Bi_{0.01}Sn_{0.01}Sb_{0.01})_{\Sigma=4.01}$. (2) Pd_9Te_4.

Occurrence: As tiny grains in mineral concentrates.

Association: Keithconnite, magnetite, kotulskite, merenskyite, moncheite, braggite, vysotskite.

Distribution: From the Banded and Upper Zones of the Stillwater Complex, Montana, USA.

Name: For the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 144958; Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada.

References: (1) Cabri, L.J., J.R. Rowland, J.H.G. Laflamme, and J. M. Stewart (1979) Keithconnite, telluropalladinite and other Pd–Pt tellurides from the Stillwater Complex, Montana. Can. Mineral., 17, 589–594. (2) Matkovic, P. and K. Schubert (1978) Kristallstruktur von Pd_9Te_4. Jour. Less Common Metals, 58, 39–46.

Temagamite Pd_3HgTe_3

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Crystal Data: Orthorhombic. *Point Group:* n.d. As rounded to irregular inclusions, to 115 μm, in chalcopyrite.

Physical Properties: Hardness = n.d. VHN = 92 (25 g load). D(meas.) = 9.5 (synthetic). D(calc.) = 9.45

Optical Properties: Opaque. *Color:* In polished section, white with a gray tinge. *Luster:* Metallic. *Anisotropism:* Weak in air, stronger in oil, in pale gray to dark gray.

R_1–R_2: (470) 51.8–52.8, (546) 52.9–53.9, (589) 54.2–55.0, (650) 57.1–57.7

Cell Data: *Space Group:* n.d. (synthetic). $a = 11.608(2)$ $b = 12.186(1)$ $c = 6.793(1)$ $Z = 6$

X-ray Powder Pattern: Synthetic.
2.912 (10), 2.187 (9), 1.959 (7), 1.661 (5), 1.624 (5), 1.462 (5), 1.155 (5)

Chemistry:

	(1)	(2)
Pd	34.9	34.5
Pt		1.0
Hg	22.1	22.0
Bi	n.d.	0.13
Te	42.1	42.1
Total	99.1	99.73

(1) Temagami Mine, Canada; by electron microprobe, corresponding to $Pd_{2.99}Hg_{1.00}Te_{3.01}$.
(2) Stillwater complex, Montana, USA; by electron microprobe, corresponding to $(Pd_{2.95}Pt_{0.05})_{\Sigma=3.00}Hg_{1.00}Te_{3.00}$.

Occurrence: Cogenetic with moderately high-temperature invasive chalcopyrite magma (Temagami Mine, Canada).

Association: Merenskyite, hessite, chalcopyrite, stützite.

Distribution: In Canada, in Ontario, from the Temagami Cu–Ni mine, Temagami Island, Lake Temagami, Nipissing district [TL] and from a prospect near Rathbun Lake. In the USA, from the Stillwater complex, Montana; and the New Rambler Cu–Ni mine, Medicine Bow Mountains, east of Encampment, Albany Co., Wyoming.

Name: For the Temagami mine in Canada, where the mineral was first found.

Type Material: Royal Ontario Museum, Toronto, Canada, M32528.

References: (1) Cabri, L.J., J.H.G. Laflamme, and J.M. Stewart (1973) Temagamite, a new palladium–mercury telluride from the Temagami copper deposit, Ontario, Canada. Can. Mineral., 12, 193–198. (2) (1975) Amer. Mineral., 60, 947 (abs. ref. 1). (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 143, 157.

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Tengchongite $CaO_5(UO_2)_6(MoO_4)_2 \cdot 12H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. As fine granular crystals, thin tabular to micaceous on {001}.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 2–2.5 D(meas.) = 4.25(2) D(calc.) = 4.24 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow; yellow in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = c$. $\alpha = 1.663(2)$ $\beta = 1.760(2)$ $\gamma = 1.762(2)$ 2V(meas.) = 16° 2V(calc.) = 16°

Cell Data: *Space Group:* $A2_122$. $a = 15.616(4)$ $b = 13.043(6)$ $c = 17.716(14)$ Z = 4

X-ray Powder Pattern: Tongbiguan village, China.
8.84 (10), 3.17 (8), 3.38 (7), 5.37 (5), 4.27 (5), 3.65 (4), 2.04 (4)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	74.30	75.39	Al_2O_3	0.66	
MoO_3	11.46	12.65	MnO	0.02	
P_2O_5	0.28		MgO	0.02	
SiO_2	1.04		CaO	2.19	2.46
TiO_2	0.07		Na_2O	0.07	
ThO_2	0.12		K_2O	0.09	
Fe_2O_3	0.12		H_2O	9.00	9.50
			Total	99.44	100.00

(1) Tongbiguan village, China; IR confirmed the presence of $(MoO_4)^{2-}$, $(UO_2)^{2-}$, H_2O, and lack of $(OH)^{1-}$; after deduction of impurities, corresponds to $Ca_{0.96}O_5(UO_2)_{6.18}(MoO_4)_{1.89} \cdot 11.88H_2O$.
(2) $CaO_5(UO_2)_6(MoO_4)_2 \cdot 12H_2O$.

Occurrence: In the oxidized portions of a uranium deposit in migmatite and gneiss.

Association: Studtite, calcurmolite.

Distribution: From Tongbiguan village, Tengchong Co., Yunnan Province, China.

Name: For Tengchong Co., China, where the first specimens were found.

Type Material: Beijing Uranium Geology Research Institute, Beijing, China.

References: (1) Chen Zhangru, Luo Keding, Tan Falan, Zhang Yi, and Gu Xiaofa (1986) Tengchongite, a new mineral of hydrated calcium uranyl molybdate. Kexue Tongbao, 31, 396–401 (in English). (2) (1988) Amer. Mineral., 73, 195–196 (abs. ref. 1).

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Tengerite-(Y) $Y_2(CO_3)_3 \cdot 2{-}3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Rarely small mammillary with radial fibrous internal structure, to 1 mm; typically in thin coatings and powders.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.110

Optical Properties: Semitransparent. *Color:* White. *Luster:* Dull, chalky.
Optical Class: Biaxial. $\alpha = 1.587$ β = n.d. $\gamma = 1.616$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $Bb2_1m$. $a = 6.078(4)$ $b = 9.157(2)$ $c = 15.114(6)$ Z = 4

X-ray Powder Pattern: Ytterby, Sweden.
5.70 (10), 4.62 (10), 3.91 (10), 7.66 (8), 3.59 (8), 2.98 (8), 2.55 (6)

Chemistry:

	(1)	(2)		(1)	(2)
CO_2	[26.9]	32.35	Tb_2O_3	0.7	0.22
Y_2O_3	26.5	46.46	Dy_2O_3	6.2	1.92
La_2O_3	0.2	0.17	Ho_2O_3	0.7	0.47
Ce_2O_3	1.5	0.17	Er_2O_3	1.4	1.46
Pr_2O_3	0.6	0.09	Tm_2O_3	0.6	0.19
Nd_2O_3	5.1	0.52	Yb_2O_3	0.7	1.16
Sm_2O_3	4.4	0.39	Lu_2O_3	0.1	0.16
Eu_2O_3	n.d.	0.01	CaO	1.2	1.79
Gd_2O_3	6.1	1.00	H_2O	[17.1]	13.40
			Total	[100.0]	101.93

(1) Ytterby, Sweden; by X-ray fluorescence analysis, CO_2 calculated for charge balance, H_2O calculated by difference, CaO attributed to impurities; corresponds to $(Y_{1.14}Gd_{0.16}Dy_{0.16}Nd_{0.15}Sm_{0.12}Ce_{0.04}Er_{0.04}Tb_{0.02}Pr_{0.02}Yb_{0.02}Ho_{0.02}Tm_{0.01}La_{0.01})_{\Sigma=1.91}(CO_3)_{2.95} \cdot nH_2O$. (2) Iisaka, Japan; by ICP-AES analysis, CaO attributed to impurities; corresponds to $(Y_{1.70}Dy_{0.04}Er_{0.03}Yb_{0.02}Gd_{0.02}Nd_{0.01}Ho_{0.01}Sm_{0.01})_{\Sigma=1.84}C_{3.03}O_9 \cdot 3.07H_2O$.

Occurrence: An alteration coating on yttrium-bearing minerals.

Association: Gadolinite-(Y), lokkaite-(Y), kimuraite-(Y), bastnäsite-(Ce), lanthanite, synchysite, calcite, quartz.

Distribution: In Sweden, from Ytterby, on Resarö Island, near Vaxholm, and at Åskagen, Värmland. From Rosås, Norway. At the Pyörönmaa pegmatite, Kangasala, and Lövböle, Kemiö, Finland. From Iisaka and Suishoyama, Fukushima Prefecture, Japan. In the Evans-Lou pegmatite, 32 km north of Hull, Quebec, Canada. In the USA, from the Baringer Hill pegmatite, 26 km west of Burnet, and the Rode Ranch pegmatite, near Bluffton, Llano Co., and from the Clear Creek pegmatite, Burnet Co. Texas. Additionally reported localities require modern confirmation.

Name: To honor C. Tenger, Swedish chemist who studied the mineral.

Type Material: National Science Museum, Tokyo, Japan, M25981; National Museum of Natural History, Washington, D.C., USA, R13924.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 275–276. (2) Miyawaki, R., J. Kuriyama, and I. Nakai (1993) The redefinition of tengerite-(Y), $Y_2(CO_3)_3 \cdot 2{-}3H_2O$, and its crystal structure. Amer. Mineral., 78, 425–432.

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Tennantite $(Cu, Ag, Zn, Fe)_{12}As_4S_{13}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals are tetrahedral, as large as 20 cm; may be as groups of parallel crystals; commonly massive, coarse or fine granular to compact. *Twinning:* Twin axis [111], twin plane {111}, as contact and penetration twins, commonly repeated.

Physical Properties: *Fracture:* Subconchoidal to uneven. *Tenacity:* Somewhat brittle. Hardness = 3–4.5 VHN = 294–380 (100 g load). D(meas.) = 4.62 D(calc.) = 4.61

Optical Properties: Opaque, except in very thin fragments. *Color:* Flint-gray to iron-black, cherry-red in transmitted light; in polished section, gray inclining to black to brown to cherry-red (high As and low Fe). *Luster:* Metallic, commonly splendent.
Optical Class: Isotropic. $n = > 2.72$ (Li).

R: (400) 31.5, (420) 31.4, (440) 31.4, (460) 31.2, (480) 31.0, (500) 30.8, (520) 30.6, (540) 30.2, (560) 29.7, (580) 29.0, (600) 28.3, (620) 27.7, (640) 27.1, (660) 26.6, (680) 26.2, (700) 25.9

Cell Data: *Space Group:* $I\bar{4}3m$. $a = 10.19$ $Z = 2$

X-ray Powder Pattern: Binntal, Switzerland.
2.94 (100), 1.801 (80), 1.535 (50), 2.55 (30), 1.169 (30), 1.041 (30), 2.40 (20)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Cu	35.72	42.05	51.56	As	17.18	12.57	20.26
Ag	13.65	0.04		Sb	0.13	10.87	
Zn	6.90	6.09		S	25.04	27.12	28.18
Pb	0.86			Total	99.90	100.22	100.00
Fe	0.42	1.48					

(1) Molly Gibson mine, Colorado, USA; corresponds to $(Cu_{9.36}Ag_{2.11}Zn_{1.75}Fe_{0.12}Pb_{0.07})_{\Sigma=13.41}(As_{3.82}Sb_{0.02})_{\Sigma=3.84}S_{13.00}$. (2) San Lorenzo mine, Santiago, Chile; corresponds to $(Cu_{10.17}Zn_{1.43}Fe_{0.41}Ag_{0.01})_{\Sigma=12.02}(As_{2.58}Sb_{1.37})_{\Sigma=3.95}S_{13.00}$. (3) $Cu_{12}As_4S_{13}$.

Polymorphism & Series: Forms a series with tetrahedrite.

Mineral Group: Tetrahedrite group.

Occurrence: In hydrothermal veins and contact metamorphic deposits.

Association: Cu–Pb–Zn–Ag sulfides and sulfosalts, pyrite, calcite, dolomite, siderite, barite, fluorite, quartz.

Distribution: From numerous localities; rarer than tetrahedrite. In England, in Cornwall [TL], from a number of mines in Gwennap, Gwinear, Illogan, St. Just, and elsewhere. An ore mineral in the Gortdrum mine, near Tipperary, Co. Tipperary, Ireland. In Germany, from Freiberg, Saxony. In Poland, at Kupferberg-Rudelstadt, Silesia. In Switzerland, from the Lengenbach quarry, Binntal, Valais. At Dzhezkazgan, Kazakhstan. In the USA, in Colorado, from many localities, including the Freeland mine, Idaho Springs, Clear Creek Co.; in the Central City district, Gilpin Co.; at the Molly Gibson and other mines, Aspen, Pitkin Co.; in the Red Mountain district, San Juan Co.; from the Champion Lode, Geneva, Georgetown district, Clear Creek Co.; at Butte, Silver Bow Co., Montana. From Concepción del Oro, Zacatecas, Mexico. At Morococha and Quiruvilca, Peru. From the El Teniente mine, 67 km west of Rancagua, O'Higgins Province, Chile. At Yaogonxian, Hunan Province, China. From Tsumeb, Namibia, remarkable large crystals.

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Name: In honor of Professor Smithson Tennant (1761–1815), English chemist of Oxford University, Oxford, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 374–384. (2) Weunsch, B.J., Y. Takéuchi, and W. Nowacki (1966) Refinement of the crystal structure of binnite, $Cu_{12}As_4S_{13}$. Zeits. Krist., 123, 1–20. (3) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 55–56. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 557.

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Tenorite CuO

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Lathlike crystals, flattened on [100], elongated along [011], to 2 mm; curved, scaly, dendritic; commonly pulverulent, earthy, massive. *Twinning:* On {011}, contact plane, common, forming stellate groups; lamellar.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle; flexible and elastic in thin scales. Hardness = 3.5 VHN = 190–300 (100 g load). D(meas.) = 6.45 (synthetic). D(calc.) = 6.515(2)

Optical Properties: Opaque, transparent only in the thinnest scales. *Color:* Steel-gray, iron-gray, black; brown in transmitted light; light gray with golden tint in reflected light. *Luster:* Metallic.
Optical Class: Biaxial. *Pleochroism:* Distinct; light to dark brown. *Orientation:* $Y = b$; $Z \simeq c$. 2V(meas.) = Large. *Anisotropism:* Strong; blue to gray. *Bireflectance:* Strong.
R_1–R_2: (400) 22.8–29.6, (420) 21.9–30.0, (440) 21.0–30.4, (460) 20.4–30.6, (480) 20.1–30.8, (500) 19.8–30.7, (520) 19.7–30.4, (540) 19.6–30.2, (560) 19.5–29.8, (580) 19.5–29.6, (600) 19.4–29.4, (620) 19.4–29.2, (640) 19.4–29.1, (660) 19.4–28.8, (680) 19.3–28.6, (700) 19.3–28.2

Cell Data: *Space Group:* $C2/c$. $a = 4.6837(5)$ $b = 3.4226(5)$ $c = 5.1288(6)$ $\beta = 99.54(1)^\circ$ Z = 4

X-ray Powder Pattern: Synthetic.
2.523 (100), 2.323 (96), 2.530 (49), 2.312 (30), 1.866 (25), 1.505 (20), 1.375 (19)

Chemistry: Nearly pure CuO; modern analyses are not available.

Occurrence: Commonly in the oxidized zone of hydrothermal copper deposits; a volcanic sublimate.

Association: Cuprite, copper, chrysocolla, malachite, azurite, Fe–Mn oxides (hydrothermal); copper chlorides, alkali chlorides, cotunnite (volcanic).

Distribution: Many localities, but few for well-crystallized or pure material. From Vesuvius, Campania, and Etna, Sicily, Italy. In England, at a number of mines in Gwennap, Redruth, St. Just, and elsewhere in Cornwall. At Leadhills, Lanarkshire, Scotland. From Rio Tinto, Huelva Province, Spain. In Germany, at Siegen, Westphalia; from Daaden, Rhineland-Palatinate; and at Neubulach, Black Forest. At Jáchymov (Joachimsthal), Czech Republic. In Russia, from Bogoslovsk and Nizhni Tagil, Ural Mountains, and at the Tolbachik fissure volcano, Kamchatka Peninsula. In the USA, from Copper Harbor, Keweenaw Co., Michigan; at Darwin, Inyo Co., California; an ore at Bisbee, Cochise Co., Arizona. From Chuquicamata, Antofagasta, Chile. At Tsumeb, Namibia.

Name: To honor Professor Michele Tenore (1781–1861), Italian botanist, University of Naples, Naples, Italy.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 507–510. (2) Åsbrink, S. and L.-J. Norrby (1970) A refinement of the crystal structure of copper(II) oxide with a discussion of some exceptional e.s.d.'s. Acta Cryst., 26, 8–15. (3) (1953) NBS Circ. 539, 1, 49.

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Tephroite $Mn_2^{2+}SiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals typically short, prismatic, to 4 cm, or anhedral, equidimensional. Commonly in disseminated grains, compact, or massive. *Twinning:* {011}, not common.

Physical Properties: *Cleavage:* {010}, distinct; {001}, imperfect. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.87–4.12 D(calc.) = 4.15

Optical Properties: Transparent to translucent. *Color:* Olive-green, bluish green, gray, flesh-red, reddish brown; pale green in thin section, may be colorless. *Streak:* Pale gray. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (–). *Pleochroism:* None or weak; X = brownish red; Y = reddish; Z = greenish blue. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$. $\alpha = 1.770$–1.788 $\beta = 1.807$–1.810 $\gamma = 1.817$–1.825 2V(meas.) = 60°–70°

Cell Data: *Space Group: Pbnm.* $a = 4.86$–4.90 $b = 10.59$–10.62 $c = 6.22$–6.25 Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 35-748).
2.560 (100), 2.867 (90), 1.814 (72), 2.607 (67), 3.627 (50), 1.565 (33), 2.695 (30)

Chemistry:

	(1)	(2)
SiO_2	29.27	29.75
FeO	1.20	
MnO	65.23	70.25
MgO	1.98	
CaO	2.32	
Total	100.00	100.00

(1) Benallt mine, Wales; corresponds to $(Mn^{2+}_{1.84}Mg_{0.10}Ca_{0.08}Fe^{2+}_{0.03})_{\Sigma=2.05}Si_{0.97}O_4$. (2) Mn_2SiO_4.

Polymorphism & Series: Forms two series, with fayalite, and with forsterite.

Mineral Group: Olivine group.

Occurrence: In Fe–Mn ore deposits, related skarns, and metamorphosed manganese-rich sediments.

Association: Zincite, willemite, franklinite, rhodonite, jacobsite, diopside, gageite, bustamite, manganocalcite, glaucochroite, calcite, banalsite, alleghanyite.

Distribution: In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; at Bald Knob, near Sparta, Alleghany Co., North Carolina; and in the Sunnyside mine, San Juan Co., Colorado. From Buritirama, Piaui, Brazil. In the Harstigen mine, near Persberg; at Långban, Värmland; and in the Sjö mine, near Grythyttan, Örebro, Sweden. From the Benallt mine, near Rhiw, Lleyn Peninsula, Gwennyd, Wales. In the Meldon quarry, Okehampton, Devon, and the Treburland mine, Altarnun, Cornwall, England. At Val Malenco, Lombardy, Italy. From Bonneval-sur-Arc, Haute-Maurienne, Isère, France. Large crystals from the Wessels mine, near Kuruman, Cape Province, South Africa. In the Kaso mine, Totigi Prefecture, and the Noda-Tamagawa mine, Iwate Prefecture, Japan. From Broken Hill and Tamworth, New South Wales, Australia. On the Clark Peninsula, Wilkes Land, Antarctica.

Name: From the Greek for *ash-colored.*

Type Material: Mining Academy, Freiberg, Germany, 23653.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 457–459. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 337–357. (3) Francis, C.A. and P.H. Ribbe (1980) The forsterite-tephroite series: I. Crystal structure refinements. Amer. Mineral., 65, 1263–1269. (4) (1984) NBS Mono. 25, 21, 92.

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Terlinguaite Hg_2OCl

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, exhibiting a multitude of forms, are commonly equant, may be elongated along [010], flattened on {001} or rarely thick tabular on {001}; in aggregates of crystals, powdery, massive.

Physical Properties: *Cleavage:* $\{\bar{1}01\}$, perfect. *Tenacity:* Brittle. Hardness = 2.5
D(meas.) = 9.22 D(calc.) = 9.35

Optical Properties: Transparent to translucent. *Color:* Sulfur-yellow, greenish yellow, brown; turns olive-green on exposure to light; pale olive-green in transmitted light.
Streak: Lemon-yellow, turning olive-green. *Luster:* Brilliant adamantine.
Optical Class: Biaxial (–). *Pleochroism:* Slight; green to yellow. *Orientation:* OAP $\parallel b$ and inclined –7° to c. *Dispersion:* $r < v$, extreme. $\alpha = 2.35(2)$ $\beta = 2.64(2)$ $\gamma = 2.66(2)$
2V(meas.) = 20(2)°

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 11.953(4)$ $b = 5.904(3)$ $c = 9.466(4)$
$\beta = 105.59(6)°$ Z = 4

X-ray Powder Pattern: Synthetic. (ICDD 25-559).
2.505 (100), 5.76 (80), 4.17 (80), 3.28 (80), 2,815 (80), 2.596 (80), 4.34 (60)

Chemistry:

	(1)	(2)	(3)
Hg	88.24	88.61	88.63
O	3.47	3.75	3.54
Cl	7.89	7.83	7.83
Total	99.60	100.19	100.00

(1–2) Terlingua, Texas, USA; each value is an average of several analyses. (3) Hg_2OCl.

Occurrence: A rare secondary mineral in hydrothermal mercury deposits.

Association: Cinnabar, metacinnabar, eglestonite, kleinite, montroydite, calomel, mercury.

Distribution: In the USA, from Terlingua, Brewster Co., Texas; in the McDermitt mercury mine, Opalite district, and from the Cahill mine, Poverty Peak district, Humboldt Co., Nevada; at the Kings mine, Parkfield district, Kings Co., and the Nepper and Clear Creek mines, New Idria district, San Benito Co., California. In Mexico, from Huahuaxtla, Guerrero; Pedernales, Chihuahua; and Guadalćazar, San Luis Potosi. At Landsberg, near Obermoschel, Rhineland-Palatinate, Germany. From Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan. A few other minor or poorly-defined localities are known.

Name: For its occurrence at Terlingua, Texas, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 52–56. (2) Aurivillius, K. and L. Folkmarson (1968) The crystal structure of terlinguaite, $Hg_4O_2Cl_2$. Acta Chem. Scand., 22, 2529–2540. (3) Broderson, K., G. Göbel, and G. Liehr (1989) Terlinguait $Hg_4O_2Cl_2$ – ein Mineral mit ungewöhnlichen Hg_3−Baueinheiten. Zeitschrift für anorganische und allgemeine Chemie, 575, 145–153 (in German with English abs.).

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Ternovite $\mathbf{(Mg,Ca)Nb_4O_{11}\cdot nH_2O}$ (n ∼10)

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m$ (probable). Pyramidal pseudo-octahedral crystals, with prominent {112}, {001}, and {100}, pseudocubic to rhombic; in globular, rough masses, to 1 mm.

Physical Properties: Hardness = n.d. D(meas.) = 3.65 D(calc.) = 3.79

Optical Properties: Transparent to translucent. *Color:* Honey-yellow, brownish orange, bright yellow.
Optical Class: Uniaxial (–). $\omega = 1.724$ $\epsilon = 1.720$

Cell Data: *Space Group:* $P4_2/n$. $a = 7.787(1)$ $c = 7.797(1)$ Z = [4]

X-ray Powder Pattern: Foote mine, North Carolina, USA.
3.939 (100), 2.7698 (90), 1.7604 (50), 1.6050 (40), 4.518 (30), 3.880 (30), 2.2637 (25)

Chemistry:

	(1)	(2)	(3)
WO_3		6.52	
SiO_2	0.9		
SnO_2	45.7	45.02	54.67
Al_2O_3	0.4		
Fe_2O_3	1.3		
MnO	25.2	25.90	25.73
CaO	0.3	0.16	
MgO	0.2	0.59	
H_2O		[21.81]	19.60
Total		[100.00]	100.00

(1) Foote mine, North Carolina, USA; by electron microprobe, original analysis given as elements, here converted to oxides, total Mn as MnO, total Fe as Fe_2O_3, H_2O by difference; corresponding to $(Mn^{2+}_{0.94}Fe^{3+}_{0.04}Ca_{0.01}Mg_{0.01})_{\Sigma=1.00}(Sn^{4+}_{0.98}Si_{0.01}Al_{0.01})_{\Sigma=1.00}(OH)_6$. (2) Långban, Sweden; by electron microprobe, total Mn as MnO. (3) $MnSn(OH)_6$.

Polymorphism & Series: Dimorphous with wickmanite.

Mineral Group: Stottite group.

Occurrence: As a very rare late-formed mineral in fractures in lithium-rich pegmatite (Foote mine, North Carolina, USA); on a museum specimen from a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Bavenite, eakerite, siderite–rhodochrosite, albite, quartz (Foote mine, North Carolina, USA); magnetite, barite (Långban, Sweden).

Distribution: In the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA. At Långban, Värmland, Sweden.

Name: As the TETRAgonal dimorph of *wickmanite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120239, 121265.

References: (1) White, J.S., Jr. and J.A. Nelen (1973) Tetrawickmanite, tetragonal $MnSn(OH)_6$, a new mineral from North Carolina, and the stottite group. Mineral. Record, 4, 24–30. (2) (1973) Amer. Mineral., 58, 966-967 (abs. ref. 1). (3) Dunn, P.J. (1978) Tungstenian tetrawickmanite from Långban, Sweden. Mineral. Record, 9, 41.

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Terskite $Na_4ZrSi_6O_{15}(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $mm2$. Crystals platy, to 3.5 mm.

Physical Properties: Hardness = ∼5 VHN = 426–519 (40 g load). D(meas.) = 2.71 D(calc.) = 2.74 Fluoresces bright green or very pale yellow under SW UV.

Optical Properties: Semitransparent. *Color:* Pale lilac; nearly colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, weak. $\alpha = 1.576(2)$ $\beta = 1.582(2)$ $\gamma = 1.584(2)$ 2V(meas.) = 53°

Cell Data: *Space Group:* $Pnc2$. $a = 14.195(8)$ $b = 14.750(5)$ $c = 7.511(2)$ Z = 4

X-ray Powder Pattern: Mt. Alluaiv, Russia.
3.324 (100), 3.299 (100), 3.257 (100), 3.186 (80), 2.615 (70), 3.126 (60), 2.565 (60)

Chemistry:

	(1)
SiO_2	56.3
ZrO_2	17.8
MnO	0.4
Na_2O	19.0
LOI	6.37
Total	99.87

(1) Mt. Alluaiv, Russia; by electron microprobe, average of analyses on three grains, loss on ignition taken as H_2O; corresponds to $(Na_{3.97}Mn_{0.04})_{\Sigma=4.01}Zr_{0.94}Si_{6.06}O_{16.02} \cdot 2.29H_2O$.

Occurrence: In veins in pegmatites in alkalic massifs.

Association: Potassic feldspar, sodalite, davyne, arfvedsonite, aegirine, eudialyte (Mt. Alluaiv, Russia); villiaumite, ussingite, gmelinite, tetranatrolite, epistolite, eudialyte, polylithionite, albite (Mont Saint-Hilaire, Canada); eudialyte, microcline, zakharovite, aegirine, nenadkevichite, mangan-neptunite, shkatulkaite (Saint-Amable, Canada).

Distribution: On Mts. Alluaiv and Karnasurt, Lovozero massif, and on Mt. Rasvumchorr, Khibiny massif, Kola Peninsula, Russia. In the Ilímaussaq intrusion, southern Greenland. From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada.

Name: For the Tersk shore of the White Sea, southeastern Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5778/1; Mineralogical Museum, St. Petersburg University, St. Petersburg, 17090; Mining Institute, St. Petersburg, 1034/1; Vernadsky Geological Museum, Moscow, 57773; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82755.

References: (1) Khomyakov, A.P., E.I. Semenov, A.A. Voronkov, and G.N. Nechelyustov (1983) Terskite $Na_4ZrSi_6O_{16} \cdot 2H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 112, 226–232 (in Russian). (2) (1984) Amer. Mineral., 69, 212 (abs. ref. 1). (3) Pudovkina, Z.V. and N.M. Chernitsova (1991) Crystal structure of terskite $Na_4Zr[H_4Si_6O_{18}]$. Doklady Acad. Nauk SSSR, 316, 645–649 (in Russian). (4) (1992) Amer. Mineral., 77, 452 (abs. ref. 3). (5) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 195.

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Tertschite $Ca_4B_{10}O_{19}\cdot 20H_2O$

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Crystal Data: Monoclinic (?). *Point Group:* n.d. As finely fibrous crystalline aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Slightly soluble in hot H_2O; fluoresces pale to dark blue-violet under UV.

Optical Properties: Semitransparent. *Color:* Snow-white. *Luster:* Silky.
Optical Class: [Biaxial.] *Orientation:* Inclined extinction; $Z' \wedge$ long axis = 30°–33°.
α = ∼1.502 (α') β = n.d. γ = ∼1.517 (γ') 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Kurtpınarımine, near Faras, Turkey; only strongest lines given.
2.83, 2.35, 2.02, 3.12, 2.16, 1.93

Chemistry:

	(1)	(2)
B_2O_3	37.26	37.32
MgO	trace	
CaO	22.40	24.05
H_2O	37.72	38.63
Gangue	2.68	
Total	100.06	100.00

(1) Kurtpınarımine, near Faras, Turkey. (2) $Ca_4B_{10}O_{19}\cdot 20H_2O$.

Occurrence: In a borate deposit.

Association: Colemanite, meyerhofferite, ulexite.

Distribution: From the Kurtpınarımine, near Faras, Bigadiç borate district, Balıkesir Province, Turkey.

Name: Honors Professor Hermann Tertsch (1880–1962), Austrian mineralogist, University of Vienna, Vienna, Austria.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1978,489; Royal Ontario Museum, Toronto, Canada, M35725; National Museum of Natural History, Washington, D.C., USA, 112733.

References: (1) Meixner, H. (1953) Einige Boratminerale (Colemanit und Tertschit, ein neues Mineral) aus der Türkei. Fortschr. Mineral., 31, 39–42 (in German). (2) (1954) Amer. Mineral., 39, 849 (abs. ref. 1).

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Teruggite $Ca_4MgAs_2B_{12}O_{22}(OH)_{12}\cdot 14H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Acicular [001] to tabular {100} crystals, prismatic {110} with rhomboidal cross-section, to 0.1 mm; aggregated into cauliflower-shaped nodules.

Physical Properties: *Cleavage:* On {001}, good; on {110}, fair. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.149–2.20 D(calc.) = 2.192

Optical Properties: Transparent. *Color:* Colorless to white. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z = b$; $X \wedge c = -26°$. *Dispersion:* $r > v$, weak. $\alpha = 1.526(1)$ $\beta = 1.528(1)$ $\gamma = 1.551(1)$ 2V(meas.) = 33°

Cell Data: *Space Group:* $P2_1/a$. $a = 15.675(13)$ $b = 19.920(14)$ $c = 6.255(4)$ $\beta = 99°20(5)'$ Z = 2

X-ray Powder Pattern: Loma Blanca deposit, Argentina.
12.13 (100b), 2.785 (30), 9.98 (22b), 3.577 (22b), 4.65 (21b), 8.37 (20b), 4.571 (17)

Chemistry:

	(1)	(2)
As_2O_5	17.99	18.06
B_2O_3	32.88	32.83
MgO	3.17	3.17
CaO	17.57	17.62
H_2O^+	25.57	
H_2O^-	2.82	
H_2O		28.32
Total	[100.00]	100.00

(1) Loma Blanca deposit, Argentina; recalculated to 100% from an original total of 99.94% after deduction of SiO_2 0.29%; then corresponds to $Ca_{3.98}Mg_{1.00}As_{1.99}B_{12}O_{22}(OH)_{12}\cdot 14H_2O$.
(2) $Ca_4MgAs_2B_{12}O_{22}(OH)_{12}\cdot 14H_2O$.

Occurrence: In lacustrine borate deposits, typically associated with volcanic hot springs and diagensis of playa sediments.

Association: Inyoite, calcite, ulexite, aragonite, realgar, montmorillonite (Loma Blanca deposit, Argentina); colemanite, meyerhofferite, ulexite (Emet deposits, Turkey).

Distribution: From the Loma Blanca borate deposit, eight km southwest of Coranzulí, Jujuy Province, Argentina. At the Hisarcık borate mine, near Emet, Kütahya Province. Turkey.

Name: Honors Mario E. Teruggi, Professor of Sedimentology and Petrology, National University, Plata, Argentina.

Type Material: Harvard University, Cambridge, Massachusetts, 109056; National Museum of Natural History, Washington, D.C., USA, 145925.

References: (1) Aristarain, L.F. and C.S. Hurlbut, Jr. (1968) Teruggite, $4CaO\cdot MgO\cdot 6B_2O_3\cdot As_2O_5\cdot 18H_2O$, a new mineral from Jujuy, Argentina. Amer. Mineral., 53, 1815–1827.
(2) Dal Negro, A., I. Kumbasar, and L. Ungaretti (1973) The crystal structure of teruggite. Amer. Mineral., 58, 1034–1043.

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Teschemacherite $(NH_4)HCO_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As compact fine-grained crystalline aggregates, in beds several cm thick.

Physical Properties: *Cleavage:* On {110}, perfect. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = 1.45 D(calc.) = 1.545 Soluble in H_2O, decomposes in humid air.

Optical Properties: Transparent. *Color:* Colorless to white, pale yellow; colorless in transmitted light.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, weak.
$\alpha = 1.423$ $\beta = 1.536$ $\gamma = 1.554$ 2V(calc.) = 41°38′

Cell Data: *Space Group: Pccn.* $a = 7.225$ $b = 10.709$ $c = 8.746$ Z = 8

X-ray Powder Pattern: Synthetic.
2.998 (100), 5.34 (60), 3.62 (55), 4.05 (45), 3.005 (45), 3.068 (30), 2.1547 (30)

Chemistry:

	(1)	(2)
P_2O_5	0.60	
CO_2	51.53	55.67
CaO	6.02	
$(NH_4)_2O$	29.76	32.94
H_2O	11.00	11.39
uric acid	1.09	
Total	100.00	100.00

(1) Chincha Islands, Peru. (2) $(NH_4)HCO_3$.

Occurrence: Rarely found in guano deposits.

Association: n.d.

Distribution: From an undefined locality in Patagonia [probably in Argentina]. At Saldanha Bay, Cape Province, South Africa. On the Chincha and Guañape Islands, off the coast of Peru.

Name: To honor Frederick Edward Teschemacher (1791–1863), English chemist, who first described the species.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 294.
(2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 137–138. (3) Pertlik, F. (1981) Verfeinerung der Kristallstruktur des Teschemacherits, $NH_4CO_2(OH)$. Tschermaks Mineral. Petrog. Mitt., 29, 67–74 (in German with English abs.).
(4) (1959) NBS Circ. 539, 9.

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Testibiopalladite — Pd(Sb, Bi)Te

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Crystal Data: Cubic. *Point Group:* 23. As irregular to short prismatic grains, to 0.10 mm, typically imbedded in sulfide minerals.

Physical Properties: *Cleavage:* Imperfect in two directions. *Tenacity:* Brittle. Hardness = 3.5–4 VHN = 165–267 (10 g load). D(meas.) = n.d. D(calc.) = 8.991

Optical Properties: Opaque. *Color:* Bright steel-gray with pale brown tint; in polished section, bright white with faint blue tint. *Luster:* Metallic, commonly tarnished yellow-brown. R: (400) — , (420) — , (440) — , (460) — , (480) 54.4, (500) 54.2, (520) 54.0, (540) 53.9, (560) 54.0, (580) 54.9, (600) 54.0, (620) 54.0, (640) 54.0, (660) 54.7, (680) — , (700) —

Cell Data: *Space Group:* $P2_13$. a = 6.572(3). Z = 4

X-ray Powder Pattern: Locality "Y", China.
2.940 (10), 1.983 (9), 2.680 (8), 1.755 (7), 1.066 (7), 1.267 (6), 1.162 (6)

Chemistry:

	(1)	(2)	(3)
Pd	25	26	26.6
Pt			0.5
Ag			0.2
Ni	1		0.1
Sb	20	21	19.8
Bi	19	17	18.1
Te	35	36	34.4
Total	100	100	99.7

(1) Locality "Y", China; by electron microprobe, corresponding to $(Pd_{0.89}Ni_{0.06})_{\Sigma=0.95}(Sb_{0.63}Bi_{0.34})_{\Sigma=0.97}Te_{1.03}$. (2) Do.; by electron microprobe, corresponding to $Pd_{0.91}(Sb_{0.65}Bi_{0.30})_{\Sigma=0.95}Te_{1.05}$. (3) Kambalda, Western Australia; by electron microprobe, corresponding to $(Pd_{0.97}Pt_{0.01}Ni_{0.01}Ag_{0.01})_{\Sigma=1.00}(Sb_{0.63}Bi_{0.33})_{\Sigma=0.96}Te_{1.04}$.

Mineral Group: Pyrite group.

Occurrence: In a Cu–Ni sulfide deposit in a serpentine body intruded into a Permian formation of metamorphic rocks (Locality "Y", China); in Cu–Ni sulfide deposits in clinopyroxenite intruding sandy shales and volcanics (Locality "W", China).

Association: Michenerite, gersdorffite, cobaltite, pyrrhotite, chalcopyrite, pentlandite (Locality"Y", China); pyrrhotite, pentlandite, chalcopyrite, violarite, cubanite, bornite, sphalerite, galena, linnaeite, magnetite, sudburyite, sperrylite, omeiite, gold (Danba, China).

Distribution: From Locality "Y" (a code name), in southwestern China [TL]; also at the "W" deposit, in northeastern China [TL]. From Danba, Sichuan Province, China. At Kambalda, 56 km south of Kalgoorlie, Western Australia. From the Nausahi complex, Orissa, India. In the Uitkomst complex, Eastern Transvaal, South Africa. From the Wellgreen Cu–Ni–Pt–Pd deposit, Yukon Territory, Canada.

Name: For TEllurium, antimony (STIBium), and PALLADium in the composition.

Type Material: n.d.

References: (1) Platinum Metal Mineral Research Group, Microprobe Analysis Laboratory, X-ray Powder Laboratory, and Mineral Dressing Laboratory, Kweiyang Institute of Geochemistry, Academia Sinica (1974) Tellurostibnide of palladium and nickel and other new minerals and varieties of platinum metals. Geochimica, 3, 169–181 (in Chinese with English abs.). (2) (1976) Amer. Mineral., 61, 182 (abs. ref. 1). (3) Kim, W.-S. and G.Y. Chao (1991) Phase relations in the system Pd-Sb-Te. Can. Mineral., 29, 401–409. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 143–144.

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Tetra-auricupride **AuCu**

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As irregular grains, to 600 μm, commonly striated.

Physical Properties: *Tenacity:* Malleable. Hardness = 1.6 VHN = 294 (20 g load). D(meas.) = n.d. D(calc.) = 14.67

Optical Properties: Opaque. *Color:* Golden yellow; copper-red with a yellow tint in reflected light. *Luster:* Metallic. *Anisotropism:* Weak, with colors from gray to light gray.

R: (405) 44.6, (436) 46.8, (480) 50.3, (526) 55.8, (546) 61.2, (578) 74.4, (589) 76.6, (622) 83.6, (644) 84.9, (656) 85.4, (664) 86.6, (700) 91.3

Cell Data: *Space Group:* $C4/mmm$. a = 3.98 3.89??Chem.Abs.?? $c = 3.72$ Z = 2

X-ray Powder Pattern: Sardala, China.
2.24 (10), 1.195 (10), 0.797 (9b), 0.877 (7b), 1.125 (6b), 0.832 (6), 1.99 (5)

Chemistry:

	(1)	(2)
Au	75.18	75.61
Cu	23.74	24.39
Total	98.92	100.00

(1) Sardala, China; by electron microprobe, corresponding to $Au_{1.01}Cu_{0.99}$. (2) AuCu.

Occurrence: In mafic to ultramafic rocks that also contain platinum group elements.

Association: Pyrrhotite, pyrite, chalcopyrite, gold, silver, platinum group minerals, magnetite, chromite, tremolite, diopside, serpentine, chlorite, epidote, apatite, zircon.

Distribution: From Sardala [Saar-Dala ??syn ck??in 2004 MFG - upper Qingshui River, Malas (Manas?, Marneshi) Co.], Xinjiang Uygur Autonomous Region, China [TL]. [??and attribute other statements if additional localiies are accepted] In the [better loc??] Noril'sk region, western Siberia, Russia. Additional localities are attributed for this species, but analyses are not given or do not approximate AuCu.

Name: In allusion to the composition and symmetry.

Type Material: Geological Museum, Ministry of Geology, Beijing, China.

References: (1) Chen Keqiao, Yu Tinggao, Zhang Yongge, and Peng Zhizhong (1982) Tetraauricupride, CuAu, discovered in China. Scientia Geologica Sinica, 111–116 (in Chinese with English abs.). (2) (1983) Amer. Mineral., 68, 1250–1251 (abs. ref. 1). (3) Johannsen, C.H. and J.O. Linde (1936) Röntgenographische und elektrische Untersuchungen des CuAu-Systems. Ann. Phys. (Leipzig), 25(1), 1–48 (in German).

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Tetradymite Bi_2Te_2S

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Crystals steep pyramidal, resembling hexagonal prisms but rarely distinct, to 6 mm; commonly granular, massive to foliated, also bladed. *Twinning:* Fourlings with twin plane $\{01\overline{1}8\}$, also $\{01\overline{1}5\}$.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Laminae flexible but not elastic; slightly sectile. Hardness = 1.5–2 VHN = 30–44 (25 g load). D(meas.) = 7.3 D(calc.) = 7.271

Optical Properties: Opaque. *Color:* Pale steel-gray, tarnishes dull or iridescent; in polished section, white. *Streak:* Pale steel-gray. *Luster:* Metallic, splendent on fresh surfaces. *Anisotropism:* Weak.
R_1–R_2: (400) 51.9–56.8, (420) 52.0–56.9, (440) 52.0–57.0, (460) 52.1–57.5, (480) 52.4–58.2, (500) 53.0–59.0, (520) 53.9–59.9, (540) 54.7–60.4, (560) 55.1–60.5, (580) 55.3–60.5, (600) 55.2–60.3, (620) 55.0–60.2, (640) 54.8–60.1, (660) 54.6–60.0, (680) 54.2–59.8, (700) 54.0–59.7

Cell Data: *Space Group:* $R\overline{3}m$. $a = 4.2381$ $c = 29.589$ Z = 3

X-ray Powder Pattern: Paonia, Delta Co., Colorado, USA.
3.10 (100), 2.292 (100), 2.111 (75), 1.965 (75), 1.929 (75), 1.638 (75b), 1.348 (75)

Chemistry:

	(1)	(2)	(3)	(4)
Bi	59.12	62.23	60.4	59.27
Te	35.94	33.25	34.5	36.19
Se			0.9	
S	4.75	4.50	4.0	4.54
Total	99.81	99.98	99.8	100.00

(1) Ciclova, Romania. (2) Near Bradshaw City, Yavapai Co., Arizona, USA. (3) Žubkov, Slovakia; by electron microprobe. (4) Bi_2Te_2S.

Mineral Group: Tetradymite group.

Occurrence: In hydrothermal gold-quartz veins of medium to high temperature of formation; also in contact metamorphic deposits.

Association: Tellurium, tellurobismuthite, gold, silver, bismuth, hessite, petzite, calaverite, matildite, altaite, pyrite, pyrrhotite, galena, sphalerite, arsenopyrite, chalcopyrite, quartz.

Distribution: In small amounts at numerous localities world-wide; the following are only a sampling. In Slovakia, from Žubkov (Schubkau) [TL], as fine twinned crystals. In Romania, from Băiţa (Rezbánya), also Ciclova, Moraviţa (Moravicza), and Oraviţa (Oravicza). In Norway, from Narverud and Seljord. Rich at Boliden, Västerbotten, Sweden. In the USA, from Trail Creek, Blaine Co., Idaho; in New Mexico, in the Sylvanite district, Hidalgo Co.; and in Virginia, at the Whitehall mines, Spotsylvania Co. In Canada, from many localities, as near Liddle Creek, West Kootenay, and at the White Elephant mine, near Vernon, British Columbia; from Red Lake at Bigstone Bay, Lake of the Woods, Ontario; in Quebec, at the McWatters mine, Rouyn Township, and in the Eureka mine, Abitibi Co. The principal ore mineral, in large crystals, from the Dashuigou tellurium deposit, Sichuan Province, China.

Name: From the Greek for *fourfold* and *twin*, an allusion to the twin crystals.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 161–164. (2) Glatz, A.C. (1967) The Bi_2Te_3–Bi_2S_3 system and the synthesis of the mineral tetradymite. Amer. Mineral., 52, 161–170. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 564.

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Tetraferroplatinum ≈PtFe

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Crystal Data: Tetragonal. *Point Group:* n.d. As tiny grains typically embedded in other Pt–Fe alloys.

Physical Properties: Hardness = n.d. VHN = 306–401. D(meas.) = n.d. D(calc.) = [15.7] Ferromagnetic.

Optical Properties: Opaque. *Color:* White in reflected light. *Luster:* Metallic. *Anisotropism:* Weak, in oil.
R: (400) – , (420) 58.5, (440) 59.9, (460) 61.4, (480) 61.9, (500) 62.7, (520) 63.7, (540) 64.2, (560) 64.5, (580) 64.8, (600) 65.0, (620) 64.8, (640) 64.8, (660) 64.6, (680) 64.9, (700) 65.2

Cell Data: *Space Group:* n.d. $a = 3.850(5)$ $c = 3.693(6)$ Z = [2]

X-ray Powder Pattern: Mooihoek mine, South Africa.
2.191 (100), 1.920 (70b), 1.342 (60b), 1.152 (50b), 1.099 (30b), 2.721 (20), 1.709 (20)

Chemistry:

	(1)	(2)	(3)
Pt	78.0	77.0	77.74
Rh		0.8	
Ir	0.32		
Fe	14.9	22.0	22.26
Cu	6.1		
Ni	0.50		
Sb	0.40		
Total	100.22	100.6	100.00

(1) Mooihoek mine, South Africa; by electron microprobe, corresponding to $(Pt_{1.03}Ir_{0.01})_{\Sigma=1.04}(Fe_{0.69}Cu_{0.24}Ni_{0.02}Sb_{0.01})_{\Sigma=0.96}$. (2) Sorashigawa placers, Japan; by electron microprobe, corresponding to $Pt_{0.50}Rh_{<0.01}Fe_{0.50}$. (3) PtFe.

Occurrence: In a hortonolite dunite (Mooihoek, South Africa); in Uralian ultramafics and placers derived therefrom.

Association: Geversite, irarsite, majakite, sperrylite, stannopalladinite, plumbopalladinite, chalcopyrite, pentlandite, chromite, galena, magnetite.

Distribution: In South Africa, from the Mooihoek [TL] and Onverwacht mines, in the Merensky Reef, Bushveld complex, Transvaal. At the Taimyr and Noril'sk-I mines, Noril'sk region, western Siberia; from the Ioko-Dovyren massif, Baikal region, southern Siberia; at the Kytlym and Uktus complexes, and in placers around Nizhni Tagil, Ural Mountains; and at the Konder massif, Aldan Shield, Sakha Russia. From Yubdo, Ethiopia. At the Herbeira ultramafic massif, Cabo Ortegal, [notinColombiaG]??, Spain. In the Pirogues River, New Zealand. From the Sorashigawa placers, ??Prefecture, Japan. In Canada, in the Tulameen and Similkameen Rivers, British Columbia, and in concentrates from the Wellgreen Cu–Ni–Pt–Pd deposit, Yukon Territory. At Nye, Stillwater Co., Montana, USA.

Name: For crystallization in the TETRAgonal system, and iron, FERRum, and PLATINUM in its composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 136552.

References: (1) Cabri, L.J. and C.E. Feather (1975) Platinum–iron alloys: a nomenclature based on a study of natural and synthetic alloys. Can. Mineral., 13, 117–126. (2) (1976) Amer. Mineral., 61, 341 (abs. ref. 1). (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 144–145. (4) Tarkian, M. (1987) Compositional variations and reflectance of the common platinum-group minerals. Mineral. Petrol., 36, 169–190. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 565.

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Tetrahedrite $(Cu, Fe, Ag, Zn)_{12}Sb_4S_{13}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals are tetrahedral, to 15 cm; common as groups of parallel crystals; massive, coarse or fine and granular to compact. *Twinning:* On {111} around [111] as twin axis; contact and penetration twins, commonly repeated.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Somewhat brittle.
Hardness = 3–4.5 VHN = 312–351 (100 g load). D(meas.) = 4.97 D(calc.) = 4.99

Optical Properties: Opaque, except in very thin fragments. *Color:* Flint-gray to iron-black to dull black, cherry-red in transmitted light; in polished section, gray inclining to olive-brown. *Streak:* Black to brown. *Luster:* Metallic, commonly splendent.
Optical Class: Isotropic. $n = > 2.72$ (Li).

R: (400) 32.1, (420) 31.8, (440) 31.7, (460) 31.7, (480) 31.8, (500) 32.0, (520) 32.2, (540) 32.4, (560) 32.4, (580) 32.3, (600) 32.0, (620) 31.5, (640) 31.0, (660) 30.6, (680) 30.2, (700) 29.8

Cell Data: *Space Group:* $I\bar{4}3m$. $a = 10.23$–10.55 $Z = 2$

X-ray Powder Pattern: Neuglück mine, Wittichen, Black Forest, Germany.
3.00 (100), 1.831 (60), 1.563 (30), 2.61 (20), 1.056 (20), 3.69 (10), 2.46 (10)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Cu	45.39	37.7	45.77	Fe	1.32	5.5	
Ag		0.4		Sb	28.85	29.3	29.22
Pb	0.11			As	trace	0.8	
Zn		1.8		S	24.48	24.9	25.01
				Total	100.15	100.4	100.00

(1) Bourg d'Oisans, France. (2) Val del Frigido, Tuscany, Italy; by electron microprobe.
(3) $Cu_{12}Sb_4S_{13}$.

Polymorphism & Series: Forms a series with tennantite and freibergite.

Mineral Group: Tetrahedrite group.

Occurrence: Typically in hydrothermal veins or contact metamorphic deposits of low to medium temperature of formation.

Association: Chalcopyrite, galena, sphalerite, pyrite, bornite, acanthite, calcite, dolomite, siderite, barite, fluorite, quartz.

Distribution: One of the most common of the sulfosalts. Only a few localities which have produced well-crystallized material can be mentioned. In Germany, from Freiberg, Saxony, and in the Harz Mountains, at Clausthal and Horhausen. From near Brixlegg, Tirol, Austria. At Botés, near Zlatna, and Cavnic (Kapnikbánya), Romania. In France, at Irazein, Ariège, France, a few exceptionally large crystals, and from Sainte-Marie-aux-Mines, Haut-Rhin. In Cornwall, England, at the Herodsfoot mine. In Algeria, from near Tenés and Mouzaía. In Bolivia, at the San José mine, Oruro. In Peru, from Casapalca, Junin, in the Huallanca and Quiruvilca districts, and at many other places. From the Noche Buena mine, Mazapil, and at the El Cobre mine, Concepción del Oro, Zacatecas, Mexico. In the USA, in the Daly-Judge and other mines, Park City district, Summit Co., Utah. From the Nanisivik mine, Baffin Island, Nunavut, Canada.

Name: In allusion to the tetrahedral crystal shape.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 374–384. (2) Johnson, N.E., J.R. Craig, and J.D. Rimstidt (1988) Crystal chemistry of tetrahedrite. Amer. Mineral., 73, 389–397. (3) Peterson, R.C. and I. Miller (1986) Crystal structure and cation distribution in freibergite and tetrahedrite. Mineral. Mag., 50, 717–721. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 53–54. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 566.

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Tetrarooseveltite β–$Bi(AsO_4)$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As indistinct crystals, to 50 μm, in powdery aggregates.

Physical Properties: Hardness = 2.5 D(meas.) = n.d. D(calc.) = 7.64

Optical Properties: Semitransparent. *Color:* White to pale yellowish. *Luster:* Earthy. *Optical Class:* Uniaxial (+). $n = 2.20(5)$

Cell Data: *Space Group:* $I4_1/a$ (synthetic). $a = 5.085(5)$ $c = 11.69(2)$ $Z = 4$

X-ray Powder Pattern: Moldava fluorite mine, Czech Republic.
3.066 (100), 1.933 (55), 1.551 (17), 2.546 (12), 4.660 (11), 1.797 (11), 1.581 (10)

Chemistry:

	(1)	(2)
P_2O_5	0.02	
As_2O_5	33.02	33.03
Bi_2O_3	66.96	66.97
Total	100.00	100.00

(1) Moldava fluorite mine, Czech Republic; average of six analyses. (2) $Bi(AsO_4)$.

Polymorphism & Series: Dimorphous with rooseveltite.

Occurrence: A rare secondary mineral in vugs in an oxidized fluorite–barite–quartz vein.

Association: Bayldonite, malachite, mimetite, fluorite, quartz.

Distribution: In the Moldava fluorite mine, about 20 km northwest of Teplice, Krušné hory Mountains, Czech Republic.

Name: As the *tetra*gonal dimorph of *rooseveltite*.

Type Material: Národní Museum, Prague, Czech Republic, P1N 84 563.

References: (1) Sejkora, J. and T. Řídkošil (1994) Tetrarooseveltite, β–$Bi(AsO_4)$, a new mineral species from Moldava deposit, the Krušné hory Mts., northwestern Bohemia, Czech Republic. Neues Jahrb. Mineral., Monatsh., 179–184. (2) (1994) Amer. Mineral., 79, 1210–1211 (abs. ref. 1). (3) Mooney, R.C.L. (1948) Crystal structure of tetragonal bismuth arsenate. Acta Cryst., 1, 163–165.

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Tetrataenite FeNi

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Irregular crystals, to 100 μm, as grains and in rims around taenite.

Physical Properties: Hardness = n.d. VHN = 170–200 (25 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Creamy in reflected light. *Luster:* Metallic. *Anisotropism:* Distinct on well-polished surfaces, bluish green to brownish orange.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P4/mmm$. a = 2.533(2) c = 3.582(2) Z = 1

X-ray Powder Pattern: Linville Ni-rich ataxite meteorite.
3.40 (100), 2.879 (80), 2.526 (80), 4.239 (60), 2.279 (10), 2.187 (10), 2.070 (10)

Chemistry:

	(1)	(2)
Fe	49.00	48.75
Ni	51.00	51.25
Cu	0.20	
Co	0.08	
P	< 0.01	
Total	100.28	100.00

(1) By electron microprobe, average of analyses from 18 meteorites. (2) FeNi.

Occurrence: In slowly cooled meteorites, by the ordering of Fe and Ni atoms in taenite. It is most abundant in mesosiderites and chondrites.

Association: Kamacite, troilite, taenite.

Distribution: Widely distributed in chondrite, mesosiderite, iron, and pallas types of meteorites.

Name: In allusion to the symmetry of the mineral, and the genetic link to taenite.

Type Material: National Museum of Natural History, Washington, D.C., USA, meteorite collection 1025.

References: (1) Ramsden, A.R. and E.N. Cameron (1966) Kamacite and taenite superstructures and a metastable tetragonal phase in iron meteorites. Amer. Mineral., 51, 37–55. (2) Clark, R.S., Jr. and E.R.D. Scott (1980) Tetrataenite – ordered FeNi, a new mineral in meteorites. Amer. Mineral., 65, 624–630. (3) Albertson, J.F., G.B. Jensen, and J.M. Knudsen (1978) Structure of taenite in two iron meteorites. Nature, 273, 453–454. (4) Rubin, A.E. (1994) Euhedral tetrataenite in the Jelica meteorite. Mineral. Mag., 58, 215–221.

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m$ (probable). Pyramidal pseudo-octahedral crystals, with prominent {112}, {001}, and {100}, pseudocubic to rhombic; in globular, rough masses, to 1 mm.

Physical Properties: Hardness = n.d. D(meas.) = 3.65 D(calc.) = 3.79

Optical Properties: Transparent to translucent. *Color:* Honey-yellow, brownish orange, bright yellow.
Optical Class: Uniaxial (–). $\omega = 1.724$ $\epsilon = 1.720$

Cell Data: *Space Group:* $P4_2/n$. $a = 7.787(1)$ $c = 7.797(1)$ Z = [4]

X-ray Powder Pattern: Foote mine, North Carolina, USA.
3.939 (100), 2.7698 (90), 1.7604 (50), 1.6050 (40), 4.518 (30), 3.880 (30), 2.2637 (25)

Chemistry:

	(1)	(2)	(3)
WO_3		6.52	
SiO_2	0.9		
SnO_2	45.7	45.02	54.67
Al_2O_3	0.4		
Fe_2O_3	1.3		
MnO	25.2	25.90	25.73
CaO	0.3	0.16	
MgO	0.2	0.59	
H_2O		[21.81]	19.60
Total		[100.00]	100.00

(1) Foote mine, North Carolina, USA; by electron microprobe, original analysis given as elements, here converted to oxides, total Mn as MnO, total Fe as Fe_2O_3, H_2O by difference; corresponding to $(Mn^{2+}_{0.94}Fe^{3+}_{0.04}Ca_{0.01}Mg_{0.01})_{\Sigma=1.00}(Sn^{4+}_{0.98}Si_{0.01}Al_{0.01})_{\Sigma=1.00}(OH)_6$. (2) Långban, Sweden; by electron microprobe, total Mn as MnO. (3) $MnSn(OH)_6$.

Polymorphism & Series: Dimorphous with wickmanite.

Mineral Group: Stottite group.

Occurrence: As a very rare late-formed mineral in fractures in lithium-rich pegmatite (Foote mine, North Carolina, USA); on a museum specimen from a metamorphosed Fe–Mn orebody (Långban, Sweden).

Association: Bavenite, eakerite, siderite–rhodochrosite, albite, quartz (Foote mine, North Carolina, USA); magnetite, barite (Långban, Sweden).

Distribution: In the Foote mine, Kings Mountain, Cleveland Co., North Carolina, USA. At Långban, Värmland, Sweden.

Name: As the TETRAgonal dimorph of *wickmanite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 120239, 121265.

References: (1) White, J.S., Jr. and J.A. Nelen (1973) Tetrawickmanite, tetragonal $MnSn(OH)_6$, a new mineral from North Carolina, and the stottite group. Mineral. Record, 4, 24–30. (2) (1973) Amer. Mineral., 58, 966-967 (abs. ref. 1). (3) Dunn, P.J. (1978) Tungstenian tetrawickmanite from Långban, Sweden. Mineral. Record, 9, 41.

Thadeuite $(Ca, Mn^{2+})(Mg, Fe^{2+}, Mn^{2+})_3(PO_4)_2(OH, F)_2$

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Crystal Data: Orthorhombic. *Point Group:* 222. Cleavable massive, to ∼1 cm, also granular.

Physical Properties: *Cleavage:* On {010}, very good; another perpendicular. Hardness = < 4 D(meas.) = 3.25(1) D(calc.) = 3.21

Optical Properties: Translucent. *Color:* Yellow-orange. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = [1.568]$ $\beta = 1.597(2)$ $\gamma = 1.600(2)$ 2V(meas.) = 33(2)°

Cell Data: *Space Group:* $C222_1$. $a = 6.412(3)$ $b = 13.563(8)$ $c = 8.545(5)$ Z = 4

X-ray Powder Pattern: Panasqueira, Portugal.
3.38 (100), 3.00 (31), 2.793 (31), 2.626 (23), 2.185 (18), 3.61 (16), 1.696 (11)

Chemistry:

	(1)
P_2O_5	38.7
FeO	11.3
MnO	5.6
MgO	24.3
CaO	14.7
F	2.4
OH	[7.1]
$-O = (F_2, OH)$	[4.3]
Total	[99.8]

(1) Panasqueira, Portugal; by electron microprobe, average of three analyses, total Fe as FeO, total Mn as MnO; $(OH)^{1-}$ calculated for P:(OH+F) = 1:1; corresponds to $(Ca_{0.96}Mn_{0.04})_{\Sigma=1.00}(Mg_{2.21}Fe_{0.57}Mn_{0.25})_{\Sigma=3.03}(PO_4)_{2.00}[(OH)_{1.53}F_{0.46}]_{\Sigma=1.99}$.

Occurrence: A very rare primary mineral in the margins of hydrothermal veins, formed between 230°–360° C and 100–1000 bars.

Association: Fluorapatite, wolfeite, topaz, muscovite, sphalerite, quartz, chalcopyrite, pyrrhotite, siderite, arsenopyrite, chlorite, vivianite, althausite, panasqueiraite.

Distribution: In the Panasqueira Sn–W deposit, Portugal.

Name: Honoring Professor Décio Thadeu, Technical University, Lisbon, Portugal, for his studies on Portuguese ore deposits.

Type Material: Department of Geology and Mineralogy, University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA, 143141.

References: (1) Isaacs, A., D.R. Peacor, and W.C. Kelly (1979) Thadeuite, $Mg(Ca, Mn)(Mg, Fe, Mn)_2(PO_4)_2(OH, F)_2$, a new mineral from Panasqueira, Portugal. Amer. Mineral., 64, 359–361. (2) Isaacs, A.M. and D.R. Peacor (1982) The crystal structure of thadeuite, $Mg(Ca, Mn)(Mg, Fe, Mn)_2(PO_4)_2(OH, F)_2$. Amer. Mineral., 67, 120–125.

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Thalcusite $Tl_2Cu_3FeS_4$

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$, $4mm$, 422, or $4/m\ 2/m\ 2/m$. As bladed crystals, to 1 mm; most commonly as grains.

Physical Properties: *Cleavage:* Parallel to grain elongation. *Tenacity:* Brittle. Hardness = n.d. VHN = 82–92, 88 average (10 g load). D(meas.) = 6.15 (synthetic). D(calc.) = 6.54

Optical Properties: Opaque. *Color:* Bronzy-black; in reflected light, rose-gray to pale lilac. *Luster:* Metallic. *Pleochroism:* Weak; pale gray with brownish lilac tint to dark gray. *Anisotropism:* Moderate; pale yellowish to very dark gray.
R_1–R_2: (400) — , (420) — , (440) 29.3–30.7, (460) 30.4–31.3, (480) 29.6–30.1, (500) 29.8–30.8, (520) 29.7–30.8, (540) 28.4–29.9, (560) 27.9–29.8, (580) 27.9–30.3, (600) 28.4–30.3, (620) 29.2–32.1, (640) 29.7–33.0, (660) 30.6–33.7, (680) 30.7–34.5, (700) 31.7–35.9

Cell Data: *Space Group:* $I\bar{4}md$, $I\bar{4}2m$, $I4mm$, $I422$, or $I4/mmm$. a = 3.882(5) c = 13.25(2) Z = 1

X-ray Powder Pattern: Majak mine, Russia.
2.91 (100), 2.53 (100), 3.73 (80), 1.941 (50), 1.717 (50), 3.31 (40), 2.18 (40)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
K		2.30	0.02	Ag			0.02
Tl	52.2	42.34	51.07	Sb		0.23	0.03
Cu	22.6	26.55	24.91	As		0.54	
Fe	9.1	7.43	7.59	S	16.3	18.17	16.74
				Total	100.2	97.97	100.38

(1) Majak mine, Russia; by electron microprobe, corresponding to $Tl_{2.01}Cu_{2.79}Fe_{1.28}S_{4.00}$. (2) Murun massif, Russia; by electron microprobe, corresponding to $(Tl_{0.94}K_{0.42})_{\Sigma=1.36}$ $Cu_{3.00}Fe_{0.94}S_{4.00}$. (3) Ilímaussaq intrusion, Greenland; by electron microprobe, original total given as 100.37%; corresponding to $Tl_{1.91}Cu_{3.01}Fe_{1.04}S_{4.00}$.

Occurrence: In base-metal sulfide deposits and hyperalkalic massifs.

Association: Platinum and palladium minerals, altaite, galena, sphalerite, djerfisherite, pentlandite, cubanite, chalcopyrite (Majak mine, Russia); chalcopyrite, chalcocite, bornite, idaite (Murun massif, Russia); gudmundite, cuprostibite, djerfisherite, galena, troilite (Ilímaussaq intrusion, Greenland).

Distribution: In Russia, from the Majak mine, Talnakh area, Noril'sk region, western Siberia [TL]; and at the Murun massif, southwest of Olekminsk, Sakha. From Kangerdluarssuk Fjord and at Nakkaalaaq Mountain, southern Greenland. In the Rajpura-Dariba polymetallic deposit, Rajasthan, India. From Mont Saint-Hilaire, Quebec, Canada.

Name: For the constituents THALlium; CUprum, *copper*; and Sulfur.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 77165.

References: (1) Kovalenker, V.A., I.P. Laputina, T.L. Evstigneeva, and V.M. Izoitko (1976) Thalcusite, $Cu_{3-x}Tl_2Fe_{1+x}S_4$, a new thallium sulfide from copper-nickel ores of the Talnakh deposits. Zap. Vses. Mineral. Obshch., 105, 202–206 (in Russian). (2) (1977) Amer. Mineral., 62, 396 (abs. ref. 1). (3) Dobrovol'skaya, M.G., V.S. Malov, V.P. Rogova, and L.N. Vyal'sov (1982) New occurrence of potassium-containing thalcusite in charoite rocks of the Murun massif. Doklady Acad. Nauk SSSR, 267, 1214–1217 (in Russian). (4) Mackovicky, E., Z. Johan, and S. Karup-Møller (1980) New data on bukovite, thalcusite, chalcothallite and rohaite. Neues Jahrb. Mineral., Abh., 138, 122–146.

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Thalénite-(Y) $Y_3Si_3O_{10}(F,OH)$

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Crystal Data: Monoclinic; commonly metamict. *Point Group:* $2/m$. As tabular prismatic crystals, to 20 cm; commonly lamellar; as irregular segregations and embedded in fluorite.

Physical Properties: *Fracture:* Conchoidal, uneven to splintery. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 4.16–4.41 D(calc.) = 4.29

Optical Properties: Transparent to opaque. *Color:* Black, brown, greenish, pink; in thin section, colorless. *Luster:* Greasy.
Optical Class: Biaxial (–). n = ~1.73–1.76 when metamict. α = 1.716–1.731 β = 1.716–1.739 γ = 1.729–1.746 2V(meas.) = 68°–79°

Cell Data: *Space Group:* $P2_1/n$. a = 7.318(2) b = 11.134(3) c = 10.379(3) β = 97.24(2)° Z = 4

X-ray Powder Pattern: Kingman, Arizona, USA.
3.104 (vs), 2.808 (m+), 5.52 (m), 3.79 (m), 3.276 (m), 3.159 (m), 3.453 (mw)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	29.88	33.75	CaO	0.49	
SnO_2	0.23		Na_2O	0.26	
Al_2O_3	0.45		F	n.d.	3.39
Fe_2O_3	0.30		H_2O	2.08	
Y_2O_3	63.35	55.98	CO_2	1.04	
RE_2O_3		8.00	He, etc.	1.40	
MgO	0.21		$-O = F_2$		[1.44]
			Total	99.69	[99.68]

(1) Österby, Sweden. (2) Kola Peninsula, Russia; by X-ray spectroscopy, $RE_2O_3 = Gd_2O_3$ 0.24%, Dy_2O_3 1.77%, Ho_2O_3 0.22%, Er_2O_3 2.92%, Tm_2O_3 0.26%, Yb_2O_3 2.40%, Lu_2O_3 0.19%; corresponds to $[Y_{2.70}Er_{0.08}Yb_{0.07}Dy_{0.05}(Lu,Gd,Tm,Ho)_{0.03}]_{\Sigma=2.93}Si_{3.06}O_{10}[F_{0.97}(OH)_{0.03}]_{\Sigma=1.00}$.

Occurrence: In granite pegmatites.

Association: Fluocerite, fergusonite, gadolinite, zircon, magnetite, allanite, fluorite, quartz, microcline.

Distribution: In Sweden, from Österby, Dalekarlien, and at Åskagen, Torsbacken, and Forskeelbach, Värmland. In Norway, from Hundholmen, Tysfjord, and Kragerö, Nordland; Högetveit, Evje; and Rossås, Setesdal. In the Pyörönmaa pegmatite, Kangasala, Finland. From the Keivy massif, Kola Peninsula, Russia. In the USA, in the Baringer Hill pegmatite, 26 km west of Burnet, Llano Co., Texas; in the Snowflake feldspar mine, Teller Co., and the White Cloud pegmatite, South Platte district, Jefferson Co., Colorado; and on the Guy Hazen claims, seven km south of Kingman, Mohave Co., Arizona. From Suishoyama and Iizaka, Fukushima Prefecture, and at Nosen, Yamanashi Prefecture, Japan.

Name: For Professor Tobias Robert Thalén (1827–1905), Swedish physicist, and its high *yttrium* content.

Type Material: n.d.

References: (1) Dana, E.S. (1899) Dana's system of mineralogy, (6th edition), app. I, 68. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 243–246. (3) Fitzpatrick, J. and A. Pabst (1986) Thalenite from Arizona. Amer. Mineral., 71, 188–193. (4) Yakubovich, O.V., A.V. Voloshin, Y.A. Pakhomovskii, and M.A. Simonov (1988) Refined crystal structure of thalenite. Kristallografiya (Sov. Phys. Crystal.), 33, 605–608 (in Russian).

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Thalfenisite $Tl_6(Fe,Ni,Cu)_{25}S_{26}Cl$

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Crystal Data: Cubic. *Point Group:* n.d. As grains, to 5 μm, in aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 130–164 (10 g load). D(meas.) = n.d. D(calc.) = 5.26

Optical Properties: Opaque. *Color:* Brown in reflected light, dark brown in oil.
R: (400) 24.2, (440) 23.6, (480) 23.6, (520) 24.3, (560) 25.6, (600) 27.3, (640) 28.7, (700) 30.3

Cell Data: *Space Group:* n.d. $a = 10.29(2)$ $Z = 1$

X-ray Powder Pattern: Oktyabr mine, Russia.
2.96 (10), 3.42 (9), 3.24 (7), 1.810 (7), 2.35 (6), 4.16 (5), 1.965 (4)

Chemistry:

	(1)	(2)
Tl	33.4	26.1
K	0.03	1.51
Fe	29.4	31.1
Ni	10.3	10.1
Cu	1.74	2.11
S	24.8	26.1
Cl	0.84	1.01
Total	100.51	98.03

(1) Oktyabr mine, Russia; by electron microprobe, average of 15 grains of 2 samples; corresponding to $(Tl_{5.58}K_{0.03})_{\Sigma=5.61}(Fe_{17.96}Ni_{5.99}Cu_{0.93})_{\Sigma=24.88}S_{26.39}Cl_{0.81}$. (2) Do.; by electron microprobe, the border zone of a zoned grain; corresponding to $(Tl_{4.15}K_{1.52})_{\Sigma=5.67}(Fe_{18.01}Ni_{5.51}Cu_{1.07})_{\Sigma=24.59}S_{26.33}Cl_{0.92}$.

Occurrence: In pentlandite-galena-chalcopyrite ores, localized at the contact of chalcopyrite and galena and included in pentlandite.

Association: Pentlandite, galena, chalcopyrite.

Distribution: From the Oktyabr mine, Talnakh area, Noril'sk region, western Siberia, Russia [TL].

Name: For the principal constituents, THALlium, FErrum for *iron*, NI for *nickel*, and Sulfur.

Type Material: Mining Institute, St. Petersburg, Russia, 1128/1.

References: (1) Rudashevskii, N.S., A.M. Karpenov, G.S. Shipova, N.N. Shishkin, and V.A. Ryabkin (1979) Thalfenisite, the thallium analog of djerfisherite. Zap. Vses. Mineral. Obshch., 108, 696–701 (in Russian). (2) (1981) Amer. Mineral., 66, 219 (abs. ref. 1).

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Thaumasite $Ca_3Si(SO_4)(CO_3)(OH)_6 \cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6. Crystals prismatic, to 5 cm; typically acicular, radiating; powdery, compact, massive.

Physical Properties: *Cleavage:* Traces observed. *Fracture:* Subconchoidal.
Tenacity: Brittle. Hardness = 3.5 D(meas.) = 1.877 D(calc.) = [1.90]

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale yellow.
Luster: Vitreous to dull, greasy, silky.
Optical Class: Uniaxial (–). ω = 1.498–1.507 ϵ = 1.458–1.470

Cell Data: *Space Group:* $P6_3$. a = 11.030(7) c = 10.396(6) Z = 2

X-ray Powder Pattern: Ballyalton, Ireland.
9.56 (100), 5.51 (40), 3.41 (20), 3.78 (16), 3.18 (16), 2.713 (14), 2.155 (13b)

Chemistry:

	(1)	(2)
SiO_2	10.00	10.20
Al_2O_3	0.08	
Fe_2O_3	0.14	
MgO	0.50	
CaO	27.38	27.85
H_2O	42.61	42.57
CO_2	6.73	6.99
SO_3	12.61	12.80
Total	100.05	100.41

(1) Hatrurim, Israel; corresponds to $(Ca_{2.96}Mg_{0.08})_{\Sigma=3.04}Si_{1.01}(SO_4)_{0.96}(CO_3)_{0.93}(OH)_{6.00} \cdot 12.3H_2O$. (2) N'Chwaning mine, South Africa; by AA, CO_3 volumetrically, H_2O by TGA; corresponds to $Ca_{3.10}Si_{1.06}(SO_4)_{1.00}(CO_3)_{0.99}(OH)_{6.37} \cdot 11.60H_2O$.

Occurrence: A very late-stage mineral in some sulfide ore deposits. In contact metamorphic zones and from the reaction of geothermal waters or seawaters with basalts and tuffs.

Association: Zeolites, apophyllite, analcime, calcite, gypsum, pyrite.

Distribution: In the Bjelke mine, near Åreskuta, and at Kjölland, Jämtland, and at Långban, Värmland, Sweden. From Sulitjelma, Norway. At Ballyalton, Co. Down, Ireland. From the Bellerberg volcano and at the Schellkopf, Eifel district; and on the Zeilberg, near Maroldsweisach, Bavaria, Germany. At Klöch, Styria, Austria. In the Hatrurim Formation, Israel. Large crystals from the Wessels and N'Chwaning mines, Kuruman, Cape Province, South Africa. In the USA, at Paterson and Great Notch, Passaic Co., New Jersey; in the Goose Creek quarry, Leesburg, Loudoun Co., and the Fairfax quarry, Centreville, Fairfax Co., Virginia; from Crestmore, Riverside Co., California. From Concepción del Oro, Zacatecas, Mexico. In the Basalt quarry, Prospect, New South Wales, Australia. A number of other occurrences are known.

Name: From the Greek *to be surprised*, because of its remarkable composition, without parallel at the time of its discovery.

Type Material: Wroclaw University, Wroclaw, Poland, II–18500.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 698. (2) Knill, D.C. and B.R. Young (1960) Thaumasite from Co. Down, Northern Ireland. Mineral. Mag., 32, 416–418. (3) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 37–38. (4) Effenberger, H., A. Kirfel, G. Will, and E. Zobetz (1983) A further refinement of the crystal structure of thaumasite, $Ca_3Si(OH)_6CO_3SO_4 \cdot 12H_2O$. Neues Jahrb. Mineral., Monatsh., 60–68. (5) Grubessi, O., A. Mottana, and E. Paris (1986) Thaumasite from the Tschwinning [N'Chwaning] mine, South Africa. Tschermaks Mineral. Petrog. Mitt., 35, 149–156.

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Theisite $Cu_5Zn_5(AsO_4,SbO_4)_2(OH)_{14}$

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Crystal Data: Orthorhombic (probable), pseudohexagonal. *Point Group:* n.d. Crystal cleavage plates are usually curved or crumpled, to 2 mm; may be micaceous, lamellar, in spherical aggregates and crusts.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Sectile. Hardness = 1.5 D(meas.) = 4.3 D(calc.) = 4.45

Optical Properties: Semitransparent. *Color:* Greenish blue, turquoise-blue, pale turquoise-green, pale emerald-green; pale blue-green in transmitted light. *Streak:* White. *Luster:* Pearly on cleavages.
Optical Class: Biaxial (–), nearly uniaxial (–). $\alpha = 1.755$ $\beta = 1.785$ $\gamma = 1.785$
2V(meas.) = ≈0°

Cell Data: *Space Group:* n.d. $a = 8.220$–8.225 $b = 7.123$ $c = 14.934$–15.019 Z = 2

X-ray Powder Pattern: Near Durango, Colorado, USA.
3.741 (10), 14.97 (9), 2.534 (9), 7.483 (5), 1.830 (5), 1.533 (5), 4.112 (4)

Chemistry:

	(1)	(2)	(3)
As_2O_5	14.8	14.06	13.03
Sb_2O_5	7.0	8.11	9.92
CuO	33.3	34.32	33.97
ZnO	33.1	35.83	34.50
CaO	0.3		
H_2O	10.5		
Total	99.0		

(1) Near Durango, Colorado, USA; H_2O on a separate sample; corresponds to $Cu_{4.9}Zn_{4.7}Ca_{0.1}[(As_{0.74}Sb_{0.26})_{\Sigma=1.0}O_4]_2(OH)_{13.6}$. (2) Sa Duchessa mine, Italy; by electron microprobe, average of 11 analyses, $(OH)^{1-}$ calculated for charge balance; corresponds to $Cu_{5.0}Zn_{5.2}[(As_{0.7}Sb_{0.3})_{\Sigma=1.0}O_4]_2(OH)_{14.4}$. (3) Forno, Italy; by electron microprobe, average of 13 analyses, $(OH)^{1-}$ calculated for charge balance; corresponds to $Cu_{4.9}Zn_{4.9}[(As_{0.65}Sb_{0.35})_{\Sigma=1.0}O_4]_2(OH)_{13.6}$.

Occurrence: A rare secondary mineral in thin seams cutting other oxidized minerals (near Durango, Colorado, USA); in dolomitized marble (Forno, Italy).

Association: Cuprite, malachite, azurite, kolwezite, partzite, parnauite, anglesite, cerussite, tenorite, adamite, hemimorphite, chrysocolla, zeunerite, duftite (near Durango, Colorado, USA); azurite, chrysocolla (Sa Duchessa mine, Italy); cinnabar, tetrahedrite, azurite, malachite, fluorite (Forno, Italy).

Distribution: From the Tucker's tunnel uranium deposit, near Durango, Hinsdale Co., Colorado, USA. At the Tynagh mine, near Loughrea, Co. Galway, Ireland. In Germany, from the Glücksrad mine, Oberschulenberg, Harz Mountains; in the Richelsdorf Mountains, Hesse; at the Clara mine, near Oberwolfach, Black Forest. From near Padern, Pyrénées-Orientales, France. In Italy, at the Sa Duchessa mine, Oridda district, and the Is Murvonis mine, Domusnovas, Sardinia; at Canale Fondone, near Forno, Piedmont. From Brixlegg, Tirol, Austria.

Name: To honor Dr. Nicholas J. Theis, who provided the first specimens.

Type Material: The Natural History Museum, London, England, 1984,478.

References: (1) Williams, S.A. (1982) Theisite, a new mineral from Colorado. Mineral. Mag., 46, 49–50. (2) (1983) Amer. Mineral., 68, 282 (abs. ref. 1). (3) Bonazzi, P. and F. Olmi (1989) Theisite from Forno (Alpi Apuane) and from Sa Duchessa (Sardinia), Italy. Neues Jahrb. Mineral., Monatsh., 241–244.

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Thénardite Na_2SO_4

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals dipyramidal {111}, or tabular {010} with large {101}, rarely prismatic along [100], to 20 cm; as pulverulent crusts and efflorescences. *Twinning:* On {110}, commonly forming cruciform groups; as crude butterflylike twins on {011}.

Physical Properties: *Cleavage:* On {010}, perfect; on {101}, fair; on {100}, interrupted. *Fracture:* Uneven to hackly. *Tenacity:* Somewhat brittle. Hardness = 2.5–3 D(meas.) = 2.664 D(calc.) = 2.66 Soluble in H_2O, taste slightly saline.

Optical Properties: Transparent to translucent. *Color:* Colorless; grayish white, pale yellow, yellow-brown, reddish due to inclusions; colorless in transmitted light. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, weak.
$\alpha = 1.464$–1.471 $\beta = 1.473$–1.477 $\gamma = 1.481$–1.485 2V(meas.) = 82°35′

Cell Data: *Space Group:* $Fddd$. $a = 9.829(1)$ $b = 12.302(2)$ $c = 5.868(1)$ Z = 8

X-ray Powder Pattern: Synthetic.
2.783 (100), 4.66 (73), 3.178 (51), 2.646 (48), 3.075 (47), 1.864 (31), 2.329 (21)

Chemistry:

	(1)	(2)
SO_3	54.34	56.37
CaO	2.66	
Na_2O	41.91	43.63
H_2O	0.93	
Total	99.84	100.00

(1) Aguas Blancas, Chile. (2) Na_2SO_4.

Occurrence: Typically in lacustrine (salt and soda lake) evaporite deposits in arid regions, also as crusts and efflorescences, which may be ephemeral, in a wide range of geologic environments; as precipitates around fumaroles.

Association: Mirabilite, blödite, glauberite, epsomite, gypsum, natron, halite.

Distribution: Numerous minor occurrences; rarely in thick beds or as large crystals. From the Espartinas salt lake, near Aranjuez, Madrid Province, Spain. On Vesuvius, Campania, and Etna, Sicily, Italy. From Natron Lakes, northwest of Cairo, Egypt. At Etosha Pan, Namibia. In Chile, from Salar de San Sebastian and as large crystals at Salar de Pintados, near La Guaica, Tarapacá; from Aguas Blancas, near Copiapó, Atacama. In the USA, in California, large crystals from Searles Lake, San Bernardino Co., at Soda Lake, Carrizo Plain, San Luis Obispo Co., and from Bertram Siding, near the Salton Sea, Imperial Co.; at a large deposit five km southwest of Camp Verde, Yavapai Co., Arizona; in Kilauea Crater, Mauna Loa volcano, Hawaii. From the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China.

Name: Honors Professor Louis Jacques Thénard (1777–1857), French chemist, University of Pierre and Marie Curie, Paris, France.

Type Material: Natural History Museum, Paris, France, 26.252.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 404–407. (2) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 895–896. (3) Nord, A.G. (1973) Refinement of the crystal structure of thenardite, Na_2SO_4(V). Acta Chem. Scandia., 27, 814–822. (4) Hawthorne, F.C. and R.B. Ferguson (1975) Anhydrous sulfates. I: Refinement of the crystal structure of celestite with an appendix on the structure of thenardite. Can. Mineral., 13, 181–187. (5) NBS Circ. 539, 2, 59.

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Theoparacelsite $Cu_3As_2O_7(OH)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. In minute crystals, platy or finely parallel fibrous, in botryoidal crusts, to 0.5 cm; may be interstratified with other layer-structure minerals.

Physical Properties: *Cleavage:* {0001}, perfect. *Fracture:* Conchoidal. Hardness = 3.5 D(meas.) = 4.00 D(calc.) = 3.95

Optical Properties: Translucent. *Color:* Emerald-green to blue-green; pale green in thin section. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Uniaxial (+); birefringence very weak. *Pleochroism:* Weak. ω = 1.759–1.760 ϵ = 1.759–1.760

Cell Data: *Space Group:* $P\overline{3}m1$ (synthetic). $a = 3.131$ $c = 4.608$ Z = 1

X-ray Powder Pattern: Vermion district, Greece.
2.335 (100), 4.61 (95), 1.755 (50), 2.708 (30), 1.563 (25), 1.480 (18), 1.336 (10)

Chemistry:

	(1)	(2)
NiO	80.21	80.57
H_2O	19.30	19.43
Total	99.51	100.00

(1) Vermion district, Greece; by electron microprobe, H_2O by the Penfield method. (2) $Ni(OH)_2$.

Occurrence: As coatings in chromitite in lenses in serpentinites (Vermion district, Greece); on chromitite (Hagdale quarry, Scotland).

Association: Magnetite, chromite, millerite, vesuvianite, chlorite, andradite–grossular, nickeliferous serpentine minerals, calcite (Vermion district, Greece); zaratite, reevesite, honessite, hydrohonessite, nakauriite, pentlandite, heazlewoodite (Hagdale quarry, Scotland).

Distribution: From the Vermion district, 50 km west of Thessalonike, Macedonia, Greece. In the Hagdale quarry, Unst, Shetland Islands, Scotland. At the Lord Brassey mine, Heazlewood, Tasmania, Australia.

Name: For Theophrastus, (ca. 371 BC–ca. 287 BC), the first Greek mineralogist.

Type Material: National Museum of Natural History, Washington, D.C., USA, 148460.

References: (1) Marcopoulos, T. and M. Economou (1981) Theophrastite, $Ni(OH)_2$, a new mineral from northern Greece. Amer. Mineral., 66, 1020–1021. (2) Livingstone, A. and D. Bish (1982) On the new mineral theophrastite, a nickel hydroxide, from Unst, Shetland, Scotland. Mineral. Mag., 46, 1–5.

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\ 2/m$. In minute crystals, platy or finely parallel fibrous, in botryoidal crusts, to 0.5 cm; may be interstratified with other layer-structure minerals.

Physical Properties: *Cleavage:* {0001}, perfect. *Fracture:* Conchoidal. Hardness = 3.5 D(meas.) = 4.00 D(calc.) = 3.95

Optical Properties: Translucent. *Color:* Emerald-green to blue-green; pale green in thin section. *Streak:* Pale green. *Luster:* Vitreous.
Optical Class: Uniaxial (+); birefringence very weak. *Pleochroism:* Weak. ω = 1.759–1.760 ϵ = 1.759–1.760

Cell Data: *Space Group:* $P\bar{3}m1$ (synthetic). $a = 3.131$ $c = 4.608$ $Z = 1$

X-ray Powder Pattern: Vermion district, Greece.
2.335 (100), 4.61 (95), 1.755 (50), 2.708 (30), 1.563 (25), 1.480 (18), 1.336 (10)

Chemistry:

	(1)	(2)
NiO	80.21	80.57
H_2O	19.30	19.43
Total	99.51	100.00

(1) Vermion district, Greece; by electron microprobe, H_2O by the Penfield method. (2) $Ni(OH)_2$.

Occurrence: As coatings in chromitite in lenses in serpentinites (Vermion district, Greece); on chromitite (Hagdale quarry, Scotland).

Association: Magnetite, chromite, millerite, vesuvianite, chlorite, andradite–grossular, nickeliferous serpentine minerals, calcite (Vermion district, Greece); zaratite, reevesite, honessite, hydrohonessite (Hagdale quarry, Scotland).

Distribution: From the Vermion district, 50 km west of Thessalonike, Macedonia, Greece. In the Hagdale quarry, Unst, Shetland Islands, Scotland. At the Lord Brassey mine, Heazlewood, Tasmania, Australia.

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References: (1) Marcopoulos, T. and M. Economou (1981) Theophrastite, $Ni(OH)_2$, a new mineral from northern Greece. Amer. Mineral., 66, 1020–1021. (2) Livingstone, A. and D. Bish (1982) On the new mineral theophrastite, a nickel hydroxide, from Unst, Shetland, Scotland. Mineral. Mag., 46, 1–5.

Therasiaite $(NH_4)_3KNa_2Fe^{2+}Fe^{3+}(SO_4)_3Cl_5$

Crystal Data: Monoclinic. *Point Group*: *m*. Displaying forms {012},{210},{101},{$\bar{1}$ 01} and {010}, crystals are well-formed equant to short prismatic, to 0.1 mm.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 1.5-2 D(meas.) = 2.41(1) D(calc.) = 2.397

Optical Properties: Translucent. *Color*: Brown to dark brown. *Streak*: Brown. *Luster*: Vitreous. *Optical Class*: Biaxial (-). α =1.585(3) β = 1.615(3) γ = 1.630(3)

Cell Data: *Space Group*: *Cc*. *a* = 18.284(4) *b* = 12.073(2) *c* = 9.535(2) Z = 4

X-ray Powder Pattern: La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy.
2.812 (100), 2.664 (77), 3.297 (28), 3.208 (14), 3.008 (12), 2.942 (11), 7.36 (8)

Chemistry:

	(1)	(2)
$(NH_4)_2O$	[9.64]	10.91
K_2O	8.61	6.58
Na_2O	8.72	8.65
FeO	[8.75]	10.03
Fe_2O_3	[9.72]	11.15
MnO	1.21	
Al_2O_3	0.87	
SO_3	32.93	33.53
Cl	24.70	24.74
–O=Cl	5.58	5.59
Total	99.57	100.00

(1) La Fossa crater, Vulcano, Sicily, Italy; average of 12 electron microprobe analyses, $(NH_4)_2O$ calculated from stoichiometry and confirmed by IR spectroscopy, Fe^{2+}/Fe^{3+} calculated from structure analysis; corresponding to $(NH_4)_{2.68}K_{1.32}Na_{2.04}Fe_{1.76}Al_{0.12}Mn_{0.12}S_{2.98}O_{11.95}Cl_{5.05}$.
(2) $(NH_4)_3KNa_2Fe^{2+}Fe^{3+}(SO_4)_3Cl_5$.

Occurrence: A sublimate on pyroclastic breccia in a medium temperature (~250ºC) intracrater active volcanic fumarole.

Association: Salammoniac, kremersite, adranosite.

Distribution: (Fumarole FA) at La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy.

Name: For the type locality, *Therasia*, one of the ancient names for Vulcano island (from the Greek for "warm earth").

Type Material: In the Reference Collection, Department of Chemistry, University of Milan, Italy (specimen number 2013-01).

References: (1) Demartin, F., C. Castellano, and I. Campostrini (2014) Therasiaite, $(NH_4)_3KNa_2Fe^{2+}Fe^{3+}(SO_4)_3Cl_5$, a new sulfate chloride from La Fossa Crater, Vulcano, Aeolian islands, Italy. Mineral. Mag., 78(1), 203-213. (2) (2014) Amer. Mineral., 99, 1811 (abs. ref. 1).

Thérèsemagnanite $(Co, Zn)_6(SO_4)(OH, Cl)_{10} \cdot 8H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. Crystals are very thin, tabular on {0001}, aggregated in radial spherules, to 0.2 mm.

Physical Properties: *Cleavage:* Perfect on {0001}. *Fracture:* Irregular. *Tenacity:* "Fragile". Hardness = "Very soft". D(meas.) = 2.52(2) D(calc.) = 2.48

Optical Properties: Transparent. *Color:* Pink to pale pink. *Streak:* Pale pink.
Luster: Pearly.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = pink; E = pale pink. $\omega = 1.568(2)$
$\epsilon = 1.542(2)$

Cell Data: *Space Group:* n.d. $a = 8.363(8)$ $c = 26.18(7)$ $Z = 3$

X-ray Powder Pattern: Cap Garonne mine, France.
13.1 (100), 2.527 (90), 2.681 (40), 3.523 (30), 6.552 (25), 4.177 (25), 2.736 (25)

Chemistry:

	(1)
SO_3	10.54
CoO	32.95
NiO	3.18
CuO	0.16
ZnO	20.42
Cl	5.65
H_2O	28.40
$-O = Cl_2$	1.28
Total	100.02

(1) Cap Garonne mine, France; by electron microprobe, average of five analyses, H_2O by CHN analyzer; corresponds to $(Co_{3.47}Zn_{1.98}Ni_{0.34}Cu_{0.02})_{\Sigma=5.81}(SO_4)_{1.04}[(OH)_{8.29}Cl_{1.25}]_{\Sigma=9.54} \cdot 8.3H_2O$.

Occurrence: A secondary mineral in the oxidized portions of a polymetallic sulfide deposit.

Association: Anglesite, antlerite, cobaltoan-nickeloan ktenasite, cerussite, brochantite, covellite, tennantite, gersdorffite, guarinoite, rutile, quartz.

Distribution: From the Cap Garonne mine, near le Pradet, Var, France.

Name: To honor Thérèse Magnan (1918–), Toulon, France, former mathematics teacher, and President of the Association of Friends of the Mine of Cap Garonne.

Type Material: Mineralogy Department, Natural History Museum, Geneva, Switzerland, 435/86.

References: (1) Sarp, H. (1993) Guarinoite $(Zn, Co, Ni)_6(SO_4)(OH, Cl)_{10} \cdot 5H_2O$ et theresemagnanite $(Co, Zn, Ni)_6(SO_4)(OH, Cl)_{10} \cdot 8H_2O$, deux nouveaux minéraux de la Mine de Cap Garonne, Var, France. Archs. Sci. Genève, 46(1), 37–44 (in French with English abs.).
(2) (1993) Amer. Mineral., 78, 1314–1315 (abs. ref. 1).

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Thermessaite $K_2[AlF_3|SO_4]$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As sharp prismatic crystals, to 0.25 mm, that display {110}, {100}, {111}.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = n.d. D(meas.) = 2.77(2) D(calc.) = 2.790

Optical Properties: Translucent. *Color*: Colorless to white. *Streak*: White. *Luster*: Vitreous. *Optical Class*: n.d. $n \sim 1.445$

Cell Data: *Space Group*: *Pbcn*. $a = 10.810(2)$ $b = 8.336(2)$ $c = 6.822(1)$ $Z = 4$

X-ray Powder Pattern: La Fossa crater, Vulcano, Aeolian Islands, Italy.
2.983 (100), 2.702 (82), 6.631 (70), 1.712 (58), 2.208 (30), 3.317 (28), 5.429 (14)

Chemistry:

	(1)	(2)
K_2O	36.19	36.48
Al_2O_3	20.42	19.74
SO_3	28.74	31.01
F	22.89	22.07
-O=F	9.64	9.30
Total	98.60	100.00

(1) La Fossa crater, Vulcano, Aeolian Islands, Italy; average of 7 electron microprobe analyses, corresponding to $K_{2.02}[Al_{1.05}F_{3.17}S_{0.94}O_{3.83}]$.
(2) $K_2[AlF_3|SO_4]$.

Occurrence: In altered pyroclastic breccias in an active fumarole (300-350° C).

Association: Alunite, sassolite, anhydrite, metavoltine.

Distribution: La Fossa crater, Vulcano, Aeolian Islands, Sicily, Italy.

Name: For *Thermessa* (warm island), an ancient Greek name for the island of Vulcano.

Type Material: Reference Collection, Dipartimento di Chimica Strutturale e Stereochimica Inorganica of Università degli Studi, Milan, Italy, 2007-2.

References: (1) Demartin, F., C.M. Grammaccioli, I. Campostrini, and P. Orlandi (2008) Thermessaite, $K_2[AlF_3|SO_4]$, a new ino-aluminofluoride–sulfate from La Fossa crater, Vulcano, Aeolian Islands, Italy. Can. Mineral., 46, 693–700. (2) (2009) Amer. Mineral., 94, 404- 405 (abs. ref. 1).

Thermonatrite $Na_2CO_3 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. Very rare in acicular crystals; typically as powdery crusts and efflorescences.

Physical Properties: *Cleavage:* On {100}, difficult. *Tenacity:* Somewhat sectile. Hardness = 1–1.5 D(meas.) = 2.255 (synthetic). D(calc.) = 2.262 Soluble in H_2O, alkaline taste; dehydrates readily.

Optical Properties: Transparent. *Color:* Colorless to white, gray, pale yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r < v$, weak.
$\alpha = 1.420$ $\beta = 1.506$ $\gamma = 1.524$ 2V(meas.) = 48°

Cell Data: *Space Group:* $P2_1bc$ (synthetic). $a = 6.472(2)$ $b = 10.724(3)$ $c = 5.259(2)$
Z = 4

X-ray Powder Pattern: Synthetic.
2.768 (100), 2.372 (60), 2.753 (55), 2.678 (55), 2.684 (50), 2.475 (30), 2.010 (25)

Chemistry: (1) Identification depends on coincidence of X-ray powder pattern and optical properties with synthetic material.

Occurrence: Typically on soils and deposited from saline lakes; uncommon in volcanic fumaroles; in hydrothermal veins related to carbonatites.

Association: Trona, natron, halite.

Distribution: In minor amounts in deserts worldwide. On Vesuvius, Campania, Italy. In Russia, from the Kola Peninsula, on Mts. Rasvumchorr and Kukisvumchorr, and in the Vuonnemiok River valley, Khibiny massif; at Mt. Alluaiv, Lovozero massif; and in the Kovdor massif. From the Ilímaussaq intrusion, Greenland. At Mont Saint-Hilaire, Quebec, Canada. In the USA, crystallized from Borax Lake, Lake Co., and at Deep Spring Lake, Inyo Co., California; at Point of Rocks, east of Springer, Colfax Co., New Mexico. In the Lake Bogoria basin, Rift Valley, Kenya. Around Mt. Erebus, Victoria Land, Antarctica.

Name: From the Greek for *heat* and *natron*, as the dehydration product from heating natron.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 224–225. (2) Wu, K.K. and I.D. Brown (1975) A neutron diffraction study of $Na_2CO_3.H_2O$. Acta Cryst., 31, 890–892. (3) (1958) NBS Circ. 539, 8.

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Thomasclarkite-(Y) $(Na, Ce)(Y, Ce, La, Nd)(HCO_3)(OH)_3 \cdot 4H_2O$

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* 2. As blocky crystals, to 2 mm, showing {010}, {0$\bar{1}$0}, {101}, {$\bar{1}$01}, {111}, {$\bar{1}$11}, {1$\bar{1}$1}, {$\bar{1}\bar{1}$1}, singly and in groups. *Twinning:* On {101}, ubiquitous.

Physical Properties: *Cleavage:* Perfect on {010}; a parting on {101}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 2.30(2) D(calc.) = 2.34

Optical Properties: Semitransparent. *Color:* White to yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–), pseudouniaxial (–). $\alpha = 1.40(2)$ $\beta = 1.540(4)$ $\gamma = 1.540(4)$ 2V(meas.) = $\leq 5°$

Cell Data: *Space Group:* $P2$. $a = 4.556(1)$ $b = 13.018(6)$ $c = 4.556(2)$ $\beta = 90.15(3)°$ Z = 1

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
12.97 (10), 4.32 (5), 3.133 (5), 2.016 (4), 6.52 (3), 4.57 (3), 3.223 (3)

Chemistry:

	(1)		(1)
CO_2	12.00	Dy_2O_3	2.04
ThO_2	0.54	Er_2O_3	2.20
Y_2O_3	14.52	Yb_2O_3	1.32
La_2O_3	8.63	CaO	0.33
Ce_2O_3	17.11	Na_2O	6.72
Pr_2O_3	1.92	F	0.17
Nd_2O_3	5.63	H_2O	26.60
Sm_2O_3	1.22	$-O = F_2$	0.07
Gd_2O_3	1.22	Total	102.10

(1) Mont Saint-Hilaire, Canada; by electron microprobe, CO_2 and H_2O analyzed by TGA, $(HCO_3)^{1-}$ and H_2O confirmed by IR; corresponds to $(Na_{0.80}Ce_{0.18}Ca_{0.02})_{\Sigma=1.00}(Y_{0.48}Ce_{0.21}La_{0.20}Nd_{0.12}Pr_{0.04}Dy_{0.04}Er_{0.04}Sm_{0.03}Gd_{0.03}Yb_{0.03})_{\Sigma=1.22}(HCO_3)[(OH)_{2.97}F_{0.03}]_{\Sigma=3.00} \cdot 4.00H_2O$.

Occurrence: Rarely in a pegmatite dike associated with an intrusive alkalic gabbro-syenite complex.

Association: Aegirine, albite, analcime, ancylite-(Ce), astrophyllite, calcite, catapleiite, dawsonite, elpidite, epididymite, franconite, gaidonnayite, galena, genthelvite, microcline, molybdenite, natrolite, petersenite-(Nd), polylithionite, pyrochlore, rhodochrosite, rutile, sérandite, siderite, sphalerite, zircon.

Distribution: From Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Professor Thomas Henry Clark (1893–1996), McGill University, Montreal, Canada, who studied the geology of the area in which Mont Saint-Hilaire is situated.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 81553–81555.

References: (1) Grice, J.D. and R.A. Gault (1998) Thomasclarkite-(Y), a new sodium–rare-earth-element bicarbonate mineral species from Mont Saint-Hilaire, Quebec. Can. Mineral., 36, 1293–1300 (2) (1999) Amer. Mineral., 84, 1466 (abs. ref. 1)

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Thometzekite $Pb(Cu,Zn)_2(AsO_4)_2(OH,H_2O)_2$

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Crystal Data: Monoclinic or triclinic. *Point Group:* $2/m$ or $\overline{1}$. Thin, platy to wedge-shaped crystals, to 20 μm, in crusts.

Physical Properties: Hardness = 4.5 D(meas.) = n.d. D(calc.) = 5.21

Optical Properties: Semitransparent. *Color:* Bluish green to green, greenish yellow; pale gray in transmitted light. *Luster:* Earthy.
Optical Class: Biaxial. $n = 1.855$

Cell Data: *Space Group:* $C2/m$. $a = 9.077(8)$ $b = 6.300(8)$ $c = 7.661(8)$ $\beta = 116.99(8)^\circ$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.273 (10), 4.694 (8), 2.961 (7), 2.870 (7), 2.516 (7), 2.729 (6), 4.495 (5)

Chemistry:

	(1)	(2)
SO_3		9.00
As_2O_5	33.13	24.77
SiO_2	0.06	
Fe_2O_3		0.32
Al_2O_3		0.55
FeO	0.30	
CuO	19.18	19.44
ZnO	5.63	5.52
PbO	36.04	36.10
CaO	0.18	
H_2O	4.9	[4.72]
Total	99.42	[100.42]

(1) Tsumeb, Namibia; by electron microprobe, average of six analyses, total Fe as FeO, H_2O by TGA. (2) Do.; by electron microprobe, average of 26 analyses, total Fe as Fe_2O_3, confirmed by IR and Mössbauer spectroscopy, H_2O calculated from theory; corresponds to $Pb_{0.99}(Cu_{1.50}Zn_{0.41}Al_{0.07}Fe_{0.02})_{\Sigma=2.00}[(AsO_4)_{1.32}(SO_4)_{0.69}]_{\Sigma=2.01}[(H_2O)_{1.23}(OH)_{0.74}]_{\Sigma=1.97}$. (3) Gold Hill, Utah, USA; analysis not given, stated to correspond to $Pb_{0.98}(Cu_{1.14}Fe_{0.80}Zn_{0.02})_{\Sigma=1.96}(AsO_4)_{2.00}(OH,H_2O)_2$.

Mineral Group: Tsumcorite group.

Occurrence: A very rare secondary mineral from an oxidized zone in a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Anglesite, mimetite, gypsum (Tsumeb, Namibia).

Distribution: From Tsumeb, Namibia. At Gold Hill, Tooele Co., Utah, USA. From Moldava, 20 km northwest of Teplice, Czech Republic. At the Clara mine, near Oberwolfach, Black Forest, Germany. From Broken Hill, New South Wales, Australia.

Name: To honor Wilhelm Thometzek, former General Manager of the Tsumeb mining company.

Type Material: Mineralogical-Petrological Institute, Heidelberg University, Heidelberg, Germany.

References: (1) Schmetzer, K., B. Nuber, and O. Medenbach (1985) Thometzekite, a new mineral from Tsumeb, Namibia, and symmetry relation in the tsumcorite-helmutwinklerite family. Neues Jahrb. Mineral., Monatsh., 446–452. (2) (1988) Amer. Mineral., 73, 931 (abs. ref. 1). (3) Kokinos, M. and W.S. Wise (1993) The Gold Hill mine, Tooele County, Utah. Mineral. Record, 24, 11–22. (4) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Thomsenolite $NaCaAlF_6 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic ‖ [001], to 5.5 cm, commonly in parallel groups; may be pseudocubic through development of {001} and {110} or tabular on {001}, with a number of forms. Rarely spherulitic, stalactitic, or massive, in opaline crusts.

Physical Properties: *Cleavage:* {001}, perfect; {110}, distinct. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 2.981 D(calc.) = 2.986(3)

Optical Properties: Transparent to translucent. *Color:* Colorless to white, can be brownish or reddish with included iron oxide; colorless in transmitted light. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X \wedge c = -52°$; $Z = b$. *Dispersion:* $r < v$, weak.
$\alpha = 1.4072–1.4073$ $\beta = 1.4135–1.4136$ $\gamma = 1.4150–1.4152$ 2V(meas.) = 50°–55°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.563(2)$ $b = 5.541(2)$ $c = 16.115(1)$
$\beta = 96.35(3)°$ Z = 4

X-ray Powder Pattern: Ivigtut, Greenland.
4.02 (100), 1.963 (90), 1.996 (80), 2.92 (50), 1.761 (30), 2.16 (20), 1.640 (20)

Chemistry:

	(1)	(2)
Na	10.43	10.35
Ca	17.22	18.05
Al	13.26	12.15
F	50.61	51.34
H_2O	8.42	8.11
Total	99.94	100.00

(1) Ivigtut, Greenland. (2) $NaCaAlF_6 \cdot H_2O$.

Polymorphism & Series: Dimorphous with pachnolite.

Occurrence: As an alteration product of cryolite and other alkali aluminum fluorides, most commonly in granite pegmatites.

Association: Cryolite, pachnolite, ralstonite, chiolite, cryolithionite, elpasolite, sellaite, fluorite.

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland. At Miass, Ilmen Mountains, Southern Ural Mountains and other undefined localities in Russia. At Songshugang, Jiangxi Province, China. From near Lake Gjerdingen, Nordmarka, Norway. In the USA, at St. Peters Dome, near Pikes Peak, El Paso Co., Colorado; at the Spider mine, Honeycomb Hills, Juab Co., Utah; from the Quitman Mountains, Hudspeth Co., Texas; and in the Morefield pegmatite mine, Amelia, Amelia Co., Virginia. From near Saint-Amable, Quebec, Canada.

Name: To honor Hans Peter Jörgen Julius Thomsen (1826–1909), Danish physical chemist, who founded the Danish cryolite industry and first noted the species.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1868.1499.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 116–118. (2) Ferguson, R.B. (1946) On the crystallography of thomsenolite and pachnolite. Trans. Royal Soc. Canada, Sect. IV, 11–26. (3) Pauly, H. and O.V. Petersen (1983) Pachnolite: new optical data with a note on artificial precipitates. Neues Jahrb. Mineral., Monatsh., 241–250. (4) Adhikesavalu, D., T.S. Cameron, and O. Knop (1985) Thomsenolite, $NaCaAlF_6 \cdot H_2O$: hydrogen bonding and comparison with pachnolite. Can. J. Chem., 63, 3322–3327.

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Thomsonite $NaCa_2Al_5Si_5O_{20}\cdot 6H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals commonly prismatic, acicular, or bladed, flattened on {010}, elongated and striated ‖ [001], to 12 cm; in radiated spherical or columnar aggregates; smooth, globular, botryoidal; compact, massive. *Twinning:* On {110}.

Physical Properties: *Cleavage:* Perfect on {010}, good on {100}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 2.23–2.39 D(calc.) = 2.366 Pyroelectric.

Optical Properties: Transparent to translucent. *Color:* White, yellowish, pink, brown, greenish, may be concentrically zoned; colorless in thin section. *Streak:* White. *Luster:* Vitreous to somewhat pearly.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, strong. $\alpha = 1.497–1.530$ $\beta = 1.513–1.533$ $\gamma = 1.518–1.544$ 2V(meas.) = 42°–75°

Cell Data: *Space Group: Pncn.* $a = 13.088(2)$ $b = 13.052(2)$ $c = 13.229(2)$ $Z = 4$

X-ray Powder Pattern: Kaden [*sic*, Kadaň (Kaaden)], Czech Republic. (ICDD 19-1344). 2.86 (100), 4.64 (90), 2.68 (80), 2.95 (70), 3.51 (65), 6.60 (60), 3.19 (45)

Chemistry:

	(1)	(2)
SiO_2	37.17	41.49
Al_2O_3	31.93	28.59
CaO	13.98	11.89
Na_2O	4.00	4.23
K_2O	trace	
H_2O	13.35	[13.80]
Total	100.43	[100.00]

(1) Old Kilpatrick, Scotland; corresponds to $Na_{1.04}Ca_{2.00}Al_{5.03}Si_{4.97}O_{20}\cdot 5.95H_2O$. (2) Goble, Oregon, USA; by electron microprobe, H_2O by difference; corresponds to $Na_{1.09}Ca_{1.70}Al_{4.48}Si_{5.52}O_{20}\cdot 6H_2O$.

Mineral Group: Zeolite group.

Occurrence: In amygdules and fractures in mafic igneous rocks, typically basalts; in some alkalic igneous rocks, contact metamorphic zones, and hypabyssal rocks. As an authigenic cement in some sandstones.

Association: Zeolites, calcite, prehnite, datolite, quartz.

Distribution: A common zeolite with many localities known; a few for good crystals are: from Old Kilpatrick, Dumbartonshire, and Bishopton, Renfrew, Scotland. At Mt. Monzoni, Val di Fassa, Trentino-Alto Adige, Italy. From Ostroh (Seeberg), Kadaň (Kaaden), and Ústí nad Lábem (Aussig), Czech Republic. At Hammer-Unterwiesenthal, Saxony, Germany. From Nolsoy, Essuroy, and Streymoy, Faeroe Islands. In the USA, from Paterson, Passaic Co., New Jersey; on North and South Table Mountain, Jefferson Co., Colorado; and in Oregon, at Springfield, Lane Co., Drain, Douglas Co., Goble, Columbia Co., Ritter Hot Springs, Grant Co., and elsewhere. At Flinders, Victoria, Australia.

Name: For Dr. Thomas Thomson (1773–1852), Scottish chemist and mineralogist of Glasgow, Scotland, who first analyzed the mineral.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 607–609. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 359–376. (3) Wise, W.S. and R.W. Tschernich (1978) Habits, crystal forms and composition of thomsonite. Can. Mineral., 16, 487–493. (4) Pluth, J.J., J.V. Smith, and Å. Kvick (1985) Neutron diffraction study of the zeolite thomsonite. Zeolites, 5(2), 74–80. (5) (1986) Mineral. Abs., 37, 154 (abs. ref. 4).

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Thorbastnäsite $Th(Ca,Ce)(CO_3)_2F_2 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{6}m2$. As cryptocrystalline masses.

Physical Properties: Hardness = n.d. D(meas.) = 4.04, thought low due to excess H_2O. D(calc.) = 5.70 Radioactive.

Optical Properties: Semitransparent. *Color:* Brown.
Optical Class: Uniaxial. n = 1.670–1.678 ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P\overline{6}2c$. $a = 6.99(2)$ $c = 9.71(2)$ $Z = 3$

X-ray Powder Pattern: Pichikhol massif, Russia.
2.85 (10), 2.03 (10b), 3.54 (8), 1.870 (7), 1.279 (6), 1.656 (5), 1.165 (5)

Chemistry:

	(1)		(1)
CO_2	14.78	Dy_2O_3	0.32
SiO_2	2.01	Ho_2O_3	0.12
ThO_2	46.79	Er_2O_3	0.21
TiO_2	0.05	Yb_2O_3	0.15
U_3O_8	0.11	Fe_2O_3	3.62
Al_2O_3	1.76	PbO	0.33
Y_2O_3	1.73	CaO	7.97
La_2O_3	1.59	F	6.87
Ce_2O_3	1.28	H_2O^+	9.04
Pr_2O_3	0.34	H_2O^-	2.14
Nd_2O_3	1.22	$-O = F_2$	2.89
Sm_2O_3	0.25	Total	100.04
Gd_2O_3	0.25		

(1) Pichikhol massif, Russia; RE by spectroscopic analysis, IR confirms H_2O; corresponds to $Th_{1.05}(Ca_{0.85}Y_{0.09}La_{0.06}Ce_{0.04}Nd_{0.04}Pr_{0.01}Sm_{0.01}Gd_{0.01}Dy_{0.01}Er_{0.01}Yb_{0.01})_{\Sigma=1.14}(CO_3)_{2.00}F_{2.15} \cdot 3.70H_2O$.

Occurrence: In metasomatic albitite and quartz–muscovite veinlets in an alkaline exocontact surrounding a syenite intrusive.

Association: Rinkite, zircon, pyrochlore, euxenite-(Y), thorite.

Distribution: From the Pichikhol alkaline massif, Balygtyg-Khem River, Sangilen Upland, Tuva, Siberia, Russia.

Name: For a *thorium*-bearing mineral chemically similar to *bastnäsite*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72030.

References: (1) Pavlenko, A.S., L.P. Orlova, M.V. Akhmanova, and K.I. Tobelko (1965) A thorium fluorcarbonate – thorbastnäsite. Zap. Vses. Mineral. Obshch., 94, 105–113 (in Russian). (2) (1965) Amer. Mineral., 50, 1505 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 208.

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Thoreaulite $Sn^{2+}(Ta,Nb)_2O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals rough, prismatic along [001]; in aggregates, to 10 cm. *Twinning:* On {010} as composition face, lamellar.

Physical Properties: *Cleavage:* {100}, perfect; {011}, imperfect. Hardness = 6
D(meas.) = 7.6–7.9 D(calc.) = 7.21–8.12

Optical Properties: Opaque, transparent in thin fragments. *Color:* Brown, red when altered; yellow in transmitted light. *Streak:* Brown to yellow, slightly greenish. *Luster:* Resinous to adamantine on the cleavage.
Optical Class: Biaxial (+); birefringence ∼0.039 on {100}. *Orientation:* $Y = b$; $Z \wedge c = 27°$.
$n = 2.38$ 2V(meas.) = 25°

Cell Data: *Space Group:* $C2/c$. $a = 17.107$–17.148 $b = 4.864$–4.873 $c = 5.551$–5.554
$\beta = 90.88°-90.93°$ Z = 4

X-ray Powder Pattern: Manono pegmatite, Congo; close to foordite. (ICDD 23-596).
3.10 (10), 3.07 (10), 2.857 (8), 2.432 (8), 1.724 (8), 3.59 (6), 3.57 (6)

Chemistry:

	(1)	(2)
Nb_2O_5	4.1	
Ta_2O_5	69.7	76.64
SnO_2	0.4	
Sb_2O_3	1.2	
PbO	2.8	
SnO	21.1	23.36
Total	99.3	100.00

(1) Manono pegmatite, Congo; by electron microprobe, Sn^{2+}:Sn^{4+} from stoichiometric considerations; corresponding to $(Sn^{2+}_{0.89}Pb_{0.07}Sb_{0.04})_{\Sigma=1.00}(Ta_{1.80}Nb_{0.18}Sn^{4+}_{0.02})_{\Sigma=2.00}O_6$.
(2) $SnTa_2O_6$.

Polymorphism & Series: Forms a series with foordite.

Occurrence: A very rare mineral formed in differentiated granite pegmatites deficient in O, Fe, Mn, Na, Ca, and F.

Association: Cassiterite, lithiotantite, microlite, calciotantite, cesplumtantite (Manono pegmatite, Congo).

Distribution: In Congo (Zaire), from the Manono pegmatite, Katanga (Shaba) Province, and the Maniéma district, Kivu Province. From Gitebi, near Rutsiro, Rwanda. In the Urubú pegmatite, Itinga, Minas Gerais, Brazil. At Ungursai, Kazakhstan. From an undefined locality [Kalbinskiy Range] in Siberia, Russia.

Name: Honors Professor Jacques Thoreau (1886–1973), University of Liège, Liège, Belgium, authority on Congolese (Zairian) mineral occurrences.

Type Material: University of Liège, Liège, Belgium, 2067 and 2068.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 802. (2) Černý, P., A.-M. Fransolet, T.S. Ercit, and R. Chapman (1988) Foordite $SnNb_2O_6$, a new mineral species, and the foordite-thoreaulite series. Can. Mineral., 26, 889–898. (3) Ercit, T.S. and P. Černý (1988) The crystal structure of foordite. Can. Mineral., 26, 899–903.

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Thorianite ThO_2

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Typically as more or less rough cubes, rarely modified by {111} and {113}, to 9 cm; as rounded grains. *Twinning:* Common on {111}, interpenetrant.

Physical Properties: *Cleavage:* {001}, poor. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 6.5–7, unaltered. VHN = 1132–1278, 1180 average (100 g load). D(meas.) = 9.7–9.8 D(calc.) = 9.991 Radioactive; diamagnetic.

Optical Properties: Opaque, transparent in very thin fragments. *Color:* Black, brownish black, dark gray, dark reddish brown, may have a bronzy tarnish; in transmitted light, dark brown, reddish brown, greenish; gray with red-brown internal reflections in reflected light. *Streak:* Gray to greenish gray. *Luster:* Submetallic when fresh, altering to resinous or hornlike. *Optical Class:* Isotropic; may show weak anomalous anisotropism. $n = 2.20$–2.35
R: (400) 16.6, (420) 16.6, (440) 16.6, (460) 16.5, (480) 16.3, (500) 16.0, (520) 15.7, (540) 15.4, (560) 15.2, (580) 15.1, (600) 15.0, (620) 14.9, (640) 14.8, (660) 14.7, (680) 14.6, (700) 14.5

Cell Data: *Space Group: Fm3m.* $a = 5.595$ $Z = 4$

X-ray Powder Pattern: Synthetic; may be confused with uraninite or cerianite.
3.234 (100), 1.689 (64), 1.980 (58), 2.800 (35), 1.284 (26), 1.1432 (20), 1.0779 (19)

Chemistry:

	(1)	(2)
UO_3		18.88
ThO_2	93.02	62.16
UO_2	4.73	10.32
$(Ce,La)_2O_3$		1.84
Fe_2O_3	0.29	1.11
PbO	1.80	2.29
CaO		0.59
H_2O		1.05
insol.		0.77
Total	99.84	99.01

(1) Betroka, Madagascar. (2) Galle district, Sri Lanka.

Polymorphism & Series: Forms a series with uraninite.

Occurrence: An accessory mineral in granite pegmatites, more rarely in carbonatites or serpentinites; commonly detrital in heavy mineral concentrates.

Association: Thorite, zircon, ilmenite, cassiterite, allanite (Sri Lanka); phlogopite, diopside, spinel (Andolobe, Madagascar).

Distribution: In Sri Lanka, at Balangoda and near Kondrugala; in the Galle district; at Bambarabotuwa; and elsewhere. In Madagascar, very large crystals from Taolañaro (Fort Dauphin); at Andranondambo, Antanimora, Betroka, Andolobe, and other localities. From Phalaborwa, Transvaal, South Africa. From Russia, in the Kovdor massif, Kola Peninsula; in the Yenisei Range, Siberia; and along the Boshogoch River, Siberia. In the USA, at Easton, Northampton Co., Pennsylvania; from the Nixon Fork and Wiseman districts, Alaska. In Canada, at a number of places in Pontiac Co., Quebec, and elsewhere. Many minor localities are known.

Name: For THORium in the composition.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 620–622. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 47–53. (3) (1953) NBS Circ. 539, 1, 57.

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Thorikosite $Pb_3(Sb^{3+},As^{3+})O_3Cl_2(OH)$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are extremely small prisms, tabular on {001}, composite and with curved faces.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Very brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 7.24

Optical Properties: Transparent to translucent. *Color:* Light yellow. *Luster:* Vitreous. *Optical Class:* Uniaxial. ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $I4/mmm$. $a = 3.919(1)$ $c = 12.854(5)$ $Z = 1$

X-ray Powder Pattern: Laurium, Greece; might be easily confounded with related natural and synthetic phases.
2.891 (10), 3.754 (7), 2.775 (5), 6.39 (3), 3.203 (3), 2.099 (3), 1.621 (3)

Chemistry:

	(1)
As_2O_3	4.4
Sb_2O_3	9.8
PbO	77.6
Cl	7.7
H_2O	[2.2]
$-O = Cl_2$	1.7
Total	[100.0]

(1) Laurium, Greece; by electron microprobe, H_2O by difference; corresponds to $Pb_{2.9}(Sb^{3+}_{0.6}As^{3+}_{0.4})_{\Sigma=1.0}Cl_{1.8}H_{2.0}O_{4.5}$.

Occurrence: A rare secondary mineral formed through alteration of lead-bearing slag by sea water.

Association: Paralaurionite, laurionite, hydrocerussite, sphalerite, calcite, aragonite.

Distribution: From Laurium, Greece, in slag.

Name: For *Thorikos*, an ancient town in Greece, where ores obtained from the nearby Laurium mines were smelted.

Type Material: National Museum of Natural History, Washington, D.C., USA, 161928, 149042.

References: (1) Dunn, P.J. and R.C. Rouse (1985) Freedite and thorikosite from Långban, Sweden, and Laurion, Greece: two new species related to the synthetic bismuth oxyhalides. Amer. Mineral., 70, 845–848. (2) Rouse, R.C. and P.J. Dunn (1985) The structure of thorikosite, a naturally occurring member of the bismuth oxyhalide group. J. Solid State Chem., 57, 389–395.

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Thorite $(Th,U)SiO_4$

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Crystal Data: Tetragonal; commonly metamict. *Point Group:* $4/m\ 2/m\ 2/m$. In square prisms, terminated by {111}, or pseudo-octahedral crystals, to 8 cm; also massive and compact.

Physical Properties: *Cleavage:* {110}, distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 D(meas.) = 6.63–7.20 D(calc.) = 6.70 Paramagnetic; radioactive.

Optical Properties: Nearly opaque, transparent in thin fragments. *Color:* Yellow-orange, brownish yellow, brownish black, black. *Streak:* Light orange to dark brown. *Luster:* Vitreous to resinous or greasy.
Optical Class: Uniaxial (+). $n = 1.664$–1.87 (metamict). $\omega = 1.78$–1.837 $\epsilon = 1.79$–1.840

Cell Data: *Space Group:* $I4_1/amd$. $a = 7.1328(2)$ $c = 6.3188(2)$ $Z = 4$

X-ray Powder Pattern: Synthetic $ThSiO_4$.
3.56 (10), 1.84 (10), 4.69 (9), 2.66 (8), 1.336 (8), 2.84 (7), 1.438 (7)

Chemistry:

	(1)	(2)
SiO_2	16.47	18.54
TiO_2	0.10	
ThO_2	71.61	81.46
UO_2	8.36	
Al_2O_3	1.29	
RE_2O_3	0.54	
FeO	0.59	
PbO	0.10	
MgO	0.01	
H_2O	0.86	
rem.	0.07	
Total	[100.00]	100.00

(1) Tuolumne River, California, USA; recalculated to 100.00% from original total of 97.24%.
(2) $ThSiO_4$.

Polymorphism & Series: Dimorphous with huttonite.

Occurrence: An accessory mineral in felsic igneous rocks and their associated pegmatites. As a detrital mineral in sediments.

Association: Zircon, monazite, gadolinite, fergusonite, uraninite, yttrialite, pyrochlore.

Distribution: In Norway, from Lomo, Brevik, and around the Langesundsfjord; at Ødegården, Bamble; also Arendal, Tvedestrand, Kragerö, and elsewhere. From Mendig, Eifel district, Germany. In Madagascar, at Ambatofotsy, Androtsabo, Befaritra, and elsewhere. In the USA, from the Baringer Hill pegmatite, 26 km west of Burnet, Llano Co., Texas; at St. Peters Dome, near Pikes Peak, El Paso Co., and the Powderhorn district, Gunnison Co., Colorado; from the Wet Mountains, Custer Co., Colorado. In Canada, as large but crude crystals from the McDonald mine, Hybla, and at Wilberforce, Ontario. Additional minor localities are known.

Name: For its content of *thorium*, in turn named for *Thor*, Scandinavian god of war.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 488–490.
(2) Pabst, A. (1951) X-ray examination of uranium and thorium. Amer. Mineral., 36, 557–562.
(3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 265–276. (4) Taylor, M. and R.C. Ewing (1978) The crystal structures of the $ThSiO_4$ polymorphs: huttonite and thorite. Acta Cryst., 34, 1074–1079.

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Thornasite $(Na,K)ThSi_{11}(O,F,OH)_{25}\cdot 8H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$ or 32. As anhedral to parallel prismatic crystals, to 1.5 mm.

Physical Properties: *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.62(2) D(calc.) = 2.627 Pyroelectric; fluoresces bright apple-green or pale bluish under LW and SW UV; radioactive.

Optical Properties: Opaque to transparent. *Color:* Colorless to very pale green, beige. *Streak:* White. *Luster:* Vitreous to waxy or greasy, may be pearly.
Optical Class: Uniaxial (+). $\omega = 1.510(1)$ $\epsilon = 1.512(1)$

Cell Data: *Space Group:* $R3m$ or $R32$. $a = 29.08(1)$ $c = 17.30(1)$ $Z = 18$

X-ray Powder Pattern: Mont Saint-Hilaire, Canada; slightly metamict.
7.27 (100), 4.17 (70), 8.17 (30), 3.239 (30), 2.890 (25), 14.54 (20), 5.09 (20)

Chemistry:

	(1)
SiO_2	57.93
ThO_2	22.45
UO_2	0.88
Al_2O_3	1.42
CaO	0.17
Na_2O	1.55
K_2O	1.10
F	0.40
Cl	0.05
H_2O^+	5.14
H_2O^-	8.62
$-O = (F,Cl)_2$	0.18
Total	99.53

(1) Mont Saint-Hilaire, Canada; by electron microprobe, average of five analyses, H_2O by TGA; corresponds to $(Na_{0.56}K_{0.26}Ca_{0.03})_{\Sigma=0.85}(Th_{0.94}U_{0.04})_{\Sigma=0.98}(Si_{10.69}Al_{0.31})_{\Sigma=11.00}O_{24.12}F_{0.23}Cl_{0.02}\cdot 8.5H_2O$.

Occurrence: In an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada); in a cavity in a nepheline syenite sill (Saint-Amable, Canada).

Association: Brockite, yofortierite, analcime, eudialyte, sérandite, polylithionite, leifite, natrolite, microcline, albite, mangan-neptunite, steacyite, catapleiite, epididymite, calcite (Mont Saint-Hilaire, Canada); natrolite, nenadkevichite, yofortierite, monazite-(Ce), eudialyte, rhodochrosite (Saint-Amable, Canada).

Distribution: From Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada.

Name: For THORium, sodium or NAtrium, and SIlicon in its composition.

Type Material: Royal Ontario Museum, Toronto, M42070; Canadian Museum of Nature, Ottawa, Canada, 50770.

References: (1) Ansell, V.E. and G.Y. Chao (1987) Thornasite, a new hydrous sodium thorium silicate from Mont St-Hilaire, Quebec. Can. Mineral., 25, 181–183. (2) (1988) Amer. Mineral., 73, 931 (abs. ref. 1). (3) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 95.

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Thorosteenstrupine $CaMnThSi_4O_{11}(OH)F \cdot 6H_2O$

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Crystal Data: Metamict. *Point Group:* n.d. Platy crystals, with rough faces, to 1 cm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼4 D(meas.) = 3.02(2) D(calc.) = n.d. Weakly magnetic; radioactive.

Optical Properties: Opaque, translucent in thin fragments. *Color:* Dark brown, nearly black; reddish brown in transmitted light. *Streak:* Dark brown. *Luster:* Greasy to vitreous. *Optical Class:* Isotropic. $n = 1.63–1.66$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Chergien deposit, Russia; after heating at 900° for 30 minutes. 4.08 (10), 3.25 (10), 2.61 (10), 3.06 (9), 2.84 (8), 1.790 (8), 1.940 (7)

Chemistry:

	(1)
SiO_2	31.87
TiO_2	0.00
ThO_2	35.70
Al_2O_3	0.31
RE_2O_3	1.12
Fe_2O_3	0.65
MnO	7.75
MgO	0.00
CaO	8.38
F	2.43
H_2O	13.77
P_2O_5	0.00
$-O = F_2$	1.02
Total	100.96

(1) Chergien deposit, Russia; by microchemical analysis, corresponding to $(Ca_{1.11}Th_{1.01}Mn_{0.81}RE_{0.06}Fe^{3+}_{0.06})_{\Sigma=3.05}(Si_{3.96}Al_{0.04})_{\Sigma=4.00}[O_{11.24}(OH)_{0.76}]_{\Sigma=12.00}F_{0.95} \cdot 5.32H_2O$.

Occurrence: In metasomatic veins.

Association: Microcline, albite, "aegirine-augite," quartz, fluorite, thorite, miserite.

Distribution: From the Chergien rare-earth deposit, Turana Mountains, 60 km northwest of Chekunda, eastern Siberia, and on Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: For *thorium* in the composition and its close relation to *steenstrupine*.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64285.

References: (1) Kupriyanova, I.I., T.I. Stolyarova, and G.A. Sidorenko (1962) A new thorium silicate – thorosteenstrupine. Zap. Vses. Mineral. Obshch., 91, 325–330 (in Russian). (2) (1963) Amer. Mineral., 48, 433–434 (abs. ref. 1).

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Thortveitite $(Sc,Y)_2Si_2O_7$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals typically prismatic along [110], to 35 cm. *Twinning:* Commonly twinned, axis $\perp$ {110}, composition plane {110}, rarely polysynthetically.

Physical Properties: *Cleavage:* Prismatic. *Fracture:* Uneven to conchoidal. *Tenacity:* Very brittle. Hardness = 6–7 D(meas.) = 3.27–3.58 D(calc.) = [3.32]

Optical Properties: Semitransparent. *Color:* Grayish green to black. *Luster:* Vitreous to subadamantine.
Optical Class: Biaxial (–). *Pleochroism:* X = deep green; $Y = Z$ = brownish yellow in thick grains. *Orientation:* $X \wedge c = 5°$. *Absorption:* $X \geq Y = Z$. α = 1.750–1.756 β = 1.789–1.793 γ = 1.802–1.809 2V(meas.) = 65°30′ 2V(calc.) = 60°–65°

Cell Data: *Space Group:* $C2/m$. a = 6.650(1) b = 8.616(1) c = 4.686(1) β = 102.20(1)° Z = 1

X-ray Powder Pattern: Tuftane, Norway.
3.14 (100), 2.965 (65), 5.18 (60), 2.596 (50), 3.18 (45), 2.627 (30), 2.200 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	42.9	37.59	Fe_2O_3	2.1	2.06
ZrO_2		2.28	FeO	0.8	
HfO_2		0.55	MnO		0.67
Al_2O_3		0.61	MgO		0.26
Sc_2O_3	37.0	25.01	CaO	0.0	0.19
Y_2O_3		17.73	LOI	0.4	
RE_2O_3	17.7	12.26	Total	100.9	99.21

(1) Iveland, Norway. (2) Saetersdalen, Norway; by electron microprobe, $RE_2O_3 = Dy_2O_3$ 1.38%, Er_2O_3 1.65%, Tm_2O_3 0.54%, Yb_2O_3 7.01%, Lu_2O_3 1.68%; corresponds to $(Sc_{1.13}Y_{0.49}RE_{0.20}Fe_{0.08}Zr_{0.06}Mn_{0.03}Mg_{0.02}Ca_{0.01})_{\Sigma=2.02}(Si_{1.95}Al_{0.04})_{\Sigma=1.99}O_7$.

Occurrence: In granite pegmatite dikes (Norway).

Association: Euxenite, biotite, oligoclase, microcline, quartz (Iveland, Norway); monazite, fergusonite, ilmenorutile, beryl, muscovite, magnetite (Befanamo, Madagascar); kobeite, perrierite, tourmaline, euxenite, monazite, zircon, allanite, magnetite, ilmenite (Isanago mine, Japan).

Distribution: From a number of localities in Norway, including: in Iveland, at Saetersdalen, Ljosland, Frøysa, and Tuftane, near Frikstad; in Evje, at Flåt, Landverk, and Rampetrollsinken. At Befanamo, Madagascar. In Japan, in Kyoto Prefecture, in the Isanago mine, Oro, Nakagun, and at Shoroishi, Kobe, Omiya. From the Shilovo-Koneva massif, Ural Mountains, Russia. In the USA, from the Crystal Mountain fluorite mine, at Darby, Ravalli Co., Montana.

Name: For Olaus Thortveit, Norwegian mineralogist who discovered the mineral.

Type Material: n.d.

References: (1) Schetelig, J. (1911) Über thortveitit, ein neues Mineral. Zbl. Mineral. Geol. und Paleontol., 721–726 (in German). (2) Schetelig, J. (1922) Thortveitite, a silicate of scandium, $(Sc,Y)_2Si_2O_7$. Norsk. Geol. Tidsskr., 6, 233–244. (3) (1922) Amer. Mineral., 7, 195 (abs. refs. 1 and 2). (4) Marble, J.P. and J.J. Glass (1942) Some new data on thortveitite. Amer. Mineral., 27, 696–698. (5) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 212–217. (6) Horne, J.E.T. (1966) Mineralogical notes. 7. X-ray diffraction data for thortveitite. Bull. Geol. Sur. Great Britain, 25, 97–99. (7) Bianchi, R., T. Pilati, V. Diella, C.M. Gramaccioli, and G. Mannucci (1988) A re-examination of thortveitite. Amer. Mineral., 73, 601–607.

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Thorutite $(Th, U, Ca)Ti_2(O, OH)_6$

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Crystal Data: Monoclinic; always metamict. *Point Group:* 2, m, or $2/m$. As short prismatic crystals, to 2 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5–6 D(meas.) = 5.82; 6.0(5) (synthetic $ThTi_2O_6$). D(calc.) = [5.65]; 6.08 (synthetic $ThTi_2O_6$).

Optical Properties: Translucent. *Color:* Black; brown on thin edges. *Streak:* Pale brown. *Luster:* Resinous.
Optical Class: Isotropic. $n = > 2.1$

Cell Data: *Space Group:* $C2$, Cm, or $C2/m$ (synthetic $ThTi_2O_6$). $a = 9.822(5)$ $b = 3.824(2)$ $c = 7.036(5)$ $\beta = 118.84(5)°$ Z = 2

X-ray Powder Pattern: Kutyur-Tyube deposit, Russia; after heating at 1000 °C.
3.17 (7), 1.728 (6), 1.695 (6), 1.632 (3), 2.72 (2), 1.226 (2), 4.35 (1.5)

Chemistry:

	(1)
UO_3	0.14
Nb_2O_5	1.12
Ta_2O_5	0.08
SiO_2	0.44
TiO_2	36.1
ThO_2	54.10
UO_2	1.43
Al_2O_3	1.50
Fe_2O_3	1.10
CaO	1.07
H_2O	0.94
LOI	1.72
Total	99.74

(1) Kutyur-Tyube deposit, Russia; corresponds to $(Th_{0.87}Ca_{0.08}Fe^{2+}_{0.06}U^{4+}_{0.02})_{\Sigma=1.03}(Ti_{1.92}Al_{0.09}Nb_{0.03})_{\Sigma=2.04}(O, OH)_6$.

Polymorphism & Series: Forms a series with brannerite.

Occurrence: In veins of microcline and sericitized nepheline, in a syenite massif.

Association: Thorite, zircon, calcite, barite, galena.

Distribution: Kutyur-Tyube thorium deposit, near Urusai Peak, Sokh River basin, Alai Range, Kyrgyzstan.

Name: For the composition, THORium, Uranium, and TItanium.

Type Material: All-Union Research Institute of Mineral Resources, Moscow, Russia.

References: (1) Gotman, Y.D. and I.A. Khapaev (1958) Thorutite – a new mineral of the group of titanites of thorium. Zap. Vses. Mineral. Obshch., 87, 201–202 (in Russian). (2) (1958) Amer. Mineral., 43, 1007 (abs. ref. 1). (3) Povilaitis, M.M. (1963) On the new minerals lodochnikite, absite, and thorutite. Zap. Vses. Mineral. Obshch., 92, 113–123 (in Russian). (4) Ruh, R. and A.D. Wadsley (1966) The crystal structure of $ThTi_2O_6$ (brannerite) [= thorutite]. Acta Cryst., 21, 974–978.

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Threadgoldite $Al(UO_2)_2(PO_4)_2(OH)\cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Tabular micaceous crystals, elongated along [010], showing {100}, {001}, {010}, {012}, to 1 mm.

Physical Properties: *Cleavage:* On {100}, micaceous; also on {001}, {010}, {012}. Hardness = n.d. D(meas.) = 3.4 D(calc.) = 3.33 Radioactive; fluoresces green under LW UV, pale green under SW UV.

Optical Properties: Transparent. *Color:* Yellow-green; very pale yellow to colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 4°$. $\alpha = [1.573]$ $\beta = 1.583$ $\gamma = 1.588$ 2V(meas.) = 70°

Cell Data: *Space Group:* $C2/m$ or Cc. $a = 20.168(8)$ $b = 9.847(2)$ $c = 19.719(4)$ $\beta = 110.71(2)°$ Z = 8

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
9.43 (100), 3.474 (80), 3.366 (60), 2.197 (60), 5.35 (50), 4.10 (50), 4.93 (40b)

Chemistry:

	(1)	(2)
UO_3	63.5	62.31
P_2O_5	13.7	15.46
Al_2O_3	5.4	5.55
H_2O	17.0	16.68
Total	99.6	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, H_2O by TGA on a separate sample; corresponding to $Al_{0.98}(UO_2)_{2.05}(PO_4)_{1.78}(OH)\cdot 8H_2O$. (2) $Al(UO_2)_2(PO_4)_2(OH)\cdot 8H_2O$.

Occurrence: A rare secondary mineral in the uraniferous zone of a complex zoned granite pegmatite.

Association: Meta-autunite, phosphuranylite, phuralumite, bolivarite, upalite, eylettersite, mundite.

Distribution: Found in the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire). From the South Alligator Valley, Northern Territories, Australia.

Name: Honoring Ian Malcomb Threadgold (1929–), Australian mineralogist, University of Sydney, Sydney, Australia.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG5951; National Museum of Natural History, Washington, D.C., USA, 145687.

References: (1) Deliens, M. and P. Piret (1979) Les phosphates d'uranyle et d'aluminium de Kobokobo IV. La threadgoldite, $Al(UO_2)_2(PO_4)_2(OH)\cdot 8H_2O$, nouveau minéral. Bull. Minéral., 102, 338–341 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 209 (abs. ref. 1). (3) Piret, P., J.-P. Declercq, and D. Wauters-Stoop (1979) Structure of threadgoldite. Acta Cryst., 35, 3017–3020. (4) Khosrawan-Sazedj, F. (1982) On the space group of threadgoldite. Tschermaks Mineral. Petrog. Mitt., 30, 111–115.

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Tiemannite HgSe

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. Crystals are tetrahedral, to 0.5 cm; {111} is typically dull, {$\bar{1}$11} is bright; may be striated ‖ [1$\bar{1}$0]; commonly massive, compact, granular. *Twinning:* Common with [111] as twin axis.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 2.5 VHN = 22–26 (5 g load). D(meas.) = 8.19–8.47 D(calc.) = 8.239

Optical Properties: Opaque. *Color:* Steel-gray to brownish lead-gray; in polished section, pale gray. *Streak:* Nearly black. *Luster:* Metallic.

R: (400) 34.5, (420) 35.2, (440) 35.0, (460) 34.0, (480) 32.7, (500) 31.6, (520) 30.6, (540) 29.9, (560) 29.4, (580) 29.0, (600) 28.8, (620) 28.6, (640) 28.5, (660) 28.4, (680) 28.3, (700) 28.2

Cell Data: *Space Group:* $F\bar{4}3m$. a = 6.085 (synthetic). Z = 4

X-ray Powder Pattern: Synthetic.
3.51 (100), 2.151 (50), 1.835 (30), 3.04 (16), 1.396 (10), 1.2424 (8), 1.521 (6)

Chemistry:

	(1)	(2)	(3)		(1)	(2)	(3)
Hg	69.84	70.4	71.75	S	0.37		
Cu		0.1		insol.	0.06		
Cd	0.34			Total	99.80	99.4	100.00
Se	29.19	28.9	28.25				

(1) Utah, USA. (2) Hope's Nose, England; by electron microprobe. (3) HgSe.

Occurrence: In hydrothermal veins with other selenides and calcite.

Mineral Group: Sphalerite group.

Association: Clausthalite, eucairite, naumannite, klockmannite, umangite, metacinnabar, galena, sphalerite, barite, manganese oxides, calcite.

Distribution: In Germany, in the Harz Mountains, from Clausthal [TL], Tilkerode, Lerbach, and Zorge; at Niederschlema, Saxony. From Hope's Nose, Torquay, Devon, England. At Silver Glen, Alva, Scotland. In the Petrovice uranium deposit, near Ždăr, and the Předbořice uranium deposit, near Krásna Hora, Czech Republic. From the Zapadno-Ozernoe Cu–Zn deposit, Southern Ural Mountains, Russia. In the La'erma and Qiongmo gold deposits, western Qinling Mountains, Shaanxi Province, China. In Bolivia, at the Pacajake mine, Hiaco, 24 km east-northeast of Colquechaca, Potosí. In Argentina, in the Sierra de Umango, at the Santa Brigida mine, and from Tuminico, Sierra de Cacho, La Rioja Province. In Mexico, at Rio Blanco, Pinal de Arvole, Artiaga district, and the Cadereyta district, Queretaro, Mexico. In the USA, near Marysvale, Ohio district, Piute Co., Utah; in California, from New Idria, San Benito Co., California. At Nicholson Bay, Lake Athabasca, Saskatchewan, Canada. From El Sharana, Northern Territories, Australia.

Name: To honor Johann Carl Wilhelm Ferdinand Tiemann (1848–1899), chemist of Berlin, Germany, who discovered the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 217–218. (2) Early, J.W. (1950) Description and synthesis of the selenide minerals. Amer. Mineral., 35, 337–364. (3) ?? (1970) ??title?? Zeits. Krist., 132, 276–287 str MFG ordered (4) (1957) NBS Circ. 539, 7, 35. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 575.

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Tienshanite $Na_2BaMn^{2+}TiB_2Si_6O_{20}$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Microcrystalline monomineralic aggregates, to 6 cm.

Physical Properties: *Cleavage:* {001}, distinct. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 3.29 D(calc.) = [3.14]

Optical Properties: Transparent to translucent. *Color:* Pistachio-green. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.666$ $\epsilon = 1.653$

Cell Data: *Space Group:* $P6/m$. a = 16.722(5) $c = 10.434(4)$ Z = 6

X-ray Powder Pattern: Dara-i-Pioz massif, Tajikistan.
4.19 (100), 3.18 (90), 3.47 (80), 2.803 (50), 2.419 (50), 10.5 (35), 3.89 (30)

Chemistry:

	(1)		(1)
SiO_2	43.24	MgO	trace
TiO_2	6.90	CaO	1.95
B_2O_3	7.50	BaO	18.00
Fe_2O_3	1.00	Na_2O	5.93
Ta_2O_5	0.84	K_2O	2.12
Nb_2O_5	4.14	H_2O^+	0.00
MnO	7.80	Total	99.42

(1) Dara-i-Pioz massif, Tajikistan; corresponds to $(Ba_{0.97}K_{0.13})_{\Sigma=1.10}(Na_{1.58}Ca_{0.29}K_{0.24})_{\Sigma=2.11}(Mn^{2+}_{0.91}Fe^{3+}_{0.10})_{\Sigma=1.01}(Ti_{0.72}Nb_{0.26}Ta_{0.03})_{\Sigma=1.01}B_{1.78}Si_{5.93}O_{19.96}$.

Occurrence: In the central portions of alkalic pegmatites in syenite.

Association: Pyrochlore, astrophyllite, bafertisite, stillwellite, danburite, galena, titanite, calcite, datolite.

Distribution: From the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan.

Name: For the occurrence in the Tien Shan (Tien Mountains), Tajikistan.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, 16249; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 70146.

References: (1) Dusmatov, V.D., A.F. Efimov, V.Y. Alkhazov, M.E. Kazakova, and N.G. Mumyatskaya (1967) Tienshanite, a new mineral. Doklady Acad. Nauk SSSR, 177, 678–680 (in Russian). (2) (1968) Amer. Mineral., 53, 1426 (abs. ref. 1). (3) Malinovskii, Y.A., E.A. Pobedimskaya, and N.V. Belov (1977) Crystal structure of tienshanite. Doklady Acad. Nauk SSSR, 236, 863–865 (in Russian). (4) (1979) Mineral. Abs., 30, 217 (abs. ref. 3).

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Tiettaite $(Na,K)_{17}Fe^{3+}TiSi_{16}O_{29}(OH)_{30}\cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As acicular crystals, elongated along [001] and flattened $\perp$ {100}; in rounded aggregates, to 1 cm.

Physical Properties: *Cleavage:* On {100} and {010}, perfect. *Fracture:* Steplike. *Tenacity:* Friable, in aggregate. Hardness = 3 D(meas.) = 2.42(2) D(calc.) = 2.39 Tarnishes on exposure to air.

Optical Properties: Transparent. *Color:* Grayish white; colorless in thin section. *Streak:* [White.] *Luster:* Vitreous or silky.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$. $\alpha = 1.532(2)$ $\beta = 1.548(2)$ $\gamma = 1.559(2)$ 2V(meas.) = 79(1)° 2V(calc.) = 79°

Cell Data: *Space Group:* $Cmcm$, $Cmc2_1$, or $C2cm$. $a = 29.77(1)$ $b = 11.03(2)$ $c = 17.111(5)$ Z = 4

X-ray Powder Pattern: Khibiny massif, Russia.
10.38 (100), 2.773 (90), 3.097 (80), 4.516 (75), 3.220 (65), 2.972 (65), 3.702 (60)

Chemistry:

	(1)
SiO_2	47.65
TiO_2	3.91
Fe_2O_3	4.05
CaO	0.30
Na_2O	19.21
K_2O	9.93
H_2O	14.95
Total	[100.00]

(1) Khibiny massif, Russia; by electron microprobe, total Fe as Fe_2O_3, recalculated to 100.00% after deduction of rasvumite inclusions; corresponding to $(Na_{12.51}K_{4.25}Ca_{0.11})_{\Sigma=16.87}Fe_{1.02}Ti_{0.99}Si_{16}O_{29.10}(OH)_{29.80}\cdot 1.84H_2O$.

Occurrence: In unweathered ultra-alkalic pegmatites in an alkalic massif.

Association: Nepheline, orthoclase, sodalite, aegirine, rasvumite, natrite, many others.

Distribution: On Mts. Koashva and Rasvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: From the Saamsk word *tietta*, for *science* or *knowledge*, also after the name of the first Khibiny research laboratory founded by A.E. Fersman.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, r723/1.

References: (1) Khomyakov, A.P., V.P. Pavlov, D.L. Rogacheva, O.A. Zalkind, and A.V. Martynova (1993) Tiettaite $(Na,K)_{17}FeTiSi_{16}O_{29}(OH)_{30}\cdot 2H_2O$ – a new mineral. Zap. Vses. Mineral. Obshch., 122(1), 121–125 (in Russian). (2) (1994) Amer. Mineral., 79, 1012–1013 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 378 (abs. ref. 1).

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Tikhonenkovite $SrAlF_4(OH)\cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals equant to flattened on {100}, to 1 cm, with prominent {010}, {011}, {10$\overline{2}$}, {11$\overline{1}$}, and a number of rarer forms; may be in flat radial rosettes, or drusy incrustations.

Physical Properties: *Cleavage:* {100}, perfect. *Fracture:* Conchoidal to irregular. Hardness = 3.5 D(meas.) = 3.26(1) D(calc.) = [3.30]

Optical Properties: Transparent. *Color:* Colorless, may be pinkish when included with iron oxides; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.452(1)$ $\beta = 1.456(1)$ $\gamma = 1.458(1)$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.02(2)$ $b = 10.62(4)$ $c = 8.73(3)$ $\beta = 102°43(10)'$ Z = [4]

X-ray Powder Pattern: Karasug deposit, Russia.
4.89 (10), 3.64 (9), 3.27 (8), 2.095 (7), 2.299 (6), 4.44 (5), 3.33 (5)

Chemistry:

	(1)
Na	0.007
K	0.012
Ca	0.93
Sr	36.74
Al	12.10
F	33.88
H_2O	[7.97]
OH	[7.62]
Fe_2O_3	0.52
Total	[99.78]

(1) Karasug deposit, Russia; alkalies by flame photometry, "H_2O^+ 12.0% recalculated into 15.59% H_2O and OH"; after deduction of Fe_2O_3 as impurity, corresponds to $(Sr_{0.94}Ca_{0.05})_{\Sigma=0.99}Al_{1.01}F_{4.00}(OH)_{1.01}\cdot 0.99H_2O$.

Polymorphism & Series: Dimorphous with acuminite.

Occurrence: A secondary mineral formed in fissures in the oxidation zone of veins of iron ores in tectonic breccias.

Association: Gearksutite, karasugite, fluorite, barian celestine, strontianite, "limonite", hematite, quartz.

Distribution: In the Karasug iron-rare earth-barite–fluorite deposit, 15 km north of Karasug, western Tannu-Ola Mountains, Tuva, Siberia, Russia.

Name: To honor Igor Petrovich Tikhonenkov (1927–1961), student of alkalic rocks and minerals, Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 994/1; Geological Survey Institute, Moscow; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67133, 67134, vis1209–1212.

References: (1) Khomyakov, A.P., V.I. Stepanov, V.A. Moleva, and Z.V. Pudovkina (1964) The new mineral tikhonenkovite, $SrAlF_4(OH)\cdot H_2O$. Doklady Acad. Nauk SSSR, 156, 345–347 (in Russian). (2) (1964) Amer. Mineral., 49, 1774–1775 (abs. ref. 1). (3) Smol'yaninova, N.N. (1966) Tikhonenkovite crystals. Trudy Mineral. Muzeya Akad. Nauk SSSR, 17, 229–230 (in Russian). (4) Pudovkina, Z.V., N.M. Chernitsova, and Y.A. Pyatenko (1973) Crystal structure refinement of tikhonenkovite, $Sr_2[Al_2F_8(OH)_2]\cdot 2H_2O$. Zhurnal Strukturnoi Khimii, 14(3), 487–491 (in Russian).

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Tilasite $CaMg(AsO_4)F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Crystals equant, may be elongated along [100], flattened on {010}, with complex domatic form development, to 3.5 cm; in subparallel groups, granular, in veinlets, massive. *Twinning:* On {001}, as contact twins.

Physical Properties: *Cleavage:* On $\{10\overline{1}\}$, good; partings on $\{1\overline{3}3\}$, $\{10\overline{2}\}$, $\{0\overline{1}1\}$. Hardness = 5 D(meas.) = 3.77(2) D(calc.) = [3.80] Piezoelectric; may fluoresce pale yellow, pale pinkish orange, dark red under SW UV.

Optical Properties: Translucent. *Color:* Milky white, gray, violet-gray, rose-red, olive-green, apple-green; colorless or pale green in transmitted light. *Streak:* White. *Luster:* Resinous, vitreous on cleavages.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c \simeq 30°$. *Dispersion:* $r < v$, slight.
$\alpha = 1.640$ $\beta = 1.660$ $\gamma = 1.675$ 2V(meas.) = 82°44′

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 6.681$–6.701 $b = 8.950$–8.944 $c = 7.553$–7.573 $\beta = 120°58'$–$121°14'$ Z = 4

X-ray Powder Pattern: Bisbee, Arizona, USA.
3.246 (10), 2.682 (9), 3.073 (8), 2.860 (7), 1.743 (7), 2.625 (6), 2.266 (6)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	0.10			F	7.45	6.85	8.55
As_2O_5	51.13	51.51	51.70	Cl	trace		
FeO	0.21			H_2O	0.43		
MnO	0.05			insol.	0.08		
MgO	18.12	18.84	18.13	$-O = F_2$	3.04	2.88	3.60
CaO	25.69	26.11	25.22	Total	100.22	100.43	100.00

(1) Långban, Sweden. (2) Sterling Hill, New Jersey, USA; by electron microprobe.
(3) $CaMg(AsO_4)F$.

Polymorphism & Series: Forms a series with maxwellite and with durangite.

Occurrence: Typically in metamorphosed manganese or zinc deposits containing arsenic.

Association: Manganoan diopside, manganberzeliite, svabite, allactite, pyroaurite, dixenite, bergslagite, hematite, calcite, barite (Långban, Sweden); spessartine, braunite, barite, quartz (Kajlidongri, India); friedelite, willemite, barite (Sterling Hill, New Jersey, USA).

Distribution: From Långban, Värmland, Sweden. In Switzerland, from the Falotta mine, Oberhalbstein, Graubünden, and on the west flank of Cherbadung [Pizzo Cervandone], Binntal, Valais. On the east flank of Pizzo Cervandone, Alpe Devero, Val d'Aosta, Piedmont, and at Val Strona, Ossola, Italy. From the Urupskoye copper deposit, northern Caucasus Mountains, Russia. At Sailauf, northeast of Aschaffenburg, Bavaria, Germany. From near Nežilovo, Macedonia. At Kajlidongri, Madhya Pradesh, India. From Guettera, Algeria. In the Puttapa zinc deposit, near Beltana, South Australia. In the USA, at Sterling Hill, Ogdensburg, Sussex Co., New Jersey; from the White Tail Deer mine, Bisbee, Cochise Co., Arizona; in the Monticello tin district, Sierra Co., New Mexico.

Name: Honoring Daniel Tilas (1712–1772), Swedish mining engineer and mineral collector of Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 827–829. (2) Williams, S.A. (1970) Tilasite from Bisbee, Arizona. Mineral. Record, 1, 68–69. (3) Bladh, K.W., R.K. Corbett, W.J. McLean, and R.B. Laughon (1972) The crystal structure of tilasite. Amer. Mineral., 57, 1880–1884. (4) Bermanec, V. (1994) Centro-symmetric tilasite from Nežilovo, Macedonia: a crystal structure refinement. Neues Jahrb. Mineral., Monatsh., 289–294. (5) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 683–684.

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Tilleyite $Ca_5Si_2O_7(CO_3)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As subhedral crystals, rounded grains, and irregular plates. *Twinning:* On {100}, simple; rarely, lamellar.

Physical Properties: *Cleavage:* Perfect on $\{20\bar{1}\}$; poor on {100} and {010}; very poor on {001}. Hardness = n.d. D(meas.) = 2.82–2.84 D(calc.) = 2.88

Optical Properties: Transparent to translucent. *Color:* White; colorless in thin section. *Luster:* Dull.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 24°$; $Z \wedge a = 38°$. *Dispersion:* $r < v$, perceptible. $\alpha = 1.605–1.617$ $\beta = 1.626–1.635$ $\gamma = 1.651–1.654$ 2V(meas.) = 85°–89°

Cell Data: *Space Group:* $P2_1/a$. $a = 15.108(3)$ $b = 10.241(1)$ $c = 7.579(1)$ $\beta = 105.17(1)°$ Z = 4

X-ray Powder Pattern: Carlingford, Ireland.
3.01 (100), 3.10 (60), 1.896 (45), 2.982 (40), 2.803 (40), 2.100 (40), 3.19 (30)

Chemistry:

	(1)	(2)
SiO_2	24.09	24.39
Al_2O_3	0.61	0.23
Fe_2O_3	0.12	0.08
MgO	0.43	0.21
CaO	57.75	57.01
H_2O	1.09	0.62
CO_2	15.82	17.23
Total	99.91	99.77

(1) Crestmore, California, USA; corresponding to $(Ca_{5.19}Al_{0.06}Mg_{0.05}Fe^{3+}_{0.01})_{\Sigma=5.31}Si_{2.02}O_7(C_{0.91}O_3)_2$. (2) Carlingford, Ireland; corresponding to $(Ca_{5.04}Mg_{0.03}Al_{0.02}Fe^{3+}_{0.01})_{\Sigma=5.10}Si_{2.01}O_7(C_{0.94}O_3)_2$.

Occurrence: In the contact metamorphic zone between igneous rocks and limestones, formed at low pressure and high temperature.

Association: Merwinite, spurrite, gehlenite, vesuvianite, grossular, wollastonite, thaumasite, fluorite, calcite.

Distribution: At Crestmore, Riverside Co., California; on North Peak, Iron Mountains, Sierra Co., New Mexico; and near Helena, Lewis and Clark Co., Montana, USA. In Ireland, at Barnavave, near Carlingford, Co. Louth. From near Kilchoan, Ardnamurchan, Argyllshire, and Camas Mòr, Isle of Muck, also on the Isles of Skye and Rhum, Scotland. From the Güneyce-İkizdere area, Trabzon Province, Turkey. In Russia, from near Anakit Creek, at the mouth of the Lower Tunguska River, central Siberia, and several other less-well-defined localities. At Kushiro, Hiroshima Prefecture, and the Akagané mine, Iwate Prefecture, Japan. From Redcap Creek, Queensland, Australia.

Name: For Cecil Edgar Tilley (1894–1973), British petrologist, Cambridge University, Cambridge, England.

Type Material: Harvard University, Cambridge, Massachusetts, 97301; National Museum of Natural History, Washington, D.C., USA, 97246.

References: (1) Larson, E.S. and K.C. Dunham (1933) Tilleyite, a new mineral from the contact zone at Crestmore, California. Amer. Mineral., 18, 469–473. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 278–284. (3) Harker, I. (1959) The synthesis and stability of tilleyite, $Ca_5Si_2O_7(CO_3)_2$. Amer. J. Sci., 257, 656–667. (4) Louisnathan, S.J. and J.V. Smith (1970) Crystal structure of tilleyite: refinement and coordination. Zeits. Krist., 132, 288–306.

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Tin Sn

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Natural crystals are not known; in irregular rounded grains and aggregates, to 1.5 mm.

Physical Properties: *Fracture:* Hackly. *Tenacity:* Ductile, malleable. Hardness = 2 VHN = 7–9 (10 g load). D(meas.) = 7.31 D(calc.) = 7.286

Optical Properties: Opaque. *Color:* Tin-white. *Luster:* Metallic. *Anisotropism:* Moderate.

R_1–R_2: (400) 76.3–72.7, (420) 79.4–74.2, (440) 81.9–75.8, (460) 84.0–77.6, (480) 85.5–79.2, (500) 86.7–80.5, (520) 87.5–81.4, (540) 88.1–81.9, (560) 88.2–82.0, (580) 88.0–81.9, (600) 87.7–81.5, (620) 87.2–81.1, (640) 86.7–80.7, (660) 86.3–80.4, (680) 85.8–80.1, (700) 85.4–79.8

Cell Data: *Space Group:* $I4_1/amd$. $a = 5.831$ $c = 3.182$ $Z = 4$

X-ray Powder Pattern: Synthetic.
2.915 (100), 2.793 (90), 2.017 (74), 2.062 (34), 1.484 (23), 1.442 (20), 1.205 (20)

Chemistry: Typically nearly pure tin by electron micoprobe analyses.

Occurrence: Rare, in some placers; in unspecified kimberlite pipes; in seafloor spreading zones.

Association: Platinum, iridosmine, gold, copper, sorosite, cassiterite.

Distribution: From the Nesbitt LaBine uranium mines, Beaverlodge area, Saskatchewan, Canada. At a placer in Broad Brook, Five Corners Hamlet, Windsor Co., Vermont, USA. From the Rio Tamaná, the Department of Chocó, Cauca, Colombia. At the Ilímaussaq intrusion, southern Greenland. In Nigeria, from the Badiko district, Bauchi, and in the Agbaja ironstone formation. From Oued Berkou, Algeria. At the Gasborn district, Filipstad, Sweden. From the Elkiaidan River, eastern North Nuratin Range, Uzbekistan. At the Baimka gold-PGE placer deposit, in the Bol'shoy Anyuy River area, western Chukotka, Russian Far East, Russia. In the Aberfoyle and Sam Rivers, headwaters of the Clarence River, near Oban, New South Wales, Australia. From the Mid-Atlantic Ridge (26°N) and East Pacif Rise (21°S).

Name: A word of Old English origin, related to the Dutch *tin* and German *zinn*; the chemical symbol from the Latin *stannum*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 126–127. (2) Dekov, V.M., Z.K. Damyanov, and E.D. Mandova (1996) Native tin and tin alloys from axial metalliferous sediments of an ultra-fast spreading centre: East Pacific Rise, 21° S survey area. Neues Jahrb. Mineral., Monatsh., 385–405. (3) Mark, H. and M. Polanyi (1923) ??title? Naturwiss., 11, 256. order?? (4) (1953) NBS Circ. 539, 1, 24. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 576. (6) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 364–365.

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Tinaksite $K_2Na(Ca,Mn^{2+})_2TiSi_7O_{19}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As well-formed long prismatic crystals, to 15 cm; commonly as bundles and rosettes of radiating crystals, or compact fibrous aggregates, to 10 cm.

Physical Properties: *Cleavage:* Perfect on {010}, imperfect on {110}; (010) ∧ (110) = 131.5°. Hardness = 6 VHN = 646–762 D(meas.) = 2.82–2.90 D(calc.) = 2.85

Optical Properties: Transparent to translucent. *Color:* White, colorless, light yellow, light pink. *Luster:* Vitreous on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = colorless; Z = pale orange-brown.
Orientation: $X' \wedge \{010\} = 1°–4°$; $Y \wedge \{010\} = 16°–18°$. *Dispersion:* Strong. $\alpha = 1.593–1.599$ $\beta = 1.621–1.627$ $\gamma = 1.666–1.673$ 2V(meas.) = 68°–78°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.377(3)$ $b = 12.166(3)$ $c = 7.059(1)$ $\alpha = 90.91(1)°$ $\beta = 99.3(1)°$ $\gamma = 92.76(3)°$ Z = 2

X-ray Powder Pattern: Murun massif, Russia.
3.03 (100), 3.25 (80), 2.331 (55), 3.09 (50), 2.952 (50), 2.865 (50), 2.674 (45)

Chemistry:

	(1)
SiO_2	55.82
TiO_2	10.12
Al_2O_3	trace
Fe_2O_3	0.91
FeO	0.92
MnO	0.40
MgO	0.04
CaO	14.20
Na_2O	4.30
K_2O	12.55
H_2O^+	1.20
H_2O^-	0.08
Total	100.54

(1) Murun massif, Russia; corresponds to $K_{1.97}Na_{1.02}(Ca_{1.88}Fe^{2+}_{0.10}Fe^{3+}_{0.08}Mn_{0.04})_{\Sigma=2.10}$ $Ti_{0.94}Si_{6.88}O_{19.76}(OH)_{0.98}$.

Occurrence: An accessory mineral in potassic feldspar metasomatites at the contact with limestones (Murun massif, Russia).

Association: Potassic feldspar, aegirine, quartz, canasite, xonotlite (Murun massif, Russia); orthoclase, pyroxene, aegirine, astrophyllite, hisingerite (Khibiny massif, Russia).

Distribution: In Russia, in the Murun massif, southwest of Olekminsk, Yakutia, and on Mt. Rasvumchorr, Khibiny massif, Kola Peninsula.

Name: For the *Ti, Na, K, Si* in the composition.

Type Material: n.d.

References: (1) Rogov, Y.G., V.P. Rogova, A.A. Voronkov, and V.A. Moleva (1965) Tinaksite, $NaK_2Ca_2TiSi_7O_{19}(OH)$, a new mineral. Doklady Acad. Nauk SSSR, 162, 658–661 (in Russian). (2) (1965) Amer. Mineral., 50, 2098–2099 (abs. ref. 1). (3) Sokolova, M.N., N.I. Zabavnikova, T.A. Yakovlevskaya, and E.S. Rudnitskaya (1975) Tinaksite from pegmatites of the apatite deposit Rasvumchorr (Khibiny Massif). Miner. Paragenezisy Miner. Endog. Mestorozhd., 39–43 (in Russian). (4) (1976) Chem. Abs., 85, 80928 (abs. ref. 3). (5) Bissert, G. (1980) Verfeinerung der Struktur von Tinaksit, $Ca_2K_2NaTiO[Si_7O_{18}(OH)]$. Acta Cryst., 36, 259–263 (in German with English abs.).

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Tincalconite $Na_2B_4O_5(OH)_4 \cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* 32. Rare crystals are pseudo-octahedral, exhibiting $\{10\bar{1}1\}$, $\{01\bar{1}2\}$, and $\{0001\}$, to 1 cm; commonly as a powder.

Physical Properties: Hardness = n.d. D(meas.) = 1.880 D(calc.) = 1.894

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous to dull.
Optical Class: Uniaxial (+). $\omega = 1.461$ $\epsilon = 1.474$

Cell Data: *Space Group:* $R32$. $a = 11.097(2)$ $c = 21.114(4)$ Z = 9

X-ray Powder Pattern: Synthetic. (ICDD 7-277).
2.92 (100), 4.38 (90), 8.75 (55), 3.44 (55), 2.187 (40), 4.71 (30), 3.00 (30)

Chemistry:

	(1)	(2)
B_2O_3	47.52	47.80
Na_2O	20.80	21.28
H_2O	30.59	30.92
insol.	0.48	
Total	99.39	100.00

(1) Kramer district, California, USA. (2) $Na_2B_4O_5(OH)_4 \cdot 3H_2O$.

Occurrence: Typically a dehydration product of other borates.

Association: Borax, kernite.

Distribution: Probably more widespread than the few recorded localities suggest. In the USA, from the Kramer borate deposit, Boron, Kern Co. and as crystals at Searles Lake, San Bernardino Co., California. From the Tincalayu borax deposit, Salar del Hombre Muerto, Salta Province, Argentina. In the Kirka borate deposit, Eskiçehir Province, Turkey. At Larderello, Val di Cecina, Tuscany, Italy. From mud volcanoes, Kerch Peninsula, Ukraine.

Name: From *tincal*, an Oriental name for *borax*, and the Greek for *powder*, in allusion to the typical powdery habit.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 337–339. (2) Powell, D.R., D.F. Gaines, P.J. Zerella, and R.A. Smith (1991) Refinement of the structure of tincalconite. Acta Cryst., C47, 2279–2282.

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Tinsleyite $KAl_2(PO_4)_2(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Composite prismatic crystals, tabular on $\{\bar{1}01\}$, showing $\{\bar{1}01\}$, $\{\bar{1}11\}$, $\{011\}$, $\{110\}$, to 2 mm; in thin films and intergrown with leucophosphite.

Physical Properties: *Tenacity:* Brittle. Hardness = ∼5 D(meas.) = 2.69(5) D(calc.) = 2.62

Optical Properties: Semitransparent. *Color:* Magenta to light brownish red, commonly zoned with colorless leucophosphite. *Streak:* Pink. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = pale orange-brown; Y = pale purple; Z = dark purplish red. *Orientation:* $X = b$. *Absorption:* $Z > Y > X$. $\alpha = 1.591(3)$ $\beta = 1.597(3)$ $\gamma = 1.604(3)$ 2V(meas.) = 86° 2V(calc.) = 86°

Cell Data: *Space Group:* $P2/n$ or Pn. a = 9.602(8) $b = 9.532(6)$ $c = 9.543(11)$ $\beta = 103.16(6)°$ Z = 4

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
6.68 (10), 5.91 (8), 3.006 (7), 2.616 (6b), 4.157 (5), 3.723 (5), 2.836 (5)

Chemistry:

	(1)	(2)
P_2O_5	42.2	42.24
Al_2O_3	26.6	30.34
Fe_2O_3	5.2	
Mn_2O_3	1.1	
K_2O	12.4	14.02
H_2O	[12.5]	13.40
Total	[100.0]	100.00

(1) Tip Top mine, South Dakota, USA; by electron microprobe, total Fe as Fe_2O_3, total Mn as Mn_2O_3, H_2O by difference; corresponds to $K_{0.89}(Al_{1.75}Fe_{0.22}Mn_{0.05})_{\Sigma=2.02}(PO_4)_2(OH)_{0.95}\cdot 1.86H_2O$. (2) $KAl_2(PO_4)_2(OH)\cdot 2H_2O$.

Occurrence: Moderately abundant in highly altered triphylite pods in a complex zoned granite pegmatite (Tip Top mine, South Dakota, USA).

Association: Leucophosphite, triphylite, rockbridgeite–frondelite, tavorite, robertsite, jahnsite, carbonate-apatite, laueite (Tip Top mine, South Dakota, USA).

Distribution: Found in the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA. At the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. Well-crystallized from the Bendada pegmatite, near Guarda, Portugal.

Name: To honor Frank C. Tinsley (1916–), Rapid City, South Dakota, USA, for his efforts to preserve mineral specimens for research.

Type Material: National Museum of Natural History, Washington, D.C., USA, 149791, 159882.

References: (1) Dunn, P.J., R.C. Rouse, T.J. Campbell, and W.L. Roberts (1984) Tinsleyite, the aluminum analogue of leucophosphite, from the Tip Top pegmatite in South Dakota. Amer. Mineral., 69, 374–376.

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Tinticite $Fe_4^{3+}(PO_4)_3(OH)_3 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, m, or 2. As thick claylike coatings or fine-grained massive nodules, composed of platy crystals, to 1.5 μm.

Physical Properties: Hardness = ~2.5 D(meas.) = 2.8–2.94 D(calc.) = 2.97

Optical Properties: Semitransparent. *Color:* Creamy white with yellowish or brownish tint, may be bright ocher-yellow. *Luster:* Dull.
Optical Class: Biaxial. $n = 1.745$

Cell Data: *Space Group:* $P2/m$, Pm, or $P2$. $a = 13.65(1)$ $b = 6.542(5)$ $c = 12.31(1)$ $\beta = 91.2(1)°$ Z = 3

X-ray Powder Pattern: Bruguers, Spain.
3.307 (100), 3.950 (95), 3.027 (95), 2.984 (60), 4.604 (40), 2.361 (40), 1.946 (40)

Chemistry:

	(1)	(2)	(3)
SO_3	0.71		
P_2O_5	30.21	29.4	32.79
V_2O_5		4.0	
Fe_2O_3	49.28	48.9	49.18
H_2O^+	17.21		
H_2O^-	1.72		
H_2O		17.9	18.03
Total	99.13	100.2	100.00

(1) East Tintic district, Utah, USA. (2) Bruguers, Spain; corresponds to $Fe_4[(PO_4)_{2.70}(VO_4)_{0.30}]_{\Sigma=3.00}(OH)_3 \cdot 5H_2O$. (3) $Fe_4(PO_4)_3(OH)_3 \cdot 5H_2O$.

Occurrence: Formed by reaction between phosphatic solutions derived from bat guano and iron from oxidizing pyrite (East Tintic district, Utah, USA); formed by weathering rocks containing apatite and jarosite (Bruguers, Spain).

Association: Jarosite, "limonite" (East Tintic district, Utah, USA); montgomeryite, carbonate-apatite, goethite (Bruguers, Spain).

Distribution: In the USA, found in a limestone cave near the Tintic Standard mine, near Dividend, East Tintic district, Utah Co., Utah; in the Gold Quarry mine, near Carlin, Maggie Creek district, Eureka Co., Nevada; in the Foote mine, near Kings Mountain, Cleveland Co., North Carolina. From Bruguers, 15 km southwest of Barcelona, Barcelona Province, Spain. At the Leveäniemi mine, Svappavaara, near Kiruna, Sweden. From Hagendorf, Bavaria, and in the Clara Mine, near Oberwolfach, Black Forest, Germany. In an unspecified gold deposit, central Kyzylkum, Uzbekistan. At the Moculta phosphate quarry, northeast of Angaston, South Australia. From the Suwa mine, Nagano Prefecture, Japan.

Name: For its initially noted occurrence in the East Tintic distict, Utah, USA.

Type Material: The Natural History Museum, London, England, 1986,61; National Museum of Natural History, Washington, D.C., USA, 105407, 105609.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 970–971. (2) Melgarejo, J.C., S. Galí, and C. Ayora (1988) Tinticite: new structural and chemical data. Neues Jahrb. Mineral., Monatsh., 446–453.

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Tintinaite $\mathbf{Cu_2Pb_{10}(Sb,Bi)_{16}S_{35}}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As blades forming parallel aggregates, to 2 mm; in small masses and veinlets.

Physical Properties: *Cleavage:* Distinct on {010}. Hardness = n.d. VHN = n.d. D(meas.) = 5.48 D(calc.) = 5.51

Optical Properties: Opaque. *Color:* Lead-gray. *Streak:* Black. *Luster:* Metallic. R_1–R_2: (400) 39.3–44.5, (420) 39.0–44.3, (440) 38.8–44.0, (460) 38.5–43.7, (480) 38.2–43.6, (500) 38.1–43.8, (520) 38.0–43.8, (540) 37.9–43.6, (560) 37.9–43.3, (580) 37.3–42.6, (600) 36.7–41.8, (620) 36.0–41.0, (640) 35.6–40.8, (660) 35.5–40.3, (680) 34.9–39.7, (700) 34.2–38.5

Cell Data: *Space Group: Pnnm.* $a = 22.30$ $b = 34.00$ $c = 4.04$ Z = 2

X-ray Powder Pattern: Tintina mine, Canada.
3.40 (100), 3.51 (80), 2.71 (70), 2.022 (60), 2.87 (50), 3.96 (40), 3.27 (40)

Chemistry:

	(1)	(2)	(3)
Pb	40.97	42.3	41.05
Cu	2.21		
Ag	0.12		
Sb	34.96	17.6	30.68
Bi		23.0	5.3
As			0.84
S	21.33	20.0	21.7
Total	99.59	102.9	99.57

(1) Tintina mine, Canada; by electron microprobe, corresponding to $Cu_{1.85}Ag_{0.06}Pb_{10.50}Sb_{15.11}S_{35.00}$. (2) Rossland, Canada; by electron microprobe, corresponding to $Pb_{11.46}(Sb_{8.41}Bi_{6.41})_{\Sigma=14.82}S_{35.00}$. (3) Shexingping mine, China; by electron microprobe, corresponding to $Pb_{10.25}(Sb_{13.03}Bi_{1.31}As_{0.58})_{\Sigma=14.92}S_{35.00}$.

Polymorphism & Series: Forms a series with kobellite.

Occurrence: As small masses and veinlets in malachite-stained quartz (Tintina mines, Canada).

Association: Jamesonite, argentian tetrahedrite, galena, sphalerite, pyrite, arsenopyrite, marcasite, bournonite, owyheeite, pyrrhotite, chalcopyrite (Tintina mines, Canada); joséite, kobellite (Boliden, Sweden).

Distribution: In Canada, from the Tintina silver mines, Watson Lake, Yukon Territory [TL]; at the Deer Park mine, Rossland, British Columbia. In the Cofer deposit, near Mineral, Louisa Co., Virginia, USA. From Boliden, Västerbotten, Sweden. In Slovkia, at the Mária mine, Rožňava, and in the Däbrava deposit, Low Tatra Mountains. From the Shexingping mine, Cheng Co., Hunan Province, China. In the Srednegolgotaiskoe gold deposit, eastern Transbaikalia, Siberia, Russia.

Name: For the Tintina mines, Canada.

Type Material: Geological Survey of Canada, Ottawa, 12133 (Tintina material); Royal Ontario Museum, Toronto, Canada, M27173 (Rossland material).

References: (1) Harris, D.C., J.L. Jambor, G.R. Lachance, and R.I. Thorpe (1968) Tintinaite, the antimony analogue of kobellite. Can. Mineral., 9, 371–382. (2) (1969) Amer. Mineral., 54, 573 (abs. ref. 1). (3) Moëlo, Y., J.L. Jambor, and D.C. Harris (1984) Tintinaïte et sulfosels associés de Tintina (Yukon): la cristallochimie de la série de la kobellite. Can. Mineral., 22, 219–226 (in French with English abs.). (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 577.

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Tinzenite $(Ca, Mn^{2+}, Fe^{2+})_3Al_2BSi_4O_{15}(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As aggregates of prismatic crystals, to 5 mm; massive.

Physical Properties: *Cleavage:* [{100} good; {001}, {110}, {011}, poor] (by analogy to the axinite group). *Fracture:* [Uneven to conchoidal.] *Tenacity:* [Brittle.] Hardness = 6.5 D(meas.) = 3.355–3.433 D(calc.) = 3.455

Optical Properties: [Transparent to translucent.] *Color:* Yellow, brownish yellow-green; orange to red in thin section. *Luster:* [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* In thick sections, weak; X = light brown; Y = violet; Z = light yellow or colorless. $\alpha = 1.690(2)$ $\beta = 1.698(3)$ $\gamma = 1.705(3)$ 2V(meas.) = 80°–84°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.095$–7.162 $b = 9.103$–9.129 $c = 8.874$–8.946 $\alpha = 91.35°-91.90°$ $\beta = 98.27°-98.68°$ $\gamma = 76.73°-76.97°$ Z = 2

X-ray Powder Pattern: Tinzen, Switzerland.
2.812 (10), 3.46 (8), 6.30 (7), 3.14 (7), 2.975 (7), 2.152 (7), 2.008 (7b)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.80	41.20	CaO	12.51	13.50
TiO_2		0.08	BaO		0.06
B_2O_3	5.65	4.98	Na_2O	0.27	0.38
Al_2O_3	16.23	16.20	K_2O	0.13	0.50
Fe_2O_3	1.59	1.60	H_2O^+	1.20	1.15
MnO	21.19	19.15	H_2O^-	0.10	
MgO	0.17	0.90	Total	99.84	99.70

(1) Tinzen, Switzerland; corresponds to $(Mn_{1.77}Ca_{1.32}Na_{0.05}K_{0.02}Mg_{0.02})_{\Sigma=3.18}(Al_{1.88}Fe^{3+}_{0.12})_{\Sigma=2.00}B_{0.96}Si_{4.01}O_{15}(OH)_{0.79}$. (2) Gambatesa mine, Italy; corresponds to $(Mn_{1.60}Ca_{1.42}Mg_{0.13}Na_{0.07}K_{0.06})_{\Sigma=3.28}(Al_{1.88}Fe^{3+}_{0.12})_{\Sigma=2.00}B_{0.85}Si_{4.06}O_{15}(OH)_{0.76}$.

Polymorphism & Series: Forms a series with manganaxinite.

Mineral Group: Axinite group; Ca < 1.5 per formula unit, Mn > Fe.

Occurrence: In metamorphosed manganese-bearing ophiolites (Liguria, Italy); in quartz veins in cherts of the greenschist facies (Akatore, New Zealand).

Association: Braunite, quartz.

Distribution: From near Tinzen, in the Val d'Err, Graubünden, Switzerland. In the Cassagna and Gambatesa mines, Val Graveglia, near Chiavari, Liguria, Italy. From Akatore, New Zealand.

Name: For the locality near Tinzen, Switzerland.

Type Material: Federal Institute of Technology, Zurich, Switzerland, 194804; The Natural History Museum, London, England, 1926,499–501; Harvard University, Cambridge, Massachusetts, USA.

References: (1) Jakob, J. (1923) Vier Mangansilikate aus dem Val d'Err (Kt. Graubünden). Schweiz. Mineral. Petrog. Mitt., 3, 227–237 (in German). (2) Milton, C., F.A. Hildebrand, and A.M. Sherwood (1953) The identity of tinzenite with manganoan axinite. Amer. Mineral., 38, 1148–1158. (3) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 603–623. (4) Basso, R., A. Della Giusta, and G. Vlaic (1973) La struttura della Tinzenite. Period. Mineral., 42, 369–379 (in Italian). (5) (1975) Chem. Abs., 83, 19637 (abs. ref. 4). (6) Lumpkin, G.R. and P.H. Ribbe (1979) Chemistry and physical properties of axinites. Amer. Mineral., 64, 635–645.

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Tiptopite $K_2(Li, Na, Ca)_6Be_6(PO_4)_6(OH)_2 \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 6. Crystals are acicular hexagonal prisms, to 5 mm, terminated by {0001}, which may contain cavernous tubes, aggregated into radial sprays and divergent bundles.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.65(2) D(calc.) = 2.52

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.551(1)$ $\epsilon = 1.559(1)$

Cell Data: *Space Group:* $P6_3$. $a = 11.655(5)$ $c = 4.692(2)$ $Z = 1$

X-ray Powder Pattern: Tip Top mine, South Dakota, USA.
2.966 (10), 2.525 (9), 2.348 (7), 2.223 (6), 3.364 (5), 2.077 (5), 3.808 (4)

Chemistry:

	(1)
P_2O_5	55.1
Al_2O_3	0.3
MnO	0.2
BeO	15.1
CaO	4.3
Li_2O	4.5
Na_2O	6.1
K_2O	9.9
H_2O	3.4
Total	98.9

(1) Tip Top mine, South Dakota, USA; by electron microprobe, Li and Be by AA, H_2O by TGA; based on crystal-structure analysis, approximates $K_2(Li_{2.9}Na_{1.7}Ca_{0.7})_{\Sigma=5.3}$ $Be_6(PO_4)_6(OH)_2 \cdot 1.3H_2O$.

Occurrence: On fracture surfaces in earlier minerals in a complex zoned granite pegmatite.

Association: Roscherite, fransoletite, montgomeryite, englishite, beryl, quartz, microcline.

Distribution: From the Tip Top mine, about 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: For its first-noted occurrence at the Tip Top mine, South Dakota, USA.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 48833; Museum of Geology, South Dakota School of Mines, Rapid City, South Dakota, 81-5102; National Museum of Natural History, Washington, D.C., USA, 149609.

References: (1) Grice, J.D., D.R. Peacor, G.W. Robinson, J. Van Velthuizen, W.L. Roberts, T.J. Campbell, and P.J. Dunn (1985) Tiptopite $(Li, K, Na, Ca, \square)_8Be_6(PO_4)_6(OH)_4$, a new mineral species from the Black Hills, South Dakota. Can. Mineral., 23, 43–46. (2) (1986) Amer. Mineral., 71, 230 (abs. ref. 1). (3) Peacor, D.R., R.C. Rouse, and J.-H. Ahn (1987) Crystal structure of tiptopite, a framework beryllophosphate isotypic with basic cancrinite. Amer. Mineral., 72, 816–820.

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Tiragalloite $Mn_4^{2+}As^{5+}Si_3O_{12}(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As grains, which may be elongated, to 1.5 mm; also as aggregates. *Twinning:* On {100}.

Physical Properties: *Cleavage:* Good on {100}; a distinct parting, normal to elongation. Hardness = n.d. D(meas.) = 3.84(6) D(calc.) = 3.829

Optical Properties: Transparent to translucent. *Color:* Orange, brownish orange; orange to yellow in thin section. *Luster:* Subadamantine.
Optical Class: Biaxial (+). *Orientation:* $X \simeq a$; $Y = b$; $Z \simeq c$. *Dispersion:* Inclined.
$\alpha = 1.745(5)$ $\beta = 1.751(3)$ $\gamma = 1.760(5)$ 2V(meas.) = 38°–46°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.66(1)$ $b = 19.92(2)$ $c = 7.67(1)$ $\beta = 95.7(1)°$
Z = 4

X-ray Powder Pattern: Molinello mine, Italy.
3.258 (100), 3.151 (73), 3.034 (72), 3.003 (72), 2.608 (65), 2.489 (58), 2.736 (54)

Chemistry:

	(1)	(2)
SiO_2	32.38	31.91
TiO_2		0.02
Al_2O_3		0.02
As_2O_5	16.07	18.35
V_2O_5	1.67	
FeO	0.17	0.56
MnO	48.34	46.02
MgO		0.00
CaO	0.75	0.75
Na_2O		0.03
K_2O		< 0.01
Total	99.38	97.67

(1) Molinello mine, Italy; by electron microprobe, average of 28 analyses; corresponds to $(Mn^{2+}_{3.91}Ca_{0.08}Fe_{0.01})_{\Sigma=4.00}(As^{5+}_{0.84}V^{5+}_{0.12})_{\Sigma=0.96}Si_3O_{12}(OH)$. (2) Ködnitz Valley, Austria; by electron microprobe, average of 15 analyses; corresponds to $(Mn^{2+}_{3.66}Ca_{0.08}Fe_{0.04}Na_{0.01})_{\Sigma=3.79}$ $As^{5+}_{0.90}Si_{3.00}O_{12}(OH)$.

Occurrence: In veinlets cutting massive aggregates of braunite and quartz (Molinello mine, Italy); in manganese-rich lenses in quartzitic chlorite schists probably derived from marine sediments (Ködnitz Valley, Austria).

Association: Quartz, manganoan calcite, parsettensite, albite, medaite (Molinello mine, Italy); tephroite, pyroxmangite, rhodonite, spessartine, rhodochrosite (Ködnitz Valley, Austria).

Distribution: From the Molinello manganese mine, Val Graveglia, near Chiavari, Liguria, Italy. In the Ködnitz Valley, Tirol, Austria.

Name: For Paolo Tiragallo (1905–), amateur mineralogist of Liguria, Italy.

Type Material: University of Rome, Rome, 24314; Municipal Museum of Natural History, Milan, Italy; University of Oslo, Oslo, Norway.

References: (1) Gramaccioli, C.M., W.L. Griffin, and A. Mottana (1980) Tiragalloite, $Mn_4[AsSi_3O_{12}(OH)]$, a new mineral and the first example of arsenatotrisilicate. Amer. Mineral., 65, 947–952. (2) Gramaccioli, C.M., T. Pilati, and G. Liborio (1979) Structure of a manganese(II) arsenatotrisilicate, $Mn_4[AsSi_3O_{12}(OH)]$: the presence of a new tetrapolyphosphate-like anion. Acta Cryst., 35, 2287–2291. (3) Albrecht, J. (1990) An As-rich manganiferous mineral assemblage from the Ködnitz Valley (Eastern Alps, Austria): geology, mineralogy, genetic considerations, and implications for metamorphic Mn deposits. Neues Jahrb. Mineral., Monatsh., 363–375.

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Tischendorfite $Pd_8Hg_3Se_9$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

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Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Tisinalite $\mathbf{Na_3H_3(Mn^{2+}, Ca, Fe)TiSi_6(O, OH)_{18} \cdot 2H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\,2/m$. As rough crystals, to 1 mm, and granular aggregates.

Physical Properties: *Fracture:* Uneven to conchoidal. Hardness = 5 D(meas.) = 2.66–2.69 D(calc.) = 2.862

Optical Properties: Transparent to translucent. *Color:* Yellow-orange. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). $\omega = 1.624$ $\epsilon = 1.590$–1.592

Cell Data: *Space Group:* n.d. $a = 10.14$ $c = 13.08$ Z = 3

X-ray Powder Pattern: Mt. Koashva, Russia.
3.60 (100), 3.18 (80), 5.19 (70), 3.26 (60), 2.590 (60), 1.802 (55), 2.510 (50)

Chemistry:

	(1)
SiO_2	53.27
TiO_2	8.45
ZrO_2	1.00
RE_2O_3	0.11
FeO	4.49
MnO	5.40
CaO	2.46
SrO	0.00
Na_2O	13.83
K_2O	trace
H_2O	10.65
Total	99.66

(1) Mt. Koashva, Russia; traces of Ba, V, and Zn found spectrographically; corresponds to $Na_{3.00}H_{3.00}(Mn_{0.54}Ca_{0.30}Fe_{0.16})_{\Sigma=1.00}(Ti_{0.72}Fe_{0.28})_{\Sigma=1.00}Si_{6.00}[O_{17.40}(OH)_{0.60}]_{\Sigma=18.00} \cdot 2.23H_2O$.

Mineral Group: Lovozerite group.

Occurrence: Formed by the hydrothermal alteration of lomonosovite and barytolamprophyllite in alkalic pegmatites in a differentiated alkalic massif.

Association: Koashvite, shcherbakovite, lamprophyllite.

Distribution: From Mt. Koashva, Khibiny massif, Kola Peninsula, Russia.

Name: For TItanium, SIlicon, and sodium, NAtrium, in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81407; The Natural History Museum, London, England, 1994,33.

References: (1) Kapustin, Y.L., Z.V. Pudovkina, and A.V. Bykova (1980) Tisinalite, $Na_3H_3(Mn, Ca, Fe)TiSi_6(O, OH)_{18} \cdot 2H_2O$, a new mineral of the lovozerite group. Zap. Vses. Mineral. Obshch., 109, 223–229 (in Russian). (2) (1981) Amer. Mineral., 66, 219–220 (abs. ref. 1).

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Titanite $CaTiSiO_5$

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Crystal Data: Monoclinic; may be metamict. *Point Group:* $2/m$. Crystals wedge-shaped, flattened ∥ {001} or prismatic by extension along [110], to 16 cm; compact, massive.
Twinning: On {100}, contact and penetration; less commonly lamellar on {221}.

Physical Properties: *Cleavage:* Good on {110}; parting due to twinning on {221}.
Hardness = 5–5.5 D(meas.) = 3.48–3.60 D(calc.) = [3.53]

Optical Properties: Transparent to opaque. *Color:* Black, brown, gray, colorless, green, yellow, red; colorless to yellow or brown in thin section. *Streak:* White. *Luster:* Adamantine to resinous.
Optical Class: Biaxial (+). *Pleochroism:* Distinct when deeply colored; X = nearly colorless; Y = yellow to green; Z = red to yellow-orange. *Orientation:* $Z \wedge c = 51°$. *Dispersion:* $r > v$, strong. $\alpha = 1.843–1.950$ $\beta = 1.870–2.034$ $\gamma = 1.943–2.110$ 2V(meas.) = 17°–40°

Cell Data: *Space Group:* $P2_1/a$ or $A2/a$. $a = 7.057$ $b = 8.707$ $c = 6.555$ $\beta = 113.81°$
Z = 4

X-ray Powder Pattern: "Tyrol," Switzerland (?). (ICDD 11-142).
3.233 (100), 2.989 (90), 2.595 (90), 2.058 (40), 1.643 (40), 1.494 (40), 1.418 (40)

Chemistry:

	(1)	(2)
SiO_2	30.61	30.75
TiO_2	39.43	30.39
Al_2O_3	0.09	4.93
RE_2O_3		1.22
Fe_2O_3	1.14	2.92
Nb_2O_5		1.0
CaO	28.57	27.96
F	0.00	2.27
$-O = F_2$		0.95
Total	99.84	100.49

(1) Goschener Alp, Switzerland; by electron microprobe, total Fe as Fe_2O_3; corresponding to $Ca_{1.00}(Ti_{0.97}Fe^{3+}_{0.03})_{\Sigma=1.00}Si_{1.00}O_{4.96}$. (2) Pierceville [*sic*], New York, USA; by electron microprobe, total Fe as Fe_2O_3, F by ion microprobe; corresponding to $(Ca_{0.97}Nb_{0.01}RE_{0.01})_{\Sigma=0.99}(Ti_{0.74}Al_{0.19}Fe^{3+}_{0.07})_{\Sigma=1.00}Si_{1.00}O_{4.91}F_{0.23}$.

Occurrence: A common accessory mineral in intermediate and felsic plutonic rocks, pegmatites, and alpine veins. In gneisses, schists, and some skarns; rarely detrital.

Association: Albite, chlorite, epidote, apatite, allanite, monazite, magnetite, ilmenite, nepheline, biotite, diopside, calcite.

Distribution: Fine specimens from: in Switzerland, at Tavetsch, Graubünden; St. Gotthard, Ticino; Zermatt, Valais, and elsewhere. At Val Maggia and St. Marcel, Val d'Aosta, Italy. In Austria, in the Schwartzenstein and Rothenkopf Mountains, Zillertal, Tirol. From Arendal, Norway. At Nordmark, Värmland, Sweden. From the Lovozero and Khibiny massifs, Kola Peninsula, and large crystals in the Dodo mine, about 100 km west-northwest of Saranpaul, Subpolar Ural Mountains, Russia. In the USA, at the Tilly Foster mine, Brewster, Putnam Co., at Diana, Lewis Co., Natural Bridge, Jefferson Co., and Monroe, Orange Co., New York. In Canada, at Eganville and on Turner's Island, in Lake Clear, Renfrew Co., Ontario, and at Litchfield, Quebec. In Mexico, from Baja California, at El Rodeo, La Huerta, and Piño Solo. From Campo do Boa, Capelinha, Minas Gerais, Brazil. At Naevatanana and Ambalavaokely, Madagascar.

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Name: For TITANium in its composition.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 712–716, 717 [keilhauite]. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 443–466. (3) Oberti, R., D.C. Smith, G. Rossi, and F. Caucia (1991) The crystal-chemistry of high-aluminum titanites. Eur. J. Mineral., 3, 777–792.

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Titanowodginite $Mn^{2+}TiTa_2O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Diamond-shaped crystals, dipyramidal {111}, with {101}, {100}, as euhedral individuals, to 1 cm, and in aggregates. *Twinning:* Penetration twins, on {001} and {100} as composition planes, typical.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 5.5
D(meas.) = 6.86(3) D(calc.) = 6.89

Optical Properties: Transparent to translucent. *Color:* Dark brown to black. *Streak:* Dark brown. *Luster:* Vitreous.
Optical Class: Biaxial (+). $n = > 2.0$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/c$. $a = 9.466(1)$ $b = 11.431(1)$ $c = 5.126(1)$ $\beta = 90.31(2)^\circ$
Z = 4

X-ray Powder Pattern: Tanco pegmatite, Canada.
2.976 (100), 2.966 (95), 3.644 (46), 2.495 (36), 1.715 (23), 1.455 (18), 1.767 (17)

Chemistry:

	(1)	(2)	(3)
Nb_2O_5	11.1	11.1	
Ta_2O_5	59.9	60.3	74.55
TiO_2	9.2	8.0	13.48
SnO_2	7.4	8.3	
Fe_2O_3	0.1	0.5	
FeO	3.1	2.5	
MnO	9.0	9.6	11.97
Total	[99.8]	100.3	100.00

(1) Tanco pegmatite, Canada; by electron microprobe, core of a grain; original total given as 99.7%. (2) Do.; rim of a grain, Fe^{2+}:Fe^{3+} calculated from stoichiometry. The average of (1) and (2) corresponds to $(Mn_{0.76}Fe^{2+}_{0.22})_{\Sigma=0.98}(Ti_{0.62}Sn_{0.30}Ta_{0.06}Fe^{3+}_{0.02})_{\Sigma=1.00}(Ta_{1.52}Nb_{0.48})_{\Sigma=2.00}O_8$.
(3) $Mn^{2+}TiTa_2O_8$.

Mineral Group: Wodginite group: $Li_A \leq 0.5$; $Fe^{2+}_A \leq 0.5$; $Ti_B > 0.5$.

Occurrence: In a complex zoned granite pegmatite (Tanco pegmatite, Canada).

Association: Microlite, manganocolumbite, albite, quartz, muscovite, beryl (Tanco pegmatite, Canada).

Distribution: In the Tanco pegmatite, Bernic Lake, Manitoba, Canada. From San Piero in Campo, Elba, Italy.

Name: For predominant TITANium and its relation to *wodginite*.

Type Material: R.B Ferguson Mineralogical Museum, University of Manitoba, Winnipeg, Canada.

References: (1) Ercit, T.S., P. Černý, and F.C. Hawthorne (1992) The wodginite group. III. Classification and new species. Can. Mineral., 30, 633–638. (2) (1993) Amer. Mineral., 78, 848 (abs. ref. 1).

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Titantaramellite $\mathbf{Ba_4(Ti,Fe^{3+},Fe^{2+},Mg)_4(B_2Si_8O_{27})O_2Cl_x}$

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Crystal Data: Orthorhombic. *Point Group:* [$2/m$ $2/m$ $2/m$] (by analogy to taramellite). As well-formed crystals, equidimensional to tabular ∥ {100}; in anhedral grains, up to 10 cm.

Physical Properties: *Cleavage:* {100}, perfect. Hardness = 6 D(meas.) = 4.05 D(calc.) = [3.93]

Optical Properties: Transparent to translucent or opaque. *Color:* Dark brown to black. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; $X = Y$ = yellow-brown; Z = opaque. *Orientation:* $X = c$; $Y = b$; Z = a. α = 1.739–1.753 β = 1.749–1.761 γ = 1.770–1.782 2V(meas.) = 45°–77°

Cell Data: *Space Group:* [*Pnmm.*] a = 12.053–12.220 b = 13.938–14.005 c = 7.127–7.141 Z = [2]

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
SiO_2	33.03
TiO_2	10.63
B_2O_3	3.64
Fe_2O_3	6.79
FeO	3.60
MnO	0.09
MgO	0.55
BaO	40.45
Cl	1.83
H_2O^+	< 0.01
H_2O^-	< 0.01
$-O = Cl_2$	0.41
Total	100.20

(1) Rush Creek, California, USA; corresponds to $Ba_{3.86}(Ti_{1.94}Fe^{2+}_{0.96}Fe^{3+}_{0.37}Mg_{0.20}Mn_{0.02})_{\Sigma=3.49}B_{1.52}Si_8O_{29}Cl_{0.75}$.

Polymorphism & Series: Forms a series with taramellite.

Occurrence: In the contact zones around granite, quartz monzonite, and quartz diorite intrusives.

Association: Sanbornite, quartz, macdonaldite, walstromite, fresnoite, verplanckite, muirite, traskite, benitoite, pabstite, bazirite (Rush Creek and Big Creek areas, California, USA); tremolite, celsian, pabstite, galena, cassiterite, quartz (Kalkar quarry, California, USA).

Distribution: In the USA, in California, at Rush Creek and Big Creek, Fresno Co., at Chickencoop Canyon, Tulare Co., on Trumbull Peak, near Incline, Mariposa Co., and in the Kalkar quarry, Santa Cruz Co. From near Ross River [Gunn claim, Itsy Mountains, near Macmillan Pass], Yukon Territory, Canada. In the La Madrelena mine, Tres Pozos, Baja California, Mexico.

Name: For its TITANium content and relation to *taramellite*.

Type Material: n.d.

References: (1) Alfors, J.T. and A. Pabst (1984) Titanian taramellites in western North America. Amer. Mineral., 69, 358–373.

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Tivanite $V^{3+}TiO_3(OH)$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Irregular crystallites, to 30 μm, in complexly twinned aggregates. *Twinning:* Very common to universal, as seen in section; by four complex twin laws determined from structural analysis, enhancing the pseudohexagonality.

Physical Properties: Hardness = n.d. VHN = 650(100) (50 g load). D(meas.) = n.d. D(calc.) = 4.17

Optical Properties: Opaque. *Color:* Black; gray in reflected light. *Streak:* Black. *Luster:* Submetallic.
Optical Class: Biaxial. *Anisotropism:* Weak to moderate; in shades of gray.
R: (470) 16.8, (546) 17.4, (589) 17.7

Cell Data: *Space Group:* $P2_1/c$. $a = 7.494(5)$ $b = 4.552(4)$ $c = 10.005(8)$ $\beta = 129.79(2)^\circ$ Z = [4]

X-ray Powder Pattern: Calculated from the crystal structure of natural material.
3.880 (100), 2.795 (94), 2.636 (69), 1.693 (31), 1.683 (30), 3.917 (25), 2.535 (24)

Chemistry:

	(1)	(2)
TiO_2	41.03	48.76
Fe_2O_3	1.57	
V_2O_3	48.27	45.74
H_2O	[5.97]	5.50
Total	[96.84]	100.00

(1) Lake View mine, Western Australia; by electron microprobe, average of three analyses, total V as V_2O_3, total Fe as Fe_2O_3, H_2O calculated from stoichiometry; corresponding to $(V^{3+}_{1.09}Fe^{3+}_{0.04})_{\Sigma=1.13}Ti_{0.87}O_{2.87}(OH)_{1.13}$. (2) $V^{3+}TiO_3(OH)$.

Occurrence: As a grain in micaceous V–Au-rich stringers in a hydrothermal gold deposit.

Association: Quartz, nolanite, vanadium-rich muscovite.

Distribution: From the Lake View mine, Kalgoorlie, Western Australia.

Name: For TItanium and VANadium in the composition.

Type Material: C.S.I.R.O, Perth, Australia, 5996, gone walkabout.

References: (1) Grey, I.E. and E.H. Nickel (1981) Tivanite, a new oxyhydroxide mineral from Western Australia, and its structural relationship to rutile and diaspore. Amer. Mineral., 66, 866–871.

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Tlalocite $(Cu,Zn)_{16}(Te^{4+}O_3)(Te^{6+}O_4)_2Cl(OH)_{25}\cdot 27H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As velvety crusts composed of spherules or arcuate bands of subparallel lath-shaped crystals, to 10 μm.

Physical Properties: *Tenacity:* Gummy and sectile. Hardness = 1 D(meas.) = 4.55(1) D(calc.) = 4.58

Optical Properties: Semitransparent. *Color:* Capri blue; pale green in transmitted light. *Streak:* Very pale blue.
Optical Class: Biaxial (–). *Pleochroism:* X = green; $Y = Z$ = bluish green. *Absorption:* $Z > Y > X$. $\alpha = 1.758(2)$ $\beta = 1.796(2)$ $\gamma = 1.810(5)$ 2V(meas.) = 64° 2V(calc.) = 61°

Cell Data: *Space Group:* n.d. $a = 16.780(3)$ $b = 19.985(4)$ $c = 12.069(3)$ Z = 4

X-ray Powder Pattern: Bambollita mine, Mexico.
16.787 (10), 4.201 (10), 8.394 (8), 3.355 (6), 1.560 (5), 2.796 (3), 2.588 (3b)

Chemistry:

	(1)
TeO_3	15.0
TeO_2	6.1
CuO	31.0
ZnO	19.3
Cl	1.3
H_2O	27.7
$-O = Cl_2$	0.3
Total	100.1

(1) Bambollita mine, Mexico; results from several partial analyses, CuO and ZnO by AA, Te and Cl by spectrophotometry, H_2O by gravimetry; corresponds to $Cu_{9.92}Zn_{6.03}(Te^{4+}O_3)_{0.97}(Te^{6+}O_4)_{2.17}Cl_{0.93}(OH)_{24.69}\cdot 26.78H_2O$.

Occurrence: Very rare in partially oxidized portions of a tellurium-bearing polymetallic hydrothermal sulfide vein.

Association: Tenorite, azurite, malachite.

Distribution: From the Oriental (Bambollita) mine, northeast of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: For *Tlaloc*, the Toltec and Aztec god of rain, in allusion to the high essential water content.

Type Material: Natural History Museum, Paris; National School of Mines, Paris, France; The Natural History Museum, London, England; Harvard University, Cambridge, Massachusetts, 119091; National Museum of Natural History, Washington, D.C., USA, 135057.

References: (1) Williams, S.A. (1975) Xocomecatlite, $Cu_3TeO_4(OH)_4$, and tlalocite, $Cu_{10}Zn_6(TeO_3)(TeO_4)_2Cl(OH)_{25}\cdot 27H_2O$, two new minerals from Moctezuma, Sonora, Mexico. Mineral. Mag., 40, 221–226. (2) (1976) Amer. Mineral., 61, 504 (abs. ref. 1). (3) Roberts, A.C. (1978) An orthorhombic cell for tlalocite. Geol. Surv. Can. Paper 78–1C, 104.

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Tlapallite $H_6(Ca,Pb)_2Cu_3(SO_4)(Te^{4+}O_3)_4(Te^{6+}O_6)$

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Crystal Data: Monoclinic. *Point Group:* n.d. As paintlike to botryoidal crusts, comprised of sheaves or rosettes of tabular or bladed crystals, to 0.1 mm.

Physical Properties: Hardness = 3 D(meas.) = 5.38(1) D(calc.) = 5.05–5.465

Optical Properties: Semitransparent. *Color:* Veridian green to Cyprus green. *Streak:* Pale green.
Optical Class: Biaxial (–). *Pleochroism:* Moderate; in shades of bottle-green. *Absorption:* $Z = Y > X$. $\alpha = 1.815$–1.915 $\beta = 1.960$–2.115 $\gamma = 1.960$–2.115 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 11.97$ $b = 9.11$ $c = 15.66$ $\beta = 90°36'$ Z = 4

X-ray Powder Pattern: Moctezuma mine, Mexico.
11.97 (10), 2.985 (10), 3.540 (6), 5.946 (5), 4.731 (5), 2.887 (5), 3.732 (4)

Chemistry:

	(1)	(2)
SO_3	5.2	5.57
TeO_3	11.4	12.5
TeO_2	41.4	44.3
CuO	15.6	15.8
ZnO	0.8	0.7
PbO		13.6
CaO	8.3	4.3
H_2O		4.25
Total		101.02

(1) Moctezuma mine, Mexico; with H^{1+} calculated for charge balance, corresponds to $H_{4.76}Ca_{2.00}Cu_{2.65}(SO_4)_{0.88}(Te^{4+}O_3)_{3.51}(Te^{6+}O_6)_{0.88}$. (2) Tombstone, Arizona, USA; H_2O by the Penfield method, with H^+ calculated for charge balance, corresponds to $H_{6.26}(Ca_{1.12}Pb_{0.88})_{\Sigma=2.00}(Cu_{2.88}Zn_{0.13})_{\Sigma=3.01}(SO_4)_{1.01}(Te^{4+}O_3)_{4.04}(Te^{6+}O_6)_{1.03}$.

Occurrence: Very rare in partially oxidized portions of a tellurium-bearing polymetallic hydrothermal sulfide deposit (Moctezuma mine, Mexico); an alteration product of tellurides in calcsilicate tactite (Tombstone, Arizona).

Association: Carlfriesite, calcite, barite, muscovite, quartz (Moctezuma mine, Mexico).

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the USA, at Tombstone, Cochise Co., Arizona, from the Lucky Cuss and Emerald mines.

Name: From the Nahua language for *paint*, in allusion to the typical habit as films as though painted on rock.

Type Material: The Natural History Museum, London, England; University of Arizona, Tucson, Arizona; Harvard University, Cambridge, Massachusetts, 119092; National Museum of Natural History, Washington, D.C., USA, 144519.

References: (1) Williams, S.A. and M. Duggan (1978) Tlapallite, a new mineral from Moctezuma, Sonora, Mexico. Mineral. Mag., 42, 183–186. (2) (1979) Amer. Mineral., 64, 465 (abs. ref. 1).

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Tobelite $(NH_4, K)Al_2(Si_3Al)O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ (probable). As aggregates of crystals and flakes, up to 0.1 mm.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Clayey. Hardness = n.d. D(meas.) = 2.58–2.62 D(calc.) = 2.617

Optical Properties: Semitransparent. *Color:* White to yellowish green; nearly colorless in thin section. *Luster:* Silky.
Optical Class: Biaxial (–). $\alpha = 1.555$–1.560 $\beta = 1.575$–1.587 $\gamma = 1.581$–1.595
2V(meas.) = 28° 2V(calc.) = 28°–30°

Cell Data: *Space Group:* $C2/m$ (probable). $a = 5.219(4)$ $b = 8.986(3)$ $c = 10.447(2)$ $\beta = 101.31(1)°$ Z = 2

X-ray Powder Pattern: Tobe, Japan; 1M.
10.24 (100), 5.12 (70), 4.486 (70), 3.408 (60), 2.566 (45), 3.103 (35), 4.360 (30)

Chemistry:

	(1)	(2)
SiO_2	48.40	48.34
TiO_2	0.02	0.30
Al_2O_3	36.27	37.87
Fe_2O_3	0.57	1.02
MgO	0.52	0.11
CaO	0.00	0.00
Na_2O	0.04	−0.01
K_2O	2.30	3.25
$(NH_4)_2O$	3.51	3.85
H_2O^+	6.40	4.96
H_2O^-	1.97	0.31
Total	[100.00]	[100.00]

(1) Tobe, Japan; recalculated to 100.00% after deduction of 0.25% quartz; corresponds to $[(NH_4)_{0.53}K_{0.19}Na_{0.01}]_{\Sigma=0.73}(Al_{1.97}Mg_{0.05}Fe^{3+}_{0.03})_{\Sigma=2.05}(Si_{3.17}Al_{0.83})_{\Sigma=4.00}O_{10}(OH)_2$. (2) Horo, Japan; recalculated after deduction of 1% quartz and 20% ammonium-rich mica, analyzed separately, the "negative" Na_2O a result of this correction; corresponds to $[(NH_4)_{0.57}K_{0.27}]_{\Sigma=0.84}(Al_{1.95}Fe^{3+}_{0.05}Ti_{0.01}Mg_{0.01})_{\Sigma=2.02}(Si_{3.09}Al_{0.91})_{\Sigma=4.00}O_{10}(OH)_2$.

Polymorphism & Series: 1M, $2M_2$ polytypes.

Mineral Group: Mica group.

Occurrence: A hydrothermal alteration product of a biotite andesite dike (Tobe, Japan); in a hydrothermally altered rhyolite tuff (Horo, Japan).

Association: Quartz (Tobe, Japan); quartz, ammonium-rich mica, pyrophyllite, diaspore, kaolinite, corundum, andalusite (Horo, Japan).

Distribution: In the Ohgidani pottery stone deposit, Tobe, Ehime Prefecture, and in the Horo pyrophyllite deposit, Toyosaka, Hiroshima Prefecture, Japan.

Name: For the occurrence at Tobe, Japan.

Type Material: National Science Museum, Tokyo, Japan, M23773.

References: (1) Higashi, S. (1982) Tobelite, a new ammonium dioctahedral mica. Mineral. J. (Japan), 11, 138–146. (2) (1983) Amer. Mineral., 68, 850 (abs. ref. 1).

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Tobermorite $Ca_5Si_6(O,OH)_{18}\cdot 5H_2O$

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Crystal Data: Orthorhombic or monoclinic, pseudo-orthorhombic. *Point Group:* 2. As minute laths resembling fibers; as fibrous bundles, rosettes or sheaves, radiating or plumose, to 6 cm; fine granular, massive.

Physical Properties: *Cleavage:* Perfect on {001}, imperfect on {100}. Hardness = n.d. D(meas.) = 2.423–2.458 D(calc.) = [2.49]

Optical Properties: Transparent to translucent. *Color:* Pale pinkish white, white, brown; colorless in thin section. *Luster:* Vitreous, silky in fibrous aggregates.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* Weak.
$\alpha = 1.570(2)$ $\beta = 1.571(2)$ $\gamma = 1.575(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1$ (14 Å hydrate). $a = 11.17$ $b = 7.38$ $c = 27.94$ $\beta = [90.0°]$ Z = [4]

X-ray Powder Pattern: Crestmore, California, USA. (ICDD 29-331).
14.0 (100), 3.076 (65), 3.001 (45), 1.835 (35), 2.812 (30), 5.50 (25), 2.798 (13)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	46.51	48.08	CaO	33.40	35.24
Al_2O_3	2.40	3.96	Na_2O	0.36	0.03
Fe_2O_3	1.14		K_2O	1.45	0.03
FeO	1.85	0.01	H_2O	12.61	[12.62]
MgO	0.47	0.03	Total	100.19	[100.00]

(1) Tobermory, Scotland. (2) Portree, Scotland; by electron microprobe, H_2O by difference; corresponds to $(Ca_{4.30}Mg_{0.01}Na_{0.01}K_{0.01})_{\Sigma=4.33}(Si_{5.47}Al_{0.53})_{\Sigma=6.00}[O,(OH)]_{18}\cdot nH_2O$.

Mineral Group: A group name including the 9-Å, 10-Å, 11-Å, and 14-Å hydrates; dimorphous with clinotobermorite.

Occurrence: A hydrothermal alteration product of calcium carbonate rocks, due to contact metamorphism and metasomatism; filling vesicles and cavities in basaltic rocks.

Association: Zeolites, ettringite, portlandite, calcite.

Distribution: In Scotland, on the Isle of Mull, around Tobermory; on the Isle of Skye, at Dunvegan and Portree; and at Ardtornish Bay, Morvern, Argyllshire. From Ballycraigy, near Larne, Co. Antrim, Ireland. In Germany, on the Zeilberg, near Maroldsweisach, Bavaria. From the Hatrurim Formation, Israel. In the Güneyce-İkizdere area, Trabzon Province, Turkey. From Fuka, near Bicchu, Okayama Prefecture, Japan. At Golden Gully, Tokatoka district, about 150 km north of Auckland, New Zealand. In the USA, from Crestmore, Riverside Co., California. At Concepción del Oro, and in the Noche Buena mine, Mazapil, Zacatecas, Mexico. Large masses from the Wessels mine, near Kuruman, Cape Province, South Africa. A few additional minor occurrences are known.

Name: For the type locality, Tobermory, Isle of Mull, Scotland.

Type Material: The Natural History Museum, London, England, 1937,1490; National Museum of Natural History, Washington, D.C., USA, 119008.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 570. (2) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 30–45. (3) Livingstone, A. (1988) Reyerite, tobermorite, calcian analcime and bytownite from amygdales in a Skye basalt. Mineral. Mag., 52, 711–713. (4) Hamid Rahman, S. and H. Beyrau (1988) Die Bestimmung der Kristallstruktur von einem natürlichen 14 Å-Tobermorit mit Hilfe von Röntgen- und Elektronenbeugung. Zeits. Krist., 182, 114–116 (in German).

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Tochilinite $6Fe_{0.9}S \cdot 5(Mg, Fe^{2+})(OH)_2$

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Crystal Data: Monoclinic or triclinic. *Point Group:* 2, m, $2/m$ or 1. As radiating aggregates of cylindrical acicular crystals, which may be hollow, to 1 cm; as paper-thin coatings, felted masses, and as clots.

Physical Properties: *Cleavage:* On {001}. Hardness = n.d. VHN = 15–49 (5 g load). D(meas.) = 2.96 D(calc.) = 3.03

Optical Properties: Opaque. *Color:* Bronze-black; yellowish brown in reflected light. *Luster:* Moderately metallic. *Pleochroism:* Strong, from yellowish brown to yellowish gray. *Anisotropism:* Strong, pinkish cream to gray.

R_1–R_2: (400) — , (420) — , (440) 9.3–15.0, (460) 9.2–15.8, (480) 9.1–16.3, (500) 8.9–16.9, (520) 8.8–17.4, (540) 8.8–17.8, (560) 8.7–18.2, (580) 8.6–18.8, (600) 8.4–19.3, (620) 8.3–19.8, (640) 8.2–20.2, (660) 8.1–20.5, (680) 8.0–20.8, (700) 8.0–21.0

Cell Data: *Space Group:* $P2$, Pm, or $P2/m$ with $a = 5.42$ $b = 15.77$ $c = 10.74$ $\beta = 95°$ Z = 6, or *Space Group:* $C1$ with $a = 5.37$ $b = 15.65$ $c = 10.72$ $\alpha = 90°$ $\beta = 95°$ $\gamma = 90°$ Z = 1

X-ray Powder Pattern: Voronezh region, Russia.
5.34 (10), 10.68 (9), 1.845 (7b), 2.20 (6b), 2.04 (5b), 1.537 (5vb), 3.57 (4)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
Fe	40.25	44.92	MgO	16.87		H_2O	11.25	
FeO	6.56		S	23.00	21.73	rem.	1.60	
Mg		10.94	$(OH)^{1-}$		[20.99]	Total	99.53	[98.58]

(1) Voronezh region, Russia; by electron microprobe, remainder deducted as gibbsite, $Al(OH)_3$; corresponds to $2(Fe_{0.88}S) \cdot 1.67[(Mg_{0.71}Fe_{0.29})_{\Sigma=1.00}(OH)_2]$ by analogy to valleriite.
(2) Dumont property, Canada; by electron microprobe, $(OH)^{1-}$ calculated; corresponds to $2(Fe_{0.94}S) \cdot 1.82[(Mg_{0.73}Fe_{0.27})_{\Sigma=1.00}(OH)_2]$.

Occurrence: In sulfide-rich serpentinized ultramafic bodies, where it may be of rock-forming mineral abundance; in some carbonaceous chondrite meteorites.

Association: Troilite, pyrrhotite, sphalerite, calcite, lizardite (Voronezh region, Russia); pyrrhotite, forsterite, clinohumite, hydromagnesite, graphite, calcite (Bancroft, Canada).

Distribution: In Russia, in the Voronezh district, from the Nizhnii Mamon Cu–Ni deposit, Nizhnii Mamon intrusive, 45 km southeast of Pavlovsk [TL], and in the Staromelovatskii intrusive; in the Mir, Udachnaya, and Obnazhennaya diamond pipes, Sakha. At the Grace mine, Morgantown, Berks Co., and the Cornwall open pit, Lebanon Co., Pennsylvania, USA. In Canada, in the Stephen Cross and Maxwell quarries, near Wakefield, and from the Dumont property, near Amos, Quebec; in the Muskox intrusion, Northwest Territories; from near Bancroft, Ontario; other occurrences are known. At the Jacupiranga mine, São Paulo, Brazil. In the Kamaishi mine, Iwate Prefecture, Japan. At the Mt. Keith nickel deposit, 15 km north of Betheno, Western Australia. From The Lizard, Cornwall, England. At Vâlsan, Romania.

Name: In honor of Professor Mitrofan Stepanovich Tochilin (1919–1968), mineralogist and geologist, Voronezh University, Voronezh, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

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References: (1) Organova, N.I., A.D. Genkin, V.A. Drits, S.P. Molotkov, O.V. Kuz'mina, and A.L. Dmitrik (1971) Tochilinite, a new sulfide-hydroxide of iron and magnesium. Zap. Vses. Mineral. Obshch., 100, 477–487 (in Russian). (2) (1972) Amer. Mineral., 57, 1552 (abs. ref. 1). (3) Organova, N.I., V.A. Drits, and A.L. Dmitrik (1973) Structural study of tochilinite. Part I. The isometric variety. Kristallografiya (Sov. Phys. Crystal.), 17, 761–767 (in Russian). (4) Jambor, J.L. (1976) New occurrences of the hybrid sulphide tochilinite. Geol. Surv. Can. Paper 76-1B, 65–69. (5) Zolensky, M.E. and I.D.R. Mackinnon (1986) Microstructures of cylindrical tochilinites. Amer. Mineral., 71, 1201–1209. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 579.

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Tocornalite $Ag_xHg_yI_z$

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Crystal Data: n.d. *Point Group:* n.d. Granular, massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Pale yellow, darkening on exposure.
Streak: Yellow.
Optical Class: n.d. n = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Ag	33.80	42.53	45.94
Hg	3.90	4.91	
I	41.77	52.56	54.06
rem.	16.65		
loss	[3.88]		
Total	[100.00]	[100.00]	100.00

(1) Chañarcillo, Chile; remnant is principally silica, loss is nonessential H_2O and probably some I. (2) Analysis (1) recalculated to 100% after deduction of remnant and loss. (3) AgI.

Occurrence: In a very rich hydrothermal silver deposit.

Association: n.d.

Distribution: From Chañarcillo, south of Copiapó, Atacama, Chile.

Name: For S.F. Tocornal, formerly Rector, Santiago University, Santiago, Chile.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 25. (2) Mason, B. (1972) Tocornalite. Smithsonian Contribution to the Earth Sciences, 9, 79-80. (3) Mason, B., W.G. Mumme, and H. Sarp (1992) Capgaronnite, $HgS \bullet Ag(Cl, Br, I)$, a new sulfide-halide mineral from Var, France. Amer. Mineral., 77, 197–200.

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Todorokite $(Mn^{2+}, Ca, Na, K)(Mn^{4+}, Mn^{2+}, Mg)_6O_{12}\cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals poor, lathlike, fibrous, elongated ‖ [001] and flattened ‖ {010}, to 15 cm; in banded, reniform, or stalactitic aggregates of crystals; may be very porous. *Twinning:* As contact twins or trillings on an unknown law.

Physical Properties: *Cleavage:* {100} and {010}, perfect. Hardness = Soft.
D(meas.) = 3.66 D(calc.) = 3.67

Optical Properties: Opaque, transparent in thinnest slivers. *Color:* Black to dark brownish black; in transmitted light, brown; in reflected light, gray-white. *Streak:* Black. *Luster:* Metallic to dull; silky in aggregates.
Optical Class: Biaxial; birefringence ∼0.02. *Pleochroism:* Strong to faint; X = dark brown; Z = yellowish brown. *Orientation:* $Y = b$; $Z \simeq c$. *Absorption:* $Z > X$. $n = > 2.00$
2V(meas.) = n.d. *Anisotropism:* Very strong; bluish or brownish.
R_1–R_2: (400) 13.9–24.7, (420) 13.2–24.2, (440) 12.5–23.7, (460) 11.7–22.0, (480) 11.1–20.6, (500) 10.6–19.4, (520) 10.2–18.6, (540) 10.0–17.9, (560) 9.7–17.3, (580) 9.5–16.8, (600) 9.3–16.4, (620) 9.1–16.1, (640) 9.0–15.8, (660) 9.0–15.5, (680) 8.9–15.3, (700) 8.9–15.1

Cell Data: *Space Group:* $P2/m$ (ICDD 38-475). $a = 9.7570(15)$ $b = 2.8419(5)$ $c = 9.5684(14)$ $\beta = 94.074(14)°$ Z = 1

X-ray Powder Pattern: N'Chwaning mine, Kuruman district, South Africa. (ICDD 38-475).
9.555 (100), 2.399 (36), 4.773 (25), 4.462 (25), 2.388 (25), 2.355 (24), 4.860 (17)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	0.45	0.24	CaO	3.28	1.52	H_2O^-	1.56	
MnO_2	65.89	72.15	BaO	2.05	0.20	H_2O		10.61
Al_2O_3	0.28	0.14	SrO		0.24	CO_2	trace	
Fe_2O_3	0.20	0.06	Na_2O	0.21	1.23	P_2O_5	0.42	
MnO		8.87	K_2O	0.54	0.48	SO_3	0.28	
CoO		0.02	O	12.07		insol.	1.28	
MgO	1.01	3.51	H_2O^+	9.72		Total	99.24	99.27

(1) Todoroki mine, Japan; corresponds to $(Ca_{0.48}Mn^{2+}_{0.40}K_{0.08}Na_{0.05})_{\Sigma=1.01}(Mn^{4+}_{5.06}Mn^{2+}_{0.77}Mg_{0.17})_{\Sigma=6.00}O_{12}\cdot 3.62H_2O$. (2) Tarantana mine, Cuba; corresponds to $(Mn^{2+}_{0.49}Na_{0.25}Ca_{0.19}K_{0.06})_{\Sigma=0.99}(Mn^{4+}_{5.17}Mg_{0.54}Mn^{2+}_{0.29})_{\Sigma=6.00}O_{12}\cdot 3.06H_2O$.

Occurrence: A secondary mineral produced from weathering or hydrothermal alteration of other manganese-bearing species; in sedimentary marine fumarolic deposits; the principal manganese oxide in deep-sea manganese nodules.

Association: Pyrolusite, cryptomelane, romanèchite, manganite, rhodochrosite, quartz, "opal".

Distribution: Widespread. Well-characterized material from: the Todoroki mine, south of Ginzan, Hokkaido, Japan. On Groote Eylandt, Northern Territory, Australia. In Cuba, an ore in the Charco Redondo–Taratana district, and elsewhere in Oriente Province. In the USA, at Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota. From Urandi, Bahia, Brazil. At Nsuta, Ghana. Large crystals from the Smartt mine and elsewhere in the Kuruman district, Cape Province, South Africa. At Romanèche, Saône-et-Loire, France. From Bleiberg and Hüttenberg, Carinthia, Austria.

Name: For its first-noted occurrence in the Todoroki mine, Japan.

Type Material: Harvard University, Cambridge, Massachusetts, 106214; National Museum of Natural History, Washington, D.C., USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 573–574. (2) Frondel, C., U.B. Marvin, and J. Ito (1960) New occurrences of todorokite. Amer. Mineral., 45, 1167–1173. (3) Straczek, J.A., A. Horen, M. Ross, and C.M. Warshaw (1960) Studies of the manganese oxides. IV. Todorokite. Amer. Mineral., 45, 1174–1184. (4) Post, J.E. and D.L. Bish (1988) Rietveld refinement of the todorokite structure. Amer. Mineral., 73, 861–869.

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Tokkoite $K_2Ca_4Si_7O_{17}(O,OH,F)_4$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As compact aggregates of columnar or radiating crystals, up to several cm long.

Physical Properties: *Cleavage:* Perfect on {010}, less perfect on {110}. *Fracture:* Splintery. Hardness = 4–5 D(meas.) = 2.761 D(calc.) = 2.77

Optical Properties: Transparent. *Color:* Light brown to pale yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z \wedge c = 0°–15°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.570(2)$ $\beta =$ n.d. $\gamma = 1.577(2)$ 2V(meas.) = 38(5)°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.438(3)$ $b = 12.511(3)$ $c = 7.112(2)$ $\alpha = 89.92(2)°$ $\beta = 99.75(2)°$ $\gamma = 92.89(2)°$ Z = 2

X-ray Powder Pattern: Murun massif, Russia.
3.15 (100), 3.044 (91b), 3.32 (85), 3.125 (85), 3.075 (62), 3.34 (55), 3.26 (49)

Chemistry:

	(1)	(2)
SiO_2	55.65	54.17
TiO_2	1.42	1.18
Fe_2O_3	1.58	1.57
MnO	0.70	0.54
MgO	0.30	0.98
CaO	25.10	24.15
Na_2O	0.60	0.41
K_2O	11.33	12.95
F	1.50	1.50
H_2O	2.40	2.40
$-O = F_2$	0.63	0.63
Total	99.95	99.22

(1) Murun massif, Russia; corresponds to $K_{1.85}(Ca_{3.45}Fe_{0.15}Na_{0.15}Ti_{0.13}Mn_{0.08}Mg_{0.06})_{\Sigma=4.02}Si_{7.13}O_{17}[(OH)_{2.02}O_{1.63}F_{0.61}]_{\Sigma=4.26}$. (2) Do.; by electron microprobe, average of two analyses; corresponds to $K_{2.09}(Ca_{3.32}Mg_{0.19}Fe_{0.15}Na_{0.13}Ti_{0.11}Mn_{0.06})_{\Sigma=3.96}Si_{6.95}O_{17}[(OH)_{2.05}O_{1.39}F_{0.61}]_{\Sigma=4.05}$.

Occurrence: In nearly monomineralic segregations in an alkalic massif.

Association: Charoite, tinaksite, miserite, aegirine, potassic feldspar.

Distribution: From the Magistral'nyi area, right bank of the Davan Stream, between the Chara and Tokko Rivers, in the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: For the Tokko River, nearby the type locality in Russia.

Type Material: Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, Novosibirsk; Geological Museum, Yakutsk Scientific Center, Academy of Sciences, Yakutsk, Russia.

References: (1) Lazebnik, K.A., L.V. Nikishova, and Y.D. Lazebnik (1986) Tokkoite – a new mineral of charoitites. Mineral. Zhurnal, 8(3), 85–89 (in Russian). (2) (1988) Amer. Mineral., 73, 196 (abs. ref. 1). (3) Rozhdestvenskaya, I.V. (1989) The crystal structure of tokkoite and its relation to the structure of tinaksite. Zeits. Krist., 189, 195–204.

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Tokyoite $Ba_2Mn^{3+}(VO_4)_2(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As aggregates to 250 μm composed of irregular 15 μm grains.

Physical Properties: *Cleavage:* None. *Tenacity:* n.d. *Fracture:* Irregular. Hardness = 4-4.5 VHN = 363-390 (25 g load). D(meas.) = n.d. D(calc.) = 4.62

Optical Properties: Translucent. *Color:* Red-black. *Streak:* Dark brownish red.
Luster: Vitreous. *Pleochroism:* Distinct; reddish orange to dark brownish red.
Optical Class: n.d. *n*(calc.) = 2.03
R_1-R_2: (470) 12.8-13.2 $(3.3\text{-}3.5)_{oil}$, (546) 12.3-12.6 $(3.1\text{-}3.4)_{oil}$, (589) 12.2-12.5 $(3.1\text{-}3.6)_{oil}$, (650) 12.5-12.6 $(3.6\text{-}4.3)_{oil}$

Cell Data: Space Group: $P2_1/m$ (by analogy to gamagarite). a = 9.10(4) b = 6.13(2) c = 7.89(5) β = 112.2(5)° Z = 2

X-ray Powder Pattern: The Shiromaru mine, Okutama Town, Tokyo, Japan.
3.31(100), 2.80 (62), 2.71 (40), 3.46 (26), 3.08 (20), 2.90 (19), 2.16 (18)

Chemistry:

	(1)
V_2O_5	31.77
SiO_2	0.15
Al_2O_3	0.07
Fe_2O_3	2.33
Mn_2O_3	11.27
CaO	0.07
BaO	51.91
SrO	0.22
Na_2O	0.13
$[H_2O]$ `	1.59
Total	99.51

(1) The Shiromaru mine, Okutama Town, Tokyo, Japan; average of 6 electron microprobe analyses, H_2O calculated by analogy to gamagarite, corresponds to $(Ba_{1.92}Na_{0.02}Sr_{0.01}Ca_{0.01})_{\Sigma=1.96}(Mn^{3+}_{0.81}Fe^{3+}_{0.17}Al_{0.01})_{\Sigma=0.99}[(V_{1.99}Si_{0.01})O_{7.92}](OH)_{1.00}$.

Mineral Group: Brackebuschite group.

Occurrence: From an outcrop, in an abandoned Mn deposit in brecciated braunite and in veinlets in chert blocks enclosed in sandstone in an accretionary complex. Probably a primary mineral derived from the reaction of braunite with Ba- and V-bearing fluids.

Association: Braunite, hyalophane, tamaite.

Distribution: From the Shiromaru mine, Okutama Town, Tokyo, Japan.

Name: For the metropolitan area containing the first locality.

Type Material: National Science Museum, Tokyo, Japan (NSM-M 28569).

References: (1) Matsubara, S., R. Miyawaki, K. Yokoyama, M. Shimizu, and H. Imai (2004) Tokyoite, $Ba_2Mn^{3+}(VO_4)_2(OH)$, a new mineral from the Shiromaru mine, Okutama, Tokyo, Japan. J. Mineral. Petrol. Sci., 99, 363-367. (2) (2005) Amer. Mineral., 90, 1468 (abs. ref. 1).

Tolbachite $CuCl_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, elongated, to 2 mm, in fibrous, mosslike growths incrusting basalt.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.42 Readily soluble in cold H_2O; hygroscopic, alters rapidly to eriochalcite in air.

Optical Properties: Semitransparent. *Color:* Brown to golden brown. *Luster:* Pearly. *Optical Class:* Biaxial; high birefringence. *Pleochroism:* Pale greenish $\perp$ elongation; dark reddish brown $\parallel$ elongation. *Orientation:* Elongation positive. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$ (synthetic). $a = 6.9038(9)$ $b = 3.2995(4)$ $c = 6.824(1)$ $\beta = 122.197(8)^\circ$ Z = 2

X-ray Powder Pattern: Tolbachik volcano, Russia.
5.76 (100), 2.915 (35), 3.445 (25), 1.923 (5), 2.373 (3)

Chemistry:

	(1)	(2)
CuO	51.99	59.16
ZnO	0.30	
PbO	0.11	
Na_2O	0.74	
K_2O	1.50	
Cl	42.59	52.74
H_2O^+	1.05	
H_2O^-	4.45	
SO_4	4.24	
$-O = Cl_2$	9.61	11.90
insol.	2.68	
Total	100.04	100.00

(1) Tolbachik volcano, Russia; analysis of a water extract. (2) $CuCl_2$.

Occurrence: As fumarolic incrustations on basalt (Tolbachik volcano, Russia); formed with other copper chlorides in an oxidized copper deposit (Bisbee, Arizona, USA).

Association: Tenorite, euchlorine, dolerophanite, piypite, ponomarevite, kamchatkite, klyuchevskite, chalcocyanite, cotunnite, sofiite, halite, sylvite, (Tolbachik volcano, Russia); paratacamite, nantokite, cuprite (Bisbee, Arizona, USA).

Distribution: At the Tolbachik fissure volcano, Kamchatka Peninsula, Russia. In the Southwest mine, Bisbee, Cochise Co., Arizona, USA.

Name: For its occurrence at the Tolbachik volcano, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1290/1.

References: (1) Bergasova, L.P. and S.K. Filatov (1983) The new mineral tolbachite $CuCl_2$. Doklady Acad. Nauk SSSR, 270, 415–417 (in Russian). (2) (1984) Amer. Mineral., 69, 408 (abs. ref. 1). (3) (1983) Mineral. Abs., 35, 194 (abs. ref. 1). (4) Burns, P.C. and F.C. Hawthorne (1993) Tolbachite, $CuCl_2$, the first example of Cu^{2+} octahedrally coordinated by Cl^-. Amer. Mineral., 78, 187–189.

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Tolovkite IrSbS

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Crystal Data: Cubic. *Point Group:* n.d. As aggregates of corroded, anhedral grains that define a skeletal isometric outline, to 72 μm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = Very hard. VHN = 1431–1703 (10 g load). D(meas.) = n.d. D(calc.) = 10.50

Optical Properties: Opaque. *Color:* Steel-gray; gray with a pale brown tint in reflected light. *Luster:* Metallic.

R: (442) 36.7, (468) 39.0, (484) 39.9, (525) 42.0, (554) 42.5, (586) 42.9, (621) 43.5, (666) 43.8, (699) 44.0

Cell Data: *Space Group:* n.d. a = 6.027(3) Z = 4

X-ray Powder Pattern: Tolovka River, Russia.
1.813 (100), 2.99 (90), 1.146 (90), 1.065 (90), 2.126 (80), 1.005(80), 1.233 (70)

Chemistry:

	(1)	(2)	(3)
Ir	55.60	55.00	55.55
Pt	0.25	0.69	
Os	0.12	0.49	
Ni	0.06	0.06	
Sb	35.00	34.70	35.19
S	9.22	9.20	9.26
Total	100.25	100.14	100.00

(1–2) Tolovka River, Russia; by electron microprobe, the average of which corresponds to $(Ir_{0.99}Pt_{0.01}Os_{0.01})_{\Sigma=1.01}Sb_{0.99}S_{0.99}$. (3) IrSbS.

Mineral Group: Cobaltite group.

Occurrence: In a placer derived from an Alpine-type gabbro massif (Tolovka River, Russia).

Association: Os–Ir alloys, laurite, pentlandite, heazlewoodite (Tolovka River, Russia).

Distribution: In Russia, from the Tolovka River placer, Ust'-Bel'skii massif, Magadan district [TL]; at the Voykar-Syn'ya and Rayiz massifs, Polar Ural Mountains. In the Similkameen River, British Columbia, Canada. From Fox Gulch, Goodnews Bay, Alaska, USA.

Name: For the type locality near the Tolovka River, Russia.

Type Material: Mining Institute, St. Petersburg, Russia; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72030.

References: (1) Razin, L.V., N.S. Rudashevskii, and G.A. Sidorenko (1981) Tolovkite, IrSbS, a new sulfoantimonide of iridium from the northeastern USSR. Zap. Vses. Mineral. Obshch., 110, 474–480 (in Russian). (2) (1982) Amer. Mineral., 67, 1076–1077 (abs. ref. 1). (3) Bayliss, P. (1989) Crystal chemistry and crystallography of some minerals within the pyrite group. Amer. Mineral., 74, 1168–1176. [??ck this, as paper not even in pyrite folder - and MFG 2004 gives it as structure ref??]

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Tombarthite-(Y) $Y_4(Si,H_4)_4O_{12-x}(OH)_{4+2x}$

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Crystal Data: Monoclinic, partially metamict. *Point Group:* $2/m$. Massive, to about 1 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 5–6 D(meas.) = 3.51–3.65 D(calc.) = 3.64–3.68

Optical Properties: Translucent to opaque. *Color:* Brownish black. *Luster:* Dull. *Optical Class:* Isotropic; may be slightly anisotropic. $n = 1.639(2)$

Cell Data: *Space Group:* $P2_1/n$. $a = 7.12$ $b = 7.29$ $c = 6.71$ $\beta = 102°41'$ Z = 1

X-ray Powder Pattern: Högetveit quarry, Norway.
6.55 (100), 3.42 (80), 3.23 (70b), 2.97 (60), 2.89 (50), 2.40 (40), 7.32 (30)

Chemistry:

	(1)
SiO_2	15.90
ThO_2	0.85
UO_2	0.57
Y_2O_3	28.00
RE_2O_3	19.54
FeO	5.52
MnO	1.02
MgO	0.26
CaO	4.88
P_2O_5	0.00
LOI	22.71
Total	99.25

(1) Högetveit quarry, Norway; RE by XRF, CaO includes l5% SrO, loss on ignition taken as H_2O; $RE_2O_3 = La_2O_3$ 0.06%, Ce_2O_3 0.42%, Pr_2O_3 0.08%, Nd_2O_3 0.48%, Sm_2O_3 0.57%, Eu_2O_3 0.05%, Gd_2O_3 1.53%, Tb_2O_3 0.47%, Dy_2O_3 3.85%, Ho_2O_3 0.90%, Er_2O_3 3.91%, Tm_2O_3 0.64%, Yb_2O_3 5.79%, Lu_2O_3 0.79%; corresponds to $(Y,RE,Ca,Fe,Mn,Mg,Th,U)_4Si_{1.96}H_{8.16}O_{8.11}(OH)_{10.45}$.

Occurrence: In pegmatite dikes cutting amphibolites.

Association: Thalenite, feldspar.

Distribution: In the Högetveit quarry, near Setesdal, Evje, and at Reiarsdal, Norway.

Name: For Professor Thomas Fredrik Weiby Barth (1899-1971), mineralogist and petrologist, Oslo University, Oslo, Norway, who studied the area of first occurrence, and for its *yttrium* content.

Type Material: Oslo University, Oslo, Norway.

References: (1) Neumann, H. and B. Nilssen (1968) Tombarthite, a new mineral from Høgetveit, Evje, south Norway. Lithos, 1, 113–123. (2) (1969) Amer. Mineral., 54, 327–328 (abs. ref. 1).

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Tomichite $(V^{3+},Fe^{3+})_4Ti_3As^{3+}O_{13}(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In euhedral tabular crystals, to 3 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 6 VHN = 800(136) (50 g load). D(meas.) = 4.16 D(calc.) = 4.42

Optical Properties: Opaque. *Color:* Black; gray in reflected light. *Streak:* Black. *Optical Class:* Biaxial. *Anisotropism:* Moderate; yellowish gray to dark gray. R_1–R_2: (400) 17.9–18.3, (420) 17.5–17.9, (440) 17.2–17.6, (460) 17.0–17.5, (480) 17.0–17.5, (500) 16.9–17.5, (520) 17.0–17.6, (540) 17.0–17.7, (560) 17.1–17.8, (580) 17.1–17.9, (600) 17.2–17.9, (620) 17.2–18.0, (640) 17.2–18.0, (660) 17.2–18.0, (680) 17.3–18.0, (700) 17.3–18.0

Cell Data: *Space Group:* $P2_1/m$, with $a = 7.119(3)$ $b = 14.176(5)$ $c = 4.992(2)$ $\beta = 105.05(1)^\circ$ Z = 2, or *Space Group:* $A2/m$ (barian), with $a = 7.105(4)$ $b = 14.217(4)$ $c = 5.043(2)$ $\beta = 104.97(7)^\circ$ Z = 2

X-ray Powder Pattern: Kalgoorlie, Western Australia.
2.663 (10), 2.836 (9), 1.572 (5), 3.092 (4), 2.023 (3), 1.712 (3), 4.994 (2)

Chemistry:

	(1)	(2)
SiO_2	0.21	
TiO_2	37.42	27.23
Al_2O_3		0.98
Fe_2O_3	11.39	13.14
V_2O_3	34.92	34.78
As_2O_3	11.31	13.27
Sb_2O_3	1.22	0.81
BaO		7.58
H_2O	[1.36]	
Total	[97.83]	97.79

(1) Kalgoorlie, Western Australia; by electron microprobe, average of four analyses, total Fe as Fe_2O_3, total V as V_2O_3, total As as As_2O_3, total Sb as Sb_2O_3, H_2O calculated from stoichiometry; corresponding to $(V^{3+}_{3.08}Fe^{3+}_{0.94})_{\Sigma=4.02}Ti_{3.10}(As^{3+}_{0.76}Sb^{3+}_{0.06}Si_{0.02})_{\Sigma=O.84}O_{13}(OH)$.
(2) Hemlo deposit, Canada; by electron microprobe, average of several analyses Fe^{2+}:Fe^{3+} calculated from charge balance; corresponding to $(V^{3+}_{3.29}Fe^{3+}_{1.09}Al_{0.13}Fe^{2+}_{0.08})_{\Sigma=4.59}Ti_{2.41}(As^{3+}_{0.95}Ba_{0.35}Sb^{3+}_{0.04})_{\Sigma=1.34}O_{13}(OH)$.

Occurrence: In a specimen from a hydrothermal gold deposit (Kalgoorlie, Western Australia); in a gold deposit at the contact of felsic metavolcanic and metasedimentary rocks (Hemlo deposit, Canada).

Association: Vanadian muscovite, rutile, pyrite, calaverite, calcite, quartz (Kalgoorlie, Western Australia); quartz, microcline, barite, pyrite, molybdenite, stibnite, arsenic, sphalerite, zinkenite, aktashite, tetrahedrite, vanadian muscovite (Hemlo mine, Canada).

Distribution: In Western Australia, from Kalgoorlie, probably from the Perseverance mine. In the Hemlo gold deposit, Thunder Bay district, Ontario, Canada.

Name: To honor Stephan A. Tomich (1914–), consulting geologist, Perth, Western Australia, who presented the first specimen for examination.

Type Material: Western Australian Museum, Perth, Australia, M.67.1991, MDC6417; The Natural History Museum, London, England, 1979,532; National Museum of Natural History, Washington, D.C., USA, 146187.

References: (1) Nickel, E.H. and I.E. Grey (1979) Tomichite, a new oxide mineral from Western Australia. Mineral. Mag., 43, 469–471. (2) (1980) Amer. Mineral., 65, 811 (abs. ref. 1). (3) Grey, I.E., I.C. Madsen, and D.C. Harris (1987) Barian tomichite, $Ba_{0.5}(As_2)_{0.5}Ti_2(V,Fe)_5O_{13}(OH)$, its crystal structure and relationship to derbylite and tomichite. Amer. Mineral., 72, 201–208.

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Tondiite $Cu_3Mg(OH)_6Cl_2$

Crystal Data: Hexagonal. *Point Group*: $\bar{3}\,2/m$. As irregularly shaped crystals dominated by {101} and {012}, to ~ 0.2 mm, often with stepped faces.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = 3-3.5 D(meas.) = n.d. D(calc.) = 3.503

Optical Properties: Transparent. *Color*: Emerald green to bright green. *Streak*: n.d. *Luster*: Vitreous. *Pleochroism*: Slight, green to faintly green. *Optical Class*: Uniaxial (+). ω = 1.749(6) ε = 1.766 (7)

Cell Data: *Space Group*: $R\bar{3}\,m$. a = 6.8377(7) c = 14.088(2) Z = n.d.

X-ray Powder Pattern: Calculated pattern.
2.764 (100), 5.459 (88), 2.266 (54), 1.709 (26), 3.419 (22), 1.820 (19), 2.898 (15)

Chemistry:

	(1)	(2)	(3)
CuO	65.90	66.78	61.52
MnO	0.94		
MgO	6.61	6.12	10.39
Cl	16.79	17.05	18.28
H_2O	13.84	13.52	13.94
–O=Cl	3.79	3.85	4.12
Total	100.29	99.62	100.00

(1) Vesuvius, Italy; average of 15 electron microprobe analyses, H_2O calculated from stoichiometry assuming Cl^- and OH^- as the only anions; corresponding to $Cu_{3.29}Mg_{0.65}Mn_{0.05}(OH)_{6.11}Cl_{1.89}$. (2) Santo Domingo Cu Mine, Chile; average of 20 electron microprobe analyses, H_2O calculated from stoichiometry assuming Cl^- and OH^- as the only anions; corresponding to $Cu_{3.38}Mg_{0.62}(OH)_{6.06}Cl_{1.94}$. (3) $Cu_3Mg(OH)_6Cl_2$.

Occurrence: A secondary mineral in vesicles in phonolitic tephrite (Vesuvius); a secondary oxidation product of chalcocite, bornite and chalcopyrite in an environment rich in Cl in andesitic porphyric lavas and lava tuff (Chile).

Association: Leucite, sodalite, nepheline, sanidine, Fe oxides and hydroxides (Vesuvius); haydeeite, anhydrite, atacamite (Chile).

Distribution: From Vesuvius volcano, Italy, and from the Santo Domingo Cu Mine, Caleta Vitor district, Arica Province, Chile.

Name: Honors Matteo Tondi (1762-1835), an Italian mineralogist and co-author with R.J. Haüy of the classic *Traité de Minéralogie*.

Type Material: Collezione Vesuviana of the Real Museo Mineralogico, University of Naples, Italy (# 1178R), labeled as "1906 lava", and at the Mineralogical Museum, University of Hamburg, Germany (MD480).

References: (1) Malcherek, T., L. Bindi, M. Dini, M.R. Ghiara, A. Molina Donoso, F. Nestola, M. Rossi, and J. Schlüter (2014) Tondiite, $Cu_3Mg(OH)_6Cl_2$, the Mg-analog of herbertsmithite. Mineral. Mag., 78(3), 583-590. (2) (2015) Amer. Mineral., 100, 662-663 (abs. ref. 1).

Tongbaite Cr_3C_2

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Prismatic, pseudohexagonal crystals, to 0.3 mm, may have spearhead-shaped terminations.

Physical Properties: *Tenacity:* Brittle. Hardness = 8.5 VHN = 1885 (100 g load). D(meas.) = n.d. D(calc.) = 6.64

Optical Properties: Opaque. *Color:* Pale brownish yellow; pale violet in reflected light. *Streak:* Dark gray. *Luster:* Strong metallic.
Optical Class: Biaxial. *Pleochroism:* Distinct. *Anisotropism:* Strong; purplish yellow to yellow-orange. *Bireflectance:* Distinct.
R_1–R_2: (405) 46.54–49.10, (436) 48.50–51.28, (480) 51.14–53.86, (526) 53.72–55.94, (546) 54.68–56.89, (578) 57.07–57.51, (589) 57.38–57.82, (622) 58.72–57.68, (644) 60.33–59.02, (656) 61.50–59.97, (664) 61.56–59.97, (700) 61.35–59.20

Cell Data: *Space Group: Pnma.* $a = 5.57(5)$ $b = 11.47(8)$ $c = 2.816(8)$ Z = 4

X-ray Powder Pattern: China.
2.30 (100), 2.23 (80), 1.193 (70), 1.70 (40), 1.164 (40), 1.94 (30), 1.86 (30)

Chemistry:

	(1)	(2)
Cr	84.26	86.66
Fe	1.18	
Ni	1.25	
C	13.37	13.34
Total	100.06	100.00

(1) China; by electron microprobe, average of four analyses; corresponding to $(Cr_{2.91}Fe_{0.04}Ni_{0.04})_{\Sigma=2.99}C_{2.00}$. (2) Cr_3C_2.

Occurrence: In ultramafic rocks (China).

Association: Magnesiochromite, pyrrhotite, pentlandite, pyrite, chalcopyrite, cubanite, magnetite, ilmenite, altaite, violarite, awaruite, bismutohauchecornite, lead, chromium, gold, copper, platinum, iron, forsterite, phlogopite, apatite, diopside, enstatite, hydrogrossular (Liu Zhuang, China); iron sulfides, iron oxides, platinum-group minerals, copper, diamond, moissanite, olivine, pyroxene, pyrope (Hong district, Tibet, China).

Distribution: In China, from Liu Zhuang, Tongbai Co., Henan Province, and in the Hong district, Tibet.

Name: For Tongbai Co., China, where the mineral occurs.

Type Material: n.d.

References: (1) Tian Peixue, Fang Qingsong, Chen Keqiao, and Peng Zhizhong (1983) A study on tongbaite – a new mineral. Acta Mineralogica Sinica, 4, 241–245 (in Chinese with English abs.). (2) Chen Keqiao, Tian Peixue, Shi Nicheng, and Peng Zhizhong (1983) A study on tongbaite, Cr_3C_2 – a new mineral. Ziran Zazhi, 6, 478–479 (in Chinese). (3) (1985) Amer. Mineral., 70, 218 (abs. refs. 1 and 2). (4) Rundqvist, S. and G. Runnsjö (1969) Crystal structure refinement of Cr_3C_2. Acta Chem. Scand., 23, 1191–1199.

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Tooeleite $Fe_8^{3+}(AsO_4, SO_4)_6(OH)_6 \cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$ (probable). Bladed crystals, to 1 cm, are elongate along [001], showing {010}, {304}, {100}; usually in compact crystalline crusts.

Physical Properties: *Cleavage:* On {010}, good. Hardness = 3 D(meas.) = 4.23(8) D(calc.) = 4.15

Optical Properties: Transparent. *Color:* Cadmium-orange, may be brownish orange or yellowish orange. *Streak:* Cadmium-orange. *Luster:* Greasy.
Optical Class: Biaxial (–). *Pleochroism:* Moderate; Y = orange; $X = Z$ = lemon-yellow. *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r > v$, slight. *Absorption:* $Y > X = Z$. $\alpha = 1.94$ $\beta = 2.04$ $\gamma = 2.05$ 2V(meas.) = 2°–5° 2V(calc.) = 32°

Cell Data: *Space Group:* $Pbcm$ or $Pbc2_1$ (probable). $a = 6.416(4)$ $b = 19.45(17)$ $c = 8.941(8)$ Z = 2

X-ray Powder Pattern: U.S. mine, Utah, USA.
9.725 (10), 3.208 (9), 3.047 (5), 4.476 (4), 2.680 (4), 2.153 (4), 1.604 (4)

Chemistry:

	(1)
SO_3	7.24
As_2O_5	38.61
Fe_2O_3	43.56
H_2O	9.80
Total	99.21

(1) U.S. mine, Utah, USA; by electron microprobe, average of 11 analyses, total Fe as Fe_2O_3, H_2O by the Penfield method; corresponds to $Fe_{7.58}[(AsO_4)_{4.73}(SO_4)_{1.27}]_{\Sigma=6.00}(OH)_{6.00} \cdot 4.66H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized zone of a replacement orebody in metamorphosed limestone.

Association: Jarosite, scorodite, sulfur, kaatialaite, pyrite, arsenopyrite, galena, sphalerite, goethite, gypsum.

Distribution: From the U.S. mine, Gold Hill, Tooele Co., Utah, USA.

Name: For its initially noted occurrence in Tooele Co., Utah, USA.

Type Material: National School of Mines, Paris, France.

References: (1) Cesbron. F.P. and S.A. Williams (1992) Tooeleite, a new mineral from the U.S. Mine, Tooele County, Utah. Mineral. Mag., 56, 71–73. (2) (1992) Amer. Mineral., 77, 1306–1307 (abs. ref. 1).

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Topaz **$Al_2SiO_4(F,OH)_2$**

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Well-formed crystals common, typically morphologically complex, long to short prismatic, to 1.2 m. Prism faces commonly vertically striated, with etch and growth figures on non-prism faces; columnar, compact, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 8 D(meas.) = 3.49–3.57 D(calc.) = 3.55

Optical Properties: Transparent to opaque with inclusions. *Color:* Colorless, yellow, pink, red, orange, brown, green, blue, violet; in transmitted light, colorless, thick sections yellow, red, or blue. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* In thick sections, X = yellow; Y = yellow, violet, reddish; Z = violet, bluish, yellow, pink. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r > v$. $\alpha = 1.606$–1.634 $\beta = 1.609$–1.637 $\gamma = 1.616$–1.644 2V(meas.) = 48°–68°

Cell Data: *Space Group: Pbnm.* $a = 4.6499(3)$ $b = 8.7968(6)$ $c = 8.3909(5)$ Z = 4

X-ray Powder Pattern: Minas Gerais, Brazil; Durango, Mexico; Thomas Range, Utah, USA; average of three patterns. (ICDD 12-765).
2.937 (100), 3.195 (66), 3.693 (60), 2.3609 (45), 2.1049 (44), 3.037 (37), 1.6706 (27)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	31.93	33.00	H_2O^+	0.19	2.67
Al_2O_3	56.26	56.76	H_2O^-		0.04
F	20.37	13.23	$-O = F_2$	8.58	5.57
			Total	100.17	100.13

(1) Thomas Range, Utah, USA; corresponds to $Al_{2.00}(Si_{0.98}Al_{0.02})_{\Sigma=1.00}O_{3.99}[F_{1.97}(OH)_{0.04}]_{\Sigma=2.01}$. (2) Brewer mine, Chesterfield Co., South Carolina, USA.

Occurrence: In veins and cavities in granite, granite pegmatite, rhyolite, and in greisen, formed from high-temperature, volatile-rich pneumatolytic hydrothermal fluids. From high-grade metamorphism of aluminous, quartz-rich, and fluorine-bearing sediments. As a heavy detrital mineral.

Association: Tourmaline, beryl, microcline, albite, fluorite, cassiterite, zinnwaldite, quartz.

Distribution: Widespread; only a few localities for the finest specimens can be mentioned. In Russia, near Mursinka, Ural Mountains, and in the Adun-Chilon and Borshchovochnoii Mountains, Nerchinsk district, Siberia. At Schneckenstein, Saxony, Germany. At Xilingeleimeng, Inner Mongolia, China. On Ghundao Hill, near Katlang, Mardan district, and in the Skardu and Gilgit districts, Pakistan. From the Mogok district, Myanmar (Burma). At Tanokamiyama, Shiga Prefecture, and the Naegi district, Gifu Prefecture, Japan. From Ouro Preto and near Virgem da Lapa, Minas Gerais, Brazil. In the USA, at Devils Head, Douglas Co., Colorado; from the Thomas Range, Juab Co., Utah; Lord's Hill, Stoneham, Oxford Co., Maine; Baldface Mountain, Carroll Co., New Hampshire; from Ramona, San Diego Co., California; near Streeter, Mason Co., Texas. At Tepetate, San Luis Potosí, Mexico. In the St. Anne's mine, Miami district, Zimbabwe. From the Alto Ligonha district, Mozambique. At Klein Spitzkopje, Namibia. In the Jos district, Nigeria.

Name: From the Greek *topazion*, meaning *to seek*, apparently in allusion to the Island of Zabargad (Zabirget or St. Johns), in the Red Sea, Egypt; the location of which was long hidden, known for olivine ("peridot" and "chrysolite"), referred to since antiquity as *topaz*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 492–496. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 801–815. (3) Pardee, J.T., J.J. Glass, and R.E. Stevens (1937) Massive low-fluorine topaz from the Brewer mine, South Carolina. Amer. Mineral., 22, 1058–1064.

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Torbernite $Cu(UO_2)_2(PO_4)_2 \cdot 8{-}12H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Thin to thick tabular crystals, square or octagonal, with prominent {001}, {011}, {110}, rarely pyramidal {111}, to 2.5 cm. Typically in subparallel aggregates, foliated, micaceous, scaly. *Twinning:* Rare on {110}.

Physical Properties: *Cleavage:* Perfect on {001}, micaceous; indistinct on {100}. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 3.22 D(calc.) = n.d. Radioactive. H_2O content varies with relative humidity.

Optical Properties: Transparent to translucent. *Color:* Emerald-green, grass-green, leek-green, siskin-green, apple-green. *Streak:* Pale green. *Luster:* Vitreous, subadamantine, waxy, pearly on cleavages; becoming dull on dehydration to metatorbernite.
Optical Class: Uniaxial (–). *Pleochroism: O* = dark green to sky-blue; *E* = green.
$\omega = 1.590–1.592$ $\epsilon = 1.581–1.582$

Cell Data: *Space Group:* $I4/mmm$. a = 7.025(5) $c = 20.63(2)$ Z = 2

X-ray Powder Pattern: Synthetic $Cu(UO_2)_2(PO_4)_2 \cdot 12H_2O$.
10.30 (10), 4.94 (9), 3.578 (9), 3.512 (8), 6.61 (4), 4.476 (4), 3.674 (4)

Chemistry:

	(1)	(2)
UO_3	57.03	56.65
P_2O_5	14.50	14.06
SiO_2	0.59	
CuO	7.73	7.88
H_2O	20.30	21.41
Total	100.15	100.00

(1) Leupoldsdorf, Bavaria, Germany. (2) $Cu(UO_2)_2(PO_4)_2 \cdot 12H_2O$.

Mineral Group: Autunite group.

Occurrence: An uncommon secondary mineral formed in the oxidized zone of some uraniferous copper deposits.

Association: Metatorbernite, autunite, zeunerite, uraninite.

Distribution: Many localities, but rarely in large amounts. From Jáchymov (Joachimsthal), Czech Republic. In Germany, at Schneeberg, Johanngeorgenstadt, and elsewhere in Saxony. Fine examples from Margabal, Aveyron, and at Les Bois Noirs, Puy-de-Dôme, France. In England, from a number of mines in Cornwall, as Wheal Basset, Stenna Gwyn, etc. From Richelle, near Visé, Belgium. At Sabugal, Portugal. Large crystals especially at the Musonoi mine, near Kolwezi, and as rich specimens from Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). On Mt. Painter, Flinders Ranges, South Australia; from the South Alligator Valley, Northern Territories, Australia. In the USA, at Chalk Mountain, near Spruce Pine, Mitchell Co., North Carolina; large crystals from the Majuba Hill mine, Antelope district, Pershing Co., Nevada.

Name: To honor Torbern Olof Bergmann (1735–1784), Swedish chemist and mineralogist, Professor of Chemistry, Uppsala University, Uppsala, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 980–984. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 170–177.

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Törnebohmite-(Ce) $(Ce,La)_2Al(SiO_4)_2(OH)$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Fine-grained, massive; as inclusions in cerite.

Physical Properties: Hardness = 4.5 D(meas.) = 4.94 D(calc.) = 5.12

Optical Properties: Semitransparent. *Color:* Light green to olive. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* Very strong; X = light rose to greenish yellow; Y = bluish green; Z = light rose. *Dispersion:* $r < v$, very strong. *Absorption:* $Y > X = Z$. α = 1.808–1.845 β = 1.81–1.852 γ = 1.838–1.878 2V(meas.) = 20°–40°

Cell Data: *Space Group:* $P2_1/c$. $a = 7.383(3)$ $b = 5.673(3)$ $c = 16.937(6)$ $\beta = 112.04(2)°$ Z = 4

X-ray Powder Pattern: Bastnäs mine, Sweden.
3.08 (100), 2.82 (90), 2.01 (60), 2.18 (50), 1.783 (50), 4.57 (40), 3.53 (40)

Chemistry:

	(1)	(2)
SiO_2	22.05	23.64
Al_2O_3	8.55	10.03
$(La,Nd)_2O_3$	34.85	
Ce_2O_3	27.52	64.56
FeO	1.91	
MnO	0.05	
MgO	0.49	
CaO	0.23	
F	0.29	
H_2O		1.77
LOI	1.70	
insol.	0.95	
chalcopyrite	0.96	
Total	99.55	100.00

(1) Bastnäs mine, Sweden. (2) $Ce_2Al(SiO_4)_2(OH)$.

Occurrence: In a contact metamorphosed limestone deposit (Bastnäs mine, Sweden).

Association: Allanite, cerite, bastnäsite.

Distribution: From the Bastnäs mine, Riddarhyttan, Västmanland, Sweden. In the Jamestown district, Boulder Co., and the Black Cloud pegmatite. Teller Co., Colorado, USA.

Name: For Alfred Elis Törnebohm (1838–1911), former Director of the Geological Survey of Sweden, and for its *cerium* content.

Type Material: n.d.

References: (1) Geijer, P. (1920) The cerium minerals of Bastnäs at Riddarhyttan. Swedish Geol. Sur., Yearbook, 14, 16–20. (2) (1921) Amer. Mineral., 6, 118–119 (abs. ref. 1). (3) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 319–320. (4) Traill, R.J. and A.P. Sabina (1960) Catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada. Geol. Sur. of Canada, Paper 60-4, 105. (5) Shen, J. and P.B. Moore (1982) Törnebohmite, $RE_2Al(OH)[SiO_4]_2$: crystal structure and genealogy of RE(III)Si(IV) ⇌ Ca(II)P(V) isomorphisms. Amer. Mineral., 67, 1021–1028.

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Törnebohmite-(La) $(La,Ce)_3Al(SiO_4)_2(OH)$

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Crystal Data: [Monoclinic, pseudohexagonal] [by analogy to törnebohmite-(Ce)]. *Point Group:* [$2/m$.] Rare crystals in fissures; more commonly as grains, to 3 mm, or veins in cerite; in concentrically zoned aggregates around cerite and bastnäsite.

Physical Properties: *Fracture:* Uneven. Hardness = 5 D(meas.) = 4.805 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark green or greenish gray. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (+). *Pleochroism:* Extreme; X = strong bluish green; Y = yellow-green; Z = pinkish. *Dispersion:* $r > v$, very strong. α = 1.845–1.850 β = n.d. γ = 1.870–1.880 2V(meas.) = 18°–40°

Cell Data: *Space Group:* [$P2_1/c$.] pseudohexagonal cell $a = 7.74$ $c = 8.5$ Z = n.d.

X-ray Powder Pattern: Mochalin Log, Russia; diffuse.
3.15 (7.5), 2.860 (7.5), 2.665 (6), 2.202 (4.5), 2.003 (4.5), 1.807 (2.5), 1.734 (2)

Chemistry:

	(1)
SiO_2	20.33
TiO_2	0.12
Al_2O_3	10.11
RE_2O_3	62.88
Fe_2O_3	2.61
MgO	0.92
CaO	2.46
H_2O^+	0.78
Total	100.21

(1) Mochalin Log, Russia; RE = La 48.1%, Ce 41.6%, Pr 2.9–3.2%, Nd 7.0–7.5%, Sm 0.2–0.4%, Gd 0.1–0.2%, Tb 0.1–0.2%, traces of Sc, Be, U, Zr; corresponds to $(La_{1.02}Ce_{0.87}Ca_{0.23}Nd_{0.14})_{\Sigma=2.26}(Al_{1.04}Fe^{3+}_{0.17}Mg_{0.11})_{\Sigma=1.32}Si_2O_8[O_{0.55}(OH)_{0.45}]_{\Sigma=1.00}$.

Occurrence: Replaces cerite, in turn replacing bastnäsite, in granite pegmatite in the fenitization zone of a nepheline syenite massif.

Association: Cerite, bastnäsite, allanite, feldspar.

Distribution: From Mochalin Log, Kyshtym district, Southern Ural Mountains, Russia.

Name: For its content of *lanthanum* and relation to törnebohmite-(Ce).

Type Material: n.d.

References: (1) Svyazhin, N.V. (1962) Törnebohmite from the alkaline area of the Ural. Zap. Vses. Mineral. Obshch., 91, 97–99 (in Russian). (2) (1962) Chem. Abs., 6904 (abs. ref. 1).

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Torrecillasite $Na(As,Sb)_4^{3+}O_6Cl$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As thin prisms elongated on [100] with diamond-shaped cross section and irregular terminations to 0.4 mm; in jack-straw aggregates, "puff balls", and massive intergrowths.

Physical Properties: *Cleavage*: None observed, however likely on {001}. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = 2.5 D(meas.) = n.d. D(calc.) = 4.056

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Adamantine. *Optical Class*: Biaxial (-). α = 1.800(5) β = 1.96(1) γ = 2.03(calc) 2V(meas.) = 62.1(5)° 2V(calc.) = n.d. *Dispersion*: None. *Orientation: X = c, Y = b, Z = a*.

Cell Data: *Space Group*: *Pmcn*. *a* = 5.2580(9) *b* = 8.0620(13) *c* = 18.654(3) Z = 4

X-ray Powder Pattern: Torrecillas mine, Iquique Province, Chile.
3.035 (100), 2.642 (84), 4.031 (78), 2.853 (39), 2.426 (34), 4.298 (33), 1.8963 (32)

Chemistry:

	(1)	(2)
Na_2O	6.56	6.82
MgO	0.15	
As_2O_3	68.64	87.13
Sb_2O_3	18.43	
Cl	6.75	7.81
–O=Cl	1.52	1.76
Total	99.01	100.00

(1) Torrecillas mine, Iquique Province, Chile; average of 6 electron microprobe analyses; corresponding to $(Na_{1.03}Mg_{0.02})_{\Sigma=1.05}(As_{3.39}Sb_{0.62})_{\Sigma=4.01}O_{6.07}Cl_{0.93}$. (2) $NaAs^{3+}{}_4O_6Cl$.

Occurrence: A secondary mineral formed by the oxidation of native As and As-bearing minerals in hydrothermal veins followed by later alteration by saline fluids derived from evaporating meteoric water under hyperarid conditions.

Association: Anhydrite, cinnabar, gypsum, halite, lavendulan, magnesiokoritnigite, marcasite, quartz, pyrite, scorodite, wendwilsonite, leverettite, canutite.

Distribution: From the Torrecillas mine, Torrecillas Hill, northern Atacama Desert, Iquique Province, Tarapacá Region, Chile.

Name: For the locality that produced the first specimens.

Type Material: Natural History Museum of Los Angeles County, Los Angeles, California, USA (#64079, 64080, 64081, 64082).

References: (1) Kampf, A.R., B.P. Nash, M. Dini, and A.A. Molina Donoso (2014) Torrecillasite, $Na(As,Sb)^{3+}{}_4O_6Cl$, a new mineral from the Torrecillas mine, Iquique Province, Chile: description and crystal structure. Mineral. Mag., 78(3), 747-755. (2) (2015) Amer. Mineral., 100, 338 (abs. ref. 1).

Torreyite $(Mg, Mn^{2+})_9Zn_4(SO_4)_2(OH)_{22}\cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare blocky crystals, to 1 mm, in parallel growth; foliated, fine-grained granular to massive. *Twinning:* Ubiquitous microscopic polysynthetic twinning on a twin plane in [010].

Physical Properties: *Cleavage:* {010}, good. *Tenacity:* Somewhat brittle. Hardness = 3
D(meas.) = 2.665 D(calc.) = 2.65

Optical Properties: Translucent. *Color:* Bluish white to colorless; colorless in transmitted light. *Luster:* Vitreous to almost pearly, dull.
Optical Class: Biaxial (–). *Orientation:* $X = b$. $\alpha = 1.570$ $\beta = 1.584$ $\gamma = 1.585$
2V(meas.) = ∼40°

Cell Data: *Space Group:* $P2_1/a$. $a = 10.522$ $b = 9.433$ $c = 16.443$ $\beta = 94.91°$ Z = 2

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
10.2 (100), 5.16 (50), 1.566 (50), 3.84 (40), 2.729 (40), 6.10 (30), 4.52 (20)

Chemistry:

	(1)
SO_3	11.64
SiO_2	0.08
MnO	17.98
ZnO	26.30
MgO	17.27
H_2O	26.39
Total	99.66

(1) Sterling Hill, New Jersey, USA; deducting SiO_2, corresponds to $(Mg_{5.60}Mn_{3.31})_{\Sigma=8.91}$ $Zn_{4.22}(SO_4)_{1.90}(OH)_{22.46}\cdot 7.928H_2O$.

Occurrence: Very rare, in veinlets cutting calcite–franklinite–willemite ore in a metamorphosed stratiform zinc orebody.

Association: Mooreite, fluoborite, pyrochroite, sussexite, rhodochrosite, zincite, franklinite, willemite, calcite.

Distribution: At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: Honors Dr. John Torrey (1796–1873), American naturalist who early studied Franklin, New Jersey, USA minerals.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 113732.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 575–576. (2) Dunn, P., D.R. Peacor, and B.D. Sturman (1979) Lawsonbauerite, a new mineral from the Sterling Hill mine, New Jersey, and new data for torreyite. Amer. Mineral., 64, 949–952. (3) Treiman, A.H. and D.R. Peacor (1982) The crystal structure of lawsonbauerite, $(Mn, Mg)_9Zn_4(SO_4)_2(OH)_{22}\cdot 8H_2O$, and its relation to mooreite. Amer. Mineral., 67, 1029–1034. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 639–640.

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Tosudite

$[(Mg, Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8]\cdot$
$[(Ca_{0.5}, Na)_{0.33}(Al, Fe, Mg)_{2-3}(Al, Si)_4O_{10}(OH)_2\cdot nH_2O]$

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Crystal Data: Monoclinic. *Point Group:* 2. Microscopically crystalline, in aggregates.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ∼1 D(meas.) = 2.83 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Colorless, white, dark blue to azure. *Luster:* Nonmetallic.
Optical Class: Biaxial (–). $\alpha = 1.564$ $\beta = 1.570$ $\gamma = 1.574$ 2V(meas.) = 59°

Cell Data: *Space Group:* $C2$. $a = 5.17$ $b = 8.97$ $c = 24.2$ $\beta = 94°$ Z = n.d.

X-ray Powder Pattern: Takatama mine, Japan.
30.4 (100), 15.2 (75), 4.480 (30), 5.006 (20), 2.562 (12), 1.493 (12), 3.30 (8)

Chemistry:

	(1)
SiO_2	41.60
Al_2O_3	36.40
Fe_2O_3	1.82
MgO	0.29
CaO	0.38
Li_2O	1.04
Na_2O	0.14
K_2O	0.38
H_2O^+	11.12
H_2O^-	6.87
rem.	0.37
Total	100.41

(1) Tooho mine, Japan.

Polymorphism & Series: A 1:1 regular interstratification of dioctahedral chlorite and smectite.

Occurrence: A hydrothermal alteration product of intermediate to felsic igneous rocks. From the alteration of sandstone by acidic pore waters.

Association: Rectorite, dickite, quartz, fluorite (Tooho mine, Japan).

Distribution: At Alushta, Crimea, Ukraine. From Huy, Belgium. At Ehrenfriedersdorf, Saxony, Germany. In Japan, in the Tooho mine, Aichi Prefecture; the Hokuno mine, Hokuno, Gifu Prefecture; the Takatama mine, Fukushima Prefecture; the Kurata mine, Yamaguchi Prefecture, and elsewhere. From the White Mountain gold mine, Cottonwood district, Washoe Co., Nevada, USA.

Name: Honors Professor Toshio Sudo (1911–), mineralogist and crystallographer, of the University of Tokyo, Tokyo, Japan.

Type Material: n.d.

References: (1) Frank-Kamenetskii, V.A., N.V. Logvinenko, and V.A. Drits (1963) A dioctahedral mixed-layer clay mineral, tosudite. Zap. Vses. Mineral. Obshch., 92, 560–565 (in Russian). (2) (1964) Amer. Mineral., 49, 816 (abs. ref. 1). (3) Korolev, Y.M. (1970) An electron-diffraction study of the polytypes of tosudite. Kristallografiya (Sov. Phys. Crystal.), 15, 1152–1155 (in Russian). (4) Shimoda, S. (1969) New data for tosudite. Clays and Clay Minerals, 17, 179–184. (5) Nishiyama, T., S. Shimoda, K. Shimosaka, and S. Kanaoka (1975) Lithium-bearing tosudite. Clays and Clay Minerals, 23, 337–342. (6) Bailey, S.W. (1982) Nomenclature for regular interstratifications. Amer. Mineral., 67, 394–398.

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Tounkite $(Na, Ca, K)_8Si_6Al_6O_{24}(SO_4)_2Cl \cdot H_2O$

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Crystal Data: Hexagonal. *Point Group:* 622. As elongated crystals, to 1 cm.

Physical Properties: *Cleavage:* $\{10\bar{1}0\}$, fair. Hardness = 5–5.5 D(meas.) = 2.557(4) D(calc.) = 2.60

Optical Properties: Transparent. *Color:* Yellowish bottle-green, may be tinted blue by included lazurite; colorless in thin section. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). *Pleochroism:* O = colorless; E = yellow-green. *Absorption:* $E > O$. $\omega = 1.528$ $\epsilon = 1.543$

Cell Data: *Space Group:* $P6_222$. a = 12.843(3) $c = 32.239(8)$ Z = 6

X-ray Powder Pattern: Malo-Bystrinskoye or Tultuy deposit, Russia.
3.711 (100), 3.314 (80), 4.842 (40), 2.687 (25), 2.139 (25), 3.035 (20), 2.988 (16)

Chemistry:

	(1)
SiO_2	30.71
Al_2O_3	25.43
CaO	10.82
Na_2O	10.25
K_2O	6.46
Cl	2.90
H_2O	0.77
SO_3	13.28
$-O = Cl_2$	0.66
Total	99.96

(1) Malo-Bystrinskoye or Tultuy deposit, Russia; by electron microprobe, H_2O by microcoulometry; corresponds to $(Na_{3.93}Ca_{2.30}K_{1.64})_{\Sigma=7.87}(Si_{6.07}Al_{5.93})_{\Sigma=12.00}O_{24}(SO_4)_{1.97}Cl_{0.96} \cdot 1.02H_2O$.

Mineral Group: Cancrinite group.

Occurrence: Replacing lazurite in diopside-lazurite rocks (Malo-Bystrinskoye deposit, Russia); in lazurite calciphyres (Tultuy deposit, Russia).

Association: Diopside, lazurite (Malo-Bystrinskoye deposit, Russia); calcite, diopside, pyrite, apatite (Tultuy deposit, Russia).

Distribution: In the Malo-Bystrinskoye and Tultuy lazurite deposits, near Slyudyanka, south of Lake Baikal, Siberia, Russia.

Name: For the Tunka (Tounka) Valley, which is nearby the two deposits.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Ivanov, V.G., A.N. Sapozhnikov, L.F. Piskunova, and A.A. Kashaev (1992) Tounkite $(Na, Ca, K)_8(Al_6Si_6O_{24})(SO_4)_2Cl \cdot H_2O$ – a new cancrinite-like mineral. Zap. Vses. Mineral. Obshch., 121(2), 92–95 (in Russian). (2) (1994) Amer. Mineral., 79, 187 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 241 (abs. ref. 1).

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Toyohaite $Ag_2FeSn_3S_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As tiny grains.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 7.25

Optical Properties: Opaque. *Color:* In polished section, white. *Anisotropism:* Distinct to strong; pale gray to steel-bluish black.

R_1–R_2: n.d.

Cell Data: *Space Group:* $B2/m$, $B2$, or Bm. $a = 13.349(10)$ $b = 26.538(20)$ $c = 4.092(7)$ $\beta = 92.77(7)°$ Z = 4

X-ray Powder Pattern: Treasury [*sic*] mine, Colorado, USA.
3.49 (100), 3.22 (80), 1.989 (60), 1.955 (60), 3.63 (50), 2.93 (50), 2.86 (50)

Chemistry:

	(1)	(2)
Ag	12.7	12.26
Pb	19.6	20.18
Bi	50.5	50.90
S	16.4	16.66
Total	99.2	100.00

(1) Treasury (*sic*) mine, Colorado, USA; by electron microprobe, corresponding to $Ag_{1.82}Pb_{1.46}Bi_{3.73}S_{7.89}$. (2) $Ag_7Pb_6Bi_{15}S_{32}$.

Occurrence: In hydrothermal vein material (Treasure Vault mine, Colorado, USA).

Association: A fine-grained decomposition product of treasurite having very similar optical properties (Treasure Vault mine, Colorado, USA).

Distribution: In the USA, from the Treasure Vault (misnamed Treasury) mine, Geneva district, Clear Creek Co., Colorado [TL]; and from a prospect, 10 km southwest of Tyrone, Grant Co., New Mexico. At the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In the Beregovo district, near Mukachevo, Ukraine.

Name: For the Treasure Vault lode, Colorado, USA, where it occurs.

Type Material: National Museum of Natural History, Washington, D.C., USA, R9714.

References: (1) Karup-Møller, S. (1977) Mineralogy of some Ag–(Cu)–Pb–Bi sulfide associations. Bull. Geol. Soc. Denmark, 26, 41–68. (2) Makovicky, E. and S. Karup-Møller (1977) Chemistry and crystallography of the lillianite homologeous series. Neues Jahrb. Mineral., Abh., 131, 56–82. (3) (1979) Amer. Mineral., 64, 243 (abs. refs. 1 and 2).

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Trabzonite $Ca_4Si_3O_{10}\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2 or $2/m$. As irregular grains, to 0.2 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. D(meas.) = 2.9 D(calc.) = 3.08

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z = a$; $X \wedge c = 8°$. *Dispersion:* $r > v$, weak to moderate. $\alpha = 1.632(2)$ $\beta = 1.634(2)$ $\gamma = 1.640(2)$ 2V(meas.) = 55(5)° 2V(calc.) = 60°

Cell Data: *Space Group:* $P2_1$ or $P2_1/m$. $a = 6.895(2)$ $b = 20.640(3)$ $c = 6.920(2)$ $\beta = 98°$ Z = 4

X-ray Powder Pattern: İkizdere, Turkey.
3.062 (100), 2.585 (90), 3.442 (60), 2.851 (50), 2.635 (50), 5.71 (35), 2.912 (30)

Chemistry:

	(1)
SiO_2	40.38
Al_2O_3	0.05
MnO	0.04
MgO	0.13
CaO	50.20
Na_2O	0.30
H_2O	7.0
Total	98.10

(1) İkizdere, Turkey; by electron microprobe, H_2O by weight loss; corresponds to $(Ca_{3.99}Na_{0.05}Mg_{0.01})_{\Sigma=4.05}Si_{3.07}O_{12}H_{3.66}$.

Occurrence: A product of retrograde alteration, in a skarn produced by intrusion of a granite into sediments.

Association: Spurrite, rustumite, calcite, vesuvianite, hillebrandite, defernite, tobermorite, killalaite, garnet, perovskite, molybdenite.

Distribution: From İkizdere, northwest of Varda Yaylasi, Trabzon Province, Turkey.

Name: For Trabzon Province, Turkey, where it was first found.

Type Material: Natural History Museum, Geneva, Switzerland, 435/78.

References: (1) Sarp, H. and G. Burri (1986) Trabzonite $Ca_4Si_3O_{10}\cdot 2H_2O$ a new hydrated silicate. Schweiz. Mineral. Petrog. Mitt., 66, 453 (abs.). (2) (1988) Mineral. Abs., 39, 303 (abs. ref. 1). (3) Sarp, H. and G. Burri (1987) Trabzonite $Ca_4Si_3O_{10}\cdot 2H_2O$, a new mineral. Bull. Geol. Soc. Turkey, 30, 57–60 (in Turkish with English abs.). (4) (1988) Amer. Mineral., 73, 1497 (abs. ref. 3).

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Tranquillityite $Fe_8^{2+}(Zr,Y)_2Ti_3Si_3O_{24}$

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Crystal Data: Hexagonal. *Point Group:* n.d. As thin laths, to 65 μm, and as sheaves of laths.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.7(1)

Optical Properties: Opaque to semitransparent. *Color:* Gray; foxy-red [deep reddish brown] in strong transmitted light.
Optical Class: Isotropic to weakly anisotropic. $n = 2.11–2.13$

Cell Data: *Space Group:* n.d. $a = 11.69(5)$ $c = 22.25(10)$ $Z = 3$

X-ray Powder Pattern: Sea of Tranquillity, Moon.
3.23 (100), 1.781 (70), 2.155 (60), 4.04 (50), 3.34 (40), 3.18 (40), 3.13 (40)

Chemistry:

	(1)
SiO_2	14.00
TiO_2	19.45
ZrO_2	17.15
HfO_2	0.17
Al_2O_3	1.12
Cr_2O_3	0.11
Nb_2O_3	0.33
Y_2O_3	2.76
Nd_2O_3	0.24
FeO	42.48
MnO	0.29
CaO	1.26
Total	[99.36]

(1) Sea of Tranquillity, Moon; by electron microprobe, average of 12 analyses, original total given as 99.32%; corresponds to $(Fe_{7.36}Ca_{0.28}Ti_{0.25}Mn_{0.05})_{\Sigma=7.94}(Zr_{1.73}Y_{0.30}Nd_{0.02}Hf_{0.01})_{\Sigma=2.06}(Ti_{2.78}Al_{0.17}Nb_{0.03}Cr_{0.02})_{\Sigma=3.00}(Si_{2.90}Al_{0.10})_{\Sigma=3.00}O_{24}$.

Occurrence: A late-stage crystallization product of lunar basaltic magma.

Association: Troilite, pyroxferroite, tridymite, cristobalite, alkalic feldspar, felsic glass.

Distribution: On the Moon, at the Apollo 11, 12, 14, 16, and 17 collection sites.

Name: For the Sea of Tranquillity, Moon, from which the mineral was first collected.

Type Material: Lunar Science Institute, Houston, Texas, USA.

References: (1) Lovering, J.F., D.A. Wark, A.F. Reid, N.G. Ware, K. Keil, M. Prinz, T.E. Bunch, A. El Goresy, P. Ramdohr, G.M. Brown, A. Peckett, R. Phillips, E.N. Cameron, J.A.V. Douglas, and A.G. Plant (1971) Tranquillityite: a new silicate mineral from Apollo 11 and Apollo 12 basaltic rocks. Proc. Second Lunar Sci. Conf., 1, Geochim. Cosmochim. Acta, 35, suppl., 39–45. (2) (1973) Amer. Mineral., 58, 140–141 (abs. ref. 1).

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Traskite $\mathbf{Ba_9Fe_2^{2+}Ti_2(SiO_3)_{12}(OH,Cl,F)_6 \cdot 6H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Rarely as euhedral pyramidal crystals, with {0001} and $\{10\bar{1}0\}$ prominent. Commonly as equant anhedral grains, to 3 mm.

Physical Properties: *Fracture:* Conchoidal. Hardness = ∼5 D(meas.) = 3.71(2) D(calc.) = 3.75

Optical Properties: Transparent to translucent. *Color:* Brownish red. *Streak:* Pale reddish brown. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = brownish red; E = colorless or straw-yellow.
$\omega = 1.714(3)$ $\epsilon = 1.702(3)$

Cell Data: *Space Group:* $P\bar{6}m2$. $a = 17.89(1)$ $c = 12.33(1)$ $Z = 3$

X-ray Powder Pattern: Big Creek area, California, USA.
2.96 (100), 15.4 (50), 3.51 (40), 3.08 (35), 3.27 (25), 2.90 (25), 3.21 (20)

Chemistry:

	(1)		(1)
SiO_2	27.77	SrO	0.34
TiO_2	5.6	BaO	51.19
Al_2O_3	0.33	K_2O	< 0.05
FeO	4.2	F	0.4
MnO	1.36	Cl	3.5
MgO	0.30	LOI	[5.1]
CaO	0.86	$-O = (F,Cl)_2$	1.0
		Total	[100.00]

(1) Big Creek area, California, USA; K and Cl by XRF, loss on ignition taken as H_2O, recalculated to 100.00%; corresponds to $(Ba_{8.46}Ca_{0.39}Sr_{0.08}K_{0.03})_{\Sigma=8.96}(Fe^{2+}_{1.48}Mn^{2+}_{0.47}Mg_{0.19})_{\Sigma=2.14}Ti_{1.78}(Si_{11.84}Al_{0.16})_{\Sigma=12.00}O_{29.91}[(OH)_{14.36}Cl_{2.50}F_{0.53}]_{\Sigma=17.39}$.

Occurrence: As local concentrations in thin layers in metamorphic sanbornite-quartz rock.

Association: Sanbornite, quartz, celsian, diopside, taramellite, fresnoite, muirite, verplanckite, pyrrhotite, pyrite.

Distribution: In the Rush Creek and Big Creek areas, Fresno Co., California, USA.

Name: For Dr. John Boardman Trask (1824–1879), first California State Geologist (1850–1857).

Type Material: California Division of Mines & Geology, San Francisco, California, USA.

References: (1) Alfors, J.T., M.C. Stinson, R.A. Matthews, and A. Pabst (1965) Seven new barium minerals from eastern Fresno County, California. Amer. Mineral., 50, 314–340. (2) Alfors, J.T. and G.W. Putman (1965) Revised chemical analyses of traskite, verplanckite and muirite from Fresno County, California. Amer. Mineral., 50, 1500–1503. (3) Malinovskii, Y.A., E.A. Pobedimskaya, and N.V. Belov (1976) Crystal structure of traskite. Doklady Acad. Nauk SSSR, 229, 1101–1104 (in Russian). (4) (1976) Chem. Abs., 85, 152258 (abs. ref. 3).

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Trattnerite $(Fe,Mg)_2(Mg,Fe)_3[Si_{12}O_{30}]$

Crystal Data: Hexagonal. *Point Group:* 6*/m 2/m* 2*/m*. Short prismatic to tabular crystals to 1 mm, showing {100}, {001}, {101} and {111}.

Physical Properties: *Cleavage:* Good on {001}, poor on {100}. *Fracture:* n.d. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.68

Optical Properties: Translucent. *Color:* Deep blue to yellowish green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (-). $\omega = 1.589(1)$ $\varepsilon = 1.586(1)$
Pleochroism: *Strong; O* = deep blue, *E* = yellowish green.

Cell Data: *Space Group: P*6*/mcc*. $a = 10.050(1)$ $c = 14.338(2)$ Z = 2

X-ray Powder Pattern: Stradner Kogel quarry, near Bad Gleichenberg, eastern Styria, Austria. 7.17 (100), 8.7 (97), 5.535 (96), 3.207 (85), 5.026 (61), 4.352 (53), 2.767 (38)

Chemistry:

	(1)
Na_2O	0.03
K_2O	0.33
CaO	0.02
MgO	9.75
MnO	0.56
ZnO	0.36
Al_2O_3	0.21
Fe_2O_3	17.93
TiO_2	0.07
SiO_2	70.80
Total	100.06

(1) Stradner Kogel quarry, near Bad Gleichenberg, eastern Styria, Austria; average of 17 electron microprobe analyses, no H_2O detected by IR; Mg and Fe distributions from crystal structure analysis, Fe^{3+}/Fe^{2+} by charge balance; corresponding to $(K_{0.07}Na_{0.01})_{\Sigma=0.08}(Mg_{2.46}Fe^{3+}_{1.99}Fe^{2+}_{0.30}Mn_{0.08}Zn_{0.05}Al_{0.04}Ti_{0.01})_{\Sigma=4.93}[Si_{12}O_{30}]$.

Mineral Group: Milarite (osumilite) group.

Occurrence: In small cavities within a Si-rich xenolith in nephelinite volcanic rock.

Association: Sanidine, plagioclase, quartz, tridymite, hematite, orthopyroxene, clinopyroxene, clinoamphibole**.**

Distribution: From the Stradner Kogel haüyne–nephelinite quarry, near Bad Gleichenberg, eastern Styria, Austria.

Name: Honors the knowledgeable mineral collector, Walter Trattner, who found the specimen.

Type Material: Landesmuseum, Joanneum Graz and in the Natural History Museum, Vienna, Austria; 82775-82779.

References: (1) Postl, W., F. Walter, K. Ettinger, C. Hauzenberger, H.-P. Bojar (2004) Trattnerite, $(Fe,Mg)_2(Mg,Fe)_3[Si_{12}O_{30}]$, a new mineral of the milarite group: mineral data and crystal structure. Eur. J. Mineral., 16, 375-380. (2) (2005) Amer. Mineral., 90, 273-274 (abs. ref. 1).

Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As tiny grains.

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 7.25

Optical Properties: Opaque. *Color:* In polished section, white. *Anisotropism:* Distinct to strong, in light gray to steel bluish black.
R_1–R_2: n.d.

Cell Data: *Space Group:* $B2/m$, $B2$, or Bm. $a = 13.349(10)$ $b = 26.538(20)$ $c = 4.092(7)$ $\beta = 92.77(7)°$ Z = 4

X-ray Powder Pattern: Treasury (sic) mine, Colorado, USA.
3.49 (100), 3.22 (80), 1.989 (60), 1.955 (60), 3.63 (50), 2.93 (50), 2.86 (50)

Chemistry:

	(1)	(2)
Ag	12.7	12.26
Pb	19.6	20.18
Bi	50.5	50.90
S	16.4	16.66
Total	99.2	100.00

(1) Treasury (sic) mine, Colorado, USA; by electron microprobe, corresponding to $Ag_{1.82}Pb_{1.46}Bi_{3.73}S_{7.89}$. (2) $Ag_7Pb_6Bi_{15}S_{32}$.

Occurrence: In hydrothermal vein material.

Association: A fine-grained decomposition product of treasurite having very similar optical properties (Treasure Vault mine, Colorado, USA).

Distribution: From the Treasure Vault (misnamed Treasury) mine, Geneva district, Park and Summit Cos., Colorado; and from a prospect, 10 km southwest of Tyrone, Grant Co., New Mexico, USA. In the Kochbulak deposit, eastern Uzbekistan, USSR.

Name: For the Treasure Vault lode, Colorado, USA, in which it occurs.

Type Material: National Museum of Natural History, Washington, D.C., USA, R9714.

References: (1) Karup-Møller, S. (1977) Mineralogy of some Ag–(Cu)–Pb–Bi sulfide associations. Bull. Geol. Soc. Denmark, 26, 41–68. (2) Makovicky, E. and S. Karup-Møller (1977) Chemistry and crystallography of the lillianite homologeous series. Neues Jahrb. Mineral., Abh., 131, 56–82. (3) (1979) Amer. Mineral., 64, 243 (abs. refs. 1 and 2).

Trechmannite $AgAsS_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Crystals short prismatic; equant, also irregular. size??ckMinSwitz

Physical Properties: *Cleavage:* Good on $\{10\overline{1}1\}$, distinct on {0001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5–2 VHN = 97–100 (25 g load). D(meas.) = n.d. D(calc.) = 4.77 (synthetic).

Optical Properties: Opaque, except in thin pieces. *Color:* Scarlet-vermilion; in polished section, white having a bluish cast, with red-orange internal reflections. *Streak:* Scarlet-vermilion. *Luster:* Adamantine.
Optical Class: Uniaxial (–). *Pleochroism:* In transmitted light, faint; O = pale reddish; E = near colorless. $n = > 2.61$ (Li). *Anisotropism:* Moderate (synthetic).

R_1–R_2: (400) 26.2–37.6, (420) 25.7–36.9, (440) 24.9–35.5, (460) 23.7–33.8, (480) 23.0–32.6, (500) 23.4–31.6, (520) 23.7–30.7, (540) 23.4–29.9, (560) 22.7–29.1, (580) 22.1–28.5, (600) 21.5–28.0, (620) 21.0–27.6, (640) 20.6–27.2, (660) 20.3–26.9, (680) 20.0–26.4, (700) 19.9–26.2

Cell Data: *Space Group:* $R\overline{3}$. $a = 13.98$ $c = 9.12$ Z = 18

X-ray Powder Pattern: Binntal, Switzerland. (ICDD 16-700).
2.702 (100), 3.15 (80), 1.887 (80), 1.937 (70), 7.0 (60), 4.26 (60), 3.64 (60)

Chemistry:

	(1)	(2)
Ag	43.9	43.69
As	30.8	30.34
S	26.1	25.97
Total	100.8	100.00

(1) Binntal, Switzerland; by electron microprobe. (2) $AgAsS_2$.

Polymorphism & Series: Dimorphous with smithite.

Occurrence: Of hydrothermal origin, in dolostone (Binntal, Switzerland).

Association: Seligmannite, tennantite, pyrite, chromian muscovite (Binntal, Switzerland).

Distribution: From the Lengenbach quarry, Binntal, Valais, Switzerland [TL]. At Niederbeerbach, Odenwald, Hesse, Germany.

Name: Honoring Dr. Charles Otto Trechmann (1851–1917), English crystallographer.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 432–433. (2) Roland, G.W. (1968) Synthetic trechmannite. Amer. Mineral., 53, 1208–1214. (3) Matsumo, T. and W. Nowacki (1969) The crystal structure of trechmannite, $AgAsS_2$. Zeits. Krist., 129, 163–177. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 581.

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Trembathite $(Mg, Fe^{2+})_3B_7O_{13}Cl$

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Crystal Data: Hexagonal. *Point Group:* 3*m*. As pseudocubic rhombohedra, to 2 cm, isolated or in groups. *Twinning:* Microscopic polysynthetic twinning typical.

Physical Properties: *Fracture:* Conchoidal. Hardness = 6–8 D(meas.) = 2.84–3.34 D(calc.) = 3.225

Optical Properties: Transparent. *Color:* Colorless to pale blue, pink; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.684(2)$ $\epsilon = 1.668(2)$

Cell Data: *Space Group: R*3*c*. $a = 8.588(2)$ $c = 21.050(6)$ Z = 6

X-ray Powder Pattern: Salt Springs deposit, Canada.
3.028 (100), 2.050 (73), 2.711 (66), 2.144 (37), 3.497 (34), 1.828 (25), 2.475 (23)

Chemistry:

	(1)	(2)
B_2O_3	57.33	55.67
FeO	13.59	23.51
MnO	0.49	0.37
MgO	22.02	14.27
CaO	0.01	0.01
Cl	9.29	8.00
$-O = Cl_2$	2.09	1.81
Total	[100.64]	100.02

(1) Salt Springs deposit, Canada; by electron microprobe, total Fe as FeO, weighted average of compositional zones, original total given as 100.63%; corresponding then to $Mg_{2.29}Fe_{0.79}Mn_{0.03}B_{6.89}O_{12.90}Cl_{1.10}$. (2) Boulby mine, England; by electron microprobe, total Fe as FeO; corresponding to $(Mg_{1.55}Fe_{1.43}Mn_{0.02})_{\Sigma=3.00}B_{7.00}O_{13.01}Cl_{0.99}$.

Polymorphism & Series: Dimorphous with boracite.

Occurrence: A rare component of marine evaporite borate deposits.

Association: Halite, hilgardite (Salt Springs deposit, Canada).

Distribution: In Canada, from the Salt Springs evaporite deposit, and in the Potash Corporation of America mine, Penobsquis evaporite deposit, near Sussex, New Brunswick, Canada. Large crystals from the Boulby potash mine, northwest of Whitby, Yorkshire, England.

Name: Honors Dr. Lowell T. Trembath (1936–1994), Canadian mineralogist, Professor of Mineralogy, University of New Brunswick, Fredericton, Canada.

Type Material: Royal Ontario Museum, Toronto, Canada, M44741.

References: (1) Burns, P.C., F.C. Hawthorne, and J.A.R. Stirling (1992) Trembathite, $(Mg, Fe)_3B_7O_{13}Cl$, a new borate mineral from the Salt Springs potash deposit, Sussex, New Brunswick. Can. Mineral., 30, 445–448. (2) (1993) Amer. Mineral., 78, 233 (abs. ref. 1). (3) Schindler, M. and F.C. Hawthorne (1998) The crystal structure of trembathite, $(Mg_{1.55}Fe_{1.43}Mn_{0.02})B_7O_{13}Cl$, a mineral of the boracite group: an example of the insertion of a cluster into a three-dimensional net. Can. Mineral., 36, 1195–1201.

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Tremolite $Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Elongated, stout prismatic, or flattened bladed crystals, to 20 cm; also fibrous, granular or columnar aggregates. *Twinning:* Simple or multiple, common ∥ {100}; rarely multiple ∥ {001}.

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; partings on {010}, {100}. *Tenacity:* Brittle. Hardness = 5–6 D(meas.) = 2.99–3.03 D(calc.) = 2.964

Optical Properties: Transparent to translucent. *Color:* White, gray, lavender to pink; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = -21°$ to $-19°$; $X \wedge a = -6°$ to $-4°$. *Dispersion:* $r < v$, weak. α = 1.605–1.613 β = 1.616–1.624 γ = 1.630–1.636 2V(meas.) = 86°–88°

Cell Data: *Space Group:* $C2/m$. a = 9.863(1) b = 18.048(2) c = 5.285(1) β = 104.79(1)° Z = 2

X-ray Powder Pattern: St. Gotthard, Switzerland.
8.38 (100), 3.121 (100), 2.705 (90), 3.268 (75), 1.892 (50), 2.805 (45), 2.015 (45)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	56.57	59.30	Na_2O	1.44	2.07
TiO_2	0.01	trace	K_2O	0.68	0.61
Al_2O_3	1.41	0.26	F	1.52	3.84
FeO	0.08	trace	Cl	0.05	trace
MnO	0.03	trace	H_2O^+	1.46	0.50
MgO	24.41	24.58	$-O = (F,Cl)_2$	[0.64]	[1.62]
CaO	12.25	12.03	Total	[99.27]	[101.57]

(1) Gouverneur, New York, USA; Fe_2O_3 trace; corresponds to $(Ca_{1.80}Na_{0.38}K_{0.12})_{\Sigma=2.30}(Mg_{5.00}Fe^{2+}_{0.01})_{\Sigma=5.00}(Si_{7.77}Al_{0.23})_{\Sigma=8.00}O_{22}[(OH)_{1.34}F_{0.66}Cl_{0.01}]_{\Sigma=2.01}$. (2) Balmat No. 3 mine, St. Lawrence Co., New York; by electron microprobe, original total given as 101.47%; corresponds to $(Ca_{1.74}Na_{0.54}K_{0.10})_{\Sigma=2.38}(Mg_{4.95}Al_{0.04})_{\Sigma=4.99}Si_{8.01}O_{22}[F_{1.64}(OH)_{0.35}Cl_{0.01}]_{\Sigma=2.00}$.

Polymorphism & Series: Forms a series with actinolite and ferro-actinolite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.90$; $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si \geq 7.5$.

Occurrence: From contact metamorphism of Ca-Mg siliceous sediments; in greenschist facies metamorphics derived from ultramafic or magnesium carbonate rocks.

Association: Calcite, dolomite, calcian garnet, wollastonite, talc, diopside, forsterite, cummingtonite, magnesio-cummingtonite, riebeckite, winchite.

Distribution: Notable localities include: on Campolungo Alp, Ticino, and Bristenstock, Uri, Switzerland. From St. Marcel, Piedmont, Italy. At Bilin, Czech Republic. In the USA, from Pierrepont, Gouverneur, Edwards, and Macomb, St. Lawrence Co., New York; at Franklin, Sussex Co., New Jersey; and Lee, Berkshire Co., Massachusetts. At Wilberforce, Ontario, Canada. From Kozano, Badakhshan Province, Afghanistan. At Lelatema, Tanzania. In the Brumado mine, Bahia, Brazil.

Name: For an occurrence in the Tremola Valley, southern St. Gotthard Mountains, Switzerland.

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References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 385–398. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 249–262. (3) Hawthorne, F.C. and H.D. Grundy (1976) The crystal chemistry of the amphiboles: IV. X-ray and neutron refinements of the crystal structure of tremolite. Can. Mineral., 14, 334–345. (4) Petersen, E.U., E.J. Essene, D.R. Peacor, and J.W. Valley (1982) Fluorine end-member micas and amphiboles. Amer. Mineral., 67, 538–544. (5) Walitzi, E.M. and K. Ettinger (1986) Verfeinerung der Kristallstruktur eines Tremolites vom Ochsenkogel (Gleinalpe/Styria), Österreich. Neues Jahrb. Mineral., Monatsh., 360–366 (in German). (6) Phillips, W.R. and D.T. Griffen (1981) Optical mineralogy, 229–231.

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Trevorite $NiFe_2^{3+}O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rarely as small octahedra; granular, massive.

Physical Properties: *Fracture:* Uneven. Hardness = 5 D(meas.) = 5.164 D(calc.) = 5.20 Strongly magnetic.

Optical Properties: Opaque, transparent in thinnest fragments. *Color:* Black with greenish hue. *Streak:* Brown. *Luster:* Metallic.
Optical Class: Isotropic. $n = 2.3$
R: n.d.

Cell Data: *Space Group:* $Fd3m$ (synthetic). $a = 8.839$ Z = 8

X-ray Powder Pattern: Synthetic.
2.513 (100), 1.4760 (40), 2.948 (30), 1.6051 (30), 2.085 (25), 4.82 (20), 1.0857 (16)

Chemistry:

	(1)	(2)	(3)
V_2O_5		0.02	
P_2O_5		0.02	
SiO_2	1.40	0.25	
TiO_2		0.05	
Al_2O_3		0.18	
Fe_2O_3	66.24		68.13
FeO	1.96	73.06	
MnO		0.07	
NiO	29.71	21.81	31.87
MgO	0.24	0.71	
H_2O	0.36		
Total	99.91	96.17	100.00

(1) Bon Accord, South Africa. (2) Mt. Clifford, Australia; by electron microprobe, total Fe as FeO; with Fe^{3+}:Fe^{2+} calculated from stoichiometry, corresponds to $(Ni_{0.66}Fe^{2+}_{0.30}Mg_{0.04})_{\Sigma=1.00}(Fe^{3+}_{1.99}Al_{0.01})_{\Sigma=2.00}O_4$. (3) $NiFe_2O_4$.

Mineral Group: Spinel group.

Occurrence: In a small tabular body of nickeliferous serpentinite, probably a contact deposit, along the junction of quartzite and an ultramafic intrusive (Bon Accord, South Africa); below a nickel sulfide deposit in gabbro intruding peridotites (Mt. Clifford, Australia).

Association: Nimite, willemseite, nickeloan talc, violarite, millerite, reevesite, goethite (Bon Accord, South Africa); nickel, heazlewoodite, millerite (Mt. Clifford, Australia).

Distribution: Found three km west of the Scotia talc mine, Bon Accord area, Barberton, Transvaal, South Africa. In the Mt. Clifford nickel deposit, 54 km north-northwest of Leonora, Western Australia. As a minor constituent of the widespread sediments marking major geological period boundaries, as the Cretaceous-Tertiary.

Name: Honors Major Tudor Gruffydd Trevor (1865–1958), Welsh–South African geologist, Mining Inspector for the Pretoria district, Transvaal, South Africa.

Type Material: National Museum of Natural History, Washington, D.C., USA, 132464, 132465.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 698–707. (2) Walker, T.L. (1923) Trevorite, a distinct mineral species. Univ. Toronto Stud. Geol. Ser., 16, 53–54. (3) Hudson, D.R. and G.A. Travis (1981) A native nickel-heazlewoodite-ferroan trevorite assemblage from Mount Clifford, Western Australia. Econ. Geol., 76, 1686–1697. (4) (1960) NBS Circ. 539, 10, 44.

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Triangulite $Al_3(UO_2)_4(PO_4)_4(OH)_5 \cdot 5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Tablets, flattened on {100}, with triangular outline, to 0.2 mm, less commonly pseudo rhombohedral. *Twinning:* Common, about [011].

Physical Properties: Hardness = 2–3 D(meas.) = 3.7(2) D(calc.) = 3.68 Radioactive.

Optical Properties: Transparent. *Color:* Bright yellow, yellow-green. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* Y = pale yellow-green; Z = bright yellow. *Orientation:* $X \perp \{100\}$; $Y \simeq [011]$; $Z \simeq [0\overline{1}1]$. $\alpha = [1.639]$ $\beta = 1.665(2)$ $\gamma = 1.704(2)$ 2V(meas.) = 80°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.39$ (3) $b = 10.56(3)$ $c = 10.60(3)$ $\alpha = 116.4(1)°$ $\beta = 107.8(1)°$ $\gamma = 113.4(1)°$ Z = 1

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
7.80 (100), 3.87 (80), 3.15 (70), 2.99 (50), 4.70 (30), 3.74 (20), 3.63 (20)

Chemistry:

	(1)	(2)
UO_3	67.10	66.68
P_2O_5	16.24	16.54
Al_2O_3	8.90	8.91
H_2O	[7.76]	7.87
Total	[100.00]	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, average of seven analyses, H_2O by difference; corresponds to $Al_{3.01}(UO_2)_{4.04}(PO_4)_{3.94}(OH)_{5.29} \cdot 4.78H_2O$. (2) $Al_3(UO_2)_4(PO_4)_4(OH)_5 \cdot 5H_2O$.

Occurrence: A rare secondary species in the uraniferous oxidized zone of a complex zoned granite pegmatite.

Association: Meta-autunite, furongite, phosphuranylite, ranunculite, beryl, zircon, columbite, feldspar, quartz.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: For the typical *triangular* habit of the crystals.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG6192.

References: (1) Deliens, M. and P. Piret (1982) Les phosphates d'uranyle et d'aluminium de Kobokobo. VI. La triangulite, $Al_3(UO_2.PO_4)_4(OH)_5.5H_2O$, nouveau minéral. Bull. Minéral., 105, 611–614 (in French with English abs.). (2) (1984) Amer. Mineral., 69, 212 (abs. ref. 1).

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Tridymite SiO_2

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Crystal Data: Orthorhombic, pseudohexagonal; triclinic below about 100 °C. *Point Group:* 222 or lower; 1. As pseudohexagonal plates ∥ {0001} with prism faces $\{10\bar{1}0\}$, to 1 cm. Typically wedge-shaped or tabular; in radiating and rosettelike aggregates. *Twinning:* Paramorphs have simple, trilling, or multiple contact twins on $\{10\bar{1}6\}$, very common; contact or penetration twins on {3034}.

Physical Properties: *Cleavage:* Prismatic, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7 D(meas.) = 2.25–2.28 D(calc.) = [2.28]

Optical Properties: Transparent. *Color:* Colorless to white; in transmitted light, colorless. *Luster:* Vitreous, may be pearly on {0001}.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y = a$; $Z = c$. α = 1.468–1.482 β = 1.470–1.484 γ = 1.474–1.486 2V(meas.) = 40°–86°

Cell Data: *Space Group:* $C222$ or lower. $a = 9.88$ $b = 17.1$ $c = 16.3$ Z = 64, or *Space Group:* $F1$. $a = 9.932(5)$ $b = 17.216(6)$ $c = 81.864(9)$ $\alpha = 90°$ $\beta = 90°$ $\gamma = 90°$ Z = 320

X-ray Powder Pattern: Mule Springs, Oregon, USA.
4.30 (100), 4.09 (90), 3.80 (60), 3.249 (30), 2.964 (16), 2.483 (16), 2.305 (8)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	[95.1]	99.03	MgO	0.3	trace
TiO_2	0.26	0.02	CaO	0.4	trace
Al_2O_3	2.4	0.50	Na_2O	0.80	0.24
Fe_2O_3	0.36	0.01	K_2O	0.37	0.08
MnO	trace	0.00	H_2O^+		0.1
			Total	[100.0]	99.98

(1) Cerro San Cristóbal, Mexico; spectrographic analysis, SiO_2 by difference. (2) Mule Springs, Oregon, USA.

Polymorphism & Series: Quartz, cristobalite, stishovite, and coesite are polymorphs; high tridymite is formed between 870 °C and 1470 °C; a number of stacking polytypes are known, especially non-terrestrial.

Occurrence: Deposited from hot gases in vesicles and lithophysae; as phenocrysts in felsic volcanic rocks, and less commonly, in basalts; in contact metamorphosed sandstone.

Association: Cristobalite, sanidine, quartz, augite, fayalite, "hornblende," hematite, ferroan enstatite, troilite.

Distribution: Prominent localities include: on Cerro San Cristóbal, Pachuca, Hidalgo, Mexico. In the USA, in California, from near Portola, Plumas Co., Pomona, Los Angeles Co., and at Bumpass Hill, Lassen National Park, Shasta Co.; at Mule Springs, 160 km northeast of Lakeview, Harney Co., Oregon; in the San Juan Mountains, San Juan Co., Colorado; large crystals from the Thomas Range, Juab Co., Utah. At the Bellerberg volcano, two km north of Mayen, Eifel district, Germany. From the Colli Euganei, near Padua, Vicenza, and Marriabu, Sardinia, Italy. At Puy Capuchin, Puy-de-Dôme, France. On Tardree Mt., Co. Antrim, Ireland. In Japan, at Kumamoto, Kumamoto Prefecture, and Yugawara, Kanagawa Prefecture. In a number of meteorites.

Name: From the Greek meaning *three-twin*, in allusion to the common occurrence of trillings.

References: (1) Frondel, C. (1962) Dana's system of mineralogy, (7th edition), v. III, silica minerals, 259–272. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 179–230. (3) Grant, R.W. (1967) New data on tridymite. Amer. Mineral., 52, 536–541. (4) Konnert, J.H. and D.E. Appleman (1978) The crystal structure of low tridymite. Acta Cryst., 34, 391–403. (5) Wennemer, M. and A.B. Thompson (1984) Tridymite polymorphs and polytypes. Schweiz. Mineral. Petrog. Mitt., 64, 335–353.

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Trigonite $Pb_3Mn^{2+}(As^{3+}O_3)_2(As^{3+}O_2OH)$

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Crystal Data: Monoclinic. *Point Group: m.* As crystals with a trigonal outline from development of many domatic forms, flattened on {010}, to 5 mm; in subparallel growths.

Physical Properties: *Cleavage:* {010}, perfect; {101}, good. *Fracture:* Uneven. Hardness = 2–3 D(meas.) = 6.1–7.1 D(calc.) = 6.35

Optical Properties: Translucent. *Color:* Sulfur-yellow to yellowish brown, dark brown; pale yellow to brownish yellow in transmitted light. *Luster:* Vitreous to adamantine. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$. *Dispersion:* $r < v$, observable. $\alpha = 2.07$ $\beta = 2.10$ $\gamma = 2.12$ 2V(meas.) = Very large.

Cell Data: *Space Group: Pn.* $a = 7.258(3)$ $b = 6.822(4)$ $c = 11.088(6)$ $\beta = 94.45(4)°$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
2.99 (10), 3.08 (9), 3.24 (7), 4.90 (6), 4.50 (4), 3.65 (4), 2.76 (4)

Chemistry:

	(1)	(2)
As_2O_3	28.83	28.36
FeO	0.15	
MnO	6.79	6.78
PbO	63.40	64.00
MgO	0.11	
CaO	0.23	
Cl	trace	
H_2O	0.81	0.86
insol.	0.13	
Total	100.45	100.00

(1) Långban, Sweden; averages of several analyses. (2) $Pb_3Mn(AsO_3)_2(AsO_2OH)$.

Occurrence: In a metamorphosed Fe–Mn orebody.

Association: Lead, dixenite, hausmannite, finnemanite, rouseite, dolomite, barite.

Distribution: At Långban, Värmland, Sweden.

Name: From the Greek for *triangle*, alluding to the characteristic crystal outline.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1032–1033. (2) Pertlik, F. (1978) The crystal structure of trigonite, $Pb_3Mn(AsO_3)_2(AsO_2OH)$. Tschermaks Mineral. Petrog. Mitt., 25, 95–105. (3) Pertlik, F. (1987) [Crystal structure refinement of trigonite, $Pb_3Mn(AsO_3)_2(AsO_2OH)$, with a remark on errors in inorganic crystal structure databases.] Österreichische Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse, Anzeiger, 124, 81–84 (in German). (4) (1989) Mineral. Abs., 40, 178 (abs. ref. 3). (5) Welin, E. (1968) X-ray powder data for minerals from Långban and the related mineral deposits of Central Sweden. Arkiv Mineral. Geol., 4(30), 499–541.

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Trikalsilite $(K, Na)AlSiO_4$

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Crystal Data: Hexagonal. *Point Group:* 6. Extremely fine-grained; in parallel growth with nepheline and kalsilite.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* [White.]
Optical Class: [Uniaxial.] ω = n.d. ϵ = n.d.

Cell Data: *Space Group:* $P6_3$. $a = 15.339(4)$ $c = 8.501(2)$ Z = n.d.

X-ray Powder Pattern: Kabfumu volcanic flow, Congo.
3.076 (100), 3.050 (95), 2.558 (45), 4.269 (35), 2.410 (35), 3.932 (30), 3.384 (25)

Chemistry: Apparently no analysis is available.

Polymorphism & Series: Polymorphous with kaliophilite, kalsilite, and panunzite.

Occurrence: In lava.

Association: Nepheline, kalsilite.

Distribution: From the Kabfumu volcanic flow, between the Mt. Mikeno and Mt. Nyiragongo volcanos, Kivu Province, Congo (Zaire).

Name: For the length of the [100] axis, three times that of *kalsilite*.

Type Material: n.d.

References: (1) Sahama, T.G. and J.V. Smith (1957) Tri-kalsilite, a new mineral. Amer. Mineral., 42, 286. (2) Bonaccorsi, E., S. Merlino, and M. Pasero (1988) Trikalsilite: its structural relationships with nepheline and tetrakalsilite. Neues Jahrb. Mineral., Monatsh., 559–567. (3) Sahama, T.G. (1957) Complex nepheline-kalsilite phenocrysts in Kabfumu lava, Nyiragongo area, north Kivu in Belgian Congo. J. Geol., 65, 515–526.

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Trimerite $CaMn_2^{2+}Be_3(SiO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic, pseudohexagonal by twinning, to 12 mm; as crystal intergrowths. *Twinning:* Triple twins with composition planes (110) and $(1\bar{1}0)$; in basal section, twin lamellae in three directions intersect at an angle of 120°.

Physical Properties: *Cleavage:* Distinct on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 3.474 D(calc.) = 3.47

Optical Properties: Transparent to translucent. *Color:* Salmon-pink, pale yellowish red to nearly colorless; in thin section, colorless. *Luster:* Vitreous, brilliant.
Optical Class: Biaxial (–). *Orientation:* $X \perp \{001\}$. *Dispersion:* Perceptible. $\alpha = 1.715$ $\beta = 1.720$ $\gamma = 1.725$ 2V(meas.) = 83°

Cell Data: *Space Group:* $P2_1/n$. $a = 8.098$ $b = 7.613$ $c = 14.065$ $\beta = 90°$ Z = 4

X-ray Powder Pattern: Harstigen mine, Sweden. (ICDD 17-477).
2.764 (100), 3.56 (40), 2.229 (35), 2.332 (30), 1.420 (30), 2.053 (25), 1.784 (25)

Chemistry:

	(1)	(2)
SiO_2	39.77	39.77
FeO	3.87	
MnO	26.86	31.30
BeO	17.08	16.56
MgO	0.61	
CaO	12.44	12.37
Total	100.63	100.00

(1) Harstigen mine, Sweden. (2) $CaMn_2Be_3(SiO_4)_3$.

Occurrence: A rare mineral, probably formed during late-stage hydrothermal activity associated with contact metamorphism and metasomatism.

Association: Calcite, hematite.

Distribution: At the Harstigen mine, near Persberg, at Jakobsberg, and at Långban, Värmland, Sweden.

Name: From the Greek for *three parts*, in allusion to the trilling twinning and associated optical effects.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 460.
(2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 417–419. (3) Aminoff, G. (1926) Zur Kristallographie des Trimerits. Geol. Fören. Förhandl. Stockholm, 48, 19–43 (in German). (4) (1927) Amer. Mineral., 12, 381 (abs. ref. 3). (5) Klaska, K.H. and O. Jarchow (1977) Die Bestimmung der Kristallstruktur von Trimerit $CaMn_2(BeSiO_4)_3$ und das Trimeritgesetz der Verzwillingung. Zeits. Krist., 145, 46–65 (in German with English abs.).

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Trimounsite-(Y) $Y_2Ti_2SiO_9$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, elongated along [001], up to 5 mm; showing {110}, {130}, {010}, {211}, {121}, {011}, striated on {110} and {130}.

Physical Properties: *Tenacity:* Brittle. Hardness = 7 D(meas.) = 5.0(1) D(calc.) = 4.85 Blue cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Light brown. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, strong. $\alpha = > 2.10$ $\beta = > 2.10$ $\gamma = > 2.10$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/c$. $a = 12.299(2)$ $b = 11.120(2)$ $c = 4.854(1)$ $\beta = 95.62(1)^\circ$ Z = 4

X-ray Powder Pattern: Trimouns, France.
2.820 (100), 3.44 (90), 1.959 (60), 1.643 (60), 2.117 (50), 1.628 (50), 2.777 (40)

Chemistry:

	(1)
SiO_2	11.77
TiO_2	34.47
Y_2O_3	34.62
Sm_2O_3	0.40
Gd_2O_3	1.92
Tb_2O_3	0.71
Dy_2O_3	5.67
Ho_2O_3	0.79
Er_2O_3	5.04
Yb_2O_3	4.83
Total	100.22

(1) Trimouns, France; by electron microprobe, mean of several analyses; corresponds to $(Y_{1.48}Dy_{0.15}Er_{0.13}Yb_{0.12}Gd_{0.05}Ho_{0.02}Tb_{0.02}Sm_{0.01})_{\Sigma=1.98}Ti_{2.08}Si_{0.94}O_9$.

Occurrence: In dolomitic portions of a talc deposit.

Association: Allanite, bastnäsite, monazite, parisite, synchysite, calcite, dolomite.

Distribution: From the Trimouns talc deposit, six km northeast of Luzenac, Ariège, France.

Name: For the locality, the Trimouns talc deposit, France, and its *yttrium* content.

Type Material: Royal Institute of Natural Sciences of Belgium, Brussels, Belgium, RC3967.

References: (1) Piret, P., M. Deliens, and M. Pinet (1990) La trimounsite-(Y), nouveau silicotitanate de terres rares de Trimouns, Ariège, France: $(TR)_2Ti_2SiO_9$. Eur. J. Mineral., 2, 725–729 (in French with English abs.). (2) (1991) Amer. Mineral., 76, 2024 (abs. ref. 1).

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Trinepheline $NaAlSiO_4$

Crystal Data: Hexagonal. *Point Group*: n.d. Pseudomorphous after jadeite, as skeletal crystals, to 20 mm, and rarely as pseudo prismatic crystals.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = ~5-5.5
D(meas.) = n.d. D(calc.) = 2.642

Optical Properties: Transparent. *Color*: White to yellow, colorless in thin section.
Streak: White. *Luster*: Vitreous to greasy.
Optical Class: n.d. *n*(calc.) = 1.538

Cell Data: *Space Group*: $P6_1$. a = 9.995 c = 24.797 Z = 24 [synthetic hexagonal $NaAlSiO_4$]

X-ray Powder Pattern: Calculated pattern. [identifiable only by a combination of scanning electron microscopy, electron microprobe analyses and electron backscatter diffraction]
3.163 (100), 3.834 (81), 4.133 (49), 3.272 (40), 2.403 (31), 4.328 (22), 2.401 (22)

Chemistry:

	(1)
Na_2O	21.68
MgO	0.01
SiO_2	41.76
Al_2O_3	36.19
K_2O	0.08
CaO	0.10
FeO	0.06
Total	99.88

(1) Tawmaw-Hpakant Jade Tract, Myanmar; average of 12 electron microprobe analyses; corresponding to $Na_{1.00}Al_{1.01}Si_{0.99}O_4$.

Occurrence: In serpentinized peridotite, replacing jadeite during late stage metamorphism along veins, likely related to decompression.

Association: Nepheline, fabriesite, more rarely with albite, banalsite, stronalsite.

Distribution: From the Tawmaw-Hpakant Jade Tract, Hpakant Township, Mohnyin District, Kachin State, Myanmar.

Name: For the naturally occurring polymorphs of synthetic $NaAlSiO_4$ with a value of the c crystallographic dimension that is three times that of nepheline.

Type Material: National Museum of Natural History, Paris, France (MNHN 212.001).

References: (1) Ferraris, C., G.C. Parodi, S. Pont, B. Rondeau, and J-P. Lorand (2014) Trinepheline and fabriesite: two new mineral species from the jadeite deposit of Tawmaw (Myanmar). European Journal of Mineralogy, 26(2), 257-265. (2) (2014) Amer. Mineral., 99, 1808-1809 (abs. ref. 1).

Triphylite $\mathbf{Li(Fe^{2+},Mn^{2+})PO_4}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals rare, typically prismatic, with large {011}, {100}, {010}, {021}, {120}, several other forms. Commonly subhedral, to 6.5 m, cleavable, compact, massive.

Physical Properties: *Cleavage:* {100}, perfect; {010}, imperfect; {011}, interrupted. *Fracture:* Uneven to subconchoidal. Hardness = 4–5 D(meas.) = 3.50–3.58 D(calc.) = 3.562

Optical Properties: Transparent to translucent. *Color:* Bluish gray to greenish gray; brownish to black where altered. *Streak:* White to grayish white. *Luster:* Vitreous to subresinous. *Optical Class:* Biaxial (+). *Orientation:* X = a or c; Y = c or b; Z = b or a. *Dispersion:* $r < v$, strong. α = 1.675–1.694 β = 1.684–1.695 γ = 1.685–1.700 2V(meas.) = 0°–55°

Cell Data: *Space Group: Pmnb.* a = 6.0285(6) b = 10.3586(9) c = 4.7031(3) Z = 4

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
3.008 (100), 2.525 (81), 4.277 (76), 3.487 (70), 5.175 (34), 2.781 (34), 3.923 (26)

Chemistry:

	(1)	(2)
P_2O_5	44.76	45.11
Fe_2O_3	1.07	
FeO	30.05	22.84
MnO	12.40	22.55
MgO	0.72	
CaO	0.34	
Li_2O	8.33	9.50
H_2O	0.25	
insol.	1.55	
Total	99.47	100.00

(1) "Central Asia", Russia. (2) $Li(Fe,Mn)PO_4$ with Mn:Fe = 1:1.

Mineral Group: Forms a series with lithiophilite.

Occurrence: The most abundant primary phosphate in complex zoned granite pegmatites.

Association: Ferrisicklerite, heterosite, alluaudite, many other Fe–Mn phosphates and oxides.

Distribution: Occurs at numerous localities; in Germany, from Hühnerkobel, near Zwiesel, and Hagendorf, Bavaria. At Sukula and Tammela, Finland. From Varuträsk, Norrö, and Skrumpetorp, Sweden. In the La Vilate quarry, near Chanteloube, and at Huréaux, Haute-Vienne, France. From Dolni Borí, near Velké Meziříčí, Czech Republic. At the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. In the USA, large crystals from the G.E. Smith quarry, Newport, Sullivan Co., the Palermo #1 mine, near North Groton, Grafton Co., and elsewhere in New Hampshire; at Newry, Oxford Co. and other places in Maine; from the Dan Patch, Big Chief, and Hesnard mines, near Keystone, Pennington Co., and at the Bull Moose and Tip Top mines, near Custer, Custer Co., South Dakota; in the White Picacho district, Maricopa and Yavapai Cos., Arizona. At Point de Bois, Manitoba, Canada.

Name: From the Greek for *threefold* and *family*, as it contains three cations.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 665–669. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 40–45. (3) Finger, L.W. and G.R. Rapp, Jr. (1970) Refinement of the crystal structure of triphylite. Carnegie Inst. Yearbook, 68, 230–232. (4) Yakubovich, O.V., M.A. Simonov, and N.V. Belov (1977) The crystal structure of a synthetic triphylite $LiFe(PO_4)$. Doklady Acad. Nauk SSSR, 235, 93–95 (in Russian). (5) Blanchard, F.N. and S.P. Saligan (1989) High quality powder diffraction data from an impure specimen: triphylite, $Li(Fe,Mn)PO_4$. Powder Diffraction, 4(1), 26–28.

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Triplite $(Mn^{2+}, Fe^{2+}, Mg, Ca)_2(PO_4)(F, OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are typically very rough, but may have many indistinct forms, to 4 m; usually nodular, massive.

Physical Properties: *Cleavage:* On {001}, good; on {010}, fair; on {100}, poor. *Fracture:* Uneven to subconchoidal. Hardness = 5–5.5 D(meas.) = 3.5–3.9 D(calc.) = 3.85–3.94

Optical Properties: Translucent to opaque. *Color:* Chestnut-brown, reddish brown, flesh-red, salmon-pink; brownish black to black if altered; in transmitted light, pale brownish yellow to dark reddish brown. *Streak:* White to brown. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (+). *Pleochroism:* Distinct; yellow-brown to reddish brown. *Orientation:* $Y = b$; $Z \wedge c = -41°$. *Dispersion:* $r > v$, , moderate to strong. *Absorption:* $X > Z = Y$.
$\alpha = 1.643–1.684$ $\beta = 1.647–1.693$ $\gamma = 1.668–1.703$ 2V(meas.) = 25°–76°

Cell Data: *Space Group:* $I2/a$. $a = 12.065–12.134$ $b = 6.454–6.546$ $c = 9.937–9.939$ $\beta = 106.08°–107.09°$ Z = 8

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA; close to zwieselite. (ICDD 40-1499).
3.008 (100), 2.525 (81), 4.277 (76), 3.487 (70), 5.175 (34), 3.923 (26), 2.462 (25)

Chemistry:

	(1)	(2)	(3)
P_2O_5	31.84	31.9	31.58
FeO	1.68	14.2	31.97
MnO	57.63	46.8	31.56
MgO	1.21	2.2	
CaO	2.86	0.7	
F	7.77	10.0	8.45
$-O = F_2$	3.27	4.2	3.56
Total	99.72	101.6	100.00

(1) Aurum, Reagan district, White Pine Co., Nevada, USA. (2) East Kemptville, Canada; by electron microprobe, total Fe as FeO, total Mn as MnO, corresponds to $(Mn_{1.43}Fe_{0.43}Mg_{0.12}Ca_{0.03})_{\Sigma=2.01}P_{0.97}O_{3.86}F_{1.14}$. (3) $(Mn, Fe)_2(PO_4)F$ with Mn:Fe = 1:1.

Polymorphism & Series: Forms a series with zwieselite.

Occurrence: A principal primary phosphate, or replacing earlier species, commonly lithiophilite, in complex zoned granite pegmatites; in hydrothermal tin veins.

Association: Triploidite–wolfeite, triphylite–lithiophilite, phosphosiderite, vivianite, apatite, tourmaline, sphalerite, pyrite, quartz.

Distribution: Many localities; some prominent occurrences follow: from Limoges and in the La Vilate quarry, near Chanteloube, Haute-Vienne, France. In Germany, from Hagendorf, and on the Kreuzberg, Pleystein, Bavaria. At Horní Slavkov (Schlaggenwald), Czech Republic. From the Mangualde pegmatite, near Mesquitela, Portugal. At Lemnäs, Finland. In the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, Sweden. At the East Kemptville tin mine, Nova Scotia, Canada. In the USA, at the Mica Lode, Fremont Co., Colorado; in the White Picacho district, Maricopa and Yavapai Cos., Arizona; from Lord Hill, Stoneham, Oxford Co., Maine; at the Elk Ridge pegmatite, Custer, Custer Co., South Dakota. From the El Criollo pegmatite, Cerro Blanco, Tanti district, 45 km west of Córdoba, Córdoba Province, Argentina, large nodules.

Name: From the Greek for *threefold*, probably for its cleavages.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 849–852. (2) Waldrop, L. (1969) The crystal structure of triplite, $(Mn, Fe)_2FPO_4$. Zeits. Krist., 130, 1–14. (3) Mandarino, J.A., J.M.G. Richardson, P.J. Dunn, and E.T.C. Spooner (1984) Triplite from East Kemptville, Nova Scotia. Mineral. Mag., 48, 142–143.

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Triploidite $(Mn^{2+},Fe^{2+})_2(PO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, elongated and striated ‖ [001], to 1 mm, columnar to parallel fibrous, may be spherulitic to divergent fibrous; rarely granular.

Physical Properties: *Cleavage:* {100}, good; {120}, fair; {010}, poor. *Fracture:* Uneven to subconchoidal. Hardness = 4.5–5 D(meas.) = 3.70 D(calc.) = [3.80]

Optical Properties: Transparent to translucent. *Color:* Pinkish brown, wine-yellow, yellowish brown, red-orange; pale pink in transmitted light. *Streak:* White, nearly. *Luster:* Vitreous, adamantine, greasy.
Optical Class: Biaxial (+); abnormal interference colors due to strong dispersed extinction. *Pleochroism:* Faint in thick grains. *Orientation:* $X = b$; $Z \wedge c = 4°$–$14°$. *Dispersion:* $r > v$, very strong. *Absorption:* $Z > X = Y$. $\alpha = 1.709$–1.735 $\beta = [1.710]$–1.736 $\gamma = 1.714$–1.740
2V(meas.) = ∼50°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.366$ $b = 13.276$ $c = 9.943$ $\beta = 108.23°$
Z = 16

X-ray Powder Pattern: Branchville, Connecticut, USA; close to wolfeite.
2.94 (10), 3.10 (9), 3.19 (8), 1.80 (6), 3.41 (5), 2.58 (5), 2.31 (5)

Chemistry:

	(1)	(2)	(3)
P_2O_5	32.11	28.54	31.86
As_2O_5		3.64	
SiO_2		0.68	
FeO	14.88	0.03	32.25
MnO	48.45	59.16	31.85
CaO	0.33	0.34	
H_2O	4.08	[7.61]	4.04
Total	99.85	[100.00]	100.00

(1) Branchville, Connecticut, USA. (2) Wheal Owles, England; H_2O by difference, corresponds to $(Mn_{1.95}Ca_{0.01}Si_{0.03})_{\Sigma=1.99}[(P_{0.94}As_{0.07})_{\Sigma=1.01}O_4](OH)_{1.00} \bullet 0.49H_2O$. (3) $(Mn,Fe)_2(PO_4)(OH)$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with wolfeite.

Occurrence: An uncommon hydrothermal alteration product of primary phosphates in complex zoned granite pegmatites.

Association: Triplite, lithiophilite, triphylite, eosphorite, dickinsonite, rhodochrosite.

Distribution: In the USA, from Branchville, Fairfield Co., Connecticut; at the Ross (Highland Lode) mine, 6.5 km west of Custer, Custer Co. and the Peerless mine, near Keystone, Pennington Co., South Dakota; in the White Picacho district, Maricopa and Yavapai Cos., Arizona; from the Foote mine, Kings Mountain, Cleveland Co., North Carolina; in the Emmons quarry, Greenwood, Oxford Co., Maine. At Wheal Owles, St. Just, Cornwall, England. In the Hunnakko pegmatite, Alavus district, Finland. From Vídeň, near Velkého Meziříči, Czech Republic. In Germany, at Hagendorf and Waidhaus, Bavaria. In the Lion Hill mine, Urungwe, Zimbabwe. From Parelhas, Rio Grande do Norte, Brazil.

Name: From *triplite* and the Greek for *form*, as it closely resembles that species.

Type Material: Yale University, New Haven, Connecticut, USA, 5.5646–5.5648.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 853–855. (2) Waldrop, L. (1970) The crystal structure of triploidite and its relation to the structures of other minerals of the triplite–triploidite group. Zeits. Krist., 131, 1–20. (3) Clark, A.M. and A.G. Couper (1979) End-member triploidite from Cornwall. Mineral. Mag., 43, 179–180. (4) Frondel, C. (1949) Wolfeite, xanthoxenite, and whitlockite from the Palermo mine, New Hampshire. Amer. Mineral., 34, 692–705.

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Trippkeite $CuAs_2^{3+}O_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals short prismatic to equant, with {021}, {100}, {001} dominant, four additional forms, may be bent.

Physical Properties: *Cleavage:* {100}, perfect; {110}, good. *Tenacity:* Fibers formed by cleavage are easily bent. Hardness = Soft. D(meas.) = 4.8(5) D(calc.) = 4.48

Optical Properties: Semitransparent. *Color:* Greenish blue; pale bluish green in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.90(1)$ $\epsilon = 2.12(1)$

Cell Data: *Space Group:* $P4_2/mbc$ (synthetic). $a = 8.592(4)$ $c = 5.573(4)$ Z = 4

X-ray Powder Pattern: Synthetic; calculated from crystal structure.
3.16 (100), 6.07 (57), 3.04 (47), 2.34 (36), 1.95 (36), 2.72 (34), 1.64 (25)

Chemistry: Apparently no analysis has ever been performed.

Occurrence: In a copper deposit.

Association: Cuprite, malachite, olivenite, chalcopyrite.

Distribution: From near Copiapó, Atacama, Chile.

Name: To honor Dr. Paul Trippke (1851–1880), Polish mineralogist, who discovered the mineral.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1034. (2) Zemann, J. (1951) Formel und Kristallstruktur des Trippkeits. Tschermaks Mineral. Petrog. Mitt., 2, 417–423 (in German). (3) Pertlik, F. (1975) Verfeinerung der Kristallstruktur von synthetischem Trippkeite, $CuAs_2O_4$. Tschermaks Mineral. Petrog. Mitt., 22, 211–217 (in German with English abs.). (4) Pertlik, F. (1977) Zur Synthese von Kristallen von $CuAs_2O_4$ (Trippkeit) und $Cu_2As_3O_6CH_3COO$. (Ein Komponente des Farbpigments "Schweinfurter Grün"). Z. Anorg. Allg. Chem., 436, 201–206 (in German with English abs.).

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Tripuhyite $Fe^{2+}Sb_2^{5+}O_6$

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Crystal Data: Tetragonal. *Point Group:* [$4/m$ $2/m$ $2/m$] (by analogy to the ferrotapiolite group). As fibrous to very fine-grained aggregates.

Physical Properties: Hardness = 6–7 D(meas.) = 5.82 D(calc.) = [6.70]

Optical Properties: Translucent. *Color:* Greenish yellow, dark brown to black; bright canary-yellow in transmitted light. *Streak:* Canary-yellow to dark brown with a greenish tinge. *Luster:* Dull.
Optical Class: Biaxial (+), anomalous. *Dispersion:* $r < v$, very strong. $\alpha = 2.19(1)$ $\beta = 2.20(1)$ $\gamma = 2.33(1)$ 2V(meas.) = Small.

Cell Data: *Space Group:* [$P4/mnm$] (by analogy to the ferrotapiolite group). $a = 4.63$ $c = 9.14$ Z = 2

X-ray Powder Pattern: El Antimonio, Mexico.
3.28 (10), 2.56 (9), 1.72 (9), 1.64 (5), 2.32 (4), 1.47 (4), 1.52 (3)

Chemistry:

	(1)	(2)	(3)
Sb_2O_5	66.68	70.3	81.83
SiO_2	1.35		
TiO_2	0.86	2.1	
Al_2O_3	1.40	2.3	
Fe_2O_3		23.6	
FeO	27.70		18.17
MgO		0.2	
CaO	0.82		
H_2O		1.5	
Total	98.81	[100.0]	100.00

(1) Tripuhy mine, Brazil; total Fe as FeO. (2) El Antimonio, Mexico; recalculated to 100% after deduction of quartz 36%. (3) $FeSb_2O_6$.

Mineral Group: Ferrotapiolite group.

Occurrence: An alteration product of stibnite and pyrite in the oxidation zone of some hydrothermal antimony deposits; a detrital mineral.

Association: Lewisite, monazite, rutile, kyanite, magnetite (Tripuhy mine, Brazil); selenium, sulfur, stibiconite, sénarmontite, roméite, mopungite (Mopung Hills, Nevada, USA).

Distribution: From the Tripuhy cinnabar mine, Ouro Prêto, Minas Gerais, Brazil. At Doncellas, Jujuy Province, Argentina. In the USA, from the Bear Mountain district, Socorro Co., New Mexico; at the McDermitt mine, Ophir district, Humboldt Co., from the Goldstrike mine, Lynn district, and the Gold Quarry mine, Maggie Creek district, Eureka Co., and at the Green prospect, Mopung Hills, Lake district, Churchill Co., and elsewhere in Nevada. At El Antimonio, Sonora, Mexico. From Djebel Nador, Qacentina (Constantine), Algeria. At Tsumeb, Namibia. In the Clara mine, near Oberwolfach, Black Forest, Germany. At the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. From Steel's Creek, near Yarra Glen, Victoria, Australia. In Japan, in the Kinka mine, Gifu Prefecture. From the Dzhizhikrut and Obi-Khunda deposits, Zeravshan–Hissar district, Hissar Range, Tien Shan, Tajikistan. From several antimony deposits in the southern Tien Shan, Kyrgyzstan.

Name: For its occurrence at the Tripuhy mine, Brazil.

Type Material: The Natural History Museum, London, England, 86044.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1024. (2) Mason, B. and C.J. Vitaliano (1953) The mineralogy of the antimony oxides and antimonates. Mineral. Mag., 30, 100–112.

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Tristramite $(Ca, U^{4+}, Fe^{3+})(PO_4, SO_4)\cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Acicular to fibrous crystals, to 0.1 mm, in coarse- to fine-grained aggregates, which may be radial or cross-vein.

Physical Properties: Hardness = n.d. D(meas.) = 3.8–4.2 D(calc.) = 4.18 Radioactive.

Optical Properties: Semitransparent. *Color:* Yellow, greenish yellow; in transmitted light, pale yellow to greenish yellow, showing color banding. *Luster:* Vitreous.
Optical Class: Uniaxial (+); may exhibit anomalous blue birefringence. *Orientation:* Positive elongation. $\omega = 1.644(2)$ $\epsilon = 1.664(2)$

Cell Data: *Space Group:* $P6_222$. $a = 6.913(6)$ $c = 6.422(6)$ $Z = 3$

X-ray Powder Pattern: Wheal Trewavas, England.
2.99 (100), 2.83 (100), 2.14 (50), 1.850 (50), 5.99 (40), 4.37 (40), 3.46 (30)

Chemistry:

	(1)
SO_3	4.31
P_2O_5	25.09
CO_2	[1.46]
UO_2	35.08
Fe_2O_3	5.99
CaO	13.74
H_2O	[14.33]
Total	[100.00]

(1) Wheal Trewavas, England; by electron microprobe, total U as UO_2, total Fe as Fe_2O_3, CO_2 for charge balance, H_2O by difference; corresponds to $(Ca_{0.54}U_{0.29}Fe_{0.17})_{\Sigma=1.00}[(PO_4)_{0.79}(SO_4)_{0.12}(CO_3)_{0.07}]_{\Sigma=0.98}\cdot 1.77H_2O$.

Mineral Group: Rhabdophane group.

Occurrence: In fractures and cavities in hydrothermal veins.

Association: Uraninite, goethite, digenite, chalcopyrite, pyrite, sphalerite, galena, marcasite, quartz.

Distribution: In England, from Cornwall, at Wheal Trewavas, Breage; Trequeen; Wheal Buller, Redruth; Wheal Damsel, Gwennap; Wheals Providence and Alice, Lelant.

Name: For Sir Tristram, a figure in the Arthurian legend.

Type Material: Institute of Geological Sciences, London; The Natural History Museum, London, England, 1983,201.

References: (1) Atkin, D., I.R. Basham, and J.F.W. Bowles (1983) Tristramite, a new calcium uranium phosphate of the rhabdophane group. Mineral. Mag., 47, 393–396. (2) (1984) Amer. Mineral., 69, 813 (abs. ref. 1).

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Tritomite-(Ce) $(Ce, La, Ca, Y, Th)_5(Si, B)_3(O, OH, F)_{13}(?)$

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Crystal Data: Metamict; hexagonal after heating at 1000 °C. *Point Group:* n.d. As pseudotetrahedral crystals, also as rounded aggregates.

Physical Properties: Hardness = 5.5 VHN = 544 D(meas.) = 3.72–3.81; 4.20 D(calc.) = n.d. Radioactive.

Optical Properties: Translucent. *Color:* Dark red-brown, amber, black; amber in thin section. *Streak:* Yellowish grey. *Luster:* Resinous.
Optical Class: Isotropic to weakly anisotropic. $n = 1.685$–1.763

Cell Data: *Space Group:* n.d. $a = 9.35$, after heating at 1000 °C. $c = 6.88$ Z = n.d.

X-ray Powder Pattern: Langesundsfjord, Norway; after heating at 600 °C–1000 °C, and the appearance of an apatitelike phase.
2.81 (100), 3.44 (40), 1.84 (40), 1.24 (40), 3.08 (30), 2.70 (30), 1.94 (30)

Chemistry:

	(1)		(1)
SiO_2	14.40	Nb_2O_5	1.70
TiO_2	0.28	MnO	0.30
ZrO_2	2.31	MgO	0.60
ThO_2	15.00	CaO	7.52
B_2O_3	2.00	SrO	0.62
Al_2O_3	0.85	F	4.00
RE_2O_3	41.44	H_2O^+	8.44
Fe_2O_3	1.71	$-O = F_2$	1.69
		Total	99.48

(1) Langesundsfjord, Norway; lanthanides by X-ray spectroscopy, Y by difference, approximate relative RE = Y [16.8]%, La 25.0%, Ce 44.0%, Pr 2.5%, Nd 10.0%, Sm 0.6%, Eu 0.1%, Gd 0.4%, Dy 0.5%, Er 0.1%.

Occurrence: In nepheline syenite pegmatites (Langesundsfjord, Norway).

Association: Aegirine, leucophanite, analcime, mosandrite, catapleiite (Langesundsfjord, Norway); augite, plagioclase, microcline, allanite, calcite, fluorite, quartz (Cardiff property, Canada).

Distribution: From Låven, Stokø, Arø, and other islands in the Langesundsfjord, from Brevik, and from Barkevik, Norway. On the Cardiff property, and in the Faraday mine, Bancroft district, Ontario, Canada.

Name: From the Greek for *three-fold* and *to cut*, describing the triangular, pseudotetrahedral shape of cavities left by the mineral in gangue, and *cerium* in the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, R1297.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 416. (2) Jaffe, H.W. and V.J. Molinski (1962) Spencite, the yttrium analogue of tritomite from Sussex County, New Jersey. Amer. Mineral., 47, 9–25. (3) Hogarth, D.D., H.R. Steacy, E.I. Semenov, E.G. Proshchenko, M.E. Kazakova, and Z.T. Kataeva (1973) New occurrences and data for spencite. Can. Mineral., 12, 66–71.

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Tritomite-(Y) $(Y, Ca, La, Fe^{2+})_5(Si, B, Al)_3(O, OH, F)_{13}(?)$

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Crystal Data: Metamict; hexagonal after heating at 1000 °C. *Point Group:* n.d. As irregular grains and masses, to 2.5 cm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3.5–6.5 VHN = 515–609 D(meas.) = 3.05–3.40 D(calc.) = n.d.

Optical Properties: Translucent in thin fragments. *Color:* Greenish black, dark reddish brown to brownish black; pale green, pale olive-brown to yellowish brown in thin section. *Streak:* Greenish gray. *Luster:* Weakly vitreous to resinous. *Optical Class:* Isotropic. $n = 1.627–1.685$

Cell Data: *Space Group:* n.d. $a = 9.32$, after heating at 1000 °C. $c = 6.84$ Z = n.d.

X-ray Powder Pattern: Cranberry Lake, New Jersey, USA; after heating at 1000 °C and the appearance of an apatitelike phase.
2.78 (100), 4.02 (50), 3.13 (50), 3.83 (40), 3.05 (40), 2.76 (40), 1.930 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	24.89	24.66	PbO		0.11
TiO_2	0.27	0.23	BeO		0.23
ThO_2	1.84	2.84	MgO	0.50	0.20
UO_3		0.92	CaO	7.81	16.61
B_2O_3	10.04	11.12	SrO	0.05	
Al_2O_3	3.87	6.21	Na_2O	0.11	0.08
Y_2O_3	17.77	20.03	K_2O	0.01	
La_2O_3	0.73	5.72	F	0.44	1.02
CeO_2	2.49		Cl	0.45	
Ce_2O_3		2.85	H_2O^+	9.82	3.68
RE_2O_3	13.41		H_2O^-	1.93	
Fe_2O_3	3.22		P_2O_5	0.02	
FeO		3.47	$-O = (F, Cl)_2$	0.28	0.43
MnO	0.60	0.45	Total	99.99	[100.00]

(1) Cardiff township, Canada; spectrographic analysis of RE = Pr_6O_{11} 0.54%, Nd_2O_3 1.84%, Sm_2O_3 1.07%, Eu_2O_3 0.14%, Gd_2O_3 1.61%, Tb_4O_7 0.34%, Dy_2O_3 1.92%, Ho_2O_3 0.50%, Er_2O_3 1.99%, Tm_2O_3 0.31%, Yb_2O_3 2.88%, Lu_2O_3 0.27%. (2) Cranberry Lake, New Jersey, USA; recalculated to 100.00% after removal of calcite impurity; Y_2O_3 includes all Y group RE, La_2O_3 includes all Ce group RE.

Occurrence: In granite pegmatites and pegmatite veins cutting pyroxenite.

Association: Calcite, apatite, diopside, fluorite, scapolite (Cardiff township, Canada); albite, calcite, arfvedsonite, pyrite, quartz, tourmaline (Faraday mine, Canada); magnetite, zircon, apatite, calcite, fergusonite (Cranberry Lake, New Jersey, USA).

Distribution: In the USA, from near Cranberry Lake, Sussex Co., New Jersey. In Canada, from a prospect pit in Cardiff township, and in the Faraday mine, Bancroft district, Ontario.

Name: For its relation to *tritomite*-(Ce), and *yttrium* in the composition.

Type Material: Harvard University, Cambridge, Massachusetts, 108000; The Natural History Museum, London, England, 1963,226; Canadian Geological Survey, Ottawa, Canada, 14270.

References: (1) Frondel, C. (1961) Two yttrium minerals: spencite and rowlandite. Can. Mineral., 6, 576–581. (2) (1961) Amer. Mineral., 46, 1204 (abs. ref. 1). (3) Jaffe, H.W. and V.J. Molinski (1962) Spencite, the yttrium analogue of tritomite from Sussex County, New Jersey. Amer. Mineral., 47, 9–25. (4) Joensuu, O.I. and C.O. Ingamells (1966) Additional data on the composition of spencite. Can. Mineral., 8, 647–649. (5) Hogarth, D.D., H.R. Steacy, E.I. Semenov, E.G. Proshchenko, M.E. Kazakova, and Z.T. Kataeva (1973) New occurrences and data for spencite. Can. Mineral., 12, 66–71.

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Trögerite $(UO_2)_3(AsO_4)_2 \cdot 12H_2O(?)$

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Crystal Data: Tetragonal or monoclinic. *Point Group:* $4/m$ $2/m$ $2/m$ or $2/m$. As thin crystals, tabular on {001}, to 1 mm.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, good; on {011}, probable. Hardness = 2–3 D(meas.) = 3.3 D(calc.) = [5.13] Reversible H_2O content. May fluoresce lemon-yellow under UV. Radioactive.

Optical Properties: Transparent. *Color:* Lemon-yellow. *Luster:* Vitreous, pearly on {001} cleavage.
Optical Class: Uniaxial (–) or biaxial (–), probably anomalous, zoned due to differences in H_2O content. *Pleochroism:* $O = Y = Z$ = lemon-yellow; $E = X$ = nearly colorless. *Orientation:* $X = c$; $Z \wedge a = 12°–14°$. *Dispersion:* $r > v$, moderate. $\omega = 1.624–1.627$ $\epsilon = 1.580–1.582$ $\alpha = 1.584–1.600$ $\beta = 1.620–1.630$ $\gamma = 1.623–1.630$ 2V(meas.) = 0°–40°

Cell Data: *Space Group:* n.d. $a = 6.99$ $c = 8.48$ Z = 8, or *Space Group:* n.d. $a = 7.15$ $b = 6.98$ $c = 11.2$ $\beta = \sim 95°$ Z = 1

X-ray Powder Pattern: Synthetic.
8.59 (10), 3.79 (9), 3.30 (8), 5.50 (7), 4.35 (7), 2.70 (7), 2.19 (7)

Chemistry:

	(1)	(2)	(3)
UO_3	63.76	65.17	65.80
P_2O_5		1.20	
As_2O_5	19.64	22.08	17.62
Bi_2O_3		8.79	
PbO		1.56	
MgO		0.25	
CaO		0.65	
H_2O	14.81		16.58
Total	98.21	99.70	100.00

(1) Weisser Hirsch mine, Germany. (2) Do.; by electron microprobe, after drying at 210 °C; corresponds to $(UO_2)_{2.72}Bi_{0.18}Ca_{0.11}Pb_{0.07}Mg_{0.06}[(AsO_4)_{1.84}(PO_4)_{0.16}]_{\Sigma=2.00}$. (3) $(UO_2)_3(AsO_4)_2 \cdot 12H_2O$.

Mineral Group: Autunite group.

Occurrence: A rare mineral formed in the oxidation zone of some uranium deposits.

Association: Walpurgite, uranospinite, uranospathite, asselbornite, zeunerite, uranosphaerite, erythrite, cobaltian wad (Weisser Hirsch mine, Germany); realgar, orpiment, scorodite, mansfieldite, sodium uranospinite, arseniosiderite, metatorbernite, metazeunerite, uranophane, arsenopyrite, pyrite, galena (Bota-Burum deposit, Kazakhstan).

Distribution: From the Walpurgis vein, in the Weisser Hirsch mine, and at the Daniel mine, Neustädtel-Schneeberg, Saxony, Germany. From Marbruie, near Dalbeattie, Kirkcudbrightshire, Scotland. In the Rabéjac, Riviéral, and Mas-d'Alary uranium deposits, near Lodève, Hérault, France. At the Bota-Burum uranium deposit, 15 km southwest of Alakol Lake, Chu-Ili Mountains, southwestern Balkhash district, Kazakhstan. From the Bald Mountain district, Lawrence Co., South Dakota, USA.

Name: To honor Mining Foreman R. Tröger, Schneeberg, Germany, who found the first specimens.

Type Material: Mining Academy, Freiberg, Germany, 21800; Harvard University, Cambridge, Massachusetts, USA, 106035.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 966–967. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 187–191. (3) Weiss, A., F. Taborszky, K. Hartl, and E. Tröger (1957) Zur Kenntnis des Uranminerals Trögerit. Zeits. Naturforsch., 12b, 356–358.

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Trogtalite $CoSe_2$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Intergrown with clausthalite as irregular grains, to 1 mm.

Physical Properties: Hardness = ∼7 VHN = n.d. D(meas.) = 7.09 (synthetic). D(calc.) = 7.12

Optical Properties: Opaque. *Color:* Rose-violet. *Luster:* Metallic.

R: (400) 42.5, (420) 42.2, (440) 41.9, (460) 41.4, (480) 41.0, (500) 40.8, (520) 41.1, (540) 41.3, (560) 42.0, (580) 42.6, (600) 43.3, (620) 43.9, (640) 44.5, (660) 45.2, (680) 45.6, (700) 45.8

Cell Data: *Space Group: Pa*3. $a = 5.87(2)$ $Z = 4$

X-ray Powder Pattern: Musonoi mine, Congo.
2.64 (100), 2.419 (90), 1.788 (80), 2.95 (70), 1.585 (70), 1.644 (50), 1.295 (50)

Chemistry:

	(1)	(2)
Co	17.09	27.18
Cu	9.02	
Pd	4.67	
Se	69.77	72.82
Total	100.55	100.00

(1) Musonoi mine, Congo; by electron microprobe, corresponding to a cuproan-palladian variety $(Co_{0.65}Cu_{0.32}Pd_{0.09})_{\Sigma=1.06}Se_{2.00}$. (2) $CoSe_2$.

Polymorphism & Series: Dimorphous with hastite.

Mineral Group: Pyrite group.

Occurrence: Intergrown with clausthalite (Trogtal quarry, Germany).

Association: Clausthalite, hastite, bornhardtite, selenium, gold (Trogtal quarry, Germany); oosterboschite (Musonoi mine, Congo).

Distribution: From the Trogtal quarry, near Lautenthal, Harz Mountains, Germany [TL]. At the Musonoi Cu–Co mine, near Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). In Argentina, from Tuminico, Sierra de Cacho, and at Los Llantenes, La Rioja Province.

Name: For the occurrence at the Trogtal quarry, Germany.

Type Material: The Natural History Museum, London, England, 1980,400; National Museum of Natural History, Washington, D.C., USA, 112811.

References: (1) Ramdohr, P. and M. Schmitt (1955) Vier neue natürliche Kobaltselenide vom Steinbruch Trogtal bei Lautenthal im Harz. Neues Jahrb. Mineral., Monatsh., 133–142 (in German). (2) (1956) Amer. Mineral., 41, 164–165 (abs. ref. 1). (3) Johan, Z., P. Picot, R. Pierrot, and T. Verbeek (1970) L'oosterboschite $(Pd, Cu)_7Se_5$, une nouvelle espèce minérale et la trogtalite cupro-palladifère de Musonoï (Katanga). Bull. Soc. fr. Minéral., 93, 476–481 (in French with English abs.). (4) Bøhm, F., F. Grønvold, H. Haraldsen, and H. Prydz (1955) X-ray and magnetic study of the system cobalt selenium. Acta Chem. Scand., 9, 1510–1522.

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Troilite FeS

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Massive, granular; nodular.

Physical Properties: Hardness = 3.5–4.5 VHN = 250(3) D(meas.) = 4.67–4.79 D(calc.) = 4.85

Optical Properties: Opaque. *Color:* Pale grayish brown, tarnishes rapidly on exposure. *Streak:* Dark grayish brown. *Luster:* Metallic. *Anisotropism:* Strong.

R_1–R_2: (400) 24.3–28.4, (420) 24.9–29.6, (440) 25.8–30.9, (460) 27.1–32.6, (480) 28.4–34.0, (500) 29.9–35.5, (520) 31.3–36.7, (540) 32.7–37.9, (560) 34.2–39.0, (580) 35.5–40.0, (600) 36.9–41.0, (620) 38.1–41.7, (640) 39.2–42.4, (660) 40.2–43.1, (680) 41.1–43.5, (700) 42.0–44.0

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.958$ $c = 11.74$ $Z = 12$

X-ray Powder Pattern: Del Norte Co., California, USA.
2.09 (100), 2.66 (60), 1.719 (50), 2.98 (40), 1.331 (40), 1.119 (40), 1.923 (30)

Chemistry:

	(1)	(2)	(3)
Fe	62.70	63.0	63.53
S	35.40	35.0	36.47
Total	98.10	98.0	100.00

(1) Del Norte Co., California, USA. (2) Cranbourne meteorite. (3) FeS.

Occurrence: In serpentine (Del Norte Co., California, USA); with Fe–Cu–Ni sulfides in a layered ultramafic intrusive (Sally Malay deposit, Australia); and as nodules in meteorites.

Association: Pyrrhotite, pentlandite, mackinawite, cubanite, valleriite, chalcopyrite, pyrite (Wannaway deposit, Australia); daubréelite, chromite, sphalerite, graphite, various phosphates and silicates (meteorites).

Distribution: From the Alta mine, Del Norte Co., California, USA. In the Wannaway Fe–Ni–Cu deposit, and at the Sally Malay Cu–Ni deposit, 120 km north of Halls Creek, Western Australia. In the Panzhihua-Xichang district, Sichuan Province, China. From Disco Island and the Ilímaussaq intrusion, southern Greenland. At Nordfjellmark, Norway. In many meteorites and some lunar rocks.

Name: In honor of Dominico Troili (1722–1792), Italian Jesuit, who described, in 1766, a meteorite which fell in Albareto, near Modena, Italy, which contained the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 231–234. (2) King, H.E. and C.T. Pruitt (1982) ??title?? Acta Cryst., 38, 1877–??. (3) Buchwald, V.F. (1977) The mineralogy of iron meteorites. Phil. Trans. Royal Soc. London, A. 286, 453–491. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 61. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 582–601. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 583.

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Trolleite $Al_4(PO_4)_3(OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Lamellar, massive, to 3 cm.

Physical Properties: *Cleavage:* In two directions, indistinct. *Fracture:* Even to conchoidal. Hardness = 8.5 D(meas.) = 3.10 D(calc.) = 3.08

Optical Properties: Translucent. *Color:* Pale green to bright blue. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Dispersion:* $r > v$, weak. $\alpha = 1.619$ $\beta = 1.639$ $\gamma = 1.643$ 2V(meas.) = 49°

Cell Data: *Space Group:* $I2/c$. $a = 18.894(5)$ $b = 7.161(1)$ $c = 7.162(2)$ $\beta = 99.99(2)°$ Z = 4

X-ray Powder Pattern: Champion mine, California, USA.
3.208 (100), 3.095 (90), 3.075 (50), 2.519 (45), 3.336 (40), 6.667 (35), 1.983 (35)

Chemistry:

	(1)	(2)	(3)
P_2O_5	46.72	48.00	47.97
Al_2O_3	43.26	43.87	45.94
Fe_2O_3	2.75	0.34	
CaO	0.97	0.02	
H_2O	6.23	[7.77]	6.09
Total	99.93	[100.00]	100.00

(1) Västanå mine, Sweden. (2) Hökensås, Sweden; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference. (3) $Al_4(PO_4)_3(OH)_3$.

Occurrence: In amphibolite-grade metamorphic rocks.

Association: Berlinite, attakolite, augelite, lazulite (Västanå mine, Sweden); scorzalite, augelite, viséite (Champion mine, California, USA); montebrasite, scorzalite, bertossaite, brazilianite, apatite, gatumbaite, samuelsonite, wyllieite (Buranga pegmatite, Rwanda).

Distribution: In Sweden, from the Västanå mine, near Näsum, Skåne; at Hålsjöberg, Värmland; from Hökensås, Västergötland. In the Buranga pegmatite, Rwanda. On Mt. Perry, 75 km southwest of Bundaberg, Queensland, Australia. In the USA, at the Kyanite Corporation mine on Willis Mountain, Buckingham Co., Virginia; four km west of Glendevey, Larimer Co., Colorado; in the Champion mine, White Mountains, Mono Co., California.

Name: To honor Hans Gabriel Trolle-Wachtmeister (1782–1871), Swedish chemist.

Type Material: Wroclaw University, Wroclaw, Poland, II–9575.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 911. (2) Sclar, C.B., L.C. Carrison, and C.M. Schwartz (1964) Synthesis and properties of trolleite (aluminian lazulite?), a high-pressure mineral from the Westanå iron deposit, Kristianstad, Sweden. Geol. Soc. Amer., Spec. Paper 76, 145. (3) Moore, P.B. and T. Araki (1974) Trolleite, $Al_4(OH)_3[PO_4]_3$: a very dense structure with octahedral face-sharing dimers. Amer. Mineral., 59, 974–984. (4) Ek, R. and P. Nysten (1990) Phosphate mineralogy of the Hålsjöberg and Hökensås kyanite deposits. Geol. Fören. Förhandl. Stockholm, 112, 9–18.

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Trona $Na_3(CO_3)(HCO_3)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are dominated by {001}, {100}, flattened on {001} and elongated on [010], with minor {201}, {$\overline{3}$01}, {211}, {$\overline{2}$11}, {411}, to 10 cm; may be fibrous or columnar massive, as rosettelike aggregates.

Physical Properties: *Cleavage:* {100}, perfect; {$\overline{2}$11} and {001}, interrupted. *Fracture:* Uneven to subconchoidal. Hardness = 2.5–3 D(meas.) = 2.11 D(calc.) = 2.124 Soluble in H_2O, alkaline taste; may fluoresce under SW UV.

Optical Properties: Translucent. *Color:* Colorless, gray, pale yellow, brown; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge c = 83°$. *Dispersion:* $r < v$; strong.
$\alpha = 1.412–1.417$ $\beta = 1.492–1.494$ $\gamma = 1.540–1.543$ 2V(meas.) = 76°16′ 2V(calc.) = 74°

Cell Data: *Space Group:* $I2/a$. $a = 20.4218(9)$ $b = 3.4913(1)$ $c = 10.3326(6)$
$\beta = 106.452(4)°$ Z = 4

X-ray Powder Pattern: Sweetwater Co., Wyoming, USA.
2.647 (100), 3.071 (80), 4.892 (55), 9.77 (45), 2.444 (30), 2.254 (30), 2.029 (30)

Chemistry:

	(1)	(2)
CO_2	38.13	38.94
SO_3	0.70	
Na_2O	41.00	41.13
Cl	0.19	
H_2O	20.07	19.93
insol.	0.02	
$-O = Cl_2$	0.04	
Total	100.07	100.00

(1) Owens Lake, California, USA; average of several analyses. (2) $Na_3(CO_3)(HCO_3)\cdot 2H_2O$.

Occurrence: Deposited from saline lakes and along river banks as efflorescences in arid climates; rarely from fumarolic action.

Association: Natron, thermonatrite, halite, glauberite, thénardite, mirabilite, gypsum (alkali lakes); shortite, northupite, bradleyite, pirssonite (Green River Formation, Wyoming, USA).

Distribution: Widespread in arid regions. Historically important deposits in the lower Nile delta, near Memphis, Egypt, and elsewhere in the Sahara Desert, Africa. Large crystals at Lake Magadi, Kenya, about which 2 billion tons have formed. Around Lake Chad, Chad. At Lake Katwe, western Uganda. From Lake Nyassa, Tanzania. At the Otjiwalundo salt pan, about 400 km west-northwest of Otavi, Namibia. In the USA, in California, at Searles Lake, San Bernardino Co., Borax Lake, Lake Co., and Owens Lake, Inyo Co.; extensive deposits, aggregating over 100 billion tons, occur in the Green River Formation, Wyoming, Colorado, and Utah; in Nevada, from Little Soda Lake, Churchill Co., and elsewhere. At Lagunillas, about 80 km southeast of Merida, Venezuela. In the Beypazari deposit, west of Ankara, Turkey, estimated at over 200 million tons. On Vesuvius, and at Campi Flegrei, near Naples, Campania, Italy.

Name: A short form of the Arabic word for the natural compound.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 138–140. (2) Pabst, A. (1959) On the hydrates of sodium carbonate, a correction, and the crystallography of trona. Amer. Mineral., 44, 274–281. (3) Choi, C.S. and A.D. Mighell (1982) Neutron diffraction study of sodium sesquicarbonate dihydrate. Acta Cryst., 38, 2874–2876. (4) Pertlik, F. (1986) Ein vergleich von ergebnissen routinemässiger strukturbestimmungen mittels röntgen-bzw. neutronen-einkristalldaten am beispiel der Trona, $Na_3H[CO_3]_2.2H_2O$. Mitt. Österr. Miner. Ges., 131, 7–14 (in German). (5) (1978) NBS Mono. 25, 15, 71.

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Truscottite $(Ca, Mn^{2+})_{14}Si_{24}O_{58}(OH)_8 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$ or 3. In scales; as spheroidal aggregates, to 7 mm, with fibrous, platy structure.

Physical Properties: *Cleavage:* Perfect on {0001}, micaceous. Hardness = 3.5
D(meas.) = 2.47–2.48 D(calc.) = 2.47

Optical Properties: Transparent to translucent. *Color:* White. *Luster:* Pearly on the cleavage.
Optical Class: Uniaxial (–). ω = 1.549–1.552 ϵ = 1.522–1.530

Cell Data: *Space Group:* $P\bar{3}$ or $P3$. a = 9.720–9.735 c = 18.84–18.85 Z = 1

X-ray Powder Pattern: Benkulen, Sumatra; resembles gyrolite or reyerite. (ICDD 29-382). 3.141 (100), 2.840 (80), 4.21 (70), 1.839 (70), 18.8 (60), 2.638 (55), 3.501 (45)

Chemistry:

	(1)	(2)	(3)
SiO_2	58.95	63.56	61.75
TiO_2	0.00	0.08	
Al_2O_3	1.03	0.81	
Fe_2O_3	0.03		
FeO		0.66	
MnO	0.18	2.41	
MgO	0.27	0.70	
CaO	25.54	26.24	33.62
Na_2O	1.03		
K_2O	1.37		
H_2O^+	4.61	4.31	4.63
H_2O^-	1.07	0.48	
CO_3	2.32		
SO_3	2.57		
Total	98.97	99.25	100.00

(1) Benkulen, Sumatra; corresponding to $(Ca_{1.78}Na_{0.13}K_{0.12}Mg_{0.03}Fe_{0.03}Mn_{0.02})_{\Sigma=2.11}(Si_{3.82}Al_{0.08})_{\Sigma=3.90}O_{9.48}(OH)_{2.00}$. (2) Toi mine, Japan; corresponding to $(Ca_{1.77}Mn_{0.13}Mg_{0.06}Fe_{0.03})_{\Sigma=1.99}(Si_{4.00}Al_{0.06})_{\Sigma=4.06}O_{9.18}(OH)_{1.81}$. (3) $Ca_{14}Si_{24}O_{58}(OH)_8 \cdot 2H_2O$.

Occurrence: In epithermal gold-silver quartz veins cutting altered pyroclastics (Toi mine, Japan).

Association: Quartz, adularia, rhodochrosite (Toi mine, Japan).

Distribution: At the Lebong Donok Au-Ag mine, Benkulen, Sumatra, Indonesia. In Japan, in the Toi mine, Shizuoka Prefecture. From the Hatrurim Formation, Israel. On Kilauea volcano, Hawaii, and from Yellowstone National Park, Wyoming, USA.

Name: For Professor Samuel John Truscott (1870–?), English mining geologist and formerly Manager of the Lebong Donok mine, Sumatra.

Type Material: The Natural History Museum, London, England, 1925,1044.

References: (1) Hövig, P. (1914) [Truscottiet.] Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië, Batavia, 41 (for 1912), 202. (2) (1925) Mineral. Mag., 20, 466 (abs. ref. 1). (3) MacKay, A.L. and H.F.W. Taylor (1954) Truscottite. Mineral. Mag., 30, 450–457. (4) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 26–28. (5) Minato, H. and A. Kato (1967) Truscottite from the Toi mine, Shizuoka Prefecture. Mineral. J. (Japan), 5, 144–156. (6) Lachowski, E.E., L.W. Murray, and H.F.W. Taylor (1979) Truscottite: composition and ionic substitutions. Mineral. Mag., 43, 333–336.

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Trüstedtite $(Ni, Co)_3Se_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As minute euhedral crystals embedded in clausthalite.

Physical Properties: Hardness = ∼2.5 VHN = n.d. D(meas.) = n.d. D(calc.) = 6.62

Optical Properties: Opaque. *Color:* Yellow. *Luster:* Metallic.

R: (400) 42.2, (420) 43.6, (440) 45.0, (460) 46.4, (480) 47.5, (500) 48.5, (520) 49.4, (540) 50.3, (560) 51.2, (580) 52.0, (600) 52.6, (620) 53.1, (640) 53.8, (660) 54.3, (680) 54.9, (700) 55.4

Cell Data: *Space Group:* $Fd3m$ (probable). $a = 9.94$ $Z = 8$

X-ray Powder Pattern: Kuusamo, Finland.
2.48 (100), 1.755 (100), 3.00 (80), 2.87 (80), 1.905 (60), 5.75 (40), 3.52 (40)

Chemistry:

	(1)	(2)
Ni	29.5	35.80
Co	6.4	
Cu	trace	
Se	64.4	64.20
S	trace	
Total	100.3	100.00

(1) Kuusamo, Finland; by X-ray fluorescence analysis; corresponds to $(Ni_{2.47}Co_{0.53})_{\Sigma=3.00}3Se_{4.00}$.
(2) Ni_3Se_4.

Polymorphism & Series: Dimorphous with wilkmanite.

Mineral Group: Linnaeite group.

Occurrence: In uranium-bearing calcite veins in sills of albite diabase in schist (Kuusamo, Finland); in stibnite-quartz-barite veins in schists (Qiongmo deposit, China).

Association: Clausthalite, penroseite, sederholmite, wilkmanite, kullerudite (Kuusamo, Finland); gold, tiemannite, clausthalite, selenian famatinite, selenian gersdorffite, antimonselite, selenian stibnite, quartz, barite (Qiongmo deposit, China).

Distribution: From Kuusamo, northeastern Finland [TL]. At the Qiongmo gold deposit, western Qinling Mountains, Shaanxi Province, China.

Name: In honor of Otto Trüstedt (1866–1929), Finnish mining engineer, whose work on prospecting methods lead to the discovery of the Outokumpu ore deposit, Finland.

Type Material: National School of Mines, Paris, France.

References: (1) Vuorelainen, Y., A. Huhma, and A. Häkli (1964) Sederholmite, wilkmanite, kullerudite, mäkinenite, and trüstedtite, five new nickel selenide minerals. Compt. Rendus Soc. Géol. Finlande, 36, 113–125. (2) (1965) Amer. Mineral., 50, 519–520 (abs. ref. 1).

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Tsaregorodtsevite $N(CH_3)_4[Si_2(Si_{0.5}Al_{0.5})O_6]_2$

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* 222. Pseudocubic crystals, to 1 cm, with dull {100}, {010}, and {001}, additional faces {110}, {011}, {101} lustrous. *Twinning:* Commonly sector twinned, as seen in thin section.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6 VHN = 796–893, average 835 (120 g load). D(meas.) = 2.04(5) D(calc.) = 2.01 Evolves ammonia and eurotropine above 600 °C, becoming pitch-black.

Optical Properties: Transparent. *Color:* Colorless, white to faintly yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Dispersion:* $r < v$, weak. $\alpha = 1.529(2)$ $\beta =$ n.d. $\gamma = 1.531(2)$ 2V(meas.) = 76(5)°

Cell Data: *Space Group:* $I222$. $a = 8.984(3)$ $b = 8.937(2)$ $c = 8.927(2)$ Z = 2

X-ray Powder Pattern: Man'-Khambo Mountains, Russia; very close to ammonian sodalite. 3.66 (100), 4.46 (82), 6.33 (60), 2.586 (15), 4.50 (12b), 3.16 (12), 2.832 (10)

Chemistry:

	(1)	(2)	(3)
SiO_2	66.38	66.7	69.29
Al_2O_3	12.19	12.2	11.76
C			11.08
H			2.79
O			1.85
N	3.2		3.23
Total			100.00

(1) Man'-Khambo Mountains, Russia; by electron microprobe, average of three analyses, given as Si 31.03%, Al 6.45%, N 3.2%, O 45.6%, here converted to oxides; CH_3 shown to be present by gas chromatography, IR spectroscopy, and Raman microanalysis. (2) Do. (3) $N(CH_3)_4[Si_2(Si_{0.5}Al_{0.5})O_6]_2$.

Occurrence: In friable material filling tectonic fractures in muscovite-chlorite schist.

Association: Chlorite, quartz, anatase, brookite, rutile, monazite, phillipsite, albite.

Distribution: On Mt. Yaruta, Man'-Khambo Mountains, Khanty Mansiysk region, Northern Ural Mountains, Russia.

Name: For Sergei Vasil'evich Tsaregorodtsev (1953–1986), Yekaterinberg (Sverdlovsk), Russia, expert collector of Uralian minerals, who found this mineral.

Type Material: Mining Institute, St. Petersburg, 2054/1; Il'menskii Preserve Museum, Miass, 3303, 3374, 5121; Vernadsky Geological Museum, Moscow, 59719, 59859; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87949; National Museum, Sofia, Bulgaria; National Museum, Prague, Czech Republic.

References: (1) Pautov, L.A., V.Y. Karpenko, E.V. Sokolova, and K.I. Ignatenko (1993) Tsaregorodtsevite $N(CH_3)_4[Si_2(Si_{0.5}Al_{0.5})O_6]_2$ – a new mineral. Zap. Vses. Mineral. Obshch., 122(1), 128–135 (in Russian). (2) (1994) Amer. Mineral., 79, 1013 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 378 (abs. ref. 1). (4) Sokolova, E.V., V.B. Rybakov, and L.A. Pautov (1991) Crystal structure of a new natural tetramethyammonium aluminosilicate $[N(CH_3)_4][Si_2(Si_{0.5}Al_{0.5})O_6]_2$. Doklady Acad. Nauk SSSR, 317, 884–887 (in Russian). (5) Pautov, L.A. and V.Y. Karpenko (1994) Discovery of czaregorodczevite [tsaregorodtsevite]. World of Stones, 1(4), 28–29.

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Tschermakite $Ca_2[(Mg,Fe^{2+})_3Al_2](Si_6Al_2)O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. [As prismatic crystals; as reaction rims on other minerals.] *Twinning:* [Simple or multiple twinning ∥ {100}.]

Physical Properties: *Cleavage:* Perfect on {110}, intersecting at 56° and 124°; partings on {100}, {001}. *Tenacity:* [Brittle.] Hardness = 5–6 D(meas.) = ∼3.15 D(calc.) = [3.25]

Optical Properties: Transparent to translucent. *Color:* Green. *Luster:* [Vitreous.] *Optical Class:* Biaxial (+) or (–). *Pleochroism:* Distinct in browns and greens. *Orientation:* $Y = b$. *Absorption:* $Z = Y > X$. α = 1.623–1.660 β = 1.630–1.680 γ = 1.638–1.688 2V(meas.) = 60°–90°

Cell Data: *Space Group:* $C2/m$. a = 9.762(6) b = 17.994(12) c = 5.325(6) β = 105.10(8)° Z = 2

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SiO_2	41.06	41.36
TiO_2	0.24	1.95
Al_2O_3	18.52	12.49
Fe_2O_3	4.67	4.25
FeO	7.81	12.36
MnO	0.25	0.11
MgO	15.31	11.45
CaO	9.92	10.85
Na_2O	1.24	1.68
K_2O	0.34	1.50
H_2O^+	0.46	1.87
H_2O^-	0.11	
Total	99.93	99.87

(1) Hurry Inlet, Greenland; corresponds to $(Ca_{1.56}Na_{0.35}K_{0.06})_{\Sigma=1.97}(Mg_{3.35}Al_{1.22}Fe^{2+}_{0.96}Fe^{3+}_{0.51}Mn_{0.03}Ti_{0.03})_{\Sigma=6.10}(Si_{6.02}Al_{1.98})_{\Sigma=8.00}O_{22}(OH)_{0.45}$. (2) Central Bug region, Ukraine; corresponds to $(Ca_{1.71}Na_{0.48}K_{0.28})_{\Sigma=2.47}(Mg_{2.51}Fe^{2+}_{1.52}Fe^{3+}_{0.47}Al_{0.27}Ti_{0.22}Mn_{0.01})_{\Sigma=5.00}(Si_{6.10}Al_{1.90})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with ferrotschermakite.

Mineral Group: Amphibole (calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.5$; $(Na + K)_A < 0.5$; $Na_B < 0.67$; $(Ca + Na)_B \geq 1.34$; $Si < 6.25$; $Ti < 0.5$.

Occurrence: From eclogites and other ultramafic igneous rocks, and in medium- to high-grade metamorphic rocks, typically amphibolites.

Association: Kyanite, garnet.

Distribution: Probably widespread. Well-studied material from: Hurry Inlet, Fiskenæsset, Greenland. At Glenelg and Knockormal, Ayrshire, Scotland. From Lake Kutemajärvi, Orivesi, and Perniö, Finland. In France, from Le Viala du Tarn, Aveyron. From the central Bug region, Ukraine.

Name: To honor Professor Gustav Tschermak von Seysenegg (1836–1927), Austrian mineralogist, University of Vienna, Vienna, Austria.

Type Material: n.d.

References: (1) Winchell, A.N. (1945) Variations in composition and properties of the calciferous amphiboles. Amer. Mineral., 30, 27–50. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 2, chain silicates, 263–314. (3) Hawthorne, F.C. (1983) The crystal chemistry of the amphiboles. Can. Mineral., 21, 173–480, esp. 368, 386.

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Tschermigite $(NH_4)Al(SO_4)_2 \cdot 12H_2O$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As dominantly octahedral crystals, to 1 cm; also fibrous columnar aggregates, which may be spiral; most commonly powdery.

Physical Properties: *Fracture:* Conchoidal. Hardness = 1.5 D(meas.) = 1.645 D(calc.) = 1.641(1) Soluble in H_2O, sweetish astringent taste.

Optical Properties: Transparent. *Color:* Colorless to white; colorless in transmitted light. *Luster:* Vitreous, silky if fibrous.
Optical Class: Isotropic, may be anomalously birefringent. $n = 1.458$

Cell Data: *Space Group:* $Pa3$. $a = 12.242(1)$ $Z = 4$

X-ray Powder Pattern: Synthetic.
4.327 (100), 4.079 (80), 3.273 (75), 7.07 (55), 5.48 (55), 4.998 (35), 3.691 (35)

Chemistry:

	(1)	(2)
SO_3	35.11	35.32
Al_2O_3	11.57	11.25
MgO	0.13	
Na_2O	0.21	
$(NH_4)_2O$	5.23	5.74
H_2O	47.82	47.69
insol.	0.06	
Total	100.13	100.00

(1) Wamsutter, Wyoming, USA. (2) $(NH_4)Al(SO_4)_2 \cdot 12H_2O$.

Occurrence: An uncommon secondary mineral in lignite and brown coal deposits and bituminous shales and on burning coal seams or waste heaps; as efflorescences around solfataras or geothermal gas vents and fumaroles.

Association: Gypsum, ammoniojarosite, epsomite, rostite, alunogen (shales and coals); boussingaultite, mascagnite, voltaite (The Geysers, California, USA).

Distribution: In the Czech Republic, from Čermníky (Tschermig), east of Kaaden, at Libušín, near Kladno, Zastávka, near Brno, and elsewhere in the brown coal basins near Most and Bílina. From Voinesti, Romania. At Magyarórosbánya, Hungary. In Italy, in the Cetine mine, 20 km southwest of Siena, and at Larderello, Val di Cecina, Tuscany; from the Solfatara di Pozzuoli, Campi Flegri, near Naples, Campania. On the Nyamlagira volcano, near Goma, Kivu Province, Congo (Zaire). In the Te Kopia geothermal field, New Zealand. In the USA, on burning coal waste piles at Glen Lyon, Luzerne Co., and Williamstown, Dauphin Co., Pennsylvania; from The Geysers, Sonoma Co., and at Sulfur Bank, Lake Co., California; from coal deposits about five km south of Wamsutter, Sweetwater Co., Wyoming. A number of additional minor localities are documented.

Name: For the locality near the former Tschermig, Czech Republic.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 475–476 [ammonia alum]. (2) Abdeen, A.M., G. Will, W. Schäfer, A. Kirfel, M.O. Bargouth, K. Recker, and A. Weiss (1981) X-ray and neutron diffraction study of alums. II. The crystal structure of methylammonium aluminium alum. III. The crystal structure of ammonium aluminium alum. Zeits. Krist., 157, 147–166. (3) (1956) NBS Circ 539, 6.

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Tschernichite $CaAl_2Si_6O_{16}\cdot 8H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Steep dipyramidal {302}, terminated by {001}, striated ‖ {001}, to 1 cm. Also as hemispherical to drusy aggregates. *Twinning:* Common, on {302}, {304}, and {101}, contact and multiple.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4.5
D(meas.) = 2.02 D(calc.) = 2.12 May show pale yellow fluorescence under SW and LW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (–), in part biaxial (–). $\omega = 1.484(1)$ $\epsilon = 1.483(1)$
2V(meas.) = 0°–35°

Cell Data: *Space Group:* $P4/mm$ (most probable). $a = 12.880(2)$ $c = 25.020(5)$ Z = 8

X-ray Powder Pattern: Goble, Oregon, USA.
4.03 (100), 11.6 (32), 3.156 (16), 2.114 (16), 3.062 (15), 4.22 (14), 12.5 (10)

Chemistry:

	(1)	(2)
SiO_2	54.09	65.77
Al_2O_3	15.43	14.44
FeO	0.26	n.d.
MgO	0.51	n.d.
CaO	8.27	6.58
Na_2O	0.22	0.00
K_2O	n.d.	0.06
H_2O^+	22.7	[13.15]
Total	101.48	[100.00]

(1) Goble, Oregon, USA; by electron microprobe, H_2O by loss of weight on heating; corresponds to $(Ca_{0.97}Mg_{0.08}Na_{0.05}Fe_{0.02})_{\Sigma=1.12}Al_{2.00}Si_{5.95}O_{16}\cdot 7.96H_2O$. (2) Do.; by electron microprobe, H_2O by difference; corresponds to $(Ca_{0.73}Na_{0.11}K_{0.02}Fe_{0.02})_{\Sigma=0.88}Al_{1.69}Si_{6.33}O_{16}\cdot 3.98H_2O$.

Mineral Group: Zeolite group.

Occurrence: In vesicles in an olivine basalt, formed by hydrothermal action.

Association: Zeolites, apophyllite, copper, quartz, aragonite, smectite.

Distribution: At Neer Road pit, Goble, Columbia Co., Oregon, USA.

Name: Honoring Rudy Warren Tschernich (1945–), amateur mineralogist specializing in zeolites, of Snohomish, Washington, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA.

References: (1) Boggs, R.C., D.G. Howard, J.V. Smith, and G.L. Klein (1993) Tschernichite, a new zeolite from Goble, Columbia County, Oregon. Amer. Mineral., 78, 822–826.

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Tsnigriite $Ag_9SbTe_3(S,Se)_3$

Crystal Data: Monoclinic. *Point Group*: 2/*m* or *m*. As irregular grains, to 0.1 mm, rarely with rhombic cross sections.

Physical Properties: *Cleavage*: None reported. *Tenacity*: n.d. *Fracture*: n.d.
Hardness = n.d. VHN = 125 (20 g load). D(meas.) = n.d. D(calc.) = 7.38

Optical Properties: Opaque (?). *Color*: n.d.; gray with a weak greenish blue tint in reflected light. *Streak*: n.d. *Luster*: Metallic. *Bireflectance*: Weak. *Anisotropism*: Brown and gray. *Optical Class*: n.d.
R_1-R_2: (470) 38.0–34.2, (546) 36.6–32.2, (589) 35.7–31.8, (650) 34.0–30.2

Cell Data: *Space Group*: *P2/m* or *Pm*. a = 8.89(1) b = 8.292(8) c = 19.50(1) β = 97.02(3)°
Z = 4

X-ray Powder Pattern: Bethumi, India.
2.20 (100), 3.78 (70), 4.26 (50), 2.89 (40), 2.85 (40), 2.29 (40), 2.10(40)

Chemistry:

	(1)	(2)
Ag	60.7	59.95
Cu		0.04
Pb		1.84
Sb	7.7	7.28
As		0.05
Bi		0.06
Te	24.4	25.25
S	5.2	6.08
Se	1.9	
Total	99.9	100.53

(1) Vysokovol'tnoye, Uzbekistan, average of 6 electron microprobe analyses, corresponding to $Ag_{8.99}Sb_{1.01}Te_{3.05}(S_{2.57}Se_{0.38})_{\sum=2.95}$. (2) Bethumi, India, average of 2 electron microprobe analyses, corresponding to $(Ag_{8.78}Pb_{0.14}Cu_{0.01})_{\sum=8.93}(Sb_{0.94}As_{0.01})_{\sum=0.95}Te_{3.13}S_{3.00}$.

Occurrence: In hydrothermal polymetallic gold silver or lead zinc deposits.

Association: Galena, sphalerite, pyrrhotite, falkmanite (Bethumi, India); hessite, mercurian gold, trellurian canfieldite or quartz, tetrahedrite, miargyrite (Vysokovol'tnoye, Uzbekistan).

Distribution: Vysokovol'tnoye deposit, western part of the south Tian Shan fold belt, Uzbekistan, and the Bethumi deposit, Rajasthan, India.

Name: An acronym derived from the initials of the Russian name for the Central Scientific Research Institute of Geological Prospecting in Moscow.

Type Material: A.E. Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow.

References: (1) Sandomirskaya, S.M., Ch. Kh. Arifulov, M.M. Botova, N.N. Mozgova, S.N. Nenasheva, A.I. Tsepin, A.V. Sivtsov (1992) Tsnigriite $Ag_9SbTe_3(S,Se)_3$: a new mineral. Zapiski Vses. Mineral. Obsch., l2l, 95-l0l (in Russian). (2) (1994) Amer. Mineral., 79, 389-390 (abs. ref. 1).

Tsumcorite $\mathbf{Pb(Zn,Fe^{3+})_2(AsO_4)_2(OH,H_2O)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are prismatic, elongated along [010], wedge-shaped, showing {201}, {401}, {001}, {111}, to 5 mm, in radiating sheaves and spherulites, may be feathery, aggregated into crusts, earthy, powdery. *Twinning:* Common, on a unknown law.

Physical Properties: *Cleavage:* On {001}, good. Hardness = 4.5 D(meas.) = 5.2 D(calc.) = 5.39

Optical Properties: Semitransparent. *Color:* Bright yellow, orange, yellowish brown, red, red-brown. *Streak:* Yellow. *Luster:* Vitreous.
Optical Class: Biaxial. *Pleochroism:* Weak; $X = Z$ = pale yellow; Y = yellow. *Orientation:* $Y = b$; $X \wedge c = 8°$–$15°$. *Dispersion:* $r > v$, weak. $\alpha = 1.87$–1.91 $\beta = 1.89$–1.93 $\gamma = 1.92$–1.96 2V(meas.) = 67°–83.5°

Cell Data: *Space Group:* $C2/m$. $a = 9.117$–9.163 $b = 6.321$–6.347 $c = 7.577$–7.611 $\beta = 115.07°-115.45°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.244 (100), 4.663 (90), 2.863 (90), 2.742 (70), 3.021 (60), 2.573 (50), 2.540 (40)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
As_2O_5	34.80	36.20	CuO	1.50	0.15	CaO	0.98	< 0.1
Fe_2O_3		10.62	ZnO	14.69	14.97	H_2O	4.40	[4.44]
FeO	10.99		PbO	31.66	33.39	Total	99.13	[99.77]
Ge	0.09		MgO	0.02				

(1) Tsumeb, Namibia; H_2O confirmed by IR. (2) Do.; by electron microprobe, average of 19 analyses, total Fe as Fe_2O_3, confirmed by IR and Mössbauer spectroscopy, H_2O from theory; corresponds to $Pb_{0.95}(Zn_{1.17}Fe_{0.85})_{\Sigma=2.02}(AsO_4)_{2.01}[(OH)_{0.70}(H_2O)_{1.17}]_{\Sigma=1.87}$.

Mineral Group: Tsumcorite group.

Occurrence: A rare secondary mineral in the oxidized zone of some arsenic-bearing hydrothermal Pb–Zn deposits.

Association: Willemite, smithsonite, mimetite, scorodite, anglesite, arseniosiderite, beaverite, beudantite, carminite, ludlockite, o'danielite, zincroselite, stranskiite, leiteite (Tsumeb, Namibia); adamite, mimetite, smithsonite, goethite, quartz (Puttapa mine, Australia).

Distribution: From Tsumeb, Namibia. At Thasos, Greece. In Germany, from the Michael mine, Weiler, near Lahr, and the Clara mine, near Oberwolfach, Black Forest; and at the Rappold mine and a dump on the Roter Berg, Schneeberg, Saxony. In Mexico, from Mina Ojuela, Mapimí, Durango; at Las Animas, near Benjamin Hill, Sonora. In the USA, from the Richmond-Sitting Bull mine, Galena, Lawrence Co., South Dakota; in the Centennial Eureka mine, Tintic district, Juab Co., Utah. In Australia, at the Puttapa zinc mine, near Beltana, South Australia; from Broken Hill, New South Wales; at the Anticline prospect, 11 km west-southwest of Ashburton Downs homestead, Capricorn Range, Western Australia.

Name: In recognition of the TSUMeb CORporation's support of mineralogical investigations of the Tsumeb, Namibia orebody.

Type Material: n.d.

References: (1) Geier, B.H., K. Kautz, and G. Müller (1971) Tsumcorit(e) $[PbZnFe(AsO_4)_2]\cdot H_2O$, ein neues Mineral aus den Oxidationszonen der Tsumeb-Mine, Südwestafrika. Neues Jahrb. Mineral., Monatsh., 304–309 (in German with English abs.). (2) (1972) Amer. Mineral., 57, 1558 (abs. ref. 1). (3) Tillmanns, E. and W. Gebert (1973) The crystal structure of tsumcorite, a new mineral from the Tsumeb mine, S.W. Africa. Acta Cryst., 29, 2789–2794. (4) Krause, W., K. Belendorff, H.-J. Bernhardt, C. McCammon, H. Effenberger, and W. Mikenda (1998) Crystal chemistry of the tsumcorite-group minerals. New data on ferrilotharmeyerite, tsumcorite, thometzekite, mounanaite, helmutwinklerite, and a redefinition of gartrellite. Eur. J. Mineral., 10, 179–206.

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Tsumebite $Pb_2Cu(PO_4)(SO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically well crystallized, platy, with large {110}, {101}, narrow {100}, many minor forms, to 3 mm. *Twinning:* Always twinned on $\{\overline{1}22\}$, may be multiple, with serrated re-entrants oscillatory between {011} and $\{\overline{1}04\}$.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5
D(meas.) = 6.01–6.13 D(calc.) = 6.22

Optical Properties: Transparent. *Color:* Emerald-green, bluish green; green in transmitted light. *Luster:* Vitreous, brilliant.
Optical Class: Biaxial (+). *Pleochroism:* Faint; $X = Y$ = very pale blue to colorless; Z = robin's-egg-blue. *Dispersion:* $r < v$, strong. *Absorption:* $Z > X$. $\alpha = 1.885$–1.900 $\beta = 1.920$ $\gamma = 1.943$–1.956 2V(meas.) = ∼90°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.70$ $b = 5.80$ $c = 7.85$ $\alpha = 111.5°$ Z = 2

X-ray Powder Pattern: Otavi mine, Southwest Africa [=Tsumeb, Namibia]; close to arsentsumebite. (ICDD 29-568).
3.24 (100), 2.897 (65), 2.936 (35), 2.718 (35), 2.267 (35), 4.70 (30), 2.619 (25)

Chemistry:

	(1)	(2)
SO_3	n.d.	11.67
P_2O_5	10.26	10.35
CuO	11.97	11.60
PbO	65.09	65.07
H_2O	n.d.	1.31
Total		100.00

(1) Tsumeb, Namibia. (2) $Pb_2Cu(PO_4)(SO_4)(OH)$.

Mineral Group: Brackebuschite group.

Occurrence: A rare secondary mineral in the oxidized zone of some arsenic-bearing Pb–Cu deposits.

Association: Azurite, smithsonite, malachite, cerussite, mimetite, wulfenite, olivenite.

Distribution: From Tsumeb, Namibia. At Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). In the USA, in Arizona, at Morenci, Greenlee Co.; from the Mammoth-St. Anthony mine, Tiger, Pinal Co.; from the Mex-Tex mine, near Bingham, Hansonburg district, Socorro Co., New Mexico; on the Blue Bell claims, near Baker, San Bernardino Co., California; in the Black Pine mine, near Philipsburg, Granite Co., Montana. From Roughton Gill, Carrock Fell, Cumbria, England. At Altenmittlau, Hesse, and in the Clara mine, near Oberwolfach, Black Forest, Germany. From Broken Hill, New South Wales, Australia.

Name: For its first-noted occurrence at Tsumeb, Namibia.

Type Material: Destroyed by bombing.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 918–919. (2) Bideaux, R.A., M.C. Nichols, and S.A. Williams (1966) The arsenate analog of tsumebite, a new mineral. Mineral. Soc. Amer. Annual Meeting. Amer. Mineral., 51, 258–259 (abs.). (3) Nichols, M.C. (1966) The structure of tsumebite. Mineral. Soc. Amer. Annual Meeting. Amer. Mineral., 51, 267 (abs.). (4) Fanfani, L. and P.F. Zanazzi (1967) Structural similarities of some secondary lead minerals. Mineral. Mag., 36, 522–529. (5) Schlüter, J., G. Gebhard, and G. Wappler (1994) Tsumebit oder Arsentsumebit aus Tsumeb? Lapis, 19(10), 31–34, 86 (in German).

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Tsumoite BiTe

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As hexagonal plates, commonly rounded, to 5 mm, in irregular aggregates.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. VHN = 51–90 (15 g load). D(meas.) = 8.16(5) D(calc.) = 8.23

Optical Properties: Opaque. *Color:* Silver-white; in polished section, white with a creamy tint. *Streak:* Steel-gray. *Luster:* Metallic. *Pleochroism:* Very weak. *Anisotropism:* Moderate.

R_1–R_2: (400) 61.0–62.2, (420) 61.1–62.3, (440) 61.2–62.4, (460) 61.3–62.7, (480) 61.4–63.1, (500) 61.5–63.4, (520) 61.6–63.8, (540) 61.7–64.2, (560) 61.9–64.6, (580) 62.2–65.0, (600) 62.5–65.4, (620) 62.7–65.7, (640) 63.0–65.9, (660) 63.1–66.0, (680) 63.2–66.1, (700) 63.3–66.2

Cell Data: *Space Group:* $P\overline{3}m1$. $a = 4.422(2)$ $c = 24.05(2)$ $Z = 6$

X-ray Powder Pattern: Tsumo mine, Japan.
3.23 (vs), 2.36 (s), 2.21 (s), 1.825 (s), 1.487 (s), 2.01 (m), 1.617 (m)

Chemistry:

	(1)	(2)
Bi	61.1	62.09
Pb	1.0	
Te	37.6	37.91
Total	99.7	100.00

(1) Tsumo mine, Japan; by electron microprobe, corresponding to $(Bi_{0.99}Pb_{0.02})_{\Sigma=1.01}Te_{1.00}$.
(2) BiTe.

Occurrence: In massive Ni–Cu–PGE deposits; in Cu–Zn–Pb deposits, with sulfosalts, formed at lower temperatures.

Association: Pentlandite, chalcopyrite, pyrrhotite, sperrylite, parkerite, maucherite, michenerite, tetradymite, pilsenite, cosalite, altaite, bismuthinite, galena.

Distribution: From Japan, in the Tsumo mine, about 50 km northwest of Hiroshima City, Shimane Prefecture [TL]. At the Dashuigou tellurium deposit, Sichuan Province, China. In the Ban Phuc deposit, northwestern Vietnam. From the Kolar Gold Fields, Karnataka, India. In Russia, at the Tyrnyauz W–Mo deposit, left bank of the Baksan River Valley, northern Caucasus Mountains; in the Alekseevskoye mine, Sutam district, Stanovoi Range, southeast Sakha. From the Ransko massif, about 18 km east-northeast of Havlíčkův Brod, Czech Republic. At Úhorná, Slovakia. From the Bjorkdal gold mine, Vasterbotten, and at Tunaberg, Sweden. From Sylvanite, Hidalgo Co., New Mexico, USA. In the Copper Cliff South mine, Sudbury, Ontario, Canada. A few additional poorly located localities are known.

Name: For the Tsumo mine, Japan, where it was first found.

Type Material: University Museum, University of Tokyo, Tokyo, Japan.

References: (1) Shimazaki, H. and T. Ozawa (1978) Tsumoite, BiTe, a new mineral from the Tsumo mine, Japan. Amer. Mineral., 63, 1162–1165. (2) Vavřín, I. and J. Frýda (1998) Michenerite PdBiTe and froodite $PdBi_2$ from the Cu–Ni mineralization in the Ransko massif, Czech Republic. Mineral. Petrol., 63, 141–146. str?? (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 584.

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Tubulite ~ $Ag_2Pb_{22}Sb_{20}S_{53}$

Crystal Data: Monoclinic. *Point Group*: *m* or 2/*m*. Forms hollow thin-walled cylinders, to 600 μm, or fibrous.

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: Non-plastic. Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color*: Black. *Streak*: n.d. *Luster*: Metallic.
Optical Class: n.d.

Cell Data: *Space Group*: *Pc*, *P*2/*c* or *P*2_1/*c*. a = 4.132(2) b = 43.1(2) c = 27.4(1) β = 93.2° Z = 2

X-ray Powder Pattern: Le Rivet quarry, France.
3.36 (100), 2.063 (75), 3.69 (60), 3.28 (55), 2.99 (55), 2.912 (55), 3.99 (35)

Chemistry:

	(1)
Ag	2.7
Pb	46.6
Sb	26.1
S	17.8
Total	93.2

(1) Biò, Italy; average of 8 electron microprobe analyses, microprobe analysis did not reveal any other elements (Z >10) in significant amount, low analytical total ascribed to thinness of sample material; corresponding to ~ $Ag_2Pb_{22}Sb_{20}S_{53}$.

Occurrence: In sulfide and sulfosalt-bearing veins of quartz, barite, calcite, dolomite and siderite, cutting metamorphosed volcano-sedimentary rocks (Le Rivet, France) or in metamorphosed clastic sedimentary rocks (Biò, Italy).

Association: Galena, boulangerite (Le Rivet); geocronite, bournonite, fizélyite (Biò).

Distribution: At the Le Rivet quarry, Peyerebrune Pb-Zn-Ag ore field, 6 km E-SE of Réalmont, on the commune of Montredon-Labessonié, Tarn department, France, and at Biò, in the upper galleries (Veneziana and Torinese) of the Pb-Ag-As-Sb Borgofranco mines, near Borgofranco d'Ivrea, 50 km north of Turin, Piedmont, Italy.

Name: For its appearance, as it occurs as thin micro-tubes.

Type Material: Specimens from Le Rivet quarry are in the Museum of Mineralogy, École Nationale Supérieure des Mines de Paris, France (M 82939); from Biò in the Museo Regionale di Scienze Naturali, Turin (# 15905), and the Museo di Storia Naturale, Università di Pisa, Italy (# 19630); and in the Musée Cantonal de Géologie, Université-Anthropole, Switzerland (MGL#92635).

References: (1) Moëlo, Y., R. Pecorini, M.E. Ciriotti, N. Meisser, M.T. Caldes, P. Orlandi, P-E. Petit, B. Martini, and A. Salvetti (2013) Tubulite, ~$Ag_2Pb_{22}Sb_{20}S_{53}$, a new Pb-Ag-Sb sulfosalt from Le Rivet quarry, Peyrebrune ore field (Tarn, France) and Biò, Borgofranco mines, Borgofranco d'Ivrea (Piedmont, Italy). European Journal of Mineralogy, 25, 1017-1030. (2) (2014) Amer. Mineral., 99, 1811-1812 (abs. ref. 1).

Tučekite $Ni_9Sb_2S_8$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As rims and irregular grains, to 20 μm, partly replacing millerite and gold.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 718 (20 g load). D(meas.) = n.d. D(calc.) = 6.15

Optical Properties: Opaque. *Color:* Pale brass-yellow; in polished section, brownish yellow. *Luster:* Metallic. *Pleochroism:* Very weak to absent. *Anisotropism:* Very strong to distinct; deep brown to grayish blue.

R_1–R_2: (400) 37.5–38.2, (420) 38.0–39.4, (440) 38.6–41.0, (460) 39.5–42.5, (480) 40.7–44.0, (500) 42.3–45.6, (520) 44.0–47.0, (540) 45.4–48.0, (560) 46.6–48.8, (580) 47.6–49.4, (600) 48.4–50.1, (620) 49.2–50.7, (640) 49.9–51.4, (660) 50.6–52.0, (680) 51.2–52.6, (700) 51.8–53.1

Cell Data: *Space Group:* $P4/mmm$. $a = 7.174(6)$ $c = 5.402(7)$ $Z = 1$

X-ray Powder Pattern: Witwatersrand, South Africa.
2.76 (100), 2.38 (80), 2.28 (80b), 1.850 (80), 4.33 (70), 1.793 (70), 3.21 (60)

Chemistry:

	(1)	(2)	(3)
Ni	47.34	47.8	51.38
Co	1.06		
Fe	3.61	3.75	
As	0.86	1.34	
Sb	21.62	21.87	23.68
Bi	1.84	1.02	
Te	0.30		
S	25.19	25.13	24.94
Total	101.81	100.91	100.00

(1) Kanowna, Australia; by electron microprobe, selected representative values; corresponding to $(Ni_{8.21}Fe_{0.66}Co_{0.18})_{\Sigma=9.05}(Sb_{1.81}As_{0.12}Bi_{0.09}Te_{0.02})_{\Sigma=2.04}S_{8.00}$. (2) Witwatersrand, South Africa; by electron microprobe, average of a range of measurements, corresponding to $(Ni_{8.31}Fe_{0.69})_{\Sigma=9.00}(Sb_{1.83}As_{0.18}Bi_{0.05})_{\Sigma=2.06}S_{8.00}$. (3) $Ni_9Sb_2S_8$.

Mineral Group: Hauchecornite group.

Occurrence: In a hydrothermal deposit (Kanowna, Australia); in heavy mineral concentrates (Witwatersrand, South Africa); in serpentinites (Vozhmin massif, Russia).

Association: Millerite, pyrite, chalcopyrite, gersdorffite, pentlandite, magnetite, polydymite (Kanowna, Australia); gold, dyscrasite, michenerite, geversite, tetrahedrite, stibnite, sudburyite, stibiopalladinite (Klerkdorp, South Africa); vozhminite, heazlewoodite, nickeline, maucherite, melonite, cobaltite, gersdorffite, magnetite, geversite, copper, silver (Vozhmin massif, Russia).

Distribution: From Kanowna, north of Kalgoorlie [TL], and in the Whim Creek copper deposit, Pilbara district, Western Australia; at the Central Balstrup lease, Zeehan, Tasmania. In South Africa, from the Witwatersrand, in the Vaal Reefs mine, Klerkdorp. In the Vozhmin massif, Segezha district, central Karelia, Russia. From the Kapitanov chromite deposit, near Zvenyhorodka, Ukraine. At Rocheservières, Vendée, France.

Name: Honors Dr. Karel Tuček (1906–1990), Curator of Minerals in the National Museum, Prague, Czech Republic.

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Type Material: Museum Victoria, Melbourne, Australia, M34238; National School of Mines, Paris, France; The Natural History Museum, London, England, 1979,6; National Museum of Natural History, Washington, D.C., USA, 146920, 146921.

References: (1) Just, J. and C.E. Feather (1978) Tučekite, a new mineral. Mineral. Mag., 42, M21–M22. (2) (1979) Amer. Mineral., 64, 465 (abs. ref. 1). (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 585.

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Tugarinovite $Mo^{4+}O_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, prismatic to thick tabular, striated ‖ length, subangular, to 1.5 mm. *Twinning:* Typical, polysynthetic, on an unknown law.

Physical Properties: Hardness = 4.6 VHN = 300 (20 g load). D(meas.) = n.d. D(calc.) = 6.58

Optical Properties: Semitransparent. *Color:* Dark lilac-brown. *Streak:* Greenish gray. *Luster:* Greasy to metallic.
Optical Class: Biaxial. *Anisotropism:* Light gray to dark pink; pale yellow to bluish olive-brown. *Bireflectance:* Observed.
R_1–R_2: (440) 16.8–27.5, (460) 15.5–24.9, (480) 14.9–23.1, (500) 14.6–21.7, (520) 14.5–20.9, (540) 14.7–20.3, (560) 16.2–19.9, (580) 19.7–18.7, (600) 21.3–19.6, (620) 24.6–19.6, (640) 27.6–19.9, (660) 30.7–19.6, (680) 33.9–21.7, (700) 37.2–23.2

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy to synthetic material). $a = 5.59(1)$ $b = 4.82(1)$ $c = 5.51(1)$ $\beta = 119°32'$ Z = 4

X-ray Powder Pattern: Lenskoye Mo–U deposit, Russia.
3.391 (100), 2.412 (8), 1.703 (8), 1.716 (6), 1.398 (6), 1.077 (5), 2.388 (4)

Chemistry: (1) Lenskoye Mo–U deposit, Russia; by electron microprobe, average of five analyses MoO_2 99.86%, with traces of Fe, Ti, Ca, Si.

Occurrence: Formed as a primary mineral, by metasomatism in a reducing environment deficient in sulfur.

Association: Uraninite, molybdenite, galena, zircon, wulfenite.

Distribution: From the Lenskoye Mo–U deposit, Amur district, eastern Siberia, Russia.

Name: For Aleksei Ivanovich Tugarinov (1917–1977), geochemist, Moscow University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81395.

References: (1) Kruglova, V.G., A.A. Poteryaikina, G.A. Sidorenko, L.S. Dubakina, and Y.G. Ryabeva (1980) Tugarinovite (MoO_2) – a new hypogene molybdenum mineral. Zap. Vses. Mineral. Obshch., 109, 465–468 (in Russian). (2) (1981) Amer. Mineral., 66, 438–439 (abs. ref. 1). (3) Kruglova, V.G., G.A. Sidorenko, Y.G. Ryabeva, A.A. Poteryaikina, and L.S. Dubakina (1984) New data on tugarinovite. Doklady Acad. Nauk SSSR, 264, 689–693 (in Russian). (4) Bolzan, A.A., B.J. Kennedy, and C.J. Howard (1995) Neutron powder diffraction study of molybdenum and tungsten dioxides. Aust. J. Chem., 48, 1473–1477.

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Tugtupite $Na_4AlBeSi_4O_{12}Cl$

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Crystal Data: Tetragonal, pseudocubic. *Point Group:* $\bar{4}$, $\bar{4}2m$ based on morphology. As short tetragonal prisms with pyramids, sphenoids, and bisphenoids, to 3 mm; fine-grained aggregates, massive. *Twinning:* Penetration twinning on (101) produces pseudocubic triplets; pseudotrigonal contact twins with composition planes $(10\bar{1})$ and $(01\bar{1})$.

Physical Properties: *Cleavage:* Distinct on {101}, fair on {110}. *Fracture:* Conchoidal. Hardness = ∼4 D(meas.) = 2.33(1) D(calc.) = 2.34–2.35 Piezoelectric; fluorescent and phosphorescent red to rose-pink under UV; photochromic, pale colors become pink on exposure to sunlight or X-rays.

Optical Properties: Transparent to translucent. *Color:* White, pink, carmine, bluish, greenish; colorless in thin section. *Luster:* Vitreous.
Optical Class: Uniaxial (+); anomalously biaxial. *Pleochroism:* Weak violet to weak red-orange. $\omega = 1.492–1.496$ $\epsilon = 1.499–1.502$ $2V(meas.) = < 10°$

Cell Data: *Space Group:* $I\bar{4}$. $a = 8.640(1)$ $c = 8.873(1)$ $Z = 2$

X-ray Powder Pattern: Tugtup agtakôrfia, Greenland.
3.52 (100), 6.13 (80), 3.57 (60), 2.497 (60), 2.023 (60), 4.40 (40), 2.331 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	51.58	50.45	51.38	Na_2O	25.52	23.26	26.50
Al_2O_3	11.15	12.56	10.90	K_2O	0.12	0.40	
Fe_2O_3	trace			Cl	7.28	6.04	7.58
Ga_2O_3		0.04		H_2O^+		1.50	
BeO	5.40	5.30	5.35	H_2O^-	0.03	1.51	
MgO	0.20			S	0.33		
CaO		0.50		$-O = Cl_2, S_2$	1.99	1.37	1.71
				Total	99.62	100.19	100.00

(1) Ilímaussaq intrusion, Greenland. (2) Lovozero massif, Russia. (3) $Na_4AlBeSi_4O_{12}Cl$.

Occurrence: Replaces chkalovite in hydrothermal veins cutting sodalite syenite and syenite (Ilímaussaq intrusion, Greenland); an alteration product in pegmatites in a differentiated alkalic massif (Lovozero massif, Russia).

Association: Albite, analcime, aegirine, natrolite, tetranatrolite, chkalovite, lithian mica, epistolite, niobophyllite, monazite, rhabdophane, gerasimovskite, nenadkevichite, beryllite.

Distribution: In Greenland, in the Ilímaussaq intrusion, at Tugtup agtakôrfia, around the Tunugdliarfik Fjord and on the Kangerdluarssuk Plateau; on Qeqertaussaq Island; in the Gletscherelv Valley; and on the Kvanefjeld and Taseq Plateaus. From Mts. Sengischorr and Punkaruaiv, Lovozero massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For the occurrence at Tugtup agtakôrfia, Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1970.276; The Natural History Museum, London, England, 1967,394.

References: (1) Sørenson, H. (1962) On the occurrence of steenstrupine in the Ilimaussaq massif, southwest Greenland. Medd. om Grønland, 167(1), 1–251, esp. 218–219. (2) (1963) Amer. Mineral., 48, 1178 (abs. ref. 1). (3) Danø, M. (1966) The crystal structure of tugtupite – a new mineral, $Na_8Al_2Be_2Si_8O_{24}(Cl,S)_2$. Acta Cryst., 20, 812–816. (4) Sørensen, H., M. Danø, and O.V. Petersen (1971) On the mineralogy and paragenesis of tugtupite. Grønlands Geologiske Undersøgelse Bull. 95, 38 p. (5) Petersen, O.V. (1978) The twin formation of tugtupite, a contribution. Mineral. Mag., 42, 251–254. (6) Hassan, I. and H.D. Grundy (1991) The crystal structure and thermal expansion of tugtupite, $Na_8[Al_2Be_2Si_8O_{24}]Cl_2$. Can. Mineral., 29, 385–390.

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Tuhualite $(Na,K)Fe^{2+}Fe^{3+}Si_6O_{15}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. In well-formed tabular crystals, flattened on {100}, with pyramidal terminations, to 1.5 mm. Also as irregular mosslike aggregates.

Physical Properties: *Cleavage:* Three good, on {100}, {001}, and {010}. *Tenacity:* Very brittle. Hardness = 3–4 D(meas.) = 2.89(2) D(calc.) = 2.86

Optical Properties: Semitransparent. *Color:* Violet.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = colorless to very pale pink; Y = violet or lavender; Z = intense purplish blue. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, strong. *Absorption:* $Z > Y \gg X$. $\alpha = 1.608(1)$ $\beta = 1.612$ $\gamma = 1.621(3)$ 2V(meas.) = 70°–91°

Cell Data: *Space Group: Cmca.* a = 14.31(3) $b = 17.28(3)$ $c = 10.11(3)$ Z = 1

X-ray Powder Pattern: Mayor Island, New Zealand.
7.16 (100), 2.766 (90), 3.18 (80), 8.62 (70), 5.515 (70), 4.85 (70), 4.35 (70)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	62.93	67.2	66.37	CaO	trace	0.17	
TiO_2	0.42	0.04		Na_2O	7.11	6.3	5.71
ZrO_2		0.03		K_2O	1.74	0.8	
Al_2O_3	0.63	0.22		F		< 0.1	
Fe_2O_3	14.09		14.70	Cl		< 0.05	
FeO	9.58	24.0	13.22	H_2O^+	1.61		
MnO	0.81	0.55		H_2O^-	0.38		
MgO	0.42	trace		Total	99.72	99.3	100.00

(1) Mayor Island, New Zealand. (2) Do.; by electron microprobe. (3) $NaFe^{2+}Fe^{3+}Si_6O_{15}$.

Occurrence: A primary igneous mineral and in vesicles of some silicic lavas, as comendites and pantellerites.

Association: Alkalic feldspar, quartz, aegirine, riebeckite, aenigmatite, arfvedsonite.

Distribution: From Mayor Island, near Opo Bay, New Zealand.

Name: For the type locality, Mayor Island, New Zealand, which is called *Tuhua* by the native Maori.

Type Material: Geological Survey of New Zealand, Lower Hutt, New Zealand, P2077; National Museum of Natural History, Washington, D.C., USA, 96879, 96880, 103053, 136507.

References: (1) Marshall, P. (1932) Notes on some volcanic rocks of the North Island of New Zealand. New Zealand J. Sci. Tech., 13, 202. (2) (1933) Amer. Mineral., 18, 180 (abs. ref. 1). (3) Hutton, C.O. (1956) Re-examination of the mineral tuhualite. Mineral. Mag., 31, 96–106. (4) (1956) Amer. Mineral., 41, 959 (abs. ref. 3). (5) Nicholls, J. and J.S.E. Carmichael (1969) Peralkaline acid liquids: a petrological study. Contr. Mineral. Petrol., 20, 268–294. (6) Merlino, S. (1969) Tuhualite crystal structure. Science, 166, 1399–1401.

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Tulameenite Pt_2FeCu

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2m$. As rounded to irregular grains, to 0.4 mm, which may have complex inclusions, typically associated with Pt–Fe alloys.

Physical Properties: Hardness = n.d. VHN = 420–456, 442 average (50 g load). D(meas.) = 14.9 (synthetic). D(calc.) = 15.62 Distinctly ferromagnetic.

Optical Properties: Opaque. *Color:* White in reflected light. *Luster:* Metallic. *Anisotropism:* Very weak.
R_1–R_2: (470) 61.0–65.3, (546) 60.0–66.5, (589) 61.5–65.5, (650) 61.1–64.9

Cell Data: *Space Group:* $P4/mmm$. $a = 3.891(2)$ $c = 3.577(2)$ $Z = 1$

X-ray Powder Pattern: Tulameen River, Canada.
2.179 (100), 1.163 (80), 1.093 (80), 1.946 (70), 1.016 (60), 1.317 (50), 2.753 (40)

Chemistry:

	(1)	(2)	(3)
Pt	73.98	76.7	76.57
Ir	1.99		
Fe	10.38	10.6	10.96
Cu	13.13	7.0	12.47
Ni	n.d.	3.8	
Sb	n.d.	2.1	
Total	99.48	100.2	100.00

(1) Similkameen River area, Canada; by electron microprobe, corresponding to $(Pt_{1.94}Ir_{0.06})_{\Sigma=2.00}Fe_{1.06}Cu_{0.94}$. (2) Tulameen River area, Canada; by electron microprobe, corresponding to $Pt_{2.04}Fe_{0.98}(Cu_{0.56}Ni_{0.54}Sb_{0.08})_{\Sigma=1.18}$. (3) Pt_2FeCu.

Occurrence: In placers (Canada); in Uralian ultramafics (Nizhni Tagil, Russia); in Cu–Ni–PGM deposits in dunite-troctolite-gabbro (Ioko-Dovyren massif, Russia).

Polymorphism & Series: Forms a series with ferronickelplatinum.

Association: Pt–Fe alloys, geversite, chalcopyrite, chromite, magnetite.

Distribution: In Canada, from placers in the Tulameen and Similkameen River areas, British Columbia [TL]. In the Stillwater complex, Montana, and in the Salmon River placers, Goodnews Bay, Alaska, USA. From Guma Water, Sierra Leone. At Yubdo, Ethiopia. In Russia, from Nizhni Tagil, Ural Mountains; in a placer in the Upper Miask River, Southern Ural Mountains; in the Ioko-Dovyren massif, northern Baikal region, Siberia; at the Konder massif, Aldan Shield, Sakha.

Name: For the Tulameen River, Canada, from the vicinity of which the mineral was first noted.

Type Material: Royal Ontario Museum, Toronto, Canada, M33256; National Museum of Natural History, Washington, D.C., USA, 128460.

References: (1) Cabri, L.J., D.R. Owens, and J.H.G. Laflamme (1973) Tulameenite, a new platinum–iron–copper mineral from placers in the Tulameen River area, British Columbia. Can. Mineral., 12, 21–25. (2) (1974) Amer. Mineral., 59, 383–384 (abs. ref. 1). (3) Shahmiri, M., S. Murphy, and D.J. Vaughn (1985) Structural and phase equilbria studies in the system Pt-Fe-Cu and the occurrence of tulameenite (Pt_2FeCu). Mineral. Mag., 49, 547–554. [ck Z=1 here and for tetraferroPt and ferronickelPt??vs Strunz??] (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 145.

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Tuliokite $Na_6BaTh(CO_3)_6 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As prismatic to rhombohedral crystals, to 4 mm, dominated by $\{10\overline{1}0\}$ and $\{10\overline{1}1\}$.

Physical Properties: *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 3.15(1) D(calc.) = 3.25 Radioactive.

Optical Properties: Translucent. *Color:* Pale to dark gray, due to included organic matter; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.574(2)$ $\epsilon = 1.587(2)$

Cell Data: *Space Group:* $R\overline{3}$. $a = 14.175(7)$ $c = 8.605(4)$ Z = 3

X-ray Powder Pattern: Khibiny massif, Russia.
2.354 (100), 2.674 (90), 7.03 (85), 3.15 (80), 1.959 (65), 4.07 (60), 2.039 (60)

Chemistry:

	(1)	(2)
CO_2	[25.5]	27.07
ThO_2	24.3	27.07
Fe_2O_3	0.4	
CaO	0.1	
BaO	14.6	15.72
Na_2O	17.9	19.06
H_2O	14.0	11.08
Total	[96.8]	100.00

(1) Khibiny massif, Russia; by electron microprobe, total Fe as Fe_2O_3, CO_2 calculated from stoichiometry, H_2O by coulometry, crystal-structure analysis indicates $6H_2O$; presence of CO_2 and H_2O confirmed by IR; then corresponds to $Na_{5.99}(Ba_{0.99}Ca_{0.02})_{\Sigma=1.01}(Th_{0.95}Fe_{0.05})_{\Sigma=1.00}(CO_3)_{6.01} \cdot 8.06H_2O$. (2) $Na_6BaTh(CO_3)_6 \cdot 6H_2O$.

Occurrence: In hydrothermal veins in nepheline syenite pegmatite.

Association: Sidorenkite, vinogradovite, villiaumite, microcline (vein 1); pirssonite, shortite, trona, thermonatrite, natron, villiaumite, natrolite, aegirine, microcline (vein 2).

Distribution: From the Kirov apatite mine, Mt. Kukisvumchorr, Khibiny massif, Kola Peninsula, Russia.

Name: For the Tuliok River, Kola Peninsula, Russia, near where the mineral was first found.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5947; Mining Institute, St. Petersburg, 2024/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, r430/2.

References: (1) Yakovenchuk, V.N., Y.A. Pakhomovskii, A.V. Voloshin, A.N. Bogdanova, N.A. Yamnova, and D.Y. Pushcharovskiy (1990) Tuliokite $Na_6BaTh(CO_3)_6 \cdot 6H_2O$ – a new hydrous carbonate of sodium, barium, and thorium from alkalic pegmatites of the Khibiny massif (Kola Peninsula). Mineral. Zhurnal, 12, 74–78 (in Russian with English abs.). (2) (1992) Amer. Mineral., 77, 209 (abs. ref. 1). (3) Yanova, N.A, D.Y. Pushcharovskiy, and A.V. Voloshin (1990) Crystal structure of tuliokite – a new sodium, barium, thorium carbonate. Doklady Acad. Nauk SSSR, 310, 99–102 (in Russian). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 217.

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Tundrite-(Ce) $Na_3(Ce,La)_4(Ti,Nb)_2(SiO_4)_2(CO_3)_3O_4(OH)\cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals acicular along [001] and flattened on {010}, to 3 cm; as stellate groups and spherulitic masses. *Twinning:* On {010}, producing pseudorhombohedra.

Physical Properties: *Cleavage:* Pronounced on {010}. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 3.70–4.12 D(calc.) = 4.06

Optical Properties: Transparent. *Color:* Brownish yellow, greenish yellow to bright light green. *Streak:* Yellowish gray. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = pale yellow; Z = greenish yellow.
Orientation: $Z \wedge c = 4°–14°$. $\alpha = 1.743$ $\beta = 1.80$ $\gamma = 1.88$ 2V(meas.) = 76°

Cell Data: *Space Group:* $P1$. $a = 7.533(4)$ $b = 13.924(6)$ $c = 5.010(2)$ $\alpha = 99°52(2)'$ $\beta = 70°50(3)'$ $\gamma = 100°59(2)'$ Z = 1

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
13.49 (100), 2.505 (100), 3.448 (90), 2.766 (90), 3.535 (80), 6.784 (70), 1.914 (70)

Chemistry:

	(1)
SiO_2	10.03
TiO_2	12.20
La_2O_3	8.57
Ce_2O_3	24.38
Nd_2O_3	10.25
RE_2O_3	5.80
Nb_2O_5	3.44
CaO	0.75
Na_2O	8.20
CO_3	16.38
Total	[100.00]

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, C confirmed by loss on ignition; original analysis given as elements, here recalculated to oxides, corresponding to $Na_{3.17}(Ce_{1.78}Nd_{0.73}La_{0.63}RE_{0.41}Ca_{0.16})_{\Sigma=3.71}(Ti_{1.83}Nb_{0.31})_{\Sigma=2.14}(SiO_4)_{2.00}(CO_3)_{3.27}O_{4.25}$.

Occurrence: In pegmatite veins associated with nepheline syenites.

Association: Aegirine, lamprophyllite, lorenzenite, rhabdophane (Mt. Lepkhe-Nelm, Russia); natrolite, microcline, albite, aegirine, fluorite, rinkite, eudialyte (Ilímaussaq intrusion, Greenland).

Distribution: On Mt. Lepkhe-Nelm, Lovozero massif, Kola Peninsula, Russia. In southern Greenland, from the Ilímaussaq intrusion, at Kringlerne, on the Kangerdluarssuk Plateau, and at Kvanefjeld. From Mont Saint-Hilaire, Quebec, Canada.

Name: After the Lovozero massif (formerly the Lovozero tundra), Kola Peninsula, Russia, where it was discovered, and the *cerium* content.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72020.

References: (1) Semenov, E.I. (1963) Mineralogy of the rare earths. Izdatelstvo Akad. Nauk SSSR, Moscow, 209–210 (in Russian). (2) (1965) Amer. Mineral., 50, 2097–2098 (abs. ref. 1). (3) Semenov, E.I., M.E. Kazakova, and R.A. Aleksandrova (1967) The Lovozero minerals

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– nenadkevichite, gerasimovskite, and tundrite – from Ilímaussaq, South Greenland. Medd. Grønland, 181(5), 1–11. (4) (1968) Amer. Mineral., 53, 1780 (abs. ref. 3). (5) Shumyatskaya, N.G., A.A. Voronkov, V.V. Ilyukhin, and N.V. Belov (1976) Tundrite, $Na_2Ce_2TiO_2[SiO_4](CO_3)_2$ – refinement of the crystal structure and chemical formula. Kristallografiya (Sov. Phys. Crystal.), 21, 705–7155 (in Russian). (6) Moller, S.K. (1982) Tundrite from the Ilímaussaq alkaline intrusion, South Greenland. Neues Jahrb. Mineral., Monatsh., 481–494. (7) Mandarino, J.A. and V. Anderson (1989) Monteregian treasures. Cambridge Univ. Press, 206.

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Tundrite-(Nd) $Na_3(Nd,La)_4(Ti,Nb)_2(SiO_4)_2(CO_3)_3O_4(OH)\cdot 2H_2O$

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Crystal Data: [Triclinic] [by analogy to tundrite-(Ce)]. *Point Group:* [$\bar{1}$.] As spherulitic masses up to 5 mm.

Physical Properties: Hardness = n.d. D(meas.) = 4.02 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* [Brownish to greenish yellow.]
Optical Class: Biaxial (+). $\alpha = 1.731$ $\beta = > 1.80$ γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
SiO_2	10.98
TiO_2	11.21
RE_2O_3	48.78
Fe_2O_3	1.00
Nb_2O_5	6.09
CaO	0.97
Na_2O	[7.08]
H_2O^+	13.65
H_2O^-	0.24
Total	[100.00]

(1) Ilímaussaq intrusion, Greenland; Na_2O by difference, CO_2 presumably driven off with H_2O^+; relative proportions of RE = La 24%, Ce 7.5%, Pr 12%, Nd 45%, Sm 6.6%, Eu 0.1%, Gd 4%, Tb 0.3%, Dy 0.5%.

Occurrence: In pegmatite veins associated with layered nepheline syenite.

Association: Microcline, arfvedsonite.

Distribution: In the Ilímaussaq intrusion, at Kringlerne, Kangerdluarssuk Plateau, southern Greenland.

Name: For its relation to *tundrite*-(Ce), and its *neodymium* content.

Type Material: n.d.

References: (1) Semenov, E.I., M.E. Kazakova, and R.A. Aleksandrova (1967) The Lovozero minerals – nenadkevichite, gerasimovskite, and tundrite – from Ilímaussaq, South Greenland. Medd. Grønland, 181(5), 1–11. (2) (1968) Amer. Mineral., 53, 1780 (abs. ref. 1).

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Tunellite $SrB_6O_9(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, to 10 cm, elongated along [001], or flattened on {100}, showing {100}, {001}, {110}, {011}, {111}; as compact fine-grained nodules.

Physical Properties: *Cleavage:* On {100}, perfect; on {001}, distinct. *Tenacity:* Flexible, inelastic, sectile. Hardness = 2.5 D(meas.) = 2.40(1) D(calc.) = 2.391

Optical Properties: Transparent. *Color:* Colorless to grayish white. *Luster:* Subvitreous, pearly on {100} faces and cleavages.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $X \wedge a = 29°$; $Z \wedge c = -5°$. *Dispersion:* $r > v$, weak. $\alpha = 1.519(3)$ $\beta = 1.534(2)$ $\gamma = 1.569(2)$ 2V(meas.) = n.d. 2V(calc.) = 68°

Cell Data: *Space Group:* $P2_1/a$. $a = 14.415(3)$ $b = 8.213(1)$ $c = 9.951(2)$ $\beta = 114.05(1)°$ Z = 4

X-ray Powder Pattern: Furnace Creek district, California, USA.
6.57 (100), 4.525 (11), 3.867 (9), 5.138 (8), 3.592 (8), 2.503 (8), 6.78 (7)

Chemistry:

	(1)	(2)
B_2O_3	53.70	54.31
SrO	27.71	26.95
H_2O	18.71	18.74
Total	100.12	100.00

(1) Boron, California, USA; H_2O by loss on ignition. (2) $SrB_6O_9(OH)_2 \cdot 3H_2O$.

Occurrence: A rare secondary mineral formed in borate deposits.

Association: Inderite, kurnakovite, ulexite, hydroboracite, colemanite, realgar, stibnite, celestine, analcime.

Distribution: In the USA, in California, from the Kramer borate deposit, Boron, Kern Co.; at the Thompson mine, near Ryan, Furnace Creek district, Death Valley, and in the east Kramer district, Inyo Co. In Turkey, from the Günevi and Kireçlik deposits, Bigadiç borate district, Balıkesir Province; in the Killik and Espey borate mines, near Emet, and at Sarıkaya, near Kirka, Kütahya Province.

Name: To honor Dr. George Gerard Tunell, Jr. (1900–1996), Professor of Geology, University of California, Los Angeles, California, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 123928.

References: (1) Erd, R.C., V. Morgan, and J.R. Clark (1961) Tunellite, a new hydrous strontium borate from the Kramer borate district, California. U.S. Geol. Surv. Prof. Paper 424-C, 294–297. (2) (1962) Amer. Mineral., 47, 416 (abs. ref. 1). (3) Burns, P.C. and F.C. Hawthorne (1994) Hydrogen bonding in tunellite. Can. Mineral., 32, 895–902.

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Tungstenite WS_2

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$ (2H); $3m$ (3R). Massive, fine scaly or feathery aggregates.

Physical Properties: *Cleavage:* {0001}. *Tenacity:* Sectile. Hardness = 2.5 VHN = n.d. D(meas.) = 7.4 D(calc.) = 7.732 Soils the fingers.

Optical Properties: Opaque. *Color:* Dark lead-gray; in polished section, pure white. *Luster:* Metallic. *Pleochroism:* Very high. *Anisotropism:* Strong; in striking colors including pink and deep blue.
R_1–R_2: (400) 24.4–53.4, (420) 22.6–48.0, (440) 20.8–48.6, (460) 19.9–40.5, (480) 19.3–39.0, (500) 18.8–37.8, (520) 18.5–36.8, (540) 18.2–36.0, (560) 18.0–35.3, (580) 17.8–35.0, (600) 17.8–34.9, (620) 17.9–34.9, (640) 18.0–34.8, (660) 18.1–34.7, (680) 18.0–34.5, (700) 17.9–34.2

Cell Data: *Space Group:* $P6_3/mmc$ (synthetic 2H). $a = 3.132(4)$ $c = 12.323(5)$ Z = 2, or *Space Group:* $R3m$ (synthetic 3R). $a = 3.158(1)$ $c = 18.49(1)$ Z = 3

X-ray Powder Pattern: Synthetic (2H).
6.18 (100), 2.2772 (35), 2.731 (25), 2.667 (25), 1.8335 (18), 1.5783 (16), 3.089 (14)

X-ray Powder Pattern: Emma mine, Utah, USA (3R). (ICDD 35-651).
6.13 (100), 1.528 (70), 2.674 (60), 1.571 (50), 2.037 (40), 1.100 (40), 3.04 (35)

Chemistry:

	(1)	(2)
W	73.8	74.14
S	25.5	25.86
Total	99.3	100.00

(1) Angokitsk deposit, Russia; by electron microprobe. (2) WS_2.

Polymorphism & Series: Both 2H and 3R polytypes occur naturally.

Occurrence: In a deposit replacing limestone (Emma mine, Utah, USA); replacing scheelite (Angokitsk deposit, Russia); in high-temperature fumaroles (Kudryavyy volcano, Russia).

Association: Pyrite, sphalerite, galena, cinnabar, tetrahedrite, wolframite, scheelite, quartz.

Distribution: In the USA, from the Emma mine, Little Cottonwood Canyon, Alta district, Salt Lake Co., Utah [TL, 2H and 3R]; at the Goldstrike mine, Lynn district, Eureka Co., Nevada. From near Chase, British Columbia, and in the Kidd Creek mine, near Timmins, Ontario, Canada. From Tsumeb, Namibia. At Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). From Crevola d'Ossola, Piedmont, Italy. In Russia, at the Angokitsk tungsten deposit, Buryat; an ore in the Tamvatnei As–Hg–W deposit, Kamchatka; and on Kudryavyy volcano, Iturup, Kuril Islands. From Lyangar, Uzbekistan.

Name: For the composition.

Type Material: National Museum of Natural History, Washington, D.C., USA, 94490.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 331–332. (2) Gait, R.I. and J.A. Mandarino (1970) Polytypes of tungstenite. Can. Mineral., 10, 729–730. (3) Getmanskaya, T.I., E.G. Ryabeva, G.A. Sidorenko, and K.V. Yurkina (1979) Tungstenite — a new discovery in the USSR. Doklady Acad. Nauk SSSR, 247, 194–198 (in Russian). (4) Schutte, W.J., J.L. De Boer, and F. Jellinek (1987) Crystal structures of tungsten disulfide and diselenide. J. Solid State Chem., 70, 207–209. (5) (1959) NBS Circ. 539, 8, 65. (6) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 866.

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Tungstibite Sb_2WO_6

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As thin crystals, flattened on {001}, elongated, may be spearhead-shaped, to 0.5 mm; commonly in globular aggregates.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Irregular. Hardness = ∼2 D(meas.) = 6.69 (synthetic). D(calc.) = 6.90

Optical Properties: Translucent to opaque. *Color:* Green to dark green. *Streak:* Green. *Luster:* Dull, may be pearly.
Optical Class: Biaxial (+). *Pleochroism:* X = dark green to brownish green; Y = dark green; Z = pale green to yellowish. *Orientation:* $Z = c$. *Dispersion:* $r \ll v$, strong. $\alpha = 2.285(2)$ $\beta = 2.40(2)$ $\gamma = 2.58(2)$ 2V(meas.) = n.d. 2V(calc.) = 82°

Cell Data: *Space Group:* $P22_12_1$ (probable). $a = 8.59(2)$ $b = 9.58(2)$ $c = 6.12(2)$ Z = 4

X-ray Powder Pattern: Clara mine, Germany.
3.32 (10), 3.06 (10), 2.73 (6), 2.46 (5), 2.98 (4), 1.919 (4), 1.829 (3)

Chemistry:

	(1)	(2)
WO_3	43.6	44.30
Sb_2O_3	55.5	55.70
Total	99.1	100.00

(1) Clara mine, Germany; by electron microprobe, average of three analyses; corresponding to $Sb_{2.01}W_{0.99}O_6$. (2) Sb_2WO_6.

Occurrence: In a hydrothermal polymetallic barite–fluorite deposit.

Association: Cervantite, quartz, barite, fluorite, tetrahedrite–tennantite, chalcopyrite.

Distribution: From the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: For TUNGsten and antimony, STIBium, in the composition.

Type Material: n.d.

References: (1) Walenta, K. (1995) Tungstibit, $Sb_2O_3 \cdot WO_3$ – ein neues Mineral von der Grube Clara bei Oberwolfach im mittleren Schwarzwald (Deutschland). Chem. Erde, 55(3), 217–224 (in German with English abs.). (2) (1996) Amer. Mineral., 81, 767 (abs. ref. 1).

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Tungstite $WO_3 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As platy crystals with rhombic outline, to 75 μm, in radiating aggregates; commonly earthy to pulverulent, massive.

Physical Properties: *Cleavage:* {001}, perfect; {110}, imperfect. Hardness = 2.5
D(meas.) = 5.517 D(calc.) = 5.78

Optical Properties: Transparent. *Color:* Bright yellow, golden yellow, dark yellow-orange, yellowish green; yellow in transmitted light. *Luster:* Resinous, pearly on cleavages.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = deep yellow. *Orientation:* $X = c$; $Y = b$. *Dispersion:* $r < v$, rather strong. *Absorption:* Strong; $Z < Y < X$ or $X > Y > Z$.
$\alpha = 2.09(2)$ $\beta = 2.24(2)$ $\gamma = 2.26(2)$ 2V(meas.) = 26°–27°

Cell Data: *Space Group: Pmnb.* $a = 5.249(2)$ $b = 10.711(5)$ $c = 5.133(2)$ Z = 4

X-ray Powder Pattern: Kootenay Belle mine, Canada.
3.463 (100), 5.36 (80), 2.556 (50), 1.731 (45), 2.616 (40), 1.851 (40), 1.634 (40)

Chemistry:

	(1)	(2)	(3)
WO_3	86.20	91.30	92.79
SiO_2		0.96	
Fe_2O_3	4.14	0.18	
FeO	1.21		
CaO	0.54		
H_2O	7.72	7.46	7.21
Total	99.81	99.90	100.00

(1) Kootenay Belle mine, Canada. (2) Calacalani mine, Bolivia. (3) $WO_3 \cdot H_2O$.

Occurrence: An alteration product of tungsten minerals, especially wolframite and ferberite, in hydrothermal tungsten-bearing deposits.

Association: Hydrotungstite, ferritungstite, wolframite, ferberite, scheelite.

Distribution: In the USA, from Lane's bismuth mine, Monroe, north of Trumbull, Fairfield Co., Connecticut; in the Boriana mine, Mohave Co., and the Black Pearl mine, Camp Wood district, Yavapai Co., Arizona. From the San Alberto mine, near Alamos, Sonora, Mexico. In Canada, in the Kootenay Belle mine, Salmo, British Columbia; at Marlow, Quebec; and elsewhere. At La Vilate, near Chanteloube, Haute-Vienne, France. From Panasqueira, Portugal. In the Calacalani mine, near Colquiri, the Juliani mine, Conde-Auqui district, Tazna, and the San Antonio mines, La Paz, Oruro, Bolivia. At Kingsgate, New South Wales, Australia. In the Kirwa mine, Ubale, Uganda. From Nzombe, Kivu Province, Congo (Zaire). Other localities have been reported but require modern confirmation.

Name: For TUNGSTen in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 605–606. (2) Kerr, P.F. and F. Young (1944) Hydrotungstite, a new mineral from Oruro, Bolivia. Amer. Mineral., 29, 192–210. (3) Roberts, A.C. (1981) The X-ray crystallography of tungstite. Geol. Surv. Canada Paper 81-1C, 82. (4) Szymański, J.T. and A.C. Roberts (1984) The crystal structure of tungstite, $WO_3 \cdot H_2O$. Can. Mineral., 22, 681–688.

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Tungusite $Ca_{14}Fe_9^{2+}(Si_8O_{20})_3(OH)_{22}$

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Crystal Data: n.d. *Point Group:* n.d. As flakes, to 15 mm, and as platy aggregates with a radial-fibrous structure, to 8 cm.

Physical Properties: *Tenacity:* Brittle; platelets flexible. Hardness = ∼2 D(meas.) = 2.59 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* Grass-green to greenish white, may have a grayish tint; in transmitted light, yellowish green. *Luster:* Slightly pearly on flakes.
Optical Class: Uniaxial (–); may be biaxial. *Pleochroism:* Weak; yellowish green. ω = 1.568(2) ϵ = n.d. 2V(meas.) = Very small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Lower Tunguska River, Russia.
1.818 (100), 4.17 (80), 3.12 (80), 3.01 (80), 3.58 (60b), 1.605 (30), 1.570 (30)

Chemistry:

	(1)	(2)
SiO_2	47.56	45.07
Al_2O_3	2.90	2.97
Fe_2O_3	1.91	1.71
FeO	11.69	11.36
MnO	1.33	1.44
MgO	0.84	1.31
CaO	24.33	26.11
Na_2O	1.61	2.21
H_2O^+	7.40	6.37
H_2O^-	0.60	1.45
Total	100.17	100.00

(1–2) Lower Tunguska River, Russia; average of two analyses, corresponds to $(Ca_{3.46}Na_{0.48}Mn_{0.06})_{\Sigma=4.00}(Fe^{2+}_{1.23}Al_{0.37}Mg_{0.21}Fe^{3+}_{0.17}Mn_{0.08})_{\Sigma=2.06}(Si_{5.94}Al_{0.06})_{\Sigma=6.00}O_{15}(OH)_6$.

Occurrence: A secondary mineral forming crusts lining cavities and amygdules in hydrothermally altered basalts.

Association: Analcime, apophyllite, gyrolite, calcite, quartz.

Distribution: Found along the Lower Tunguska River, near Tura, central Siberia, Russia.

Name: For the Tunguska River, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Kudryashova, V.I. (1966) Tungusite, a new mineral of the hydrous calcium silicate group. Doklady Acad. Nauk SSSR, 171, 1167–1170 (in Russian). (2) (1967) Amer. Mineral., 52, 927–928 (abs. ref. 1).

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Tunisite $NaCa_2Al_4(CO_3)_4Cl(OH)_8$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals are tabular {001}, modified by {010}, {110}, and numerous vicinal forms, to 8 mm; as booklike subparallel to random aggregates and powdery coatings.

Physical Properties: *Cleavage:* Perfect on {001}; another on {hk0}. Hardness = 4.5
D(meas.) = 2.51(2) D(calc.) = [2.51]

Optical Properties: Semitransparent. *Color:* White, colorless.
Optical Class: Uniaxial (+). $\omega = 1.573(1)$ $\epsilon = 1.599(1)$

Cell Data: *Space Group:* $P4/nmm$. a = 11.1983(11) $c = 6.5637(7)$ Z = 2

X-ray Powder Pattern: Sakiet Sidi Yousseff mine, Tunisia.
5.615 (10), 2.592 (9), 3.551 (8), 3.288 (7), 2.754 (7), 2.526 (7), 5.070 (6)

Chemistry:

	(1)	(2)	(3)
CO_2	28.66	26.8	28.27
Al_2O_3	32.56	35.0	32.75
CaO	18.08	20.3	18.01
Na_2O	4.77	4.6	4.98
K_2O	0.35		
Cl	n.d.	4.9	5.69
H_2O^+	15.04		
H_2O^-	0.51		
H_2O		10.7	11.57
$-O = Cl_2$		1.1	1.27
Total	99.97	101.2	100.00

(1) Sakiet Sidi Yousseff mine, Tunisia; CO_2 by volumetric-absorption gas analysis, alkalies by flame photometry, H_2O by the Penfield method. (2) Do.; by neutron activation.
(3) $NaCa_2Al_4(CO_3)_4Cl(OH)_8$.

Occurrence: A very rare hydrothermal mineral, filling cavities in calcite (Sakiet Sidi Yousseff mine, Tunisia).

Association: Calcite (Sakiet Sidi Yousseff mine, Tunisia); celestine, calcite, pyrite, chalcopyrite, gypsum, whewellite (Condorcet, France).

Distribution: From the Sakiet Sidi Yousseff Pb–Zn mine, between Le Kef and Souk Ahras, Tunisia. In the Slavyansk salt deposit, Dnieprovsk-Donets Basin, Ukraine. From Condorcet, Drôme, France.

Name: For Tunisia, the country in which it was first found to occur.

Type Material: National Museum, Prague, Czech Republic, 53823; National School of Mines, Paris, France.

References: (1) Johan, Z., P. Povondra, and E. Slánsky (1969) Tunisite, a new carbonate from Tunisia. Amer. Mineral., 54, 1–13. (2) Martin, R., J. Mullis, W. Nungässer, and J. von Raumer (1979) La tunisite des "Terres Noires" de la Drôme (France). Schweiz. Mineral. Petrog. Mitt., 59, 223–228 (in French). (3) Effenberger, H., F. Kluger, F. Pertlik, and J. Zemann (1981) Tunisit: Kristallstruktur und Revision der chemischen Formel. Tschermaks Mineral. Petrog. Mitt., 28, 65–77 (in German with English abs.).

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Tuperssuatsiaite $Na(Fe^{3+},Mn^{2+})_3Si_8O_{20}(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. As needles and blades elongated $\parallel$ [001], to 2 cm; typically in radiating aggregates of fine fibers. *Twinning:* With {100} as both twin and composition plane, common.

Physical Properties: *Cleavage:* Good on {100}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.28

Optical Properties: Transparent. *Color:* Dark to light red-brown; in transmitted light, colorless to light yellowish brown. *Luster:* Vitreous to nearly metallic, dull in aggregate. *Optical Class:* Biaxial (+). *Pleochroism:* Slight; X = colorless; Y = colorless to light reddish brown; Z = pale yellowish brown to dark reddish brown. *Orientation:* $Y = b$; $Z \wedge c = 5°–7°$. $\alpha = 1.54$ $\beta = 1.56$ $\gamma = 1.58–1.60$ 2V(meas.) = n.d. 2V(calc.) = 104°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 13.92–13.99$ $b = 17.70–17.73$ $c = 5.30–5.31$ $\beta = 104.54° – 104.78°$ Z = [2]

X-ray Powder Pattern: Tuperssuatsiait Bay, Greenland.
10.82 (10), 2.638 (4), 3.395 (3), 2.544 (3), 2.510 (3), 2.235 (3), 4.140 (2)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	56.33	55.66	CaO		0.11
TiO_2		0.18	Na_2O	3.24	6.70
Al_2O_3	0.47	0.15	K_2O	0.78	0.07
Fe_2O_3	20.63	26.26	F		0.09
MnO	5.31	0.66	Cl		0.13
ZnO	0.81	0.11	H_2O	[11.39]	[9.77]
MgO	1.04	0.18	$-O = (F_2, Cl_2)$		[0.07]
			Total	[100.00]	[100.00]

(1) Tuperssuatsiait Bay, Greenland; by electron microprobe, average of seven analyses; original analysis given as elements, here recalculated to oxides, H_2O by difference; corresponds to $(Na_{0.88}K_{0.14})_{\Sigma=1.02}(Fe^{3+}_{2.18}Mn^{2+}_{0.63}Mg_{0.22}Zn_{0.08})_{\Sigma=3.11}(Si_{7.92}Al_{0.08})_{\Sigma=8.00}O_{20}(OH)_{1.38} \cdot 4.39H_2O$. (2) Windhoek, Namibia; by electron microprobe, average of 10 analyses, original analysis given as elements, here converted to oxides, H_2O by difference; corresponds to $(Na_{1.85}K_{0.01})_{\Sigma=1.86}(Fe^{3+}_{2.83}Mn^{2+}_{0.08}Mg_{0.04}Ca_{0.02}Zn_{0.02})_{\Sigma=2.99}(Si_{7.96}Al_{0.03}Ti_{0.02})_{\Sigma=8.01}O_{20}[(OH)_{2.47}F_{0.04}Cl_{0.03}]_{\Sigma=2.54} \cdot 3.90H_2O$.

Occurrence: A late-stage, low-temperature, hydrothermal mineral in veins cutting nepheline syenite and in sodalite-nepheline syenite pegmatite (Tuperssuatsiait Bay, Greenland); in miarolitic cavities in phonolite (Windhoek, Namibia).

Association: Natrolite, albite, orthoclase, aegirine, sodalite, steenstrupine (Tuperssuatsiait Bay, Greenland); microcline, aegirine, natrolite, eudialyte, bastnäsite, makatite, villiaumite, titanite, apophyllite, analcime, aragonite (Windhoek, Namibia).

Distribution: In the Ilímaussaq intrusion, at Tuperssuatsiait Bay, Kangerdluarssuk Fjord, and the north shore of Tunugdliarfik Fjord, southern Greenland. From the Aris quarry, about 25 km south of Windhoek, Namibia. In Canada, from near Saint-Amable, Quebec.

Name: For Tuperssuatsiait Bay, Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark; National Museum of Natural History, Washington, D.C., USA, 162402.

References: (1) Karup-Møller, S. and O.V. Petersen (1984) Tuperssuatsiaite, a new mineral species from the Ilímaussaq intrusion in South Greenland. Neues Jahrb. Mineral., Monatsh., 501–512. (2) (1985) Amer. Mineral., 70, 1332 (abs. ref. 1). (3) von Knorring, O., O.V. Petersen, S. Karup-Møller, E.S. Leonardsen, and E. Condliffe (1992) Tuperssuatsiaite, from Aris phonolite, Windhoek, Namibia. Neues Jahrb. Mineral., Monatsh., 145–152.

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As narrow tabular to fibrous crystals in reniform crusts and radial spherical concretions, to 6mm. *Twinning:* Polysynthetic.

Physical Properties: Hardness = 5 D(meas.) = n.d. D(calc.) = 4.898

Optical Properties: Semitransparent. *Color:* Olive-green.
Optical Class: Biaxial (–). *Pleochroism: X* = *Y* = brown; *Z* = green. *Orientation:* Positive elongation. *Dispersion: r* > *v*, strong. α = 2.00 β = 2.01 γ = 2.02 2V(meas.) = Medium.

Cell Data: *Space Group:* $P\bar{1}$. *a* = 5.3834(2) *b* = 6.2736(3) *c* = 6.8454(3) α = 86.169(1)° β = 91.681(1)° γ = 92.425(1)° *Z* = 1

X-ray Powder Pattern: Locality unknown [Tyuya-Muyun Cave, Kyrgyzstan].
4.76 (10), 7.25 (8), 2.56 (6), 2.70 (4), 2.47 (3), 2.29 (3), 2.11 (3)

Chemistry: (1)

CuO	62.94
V_2O_5	28.90
H_2O	5.85
Total	97.69

(1) Tyuya-Muyun Cave, Kyrgyzstan; average of 4 electron microprobe analyses, H_2O from structural analysis, corresponding to $Cu^{2+}_{4.97}(V^{5+}O_4)_2(OH)_{4.08}$.

Occurrence: A rare secondary oxidation mineral in vanadium-bearing mineral deposits.

Association: Tangeite, other vanadates, uranovanadates, malachite, calcite, barite.

Distribution: From the Tyuya-Muyun Cave, Fergana Valley, Alai Range, Kyrgyzstan. In Nevada, USA, at the Van-Nav-San claim, Gibellini district and Gold Quarry mine, Maggie Creek district.

Name: For the Turan region, Kyrgyzstan, where the mineral was first found.

Type Material: A.E. Fersman Mineral Museum, Moscow, Russia; #3578.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 818. (2) Guillemin, C. (1956) Contribution a la minéralogie des arséniates, phosphates et vanadates de cuivre. II. phosphates et vanadates de cuivre. Bull. Soc. fr. Minéral., 79, 219–275, esp. 245–246 (in French). (3) Sokolova, E., F.C. Hawthorne, V.V. Karpenko, A.A. Agakhanov, and L.A. Pautov (2004) Turanite, $Cu^{2+}_5(V^{5+}O_4)_2(OH)_4$, from the Tyuya–Muyun radium–uranium deposit, Osh district, Kyrgyzstan: a new structure for an old mineral. Can. Mineral., 42, 731–739.

Turneaureite $Ca_5(AsO_4,PO_4)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As prismatic crystals exhibiting $\{10\bar{1}0\}$ and $\{0001\}$, to 1.5 mm; usually massive.

Physical Properties: *Fracture:* Uneven. Hardness = 5 D(meas.) = 3.60(5) D(calc.) = 3.63 Fluoresces bright orange under SW UV; may be phosphorescent.

Optical Properties: Translucent. *Color:* Colorless, grayish white. *Streak:* White. *Luster:* Vitreous to slightly greasy.
Optical Class: Uniaxial (–). $\omega = 1.708(3)$ $\epsilon = 1.700(3)$

Cell Data: *Space Group:* $[P6_3/m]$ (by analogy to the apatite group). $a = 9.810(4)$ $c = 6.868(4)$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
2.907 (100), 2.826 (90), 3.43 (60), 3.98 (50), 2.670 (50), 1.864 (40), 1.995 (30)

Chemistry:

	(1)
P_2O_5	6.1
As_2O_5	44.9
MnO	1.9
PbO	0.7
MgO	0.0
CaO	43.8
F	1.2
Cl	3.2
H_2O	n.d
$-O = (F,Cl)_2$	1.2
Total	100.6

(1) Långban, Sweden; by electron microprobe, total Mn as MnO, corresponding to $(Ca_{4.85}Mn_{0.16}Pb_{0.02})_{\Sigma=5.03}[(AsO_4)_{2.42}(PO_4)_{0.54}]_{\Sigma=2.96}(Cl_{0.56}F_{0.39})_{\Sigma=0.95}$.

Mineral Group: Apatite group.

Occurrence: A rare component of manganiferous ores in high-grade marbles.

Association: Andradite, magnetite, calcite (Långban, Sweden); magnetite, andradite, manganoan calcite (Franklin, New Jersey, USA); donpeacorite, tirodite, ferrian braunite, dravite, anhydrite, manganoan dolomite (Fowler, New York, USA).

Distribution: From Långban, Värmland, Sweden. At Franklin, Sussex Co., New Jersey and in the Balmat #4 mine, Fowler, St. Lawrence Co., New York, USA.

Name: Honors Dr. Frederick Stewart Turneaure (1899–1986), Professor Emeritus of Geology, University of Michigan, Ann Arbor, Michigan, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 124237; National Museum of Natural History, Washington, D.C., USA, 134981, C6270-1, C6270-2, 159862.

References: (1) Dunn, P.J., E.U. Petersen, and D.R. Peacor (1985) Turneaureite, a new member of the apatite group from Franklin, New Jersey, Balmat, New York and Långban, Sweden. Can. Mineral., 23, 251–254. (2) (1986) Amer. Mineral., 71, 1280 (abs. ref. 1).

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Turquoise **$CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$**

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Rare steep pinacoidal crystals, {010}, {1$\overline{1}$0}, {001}, to 3 mm; fine granular to cryptocrystalline, nodular to globular crusts, veinlets, massive.

Physical Properties: *Fracture:* Small conchoidal to smooth. Hardness = 5–6
D(meas.) = 2.86, less if massive. D(calc.) = 2.91

Optical Properties: Transparent in crystals; translucent to opaque if massive.
Color: Sky-blue, bluish green, apple-green, greenish gray. *Streak:* White to pale greenish blue.
Luster: Vitreous in crystals; dull to waxy if massive.
Optical Class: Biaxial (+). *Pleochroism:* Weak in thick grains; X = colorless; Z = pale blue or pale green. *Orientation:* X (-30°,60°); Y (63°,83°); Z (163°,32°) [using (ϕ,ρ)]. *Dispersion:* $r < v$, strong. $\alpha = 1.61$ $\beta = 1.62$ $\gamma = 1.65$ 2V(meas.) = 40(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.409(1)$ $b = 9.914(2)$ $c = 7.635(1)$ $\alpha = 111.356°$ $\beta = 114.973°$ $\gamma = 69.532°$ Z = 1

X-ray Powder Pattern: Lynch Station, Virginia, USA; nearly identical to faustite.
3.674 (100), 2.900 (80), 6.165 (75), 5.986 (45), 4.786 (45), 3.429 (45), 2.062 (40)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	34.13	34.90	CuO	9.00	9.78
Al_2O_3	36.50	37.60	H_2O	20.12	17.72
Fe_2O_3	0.21		Total	99.96	100.00

(1) Lynch Station, Virginia, USA; H_2O by the Penfield method, corresponds to $Cu_{0.95}(Al_{5.98}Fe_{0.02})_{\Sigma=6.00}(PO_4)_{3.91}(PO_3OH)_{0.10}(OH)_8 \cdot 5.27H_2O$. (2) $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$.

Polymorphism & Series: Forms two series, with chalcosiderite, and with planerite.

Mineral Group: Turquoise group.

Occurrence: A secondary mineral formed in the potassic alteration zone of hydrothermal porphyry copper deposits; a vein-filling in volcanic rocks and phosphate-rich sediments.

Association: Kaolinite, montmorillonite, allophane, wavellite, pyrite.

Distribution: Dozens of localities, of which only a few can be mentioned, for commercial amounts or good crystals. In Iran, at Ma'dan, 45 km northwest of Neyshabur (Nishapur). From Ottré, near Vielsalm, Belgium. At the Bunny mine, St. Austell, and elsewhere in Cornwall, England. From Katonto, north of Kolwezi, Katanga Province, Congo (Shaba Province, Zaire), good crystals. In the USA, crystallized from the Bishop mine, Lynch Station, Campbell Co., Virginia; in the Cerrillos district, Santa Fe Co., and the Burro Mountains district, Grant Co., New Mexico; in Arizona, commercial production from Mineral Park, Mohave Co., Morenci, Greenlee Co., the Globe-Miami district, Gila Co., and others; numerous small deposits in Lander Co. and elsewhere in Nevada. In the Itatiaiuçu iron mine, southwest of Belo Horizonte, Minas Gerais, Brazil, large crystals. At Chuquicamata, Antofagasta, Chile. In Australia, at Narooma, New South Wales, as crystals; in the Iron Monarch quarry, Iron Knob, South Australia. In China, from Yunxian and Zhushan, Wudang Mountains, Hubei Province, and near Shanyang, Shaanxi Province.

Name: From the French *Turquie*, as Iranian material was early imported through Turkey.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 946–951. (2) Foord, E.E. and J.E. Taggart, Jr. (1998) A reexamination of the turquoise group: the mineral aheylite, planerite (redefined), turquoise and coeruleolactite. Mineral. Mag., 62, 93–111. (3) Cid-Dressner, H. (1965) Determination and refinement of the crystal structure of turquois, $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$. Zeits. Krist., 121, 87–113. (4) Guthrie, G.D., Jr. and D.L. Bish (1991) Refinement of the turquoise structure and determination of the hydrogen positions. Geol. Soc. Amer., Annual Meeting Abs. with Prog., 23(5), 158A (abs.). (5) Pogue, J.E. (1915) The Turquois, a study of its history, mineralogy, geology, ethnology, archaeology, mythology, folklore, and technology. Nat. Acad. of Sci. Mem., 12, part 2, 207 pp.

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Tuscanite $\mathbf{K(Ca,Na)_6(Si,Al)_{10}O_{22}(SO_4,CO_3)_2(OH)\cdot H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In platy crystals, flattened on {100}, to 1 cm. *Twinning:* Common, twin plane {100}.

Physical Properties: *Cleavage:* {100}, distinct. Hardness = 5.5–6 D(meas.) = 2.83 D(calc.) = 2.77

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 40°$. $\alpha = 1.581(1)$ $\beta = 1.590(1)$ $\gamma = 1.591(1)$ 2V(meas.) = 40°

Cell Data: *Space Group:* $P2_1/a$. $a = 24.036(14)$ $b = 5.110(3)$ $c = 10.888(8)$ $\beta = 106.96(3)°$ Z = [2]

X-ray Powder Pattern: Latera caldera, Italy.
11.51 (100), 2.872 (100), 3.065 (47), 3.832 (24), 2.962 (24), 5.75 (17), 2.830 (16)

Chemistry:

	(1)
SiO_2	34.64
Al_2O_3	16.95
Fe_2O_3	0.76
MgO	0.40
CaO	26.76
SrO	0.38
Na_2O	1.45
K_2O	3.79
Cl	0.02
H_2O	2.61
CO_2	2.20
SO_3	10.04
Total	100.00

(1) Latera caldera, Italy; by AA and XRF, corresponds to $(K_{0.88}Sr_{0.04})_{\Sigma=0.92}(Ca_{5.25}Na_{0.51}Mg_{0.11}Fe^{3+}_{0.10})_{\Sigma=5.97}(Si_{6.34}Al_{3.66})_{\Sigma=10.00}O_{22}[(SO_4)_{1.38}(CO_3)_{0.55}]_{\Sigma=1.93}(OH)_{0.99}\cdot(H_2O)_{1.08}$.

Occurrence: Within ejected blocks of metasomatized carbonate rocks in a pumice deposit.

Association: Vesuvianite, andradite, grossular, pyroxene, wollastonite, anorthite, clintonite, latiumite.

Distribution: From the Casa Collina quarry, in the Latera caldera, Pitigliano, near Grosseto, Tuscany, and at Sacrofano, Lazio, Italy.

Name: For the Tuscany region of Italy where the mineral was first found.

Type Material: University of Pisa, Pisa, 3210; University of Modena, Modena, Italy; National Museum of Natural History, Washington, D.C., USA, 143944.

References: (1) Orlandi, P., L. Leoni, M. Mellini, and S. Merlino (1977) Tuscanite, a new mineral related to latiumite. Amer. Mineral., 62, 1110–1113. (2) Mellini, M., S. Merlino, and G. Rossi (1977) The crystal structure of tuscanite. Amer. Mineral., 62, 1114–1120.

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Tusionite $Mn^{2+}Sn^{4+}(BO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Thin platy crystals, to 1.5 cm, in rosettelike aggregates.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = n.d. VHN = 400–500 ∥ {0001}, 700–750 ⊥ {0001} (40 g load). D(meas.) = 4.73 D(calc.) = 4.85

Optical Properties: Transparent to translucent. *Color:* Honey-yellow, yellowish brown; nearly colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.854(2)$ $\epsilon = 1.757(2)$

Cell Data: *Space Group:* $R\overline{3}$. $a = 4.781(1)$ $c = 15.381(7)$ Z = 3

X-ray Powder Pattern: Along the upper Tusion River, Tajikistan.
2.818 (10), 3.65 (9), 1.744 (8), 2.393 (6), 1.999 (6), 5.12 (4), 4.02 (4)

Chemistry:

	(1)	(2)	(3)
B_2O_3	23.51	[23.72]	23.90
WO_3		0.45	
SnO_2	52.45	51.62	51.74
ZrO_2		0.10	
Sc_2O_3		0.06	
FeO	3.57	2.31	
MnO	20.46	18.72	24.36
MgO		0.00	
CaO	0.39	1.71	
H_2O	0.00		
Total	[100.38]	98.69	100.00

(1) Along the upper Tusion River, Tadjikistan; by electron microprobe, total Fe as FeO, total Mn as MnO, original total given as 100.38%; corresponds to $(Mn_{0.84}Fe_{0.15}Ca_{0.02})_{\Sigma=1.01}Sn_{1.02}(B_{0.98}O_3)_2$. (2) Belo Horizonte No. 1 pegmatite, California, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; B_2O_3 calculated for stoichiometry; corresponds to $(Mn_{0.78}Fe_{0.09}Ca_{0.09})_{\Sigma=0.96}Sn_{1.00}(BO_3)_2$. (3) $MnSn(BO_3)_2$.

Occurrence: Of late-stage hydrothermal origin, rare in granite pegmatites, typically in miarolitic cavities.

Association: Tetrawickmanite, hambergite, danburite, tourmaline, orthoclase, albite, quartz (along the upper Tusion River, Tajikistan); tourmaline, hambergite, danburite, hellandite, boromuscovite, cassiterite (Řečice, Czech Republic; Thomas Mountain, California, USA).

Distribution: From along the upper Tusion River, Shakhdara Range, southwestern Pamir Mountains, Tadjikistan. At Řečice, Czech Republic. In the Belo Horizonte No. 1 and New Columbia No. 1 pegmatites, Thomas Mountain, Riverside Co., California, USA.

Name: For its first-noted occurrence along the upper Tusion River, Tadjikistan.

Type Material: Mineralogical Museum, St. Petersburg University, St. Petersburg, 17096; Mining Institute, St. Petersburg, 1661/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82546.

References: (1) Konovalenko, S.I., A.V. Voloshin, Y.A. Pakhomovskii, S.S. Anen'yev, G.A. Perlina, D.L. Rogachev, and V.Y. Kuznetsov (1983) Tusionite, $MnSn(BO_3)_2$, a new borate from granite pegmatite of southwestern Pamir. Doklady Acad. Nauk SSSR, 272, 1449–1553 (in Russian). (2) (1984) Amer. Mineral., 69, 1193 (abs. ref. 1). (3) Cooper, M., F.C. Hawthorne, M. Novák, and M.C. Taylor (1994) The crystal structure of tusionite, $Mn^{2+}Sn^{4+}(BO_3)_2$, a dolomite-structure borate. Can. Mineral., 32, 903–907.

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Tuzlaite $NaCaB_5O_8(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, elongated along [001], showing {100}, {010}, {011}, {110}, $\{\bar{1}11\}$ to 0.5 mm, typically in nearly parallel aggregates; massive in veins.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 2–3 D(meas.) = 2.21(2) D(calc.) = 2.23

Optical Properties: Semitransparent. *Color:* Colorless to white. *Streak:* White. *Luster:* Silky to pearly.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge a = 14°$. $\alpha = 1.532(2)$ $\beta = 1.544(2)$ $\gamma = 1.561(2)$ 2V(meas.) = 80.9°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.506(1)$ $b = 13.280(3)$ $c = 11.462(3)$ $\beta = 92.97(2)°$ Z = 4

X-ray Powder Pattern: Tuzla mine, Bosnia-Herzegovina.
8.638 (100), 6.617 (30), 2.868 (29), 4.179 (17), 2.586 (15), 2.845 (14), 2.065 (14)

Chemistry:

	(1)	(2)
B_2O_3	52.19	52.24
Al_2O_3	0.26	
CaO	14.64	16.83
SrO	0.21	
Na_2O	10.25	9.30
H_2O	21.66	21.63
Total	99.21	100.00

(1) Tuzla mine, Bosnia-Herzegovina; average of six analyses, by flamephotometry, TGA, and crystal-structure analysis; corresponds to $Na_{1.00}(Ca_{0.87}Na_{0.10}Sr_{0.01})_{\Sigma=0.98}B_{4.98}Al_{0.02}O_{7.92}(OH)_2 \cdot 3H_2O$. (2) $NaCaB_5O_8(OH)_2 \cdot 3H_2O$.

Occurrence: In a saline evaporite deposit, as veins in dolomitic marl between salt layers.

Association: Halite.

Distribution: From the Tuzla salt mine, Bosnia-Herzegovina.

Name: For Tuzla, Bosnia-Herzegovina, the town near the salt mine in which the species was found.

Type Material: Croatian Museum of Natural History, Zagreb, Croatia, HPM 8888; Natural History Museum, Bern, Switzerland, B 8361; Royal Ontario Museum, Toronto, Canada, M45848a.

References: (1) Bermanec, V., T. Armbruster, D. Tibljaš, D. Sturman, and G. Kniewald (1994) Tuzlaite, $NaCa[B_5O_8(OH)_2] \cdot 3H_2O$, a new mineral with a pentaborate sheet structure from the Tuzla salt mine, Bosnia and Hercegovina [*sic*]. Amer. Mineral., 79, 562–569.

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Tvalchrelidzeite $Hg_3(As,Sb)_2S_3$

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Crystal Data: Triclinic. *Point Group:* 1. As granular aggregates, to 1 cm, without well-formed crystals.

Physical Properties: *Cleavage:* Perfect in one direction. *Fracture:* Uneven and conchoidal. Hardness = < 3 VHN = 172 D(meas.) = 7.380(5) D(calc.) = 7.234

Optical Properties: Translucent. *Color:* Lead-gray; whitish in reflected light, with strong dark red internal reflections; in transmitted light, cherry-red. *Streak:* Nearly black, with a dark reddish tint. *Luster:* Adamantine. *Pleochroism:* White to grayish white, pale lilac to a distinctly greenish tint. *Anisotropism:* Distinct; dark olive to dark violet.

R_1–R_2: (400) 39.9–45.0, (420) 40.0–44.5, (440) 40.1–43.4, (460) 40.3–42.6, (480) 40.7–40.9, (500) 40.8–39.9, (520) 40.6–38.7, (540) 39.2–37.1, (560) 37.7–35.8, (580) 36.5–34.8, (600) 35.5–34.0, (620) 34.7–33.4, (640) 33.8–32.8, (660) 33.2–32.4, (680) 32.6–32.0, (700) 32.0–31.6

Cell Data: *Space Group:* $P1$. $a = 4.39$ $b = 11.57$ $c = 15.67$ $\alpha = 88.17°$ $\beta = 90.01°$ $\gamma = 89.98°$ Z = 1

X-ray Powder Pattern: Gomi deposit, Georgia.
3.49 (100), 2.92 (100), 2.89 (100), 2.080 (100), 3.29 (70), 2.031 (35), 3.19 (30)

Chemistry:

	(1)	(2)	(3)
Hg	66.50	66.1	66.4
Cu		0.15	
Fe		0.11	
Sb	13.75	12.9	14.0
As	8.60	8.54	8.4
S	10.95	10.3	10.9
Total	99.80	98.1	99.7

(1) Gomi deposit, Georgia; by electron microprobe, average of two analyses; corresponding to $Hg_{2.91}(As_{1.01}Sb_{0.99})_{\Sigma=2.00}S_{3.00}$. (2) Tyute deposit, Russia; by electron microprobe, corresponding to $Hg_{3.00}Cu_{0.02}Fe_{0.02}(As_{1.04}Sb_{0.96})_{\Sigma=2.00}S_{2.92}$. (3) Chauvai deposit, Russia; by electron microprobe, corresponding to $Hg_{2.92}(Sb_{1.01}As_{0.99})_{\Sigma=2.00}S_{2.99}$.

Occurrence: In gold-bearing hydrothermal As–Sb–Hg deposits.

Association: Cinnabar, metacinnabar, realgar, mercurian tennantite, mercury, cubanite, pyrrhotite, chalcopyrite, marcasite, fluorite, quartz.

Distribution: From the Gomi deposit, Caucasus Mountains, Georgia [TL]. At the Tyute mercury deposit, Altai Mountains, Russia. In the Chauvai Sb–Hg deposit, Fergana Valley, Alai Range, southern Kyrgyzstan. From the Hemlo gold deposit, Thunder Bay district, Ontario, Canada. At the Getchell mine, Potosi district, Humboldt Co., Nevada, USA.

Name: In honor of Academician Aleksander Antonovich Tvalchrelidze (1881–1957), founder of the Georgian Mineralogical-Petrographic School, Tbilisi University, Tbilisi, Georgia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 77110; National Museum of Natural History, Washington, D.C., USA, 143827.

References: (1) Gruzdev, V.S., N.M. Mchedlishvili, G.A. Terekhova, Z.Y. Tsertsvadze, N.M. Chernitsova, and N.G. Shumkova (1975) Tvalchrelidzeite, $Hg_{12}(Sb,As)_8S_{15}$, a new mineral

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from the Gomi arsenic–antimony–mercury deposit, Caucasus. Doklady Acad. Nauk SSSR, 225, 911–913 (in Russian). (2) (1977) Amer. Mineral., 62, 174 (abs. ref. 1). (3) Vasil'ev, V.I. (1979) The second discovery of tvalchrelidzeite $Hg_{12}(Sb, As)_8S_{15}$ in ores of mercury deposits. Geol. Geofiz., 9, 159–162 (in Russian with English abs.). (4) (1980) Chem. Abs., 92, 25693 (abs. ref. 3). (5) Krapiva, L.Y, V.I. Stepanov, G.N. Nechelyustov, and V.Y. Volgin (1986) New data on tvalchrelidzeite $Hg_{12}(As, Sb)_8S_{12}$. Doklady Acad. Nauk SSSR, 290, 1208–1212 (in Russian). (6) Pobedimskaya, Y.A., N.V. Belov, L.N. Kaplunnik, and I.V. Petrova (1980) The crystal chemistry of the series of Pb and Hg sulfosalts, in: Sulfosalts, platinum minerals, and ore microscopy. Nauka Press, Moscow, 49–58 (in Russian with English abs.).

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Tvedalite $(Ca, Mn^{2+})_4Be_3Si_6O_{17}(OH)_4 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As spherulites of platy crystals, up to 3 mm, always incrusted with chiavennite.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 4.5 D(meas.) = 2.541(6) D(calc.) = 2.554

Optical Properties: Semitransparent. *Color:* Cream-white to pale beige, zoned.
Streak: White. *Luster:* Vitreous.
Optical Class: Biaxial. $n = 1.604$

Cell Data: *Space Group:* C-centered. $a = 8.724(6)$ $b = 23.14(1)$ $c = 4.923(4)$ $Z = 2$

X-ray Powder Pattern: Vevja quarry, Norway.
2.837 (100), 11.6 (93), 3.87 (75), 2.889 (75), 3.16 (74), 5.80 (68), 2.494 (58)

Chemistry:

	(1)
SiO_2	45.00
Al_2O_3	0.68
FeO	1.11
MnO	11.56
BeO	10.69
CaO	18.44
H_2O	11.8
Total	99.28

(1) Vevja quarry, Norway; by AA, H_2O by elemental analyzer; corresponding to $(Ca_{2.52}Mn_{1.25}Fe_{0.12})_{\Sigma=3.89}Be_{3.00}(Si_{5.74}Be_{0.27}Al_{0.10})_{\Sigma=6.11}O_{17}(OH)_4 \cdot 3.06H_2O$.

Occurrence: In nepheline syenite pegmatite.

Association: Chiavennite, analcime, natrolite, parisite-(Ce), bastnäsite-(Ce), leucophanite, epididymite, albite, calcite, chlorite, todorokite, fluorite, magnetite, molybdenite.

Distribution: In the Vevja quarry, Tvedalen, Norway.

Name: For the Tvedalen area in Norway, which has produced many interesting minerals from the nepheline syenites.

Type Material: University of Oslo, Oslo, Norway, 14770.

References: (1) Larsen, A.O., A. Åsheim, G. Raade, and J. Taftø (1992) Tvedalite, $(Ca, Mn)_4Be_3Si_6O_{17}(OH)_4 \cdot 3H_2O$, a new mineral from syenite pegmatite in the Oslo Region, Norway. Amer. Mineral., 77, 438–443.

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Tveitite-(Y) $Ca_{14}Y_5F_{43}$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Crystalline, massive. *Twinning:* Complex, polysynthetic, forming a three-dimensional grating of spindles, each of which is twinned internally in two directions.

Physical Properties: Hardness = n.d. D(meas.) = 3.94 D(calc.) = 3.99 Faint yellow-orange fluorescence under SW UV; dark blue cathodoluminescence.

Optical Properties: Transparent. *Color:* White to pale yellow. *Luster:* Greasy. *Optical Class:* Biaxial (–). $\alpha = 1.476$ $\beta = 1.479$ $\gamma = 1.481$ 2V(meas.) = 34°

Cell Data: *Space Group:* $R\overline{3}$. $a = 16.6920(9)$ $c = 9.6664(8)$ Z = 3

X-ray Powder Pattern: Høydalen, Norway.
3.184 (10), 1.265 (8), 1.949 (7), 1.664 (6), 2.764 (5), 1.963 (5), 3.222 (4)

Chemistry:

	(1)	(2)
Y	22.2	24.39
RE	8.06	
U	0.05	
Fe	0.08	
Mn	0.02	
Ca	27.4	30.79
F	41.3	44.82
Total	99.11	100.00

(1) Høydalen, Norway; RE = La 1.28%, Ce 3.86%, Pr 0.56%, Nd 0.90%, Sm 0.12%, Eu 0.04%, Gd 0.12%, Tb 0.03%, Dy 0.26%, Ho 0.05%, Er 0.17%, Tm 0.13%, Yb 0.35%, Lu 0.19%; corresponds to $Ca_{13.89}(Y_{4.09}RE_{0.98})_{\Sigma=5.07}F_{43}$. (2) $Ca_{14}Y_5F_{43}$.

Occurrence: In a pegmatite dike in amphibolites, probably formed by inversion of yttrofluorite.

Association: Kainosite, fluocerite, cerianite, monazite, beryl, topaz, muscovite, microcline, quartz.

Distribution: From Høydalen, Tørdal, Telemark, Norway.

Name: Honors John Tveit, in whose quarry in Norway the mineral was first found.

Type Material: Mineralogical-Geological Museum, University of Oslo, Oslo, Norway; National Museum of Natural History, Washington, D.C., USA, 137096.

References: (1) Bergstøl, S., B.B. Jensen, and H. Neumann (1977) Tveitite, a new calcium yttrium fluoride. Lithos, 10, 81–87. (2) (1977) Amer. Mineral., 62, 1060 (abs. ref. 1). (3) Bevan, D.J.M., J. Strähle, and O. Greis (1982) The crystal structure of tveitite, an ordered yttrofluorite mineral. J. Solid State Chem., 44, 75–81.

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Twinnite $Pb(Sb,As)_2S_4$

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Crystal Data: Triclinic, probable; pseudo-orthorhombic. *Point Group:* $2/m$ $2/m$ $2/m$, apparent. As grains, to 1.5 mm. *Twinning:* Polysynthetic, the trace of the composition plane parallel to {100}.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Brittle. Hardness = n.d. VHN = 147 (50 g load). D(meas.) = n.d. D(calc.) = 5.323 (for Sb:As=3:2).

Optical Properties: Opaque. *Color:* Black; white in polished section. *Streak:* Black, with a slightly brownish tint. *Luster:* Metallic. *Pleochroism:* Strong, displaying twin lamellae. R_1–R_2: (400) 39.1–45.2, (420) 38.2–44.7, (440) 37.3–44.2, (460) 36.6–43.7, (480) 36.2–43.2, (500) 35.8–42.9, (520) 35.5–42.5, (540) 35.0–42.0, (560) 34.4–41.4, (580) 34.0–40.8, (600) 33.5–40.0, (620) 33.2–39.4, (640) 32.8–38.7, (660) 32.3–38.1, (680) 31.7–37.5, (700) 31.0–37.0

Cell Data: *Space Group:* *Pnmn* pseudocell. $a = 19.6(2)$ $b = 7.99(5)$ $c = 8.60(5)$ $\alpha = 90°$ $\beta = 90°$ $\gamma = 90°$ Z = 8

X-ray Powder Pattern: Madoc, Canada.
3.51 (100), 2.344 (80), 2.78 (70), 4.18 (50), 3.91 (50), 2.689 (50), 2.645 (50)

Chemistry:

	(1)	(2)	(3)
Pb	41	39.3	38.7
Sb	28	28.1	24.8
As	11	8.9	12.0
S	23	23.7	23.9
Total	103	100.0	99.4

(1) Madoc, Canada; by electron microprobe, corresponding to $Pb_{1.10}(Sb_{1.28}As_{0.82})_{\Sigma=2.10}S_{4.00}$. (2) Do.; by electron microprobe, corresponding to $Pb_{1.03}(Sb_{1.25}As_{0.64})_{\Sigma=1.89}S_{4.00}$. (3) Novoye, Kyrgyzstan; by electron microprobe, corresponding to $Pb_{1.00}(Sb_{1.09}As_{0.86})_{\Sigma=1.95}S_{4.00}$.

Polymorphism & Series: Dimorphous with guettardite.

Occurrence: In marble with other lead sulfantimonides (Madoc, Canada).

Association: Chabournéite, pierrotite, parapierrotite, stibnite, pyrite, sphalerite, zinkenite, madocite, andorite, smithite, laffittite, routhierite, aktashite, wakabayashilite, realgar, orpiment (Jas Roux, France); sphalerite, pyrite, galena, playfairite, sorbyite, guettardite, baumhauerite, realgar, orpiment, cinnabar, fluorite, quartz (Novoye, Kyrgyzstan).

Distribution: In Canada, from near Madoc [TL], and in the Hemlo gold deposit, Thunder Bay district, Ontario. In France, from the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes. At the Rujevac Sb–Zn–Pb deposit, western Serbia. From Novoye, Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan.

Name: In honor of Robert Mitchell Thompson (1918–1967), Canadian mineralogist, University of British Columbia, Vancouver, Canada. Thompson is "son of Thomas"; the latter is Aramaic for "a twin". The name is doubly appropriate in alluding to the polysynthetic twinning present in the mineral.

Type Material: Canadian Geological Survey, Ottawa, 12175; Canadian Museum of Nature, Ottawa, Canada.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Canada. Part 2 — Mineral descriptions. Can. Mineral., 9, 191–213. (2) (1968) Amer. Mineral., 53, 1424 (abs. ref. 1). (3) Jambor, J.L., J.H.G. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100. (4) Mozgova, N.N., N.S. Bortnikov, Y.S. Borodaev, and A.I. Tzépine (1982) Sur la non-stoechiométrie des sulfosels antimonieux arséniques de plomb. Bull. Minéral., 105, 3–10 (in French with English abs.).

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Tychite $Na_6Mg_2(SO_4)(CO_3)_4$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Crystals, to 8 mm, {111}, perhaps modified by small {100}.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 3.5–4
D(meas.) = 2.367–2.743 D(calc.) = 2.586

Optical Properties: Transparent to translucent. *Color:* White; colorless in transmitted light.
Luster: Vitreous.
Optical Class: Isotropic. $n = 1.508–1.510$

Cell Data: *Space Group:* $Fd3$. $a = 13.880–13.942$ $Z = 8$

X-ray Powder Pattern: Searles Lake, California, USA.
2.674 (100), 4.18 (76), 2.459 (40), 3.190 (24), 1.605 (24), 2.006 (17), 1.736 (17)

Chemistry:

	(1)	(2)
SO_3	15.07	15.32
CO_2	33.50	33.68
MgO	15.80	15.42
Na_2O	35.57	35.58
Total	99.94	100.00

(1) Searles Lake, California, USA; average of two analyses. (2) $Na_6Mg_2(SO_4)(CO_3)_4$.

Polymorphism & Series: Forms a series with ferrotychite.

Occurrence: Uncommon in lake-bed evaporite deposits.

Association: Northupite, gaylussite, thénardite, schairerite, pirssonite (Searles Lake, California, USA); northupite (Katwe Lake, Uganda).

Distribution: In the USA, from Searles Lake, San Bernardino Co., California; and in the Green River Formation, Northern Piceance Creek Basin, Colorado. At Lake Katwe, western Uganda.

Name: From the Greek for *good fortune*, as the first and one of the last ten crystals examined were of this species, from a lot of about 5000 examined.

Type Material: Yale University, New Haven, Connecticut, USA, 3.1634.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 294–295. (2) Mwanje, J. and Y. Kaahwa (1977) Observations on Uganda tychite. Mineral. Record, 8, 396. (3) Keester, K.L., G.J. Johnson, Jr., and V. Vand (1969) New data on tychite. Amer. Mineral., 54, 302–305.

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Tyretskite $Ca_2B_5O_9(OH,Cl)\cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As lamellar crystals, to 4 mm, in radiating and spherulitic aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.189 D(calc.) = [2.57]

Optical Properties: Semitransparent. *Color:* White to pale brown.
Optical Class: Biaxial. $\alpha = 1.637$ β = n.d. $\gamma = 1.670$ 2V(meas.) = ∼46°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.44$ $b = 6.45$ $c = 6.41$ $\alpha = 118.23°$ $\beta = 119.75°$ $\gamma = 73.50°$ Z = 1

X-ray Powder Pattern: Tyret station, Russia.
2.93 (10), 2.86 (10), 2.14 (9), 1.846 (9), 2.06 (8), 2.80 (7), 3.23 (6), 1.985 (6)

Chemistry:

	(1)	(2)	(3)
SO_3	2.38		
CO_2	4.73		
B_2O_3	43.36	55.54	55.56
R_2O_3	0.36		
MgO	2.14		
CaO	29.77	32.08	35.81
SrO	1.94	2.49	
Na_2O	3.50		
Cl	5.13	1.44	
H_2O	6.85	8.77	8.63
insol.	0.54		
$-O = Cl_2$	1.16	0.32	
Total	99.54	[100.00]	100.00

(1) Tyret station, Russia; (2) Do.; analysis (1) after deduction of halite 6.64%, anhydrite 4.07%, dolomite 9.8%, calcite 0.13%, R_2O_3, and insoluble; corresponds to $(Ca_{1.80}Sr_{0.08})_{\Sigma=1.88}B_{5.02}O_{9.00}[(OH)_{0.69}Cl_{0.13}]_{\Sigma=0.82}\cdot 1.18H_2O$. (3) $Ca_2B_5O_9(OH)\cdot H_2O$.

Polymorphism & Series: The 1A polytype is known.

Occurrence: Very rare, in a cavity in dolomitic saline rock, in drillcore from a depth of 1233 m.

Association: Sylvite, halite, carnallite, halite.

Distribution: From near the Tyret railway station, on the east Siberian railway, in the Lena-Angara salt basin, Irkutsk district, Siberia, Russia.

Name: For its initial occurrence near the Tyret station, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 76340.

References: (1) Ivanov, A.A. and Y.Y. Yarzhemskii (1954) Boron manifestations in the saline strata of the Leno-Angar basin. Trudy Vses. Nauch. Issled. Inst. Halurgi, 29, 210-214. (2) Kondrat'eva, V.V. (1964) X-ray study of some minerals of the hilgardite group. X-ray study of minerals. 'Nedra', Moscow, 4, 10–18 (in Russian). (3) (1966) Mineral. Abs., 17, 500–501 (abs. ref. 1–2). (4) Davies, W.O. and M.P. Machin (1968) Strontiohilgardite-1Tc and tyretskite, a structural pair. Amer. Mineral., 53, 2084–2087. (5) Ghose, S. (1985) A new nomenclature for the borate minerals in the hilgardite ($Ca_2B_5O_9\cdot H_2O$)−tyretskite ($Ca_2B_5O_9\cdot H_2O$) group. Amer. Mineral., 70, 636–637. (6) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 219–220.

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Tyrolite $CaCu_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Scaly to lathlike crystals, flattened on {010}, to 3 mm; typically foliated to fibrous, in radiating groups and crusts.

Physical Properties: *Cleavage:* On {001}, perfect, micaceous. *Tenacity:* Sectile, flexible in thin flakes. Hardness = ∼2 D(meas.) = 3.25 D(calc.) = 3.27

Optical Properties: Translucent. *Color:* Verdigris-green, pale apple-green, may be sky-blue; pale green in transmitted light. *Streak:* Pale green or pale blue. *Luster:* Vitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Pleochroism:* $X = Z$ = pale grass-green; Y = pale yellowish green. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, strong. α = 1.673–1.694 β = 1.690–1.726 γ = 1.703–1.730 2V(meas.) = 36°–70°

Cell Data: *Space Group: Pmma.* a = 10.21–10.50 b = 54.71–55.51 c = 5.59–5.60 Z = 8

X-ray Powder Pattern: Peñamellera, Spain.
28.0 (FFF), 14.1 (F), 2.98 (F), 2.70 (F), 4.85 (mF), 4.44 (m), 5.27 (fm)

Chemistry:

	(1)	(2)
As_2O_5	27.07	26.36
CO_2	5.05	5.05
CuO	46.24	45.63
CaO	6.44	6.43
H_2O	15.68	16.53
Total	100.48	100.00

(1) Falkenstein, Austria. (2) $CaCu_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized zone of hydrothermal copper deposits, typically formed by alteration of tennantite.

Association: Tennantite, malachite, azurite, brochantite, chrysocolla.

Distribution: Numerous minor localities; a few for good material include: in Austria, in the Tirol, on the Falkenstein, near Schwaz; at Kogel, near Brixlegg; from Rattenberg; and elsewhere. At L'ubietová, near Baňská Bystrica (Libethen, near Neusohl), Slovakia. In the Midezianka copper mine, near Kielce, Poland. In Germany, at Schneeberg, Saxony; from Saalfeld and Stahlberg, Thuringia; at Bieber and Richelsdorf, Hesse. From the Cap Garonne mine, near le Pradet, Var, France. In Spain, rich material from Peñamellera, Oviedo Province; at Villamanin, Léon Province. From the Gortdrum mine, Co. Tipperary, Ireland. In the Gwaithyafon mine, Cwmsymlog, Wales. In Russia, from the Turinsk copper mine, Bogoslovsk, Ural Mountains; at Nerchinsk, Transbaikalia. From the Talmessi mine, 35 km west of Anarak, Iran. In the USA, fine examples from the Centennial Eureka, Mammoth, and other mines, Tintic district, Juab Co., and the Gold Hill mine, Tooele Co., Utah; at the Majuba Hill mine, Antelope district, Pershing Co., and elsewhere in Nevada. From the Kitabira mine, Yamaguchi Prefecture, and Toroku mine, Miyazaki Prefecture, Japan.

Name: For its occurrence in the Tirol (Tyrol), Austria.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 925–926. (2) Guillemin, C. (1956) Contribution a la minéralogie des arséniates, phosphates et vanadates de cuivre. I. Arséniates de cuivre. Bull. Soc. fr. Minéral., 59, 7–95, esp. 35–37, 91 (in French).

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Tyrrellite $(Cu, Co, Ni)_3Se_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Rounded grains and subhedral cubes.

Physical Properties: *Cleavage:* {001}, poor. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼3.5 VHN = 343–368 (100 g load). D(meas.) = n.d. D(calc.) = 6.6(2)

Optical Properties: Opaque. *Color:* Pale bronze; pale brassy bronze in reflected light. *Streak:* Black. *Luster:* Metallic.

R: (400) 41.8, (420) 42.6, (440) 43.5, (460) 44.4, (480) 45.0, (500) 45.5, (520) 45.9, (540) 46.3, (560) 46.5, (580) 46.8, (600) 47.0, (620) 47.3, (640) 47.5, (660) 47.6, (680) 47.8, (700) 48.0

Cell Data: *Space Group:* $Fm3m$. a = 10.005(4) Z = 8

X-ray Powder Pattern: Ato Bay, Canada.
1.769 (10), 2.501 (9), 2.886 (7), 3.016 (6), 1.926 (6), 5.780 (4), 3.537 (4)

Chemistry:

	(1)	(2)
Cu	12.7	13.7
Co	17.7	11.6
Ni	6.9	12.0
Se	62.4	62.0
Total	99.7	99.3

(1) Beaverlodge district [*sic*; Goldfields district], Canada; by electron microprobe, corresponding to $Cu_{1.01}Co_{1.52}Ni_{0.60}Se_{4.00}$. (2) Hope's Nose, England; by electron microprobe; corresponding to $Cu_{1.10}Ni_{1.04}Co_{1.00}Se_{4.00}$.

Mineral Group: Linnaeite group.

Occurrence: With other selenides, as the youngest hydrothermal replacements and open space fillings in sheared Precambrian rocks, which also contain uraninite deposits (Goldfields district, Canada).

Association: Umangite, klockmannite, clausthalite, pyrite, hematite, chalcopyrite, chalcomenite (Ato Bay, Canada); berzelianite, eucairite, crookesite, ferroselite, bukovite, kruťaite, athabascaite, calcite, dolomite (Petrovice deposit, Czech Republic).

Distribution: In Canada, from the western part of the Eagle claims, and also at the head of Ato Bay, Beaverlodge Lake, Goldfields district, Saskatchewan [TL]. From Bukov, near Tisnova, on Koksín Hill, near Mitov, and in the Petrovice uranium deposit, near Ždăr, Czech Republic. At Hope's Nose, Torquay, Devon, England. In Argentina, from Tuminico, Sierra de Cacho, and at Los Llantenes, La Rioja Province.

Name: Honors Joseph Burr Tyrell (1858–1957), American geologist, first to visit the area of discovery in Canada.

Type Material: Canadian Geological Survey, Ottawa, 61592; Royal Ontario Museum, Toronto, Canada.

References: (1) Robinson, S.C. and E.J. Brooker (1952) A cobalt–nickel–copper selenide from the Goldfields district, Saskatchewan. Amer. Mineral., 37, 542–544. (2) Sindeeva, N.D. (1964) Mineralogy and types of deposits of selenium and tellurium, 77–78. (3) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 590–591.

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Tyuyamunite $Ca(UO_2)_2(V_2O_8)\cdot 5–8H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Elongated, platy crystals, flattened on {001}, elongated along [010], with {010}, {110}, several other forms, may be curved or scaly, to 2 mm. As fanlike or radial aggregates; in thin films, coatings, and massive impregnations.

Physical Properties: *Cleavage:* On {001}, perfect, micaceous; on {100}, {010}, distinct. Hardness = ∼2 D(meas.) = 3.57–4.35 D(calc.) = [3.59] Radioactive; may exhibit weak yellow-green fluorescence under UV.

Optical Properties: Translucent to opaque. *Color:* Canary-yellow, lemon-yellow, greenish yellow on exposure to sunlight; colorless to pale yellow in transmitted light. *Luster:* Adamantine, pearly on {001}, may be dull to waxy if massive.
Optical Class: Biaxial (–). *Pleochroism:* Faint; X = nearly colorless; Y = pale canary-yellow; Z = canary-yellow. *Orientation:* $X = c$; $Y = a$; $Z = b$. *Dispersion:* $r < v$ weak to strong.
$\alpha = 1.675$ $\beta = 1.860–1.870$ $\gamma = 1.885–1.895$ 2V(meas.) = 30°–45°

Cell Data: *Space Group:* n.d. $a = 10.63$ $b = 8.36$ $c = 20.40$ Z = n.d.

X-ray Powder Pattern: Hudspeth Co., Texas, USA.
10.18 (10), 5.02 (9), 3.20 (5), 2.04 (4), 6.62 (3), 3.37 (3), 3.12 (3)

Chemistry:

	(1)	(2)
UO_3	57.29	59.96
V_2O_5	18.49	19.06
CO_2	0.91	
PbO	0.14	
MgO	0.08	
CaO	6.75	5.88
H_2O	15.37	15.10
insol.	0.20	
Total	99.23	100.00

(1) Tyuya-Muyun Cave, Kyrgyzstan; the H_2O content varies zeolitically as a function of relative humidity, reversibly altering to metatyuyamunite. (2) $Ca(UO_2)_2(V_2O_8)\cdot 8H_2O$.

Occurrence: An uncommon mineral in the oxidized zone of U–V deposits, especially those of the Colorado Plateau-type.

Association: Metatyuyamunite, carnotite, corvusite, uranophane, volborthite, gypsum.

Distribution: From Tyuya-Muyun Cave, Fergana Valley, Alai Range, Kyrgyzstan. At West Wheal Owles, St. Just, Cornwall, England. In the USA, an ore mineral at the Jackpile mine, Laguna district, Cibola Co., and at a number of mines in the Grants district, New Mexico; in Colorado, from Paradox Valley, Montrose Co., Calamity Creek, Mesa Co., and elsewhere; at many mines in Utah, as Richardson and Thompsons, Grand Co. In Arizona, at the Monument No. 2 mine, Monument Valley, Apache Co., in the Ridenaur breccia pipe, Coconino Co., and many other places; from the Gold Quarry mine, near Carlin, Eureka Co., Nevada; at Warren and the Dandy mine, Pryor Mountains, Carbon Co., Montana. From Santa Eulalia, Chihuahua, Mexico. In the Malargüe district, Mendoza Province, and at the Urcal deposit, La Rioja Province, Argentina. In the Hatrurim Formation, Israel. A number of additional minor localities are known.

Name: For the Tyuya-Muyun Cave, Kyrgyzstan, its original locality.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 3575–3577.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1045–1047. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 248–253. (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 220–221.

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Törnroosite $Pd_{11}As_2Te_2$

Crystal Data: Cubic. *Point Group*: 4/*m* $\bar{3}$ 2/*m*. As irregular subrounded grains to 200 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: n.d.
Hardness = 5 VHN = 519 (25 g load). D(meas.) = n.d. D(calc.) = 11.205

Optical Properties: Opaque. *Color*: Black, yellowish white in reflected light. *Streak*: Silvery black. *Luster*: Metallic.
Optical Class: Isotropic.
R: (470) 45.4, (546) 51.0, (589) 54.1, (650) 57.45

Cell Data: *Space Group: Fd*3*m*. a = 12.3530(4) Z = 8 (by analogy with isomertieite ($Pd_{11}Sb_2As_2$).

X-ray Powder Pattern: Miessijoki River, Lemmenjoki area, Finnish Lapland, Finland.
2.182 (100), 2.376 (90), 1.544 (14), 1.862 (13), 1.261 (13), 2.519 (11), 1.608 (11)

Chemistry:

	(1)	(2)
Pd	72.04	74.29
Pt	1.75	
Sn	2.13	
Sb	0.85	
As	8.77	9.51
Te	13.15	16.20
Bi	0.79	.
Total	99.48	100.00

(1) Miessijoki River, Lemmenjoki area, Finnish Lapland, Finland; average of 10 electron microprobe analyses, corresponding to $(Pd_{10.85}Pt_{0.14})_{\Sigma=10.99}(As_{1.88}Sb_{0.11})_{\Sigma=1.99}(Te_{1.65}Sn_{0.29}Bi_{0.06})_{\Sigma=2.00}$. (2) $Pd_{11}As_2Te_2$.

Occurrence: In heavy concentrate from glaciofluvial gravels and sands derived from mafic-ultramafic intrusions in a granulitic complex.

Association: Gold, platinum, sperrylite, cooperite, braggite, irarsite, laurite, isomertieite, mertieite II, atokite, and Pt-Fe, Pt-Cu, Os-Ir-Ru, Cu-Pt-Pd, Cu-Pd-Pt-Au, Pd-Au, and Au-Ag natural alloys, and pyrite, rutile, uraninite-thorianite, galena, wolframite, magnetite, ilmenite, chromite, hematite, columbite-tantalite, tapiolite, almandine, zircon.

Distribution: Miessijoki River, Lemmenjoki area, Inari Commune, Finnish Lapland, Finland.

Name: Honors Professor Ragnar Törnroos (b. 1943), University of Helsinki, Finland, who first reported a mineral of similar composition at Finnish Lapland.

Type Material: Natural History Museum, London, England, (2010,100).

References: (1) Kojonen, K.K., A.M. McDonald, C.J. Stanley, and B. Johanson (2011) Törnroosite, $Pd_{11}As_2Te_2$, a new mineral species related to isomertierite from Miessijoki, Finnish Lapland, Finland. Canadian Mineralogist, 49, 1643-1651. (2) (2014) Amer. Mineral., 99, 874-875 (abs. ref. 1).

Uchucchacuaite $AgPb_3MnSb_5S_{12}$

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Crystal Data: Monoclinic likely, pseudo-orthorhombic. *Point Group:* $2/m$ $2/m$ $2/m$, 222, or $mm2$. Subhedral crystals, anhedral grains, to 200 μm. *Twinning:* Polysynthetic along one direction.

Physical Properties: Hardness = n.d. VHN = 168 (100 g load). D(meas.) = n.d. D(calc.) = 5.61

Optical Properties: Opaque. *Color:* Gray. *Luster:* Metallic.

R_1–R_2: (400) 36.2–44.3, (420) 36.3–44.2, (440) 35.8–44.2, (460) 35.2–43.8, (480) 35.0–43.9, (500) 34.7–43.7, (520) 34.5–43.4, (540) 34.1–43.3, (560) 33.8–43.0, (580) 33.5–42.6, (600) 33.2–42.4, (620) 33.0–42.0, (640) 32.7–41.8, (660) 32.3–41.2, (680) 31.8–40.6, (700) 31.2–39.9

Cell Data: *Space Group:* $Pmmm$, $P222$, or $Pmm2$. $a = 12.67$ $b = 19.32$ $c = 4.38$ $Z = 2$

X-ray Powder Pattern: Uchuc-Chacua deposit, Peru.
3.30 (100), 2.90 (80), 3.80 (30), 3.49 (30), 2.75 (30), 2.08 (30), 2.29 (10)

Chemistry:

	(1)	(2)
Ag	5.9	6.07
Pb	34.8	34.96
Mn	2.8	3.09
Fe	0.2	
Sb	34.4	34.24
Se	0.3	
S	21.1	21.64
Total	99.5	100.00

(1) Uchuc-Chacua deposit, Peru; by electron microprobe, corresponding to $Ag_{0.98}Pb_{3.04}(Mn_{0.91}Fe_{0.06})_{\Sigma=0.97}Sb_{5.09}(S_{11.93}Se_{0.07})_{\Sigma=12.00}$. (2) $AgPb_3MnSb_5S_{12}$.

Occurrence: In a telescoped polymetallic hydrothermal deposit.

Association: Alabandite, galena, benavidesite, sphalerite, pyrite, pyrrhotite, arsenopyrite.

Distribution: From the Uchuc-Chacua deposit, Cajatambo Province, Peru [TL].

Name: For the Uchuc-Chacua deposit in Peru.

Type Material: National School of Mines, Paris, France.

References: (1) Moëlo, Y., E. Oudin, P. Picot, and R. Caye (1984) L'uchucchacuaïte, $AgMnPb_3Sb_5S_{12}$, une nouvelle espèce minérale de la sèrie de l'andorite. Bull. Minéral., 107, 597–604 (in French with English abs.). (2) (1985) Amer. Mineral., 70, 1332–1333 (abs. ref. 1).

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Uedaite-(Ce) $Mn^{2+}CeAl_2Fe(Si_2O_7)(SiO_4)O(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. Prismatic crystals, to 1 mm, elongated on [010].

Physical Properties: *Cleavage*: Poor {001}. *Fracture*: Uneven. *Tenacity*: Brittle.
Hardness = 5-6 D(meas.) = n.d. D(calc.) = 4.19

Optical Properties: Translucent to opaque. *Color*: Black to dark brown. *Streak*: Gray.
Luster: Vitreous.
Optical Class: Biaxial (-). α = n.d. β = 1.770(5) γ = n.d. 2V (meas.) = Large.
Orientation: *Y* = *b*. *Pleochroism*: brown to yellow.

Cell Data: *Space Group*: $P2_1/m$. a = 8.939(8) b = 5.742(4) c = 10.187(8) β = 115.10(6)°
Z = 2

X-ray Powder Pattern: Shodoshima Island, Kagawa Prefecture, Japan.
2.92 (100), 3.53 (54), 2.71 (43), 2.62 (39), 8.03 (26), 9.23 (24), 2.87 (23)

Chemistry:

	(1)	(2)
SiO_2	29.94	30.13
Al_2O_3	16.02	17.07
FeO	16.01	12.01
MnO	6.01	11.86
MgO	0.07	
CaO	2.42	
La_2O_3	3.09	
Ce_2O_3	10.75	27.44
Pr_2O_3	1.83	
Nd_2O_3	6.44	
Sm_2O_3	1.35	
Gd_2O_3	0.54	
Y_2O_3	0.72	
ThO_2	0.51	
H_2O	1.50	1.51
Total	97.20	100.00

(1) Shodoshima Island, Kagawa Prefecture, Japan; average of 5 electron microprobe analyses, water calculated from structure, corresponding to $(Mn_{0.51}Ca_{0.26})_{\Sigma=0.77}(Ce_{0.39}Nd_{0.23}La_{0.11}Pr_{0.07}Sm_{0.05}Y_{0.04}Gd_{0.02}Th_{0.01})_{\Sigma=0.92}(Al_{1.89}Fe_{1.34}Mg_{0.01})_{\Sigma=3.24}(Si_2O_7)(SiO_4)O_{0.85}(OH)$.
(2) $Mn^{2+}CeAl_2Fe^{2+}(Si_2O_7)(SiO_4)O(OH)$.

Mineral Group: Epidote group, allanite subgroup.

Occurrence: An accessory mineral in granite.

Association: Allanite-(Ce), monazite-(Ce), zircon, thorite, bastnaesite-(Ce).

Distribution: Shodoshima Island, Kagawa Prefecture, Japan.

Name: Honors Tateo Ueda (1912–2000), who was the first to solve the crystal structure of allanite.

Type Material: National Museum of Nature and Science, Tokyo, Japan, NSM-M28864.

References: (1) Miyawaki, R., K. Yokoyama, S. Matsubara, Y. Tsutsumi, and A. Goto (2008) Uedaite-(Ce), a new member of the epidote group with Mn at the A site, from Shodoshima, Kagawa Prefecture, Japan. Eur. J. Mineral., 20, 261–269. (2) (2008) Amer. Mineral., 93, 1944-1945 (abs. ref. 1).

Uhligite $Ca_3(Ti, Al, Zr)_9O_{20}(?)$

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Crystal Data: Cubic, probably pseudocubic. *Point Group:* n.d. Octahedra, modified by the cube; {111} striated ‖ [011]. *Twinning:* On {111}.

Physical Properties: *Cleavage:* {001}, imperfect. *Fracture:* Conchoidal. Hardness = 5.5 D(meas.) = 4.15 D(calc.) = n.d.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black; yellowish brown to dark brown in transmitted light. *Streak:* Gray to brownish gray. *Luster:* Metallic. *Optical Class:* Isotropic, with biaxial lamellae. n = n.d.
R: n.d.

Cell Data: *Space Group:* n.d. $a = 7.639$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
Nb_2O_5	trace
TiO_2	48.25
ZrO_2	21.95
Al_2O_3	10.50
Fe_2O_3	trace
CaO	19.00
Total	99.70

(1) Lake Magadi, Kenya.

Occurrence: In nepheline syenite.

Association: n.d.

Distribution: At Lake Magadi, Kenya.

Name: To honor Alfred Lewis Johannes Uhlig (1883–1919), German geologist, who lead the expedition on which the mineral was discovered.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 735–736.

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Uklonskovite $NaMg(SO_4)F \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As flattened prismatic crystals, elongated along [010], to 2 mm, in tufts and sprays.

Physical Properties: *Cleavage:* One or more ‖ [010]. Hardness = n.d. D(meas.) = 2.42 D(calc.) = 2.414

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (+). $\alpha = 1.476(1)$ $\beta =$ n.d. $\gamma = 1.500(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$. $a = 7.202(1)$ $b = 7.214(1)$ $c = 5.734(1)$ $\beta = 113.23(1)^\circ$ $Z = 2$

X-ray Powder Pattern: Cetine mine, Italy.
3.505 (100), 6.608 (78), 5.270 (60), 3.154 (56), 2.970 (54), 3.309 (46), 3.008 (46)

Chemistry:

	(1)	(2)	(3)
SO_3	42.80	42.55	40.35
MgO	20.61	20.99	20.32
CaO	2.40	2.20	
Na_2O	14.87		15.62
K_2O	1.01		
F	n.d.		9.58
H_2O	18.00		18.16
$-O = F_2$			4.03
Total	99.69		100.00

(1) Kushkanatau salt deposit, Uzbekistan; H_2O by TGA. (2) Do.; separate partial determinations. (3) $NaMg(SO_4)F \cdot 2H_2O$.

Occurrence: Of very rare occurrence in cavities in clays above the salt strata (Kushkanatau salt deposit, Uzbekistan); on gypsum, sulfate derived from oxidizing sulfides, the other elements from limestones and clays (Cetine mine, Italy).

Association: Glauberite, polyhalite (Kushkanatau salt deposit, Uzbekistan); jurbanite, rostite, tamarugite, ferrinatrite, sideronatrite (Cetine mine, Italy).

Distribution: From the Kushkanatau salt deposit, lower Amu Darya River, Kara-Kalpakii, Uzbekistan. In the Cetine mine, 20 km southwest of Siena, Tuscany, Italy.

Name: Honors Aleksandr Sergeevich Uklonskii (1882–1972), mineralogist, Tashkent University, Tashkent, Uzbekistan, who studied central Asian mineral deposits.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 67132, 67135.

References: (1) Slyusareva, M.N. (1964) The new mineral uklonskovite. Doklady Acad. Nauk SSSR, 158, 1093–1095 (in Russian). (2) Rumanova, I.M. and E.P. Popova (1964) The new mineral uklonskovite. Kristallografiya (Sov. Phys. Crystal.), 9, 275–277 (in Russian). (3) (1965) Amer. Mineral., 50, 520–521 (abs. ref. 1–2). (4) Sabelli, C. (1985) Uklonskovite, $NaMg(SO_4)F.2H_2O$: new mineralogical data and structure refinement. Bull. Minéral., 108, 133–138. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 221.

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Ulexite **$NaCaB_5O_6(OH)_6 \cdot 5H_2O$**

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Rare as measurable crystals, which may have many forms; typically elongated to acicular along [001], to 5 cm, then forming fibrous cottonball-like masses; in compact parallel fibrous veins, and radiating and compact nodular groups. *Twinning:* Polysynthetic on {010} and {100}; possibly also on {$\overline{3}$40}, {2$\overline{3}$0}, and others.

Physical Properties: *Cleavage:* On {010}, perfect; on {1$\overline{1}$0}, good; on {110}, poor. *Fracture:* Uneven across fiber groups. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 1.955 D(calc.) = 1.955 Slightly soluble in H_2O; parallel fibrous masses can act as fiber optical light pipes; may fluoresce yellow, greenish yellow, cream, white under SW and LW UV.

Optical Properties: Transparent to opaque. *Color:* Colorless; white in aggregates, gray if included with clays. *Luster:* Vitreous; silky or satiny in fibrous aggregates. *Optical Class:* Biaxial (+). *Orientation:* X (11.5°,81°); Y (100°,21.5°); Z (107°,70°) [with c (0°,0°) and b^* (0°,90°) using (ϕ,ρ)]. α = 1.491–1.496 β = 1.504–1.506 γ = 1.519–1.520 2V(meas.) = 73°–78°

Cell Data: *Space Group:* $P\overline{1}$. $a = 8.816(3)$ $b = 12.870(7)$ $c = 6.678(1)$ $\alpha = 90.36(2)°$ $\beta = 109.05(2)°$ $\gamma = 104.98(4)°$ Z = 2

X-ray Powder Pattern: Jenifer mine, Boron, California, USA.
12.2 (100), 7.75 (80), 6.00 (30), 4.16 (30), 8.03 (15), 4.33 (15), 3.10 (15b)

Chemistry:

	(1)	(2)
B_2O_3	43.07	42.95
CaO	13.92	13.84
Na_2O	7.78	7.65
H_2O	35.34	35.56
Total	100.11	100.00

(1) Suckow mine, Boron, California, USA. (2) $NaCaB_5O_6(OH)_6 \cdot 5H_2O$.

Occurrence: Typically in playa and salt-marsh deposits in arid regions and bedded sedimentary deposits formed from these, the boron supplied from surrounding hot springs. Some occurrences contain upwards of one billion tons of ulexite.

Association: Colemanite, borax, meyerhofferite, hydroboracite, probertite, glauberite, trona, mirabilite, calcite, gypsum, halite.

Distribution: In Chile, from near Iquique, and in a large deposit at the Surire salt lake, southeast of Arica, Tarapacá; from the Salar de Ascotan, Antofagasta. At more than 60 deposits in Jujuy, Salta, and Catamarca Provinces, Argentina. From Laguna Salinas, 70 km east of Arequipa, Peru. In the USA, at Columbus Marsh, Rhodes Marsh, and Teels Marsh, Esmeralda Co., Nevada; in California, from Death Valley and Saline Valley, Inyo Co., in the Kramer borate deposit, Boron, Kern Co. In Canada, at Windsor, Nova Scotia; from Hillsborough, in the Potash Corporation of America mine, Penobsquis evaporite deposit, near Sussex, with other minor occurrences in New Brunswick. From Niederellenbach, Hesse, Germany. Found near Bela Stena, Jarandol Basin, Serbia, ??Yugoslavia. At the Inder boron deposit, Kazakhstan. From the Da-Chaidan and Zazangzaka salt lakes, Tibet, China. In Turkey, immense deposits in the Bigadiç borate district, Balıkesir Province; in the Kirka borate deposit, Eskiçehir Province.

Name: Honors George Ludwig Ulex (1811–1883), German chemist who obtained the first reliable analysis of the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 345–348. (2) Clark, J.R. and C.L. Christ (1959) Studies of borate minerals (V): reinvestigation of the X-ray crystallography of ulexite and probertite. Amer. Mineral., 44, 712–719. (3) Ghose, S., C. Wan, and J.R. Clark (1978) Ulexite, $NaCaB_5O_6(OH)_6 \cdot 5H_2O$: structure refinement, polyanion configuration, hydrogen bonding, and fiber optics. Amer. Mineral., 63, 160–171.

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Ullmannite NiSbS

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Crystal Data: Cubic. *Point Group:* 23. As cubes and, less commonly, octahedra, pyritohedra, tetrahedra, to 3 cm. Cube faces striated by [110], twin boundaries of enantiomorphs. *Twinning:* Forms penetration twins about [110] with {001} the approximate composition plane; re-entrants develop on cube edges.

Physical Properties: *Cleavage:* Perfect on {001}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 VHN = 592–627 (100 g load). D(meas.) = 6.65 ??6.85 D(calc.) = 6.793

Optical Properties: Opaque. *Color:* Steel-gray to silver-white; white in reflected light. *Streak:* Grayish black. *Luster:* Metallic. *Anisotropism:* Individuals may be weakly anisotropic revealing a fine lamellar structure.

R: (400) 52.0, (420) 51.0, (440) 50.0, (460) 49.0, (480) 48.2, (500) 47.4, (520) 46.7, (540) 46.1, (560) 45.7, (580) 45.5, (600) 45.5, (620) 45.6, (640) 46.0, (660) 46.4, (680) 47.0, (700) 47.6

Cell Data: *Space Group:* $P2_13$ ($P1$ for arsenian ullmannite). $a = 5.88$–5.93 $Z = 4$

X-ray Powder Pattern: Salchendorf, Germany.
2.64 (100), 1.774 (70), 2.40 (60), 1.573 (50), 1.092 (50), 0.810 (50), 0.802 (50)

Chemistry:

	(1)	(2)	(3)	(4)
Ni	28.91	27.3	23.3	27.62
Co	1.13	0.8	3.8	
Fe	0.40			
Sb	42.93	52.8	58.9	57.29
As	10.28	3.5	0.4	
Bi	0.68	1.0		
S	16.22	15.1	14.8	15.09
Total	100.55	100.5	101.2	100.00

(1) Gosenbach, Germany. (2) Petersbach mine, Germany; by electron microprobe. (3) Broken Hill, Australia; by electron microprobe. (4) NiSbS.

Polymorphism & Series: Forms a series with willyamite.

Mineral Group: Cobaltite group.

Occurrence: With nickel minerals in hydrothermal veins.

Association: Nickeline, gersdorffite, pentlandite, chalcopyrite, pyrrhotite, galena, tetrahedrite, dyscrasite.

Distribution: In Germany, in North Rhine-Westphalia, from [Freusburg [spelling OK = mindat.org, but see notes??], near Siegen?? ck USNM catalog??]; at the Friedrich mine, near Wissen; the Petersbach mine, near Eichelhardt; Gosenbach; Salchendorf; and at Ramsbeck; in the Harz Mountains, from Neudorf; and elsewhere From Lölling, Carinthia, Austria. In France, at Ar, near Eaux-Bonnes, Pyrénées-Atlantiques. From Monte Narba and Masaloni, Sarrabus, Sardinia, Italy. In the Settlingstones mine, Fourstones, Northumberland, and at New Brancepeth colliery, Durham, England. From the Talnakh area, Noril'sk region, western Siberia, Russia. In the Esperanza mine, Salta Province, Argentina. In Canada, at the Kerr Addison mine, Timiskaming district, Ontario; and from the Nicholson mine, near Goldfields, Saskatchewan. At Broken Hill, New South Wales, Australia. In the Champion Reef mine, Kolar Gold Fields, Karnataka, India. Dozens of additional minor localities are known.

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Name: In honor of Johan Christoph Ullmann (1771–1821), German chemist and mineralogist, who first discovered the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 301–302. (2) Bayliss, P. (1986) Subdivision of the pyrite group, and a chemical and X-ray diffraction investigation of ullmannite. Can. Mineral., 24, 27–33. (3) Takéuchi, Y. (1957) The absolute structure of ullmanite, NiSbS. Mineral. J. (Japan), 2, 90–102. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 95–96.

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Ulrichite $CaCu(UO_2)(PO_4)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, composed of flat prismatic fibers with complex terminations, to 1 mm, in radial aggregates. *Twinning:* On {100}, common.

Physical Properties: Hardness = ~3.5 D(meas.) = n.d. D(calc.) = 3.71 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Pale apple-green to lime-green; in transmitted light, pale green. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–) (?). *Orientation:* Parallel extinction, length slow. $\alpha = 1.622(2)$ β = n.d. $\gamma = 1.634(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m$. $a = 12.79(3)$ $b = 6.85(2)$ $c = 13.02(3)$ $\beta = 91.03(7)^\circ$ Z = 4

X-ray Powder Pattern: Lake Boga quarry, Australia.
6.389 (100), 3.193 (45), 2.879 (20), 4.498 (15), 2.373 (15), 5.602 (14), 3.480 (14)

Chemistry:

	(1)	(2)
UO_3	46.36	45.00
P_2O_5	22.09	22.33
CuO	11.02	12.51
CaO	9.23	8.82
H_2O	9.9	11.34
Total	98.60	100.00

(1) Lake Boga quarry, Australia; by electron microprobe, average of 14 analyses, H_2O by CHN analyzer on a separate sample; corresponds to $Ca_{1.09}Cu_{0.92}(UO_2)_{1.07}(PO_4)_{2.06} \cdot 3.65H_2O$.
(2) $CaCu(UO_2)(PO_4)_2 \cdot 4H_2O$.

Occurrence: A secondary mineral in miarolitic cavities in pegmatoidal granite.

Association: Turquoise-chalcosiderite, cyrilovite, torbernite, libethenite, sampleite, saléeite, fluorapatite.

Distribution: From the Lake Boga granite quarry, near Swan Hill, Victoria, Australia.

Name: To honor George Henry Frederick Ulrich (1830–1900), for his contributions to the mineralogy of Victoria, Australia.

Type Material: Museum Victoria, Melbourne, Australia, M38576.

References: (1) Birch, W.D., W.G. Mumme, and E.R. Segnit (1988) Ulrichite: a new copper calcium uranium phosphate from Lake Boga, Victoria, Australia. Australian Mineral., 3, 125–131.
(2) (1990) Amer. Mineral., 75, 243 (abs. ref. 1).

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Ulvöspinel $TiFe^{2+}_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Commonly as an exsolution, forming a fine network along {100} in magnetite, or in ilmenite; rarely as skeletal crystals, to 2 cm.

Physical Properties: Hardness = n.d. VHN = ∼650 D(meas.) = n.d. D(calc.) = 4.78

Optical Properties: Opaque. *Color:* Black; brown to reddish brown in reflected light. *Optical Class:* Isotropic.

R: (400) 17.9, (420) 17.5, (440) 17.1, (460) 17.0, (480) 16.9, (500) 17.0, (520) 17.2, (540) 17.5, (560) 17.8, (580) 18.2, (600) 18.6, (620) 18.9, (640) 19.1, (660) 19.2, (680) 19.2, (700) 19.2

Cell Data: *Space Group: Fd3m* (synthetic). a = 8.398–8.504 Z = 8

X-ray Powder Pattern: Synthetic.
2.573 (100), 1.5089 (39), 3.018 (33), 1.6426 (33), 2.1339 (19), 1.7419 (10), 0.8711 (10)

Chemistry:

	(1)	(2)
SiO_2	0.2	
TiO_2	26.3	35.73
Al_2O_3	1.4	
Fe_2O_3	16.5	
V_2O_3	0.2	
FeO	51.7	64.27
MnO	0.7	
MgO	1.8	
CaO	0.3	
Total	99.1	100.00

(1) Nass River Valley, British Columbia, Canada; by electron microprobe, Fe^{2+}:Fe^{3+} from charge balance; corresponds to $(Fe^{2+}_{1.60}Ti_{0.73}Fe^{3+}_{0.46}Mg_{0.10}Al_{0.06}Mn_{0.02}Ca_{0.01}Si_{0.01}V_{0.01})_{\Sigma=3.00}O_4$.
(2) $TiFe_2O_4$.

Mineral Group: Spinel group.

Occurrence: A common component of titaniferous magnetite iron ores; in kimberlites; in strongly reduced iron-bearing basalts, terrestrial and lunar.

Association: Iron, magnetite, troilite, cohenite, graphite, ilmenite, pyrrhotite, chalcopyrite, olivine, pyroxene, biotite, plagioclase, apatite.

Distribution: A few localities for studied material include: from the Grundhamn and other mines, near Södra Ulvön mountain, and elsewhere in the Ulvö Islands, Ångermanland archipelago, northern Sweden. In Finland, at Susimäki, Kuisaari, Sammali, and elsewhere. At Bühl, near Weimar, Hesse, Germany. At Padvinsk, Ural Mountains, and in the Udachnaya kimberlite pipe, Sakha, Russia. On Disko Island, near Uivfaq and Kitdlît, Greenland. At the Mooihoek Farm, Lydenburg district; Spitzkop, near Middelburg; and Vygenhoek, Transvaal, South Africa. In Mozambique, from Chapanduka, Massamba, and Canjueira. At Chinumba, Gambos, and Chihamji, Angola. In the USA, in the Duluth Gabbro complex, near Hibbing, St. Louis Co., Minnesota; around Lake Sanford, Essex Co., New York; large crystals from the Soda Springs vent, Gila Co., Arizona. At Lac de Blanche and Benoite Lake, Quebec, Canada. Abundant in some basalts on the Moon.

Name: For the occurrence on the Ulvö Islands, Sweden, and as a member of the *spinel* group.

Type Material: n.d.

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References: (1) Mogensen, F. (1946) A ferro-ortho-titanate ore from Södra Ulvön. Geol. Fören. Förhandl. Stockholm, 68, 578–588. (2) Ramdohr, P. (1953) Ulvöspinel and its significance in titaniferous iron ores. Econ. Geol., 48, 677–688. (3) (1955) Amer. Mineral., 40, 138 (abs. refs. 1 and 2). (4) Stout, M.V. and P. Bayliss (1980) Crystal structure of two ferrian ulvöspinels from British Columbia. Can. Mineral., 18, 339–341. (5) Picot, P. and Z. Johan (1982) Atlas of ore minerals. B.R.G.M., Orléans, France, and Elsevier, Amsterdam, Holland, 378. (6) (1983) NBS Mono. 25, 20, 61.

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Umangite Cu_3Se_2

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Crystal Data: Tetragonal. *Point Group:* $\bar{4}2m$. Massive, as disseminated small grains; individual grains commonly exhibit rectangular outlines. *Twinning:* Rarely lamellar.

Physical Properties: *Cleavage:* Poor, rectangular. *Fracture:* Uneven, subconchoidal. *Tenacity:* Brittle. Hardness = 3 VHN = 88–100 (100 g load). D(meas.) = 6.44–6.49 D(calc.) = 6.590

Optical Properties: Opaque. *Color:* Bluish black with reddish cast, weathers to a dull iridescent purple. *Streak:* Black. *Pleochroism:* Pronounced; reddish purple to grayish blue. *Anisotropism:* Very strong; fiery orange to straw-yellow with a rose tint.
R_1–R_2: (400) 23.3–24.7, (420) 22.1–22.5, (440) 20.7–20.3, (460) 19.4–18.4, (480) 18.5–17.0, (500) 17.7–15.6, (520) 16.8–14.2, (540) 16.0–13.0, (560) 15.5–12.3, (580) 15.3–12.4, (600) 15.5–13.8, (620) 16.0–16.2, (640) 16.7–19.4, (660) 17.4–22.8, (680) 18.0–26.3, (700) 18.5–29.4

Cell Data: *Space Group:* $P\bar{4}2_1m$. $a = 6.4024(5)$ $c = 4.2786(4)$ Z = 2

X-ray Powder Pattern: Sierra de Umango, Argentina.
3.559 (100), 1.829 (90), 1.778 (80), 3.108 (70), 2.258 (70), 3.202 (60), 1.908 (50)

Chemistry:

	(1)	(2)
Cu	54.35	54.69
Ag	0.55	
Se	45.10	45.31
Total	100.00	100.00

(1) Sierra de Umango, Argentina. (2) Cu_3Se_2.

Occurrence: With other selenides in hydrothermal veins, formed below 112 °C.

Association: Clausthalite, tiemannite, berzelianite, guanajuatite, eucairite, klockmannite, hessite, naumannite, chalcomenite, chalcopyrite, cobaltite, pyrite, malachite, calcite.

Distribution: In Argentina, from the Sierra de Umango [TL], in the Santa Brigida mine, at Los Llantenes, and from Tuminico, Sierra de Cacho, La Rioja Province; and at the Cerro de Cacheuta, Mendoza Province. In Canada, from Lodge Bay on Lake Athabasca, to Ato Bay on Beaverlodge Lake, Saskatchewan, and on Christopher Island, Baker Lake, Northwest Territories. At Skrikerum, near Tryserum, Kalmar, Sweden. In Germany, in the Harz Mountains, at St. Andreasberg, Tilkerode, Zorge, Lerbach, and Clausthal. From the Chaméane uranium mine, near Vernet-la-Varenne, Puy-de-Dôme, France. At Hope's Nose, Torquay, Devon, England. From Kletno, Poland. In the Czech Republic, in the Bukov and Habrí mines, near Tisnova; at the Petrovice uranium deposit, near Ždăr; and from the Předbořice uranium deposit, near Krásna Hora. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From Tsumeb, Namibia. At Kalgoorlie, and from the Copper Hills prospect, East Pilbara region, Western Australia; in the Iron Monarch quarry, Iron Knob, South Australia. In the Frederik VII's mine, near Julianehåb, southern Greenland. A few additional localities are known.

Name: For the Sierra de Umango, Argentina, place of first discovery.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 194–195. (2) Earley, J.W. (1950) Description and synthesis of the selenide minerals. Amer. Mineral., 35, 337–364. (3) Heyding, R.D. and R.M. Murray (1976) The crystal structures of $Cu_{1.8}Se$, Cu_3Se_2, α– and β–CuSe, $CuSe_2$, and $CuSe_2$II. Can. J. Chem., 54, 841–848. (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 43–44. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 596.

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Umbite $K_2ZrSi_3O_9 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* 222. Crystals platy, flattened on {010}, to 1 mm, with forms {010}, {101}, {110}, and {001}.

Physical Properties: *Cleavage:* On {010}, perfect, micaceous; {100}, less perfect. Hardness = ~4.5 VHN = 305–401, 381 average. D(meas.) = 2.79 D(calc.) = 2.79 Weak yellowish fluorescence under UV.

Optical Properties: Semitransparent. *Color:* Colorless to yellowish. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.596(2)$ $\beta = 1.619(2)$ γ = n.d. 2V(meas.) = 80°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 10.208(2)$ $b = 13.241(4)$ $c = 7.174(1)$ Z = 4

X-ray Powder Pattern: Khibiny massif, Russia.
3.02 (10b), 5.91 (9), 2.87 (8), 1.797 (8b), 3.31 (7), 6.56 (6b), 2.156 (4)

Chemistry:

	(1)	(2)
SiO_2	42.36	43.37
TiO_2	3.33	
ZrO_2	22.28	29.64
HfO_2	0.43	
Fe_2O_3	0.12	
CaO	0.00	
Na_2O	0.16	
K_2O	22.41	22.66
F	2.00	
H_2O	5.03	4.33
$-O = F_2$	0.84	
Total	97.28	100.00

(1) Khibiny massif, Russia; by electron microprobe, average of three analyses; corresponds to $(K_{2.02}Na_{0.02})_{\Sigma=2.04}(Zr_{0.77}Ti_{0.18}Hf_{0.01}Fe_{0.01})_{\Sigma=0.97}Si_{3.00}O_{9.92}H_{2.38}F_{0.45}$. (2) $K_2ZrSi_3O_9 \cdot H_2O$.

Polymorphism & Series: Dimorphous with kostylevite.

Occurrence: In pegmatite in a differentiated alkalic massif.

Association: Kostylevite, wadeite, eudialyte, potassic feldspar, aegirine.

Distribution: In the valley of the Vuonnemiok River, Khibiny massif, Kola Peninsula, Russia.

Name: For Lake Umbozero, which separates the Khibiny massif from the Lovozero massif, Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity; Mineralogical Museum, St. Petersburg University, St. Petersburg, 17072; Mining Institute, St. Petersburg, 1631/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82758; The Natural History Museum, London, England, 1994,35.

References: (1) Khomyakov, A.P., A.A. Voronkov, Y.S. Kobyashev, and L.I. Polezhaeva (1983) Umbite and paraumbite, new potassium zirconosilicates from the Khibiny alkalic massif. Zap. Vses. Mineral. Obshch., 112, 461–469 (in Russian). (2) Ilyushin, G.D., Z.V. Pudovkina, A.A. Voronkov, A.P. Khomyakov, V.V. Ilyukhin, and Y.A. Pyatenko (1981) Crystal structure of a new natural modification of $K_2ZrSi_3O_9 \cdot H_2O$. Doklady Acad. Nauk SSSR, 257, 608–610 (in Russian). (3) (1984) Amer. Mineral., 69, 813–814 (abs. refs. 1 and 2).

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Umbozerite $Na_3Sr_4ThSi_8(O, OH)_{24}$

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Crystal Data: Metamict; tetragonal after recrystallization. *Point Group:* n.d. As acicular prismatic crystals, to 1.5 cm, sometimes curved; as irregular segregations.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ~5 VHN = 470–535, 506 average. D(meas.) = 3.60 D(calc.) = n.d. Radioactive.

Optical Properties: Translucent to transparent. *Color:* Bottle-green to mottled greenish brown. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.640$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Mt. Karnasurt, Russia; pattern after heating to 1100 °C.
3.29 (100), 1.701 (80), 3.38 (60), 1.999 (60), 2.98 (50), 2.82 (50), 2.09 (45)

Chemistry:

	(1)		(1)
SiO_2	37.1	CaO	0.2
TiO_2	0.3	SrO	27.7
ThO_2	17.6	BaO	2.0
Ce_2O_3	0.3	Na_2O	6.13
Fe_2O_3	1.8	K_2O	0.74
U_3O_8	0.4	LOI	0.43
MnO	2.2	Total	96.8

(1) Mt. Karnasurt, Russia; by electron microprobe and flame photometry, average of six analyses; corresponds to $(Na_{2.56}K_{0.19})_{\Sigma=2.75}(Sr_{3.46}Mn_{0.40}Ba_{0.17}Ca_{0.05})_{\Sigma=4.08}(Th_{0.86}Fe_{0.30}Ti_{0.05}U_{0.02}Ce_{0.02})_{\Sigma=1.25}Si_8O_{23.35}(OH)_{0.68}$.

Occurrence: In pneumatolytic-hydrothermal veins cutting alkalic rocks in the upper part of a differentiated alkalic massif.

Association: Ussingite, sphalerite, belovite, manganoan pectolite, lorenzenite, niobium-bearing minerals of the lomonosovite group.

Distribution: Found on Mts. Karnasurt and Punkaruaiv, near Lake Umba, Lovozero massif, Kola Peninsula, Russia.

Name: For Lake Umbozero, Kola Peninsula, Russia, near where the mineral was discovered.

Type Material: Mining Institute, St. Petersburg, 992/1; Institute of Mineralogy and Geochemistry of Rare Elements, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75150; National School of Mines, Paris, France.

References: (1) Es'kova, Y.M., E.I. Semenov, A.P. Khomyakov, A.N. Mer'kov, S.I. Lebedeva, and L.S. Dubakina (1974) Umbozerite, a new mineral. Doklady Acad. Nauk SSSR, 216, 169–174 (in Russian). (2) (1975) Amer. Mineral., 60, 341 (abs. ref. 1).

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Umohoite $(UO_2)Mo^{6+}O_4 \cdot 2H_2O$

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Crystal Data: Triclinic, pseudorhombohedral. *Point Group:* $\overline{1}$ or 1. Tabular plates, to 0.5 mm, in rosettes; also massive, in thin veinlets, and disseminated.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = n.d. D(meas.) = 4.53–4.66 D(calc.) = 4.523–4.457 Radioactive.

Optical Properties: Semitransparent to opaque. *Color:* Blue-black with dark green patches. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = dark blue; Y = pale blue; Z = olive-green. *Orientation:* $Y = b$; $X \wedge c \simeq 9°05'$; $Z \simeq a$. *Dispersion:* $r > v$. $\alpha = [1.66(1)]$ $\beta = 1.831(5)$ $\gamma = 1.915(5)$ 2V(meas.) = 65(2)°

Cell Data: *Space Group:* $P\overline{1}$, with $a = 6.3748(4)$ $b = 7.5287(5)$ $c = 14.628(1)$ $\alpha = 82.64(1)°$ $\beta = 85.95(1)°$ $\gamma = 89.91(1)°$ Z = 4, or *Space Group:* $P1$, with $a = 6.372(3)$ $b = 7.535(4)$ $c = 14.69(3)$ $\alpha = 97.1°$ $\beta = 85.9°$ $\gamma = 90.07°$ Z = 4

X-ray Powder Pattern: Marysvale, Utah, USA; after heating to 50°C overnight, as the pattern changes with humidity and temperature, grinding, or X-ray bombardment.
4.13 (10), 3.20 (5), 3.15 (4), 12.2 (3), 6.18 (3), 2.07 (3), 3.11 (2)

Chemistry:

	(1)	(2)	(3)
MoO_3	28.23	34.80	30.89
UO_3	57.65	55.35	61.38
As_2O_3	1.		

	(1)	(2)	(3)
MgO		1.00	
H_2O	14.	[8.85]	7.73
Total		[100.00]	100.00

(1) Marysvale, Utah, USA. (2) Shinkolobwe, Congo; by electron microprobe, average of two analyses; H_2O by difference. (3) $(UO_2)MoO_4 \cdot 2H_2O$, determined from crystal-structure analysis.

Occurrence: A rare secondary mineral, typically in sediment-hosted uranium-bearing deposits, formed in the oxidation zone above the water table.

Association: Uraninite, ilsemannite, jordisite, iriginite, schoepite, uranophane, rutherfordine, calcurmolite, fluorite, pyrite, gypsum, quartz.

Distribution: From the USA, from the Freedom No. 2 mine, Marysvale, Ohio district, Piute Co., Utah; at the Lucky Mc mine, Gas Hills, Fremont Co., Wyoming; and in the Alyce Tolino mine, Cameron district, Coconino Co., Arizona. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From the Rabéjac and Mas-d'Alary uranium deposits, south of Lodève, Hérault, France. At the Kyzylsai Mo–U deposit, Chu-Ili Mountains, southwestern Balkhash region, Kazakhstan. From unspecified localities in the former Soviet Union.

Name: For Uranium, MOlybdenum, Hydrogen, and Oxygen in the composition.

Type Material: n.d.

References: (1) Brophy, G.P. and P.F. Kerr (1953) Hydrous uranium molybdate in Marysvale ore, a preliminary report; in: Annual Report for June 30, 1952 to April 1, 1953, U.S. Atomic Energy Comm. RME-3046, 45–51. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 148–149. (3) Coleman, R.G. and D.E. Appleman (1957) Umohoite from the Lucky Mc mine, Wyoming. Amer. Mineral., 42, 657–660. (4) Kamhi, S.R. (1959) An X-ray study of umohoite. Amer. Mineral., 44, 920–925. (5) Hamilton, P.-K. and P.F. Kerr (1959) Umohoite from Cameron, Arizona. Amer. Mineral., 44, 1248–1260. (6) Krivovichev, S.Y. and P.C. Burns (2000) Crystal chemistry of uranyl molybdates. I. The structure and formula of umohoite. Can. Mineral., 38, 717–726. (7) Rastsvetaeva, R.K., A.V. Barinova, G.A. Sidorenko, and D.Y. Pushcharovskiy (2000) Crystal structure of triclinic umohoite $[UMoO_6H_2O] \cdot H_2O$. Doklady Acad. Nauk SSSR, 373, 202–205.

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Ungemachite $K_3Na_8Fe^{3+}(SO_4)_6(NO_3)_2 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. Tabular crystals, to 1 mm, thick on {0001}, bounded by large {0001} and {$10\overline{1}1$}, {$01\overline{1}2$}, {$11\overline{2}3$}, {$10\overline{1}4$}, with more than 20 other modifying forms noted.

Physical Properties: *Cleavage:* On {0001}, perfect. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.287(3) D(calc.) = [2.259]

Optical Properties: Transparent. *Color:* Colorless to pale yellow; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.502(2)$ $\epsilon = 1.449(2)$

Cell Data: *Space Group:* $R\overline{3}$. $a = 10.898(1)$ $c = 24.989(6)$ Z = 3

X-ray Powder Pattern: Chuquicamata, Chile. (ICDD 20-1326).
3.43 (100), 8.33 (60), 2.72 (55), 2.59 (35), 8.82 (30), 7.55 (30), 1.880 (25)

Chemistry:

	(1)	(2)
SO_3	41.23	41.22
N_2O_5	trace	9.27
Fe_2O_3	7.88	6.85
Na_2O	22.15	21.27
K_2O	11.63	12.12
H_2O	17.11	9.27
Total	[100.00]	100.00

(1) Chuquicamata, Chile; recalculated to 100% after deduction of 2.07% insoluble, from an original total of 99.64%; stated then to correspond to $K_{2.88}Na_{8.34}Fe_{1.15}(SO_4)_{6.01}(OH)_2 \cdot 10H_2O$.
(2) $K_3Na_8Fe(SO_4)_6(NO_3)_2 \cdot 6H_2O$ as verified by crystal-structure analysis.

Occurrence: Rarely formed by the oxidation of pyrite in an arid climate, in veins and cavities in other massive iron sulfates.

Association: Clinoungemachite, jarosite, sideronatrite, metasideronatrite, metavoltine, fibroferrite.

Distribution: From Chuquicamata, Antofagasta, Chile.

Name: Honors Henri Léon Ungemach (1879–1936), Belgian crystallographer who studied the natural sulfates of Chile.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 98282, 98283.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 596–597. (2) Groat, L.A. and F.C. Hawthorne (1986) Structure of $K_3Na_8Fe^{3+}(SO_4)_6(NO_3)_2 \cdot 6H_2O$, a mixed sulfate-nitrate mineral. Amer. Mineral., 71, 826–829.
(3) Peacock, M.A. and M.C. Bandy (1938) Ungemachite and clino-ungemachite: new minerals from Chile. Amer. Mineral., 23, 314–328.

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Upalite $Al(UO_2)_3O(PO_4)_2(OH)\cdot 7H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Acicular to fibrous crystals, elongated along [001], poorly terminated, to 0.3 mm. *Twinning:* By reflection on {001}, universal.

Physical Properties: *Cleavage:* On {010}, distinct. Hardness = 3 D(meas.) = 3.9(1) D(calc.) = 3.94 Radioactive.

Optical Properties: Transparent. *Color:* Amber-yellow; canary-yellow in transmitted light. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = colorless; $Y = Z$ = canary-yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Orientation:* Negative elongation. $\alpha = 1.649$ $\beta = 1.666$ $\gamma = 1.676$ 2V(meas.) = n.d. 2V(calc.) = 74(9)°

Cell Data: *Space Group:* $P2_1/a$. $a = 13.704(4)$ $b = 16.82(1)$ $c = 9.332(2)$ $\beta = 111.5(1)°$ Z = 4

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
8.4 (100), 4.18 (80), 3.43 (80), 2.903 (75), 3.17 (70), 3.084 (70), 4.24 (60)

Chemistry:

	(1)	(2)
UO_3	80.2	72.34
P_2O_5	12.3	11.97
Al_2O_3	4.0	4.30
H_2O	[3.5]	11.39
Total	[100.0]	100.00

(1) Kobokobo pegmatite, Congo; by electron microprobe, H_2O by difference.
(2) $Al(UO_2)_3O(PO_4)_2(OH)\cdot 7H_2O$.

Occurrence: A rare secondary mineral in the oxidized uraniferous zone of a complex granite pegmatite.

Association: Meta-autunite, phosphuranylite, threadgoldite, phuralumite.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: For Uranium, Phosphorus, and ALuminum in the composition.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG5951, RMG13457, RMG11888.

References: (1) Deliens, M. and P. Piret (1979) Les phosphates d'uranyle et d'aluminium de Kobokobo. II. La phuralumite $Al_2(UO_2)_3(PO_4)_2(OH)_6\cdot 10H_2O$ et l'upalite $Al(UO_2)_3(PO_4)_2(OH)_3$, nouveaux minéraux. Bull. Minéral., 102, 333–337 (in French with English abs.). (2) (1980) Amer. Mineral., 65, 208 (abs. ref. 1). (3) Piret, P. and J.-P. Declercq (1983) Structure cristalline de l'upalite $Al[(UO_2)_3O(OH)(PO_4)_2]\cdot 7H_2O$. Un exemple de macle mimétique. Bull. Minéral., 106, 383–389 (in French with English abs.).

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Uralborite $CaB_2O_2(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, to several cm, elongated along [100], typically in radiating fibrous aggregates.

Physical Properties: *Cleavage:* One, ‖ elongation, distinct. Hardness = 4–4.5 D(meas.) = 2.58–2.60 D(calc.) = 2.58 Fluoresces violet under LW UV.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+), anomalous dark blue and brown interference colors may be observed. *Dispersion:* $r > v$, strong. $\alpha = 1.604$–1.605 $\beta = 1.609$–1.611 $\gamma = 1.615$–1.618 2V(meas.) = 85° 2V(calc.) = 86°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.923$–6.927 $b = 12.326$–12.331 $c = 9.831$–9.836 $\beta = 97.09°$–$97.81°$ Z = 4

X-ray Powder Pattern: Novofrolovskoye deposit, Russia. 7.61 (10), 2.13 (10), 2.97 (9), 1.407 (8), 6.18 (6), 3.42 (6), 4.81 (5).

Chemistry:

	(1)	(2)	(3)
B_2O_3	38.06	43.42	43.05
SiO_2	4.00		
Al_2O_3	1.12		
Fe_2O_3	2.13		
MgO	0.67		
CaO	35.27	34.87	34.67
H_2O^+	19.08	21.88	
H_2O^-	0.00	0.54	
H_2O			22.28
Total	100.33	100.71	100.00

(1) Novofrolovskoye deposit, Russia; after deducting andradite–grossular and szaibélyite, corresponds to $Ca_{1.05}B_{2.00}O_{1.95}(OH)_4$. (2) Fuka, Japan; CaO by electron microprobe, B_2O_3 by ICP, H_2O by TGA; corresponds to $Ca_{1.01}B_{2.02}O_{2.07}(OH)_{3.93}$. (3) $CaB_2O_2(OH)_4$.

Polymorphism & Series: Dimorphous with vimsite.

Occurrence: A rare secondary mineral in boron-rich iron-ore skarns (Novofrolovskoye deposit, Russia); in a vein cutting limestone (Fuka, Japan).

Association: Andradite–grossular, magnetite, szaibélyite, frolovite (Novofrolovskoye deposit, Russia); sibirskite, borcarite, fluorite, calcite (Fuka, Japan).

Distribution: In Russia, from the Novofrolovskoye copper deposit, near Krasnoturinsk, Turinsk district, Northern Ural Mountains, and in the Solongo boron deposit, Buryatia. Found at Fuka, near Bicchu, Okayama Prefecture, Japan.

Name: For the original locality in the URAL Mountains, Russia, and BORate in its composition.

Type Material: Vernadsky Geological Museum, Moscow, 48613; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64944, vis3597.

References: (1) Malinko, S.V. (1961) New boron minerals – uralborite and pentahydroborite. Zap. Vses. Mineral. Obshch., 90, 673–681 (in Russian). (2) (1962) Amer. Mineral., 47, 1482 (abs. ref. 1). (3) Simonov, M.A., Y.K. Yegorov-Tismenko, and N.V. Belov (1977) Accurate crystal structure of uralborite $Ca_2[B_4O_4(OH)_8]$. Doklady Acad. Nauk SSSR, 234, 822–825 (in Russian). (4) Kusachi, I., K. Shiraga, S. Kobayashi, J. Yamakawa, and Y. Takechi (2000) Uralborite from Fuka, Okayama Prefecture, Japan. Mineral. J. (Japan), 95, 43–47.

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Uralolite $Ca_2Be_4(PO_4)_3(OH)_3 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Bladed crystals, elongated and striated ‖ [100], flattened on {010}, with {010}, {001}, {101}, {021}; typically in radial fibrous spherulites and matted aggregates, to 5 mm. *Twinning:* May show multiple twinning.

Physical Properties: *Cleavage:* {010}, {100}, indistinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 2.05–2.14 D(calc.) = 2.197 Pale yellowish green fluorescence under LW UV, deep green under SW UV.

Optical Properties: Transparent to translucent. *Color:* White, colorless. *Luster:* Vitreous, silky for fibrous aggregates.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Z \wedge a = 9°–20°$. $\alpha = 1.510–1.512$ $\beta = 1.525–1.526$ $\gamma = 1.533–1.536$ 2V(meas.) = 66° 2V(calc.) = 70°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.550(1)$ $b = 16.005(3)$ $c = 15.969(4)$ $\beta = 101.64(2)°$ Z = 4

X-ray Powder Pattern: Boevskoye deposit, Russia; spacings from a calculated pattern, intensities estimated visually.
3.562 (10), 7.12 (7), 5.59 (5), 3.03 (5), 5.25 (3), 3.203 (3), 7.82 (2)

Chemistry:

	(1)	(2)	(3)	(4)
P_2O_5	39.57	38.26	40.1	39.27
Al_2O_3	0.95			
BeO	19.28	18.31	17.5	18.45
CaO	18.02	20.15	21.2	20.68
H_2O	24.10	21.17	21.0	21.60
insol.	0.11			
Total	[102.03]	97.89	99.8	100.00

(1) Boevskoye deposit, Russia; H_2O taken as LOI, original total given as 102.05%; corresponding to $Ca_{1.73}Be_{4.11}(PO_4)_{3.00}(OH)_{2.94} \cdot 5.69H_2O$. (2) Dunton quarry, Maine, USA; corresponding to $Ca_{2.00}Be_{4.07}(PO_4)_{3.00}(OH)_3 \cdot 5H_2O$. (3) Weinebene Pass, Austria; by electron microprobe, H_2O by LOI. (4) $Ca_2Be_4(PO_4)_3(OH)_3 \cdot 5H_2O$.

Occurrence: In complex zoned granite pegmatites (Boevskoye deposit, Russia; Dunton quarry, Maine, USA); in a spodumene-rich pegmatite in high-grade metamorphic rocks (Weinebene Pass, Austria).

Association: Moraesite, beryllonite, apatite, carbonate-apatite, crandallite, beryl, fluorite (Boevskoye deposit, Russia); roscherite, hydroxyl-herderite, elbaite, beryllonite, lepidolite, albite (Dunton quarry, Maine, USA).

Distribution: In the Boevskoye beryllium deposit, 35 km southwest of Kamensk–Ural'skii, Middle Ural Mountains, Russia. At the Dunton quarry, Newry, Oxford Co., Maine, USA. From near Taquaral, Minas Gerais, Brazil. In the Weinebene Pass, Carinthia, Austria.

Name: For the Ural Mountain region, Russia, in which it was first found.

Type Material: Il'menskii Preserve Museum, Miass, 5523; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75439.

References: (1) Grigor'ev, N.A. (1964) Uralolite – a new mineral. Zap. Vses. Mineral. Obshch., 93, 156–162 (in Russian). (2) (1964) Amer. Mineral., 49, 1776 (abs. ref. 1). (3) Dunn, P.J. and R.V. Gaines (1978) Uralolite from the Dunton gem mine, Newry, Maine: a second occurrence. Mineral. Record, 9, 99–100. (4) Mereiter, K., G. Niedermayr, and F. Walter (1994) Uralolite, $Ca_2Be_4(PO_4)_3(OH)_3 \cdot 5H_2O$: new data and crystal structure. Eur. J. Mineral., 6, 887–896.
(5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 222.

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Uramarsite $(NH_4, H_3O)_2(UO_2)_2(AsO_4, PO_4)_2 \cdot 6H_2O$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As imperfect platy crystals, to 2 mm, as films and, less often, as flattened square crystals, to 0.1 mm; dominated by {001} with minor {010}.

Physical Properties: *Cleavage*: Perfect {001}, imperfect {010}. *Fracture*: Stepped. *Tenacity*: Brittle. Hardness = 2.5 D(meas.) = 3.22 D(calc.) = 3.286

Optical Properties: Transparent. *Color*: Pale green; colorless in thin section. *Streak*: White. *Luster*: Vitreous. Fluoresces green in UV.
Optical Class: Anomalously biaxial (–). $\alpha = 1.562(2)$ $\beta \approx \gamma = 1.593(2)$ $2V < 5°$
Orientation: $X = c$; $Y \approx b$.

Cell Data: *Space Group*: *P*4/*nmm*. $a = 7.19(1)$ $c = 9.15(2)$ $Z = 1$

X-ray Powder Pattern: Bota-Burum deposit, Southern Kazakhstan Region, Kazakhstan.
9.27 (100), 4.58 (25), 3.86 (20), 2.28 (20), 2.80 (13), 1.823 (8), 1.713 (7)

Chemistry:

	(1)	(2)
Na_2O	0.3	
UO_3	61.8	59.46
As_2O_5	15.0	23.89
P_2O_5	5.9	
$(NH_4)_2O$	3.2	5.41
H_2O	13.8	11.24
total	86.2	100.00

(1) Bota-Burum deposit, Southern Kazakhstan Region, Kazakhstan; electron microprobe analysis, NH_4 by ionometric electrode, H_2O by difference; water, hydronium and anionic groups confirmed by IR, corresponding to $[(NH_4)_{1.15}(H_3O)_{0.72}Na_{0.09}]_{\Sigma=1.96}(UO_2)_{2.02}[(AsO_4)_{1.22}(PO_4)_{0.78}]_{\Sigma=2} \cdot 6.1H_2O$.
(2) $(NH_4)_2(UO_2)_2(AsO_4)_2 \cdot 6H_2O$.

Occurrence: In the oxidized zone of pitchblende-sulfide mineralization in highly-fractured, hydrothermally-altered felsite porphyry and tuff breccia.

Association: Calcite, arsenopyrite, pyrite, galena, chistyakovaite, natrouranospinite, scorodite, arseniosiderite, mansfieldite, metazeunerite, trögerite.

Distribution: Bota-Burum deposit, south of Alakol' Lake, southwestern Balkhash area, Southern Kazakhstan Region, Kazakhstan.

Name: An acronym for the major chemical components URanium, AMmonium, ARSenate.

Type Material: Fedorovskiy All-Russia Research Institute of Mineral Resources, Moscow, 350/59/zel.

References: (1) Sidorenko, G.A., N.V. Chukanov, N.I. Chistyakova, G.I. Bebeshko, A.E. Zadov, and I.S. Naumova (2007) Uramarsite $(NH_4, H_3O)_2(UO_2)_2(AsO_4, PO_4)_2 \cdot 6H_2O$: a new mineral of the metaautunite group. Dokl. Akad. Nauk 415, 804–808 (in Russian); Dokl. Earth Sci. 415A, 965–969 (in English). (2) (2009) Amer. Mineral., 94, 405 (abs. ref. 1).

Uramphite $(NH_4)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$

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Crystal Data: Tetragonal (synthetic). *Point Group:* $4/m\ 2/m\ 2/m$. Square tablets, to 0.2 mm, in rosettes and coatings.

Physical Properties: *Cleavage:* Distinct in two directions. Hardness = n.d. D(meas.) = 3.7 D(calc.) = 3.26 Radioactive; fluoresces yellow-green.

Optical Properties: Semitransparent. *Color:* Bottle-green to pale green. *Luster:* Vitreous. *Optical Class:* Biaxial (–), anomalous. *Pleochroism:* X = colorless; $Y = Z$ = pale green. $\alpha = 1.564$ $\beta = 1.585$ $\gamma = 1.585$ 2V(meas.) = 0°–3°

Cell Data: *Space Group:* $P4/ncc$ (synthetic). $a = 7.02(1)$ $c = 18.08(4)$ Z = 4

X-ray Powder Pattern: Tura-Kavak deposit, Kyrgyzstan.
3.78 (10), 2.22 (9), 1.694 (8.5), 2.75 (8), 2.12 (8), 3.24 (7), 1.399 (7)

Chemistry:

	(1)	(2)
UO_3	68.70	66.66
P_2O_5	15.63	16.54
NH_4	4.60	4.20
H_2O	11.00	12.60
Total	99.93	100.00

(1) Tura-Kavak deposit, Kyrgyzstan; corresponds to $(NH_4)_{2.2}(UO_2)_{2.3}(PO_4)_{2.0} \cdot 5.5H_2O$.
(2) $(NH_4)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$.

Mineral Group: Meta-autunite group.

Occurrence: In the oxidized zone of a uranium-coal deposit, in fractures in the coal at depths between 20 and 50 m.

Association: n.d.

Distribution: From the Tura-Kavak uranium-coal deposit, Kyrgyzstan.

Name: For its content of URanium, AMmonium, and PHosphate.

Type Material: n.d.

References: (1) Nekrasova, Z.A. (1957) Hydrous phosphate of uranyl and ammonium (uramphite), $NH_4(UO_2)(PO_4) \cdot 3H_2O$. Problems of uranium geology, 67–72 (in Russian). (2) (1959) Amer. Mineral., 44, 464 (abs. ref. 1). (3) Markovic, M. and N. Pavkovic (1988) J. Res. NBS, 93, 557. (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 222.

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Urancalcarite $Ca(UO_2)_3(CO_3)(OH)_6 \cdot 3H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Acicular crystals, elongated along [001] and flattened on {100}, showing {100}, {010}, and {001}, in radiating aggregates, to 4 mm.

Physical Properties: Hardness = 2–3 D(meas.) = 4.03 D(calc.) = 4.10 Radioactive.

Optical Properties: Transparent. *Color:* Bright yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* X = pale yellow; $Y = Z$ = bright yellow. *Orientation:* $X = a$; $Y = b$; $Z = c$. $\alpha = 1.660(3)$ $\beta = 1.712(2)$ $\gamma = 1.736(2)$ 2V(calc.) = 66.6°

Cell Data: *Space Group:* $Pbnm$ or $Pbn2_1$. $a = 15.42(3)$ $b = 16.08(4)$ $c = 6.970(6)$ Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
8.06 (100), 4.02 (80), 3.488 (70), 3.193 (50), 2.101 (50), 2.829 (40), 7.00 (30)

Chemistry:

	(1)	(2)	(3)
UO_3	78.68	76.16	80.47
P_2O_5		0.10	
SiO_2		0.80	
CO_2	4.93	4.29	4.13
MnO		0.08	
PbO		0.13	
CaO	4.36	4.66	5.26
Na_2O		0.10	
K_2O		0.35	
H_2O	10.61	13.27	10.14
Total	98.58	99.94	100.00

(1) Shinkolobwe, Congo; by electron microprobe, average of six analyses, CO_2 by gas chromatography, $CO_2 + H_2O$ by TGA; corresponds to $Ca_{0.83}(UO_2)_{2.93}(CO_3)_{1.19}(OH)_{5.14} \cdot 3.70H_2O$. (2) Hunan Province, China; CO_2 and H_2O determined on a separate sample. (3) $Ca(UO_2)_3(CO_3)(OH)_6 \cdot 3H_2O$.

Occurrence: In the oxidation zone of uranium deposits.

Association: Uraninite, uranophane, wyartite, masuyite (Shinkolobwe, Congo); fourmarierite, vandendriesscheite, studtite, uranophane-beta, rutherfordine (Hunan Province, China).

Distribution: From Shinkolobwe, Katanga Province, Congo [Shaba Province, Zaire]. Found at an undisclosed locality in Hunan Province, China.

Name: For URANium, CALcium, and CARbonate in the composition.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RGM13995.

References: (1) Deliens, M. and P. Piret (1984) L'urancalcarite, $Ca(UO_2)_3(CO_3)(OH)_6 \cdot 3H_2O$, nouveau minéral de Shinkolobwe, Shaba, Zaire. Bull. Minéral., 107, 21–24 (in French with English abs.). (2) (1985) Amer. Mineral., 70, 438–439 (abs. ref. 1). (3) Wang Aizhen (1992) The first discovery of urancalcarite in China. Acta Mineral. Sinica, 12(1), 78–82 (in Chinese with English abs.).

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Uraninite UO_2

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals uncommon, typically cubes modified by the octahedron and dodecahedron, to 11 cm; botryoidal to reniform, colloform banded, columnar, dense massive; may be dendritic. *Twinning:* On {111}, rare.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 5–6 VHN = 499–548 (50 g load). D(meas.) = 10.63–10.95, decreasing markedly with oxidation, to as low as 6.5. D(calc.) = 10.88 Radioactive.

Optical Properties: Opaque, transparent in thinnest fragments. *Color:* Steel-black to velvet-black, brownish black, pale gray, pale green; in transmitted light, pale green, pale yellow, deep brown; pale gray with brownish tint in reflected light, may show dark brown internal reflections. *Streak:* Brownish black, gray, olive-green, shining. *Luster:* Submetallic to greasy, dull.
Optical Class: Isotropic.
R: (400) 17.6, (420) 17.3, (440) 17.0, (460) 16.8, (480) 16.5, (500) 16.3, (520) 16.2, (540) 16.0, (560) 15.9, (580) 15.8, (600) 15.9, (620) 15.9, (640) 16.0, (660) 16.0, (680) 16.1, (700) 16.2

Cell Data: *Space Group:* $Fm3m$ (synthetic $UO_{2.03}$). $a = 5.4682$ $Z = 4$

X-ray Powder Pattern: Synthetic $UO_{2.03}$; may be confused with thorianite or cerianite. 3.157 (100), 1.934 (49), 2.735 (48), 1.649 (47), 1.255 (18), 1.223 (15), 1.0523 (15)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	22.69	20.1	Al_2O_3	0.25	
ThO_2	0.20	14.3	Fe_2O_3	0.10	
CeO_2	0.71		FeO		0.1
UO_2	70.09	50.0	PbO	0.40	13.9
$(Y,Er)_2O_3$	3.41	0.0	CaO	0.30	0.1
La_2O_3	1.02	0.1	H_2O	[0.41]	
Ce_2O_3		0.8	rem.	0.12	
			Total	[99.70]	[99.4]

(1) Placer de Guadalupe, Chihuahua, Mexico; average of two analyses, H_2O calculated from gain in weight on ignition. (2) Locality not stated; by electron microprobe; U^{4+}:U^{6+} from stoichiometry, original total given as 100.4%; corresponding to $(U^{4+}_{0.48}U^{6+}_{0.18}Pb_{0.16}Th_{0.15}Ca_{0.01}Ce_{0.01})_{\Sigma=0.99}O_{2.01}$.

Mineral Group: Forms a series with thorianite.

Occurrence: In granite and syenite pegmatites; in hydrothermal high-temperature tin and moderate-temperature Co–Ni–Bi–Ag–As and other sulfide veins; in Colorado Plateau-type sandstone-hosted U–V deposits; in uraniferous conglomerates; a detrital mineral.

Association: Zircon, monazite, tourmaline, mica, feldspar (pegmatitic); pyrite, chalcopyrite, galena, bismuth, silver, nickeline, barite, fluorite, carbonates (Co–Bi–Ag hydrothermal veins).

Distribution: Widespread; may form an important ore. At Jáchymov (Joachimsthal) and Horní Slavkov (Schlaggenwald), Czech Republic. In Germany, from Johanngeorgenstadt, Schneeberg, and Annaberg, Saxony; in Bavaria, from Wölsendorf and Hagendorf. From many mines in Cornwall, England. Large crystals from the Sierra Albarrana, Córdoba Province, Spain. At Wilberforce, Ontario, and Great Bear Lake, Northwest Territories, Canada. In the USA, from Branchville, Fairfield Co., Connecticut; Grafton, Grafton Co., New Hampshire; fine crystals from Standpipe Hill, Topsham, Sagadahoc Co., Maine; around Spruce Pine, Mitchell Co., North Carolina; in the Ingersoll mine, near Keystone, Pennington Co., South Dakota. From Shinkolobwe

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and Kalongwe, Katanga Province, Congo (Shaba Province, Zaire). At Morogoro, Uruguru Mountains, Tanzania.

Name: For URANium in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 611–620. (2) Grandstaff, D.E. (1976) A kinetic study of the dissolution of uraninite. Econ. Geol., 71, 1493–1506. (3) Janeczek, J. and R.C. Ewing (1992) Structural formula of uraninite. J. Nuclear Materials, 190, 128–132. (4) (1953) NBS Circ. 539, 2, 33.

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Uranmicrolite $(U, Ca)_2(Ta, Nb)_2O_6(OH, F)$

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Crystal Data: Cubic; typically metamict. *Point Group:* $4/m\ \bar{3}\ 2/m$. As octahedra modified by {113}.

Physical Properties: *Fracture:* Irregular. *Tenacity:* [Brittle] (by analogy to the pyrochlore group). Hardness = 5.5 D(meas.) = 5.75–5.88 D(calc.) = [5.97] Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Yellowish brown, greenish brown, brownish black; yellowish brown in transmitted light. *Streak:* Pale yellow. *Luster:* Greasy.
Optical Class: Isotropic. $n = 1.97$

Cell Data: *Space Group:* $Fd3m$. a = 10.40 Z = 8

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	9.38		FeO	0.56	
WO_3	0.18		MnO		0.59
Nb_2O_5	1.41	13.18	PbO	1.10	1.03
Ta_2O_5	72.27	56.12	MgO	0.24	
TiO_2	2.54		CaO	3.40	6.87
ZrO_2	0.80		SrO		0.54
SnO_2	trace		Na_2O		0.86
UO_2	2.17	14.35	F		0.47
Fe_2O_3		0.58	H_2O	4.62	
Bi_2O_3	0.98		$-O = F_2$		0.19
			Total	99.65	94.40

(1) Posse Farm, Brazil. (2) Okangava Ost, Namibia; by electron microprobe, average of eight analyses; corresponding to $(Ca_{0.68}U_{0.30}Na_{0.15}Mn_{0.05}Sr_{0.03}Pb_{0.03})_{\Sigma=1.24}(Ta_{1.41}Nb_{0.55}Fe_{0.04})_{\Sigma=2.00}O_6(OH, F)$.

Mineral Group: Pyrochlore group, microlite subgroup; $U_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Ta_B \geq Nb_B$.

Occurrence: In a granite pegmatite (Posse Farm, Brazil).

Association: Columbite, magnetite, samarskite, garnet, beryl, tourmaline, bismuth minerals, kaolinite, microcline, quartz (Posse Farm, Brazil); lepidolite (Okangava Ost, Namibia).

Distribution: In Brazil, on the Posse Farm, Brejaúba district, Minas Gerais. From Jooste's pegmatite, Okangava Ost, near Karibib, Namibia. At San Piero in Campo, Elba, Italy.

Name: As a member of the *microlite* subgroup with significant *uranium* content.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 805 [djalmaite]. (2) Guimarães, C.P. (1941) Djalmaite, a new radioactive mineral. Amer. Mineral., 26, 343–346. (3) Strunz, H. (1957) Mineralogische Tabellen, Akademische Verlagsgesellschaft, 147 (in German) [Djalmaite = Uran-Microlith]. (4) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410 [djalmaite = uranmicrolite]. (5) Baldwin, J.R. (1989) Replacement phenomena in tantalum minerals from rare-metal pegmatites in South Africa and Namibia. Mineral. Mag., 53, 571–581.

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Uranophane $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals are composite needles, elongated ‖ [010], to over 1 cm, poorly developed, warped or bent. As stellate aggregates; in fibrous or felted crusts, and massive.

Physical Properties: *Cleavage:* Perfect on {100} (?); traces of another, parallel elongation. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 3.81–3.90 D(calc.) = 3.78 Crystals weakly fluorescent green under UV, typically not fluorescent when massive; radioactive.

Optical Properties: Transparent to translucent. *Color:* Lemon-yellow to pale straw-yellow or honey-brown; also greenish yellow to yellowish green, yellow-orange. *Luster:* Vitreous, pearly on the good cleavage; waxy or dull when massive.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = colorless; Y = pale canary-yellow; Z = canary-yellow. *Orientation:* $Z = b$; $X \perp$ {100} cleavage or a flat face. *Dispersion:* $r < v$, strong, crossed. $\alpha = 1.642–1.648$ $\beta = 1.661–1.667$ $\gamma = 1.667–1.675$ 2V(meas.) = 32°–49°

Cell Data: *Space Group:* $P2_1$. $a = 15.858–15.909$ $b = 6.985–7.002$ $c = 6.641–6.665$ $\beta = 97°27'–97°33'$ Z = 2

X-ray Powder Pattern: Ruggles pegmatite, Grafton Co., New Hampshire, USA.
7.88 (100), 3.94 (90), 2.99 (80), 2.91 (80), 1.969 (70), 4.76 (50), 3.20 (50)

Chemistry:

	(1)	(2)
SiO_2	12.66	14.03
UO_3	65.24	66.80
CaO	8.53	6.55
H_2O	13.02	12.62
Total	99.45	100.00

(1) Lusk, Wyoming, USA. (2) $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$.

Polymorphism & Series: Dimorphous with uranophane-beta.

Occurrence: A common secondary mineral in uranium deposits and pegmatites, formed by alteration of uraninite; as coatings, presumably through deposition from meteoric waters.

Association: Uranophane-beta, kasolite, meta-autunite, phosphuranylite, uranium oxides.

Distribution: Only a few localities can be given for exceptional crystals or abundant material. At Miedzianka (Kupferberg), Silesia, Poland. From Wölsendorf, Bavaria, and at Neustädtl, near Schneeberg, Saxony, Germany. From Jáchymov (Joachimsthal), Czech Republic. At Lachaux, Puy de Dôme, France. In the USA, at the Monument No. 2 mine, Apache Co., Arizona; from the Happy Jack mine, White Canyon, San Juan Co., Utah; as large crystals in the Hanosh mine, Grants district, McKinley Co., New Mexico. In the Silver Cliff mine, Lusk, Niobrara Co., Wyoming, and from the Spruce Pine district, Mitchell Co., North Carolina. Large crystals from the Faraday mine, near Bancroft, Ontario, Canada. On Mt. Painter, in the Flinders Ranges, South Australia. In Congo (Zaire), at Shinkolobwe, and the Musonoi mine, Kolwezi, Katanga (Shaba) Province. From Rössing, Namibia.

Name: From URANium and the Greek for *to appear*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 699. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 294–300. (3) Viswanathan, K. and O. Harneit (1986) Refined crystal structure of beta-uranophane, $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$. Amer. Mineral., 71, 1489–1493. (4) Ginderow, D. (1988) Structure de l'uranophane alpha, $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$. Acta Cryst., C44, 421–424 (in French).

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Uranophane-beta $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals prismatic by extension on [100], to 5 mm, with square cross sections or flattened on {010}, terminated by large {001}. As subradial to fanlike aggregates, or velvety or bristly coatings. *Twinning:* Common on {001}, contact and penetration.

Physical Properties: *Cleavage:* Perfect on {010}; reported on {001}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 3.90–3.95 D(calc.) = [4.11] Fluoresces faint green under UV; radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellowish green to citron-yellow. *Luster:* Vitreous; also silky, greasy, waxy in aggregates.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = lemon-yellow. *Orientation:* $X = b$; $Z \wedge c = 26°$. *Dispersion:* $r > v$, strong, crossed. *Absorption:* $Y = Z > X$.
$\alpha = 1.660–1.678$ $\beta = 1.682–1.723$ $\gamma = 1.689–1.730$ 2V(meas.) = 35°–71°

Cell Data: *Space Group:* $P2_1/a$. $a = 13.966(2)$ $b = 15.443(4)$ $c = 6.632(1)$ $\beta = 91.38(2)°$ Z = [4]

X-ray Powder Pattern: Jáchymov, Czech Republic; may convert to uranophane on crushing.
7.83 (100), 3.90 (90), 3.51 (60), 3.19 (50), 2.59 (50), 6.66 (40), 6.15 (40)

Chemistry:

	(1)	(2)
SiO_2	13.11	14.03
UO_3	66.29	66.80
CaO	7.32	6.55
H_2O	12.87	12.62
Total	99.59	100.00

(1) Jáchymov, Czech Republic. (2) $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$.

Polymorphism & Series: Dimorphous with uranophane.

Occurrence: A secondary mineral, altering from other uranium minerals under oxidizing conditions.

Association: Uraninite, uranophane.

Distribution: Now known from numerous localities; some for well-characterized material follow. From Jáchymov (Joachimsthal), Czech Republic. At Wölsendorf, Bavaria, Germany. From Bigay and La Crouzille, Puy-de-Dôme, France. At Sankra, near Nellore, Andhra Pradesh, India. In the USA, from Bedford, Westchester Co., New York; at Newry, Oxford Co., Maine; large crystals in the Ruggles mine, Grafton, and the Palermo mine, near North Groton, Grafton Co., New Hampshire; from near Spruce Pine and Deer Park, Mitchell Co., North Carolina; abundant in the Grants district, McKinley Co., New Mexico; in the Freedom No. 2 mine, Marysvale, Piute Co., Utah. In Canada, at Theano Point, Lake Superior, and in the Faraday mine, Bancroft district, Ontario. From Rössing, Namibia.

Name: In allusion to its dimorphous relation to *uranophane*.

Type Material: Natural History Museum, Vienna, Austria, J3747.

References: (1) Nováček, R. (1935) Study of some secondary uranium minerals. Věstníku Královské České Společnosti Nauk, 2, 15–16 (in English). (2) (1935) Amer. Mineral., 20, 813 (abs. ref. 1). (3) Steinacher, V. and R. Novacek (1939) On β-uranotile. Amer. Mineral., 24, 324–338. (4) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 307–309. (5) Viswanathan, K. and O. Harneit (1986) Refined crystal structure of beta-uranophane, $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$. Amer. Mineral., 71, 1489–1493.

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Uranopilite $(UO_2)_6(SO_4)(OH)_{10}\cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As needles and laths, elongated along [001] and flattened on {010}, to 0.5 mm; in rosettes and fibrous velvety incrustations, also as warty, globular, and reniform masses; commonly in efflorescences and coatings.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = "Soft". D(meas.) = 3.7–4.0 D(calc.) = [3.74] Radioactive; strong lemon-yellow or yellow-green fluorescence under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Bright yellow, lemon-yellow, golden yellow, straw-yellow; colorless to pale yellow in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; $Y = Z$ = yellow. *Orientation:* $X \simeq b$; $Y \wedge c = 17°$–$23°$. *Dispersion:* $r < v$, very strong, also $r > v$. $\alpha = 1.621$–1.623 $\beta = 1.623$–1.625 $\gamma = 1.631$–1.634 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. $a = 14.03(1)$ $b = 14.60(1)$ $c = 9.184(6)$ $\beta = 96.87(6)°$ Z = 2

X-ray Powder Pattern: Wheal Owles, England.
7.12 (10), 9.18 (8), 4.28 (8), 3.65 (5), 5.51 (4), 3.31 (4), 2.99 (3)

Chemistry:

	(1)	(2)
SO_3	4.04	3.81
UO_3	81.20	81.62
CaO	0.93	
H_2O	14.03	14.57
Total	100.20	100.00

(1) Jáchymov, Czech Republic. (2) $(UO_2)_6(SO_4)(OH)_{10}\cdot 12H_2O$.

Occurrence: A locally abundant secondary mineral formed under acid conditions by the oxidation of sulfides in the presence of uraninite; may be of post-mining origin.

Association: Uraninite, zippeite, johannite, uranophane, soddyite, fourmarierite, gypsum.

Distribution: From Jáchymov (Joachimsthal) and Příbram, Czech Republic. At Johanngeorgenstadt, Saxony, Germany. In France, from the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, at La Crouzille, Haute-Vienne, and from Grury, Saône-et-Loire, France. In Wheal Owles, Wheal Edward, and the Geevor mine, St. Just, Cornwall, England. From Nowa Ruda, Lower Silesia, Poland. In the Urgeiriça mine, Viseu district, Portugal. At Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). In the Mounana uranium mine, Franceville, Gabon. From South Alligator Valley, Northern Territory, Australia. In Japan, in the Togo mine, Tottori Prefecture. In the USA, found at many localities in the Uravan district, Montrose Co., Colorado; also at the Happy Jack and Jomac mines, White Canyon district, San Juan Co., and at Capitol Wash, Wayne Co., Utah. In Canada, from Great Bear Lake and Hottah Lake, Northwest Territories, and at Goldfields, Saskatchewan.

Name: From its content of URANium and the Greek for *felt*, for its texture.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 581–582. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 135–140. (3) Ondruš, P., F. Veselovský, J. Hloušek, R. Skála, I. Vavřín, J. Frýda, J. Čejka, and A. Gabašová (1997) Secondary minerals of the Jáchymov (Joachimsthal) ore district. J. Czech Geol. Soc., 42(4), 3–76, esp. 51–52.

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Uranopolycrase $(U,Y)(Ti,Nb)_2O_6$

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Crystal Data: Orthorhombic; metamict. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral crystals, elongated along [001], tabular on {100}, with {100}, {010} and {011}, to 0.15 mm, intergrown with uranoan polycrase-(Y).

Physical Properties: *Cleavage:* {100}, good. Hardness = n.d. VHN = 659 (20 g load). D(meas.) = n.d. D(calc.) = [6.60] Radioactive.

Optical Properties: Opaque. *Color:* Red-brown; in reflected light, pale gray with bluish tint and dark red-brown internal reflections. *Streak:* Brown. *Luster:* Adamantine.
Optical Class: Isotropic.
R: (470) 23.6, (546) 21.5, (589) 22.3, (650) 25.1

Cell Data: *Space Group: Pbcn.* $a = 14.51(1)$ $b = 5.558(5)$ $c = 5.173(4)$ Z = [4]

X-ray Powder Pattern: San Piero in Campo, Elba, Italy; after heating at 900 °C for ten hours.
2.99 (100), 1.90 (50), 1.48 (40), 1.77 (35), 2.78 (25), 3.21 (12), 1.86 (10)

Chemistry:

	(1)
Nb_2O_5	11.27
Ta_2O_5	5.98
TiO_2	27.36
ThO_2	4.14
UO_2	39.08
Y_2O_3	7.78
Nd_2O_3	0.37
MnO	0.48
CaO	0.22
Total	[96.68]

(1) San Piero in Campo, Elba, Italy; by electron microprobe, original total given as 96.73%; corresponding to $(U_{0.62}Y_{0.29}Th_{0.07}Mn_{0.03}Ca_{0.02}Nd_{0.01})_{\Sigma=1.04}(Ti_{1.46}Nb_{0.36}Ta_{0.12})_{\Sigma=1.94}O_6$.

Occurrence: In a zoned pegmatite vein near the contact with granodiorite.

Association: Uranoan polycrase-(Y), euxenite-(Y), manganocolumbite, titanowodginite, uranmicrolite, beryl, stilbite, quartz, orthoclase, albite, lepidolite, elbaite.

Distribution: From San Piero in Campo, Elba, Italy.

Name: For its content of URANium and relation to *polycrase-(Y)*.

Type Material: University of Pisa, Pisa, Italy.

References: (1) Aurisicchio, C., P. Orlandi, M. Pasero, and N. Perchiazzi (1993) Uranopolycrase, the uranium-dominant analogue of polycrase-(Y), a new mineral from Elba Island, Italy, and its crystal structure. Eur. J. Mineral., 5, 1161–1165. (2) (1994) Amer. Mineral., 79, 766 (abs. ref. 1).

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Uranosilite $U^{6+}Si_7O_{17}$

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Crystal Data: Orthorhombic. *Point Group:* 222 or $2/m\ 2/m\ 2/m$. Needlelike crystals are visible only under the scanning electron microscope at high magnification.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.25 Radioactive.

Optical Properties: Semitransparent. *Color:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–) (probable). $\alpha = 1.570(2)$ β = n.d. $\gamma = 1.584(2)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P22_12_1$, $Pmmb$, or $Pmcb$. $a = 11.60$ $b = 14.68$ $c = 12.83$
Z = 6

X-ray Powder Pattern: Menzenschwand, Germany.
7.30 (10), 11.58 (9), 6.19 (9), 3.50 (8), 2.77 (7), 3.42 (6), 3.20 (6)

Chemistry:

	(1)	(2)
SiO_2	60.2	59.52
UO_3	36.8	40.48
PbO	1.6	
K_2O	1.4	
Total	[100.0]	100.00

(1) Menzenschwand, Germany; by electron microprobe, original analysis given as Si 28.5%, U 31.0%, Pb 1.5%, K 1.2%, O 38.0%, total 100.2%, here recalculated to oxides. (2) USi_7O_{17}.

Occurrence: In a uranium deposit.

Association: Studtite, uranophane, quartz, hematite.

Distribution: From Menzenschwand, Black Forest, Germany.

Name: For URANium and SILicon in the chemical composition.

Type Material: n.d.

References: (1) Walenta, K. (1983) Uranosilit, ein neues Mineral aus der Uranlagerstätte von Menzenschwand im südlichen Schwarzwald. Neues Jahrb. Mineral., Monatsh., 259–269 (in German with English abs.). (2) (1984) Amer. Mineral., 69, 408–409 (abs. ref. 1).

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Uranospathite $HAl(UO_2)_4(PO_4)_4 \cdot 40H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$ (probable). Rectangular platy crystals, to 1 mm, flattened on {001}, showing {100}, {010}, in fanlike groups. *Twinning:* May be twinned on {110}, forming cruciform groupings.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, {010}, good. Hardness = 2–2.5 D(meas.) = 2.50 D(calc.) = 2.49 Radioactive. Yellowish green fluorescence under UV. Readily dehydrates to sabugalite.

Optical Properties: Translucent. *Color:* Yellow to pale green.
Optical Class: Biaxial (–), anomalous. *Pleochroism:* X = pale yellow; $Y = Z$ = deep yellow.
Orientation: $X = c$; $Y = a$; $Z = b$. $\alpha = [\sim 1.49]$ $\beta = 1.510$ $\gamma = 1.521$ 2V(meas.) = 69°

Cell Data: *Space Group:* $P4_2/n$ (probable). $a = 7.00$ $c = 30.02$ Z = 2

X-ray Powder Pattern: Basset mines, Cornwall, England.
15.22 (10), 7.60 (10), 4.93 (10), 3.50 (8), 4.48 (6b), 2.21 (6), 4.08 (4)

Chemistry: (1) Basset mines, Cornwall, England; Al confirmed by electron microprobe, P and U confirmed by microchemical and spectrochemical techniques, formula established by analogy to the torbernite group.

Occurrence: A rare secondary mineral in the oxidized zone of uranium-bearing hydrothermal mineral deposits.

Association: Bassetite.

Distribution: From the Basset group of mines, Illogan, Cornwall, England. In France, at the La Crouzille and Sagnes mines, Haute-Vienne. From the Pedro Alvaro vanadium mine, Salamanca Province, and at El Padregal, Badajoz Province, Spain. In the Weisser Hirsch mine, Neustädtel-Schneeberg, Saxony, and at Menzenschwand, Black Forest, Germany. On Radium Hill, Olary, South Australia.

Name: For its content of *uranium* and the Greek for *a broad blade*, an allusion to the bladed character of its crystals.

Type Material: [Museum of Practical Geology, Ludlam collection, L1941] now in The Natural History Museum, London, England.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 990. (2) Walenta, K. (1978) Uranospathite and arsenuranospathite. Mineral. Mag., 42, 117–128.

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Uranosphaerite $Bi_2U_2O_9 \cdot 3H_2O$

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Crystal Data: Orthorhombic (probable). *Point Group:* n.d. In concentric, radiated to spherulitic aggregates, to 0.5 mm, of tiny crystals elongated ‖ [001].

Physical Properties: *Cleavage:* {100}. Hardness = 2–3 D(meas.) = 6.36; 6.89 D(calc.) = n.d. Radioactive.

Optical Properties: Semitransparent. *Color:* Yellow-orange, golden to reddish orange, brick-red. *Streak:* Yellow. *Luster:* Greasy.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, strong.
$\alpha = 1.955$–1.959 $\beta = 1.981$–1.985 $\gamma = 2.05$–2.060 2V(meas.) = Large. 2V(calc.) = 56°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Schneeberg, Germany.
3.16 (10), 1.83 (8), 3.87 (7), 5.25 (6), 3.47 (6), 1.90 (5), 4.37 (4)

Chemistry:

	(1)	(2)	(3)
UO_3	50.88	52.62	52.38
Bi_2O_3	44.34	43.46	42.67
H_2O	4.75	3.59	4.95
Total	99.97	99.67	100.00

(1–2) Schneeberg, Germany. (3) $Bi_2U_2O_9 \cdot 3H_2O$.

Occurrence: An oxidation product of uraninite in a Co–Ni–Bi-bearing hydrothermal vein (Schneeberg, Germany).

Association: Walpurgite, uranospinite, uranospathite, asselbornite, trögerite, zeunerite, erythrite, cobaltian wad (Schneeberg, Germany); uraninite, wölsendorfite, renardite (Kersegalec, France).

Distribution: From the Walpurgis vein, Weisser Hirsch mine, Neustädtl, near Schneeberg, Saxony, Germany. At Kersegalec, near Lignol, Morbihan, France.

Name: For URANium in the composition, and the Greek for *sphere*, for the typical habit.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 631. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 98–99. (3) Protas, J. (1959) Contribution à l'étude des oxydes d'uranium hydratés. Bull. Soc. fr. Minéral., 82, 239–272, esp. 265–268.

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Uranospinite $Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$ (synthetic, probable). Rare as thin tabular crystals, flattened on {001}, to 1 mm; in aggregates and crusts.

Physical Properties: *Cleavage:* Perfect on {001}; distinct on {100}. Hardness = 2–3 D(meas.) = 3.45 D(calc.) = 3.30 Radioactive; bright lemon-yellow fluorescence under UV.

Optical Properties: Semitransparent. *Color:* Lemon-yellow to siskin-green. *Luster:* Waxy, pearly on {001}.
Optical Class: Uniaxial (–), commonly anomalously biaxial (–), may be zoned.
Pleochroism: $O = Y = Z$ = pale yellow; $E = X$ = nearly colorless. *Orientation:* $X = c$ in biaxial material. *Dispersion:* $r > v$, moderate. ω = 1.572–1.587 ϵ = 1.55–1.560 α = 1.55 β = 1.567–1.582 γ = 1.572–1.587 2V(meas.) = 0°–62°

Cell Data: *Space Group:* $P4/nmm$ (synthetic). a = 7.16 c = 20.4 Z = 2

X-ray Powder Pattern: Synthetic.
10.16 (10), 3.56 (9), 3.39 (8), 5.13 (7), 4.90 (6), 1.90 (6), 2.52 (5b)

Chemistry:

	(1)	(2)
UO_3	59.18	55.11
As_2O_5	19.37	22.14
CaO	5.47	5.40
H_2O	16.19	17.35
Total	100.21	100.00

(1) Weisser Hirsch mine, Germany. (2) $Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$.

Mineral Group: Autunite group.

Occurrence: A secondary mineral in the oxide zone of U–As-bearing hydrothermal mineral deposits.

Association: Metazeunerite, metauranocircite, uranophane, trögerite, walpurgite, uranosphaerite, asselbornite (Weisser Hirsch mine, Germany); schoepite, paraschoepite, arsenuranylite, metazeunerite, nováčekite (Cherkasar deposit, Uzbekistan).

Distribution: In Germany, from the Walpurgis vein, Weisser Hirsch mine, Neustädtel-Schneeberg, Saxony; in the Black Forest, from the Clara mine, near Oberwolfach, the Sophia mine, near Wittichen, at the Gottesehre mine, near Urberg, and from Menzenschwand; from the Bühlskopf, near Ellweiler, Rhineland-Palatinate. In the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France. At Tyndrum, Perthshire, Scotland. From the Cherkasar uranium deposit, 30 km northwest of Pap, Chaktal Mountains, Uzbekistan. In the Talmessi mine, 35 km west of Anarak, Iran. From near Myponga, Fleurieu Peninsula, and at the Radium Hill mine, Mt. Painter, Flinders Ranges, South Australia. In the USA, on the Clyde Long property, Elk Park, San Juan Co., Colorado; in Utah, from near Spanish Fork, Utah Co., and at Paria, Kane Co.; at the Orphan mine, Coconino Co., Arizona.

Name: For its *uranium* content and from the Greek for *siskin*, in allusion to its typical color.

Type Material: State Museum for Mineralogy and Geology, Dresden; Mining Academy, Freiberg, Germany, 21722.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 990–991. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 183–187.

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Uranotungstite $(Fe^{2+}, Ba, Pb)(UO_2)_2(WO_4)(OH)_4 \cdot 12H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. Lathlike crystals, flattened on {010} in spherulitic aggregates, to 0.3 mm; as crusts.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Irregular. Hardness = ∼2 D(meas.) = > 4.03 D(calc.) = 4.27 Radioactive.

Optical Properties: Translucent. *Color:* Yellow, orange, pale brown. *Streak:* Yellow. *Luster:* Dull.
Optical Class: Biaxial (–). *Pleochroism:* X = nearly colorless, $Y = Z$ = yellow. *Orientation:* $X = b$. *Dispersion:* $r > v$. $\alpha = 1.682(5)$ $\beta = 1.845(5)$ $\gamma = 1.855(5)$ 2V(meas.) = 42°

Cell Data: *Space Group:* $Pmmm$, $Pmm2$. or $P222$. $a = 9.22$ $b = 13.81$ $c = 7.17$ Z = 2

X-ray Powder Pattern: Clara mine, Germany.
6.96 (10), 3.21 (7), 4.60 (6), 3.46 (5), 2.77 (4), 1.970 (4), 3.01 (3)

Chemistry:

	(1)
UO_3	45.1
WO_3	19.8
FeO	2.3
PbO	6.9
BaO	4.9
H_2O	22.5
Total	101.5

(1) Menzenschwand, Germany; by electron microprobe and AA, average of two analyses, total Fe as FeO, H_2O by loss on heating; corresponds to $(Fe_{0.38}Ba_{0.37}Pb_{0.36})_{\Sigma=1.11}(UO_2)_{1.82}(WO_4)_{0.99}(OH)_{3.88} \cdot 12.52H_2O$.

Occurrence: A rare secondary mineral formed in polymetallic base metal deposits.

Association: Metauranocircite, metaheinrichite, bergenite, metatorbernite, metazeunerite, schoepite, quartz.

Distribution: From Menzenschwand and the Clara mine, near Oberwolfach, Black Forest, Germany.

Name: For its content of URANium and TUNGsten.

Type Material: University of Stuttgart, Stuttgart, Germany.

References: (1) Walenta, K. (1985) Uranotungstit, ein neues sekundäres Uranmineral aus dem Schwarzwald. Tschermaks Mineral. Petrog. Mitt., 34, 25–34 (in German with English abs.).
(2) (1986) Amer. Mineral., 71, 1547 (abs. ref. 1).

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Uranpyrochlore $(U, Ca, Ce)_2(Nb, Ta)_2O_6(OH, F)$

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Crystal Data: Cubic; commonly metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are octahedra, modified by {001} and {113}; also massive. *Twinning:* Rarely on {111}.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 4.51–4.90 D(calc.) = [4.88] Radioactive.

Optical Properties: Transparent. *Color:* Black, yellowish brown, or amber-yellow; deep red-brown in transmitted light. *Luster:* Resinous to adamantine.
Optical Class: Isotropic. $n = 1.89$–1.98

Cell Data: *Space Group:* $Fd3m$. $a = 10.33$–10.44 $Z = 8$

X-ray Powder Pattern: Berere, Madagascar.
3.01 (10), 1.84 (8), 1.575 (6), 7.3 (4), 2.61 (3), 1.202 (2), 1.168 (2)

Chemistry:

	(1)	(2)		(1)	(2)
UO_3	15.50		Fe_2O_3		0.64
Nb_2O_5	34.24	32.30	FeO	2.19	
Ta_2O_5	29.83	15.76	PbO	trace	
TiO_2	1.61	9.27	MgO	0.15	
ZrO_2		0.28	CaO	8.87	8.69
SnO_2	0.30		SrO		0.16
ThO_2		0.07	Na_2O	1.37	5.29
UO_2		26.44	K_2O	trace	
Y_2O_3		0.17	F		0.19
La_2O_3		0.12	H_2O	4.49	
Ce_2O_3		0.21	$-O = F_2$		[0.08]
			Total	98.55	[99.43]

(1) Mitchell Co., North Carolina, USA. (2) Near Kasenda, Uganda; by electron microprobe, total Fe as FeO, original total given as 99.51%; corresponding to $(Na_{0.78}Ca_{0.70}U_{0.44}Ce_{0.01}Y_{0.01}Sr_{0.01})_{\Sigma=1.95}(Nb_{1.10}Ti_{0.53}Ta_{0.32}Fe_{0.04}Zr_{0.01})_{\Sigma=2.00}O_6(OH, F)$.

Mineral Group: Pyrochlore group and subgroup; $U_A > 20\%$; $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: In cemented calcareous tuffs associated with carbonatite (near Kasenda, Uganda).

Association: Calcite, feldspars, quartz, magnetite, ilmenite, almandine, apatite, epidote, diopside, "hypersthene", pyrite, rutile, anatase, pyrochlore, zircon, titanite, monazite (near Kasenda, Uganda).

Distribution: From Mitchell Co., North Carolina, USA. In the Antsakoa I pegmatite, Berere, 40 km northeast of Tsaratanana, Madagascar. Near Kasenda, Fort Portal area, Uganda. In Germany, from Hagendorf, Bavaria.

Name: As a member of the *pyrochlore* subgroup with significant *uranium* content.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 748–757 [pyrochlore, part]. (2) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (3) Mücke, A. and H. Strunz (1978) Petscheckite and liandratite, two new pegmatite minerals from Madagascar. Amer. Mineral., 63, 941–946. (4) Hogarth, D.D. and J.E.T. Horne (1989) Non-metamict uranoan pyrochlore and uranpyrochlore from tuff near Ndale, Fort Portal area, Uganda. Mineral. Mag., 53, 257–262.

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Urea $CO(NH_2)_2$

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Crystal Data: Tetragonal. *Point Group:* $\overline{4}2m$. Elongated pyramidal crystals, to 3 mm, in massive groupings, crusts, and crystalline stalagmites.

Physical Properties: Hardness = n.d. D(meas.) = 1.33(1) D(calc.) = [1.33] Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Pale yellow to pale brown.
Optical Class: Uniaxial (+). $\omega = 1.484$ $\epsilon = 1.601$

Cell Data: *Space Group:* $P\overline{4}2_1m$. $a = 5.646(1)$ $c = 4.701(1)$ Z = [2]

X-ray Powder Pattern: Toppin Hill, Western Australia.
3.98 (10), 3.04 (3), 3.61 (2), 2.552 (1b), 2.172 (1), 1.837 (1), 4.70 (< 1)

Chemistry:

	(1)
$CO(NH_2)_2$	96.
NH_3	< 1.0
P	0.24
S	0.11
Ca	0.07
Mg	0.03
Na	0.13
K	0.35
H_2O^-	0.46
Total	< 98.39

(1) Toppin Hill, Western Australia; by urease reduction, remainder probably mostly H_2O^+.

Occurrence: Derived from bat guano and urine, stable only under very arid conditions.

Association: Ammonian aphthitalite, weddellite, phosphammite.

Distribution: In Australia, from Toppin Hill, near Lake Rason, about 320 km northeast of Kalgoorlie, and in Wilgie Mia Cave, Western Australia.

Name: From the Greek for *urine*, in which urea was first found.

Type Material: Western Australia Museum, Perth, Australia, S4688.

References: (1) Bridge, P.J. (1973) Urea, a new mineral, and neotype phosphammite from Western Australia. Mineral. Mag., 39, 346–348. (2) (1974) Amer. Mineral., 59, 874 (abs. ref. 1). (3) Swaminathan, S., B.M. Craven, and R.K. McMullan (1984) The crystal structure and molecular thermal motion of urea at 12, 60 and 123 K from neutron diffraction. Acta Cryst., 40, 300–306.

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Uricite $C_5H_4N_4O_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. A component of guano.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 1.851 (synthetic).

Optical Properties: Semitransparent. *Color:* Colorless, white.
Optical Class: Biaxial. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/a$ (synthetic). $a = 14.464(3)$ $b = 7.403(2)$ $c = 6.208(1)$ $\beta = 65.10(5)^\circ$ Z = 4

X-ray Powder Pattern: Calculated from the crystal structure. (ICDD 28-2016).
3.093 (100), 3.087 (69), 3.180 (55), 4.91 (51), 6.55 (43), 3.864 (42), 2.866 (25)

Chemistry: (1) Presence inferred from chemical analysis of whole guanos.

Occurrence: Formed in guanos.

Association: Biphosphammite, brushite, syngenite (Dingo Donga Cave, Australia).

Distribution: From an undefined locality in Peru. In Dingo Donga Cave, near Rawlinna, Western Australia.

Name: For its composition, anhydrous *uric* acid.

Type Material: Western Australian Museum, Perth, MDC5295.

References: (1) Bridge, P.J. (1974) Guanine and uricite, two new organic minerals from Peru and Western Australia. Mineral. Mag., 39, 889–890. (2) Ringertz, H. (1966) The molecular and crystal structure of uric acid. Acta Cryst., 20, 397–403.

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Urvantsevite $Pd(Bi,Pb)_2$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. In irregular polymineralic intergrowths, to 4 mm.

Physical Properties: *Cleavage:* Perfect in one direction. Hardness = n.d. VHN = 47–68 (10 g load). D(meas.) = n.d. D(calc.) = 9.66

Optical Properties: Opaque. *Color:* Grayish white in reflected light. *Pleochroism:* Weak to none. *Anisotropism:* Slight.

R_1–R_2: (400) — , (420) — , (440) 48.7–50.5, (460) 53.2–54.9, (480) 54.6–53.8, (500) 54.1–53.3, (520) 54.8–53.7, (540) 55.2–54.0, (560) 56.2–54.9, (580) 56.7–55.2, (600) 57.0–56.1, (620) 58.3–56.8, (640) 59.2–57.8, (660) 60.1–58.6, (680) 60.9–59.6, (700) 61.3–59.6

Cell Data: *Space Group:* $I/4mmm$. $a = 3.3628(16)$ $c = 12.902(11)$ $Z = 2$

X-ray Powder Pattern: Majak mine, Russia.
2.643 (100), 2.372 (80), 1.420 (70), 1.111 (70), 1.166 (60), 2.043 (50), 1.685 (50)

Chemistry:

	(1)
Pd	20.5
Bi	64.6
Pb	15.3
Total	100.4

(1) Majak mine, Russia; by electron microprobe, corresponding to $Pd_{1.00}(Bi_{1.61}Pb_{0.38})_{\Sigma=1.99}$.

Occurrence: In massive zoned Cu–Ni sulfide ores (Talnakh area, Russia).

Association: Froodite, sobolevskite, paolovite, cabriite, silver, hibbingite, altaite, galena, pentlandite, cubanite, chalcopyrite (Talnakh area, Russia).

Distribution: From the Majak mine, Talnakh area, Noril'sk region, western Siberia, Russia [TL]. From Tilkerode, Harz Mountains, Germany.

Name: Honors Professor Nikolai Nikolaevich Urvantsev (1893–1985), of St. Petersburg, Russia, one of the discoverers of the Noril'sk deposits.

Type Material: Mining Institute, St. Petersburg, Russia, 1176/1.

References: (1) Rudashevskii, N.S., V.N. Makarov, E.M. Mededeva, V.V. Ballakh, Y.I. Permyakov, G.A. Mitenkov, A.M. Karpenkov, I.A. Bud'ko, and N.N. Shishkin (1976) Urvantsevite, $Pd(Bi,Pb)_2$, a new mineral in the system Pd–Bi–Pb. Zap. Vses. Mineral. Obshch., 105, 704–709 (in Russian). (2) (1977) Amer. Mineral., 62, 1260–1261 (abs. ref. 1). (3) Bayliss, P. 1990) Revised unit-cell dimensions, space group, and chemical formula of some metallic minerals. Can. Mineral., 28, 751–755. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 145–146.

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Ushkovite $\mathbf{MgFe_2^{3+}(PO_4)_2(OH)_2 \cdot 8H_2O}$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As crystals, typically equant to short prismatic along [001], may be flattened on [001], showing prominent {001}, {010}, {1$\overline{1}$0}, minor {100}, {110}, {210}, {0$\overline{1}$1}, to 2 mm; in radiating fibrous aggregates. *Twinning:* On {*hk*0}.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Very brittle. Hardness = 3.5 D(meas.) = 2.38 D(calc.) = 2.40

Optical Properties: Transparent to translucent. *Color:* Pale yellow, yellow-orange, to light brown; faint yellow in transmitted light. *Streak:* Pale yellowish. *Luster:* Vitreous to pearly on cleavages, greasy on fractures.
Optical Class: Biaxial (–). *Orientation:* $Y \wedge c = 26°$; X and Y nearly in {010}.
Dispersion: $r > v$, strong. $\alpha = 1.584(2)$ $\beta = 1.637(2)$ $\gamma = 1.670(2)$ 2V(meas.) = 50°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.196(9)$ $b = 10.70(2)$ $c = 7.14(2)$
$\alpha = 108.6(1)°$ $\beta = 106.95(5)°$ $\gamma = 72.70(5)°$ Z = 1

X-ray Powder Pattern: Ilmen Mountains, Russia; close to laueite.
9.86 (100), 6.57 (80), 3.20 (80), 3.28 (60), 4.95 (50), 4.85 (50), 4.01 (40)

Chemistry:

	(1)	(2)	(3)
P_2O_5	30.47	28.2	28.16
Al_2O_3	0.00	0.1	
Fe_2O_3	29.87	31.8	31.68
FeO	0.00		
MnO	1.88	0.2	
MgO	8.79	8.1	8.00
CaO	2.54		
H_2O^+	14.83		
H_2O^-	12.28		
H_2O		[31.6]	32.16
Total	100.66	[100.0]	100.00

(1) Ilmen Mountains, Russia; part of H_2O thought lost during sample preparation; after deduction of Ca and some P as francolite, and Mn as Mn oxide, corresponds to $Mg_{1.15}Fe^{3+}_{1.98}(PO_4)_{2.12}(OH)_2 \cdot 7H_2O$. (2) Hagendorf, Germany; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; corresponds to $(Mg_{1.01}Mn^{2+}_{0.01})_{\Sigma=1.02}(Fe^{3+}_{2.00}Al_{0.01})_{\Sigma=2.01}(PO_4)_{2.00}(OH)_2 \cdot 8H_2O$.
(3) $MgFe_2(PO_4)_2(OH)_2 \cdot 8H_2O$.

Mineral Group: Paravauxite group.

Occurrence: In granite pegmatites, as an alteration product of triplite formed by weathering.

Association: Triplite, francolite, mitridatite, beraunite, Fe–Mn oxides (Ilmen Mountains, Russia).

Distribution: On the southern shore of Lake Bol'shoy Tatkul', Il'men Mountains, Southern Ural Mountains, Russia. In the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; at the Dunton quarry, Newry, Oxford Co., Maine, USA. From the Sandamap pegmatite, west of Usakos, Namibia. At Boa Vista, near Galiléia, Minas Gerais, Brazil.

Name: To honor Sergei L'vovich Ushkov (1880–1951), Russian naturalist, student of the Il'men National Forest, Russia.

Type Material: Il'menskii Preserve Museum, Miass, iz4523; Mining Institute, St. Petersburg, 1293/1; Vernadsky Geological Museum, Moscow, 53492; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82364.

References: (1) Chesnokov, B.V., V.A. Vilisov, G.Y. Cherepivskaya, and M.G. Gorskaya (1983) Ushkovite, $MgFe_2^{3+}(PO_4)_2(OH)_2 \cdot 8H_2O$, a new mineral. Zap. Vses. Mineral. Obshch., 112, 42–46 (in Russian). (2) (1984) Amer. Mineral., 69, 212–213 (abs. ref. 1). (3) Dunn, P.J. (1985) New occurrences for ushkovite and comments on laueite. Mineral. Record, 16, 463–464.

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Usovite **$Ba_2CaMgAl_2F_{14}$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral elongated platy crystals, to 1.5 cm; commonly in irregular grains.

Physical Properties: *Cleavage:* One direction, perfect; another at 44° to the first noted under the microscope. *Fracture:* Irregular. Hardness = 3.5 VHN = 294 D(meas.) = n.d. D(calc.) = [4.26] Diamagnetic.

Optical Properties: Opaque, translucent in thin fragments. *Color:* Brown to dark brown, spotty; yellowish brown in transmitted light. *Streak:* White. *Luster:* Vitreous to greasy. *Optical Class:* Biaxial (+). *Pleochroism:* Weak; $X = Y$ = brownish yellow; Z = pale yellow. *Orientation:* Extinction ∥ perfect cleavage; OAP ⊥ to perfect cleavage. *Absorption:* $X = Y > Z$. $\alpha = 1.441(1)$ $\beta = 1.442(1)$ $\gamma = 1.444(1)$ 2V(meas.) = 70°

Cell Data: *Space Group:* $C2/c$. $a = 13.565(1)$ $b = 5.200(4)$ $c = 14.557(10)$ $\beta = 91°50(4)'$ Z = 4

X-ray Powder Pattern: Pravaya Noiby River, Russia.
3.41 (10), 1.205 (9), 1.025 (9), 1.132 (8), 1.093 (8), 1.012 (8), 1.005 (8)

Chemistry:

	(1)	(2)
SiO_2	1.40	
Al_2O_3	16.06	15.47
MgO	6.06	6.12
CaO	8.40	8.51
SrO	0.35	
BaO	44.04	46.54
Na_2O	0.20	
K_2O	0.05	
F	39.80	40.36
H_2O^+	0.34	
H_2O^-	0.12	
SO_3	0.21	
$-O = F_2$	16.72	17.00
Total	100.31	100.00

(1) Pravaya Noiby River, Russia; contaminated with estimated fluorite 11.7%.
(2) $Ba_2CaMgAl_2F_{14}$.

Occurrence: In a fluorite vein in quartz-mica schists.

Association: Fluorite, calcjarlite, muscovite, thorite, chamosite, zeolites, halloysite.

Distribution: From the issue of the second tributary of the Pravaya Noiby River, left tributary to the Teya River, Yenisei Ridge, Siberia, Russia.

Name: Honors Academician Mikhail Antonovich Usov (1883–1939), geologist, Karpinskii All-Union Research Institute of Geology, St. Petersburg, Russia.

Type Material: Tomsk Polytechnic Institute, Tomsk; Central Siberian Geological Museum, Novosibirsk, VI-15/1; Mining Institute, St. Petersburg, 1089/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 69852, 76161, vis1194.

References: (1) Nozhkin, A.D., V.A. Gavrilenko, and A.V. Moleva (1967) Usovite, a new barium fluoaluminate. Zap. Vses. Mineral. Obshch., 96, 63–66 (in Russian). (2) (1967) Amer. Mineral., 52, 1582 (abs. ref. 1). (3) Povarennykh, A.S., L.M. Egorova, A.L. Litvin, and A.D. Nozhkin (1974) The chemical composition and unit cell of usovite. Dokl. Akad. Nauk Ukr. RSR, Ser. B, 36(10), 891–893 (in Ukrainian with English abs.). (4) Litvin, A.L., A.A. Petrunina, S.S. Ostapenko, and A.S. Povarennykh (1980) The crystal structure of usovit. Dokl. Akad. Nauk Ukr. RSR, Ser. B, 3, 47–50 (in Ukrainian with English abs.).

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Ussingite $Na_2AlSi_3O_8(OH)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Rarely as pseudocubic to tabular crystals, to 1 cm; fine-grained, compact. *Twinning:* Common on {010}.

Physical Properties: *Cleavage:* Perfect on {110} and {1$\bar{1}$0}. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 2.457–2.49 D(calc.) = 2.51

Optical Properties: Transparent to translucent. *Color:* Pale pink, lilac-blue, or dark violet-red, may be tarnished on the surface; colorless in thin section. *Streak:* White. *Luster:* Slightly greasy to vitreous; slightly pearly on cleavage planes. *Optical Class:* Biaxial (+). α = 1.503–1.504 β = 1.506–1.508 γ = 1.543–1.545 2V(meas.) = 32°–39°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.256(3)$ $b = 7.686(3)$ $c = 8.683(3)$ $\alpha = 90°45(2)'$ $\beta = 99°45(2)'$ $\gamma = 122°29(2)'$ Z = 2

X-ray Powder Pattern: Locality unknown. (ICDD 14-426).
2.95 (100), 2.69 (100), 6.35 (90), 6.68 (70), 4.92 (70), 4.18 (70), 3.84 (70)

Chemistry:

	(1)	(2)	(3)
SiO_2	58.74	59.22	59.64
Al_2O_3	17.73	17.22	16.87
CaO		0.30	
Na_2O	19.91	19.08	20.51
K_2O		0.86	
Cl		0.04	
H_2O^+	4.19	3.40	
H_2O^-		0.30	
H_2O			2.98
S		0.08	
$-O = (Cl_2, S_2)$		0.06	
Total	100.57	100.44	100.00

(1) Ilímaussaq intrusion, Greenland. (2) Lovozero massif, Russia; average of two analyses; corresponds to $(Na_{1.81}K_{0.05}Ca_{0.02})_{\Sigma=1.88}Al_{1.00}Si_{2.90}O_8(OH)_{1.11}$. (3) $Na_2AlSi_3O_8(OH)$.

Occurrence: A secondary mineral in pegmatites associated with sodalite syenite (Ilímaussaq intrusion, Greenland); in sodalite xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Microcline, natrolite, aegirine (Ilímaussaq intrusion, Greenland); natrolite, aegirine, microcline, albite, sodalite (Lovozero massif, Russia); villiaumite, lovozerite, eudialyte, lueshite, griceite, natrophosphate (Mont Saint-Hilaire, Canada).

Distribution: In southern Greenland, on the Kangerdluarssuk Plateau, in the Ilímaussaq intrusion. From a number of places in both the Lovozero and Khibiny massifs, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: For Professor Niels Vigo Ussing (1864–1911), of Copenhagen, Denmark.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1970.527.

References: (1) Bøggild, O.B. (1915) Ussingit, ein neues Mineral von Kangerdluarsuk [*sic*]. Zeits. Krist., 54, 120–126 (in German). (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 269–272. (3) Ilyukhin, V.V. and E.I. Semenov (1959) New data on ussingite. Doklady Acad. Nauk SSSR, 129, 1386–1388 (in Russian). (4) Rossi, G., V. Tazzoli and L. Ungaretti (1974) The crystal structure of ussingite. Amer. Mineral., 59, 335–340. (5) Mandarino, J.A. and V. Anderson (1989) Monteregian treasures. Cambridge Univ. Press, 207.

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Ustarasite $Pb(Bi,Sb)_6S_{10}$

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Crystal Data: n.d. *Point Group:* n.d. Prismatic crystals; may be bent or twisted.

Physical Properties: *Cleavage:* One perfect; another present. Hardness = 2.5 VHN = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Silver-gray to gray; pure white in reflected light. *Luster:* Metallic. *Anisotropism:* Strong.

R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Ustarasai deposit, Uzbekistan.
3.53 (100), 1.102 (100), 1.057 (100), 3.08 (70), 2.508 (70), 1.915 (70), 1.732 (70)

Chemistry:

	(1)	(2)
Pb	10.51	11.35
Cu	0.30	0.74
Fe	0.60	1.40
Bi	65.33	64.90
Sb	2.96	1.87
As		0.15
S	17.25	17.25
insol.	0.34	0.54
Total	97.29	98.20

(1) Ustarasai deposit, Uzbekistan; by electron microprobe, corresponding to $Pb_{0.94}Fe_{0.20}Cu_{0.09}(Bi_{5.81}Sb_{0.45})_{\Sigma=6.26}S_{10.00}$. (2) Do.; by electron microprobe, corresponding to $Pb_{1.02}Fe_{0.47}Cu_{0.22}(Bi_{5.77}Sb_{0.29}As_{0.04})_{\Sigma=6.10}S_{10.00}$.

Occurrence: In quartz-bismuthinite veins (Ustarasai deposit, Uzbekistan).

Association: Bismuthinite, kobellite, bismuthian jamesonite, quartz (Ustarasai deposit, Uzbekistan).

Distribution: From the Ustarasai bismuth deposit, near Brichmulla, Pskem Mountains, southern Tien-Shan, northeastern Uzbekistan [TL]. At the Pangushan tungsten deposit, Huang sha district, Jiangxi Province, China. In the Monteneme W–Sn mine, Galacia[ck others]??, Spain.

Name: For the locality of first discovery, the Ustarasai deposit, Uzbekistan.

Type Material: n.d.

References: (1) Sakharova, M.S. (1955) On bismuth sulfosalts of the Ustarasai deposits. Trudy Mineral. Muzeya Akad. Nauk SSSR, 7, 112–126 (in Russian). (2) (1956) Amer. Mineral., 41, 814 (abs. ref. 1).

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Utahite $Cu_5Zn_3(Te^{6+}O_4)_4(OH)_8 \cdot 7H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Prismatic to thin tabular to bladed crystals, elongated along [001], showing {010} and {001}, in parallel to subparallel aggregates, to 0.6 mm, also as sheaves and bow tielike groups.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼4–5
D(meas.) = n.d. D(calc.) = 5.33

Optical Properties: Translucent. *Color:* Pale blue to blue-green. *Streak:* Pale blue.
Luster: Vitreous to pearly.
Optical Class: [Biaxial.] n = [1.83–1.90] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 8.794(4)$ $b = 9.996(2)$ $c = 5.660(2)$
$\alpha = 104.10(2)°$ $\beta = 90.07(5)°$ $\gamma = 96.34(3)°$ Z = 1

X-ray Powder Pattern: Centennial Eureka mine, Utah, USA.
9.638 (100), 4.841 (100), 2.747 (60), 8.736 (50), 2.600 (45), 6.862 (40), 6.172 (40)

Chemistry:

	(1)	(2)
TeO_3	45.47	45.54
CuO	25.76	25.78
ZnO	15.81	15.83
H_2O	[12.96]	12.85
Total	[100.00]	100.00

(1) Centennial Eureka mine, Utah, USA; by electron microprobe, average of six analyses, H_2O by difference, total Te as TeO_3, $(OH)^{1-}$ and H_2O confirmed by IR; corresponds to $Cu_{4.98}Zn_{2.99}(TeO_4)_{3.98}(OH)_8 \cdot 7.1H_2O$. (2) $Cu_5Zn_3(TeO_4)_4(OH)_8 \cdot 7H_2O$.

Occurrence: A very rare secondary mineral found on dump material from the oxidized zone of a Cu–Zn–Te-bearing hydrothermal ore deposit.

Association: Cesbronite, quartz.

Distribution: From the mine dumps of the Centennial Eureka mine, Tintic district, Juab Co., Utah, USA.

Name: After the state of Utah, USA, where the mineral was discovered.

Type Material: Canadian Geological Survey, Ottawa, Canada, 67415; The Natural History Museum, London, England, 1994,99.

References: (1) Roberts, A.C., J.A.R. Stirling, A.J. Criddle, M.C. Jensen, E.A. Moffatt, and W.E. Wilson (1997) Utahite, a new mineral and associated copper tellurates from the Centennial Eureka mine, Tintic district, Juab County, Utah. Mineral. Record, 28, 175–179. (2) (1998) Amer. Mineral., 83, 187–188 (abs. ref. 1).

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Uvanite $U_2^{6+}V_6^{5+}O_{21}\cdot 15H_2O(?)$

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Crystal Data: Orthorhombic (probable). *Point Group:* n.d. As minutely crystalline coatings and massive, to 1 cm thick.

Physical Properties: *Cleavage:* Two directions, pinacoidal. Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Brownish yellow; pale brown in transmitted light.
Optical Class: Biaxial (+). *Pleochroism:* X = light brown; Y = dark brown; Z = greenish yellow. $\alpha = 1.817$ $\beta = 1.879$ $\gamma = 2.057$ 2V(meas.) = 52°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Temple Rock, Utah, USA.
2.94 (10), 1.71 (9), 2.24 (8), 1.484 (7), 5.9 (6), 4.6 (4), 1.637 (4)

Chemistry:

	(1)	(2)
UO_3	39.60	41.22
P_2O_5	0.06	
As_2O_5	0.05	
V_2O_5	37.70	39.31
MgO	0.04	
CaO	1.73	
K_2O	0.30	
H_2O	18.28	19.47
insol.	1.24	
Total	99.00	100.00

(1) Temple Rock, Utah, USA. (2) $U_2V_6O_{21}\cdot 15H_2O$.

Occurrence: In a Colorado Plateau-type uranium deposit in asphaltic sandstone.

Association: Carnotite, rauvite, hewettite, metatorbernite, gypsum, "hyalite".

Distribution: From Temple Rock, about 70 km southwest of Green River, San Rafael district, Emery Co., Utah, USA.

Name: For Uranium and VANadium in the composition.

Type Material: Harvard University, Cambridge, Massachusetts, 62753; National Museum of Natural History, Washington, D.C., USA, 87512, R5708.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1056. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 261–263. (3) Weiss, A. and K.J. Hilke (1965) Uvanit, ein Uranylvanadat mit Schichstruktur und innerkristallinem Quellungsvermögen. Anorg. Chem., 7(7), 347 (in German).

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Uvarovite $Ca_3Cr_2(SiO_4)_3$

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Crystal Data: Cubic. *Point Group:* $4/m\ \bar{3}\ 2/m$. Commonly as euhedral crystals, dodecahedra or trapezohedra, or in combination with other cubic forms, to 4.5 cm. Fine or coarse granular, compact, or massive.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 6.5–7 D(meas.) = 3.77–3.81 D(calc.) = 3.848

Optical Properties: Transparent to translucent. *Color:* Emerald-green to dark green; in thin section, green; may be sectored. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic; weak anisotropism due to internal strain is typical. $n = 1.865$

Cell Data: *Space Group: Ia3d.* a = 12.00 Z = 8

X-ray Powder Pattern: Synthetic.
2.684 (100), 2.999 (70), 1.603 (60), 2.449 (55), 2.352 (25), 1.664 (25), 2.557 (20)

Chemistry:

	(1)	(2)
SiO_2	36.79	36.02
Al_2O_3	1.93	
Fe_2O_3	0.41	
Cr_2O_3	27.54	30.37
MgO	0.50	
CaO	32.74	33.61
Total	99.91	100.00

(1) Outokumpu, Finland; corresponds to $(Ca_{2.88}Mg_{0.06})_{\Sigma=2.94}(Cr_{1.79}Al_{0.19}Fe^{3+}_{0.03})_{\Sigma=2.01}Si_{3.02}O_{12}$.
(2) $Ca_3Cr_2(SiO_4)_3$.

Polymorphism & Series: Forms a series with grossular.

Mineral Group: Garnet group.

Occurrence: From hydrothermal alteration of serpentinite containing chromite; in metamorphosed limestones and skarns from the reaction of dolomite and chromite.

Association: Chromite, diopside, zoisite, olivine, dolomite, tremolite, quartz, plagioclase, epidote, calcite, chromian clinochlore, pyroxenes.

Distribution: Although an uncommon garnet, still with numerous localities. From the Saranovskii mine, Biserskoye, in the Gorozavod district, and other localities around Yekaterinburg (Sverdlovsk), Ural Mountains, Russia. Exceptional crystals from Outokumpu, Finland. From Pico do Posets, near Vénasque, Pyrenees, Spain. In Canada, at South Ham, Wolfe Co., Quebec. In the USA, from Wood's Chrome mine, Lancaster Co., Pennsylvania; at Riddle, Grant Co., Oregon; in the Red Ledge mine, near Washington, Nevada Co., around Newcastle, Placer Co., near New Idria, San Benito Co., and elsewhere in California. On Taiwan, Formosa. From Ergani Maden and in the Kop Krom [chrome] mine, Kop Mountains, near Aşkale, Turkey.

Name: For Count Sergei Semenovich Uvarov (1786–1855), Russian nobleman, President of Academy of Sciences.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 437–447. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 468–698, esp. 642–648. (3) Novak, G.A. and G.V Gibbs (1971) The crystal chemistry of the silicate garnets. Amer. Mineral., 56, 791–825. (4) (1960) NBS Circ. 539, 10, 17.

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Uvite $(Ca,Na)(Mg,Fe^{2+})_3Al_5Mg(BO_3)_3Si_6O_{18}(OH,F)_4$

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Crystal Data: Hexagonal. *Point Group:* 3*m*. Crystals prismatic to equant, may be tabular on [0001], pyramidal, in radiating groups, to 15 cm. Cross sections are typically triangular with curved, convex sides.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 7.5 D(meas.) = 2.97–3.14 D(calc.) = [3.08] Pyroelectric and piezoelectric; may fluoresce a weak mustard-yellow under SW UV.

Optical Properties: Semitransparent. *Color:* Brown, light to dark green, red, black; may be zoned parallel to prism faces. *Streak:* White, light green, light brown. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (–). *Pleochroism:* O = pale yellow; E = colorless. ω = 1.637–1.668 ϵ = 1.619–1.639

Cell Data: *Space Group: R*3*m*. a = 15.96–15.99 c = 7.18–7.22 Z = 3

X-ray Powder Pattern: Hnúšta, Slovakia. (ICDD 29-342).
2.965 (100), 2.577 (90), 2.043 (80), 4.23 (70), 3.99 (70), 3.49 (60), 1.921 (60)

Chemistry:

	(1)		(1)
SiO_2	35.96	Li_2O	0.00
TiO_2	0.62	Na_2O	0.13
B_2O_3	11.49	K_2O	0.00
Al_2O_3	26.80	F	1.49
FeO	0.41	H_2O^+	2.70
MgO	15.20	H_2O^-	0.04
CaO	5.50	$-O = F_2$	0.63
		Total	99.71

(1) Uva Province, Sri Lanka; corresponds to $(Ca_{0.96}Na_{0.04})_{\Sigma=1.00}(Mg_{2.69}Al_{0.14}Ti_{0.08}Fe^{2+}_{0.06})_{\Sigma=2.97}$ $Al_5Mg(B_{1.08}O_3)_3Si_{5.86}O_{18}[(OH)_{2.93}F_{0.77}O_{0.30}]_{\Sigma=4.00}$.

Mineral Group: Tourmaline group.

Occurrence: Typically in calcium-rich rocks subjected to contact metamorphism and metasomatic processes which added boron.

Association: Calcite, dolomite, tremolite, apatite, scapolite.

Distribution: In Uva Province, Sri Lanka. From the Sagaing district, Myanmar (Burma). In the USA, from Franklin and Hamburg, Sussex Co., New Jersey; in New York, at Gouverneur, Pierrepont, Dekalb and elsewhere in St. Lawrence Co., and at Horicon, Warren Co.; and from East Hampton, Middlesex Co., Connecticut. From Brumado, Bahia, Brazil. At Hnúšta, Slovakia.

Name: For the occurrence in Uva Province, Sri Lanka.

Type Material: Canadian Geological Survey, Ottawa, 13320; Royal Ontario Museum, Toronto, Canada; The Natural History Museum, London, England, 1976,426; Harvard University, Cambridge, Massachusetts, 116455; National Museum of Natural History, Washington, D.C., USA, C3283, C3287, C5212.

References: (1) Kunitz, W. (1929) Beiträge zur Kenntnis der magmatischen Assoziationen. I. Die Mischungsriehen in der Turmalingruppe und die genetischen Beziehungen zwischen Turmalinen und Glimmern [hypothetical end member]. Chem. Erde, 4, 208–251, esp. 221 (in German). (2) Dunn, P.J., D. Appleman, J.A. Nelen, and J. Norberg (1977) Uvite, a new (old) common member of the tourmaline group and its implications for collectors. Mineral. Record, 8, 100–108. (3) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 559–602.

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Uytenbogaardtite Ag_3AuS_2

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Crystal Data: Tetragonal. *Point Group:* 422 or 4. As small (up to 300 μm) blebs and rims.

Physical Properties: *Tenacity:* Considerably more brittle than acanthite. Hardness = ∼2 VHN = ∼20 (15 g load) D(meas.) = n.d. D(calc.) = 8.34–8.45

Optical Properties: Opaque. *Color:* In polished section, gray-white; surface changes rapidly on exposure to light. *Pleochroism:* Weak to distinct; pale gray to pale gray with a brownish tint. *Anisotropism:* Strong; without distinct colors.

R_1–R_2: (470) 33.2–34.6, (546) 30.3–34.6, (589) 31.1–35.2, (650) 30.5–33.3

Cell Data: *Space Group:* $P4_122$ or $P4_1$ (probable). $a = 9.68–9.76$ $c = 9.78–9.81$ $Z = 8$

X-ray Powder Pattern: Tambang Sawah, Indonesia.
2.712 (10), 2.591 (90), 6.94 (4), 2.112 (40), 4.33 (3), 2.802 (3), 1.980 (2)

Chemistry:

	(1)	(2)	(3)	(4)
Ag	56.1	57.1	53.2	55.34
Au	29.8	32.7	35.1	33.69
Cu	2.2			
Se	trace			
Te	trace			
S	11.2	10.3	11.7	10.97
Total	99.3	100.1	100.0	100.00

(1) Comstock Lode, Nevada, USA; by electron microprobe. (2) Zmeinogorsk, Russia; by electron microprobe. (3) Tambang Sawah, Indonesia; by electron microprobe. (4) Ag_3AuS_2.

Occurrence: In low-temperature hydrothermal Au–Ag quartz veins, in part of supergene origin.

Association: Acanthite, Au–Ag alloy, chlorargyrite, naumannite, quartz.

Distribution: In Indonesia, from Tambang Sawah, Benkoelen district, Sumatra [TL], and on Java, at the Pongkor Au–Ag deposit and in the Cirotan Au–Ag–Sn–W deposit. In the USA, in Nevada, from the Comstock Lode, Virginia City, Storey Co. [TL], at the Bullfrog and Original Bullfrog mines, Bullfrog district, Nye Co., and in the Life Preserver mine, Tolicha district; from the Equity mine, near Creede, Mineral Co., Colorado; in the Morning Star deposit, San Bernardino Co., California; at the Comstock mine, Dos Cabezos Mountains, Cochise Co., Arizona. From the Milluri prospect, Potosí, Bolivia. In Russia, at Zmeinogorsk (Schlangenberg), Altai Mountains [TL] and in the Gai deposit, Southern Ural Mountains. Als known from several undisclosed localities in China and Uzbekistan.

Name: To honor Willem Uytenbogaardt (1918–), Professor of Geology, Technical University, Delft, The Netherlands, prominent ore microscopist.

Type Material: Institute of Earth Sciences, Free University of Amsterdam; University of Amsterdam, Amsterdam, The Netherlands; National Museum of Natural History, Washington, D.C., USA, 105328, B239.

References: (1) Barton, M.D., C. Kieft, E.A.J. Burke, and I.S. Oen (1978) Uytenbogaardtite, a new silver–gold sulfide. Can. Mineral., 16, 651–657. (2) (1980) Amer. Mineral., 65, 209 (abs. ref. 1).

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Uzonite As_4S_5

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As prismatic crystals, to 0.5 mm, elongated along [001], with {110}, {001}, {101}; {110} exhibits fine striations ∥ [$1\bar{1}1$]. *Twinning:* Cruciform twins with twin axis [100] and a growth plane near {011}.

Physical Properties: *Cleavage:* {001}. Hardness = ∼1.5 VHN = 66–71 (8 g load). D(meas.) = 3.385 D(calc.) = 3.37

Optical Properties: Transparent. *Color:* Yellow; in reflected light, grayish white with bright yellow internal reflections. *Luster:* Pearly to slightly greasy on a broken surface.
Optical Class: Biaxial (+). $\alpha = 2.38(1)$ (α') $\gamma = 2.68(1)$ (γ')
R_1–R_2: (400) 18.8–20.1, (425) 18.8–20.0, (450) 18.7–19.9, (475) 18.3–19.7, (500) 18.1–19.2, (525) 19.0–19.8, (550) 19.4–20.0, (575) 19.4–19.9, (600) 19.3–19.7, (625) 19.2–19.4, (650) 19.1–19.3, (675) 19.0–19.2, (700) 18.8–19.0

Cell Data: *Space Group:* $P2_1/m$. $a = 7.98(1)$ $b = 8.10(1)$ $c = 7.09(1)$ $\beta = 100.14(3)°$
$Z = 2$

X-ray Powder Pattern: Uzon caldera, Russia.
5.81 (100), 3.602 (80), 2.905 (80), 5.31 (60), 3.100 (60), 2.820 (60)

Chemistry:

	(1)	(2)
As	64.65	65.15
S	34.09	34.85
Total	98.74	100.00

(1) Uzon caldera, Russia; by electron microprobe, average of three grains; corresponds to $As_{4.03}S_{4.97}$. (2) As_4S_5.

Occurrence: As intergrowths with realgar in the pore spaces of tuffaceous sediments 10–30 cm deep in a caldera.

Association: Realgar, cubic α–arsenic sulfide, amorphous arsenic sulfide, orpiment, alacranite, stibnite, cinnabar, pyrite, sulfur.

Distribution: From the Uzon caldera, Kamchatka, Russia [TL].

Name: For the type locality, Uzon caldera, Russia.

Type Material: Il'menskii Preserve Museum, Miass, 3911; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87574.

References: (1) Popova, V.I. and V.O. Polyakov (1985) Uzonite As_4S_5 – a new sulphide of arsenic from Kamchatka. Zap. Vses. Mineral. Obshch., 114, 369–373 (in Russian). (2) (1986) Amer. Mineral., 71, 1280 (abs. ref. 1). (3) Migdisov, A.A. and A.Y. Bychkov (1998) The behavior of metals and sulphur during the formation of hydrothermal mercury–antimony–arsenic mineralization, Uzon caldera, Kamchatka, Russia. J. Volcan. and Geothermal Res., 84, 153–171. (4) Whitfield, ?? (1973) ??title?? J. Chem. Soc., Dalton Trans., ?? 1740–1742. [??str MFG]

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Vaesite NiS_2

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. As octahedra and cubes, to 1 cm, and massive.

Physical Properties: *Cleavage:* {001}. Hardness = ∼3.5 VHN = 743–837 (100 g load). D(meas.) = 4.45 D(calc.) = 4.47

Optical Properties: Opaque. *Color:* Black; pale violet-gray in reflected light.
Luster: Metallic to submetallic.
R: (400) 34.2, (420) 33.6, (440) 33.2, (460) 32.8, (480) 32.4, (500) 32.2, (520) 32.0, (540) 31.8, (560) 31.8, (580) 31.8, (600) 32.0, (620) 32.0, (640) 32.1, (660) 32.3, (680) 32.6, (700) 32.9

Cell Data: *Space Group: Pa*3. $a = 5.66787(8)$ [=say if syn??;??5.670??Kasompi] $Z = 4$

X-ray Powder Pattern: Kasompi mine, Congo.
2.83 (100), 1.707 (80), 1.091 (60), 2.00 (50), 2.54 (40), 2.32 (40), 1.003 (40)

Chemistry:

	(1)	(2)	(3)
Ni	41.24	47.9	47.79
Co	3.41	1.1	
Fe	2.20	2.6	
S	53.15	48.4	52.21
Total	100.00	100.0	100.00

(1) Kasompi mine, Congo; corresponding to $(Ni_{0.86}Co_{0.07}Fe_{0.05})_{\Sigma=0.98}S_{2.02}$. (2) Kalgoorlie, Australia; by electron microprobe, corresponding to $(Ni_{1.02}Fe_{0.06}Co_{0.02})_{\Sigma=1.10}S_{1.90}$. (3) NiS_2.

Polymorphism & Series: Forms a series with cattierite.

Mineral Group: Pyrite group.

Occurrence: Disseminated through dolostone (Kasompi mine, Congo); an alteration product of arsenic-deficient nickel-skutterudite (Germany).

Association: Arsenic-deficient nickel-skutterudite, pyrite, polydymite, uraninite.

Distribution: From the Kasompi mine, 70 km west-southwest of Kambove [TL], and at Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). From Schneeberg, Saxony; Nentershausen, ??ck, and Iserlohn, ??ck, Germany. In the Providencia mine, near Villamanín, Cármenes district, León Province, Spain. From the Saint Marina deposit, Haskovo district, and at the Medet deposit, Panagyurishte district, Bulgaria. From the Agyatagsk mercury deposit, Kel'badzhar, Azerbaijan. At the Miliken (Sweetwater) mine, Reynolds Co., Missouri, and from the Orphan mine, in the Grand Canyon, Coconino Co., Arizona, USA. At the San Santiago mine, La Rioja Province, Argentina. Found near the Scotia nickel deposit, Kalgoorlie, Western Australia. At the Kosaka mine, Akita Prefecture, Japan.

Name: In honor of Johannes F. Vaes (1902–1978), mineralogist for the Union Minière du Haut Katanga.

Type Material: [Columbia University, New York, now at American Museum of Natural History, New York, New York, USA ?]

References: (1) Kerr, P.F. (1945) Cattierite and vaesite: new Co–Ni minerals from the Belgian Congo. Amer. Mineral., 30, 483–497. (2) Ostwald, J. (1980) Notes on a Co–Ni disulphide and a Co–Ni–Fe thiospinel from the Kalgoorlie district, Western Australia. Mineral. Mag., 43, 950–951. (3) Nowack, E., D. Schwarzenbach, and T. Hahn (1991) Charge densities in CoS_2 and NiS_2 (pyrite structure). Acta Cryst., 650–659. [in cattierite??should be??ck cell and syn??] (4) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 93–94. (5) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 815–816. (6) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 599.

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Valentinite Sb_2O_3

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic along [001], less commonly along [100], flattened on {010}, to 2 cm, spearhead-shaped with complex terminations. In fan-shaped or stellate aggregates of crystals; lamellar, columnar, granular, massive.

Physical Properties: *Cleavage:* {110}, perfect; {010}, imperfect. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 5.76 D(calc.) = 5.828

Optical Properties: Transparent to translucent. *Color:* Colorless, snow-white, pale yellow, pink, gray to brownish; colorless in transmitted light. *Streak:* White. *Luster:* Adamantine, pearly on cleavages.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$ or $r > v$. $\alpha = 2.18$ $\beta = 2.35$ $\gamma = 2.35$ 2V(meas.) = Very small.

Cell Data: *Space Group: Pccn.* $a = 4.911(1)$ $b = 12.464(2)$ $c = 5.412(1)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.142 (100), 3.118 (75), 3.494 (25), 3.174 (20), 1.8046 (20), 4.571 (18), 2.650 (14)

Chemistry:

	(1)	(2)
Sb	82.79	83.53
O	[17.21]	16.47
Total	[100.00]	100.00

(1) Tatasi, Bolivia; O by difference. (2) Sb_2O_3.

Polymorphism & Series: Dimorphous with sénarmontite.

Occurrence: An alteration product of antimony-bearing minerals in the oxidized zone of hydrothermal antimony deposits.

Association: Stibnite, antimony, stibiconite, cervantite, kermesite, tetrahedrite.

Distribution: Widespread; a few localities for good material include: in France, from the Chalanches mine, near Allemont, Isère. At Bräunsdorf, near Freiberg, Saxony, Germany. Large crystals from Příbram, Czech Republic. At Pernek, near Pezinok, Slovakia. From Baia Sprie (Felsőbánya), Romania. At the Cetine mine, 20 km southwest of Siena, Tuscany, Italy. In several mines around St. Endellion and elsewhere in Cornwall, England. At Sensa (Haminate mine), Aïn-el-Bebbouch, Qacentina (Constantine), Algeria. In the Globe and Phoenix mine, Kwekwe (Que Que), Zimbabwe. From Canada, in the Lac Nicolet mine, South Ham, Quebec. At Sombrerete and Noche Buena, Mazapil, Zacatecas, Mexico. Fine crystals from the San José mine, near Oruro, and at Tatasi, Potosí, Bolivia. In the Xikuanshan antimony mine, Lengshuijiang, Shaoyang, Hunan Province, China. From Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan.

Name: To honor Basilius Valentinus, 15th century alchemist, who early wrote concerning antimony.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 547–550. (2) Svensson, C. (1974) The crystal structure of orthorhombic antimony trioxide, Sb_2O_3. Acta Cryst., 30, 458–461. (3) (1960) NBS Circ. 539, 10, 6.

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Valleriite $4(Fe,Cu)S{\cdot}3(Mg,Al)(OH)_2$

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Crystal Data: Hexagonal *Point Group:* $\overline{3}\ 2/m$ or $3m$. Massive, as nodules, to 5 mm; also in tiny splinters, very thin flakes, and thin crusts.

Physical Properties: *Cleavage:* On {0001}, excellent. Hardness = < 1, less than graphite. VHN = n.d. D(meas.) = 3.14 D(calc.) = 3.21

Optical Properties: Opaque. *Color:* Bronze-yellow, resembling pyrrhotite. *Luster:* Metallic to submetallic. *Pleochroism:* Strong; pale yellow to deep brown. *Anisotropism:* Strong; golden yellow.

R_1–R_2: (400) 10.5–11.1, (420) 10.8–11.3, (440) 10.7–12.7, (460) 10.6–14.2, (480) 10.5–15.8, (500) 10.5–17.3, (520) 10.3–18.8, (540) 10.3–20.1, (560) 10.3–21.3, (580) 10.2–22.4, (600) 10.3–23.4, (620) 10.3–24.4, (640) 10.3–25.1, (660) 10.4–25.8, (680) 10.3–26.4, (700) 10.3–26.9

Cell Data: *Space Group:* $R\overline{3}m$ or $R3m$. $a = 64.46$ $c = 34.10$ Z = [390]

X-ray Powder Pattern: Loolekop, South Africa.
11.39 (100), 5.71 (100), 3.27 (60), 3.80 (50), 3.23 (50), 2.846 (50), 1.885 (50)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Cu	17.7	17.6	19.8	CaO	0.3	1.7	1.3
Fe	26.3	21.2	20.0	K_2O	0.3		
S	22.5	21.4	21.6	Na_2O	0.6		
Al_2O_3	5.1	8.1	8.5	H_2O	10.8	12.2	10.8
MgO	10.6	16.2	16.0	SiO_2 + insol.		1.8	3.3
				Total	94.2	100.2	101.3

(1) Kopparberg, Sweden; from five partial analyses. (2) Kaveltorp, Sweden. (3) Loolekop, South Africa.

Occurrence: An alteration product of chalcopyrite in chromitites and dunites (Cyprus); in copper-bearing carbonatites, replacing magnetite (Phalaborwa, South Africa); in Cu–Ni sulfide-bearing serpentinized and uralized ultramafic rocks.

Association: Chalcopyrite, cubanite, pyrrhotite, troilite, millerite, pentlandite, pyrite, marcasite, mackinawite, tochilinite, magnetite.

Distribution: An inconspicuous mineral, now recognized from a number of localities in addition to those listed here. In Sweden, in Kopparberg, from the Aurora mine, Ljusnarsberg [TL], and at Kaveltorp. In South Africa, in Transvaal, from the Loolekop carbonatite, Phalaborwa, and at the Mooihoek and Onverwacht pipes, in the Merensky Reef, Bushveld complex. From near Pefkos, Cyprus. In Canada, at the Little Chief mine, near Whitehorse, Yukon Territory; in the Marbridge mine, Malartic, Quebec; and at Sudbury, Ontario. In the USA, from the Elizabeth mine, South Strafford, Strafford Co., Vermont; in the Pima mine, near Tucson, Pima Co., and at the Christmas mine, Gila Co., Arizona; from the Continental mine, Fierro, Grant Co., New Mexico. In Russia, in the Talnakh area, Noril'sk region, western Siberia; from the Kovdor and Monchegorsk massifs, Kola Peninsula. At Alnalyk, Uzbekistan. In the Akagane mine, Iwate Prefecture, Japan. From Wannaway, Western Australia. On the East Pacific Rise (21°N).

Name: In honor of Johan Gottschalk Wallerius (Vallerius) (1709–1785), Swedish chemist and mineralogist.

Type Material: Wroclaw University, Wroclaw, Poland, II–14152.

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References: (1) Evans, H.T., Jr., C. Milton, E.C.T. Chao, I. Adler, C. Mead, B. Ingram, and R.A. Berner (1964) Valleriite and the new iron sulfide, mackinawite. U.S. Geol. Sur. Prof. Paper 475-D, D64–D69. (2) Evans, H.T., Jr. and R. Allmann (1968) The crystal structure and crystal chemistry of valleriite. Zeits. Krist., 127, 73–93. (3) Harris, D.C. and D.J. Vaughan (1972) Two fibrous iron sulfides and valleriite from Cyprus with new data on valleriite. Amer. Mineral., 57, 1037–1052. (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 683–692. (5) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 603.

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Vanadinite $Pb_5(VO_4)_3Cl$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Typically in well-developed hexagonal prismatic crystals, to 14 cm, short to long along [0001], with $\{10\bar{1}0\}$, $\{0001\}$, modified by $\{11\bar{2}0\}$, $\{10\bar{1}1\}$, $\{20\bar{2}1\}$, $\{11\bar{2}1\}$, many others. Commonly cavernous and in parallel groupings; may be acicular, hairlike, fibrous; rarely rounded, globular.

Physical Properties: *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3 D(meas.) = 6.88 D(calc.) = 6.95

Optical Properties: Subtransparent to opaque. *Color:* Red-orange, deep red, brownish red, brownish yellow, yellow, pale straw-yellow; may be concentrically zoned. *Streak:* White to pale red or pale yellow. *Luster:* Subresinous to subadamantine.
Optical Class: Uniaxial (–). *Absorption:* $E < O$. $\omega = 2.416$ $\epsilon = 2.350$

Cell Data: *Space Group:* $P6_3/m$. $a = 10.3174$ $c = 7.3378$ Z = 2

X-ray Powder Pattern: Synthetic.
2.987 (100), 2.995 (92), 3.069 (89), 3.380 (41), 4.470 (35), 3.397 (30), 4.224 (27)

Chemistry:

	(1)	(2)
P_2O_5	0.30	
As_2O_5	trace	
V_2O_5	19.10	19.26
PbO	78.07	78.80
CaO	0.07	
Cl	2.66	2.50
$-O = Cl_2$	0.60	0.56
Total	99.60	100.00

(1) Obir, Carinthia, Austria. (2) $Pb_5(VO_4)_3Cl$.

Mineral Group: Apatite group.

Occurrence: A secondary mineral in the oxidized zone of lead-bearing deposits, the vanadium leached from wall-rock silicates.

Association: Mimetite, pyromorphite, descloizite, mottramite, wulfenite, cerussite, anglesite, calcite, barite, iron oxides.

Distribution: Many localities, even for fine crystals. From Zimapán, Hidalgo; at San Carlos and Los Lamentos, Chihuahua; and Rayon, Sonora, Mexico. In the USA, in Arizona, fine examples from the Old Yuma mine, near Tucson, Pima Co., at the Hamburg, Red Cloud, and North Geronimo mines, Silver district, La Paz Co., and in the Puzzler mine, Castle Dome district, Yuma Co., from the Mammoth-St. Anthony mine, Tiger, Pinal Co., at the Gallagher mine, near Charleston, Cochise Co., in the Apache mine, Gila Co., at the Western Union mine, near Cerbat, Mohave Co.; in New Mexico, from the Hillsboro and Lake Valley districts, Sierra Co. In Morocco, large crystals from Mibladen, at Taouz, and in the Touissit mine, near Oujda. At Keban, Turkey. Very large crystals from Abenab, Otavi district, Namibia. At Broken Hill, New South Wales, Australia.

Name: For its content of *vanadium*.

Type Material: Lost at sea.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 895–898. (2) Dai, Y. and J.M. Hughes (1989) Crystal-structure refinements of vanadinite and pyromorphite. Can. Mineral., 27, 189–192. (3) Baker, W.E. (1966) An X-ray diffraction study of synthetic members of the pyromorphite series. Amer. Mineral., 51, 1712–1721.

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Vanadoandrosite-(Ce) $Mn^{2+}CeV^{3+}AlMn^{2+}Si_2O_7SiO_4O(OH)$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As isolated, stout prismatic grains, to tens of micrometers, or as radiating aggregates.

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: Brittle.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.27

Optical Properties: Transparent. *Color*: Very dark brown to black. *Streak*: Brown.
Luster: Vitreous to adamantine.
Optical Class: Biaxial. α > 1.74 *n*(calc.) = 1.82 2V(meas.) = n.d. 2V(calc.) = n.d.
Orientation: n.d. *Pleochroism:* Strong; yellow-brown, red-brown, dark greenish brown.

Cell Data: *Space Group*: $P2_1/m$. a = 8.856(3) b = 5.729(2) c = 10.038(4) β = 113.088(4)°
Z = 2

X-ray Powder Pattern: Vielle Aure village, central Pyrénées, France. [calculated pattern]
2.8890 (100), 2.6124 (54), 3.5004 (43), 2.8645 (41), 2.7023 (34), 2.7114 (31), 2.5916 (26)

Chemistry:

	(1)		(1)
SiO_2	28.81	CaO	2.57
Al_2O_3	9.65	Ce_2O_3	16.14
TiO_2	0.06	La_2O_3	8.29
Fe_2O_3	2.18	Nd_2O_3	0.84
MnO	17.78	Sm_2O_3	0
Mn_2O_3	1.75	F	0.57
V_2O_3	5.30	H_2O	[1.44]
MgO	1.22	Total	96.36
SrO	0		

(1) Vielle Aure village, central Pyrénées, France; average of 4 electron microprobe analyses, H_2O calculated from stoichiometry; corresponding to $[Mn^{2+}_{0.62}Ca_{0.38}]_{\Sigma=1.00}$ $[(Ce_{0.39}La_{0.15}Nd_{0.10}Sm_{0.02})_{\Sigma REE=0.66}Ca_{0.21}Sr_{0.11}]_{\Sigma=0.98}[V^{3+}_{0.80}Al_{0.16}Mg_{0.03}Ti_{0.01}]_{\Sigma=1.00}Al_{1.00}$ $[Mn^{2+}_{0.36}V^{3+}_{0.31}Fe^{2+}_{0.23}Fe^{3+}_{0.10}]_{\Sigma=1.00}Si_2O_7SiO_4O(OH)$.

Mineral Group: Epidote group, allanite subgroup.

Occurrence: In quartz-rhodochrosite-sulfide veins cross-cutting massive rhodochrosite ore, as well as in the ore itself, in quartz grains rimmed by chalcopyrite.

Association: Quartz, vuorelainenite, rhodochrosite, chalcopyrite, vanadian spessartine, friedelite.

Distribution: From the mine above Vielle Aure village, central Pyrénées, France.

Name: An epidote-group mineral in which Ce^{3+} is dominant in A2, Mn^{2+} in A1, V^{3+} in M1, Al in M2, and in which Mn^{2+} is the dominant charge-compensating (*i.e*. divalent) cation in M3.

Type Material: Mineral Museum, School of Mines, Paris, France, (73952).

References: (1) Cenki-Tok, B., A. Ragu, T. Armbruster, C. Chopin, and O. Medenbach (2006) New Mn- and rare-earth rich epidote-group minerals in metacherts: manganiandrosite-(Ce) and vanadoandrosite-(Ce). Eur. J. Mineral., 18, 569-582. (2) (2007) Amer. Mineral., 92, 704-705 (abs. ref. 1).

Vanalite $NaAl_9V_{12}O_{42}(OH)_4 \cdot 33H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. In poorly-formed flattened and ragged crystals, may have diamond-shaped outlines, to 0.02 mm.

Physical Properties: *Cleavage:* {010}, perfect; {100}, less so. Hardness = n.d.
D(meas.) = 2.3–2.4 D(calc.) = 2.15

Optical Properties: Semitransparent. *Color:* Bright yellow to yellow-orange. *Luster:* Waxy to vitreous.
Optical Class: Biaxial. *Pleochroism:* Slight; in shades of yellow. *Orientation:* Extinction parallel; elongation negative. $\alpha = 1.710(6)$ β = n.d. $\gamma = 1.735(6)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$. $a = 12.470$ $b = 21.40$ $c = 10.825$ $\beta = 97°$
Z = 2

X-ray Powder Pattern: Kurumsak River valley, Kazakhstan.
10.70 (100), 2.938 (100), 8.52 (42), 7.90 (37), 6.33 (30), 5.34 (30), 3.308 (30)

Chemistry:

	(1)	(2)
V_2O_5	47.10	49.34
V_2O_4	1.80	
SiO_2	trace	
Al_2O_3	21.00	20.75
Fe_2O_3	0.20	
MgO	trace	
CaO	trace	
Na_2O	1.40	1.40
H_2O^+	23.30	
H_2O^-	7.80	
H_2O		28.51
Total	[102.60]	100.00

(1) Kurumsak River valley, Kazakhstan; original total given as 99.40%; corresponds to $Na_{0.90}(Al_{8.18}Fe^{3+}_{0.05})_{\Sigma=8.23}(V^{5+}_{10.29}V^{4+}_{0.43})_{\Sigma=10.72}[O_{37}(OH)_{4.76}]_{\Sigma=41.76} \cdot 30H_2O$.
(2) $NaAl_9V_{12}O_{42}(OH)_4 \cdot 33H_2O$.

Occurrence: Incrusting joints and cavities in weathered shales.

Association: Steigerite, hewettite, delvauxite, satpaevite, gypsum, halloysite, montmorillonite, other clay minerals.

Distribution: From a prospect in the Kurumsak River valley, northwestern Kara-Tau Mountains, south Kazakhstan.

Name: For VANadium and ALuminum in the composition.

Type Material: Mining Institute, St. Petersburg, 1271/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 85613.

References: (1) Ankinovich, E.A. (1962) A new vanadium mineral, vanalite. Zap. Vses. Mineral. Obshch., 91, 307–314 (in Russian). (2) (1963) Amer. Mineral., 48, 1180 (abs. ref. 1). (3) Ankinovich, E.A., F.A. Kurmakaeva, and I.S. Zazubina (1987) Steigerite and vanalite from carbonaceous-siliceous vanadium-bearing formations of northwestern Karatau (southern Kazakhstan). Zap. Vses. Mineral. Obshch., 116, 100–113 (in Russian with English abs.).

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Vandenbrandeite $Cu(UO_2)(OH)_4$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals, flattened on {001}, may be lathlike, rounded, to 0.5 cm; in parallel aggregates, lamellar, scaly; massive.

Physical Properties: *Cleavage:* {110}, perfect; two others, in the [001] zone, indistinct. Hardness = 4 D(meas.) = 4.91–5.03 D(calc.) = [5.14] Radioactive.

Optical Properties: Translucent, transparent in thin fragments. *Color:* Dark green to nearly black; green in transmitted light. *Streak:* Green. *Luster:* Vitreous.
Optical Class: Biaxial, (+) or (–). *Pleochroism:* Yellow-green to blue-green. *Orientation:* $Z \wedge$ elongation $\simeq 40°$. *Dispersion:* Strong. $\alpha = 1.76$–1.77 $\beta = 1.78$–1.79 $\gamma = 1.78$–1.82 2V(meas.) = $\sim 90°$

Cell Data: *Space Group:* $P\overline{1}$ (probable). $a = 7.855(5)$ $b = 5.449(4)$ $c = 6.089(4)$ $\alpha = 91.44(5)°$ $\beta = 101.90(5)°$ $\gamma = 89.2(5)°$ Z = 2

X-ray Powder Pattern: Kalongwe, Congo.
4.29 (10), 2.92 (8), 5.06 (4), 2.56 (4), 2.09 (3), 1.85 (3), 1.47 (3)

Chemistry:

	(1)	(2)
UO_3	71.23	71.22
CuO	19.20	19.81
H_2O	9.57	8.97
Total	[100.00]	100.00

(1) Shinkolobwe, Congo; recalculated to 100% after deduction of SiO_2 0.28%, MgO 0.57%, CaO 0.26% as impurities. (2) $Cu(UO_2)(OH)_4$.

Occurrence: A rare secondary mineral in the oxide zone of hydrothermal copper-bearing uranium deposits.

Association: Cuprosklodowskite, kasolite, sklodowskite, malachite, chalcocite, chalcopyrite, uraninite, goethite (Kalongwe, Congo); curite, uranophane, sharpite (Shinkolobwe, Congo).

Distribution: In Congo (Zaire), in Katanga (Shaba) Province, from the Luiswishi mine; at Kalongwe; from Shinkolobwe; at Kambove; from Swambo; and in the Musonoi mine, near Kolwezi. In the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France.

Name: To honor Pierre Van den Brande (1896–1957), Belgian geologist, who discovered the uranium deposit at Kalongwe, Congo.

Type Material: Natural History Museum, Paris, France, 134-72; The Natural History Museum, London, England, 1933,261–263.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 632–633 [vandenbrandite]. (2) Milne, I.H. and E.W. Nuffield (1951) Studies of radioactive compounds: I – vandenbrandeite. Amer. Mineral., 36, 394–410. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 100–103. (4) Rosenzweig, A. and R.R. Ryan (1977) Vandenbrandeite $CuUO_2(OH)_4$. Crystal Structure Comm., 6, 53–56.

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Vandendriesscheite $PbU_7^{6+}O_{22}\cdot 12H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals flattened on {001}, pseudohexagonal, diamond- or barrel-shaped, to 1.5 mm, showing {001}, {011}, {111}, {010}; composite or in subparallel aggregates, intimately intergrown with metavandendriesscheite; in dense microcrystalline aggregates.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = n.d. D(meas.) = 5.45–5.46 D(calc.) = 5.86 Radioactive.

Optical Properties: Transparent. *Color:* Amber-orange, yellowish orange to orange. *Optical Class:* Biaxial (–). *Pleochroism:* X = nearly colorless; $Y = Z$ = yellow-orange to golden yellow. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, strong. $\alpha = 1.780(5)$ $\beta = 1.850(10)$ $\gamma = 1.860(10)$ 2V(meas.) = 60(2)°

Cell Data: *Space Group:* $Pmma$, $P2_1ma$, or $Pm2a$. $a = 14.07(4)$ $b = 40.85(12)$ $c = 43.33(13)$ Z = 36

X-ray Powder Pattern: Shinkolobwe, Congo; cannot be distinguished from metavandendriesscheite.
7.24 (100), 3.61 (100), 3.17 (75), 1.985 (40), 3.53 (25), 2.522 (25), 2.034 (15)

Chemistry:

	(1)	(2)	(3)	(4)
UO_3	82.36	80.48	81.63	82.00
SiO_2		0.65		
PbO	8.86	11.25	9.64	9.14
H_2O	9.26	6.86	8.73	8.86
Total	100.48	99.24	[100.00]	100.00

(1–2) Shinkolobwe, Congo. (3) Great Bear Lake, Canada; original total given as 97.65%; recalculated to 100% after deduction of insoluble 4.10%. (4) $PbU_7O_{22}\cdot 12H_2O$.

Occurrence: In the oxidized zone of uranium-bearing mineral deposits.

Association: Metavandendriesscheite, fourmarierite, becquerelite, metatorbernite, rutherfordine, uraninite (Shinkolobwe, Congo).

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Great Bear Lake, Northwest Territories, Canada. From Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland. At Les Bois Noirs, Loire, and in the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault, France. From Menzenschwand and Wittichen, Black Forest, Germany. In Sweden, at the Stackebö pegmatite, near Holsljunga, Västergötland. From the Monument No. 2 mine, Monument Valley, Apache Co., Arizona; in Leiper's quarry, Avondale, Delaware Co., Pennsylvania; at the Ruggles mine, Grafton, and the Palermo mine, near North Groton, Grafton Co., New Hampshire, USA. In the Palette mine, South Alligator Valley, Northern Territory, Australia.

Name: Honors Adrien Vandendriessche (1914–1940), Belgian mineralogist and geologist, University of Ghent, Ghent, Belgium.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 106523.

References: (1) Vaes, J.F. (1947) Six nouveaux minéraux d'urane provenant de Shinkolobwe (Katanga). Ann. Soc. Géol. Belg., 70, B212–B229, esp. B217–B219 (in French). (2) (1948) Amer. Mineral., 33, 384 (abs. ref. 1). (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 81–87. (4) Christ, C.L. and J.R. Clark (1960) Crystal chemical studies of some uranyl oxide hydrates. Amer. Mineral., 45, 1026–1061. (5) Deliens, M. (1977) Review of the hydrated oxides of U and Pb, with new X-ray powder data. Mineral. Mag., 41, 51–57.

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Vanmeersscheite $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As tabular crystals, flattened on {010} and elongated along [001], modified by {101}, $\{\bar{1}01\}$, {100}, to 0.4 mm; usually in divergent groups.

Physical Properties: *Cleavage:* Good on {010}; fair on {100}. Hardness = n.d. D(meas.) = n.d. D(calc.) = 4.67 Fluoresces bright green in SW and LW UV. Radioactive.

Optical Properties: Semitransparent. *Color:* Canary-yellow. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; yellow to pale yellow. *Orientation:* $Y = c$. $\alpha = [1.704]$ $\beta = 1.715(2)$ $\gamma = 1.718(2)$ 2V(meas.) = 56°

Cell Data: *Space Group:* $P2_1mn$. $a = 17.06$ $b = 16.76$ $c = 7.023$ Z = 4

X-ray Powder Pattern: Kobokobo pegmatite, Congo.
8.39 (100), 5.96 (80), 4.18 (70), 3.069 (70), 2.887 (70), 5.30 (50), 3.905 (50)

Chemistry:

	(1)	(2)
UO_3	80.76	81.02
P_2O_5	10.40	10.05
H_2O	[8.84]	8.93
Total	[100.00]	100.00

(1) Kobokobo pegmatite, Congo; average of five analyses, H_2O by difference; corresponds to $U(UO_2)_{2.96}(PO_4)_{2.06}(OH)_6 \cdot 3.87H_2O$. (2) $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 4H_2O$.

Occurrence: A rare secondary mineral in the uraniferous zone of an altered granite pegmatite.

Association: Metavanmeersscheite, studtite.

Distribution: From the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire).

Name: To honor Professor Maurice Van Meerssche (1923–1990), Belgian crystallographer, Catholic University of Louvain, Louvain, Belgium.

Type Material: Catholic University of Louvain, Louvain, F360; Royal Museum of Central Africa, Tervuren, Belgium, RMG13749.

References: (1) Piret, P. and M. Deliens (1982) La vanmeersscheite $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 4H_2O$, et la méta-vanmeersscheite $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 2H_2O$, nouveaux minéraux. Bull. Minéral., 105, 125–128 (in French with English abs.). (2) (1982) Amer. Mineral., 67, 1077 (abs. ref. 1).

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Vanoxite $V_4^{4+}V_2^{5+}O_{13}\cdot 8H_2O(?)$

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Crystal Data: n.d. *Point Group:* n.d. Crystals rare, may have rhombic sections, minute; commonly massive.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black; brownish in transmitted light.
Optical Class: n.d. n = n.d.
R: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
V_2O_5	27.03	29.91	27.65
V_2O_4	51.60	49.66	50.44
H_2O	21.37	20.43	21.91
Total	[100.00]	[100.00]	100.00

(1–2) Jo Dandy mine, Colorado, USA; analyses recalculated to 100% after deduction of unstated amounts of impurities. (3) $V_4^{4+}V_2^{5+}O_{13}\cdot 8H_2O$.

Occurrence: A replacement of fossil wood and cementing sandstone in Colorado Plateau-type U–V deposits.

Association: Gypsum, carnotite, hewettite, pintadoite, tyuyamunite, pascoite, pyrite.

Distribution: In the USA, in Colorado, from the Jo Dandy mine and the Bill Bryan claim, Wild Steer Canyon, about 10 km south of Gateway, and the Henry Clay claim, Long Park, Paradox Valley, Urvan district, Montrose Co.; in the Small Spot mine, Maverick Mesa, Mesa Co.; in Utah, from Poison Mesa, near Thompson, Grand Co.

Name: As a VANadium OXide.

Type Material: Harvard University, Cambridge, Massachusetts, 103477; National Museum of Natural History, Washington, D.C., USA, 95059.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 601–602.

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Vantasselite $Al_4(PO_4)_3(OH)_3 \cdot 9H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. Lamellar crystals, elongated along [100], flattened on [001], terminated by {120}. Typically in flat rosettes, to 8 mm, less commonly globular to spherical.

Physical Properties: *Cleavage:* On {001}, micaceous; imperfect on {010}. *Tenacity:* Slightly flexible. Hardness = 2–2.5 D(meas.) = 2.30(2) D(calc.) = 2.312

Optical Properties: Transparent to translucent. *Color:* White. *Luster:* Pearly on cleavages. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = [1.511]$ $\beta = 1.560(2)$ $\gamma = 1.578(2)$ 2V(meas.) = 61(2)°

Cell Data: *Space Group:* $Pmam$, $Pma2$, or $P2_1am$. $a = 10.528(4)$ $b = 16.541(3)$ $c = 20.373(6)$ Z = 8

X-ray Powder Pattern: Bihain, Belgium.
10.22 (10), 2.892 (5), 3.395 (4), 3.210 (4), 2.394 (4), 4.87 (3), 3.720 (3)

Chemistry:

	(1)	(2)
SO_3	0.35	
P_2O_5	33.47	35.14
Al_2O_3	30.46	33.65
Fe_2O_3	5.22	
H_2O	30.83	31.21
Total	100.33	100.00

(1) Bihain, Belgium; by electron microprobe, average of nine analyses; total Fe as Fe_2O_3, H_2O by TGA; corresponds to $(Al_{3.61}Fe_{0.39})_{\Sigma=4.00}[(PO_4)_{2.97}(SO_4)_{0.03}]_{\Sigma=3.00}(OH)_{3.03} \cdot 8.98H_2O$.
(2) $Al_4(PO_4)_3(OH)_3 \cdot 9H_2O$.

Occurrence: On dumps in a quartzite quarry, in quartz veinlets or lining schistosity planes.

Association: Wavellite, cacoxenite, variscite, turquoise, lithiophorite, cryptomelane, quartz, clinochlore, muscovite.

Distribution: Found about one km north of Bihain, Belgium.

Name: Honoring Dr. René Van Tassel (1916–), mineralogist, Royal Institute of Natural Sciences, Brussels, Belgium, for his work on Belgian mineralogy.

Type Material: University of Liège, Liège, Belgium.

References: (1) Fransolet, A.-M. (1987) La vantasselite, $Al_4(PO_4)_3(OH)_3 \cdot 9H_2O$, une nouvelle espèce minérale du Massif de Stavelot, Belgique. Bull. Minéral., 110, 647–656 (in French with English abs.). (2) (1988) Amer. Mineral., 73, 931 (abs. ref. 1).

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Vanthoffite $Na_6Mg(SO_4)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral granular, bedded massive.

Physical Properties: *Fracture:* Uneven to flat conchoidal. *Tenacity:* Friable. Hardness = 3.5 D(meas.) = 2.694 D(calc.) = 2.687 Soluble in H_2O, slightly bitter taste.

Optical Properties: Transparent. *Color:* Colorless, gray, pale yellow. *Luster:* Vitreous to pearly.
Optical Class: Biaxial (–). *Dispersion:* $r < v$, weak. $\alpha = 1.485$–1.486 $\beta = 1.488$ $\gamma = 1.489$ 2V(meas.) = 83°–84°

Cell Data: *Space Group:* $P2_1/c$. $a = 9.781(2)$ $b = 9.196(2)$ $c = 8.197(2)$ $\beta = 113.61(2)°$ Z = 2

X-ray Powder Pattern: Synthetic.
3.431 (100), 4.032 (95), 3.114 (75), 3.917 (70), 2.909 (70), 2.846 (60), 2.832 (60)

Chemistry:

	(1)	(2)
SO_3	58.54	58.60
MgO	7.37	7.38
Na_2O	33.64	34.02
Total	99.55	100.00

(1) Hall, Austria. (2) $Na_6Mg(SO_4)_4$.

Occurrence: Restricted to evaporite deposits of oceanic origin.

Association: Löweite, langbeinite, halite (Berlepsch mine, Germany); blödite (Hall, Austria).

Distribution: In Germany, from the Wilhelmshall potash mine, northwest of Halberstadt, Saxony; in the Berlepsch mine and at Douglashall, Stassfurt-Westeregeln district, Magdeburg, Saxony-Anhalt. At Hall, Tirol, Austria. From Borislav, Ukraine. In the "Q" Basin [Jianghan Plain] potash deposits, Hubei Province, China. From the Bikaner evaporite district, Rajasthan, India. In the USA, at Bertram Siding, Imperial Co., California; and about 36 km east of Carlsbad, Eddy Co., New Mexico.

Name: To honor Professor Jacobus Henricus van't Hoff (1852–1911), German physical chemist, University of Berlin, Berlin, Germany, who elucidated the equilibria involved in formation of oceanic salt deposits.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 430. (2) Madsen, B.M. (1966) Loewite, vanthoffite, bloedite, and leonite from southeastern New Mexico. U.S. Geol. Surv. Prof. Paper 550-B, B125–B129. (3) Kuhn, R. (1983) Ergänzungen zur Mineralogie des Vanthoffits. Kali und Steinsalz, 8(12), 411–415 (in German). (4) Nag, D.K., R. Guha, and G.L. Dwivedi (1986) Structure of natural vanthoffite from Rajasthan, India. Indian Minerals, 40(1), 1–12.

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Vanuralite $Al(UO_2)_2(V_2O_8)(OH)\cdot 11H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare crystals, to 4 mm, elongated along [010], with prominent {100}, {001}, smaller {011}, {110}, {111}, {$\overline{1}$11}, {$\overline{1}$13}; may form branching aggregates. *Twinning:* Composition plane {001}.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = ∼2 D(meas.) = 3.62 D(calc.) = 3.16 Radioactive.

Optical Properties: Translucent. *Color:* Citron-yellow, canary-yellow, pale yellow. *Optical Class:* Biaxial (–); some optical properties quoted here may be those of metavanuralite. *Pleochroism:* Strong; X = colorless; $Y = Z$ = yellow. *Orientation:* $Z = b$; $X \simeq c$; $Y \simeq a$. *Dispersion:* $r < v$, weak. $\alpha = 1.65$ $\beta = 1.85$ $\gamma = 1.90$ 2V(meas.) = 44° 2V(calc.) = 46°

Cell Data: *Space Group:* $A2_1/a$. $a = 10.55(3)$ $b = 8.44(3)$ $c = 24.52(5)$ $\beta = 103°(20)'$ Z = 4

X-ray Powder Pattern: Mounana mine, Gabon.
11.98 (FFF), 5.98 (FF), 3.975 (Fd), 3.231 (F), 3.180 (F), 5.14 (mF), 6.53 (mf)

Chemistry:

	(1)	(2)
UO_3	59.03	56.52
V_2O_5	17.74	17.97
Al_2O_3	5.05	5.04
H_2O	18.40	20.47
Total	100.22	100.00

(1) Mounana mine, Gabon; corresponds to $Al_{1.02}(UO_2)_{2.11}(V_2O_8)(OH)\cdot 10.48H_2O$.
(2) $Al(UO_2)_2(V_2O_8)(OH)\cdot 11H_2O$.

Occurrence: In the oxidized zone of a lead-bearing U–V deposit (Mounana mine, Gabon).

Association: Metavanuralite, francevillite, curienite, duttonite, chervetite, brackebuschite, mottramite, carnotite, dewindtite, torbernite, uranopilite, johannite, kasolite.

Distribution: From the Mounana uranium mine, Franceville, Gabon.

Name: For VANadium, URanium, and ALuminum in the composition.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England.

References: (1) Branche, G., P. Bariand, F. Chantret, R. Pouget, and A. Rimsky (1963) La vanuralite, nouveau minéral uranifère. Compt. Rendus Acad. Sci. Paris, 256, 5374–5376 (in French). (2) (1963) Amer. Mineral., 48, 1415–1416 (abs. ref. 1). (3) Cesbron, F. (1970) Nouvelles données sur la vanuralite. Existence de la méta-vanuralite. Bull. Minéral., 93, 242–248 (in French with English abs.).

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Variscite $AlPO_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Uncommon in crystals, then pseudo-octahedral {111}, may be lathlike; modified by numerous smaller forms, to 1.5 mm. Usually fine-grained massive, in nodules, stalactites, crusts, and veinlets.

Physical Properties: *Cleavage:* On {010}, good; on {001}, poor. *Fracture:* Uneven to splintery, conchoidal when glassy. Hardness = 4.5 D(meas.) = 2.57–2.61 D(calc.) = 2.59

Optical Properties: Transparent to translucent. *Color:* Pale green, emerald-green, bluish green, colorless, may be pale shades of brown or yellow, rarely red; typically pale green to colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to waxy.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = c$; $Z = b$. *Dispersion:* $r < v$, perceptible.
$\alpha = 1.550$–1.563 $\beta = 1.565$–1.588 $\gamma = 1.570$–1.594 2V(meas.) = Moderate.

Cell Data: *Space Group: Pcab.* $a = 9.822(3)$ $b = 9.630(3)$ $c = 8.561(3)$ Z = 8

X-ray Powder Pattern: Palazuelo de las Arribas, Spain.
3.041 (100), 5.356 (72), 4.26 (65), 2.914 (43), 2.873 (39), 4.810 (30), 3.904 (28)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	44.73	44.92	Fe_2O_3	0.06	
V_2O_5	0.32		Cr_2O_3	0.18	
Al_2O_3	32.40	32.27	H_2O	22.68	22.81
			Total	100.37	100.00

(1) Lucin, Utah, USA. (2) $AlPO_4 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with metavariscite, forms a series with strengite.

Mineral Group: Variscite group.

Occurrence: Typically deposited from phosphate-bearing waters in contact with aluminous rocks. On islands and in caves, the phosphate provided by decomposition of guano.

Association: Crandallite, carbonate-fluorapatite, wardite, millisite, gordonite, montgomeryite, overite, kolbeckite, goyazite (Little Green Monster mine, Utah, USA).

Distribution: Many localities. In Germany, in Saxony, from Messbach, near Oelsnitz; at Langenstriegis, east of Frankenberg, and at Lichtenberg, near Ronneburg, Thuringia. In the Drachenhöhle, Austria. From Železnik, Třenice, and Zaječow, Czech Republic. At Palazuelo de las Arribas, Zamora, Spain. In the Gunheath and Hensbarrow china clay pits, St. Austell, and at the Treore mine, St. Teath, Cornwall, England. An ore at the Sarysai deposit, Alma-Ata, Kazakhstan. In the USA, in Utah, large nodules from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., on Utahlite Hill, about eight km northwest of Lucin, Box Elder Co., from Amatrice Hill, Stansbury Mountains, Tooele Co., and elsewhere; from the Henry de Linde mine #3, and Dug Hill, near Avant, Garland Co., Arkansas; at the Cole mine, Bisbee, Cochise Co., Arizona; crystallized in the Goldstrike and Genesis mines, Lynn district, and the Gold Quarry mine, Maggie Creek district, Eureka Co., Nevada; From the Sapucaia pegmatite mine, about 50 km east-southeast of Governador Valadares, Minas Gerais, Brazil. In the West Driefontein Cave, Transvaal, South Africa. From Snake Hill, Voi, Kenya. At the Iron Monarch quarry, Iron Knob, South Australia, and in the Ninghanboun Hills, Western Australia. In the Kyusen-do Cave, Japan.

Name: From *Variscia*, an old name for Vogtland, the district in Germany which was the original source for the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 756–761. (2) Salvador, P.S. and J. Fayos (1972) Some aspects of the structural relationship between "Messbach-type" and "Lucin-type" variscites. Amer. Mineral., 57, 36–44. (3) Kniep, R., D. Mootz, and A. Vegas (1977) Variscite. Acta Cryst., 33, 263–265.

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Varulite $(Na, Ca)Mn^{2+}(Mn^{2+}, Fe^{2+}, Fe^{3+})_2(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $[2/m]$ (by analogy to hagendorfite). Nodular, granular, massive.

Physical Properties: *Cleavage:* Good on {100}; distinct on {010}. Hardness = 5
D(meas.) = 3.5–3.6 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dull olive-green, brownish on oxidation.
Luster: Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = yellowish green; Z = grass-green. *Orientation:* $Y = b$. *Dispersion:* $r > v$. α = 1.708–1.720 β = n.d. γ = 1.722–1.732 2V(meas.) = 70°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Varuträsk pegmatite, Sweden.
2.737 (10), 3.498 (4), 2.556 (4), 6.35 (3), 5.46 (3), 3.12 (3), 2.909 (3)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	42.80	44.93	Li_2O	0.88	1.65
Al_2O_3	0.36		Na_2O	7.12	8.08
Fe_2O_3	8.35	5.32	K_2O	0.12	0.12
FeO	7.52	11.03	F	0.06	
MnO	25.30	25.31	H_2O^+	0.75	0.64
MgO		0.13	H_2O^-	0.14	0.18
CaO	4.86	2.30	insol.	1.80	0.28
			Total	100.06	99.97

(1–2) Varuträsk pegmatite, Sweden.

Polymorphism & Series: Forms a series with hagendorfite.

Mineral Group: Alluaudite group.

Occurrence: In complex granite pegmatites, either as a primary mineral or an alteration product of triphylite–lithiophilite; as nodules in shale.

Association: Alluaudite.

Distribution: In Sweden, in the Varuträsk pegmatite, 15 km northwest of Skellefteå, Västerbotten, and from Skrumpetorp, Östergötland. In Finland, at Hunnakko and Kaatiala, near Kuertane. From the Mangualde pegmatite, near Mesquitela, Portugal. Found in the Big Fish River and Boundary Creek areas, Yukon Territory, Canada.

Name: For its initially noted occurrence in the Varuträsk pegmatite, Sweden.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 669–670. (2) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (3) Lindberg, M.L. (1950) Arrojadite, hühnerkobelite, and graftonite. Amer. Mineral., 35, 59–76.

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Vashegyite $Al_{11}(PO_4)_9(OH)_6 \cdot 38H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals are lozenge-shaped, flattened on {001}, to 1 mm. May be in hemispherical aggregates; commonly porous to compact, massive.

Physical Properties: *Cleavage:* Perfect on {001}. Hardness = 2–3 D(meas.) = 1.93–1.99 D(calc.) = 1.935

Optical Properties: Translucent to opaque. *Color:* White, pale green, pale yellow, pale brown; colorless in transmitted light. *Luster:* Dull to waxy.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. α = 1.470–1.479 β = 1.477–1.488 γ = 1.482–1.490 2V(meas.) = 67°–74°

Cell Data: *Space Group:* $Pnam$ or $Pna2_1$. a = 10.754–10.764 b = 14.954–14.971 c = 20.526–22.675 Z = 2

X-ray Powder Pattern: Železník, Slovakia.
9.80 (vs), 9.20 (vs), 7.24 (vs), 2.90 (vs), 2.51 (ms), 2.127 (ms), 6.80 (m)

Chemistry:

	(1)	(2)	(3)	(4)
P_2O_5	31.32	32.43	31.83	32.96
CO_2	0.12			
Al_2O_3	28.33	29.01	27.09	28.93
Fe_2O_3	1.19	0.04	0.12	
Na_2O	0.05			
K_2O	0.16			
H_2O	38.97	37.72	40.01	38.11
insol.	0.24		0.50	
Total	100.38	99.20	99.55	100.00

(1) Železník, Slovakia. (2) Do.; H_2O by TGA; corresponds to $(Al_{11.09}Fe^{3+}_{0.01})_{\Sigma=11.10}(PO_4)_{8.90}(OH)_{6.58} \cdot 37.51H_2O$. (3) Chvaletice, Czech Republic; corresponds to $(Al_{10.83}Fe^{3+}_{0.03})_{\Sigma=10.86}(PO_4)_{9.14}(OH)_{5.16} \cdot 42.68H_2O$. (4) $Al_{11}(PO_4)_9(OH)_6 \cdot 38H_2O$.

Occurrence: Filling cavities in boxwork "limonite" from an iron mine (Železník, Slovakia).

Association: Variscite, wavellite, evansite.

Distribution: From Zelezník (Vashegy), Slovakia. At Chvaletice, Czech Republic. From Haut-le-Wastia, Belgium. In the Feengrotten (Cave), near Saalfeld, Thuringia, Germany. In the USA, on the Van-Nav-Sand claim group, Fish Creek Range, 48 km south of Eureka, Eureka Co., and at the Train prospect, Manhattan district, Nye Co., Nevada.

Name: For its occurrence at Vashegy, Hungary (now Železník, Slovakia).

Type Material: Type specimen in Budapest destroyed in 1956; The Natural History Museum, London, England, 1910,101.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 999. (2) Johan, Z., E. Slansky, and P. Povondra (1983) Vashegyite, a sheet aluminum phosphate: new data. Can. Mineral., 21, 489–498. (3) McConnell, D. (1974) Are vashegyite and kingite hydrous aluminium phyllophosphates with kaolinite-type structures? Mineral. Mag., 39, 802–806.

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Vasilite $(Pd, Cu)_{16}(S, Te)_7$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

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Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Vaterite $CaCO_3$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As very finely fibrous crystals, to 0.1 mm, typically in spherulitic aggregates.

Physical Properties: Hardness = n.d. D(meas.) = 2.54 D(calc.) = 2.65

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Uniaxial (+). $\omega = 1.550$ $\epsilon = 1.644$–1.650

Cell Data: *Space Group:* $P6_3/mmc$. $a = 7.135$ $c = 8.524$ Z = 6

X-ray Powder Pattern: Synthetic.
3.30 (100), 2.73 (95), 1.823 (70), 2.065 (60), 3.57 (55), 1.858 (25), 1.647 (25)

Chemistry: (1) Identification depends on correspondence of the X-ray powder pattern with that of synthetic material.

Polymorphism & Series: Trimorphous with aragonite and calcite; metastable below ∼400 °C.

Occurrence: A major constituent of a carbonated calcium silicate hydrogel complex formed from larnite (Ballycraigy, Ireland); a rock-forming mineral formed at low temperatures by hydration of metamorphic calc-silicate rocks in the presence of atmospheric CO_2, in slightly metamorphosed marls and conglomerates, and in weathering crusts (Hatrurim Formation, Israel).

Association: Calcite, aragonite, tobermorite, hydrogarnet, kaolinite (Hatrurim Formation, Israel).

Distribution: From Ballycraigy, Larne, Co. Antrim, Ireland. At the Bellerberg and Emmelberg volcanoes, Eifel district, Germany. From Hopffeldboden, Salzburg, Austria. At Mont Saint-Hilaire, Quebec, Canada. From the Wessels mine, near Kuruman, Cape Province, South Africa. In the Hatrurim Formation, Israel. At Liawenee, near Great Lake, Tasmania, Australia. From the McMurdo area, Antarctica.

Name: To honor Heinrich Vater (1859–1930), Professor of Mineralogy and Chemistry, Tharandt, Germany.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 181–182 [hypothetical mineral]. (2) McConnell, J.D.C. (1960) Vaterite from Ballycraigy, Larne, Northern Ireland. Mineral. Mag., 32, 535–545. (3) Gross, S. (1977) The mineralogy of the Hatrurim Formation, Israel. Geol. Sur. Israel Bull. 70, 21–23. (4) Sato, M. and S. Matsuda (1969) Structure of vaterite and infrared spectra. Zeits. Krist., 129, 405–410. (5) Meyer, H.J. (1969) Struktur und Fehlordnung des Vaterits. Zeits. Krist., 128, 183–212 (in German with English abs.).

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Vaughanite $TlHgSb_4S_7$

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Crystal Data: Triclinic *Point Group:* $\overline{1}$ or 1. Anhedral grains, to 200 μm.

Physical Properties: *Cleavage:* A weak parting was observed. *Fracture:* Even, may be arcuate. *Tenacity:* Brittle. Hardness = 3–3.5 VHN = 100–115, 104 average (25 g load). D(meas.) = n.d. D(calc.) = 5.56

Optical Properties: Opaque. *Color:* Pale gray in reflected light; rare blood-red internal reflections. *Streak:* Black. *Luster:* Metallic. *Pleochroism:* Weak; greenish gray to bluish gray. *Anisotropism:* Moderate to strong; purple, purplish brown-gray, brownish yellow, greenish yellow, sage-green, bluish green, dark blue-bottle-green. *Bireflectance:* Weak to moderate.

R_1–R_2: (400) 35.2–41.0, (420) 35.1–40.8, (440) 34.6–40.2, (460) 33.9–39.4, (480) 33.3–39.1, (500) 32.8–39.1, (520) 32.5–39.4, (540) 32.0–39.4, (560) 31.4–39.2, (580) 30.9–38.8, (600) 30.4–38.5, (620) 30.1–37.9, (640) 29.7–36.9, (660) 29.2–35.9, (680) 28.6–35.9, (700) 28.0–34.2

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.012(3)$ $b = 13.223(3)$ $c = 5.906(2)$ $\alpha = 93.27(3)°$ $\beta = 95.05(4)°$ $\gamma = 109.16(3)°$ Z = 2

X-ray Powder Pattern: Hemlo deposit, Canada.
4.204 (100), 3.313 (60), 2.749 (40), 4.343 (30), 2.315 (30)

Chemistry:

	(1)	(2)
Tl	18.3	18.31
Hg	17.5	17.97
Sb	43.4	43.62
As	1.1	
S	20.5	20.10
Total	100.8	100.00

(1) Hemlo deposit, Canada; by electron microprobe, average of five analyses; corresponds to $Tl_{0.98}Hg_{0.95}(Sb_{3.90}As_{0.17})_{\Sigma=4.07}S_{7.00}$. (2) $TlHgSb_4S_7$.

Occurrence: A very rare primary mineral found in drill core from an epithermal-hydrothermal gold deposit.

Association: Pääkkönenite, stibarsen, realgar, arsenic, chalcostibite, quartz, calcite.

Distribution: From the Golden Giant orebody, Hemlo gold deposit, 35 km east of Marathon, Ontario, Canada [TL].

Name: To honor Professor David John Vaughan (1946–), Manchester University, Manchester, England, for his contributions to ore mineralogy.

Type Material: The Natural History Museum, London, England, 1987,95, E.1220; Canadian Geological Survey, Ottawa, Canada, 65497.

References: (1) Harris, D.C., A.C. Roberts and A.J. Criddle (1989) Vaughanite, $TlHgSb_4S_7$, a new mineral from Hemlo, Ontario, Canada. Mineral. Mag., 53, 79–83. (2) (1990) Amer. Mineral., 75, 710–711 (abs. ref. 1).

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Vauquelinite $Pb_2Cu(PO_4)(CrO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are wedge-shaped, flattened on [100], to 5 mm, as nodules, reniform crusts, granular, compact massive. *Twinning:* On {102}.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 2.5–3
D(meas.) = 6.16 D(calc.) = 6.16

Optical Properties: Translucent to transparent in thin fragments. *Color:* Apple-green, siskin-green, olive-green, canary-yellow, ocher-brown, liver-brown, nearly black. *Streak:* Greenish to brownish. *Luster:* Adamantine to resinous.
Optical Class: Biaxial (–). *Pleochroism:* X = pale green; $Y = Z$ = pale brown. $\alpha = 2.11(2)$ $\beta = 2.22(2)$ $\gamma = 2.22(2)$ 2V(meas.) = $\sim 0°$

Cell Data: *Space Group:* $P2_1/n$. $a = 13.754(5)$ $b = 5.806(6)$ $c = 9.563(3)$ $\beta = 94°34(2)'$ Z = 4

X-ray Powder Pattern: Musonoi mine, Congo.
3.271 (100B), 2.986 (80), 4.74 (70), 2.932 (70), 2.768 (70), 2.694 (70), 2.303 (70)

Chemistry:

	(1)	(2)
CrO_3	15.26	14.16
P_2O_5	8.05	10.05
Fe_2O_3	1.09	
CuO	12.43	11.27
PbO	61.26	63.24
H_2O	1.31	1.28
Total	99.40	100.00

(1) Beresovsk, Russia. (2) $Pb_2Cu(PO_4)(CrO_4)(OH)$.

Occurrence: A rare mineral in the oxidized zones of some hydrothermal base-metal deposits.

Association: Crocoite, pyromorphite, mimetite, cerussite, beudantite, duftite (Beresovsk, Russia).

Distribution: At the Tsvetnoi mine, Mt. Uspenskaya, Beresov district, near Yekaterinburg (Sverdlovsk), Middle Ural Mountains, Russia. In Germany, from Öhrenstock, near Ilmenau, Thuringia; at Obercallenberg, near Glauchau, Saxony; and from Reichenbach, near Bensheim, and Raidelbach, Hesse. At the Exi mine, near Laurium, Greece. In the Mashamba West and Musonoi mines, near Kolwezi, and at Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). In the USA, in Arizona, at a number of localities south and west of Wickenburg, Maricopa Co., as the Moon Anchor mine, the Rat Tail claim, the Potter-Kramer property, Vulture district, the Tonopah-Belmont mine, Osborne district; in the Florence Lead-Silver mine, Tortilla Mountains, Pinal Co.; at the Vanadinite mine, Lost Basin district, Mohave Co.; in Nevada, from the Killie mine, Spruce Mountain district, Elko Co., in the Silver Coin mine, near Valmy, Iron Point district, Humboldt Co., and elsewhere; at the Pequa mine, Lancaster, Lancaster Co., Pennsylvania; from the Blue Bell mine, near Baker, San Bernardino Co., California. At the Argent Pb–Zn mines, about 100 km east of Johannesburg, Transvaal, South Africa. From Broken Hill, New South Wales, Australia. Additional reported localities require modern confirmation.

Name: Honoring Professor Louis Nicolas Vauquelin (1763–1829), French chemist, University of Paris, Paris, France, who discovered chromium.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 650–652. (2) Fanfani, L. and P.F. Zanazzi (1968) The crystal structure of vauquelinite and the relationship to fornacite. Zeits. Krist., 126, 433–443. (3) Deliens, M. (1979) La chenevixite, la vauquelinite, la sterrettite et la boltwoodite, mineraux nouveaux pour les gisements du Shaba (Zaire) et du Rwanda. Ann. Soc. Géol. Belg., 101, 111–119 (in French with English abs.). (4) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 226.

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Vauxite $Fe^{2+}Al_2(PO_4)_2(OH)_2 \cdot 6H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As crystals, tabular on {010}, elongated along [001] or [101], showing {010}, {1$\overline{1}$0}, {$\overline{1}\overline{1}$1}, {101}, {1$\overline{1}$1}, {$\overline{1}$01}, {1$\overline{4}$0}; radial to subparallel aggregates, to 6 mm, nodular. *Twinning:* On {010}, twin and composition plane.

Physical Properties: *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.39–2.40 D(calc.) = 2.40

Optical Properties: Transparent. *Color:* Sky-blue to Venetian blue, greenish on exposure; pale blue in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; $X = Z$ = colorless; Y = blue. *Orientation:* $Z \simeq \perp$ {010}. *Dispersion:* $r > v$, marked. $\alpha = 1.551(3)$ $\beta = 1.555(3)$ $\gamma = 1.562(3)$ 2V(meas.) = 32°

Cell Data: *Space Group:* $P\overline{1}$. $a = 9.142(3)$ $b = 11.599(3)$ $c = 6.158(2)$ $\alpha = 98.29(2)°$ $\beta = 91.93(3)°$ $\gamma = 108.27(3)°$ Z = 2

X-ray Powder Pattern: Llallagua, Bolivia.
10.85 (100), 5.457 (20), 5.908 (12), 2.881 (12), 2.596 (12), 6.069 (10), 3.045 (10)

Chemistry:

	(1)	(2)
P_2O_5	30.52	32.12
Al_2O_3	21.42	23.08
Fe_2O_3	0.60	
FeO	15.54	16.26
MgO	0.28	
CaO	0.77	
H_2O^+	22.92	
H_2O^-	8.49	
H_2O		28.54
Total	100.54	100.00

(1) Llallagua, Bolivia. (2) $FeAl_2(PO_4)_2(OH)_2 \cdot 6H_2O$.

Occurrence: A secondary mineral derived from alteration of apatite.

Association: Wavellite, paravauxite (Llallagua, Bolivia); marcasite, wavellite (Huanuni, Bolivia).

Distribution: In Bolivia, from the Siglo XX mine, Llallagua, Potosí, and at Huanuni, Oruro.

Name: Honoring George Vaux, Jr. (1863–1927), American lawyer and mineral collector, Bryn Mawr, Pennsylvania, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 97561, 103542.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 974–975. (2) Baur, W.H. and B. Rama Rao (1968) The crystal structure and the chemical composition of vauxite. Amer. Mineral., 53, 1025–1028. (3) Blanchard, F.N. and S.A. Abernathy (1980) X-ray powder diffraction data for phosphate minerals: vauxite, metavauxite, vivianite, Mn-heterosite, scorzalite, and lazulite. Florida Scientist, 43, 257–265.

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Väyrynenite $Mn^{2+}Be(PO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare prismatic crystals, elongated and striated along [001], showing {001}, {010}, {110}, a number of additional modifying forms, to 6 cm; typically in fine-grained aggregates.

Physical Properties: *Cleavage:* {010}, perfect; {100}, good; {001}, fair. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.22 D(calc.) = 3.23

Optical Properties: Transparent to translucent. *Color:* Rose-red, salmon-pink, pale pink, brownish pink, pale gray; pink to colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = orangish; Y = red; Z = dark red. *Orientation:* $Y = b$; $X \wedge c = -31°$. *Dispersion:* $r > v$, moderate. $\alpha = 1.638$–1.640 $\beta = 1.658$–1.662 $\gamma = 1.664$–1.667 2V(meas.) = 46°–55° 2V(calc.) = 51°–57°

Cell Data: *Space Group:* $P2_1/a$. $a = 5.411(5)$ $b = 14.49(2)$ $c = 4.730(5)$ $\beta = 102°45(5)'$ Z = 4

X-ray Powder Pattern: Viitaniemi pegmatite, Finland.
3.452 (100), 7.251 (85), 2.885 (85), 4.399 (60), 2.662 (42), 2.951 (35), 4.960 (25)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	39.98	40.5	40.34	Na_2O	0.20	0.03	
Al_2O_3	0.40	0.01		K_2O	0.04	0.01	
FeO	5.92	3.4		H_2O^+	4.93		
MnO	34.01	38.4	40.32	H_2O^-	0.19		
BeO	13.85	12.2	14.22	H_2O		[5.38]	5.12
CaO	0.53	0.07		insol.	0.06		
				Total	100.11	[100.00]	100.00

(1) Viitaniemi pegmatite, Finland; corresponds to $(Mn^{2+}_{0.84}Fe^{2+}_{0.14}Ca_{0.02})_{\Sigma=1.00}Be_{0.98}(PO_4)_{0.99}(OH)_{0.96}$. (2) "Chitral" [Pakistan or Afghanistan]; by AA, H_2O by difference; corresponds to $(Mn^{2+}_{0.92}Fe^{2+}_{0.08})_{\Sigma=1.00}Be_{0.83}(PO_4)_{0.97}(OH)_{1.02}$. (3) $MnBe(PO_4)(OH)$.

Occurrence: An alteration product of beryl and triphylite in complex zoned granite pegmatites.

Association: Eosphorite, moraesite, hurlbutite, beryllonite, amblygonite, apatite, tourmaline, topaz, muscovite, microcline, quartz.

Distribution: In the Viitaniemi pegmatite, near Eräjärvi, Finland. From the Norrö pegmatite, on Rånö Island, and from near Kapelludden, Utö Island, Sweden. In the Bendada pegmatite, near Guarda, Portugal. At the Fregeneda pegmatite, Salamanca Province, Spain. From the Kalba Range, eastern Kazakhstan. Large crystals found in Broghul Pass, Chitral Valley, Pakistan.

Name: To honor Professor Heikki Allan Väyrynen (1888–1956), Technical Institute, Helsinki, Finland.

Type Material: National Museum of Natural History, Washington, D.C., USA, R11807.

References: (1) Volborth, A. (1954) Phosphatminerale aus dem Lithiumpegmatit von Viitaniemi, Eräjärvi, Zentral-Finnland. Ann. Acad. sci. Fennicae, Ser. A, III Geol.-Geogr. 39, 90 pp., esp. 66–73. (2) (1956) Amer. Mineral., 41, 371 (abs. ref. 1). (3) Mrose, M.E. and O. von Knorring (1959) The mineralogy of väyrynenite, $(Mn, Fe)Be(PO_4)(OH)$. Zeits. Krist., 112, 275–288. (4) Mrose, M.E. and D.E. Appleman (1962) The crystal structures of väyrynenite, $(Mn, Fe)Be(PO_4)(OH)$, and euclase, $AlBe(SiO_4)(OH)$. Zeits. Krist., 117, 16–32. (5) Meixner, H. and W. Paar (1976) Ein Vorkommen von Väyrynenit-Kristallen aus "Pakistan". Zeits. Krist., 143, 309–318 (in German with English abs.).

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Veatchite $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Platy crystals platy, flattened on {100}, elongated along [011], or slender primatic to fibrous, with {100}, {$0\bar{1}1$}, {111}, {$1\bar{1}1$}, with other minor forms, to 2 cm; in divergent groups and cross-fiber veinlets.

Physical Properties: *Cleavage:* On {100}, perfect; on {011}, less perfect. Hardness = 2
D(meas.) = 2.66 D(calc.) = 2.664

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Luster:* Vitreous, pearly on cleavages; silky in fibrous masses.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Y \wedge a = -2°$. *Dispersion:* $r > v$, perceptible.
$\alpha = 1.551(2)$ $\beta = [1.553]$ $\gamma = 1.621(2)$ 2V(meas.) = 37°

Cell Data: *Space Group:* Aa. $a = 20.860(5)$ $b = 11.738(3)$ $c = 6.652(2)$ $\beta = 92.10(3)°$
Z = 8

X-ray Powder Pattern: Kramer district, California, USA; nearly identical to *p*-veatchite.
10.5 (100), 3.32 (35), 2.600 (25), 3.47 (20), 2.865 (9), 5.64 (6), 5.12 (6)

Chemistry:

	(1)	(2)
B_2O_3	57.56	58.62
CaO	1.68	
SrO	30.50	31.73
H_2O^+	9.56	
H_2O^-	0.39	
H_2O		9.65
Total	99.69	100.00

(1) Sterling mine, California, USA. (2) $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$.

Polymorphism & Series: Trimorphous with *p*-veatchite and veatchite-A.

Occurrence: Uncommon in evaporite borate deposits formed by volcanic activity.

Association: Howlite, colemanite (Sterling mine, California, USA).

Distribution: In the USA, in California, from the Sterling borax mine, Tick Canyon, near Lang, Los Angeles Co.; and in drillcore no. 5, Four Corner area, Kramer district, San Bernardino Co.; at the Billie mine, Furnace Creek district, Death Valley, Inyo Co. From the Penobsquis and Salt Springs evaporite deposits, near Sussex, New Brunswick, Canada. At the Inder borate deposit, Kazakhstan. Large crystals from Mustafakemalpasa, Bursa Province, Turkey.

Name: Honors John A. Veatch (1808–1870), American physician and geologist, who first detected boron in mineral waters in California, USA in the late 1800's.

Type Material: Harvard University, Cambridge, Massachusetts, 92944; National Museum of Natural History, Washington, D.C., USA, 105697.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 348–349. (2) Clark, J.R., M.E. Mrose, A. Perloff, and G. Burley (1959) Studies of borate minerals (VI): investigation of veatchite. Amer. Mineral., 44, 1141–1149. (3) Clark, J.R and M.E. Mrose (1960) Veatchite and *p*-veatchite. Amer. Mineral., 45, 1221–1229. (4) Clark, J.R. and C.L Christ (1971) Veatchite: crystal structure and correlations with *p*-veatchite. Amer. Mineral., 56, 1934–1954.

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Veatchite-A $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Crystals are platy on {100}, with rhombic outline showing {100}, {011}, {$01\overline{1}$}, to 2 mm, in stacked aggregates. *Twinning:* On {100}, polysynthetic lamellae observed optically.

Physical Properties: *Cleavage:* Perfect on {100}; good on {011} and {$01\overline{1}$}. Hardness = n.d. D(meas.) = 2.73(2) D(calc.) = 2.77

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Pearly on cleavages. *Optical Class:* Biaxial (+). *Orientation:* $X = c$; $Z = b$. *Dispersion:* $r < v$, strong. $\alpha = 1.549(2)$ $\beta = [1.551]$ $\gamma = 1.621(2)$ 2V(meas.) = 25(1)°

Cell Data: *Space Group:* $A\overline{1}$ or $A1$. $a = 20.80(62)$ $b = 11.72(35)$ $c = 6.63(20)$ $\alpha = 90°00(05)'$ $\beta = 90°48(5)'$ $\gamma = 91°57(5)'$ Z = 4

X-ray Powder Pattern: Emet, Turkey.
10.40 (vs), 3.32 (vs), 2.592 (vs), 3.45 (s), 2.84 (s), 4.09 (m), 2.191 (m)

Chemistry:

	(1)	(2)
B_2O_3	58.15	58.62
MgO	0.04	
CaO	0.25	
SrO	30.88	31.73
H_2O^+	9.63	
H_2O^-	0.15	
H_2O		9.65
rem.	0.06	
Total	99.16	100.00

(1) Emet, Turkey; MgO and CaO by AA. (2) $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$.

Polymorphism & Series: Trimorphous with *p*-veatchite and veatchite.

Occurrence: Uncommon in evaporite borate deposits formed by volcanic activity.

Association: Realgar, orpiment, colemanite, hydroboracite, montmorillonite.

Distribution: From the Killik, Hisarcık, and Espey borate mines, near Emet, Kütahya Province, Turkey.

Name: As a polytype of *veatchite*, crystallizing in the anorthic (triclinic) system.

Type Material: Mining Department, Istanbul Technical University, Istanbul, Turkey; National Museum of Natural History, Washington, D.C., USA, 145911.

References: (1) Kumbasar, I. (1979) Veatchite-A, a new modification of veatchite. Amer. Mineral., 64, 362–366.

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p-Veatchite $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals are platy, with rhombic outline, to 3 mm.

Physical Properties: *Cleavage:* On {010}, perfect; on {001}, good. Hardness = n.d. D(meas.) = 2.60–2.65 D(calc.) = [2.68–2.74]

Optical Properties: Semitransparent. *Color:* White.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Z \wedge a = 29°40'$. $\alpha = 1.550(2)$ $\beta = 1.553(2)$ $\gamma = 1.620(2)$ 2V(meas.) = n.d. 2V(calc.) = 25°

Cell Data: *Space Group:* $P2_1$. $a = 6.70$–6.74 $b = 20.62$–20.80 $c = 6.58$–6.63 $\beta = 119°15'-119°40'$ Z = 2

X-ray Powder Pattern: Königshall-Hindenburg mine, Germany; nearly identical to veatchite.
10.4 (100), 3.31 (60), 2.592 (30), 5.64 (20), 3.46 (20), 3.38 (15), 5.10 (10)

Chemistry:

	(1)	(2)
B_2O_3	58.0	58.62
SrO	32.4	31.73
H_2O	9.6	9.65
Total	100.0	100.00

(1) Russia. (2) $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$.

Polymorphism & Series: Trimorphous with veatchite and veatchite-A.

Occurrence: A very rare component of marine evaporite salt deposits.

Association: Halite, anhydrite, boracite, magnesite, pyrite, quartz.

Distribution: From the Königshall-Hindenburg potash mine, Reyershausen, near Göttingen, Lower Saxony, Germany. In the Boulby potash mine, northwest of Whitby, Yorkshire, England. From an undisclosed locality in Russia.

Name: The prefix "*p*" used to represent a primitive unit cell, and for its close relation to *veatchite*.

Type Material: National Museum of Natural History, Washington, D.C., USA, 113264.

References: (1) Braitsch, O. (1959) Über *p*-Veatchit, eine neue Veatchit-Varietät aus dem Zechsteinsalz. Beiträge zur Mineralogie und Petrographie, 6, 352–356 (in German). (2) (1959) Amer. Mineral., 44, 1323 (abs. ref. 1). (3) Clark, J.R and M.E. Mrose (1960) Veatchite and *p*-veatchite. Amer. Mineral., 45, 1221–1229. (4) Rumanova, I.M. and O. Gandymov (1971) Crystal structure of the natural strontium borate *p*-veatchite $Sr_2[B_5O_8(OH)]_2 \cdot B(OH)_3 \cdot H_2O$. Kristallografiya (Sov. Phys. Crystal.), 16, 99–106. (5) Clark, J.R. and C.L. Christ (1971) Veatchite: crystal structure and correlations with *p*-veatchite. Amer. Mineral., 56, 1934–1954. (6) Rastsvetaeva, R.K., A.P. Khomyakov, and T.N. Sokolova (1993) Crystal structure of high-calcium *p*-veatchite and its place in the layered $[B_5O_8OH]^{2-}$ series. Crystallog. Reports, 38(2), 180–185.

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Veenite $Pb_2(Sb,As)_2S_5$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$ or $2/m\ 2/m\ 2/m$. Rarely as equant prisms elongated along [100] and flattened on {010}, grooved and roughened; typically massive, to 2 cm, and as anhedral grains. *Twinning:* Lamellar.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 146–167, 155 average (100 g load). D(meas.) = 5.92 D(calc.) = 5.96

Optical Properties: Opaque. *Color:* Steel-gray; white in reflected light. *Streak:* Black, faint brownish tinge against white background. *Pleochroism:* Weak; white to pale pinkish gray. *Anisotropism:* Moderate.

R_1–R_2: (400) 40.2–43.8, (420) 39.9–43.4, (440) 39.6–43.0, (460) 39.2–42.8, (480) 38.8–42.6, (500) 38.4–42.3, (520) 37.9–42.0, (540) 37.4–41.7, (560) 37.0–41.4, (580) 36.5–40.8, (600) 36.1–40.3, (620) 35.7–39.8, (640) 35.3–39.1, (660) 34.7–38.4, (680) 34.0–37.6, (700) 33.3–36.8

Cell Data: *Space Group:* $P2_1cn$ or $Pmcn$. $a = 8.44$ $b = 26.2$ $c = 7.90$ $Z = 8$

X-ray Powder Pattern: Madoc, Canada.
3.81 (100), 3.03 (90), 3.42 (80), 3.26 (80), 2.76 (70), 3.23 (50), 2.93 (50)

Chemistry:

	(1)
Pb	51.2
Cu	0.08
Ag	0.09
Sb	19.1
As	7.9
S	21.2
Total	99.47

(1) Madoc, Canada; by electron microprobe, corresponds to $(Pb_{1.90}Cu_{0.01}Ag_{0.01})_{\Sigma=1.92}(Sb_{1.21}As_{0.81})_{\Sigma=2.02}S_{5.06}$.

Occurrence: As small masses, stringers, and disseminated grains in marbles developed in a sequence of Precambrian metasediments near a contact with plutonic granitic gneiss (Madoc, Canada).

Association: Gratonite, calcite, boulangerite, other lead antimonides, sphalerite, pyrite, chalcopyrite, arsenopyrite, galena (Madoc, Canada).

Distribution: In Canada, in Ontario, from near Madoc [TL] and in the Mattabi mine, 60 km north of Ignace. At Huachocolpa, Huancavelica, Peru.

Name: To honor R.W. van der Veen (1883–1925), Dutch economic geologist and metallographer.

Type Material: Canadian Geological Survey, Ottawa, 12170; Canadian Museum of Nature, Ottawa; Royal Ontario Museum, Toronto, Canada.

References: (1) Jambor, J.L. (1967) New lead sulfantimonides from Madoc, Ontario, Part I. Can. Mineral., 9, 7–24. (2) (1968) Amer. Mineral., 53, 1422 (abs. ref. 1). (3) Jambor, J.L., J.H.G. Laflamme, and D.A. Walker (1982) A re-examination of the Madoc sulfosalts. Mineral. Record, 13, 93–100. (4) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 605.

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Velikite Cu_2HgSnS_4

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

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Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Verbeekite $PdSe_2$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

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Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Vergasovaite $Cu_3O(MoO_4, SO_4)(SO_4)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are stout prismatic, slightly elongated along [001], to 0.3 mm, with {100}, {110}, {120}, {130}, {111}, {263}, {315}, isolated and in radiating aggregates.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4–5
VHN = 302–413, 357 average (25 g load). D(meas.) = n.d. D(calc.) = 4.32

Optical Properties: Transparent. *Color:* Olive-green; gray in reflected light with pale green internal reflections. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial. *Pleochroism:* Distinct; olive-green $\parallel c$; yellowish to brownish green $\perp c$.
α = [1.87] β = n.d. γ = [1.98] 2V(meas.) = n.d.

Cell Data: *Space Group: Pnma.* $a = 7.421(2)$ $b = 6.754(3)$ $c = 13.624(5)$ Z = 4

X-ray Powder Pattern: Tolbachik volcano, Russia.
3.077 (100), 3.391 (60), 3.342 (60), 2.542 (60), 2.500 (60), 2.275 (60), 3.71 (30)

Chemistry:

	(1)
SO_3	21.44
MoO_3	25.29
V_2O_5	0.88
CuO	49.81
ZnO	1.76
PbO	0.63
Total	99.81

(1) Tolbachik volcano, Russia; by electron micrprobe, average of 18 analyses, $(OH)^{1-}$ and H_2O shown absent by IR; corresponds to $(Cu_{2.82}Zn_{0.10}Pb_{0.01})_{\Sigma=2.93}O[(Mo_{0.79}S_{0.20}V_{0.04})_{\Sigma=1.03}O_4](SO_4)$.

Occurrence: A rare sublimation product in fumaroles.

Association: Chalcocyanite, dolerophanite, euchlorine, fedotovite, tenorite, cuprian anglesite, gold.

Distribution: From the Tolbachik fissure volcano, Kamchatka, Russia.

Name: Honors Dr. Lidia Pavlovna Vergasova (1941–), Institute of Vulcanology, Petropavlovsk-Kamchatskii, Russia, for her contributions to the mineralogy of that volcanic region.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; Natural History Museum, Basel, Switzerland.

References: (1) Bykova, E.Y., P. Berlepsch, P.M. Kartashov, J. Brugger, T. Armbruster, and A.J. Criddle (1998) Vergasovaite $Cu_3O[(Mo,S)O_4][SO_4]$, a new copper-oxy-molybdate-sulfate from Kamchatka. Schweiz. Mineralog. Petrogr. Mitt., 78, 479–488. (2) Berlepsch, P., T. Armbruster, J. Brugger, E.Y. Bykova, and P.M. Kartashov (1999) The crystal structure of vergasovaite $Cu_3O[(Mo,S)O_4SO_4]$ and its relation to synthetic $Cu_3O[MoO_4]_2$. Eur. J. Mineral., 11, 101–110. (3) (2000) Amer. Mineral., 85, 264–265 (abs. refs. 1 and 2).

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Vermiculite $(Mg, Fe^{3+}, Al)_3(Si, Al)_4O_{10}(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As large crystalline plates, which may have a pseudohexagonal outline; in clay-sized particles.

Physical Properties: *Cleavage:* {001}, perfect, typically relic. *Tenacity:* Pliable, when in large replacement sheets. Hardness = ~1.5 D(meas.) = 2.2–2.6 D(calc.) = 2.26 Expands on heating into vermiform masses.

Optical Properties: Translucent; opaque when in large replacement sheets. *Color:* Colorless, white, yellow, green, brown; colorless in thin section. *Luster:* Dull to pearly, bronzy. *Optical Class:* Biaxial (–). *Pleochroism: X* in paler shades than *Y* and *Z*. *Dispersion:* $r < v$. $\alpha = 1.520–1.564$ $\beta = 1.530–1.583$ $\gamma = 1.530–1.583$ 2V(meas.) = 0°–15°

Cell Data: *Space Group: C*2/*m*. a = 5.24(2) b = 9.17(2) c = 28.60(5) $\beta = 94°36(24)'$ Z = 4, or *Space Group: C*2/*c*. a = 5.349(6) b = 9.255(10) c = 28.89(2) $\beta = 97°7(6)'$ Z = 4

X-ray Powder Pattern: Ajmer, India.
14.15 (10), 1.528 (7), 4.57 (6), 2.615 (5), 2.570 (5), 2.525 (4.5), 2.380–2.365 (3.5b)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	34.92	32.97	Na_2O	0.32	0.00
Al_2O_3	13.97	17.88	K_2O	0.08	0.00
Fe_2O_3	6.25	4.76	H_2O^+		10.05
FeO	0.52	0.57	H_2O^-		11.42
MgO	20.37	22.36	H_2O	21.00	
CaO	2.15	0.00	rem.	0.42	
			Total	100.00	100.01

(1) Ajmer, India; corresponds to $(Mg_{2.37}Fe^{3+}_{0.37}Ca_{0.18}Na_{0.05}Fe^{2+}_{0.03})_{\Sigma=3.00}(Si_{2.72}Al_{1.28})_{\Sigma=4.00}O_{10}(OH)_2 \cdot 4.01H_2O$. (2) Corundum Hill, Macon Co., North Carolina, USA; corresponds to $(Mg_{2.68}Al_{0.35}Fe^{3+}_{0.29}Fe^{2+}_{0.04})_{\Sigma=3.36}(Si_{2.65}Al_{1.35})_{\Sigma=4.00}O_{10}(OH)_{2.00} \cdot 4.52H_2O$.

Mineral Group: A group name; individual minerals within the group are not specified.

Occurrence: An alteration product of biotite or phlogopite, by weathering or hydrothermal action. Formed at the contact between felsic and mafic or ultramafic rocks such as pyroxenites and dunites; in carbonatites and metamorphosed limestones; a clayey constituent of soils.

Association: Corundum, apatite, serpentine, talc; interstratifies with chlorite, biotite.

Distribution: Uncommon in large amounts. In the USA, at Milbury, near Worcester, Worcester Co., Massachusetts; from near Franklin, Macon Co., and at the Rutherford quarry, near Tuxedo, Henderson Co., North Carolina; in Brinton's quarry, Westtown, Chester Co., and on Chestnut Hill, Easton, Northampton Co., Pennsylvania; from Magnet Cove, Hot Spring Co., Arkansas; and at Libby, Lincoln Co., Montana. From Ajmer, Rajasthan, India. At Phalaborwa, Transvaal, South Africa. In Australia, from Mud Tank, Valley Bore, Northern Territory, and at Bulong, Western Australia. From the Kovdor massif, Kola Peninsula, and in the Potaninskoye deposit, Southern Ural Mountains, Russia. Many other minor localities are known.

Name: From the Latin *to breed worms*, alluding to the mineral's exfoliation upon rapid heating.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 664–668. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 246–257. (3) Mathieson, A.M. (1958) Mg-vermiculite: a refinement and re-examination of the crystal structure of the 14.36 Å phase. Amer. Mineral., 43, 216–227. (4) Mukherjee, B. (1963) The structure of vermiculite and some interstratifications. Clay Minerals Bull., 5, 194–202. (5) Shirozu, H. and S.W. Bailey (1966) Crystal structure of a two-layer Mg-vermiculite. Amer. Mineral., 51, 1124–1143.

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Vernadite $(Mn^{4+}, Fe^{3+}, Ca, Na)(O, OH)_2 \cdot nH_20$

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Crystal Data: Hexagonal. *Point Group:* n.d. As poorly crystalline leaflets, characteristically curved and folded to resemble fibers, to some tens of Å; colloidal, dense microcrystalline.

Physical Properties: Hardness = Soft. VHN = 20–45 D(meas.) = 2.9–3.0 D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Black.
Optical Class: Uniaxial.
R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. a = 2.84–2.86 c = ∼4.7 Z = n.d.

X-ray Powder Pattern: Locality not stated; may be confused with feroxyhyte.
∼2.45 (b), ∼1.42 (b)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.80	1.30	CaO	2.15	5.17
TiO_2	1.50		SrO		0.33
MnO_2	46.47	56.45	BaO		1.93
Al_2O_3	1.00	1.00	Na_2O	2.29	0.12
Fe_2O_3	10.47	7.00	K_2O	0.60	0.23
MnO	1.09	4.81	Cl	1.19	
CoO	3.41		H_2O^+	6.94	3.00
NiO	0.95		H_2O^-	18.50	13.53
PbO	0.34		CO_2		3.70
MgO	2.62	0.28	P_2O_5		1.30
			Total	100.32	100.15

(1) Kurchatov fracture zone, Pacific Ocean; corresponds to $MnO_2 \cdot (R_2O)_{0.04} \cdot (RO)_{0.32} \cdot (R_2O_3)_{0.14} \cdot 2.64H_2O$. (2) Lovozero massif, Russia; corresponds to $MnO_2 \cdot (R_2O)_{0.01} \cdot (RO)_{0.26} \cdot (R_2O_3)_{0.08} \cdot 1.42H_2O$.

Occurrence: A weathering product of other manganese oxides, carbonates, and silicates; easily formed by the action of Fe, Mn-oxidizing bacteria.

Association: Todorokite, pyrolusite, romanèchite, cryptomelane, manganite, ferrihydrite.

Distribution: Undoubtedly much more common than the few well-authenticated localities indicate. In Russia, from the Kusimovskoye manganese deposit, 25 km west-northwest of Magnitogorsk, Southern Ural Mountains; on Mt. Zarod, Sikhote-Alin Mountains, Primorskiy Territory; and on Lepkhe-Nelm, Lovozero massif, Kola Peninsula. On Groote Eylandt, Northern Territory, Australia. An important component of ocean-floor manganese nodules.

Name: For Professor Vladimir Ivanovich Vernadsky (1863–1945), Russian naturalist and geochemist, Moscow University, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 43441, 43442.

References: (1) Chukhrov, F.V., A.I. Gorshkov, E.S. Rudnitskaya, V.V. Berezovskaya, and A.V. Sivtsov (1978) On vernadite. Izvest. Akad. Nauk SSSR, Ser. geol., 6, 5–19 (in Russian). (2) (1979) Amer. Mineral., 64, 1334 (abs. ref. 1). (3) Chukhrov, F.V., A.I. Gorshkov, E.S. Rudnitskaya, V.V. Berezovskaya, and A.V. Sivtsov (1980) Manganese minerals in clay: a review. Clays and Clay Minerals, 28, 346–453. (4) Manceau, A., A.I. Gorshkov, and V.A. Drits (1992) Structural chemistry of Mn, Fe, Co, and Ni in manganese hydrous oxides: Part II. Information from EXAFS spectroscopy and electron and X-ray diffraction. Amer. Mineral., 77, 1144–1157.

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Verplanckite $\mathbf{Ba_2(Mn^{2+},Fe^{2+},Ti)Si_2O_6(O,OH,Cl,F)_2 \cdot 3H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals hexagonal, elongated $\parallel$ [0001], or subhedral, to 3 mm; as radial masses or disseminated grains.

Physical Properties: *Cleavage:* Good on $\{11\bar{2}0\}$; on {0001}, poor or a fracture. Hardness = 2.5–3 D(meas.) = 3.52(2) D(calc.) = 3.33

Optical Properties: Transparent to translucent. *Color:* Brownish orange to light brownish yellow. *Streak:* Pale orange. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = yellow-orange; E = colorless. $\omega = 1.683(2)$ $\epsilon = 1.672(2)$

Cell Data: *Space Group:* $P6/mmm$. $a = 16.398(10)$ $c = 7.200(4)$ Z = 1

X-ray Powder Pattern: Big Creek, California, USA.
3.95 (100), 2.97 (70), 2.738 (70), 13.8 (65), 5.39 (45), 3.58 (30), 2.858 (30)

Chemistry:

	(1)		(1)
SiO_2	20.9	BaO	52.33
TiO_2	1.72	K_2O	< 0.05
Al_2O_3	0.41	F	0.6
FeO	1.9	Cl	3.5
MnO	8.7	LOI	10.6
MgO	0.15	$-O = (F,Cl)_2$	1.05
CaO	0.19	Total	[100.0]

(1) Big Creek, California, USA; by D-C arc spectroscopy, K and Cl by X-ray spectroscopy, loss on ignition taken as H_2O, recalculated to 100.0%; corresponds to $(Ba_{2.00}Ca_{0.02}K_{0.01})_{\Sigma=2.03}(Mn_{0.72}Fe_{0.16}Ti_{0.13}Mg_{0.02})_{\Sigma=1.03}(Si_{2.04}Al_{0.05})_{\Sigma=2.09}O_{6.19}[(OH)_{0.98}Cl_{0.58}O_{0.25}F_{0.18}]_{\Sigma=1.99} \cdot 2.96H_2O$.

Occurrence: In thin layers in a metamorphic sanbornite-quartz rock.

Association: Quartz, sanbornite, celsian, diopside, taramellite, fresnoite, muirite, traskite, pyrrhotite, pyrite.

Distribution: In the Esquire No. 7 mine, Big Creek, and on Rush Creek, Fresno Co., California, USA.

Name: For William E. Ver Planck (1916–1963), geologist of the California Division of Mines & Geology, California, USA.

Type Material: California Division of Mines & Geology, San Francisco, California, USA.

References: (1) Alfors, J.T., M.C. Stinson, R.A. Matthews, and A. Pabst (1965) Seven new barium minerals from eastern Fresno Co., California. Amer. Mineral., 50, 314–340. (2) Alfors, J.T. and G.W. Putman (1965) Revised chemical analyses of traskite, verplanckite and muirite from Fresno County, California. Amer. Mineral., 50, 1500–1503. (3) Kampf, A.R., A.A. Khan, and W.H. Bauer (1973) Barium chloride silicate with an open framework: verplanckite. Acta Cryst., 29, 2019–2021.

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Versiliaite $Fe_4^{2+}Fe_8^{3+}Sb_{12}^{3+}O_{32}S_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, very rare, platy on {001}; commonly in massive aggregates.

Physical Properties: *Cleavage:* Perfect on {110}. Hardness = n.d. VHN = 330 (20 g load). D(meas.) = 5.12 D(calc.) = [5.32]

Optical Properties: Opaque. *Color:* Black. *Luster:* Metallic.
Optical Class: Uniaxial.
R_1–R_2: (470) 18.5–19.4, (546) 18.5–17.8, (589) 18.3–16.9, (650) 17.7–16.2

Cell Data: *Space Group: Pbam.* $a = 8.492(5)$ $b = 8.326(5)$ $c = 11.938(7)$ $Z = 1$

X-ray Powder Pattern: Buca della Vena mine, Italy.
3.196 (100), 3.167 (97), 2.972 (81), 2.682 (40), 1.946 (40), 1.652 (33), 5.94 (25)

Chemistry:

	(1)	(2)
FeO	11.70	10.62
Fe_2O_3	14.92	23.59
As_2O_3	4.63	
Sb_2O_3	60.12	64.60
ZnO	2.96	
S	1.50	2.37
$-O = S$	0.75	1.18
Total	95.08	100.00

(1) Buca della Vena mine, Italy; by electron microprobe, Fe^{2+}:Fe^{3+} from crystal-structure analysis; corresponds to $Fe^{2+}_{4.65}Zn_{1.04}Fe^{3+}_{5.33}(Sb^{3+}_{11.76}As^{3+}_{1.34})_{\Sigma=13.10}O_{32}S_{1.33}$. (2) $Fe_4^{2+}Fe_8^{3+}Sb_{12}O_{32}S_2$.

Occurrence: In an iron ore deposit in barite formed by metasomatic processes at the contact between phyllites and dolostones.

Association: Schafarzikite, apuanite, derbylite, barite, magnetite, hematite, pyrite.

Distribution: In the Buca della Vena mine, northeast of Stazzema, Apuan Alps, Tuscany, Italy.

Name: For the Versilia Valley, Apuan Alps, Italy, where it was found.

Type Material: University of Pisa, Pisa, Italy, 3211.

References: (1) Mellini, M., S. Merlino, and P. Orlandi (1979) Versiliaite and apuanite, two new minerals from the Apuan Alps, Italy. Amer. Mineral., 64, 1230–1234. (2) Mellini, M. and S. Merlino (1979) Versiliaite and apuanite: derivative structures related to schafarzikite. Amer. Mineral., 64, 1235–1242. (3) Mellini, M., M. Amouric, A. Baronnet, and G. Mercuriot (1981) Microstructures and nonstoichiometry in schafarzikite-like minerals. Amer. Mineral., 66, 1073–1079.

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Vertumnite $Ca_8Al_4(Al_4Si_5)O_{12}(OH)_{36}\cdot 10H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. As flattened hexagonal prisms, to 4 mm. *Twinning:* Cyclic, contact plane ∥ {001}, common.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 5
D(meas.) = 2.15(4) D(calc.) = 2.15

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (–); rarely uniaxial (–). *Orientation:* $X = c$; $Z \wedge b = 16°$. $\alpha = 1.531(1)$ $\beta = 1.535(1)$ $\gamma = 1.541(2)$ 2V(meas.) = 62(5)°

Cell Data: *Space Group:* $P2_1/m$, $P6_3/m$ pseudocell. $a = 5.744(5)$ $b = 5.766(5)$ $c = 25.12(1)$ $\gamma = 119.72(5)°$ Z = 1

X-ray Powder Pattern: Campomorto, Italy.
4.187 (100), 12.51 (70), 6.275 (65), 2.873 (17), 4.275 (16), 2.436 (11), 2.077 (10)

Chemistry:

	(1)	(2)
SiO_2	18.01	18.08
Al_2O_3	25.26	24.55
CaO	25.88	27.00
SrO	0.81	
BaO	0.18	
Na_2O	0.07	
K_2O	0.02	
H_2O^+	23.74	
H_2O^-	5.96	
H_2O		30.37
P_2O_5		
Total	99.93	100.00

(1) Campomorto, Italy; by electron microprobe, H_2O determined by weight loss above and below 120 °C on a separate sample; corresponds to $(Ca_{7.80}Sr_{0.12}Ba_{0.04}Na_{0.04})_{\Sigma=8.00}Al_{8.36}Si_{5.08}O_{12.64}(OH)_{36.12}\cdot 9.80H_2O$. (3) $Ca_8Al_8Si_5O_{12}(OH)_{36}\cdot 10H_2O$.

Occurrence: As late-forming crystals inside a small cavity in phonolite.

Association: Tobermorite, ettringite.

Distribution: Found in a quarry at Campomorto, Montalto di Castro, Lazio, Italy.

Name: For *Vertumnus*, the god worshipped by the ancient Etruscan people who inhabited the region where the mineral was found.

Type Material: Municipal Museum of Natural History, Milan, Italy; National School of Mines, Paris, France.

References: (1) Passaglia, E. and E. Galli (1977) Vertumnite, a new natural silicate. Tschermaks Mineral. Petrog. Mitt., 24, 57–66. (2) (1977) Amer. Mineral., 62, 1061 (abs. ref. 1). (3) Galli, E. and E. Passaglia (1978) Vertumnite: its crystal structure and relationship with natural and synthetic phases. Tschermaks Mineral. Petrog. Mitt., 25, 33–46. (4) Rinaldi, R., M. Sacerdoti, and E. Passaglia (1990) Strätlingite: crystal structure, chemistry, and a reexamination of its polytype vertumnite. Eur. J. Mineral., 2, 841–849.

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Vésigniéite $BaCu_3(VO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Lamellar pseudohexagonal crystals, to 2 mm, in botryoidal aggregates; powdery. *Twinning:* Common, polysynthetic, on {001}.

Physical Properties: *Cleavage:* {001}, perfect; {110}, imperfect. Hardness = 3–4
D(meas.) = 4.56(10) D(calc.) = 4.70

Optical Properties: Semitransparent. *Color:* Yellow-green to dark olive-green.
Streak: Greenish. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* Z = elongation; extinction 10° from the twinning plane.
$\alpha = 2.04$ $\beta = 2.07$ $\gamma = 2.08$ 2V(meas.) = ∼60°

Cell Data: *Space Group:* $C2/m$. $a = 10.239$–10.270 $b = 5.885$–5.911 $c = 7.725$–7.711
$\beta = 116.42°-116.43°$ Z = 2

X-ray Powder Pattern: Vrančice, Czech Republic.
3.207 (10), 2.709 (9), 2.288 (8), 2.554 (7), 1.815 (6), 1.610 (6), 1.475 (6)

Chemistry:

	(1)	(2)
V_2O_5	32.4	30.73
CuO	39.1	40.32
BaO	24.9	25.91
H_2O	3.6	3.04
Total	[100.0]	100.00

(1) Friedrichroda, Germany; recalculated after deduction of insoluble, 3.3%, original total 99.5%.
(2) $BaCu_3(VO_4)_2(OH)_2$.

Occurrence: A rare secondary mineral formed in copper-bearing U–V deposits.

Association: Volborthite, malachite, tyuyamunite, carnotite, barite, calcite.

Distribution: From [the Gottlob mine], Friedrichroda, Thuringia, and Bad Lauterberg, Harz Mountains, Germany. At Perm, Ural Mountains, Russia. In the Agalyk U–V deposit, Kara-Tyube Mountains, 15 km south of Samarkand, Uzbekistan. At Vrančice, about 15 km south-southeast of Příbram, Czech Republic. From the Roua copper mines, about 50 km north of Nice, Alpes Maritimes, France. In the Newhurst quarry, near Shepshed, and the Bardon quarry, Coalville, Leistershire, England. At the Mashamba West mine, Kolwezi, Katanga Province, Congo (Shaba Province, Zaire). In the USA, from the Paradox Bell mine, Paradox Valley, Montrose Co., Colorado; in Arizona, at the Monument #1 mine, Navajo Co., from the Ridenaur breccia pipe, Coconino Co., and about six km south of Mercer Ranch, Copper Creek district, Pinal Co.; in the Gold Quarry mine, near Carlin, Maggie Creek district, and the Goldstrike mine, Lynn district, Eureka Co., Nevada. At the Edelweiss mine, Burra, South Australia. From the Gorob-Hope copper deposit, west-central Namibia.

Name: Honoring Colonel Jean Paul Louis Vésignié (1870–1954), noted French mineral collector.

Type Material: National School of Mines, Paris, France.

References: (1) Guillemin, C. (1955) Une nouvelle espèce minéral: la vésigniéite, $Cu_3Ba(VO_4)_2(OH)_2$. Compt. Rendus Acad. Sci. Paris, 240, 2331–2333 (in French). (2) (1955) Amer. Mineral., 40, 942–943 (abs. ref. 1). (3) Guillemin, C. and Z. Johan (1976) Étude radiocristallographie de la vésigniéite, $Cu_3Ba(VO_4)_2(OH)_2$. Compt. Rendus Acad. Sci. Paris, 282, 803–805 (in French). (4) Zhesheng Ma, Ruilin He, and Xiaoling Zhu (1990) Redetermination of the crystal structure of vesignieite. Acta Geologica Sinica, 64(4), 302–308 (in Chinese with English abs.).

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Vesuvianite $Ca_{19}(Al,Mg)_{13}B_{0-5}Si_{18}O_{68}(OH,O,F)_{10}$

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Crystal Data: Tetragonal or monoclinic. *Point Group:* $4/m\ 2/m\ 2/m$ or $2/m$. Commonly as short pyramidal to long prismatic crystals, to 15 cm, morphologically complex, with up to 30 forms reported on one crystal; columnar, granular, massive. *Twinning:* Twinned domains observed at a very fine scale.

Physical Properties: *Cleavage:* {110}, poor; {100} and {001}, very poor. *Fracture:* Subconchoidal to irregular. *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 3.32–3.43 D(calc.) = 3.42

Optical Properties: Transparent to translucent. *Color:* Yellow, green, brown; colorless to white, blue, violet, bluish green, pink, red, black, commonly zoned; in transmitted light, colorless to light yellow, green, brown. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Uniaxial (–); uniaxial (+) and biaxial examples are common, sectored. *Pleochroism:* Weak; O = colorless to yellowish; E = yellowish, greenish, brownish. *Dispersion:* Strong. $\omega = 1.703–1.752$ $\epsilon = 1.700–1.746$

Cell Data: *Space Group:* $P4/nnc$ or $P2/n$. $a = 15.4–15.7$ $c = 11.6–11.9$ $Z = 2$

X-ray Powder Pattern: Canzoccoli [Canzòcoli, Val di Fiemme, Trentino-Alto Adige], Italy. 2.759 (10), 2.599 (8), 1.625 (8), 2.948 (6), 2.465 (6), 2.128 (5), 1.767 (5)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	37.03	35.01	Fe_2O_3	1.91	3.76	CaO	36.70	35.31
TiO_2	0.52	0.43	FeO	1.42	3.67	H_2O	[2.80]	[0.86]
B_2O_3		3.18	MnO	0.06	0.13	Total	[99.65]	[99.32]
Al_2O_3	17.04	12.13	MgO	2.17	4.84			

(1) Jeffrey mine, Asbestos, Canada; by electron microprobe, FeO by wet chemical analysis, H_2O calculated from stoichiometry; corresponds to $Ca_{19.14}(Al_{9.77}Mg_{1.57}Fe^{3+}_{0.70}Fe^{2+}_{0.58}Ti_{0.19}Mn_{0.02})_{\Sigma=12.83}Si_{18.16}O_{68}[(OH)_{9.10}O_{1.16}]_{\Sigma=10.26}$. (2) Tulare Co., California, USA; by electron microprobe, FeO by wet chemical analysis, H_2O calculated from stoichiometry; corresponds to $Ca_{19.00}(Al_{7.18}Mg_{3.62}Fe^{2+}_{1.54}Fe^{3+}_{1.42}Ti_{0.16}Mn_{0.06})_{\Sigma=13.98}B_{2.76}Si_{17.58}O_{68}[O_{7.30}(OH)_{2.88}]_{\Sigma=10.18}$.

Occurrence: In skarns formed during contact or regional metamorphism of limestones; in garnetized gabbros, mafic and ultramafic rocks, and serpentinites; uncommon in alkalic igneous rocks.

Association: Grossular, diopside, wollastonite, epidote, scapolite, spinel, calcite.

Distribution: Good crystals are found throughout the world. In Italy, at Monte Somma and Vesuvius, Campania; Ariccia, Lazio; Val di Fassa, Trentino-Alto Adige; and Val d'Ala, Piedmont. From near Zermatt, Valais, Switzerland. At Arendal, Stromskien, and Egg, Norway. In Russia, at the Akhmatovsk mine, near Zlatoust, Ural Mountains, and near Chernyshevsk, at the confluence of the Akhtaragdy and Vilyui Rivers, Yakutia. In the USA, at Amity, Orange Co., and Olmsteadville, Essex Co., New York; in the Belvidere Mountain quarries, Lowell, Orleans Co., Vermont; Sanford, York Co., and Auburn, Androscoggin Co., Maine; Georgetown, El Dorado Co., and Crestmore, Riverside Co., California; near Ludwig, Yerington district, Lyon Co., Nevada. In Canada, at Litchfield, Asbestos, and Mont Saint-Hilaire, Quebec. At Xalostoc, Morelos, and Lake Jaco, Chihuahua, Mexico. From Baluchistan, Pakistan.

Name: For its occurrence at Vesuvius, Italy.

Type Material: Mining Academy, Freiberg, Germany, 23278.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 477–482. (2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 699–718. (3) Domańska, E., J. Nedoma, and W. Żabiński (1969) X-ray powder data for idocrase. Mineral. Mag., 37, 343–348. (4) Allen, F.M. and C.W. Burnham (1992) A comprehensive structure-model for vesuvianite: symmetry variations and crystal growth. Can. Mineral., 30, 1–18. (5) Groat, L.A., F.C. Hawthorne, and T.S. Ercit (1992) The chemistry of vesuvianite. Can. Mineral., 30, 19–48.

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Veszelyite $(Cu, Zn)_3(PO_4)(OH)_3 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, flattened on {100}, elongated along [001], to 5 cm, also typically pseudo-octahedral, {100} and {011}, modified by {001}, {110}, {111}, {121}; may be in granular aggregates.

Physical Properties: *Cleavage:* On {001} and {110}. Hardness = 3.5–4 D(meas.) = 3.4(1) D(calc.) = 3.42

Optical Properties: Translucent. *Color:* Greenish blue to dark blue; greenish blue in transmitted light. *Streak:* Green to white. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Faint; X = greenish blue; Z = blue. *Orientation:* $Y = b$; $Z \wedge c = -35°$ to $-43°$. *Dispersion:* $r < v$, weak to strong. $\alpha = 1.618$–1.640 $\beta = 1.622$–1.658 $\gamma = 1.658$–1.695 2V(meas.) = 38°–71°

Cell Data: *Space Group:* $P2_1/a$. $a = 9.8275(22)$ $b = 10.2244(30)$ $c = 7.5322(28)$ $\beta = 103.18(2)°$ Z = 4

X-ray Powder Pattern: Morávicza, Romania. (ICDD 12-525).
3.642 (100), 6.96 (40), 4.489 (30), 3.482 (30), 2.771 (30), 7.29 (25), 2.956 (25)

Chemistry:

	(1)	(2)
P_2O_5	18.43	19.01
FeO	0.06	
NiO	trace	
CuO	37.82	40.44
ZnO	26.69	23.64
PbO	0.05	
H_2O	16.87	16.22
Total	99.92	99.31

(1) Morávicza, Romania. (2) Arakawa mine, Japan; corresponds to $(Cu_{1.77}Zn_{1.24})_{\Sigma=3.01}(PO_4)(OH)_3 \cdot 2H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of some base-metal mineral deposits.

Association: Pseudomalachite, malachite, hemimorphite, pyromorphite, kipushite, vauquelinite, libethenite, quartz, iron oxides (Kipushi mine, Congo); hemimorphite, malachite, aurichalcite, brochantite (Wanlockhead, Scotland).

Distribution: From Ocna de Fier (Morávicza; Vaskő), Romania. At Zdravo Vrelo, near Sarajevo, Bosnia-Herzegovina. In the Straitstep vein, Wanlockhead, Dumfriesshire, Scotland. From Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). At Kabwe (Broken Hill), Zambia. In the Hisaichi (Arakawa) mine, Akita Prefecture, and the Kamioka mine, Gifu Prefecture, Japan. In the USA, large crystals from the Black Pine mine, near Philipsburg, Granite Co., Montana; from Gold Hill, Tooele Co., Utah. At the La Esperanza mine, Mayapa, Zacapoaxtla district, Puebla, Mexico.

Name: Honoring A. Veszelyi (1820–1888), Hungarian mining engineer, who discovered the species.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 916–917. (2) Ghose, S., S.R. Leo, and C. Wan (1974) Structural chemistry of copper and zinc minerals: Part I. Veszelyite, $(Cu, Zn)_2ZnPO_4(OH)_3 \cdot 2H_2O$: a novel type of sheet structure and crystal chemistry of copper-zinc substitution. Amer. Mineral., 59, 573–581. (3) Hintze, C. (1933) Handbuch der Mineralogie, I(4.2), 891–893.

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Viaeneite $(Fe, Pb)_4S_8O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As crystals, to 80 μm, in oval aggregates.

Physical Properties: *Cleavage:* On {110}, clearly observed under transmission electron microscopy. Hardness = 3 VHN = 123–357, average 252 (200 g load). D(meas.) = 3.8(1) D(calc.) = 3.65

Optical Properties: Opaque. *Color:* Yellow; in reflected light, yellow with a brassy hue. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Strong; orange, yellow-orange, greenish gray. *Bireflectance:* Distinct; grayish brown to orange to yellow-orange.

R_1–R_2: (400) 18.1–29.6, (420) 17.1–29.1, (440) 17.9–30.0, (460) 18.9–31.3, (480) 20.2–32.9, (500) 21.5–34.5, (520) 22.8–35.9, (540) 23.5–36.5, (560) 24.2–37.3, (580) 24.5–37.4, (600) 24.7–37.4, (620) 25.0–37.4, (640) 25.1–37.3, (660) 25.2–37.3, (680) 25.2–37.0, (700) 25.1–36.7

Cell Data: *Space Group:* n.d. $a = 9.717(8)$ $b = 7.280(6)$ $c = 6.559(7)$ $\beta = 95.00(3)°$ $Z = 2$

X-ray Powder Pattern: Engis, Belgium.
2.709 (10), 2.419 (8), 1.758 (8), 2.323 (7), 0.9576 (7), 1.925 (6), 0.9605 (6)

Chemistry:

	(1)	(2)
Fe	42.37	45.04
Ni	0.20	
Zn	0.05	
Pb	4.02	
As	0.17	
S	49.74	51.73
O	3.69	3.23
Total	100.24	100.00

(1) Engis, Belgium; by electron microprobe, average of three analyses, corresponds to $(Fe_{3.91}Pb_{0.10}Ni_{0.02})_{\Sigma=4.03}(S_{8.00}As_{0.01})_{\Sigma=8.01}O_{1.16}$; determination of sulfur valencies leads to $(Fe, Pb)_{12}(S_2^{2-})_{11}(S_2^{6+}O_3)$. (2) Fe_4S_8O.

Occurrence: In a carbonate-hosted Pb–Zn deposit.

Association: Pyrite, melnikovite, marcasite, greigite, sphalerite, galena, goethite, zincian siderite, smithsonite, dolomite, quartz, cerussite, anglesite.

Distribution: From the Mallieue Pb–Zn deposit, Engis, about 40 km southwest of Liège, Belgium [TL].

Name: To honor Professor Willy A. Viaene (1940–), Catholic University, Louvain, Belgium, who has made important contributions to geological sciences in Belgium.

Type Material: Academy of Mining & Metallurgy, Kraków, Poland, EMP9; Catholic University, Louvain, KUR32, ONB2, ONB3; Museum of Natural History, Brussels, Belgium, RN 6380.

References: (1) Kucha, H., W. Osuch, and J. Elsen (1996) Viaeneite, $(Fe, Pb)_4S_8O$, a new mineral with mixed sulfur valencies from Engis, Belgium. Eur. J. Mineral., 8, 93–102. (2) (1996) Amer. Mineral., 81, 1284 (abs. ref. 1).

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Vigezzite $(Ca, Ce)(Nb, Ta, Ti)_2O_6$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral prismatic crystals, elongated along [010], and flattened and striated ‖ [001] on {100}, terminated by {010}, to 3 mm.

Physical Properties: *Cleavage:* {010}, distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4.5–5 VHN = 396 (50 g load). D(meas.) = n.d. D(calc.) = 5.54

Optical Properties: Transparent. *Color:* Bright yellow-orange; yellow in transmitted light. *Optical Class:* Biaxial. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* Extreme. $\alpha = [2.14(2)]$ $\beta =$ n.d. $\gamma = [2.315(2)]$ 2V(meas.) = Large.

Cell Data: *Space Group: Pnmb.* $a = 11.065(2)$ $b = 7.527(1)$ $c = 5.343(1)$ Z = 4

X-ray Powder Pattern: Orcesco, Italy.
3.036 (100), 2.974 (100), 4.821 (90), 3.784 (80), 1.6018 (70), 1.7128 (60), 2.864 (40)

Chemistry:

	(1)	(2)
Nb_2O_5	31.0	73.8
Ta_2O_5	36.0	6.4
TiO_2	10.5	4.2
La_2O_3		0.2
Ce_2O_3	10.5	0.6
FeO		0.4
CaO	12.0	14.2
Total	100.0	99.8

(1) Orcesco, Italy; by electron microprobe, average of 12 analyses; corresponds to $(Ca_{0.82}Ce_{0.24})_{\Sigma=1.06}(Nb_{0.90}Ta_{0.62}Ti_{0.50})_{\Sigma=2.02}O_6$. (2) Kola Peninsula, Russia; by electron microprobe, average of three analyses; corresponding to $(Ca_{0.83}Fe_{0.02}La_{0.01})_{\Sigma=0.86}(Nb_{1.82}Ti_{0.17}Ta_{0.09})_{\Sigma=2.08}O_6$.

Occurrence: In miarolitic cavities in an albitized pegmatite in amphibolite and biotite gneiss (Orcesco, Italy).

Association: Pyrochlore, columbite, fersmite (Orcesco, Italy).

Distribution: From near Orcesco, on Alpe Rosso, Val Vigezzo, Piedmont, Italy. At the Kovdor massif, Kola Peninsula, Russia.

Name: For Val Vigezzo, Italy, where the mineral occurs.

Type Material: Mineralogical Institute, University of Basel, Basel; Natural History Museum, Basel, Switzerland, MB27:336.

References: (1) Graeser, S., H. Schwander, H. Hänni, and V. Mattioli (1979) Vigezzite, $(Ca, Ce)(Nb, Ta, Ti)_2O_6$, a new aeschynite-type mineral from the Alps. Mineral. Mag., 43, 459–462. (2) (1980) Amer. Mineral., 65, 811–812 (abs. ref. 1). (3) Giuseppetti, G. and C. Tadini (1990) The crystal structure of vigezzite, $(Ca, Ce)(Nb, Ta, Ti)_2O_6$, intermediate term [*sic*] of the aeschynite series. Neues Jahrb. Mineral., Monatsh., 301–308. (4) Zhuravleva, L.N., Y.G. Ryabeva, K.V. Yurkina, and L.S. Solntseva (1989) First discovery of vigezzite in the USSR, Kola Peninsula. Izv. Akad. Nauk SSSR, Ser. Geol., 1989(8), 134–136 (in Russian).

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Vigrishinite $Zn_2Ti_{4-x}Si_4O_{14}(OH,H_2O,\square)_8$ $(x < 1)$

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As split and blocky rectangular or irregular plates flattened on (001), to 3 cm.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. *Fracture:* Stepped. Hardness = 2.5-3 D(meas.) = 3.03(2) D(calc.) = 2.97

Optical Properties: Transparent to translucent. *Color:* Pale pink, yellowish pink, colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (-). α = 1.755(5) β = 1.820(10) γ = 1.835(8) 2V(meas.) = 45(10)° 2V(calc.) = 50° *Dispersion*: $r < v$, strong. *Pleochroism*: None.

Cell Data: Space Group: $P\bar{1}$. a = 8.743(9) b = 8.698(9) c = 11.581(11) α = 91.54(8)° β = 98.29(8)° γ = 105.65(8)° Z = 2

X-ray Powder Pattern: Lovozero alkaline massif, Kola Peninsula, Russia. (similar to murmanite) 2.861 (100), 11.7 (67), 4.17 (65), 5.73 (54), 8.27 (50), 6.94 (43), 2.609 (30)

Chemistry:

	(1)		(1)
Na_2O	0.98	Al_2O_3	0.36
K_2O	0.30	SiO_2	32.29
CaO	0.56	TiO_2	29.14
SrO	0.05	ZrO_2	2.08
BaO	0.44	Nb_2O_5	7.34
MgO	0.36	F	0.46
MnO	2.09	H_2O	9.1
ZnO	14.39	$-O=F_2$	0.19
Fe_2O_3	2.00	Total	101.75

(1) Lovozero alkaline massif, Kola Peninsula, Russia; average of 9 electron microprobe analyses, H_2O by modified Penfield method, corresponds to $H_{7.42}(Zn_{1.30}Na_{0.23}Mn_{0.22}Ca_{0.07}Mg_{0.07}K_{0.05}Ba_{0.02})_{\Sigma=1.96}(Ti_{2.68}Nb_{0.41}Fe^{3+}_{0.18}Zr_{0.12})_{\Sigma=3.39}(Si_{3.95}Al_{0.05})_{\Sigma=4}O_{20.31}F_{0.18}$.

Mineral Group: Epistolite group.

Occurrence: In a zoned peralkaline pegmatite located in foyaite and lujavrite rocks of a layered alkaline igneous complex. Found at the periphery of the ussingite core near its contact with the aegirine-eudialyte zone.

Association: Microcline, ussingite, aegirine, analcime, natrolite, gmelinite-Na, gmelinite-K, chabazite-Ca.

Distribution: From pegmatite 71, Malyi Punkaruaiv Mt., Lovozero alkaline massif, Kola Peninsula, Russia.

Name: Honors the Russian amateur mineralogist and mineral collector Viktor G. Grishin (b. 1953) for his significant contribution to the mineralogy of the Lovozero complex, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; 4256/1.

References: (1) Pekov, I.V., S.N. Britvin, N.V. Zubkova, N.V. Chukanov, I.A. Bryzgalov, I.S. Lykova, D.I. Belakovskiy, and D.Yu. Pushcharovsky (2012) Vigrishinite, $Zn_2Ti_{4-x}Si_4O_{14}(OH,H_2O,\square)_8$, a new mineral from Lovozero alkaline massif (Kola Peninsula, Russia). Zap. Ross. Mineral. Obshch., 141(4), 12-27 (in Russian, English abstract). (2) (2013) Amer. Mineral., 98, 2204 (abs. ref. 1).

Viitaniemiite $Na(Ca,Mn^{2+})Al(PO_4)(F,OH)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular, flattened on {100}, elongated along [010], showing {100}, {001}, {011}, may be fan-shaped, to 18 cm. *Twinning:* On {100}, twin and composition plane, polysynthetic, common.

Physical Properties: *Cleavage:* Good on $\{10\bar{1}\}$. Hardness = 5 D(meas.) = 3.245 D(calc.) = 3.242

Optical Properties: Transparent, translucent if clouded by inclusions. *Color:* Gray to white; colorless in thin section. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $X \wedge c = 24°$. α = 1.532–1.557 β = 1.544–1.565 γ = 1.551–1.571 2V(meas.) = 75°–81° 2V(calc.) = 74°–81°

Cell Data: *Space Group:* $P2_1/m$. a = 6.836–6.865 b = 7.151–7.225 c = 5.457–5.522 $\beta = 109°00'–109°36'$ Z = 2

X-ray Powder Pattern: Viitaniemi pegmatite, Finland.
2.883 (100), 2.937 (56), 3.223 (46), 2.160 (40), 2.569 (35), 4.885 (33), 1.915 (28)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	28.3	28.1	K_2O	0.27	0.0
Al_2O_3	22.4	23.4	Li_2O	0.00	
FeO	0.70	0.0	F	12.3	14.5
MnO	10.5	0.0	H_2O^+	4.9	n.d.
MgO	0.38	0.1	H_2O^-	0.03	
CaO	14.7	22.3	$-O = F_2$	5.14	6.1
Na_2O	11.6	11.4	Total	100.84	93.7

(1) Viitaniemi pegmatite, Finland; by AA, Mn and P colorimetrically, F by ion-active electrode, H_2O by the Penfield method; corresponds to $(Na_{0.91}K_{0.01})_{\Sigma=0.92}(Ca_{0.64}Mn^{2+}_{0.36}Fe^{2+}_{0.02}Mg_{0.02})_{\Sigma=1.04}Al_{1.07}P_{0.97}O_{4.11}[(F_{1.57}(OH)_{1.33}]_{\Sigma=2.90}$. (2) Francon quarry, Canada; by electron microprobe, corresponding to $Na_{0.91}(Ca_{0.98}Mg_{0.01})_{\Sigma=0.99}Al_{1.13}(P_{0.98}O_4)(F,OH)_3$.

Occurrence: An inclusion in eosphorite and rimming morinite, from a complex zoned granite pegmatite (Viitaniemi pegmatite, Finland); in druses in granite (Greifensteine, Germany).

Association: Eosphorite, fluorapatite, crandallite, montebrasite, morinite (Viitaniemi pegmatite, Finland); lacroixite, morinite, apatite, childrenite, roscherite, tourmaline (Greifensteine, Germany); cryolite, fluorite, weloganite, dresserite, dawsonite, calcite, pyrite, galena, sphalerite, quartz (Francon quarry, Canada).

Distribution: In the Viitaniemi pegmatite, near Eräjärvi, Finland. On the Greifensteine, near Ehrenfriedersdorf, Saxony, Germany. In the Francon quarry, Montreal Island, Montreal, Quebec, Canada. Large crystals from near Dassu, Braldu Valley, Pakistan.

Name: For its occurrence in the Viitaniemi pegmatite, Finland.

Type Material: Mineralogical Museum, Geological Survey of Finland, Helsinki, Finland.

References: (1) Lahti, S.I. (1981) The granite pegmatites of the Eräjärvi area in Orivesi, southern Finland. Geol. Surv. Finland Bull. 314, 82 pp, esp. 51–56. (2) (1981) Amer. Mineral., 66, 1102 (abs. ref. 1). (3) Ramik, R.A., B.D. Sturman, A.C. Roberts, and P.J. Dunn (1983) Viitaniemiite from the Francon quarry, Montreal, Quebec. Can. Mineral., 21, 499–502.
(4) Pajunen, A. and S.I. Lahti (1984) The crystal structure of viitaniemiite. Amer. Mineral., 69, 961–966.

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Vikingite $Ag_5Pb_8Bi_{13}S_{30}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Lamellar, to 0.5 mm. *Twinning:* On {010}; twin lamellae ‖ [001] commonly observed in thin section.

Physical Properties: Hardness = n.d. VHN = 185 (50 g load). D(meas.) = n.d. D(calc.) = 7.19

Optical Properties: Opaque. *Color:* In polished section, galena-white. *Pleochroism:* Absent in air, absent to weak in oil. *Anisotropism:* Distinct to strong, in pale gray to steel-bluish-black. R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/m$ (subcell). a = 13.598–13.603 b = 4.112 c = 25.249–25.248 $\beta = 95.55°–95.59°$ Z = 1

X-ray Powder Pattern: Ivigtut, Greenland.
3.40 (100), 1.754 (90), 2.06 (80), 2.91 (50), 3.62 (40), 3.05 (40), 2.10 (40)

Chemistry:

	(1)	(2)	(3)
Ag	8.9	7.04	9.18
Cu	0.2		
Cd		0.51	
Pb	27.7	33.91	28.21
Bi	47.6	41.81	46.24
Sb		0.05	
S	16.5	16.25	16.37
Se		0.04	
Total	100.9	99.61	100.00

(1) Ivigtut, Greenland; by electron microprobe, corresponding to $Ag_{4,81}Cu_{0.18}Pb_{7.79}Bi_{13.26}S_{29.96}$. (2) La Roche-Balue quarry, France; by electron microprobe, corresponding to $Ag_{3.88}Cd_{0.27}Pb_{9.74}(Bi_{11.90}Sb_{0.02})_{\Sigma=11.92}(S_{30.16}Se_{0.03})_{\Sigma=30.19}$. (3) $Ag_5Pb_8Bi_{13}S_{30}$.

Occurrence: Associated with cosalite and as lamellae in galena in the gustavite-galena paragenesis (Ivigtut, Greenland).

Association: Cosalite, galena (Ivigtut, Greenland); gustavite, heyrovskyite, quartz (La Roche-Balue quarry, France).

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland [TL]. In the USA, from near Gabbs, Gabbs district, Nye Co., Nevada; at South Mountain, Owyhee Co., Idaho; and in the Apache Hills, southeast of Hachita, Grant Co., New Mexico. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. At the La Roche-Balue quarry, west of Nantes, Loire Atlantique, France.

Name: For the Vikings, early settlers of Greenland.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1973.236; National Museum of Natural History, Washington, D.C., USA, 136172.

References: (1) Karup-Møller, S. (1977) Mineralogy of some Ag–(Cu)–Pb–Bi sulfide associations. Bull. Geol. Soc. Denmark, 26, 41–68. (2) Makovicky, E. and S. Karup-Møller (1977) Chemistry and crystallography of the lillianite homologous series. Neues Jahrb. Mineral., Abh., 131, 56–82. (3) (1979) Amer. Mineral., 64, 243 (abs. refs. 1 and 2). (4) Makovicky, E., W.G. Mumme, and I.C. Madsen (1992) The crystal structure of vikingite. Neues Jahrb. Mineral., Monatsh., 454–468.

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Villamanínite $(Cu, Ni, Co, Fe)S_2$

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Crystal Data: Triclinic, pseudocubic. *Point Group:* $\overline{1}$ or 1; pseudo $2/m\ \overline{3}$. As pseudocubes, pseudo-octahedra, and pseudocubo-octahedra, with rounded faces, to 5 mm; also as nodules with radial fibrous structure. *Twinning:* Noted, but not described.

Physical Properties: *Cleavage:* Perfect pseudocubic. *Fracture:* Uneven. Hardness = 4.5 VHN = 535–710 (spherical aggregates); 440–520 (euhedral crystals) (20 g load).
D(meas.) = 4.4–4.5 D(calc.) = 4.408–4.604

Optical Properties: Opaque. *Color:* Iron-black; pale blue-gray to violet-gray in reflected light. *Streak:* Sooty black. *Luster:* Dull metallic.
R: (400) 30.1, (420) 29.7, (440) 29.2, (460) 28.7, (480) 28.1, (500) 27.4, (520) 26.8, (540) 26.3, (560) 26.0, (580) 25.9, (600) 26.1, (620) 26.5, (640) 27.2, (660) 28.1, (680) 29.0, (700) 30.1

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 5.7030$–5.7087 $b = 5.7041$–5.7070 $c = 5.7051$–5.7086 $\alpha = 90.0089°$–$90.0250°$ $\beta = 90.0091°$–$90.0573°$ $\gamma = 90.0112°$–$90.0301°$
Z = 4

X-ray Powder Pattern: Providencia mine, Spain.
2.852 (100), 1.7174 (40), 2.548 (30), 2.325 (25), 2.014 (25), 3.289 (15), 1.0959 (15)

Chemistry:

	(1)	(2)
Cu	24.0	24.1
Ni	11.8	17.3
Co	4.0	5.7
Fe	5.3	2.2
Se	0.06	1.5
S	54.0	50.2
Total	99.2	101.0

(1) Providencia mine, Spain; corresponds to $(Cu_{0.47}Ni_{0.25}Fe_{0.12}Co_{0.08})_{\Sigma=0.92}S_{2.08}$. (2) Do.; by electron microprobe; corresponds to $(Cu_{0.48}Ni_{0.37}Co_{0.12}Fe_{0.05})_{\Sigma=1.02}(S_{1.96}Se_{0.02})_{\Sigma=1.98}$.

Occurrence: As subhedral disseminated grains in black bituminous dolostone; in white coarse-grained recrystallized dolostone; as nodular aggregates in vuggy dolomite veinlets (Providencia mine, Spain).

Association: Pyrite, chalcopyrite, dolomite, quartz (Providencia mine, Spain).

Distribution: From the Providencia mine, six km east-northeast of Villamanín, Cármenes district, León Province, Spain [TL]. In Poland, in the Lubin copper mine, near Legnica, Zechstein copper district, Lower Silesia, and at Karniowice. From Rum Jungle, Alligator River district, Northern Territory, Australia.

Name: For the town of Villamanín, Spain.

Type Material: The Natural History Museum, London, England, 1919,309; 1920,7.

References: (1) Schoeller, W.R. and A.R. Powell (1920) Villamaninite, a new mineral. Mineral. Mag., 19, 14–18. (2) (1920) Amer. Mineral., 5, 168 (abs. ref. 1). (3) Hey, M.H. (1962) A new analysis of villamaninite. Mineral. Mag., 33, 169–170. (4) Ypma, P.J.M., H.J. Evers, and C.F. Woensdregt (1968) Mineralogy and geology of the Providencia mine (León, Spain), type-locality of villamaninite. Neues Jahrb. Mineral., Monatsh., 174–191. (5) Moreiras, D., C. Marcos, A. Panaiagua, M.R. Diaz-Fernandez, and S. Garcia-Granda (1991) Preliminary data about symmetry and structure of villamaninite. Neues Jahrb. Mineral., Abh., 163, 254–256. (6) Marcos, ?? (1996) ??title?? Acta Cryst., 899–?? str??; [order-may replace 5??] (7) Bayliss, P. (1977) X-ray powder data for villamaninite. Mineral. Mag., 41, 545. (8) Criddle, A.J. and C.J. Stanley, Eds. (1993) Quantitative data file for ore minerals, 3rd ed. Chapman & Hall, London, 606.

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Villiaumite NaF

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals rare, cubic, to 15 cm, may show {111}, {*hll*}, {*hkl*}; commonly granular, massive.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 2.79 D(calc.) = 2.808 Soluble in H_2O; dark red to orange and yellow fluorescence under SW and LW UV.

Optical Properties: Transparent. *Color:* Carmine-red, lavender-pink to light orange. *Streak:* White. *Luster:* Vitreous.
Optical Class: Isotropic; weak anomalous anisotropism, then uniaxial (–). *Pleochroism:* Strong; E = yellow; O = pink to deep carmine. n = 1.327–1.328

Cell Data: *Space Group:* $Fm3m$ (synthetic). a = 4.6342 Z = 4

X-ray Powder Pattern: Synthetic.
2.319 (100), 1.639 (60), 1.338 (17), 1.0363 (12), 0.9458 (8), 1.1588 (7), 2.680 (3)

Chemistry:

	(1)	(2)	(3)
Na	53.4	53.83	54.75
K	trace	0.32	
Mg	trace		
Ca	1.2		
ZrO_2	1.5		
F	44.2	45.28	45.25
insol.		0.84	
Total	100.3	100.27	100.00

(1) Los Islands, Guinea. (2) Lovozero massif, Russia. (3) NaF.

Occurrence: In nepheline syenite and nepheline syenite pegmatites; in lake-bed deposits.

Association: Aegirine, sodalite, nepheline, neptunite, lamprophyllite, pectolite, serandite, eudialyte, ussingite, chkalovite, zeolites.

Distribution: On Rouma Isle, Los Islands, Guinea. On Mts. Karnasurt and Alluaiv, Lovozero massif, and from the Khibiny massif, Kola Peninsula, Russia. At Kvanefjeld, Ilímaussaq intrusion, Greenland. From Aris, about 20 km south of Windhoek, Namibia. At Lake Magadi, Kenya. From Poços de Caldas, Minas Gerais, Brazil. In the USA, at Point of Rocks, Colfax Co., New Mexico, and on Porphyry Mountain, Jamestown district, Boulder Co., Colorado. Large crystals from Mont Saint-Hilaire, Quebec, Canada.

Name: Honors Maxime Villiaume, French explorer, in whose collections of rocks from Guinea the mineral was first found.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 10. (2) Stormer, J.C, Jr., and I.S.E. Carmichael (1970) Villiaumite and the occurrence of fluoride minerals in igneous rocks. Amer. Mineral., 55, 126–134. (3) (1953) NBS Circ. 539, 1, 63.

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Villyaellenite $(Mn^{2+}, Ca, Zn)_5(AsO_4)_2(AsO_3OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals tabular, flattened on {100}, to prismatic, elongated along [001], showing {100}, {110}, {011}, {010}, {$\bar{1}$01}, {001}, to 4 cm; in rosettes and radial aggregates.

Physical Properties: *Cleavage:* On {100}, good. Hardness = ∼4 D(meas.) = 3.20–3.69 D(calc.) = 3.24–3.72

Optical Properties: Transparent. *Color:* Pale rose-red, orange-pink, colorless; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Moderate; X = very pale orange-pink; Y = exceedingly pale orange-pink; Z = pale orange-pink. *Orientation:* $X = b$; $Y \wedge c$ = 30°–40°. *Absorption:* $Z \gg X > Y$. α = 1.660–1.713 β = 1.670–1.723 γ = 1.676–1.729 2V(meas.) = 70.5°–76° 2V(calc.) = 75°–75.6°

Cell Data: *Space Group:* $C2/c$. a = 18.015–18.515 b = 9.261–9.484 c = 9.770–10.000 β = 96.238°−96.72° Z = 4

X-ray Powder Pattern: Sainte-Marie-aux-Mines, France.
3.297 (100), 8.476 (90), 3.132 (60), 4.606 (50), 4.761 (40), 3.811 (40), 3.025 (40)

Chemistry:

	(1)	(2)
As_2O_5	52.99	50.6
FeO		0.1
MnO	22.40	36.2
ZnO		2.9
CaO	13.58	0.5
H_2O	11.42	9.9
Total	100.39	100.2

(1) Sainte-Marie-aux-Mines, France; by electron microprobe, total Mn as MnO, H_2O by TGA; corresponds to $H_{2.27}(Mn_{2.69}Ca_{2.07})_{\Sigma=4.76}(AsO_4)_{3.93} \cdot 4.28H_2O$. (2) Mapimí, Mexico; by electron microprobe, average of five points over several crystals; total Mn as MnO, H_2O by moisture evolution analyzer; corresponds to $(Mn_{4.62}Zn_{0.32}Ca_{0.08}Fe_{0.01})_{\Sigma=5.03}(AsO_4)_{2.08}(AsO_3OH)_{1.92} \cdot 4.04H_2O$.

Occurrence: A rare post-mine low-temperature reaction product of carbonate gangue with arsenical solutions derived from arsenic (Sainte-Marie-aux-Mines, France); on a museum specimen from the oxidized zone of an arsenic-rich base metal deposit (Mapimí, Mexico); on a single specimen from a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA).

Association: Fluckite, picropharmacolite, pharmacolite, arsenic (Sainte-Marie-aux-Mines, France); ogdensburgite, arseniosiderite, chalcophanite, adamite, Fe–Mn oxides (Mapimí, Mexico); manganoan calcite, willemite, franklinite (Sterling Hill, New Jersey, USA).

Distribution: Found at Sainte-Marie-aux-Mines, Haut-Rhin, France. From Jáchymov (Joachimsthal), Czech Republic. Large crystals at the Ojuela mine, Mapimí, Durango, Mexico. In the Veta Negra mine, Pampa Larga district, Tierra Amarilla, southeast of Copiapó, Chile. From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. At the Gozaisho mine, Iwaki, Fukushima Prefecture, Japan.

Name: To honor Dr. Villy Aellen, Director, Natural History Museum, Geneva, Switzerland.

Type Material: Natural History Museum, Geneva, Switzerland, 435/76.

References: (1) Sarp, H. (1984) Villyaellenite, $H_2(Mn, Ca)_5(AsO_4)_4 \cdot 4H_2O$ un nouveau minéral de Sainte-Marie aux Mines (France). Schweiz. Mineral. Petrog. Mitt., 64, 323–328 (in French with English abs.). (2) (1986) Amer. Mineral., 71, 1547 (abs. ref. 1). (3) Kampf, A.R. and C.R. Ross II (1988) End-member villyaellenite from Mapimi, Durango, Mexico: descriptive mineralogy, crystal structure, and implications for the ordering of Mn and Ca in type villyaellenite. Amer. Mineral., 73, 1172–1178.

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Vimsite $CaB_2O_2(OH)_4$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Elongated crystals, to 3 mm, in radial aggregates. *Twinning:* Observed.

Physical Properties: *Cleavage:* Perfect along elongation. Hardness = < 4 D(meas.) = 2.54 D(calc.) = 2.56

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* Parallel extinction. $\alpha = 1.584$–1.585 $\beta = 1.613$–1.614 $\gamma = 1.613$–1.614 2V(meas.) = 24°–28°

Cell Data: *Space Group:* $C2/c$. $a = 10.026(2)$ $b = 9.558(3)$ $c = 4.440(1)$ $\beta = 91.31(2)°$ Z = 4

X-ray Powder Pattern: Novofrolovskoye deposit, Russia.
3.48 (10), 2.222 (8), 3.72 (7), 2.61 (7), 1.881 (7), 6.87 (6), 3.04 (6)

Chemistry:

	(1)	(2)	(3)
SiO_2	2.18	0.55	
B_2O_3	37.36	40.55	43.05
Al_2O_3	0.57		
Fe_2O_3	1.63		
MnO		0.06	
MgO	0.92	2.25	
CaO	36.14	38.19	34.67
H_2O	20.86	18.06	22.28
Total	99.66	99.66	100.00

(1) Novofrolovskoye deposit, Russia; corresponds to $(Ca_{1.07}Mg_{0.09})_{\Sigma=1.16}B_{1.84}O_{2.30}(OH)_{3.16}$.
(2) Solongo deposit, Russia; corresponds to $(Ca_{1.07}Mg_{0.04})_{\Sigma=1.11}B_{1.89}O_{1.84}(OH)_{4.11}$.
(3) $CaB_2O_2(OH)_4$.

Polymorphism & Series: Dimorphous with uralborite.

Occurrence: In boron-rich copper-bearing skarn (Novofrolovskoye deposit, Russia); in iron-bearing skarn (Solongo deposit, Russia).

Association: uralborite, andradite–grossular, calciborite, sibirskite, magnetite (Novofrolovskoye deposit, Russia); frolovite (Solongo deposit, Russia).

Distribution: In Russia, from the Novofrolovskoye copper deposit, Turinsk district, near Krasnoturinsk, Northern Ural Mountains, and in the Solongo boron deposit, Buryatia.

Name: For the 50th anniversary of the All-Union Scientific Research Institute of Mineral Resources [an acronym for Vses. Nauch.-Issled. Inst. Mineral. Syr'ya], Moscow, Russia.

Type Material: Vernadsky Geological Museum, Moscow, Russia.

References: (1) Shaskin, D.P., M.A. Simonov, N.I. Chernova, S.V. Malinko, Y.I. Stolyarova, and N.V. Belov (1968) A new natural borate – vimsite. Doklady Acad. Nauk SSSR, 182, 1402–1405 (in Russian). (2) Shaskin, D.P., M.A. Simonov, and N.V. Belov (1968) Crystal structure of the new natural borate mineral vimsite, $Ca[B_2O_2(OH)_4]$. Doklady Acad. Nauk SSSR, 182, 821–824 (in Russian). (3) (1969) Amer. Mineral., 54, 1219–1220 (abs. refs. 1–2). (4) Malinko, S.V. and N.N. Kuznetsova (1970) A new find of vimsite. Doklady Acad. Nauk SSSR, 195, 1419–1422 (in Russian). (5) Simonov, M.A., Y.K. Yegorov-Tismenko, and N.V. Belov (1976) Refined crystal structure of vimsite $CaB_2O_2(OH)_4$. Kristallografiya (Sov. Phys. Crystal.), 21, 592–594 (in Russian).

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Vincentite $(Pd, Pt)_3(As, Sb, Te)$

Crystal Data: Monoclinic. *Point Group:* n.d. As grains to 40 microns.

Physical Properties: *Cleavage:* n.d. *Tenacity:* n.d. Hardness = n.d.
VHN = 494 (15 g. load) D(meas.) = n.d. D(calc.) = 10.86

Optical Properties: Opaque. *Color:* In reflected light, light brownish-gray. *Anistropism*: Weak, greenish gray to dark brown. *Luster:* n.d. *Bireflectance*: Weak.
Optical Class: n.d.
R_1-R_2: (400) 36.0-36.5, (420) 36.4-37.3, (440) 36.4-38.7, (460) 38.0-41.8, (470) 38.8-43.1, (480) 40.5-44.2, (500) 42.0-46.1, (520) 43.4-48.9, (540) 45.1-51.1, (546) 45.4-51.3, (560) 46.3-52.2, (580) 47.6-53.8, (589) 48.0-54.2, (600) 48.4-54.8, (620) 48.9-55.8, (640) 50.4-55.9, (650) 50.8-55.9, (660) 51.6-56.0, (680) 53.1-55.8, (700) 54.2-56.2

Cell Data: *Space Group:* n.d. $a = 11.226(3)$ $b = 6.318(2)$ $c = 8.047(2)$ $\beta = 100.95(4)°$ $Z = 8$

X-ray Powder Pattern: Riam Kanen River, S.E. Borneo.
1.800 (10), 1.775 (9), 1.758 (8), 1.745 (8), 1.838 (6), 2.888 (4), 3.951 (3)

Chemistry:

	(1)	(2)
Pd	61.3	60.31
Pt	14.4	16.70
As	7.3	6.99
Sb	6.3	9.18
Te	8.9	7.12
Total	98.2	100.30

(1) Riam Kanen River, S.E. Borneo; electron microprobe analysis, corresponding to $(Pd_{2.66}Pt_{0.34})_{\sum=3.00}(As_{0.45}Sb_{0.24}Te_{0.42})_{\sum=1.11}$. (2) Riam Kanen River, S.E. Borneo; electron microprobe analysis, corresponding to $(Pd_{2.65}Pt_{0.34})_{\sum=2.99}(As_{0.45}Sb_{0.24}Te_{0.32})_{\sum=1.01}$.

Occurrence: As inclusions in Fe-bearing palladium grains in sediment concentrates from the Riam Kanen River, S.E. Borneo.

Association: Platinum, osmium.

Distribution: Riam Kanen River, S.E. Borneo.

Name: Honors Professor E. A. Vincent of Oxford University, England.

Type Material: Not found.

References: (1) Stumpfl, E. F. and M. Tarkian (1974) Vincentite, a new palladium mineral from south-east Borneo. Mineral. Mag., 39, 525-527. (2) (1974) Amer. Mineral, 59, 1332, (abs. ref 1). (3) Tarkian, M., K.-H. Klaska, and E.F. Stumpfl (2002) New data on vincentite. Can. Mineral., 40, 457–461.

Crystal Data: Tetragonal, pseudocubic. *Point Group:* $4/m\ 2/m\ 2/m$, $4mm$, or 422. As grains up to 1 mm. *Twinning:* Simple and poor polysynthetic twins.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = n.d. VHN = 280 (25 g load). D(meas.) = n.d. D(calc.) = 4.29

Optical Properties: Opaque. *Color:* Orange. *Luster:* Metallic. *Anisotropism:* Weak, purplish blue to greenish brown-yellow.
R_1–R_2: (420) 19.4–19.4, (460) 21.8–20.6, (500) 23.9–22.8, (540) 27.7–26.5, (580) 30.7–29.5, (620) 33.6–32.1, (660) 35.9–34.3, (700) 37.8–36.0

Cell Data: *Space Group:* $P4/mmm$, $P4mm$, $P422$, or $P4_122$. $a = 10.697(6)$ $c = 10.697(6)$ $Z = 2$

X-ray Powder Pattern: Chizeuil, France.
3.088 (100), 1.895 (90), 1.614 (70), 2.676 (50), 1.227 (40), 1.091 (40), 4.37 (30)

Chemistry:

	(1)	(2)
Cu	40.90	42.6
Fe	14.63	13.2
Zn		0.7
Sn	7.33	8.3
As	3.43	4.5
Sb	1.60	
S	31.85	31.3
Total	99.74	100.6

(1) Chizeuil, France; by electron microprobe, average of six analyses, yielding $Cu_{10.19}Fe_{4.15}Sn_{0.98}(As_{0.73}Sb_{0.21})_{\Sigma=0.94}S_{15.74}$. (2) Maggie deposit, Canada; by electron microprobe, giving $Cu_{10.60}(Fe^{+3}_{3.00}Fe^{+2}_{0.74}Zn_{0.17})_{\Sigma=3.91}Sn_{1.11}As_{0.95}S_{15.44}$.

Occurrence: In a porphyry copper deposit with other tin-bearing sulfides (Maggie deposit, Canada).

Association: Pyrite, chalcopyrite, colusite, stannite, stannoidite, mawsonite, bornite, enargite, tetrahedrite–tennantite, quartz, barite.

Distribution: From Chizeuil, Saône-et-Loire, France. At Huaron, Peru. In the Maggie copper deposit, 15 km north of Ashcroft, British Columbia, Canada.

Name: To honor Professor Henri Vincienne (1898–1965), who first called attention to the mineral.

Type Material: National School of Mines, Paris, France.

References: (1) Cesbron, F., R. Girauld, P. Picot, and F. Pillard (1985) La vinciennite $Cu_{10}Fe_4Sn(As,Sb)S_{16}$, une nouvelle espèce minérale. Etude paragénétique du gîte type de Chizeuil, Saône-et-Loire. Bull. Minéral., 108, 447–456 (in French with English abs.). (2) (1986) Amer. Mineral., 71, 1280–1281 (abs. ref. 1). (3) Jambor, J. and D.R. Owens (1987) Vinciennite in the Maggie porphyry copper deposit, British Columbia. Can. Mineral., 25, 227–228.

Vinogradovite $(Na,K)_4Ti_4(Si,Al)_8O_{26}\cdot(H_2O,Na)$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. In prismatic crystals, elongated along [100], sword-shaped or bladed, to 4 mm; commonly in spherulites, to 1 cm, and irregular fibrous aggregates. *Twinning:* On {010}, uncommon.

Physical Properties: *Cleavage:* {010}, perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ∼4 D(meas.) = 2.85–2.97 D(calc.) = 2.88

Optical Properties: Transparent. *Color:* Colorless, white, mauve, pink; in transmitted light, colorless to brownish. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Weak; X = colorless; Z = brownish. *Orientation:* $Y = b$; $X \wedge a = 7°$. *Dispersion:* $r > v$. $\alpha = 1.691$–1.745 $\beta = 1.769$–1.773 $\gamma = 1.773$–1.818 2V(meas.) = 41°–82°

Cell Data: *Space Group:* $C2/c$. $a = 24.38$–25.01 $b = 8.66$–8.72 $c = 5.21$–5.23 $\beta = 99.50°-104.43°$ Z = 2

X-ray Powder Pattern: Khibiny massif, Russia.
3.21 (10), 3.07 (10), 1.614 (8), 2.72 (7), 1.558 (7), 1.494 (7), 1.434 (7)

Chemistry:

	(1)	(2)
SiO_2	40.70	39.18
TiO_2	33.60	28.87
Al_2O_3	6.20	7.08
Fe_2O_3		1.67
Nb_2O_5		1.39
MgO	0.36	0.05
CaO	1.00	
BaO		1.02
Na_2O	12.00	15.81
K_2O	1.78	1.46
H_2O	4.80	3.68
Total	100.44	100.21

(1) Khibiny massif, Russia. (2) Mont Saint-Hilaire, Canada, by electron microprobe, H_2O by TGA; corresponds to $(Na_{4.18}K_{0.31}Ba_{0.14})_{\Sigma=4.63}(Ti_{3.67}Fe_{0.20}Nb_{0.11})_{\Sigma=3.98}(Si_{6.62}Al_{1.41})_{\Sigma=8.03}O_{26}\cdot(H_2O,Na)$.

Occurrence: A late-stage hydrothermal mineral in cavities and veins, and replacing titanium-bearing minerals, in alkalic pegmatites in differentiated alkalic massifs (Kola Peninsula, Russia).

Association: Lorenzenite, lamprophyllite, catapleiite, neptunite, labuntsovite, titanite, calcite.

Distribution: In the Khibiny, Lovozero, and Kovdor massifs, Kola Peninsula, and the Inagli massif, 30 km west of Aldan, Yakutia, Russia. At Mont Saint-Hilaire, Quebec, Canada. In the Ilímaussaq intrusion, southern Greenland.

Name: In honor of Academician Aleksander Pavlovich Vinogradov (1895–1975), Russian geochemist, Director of the Vernadsky Institute of Geochemistry and Analytical Chemistry, Academy of Sciences, Moscow, Russia.

Type Material: Vernadsky Geological Museum, Moscow, 44801; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 57962, vis4737, vis4739.

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References: (1) Semenov, E.I., E.M. Bohnshtedt-Kupletskaya, V.A. Moleva, and N.N. Sludskaya (1956) Vinogradovite – a new mineral. Doklady Acad. Nauk SSSR, 109, 617–620 (in Russian). (2) (1957) Amer. Mineral., 42, 308 (abs. ref. 1). (3) Rastsvetaeva, R.K. and V.I. Andrianov (1984) Refined crystal structure of vinogradovite. Kristallografiya (Sov. Phys. Crystal.), 29, 681–686 (in Russian). (4) Rønsbo, J.G., O.V. Petersen, and E.S. Leonardsen (1990) Vinogradovite from the Ilímaussaq alkaline complex, South Greenland, a beryllium bearing mineral. Neues Jahrb. Mineral., Monatsh., 481–492. (5) Kalsbeek, N. and J.G. Rønsbo (1992) Refinement of the vinogradovite structure, positioning of Be and excess Na. Zeits. Krist., 200, 237–245. (6) Mandarino, J.A. and V. Anderson (1989) Monteregian Treasures. Cambridge Univ. Press, 210, 264.

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Violarite $Fe^{2+}Ni_2^{3+}S_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As nodules up to 0.5 cm and massive.

Physical Properties: *Cleavage:* Perfect on {001}. *Tenacity:* Brittle. Hardness = 4.5–5.5 VHN = 455–493 (100 g load). D(meas.) = n.d. D(calc.) = 4.79

Optical Properties: Opaque. *Color:* Violet-gray; distinctly violet in reflected light. *Luster:* Metallic.

R: (400) 39.0, (420) 39.6, (440) 40.2, (460) 40.6, (480) 41.0, (500) 41.4, (520) 41.9, (540) 42.5, (560) 43.1, (580) 43.8, (600) 44.3, (620) 44.8, (640) 45.4, (660) 45.8, (680) 46.2, (700) 46.6

Cell Data: *Space Group:* $Fd3m$. a = 9.51 Z = 8

X-ray Powder Pattern: Vermilion mine, Sudbury, Canada.
2.85 (100), 1.674 (80), 1.820 (60), 2.36 (50), 1.059 (50), 1.183 (40), 1.115 (40)

Chemistry:

	(1)	(2)	(3)
Fe	17.01	19.33	18.52
Ni	38.68	33.94	38.94
Co	1.05	2.50	
Cu	1.12	1.05	
S	41.68	42.17	42.54
insol.	0.40	1.31	
Total	99.94	100.30	100.00

(1) Vermilion mine, Sudbury, Canada; contains trace chalcopyrite. (2) Friday mine, Julian, California, USA; contains trace chalcopyrite. (3) $FeNi_2S_4$.

Mineral Group: Linnaeite group.

Occurrence: Of hydrothermal origin, with other sulfides.

Association: Pyrrhotite, millerite, chalcopyrite, pentlandite.

Distribution: In the USA, from the Friday mine, Julian, San Diego Co., California; the Key West mine, Clark Co., Nevada; the Copper King mine, Gold Hill district, Boulder Co., Colorado; the Lick Fork deposit, Floyd Co., Virginia; and the Gap Nickel mine, Lancaster Co., Pennsylvania. In Canada, from the Vermilion, Levack, and Worthington mines, Sudbury, Ontario; at the Marbridge mine, Malartic, Quebec; in the Rottenstone mine, Saskatchewan; and from a number of other minor occurrences. At the Madziwa (Dry Nickel) mine, Bindura, Zimbabwe. From the Praborna mine, St. Marcel, Valle d'Aosta, Piedmont, Italy. At Kambalda, 56 km south of Kalgoorlie, and Kalgoorlie, Western Australia, and near Mount Colin, Queensland, Australia. Known from a few other localities.

Name: From the Latin for *violet*, its color on a polished surface.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 262–265. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 77–78.

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Virgilite $Li_xAl_xSi_{3-x}O_6$

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Crystal Data: Hexagonal. *Point Group:* 622. Rarely as euhedral crystals, to 50 μm, displaying a hexagonal dipyramid and prism. As irregular rosette-shaped fibrous overgrowths on other minerals.

Physical Properties: Hardness = n.d. VHN = 681–722 D(meas.) = n.d. D(calc.) = 2.46

Optical Properties: Transparent. *Color:* Colorless.
Optical Class: Uniaxial (–). $n = 1.520$

Cell Data: *Space Group:* $P6_222$ or $P6_422$. $a = 5.132(1)$ $c = 5.454(1)$ Z = [1]

X-ray Powder Pattern: Macusani, Peru.
3.441 (100), 1.870 (25), 4.442 (13), 1.605 (9), 1.408 (9), 2.567 (6), 2.224 (6)

Chemistry:

	(1)
SiO_2	77.29
Al_2O_3	16.57
FeO	0.64
Li_2O	4.93
Cl	0.0
P_2O_5	0.57
Total	100.0

(1) Macusani, Peru; by electron microprobe and laser spectrograph; traces of TiO_2, MnO, MgO, CaO, Na_2O, K_2O, F; corresponds to $Li_{0.61}(Si_{1.37}Al_{0.60}Fe_{0.02}P_{0.01})_{\Sigma=2.00}SiO_6$.

Occurrence: As inclusions in stream cobbles of peraluminous volcanic glass.

Association: Quartz, andalusite, sillimanite, potassic feldspar, biotite, spinel.

Distribution: From near Macusani, Puno Department, Peru.

Name: In honor of Professor Virgil Everett Barnes (1903–), University of Texas, Austin, Texas, USA, prominent worker on tektites, impactites, and other natural glasses.

Type Material: National Museum of Natural History, Washington, D.C., USA, Meteorite Collection, 2143-17.

References: (1) French, B.M., P.A. Jezek, and D.E. Appleman (1978) Virgilite: a new lithium aluminum silicate mineral from the Macusani glass, Peru. Amer. Mineral., 63, 461–465.

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Viséite $Ca_{10}Al_{24}(SiO_4)_6(PO_4)_{14}(O,F)_{13}\cdot 72H_2O(?)$

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Crystal Data: Cubic or pseudocubic. *Point Group:* n.d. As a botryoidal coating, consisting of concentric layers of tiny spherulites; also massive.

Physical Properties: *Tenacity:* Friable. Hardness = 3–4 D(meas.) = 2.20 D(calc.) = 2.17

Optical Properties: Transparent to translucent. *Color:* White, pale yellow, pale blue, blue; in transmitted light, colorless. *Luster:* Vitreous, chalky.
Optical Class: Isotropic. $n = 1.530$

Cell Data: *Space Group:* n.d. a = 13.65 Z = [1]

X-ray Powder Pattern: Visé, Belgium.
2.92 (100), 1.740 (60), 3.46 (50), 5.68 (40), 1.886 (30), 2.20 (20), 1.196 (20)

Chemistry:

	(1)	(2)	(3)
SiO_2	9.93	7.97	8.13
Al_2O_3	26.15	26.82	27.59
FeO		0.74	
MnO		0.01	
MgO		0.12	
CaO	14.79	12.53	12.64
Na_2O	1.77	0.02	
K_2O		0.14	
F	0.67	1.29	
H_2O	26.11	[28.28]	29.24
P_2O_5	20.49	21.54	22.40
$-O = F_2$	[0.28]	[0.54]	
Total	[99.63]	[100.00]	100.00

(1) Visé, Belgium; average of four analyses, original total given as 99.91%; probably contained admixed "opal." (2) Do.; by electron microprobe, average of seven analyses, H_2O by difference. (3) $Ca_{10}Al_{24}(SiO_4)_6(PO_4)_{14}O_{13}\cdot 72H_2O$.

Occurrence: Presumably as a secondary mineral in phosphatic sedimentary rocks, and from the weathering or low-temperature hydrothermal alteration of aluminous skarn deposits.

Association: Delvauxite, trolleite, "opal."

Distribution: From Visé, Liège, Belgium. In the USA, at the Champion mine, near Laws, Mono Co., California.

Name: For the locality where the mineral was discovered, Visé, Belgium.

Type Material: University of Liège, Liège, Belgium, 9574–9476; National Museum of Natural History, Washington, D.C., USA, 106364.

References: (1) Mélon, J. (1943) La viséite, nouvelle espèce minérale. Ann. Soc. Geol. Belg., 66, 53–56 (in French). (2) (1945) Amer. Mineral., 30, 548 (abs. ref. 1). (3) McConnell, D. (1952) Viséite, a zeolite with the analcime structure and containing linked SiO_2, PO_4 and H_xO_4 groups. Amer. Mineral., 37, 609–617. (4) Dunn, P.J. and D.E. Appleman (1977) Perhamite, a new calcium aluminum silico-phosphate mineral, and a re-examination of viséite. Mineral. Mag., 41, 437–442.

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Vishnevite $(Na, Ca, K)_6(Si, Al)_{12}O_{24}[(SO_4), (CO_3), Cl_2]_{2-4} \cdot nH_2O$

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Crystal Data: Hexagonal. *Point Group:* 6. As prismatic crystals and irregular granular masses.

Physical Properties: *Cleavage:* Perfect on $\{10\bar{1}0\}$, poor on {0001}. Hardness = 5–6 D(meas.) = 2.32–2.42 D(calc.) = 2.37

Optical Properties: Transparent to translucent. *Color:* Pale lilac, light blue to dark gray. *Optical Class:* Uniaxial (–). ω = 1.490–1.507 ϵ = 1.488–1.495

Cell Data: *Space Group:* $P6_3$. a = 12.685(6) c = 5.179(1) Z = 1

X-ray Powder Pattern: Russia.
3.273 (100), 3.695 (88), 2.769 (65), 4.742 (50), 2.649 (28), 2.101 (27), 6.4 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	37.24	34.76	K_2O	4.89	1.29
Al_2O_3	29.64	30.81	H_2O^+		2.30
CaO	0.52	3.87	H_2O^-		0.20
SrO		0.32	CO_2		1.90
Na_2O	20.08	18.90	SO_3	6.97	5.93
			Total	[99.34]	100.28

(1) Vishnevy Mountains, Russia; by electron microprobe, original total given as 99.35%; corresponds to $(Na_{6.47}K_{1.04}Ca_{0.09})_{\Sigma=7.60}(Si_{6.19}Al_{5.81})_{\Sigma=12.00}O_{24}(SO_4)_{0.87}$. (2) Allt a' Mhuillin, Scotland; corresponds to $(Na_{6.19}Ca_{0.70}K_{0.28}Sr_{0.03})_{\Sigma=7.20}(Si_{5.87}Al_{6.13})_{\Sigma=12.00}O_{23.71}[(SO_4)_{0.75}(CO_3)_{0.44}]_{\Sigma=1.19} \cdot 1.41H_2O$.

Mineral Group: Cancrinite group.

Occurrence: In poikilitic aegirine-nepheline-sodalite syenites and associated pegmatites.

Association: Aegirine, nepheline, cancrinite, sodalite, scolecite.

Distribution: From the Kurochkin Valley, Vishnevy-Ilmen Mountains, Southern Ural Mountains; on Mts. Karnasurt and Alluaiv and along the Chinglusuai River, Lovozero massif, and in the Kovdor massif, Kola Peninsula; the Synnyrskii massif, north Pribaikal, and elsewhere in Russia. From Allt a' Mhuillin, Loch Borralan, Scotland. On Alnö Island, Sweden. In the Gardiner complex, beyond the head of Kangerdlugssuaq Fjord, Greenland. On the Oldoinyo Lengai volcano, Tanzania. Along Beaver Creek, Iron Hill, Gunnison Co., Colorado, USA.

Name: For the locality in the Vishnevy Mountains, Russia.

Type Material: n.d.

References: (1) Belyankin, D.S. (1931) Zur Mineralogie und Chemie eines Feldspatvertreters aus der "Wischnewy Gory" [Vishnevy Mountains] (Ural). Centr. Min., Abt. A, 190–196 (in German). (2) (1931) Mineral. Abs., 4, 499 (abs. ref. 1). (3) Stewart, F.H. (1941) On sulphatic cancrinite and analcime (eudnophite) from Loch Borolan, Assynt. Mineral. Mag., 26, 1–8. (4) Belyankin, D.S. (1944) Vishnevite, and not sulphatic cancrinite. Doklady Acad. Nauk SSSR, 42, 304–306 (in Russian). (5) (1946) Mineral. Abs., 9, 310 (abs. ref. 4). (6) Hassan, I. and H.D. Grundy (1984) The character of the cancrinite–vishnevite solid-solution series. Can. Mineral., 22, 333–340. (7) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 4, framework silicates, 310–320. (8) Pushcharovskii, D.Y., N.A. Yamnova, and A.P. Khomyakov (1989) Crystal structure of high-potassium vishnevite. Kristallografiya (Sov. Phys. Crystal.), 34, 67–70 (in Russian). (9) Sosedko, T.A., B.K. Kasatov, L.N. Furmakova, and E.A. Lipatova (1989) New data on cancrinite–vishnevite group minerals. Zap. Vses. Mineral. Obshch., 118(5), 78–84 (in Russian with English abs.). (10) (1990) Mineral. Abs., 41, 341 (abs. ref. 9).

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Vismirnovite $ZnSn^{4+}(OH)_6$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. [Massive.]

Physical Properties: Hardness = 3.9 VHN = 173 D(meas.) = n.d. D(calc.) = 4.073

Optical Properties: Semitransparent. *Color:* Pale yellow; dark gray in reflected light.
Luster: Vitreous.
Optical Class: Isotropic. $n = 1.735$

Cell Data: *Space Group: Pn3m.* a = 7.72(2) Z = 4

X-ray Powder Pattern: Mushiston deposit, Tajikistan.
3.840 (10), 1.728 (9), 1.570 (8), 2.217 (7), 1.031 (6), 1.117 (5), 1.287 (4)

Chemistry:

	(1)	(2)
Sn	41.8	41.49
Fe	0.9	
Cu	0.3	
Zn	20.45	22.85
OH	36.0	35.66
Total	99.5	100.00

(1) Mushiston deposit, Tajikistan; by electron microprobe, average of six analyses; corresponding to $(Zn_{0.89}Fe_{0.08}Cu_{0.01})_{\Sigma=0.98}Sn_{1.00}(OH)_{6.04}$. (2) $ZnSn^{4+}(OH)_6$.

Mineral Group: Schoenfliesite group.

Occurrence: Formed by oxidation of earlier tin sulfides in tin deposits.

Association: Stannite, natanite, malachite, azurite, goethite (Mushiston deposit, Tajikistan).

Distribution: In the Trudovoye tin deposit, Inyl'chek Mountains, eastern Kyrgyzstan. From the Mushiston tin deposit, Kaznok Valley, Zeravshan Mountains, 35 km south of Pendzhikent, Tajikistan.

Name: Honors Academician Vladimir Ivanovich Smirnov (1910–1988), Moscow University, Moscow, Russia, an early investigator of tin deposits in Central Asia.

Type Material: Mining Institute, St. Petersburg, 1997/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81651.

References: (1) Marshukova, N.K., A.B. Palovskii, G.A. Sidorenko, and N.I. Chistyakova (1981) Vismirnovite, $ZnSn(OH)_6$, and natanite, $FeSn(OH)_6$, new tin minerals. Zap. Vses. Mineral. Obshch., 110, 492–500 (in Russian). (2) (1982) Amer. Mineral., 67, 1077 (abs. ref. 1). (3) (1982) Mineral. Abs., 33, 170 (abs. ref. 1). (4) Cohen-Addad, C. (1967) Étude des hydroxystannates $CaSn(OH)_6$ et $ZnSn(OH)_6$ par diffraction des rayons X et résonance magnétique nucléaire. Bull. Soc. fr. Minéral., 90, 32–35 (in French with English abs.).

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Vistepite $Mn_5^{2+}SnB_2Si_5O_{20}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As thin platelets, to 0.02 mm, intergrown with an unknown manganese silicate, in radial aggregates, up to 1.5 cm. *Twinning:* Polysynthetic.

Physical Properties: *Cleavage:* Perfect in three directions. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 3.67(5) D(calc.) = 3.70

Optical Properties: Transparent. *Color:* Yellow-orange. *Streak:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Dispersion:* $r > v$, strong. $\alpha = 1.696(3)$ $\beta = 1.711(5)$ $\gamma = 1.715(5)$ 2V(meas.) = 57(3)° 2V(calc.) = 54.3°

Cell Data: *Space Group:* $P2/m$. $a = 28.77(1)$ $b = 7.01(2)$ $c = 13.72(2)$ $\beta = 96.6(2)°$ Z = 7

X-ray Powder Pattern: Inyl'chek Mountains, Kyrgyzstan.
2.83 (10), 2.81 (10), 3.41 (8), 3.22 (8), 2.24 (7), 1.750 (6), 1.703 (5)

Chemistry:

	(1)
SiO_2	33.78
SnO_2	17.60
B_2O_3	7.98
Al_2O_3	0.66
FeO	0.44
MnO	39.40
CaO	0.66
Total	100.52

(1) Inyl'chek Mountains, Kyrgyzstan; by electron microprobe, B confirmed by a colorimetric method; corresponding to $(Mn_{4.84}Ca_{0.10}Fe_{0.05})_{\Sigma=4.99}Sn_{1.02}B_{2.00}(Si_{4.90}Al_{0.11})_{\Sigma=5.01}O_{20}$.

Occurrence: In a rhodonite vein in biotite-quartz hornfels at the margin of a tin-bearing granite massif.

Association: Rhodonite, quartz, tephroite, spessartine, galena, hübnerite, chalcopyrite, sphalerite, stannite, rhodochrosite, cassiterite, celsian, fluorite, helvite, neotocite, schorl, pyrite, pyrophanite.

Distribution: From Muzeinyi Sai [Museum Valley], near the Trudovye tin deposit, Inyl'chek Mountains, eastern Kyrgyzstan.

Name: For the mineralogist and systematic mineral collector Victor Ivanovich Stepanov (1924–1988), A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

Type Material: Il'menskii Preserve Museum, Miass; Vernadsky Geological Museum, Moscow, 57721; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 88595.

References: (1) Pautov, L.A., D.I. Belakovskii, R. Scala, E.V. Sokolova, K.I. Ignatenko, and A.V. Mokhov (1992) Vistepite $Mn_5SnB_2Si_5O_{20}$ – a new borosilicate of manganese and tin. Zap. Vses. Mineral. Obshch., 121(4), 107–112 (in Russian). (2) (1994) Amer. Mineral., 79, 1013 (abs. ref. 1). (3) (1994) Mineral. Abs., 45, 241 (abs. ref. 1).

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Vitusite-(Ce) $Na_3(Ce, La, Nd)(PO_4)_2$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $mm2$. Crystals prismatic, to 5 mm, elongated along [001], showing {100}, {010}, {110}, {120}, {210}, {101}; granular, and in fine-grained aggregates. *Twinning:* Common, on {160}, forming cross triplets, and on {120}, forming combined cross doublets; composition planes may be {130}, {140}, and {1.11.0}.

Physical Properties: *Cleavage:* On {100}, {010}, {001}, good. Hardness = 4.5
D(meas.) = 3.60–3.70 D(calc.) = [3.63]

Optical Properties: Transparent. *Color:* White, pale pink, pale green, pale yellow, pinkish tan, gray, black; colorless in thin section. *Luster:* Vitreous, may be greasy.
Optical Class: Biaxial (–). *Orientation:* $X = a$; $Y = b$; $Z = c$. α = 1.602–1.604
β = 1.646–1.650 γ = 1.649–1.654 2V(meas.) = 28.5°–30°

Cell Data: *Space Group:* $Pc2_1b$. $a = 5.3356(8)$ $b = 18.6722(9)$ $c = 14.0546(9)$ Z = 8

X-ray Powder Pattern: Ilímaussaq intrusion, Greenland.
2.811 (10), 2.801 (10), 6.580 (9), 4.665 (9), 4.634 (9), 3.512 (9), 2.690 (9)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	36.27	36.50	Pr_2O_3	1.24	1.13
SiO_2	0.25	0.15	Nd_2O_3	4.39	4.33
La_2O_3	15.56	12.20	CaO	0.92	4.75
Ce_2O_3	19.95	16.50	Na_2O	23.15	22.50
			Total	101.73	98.06

(1) Ilímaussaq intrusion, Greenland; by electron microprobe, corresponds to $(Na_{2.92}Ca_{0.06})_{\Sigma=2.98}(Ce_{0.47}La_{0.38}Nd_{0.10}Pr_{0.03})_{\Sigma=0.98}[(PO_4)_{2.00}(SiO_4)_{0.01}]_{\Sigma=2.01}$. (2) Mt. Sengischorr, Kola Peninsula, Russia; by electron microprobe, corresponds to $(Na_{2.83}Ca_{0.33})_{\Sigma=3.16}(Ce_{0.39}La_{0.29}Nd_{0.10}Pr_{0.03})_{\Sigma=0.81}[(PO_4)_{2.00}(SiO_4)_{0.01}]_{\Sigma=2.01}$.

Occurrence: An alteration product of steenstrupine in differentiated alkalic massifs (Ilímaussaq massif; Kola Peninsula, Russia); in sodalite xenoliths associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Steenstrupine, aegirine, analcime, lovozerite, sphalerite, villiaumite, arfvedsonite, albite, microcline, nepheline, sodalite (Ilímaussaq intrusion, Greenland); steenstrupine, belovite-(Ce), neptunite, leucosphenite, sazhinite-(Ce) (Jubilee pegmatite, Kola Peninsula, Russia); vuonnemite, sodalite, eudialyte, steenstrupine, kogarkoite, sidorenkite, rasvumite (Mont Saint-Hilaire, Canada).

Distribution: From Kvanefjeld, Ilímaussaq intrusion, southern Greenland. In the Jubilee pegmatite, on Mt. Karnasurt, and on Mt. Sengischorr, Lovozero massif; on Mts. Rasvumchorr and Koashva, Khibiny massif, Kola Peninsula, Russia. At Mont Saint-Hilaire, Quebec, Canada.

Name: To honor Vitus Bering (1681–1741), Danish-Russian explorer of the Arctic seas, and the dominant rare earth, *cerium*.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5544; Mining Institute, St. Petersburg, Russia, 1209/1; University of Copenhagen, Copenhagen, Denmark; National School of Mines, Paris, France; The Natural History Museum, London, England, 1994,36.

References: (1) Rønsbo, J.G., A.P. Khomyakov, E.I. Semenov, A.A. Voronkov, and V.K. Garanin (1979) Vitusite – a new phosphate of sodium and rare earths from the Lovozero alkaline massif, Kola, and the Ilímaussaq alkaline intrusion, South Greenland. Neues Jahrb. Mineral., Abh., 137, 42–53. (2) (1980) Amer. Mineral., 65, 812 (abs. ref. 1). (3) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 284–359, esp. 345–346. (4) Finch, A.A. and J.G. Fletcher (1992) Vitusite – an apatite derivative structure. Mineral. Mag., 56, 235–239. (5) Mazzi, F. and L. Ungaretti (1994) The crystal structure of vitusite from Ilímaussaq (South Greenland): $Na_3REE(PO_4)_2$. Neues Jahrb. Mineral., Monatsh., 49–66.

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Vivianite $Fe_3^{2+}(PO_4)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, to 1.3 m; flattened on [100] or [010], somewhat elongated along [100], many modifying forms, dominated by {100}, [010}, may be rounded or corroded; stellate groups, incrustations, concretionary, earthy, powdery. *Twinning:* Translation gliding T(010), t[001].

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Fibrous. *Tenacity:* Flexible, sectile. Hardness = 1.5–2 D(meas.) = 2.68(1) D(calc.) = 2.69

Optical Properties: Transparent to translucent. *Color:* Colorless, very pale green, with oxidation becoming dark blue, dark greenish blue, Indigo-blue, then black; colorless to blue in transmitted light. *Streak:* White, altering to dark blue, brown. *Luster:* Vitreous, pearly on the cleavage, dull when earthy.
Optical Class: Biaxial (+). *Pleochroism:* X = blue, deep blue, Indigo-blue; Y = pale yellowish green, pale bluish green, yellow-green; Z = pale yellowish green, olive-yellow. *Orientation:* $X = b$; $Z \wedge c = 28.5°$. *Dispersion:* $r < v$, weak. $\alpha = 1.579$–1.616 $\beta = 1.602$–1.656 $\gamma = 1.629$–1.675 2V(meas.) = 63.5°-83.5°

Cell Data: *Space Group:* $C2/m$. $a = 10.034$–10.086 $b = 13.434$–13.441 $c = 4.687$–4.714 $\beta = 102.65°-104.27°$ Z = 2

X-ray Powder Pattern: Synthetic.
6.73 (100), 3.210 (16), 7.93 (13), 4.90 (12), 4.081 (12), 2.985 (10), 2.728 (9)

Chemistry:

	(1)	(2)
P_2O_5	27.17	28.30
SiO_2	0.10	
FeO	44.10	42.97
H_2O	27.95	28.73
Total	99.32	100.00

(1) Cantwell's Bridge, New Castle Co., Delaware, USA. (2) $Fe_3(PO_4)_2 \cdot 8H_2O$.

Mineral Group: Vivianite group.

Occurrence: A secondary mineral in the oxidized zone of metallic ore deposits and complex granite pegmatites; replacing organic material in fossil bones, lake sediments, and in bog-iron ores and peat bogs; rarely in caves.

Association: Metavivianite, ludlamite, pyrite, pyrrhotite.

Distribution: Numerous localities, even for well-crystallized material. In England, from [Wheal Kind,] St. Agnes, and other mines in St. Just and Kea, Cornwall. At Hagendorf, Bavaria, Germany. From the Stari Trg mine, Trepča, Serbia. On the Taman Peninsula, Russia. Around Kerch, Crimean Peninsula, Ukraine. Huge crystals from Anloua, near Ngaoundéré, Cameroon. In the USA, from the Blackbird Mine, Lemhi Co., Idaho; in the Treece and Ibex mines, Leadville, Lake Co., Colorado; at the Bingham Canyon mine, Salt Lake Co., Utah; from Richmond, Henrico Co., Virginia; at the Foote mine, Kings Mountain, Cleveland Co., North Carolina. In Mexico, from Santa Eulalia, Chihuahua. In Brazil, from the Énio pegmatite mine, northeast of Galiléia, Minas Gerais. Exceptional examples from Bolivia, as at Poopo, Llallagua, Avicaya, Tazna, Monserrat, Morococala, Tatasi, and elsewhere. In the Ashio mine, Tochigi Prefecture, Japan.

Name: Honoring John Henry Vivian (1785–1855), Welsh-Cornish mineralogist, of Truro, Cornwall, England, who discovered the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 742–746. (2) Fejdi, P., J.-F. Poullen, and M. Gasperin (1980) Affinement de la structure de la vivianite $Fe_3(PO_4)_2 \cdot 8H_2O$. Bull. Minéral., 103, 135–138 (in French with English abs.). (3) Rodgers, K.A., H.W. Kobe, and C.W. Childs (1993) Characterization of vivianite from Catavi, Llallagua, Bolivia. Mineral. Petrol., 47, 193–208. (4) (1979) NBS Mono. 25, 16, 38.

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Vladimirite $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 5H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Acicular crystals, in cross-fiber veinlets and spherulites, to 1 mm. *Cleavage:* One, good.

Physical Properties: Hardness = 3.5 D(meas.) = 3.12–3.21 D(calc.) = 3.17

Optical Properties: Translucent. *Color:* Pale rose to colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Z \wedge c = 37°$. *Dispersion:* $r > v$, strong. $\alpha = 1.650$ $\beta = 1.654$ $\gamma = 1.661$ 2V(meas.) = 70°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.81$ $b = 10.19$ $c = 22.7$ $\beta = 82°41'$ Z = 3

X-ray Powder Pattern: Tuva, Russia.
4.09 (10), 2.78 (10), 3.01 (6), 1.853 (6), 3.27 (5), 2.56 (5), 2.11 (5)

Chemistry:

	(1)	(2)	(3)
As_2O_5	53.44	52.1	54.20
MgO	0.00		
CaO	33.65	33.2	33.06
H_2O	12.63	12.1	12.74
Total	99.72	97.4	100.00

(1) Tuva, Russia. (2) Irhtem mine, Morocco. (3) $Ca_5(AsO_4)_2(AsO_3OH)_2 \cdot 5H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of arsenic-bearing mineral deposits.

Association: Picropharmacolite, erythrite, aragonite (Tuva, Russia).

Distribution: From the Vladimirovskoye cobalt deposit, Altai Mountains, and the Khovu-Aksy Ni–Co deposit, Tuva, Siberia, Russia. In the Bauhaus district, Richelsdorf Mountains, Hesse, Germany. From the Irhtem (Ightem) mine, Bou Azzer district, Morocco. In the USA, at the Mohawk mine, Keweenaw Co., Michigan.

Name: For its first-noted occurrence in the Vladimirovskoye deposit, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1220/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 57263.

References: (1) Nefedov, Y.I. (1953) [Report on new minerals] in: V.A. Mokievsky, The scientific session of the Federov Institute together with the All-Union Mineralogical Society. Zap. Vses. Mineral. Obshch., 82, 311–317 (in Russian). (2) (1955) Amer. Mineral., 40, 551 (abs. ref. 1). (3) Pierrot, R. (1964) Contribution à la minéralogie des arséniates calciques et calcomagnésien naturels. Bull. Soc. fr. Minéral., 87, 169–211 (in French). (4) Yakhontova, L.K. and T.I. Stolyarova (1970) New data on vladimirite. Zap. Vses. Mineral. Obshch., 99, 362–364 (in Russian). (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 230.

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Vladimirivanovite $Na_6Ca_2[Al_6Si_6O_{24}](SO_4,S_3,S_2,Cl)_2 \cdot H_2O$

Crystal Data: Orthorhombic. *Point Group:* 2/*m* 2/*m* 2/*m*. As rims around lazurite to 3 mm thick, as veinlets in lazurite or in granular aggregates to 4 mm, rarely to 2 cm.

Physical Properties: *Cleavage:* Distinct on {010}. *Fracture:* Stepped. *Tenacity:* Brittle. Hardness = 5-5.5 VHN = 575 (50 g load) D(meas.) = 2.48(3) D(calc.) = 2.436

Optical Properties: Translucent. *Color:* Dark blue to ink-blue, light blue or greenish-blue. *Streak:* Blue. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (-). α = 1.502-1.507 β = 1.509-1.514 γ = 1.512-1.517
2V(meas) = 63(1)° 2V(calc) = 66° *Pleochroism:* Light to dark blue. *Absorption:* Z = Y > X.

Cell Data: *Space Group: Pnaa*. a = 9.053(3) b = 12.837(3), c = 38.445(10) Z = 6

X-ray Powder Pattern: Tultuy deposit, Irkutsk region, Russia.
3.71 (100), 2.623 (30), 2.141 (14), 2.875 (12), 6.43 (11), 1.783 (9), 2.428 (6)

Chemistry:

	(1)
SiO_2	32.59
Al_2O_3	27.39
CaO	7.66
Na_2O	17.74
K_2O	<0.04
SO_3	11.37
S	1.94
Cl	0.12
H_2O	1.0
-O = Cl	0.03
-O = S	0.16
Total	99.62

(1) Tultuy deposit, Irkutsk region, Russia; average of 15 electron microprobe analyses, H_2O by TGA, S by wet chemistry, S_3^- radical confirmed by Raman spectra; corresponding to $Na_{6.36}Ca_{1.52}(Si_{6.03}Al_{5.97})_{\Sigma=12}O_{23.99}(SO_4)_{1.58}(S_3)_{0.17}(S_2)_{0.08}Cl_{0.04} \cdot 0.62H_2O$.

Mineral Group: Sodalite group.

Occurrence: In highly metamorphosed rocks of granulite facies at the contacts of dolomitic marbles with granites.

Association: Lazurite, calcite, afhganite, tounkite, phlogopite, marialite.

Distribution: From the Lyajvardara lazurite deposit, South-Western Pamir, Tajikistan; at the Tultuy lazurite deposit, South-West of Lake Baikal, Irkutsk region, Russia.

Name: Honors Russian mineralogist and geochemist Vladimir Georgievich Ivanov (1947-2002).

Type Material: Mineralogical Museum, Saint Petersburg State University, Russia.

References: (1) Sapozhnikov, A.N., E.V. Kaneva, D.I. Cherepanov, L.F. Suvorova, V.I. Levitsky, L.A. Ivanova, and L.Z. Reznitsky (2011) Vladimirivanovite, $Na_6Ca_2[Al_6Si_6O_{24}](SO_4,S_3,S_2,Cl)_2 \cdot H_2O$ - a new mineral of the sodalite group. Zap. Ross. Mineral. Obshch., 140(5), 36-45 (in Russian, English abstract). (2) (2013) Amer. Mineral., 98, 814-815 (abs. ref. 1).

Vlasovite $Na_2ZrSi_4O_{11}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In crystals, to 15 cm; more commonly as subrounded to irregularly shaped grains and aggregates of such grains. *Twinning:* Twin plane {010}, uncommon.

Physical Properties: *Cleavage:* {010}, good; {$h0l$}, poor. *Fracture:* Uneven to conchoidal. Hardness = 6 VHN = 770 D(meas.) = 2.92–2.97 D(calc.) = [3.07] Altered portions fluoresce brownish yellow under SW UV.

Optical Properties: Transparent. *Color:* Colorless, pink, pale brown, silvery; in transmitted light, colorless. *Luster:* Greasy; highly vitreous to pearly on cleavage surfaces.
Optical Class: Biaxial (–). *Dispersion:* $r > v$, distinct. $\alpha = 1.605(3)$ $\beta = 1.623(3)$ $\gamma = 1.625(3)$ 2V(meas.) = 40°–56°

Cell Data: *Space Group:* $C2/c$. $a = 10.98(4)$ $b = 10.00(4)$ $c = 8.52(3)$ $\beta = 100°24'$ Z = 4

X-ray Powder Pattern: Kipawa River, Canada.
5.053 (100), 3.669 (75), 3.882 (45), 3.237 (40), 3.363 (35), 3.548 (25), 1.945 (20)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	55.76	56.57	CaO	0.49	0.41
TiO_2	trace		Na_2O	14.03	14.38
ZrO_2	28.11	28.14	K_2O	0.68	0.15
Al_2O_3	0.20		F	0.20	
Fe_2O_3	0.10		H_2O^+	0.32	
Nb_2O_5	0.33		H_2O^-	0.09	
FeO	0.00		LOI		0.11
MnO	trace		$-O = F_2$	0.08	
MgO	0.06	0.23	Total	100.29	99.99

(1) Mt. Vavnbed, Russia; ZrO_2 includes HfO_2 1.7%; corresponds to $(Na, K, Ca)_{2.00}Zr_{0.96}Si_{3.91}O_{11}$.
(2) Ascension Island; corresponds to $(Na, K, Ca)_{2.02}Zr_{0.97}Si_{4.01}O_{11}$.

Polymorphism & Series: May invert to triclinic symmetry below 29 °C.

Occurrence: A late phase in nepheline syenites, syenitic pegmatites, and along the contact zone of a differentiated alkalic massif (Lovozero massif, Russia); in miarolitic cavities in ejected blocks of peralkalic granite (Ascension Island).

Association: Eudialyte, microcline, albite, lorenzenite, arfvedsonite, magnesio-katophorite, aegirine, aenigmatite, fayalite, pyrochlore, apatite, fluorite.

Distribution: In Russia, from near Mt. Vavnbed, Lovozero massif, Kola Peninsula; and in the Burpala massif, about 120 km north of Lake Baikal, eastern Siberia. Large crystals from the [Sheffield Lake complex,] Kipawa River, Villedieu Township, Quebec, Canada. On Green Mountain, Ascension Island, southern Atlantic Ocean.

Name: In honor of the Russian mineralogist and geochemist Kuz'ma Alekseevich Vlasov (1905–1964), founder of the Institute of Mineralogy, Geochemistry, and Crystal Chemistry of Rare Elements, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1037/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 83207, vis5052; National School of Mines, Paris, France.

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References: (1) Tikhonenkova, R.P. and M.E. Kazakova (1961) Vlasovite, a new zirconium silicate from the Lovozero massif. Doklady Acad. Nauk SSSR, 137, 944–946 (in Russian). (2) (1961) Amer. Mineral., 46, 1202–1203. (abs. ref. 1). (3) Fleet, S.G. and J.R. Cann (1967) Vlasovite: a second occurrence and a triclinic to monoclinic inversion. Mineral. Mag., 36, 233–241. (4) Gittins, J., E.L. Gasparrini, and S.G. Fleet (1973) The occurrence of vlasovite in Canada. Can. Mineral., 12, 211–214. (5) Voronkov, A.A., T.A. Zhdanova, and Y.A. Pyatenko (1974) Refinement of the structure of vlasovite $Na_2ZrSi_4O_{11}$ and some characteristics of the composition and structure of zirconosilicates. Kristallografiya (Sov. Phys. Crystal.), 19, 252–259 (in Russian).

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Vlodavetsite $Ca_2Al(SO_4)_2F_2Cl\cdot 4H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Square to rectangular, tabular to scaly crystals, to 0.3 mm, showing {001}, {100}; commonly fine-grained massive.

Physical Properties: *Cleavage:* On {100}, perfect. *Tenacity:* Plastic in masses. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.10–2.35

Optical Properties: Semitransparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Uniaxial (+). $\omega = 1.509(2)$ $\epsilon = 1.526(3)$

Cell Data: *Space Group:* $I4/m$. $a = 6.870(1)$ $c = 13.342(2)$ Z = 2

X-ray Powder Pattern: Tolbachik volcano, Kamchatka, Russia.
3.431 (100), 3.335 (80), 6.67 (60), 3.922 (50), 3.729 (40), 3.052 (40), 2.483 (40)

Chemistry:

	(1)	(2)
SO_3	35.97	36.00
Al_2O_3	12.37	11.46
CaO	25.11	25.22
F	8.1	8.54
Cl	6.08	7.97
H_2O	16.10	16.20
$-O = (F, Cl)_2$	4.78	5.39
Total	98.95	100.00

(1) Tolbachik volcano, Kamchatka, Russia; by electron microprobe, average of 11 analyses, F and Cl by wet methods, H_2O calculated from stoichiometry; corresponds to $Ca_{2.00}Al_{1.09}(SO_4)_{2.01}F_{1.94}Cl_{0.77}\cdot 4H_2O$. (2) $Ca_2Al(SO_4)_2F_2Cl\cdot 4H_2O$.

Occurrence: A product of low-temperature hydration of minerals on the fracture walls of volcanic fumaroles.

Association: Gypsum, sellaite, bischofite, hydrophilite, spinel.

Distribution: From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Vladimir Ivanovich Vlodavets (1893–1993), volcanologist who founded the Kamchatka volcanological station.

Type Material: Mining Institute, St. Petersburg, Russia, 2078/1.

References: (1) Vergasova, L.P., S.K. Filatov, G.L. Starova, G.L. Matusevich, and T.M. Filasova (1995) Vlodavetsite $AlCa_2(SO_4)_2F_2Cl\cdot 4H_2O$ – a new mineral from volcanic exhalations. Doklady Acad. Nauk SSSR, 343, 358–360 (in Russian). (2) Starova, G.L., S.K. Filatov, G.L. Matusevich, and V.S. Fundamensky (1995) The crystal structure of vlodavetsite, $AlCa_2(SO_4)_2F_2Cl\cdot 4H_2O$. Mineral. Mag., 59, 159–162. (3) (1996) Amer. Mineral., 81, 768 (abs. refs. 1–2).

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Vochtenite $(Fe^{2+},Mg)Fe^{3+}(UO_2)_4(PO_4)_4(OH)\cdot 12{-}13H_2O$

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Crystal Data: Monoclinic. *Point Group:* n.d. As crystals, with a squarish outline defined by {001} and {100}, to 1 mm, in subparallel aggregates.

Physical Properties: *Cleavage:* On {010}, distinct. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = ∼2.5 D(meas.) = 3.650 D(calc.) = 3.663 Radioactive.

Optical Properties: Opaque, translucent in thin fragments. *Color:* Brown. *Streak:* Pale brown. *Luster:* Bronzy.
Optical Class: Biaxial (–). *Pleochroism:* Very weak. *Orientation:* $X = b$; $Z \wedge c$ = small.
$\alpha = 1.575(2)$ $\beta = 1.589(2)$ $\gamma = 1.603(2)$ 2V(meas.) = n.d. 2V(calc.) = 89(3)°

Cell Data: *Space Group:* n.d. $a = 12.606$ $b = 19.990$ $c = 9.990$ $\beta = 102.31°$ Z = 3

X-ray Powder Pattern: Wheal Basset, England.
9.998 (100), 3.475 (70), 3.333 (50), 4.892 (45), 2.152 (45), 2.111 (45), 3.087 (40)

Chemistry:

	(1)
UO_3	63.07
P_2O_5	15.65
Fe_2O_3	4.04
FeO	3.30
MgO	0.63
H_2O	13.37
Total	[100.06]

(1) Wheal Basset, England; by electron microprobe, at ten points on each of three crystals; Fe^{2+}:Fe^{3+} by Mössbauer spectroscopy, H_2O by TGA, original total given as 100.96%; corresponds to $(Fe^{2+}_{0.82}Mg_{0.28})_{\Sigma=1.10}Fe^{3+}_{0.90}(UO_2)_4(PO_4)_4(OH)_{0.90}\cdot 12.96H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a uranium-bearing Cu–Sn hydrothermal mineral deposit.

Association: Bassetite.

Distribution: From Wheal Basset, Illogan, Cornwall, England.

Name: Honoring Professor Renaud F.C. Vochten (1933–), State University, Antwerp, Belgium, uranium mineralogist, who discovered the mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA.

References: (1) Zwaan, P.C., C.E.S. Arps, and E. de Grave (1989) Vochtenite, $(Fe^{2+},Mg)Fe^{3+}[UO_2/PO_4]_4(OH)\cdot 12{-}13H_2O$, a new uranyl phosphate mineral from Wheal Basset, Redruth, Cornwall, England. Mineral. Mag., 53, 473–478. (2) (1990) Amer. Mineral., 75, 1212 (abs. ref. 1).

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Voggite $Na_2Zr(PO_4)(CO_3)(OH)\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Needlelike pseudohexagonal crystals, elongated along [010], showing {100}, {$\bar{1}$01}, {001}, to 1 mm, in hairlike mats.

Physical Properties: *Cleavage:* {010}, poor. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.70(2) D(calc.) = 2.704 Blue cathodoluminescence under the electron beam.

Optical Properties: Transparent to translucent. *Color:* Colorless to white. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge a = 22°$. *Dispersion:* $r \ll v$, strong.
$\alpha = 1.569(1)$ $\beta = 1.594(1)$ $\gamma = 1.622(1)$ 2V(meas.) = 81(5)° 2V(calc.) = 88°

Cell Data: *Space Group:* $I2/m$. $a = 12.261(2)$ $b = 6.561(1)$ $c = 11.757(2)$
$\beta = 116.19(2)°$ Z = 4

X-ray Powder Pattern: Francon quarry, Canada.
10.2 (100), 5.58 (80), 3.89 (65), 4.06 (60), 3.281 (60), 2.546 (40), 2.039 (40)

Chemistry:

	(1)	(2)
P_2O_5	25.9	20.56
CO_2	12.	12.75
ZrO_2	43.3	35.69
Na_2O	7.4	17.95
H_2O	15.	13.05
Total	103.6	100.00

(1) Francon quarry, Canada; by electron microprobe, with severe decomposition; CO_2 and H_2O by TGA. (2) $Na_2Zr(PO_4)(CO_3)(OH)\cdot 2H_2O$ from crystal-structure analysis.

Occurrence: Very rare, in cavities in an altered amygdaloidal basalt dike intruding a zirconium-bearing silicocarbonatite sill in a limestone quarry.

Association: Dawsonite, calcite, quartz.

Distribution: Found in the Francon quarry, Montreal Island, Montreal, Quebec, Canada.

Name: Honoring Adolf Vogg (1931–), Canadian amateur mineralogist who collected the original specimens.

Type Material: Canadian Geological Survey, Ottawa, Canada, NMC 65631.

References: (1) Roberts, A.C., A.P. Sabina, T.S. Ercit, J.D. Grice, J.T. Szymański, and R.A. Ramik (1990) Voggite, a new hydrated Na–Zr hydroxide-phosphate-carbonate from the Francon quarry, Montreal, Quebec. Can. Mineral., 28, 155–159. (2) (1990) Amer. Mineral., 75, 1434 (abs. ref. 1). (3) Szymański, J.T. and A.C. Roberts (1990) The crystal structure of voggite, a new hydrated Na–Zr hydroxide-phosphate-carbonate mineral. Mineral. Mag., 54, 495–500.

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Voglite $Ca_2Cu(UO_2)(CO_3)_4 \cdot 6H_2O(?)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or 2. As rhombic tabular to scaly crystals, to 0.5 mm, in parallel stacked aggregates and coatings. *Twinning:* Lamellar, with extinction angles up to 30°.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 2.8 D(calc.) = 3.06 Radioactive.

Optical Properties: Transparent. *Color:* Emerald-green to bright grass-green. *Streak:* Pale green. *Luster:* Pearly on cleavages.
Optical Class: Biaxial (+). *Pleochroism:* X = deep blue to blue-green; Y = deep bluish green to bluish green; Z = pale yellow to yellow. *Orientation:* $X = b$; $Z \wedge c = 33°–36°$. *Dispersion:* $r < v$, very strong. $\alpha = 1.513–1.544$ $\beta = 1.525–1.547$ $\gamma = 1.542–1.564$
2V(meas.) = 60°

Cell Data: *Space Group:* $P2_1/m$ or $P2_1$ (probable). $a = 25.97–26.416$ $b = 23.702–24.50$ $c = 10.655–10.70$ $\beta = 103.63°–104.02°$ Z = 16

X-ray Powder Pattern: Jáchymov, Czech Republic.
12.6 (100), 8.70 (100), 9.65 (80), 7.10 (60), 4.32 (50), 6.13 (40), 4.65 (30)

Chemistry:

	(1)	(2)
CO_2	26.41	23.11
UO_3		37.54
UO_2	37.0	
CuO	8.40	10.44
CaO	14.09	14.72
H_2O	13.9	14.19
Total	99.8	100.00

(1) Jáchymov, Czech Republic; conversion from UO_2 gives UO_3 39.2% and a total of 102.0%; then corresponds to $Ca_{1.83}Cu_{0.77}(UO_2)_{1.00}(CO_3)_4 \cdot 6H_2O$. (2) $Ca_2Cu(UO_2)(CO_3)_4 \cdot 6H_2O$.

Occurrence: A rare oxidation product of uraninite.

Association: Liebigite, cuprosklodowskite, rösslerite, brassite, zellerite, uraninite (Jáchymov, Czech Republic).

Distribution: From the Eliáš mine, Jáchymov (Joachimsthal), Czech Republic. In the USA, at the White Canyon No. 1 mine, Frey Point, San Juan Co., Utah; and from a prospect near the Red Mesa Trading Post, Red Mesa district, Navajo Co., Arizona.

Name: Honors Josef Florian Vogl (1818–1896), Austrian mining officer and mineralogist, who studied the minerals of Jáchymov, Czech Republic and first described this species.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 237. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 126–128. (3) Piret, P. and M. Deliens (1979) New crystal data for Ca, Cu, UO_2 hydrated carbonate: voglite. J. Appl. Cryst., 12, 616.

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Volaschioite $Fe_4(SO_4)O_2(OH)_6 \cdot 2H_2O$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As radial clusters of bladed crystals to 0.1 mm, elongated along [010].

Physical Properties: *Cleavage:* Perfect on {100}. *Fracture:* n.d. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.03

Optical Properties: Transparent. *Color:* Yellowish-orange. *Streak:* Orange. *Luster:* Vitreous to resinous. *Optical Class:* n.d. *n* >1.68 *Pleochroism*: Strong; red [010], yellowish-orange (010).

Cell Data: *Space Group: C2/m*. a = 18.068(4) b = 3.058(1) c = 10.929(2) β = 93.82(3)° Z = 2

X-ray Powder Pattern: Fornovolasco, Apuan Alps, Tuscany, Italy.
8.03 (s), 4.37 (m), 3.989 (m), 3.343 (mw), 2.633 (mw), 3.028 (w), 2.73 (w)

Chemistry:

	(1)	(2)
Fe_2O_3	63.33	65.24
SO_3	14.07	16.36
H_2O	17.18	18.40
Total	94.58	100.00

(1) Fornovolasco, Apuan Alps, Tuscany, Italy; average of 11 electron microprobe analyses, H_2O and OH^- calculated from structure analysis; corresponding to $Fe_{4.16}(SO_4)_{0.92}O_{2.32}(OH)_6 \cdot 2H_2O$.
(2) $Fe_4(SO_4)O_2(OH)_6 \cdot 2H_2O$.

Occurrence: An oxidation product of pyrite in tunnels through a magnetite-pyrite deposit.

Association: Pyrite, fibroferrite, goethite, melanterite, römerite.

Distribution: Cava del Ferro mining complex, Fornovolasco, Apuan Alps, Tuscany, Italy.

Name: Derived from the ancient name for the first known locality, believed to be derived from *forno* (furnace) and *Volaschio* (a locally significant proper noun).

Type Material: Museum of Natural History, University of Pisa, Italy; 19300.

References: (1) Biagioni, C., E. Bonnaccorsi, and P. Orlandi (2011) Volaschioite, $Fe_4(SO_4)O_2(OH)_6 \cdot 2H_2O$, a new mineral species from Fornovolasco, Apuan Alps, Tuscany, Italy. Canadian Mineralogist, 49, 605-614. (2) (2013) Amer. Mineral., 98, 813-814 (abs. ref. 1).

Volborthite $Cu_3V_2O_7(OH)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* $2/m$. Typically as rosettelike aggregates of scaly crystals, which may have a hexagonal or triangular outline, to 5 mm.

Physical Properties: *Cleavage:* One, perfect. Hardness = 3.5 D(meas.) = 3.5–3.8 D(calc.) = 3.52

Optical Properties: Semitransparent. *Color:* Dark olive-green, green, yellowish green; green to yellowish green in transmitted light. *Luster:* Vitreous, oily, resinous, waxy, pearly on the cleavage.
Optical Class: Biaxial (–) or biaxial (+). *Pleochroism:* Faint. *Dispersion:* $r < v, r > v$, inclined. $\alpha = 1.820$–2.01 $\beta = 1.835$–2.05 $\gamma = 1.92$–2.07 2V(meas.) = 63°–83°

Cell Data: *Space Group:* $C2/m$. $a = 10.610(2)$ $b = 5.866(1)$ $c = 7.208(1)$ $\beta = 95.04(2)°$ Z = 2

X-ray Powder Pattern: Monument No. 1 mine, Arizona, USA.
7.16 (10), 2.643 (7), 2.571 (7), 2.389 (7), 4.103 (5), 3.090 (5), 2.998 (5)

Chemistry:

	(1)	(2)		(1)	(2)
V_2O_5	36.65	38.32	CuO	48.79	50.29
SiO_2	1.37		H_2O	[11.49]	11.39
V_2O_3	1.70		Total	[100.00]	100.00

(1) Scrava mine, Italy; by electron microprobe; V_2O_3 assumed for charge balance, H_2O by difference; corresponds to $Cu_{2.89}V^{5+}_{1.90}V^{3+}_{0.11}Si_{0.11}O_7(OH)_2 \cdot 2H_2O$. (2) $Cu_3V_2O_7(OH)_2 \cdot 2H_2O$.

Occurrence: An uncommon secondary mineral in the oxidized zone of vanadium-bearing hydrothermal mineral deposits.

Association: Brochantite, malachite, atacamite, tangeite, chrysocolla, barite, gypsum.

Distribution: In Russia, originally from an unknown locality; later identified at the Sofronovskii copper mine, near Perm, and at Syssersk and Nizhni Tagil, Ural Mountains. In Uzbekistan, in the Hodzha-Akhmet quarry, near Uch-Kuduk, Kyzylkum desert. From the Uzbekistana district, Fergana Valley, Alai Range, Kyrgyzstan. In the Scrava mine, Val Graveglia, Liguria, Italy. At the Blaby mine, Glen Parva, Leistershire, England. From Ronneburg, Thuringia, Germany. In the USA, at the Tennessee Queen mine, Richardson, near Thompson, Grand Co., and elsewhere in Utah; in the Radium No. 5 mine, San Juan No. 3 mine, and Cougar mine, Slick Rock district, San Miguel Co., and probably elsewhere in Colorado; from the Gold Quarry mine, near Carlin, Maggie Creek district, and in the Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co., Nevada; at the Monument No. 1 mine, Monument Valley, Navajo Co., Arizona; in the Green Monster mine, Inyo Co., California. At Menzies Bay, Vancouver Island, British Columbia, Canada. From the Luiswishi copper mine, Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). At Uris-Bobos, Namibia. There are additional minor localities.

Name: To honor Aleksandr Fedorovich von Volborth (1800–1876), Russian paleontologist, who first noticed the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 818–819. (2) Leonardsen, E.S. and O.V. Petersen (1974) The unit cell of volborthite. Amer. Mineral., 59, 372–373. (3) Basso, R., A. Palenzona, and L. Zefiro (1988) Crystal structure refinement of volborthite from Scrava mine (Eastern Liguria, Italy). Neues Jahrb. Mineral., Monatsh., 385–394. (4) Lafontaine, M.A., A. Le Bail, and G. Férey (1990) Copper-containing minerals – I. $Cu_3V_2O_7(OH)_2, 2H_2O$: the synthetic homolog of volborthite; crystal structure determination from X-ray and neutron data; structural correlations. J. Solid State Chem., 85, 220–227. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 231–232.

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Volkonskoite $Ca_{0.3}(Cr^{3+}, Mg, Fe^{3+})_2(Si, Al)_4O_{10}(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic, presumably. *Point Group:* n.d. Fine scaly to fibrous; massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1–2 D(meas.) = 2.11–2.36 D(calc.) = n.d. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent. *Color:* Bright to dark green, emerald-green; in transmitted light, emerald-green. *Luster:* Dull.
Optical Class: Biaxial (–). $\alpha = 1.551$–1.560 $\beta = 1.569$ $\gamma = 1.564$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	37.70	41.5	40.4	CaO	2.45	1.39	2.56
TiO_2	0.06	0.07	0.05	Na_2O		< 0.15	< 0.15
Al_2O_3	4.93	5.16	4.13	K_2O	0.10	0.15	0.21
Fe_2O_3	4.89	4.52	5.16	H_2O^+	20.19	16.83	16.75
Cr_2O_3	23.50	20.4	23.5	CO_2		1.94	2.60
FeO		0.40	0.1	P_2O_5		0.07	< 0.05
MnO	0.36	0.07	0.05	Total	100.97	[99.57]	101.46
MgO	6.79	7.07	5.95				

(1) Okhansk region, Russia. (2) Mt. Efimyatskaya, Russia; by XRF and TGA, Fe^{2+}:Fe^{3+} by Mössbauer spectroscopy, original total given as 99.73% with additional "carbonate carbon;" corresponds to $(Ca_{0.11}Mg_{0.11}Fe^{2+}_{0.03}K_{0.02})_{\Sigma=0.27}(Cr_{1.18}Mg_{0.78}Fe^{3+}_{0.29}Ca_{0.02})_{\Sigma=2.27}(Si_{3.50}Al_{0.51})_{\Sigma=4.01}O_{10}(OH)_2 \cdot 3.64H_2O$. (3) Okhansk region, Russia; do.; corresponds to $(Ca_{0.25}Mg_{0.05}K_{0.03}Fe^{2+}_{0.01}Mn_{0.01})_{\Sigma=0.35}(Cr_{1.07}Mg_{0.75}Fe^{3+}_{0.35})_{\Sigma=2.17}(Si_{3.59}Al_{0.43})_{\Sigma=4.02}O_{10}(OH)_2 \cdot 4.22H_2O$.

Mineral Group: Smectite group.

Occurrence: An epigenetic mineral in sandstones, conglomerates, and red beds, commonly filling voids from the decomposition of organic matter (Okhansk region, Russia); a weathering product of serpentinite (Gotse Delchev, Bulgaria).

Association: Chlorite, tridymite.

Distribution: On Mt. Efimyatskaya and elsewhere in the Okhansk region, middle Kama River area, Perm basin, Ural Mountains, Russia. In the Belgorod-Dnestrovskii (Akkerman) area, Ukraine. In Bulgaria, near Gotse Delchev (Nevrokop), Pirin Mountains.

Name: For Prince Petr Mikhailovich Volkonskii (1776–1852), Minister of the Imperial Court, Russia, patron of the natural sciences.

Type Material: National Museum of Natural History, Washington, D.C., USA, R4820, 16308.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 696–697. (2) Khoury, H.N., R.C. Mackenzie, J.D. Russell, and J.M. Tait (1984) An iron-free volkonskoite. Clay Minerals, 19, 43–57. (3) Foord, E.E., H.C. Starkey, J.E. Taggart, Jr., and D.R. Shawe (1987) Reassessment of the volkonskoite-chromium smectite nomenclature problem. Clays and Clay Minerals, 35, 139–149.

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Volkovskite **$KCa_4B_{22}O_{32}(OH)_{10}Cl \cdot 4H_2O$.**

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Crystal Data: Triclinic, pseudohexagonal. *Point Group:* 1. Pseudohexagonal to triangular crystals and micaceous plates, to 1 cm; may be in booklike aggregates.

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Splintery. *Tenacity:* Brittle. Hardness = 2–2.5 D(meas.) = 2.27(3) D(calc.) = 2.28

Optical Properties: Transparent. *Color:* Colorless to pink. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $Z \wedge a = 31°$. $\alpha = 1.523$–1.536 $\beta = 1.530$–1.539 $\gamma = 1.596$–1.603 2V(meas.) = n.d. 2V(calc.) = 37°

Cell Data: *Space Group:* $P1$. $a = 6.575(2)$ $b = 23.921(8)$ $c = 6.522(2)$ $\alpha = 90.58(3)°$ $\beta = 119.10(2)°$ $\gamma = 95.56(3)°$ $Z = 1$

X-ray Powder Pattern: Inder deposit, Kazakhstan.
8.1 (10), 3.28 (9), 2.63 (8), 2.81 (7), 2.15 (7), 1.980 (7), 6.03 (6)

Chemistry:

	(1)	(2)	(3)	(4)
B_2O_3	59.80	61.00	60.5	62.42
CaO	14.12	19.76	17.5	18.28
SrO	4.06		0.4	
Na_2O	0.14			
K_2O	2.42	2.55	3.8	3.84
Cl	1.98	2.83	2.8	2.89
H_2O	16.30	[14.50]	13.5	13.22
$-O = Cl_2$	0.45	[0.64]	0.6	0.65
Total	98.37	[100.00]	97.9	100.00

(1) Inder deposit, Kazakhstan; corresponds to $(K_{0.63}Na_{0.06})_{\Sigma=0.69}(Ca_{3.09}Sr_{0.48})_{\Sigma=3.57}B_{21.09}O_{46.31}H_{22.21}Cl_{0.69}$. (2) Louann Salt Formation, Alabama, USA; H_2O by difference; corresponds to $K_{0.66}Ca_{4.29}B_{21.39}O_{46.03}H_{19.64}Cl_{0.97}$. (3) Denison-Potacan mine, Canada; by electron microprobe, B_2O_3 by wet methods, H_2O by TGA-EGA; corresponds to $K_{1.01}(Ca_{3.91}Sr_{0.05})_{\Sigma=3.96}B_{21.77}O_{46.01}H_{18.77}Cl_{0.99}$. (4) $KCa_4B_{22}O_{32}(OH)_{10}Cl \cdot 4H_2O$.

Occurrence: Uncommon in water-insoluble residues from salt domes and potash deposits.

Association: Halite, sylvite, hilgardite, boracite, anhydrite (Inder deposit, Kazakhstan).

Distribution: From the Inder borate deposit, Kazakhstan. In the Nepskoye potash deposit, eastern Siberia, Russia. From the Louann Salt Formation, Clarke Co., Alabama, USA. In the Penobsquis and Salt Springs evaporite deposits, near Sussex, New Brunswick, Canada.

Name: To honor A.I. Volkovskaya, petrographer, who first noted the mineral.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia; Royal Ontario Museum, Toronto, Canada, M44196.

References: (1) Kondrat'eva, V.V., I.V. Ostrovskaya, and Y.Y. Yarzhemskii (1966) A new hydrous calcium borate – volkovskite. Zap. Vses. Mineral. Obshch., 95, 45–50 (in Russian). (2) (1966) Amer. Mineral., 51, 1550 (abs. ref. 1). (3) Simmons, W.B. and K.L. Webber (1989) Volkovskite: new data from an occurrence in the subsurface, Clarke Co., Alabama. Rochester Mineral. Symposium Program Abs., 16, 16. (4) Mandarino, J.A., A.L. Rachlin, P.J. Dunn, Y. Le Page, M.E. Back, B.L. Murowchick, R.A. Ramik, and R.B. Falls (1990) Redefinition of volkovskite and its description from Sussex, New Brunswick. Can. Mineral., 28, 351–356. (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 232.

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Voltaite $K_2Fe_5^{2+}(Fe^{3+}, Al)_4(SO_4)_{12}\cdot 18H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are commonly octahedral, modified by the cube, dodecahedron, and rarely other minor forms, to 2 cm; granular, massive, and in efflorescences.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3 D(meas.) = 2.645 (synthetic). D(calc.) = 2.663 Soluble in H_2O, yielding an acid solution and citron-yellow residue.

Optical Properties: Opaque, translucent in thin splinters. *Color:* Greenish black, black, dark oil-green; pale green to oil-green in transmitted light. *Streak:* Grayish green. *Luster:* Resinous. *Optical Class:* Isotropic, but typically sectored with anomalously biaxial parts. n = 1.593–1.608

Cell Data: *Space Group:* $Fd3c$. $a = 27.254(8)$ Z = 16

X-ray Powder Pattern: Konomai mine, Hokkaido, Japan.
3.54 (10), 3.41 (9), 5.57 (7), 3.04 (5), 9.66 (3), 6.79 (3), 3.15 (3)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	46.78	46.68	ZnO	1.69	
Al_2O_3	1.58		MgO	0.48	
Fe_2O_3	13.47	15.52	Na_2O	0.50	
FeO	14.07	17.46	K_2O	4.73	4.58
NiO	0.08		H_2O	15.70	15.76
CuO	0.55		Total	99.63	100.00

(1) Smolník, Czech Republic; corresponding to $(K_{2.06}Na_{0.33})_{\Sigma=2.39}(Fe^{2+}_{4.02}Zn_{0.43}Mg_{0.24}Cu_{0.14}Ni_{0.02})_{\Sigma=4.85}(Fe^{3+}_{3.46}Al_{0.64})_{\Sigma=4.10}(SO_4)_{11.98}\cdot 17.87H_2O$. (2) $K_2Fe_5^{2+}Fe_4^{3+}(SO_4)_{12}\cdot 18H_2O$.

Occurrence: In volcanic fumaroles, solfataras, and mud volcanos; an alteration product in mineral deposits high in pyrite, especially in arid climates, where it may also be a post-mining product.

Association: Halotrichite, pickeringite, alunogen, metavoltine, römerite, hexahydrite, coquimbite, copiapite, rhomboclase, krausite, jarosite, goldichite, botryogen, melanterite.

Distribution: From the Solfatara di Pozzuoli, Campi Flegrei, near Naples, and on Vesuvius, Campania, Italy. Large crystals in the Rio Tinto mine, Huelva Province, Spain. In Slovakia, at Smolník (Szomolnok), 16 km northeast of Rožňava, Baňská Štiavnica (Schemnitz), and Kremnica (Kremnitz), Czech Republic. At the Rammelsberg mine, near Goslar, Harz Mountains, Germany. In the Rozdol deposit, Ukraine. From volcanoes on the Kamchatka Peninsula, Russia. At Saghand, Yazd district, Iran. In Chile, at Chuquicamata, Quetena, west of Calama, and Alcaparrosa, near Cerritos Bayos, southwest of Calama, Antofagasta. In Argentina, at the Jujuy and Capillitas mines, Catamarca Province, and in the Santa Bárbara sulfur mine, El Palmar district, Jujuy Province. In the USA, large crystals from Bisbee, Cochise Co., at Jerome, Yavapai Co., and in the Magma mine, Superior, Gila Co.; in California, in the Redington mercury mine, Knoxville, Napa Co.; at the Geysers, Sonoma Co.; and from the Sulfur Hole prospect, about 10 km northeast of Yermo, Calico Hills, San Bernardino Co.; at the Dexter No. 7 mine, Calf Mesa, San Rafael district, Emery Co., Utah. There are many other minor localities.

Name: To honor Alessandro Giuseppe Antonio Anastasio Volta (1745–1827), Italian physicist, early experimenter with electricity.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 464–465. (2) Mereiter, K. (1972) Die Kristallstruktur des Voltaits, $K_2Fe_5^{2+}Fe_3^{3+}Al[SO_4]_{12}\cdot 18H_2O$. Tschermaks Mineral. Petrog. Mitt., 18, 185–202 (in German with English abs.). (3) Sakurai, K., A. Kato, I. Fujiyama, and T. Imayoshi (1958) Voltaite from Konomai mine, Hokkaido. J. Min. Soc. Japan, 3, 777–781.

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Volynskite $AgBiTe_2$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Massive (?).

Physical Properties: *Cleavage:* One perfect, two imperfect. Hardness = n.d. VHN = 42–66 (25 g load). D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Pale purplish in reflected light. *Pleochroism:* Very slight in oil. *Anisotropism:* Very weak, pale pink to gray.

R_1–R_2: (400) 56.4–58.1, (420) 56.0–57.7, (440) 55.6–57.3, (460) 55.2–56.9, (480) 54.6–56.3, (500) 53.8–55.5, (520) 53.2–54.9, (540) 53.0–54.6, (560) 53.4–54.7, (580) 54.0–54.9, (600) 54.6–55.1, (620) 55.0–55.5, (640) 55.3–55.6, (660) 55.3–55.8, (680) 55.3–55.8, (700) 55.4–55.8

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Zod deposit, Armenia.
3.09 (100), 3.21 (80), 2.21 (50), 2.33 (30), 2.15 (30), 1.82 (30), 1.61 (20)

Chemistry:

	(1)	(2)	(3)
Ag	17.7	18.0	18.86
Cu	0.1		
Bi	38.8	36.6	36.53
Te	45.0	45.2	44.61
Total	101.6	99.8	100.00

(1) Campbell mine, Arizona, USA; by electron microprobe. (2) Ashley deposit, Ontario, Canada; by electron microprobe. (3) $AgBiTe_2$.

Occurrence: As complex intergrowths with other tellurides in gold ores.

Association: Tellurobismuthite, hessite, altaite, calaverite, melonite, petzite.

Distribution: From the Zod deposit, 14 km east of Vardenis, Armenia. In the Zhana-Tyube Au–Te deposit, northern Kazakhstan. From the Kochbulak gold deposit, Chatkal-Kuramin Mountains, eastern Uzbekistan. In the Campbell mine, Bisbee, Cochise Co., Arizona, and the Golden Fleece mine, Lake City district, Hinsdale Co., Colorado, USA. From the Ashley deposit, Bannockburn Township, Ontario, Canada. At the Yokozuru mine, north Kyushu, Japan. In the Champion Reef mine, Kolar Gold Fields, Karnataka, India. From Kambalda, 56 km south of Kalgoorlie, Western Australia. At Glava, Värmland, Sweden. From the Ivigtut cryolite deposit, southwestern Greenland.

Name: For Igor Sergeevich Volynskii (1900–1962), former Director of the Mineragraphic Laboratory, Institute of Mineralogy and Geochemistry of Rare Elements, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 31g/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72064, vis249.

References: (1) Bezsmertnaya, M.S. and L.N. Soboleva (1965) Volynskite, a new telluride of bismuth and silver. Akad. Nauk SSSR, Eksperimental'no Metod. Issled. Rudnykh Mineralov, 129–141. (2) (1966) Amer. Mineral., 51, 531 (abs. ref. 1). (3) Bezsmertnaya, M.S. and L.N. Soboleva (1963) A new telluride of bismuth and silver, established by the newest micromethods. Trudy Inst. Mineralog., Geokhim., Kristallokhim Redkikh. Elementov, 18, 70–84 (in Russian). (4) (1964) Amer. Mineral., 49, 818 (abs. ref. 3). (5) Harris, D.C., W.D. Sinclair, and R.I. Thorpe (1983) Telluride minerals from the Ashley deposit, Bannockburn Township, Ontario. Can. Mineral., 21, 137–143.

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Vonbezingite $Ca_6Cu_3(SO_4)_3(OH)_{12}\cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, elongated along [001], to 3 cm, showing {110}, {010}, {100} {111}, {101}. *Twinning:* On {001}, twinned by merohedry.

Physical Properties: *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = ∼4
D(meas.) = 2.82(2) D(calc.) = 2.81–2.83

Optical Properties: Semitransparent. *Color:* Dark blue. *Streak:* Pale blue. *Luster:* Vitreous on fractures, subvitreous on crystal faces.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = pale blue; Y = grayish blue; Z = dark blue. *Orientation:* $X = b$; $Y \wedge a = 30.2°$; $Z \wedge c = -11.5°$. *Dispersion:* $r > v$, moderate.
$\alpha = 1.590(2)$ $\beta = 1.610(3)$ $\gamma = 1.619(2)$ 2V(meas.) = 65(5)° 2V(calc.) = 67°

Cell Data: *Space Group:* $P2_1/c$. $a = 15.122(2)$ $b = 14.358(1)$ $c = 22.063(4)$
$\beta = 108.68(1)°$ Z = 8

X-ray Powder Pattern: Wessels mine, South Africa.
3.393 (100), 3.120 (85), 3.188 (65), 3.098 (57), 3.368 (55), 3.200 (53), 2.769 (41)

Chemistry:

	(1)	(2)
SO_3	24.0	25.04
CuO	25.5	24.87
CaO	35.4	35.07
H_2O	15.6	15.02
Total	100.5	100.00

(1) Wessels mine, South Africa; by electron microprobe, average of six analyses, H_2O by TGA-mass spectrometry; corresponds to $Ca_{6.03}Cu_{3.07}(SO_4)_{2.87}(OH)_{12.46}\cdot 2.06H_2O$. (2) $Ca_6Cu_3(SO_4)_3(OH)_{12}\cdot 2H_2O$.

Occurrence: A very rare mineral formed during a period of evaporation of surface or ground waters at ambient temperature and atmospheric pressure.

Association: Barite, azurite, sturmanite, calcite, gypsum, bultfonteinite.

Distribution: From the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: To honor Karl-Ludwig von Bezing (1945–), Austrian-South African mineral collector, for his contributions to knowledge of mineralogy of the Kalahari manganese field.

Type Material: American Museum of Natural History, New York, New York, USA, T100748.

References: (1) Dai, Y. and G.E. Harlow (1992) Descripton and crystal structure of vonbezingite, a new Ca−Cu−SO_4−H_2O mineral from the Kalahari manganese field, South Africa. Amer. Mineral., 77, 1292–1300.

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Vonsenite $Fe_2^{2+}Fe^{3+}BO_5$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Short prismatic crystals, crude and lacking terminations, with {010}, {110}, {120}, {140}, {160}; in radial fibrous, fanlike to felted aggregates, to 2 cm; granular, massive.

Physical Properties: *Tenacity:* Brittle, tough if fibrous. Hardness = 5 D(meas.) = 4.21 D(calc.) = [4.80]

Optical Properties: Opaque. *Color:* Coal-black to greenish black. *Streak:* Brownish black. *Luster:* Metallic to submetallic, silky if fibrous.
Optical Class: Biaxial (+).
R_1–R_2: (400) 14.2–14.9, (420) 13.8–14.7, (440) 13.4–14.6, (460) 13.1–14.4, (480) 12.9–14.4, (500) 12.6–14.2, (520) 12.4–14.3, (540) 12.2–14.5, (560) 12.0–14.5, (580) 11.9–14.6, (600) 11.4–14.6, (620) 11.3–14.7, (640) 10.7–14.5, (660) 10.4–14.3, (680) 9.66–14.1, (700) 9.71–14.4

Cell Data: *Space Group: Pbam* (synthetic). $a = 9.463(1)$ $b = 12.305(1)$ $c = 3.0727(6)$ $Z = 4$

X-ray Powder Pattern: Burguillos, Spain.
2.575 (100), 5.152 (30), 1.536 (17), 1.042 (15), 1.937 (12), 2.842 (9), 4.725 (8)

Chemistry:

	(1)	(2)
B_2O_3	12.40	13.48
Al_2O_3	0.22	
Fe_2O_3	29.51	30.90
FeO	54.14	55.62
CoO	0.05	
MnO	0.20	
MgO	0.28	
Total	96.80	100.00

(1) Burguillos, Spain; Al_2O_3, MnO, MgO, CoO by electron microprobe; corresponds to $(Fe^{2+}_{2.03}Mg_{0.02}Mn_{0.01})_{\Sigma=2.06}(Fe^{3+}_{0.99}Al_{0.01})_{\Sigma=1.00}B_{0.96}O_5$. (2) $Fe_2^{2+}Fe^{3+}BO_5$.

Polymorphism & Series: Forms a series with ludwigite.

Mineral Group: Ludwigite group.

Occurrence: Uncommon in boron-rich skarns.

Association: Magnetite, pyroxene, pyrrhotite.

Distribution: In the USA, from the Old City quarry, Riverside, Riverside Co., California; at the Jayville magnetite mine, Stevens Co., New York; on the northwest flank of Brooks Mountain, Seward Peninsula, Alaska. In Japan, in the Kamaishi mine, Iwate Prefecture, and at the Sengendera mine, Miyazaki Prefecture. From the Dading tin-iron deposits, Guizhou Province, China. In Italy, from near Cura di Vetralla, and at Montalto di Castro, Lazio; on Vesuvius, Campania; from Vulcano, Lipari Islands. At the St. Christophe mine, Breitenbrunn, Saxony, Germany. From the Monchi mine, Burguillos del Cerro, Badajoz Province, Spain.

Name: Honors Magnus Vonsen (1879–1954), amateur mineralogist and mineral collector of Petaluma, California, USA, who discovered the mineral.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 322–324 [paigeite, part]. (2) Bonazzi, P. and S. Menchetti (1989) Contribution to the crystal chemistry of the minerals of the ludwigite-vonsenite series. Neues Jahrb. Mineral., Monatsh., 69–83. (3) Swinnea, J.S. and H. Steinfink (1983) Crystal structure and Mössbauer spectrum of vonsenite, $2FeO \cdot FeBO_3$. Amer. Mineral., 68, 827–832. (4) Ruiz, J.L. and P.S. Salvador (1971) Chemical and crystallographic data for vonsenite from Burguillos del Cerro, Badajoz, Spain. Amer. Mineral., 56, 2149–2151.

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Vozhminite $(Ni, Co)_4(As, Sb)S_2$

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Crystal Data: Hexagonal. *Point Group:* n.d. Massive (?).

Physical Properties: *Cleavage:* One, distinct. Hardness = n.d. VHN = 240–300, 270 average, to 376–480, 436 average (100 g load), depending on orientation. D(meas.) = n.d. D(calc.) = 6.2

Optical Properties: Opaque. *Color:* Yellowish with a brown tint; in reflected light, rose-orange. *Streak:* Black. *Luster:* Metallic.

R_1–R_2: (400) — , (420) 35.0–41.2, (440) 37.0–43.0, (460) 39.2–45.0, (480) 41.7–47.0, (500) 44.0–48.6, (520) 45.9–49.8, (540) 47.5–50.9, (560) 48.9–51.9, (580) 50.2–52.7, (600) 51.1–53.3, (620) 52.1–54.2, (640) 52.8–55.0, (660) 53.4–55.8, (680) 53.7–56.6, (700) 54.1–57.1

Cell Data: *Space Group:* n.d. $a = 17.46(4)$ $c = 7.20(1)$ $Z = 18$

X-ray Powder Pattern: Vozhmin massif, Russia.
8.7 (10), 1.776 (10b), 3.07 (9), 2.111 (9), 2.303 (7), 2.717 (6)

Chemistry:

	(1)
Ni	52.7
Co	5.56
Fe	0.05
As	13.1
Sb	11.3
S	16.8
Total	99.51

(1) Vozhmin massif, Russia; by electron microprobe, average of 22 points on 2 samples, corresponding to $(Ni_{3.43}Co_{0.36})_{\Sigma=3.79}(As_{0.67}Sb_{0.35})_{\Sigma=1.02}S_{2.00}$.

Occurrence: In heazlewoodite ore in serpentinites.

Association: Heazlewoodite, tučekite, magnetite, geversite, copper.

Distribution: From the Vozhmin massif, Segezha district, central Karelia, Russia.

Name: For its occurrence in the Vozhmin massif, Karelia, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1139/1.

References: (1) Rudashevskii, N.S., Y.P. Men'shikov, A.A. Lentsi, N.I. Shumskaya, A.B. Lobanova, G.N. Goncharov, and A.G. Tutov (1982) Vozhminite, $(Ni, Co)_4(As, Sb)S_2$, a new mineral. Zap. Vses. Mineral. Obshch., 111, 480–485 (in Russian). (2) (1983) Amer. Mineral., 68, 645 (abs. ref. 1).

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Vrbaite $Tl_4Hg_3Sb_2As_8S_{20}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals, to 3 mm, tabular {010} or pyramidal {111}.

Physical Properties: *Cleavage:* {010}, good. *Fracture:* Uneven to conchoidal. *Tenacity:* Brittle. Hardness = 3.5 VHN = n.d. D(meas.) = 5.30(3) D(calc.) = [5.40]

Optical Properties: Opaque. *Color:* Dark gray-black with a bluish tint; in polished section, bluish white with red internal reflections; dark red in translucent thin fragments. *Streak:* Pale red with a yellow tone. *Luster:* Submetallic to metallic.
Optical Class: Biaxial (+). *Dispersion:* $r > v$. $n = > 2.72$
R_1–R_2: (400) 45.8–48.6, (420) 42.0–44.6, (440) 38.2–40.6, (460) 35.7–38.2, (480) 33.8–36.7, (500) 32.2–35.3, (520) 30.8–34.0, (540) 29.6–32.5, (560) 28.6–31.1, (580) 28.0–30.0, (600) 27.6–29.2, (620) 27.3–28.8, (640) 27.1–28.8, (660) 26.8–28.6, (680) 26.6–28.4, (700) 26.4–28.0

Cell Data: *Space Group: C*2*ca*. a = 13.399 b = 23.389 c = 11.287 Z = 4

X-ray Powder Pattern: Alšar, Macedonia.
4.04 (100), 3.33 (80), 2.57 (80), 5.18 (60), 3.15 (60), 2.29 (60), 4.31 (50)

Chemistry:

	(1)	(2)
Tl	28.8	28.15
Hg	20.5	20.73
Sb	8.2	8.39
As	20.5	20.64
S	22.1	22.09
Total	100.1	100.00

(1) Alšar, Macedonia; by electron microprobe. (2) $Tl_4Hg_3Sb_2As_8S_{20}$.

Occurrence: In a hydrothermal deposit with other As–Tl sulfide minerals.

Association: Realgar, orpiment.

Distribution: From Alšar (Allchar), near Rošden, Macedonia.

Name: For Professor Karel Vrba (1845–1922), University of Prague, Prague, Czechoslovakia, Czech mineralogist.

Type Material: National Museum, Prague, Czech Republic, 25292; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, R939.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 484–485. (2) Caye, R., P. Picot, R. Pierrot, and F. Permingeat (1967) Nouvelles données sur la vrbaïte, sa teneur en mercure. Bull. Soc. fr. Minéral., 90, 185–191 (in French). (3) (1968) Amer. Mineral., 53, 351 (abs. ref. 2). (4) Ohmasa, M. and W. Nowacki (1971) The crystal structure of vrbaite, $Hg_3Tl_4As_8Sb_2S_{20}$. Zeits. Krist., 134, 360–380.

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Vuagnatite $CaAlSiO_4(OH)$

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Crystal Data: Orthorhombic. *Point Group:* 222. Highly modified prismatic crystals, to 3 mm, elongated along [001] or [100], rarely as disphenoidal euhedra.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6
D(meas.) = 3.42(2) D(calc.) = 3.41

Optical Properties: Semitransparent. *Color:* White; colorless in thin section.
Luster: Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless or yellowish brown; $Y = Z$ = colorless. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, strong to very strong. *Absorption:* $X \gg Y = Z$. $\alpha = 1.701(2)$ $\beta = 1.724(2)$ $\gamma = 1.727(2)$ 2V(meas.) = 44(1)°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.0538(4)$ $b = 8.5410(4)$ $c = 5.6839(3)$ Z = 4

X-ray Powder Pattern: Red Mountain, California, USA.
2.518 (100), 2.997 (95), 2.640 (85), 2.215 (85), 2.453 (70), 2.142 (65), 2.395 (60)

Chemistry:

	(1)	(2)
SiO_2	33.59	34.11
Al_2O_3	27.76	28.94
CaO	31.52	31.84
H_2O		5.11
Total	92.87	100.00

(1) Taurus Mountains, Turkey; by electron microprobe, average of 25 partial analyses.
(2) $CaAlSiO_4(OH)$; H_2O inferred from structure determination.

Occurrence: In rodingitized dikes of pegmatitic anorthositic gabbro crosscutting harzburgite-serpentines in an ophiolite (Taurus Mountains, Turkey); in rodingitized metagabbro dikes in serpentinized peridotite (Red Mountain, California, USA); all occurrences suggest formation under conditions of relatively low temperature and high pressure.

Association: Chantalite, prehnite, hydrogrossular, vesuvianite, chlorite (Taurus Mountains, Turkey); hydrogrossular, vesuvianite, chlorite, copper, chalcocite (Red Mountain, California, USA).

Distribution: From Böğürtlen Tepe Hill, 10 km northeast of Doğanbaba, Taurus Mountains, Burdur Province, Turkey. At Red Mountain, Mendocino Co., California, USA. In the Livingstone Mountains, Southland, New Zealand. From Shiraki, Toba, Mie Prefecture, Japan. At the Wessels mine, near Kuruman, Cape Province, South Africa.

Name: For Professor Mark Bernard Vuagnat (1922–), student of ophiolites, University of Geneva, Geneva, Switzerland.

Type Material: Natural History Museum, Geneva, 435/1; University of Geneva, Geneva, Switzerland; National Museum of Natural History, Washington, D.C., USA, 146560.

References: (1) Sarp, H., J. Bertrand, and E. McNear (1976) Vuagnatite, $CaAl(OH)SiO_4$, a new natural calcium aluminum nesosilicate. Amer. Mineral., 61, 825–830. (2) McNear, E., M.G. Vincent, and E. Parthé (1976) The crystal structure of vuagnatite, $CaAl(OH)SiO_4$. Amer. Mineral., 61, 831–838. (3) Pabst, A., R.C. Erd, F. Goff, and L. Rosenhahn (1977) Vuagnatite from California. Mineral. Record, 8, 497–501.

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Vulcanite CuTe

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Minute (0.1 to 1.1 mm) prismatic or bladelike grains, massively incrusting and cementing rock fragments. *Twinning:* Very thin twin lamellae at approximately 45° to the prominent cleavage in some grains.

Physical Properties: *Cleavage:* One direction parallel to the length of the lath-shaped grains; another direction, less prominent, perpendicular to the first. *Tenacity:* Sectile. Hardness = 1–2 VHN = 34–40 (50 g load). D(meas.) = n.d. D(calc.) = 7.1

Optical Properties: Opaque. *Color:* Pale bronze to yellow-bronze. *Luster:* Metallic. *Pleochroism:* Very strong, bright yellow to blue-gray. *Anisotropism:* Very strong, brilliant yellow-white, grayish yellow-white, yellow-orange to gray.

R_1–R_2: (400) 25.6–30.7, (420) 24.4–30.0, (440) 23.0–30.5, (460) 21.3–37.0, (480) 19.7–47.9, (500) 18.1–56.8, (520) 16.6–63.4, (540) 15.2–67.8, (560) 13.8–70.8, (580) 12.7–73.1, (600) 11.8–74.9, (620) 11.3–76.4, (640) 11.2–77.4, (660) 11.6–78.2, (680) 12.9–78.9, (700) 15.0–79.3

Cell Data: *Space Group: Pmnm.* $a = 4.09$ $b = 6.95$ $c = 3.15$ Z = 2

X-ray Powder Pattern: Good Hope mine, Colorado, USA.
2.03 (100), 2.86 (70), 3.52 (60), 6.94 (40), 3.47 (30), 2.65 (30), 2.32 (30)

Chemistry:

	(1)	(2)
Cu	32.5	33.24
Te	67.8	66.76
Total	100.3	100.00

(1) Good Hope mine, Colorado, USA; by electron microprobe. (2) CuTe.

Occurrence: Intermixed with other tellurides.

Association: Rickardite, tellurium (Good Hope mine, Colorado); rickardite, petzite, sylvanite (Byn'govsk deposit, Russia).

Distribution: In the Good Hope mine, Vulcan, Gunnison Co., Colorado, USA. From the Byn'govsk Au-Te deposit, Central Ural Mountains, Russia. In the Iriki mine, Kagoshima Prefecture, Japan. From the Jabal Sayid deposit, Saudi Arabia.

Name: After the locality, Vulcan, Colorado, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, R933, 85136.

References: (1) Cameron, E.N. and I.M. Threadgold (1961) Vulcanite, a new copper telluride from Colorado, with notes on certain associated minerals. Amer. Mineral., 46, 258–268.
(2) Anderko, K. and K. Schubert (1954) Untersuchungen im System Kupfer–Tellur. Zeits. für Metallkunde, 4, 371–378 (in German).

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Vuonnemite $Na_5Nb_3Ti(Si_2O_7)_3O_2F_2 \cdot 2Na_3PO_4$

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Crystal Data: Triclinic. *Point Group:* 1 or $\overline{1}$. In aggregates of platy to scaly and bladed crystals, to over 10 cm.

Physical Properties: *Cleavage:* Perfect on {001}, and two others. *Tenacity:* Brittle. Hardness = 2–3 D(meas.) = 3.13–3.15 D(calc.) = 3.17 May be light to intense green or pale yellow under SW UV, yellow under LW UV, faint bluish green phosphorescence.

Optical Properties: Transparent to translucent. *Color:* Light yellow, white, may have a brownish hue. *Streak:* White. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (+). α = 1.636–1.639 β = 1.651–1.654 γ = 1.678–1.681
2V(meas.) = 53°–86° 2V(calc.) = 86(2)°

Cell Data: *Space Group:* $P1$ or $P\overline{1}$. a = 5.38–5.50 b = 7.02–7.16 c = 14.15–14.44
$\alpha = 87.65°-92.63°$ $\beta = 89.50°-95.33°$ $\gamma = 90.57°-93.67°$ Z = 1

X-ray Powder Pattern: Mt. Karnasurt, Russia.
2.869 (10), 7.14 (6), 3.582 (6), 1.790 (6), 5.16 (5), 4.77 (5), 4.24 (5)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	22.31	22.57	26.83	CaO	0.25	0.33	
TiO_2	8.07	7.50	5.94	Na_2O	30.23	32.03	25.36
Al_2O_3	0.46	0.26		K_2O	0.07		
Nb_2O_5	23.16	23.99	29.67	F			2.83
FeO		0.26		P_2O_5	13.50	13.13	10.56
MnO	0.53	0.08		LOI	0.96		
MgO	0.14			$-O = F_2$			1.19
				Total	99.68	100.15	100.00

(1) Khibiny massif, Russia; spectrographic traces of Ba, Sr, and RE. (2) Ilímaussaq intrusion, Greenland; by electron microprobe, traces of Mg, K, Zr, Ce; F ~1.5%–2.5%. (3) $Na_5Nb_3Ti(Si_2O_7)_3O_2F_2 \cdot 2Na_3PO_4$.

Occurrence: In albitized alkalic rocks in differentiated alkalic massifs (Kola Peninsula, Russia); in a transition zone between two nepheline syenites (Ilímaussaq intrusion, Greenland); in sodalite xenoliths in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Albite, microcline, nepheline, aegirine, lorenzenite, cancrinite, sérandite, villiaumite (Kola Peninsula, Russia); microcline, natrolite, epistolite, sodalite, villiaumite (Ilímaussaq intrusion, Greenland).

Distribution: From Mt. Eveslogchorr, Khibiny massif, and the Jubilee pegmatite and elsewhere on Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia. In the Ilímaussaq intrusion, southern Greenland. From near Gunnison, Gunnison Co., Colorado, USA. At Mont Saint-Hilaire and near Saint-Amable, Quebec, Canada.

Name: For the occurrence near the Vuonnemiok River, Khibiny massif, Kola Peninsula, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3255; Mining Institute, St. Petersburg, Russia, 1058/2; National School of Mines, Paris, France.

References: (1) Bussen, I.V., A.P. Denisov, N.I. Zabavnikova, L.V. Kozyreva, Y.P. Men'shikov, and E.A. Lipatova (1973) Vuonnemite, a new mineral. Zap. Vses. Mineral. Obshch., 102, 423–426 (in Russian). (2) (1974) Amer. Mineral., 59, 875 (abs. ref. 1). (3) Rønsbo, J.G., E.S. Leonardsen, O.V. Petersen, and O. Johnsen (1983) Second occurrence of vuonnemite: the Ilímaussaq alkaline intrusion, South West Greenland. Neues Jahrb. Mineral., Monatsh., 451–460. (4) Horváth, L. and R.A. Gault (1990) The mineralogy of Mont Saint-Hilaire, Quebec. Mineral. Record, 21, 283–359, esp. 346.

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Vuorelainenite $(Mn^{2+}, Fe^{2+})(V^{3+}, Cr^{3+})_2O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As imperfect crystals, granular, massive, along grain boundaries of other minerals, to 80 μm.

Physical Properties: Hardness = n.d. VHN = 900 (50 g load). D(meas.) = n.d. D(calc.) = 4.64

Optical Properties: Opaque. *Color:* Brownish gray in reflected light.
Optical Class: Isotropic.
R: (470) 15.7, (546) 15.4, (589) 15.6, (650) 16.2

Cell Data: *Space Group:* $[Fd3m]$ (by analogy to spinel). $a = 8.48(5)$ $Z = 8$

X-ray Powder Pattern: Sätra mine, Sweden.
2.559 (10), 1.633 (8), 1.502 (8), 2.985 (4), 2.118 (3), 4.90 (2), 2.442 (2)

Chemistry:

	(1)	(2)
TiO_2	0.1	
V_2O_3	47.4	63.3
Cr_2O_3	19.5	4.7
FeO	5.7	7.6
MnO	26.4	22.0
ZnO	0.8	[2.4]
MgO	0.1	
Total	100.0	[100.0]

(1) Sätra mine, Sweden; by electron microprobe, total Fe as FeO; corresponds to $(Mn_{0.83}Fe_{0.18}Zn_{0.02}Mg_{0.01})_{\Sigma=1.04}(V_{1.41}Cr_{0.57})_{\Sigma=1.98}O_4$. (2) Outokumpu, Finland; by electron microprobe, total Fe as FeO, ZnO by difference; corresponds to $(Mn_{0.69}Fe_{0.23}Zn_{0.06})_{\Sigma=0.98}(V_{1.87}Cr_{0.14})_{\Sigma=2.01}O_4$.

Polymorphism & Series: Forms a series with manganochromite.

Mineral Group: Spinel group.

Occurrence: In a metamorphosed iron sulfide deposit associated with submarine felsic volcanism (Sätra mine, Sweden); in quartzite schists (Ol'khon Gate Straits, Lake Baikal, Russia).

Association: Pyrrhotite, rutile, pyrophanite, manganoan sphalerite, chalcopyrite, alabandite (Sätra mine, Sweden); rutile, eskolaite, karelianite, schreyerite, olkhonskite (Ol'khon Gate Straits, Lake Baikal, Russia).

Distribution: In the Sätra mine, Doverstorp, Bergslagen metallic province, Sweden. From Outokumpu, Finland. Found 4.5 km south of the Ol'khon Gate Strait, on the western shore of Lake Baikal, Siberia, Russia.

Name: To honor Yrjö Vuorelainen (1922–), Finnish exploration geologist, formerly with the Outokumpu Company, Finland.

Type Material: Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands, 153A4.

References: (1) Zakrzewski, M.A., E.A.J. Burke, and W.J. Lustenhouwer (1982) Vuorelainenite, a new spinel, and associated minerals from the Sätra (Doverstorp) pyrite deposit, central Sweden. Can. Mineral., 20, 281–290. (2) (1983) Amer. Mineral., 68, 472–473 (abs. ref. 1).

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Vurroite $Pb_{20}Sn_2(Bi,As)_{22}S_{54}Cl_6$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As fibrous crystals, to 0.4 mm., in divergent fibrous aggregates. *Twinning:* Twinning on (001).

Physical Properties: *Cleavage*: None. *Fracture*: n.d. *Tenacity*: n.d.
Hardness = n.d. D(meas.) = n.d. D(calc.) = 6.15

Optical Properties: Opaque. *Color*: Silver-gray; white in reflected light. *Streak*: n.d.
Luster: Metallic.
Optical Class: Biaxial (+). Anisotropism: Weak.
R: (470) 34.25, (546) 32.95, (589) 32.60, (650) 31.05

Cell Data: *Space Group: C2/c.* $a = 8.371(2)$ $b = 45.502(9)$ $c = 27.273(6)$ $\beta = 98.83(3)°$ Z = 4
Frequent twins and disordered domains in the structure were observed.

X-ray Powder Pattern: La Fossa crater, Vulcano Island, Italy.
2.07 (100), 3.34 (80), 2.85 (80), 2.69 (80), 2.10 (70), 3.17 (60), 2.17 (60)

Chemistry:

	(1)	(2)
Pb	40.92	43.86
Bi	28.30	24.33
As	8.38	8.72
Sn	1.60	2.51
Tl	0.06	
S	18.28	18.33
Se	0.18	
Cl	1.85	2.25
Br	0.24	.
Total	99.81	100.00

(1) La Fossa crater, Vulcano Island, Italy; average of 12 electron microprobe analyses, corresponding to $Pb_{18.95}Sn_{1.30}(Bi_{12.99}As_{10.73}Tl_{0.03})_{\Sigma=23.75}(S_{54.71}Se_{0.22}Cl_{5.00}Br_{0.29})_{\Sigma=60.22}$.
(2) $Pb_{20}Sn_2(Bi,As)_{22}S_{54}Cl_6$.

Occurrence: As encrustations around fumaroles (400-600°C) in an active volcanic crater.

Association: Bismuthinite, lillianite, kirkiite, heyrovskýite, galena.

Distribution: Fumarole FF (and others), La Fossa crater, Vulcano Island, Italy.

Name: Honors Filippo Vurro, (b. 1940), Professor of mineralogy at the University of Bari, Italy, and specialist in the mineralogy and geochemistry of modern volcanic deposits.

Type Material: Mineralogical museum, University of Bari, Italy, (6/nm).

References: (1) Garavelli, A., N.N., Mozgova, P., Orlandi, E., Bonaccorsi, D., Pinto, Y., Moëlo, and Y.S. Borodaev, (2005) Rare sulfosalts from Vulcano, Aeolian Islands, Italy. VI. Vurroite, $Pb_{20}Sn_2(Bi,As)_{22}S_{54}Cl_6$, a new mineral species. Canadian Mineralogist, 43, 703-711.
(2) Pinto, D., E. Bonaccorsi, T. Balić-Žunić, and E. Makovicky (2005) The crystal structure of vurroite, $Pb_{20}Sn_2(Bi,As)_{22}S_{54}Cl_6$: OD-character, polytypism, twinning, and modular description. Amer. Mineral., 93, 713-727. (3) (2005) Amer. Mineral., 90, 1949-1950 (abs. ref. 1).

Vyacheslavite $U^{4+}(PO_4)(OH)\cdot 2.5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Crystals are lamellar, to 8 μm, in spherulitic to microcrystalline aggregates in veinlets.

Physical Properties: *Cleavage:* On {010}. Hardness = n.d. D(meas.) = 4.9(3) D(calc.) = 5.02 Radioactive.

Optical Properties: Semitransparent. *Color:* Green to dark green. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; in shades of green. *Orientation:* Positive elongation. $\alpha = 1.700$ $\beta = 1.726$–1.729 $\gamma = 1.729$–1.731 2V(meas.) = Small.

Cell Data: *Space Group:* $Cmcm$, $Cmc2_1$, or $C2cm$. a = 6.96(1) $b = 9.10(1)$ $c = 12.38(1)$ Z = 6

X-ray Powder Pattern: Kyzylkum region, Uzbekistan. 6.19 (10), 2.69 (7), 4.56 (6), 4.13 (6), 3.68 (5), 2.71 (5), 3.04 (3)

Chemistry:

	(1)
P_2O_5	17.0
UO_2	68.69
CaO	0.53
H_2O	[13.78]
Total	[100.00]

(1) Kyzylkum region, Uzbekistan; by electron microprobe, average of two analyses, H_2O by difference; corresponds to $(U^{4+}_{1.06}Ca_{0.04})_{\Sigma=1.10}(PO_4)_{0.96}(OH)_{1.32}\cdot 2.5H_2O$.

Occurrence: A rare secondary mineral in uranium deposits.

Association: Uraninite, ningyoite, sphalerite, covellite, chalcocite, pyrite, quartz.

Distribution: From the Dzhantuar and Rudnoye uranium deposits, Auminzatau Mountains, central Kyzylkum region, Uzbekistan.

Name: To honor Vyacheslav Gavrilovich Melkov (1911–1991), Russian mineralogist specializing in uranium minerals, Russian Research Institute of Mineral Resources, Moscow, Russia.

Type Material: Mining Institute, St. Petersburg, 1692/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82773.

References: (1) Belova, L.N., A.I. Gorshkov, O.A. Ivanova, A.V. Sivtsov, L.I. Lizorkina, and V.A. Boronikhin (1984) Vyacheslavite, $U^{4+}(PO_4)(OH)\cdot nH_2O$, a new uranium phosphate. Zap. Vses. Mineral. Obshch., 113, 360–365 (in Russian). (2) (1985) Amer. Mineral., 70, 878 (abs. ref. 1). (3) Belova, L.N., A.I. Gorshkov, O.A. Ivanova, A.V. Sivtsov, and V.A. Boronikhin (1984) A new natural phosphate of U(IV). Doklady Acad. Nauk SSSR, 273, 1460–1462 (in Russian) [unnamed = vyacheslavite]. (4) (1984) Amer. Mineral., 69, 1195 (abs. ref. 3). (5) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union, 234.

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Vyalsovite **$FeS \cdot CaAl(OH)_5$**

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
SiO_2			
TiO_2			
ZrO_2			
Al_2O_3			
Fe_2O_3			
FeO			
MnO			
MgO			
CaO			
Na_2O			
K_2O			
F			
Cl			
H_2O^+			
H_2O^-			
$-O = (F, Cl)_2$			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1) Evstigneeva, T.L., A.D. Genkin, S.M. Sandomirskaya, and N.V. Trubkin (1992) Vyalsovite, a new sulfide-hydroxide of iron, calcium, and aluminum. Amer. Mineral., 77, 201–206.

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Vysotskite (Pd, Ni)S

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Crystal Data: Tetragonal. *Point Group:* $4/m$. As minute irregular grains, and rarely as prismatic crystals up to 0.07 mm.

Physical Properties: Hardness = n.d. VHN = 715–864, 806 average (100 g load). D(meas.) = n.d. D(calc.) = 6.705

Optical Properties: Opaque. *Color:* Silvery; in reflected light, creamy white. *Luster:* Metallic, strong. *Anisotropism:* Weak to moderate, dark brown to dark blue-gray.

R_1–R_2: (400) 41.2–42.0, (420) 42.2–43.0, (440) 43.0–43.9, (460) 43.7–44.5, (480) 44.2–45.0, (500) 44.5–45.4, (520) 44.9–45.6, (540) 45.1–45.8, (560) 45.4–46.1, (580) 45.6–46.3, (600) 45.8–46.5, (620) 46.0–46.6, (640) 46.0–46.6, (660) 46.0–46.5, (680) 45.7–46.3, (700) 45.4–46.2

Cell Data: *Space Group:* $P4_2/m$. $a = 6.368(3)$ $c = 6.562(3)$ Z = 8

X-ray Powder Pattern: Lac des Iles complex, Canada. Easily confused with braggite. 2.846 (100), 2.914 (90), 2.612 (80), 2.650 (70), 1.857 (70), 1.142 (70), 2.150 (60)

Chemistry:

	(1)	(2)	(3)
Pd	57.6	67.6	60.8
Pt	4.4	2.2	13.5
Ni	16.6	5.9	4.1
S	21.4	24.1	22.1
Total	100.0	99.8	100.5

(1) Noril'sk region, Russia; by electron microprobe. (2–3) Stillwater complex, Montana, USA; by electron microprobe.

Polymorphism & Series: Forms a series with braggite.

Occurrence: In andesine diabases (Noril'sk region, Russia) and in ultramafic layered intrusives elsewhere. As disseminations that probably are crystallized products, at magmatic temperatures, of a residual immiscible sulfide melt.

Association: Chalcopyrite, millerite, nickelian pyrite, linnaeite, cooperite (Noril'sk region, Russia); pentlandite, pyrrhotite, chalcopyrite, cubanite, nickelian mackinawite, gold, braggite, cooperite, moncheite, isoferroplatinum, kotulskite, keithconnite, palladian tulameenite (Stillwater complex, Montana, USA); hongshiite, cooperite, sperrylite, isomertieite, magnetite, bornite, polydymite, diopside, actinolite, epidote (Yen deposit, China).

Distribution: One of most common and economically important platinum group minerals. From the Noril'sk region, western Siberia, Russia. In the Upper and Banded portions of the Stillwater complex, Montana; from near Moapa, Clark Co., Nevada; and from the Yuba River, Nevada Co., California, USA. At the Lac des Iles complex, Ontario, Canada. In the Yen deposit (a code name), China. From the Konttijärvi and Siikakämä intrusions, and in the Kirakkajuppura deposit, Penikat layered complex, northeast of Kemi, Finland.

Name: For Nikolai Konstaninovich Vysotskii (1864–1932), Soviet geologist, who first found platinum at Noril'sk, Russia.

Type Material: Mining Institute, St. Petersburg, 93a/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64853.

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References: (1) Genkin, A.D. and O.E. Zvyagintsev (1962) Vysotskite, a new sulfide of palladium and nickel. Zap. Vses. Mineral. Obshch., 91, 718–725 (in Russian). (2) (1963) Amer. Mineral., 48, 708 (abs. ref. 1). (3) Cabri, L.J., J.H.G. Laflamme, J.M. Stewart, K. Turner, and B.J. Skinner (1978) On cooperite, braggite, and vysotskite. Amer. Mineral., 63, 832–839. (4) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 146. (5) Criddle, A.J. and C.J. Stanley (1985) Characteristic optical data for cooperite, braggite and vysotskite. Can. Mineral., 23, 149–162.

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Vyuntspakhkite-(Y) $(Y,Yb)_4Al_2AlSi_5O_{18}(OH)_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As slender prismatic crystals, to 0.7 mm.

Physical Properties: *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 4.02 D(calc.) = 4.07 Faint yellow-green cathodoluminescence when rich in Y.

Optical Properties: Transparent. *Color:* Colorless to tan. *Luster:* Adamantine. *Optical Class:* Biaxial (+). *Orientation:* $X \wedge c = 40°$; $Z \wedge a = 68°$. $\alpha = 1.680$ $\beta = 1.692$ $\gamma = 1.720$ 2V(meas.) = 68° 2V(calc.) = 66°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.830(2)$ $b = 14.763(4)$ $c = 6.221(2)$ $\beta = 123.05(2)°$ Z = 1

X-ray Powder Pattern: Mt. Ploskaya, Russia.
3.47 (10b), 2.604 (8), 7.40 (6), 4.98 (6), 4.92 (6), 2.87 (6), 2.95 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	26.15	31.64	31.62
Al_2O_3	13.64	14.39	16.10
Y_2O_3	17.76	34.66	47.54
Gd_2O_3	0.28	0.24	
Tb_2O_3	0.37	0.00	
Dy_2O_3	2.67	1.65	
Ho_2O_3	0.22	0.32	
Er_2O_3	6.86	3.22	
Tm_2O_3	2.05	0.70	
Yb_2O_3	22.80	7.03	
Lu_2O_3	3.40	0.89	
H_2O	[3.80]	[5.26]	4.74
Total	[100.00]	[100.00]	100.00

(1) Mt. Ploskaya, Russia; by electron microprobe, H_2O by difference, original total given as 100.10%; corresponds to $(Y_{1.78}Yb_{1.31}RE_{0.98})_{\Sigma=4.07}Al_{3.03}Si_{4.94}O_{18}(OH)_{4.96}$. (2) Do.; corresponds to $(Y_{3.08}Yb_{0.36}RE_{0.36})_{\Sigma=3.80}Al_{2.83}Si_{5.28}O_{18}(OH)_{5.18}$. (3) $Y_4Al_2AlSi_5O_{18}(OH)_5$.

Occurrence: Two generations of crystals occur in fluorite in "amazonite" pegmatites.

Association: Fluorite, gadolinite, xenotime, bastnäsite (Mt. Ploskaya, Russia).

Distribution: From Mt. Ploskaya, Keivy massif, Kola Peninsula, Russia. In the Evans Lou pegmatite, Wakefield, Quebec, Canada.

Name: For Mt. Vyuntspakhk, 5 km southeast of Mt. Ploskaya, Kola Peninsula, Russia, and its *yttrium* content.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5767; Mining Institute, St. Petersburg, 1341/1; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 82544.

References: (1) Voloshin, A.V., Y.A. Pakhomovskii, Y.P. Menshikov, A.S. Povarennykh, and D.L. Rogachev (1983) Vyuntspakhite $Y_4Al_2AlSi_5O_{18}(OH)_5$, a new yttrium-aluminum silicate from amazonite pegmatites of the Kola Peninsula. Mineral. Zhurnal, 5(4), 89–94 (in Russian with English abs.). (2) (1984) Amer. Mineral., 69, 1193 (abs. ref. 1). (3) Yakubovich, O.V., M.A. Simonov, A.V. Voloshin, and Y.A. Pakhomovskii (1984) Crystal structure of vyuntspakhkite $(Y,TR)_4^{VIII}(Al_{2.5}\square_{1.5})^{V}[Al_{0.33}Si_{0.67})_{1.5}\square_{2.5}]^{IV}[SiO_4]_4[O_{0.5}(OH)_{3.5}]_2$. Kristallografiya (Sov. Phys. Crystal.), 29, 238–242 (in Russian).

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Västmanlandite-(Ce) $(Ce,La)_3CaAl_2Mg_2[Si_2O_7][SiO_4]_3F(OH)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As irregular grains to 3mm.

Physical Properties: *Cleavage*: Good on {001}. *Fracture*: Uneven to conchoidal. *Tenacity*: n.d. Hardness = 6 D(meas.) = n.d. D(calc.) = 4.51(2)

Optical Properties: Translucent. *Color*: Black to dark brown. *Streak*: Yellowish gray. *Luster*: Vitreous.
Optical Class: Biaxial (+). α = 1.781(4) β(calc) = 1.792 γ = 1.810(4) 2V = 75(5)°
Dispersion: r >v, strong. *Pleochroism*: Strong, *X* = pale yellow, *Y* = reddish brown, *Z* = dark brown. *Absorption: Z ~ Y > X* (orientation unknown).

Cell Data: *Space Group: P*$2_1/m$. a = 8.939(1) b = 5.706(1) c = 15.855(2) β = 94.58(1)°

X-ray Powder Pattern: Malmkärra iron deposit, Västmanland county, south-central Sweden. 2.9831 (100), 3.503 (20), 2.6250 (19), 15.81 (16), 2.1874 (15), 2.6852 (13), 2.6784 (11)

Chemistry:

	(1)		(1)
La_2O_3	13.65	CaO	4.65
Ce_2O_3	23.90	FeO	3.56
Pr_2O_3	2.07	MgO	5.51
Nd_2O_3	6.28	Al_2O_3	8.58
Sm_2O_3	0.42	SiO_2	26.61
Gd_2O_3	0.15	P_2O_5	0.05
Dy_2O_3	0.01	TiO_2	0.04
Ho_2O_3	0.02	F	1.06
Er_2O_3	0.00	[H_2O]	1.6
Yb_2O_3	0.03	- O = F	0.45
Y_2O_3	0.18	Total	96.31

(1) Malmkärra iron deposit, Västmanland county, south-central Sweden; average of 3 electron microprobe analyses, H_2O estimated as 2OH per formula unit, Fe^{2+}/Fe^{3+} by Mössbauer spectroscopy, OH^- confirmed by IR spectroscopy; corresponding to $(Ce_{1.62}La_{0.93}Nd_{0.42}Pr_{0.14}Sm_{0.03}Y_{0.02}Gd_{0.01})_{\Sigma=3.17}$ $Ca_{0.92}Al_{1.88}(Mg_{1.52}\ Fe^{3+}_{0.37}Fe^{2+}_{0.18})_{\Sigma=2.07}(Si_{4.94}P_{0.01})_{\Sigma=4.95}O_{0.19}(F_{0.62}O_{0.38})_{\Sigma=1.00}(OH)_2$.

Polymorphism and Series: Forms a solid solution series with an Fe analog.

Occurrence: In disseminated magnetite-amphibole calc-silicate replacements in marble.

Association: Fluorbritholite-(Ce), tremolite, dolomite, magnetite, and minor arsenopyrite, bastnäsite-(Ce), bismuthinite, cerite-(Ce), chalcopyrite, dollaseite-(Ce), ferriallanite, gadolinite-(Ce), molybdenite, pyrite, talc, zircon.

Distribution: From the Malmkärra iron deposit (also the Bastnäs and Östanmossa deposits), Norberg district, Västmanland county, Bergslagen mining region, south-central Sweden.

Name: For the county in Norway in which the first specimens were collected.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden (01+0081).

References: (1) Holtstam, D., U. Kolitsch, and U.B. Andersson (2005) Västmanlandite-(Ce) - a new lanthanide- and F-bearing sorosilicate mineral from Västmanland, Sweden: description, crystal structure, and relation to gatelite-(Ce). Eur. J. Mineral., 17, 129-141. (2) (2005) Amer. Mineral., 90, 1948-1949 (abs. ref. 1).

Wadeite $K_2ZrSi_3O_9$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. As prisms, to 5 mm, and as hexagonal-shaped basal sections.

Physical Properties: *Cleavage:* Pyramidal, poor, intersecting at 80°–90°. *Fracture:* Conchoidal. Hardness = 6–6.5 D(meas.) = 3.10–3.13 D(calc.) = 3.16 Cathodoluminescent.

Optical Properties: Transparent. *Color:* Colorless, rarely light pink or lilac. *Luster:* Adamantine.
Optical Class: Uniaxial (+). $\omega = 1.624–1.627$ $\epsilon = 1.655–1.673$

Cell Data: *Space Group:* $P6_3/m$. $a = 6.893(4)$ $c = 10.172(2)$ $Z = 2$

X-ray Powder Pattern: Wolgidee Hills, Western Australia. (ICDD 10-461).
2.85 (100), 3.85 (80), 5.97 (60), 1.85 (60), 1.69 (60), 1.63 (40), 5.11 (30)

Chemistry:

	(1)	(2)
SiO_2	45.12	42.80
TiO_2	1.58	0.24
ZrO_2	28.83	26.66
Al_2O_3	0.03	1.92
Fe_2O_3	0.04	0.25
MgO	0.02	
CaO		3.10
SrO	0.03	
Na_2O		1.50
K_2O	24.21	20.12
H_2O^+		0.93
P_2O_5		2.45
Total	99.86	99.97

(1) Wolgidee Hills, Western Australia; by electron microprobe, corresponding to $K_{2.04}(Zr_{0.93}Ti_{0.08})_{\Sigma=1.01}Si_{2.98}O_9$. (2) Khibiny massif, Russia.

Occurrence: In veins in leucite lamproites (Wolgidee Hills, Western Australia); in nepheline-feldspathoid and natrolite veins in a differentiated alkalic massif (Khibiny massif, Russia).

Association: Leucite, phlogopite, olivine, titanian potassian fluor-richterite, perovskite, apatite, calcite, barite, "chalcedony," zeolites (West Kimberley area, Western Australia); astrophyllite, biotite, aegirine, titanite, sodalite, barite, apatite, fluorite, zeolites (Khibiny massif, Russia).

Distribution: From the Wolgidee Hills and in the Argyle diamond mine, West Kimberley area, Western Australia. In the Khibiny and Kovdor massifs, Kola Peninsula, and the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: For Dr. Arthur Wade, Australian geologist who first collected the mineral.

Type Material: University of Western Australia, Perth, Australia, 18760.

References: (1) Prider, R.T. (1939) Some minerals from the leucite-rich rocks of the West Kimberley, Western Australia. Mineral. Mag., 25, 374–387. (2) (1940) Amer. Mineral., 25, 254 (abs. ref. 1). (3) Henshaw, D.E. (1955) The structure of wadeite. Mineral. Mag., 30, 585–595. (4) Kapustin, Y.L. (1963) Discovery of wadeite in the USSR. Doklady Acad. Nauk SSSR, 151, 1410–1412 (in Russian). (5) (1963) Chem. Abs., 59, 15038 (abs. ref. 4). (6) Blinov, V.A., N.G. Shumyatskaya, A.A. Voronkov, V.V. Ilyukhin, and N.V. Belov (1977) Refinement of the crystal structure of wadeite $K_2Zr[Si_3O_9]$ and its relationship to kindred structural types. Kristallografiya (Sov. Phys. Crystal.), 22, 59–65 (in Russian). (7) Birch, W.D. (1985) A note on large crystals of priderite, jeppeite, wadeite and other minerals from Walgidee [Wolgidee] Hills, Western Australia. Australian Mineral., 50, 298–302.

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Wadsleyite β–$(Mg, Fe^{2+})_2SiO_4$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ (probable).
As microcrystalline aggregates with grain sizes to 5.0 μm.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.84

Optical Properties: Transparent. *Color:* Pale fawn [light grayish brown].
Optical Class: Biaxial. $n = 1.76$ 2V(meas.) = n.d.

Cell Data: *Space Group:* *Imma* (probable). $a = 5.70(2)$ $b = 11.71(7)$ $c = 8.24(4)$
Z = 8

X-ray Powder Pattern: Peace River meteorite.
2.452 (100), 2.038 (80), 1.442 (80), 2.886 (50), 2.691 (40), 2.637 (30), 1.567 (30)

Chemistry:

	(1)
SiO_2	38.70
Cr_2O_3	0.01
FeO	22.37
MnO	0.43
NiO	0.11
MgO	38.21
CaO	0.07
ZnO	0.10
Total	100.00

(1) Peace River meteorite; by electron microprobe, corresponding to $(Mg_{1.48}Fe_{0.49}Mn_{0.01})_{\Sigma=1.98}Si_{1.01}O_4$.

Polymorphism & Series: Trimorphous with forsterite and ringwoodite.

Occurrence: In fragments within a vein in a "hypersthene"-olivine chondritic meteorite, believed to have formed during an extraterrestrial shock event.

Association: Majorite, ringwoodite, olivine, orthopyroxene, plagioclase, Fe–Ni alloys, troilite.

Distribution: In the Peace River meteorite.

Name: For Dr. A.D. Wadsley.

Type Material: Department of Geology, University of Alberta, Edmonton, Canada.

References: (1) Price, G.D., A. Putnis, S.O. Agrell, and D.G.W. Smith (1983) Wadsleyite, natural $\beta-(Mg, Fe)_2SiO_4$ from the Peace River meteorite. Can. Mineral., 21, 29–35. (2) (1983) Amer. Mineral., 68, 1040 (abs. ref. 1).

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Wagnerite $(Mg,Fe^{2+})_2(PO_4)F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Typically in prismatic coarse anhedral crystals, elongated and striated along [001], complex vincinal form development, with more than thirty forms noted, to 20 cm; granular, massive.

Physical Properties: *Cleavage:* On {100}, {120}, imperfect; on {001}, interrupted. *Fracture:* Uneven, subconchoidal, splintery. Hardness = 5–5.5 D(meas.) = 3.15 D(calc.) = 3.15

Optical Properties: Translucent to nearly opaque. *Color:* Wine-yellow, orange, yellowish brown, pale gray, white, flesh-red, pale green; colorless in transmitted light. *Luster:* Vitreous to slightly resinous.
Optical Class: Biaxial (+). *Orientation:* $Y = b$; $Z \wedge c = -20°$ to $-21.5°$. *Dispersion:* $r > v$, weak, inclined. $\alpha = 1.568–1.588$ $\beta = 1.572–1.589$ $\gamma = 1.582–1.598$ 2V(meas.) = 25°–35°

Cell Data: *Space Group:* $P2_1/a$. $a = 11.945–11.985$ $b = 12.679–12.738$ $c = 9.644–9.70$ $\beta = 108.18°–108.36°$ Z = 16

X-ray Powder Pattern: Star Lake, Canada; close to magniotriplite.
2.985 (100), 3.297 (65), 3.123 (63), 2.854 (59), 2.758 (25), 2.710 (22), 1.584 (15)

Chemistry:

	(1)	(2)	(3)
P_2O_5	43.45	42.68	43.65
FeO	0.95	6.04	
MnO	0.70	0.92	
MgO	48.35	43.76	49.58

	(1)	(2)	(3)
F	11.49	8.27	11.69
OH		2.82	
$-O = (F_2, OH)$	4.84	4.81	4.92
Total	100.10	99.68	100.00

(1) Werfen, Austria; corresponds to $(Mg_{1.96}Fe_{0.02}Mn_{0.02})_{\Sigma=2.00}(PO_4)_{1.00}F_{0.99}$. (2) Miregn, Switzerland; by electron microprobe, total Fe as FeO, $(OH)^{1-}$ from IR and stoichiometry; corresponds to $(Mg_{1.82}Fe_{0.14}Mn_{0.02})_{\Sigma=1.98}(PO_4)_{1.01}[F_{0.72}(OH)_{0.28}]_{\Sigma=1.00}$. (3) $Mg_2(PO_4)F$.

Occurrence: A rare accessory mineral in metamorphic rocks of moderate to high grade; uncommon in pegmatites.

Association: Lazulite, ferroan magnesite, chlorite (Höllgraben, Austria); corundum, sillimanite, plagioclase, biotite, monazite-(Ce), apatite, andalusite, tourmaline (Santa Fe Mountain, Colorado, USA); surinamite, musgravite, garnet, sapphirine, chrysoberyl, cordierite (Casey Bay, Antarctica).

Distribution: In Austria, in Salzburg, from Höllgraben, Färbergraben, Radelgraben, and Schladming-graben, near Werfen, and Bischofshofen, and from Webing, near Abtenau. In Germany, in the Silberberg mine, Bodenmais, Bavaria; on the Nickenicher Sattel and Bellerberg volcanoes, Eifel district; and from the Zechstein salt deposit, Hannover, Lower Saxony. At Miregn, Val d'Ambra, Tessin, Switzerland. From Skřiářov, near Velká Bíteš, and Dolní Bory, near Velké Meziříčí, Czech Republic. Large crystals from Porsgrunn and Havredal, Bamble, Norway. At Hålsjöberget, Värmland, Sweden. In the Kyakhta sillimanite deposit, Buryatia. On Santa Fe Mountain, near Idaho Springs, Clear Creek Co., Colorado; in the Dome Rock Mountains, Yuma Co., Arizona, USA. From the Star Lake area, near Sherridon, Manitoba, Canada. At Bimbowrie, near Olary, South Australia. From Casey Bay, Enderby Land, Antarctica. Additional localities are known, many from single specimens.

Name: Honoring F.M. von Wagner (1768–1851), mining official in Munich, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 845–848. (2) Coda, A., G. Giuseppetti, and C. Tadini (1967) The crystal structure of wagnerite. Atti Rend. Accad. Lincei, 43, 212–224. (3) Irouschek-Zumthor, A. and T. Armbruster (1985) Wagnerite from a metapelitic rock of the Simano Nappe (Leopontine Alps, Switzerland). Schweiz. Mineral. Petrog. Mitt., 65, 137–151. (4) Leroux, M.V. and T.S. Ercit (1992) Wagnerite, an accessory phase in cordierite-anthophyllite gneiss from Star Lake, Manitoba. Can. Mineral., 30, 1161–1165.

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Wairakite $CaAl_2Si_4O_{12}\cdot 2H_2O$

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Crystal Data: Monoclinic, pseudocubic. *Point Group:* $2/m$. Subhedral trapezohedral crystals, to 1.5 cm; also as incrustations. *Twinning:* Lamellar on {110}, common.

Physical Properties: *Cleavage:* Two sets of possible partings intersecting at 90°. *Tenacity:* Brittle. Hardness = 5.5–6 D(meas.) = 2.26 D(calc.) = 2.272

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in thin section. *Luster:* Vitreous to nearly dull.
Optical Class: Biaxial. *Orientation:* $X \simeq b$; $Y \simeq a$; $Z \simeq c$. *Dispersion:* $r > v$, weak.
$\alpha = 1.498(1)$ $\beta =$ n.d. $\gamma = 1.502(1)$ 2V(meas.) = 70°–105°

Cell Data: *Space Group:* $I2/a$. $a = 13.692(3)$ $b = 13.643(3)$ $c = 13.560(3)$
$\beta = 90.5(1)°$ Z = 8

X-ray Powder Pattern: Wairakei, New Zealand.
3.39 (10), 5.57 (8), 3.42 (6), 2.909 (5), 6.85 (4), 4.84 (4), 2.680 (4)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SiO_2	55.9	54.46	55.33	Na_2O	1.06	0.26	
Al_2O_3	23.0	23.92	23.47	K_2O	0.16	0.04	
Fe_2O_3		0.04		Cs_2O	0.02		
MgO		trace		H_2O^+	8.35		
CaO	11.7	12.94	12.91	H_2O^-	0.15		
SrO	0.05			H_2O		8.46	8.29
				Total	100.39	100.12	100.00

(1) Wairakei, New Zealand. (2) Seigoshi mine, Japan; by AA, gravimetry, and TGA.
(3) $CaAl_2Si_4O_{12}\cdot 2H_2O$.

Mineral Group: Zeolite group.

Occurrence: In pores and cavities in rocks in geothermal areas, deposited from hydrothermal fluids; may replace feldspar. In tuffaceous sandstones and breccias, vitric and welded tuffs, and in clay.

Association: Andesine, epidote, clinozoisite, prehnite, calcite, aragonite, quartz.

Distribution: Some of the known localities follow. In New Zealand, on North Island, at Wairakei, about six km north-northeast of Lake Taupo, and in the Tui mine, Te Aroha, Auckland. In the USA, from The Geysers, Sonoma Co., and near Rosamond, Kern Co., California; in Yellowstone National Park, Wyoming; and Mt. Rainier National Park, Pierce Co., Washington. On St. Thomas and St. Croix, American Virgin Islands. In the Buttle Lake area, Vancouver Island, British Columbia, Canada. In Japan, in the Seikoshi mine, Toi, and at Kawazu, Shizuoka Prefecture; from Koriyama, Fukushima Prefecture; Onikobe, Miyagi Prefecture; the Yugami district, Fukui Prefecture; Hikihara, Hyogo Prefecture, and at a number of other localities.

Name: For the first-noted locality at Wairakei, New Zealand.

Type Material: Geological Survey of New Zealand, Lower Hutt, New Zealand, P13871; National Museum of Natural History, Washington, D.C., USA, 137192.

References: (1) Steiner, A. (1955) Wairakite, the calcium analogue of analcime, a new zeolite mineral. Mineral. Mag., 30, 691–708. (2) Coombs, D.S. (1955) X-ray observations on wairakite and non-cubic analcime. Mineral. Mag., 30, 699–708. (3) (1956) Amer. Mineral., 41, 166–167 (abs. refs. 1 and 2). (4) Takéuchi, Y., F. Mazzi, N. Haga, and E. Galli (1979) The crystal structure of wairakite. Amer. Mineral., 64, 993–1001. (5) Aoki, M. and H. Minato (1980) Lattice constants of wairakite as a function of chemical composition. Amer. Mineral., 65, 1212–1216.

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Wairauite CoFe

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Crystal Data: Cubic. *Point Group:* n.d. As euhedral grains up to 7 x 4 μm in diameter, but typically below 2 μm, many showing the cube and octahedron as common forms.

Physical Properties: Hardness = 4.5 VHN = 255 D(meas.) = n.d. D(calc.) = 8.32
Highly magnetic.

Optical Properties: Opaque. *Color:* In polished section, white. *Luster:* Metallic.
R: n.d.

Cell Data: *Space Group:* n.d. $a = 2.86$ $Z = [1]$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Co	48.8	50.2	51.34
Fe	49.8	49.7	48.66
Ni	0.5	0.4	
Total	99.1	100.3	100.00

(1) Wairau Valley, New Zealand; by electron microprobe. (2) Muskox intrusion, Canada; by electron microprobe. (3) CoFe.

Occurrence: In a dominantly lizardite serpentine at the western contact of an ultramafic intrusion; thought to have formed under low-sulfur reducing conditions during the serpentinization process (Wairau Valley, New Zealand).

Association: Chromite, magnetite, awaruite, copper (Wairau Valley, New Zealand).

Distribution: From the Red Hills, Wairau Valley, Marlborough district, South Island, New Zealand. In the Muskox intrusion, Northwest Territories, Canada.

Name: For the Wairau Valley locality in New Zealand.

Type Material: Geological Survey of New Zealand, Lower Hutt, New Zealand, P25574; Cambridge University, Cambridge, England; National Museum of Natural History, Washington, D.C., USA, 137192.

References: (1) Challis, G.A. and J.V.P. Long (1964) Wairauite – a new cobalt–iron mineral. Mineral. Mag., 33, 942–948. (2) (1965) Amer. Mineral., 50, 520 (abs. ref. 1).

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Wakabayashilite $(As, Sb)_{11}S_{18}$

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Crystal Data: Monoclinic, pseudohexagonal. *Point Group:* 2 or $2/m$. As fibers elongated ‖ [010], up to 2 cm long, or as prisms.

Physical Properties: *Cleavage:* {100}, {010}, {$10\overline{1}$}, perfect. *Tenacity:* Flexible. Hardness = ∼1.5 VHN = n.d. D(meas.) = 3.96 D(calc.) = 4.06

Optical Properties: Translucent. *Color:* Golden to lemon-yellow, with golden yellow internal reflections. *Streak:* Orange-yellow. *Luster:* Silky (for fibrous aggregates) to resinous. *Anisotropism:* Weak. *Pleochroism:* Strong.

R: (400) 28.4, (420) 27.8, (440) 27.2, (460) 26.0, (480) 24.5, (500) 23.3, (520) 22.5, (540) 22.0, (560) 21.8, (580) 21.6, (600) 21.6, (620) 21.5, (640) 21.4, (660) 21.3, (680) 21.2, (700) 21.2

Cell Data: *Space Group:* $P2_1$ or $P2_1/m$; $P6_3/mmc$ (pseudocell). $a = 29.128$ $b = 6.480$ $c = 29.128$ $\beta = 120.0°$ Z = [8]

X-ray Powder Pattern: White Caps mine, Nevada, USA.
6.28 (100), 3.488 (80), 4.78 (70), 3.239 (40), 3.078 (40), 2.423 (40), 1.590 (40)

Chemistry:

	(1)	(2)
As	52.3	54.5
Sb	8.3	5.7
S	39.0	39.5
Total	99.6	99.7

(1–2) White Caps mine, Nevada, USA; by electron microprobe.

Occurrence: As fibers in druses of quartz or embedded in calcite.

Association: Realgar, orpiment, stibnite, pyrite (Nishinomaki mine, Japan); realgar, orpiment, calcite (White Caps mine, Nevada, USA); chabournéite, pierrotite, parapierrotite, stibnite, pyrite, sphalerite, twinnite, zinkenite, madocite, andorite, smithite, laffittite, routhierite, aktashite, realgar, orpiment (Jas Roux, France).

Distribution: In the Nishinomaki mine, Gumma Prefecture, Japan. From the White Caps and Black Mammoth mines, Manhattan district, Nye Co., and in the Getchell mine, Potosi district, Humboldt Co., Nevada, USA. At the Jas Roux deposit, 10 km east of Chapelle-en-Valgaudemar, Hautes-Alpes, France. In the Gal-Khaya deposit, Sakha, and from the Lukhumi arsenic deposit, central Caucasus Mountains, Russia. At Khaydarkan, Fergana Valley, Alai Range, Kyrgyzstan. From the Shuiluo arsenic deposit, Zhuang district, Guangxi Autonomous Region, China.

Name: For Yaichiro Wakabayashi (1874–1943), mineralogist for the Mitsubishi Mining Company, Japan.

Type Material: National Science Museum, Tokyo, Japan, MA5635; National Museum of Natural History, Washington, D.C., USA, C252, 98012, 94600.

References: (1) Kato, A., K.I. Sakurai, and K. Ohsumi (1970) An introduction to Japanese minerals, In: Geol. Survey Japan, 1970, 92–93. (2) (1972) Amer. Mineral., 57, 1311 (abs. ref. 1). (3) Scott, J.D. and W. Nowacki (1975) New data on wakabayashilite. Can. Mineral., 13, 418–419.

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Wakefieldite-(Ce) $(Ce, La, Nd, Pb)VO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals, to 4 mm, pyramidal {101}, or prismatic, with {100}, {001}, {110}, {111}.

Physical Properties: *Cleavage:* On {100}, good. *Tenacity:* Very brittle. Hardness = 4.5–5 VHN = 440 (100 g load). D(meas.) = 4.74(7) D(calc.) = [5.42]

Optical Properties: Translucent to opaque. *Color:* Dark red to coal-black, pale yellow to bluish gray; honey-yellow in thin section, may exhibit strong red internal reflections.
Streak: Rust-brown.
Optical Class: Uniaxial (+), may be biaxial (–). *Pleochroism:* Strong; O = light red, pale brown; E = very dark red, hazel-brown. $\omega = 1.990(5)$ $\epsilon = 2.160(5)$

Cell Data: *Space Group:* $I4_1/amd$. a = 7.33–7.35 c = 6.45–6.56 Z = 4

X-ray Powder Pattern: Kusu deposit, Congo.
3.678 (100), 2.766 (90), 1.891 (70), 4.89 (50), 2.594 (40), 1.638 (40), 2.291 (30)

Chemistry:

	(1)	(2)
V_2O_5	31.80	33.18
La_2O_3		15.53
Ce_2O_3	35.80	38.07
Nd_2O_3		7.43
Sm_2O_3		0.62
PbO_2	[18.27]	
PbO	[17.05]	
Total	[102.92]	94.83

(1) Kusu deposit, Congo; by electron microprobe, average of two analyses with Pb divided equally between Pb^{2+} and Pb^{4+}; then corresponds to $(Ce^{3+}_{0.60}Pb^{2+}_{0.22}Pb^{4+}_{0.22})_{\Sigma=1.04}V_{0.98}O_4$. (2) Yellow Lake, Canada; by X-ray fluorescence, total deficient as not all RE elements determined; corresponds to $(Ce_{0.63}La_{0.26}Nd_{0.12}Sm_{0.01})_{\Sigma=1.02}V_{0.99}O_4$.

Occurrence: In silicified limestone (Kusu deposit, Congo); in vesicles with zeolites (Yellow Lake, Canada).

Association: Mottramite (Kusu deposit, Congo); brewsterite, heulandite, analcime, mesolite, thomsonite, calcite, fluorite (Yellow Lake, Canada).

Distribution: In the Kusu vanadium deposit, 85 km south of Kinshasa, Bas-Congo Province, Congo (Bas-Zaire Province, Zaire). At Tifernine, Morocco. On the north side of Yellow Lake, British Columbia, Canada.

Name: Originally described as "kusuite"; the name later changed to reflect its identity as the *cerium* analog of *wakefieldite*-(Y).

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG5895; Natural History Museum, Paris, France, 178.119; National Museum of Natural History, Washington, D.C., USA, 136817.

References: (1) Deliens, M. and P. Piret (1977) La kusuïte $(Ce^{3+}, Pb^{2+}, Pb^{4+})VO_4$, nouveau minéral. Bull. Soc. fr. Minéral., 100, 39–41 (in French with English abs.). (2) (1977) Amer. Mineral., 62, 1058 (abs. ref. 1). (3) Deliens, M. and P. Piret (1988) La kusuïte devient la wakefieldite-(Ce) plombifère. [kusuite = plumboan wakefieldite-(Ce)] Bull. Minéral., 109, 305 (in French with English abs.). (4) Baudracco-Gritti, C., S. Quartieri, G. Vezzalini, F. Permingeat, F. Pillard, and R. Rinaldi (1987) Une wakefieldite-(Ce) non plombifère: nouvelles données sur l'espèce minérale correspondant à l'orthovanadate de cérium. Bull. Minéral., 110, 657–663 (in French with English abs.). (5) Howard, D.G. (1995) Occurrence of wakefieldite-(Ce) with zeolites at Yellow Lake, British Columbia, Canada. Neues Jahrb. Mineral., Monatsh., 127–132.

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Wakefieldite-(La) $LaVO_4$

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. Crystals prismatic on [001], to 0.5 mm, showing {001}, {100}.

Physical Properties: *Cleavage*: None observed; possible {100} inferred from X-ray study. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~4 D(meas.) = n.d. D(calc.) = 4.727 (end member)

Optical Properties: Transparent to translucent. *Color*: Light pink to brown. *Streak*: White. *Luster*: Adamantine.
Optical Class: Uniaxial (+). ω and ε > 1.90 *Pleochroism*: *E* = pale pink, *O* = pale pinkish yellow. *Absorption: E > O.*

Cell Data: *Space Group*: $I4_1/amd$. a = 7.406(6) c = 6.504(8) Z = 4

X-ray Powder Pattern: Glücksstern Mine, Friedrichroda, Thuringia, Germany.
3.707 (100), 1.853 (19), 2.759 (10), 2.623 (7), 2.939 (5), 2.309 (5), 2.088 (5)

Chemistry:

	(1)	(2)
La_2O_3	43.87	64.18
Ce_2O_3	0.31	
Nd_2O_3	9.49	
Pr_2O_3	6.65	
Sm_2O_3	0.58	
Y_2O_3	0.31	
CaO	0.10	
UO_2	0.03	
V_2O_5	34.91	35.82
As_2O_5	0.06	
P_2O_5	0.02	
SiO_2	0.04	
Total	96.37	100.00

(1) Glücksstern Mine, Friedrichroda, Thuringia, Germany; average of 10 electron microprobe analyses, corresponding to $(La_{0.71}Nd_{0.15}Pr_{0.11}Sm_{0.01}Y_{0.01})_{\Sigma=0.99}V_{1.01}O_{4.00}$. (2) $LaVO_4$.

Mineral Group: Xenotime group.

Occurrence: A low temperature mineral in a hydrothermal barite vein.

Association: Hausmannite, barite, gottlobite.

Distribution: Glücksstern Mine, near the Gottlob quarry, Gottlob hill, Friedrichroda, Thuringia, Germany.

Name: As the La analogue of wakefieldite-(Ce) and wakefieldite-(Y).

Type Material: Mineralogical Collection, Bergakademie, Freiberg, Germany, 81876.

References: (1) Witzke, T., U. Kolitsch, J.M. Warnsloh, and J. Göske (2008) Wakefieldite-(La), $LaVO_4$, a new mineral species from the Glücksstern Mine, Friedrichroda, Thuringia, Germany. Eur. J. Mineral., 20, 1135–1139. (2) (2009) Amer. Mineral., 94, 649-650 (abs. ref. 1).

Wakefieldite-(Y) YVO_4

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Prismatic crystals, to 0.1 μm, with basal or pyramidal terminations, in pulverulent masses.

Physical Properties: Hardness = ∼5 D(meas.) = n.d. D(calc.) = 4.25

Optical Properties: Semitransparent. *Color:* Canary-yellow, pale tan.
Optical Class: Uniaxial (+) (synthetic). $\omega = 2.00(1)$ $\epsilon = 2.14(1)$

Cell Data: *Space Group:* $I4_1/amd$ (synthetic). $a = 7.105(3)$ $c = 6.20(1)$ $Z = 4$

X-ray Powder Pattern: Evans-Lou quarry, Canada.
3.56 (100), 1.824 (75), 2.66 (50), 2.51 (30), 2.21 (25), 1.774 (20), 4.74 (17)

Chemistry: (1) Evans-Lou quarry, Canada; identity of wakefieldite-(Y) depends on Y and V determined as major elements, and correspondence of its X-ray pattern with synthetic YVO_4.

Occurrence: In quartz in a zoned granite pegmatite (Evans-Lou quarry, Canada).

Association: Hellandite, quartz, kainosite-(Y), montmorillonite (Evans-Lou quarry, Canada).

Distribution: In the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada. From the White Tank Mountains, Maricopa Co., Arizona, USA.

Name: For Wakefield Lake, nearby the Evans-Lou quarry, Canada, and the dominant rare earth, *yttrium*.

Type Material: Geological Survey of Canada, Ottawa, 12165; University of Ottawa, Ottawa; Royal Ontario Museum, Toronto, Canada, M30382.

References: (1) Miles, N.M., D.D. Hogarth, and D.S. Russell (1971) Wakefieldite, yttrium vanadate, a new mineral from Quebec. Amer. Mineral., 56, 395–410.

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Walentaite $\mathbf{H(Ca,Fe^{2+},Mn^{2+})Fe_3^{3+}(AsO_4,PO_4)_4 \cdot 7H_2O}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. Bladed crystals, to 200 μm, elongated along [001] and flattened on {010}, typically in aggregates of rosettes.

Physical Properties: *Cleavage:* Perfect on {010}. *Tenacity:* Brittle. Hardness = ~3 D(meas.) = 2.72 D(calc.) = 2.72

Optical Properties: Semitransparent. *Color:* Bright yellow, bright greenish yellow, pale brownish in aggregates. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = colorless; Y = pale yellow-green to pale yellow; Z = medium yellow-green to medium yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Absorption:* $Z < Y$. α = 1.65–1.738 β = [1.707]–1.74 γ = 1.76–1.779 2V(meas.) = n.d.

Cell Data: *Space Group:* $Immm$, $Imam$, $Imm2$, $Ima2$, $I222$, or $I2_12_12_1$. a = 26.24(6) b = 10.31(1) c = 7.38(1) Z = 1

X-ray Powder Pattern: White Elephant mine, South Dakota, USA.
12.9 (100), 3.00 (50), 4.43 (30), 6.56 (20), 4.82 (20), 2.931 (20), 2.776 (20)

Chemistry:

	(1)	(2)		(1)	(2)
WO_3		14.5	FeO	3.2	
P_2O_5	12.5	16.5	MnO	3.1	
As_2O_5	32.9	24.9	CaO	2.9	2.3
Al_2O_3	0.5		F	trace	
Fe_2O_3	28.3	25.3	H_2O	16.6	[16.5]
			Total	[100.0]	[100.0]

(1) White Elephant mine, South Dakota, USA; by electron microprobe, Fe^{2+}:Fe^{3+} from stoichiometry, total Mn as MnO, H_2O by TGA-EGA, normalized to 100% from an original total of 111.2%; corresponding then to $H_{0.12}(Ca_{0.42}Fe^{2+}_{0.37}Mn_{0.36})_{\Sigma=1.15}(Fe^{3+}_{2.92}Al_{0.08})_{\Sigma=3.00}[(AsO_4)_{2.36}(PO_4)_{1.45}]_{\Sigma=3.81} \cdot 7.52H_2O$. (2) Griffin's Find mine, Australia; by electron microprobe, total Fe as Fe_2O_3, H_2O by difference; with $(OH)^{1-}$ calculated for charge balance, corresponding to $Ca_{0.36}Fe^{3+}_{2.82}W_{0.56}[(AsO_4)_{1.94}(PO_4)_{2.06}]_{\Sigma=4.00}(OH)_{0.54} \cdot 7.92H_2O$.

Occurrence: A rare secondary mineral in a complex zoned pegmatite, probably formed by alteration of löllingite and triphylite–lithiophilite (White Elephant mine, South Dakota, USA); a secondary mineral in the oxidized zone of a gold mine in granulite (Griffin's Find mine, Australia).

Association: Rockbridgeite, löllingite, spessartine, muscovite, quartz, tridymite (White Elephant mine, South Dakota, USA); pharmacosiderite, jarosite, iron oxides (Griffin's Find mine, Australia).

Distribution: From the White Elephant mine, near Pringle, Custer Co., South Dakota, USA. In the Griffin's Find gold mine, about 15 km northwest of Lake Grace, Western Australia.

Name: Honoring Dr. Kurt Walenta (1927–), Professor of Mineralogy, University of Stuttgart, Stuttgart, Germany, for his contributions to the mineralogy of arsenates and phosphates, especially from the Black Forest, Germany.

Type Material: The Natural History Museum, London, England, 1984,690; National Museum of Natural History, Washington, D.C., USA, 149782, 149783.

References: (1) Dunn, P.J., D.R. Peacor, W.L. Roberts, T.J. Campbell, and R.A. Ramik (1984) Walentaite, a new calcium iron arsenate phosphate from the White Elephant mine, Pringle, South Dakota. Neues Jahrb. Mineral., Monatsh., 169–174. (2) (1984) Amer. Mineral., 69, 1193–1194 (abs. ref. 1). (3) Nickel, E.H. (1987) Tungsten-bearing walentaite from Griffins Find gold deposit, Western Australia. Australian Mineral., 2(1), 9–12.

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Walfordite $(Fe^{3+}, Te^{6+})Te_3^{4+}O_8$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Crystals are cubic {100}, may be modified by minor {111}, to 0.2 mm.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 5.841

Optical Properties: Transparent to opaque. *Color:* Orange. *Streak:* Yellow-orange. *Luster:* Adamantine.
Optical Class: Isotropic. $n = [2.23]$ (by the rule of Gladstone and Dale).

Cell Data: *Space Group:* $Ia3$. a = 11.011(5) Z = 8

X-ray Powder Pattern: Tambo mine, Chile.
3.175 (100), 1.658 (45), 1.944 (44), 2.749 (37), 4.486 (29), 2.943 (23), 2.592 (22)

Chemistry:

	(1)
TeO_3	8.67
TeO_2	81.74
TiO_2	1.11
Fe_2O_3	8.30
MgO	0.38
Total	100.20

(1) Tambo mine, Chile; by electron microprobe, total Fe as Fe_2O_3; Te calculated for $Te^{4+}O_3$, the balance as Te^{6+}; then corresponds to $(Fe^{3+}_{0.61}Te^{6+}_{0.29}Ti_{0.08}Mg_{0.06})_{\Sigma=1.04}Te^{4+}_{3.00}O_8$.

Occurrence: Very rare in the brecciated oxidized zone of a tellurium-bearing hydrothermal gold deposit.

Association: Alunite, rodalquilarite, gold, emmonsite, jarosite, pyrite.

Distribution: From the Wendy open pit, El Indio-Tambo district, east of La Serena, Coquimbo, Chile.

Name: Honors Phillip Walford (1945—), Chief Geologist, LAC Minerals Ltd., who noted the first specimens.

Type Material: Royal Ontario Museum, Toronto, Canada, M47817, M47818.

References: (1) Back, M.E., J.D. Grice, R.A. Gault, A.J. Criddle, and J.A. Mandarino (1999) Walfordite, a new tellurite species from the Wendy open pit, El Indio – Tambo mining property, Chile. Can. Mineral., 37, 1261–1268. (2) (2000) Amer. Mineral., 85, 1324 (abs. ref. 1).

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Wallisite **$PbTl(Cu, Ag)As_2S_5$**

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As small crystals to 1 mm, more commonly massive.

Physical Properties: *Cleavage:* Pronounced on {001}. Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 5.71

Optical Properties: Opaque. *Color:* Lead-gray. *Luster:* Metallic.

R_1–R_2: n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 9.215$ $b = 8.524$ $c = 7.980$ $\alpha = 55°59(6)'$ $\beta = 62°30(6)'$ $\gamma = 69°24(6)'$ Z = 2

X-ray Powder Pattern: Binntal, Switzerland.
3.339 (100), 2.834 (50), 2.879 (30), 2.667 (30), 4.555 (25), 4.233 (25), 2.985 (25)

Chemistry:

	(1)	(2)
Pb	25.2	26.38
Tl	26.	26.03
Cu	6.9	8.09
Ag	2.7	
As	20.5	19.08
S	19.	20.42
Total	100.3	100.00

(1) Binntal, Switzerland; by electron microprobe. (2) $PbTlCuAs_2S_5$.

Occurrence: Overgrowing other lead sulfosalts.

Association: Dufrénoysite, rathite, pyrite.

Distribution: In Switzerland, at the Lengenbach quarry, Binntal, Valais.

Name: For Wallis, the German name for the Swiss Canton in which the Lengenbach quarry is located.

Type Material: Mineralogical-Petrographical Institute, University of Bern, Bern, Switzerland, L2533-63.

References: (1) Nowacki, W. (1965) Über einige Mineralfunde aus dem Lengenbach (Binnatal, Kt. Wallis). Eclogae Geol. Helveticae, 58, 403–406 (in German). (2) (1966) Amer. Mineral., 51, 532 (abs. ref. 1). (3) Nowacki, W., G. Burri, P. Engel, and F. Marumo (1965) Über einige Mineralstufen aus dem Lengenbach (Binnatal) II. Neues Jahrb. Mineral., Monatsh., 43–48 (in German). (4) (1969) Amer. Mineral., 54, 1497 (abs. ref. 3). (5) Takéuchi, Y., M. Ohmasa, and W. Nowacki (1968) The crystal structure of wallisite, $PbTlCuAs_2S_5$, the Cu analogue of hatchite, $PbTlAgAs_2S_5$. Zeits. Krist., 127, 349–365.

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Wallkilldellite $\mathbf{Ca_4Mn_6^{2+}(AsO_4)_4(OH)_8 \cdot 18H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\overline{6}m2$, or $6mm$. As flattened, radial clusters of platy crystals, to about 0.1 mm.

Physical Properties: *Cleavage:* Perfect on {0001}. Hardness = ~3 D(meas.) = 2.85(5) D(calc.) = 2.90

Optical Properties: Semitransparent. *Color:* Dark red. *Streak:* Pale orange.
Luster: Vitreous on cleavage surfaces; slightly resinous on fracture surfaces.
Optical Class: Uniaxial (–). *Pleochroism:* O = reddish orange; E = pale pinkish orange.
Absorption: Moderate; $O > E$. $\omega = 1.728(4)$ ϵ = n.d.

Cell Data: *Space Group:* $P6_3/mmc$, $P\overline{6}2c$, or $P6_3mc$. a = 6.506(7) c = 23.49(3) Z = [1]

X-ray Powder Pattern: Sterling Hill, New Jersey, USA.
11.5 (100), 5.61 (90), 2.844 (60), 2.748 (50), 2.545 (50), 4.56 (40), 3.25 (40)

Chemistry:

	(1)	(2)
As_2O_5	27.4	30.52
SiO_2	1.7	
FeO	0.3	
MnO	27.0	28.26
CuO	3.3	
ZnO	0.0	
MgO	0.9	
CaO	12.4	14.90
H_2O	[27.0]	26.32
Total	100.0	100.00

(1) Sterling Hill, New Jersey, USA; H_2O by difference. (2) $Ca_4Mn_6(AsO_4)_4(OH)_8 \cdot 18H_2O$.

Occurrence: Extremely rare in massive granular franklinite-willemite ore from a metamorphosed stratiform zinc orebody.

Association: Manganoan cuprian adamite, franklinite, willemite, calcite.

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA.

Name: For the *dell* of the *Wallkill* River, in which both the Sterling Hill and the Franklin deposits were discovered.

Type Material: Harvard University, Cambridge, Massachusetts, 113445; National Museum of Natural History, Washington, D.C., USA, 149767.

References: (1) Dunn, P.J. and D.R. Peacor (1983) Kittatinnyite and wallkilldellite, silicate/arsenate analogues containing calcium and manganese, from Franklin and Sterling Hill, New Jersey. Amer. Mineral., 68, 1029–1032.

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Walpurgite $Bi_4(UO_2)O_4(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Crystals typically lathlike, elongated along [001], tabular on {010}, showing {010}, {110}, {1$\overline{1}$0}, {$\overline{1}\overline{1}$1}, a number of other forms, to 6 mm. In radial to subparallel aggregates. *Twinning:* Common, with {010} twin and composition plane.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 3.5 D(meas.) = n.d. D(calc.) = 6.59 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Wax-yellow, straw-yellow, honey-yellow; pale yellow to colorless in transmitted light, commonly zoned. *Streak:* Pale brownish yellow. *Luster:* Adamantine to greasy.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; $Y = Z$ = very faint greenish yellow. *Orientation:* $X \simeq [010]$. *Dispersion:* Small. $\alpha = 1.871$–1.90 $\beta = 1.975$–2.00 $\gamma = 2.005$–2.05 2V(meas.) = Medium large. 2V(calc.) = 52°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.135(2)$ $b = 10.426(4)$ $c = 5.494(1)$ $\alpha = 101.47(2)°$ $\beta = 110.82(2)°$ $\gamma = 88.20(2)°$ Z = 1

X-ray Powder Pattern: Schmiedestollen, Germany.
3.128 (100), 10.257 (41), 3.059 (38), 3.268 (32), 2.739 (26), 3.400 (23), 2.188 (20)

Chemistry:

	(1)	(2)	(3)
UO_3	18.7	16.16	19.28
P_2O_5	0.9	5.88	
As_2O_5	14.1	12.45	15.49
V_2O_5			
Bi_2O_3	61.8	61.87	62.80
H_2O	3.7	3.42	2.43
Total	99.2	99.78	100.00

(1) Schneeberg, Germany; microchemical analysis. (2) Do. (3) $Bi_4(UO_2)O_4(AsO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with orthowalpurgite.

Occurrence: A rare secondary mineral in the oxidized zone of Bi–U–As-bearing hydrothermal mineral deposits.

Association: Trögerite, zeunerite, uranosphaerite, uranospinite, torbernite (Schneeberg, Germany).

Distribution: In Germany, found in the Walpurgis vein, Weisser Hirsch mine, and on the dump of the Ritterzeche, Neustädtel-Schneeberg, Saxony; from the Schmiedestollen, near Wittichen, and at Nussbach, near Triberg, Black Forest. From the Geister vein, Eliáš mine, Jáchymov (Joachimsthal), Czech Republic. At Southwick Cliffs, near Dalbeattie, Kirkcudbrightshire, Scotland.

Name: For its first-noted occurrence in the Walpurgis vein, Schneeberg, Germany.

Type Material: Mining Academy, Freiberg, Germany, 21779.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 796–797. (2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 239–242. (3) Mereiter, K. (1982) The crystal structure of walpurgite, $(UO_2)Bi_4O_4(AsO_4)_2 \cdot 2H_2O$. Tschermaks Mineral. Petrog. Mitt., 30, 129–139. (4) Krause, W., H. Effenberger, and F. Brandstätter (1995) Orthowalpurgite, $(UO_2)Bi_4O_4(AsO_4)_2 \cdot 2H_2O$, a new mineral from the Black Forest, Germany. Eur. J. Mineral., 7, 1313–1324.

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Walstromite $BaCa_2Si_3O_9$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Crystals nearly equant to short prismatic; grains anhedral to subhedral, to 1.5 cm.

Physical Properties: *Cleavage:* Perfect on {011}, {010}, {100}. Hardness = ~3.5 D(meas.) = 3.67(6) D(calc.) = 3.73 Fluoresces dull pink under SW UV and bright pink under LW UV.

Optical Properties: Transparent to translucent. *Color:* White to colorless; colorless in thin section. *Streak:* White. *Luster:* Subvitreous, pearly on cleavages.
Optical Class: Biaxial (–). *Dispersion:* Weak. $\alpha = 1.668(2)$ $\beta = 1.684(2)$ $\gamma = 1.685(2)$ 2V(meas.) = 30° 2V(calc.) = 28°

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.743(5)$ $b = 9.607(5)$ $c = 6.687(5)$ $\alpha = 69°51'$ $\beta = 102°14'$ $\gamma = 97°6.5'$ Z = 2

X-ray Powder Pattern: Fresno Co., California, USA.
2.99 (100), 6.58 (20), 2.70 (20), 4.40 (15), 3.35 (15), 3.20 (15), 3.06 (15)

Chemistry:

	(1)	(2)	(3)
SiO_2	39.6	38.8	40.44
TiO_2	< 0.01	0.03	
Al_2O_3	0.07		
FeO	< 0.02	< 0.01	
MnO	0.33	0.18	
MgO	< 0.05	< 0.1	
CaO	26.1	26.2	25.16
SrO	0.53		
BaO	33.3	34.5	34.40
K_2O	< 0.05	< 0.05	
Total	[100.00]	[100.00]	100.00

(1–2) Fresno Co., California, USA; by D-C arc spectrography, stated to br recalculated to 100.00%. (3) $BaCa_2Si_3O_9$.

Occurrence: Disseminated in a sanbornite-quartz gneissic metamorphic rock, especially where the quartz content is high.

Association: Sanbornite, quartz, wollastonite, celsian, taramellite, pyrrhotite, pyrite, witherite, fresnoite.

Distribution: From the Rush Creek and Big Creek areas, Fresno Co., and on Trumbull Peak, near Incline, Mariposa Co., California, USA.

Name: For Robert E. Walstrom, mineral collector of Fresno, California, USA, who first recognized the distinctive character of the mineral.

Type Material: California Division of Mines & Geology, San Francisco, California, USA.

References: (1) Alfors, J.T., M.C. Stinson, R.A. Matthews, and A. Pabst (1965) Seven new barium minerals from eastern Fresno Co., California. Amer. Mineral., 50, 314–340. (2) Glasser, L.S.D. and F.P. Glasser (1968) The crystal structure of walstromite. Amer. Mineral., 53, 9–13.

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Walthierite $Ba_{0.5}Al_3(SO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ or $3m$. As tabular subhedral to anhedral crystals, to 100 μm, in granular aggregates.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.02

Optical Properties: Transparent. *Color:* White to pale yellow. *Streak:* White. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.588(2)$ $\epsilon = 1.604(2)$

Cell Data: *Space Group:* [$R\overline{3}m$ or $R3m$] (by analogy to alunite). $a = 6.992(4)$ $c = 34.443(8)$ $Z = 6$

X-ray Powder Pattern: Reina vein, Chile.
2.98 (100), 2.283 (80), 1.909 (70), 1.747 (60), 3.49 (55), 5.73 (50), 4.97 (45)

Chemistry:

	(1)
SO_3	34.59
P_2O_5	0.03
Al_2O_3	33.65
Fe_2O_3	0.05
CaO	0.07
SrO	0.04
BaO	16.17
Na_2O	0.28
K_2O	0.42
F	0.03
H_2O	[11.89]
$-O = F_2$	0.01
Total	[98.21]

(1) Reina vein, Chile; by electron microprobe, average of six analyses, H_2O calculated for stoichiometry; corresponds to $(Ba_{0.48}Na_{0.04}K_{0.04}Ca_{0.01})_{\Sigma=0.57}Al_{3.00}(S_{1.96}O_{3.96})_2[(OH)_{5.99}F_{0.01}]_{\Sigma=6.00}$.

Mineral Group: Alunite group.

Occurrence: Rare, in open-space filling of a fault, formed by reaction of hydrothermal fluids with barite.

Association: Alunite, barite, jarosite, pyrite, quartz.

Distribution: From the Reina vein, about seven km southeast of the El Indio mine, El Indio-Tambo district, east of La Serena, Coquimbo, Chile.

Name: To honor Dr. Thomas Nash Walthier (1923–1990), American economic geologist, St. Joseph Minerals Co., who worked in the Tambo district, Chile.

Type Material: National Museum of Natural History, Washington, D.C., USA, 170208, 170209.

References: (1) Li, G., D.R. Peacor, E.J. Essene, D.R. Brosnahan, and R.E. Beane (1992) Walthierite, $Ba_{0.5}\square_{0.5}Al_3(SO_4)_2(OH)_6$, and huangite, $Ca_{0.5}\square_{0.5}Al_3(SO_4)_2(OH)_6$, two new minerals of the alunite group from the Coquimbo region, Chile. Amer. Mineral., 77, 1275–1284.

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Wardite $NaAl_3(PO_4)_2(OH)_4 \cdot 2H_2O$

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Crystal Data: Tetragonal. *Point Group:* 422. Dipyramidal pseudo-octahedral crystals, with {010}, {011}, {012}, {100}, rarely {001}, typically striated ⊥ [001], to 4 cm.

Physical Properties: *Cleavage:* On {001}, perfect. Hardness = 5 D(meas.) = 2.81–2.87 D(calc.) = 2.805

Optical Properties: Transparent to opaque. *Color:* White, colorless, pale green, blue-green, yellow-green, pale yellow, brown; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Uniaxial (+). $\omega = 1.586–1.594$ $\epsilon = 1.595–1.604$

Cell Data: *Space Group:* $P4_12_12$ or $P4_32_12$. $a = 7.03(1)$ $c = 19.04(1)$ Z = 4

X-ray Powder Pattern: [Palermo #1 mine, New Hampshire, USA].
4.74 (10), 2.994 (7), 2.591 (7), 3.085 (6), 1.516 (5), 2.825 (4), 2.108 (4)

Chemistry:

	(1)	(2)
P_2O_5	35.12	35.67
Al_2O_3	38.70	38.43
FeO	0.26	
MgO	0.21	
Na_2O	7.51	7.79
K_2O	0.16	
H_2O	17.88	18.11
Total	99.84	100.00

(1) [Palermo #1 mine, New Hampshire,] USA. (2) $NaAl_3(PO_4)_2(OH)_4 \cdot 2H_2O$.

Occurrence: A component of low-temperature phosphatic nodules; an uncommon species in complex zoned pegmatites.

Association: Variscite, millisite, crandallite (Little Green Monster mine, Utah, USA); ferrisicklerite, mitridatite, whitlockite, montgomeryite, fairfieldite, hydroxyl-herderite, eosphorite, siderite roscherite (pegmatites).

Distribution: In the USA, from the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah; in Maine, at the Dunton quarry and the Bell Pit, Newry; at the Palermo #1 mine, North Groton, Grafton Co., New Hampshire; in the Hugo pegmatite, near Keystone, Pennington Co., and the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota. Large crystals from the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In Brazil, from the Lavra da Ilha pegmatite, in the Jequitinhonha River, three km north of Taquaral, and in the Pirineus mine, Itinga, Minas Gerais; at Alto Patrimonio, Piedras Lavradas, Paraíba. From Songo, Sierra Leone. At the Wolfsberg quarry, near Spittal, Carinthia, Austria. In France, from Ruffiac, Morbihan, and Montebras, Creuse. At the Iron Monarch quarry, Iron Knob, South Australia, from Wycheproof, Victoria, and on Milgun Station, Western Australia. A few other localities are known.

Name: Honoring Henry Augustus Ward (1834–1906), American collector and dealer in natural history objects (Ward's Natural Science Establishment) Rochester, New York, USA.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 940–941. (2) Fanfani, L., A. Nunzi, and P.F. Zanazzi (1970) The crystal structure of wardite. Mineral. Mag., 37, 598–605. (3) Lindberg, M.L. (1957) Relationship of the minerals avelinoite, cyrilovite, and wardite. Amer. Mineral., 42, 204–213.

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Wardsmithite $Ca_5MgB_{24}O_{42}\cdot 30H_2O$

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Crystal Data: Monoclinic, pseudohexagonal (?). *Point Group:* n.d. Subhedral to anhedral crystals, thin platy with hexagonal outline, to 15μm; in fine-grained clots and nodules, and irregular coatings.

Physical Properties: *Cleavage:* {001}, good. Hardness = 2.5 D(meas.) = 1.85–1.88 D(calc.) = n.d.

Optical Properties: Transparent. *Color:* White; colorless in transmitted light.
Luster: Vitreous.
Optical Class: Uniaxial (–) or biaxial. $\omega = 1.490(2)$ $\epsilon = 1.476(2)$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Death Valley, California, USA.
13.5 (100), 12.3 (62), 6.12 (55), 4.721 (42), 2.744 (26), 7.73 (22), 2.918 (20)

Chemistry:

	(1)	(2)
B_2O_3	48.58	49.24
MgO	2.26	2.38
CaO	16.50	16.53
H_2O	32.44	31.85
R_2O_3	0.30	
insol.	0.20	
Total	100.28	100.00

(1) Hard Scramble Claim, California, USA; H_2O by TGA, estimated to contain gowerite 3%; after correction corresponds to $Ca_{5.02}Mg_{0.98}B_{23.62}O_{42}\cdot 30.88H_2O$. (2) $Ca_5MgB_{24}O_{42}\cdot 30H_2O$.

Occurrence: A rare weathering product of priceite and colemanite.

Association: Gowerite, ulexite, nobleite, colemanite (Death Valley, California, USA).

Distribution: From the Hard Scramble claim, Black Mountains, 3 km north-northwest of Ryan, and on the Oliver Consolidated claim, 3 km west of Ryan, Death Valley, Inyo Co., California, USA. From about 15 km northwest of Tubutama, Sonora, Mexico.

Name: In honor of Ward Cromwell Smith (1906–1998), geologist with the U.S. Geological Survey, Menlo Park, California, USA, who studied southwestern U.S. borate occurrences.

Type Material: National Museum of Natural History, Washington, D.C., USA, 136414, 147955, 147956.

References: (1) Erd, R.C., J.F. McAllister, and A.C. Vlisidis (1970) Wardsmithite, $5CaO\cdot MgO\cdot 12B_2O_3\cdot 30H_2O$, a new borate mineral from the Death Valley region, California. Amer. Mineral., 55, 349–357.

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Warikahnite $Zn_3(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Bladed subhedral crystals, elongated along [100] and flattened on {010}, showing {010}, {100}, {001}, {0*kl*}, striated, to 2 cm, in radial to subparallel aggregates.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, {010}, good. Hardness = ∼2 D(meas.) = > 4.24 D(calc.) = 4.29

Optical Properties: Transparent. *Color:* Pale yellow to colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z \wedge a = 47°$ on {010}; OAP ≃ {001}. $\alpha = 1.747(4)$ $\beta = 1.753(4)$ $\gamma = 1.768(4)$ 2V(meas.) = 75(5)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 6.710(1)$ $b = 8.989(2)$ $c = 14.533(2)$ $\alpha = 105.59(1)°$ $\beta = 93.44(1)°$ $\gamma = 108.68(1)°$ Z = 4

X-ray Powder Pattern: Tsumeb, Namibia.
2.82 (10), 6.21 (8), 2.87 (8), 3.45 (7), 2.30 (7), 8.12 (6), 3.04 (6)

Chemistry:

	(1)	(2)
As_2O_5	44.33	45.07
FeO	0.19	
MnO	0.40	
ZnO	47.85	47.87
H_2O	6.32	7.06
Total	99.09	100.00

(1) Tsumeb, Namibia; by electron microprobe, H_2O by TGA, IR confirms $(AsO_4)^{3-}$ and H_2O; corresponds to $(Zn_{3.01}Mn_{0.03}Fe_{0.01})_{\Sigma=3.05}(As_{0.99}O_4)_2 \cdot 1.80H_2O$. (2) $Zn_3(AsO_4)_2 \cdot 2H_2O$.

Occurrence: A rare secondary mineral formed by alteration of tennantite in an oxidized zone in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tennantite, claudetite, ludlockite, cuprian adamite, stranskiite, tsumcorite.

Distribution: From Tsumeb, Namibia.

Name: Honoring WAlter RIchard KAHN (1911–), Bayersoien, Germany, dealer and collector specializing in Tsumeb minerals, for his support of research into rare secondary minerals.

Type Material: University of Stuttgart, Stuttgart, Germany, NM04; Harvard University, Cambridge, Massachusetts, 117116, 117117; National Museum of Natural History, Washington, D.C., USA, 144801, 144802, 147462.

References: (1) Keller, P., H. Hess, and P.J. Dunn (1979) Warikahnit, $Zn_3[(H_2O)_2|(AsO_4)_2]$, ein neues Mineral aus Tsumeb, Südwestafrika. Neues Jahrb. Mineral., Monatsh., 389–395 (in German with English abs.). (2) (1980) Amer. Mineral., 65, 408 (abs. ref. 1). (3) Riffel, H., P. Keller, and H. Hess (1980) Die Kristallstruktur von Warikahnit, $Zn_3[(H_2O)_2|(AsO_4)_2]$. Tschermaks Mineral. Petrog. Mitt., 27, 187–199 (in German with English abs.).

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Warwickite $(Mg, Ti, Al)_2O(BO_3)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are prismatic, {010}, {100}, {110}, {130}, {310}, with rounded terminations, to 5 mm; anhedral granular.

Physical Properties: *Cleavage:* On {100}, good. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 3.34–3.36 D(calc.) = 3.40

Optical Properties: Opaque, transparent in thinnest edges. *Color:* Dark brown to black; deep yellow, pale brown, reddish brown in thin section. *Streak:* Bluish black. *Luster:* Subvitreous to pearly, submetallic on cleavages, commonly dull if altered.
Optical Class: Biaxial (+). *Pleochroism:* Slight; X = yellow-brown; Y = reddish brown; Z = cinnamon-brown. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Absorption:* $X > Y > Z$. $\alpha = 1.806(5)$ $\beta = 1.809(5)$ $\gamma = 1.830(5)$ 2V(meas.) = Small, variable.

Cell Data: *Space Group: Pnam.* $a = 9.037$–9.255 $b = 9.358$–9.450 $c = 3.01$–3.116 Z = 4

X-ray Powder Pattern: Edenville, New York, USA.
2.57 (10), 2.75 (5), 6.55 (4), 4.20 (4), 2.97 (3), 1.979 (3), 1.721 (3)

Chemistry:

	(1)	(2)		(1)	(2)
B_2O_3	21.29	[25.8]	FeO	9.15	
SiO_2	1.39		MgO	35.71	39.3
TiO_2	24.86	20.4	CaO		0.3
Al_2O_3	2.91	7.7	Total	100.07	[100.6]
Fe_2O_3	4.76	7.1			

(1) Edenville, New York, USA; average of two analyses; corresponds to $(Mg_{1.28}Ti_{0.45}Fe^{2+}_{0.18}Al_{0.08}Fe^{3+}_{0.09})_{\Sigma=2.08}O(B_{0.88}O_3)$. (2) Do.; by electron microprobe, partial analysis, here converted to oxides from an elemental analysis; total Fe as Fe_2O_3, B_2O_3 calculated for stoichiometry; corresponds to $(Mg_{1.33}Ti_{0.34}Al_{0.21}Fe^{3+}_{0.12})_{\Sigma=2.00}O(B_{1.00}O_3)$.

Occurrence: A rare accessory mineral in boron-metasomatized limestone and associated skarns; in lamproitic rocks and carbonatitelike veinlets cutting them.

Association: Chondrodite, szaibélyite, sinhalite, spinel, diopside, titanite, dravite, apatite, fluorite, scapolite, graphite, magnetite, ilmenite, pyrite, pyrrhotite.

Distribution: From about 4 km southwest of Edenville, near Warwick, Orange Co., New York, USA. Found near Bancroft, Ontario, Canada. At La Ceila, near Jumilla, Murcia Province, Spain. In the Tayozhnoye iron deposit, 550 km south of Yakutsk, and the Taiga borate-magnetite deposit, Sakha, Siberia, Russia. At the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea.

Name: For its first-noted occurrence near Warwick, New York, USA.

Type Material: Natural History Museum, Paris, France, 74217, 99697; National Museum of Natural History, Washington, D.C., USA, 128712.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 336–337. (2) Moore, P.B. and T. Araki (1974) Pinakiolite, $Mg_2Mn^{3+}O_2[BO_3]$; warwickite, $Mg(Mg_{0.5}Ti_{0.5})O[BO_3]$; wightmanite, $Mg_5(O)(OH)_5[BO_3]\bullet nH_2O$: crystal chemistry of complex 3 Å wallpaper structures. Amer. Mineral., 59, 985–1004. (3) Bigi, S., M.F. Brigatti, and S. Capedri (1991) Crystal chemistry of Fe- and Cr-rich warwickite. Amer. Mineral., 76, 1380–1388. (4) Thompson, R.M. and J.A. Gower (1954) A magnesium borate from Isère, France, and Swift River, Yukon Territory, with X-ray powder data for some anhydrous borates. Amer. Mineral., 39, 522–524.

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Watanabeite $Cu_4(As,Sb)_2S_5$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As irregular grains to 3 mm, intergrown within aggregates of skippenite.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 155–186, 166 average (25 g load). D(meas.) = n.d. D(calc.) = 7.82

Optical Properties: Opaque. *Color:* Black on a fresh fracture; white with a bluish tint in reflected light. *Luster:* Metallic. *Anisotropism:* Moderate, in blue-gray to dark grayish brown.

R_1–R_2: (400) — , (420) 46.0–46.6, (440) 46.7–47.2, (460) 47.3–47.6, (480) 47.7–48.0, (500) 47.9–48.3, (520) 48.1–48.5, (540) 48.0–48.6, (560) 47.8–48.7, (580) 47.8–48.8, (600) 47.9–48.8, (620) 47.9–48.9, (640) 48.0–48.9, (660) 48.0–49.0, (680) 47.9–49.0, (700) 47.9–49.0

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. $a = 12.921(3)$ $b = 3.997(1)$ $c = 14.989(3)$ $\beta = 109.2(2)°$ Z = 2

X-ray Powder Pattern: Otish Mountains deposit, Canada.
2.976 (10), 2.929 (10), 3.573 (9b), 2.407 (7), 2.140 (7b), 2.065 (7b), 1.484 (7)

Chemistry:

	(1)
Cu	8.06 – 9.16
Pb	14.03 – 16.39
Bi	42.69 – 46.44
Se	27.44 – 28.73
Te	0.19 – 0.53
S	3.03 – 3.47
Total	

(1) Otish Mountains deposit, Canada; by electron microprobe, ranges of 11 grains, the average of which corresponds to $Cu_{2.36}Pb_{1.26}Bi_{3.70}(Se_{6.21}S_{1.74}Te_{0.05})_{\Sigma=8.00}$.

Occurrence: In a vein-type uranium deposit with other tellurides and selenides.

Association: Skippenite, součekite, clausthalite, chalcopyrite, Au–Ag alloy.

Distribution: From the Otish Mountains uranium deposit, Quebec, Canada.

Name: For Professor David H. Watkinson, Carleton University, Ottawa, Canada.

Type Material: n.d.

References: (1) Johan, Z., P. Picot, and F. Ruhlmann (1987) The ore mineralogy of the Otish Mountains uranium deposit, Quebec: skippenite, Bi_2Se_2Te, and watkinsonite, $Cu_2PbBi_4(Se,S)_8$, two new mineral species. Can. Mineral., 25, 625–637. (2) (1989) Amer. Mineral., 74, 948 (abs. ref. 1).

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As irregular grains to 3 mm, intergrown within aggregates of skippenite.

Physical Properties: *Fracture:* Conchoidal. Hardness = n.d. VHN = 155–186, 166 average (25 g load). D(meas.) = n.d. D(calc.) = 7.82

Optical Properties: Opaque. *Color:* Black on a fresh fracture; white with a bluish tint in reflected light. *Luster:* Metallic. *Anisotropism:* Moderate, in blue-gray to dark grayish brown. R_1–R_2: (400) — , (420) 46.0–46.6, (440) 46.7–47.2, (460) 47.3–47.6, (480) 47.7–48.0, (500) 47.9–48.3, (520) 48.1–48.5, (540) 48.0–48.6, (560) 47.8–48.7, (580) 47.8–48.8, (600) 47.9–48.8, (620) 47.9–48.9, (640) 48.0–48.9, (660) 48.0–49.0, (680) 47.9–49.0, (700) 47.9–49.0

Cell Data: *Space Group:* $P2/m$, $P2$, or Pm. $a = 12.921(3)$ $b = 3.997(1)$ $c = 14.989(3)$ $\beta = 109.2(2)°$ $Z = 2$

X-ray Powder Pattern: Otish Mountains deposit, Canada.
2.976 (10), 2.929 (10), 3.573 (9b), 2.407 (7), 2.140 (7b), 2.065 (7b), 1.484 (7)

Chemistry:

	(1)
Cu	8.06 – 9.16
Pb	14.03 – 16.39
Bi	42.69 – 46.44
Se	27.44 – 28.73
Te	0.19 – 0.53
S	3.03 – 3.47
Total	

(1) Otish Mountains deposit, Canada; by electron microprobe, ranges of 11 grains, the average of which corresponds to $Cu_{2.36}Pb_{1.26}Bi_{3.70}(Se_{6.21}S_{1.74}Te_{0.05})_{\Sigma=8.00}$.

Occurrence: In a vein-type uranium deposit with other tellurides and selenides.

Association: Skippenite, součekite, clausthalite, chalcopyrite, Au–Ag alloy.

Distribution: From the Otish Mountains uranium deposit, Quebec, Canada.

Name: For Professor David H. Watkinson, Carleton University, Ottawa, Canada.

Type Material: n.d.

References: (1) Johan, Z., P. Picot, and F. Ruhlmann (1987) The ore mineralogy of the Otish Mountains uranium deposit, Quebec: skippenite, Bi_2Se_2Te, and watkinsonite, $Cu_2PbBi_4(Se,S)_8$, two new mineral species. Can. Mineral., 25, 625–637. (2) (1989) Amer. Mineral., 74, 948 (abs. ref. 1).

Wattersite $Hg_4^{1+}Hg^{2+}Cr^{6+}O_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As crystals, prismatic, elongated along [001], with {110}, {010}, {310}, {130}, {021}, and many more forms, to 2 mm; in aggregates, shell-like or granular massive. *Twinning:* About [001], contact twins on {100}, ubiquitous.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = < 5
D(meas.) = n.d. D(calc.) = 8.91

Optical Properties: Opaque, translucent on thin edges. *Color:* Dark reddish brown, black in aggregate; in reflected light, greenish white to darker lilac-gray, with bright deep red internal reflections. *Streak:* Dark brick-red. *Luster:* Submetallic.
Optical Class: Biaxial. *Anisotropism:* Strong; purple, dark blue, bottle-green, bottle-blue, turquoise-blue, dull greenish blue. *Bireflectance:* Moderate.
R_1–R_2: (400) 19.6–16.0, (420) 21.6–18.1, (440) 22.3–20.4, (460) 21.9–22.0, (480) 21.5–23.9, (500) 21.0–25.9, (520) 20.4–26.7, (540) 19.9–26.0, (560) 19.5–24.5, (580) 18.9–23.1, (600) 18.5–21.9, (620) 18.1–21.0, (640) 17.9–20.4, (660) 17.6–19.8, (680) 17.4–19.4, (700) 17.2–19.1

Cell Data: *Space Group:* $C2/c$. $a = 11.274(2)$ $b = 11.669(2)$ $c = 6.603(1)$
$\beta = 98.19(2)^\circ$ Z = 4

X-ray Powder Pattern: Near the Clear Creek mine, California, USA.
2.655 (100), 8.06 (80), 3.300 (60), 3.260 (60), 5.58 (50), 3.60 (50), 2.948 (50)

Chemistry:

	(1)	(2)
CrO_3	8.7	8.69
HgO	18.7	18.82
Hg_2O	72.1	72.49
Total	99.5	100.00

(1) Near the Clear Creek mine, California, USA; by electron microprobe, $Hg_2^{1+}O$:$Hg^{2+}O$ from crystal-structure analysis; corresponds to $Hg^{1+}_{3.98}Hg^{2+}_{0.99}Cr^{6+}_{1.01}O_6$. (2) $Hg_4^{1+}Hg^{2+}Cr^{6+}O_6$.

Occurrence: A rare mineral in a mercury deposit in silicate–carbonate rock hydrothermally altered from serpentinite.

Association: Cinnabar, mercury.

Distribution: From a prospect near the Clear Creek mercury mine, New Idria district, San Benito Co., California, USA.

Name: Honors Lu Watters (1911–1989), American mineral collector, musician, and environmentalist, specializing in the mineralogy of the California Coast Ranges.

Type Material: Canadian Geological Survey, Ottawa, Canada, 65141; National Museum of Natural History, Washington, D.C., USA, 165271.

References: (1) Roberts, A.C., M. Bonardi, R.C. Erd, A.J. Criddle, and Y. Le Page (1991) Wattersite, $Hg_4^{+1}Hg^{+2}Cr^{+6}O_6$, a new mineral from the Clear Creek claim, San Benito County, California. Mineral. Record, 22, 269–272. (2) (1992) Amer. Mineral., 77, 672 (abs. ref. 1). (3) Groat, L.A., A.C. Roberts, and Y. Le Page (1995) The crystal structure of wattersite, $Hg_4^{1+}Hg^{2+}Cr^{6+}O_6$. Can. Mineral., 33, 41–46.

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Wattevillite $Na_2Ca(SO_4)_2 \cdot 4H_2O(?)$

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Crystal Data: Orthorhombic or monoclinic (?). *Point Group:* n.d. Acicular to hairlike crystals, minute, in aggregates. *Twinning:* Noted.

Physical Properties: Hardness = n.d. D(meas.) = 1.81 D(calc.) = n.d. Soluble in H_2O, with separation of gypsum after some time; taste initially sweet then astringent.

Optical Properties: Semitransparent. *Color:* Snow-white; colorless in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (–). *Orientation:* Highly variable extinction. $\alpha = 1.435(3)$ $\beta = 1.455(3)$ $\gamma = 1.459(3)$ 2V(meas.) = 48(3)°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Bauersberg, Germany. (ICDD 41-1360).
4.39 (100), 4.20 (64), 2.892 (53), 2.945 (49), 5.44 (45), 4.03 (42), 5.10 (36)

Chemistry:

	(1)	(2)
SO_3	44.01	45.72
Al_2O_3	0.24	
FeO	0.88	
CoO	1.30	
NiO	1.05	
MgO	2.49	
CaO	16.87	16.01
Na_2O	10.46	17.70
K_2O	4.74	
H_2O	17.73	20.57
Total	99.77	100.00

(1) Einigkeit mine, Germany; after deduction of H_2O 33.69% as hygroscopic.
(2) $Na_2Ca(SO_4)_2 \cdot 4H_2O$.

Occurrence: In pyritic lignite.

Association: Pyrite, other sulfides.

Distribution: From the Einigkeit mine, on the Bauersberg, near Bischofsheim, Bavaria, Germany.

Name: Honors Oscar de Watteville, Paris, France.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 452.

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Wattevillite $Na_2Ca(SO_4)_2 \cdot 4H_2O(?)$

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Crystal Data: Orthorhombic or monoclinic (?). *Point Group:* n.d. Acicular to hairlike crystals, minute, in aggregates. *Twinning:* Noted.

Physical Properties: Hardness = n.d. D(meas.) = 1.81 D(calc.) = n.d. Soluble in H_2O, with separation of gypsum after some time; taste initially sweet then astringent.

Optical Properties: Semitransparent. *Color:* Snow-white; colorless in transmitted light. *Luster:* Silky.
Optical Class: Biaxial (–). *Orientation:* Highly variable extinction. $\alpha = 1.435(3)$ $\beta = 1.455(3)$ $\gamma = 1.459(3)$ 2V(meas.) = 48(3)°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Bauersberg, Germany. (ICDD 41-1360).
4.39 (100), 4.20 (64), 2.892 (53), 2.945 (49), 5.44 (45), 4.03 (42), 5.10 (36)

Chemistry:

	(1)	(2)
SO_3	44.01	45.72
Al_2O_3	0.24	
FeO	0.88	
CoO	1.30	
NiO	1.05	
MgO	2.49	
CaO	16.87	16.01
Na_2O	10.46	17.70
K_2O	4.74	
H_2O	17.73	20.57
Total	99.77	100.00

(1) Einigkeit mine, Germany; after deduction of H_2O 33.69% as hygroscopic.
(2) $Na_2Ca(SO_4)_2 \cdot 4H_2O$.

Occurrence: In pyritic lignite.

Association: Pyrite, other sulfides.

Distribution: From the Einigkeit mine, on the Bauersberg, near Bischofsheim, Bavaria, Germany.

Name: Honors Oscar de Watteville, Paris, France.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 452.

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Wavellite $Al_3(PO_4)_2(OH,F)_3 \cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Euhedral crystals uncommon, short to long prismatic, elongated and striated ‖ [001], with {010}, {110}, {101}, {111}, {121}, with many {hk0} forms, to several mm. Commonly in flat to spherical radial aggregates, to 3 cm; may be stalactitic, in crusts, rarely opaline massive.

Physical Properties: *Cleavage:* Perfect on {110}; good on {101}; distinct on {010}. *Fracture:* Uneven to subconchoidal. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 2.36 D(calc.) = 2.37

Optical Properties: Translucent. *Color:* White, greenish white, green, yellow, yellowish brown, turquoise-blue, brown, brownish black, may be zoned; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous to resinous, pearly.
Optical Class: Biaxial (+). *Pleochroism:* Weak; X = greenish; Z = yellowish.
Absorption: $X > Z$. *Orientation:* $X = b$; $Y = a$; $Z = c$. *Dispersion:* $r > v$, weak.
$\alpha = 1.518$–1.535 $\beta = 1.524$–1.543 $\gamma = 1.544$–1.561 2V(meas.) = 60°–72°

Cell Data: *Space Group:* $Pcmn$. $a = 9.621(2)$ $b = 17.363(4)$ $c = 6.994(3)$ Z = 4

X-ray Powder Pattern: Black River Falls, Jackson Co., Wisconsin, USA.
8.67 (100), 8.42 (100), 3.22 (60), 5.65 (50), 3.42 (42), 4.81 (25), 2.573 (25)

Chemistry:

	(1)	(2)
P_2O_5	33.40	34.46
Al_2O_3	37.44	37.12
Fe_2O_3	0.64	
F	2.79	
H_2O	26.45	28.42
$-O = F_2$	1.17	
Total	99.55	100.00

(1) Clonmel, Ireland. (2) $Al_3(PO_4)_2(OH)_3 \cdot 5H_2O$.

Occurrence: A secondary mineral in low-grade metamorphic rocks and phosphate deposits; rare in hydrothermal veins.

Association: Crandallite, variscite.

Distribution: Many localities. In the High Down quarry, Filleigh, near South Moulton, Devon, England. At Clonmel, Co. Tipperary, Ireland. In Germany, in the Rotläufchen mine, Waldgirmes, at the Dünsberg, near Giessen, from Oberscheld, near Dillenburg, and elsewhere in the Lahr-Dill area, Hesse; on the Wachtelberg, Langenstriegis, west of Freiberg, Saxony; from the Lichtenberg quarry, near Ronneburg, Thuringia; and elsewhere. At Čerhovice, near Beroun (Beraun), Czech Republic. Near Bihain, Belgium, large rosettes. At Montebras, Creuse, France. In the USA, from General Trimble's mine, Chester Co., Pennsylvania; in the Wood mine, Cocke Co., Tennessee; abundant around Avant, as on Dug Hill, Garland Co., and from the Mauldin Mountain quarry, near Mt. Ida, Montgomery Co., Arkansas; in the Willard mine, Willard district, Pershing Co., Nevada. In Bolivia, fine examples from Llallagua, Potosí, and Oruro. At the Moculta phosphate quarry, northeast of Angaston, and the Iron Monarch quarry, Iron Knob, South Australia.

Name: For William Wavell (?–1829), physician, of Horwood Parish, Devon, England, discoverer of the species.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 962–964. (2) Araki, T. and T. Zoltai (1968) The crystal structure of wavellite. Zeits. Krist., 127, 21–33. (3) Klemic, H. and M.E. Mrose (1972) Geologic relations and X-ray crystallography of wavellite from Jackson County, Wisconsin, and their geologic implications. U.S.Geol. Surv. Prof. Paper 800C, 53–62.

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Wawayandaite $Ca_6Mn_2^{2+}BBe_9Si_6O_{23}(OH,Cl)_{15}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Rarely as sharp, thin crystals, to 0.1 mm; commonly strongly curved in three dimensions; as fine-grained aggregates. *Twinning:* On {100}, probably universal.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Brittle; curved crystals are flexible. Hardness = ∼1 in aggregates. D(meas.) = ∼3.0 D(calc.) = 2.98

Optical Properties: Transparent to opaque. *Color:* Colorless to white. *Streak:* White. *Luster:* Pearly to dull.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z = c$; $X \wedge a = 11.5°$. *Dispersion:* $r < v$, strong. $\alpha = [1.619]$ $\beta = 1.631(1)$ $\gamma = 1.641(1)$ 2V(meas.) = 85°

Cell Data: *Space Group:* $P2/c$ or Pc. $a = 15.59(2)$ $b = 4.87(1)$ $c = 18.69(4)$ $\beta = 101.84(15)°$ Z = 2

X-ray Powder Pattern: Franklin, New Jersey, USA.
3.157 (100), 15.1 (90), 3.001 (70), 2.626 (70), 2.718 (60), 2.249 (50)

Chemistry:

	(1)
SiO_2	28.2
B_2O_3	3.8
MnO	9.8
ZnO	1.1
BeO	17.6
MgO	1.9
CaO	24.8
Cl	3.0
H_2O^+	9.6
$-O = Cl_2$	0.7
Total	99.1

(1) Franklin, New Jersey, USA; by electron microprobe, B and Be by ion microprobe, H_2O by TGA-EGA; corresponds to $Ca_{5.56}Mn_{1.74}Mg_{0.60}Zn_{0.17}B_{1.38}Be_{8.86}Si_{5.90}O_{23.54}[(OH)_{13.40}Cl_{1.06}]_{\Sigma=14.46}$.

Occurrence: A late-stage vein mineral on willemite-franklinite ore in a metamorphosed stratiform zinc deposit.

Association: Willemite, friedelite, andradite, hodgkinsonite, cahnite, calcite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: From *wawayanda*, meaning *many or several windings* in the language of the Lenni Lenape Indians, early inhabitants of the Franklin area, in allusion to the grossly curved and winding habit of most crystals.

Type Material: National Museum of Natural History, Washington, D.C., USA, R5869, 93391; Royal Ontario Museum, Toronto, Canada, M44227.

References: (1) Dunn, P.J., D.R. Peacor, J.D. Grice, F.J. Wicks, and P.H. Chi (1990) Wawayandaite, a new calcium manganese beryllium boron silicate from Franklin, New Jersey. Amer. Mineral., 75, 405–408.

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Waylandite $(Bi, Ca)Al_3(PO_4, SiO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. As crystals, to 0.5 mm; as a compact fine-grained powder forming crusts and veinlets. *Twinning:* Most crystals show twinning, typically cyclic.

Physical Properties: *Fracture:* Uneven (massive). Hardness = 4–5 D(meas.) = n.d. D(calc.) = 4.08

Optical Properties: Translucent. *Color:* Colorless, white, pale blue, pale brown.
Luster: Vitreous to dull.
Optical Class: Uniaxial (+). $\omega = 1.748$ $\epsilon = 1.774$

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.9744$–6.9834 $c = 16.175$–16.293 Z = 3

X-ray Powder Pattern: Wampewo pegmatite, Uganda.
2.938 (100), 2.173 (100), 1.888 (85), 5.67 (80), 2.200 (80), 1.743 (80), 3.492 (75)

Chemistry:

	(1)	(2)	(3)
P_2O_5	22.15	23.96	24.39
SiO_2	4.68	0.15	
Al_2O_3	29.27	26.52	26.28
Bi_2O_3	28.28	34.84	40.04
FeO		0.81	
CuO		0.81	
CaO	2.93	0.75	
BaO		1.01	
H_2O^+	12.34		
H_2O^-	0.55		
H_2O		[11.15]	9.29
Total	100.20	[100.00]	100.00

(1) Wampewo pegmatite, Uganda. (2) Restormel mine, Cornwall, England; by electron microprobe, H_2O by difference. (3) $BiAl_3(PO_4)_2(OH)_6$.

Mineral Group: Crandallite group.

Occurrence: A rare secondary mineral replacing primary bismuth minerals.

Association: Bismutite (Restormel mine, Cornwall, England); bismutotantalite (Ngusa, Congo).

Distribution: From the Wampewo pegmatite, Gamba Hill, near Kampala, southwest Uganda. At Ngusa, and in the Kobokobo pegmatite, Lusungu River district, Kivu Province, Congo (Zaire). From the Restormel mine, near Lostwithiel; at Wheal Owles and the Levant mine, St. Just; Phoenix mines, near Linkinhorne; and in the Gunheath china clay pit, St. Austell, Cornwall, England. From a dump on the Roter Berg, Schneeberg, Saxony, Germany. At the Rubicon pegmatite, south of Karibib, Namibia. From an undefined deposit in China.

Name: Honors Edgar James Wayland, first Director of the Uganda Geological Survey.

Type Material: n.d.

References: (1) Von Knorring, O. and M.E. Mrose (1963) Westgrenite [= bismutomicrolite] and waylandite, two new bismuth minerals from Uganda. Geol. Soc. Amer. Spec. Paper 73, 256A (abs.). (2) (1963) Amer. Mineral., 48, 216. (abs. ref. 1). (3) Clark, A.M., A.G. Couper, P.G. Embrey, and E.E. Fejer (1986) Waylandite: new data, from an occurrence in Cornwall, with a note on 'agnesite'. Mineral. Mag., 50, 731–733. (4) Bayliss, P. (1986) X-ray powder data for nissonite and waylandite. Powder Diffraction, 1, 331–333.

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Weberite Na_2MgAlF_7

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Crystal Data: Orthorhombic, pseudocubic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. As subhedral pseudocubo-octahedral crystals, showing {001}, {010}, {110}, {011}, {101}, {111}, and {131}, and in anhedral cleavages, to several cm; as irregular grains, massive; as inclusions in cryolite and intergrowths with fluorite. *Twinning:* With $[\overline{1}11]$ as twin axis and {011} as composition plane, commonly as contact twins.

Physical Properties: *Cleavage:* {011}, poor; {010}, indistinct. *Fracture:* Uneven. Hardness = 3.5 D(meas.) = 2.96 D(calc.) = 2.966 Slightly soluble in H_2O.

Optical Properties: Translucent. *Color:* Light gray, mottled, rarely pale orange; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = c$; $Y = a$; $Z = b$. α = 1.344–1.346 β = 1.346–1.348 γ = 1.347–1.350 2V(meas.) = 83(3)°

Cell Data: *Space Group:* $Imma$, $Imm2$, or $I2_12_12_1$. a = 7.060(1) b = 10.000(10) c = 7.303(1) Z = 4

X-ray Powder Pattern: Ivigtut, Greenland.
1.779 (10), 2.95 (9), 2.89 (9), 5.05 (6), 5.89 (5), 2.30 (5), 1.542 (5)

Chemistry:

	(1)	(2)
Na	19.08	19.97
K	1.19	
Fe	0.37	
Mg	10.43	10.56
Ca	0.08	
Al	11.65	11.72
F	57.58	57.75
insol.	0.16	
Total	100.54	100.00

(1) Ivigtut, Greenland. (2) Na_2MgAlF_7.

Occurrence: In the cryolite deposit and overlying pegmatite (Ivigtut, Greenland).

Association: Cryolite, chiolite, jarlite, stenonite, thomsenolite, prosopite, pachnolite, ralstonite, fluorite, topaz, potassian mica, pyrite, galena (Ivigtut, Greenland).

Distribution: From the Ivigtut cryolite deposit, southwestern Greenland. At St. Peters Dome, near Pikes Peak, El Paso Co., and in the Goldie carbonatite, McClure Mountain-Iron Mountain, Fremont Co., Colorado; from the Zapot pegmatite, 25 km northeast of Hawthorne, Fitting district, Mineral Co., Nevada, USA. In the Mt. Cleveland tin mine, western Tasmania, Australia. At Perga, Volyn, Ukraine.

Name: Honors Theobald Weber (1823–1886), active in the early development of the Ivigtut cryolite deposit.

Type Material: University of Copenhagen, Copenhagen, Denmark, 1981.936.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 127–128. (2) Ferguson, R.B. (1949) Observations on some aluminum fluoride minerals. Amer. Mineral., 34, 383–397. (3) Giuseppetti, G. and C. Tadini (1978) Re-examination of the crystal structure of weberite. Tschermaks Mineral. Petrog. Mitt., 25, 57–62. (4) Pauly, H. and O.V. Petersen (1981) Weberite from Ivigtut, South Greenland: new data on paragenesis, twinning, habit, and optics. Neues Jahrb. Mineral., Monatsh., 511–519. (5) Knop, O., T.S. Cameron, and K. Jochem (1982) What is the true space group of weberite? J. Solid State Chem., 43, 213–221.

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Weddellite $Ca(C_2O_4)\cdot 2H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. Typically as isolated crystals, with {011}, elongated along [010], terminated by {001}, to 4 cm; commonly corroded. *Twinning:* Single or multiple twins may have been noted.

Physical Properties: *Fracture:* Subconchoidal. Hardness = ∼4 D(meas.) = 1.94(1) D(calc.) = 1.962 Dehydrates to whewellite on exposure to the atmosphere.

Optical Properties: Transparent. *Color:* Colorless to white, may be yellowish brown to brown from organic impurities; colorless in transmitted light.
Optical Class: Uniaxial (+). $\omega = 1.523(3)$ $\epsilon = 1.544(3)$

Cell Data: *Space Group:* $I4/m$. $a = 12.371(3)$ $c = 7.357(2)$ Z = 8

X-ray Powder Pattern: Husvik, Antarctic Ocean.
2.744 (100), 6.19 (72), 3.35 (66), 2.231 (63), 1.892 (49), 4.43 (40), 2.792 (38)

Chemistry: (1) Analyses of natural material are lacking. Identification is by correspondence of optical and X-ray powder data with those of synthetic material.

Occurrence: Authigenic in bottom muds and in peat sediments; in calcareous lake-bottom sediments; may be formed by reaction of calcite with oxalic acid produced by lichens.

Association: Whewellite, urea, phosphammite, aphthitalite (from bat guano).

Distribution: From the central and marginal Weddell Sea, Antarctica. On South Georgia Island, southern Atlantic Ocean. In sediments from the Japan Sea and the Coral Sea. At Jingemia Cave, Toppin Hill Cave, and Petrogale Cave, near Madura, Western Australia. From Gcwihaba Cave, 280 km west of Maun, northwestern Botswana. In the Tyllakh brown coal deposit, left bank of the Olenhinskii channel near its mouth, estuary of the Lena River, Bulun district, polar Sakha, Russia. From the Milltown quarry, Milltown, Derbyshire, England. In Canada, in the Saguenay and St. Lawrence Rivers, Quebec; from the east side of Moore Lake, near Norland, Ontario; and from Cape Herschel, Ellesmere Island, North West Territories. Large crystals from the Sami Tsubota jasper mine, four km south of Biggs, Sherman Co., Oregon, USA.

Name: For its first-noted occurrence in the Weddell Sea, Antarctica.

Type Material: The Natural History Museum, London, England, 1936,975–1936,977.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1101–1102. (2) Tazzoli, V. and C. Domeneghetti (1980) The crystal structures of whewellite and weddellite: re-examination and comparison. Amer. Mineral., 65, 327–344. (3) Van de Vijver, B., R. Vochten, J. Geys, C. Verbruggen, and L. Beyens (1997) Mineralogical observations of weddellite from South Georgia, Subantarctica. Neues Jahrb. Mineral., Monatsh., 193–202.

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Weeksite $K_2(UO_2)_2Si_6O_{15}\cdot 4H_2O$

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Crystal Data: Orthorhombic, pseudotetragonal. *Point Group:* $2/m\ 2/m\ 2/m$. As bladed or acicular crystals, flattened on {010} and elongated along [001], and as flat plates; also as spherulites and radiating fibrous clusters.

Physical Properties: *Cleavage:* Two good prismatic cleavages noted. Hardness = < 2 D(meas.) = ∼4.1 D(calc.) = 4.02 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Yellow. *Luster:* Waxy to silky. *Optical Class:* Biaxial (–). *Pleochroism:* X = colorless; Y = pale yellow-green; Z = yellow-green. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$, strong. $\alpha = 1.596$ $\beta = 1.603$ $\gamma = 1.606$ 2V(meas.) = ∼60° 2V(calc.) = 66°

Cell Data: *Space Group: Pnnb.* $a = 14.26(2)$ $b = 35.88(10)$ $c = 14.20(2)$ Z = 16

X-ray Powder Pattern: Thomas Range, Utah, USA.
7.11 (10), 5.57 (9), 8.98 (8), 3.55 (7), 3.30 (7), 2.91 (6), 3.20 (5)

Chemistry:

	(1)	(2)
SiO_2	33.6	32.81
Al_2O_3	0.6	
Fe_2O_3	< 0.1	
UO_3	51.5	52.06
CaO	1.1	
BaO	1.4	
Na_2O	0.7	
K_2O	5.5	8.57
H_2O^+	[5.5]	
H_2O^-	1.1	
H_2O		6.56
CO_2	0.3	
Total	101.3	100.00

(1) Autunite No. 8 claim, Thomas Range, Utah, USA; H_2O^+ differenced from total H_2O 6.6% less H_2O^-. (2) $K_2(UO_2)_2Si_6O_{15}\cdot 4H_2O$.

Occurrence: In "opal" veinlets in rhyolite and agglomerates, as well as in sandstones and limestones.

Association: "Opal," "chalcedony," calcite, gypsum, fluorite, uraninite, thorogummite, uranophane, boltwoodite, carnotite, margaritasite.

Distribution: In the USA, in Utah, at the Autunite No. 8 and Good Will claims, Thomas Range, Juab Co.; in California, from the Coso Mountains, Inyo Co., and in the Red Rock district, Lassen Co.; in New Mexico, from the Jackpile mine, Laguna, Valencia Co.; in Wyoming, in the Silver Cliff mine, near Lusk, Niobrara Co.; and in Nevada, at Teels Marsh, Mineral Co. From the Mammoth mine, near Presidio, Presidio Co., Texas; in Arizona, from the Red Knob claims, Muggins Mountains, Yuma Co. and the Anderson mine, Yavapai Co.; and from the Williams quarry, Easton, Northampton Co., Pennsylvania. At the Margaritas and other mines, Sierra Peña Blanca, Chihuahua, Mexico. In France, from Les Bois-Noirs, Loire. From Rössing, Namibia.

Name: For Dr. Mary Alice Dowse Weeks (1909–1988), mineralogist with the U.S. Geological Survey, noted specialist in the mineralogy of uranium and vanadium.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128713, 115886, 121949.

References: (1) Outerbridge, W.F., M.H. Staatz, R. Meyrowitz, and A.M. Pommer (1960) Weeksite, a new uranium silicate from the Thomas Range, Juab County, Utah. Amer. Mineral., 45, 39–52. (2) Stohl, F.V. and D.K. Smith (1981) The crystal chemistry of the uranyl silicate minerals. Amer. Mineral., 66, 610–625.

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Wegscheiderite $Na_5(HCO_3)_3(CO_3)$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Acicular to bladed subhedral to anhedral crystals, to 5 cm, and commonly fibrous, in aggregates.

Physical Properties: *Cleavage:* Prismatic, distinct. *Fracture:* Uneven to subconchoidal. Hardness = 2.5–3 D(meas.) = 2.341 D(calc.) = 2.334 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Dispersion:* $r < v$. $\alpha = 1.433$ $\beta = 1.519(2)$ $\gamma = 1.528$ 2V(meas.) = 32.4° 2V(calc.) = 34°

Cell Data: *Space Group:* $P\overline{1}$. $a = 10.04(3)$ $b = 15.56(4)$ $c = 3.466(10)$ $\alpha = 91°55(5)'$ $\beta = 95°49(5)'$ $\gamma = 108°40(5)'$ Z = 2

X-ray Powder Pattern: Grierson Well No. 1, Wyoming, USA.
2.954 (100b), 3.68 (60), 2.642 (60), 2.214 (60), 2.793 (50), 2.662 (42), 2.831 (35)

Chemistry:

	(1)	(2)
CO_2	46.60	49.17
Na_2O	43.40	43.28
H_2O^+	10.00	7.55
Total	[100.00]	100.00

(1) Green River Formation, Wyoming, USA; here recalculated to a conventional oxide analysis from an elemental analysis including direct determinations of $(CO_3)^{2-}$ and $(HCO_3)^{1-}$, totalling 99.75%, after deduction of Cl 0.06%, H_2O^- 0.36%, organic 4.38%. (2) $Na_5(HCO_3)_3(CO_3)$.

Occurrence: As a replacement of trona in a lacustrine deposit.

Association: Trona, halite.

Distribution: In the USA, in the Green River Formation, from the Perkins Well No. 1, the Perkins Well No. 2, about 10 km west, and as large crystals in the Grierson Well No. 1, about 20 km northwest, Sweetwater Co., Utah; in the Piceance Basin, Garfield and Rio Blanco Cos., Colorado. From the Biyang Basin, Henan Province, China.

Name: In honor of Rudolf Franz Johann Wegscheider (1859–1935), Austrian chemist, who first synthesized the compound.

Type Material: National Museum of Natural History, Washington, D.C., USA, 117710.

References: (1) Fahey, J.J. and K.P. Yorks (1963) Wegscheiderite ($Na_2CO_3 \cdot 3NaHCO_3$), a new saline mineral from the Green River Formation, Wyoming. Amer. Mineral., 48, 400–403. (2) Appleman, D.E. (1963) X-ray crystallography of wegscheiderite ($Na_2CO_3 \cdot 3NaHCO_3$). Amer. Mineral., 48, 404–406. (3) Fernandes, N.G., R. Tellgren, and I. Olovsson (1990) Structure and electron density of pentasodium trihydrogentetracarbonate. Acta Cryst., 46, 466–474.

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Weibullite $Pb_6Bi_8(S,Se)_{18}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Massive prismatic to fibrous or foliated habit; also as indistinct prismatic crystals.

Physical Properties: *Tenacity:* Very brittle, flexible. Hardness = 2–2.5 VHN = 136–156 (100 g load). D(meas.) = n.d. D(calc.) = [6.73]

Optical Properties: Opaque. *Color:* Steel-gray; white in reflected light. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong in reflected light, dark gray to red-brown.

R_1–R_2: (400) 43.6–51.5, (420) 43.0–51.0, (440) 42.4–50.5, (460) 41.8–49.3, (480) 41.4–48.4, (500) 40.9–47.8, (520) 40.5–47.4, (540) 40.0–46.6, (560) 39.5–45.9, (580) 38.9–45.1, (600) 38.4–44.4, (620) 38.0–43.9, (640) 37.5–43.3, (660) 37.0–42.8, (680) 36.7–42.5, (700) 36.4–42.2

Cell Data: *Space Group: Pnma.* $a = 53.68(9)$ $b = 4.11(1)$ $c = 15.40(2)$ $Z = 4$

X-ray Powder Pattern: Falun, Sweden.
3.847 (100), 3.080 (90), 3.268 (80), 3.019 (70), 2.811 (70), 2.278 (60), 2.138 (60)

Chemistry:

	(1)	(2)	(3)
Pb	29.7	31.5	28.3
Ag		0.9	1.0
Cu		0.3	
Bi	46.6	46.5	48.0
As	0.8		
Se	15.3	11.8	12.8
S	9.6	10.2	10.3
Total	102.0	101.2	100.4

(1–3) Falun, Sweden; by electron microprobe.

Occurrence: Intimately intergrown with laitakarite and bismuthinite in a "hornblende" rock.

Association: Laitakarite, bismuthinite, gold, chalcopyrite, bismuth, pyrrhotite, quartz.

Distribution: From Falun, Kopparberg, Sweden.

Name: For Mats Weibull (1856–1923), who first described the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 473–474. (2) Karup-Møller, S. (1970) Weibullite, laitakarite and bismuthinite from Falun, Sweden. Geol. Fören. Förhandl. Stockholm, 92, 181–187. (3) (1971) Amer. Mineral., 56, 639 (abs. ref. 2). (4) Johan, Z. and P. Picot (1976) Definition nouvelle de la weibullite et de la wittite. Compt. Rendus Acad. Sci. Paris, 282, 137–139. (5) (1977) Amer. Mineral., 62, 397 (abs. ref. 4). (6) Mumme, W.G. (1980) Weibullite $Ag_{0.32}Pb_{5.09}Bi_{8.55}Se_{6.08}S_{11.92}$ from Falun, Sweden: a higher homologue of galenobismutite. Can. Mineral., 18, 1–12. (7) Mumme, W.G. (1980) Seleniferous lead–bismuth sulphosalts from Falun, Sweden: weibullite, wittite, and nordströmite. Amer. Mineral., 65, 789–796.

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Weilite $CaHAsO_4$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Powdery, massive, typically pseudomorphous after pharmacolite or haidingerite.

Physical Properties: Hardness = n.d. D(meas.) = 3.48(5); 3.54 (synthetic). D(calc.) = 3.45; 3.541 (synthetic).

Optical Properties: Semitransparent. *Color:* White. *Luster:* Porcelaneous, may be greasy to slightly pearly.
Optical Class: Biaxial (–). *Orientation:* $X \wedge \{001\} = 20(2)°$; $Y \wedge \{001\} = 27(2)°$; $Z \wedge \perp \{001\} = 34(2)°$. $\alpha = 1.664(2)$ (α') $\beta =$ n.d. $\gamma = 1.688(2)$ (γ') 2V(meas.) = 82(1)°

Cell Data: *Space Group:* $P\overline{1}$ (synthetic). $a = 7.0591(8)$ $b = 6.8906(9)$ $c = 7.2006(16)$ $\alpha = 97°26(1)'$ $\beta = 103°33(1)'$ $\gamma = 87°45(1)'$ Z = 4

X-ray Powder Pattern: Gabe-Gottes mine, France.
3.43 (FFF), 3.07 (FFF), 3.42 (F), 2.80 (F), 2.58 (mF), 2.28 (mf), 3.60 (f), 3.21 (f)

Chemistry:

	(1)	(2)	(3)
As_2O_5	64.1	61.7	63.85
CaO	30.7	33.1	31.15
H_2O	5.2	5.2	5.00
Total	[100.0]	[100.0]	100.00

(1) Gabe-Gottes mine, France; recalculated to 100% after deduction of SiO_2 1% and pharmacolite 10% from an original total of 99.7%. (2) Schneeberg, Germany; recalculated to 100% after deduction of pharmacolite 10% from an original total of 100.0%. (3) $CaHAsO_4$.

Occurrence: A rare secondary mineral in the oxidized zone of arsenic-bearing hydrothermal mineral deposits.

Association: Pharmacolite, haidingerite, picropharmacolite.

Distribution: In Germany, from Schneeberg, at the Daniel mine, and at Schlema-Hartenstein, Saxony; from Wittichen, Black Forest; in the Bauhaus district, Richelsdorf Mountains, Hesse. In the Gabe-Gottes mine, Rauenthal, near Sainte-Marie-aux-Mines, Haut-Rhin, and at Duranus, Alpes-Maritimes, France. From the Wanthwaite mine, St. John's in the Vale, Cumbria, England. In the Bou Azzer district, Morocco. From the Getchell mine, Humboldt Co., Nevada, USA.

Name: To honor Professor René Weil (1901–), French mineralogist, University of Strasbourg, Strasbourg, France.

Type Material: National School of Mines, Paris, France, 4073; National Museum of Natural History, Washington, D.C., USA, R5543.

References: (1) Herpin, P. and R. Pierrot (1963) La weilite, $CaH(AsO_4)$, un nouvel arséniate de calcium isomorphe de la monétite. Bull. Soc. fr. Minéral., 86, 368–372 (in French). (2) (1964) Amer. Mineral., 49, 816 (abs. ref. 1). (3) Ferraris, G. and G. Chiari (1970) The crystal structure of $CaHAsO_4$ (weilite). Acta Cryst., 26, 403–410.

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Weinebeneite $CaBe_3(PO_4)_2(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Platy crystals, flattened on {001}, elongated parallel [100], showing {001}, {00$\bar{1}$}, {110}, {$\bar{1}$10}, {010}, half-a-dozen others, to 0.5 mm, typically in rosettes.

Physical Properties: *Fracture:* Irregular to splintery. *Tenacity:* Brittle. Hardness = 3–4 D(meas.) = 2.15(4) D(calc.) = 2.17

Optical Properties: Transparent to translucent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $Z \wedge c = 42°$. $\alpha = 1.520(1)$ $\beta = 1.520(1)$ $\gamma = 1.530(1)$ 2V(meas.) = $< 10°$

Cell Data: *Space Group:* Cc. $a = 11.897(2)$ $b = 9.707(1)$ $c = 9.633(1)$ $\beta = 95.76(1)°$ Z = 4

X-ray Powder Pattern: Weinebene Pass, Austria.
2.513 (100), 3.421 (70), 5.92 (60), 2.959 (60), 4.33 (49), 2.945 (45), 4.85 (44)

Chemistry:

	(1)	(2)
P_2O_5	39.2	39.09
BeO	21.1	20.66
CaO	15.5	15.44
H_2O	25.5	24.81
Total	101.3	100.00

(1) Weinebene Pass, Austria; by electron microprobe, Be by AA, H_2O by LOI; corresponds to $Ca_{0.99}Be_{3.02}(PO_4)_{1.97}(OH)_{2.11} \cdot 4H_2O$. (2) $CaBe_3(PO_4)_2(OH)_2 \cdot 4H_2O$.

Mineral Group: Zeolite group.

Occurrence: In fractures in a spodumene-rich pegmatite in high-grade metamorphic rocks.

Association: Roscherite, fairfieldite, uralolite.

Distribution: From the Weinebene Pass, Carinthia, Austria.

Name: For its occurrence in the Weinebene Pass, Austria.

Type Material: Landesmuseum Joanneum, Graz; Kärtner Landesmuseum, Klagenfurt; Natural History Museum, Vienna, Austria.

References: (1) Walter, F. (1992) Weinebeneite, $CaBe_3(PO_4)_2(OH)_2 \cdot 4H_2O$, a new mineral species: mineral data and crystal structure. Eur. J. Mineral., 4, 1275–1283. (2) (1993) Amer. Mineral., 78, 847–848 (abs. ref. 1).

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Weishanite $(Au, Ag)_3Hg_2$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Grains to 30 μm, in irregular aggregates from 0.05 to 0.4 mm.

Physical Properties: *Tenacity:* Ductile, malleable. Hardness = 2.4 VHN = 50.5
D(meas.) = n.d. D(calc.) = 18.17

Optical Properties: Opaque. *Color:* Pale yellow. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Weak.

R_1–R_2: (480) 63.75, (534) 76.30, (589) 81.03, (656) 68.6

Cell Data: *Space Group:* $[P6_3/mmc]$ (by analogy to Au_3Hg). $a = 2.9265$ $c = 4.8178$
Z = 2

X-ray Powder Pattern: Poshan district, China.
2.243 (100), 0.9396 (90), 1.3593 (80), 1.2509 (80), 0.9954 (70), 1.4609 (60), 1.2255 (60)

Chemistry:

	(1)
Au	56.91
Ag	3.17
Hg	39.92
Total	100.00

Poshan district, China; by electron microprobe, corresponding to $(Au_{2.89}Ag_{0.29})_{\Sigma=3.18}Hg_{1.99}$.

Occurrence: In the silicified zone of the silver-rich part of an Au-Ag deposit in biotite granulite.

Association: Gold, silver, acanthite, pyrite, galena, sphalerite, pyrrhotite, scheelite.

Distribution: From the Poshan mining district, Tongbai, Henan Province, China.

Name: Derivation not stated.

Type Material: National Geological Museum, Beijing, China.

References: (1) Li Yuheng, Ouyang Shan, and Tian Peixue (1984) Weishanite — a new gold-bearing mineral. Acta Mineral. Sinica, 4, 102–105 (in Chinese with English abs.). (2) (1988) Amer. Mineral., 73, 196 (abs. ref. 1).

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Weissbergite $TlSbS_2$

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Crystal Data: Triclinic. *Point Group:* 1. As grains of irregular shape, up to 0.5 mm; also prismatic or tabular with striations parallel to the long dimension.

Physical Properties: *Cleavage:* One perfect, two excellent, one good. Hardness = 1.5 VHN = n.d. D(meas.) = 5.79 D(calc.) = 6.1

Optical Properties: Opaque. *Color:* Steel-gray; creamy white in reflected light. *Streak:* Dark gray. *Luster:* Bright metallic. *Pleochroism:* Weak. *Anisotropism:* Strong, blue-green, blue-black, orange-brown, gray.

R_1–R_2: (470) 36.0–38.4, (546) 35.0–36.8, (589) 34.5–35.8, (650) 32.1–33.8

Cell Data: *Space Group:* $P1$ based on morphology. $a = 11.8$ $b = 6.4$ $c = 6.1$ $\alpha = 109.9°$ $\beta = 81.8°$ $\gamma = 105.4°$ Z = 4

X-ray Powder Pattern: Synthetic; strong preferred orientation.
2.973 (100), 3.650 (8), 3.583 (7), 2.839 (7), 2.718 (6), 2.351 (6), 3.752 (5)

Chemistry:

	(1)	(2)
Tl	52.7	52.37
Sb	31.2	31.20
S	16.4	16.43
Total	100.2	100.00

(1) Carlin mine, Nevada, USA; by electron microprobe, average of four analyses. (2) $TlSbS_2$.

Occurrence: In late-stage hydrothermal veins that brecciate silicified dolomitic carbonate rocks. The assemblage appears to fill open space between breccia fragments and to have been formed during the boiling stage at the end of the hydrothermal episode.

Association: Stibnite, quartz.

Distribution: From the east ore zone, Carlin mine, 50 km northwest of Elko, Lynn district, Eureka Co., Nevada; in Lookout Pass, Toole Co., Utah, USA. At Alšar (Allchar), near Rošden, Macedonia.

Name: For Dr. Byron G. Weissberg, Chemistry Division, D.S.I.R., New Zealand.

Type Material: Department of Geology, Stanford University, Palo Alto, California, Epithermal Minerals Collection; National Museum of Natural History, Washington, D.C., USA, 144274.

References: (1) Dickson, F.W. and A.S. Radtke (1978) Weissbergite, $TlSbS_2$, a new mineral from the Carlin gold deposit, Nevada. Amer. Mineral., 63, 720–724.

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Weissite Cu_5Te_3

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Massive, as small lenses up to 2.5 cm across.

Physical Properties: *Fracture:* Uneven. Hardness = 3 VHN = 145–158 (100 g load). D(meas.) = ∼6 D(calc.) = [5.83]

Optical Properties: Opaque. *Color:* Dark bluish black, tarnishing to deep black. *Streak:* Black. *Luster:* Shiny metallic. *Pleochroism:* Distinct. *Anisotropism:* Distinct.

R_1–R_2: (400) 40.3–41.6, (420) 39.8–41.3, (440) 38.9–40.6, (460) 37.9–39.6, (480) 36.9–38.4, (500) 35.9–37.1, (520) 34.8–35.9, (540) 33.7–34.9, (560) 32.6–34.0, (580) 31.5–33.1, (600) 30.5–32.5, (620) 29.6–32.0, (640) 28.9–31.6, (660) 28.1–31.2, (680) 27.3–30.8, (700) 26.4–30.2

Cell Data: *Space Group:* $P6/mmm$. a = 12.54 $c = 21.71$ Z = [15]

X-ray Powder Pattern: Synthetic.
2.09 (100), 3.61 (70), 2.01 (70), 3.24 (60), 1.80 (50), 2.55 (30), 2.17 (30)

Chemistry:

	(1)	(2)
Cu	45.84	45.35
Te	53.97	54.65
Total	99.81	100.00

(1) Good Hope mine, Colorado, USA; average of two analyses. (2) Cu_5Te_3.

Occurrence: In hydrothermal veins with other tellurides.

Association: Pyrite, tellurium, sylvanite, petzite, rickardite, sulfur (Colorado, USA); gold, calaverite, krennerite (Kalgoorlie, Australia).

Distribution: In the USA, from the Good Hope and Mammoth Chimney mines, Vulcan, Gunnison Co., Colorado; near Winston, Sierra Co., New Mexico. In Japan, from the Teine mine, Hokkaido. From the Kalgurli gold mines, Kalgoorlie, Western Australia.

Name: For Louis Weiss, owner of the Good Hope mine and discoverer of rickardite.

Type Material: National Museum of Natural History, Washington, D.C., USA, 95782.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 199. (2) Thompson, R.M. (1949) The telluride minerals and their occurrence in Canada. Amer. Mineral., 34, 342–382. (3) Patzak, I. (1956) Über die Struktur und die Lage der Phasen im System Kupfer–Tellur. Zeits. für Metallkunde, 47, 418–420 (in German). (4) Ramdohr, P. (1969) The ore minerals and their intergrowths, (3rd edition), 417–418.

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Welinite $(Mn^{2+},Mg)_3(W^{6+},Mn^{3+})_{1-x}(SiO_4)(O,OH)_3$ (x = 1/3)

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Crystal Data: Hexagonal. *Point Group:* 3. As sections of crystals, to 2 cm.

Physical Properties: *Cleavage:* Poor to distinct on {001}. *Tenacity:* Brittle. Hardness = 4 D(meas.) = 4.47 D(calc.) = 4.41

Optical Properties: Transparent in thin fragments. *Color:* Deep red-brown to reddish black. *Streak:* Pale reddish brown. *Luster:* Resinous.
Optical Class: Uniaxial (+); anomalously biaxial. *Absorption:* $E > O$. $\omega = 1.864$ $\epsilon = 1.88$ 2V(meas.) = Small.

Cell Data: *Space Group:* $P3$. $a = 8.155(7)$ $c = 4.785(5)$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
1.782 (100), 3.102 (80), 2.332 (80), 4.07 (60), 1.5438 (60), 7.00 (50), 2.840 (40)

Chemistry:

	(1)
SiO_2	15.7
Fe_2O_3	0.8
WO_3	21.7
Sb_2O_5	1.6
As_2O_5	0.0
V_2O_5	0.0
MnO	55.5
MgO	2.5
H_2O^+	2.9
Total	100.7

(1) Långban, Sweden; by electron microprobe, H_2O by TGA; corresponds to $Mn^{2+}_{3.00}W^{6+}_{0.36}Mg_{0.24}Sb^{5+}_{0.04}Fe^{3+}_{0.04}Si_{1.00}[O,(OH)]_{\Sigma\sim 7}$.

Occurrence: In small amounts, as fillings in fissures with other minerals cutting hausmannite ore (Långban, Sweden).

Association: Adelite, sarkinite, barite, calcite (Långban, Sweden).

Distribution: From Långban, Värmland, Sweden. In the Taguchi mine, ??, Japan.

Name: For Dr. Eric Welin, mineralogist and geochronologist, Swedish Museum of Natural History, Stockholm, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 532157; National Museum of Natural History, Washington, D.C., USA, 120067.

References: (1) Moore, P.B. (1967) Welinite, a new mineral from Långban. Arkiv Mineral. Geol., 4, 407–411. (2) (1968) Amer. Mineral., 53, 1064 (abs. ref. 1). (3) Moore, P.B. (1968) The crystal structure of welinite, $(Mn^{+4},W)_{<1}(Mn^{+2},W,Mg)_{<3}Si(O,OH)_7$. Arkiv Mineral. Geol., 4, 459–466. (4) Dunn, P.J., D.R. Peacor, R.C. Erd, and R.A. Ramik (1986) Franciscanite and örebroite, two new minerals from California and Sweden, related to redefined welinite. Amer. Mineral., 71, 1522–1526.

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Weloganite $Na_2Sr_3Zr(CO_3)_6 \cdot 3H_2O$

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Crystal Data: Triclinic, pseudorhombohedral. *Point Group:* 1. Crystals, roughly hexagonal, tapering, the prism faces deeply grooved and striated, withrough pyramidal terminations and a flat pedion, to 10 cm; may be massive. *Twinning:* About [103] repeated at 120°.

Physical Properties: *Cleavage:* Perfect on pseudo-{0001}. *Fracture:* Conchoidal. Hardness = 3.5 D(meas.) = 3.20–3.22 D(calc.) = 3.208 Pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Lemon-yellow, pale yellow, amber, commonly zoned in basal sections; colorless in thin fragments. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (–). $\alpha = 1.558(3)$ $\beta = 1.646(3)$ $\gamma = 1.648(3)$ 2V(meas.) = ∼15°

Cell Data: *Space Group:* $P1$. $a = 8.966(1)$ $b = 8.980(2)$ $c = 6.730(1)$ $\alpha = 102.72(2)°$ $\beta = 116.65(1)°$ $\gamma = 60.06(1)°$ Z = 1

X-ray Powder Pattern: Francon quarry, Canada.
2.809 (10), 4.35 (9), 2.590 (7), 2.227 (7), 2.009 (7), 6.03 (6), 1.961 (6)

Chemistry:

	(1)	(2)
CO_2	30.72	32.44
SiO_2	0.25	
ZrO_2	15.26	15.13
Fe_2O_3	0.03	
MgO	< 0.02	
CaO	1.14	
SrO	36.18	38.18
Na_2O	7.75	7.61
K_2O	0.02	
H_2O^+	7.85	
H_2O^-	0.11	
H_2O		6.64
Total	[99.29]	100.00

(1) Francon quarry, Canada; by XRF and AA, CO_2 by the Leco method, H_2O by the Penfield method, original total given as 99.20%; corresponds to $Na_{2.15}(Sr_{3.00}Ca_{0.18})_{\Sigma=3.18}Zr_{1.06}(CO_3)_6 \cdot 3.75H_2O$. (2) $Na_2Sr_3Zr(CO_3)_6 \cdot 3H_2O$.

Occurrence: In an alkalic sill (Francon quarry, Canada); associated with an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Calcite, quartz, dawsonite (Francon quarry, Canada).

Distribution: In Canada, from the Francon quarry, Montreal Island, Montreal; in a limestone quarry 15 km east; and at Mont Saint-Hilaire, Quebec.

Name: To honor William Edmond Logan (1798–1875), first Director of the Canadian Geological Survey.

Type Material: Canadian Geological Survey, Ottawa, Canada, 17257, 61337.

References: (1) Sabina, A.P., J.L. Jambor, and A.G. Plant (1968) Weloganite, a new strontium zirconium carbonate from Montreal Island, Canada. Can. Mineral., 9, 468–477. (2) (1969) Amer. Mineral., 54, 576 (abs. ref. 1). (3) (1969) Can. Mineral., 9, 654 (correction). (4) Chen, T.T. and G.Y. Chao (1975) X-ray crystallography of weloganite. Can. Mineral., 13, 22–26. (5) Grice, J.D. and G. Perrault (1975) The crystal structure of triclinic weloganite. Can. Mineral., 13, 209–216.

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Welshite $Ca_2Mg_4Fe^{3+}Sb^{5+}Si_4Be_2O_{20}$

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Crystal Data: Triclinic, pseudomonoclinic. *Point Group:* $\bar{1}$. Crystals stout prismatic ‖ [001], may be flattened on {010}, to 3 mm. *Twinning:* Polysynthetic on {010}.

Physical Properties: *Fracture:* Conchoidal. Hardness = 6 D(meas.) = 3.77 D(calc.) = [3.71]

Optical Properties: Transparent to translucent. *Color:* Deep reddish brown to reddish black; brownish orange in transmitted light. *Streak:* Pale brown. *Luster:* Subadamantine. *Optical Class:* Biaxial. $\alpha = 1.81(1)$ $\beta =$ n.d. $\gamma = 1.83(1)$ 2V(meas.) = ∼45°

Cell Data: *Space Group:* $P\bar{1}$. $a = 10.28$ $b = 10.69$ $c = 8.83$ $\alpha = 106.1°$ $\beta = 96.3°$ $\gamma = 124.5°$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
2.530 (100), 7.32 (70), 2.910 (70), 1.489 (70), 1.460 (70), 4.73 (60), 2.670 (60)

Chemistry:

	(1)	(2)
SiO_2	19.6	29.84
Al_2O_3	2.1	
Fe_2O_3	9.1	9.92
As_2O_5	3.6	
Sb_2O_5	24.8	20.08
MnO	1.0	
BeO	4.0	6.21
MgO	15.3	20.02
CaO	14.2	13.93
Total	93.7	100.00

(1) Långban, Sweden; by electron microprobe, average of 20 analyses on three crystals, total Fe as Fe_2O_3, BeO by wet chemical analysis; corresponds to $Ca_{2.41}(Mg_{3.61}Mn^{2+}_{0.13})_{\Sigma=3.74}(Fe^{3+}_{1.08}Al_{0.39})_{\Sigma=1.47}Sb^{5+}_{1.46}(Si_{3.10}As^{5+}_{0.30})_{\Sigma=3.40}Be_{1.52}O_{20.47}$. (2) $Ca_2Mg_4FeSbSi_4Be_2O_{20}$.

Mineral Group: Aenigmatite group.

Occurrence: In hematitic-dolomitic skarn.

Association: Berzeliite, manganoan phlogopite, richterite, hausmannite, roméite, adelite, swedenborgite.

Distribution: From Långban, Värmland, Sweden.

Name: For Wilfred R. Welsh, amateur mineralogist of Upper Saddle River, New Jersey, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 137022.

References: (1) Moore, P.B. (1978) Welshite, $Ca_2Mg_4Fe^{3+}Sb^{5+}O_2[Si_4Be_2O_{18}]$, a new member of the aenigmatite group. Mineral. Mag., 42, 129–132. (2) (1979) Amer. Mineral., 64, 244 (abs. ref. 1).

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Wendwilsonite $Ca_2(Mg,Co)(AsO_4)_2 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are stout prismatic, elongated along [100], showing {011}, {$\bar{1}$11}, {010}, {110}, to 6 mm. *Twinning:* On {100} as twin and composition plane; lamellar structure ∥ {010}, {011}, {111} visible optically.

Physical Properties: *Cleavage:* Perfect on {010}. *Fracture:* Uneven. Hardness = 3–4 D(meas.) = 3.52(8) D(calc.) = 3.57

Optical Properties: Transparent. *Color:* Pale to intense pink, may be red, commonly color zoned. *Streak:* Pale pink. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* X = violet-pink; Y = rose-pink; Z = colorless. *Orientation:* $Y = b$; $Z \wedge c = 92°$. *Dispersion:* $r < v$. *Absorption:* $X \geq Y > Z$. $\alpha = 1.694(3)$ $\beta = 1.703(3)$ $\gamma = 1.713(3)$ 2V(meas.) = 87(2)°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.806(1)$ $b = 12.912(2)$ $c = 5.623(2)$ $\beta = 107°24(1)'$ Z = 2

X-ray Powder Pattern: Bou Azzer, Morocco; close to roselite.
2.994 (100), 2.766 (80), 3.226 (60), 5.085 (50), 3.356 (40), 2.592 (40), 3.397 (30)

Chemistry:

	(1)	(2)
As_2O_5	55.8	52.76
CoO	2.6	8.60
MgO	7.7	4.63
CaO	26.4	25.74
H_2O	7.4	8.27
Total	99.9	100.00

(1) Bou Azzer, Morocco; by electron microprobe, H_2O by the Penfield method; corresponding to $Ca_{2.03}(Mg_{0.82}Co_{0.15})_{\Sigma=0.97}(AsO_4)_{2.09} \cdot 1.77H_2O$. (2) $Ca_2(Mg,Co)(AsO_4)_2 \cdot 2H_2O$ with Mg:Co = 1:1.

Polymorphism & Series: Forms a series with roselite.

Mineral Group: Roselite group.

Occurrence: A rare secondary mineral in cobalt-bearing hydrothermal mineral deposits.

Association: Talmessite, erythrite (Bou Azzer, Morocco).

Distribution: From Bou Azzer, Morocco. At Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. From an unknown locality in Coahuila, Mexico.

Name: To honor Dr. Wendell Eugene Wilson, Jr. (1946–), Editor and Publisher of the Mineralogical Record, for his contributions to specimen mineralogy.

Type Material: Royal Ontario Museum, Toronto, Canada, M42119; National Museum of Natural History, Washington, D.C., USA, 136288.

References: (1) Dunn, P.J., B.D. Sturman, and J.A. Nelen (1987) Wendwilsonite, the Mg analogue of roselite, from Morocco, New Jersey, and Mexico, and new data on roselite. Amer. Mineral., 72, 217–221.

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Wenkite $\mathbf{Ba_4Ca_6(Si,Al)_{20}O_{39}(OH)_2(SO_4)_3 \cdot nH_2O(?)}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{6}m2$. Columnar crystals, to 5 cm.

Physical Properties: *Cleavage:* Prismatic, very poor; pinacoidal parting. *Tenacity:* Brittle. Hardness = 6 D(meas.) = 3.19–3.24 D(calc.) = 3.276

Optical Properties: Transparent. *Color:* Bright gray. *Luster:* Vitreous to pearly, somewhat greasy on fractures.
Optical Class: Uniaxial (–); may be anomalously biaxial. $\omega = 1.595$ $\epsilon = 1.589$
2V(meas.) = $\sim 10°$

Cell Data: *Space Group:* $P\bar{6}2m$. a = 13.37–13.51 c = 7.46–7.70 Z = 1

X-ray Powder Pattern: Candoglia, Italy.
3.457 (100), 3.146 (78), 2.684 (65), 3.245 (63), 3.378 (60), 2.233 (57), 3.555 (54)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	31.0	25.10	K_2O	0.7	0.00
TiO_2		0.04	F		0.08
Al_2O_3	19.8	23.00	Cl	trace	0.26
Fe_2O_3		0.14	H_2O^+		1.53
MnO		0.13	H_2O^-		0.14
CaO	10.0	13.30	H_2O	2.3	
SrO	0.8		SO_3	6.7	10.20
BaO	27.6	24.40	rem.		1.42
Na_2O	0.6	0.72	Total	99.5	100.42

(1) Candoglia, Italy. (2) Karagaila deposit, Russia; corresponds to $Ba_{3.7}(Ca_{5.5}Na_{0.5})_{\Sigma=6.0}(Si_{9.6}Al_{10.3})_{\Sigma=19.9}O_{38.9}[(OH),F,Cl]_{4.5}(SO_4)_{2.9}$.

Mineral Group: Cancrinite group.

Occurrence: Formed between barite layers and calc-silicate rock, a product of strong metamorphism of marbles (Candoglia, Italy).

Association: Barite, calcite (Candoglia, Italy).

Distribution: At Cava Mergozzoni, Candoglia, Piedmont, Italy. From the Karagaila barite deposit, "central Asia," Russia.

Name: For Professor Eduard Wenk (1907–), mineralogist and petrologist, University of Basel, Basel, Switzerland.

Type Material: Natural History Museum, Basel, Switzerland, MB14577.

References: (1) Papageorgakis, J. (1962) Wenkit, ein neues Mineral von Candoglia. Schweiz. Mineral. Petrog. Mitt., 42, 269–274 (in German with English abs.). (2) (1963) Amer. Mineral., 48, 213 (abs. ref. 1). (3) Wenk, H.-R. (1966) New X-ray data for wenkite. Schweiz. Mineral. Petrog. Mitt., 46, 85–88. (4) Yanulova, M.K., E.M. Baigulov, and R.P. Zaitseva (1971) Wenkite in ores from the Karagaila deposit. Zap. Vses. Mineral. Obshch., 100, 492–498 (in Russian). (5) (1971) Chem. Abs., 75, 131586 (abs. ref. 4). (6) Wenk, H.-R. (1973) The structure of wenkite. Zeits. Krist., 137, 113–126. (7) Merlino, S. (1974) The crystal structure of wenkite. Acta Cryst., 30, 1262–1266.

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Werdingite $(Mg, Fe^{2+})_2Al_{14}B_4Si_4O_{37}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. Anhedral to subhedral crystals, up to 3 mm. *Twinning:* Composition plane ∥ [001], simple twins, common; also lamellar twins with several individuals.

Physical Properties: *Cleavage:* Prismatic, poor, or a parting. *Fracture:* Conchoidal. Hardness = 7 D(meas.) = 3.04(2) D(calc.) = 3.07

Optical Properties: Translucent. *Color:* Honey-yellow to brownish yellow. *Streak:* Buff-white. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* $X = Z$ = colorless; Y = yellow. *Orientation:* $Z = c$. *Dispersion:* $r > v$, moderately strong. $\alpha = 1.614(2)$ $\beta = 1.646(2)$ $\gamma = 1.651(2)$ 2V(meas.) = 33(1)° 2V(calc.) = 42°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.995(2)$ $b = 8.152(1)$ $c = 11.406(4)$ $\alpha = 110.45(2)°$ $\beta = 110.85(2)°$ $\gamma = 84.66(2)°$ Z = 1

X-ray Powder Pattern: Bok se Puts Farm, South Africa.
5.23 (100), 5.43 (80), 4.98 (75), 2.708 (60), 3.392 (50), 2.194 (50), 1.527 (40)

Chemistry:

	(1)
SiO_2	19.83
TiO_2	0.05
B_2O_3	10.19
Al_2O_3	59.49
FeO	5.06
MnO	0.00
MgO	4.46
Na_2O	0.00
Total	99.08

(1) Bok se Puts Farm, South Africa; by electron microprobe, B by ICP; corresponds to $(Mg_{1.35}Fe_{0.86})_{\Sigma=2.21}Al_{14.21}B_{3.56}Ti_{0.01}Si_{4.02}O_{36.91}$.

Occurrence: In granulite facies metamorphosed metasediments and metavolcanic cordierite-sillimanite and biotite gneisses.

Association: Kornerupine, grandidierite, sillimanite, zircon, rutile, hercynite.

Distribution: On the Bok se Puts Farm, Namaqualand, Cape Province, South Africa.

Name: For Dr. Günter Werding, of the Mineralogical Institute, Ruhr University, Bochum, Germany.

Type Material: South African Museum, SAMG 7140–7150, and the University of Cape Town, Cape Town, South Africa.

References: (1) Moore, J.M., D.J. Waters, and M.L. Niven (1990) Werdingite, a new borosilicate mineral from the granulite facies of the western Namaqualand metamorphic complex, South Africa. Amer. Mineral., 75, 415–420. (2) Niven, M.L., D.J. Waters, and J.M. Moore (1991) The crystal structure of werdingite, $(Mg, Fe)_2Al_{12}(Al, Fe)_2Si_4(B, Al)_4O_{37}$, and its relationship to sillimanite, mullite, and grandidierite. Amer. Mineral., 76, 246–256.

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Wermlandite $(Ca, Mg)Mg_7(Al, Fe^{3+})_2(SO_4)_2(OH)_{18} \cdot 12H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Thin platy crystals, to 1 cm, showing {0001}, {$10\overline{1}0$}.

Physical Properties: *Cleavage:* On {0001}, perfect, micaceous. *Tenacity:* Flexible but inelastic. Hardness = 1.5 D(meas.) = 1.932 D(calc.) = 1.96

Optical Properties: Semitransparent. *Color:* Pale greenish gray; colorless in transmitted light.
Optical Class: Uniaxial (–). $\omega = 1.493$ $\epsilon = [1.482]$ 2V(meas.) = 2°–5°

Cell Data: *Space Group:* $P\overline{3}c1$. $a = 9.303(3)$ $c = 22.57(1)$ Z = 2

X-ray Powder Pattern: Långban, Sweden.
7.98 (10), 11.16 (7), 4.63 (5), 5.62 (4), 3.89 (4), 2.608 (4), 1.541 (4)

Chemistry:

	(1)
SO_3	[15.98]
Al_2O_3	6.16
Fe_2O_3	7.33
MnO	0.39
MgO	28.72
CaO	3.78
H_2O	[37.64]
Total	[100.00]

(1) Långban, Sweden; recalculated after deduction of calcite 5.73%, SO_3 and H_2O from crystal-structure analysis, $(SO_4)^{2-}$ confirmed by IR; corresponds then to $(Ca_{0.68}Mg_{0.14}Mn_{0.06})_{\Sigma=0.88}Mg_{7.00}(Al_{1.21}Fe^{3+}_{0.92})_{\Sigma=2.13}(SO_4)_2(OH)_{18.15} \cdot 11.86H_2O$.

Occurrence: Very rare in a metamorphosed Fe–Mn orebody in a low-temperature fissure-filling assemblage among large calcite crystals.

Association: Calcite, magnetite.

Distribution: From Långban, Värmland, Sweden.

Name: For Wermland, an earlier spelling of the Swedish province Värmland, in which the Långban deposit is located.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 38001; National Museum of Natural History, Washington, D.C., USA, 137023, 149523.

References: (1) Moore, P.B. (1971) Wermlandite, a new mineral from Långban, Sweden. Lithos, 4, 213–217. (2) (1972) Amer. Mineral., 57, 327 (abs. ref. 1). (3) Rius, J. and R. Allmann (1984) The superstructure of the double layer mineral wermlandite $[Mg_7(Al_{0.57}, Fe^{3+}_{0.43})(OH)_{18}]^{2+} \cdot [(Ca_{0.6}, Mg_{0.4})(SO_4)_2(H_2O)_{12}]^{2-}$. Zeits. Krist., 168, 133–144.

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Westerveldite (Fe, Ni)As

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As irregularly shaped blebs and stringers up to 25 μm.

Physical Properties: Hardness = > 5 VHN = 707–798 (25 g load). D(meas.) = n.d. D(calc.) = 8.13

Optical Properties: Opaque. *Color:* Brownish white to gray. *Pleochroism:* Distinct. *Anisotropism:* Distinct in air, orange brown and bluish in oil.

R_1–R_2: (400) 46.9–48.6, (420) 46.3–48.5, (440) 45.7–48.4, (460) 44.9–48.0, (480) 44.3–48.0, (500) 43.7–47.8, (520) 43.4–47.9, (540) 43.4–47.9, (560) 43.4–48.0, (580) 43.5–48.0, (600) 43.7–48.1, (620) 44.1–48.3, (640) 44.4–48.6, (660) 44.9–48.9, (680) 45.6–49.1, (700) 46.2–49.4

Cell Data: *Space Group: Pmcn.* $a = 3.46(1)$ $b = 5.97(1)$ $c = 5.33(1)$ Z = 4

X-ray Powder Pattern: Synthetic FeAs.
2.588 (100), 1.996 (60), 2.635 (55), 2.076 (35), 2.019 (35), 1.725 (30), 2.116 (18)

Chemistry:

	(1)	(2)
Fe	26.6	30.1
Ni	17.4	13.9
Co	0.6	0.5
As	55.5	55.1
Sb		0.5
Total	100.1	100.1

(1) La Gallega mine, Spain; by electron microprobe, average of eight determinations on one grain, corresponding to $(Fe_{0.640}Ni_{0.400}Co_{0.015})_{\Sigma=1.055}As_{1.000}$. (2) Birchtree mine, Canada; by electron microprobe, average of 12 determinations, corresponding to $(Fe_{0.73}Ni_{0.32}Co_{0.01})_{\Sigma=1.06}As_{1.00}$.

Occurrence: As minute inclusions in maucherite which occurs in chromite-nickeline ores. The chromite ores and associated cordierite rock are schlieren veins through serpentinized ultramafic rocks (La Gallega mine, Spain).

Association: Maucherite, nickeline, cobaltite, nickeloan löllingite, Fe–Co-rich gersdorffite, rammelsbergite, antimony, serpentine.

Distribution: At the La Gallega mine, 3 km west of Ojén, Málaga Province, Spain. From the Ilímaussaq intrusion, southern Greenland. From Seinäjoki, Finland. At the Birchtree mine, near Thompson, Manitoba, Canada.

Name: For Dr. Jan Westerveld (1905–1962), Professor of Geology and Mineralogy, University of Amsterdam, The Netherlands.

Type Material: Geological Institute, University of Amsterdam, Amsterdam; Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands.

References: (1) Oen, I.S., E.A.J. Burke, C. Kieft, and A.B. Westerhof (1972) Westerveldite (Fe, Ni, Co)As, a new mineral from La Gallega, Spain. Amer. Mineral., 57, 354–363. (2) (1962) NBS Mono. 25, 1, 19. (3) Sizgoric, M.B. and C.M. Duesing (1973) Westerveldite, a Canadian occurrence. Can. Mineral., 12, 137–138.

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Wheatleyite $Na_2Cu(C_2O_4)_2 \cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Thin acicular crystals, to 2 mm, in aggregates. *Twinning:* Observed on an undetermined law.

Physical Properties: *Cleavage:* Perfect on {100}; two additionally observed optically. *Tenacity:* Very brittle. Hardness = 1–2 D(meas.) = 2.27(4) D(calc.) = 2.250 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Bright blue. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; Y = very pale blue; Z = intense dark blue. *Dispersion:* $r < v$, moderate. *Absorption:* $Z > Y > X$. $\alpha = 1.400(4)$ $\beta = 1.499(2)$ $\gamma = 1.667(2)$ 2V(meas.) = 83(5)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.559(3)$ $b = 9.665(4)$ $c = 3.589(1)$ $\alpha = 76.65(2)°$ $\beta = 103.67(2)°$ $\gamma = 109.10(2)°$ Z = 1

X-ray Powder Pattern: Wheatley mine, Pennsylvania, USA.
6.539 (10), 3.169 (9), 7.04 (100), 3.655 (5), 2.799 (4), 2.538 (3), 2.497 (3)

Chemistry:

	(1)	(2)
C_2O_3		44.79
CuO	27.	24.73
Na_2O	20.	19.27
H_2O		11.21
Total		100.00

(1) Wheatley mine, Pennsylvania, USA; partial analysis by electron microprobe, presence of C, H, and O confirmed by ion microprobe, $(C_2O_4)^{2-}$ confirmed by qualitative testing.
(2) $Na_2Cu(C_2O_4)_2 \cdot 2H_2O$.

Occurrence: Very rare, on a specimen found on the mine dumps of a Pb–Zn vein deposit.

Association: Sphalerite, galena, cerussite, quartz.

Distribution: From the Wheatley mine, near Phoenixville, Chester Co., Pennsylvania, USA.

Name: For the type locality, the Wheatley mine, Pennsylvania, USA.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 80196; National Museum of Natural History, Washington, D.C., USA, 162531.

References: (1) Rouse, R.C., D.R. Peacor, P.J. Dunn, W.B. Simmons, and D. Newbury (1986) Wheatleyite, $Na_2Cu(C_2O_4)_2 \cdot 2H_2O$, a natural sodium copper salt of oxalic acid. Amer. Mineral., 71, 1240–1242. (2) Chananont, P., P.E. Nixon, J.M. Waters, and T.N. Waters (1980) The structure of disodium *catena*-bis(μ-oxalato)-cuprate (II) dihydrate. Acta Cryst., 36, 2145–2147. (3) Gleizes, A., F. Maury, and J. Galy (1980) Crystal structure and magnetism of sodium bis(oxalato)cuprate(II) dihydrate, $Na_2Cu(C_2O_4)_2 \cdot 2H_2O$. Inorganic Chemistry, 19, 2074–2078.

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Whewellite $CaC_2O_4 \cdot H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Equant to short primatic [001] crystals, typically distorted, with {001}, {011}, {010}, {110}, {120}, {$\bar{1}$32}, {$\bar{1}$01}, several others, to 23 cm; cleavable massive. *Twinning:* Very common on {$\bar{1}$01} as twin and contact plane, with or without re-entrants.

Physical Properties: *Cleavage:* On {$\bar{1}$01}, very good; on {010}, imperfect; on {001}, {110}, indistinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2.5–3. D(meas.) = 2.21–2.23 D(calc.) = 2.22

Optical Properties: Transparent. *Color:* Colorless, white, may be pale yellow or pale brown; colorless in transmitted light. *Luster:* Vitreous, pearly on {010} and some cleavages. *Optical Class:* Biaxial (+). *Orientation:* $X = b$; $Z \wedge c = 30°$. *Dispersion:* $r < v$. $\alpha = 1.489–1.491$ $\beta = 1.553–1.554$ $\gamma = 1.649–1.650$ 2V(meas.) = 80°–84°

Cell Data: *Space Group:* $P2_1/n$. $a = 6.276–6.293$ $b = 15.561–14.59$ $c = 9.976–10.012$ $\beta = 107°1.5'–107°05'$ Z = 2

X-ray Powder Pattern: Near Havre, Montana, USA.
5.95 (100), 3.652 (90), 2.357 (80), 2.971 (50), 2.497 (20), 2.262 (20), 2.906 (10)

Chemistry:

	(1)	(2)
P_2O_5	0.01	
C_2O_3	48.68	49.29
CaO	38.27	38.38
H_2O^+	13.01	
H_2O^-	0.13	
H_2O		12.33
Total	100.10	100.00

(1) Huron River, Erie Co., Ohio; here converted to oxides. (2) $CaC_2O_4 \cdot H_2O$.

Occurrence: Of uncommon occurrence as a low-temperature primary hydrothermal mineral in carbonate-sulfide veins, geodes, or septarian nodules; may be associated with coal measures or formed by oxidation of organic material in surrounding rocks; in some uranium deposits.

Association: Calcite, barite, sphalerite, pyrite, weddellite, waxy hydrocarbons.

Distribution: Originally described from an unknown locality. Well characterized material from: in Germany, in Saxony, at Freital-Burgk, near Dresden, as large crystals; in the Himmelsfürst mine, Erbisdorf, near Freiberg; Zwickau, and Schlema-Hartenstein; at Paitzdorf, near Ronneburg, Thuringia. From Kladno, Pchery, near Slaný (Schlan), Czech Republic. At Cigelka, Slovakia. From the Boldut mine, Cavnic (Kapnikbánya), Romania, large crystals. In France, in the Saint-Sylvestre mine, Bas-Rhin, and at Condorcet, Drôme. In the Mealbank quarry, Ingleton, North Yorkshire, England. In Russia, from the Maikop district, Caucasus Mountains, and as large crystals from Dal'negorsk, Primorskiy Kray. In the USA, from about 11 km southeast of Havre, Hill Co., Montana; near Elm Springs, Meade Co., South Dakota, very large crystals; near Biggs, Sherman Co., Oregon; in the Radon mine, near Moab, San Juan Co., Utah; along the Huron River, about 2 km west of Milan, Erie Co., Ohio. There are numerous other minor localities.

Name: Honors William H. Whewell (1794–1866), English naturalist and philosopher.

Type Material: [Harvard University, Cambridge, Massachusetts, USA, 78102.]

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1099–1101. (2) Leavens, P.B. (1968) New data on whewellite. Amer. Mineral., 53, 455–463. (3) Deganello, S. and O.E. Piro (1981) The crystal structure of calcium oxalate monohydrate (whewellite). Neues Jahrb. Mineral., Monatsh., 81–88. (4) Pecora, W.T. and J.H. Kerr (1954) Whewellite from a septarian limestone concretion in marine shale near Havre, Montana. Amer. Mineral., 39, 208–214.

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Whitecapsite $H_{16}Mn^{2+}_{0.08}Fe^{2+}_{4.95}Fe^{3+}_{14.07}Sb^{3+}_{6.10}As^{5+}_{17.89}O_{88}\cdot 120H_2O$

Crystal Data: Hexagonal. *Point Group*: 6/*m*. Forms hexagonal prismatic {110} crystals, to 1.5 mm, doubly terminated by {111}.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = 2-2.5 D(meas.) = 2.30(3) D(calc.) = 2.297

Optical Properties: Transparent. *Color*: Bright orange to golden-brownish orange. *Streak*: Yellow. *Luster*: Strongly vitreous. *Pleochroism:* Very weak, yellowish. *Absorption: E >O.* *Optical Class*: Uniaxial (+). ω = 1.590(2) ε = 1.603(3)

Cell Data: *Space Group*: $P6_3/m$. a = 16.0916(8) c = 21.7127(9) Z = 1

X-ray Powder Pattern: White Caps mine, Nevada, USA.
11.73 (100), 13.99 (49), 2.999 (8), 5.267 (6), 2.648 (5), 3.644 (4), 2.757 (4)

Chemistry:

	(1)
MnO	0.09
Fe_2O_3	[22.73]
Sb_2O_3	13.30
As_2O_5	30.78
H_2O	[34.53]
Total	100.84

(1) White Caps mine, Nevada, USA; average of 5 electron microprobe analyses, presence of H_2O, ($H^+\cdot nH_2O$) and an absence of OH^- confirmed by IR and Raman spectroscopy, XANES spectroscopy revealed the valences of Sb and Fe; H_2O, FeO and Fe_2O_3 calculated from structural analysis; corresponding to $H_{16}Mn^{2+}_{0.08}Fe^{2+}_{4.95}Fe^{3+}_{14.07}Sb^{3+}_{6.10}As^{5+}_{17.89}O_{88}\cdot 120H_2O$.

Occurrence: A secondary mineral in the oxidation zone of a hydrothermal sulfide deposit containing arsenopyrite, pyrite and stibnite.

Association: Picropharmacolite, guerinite, sulfur, gypsum; or metastibnite, jarosite, goethite, pitticite, gypsum, picropharmacolite.

Distribution: At the 310 foot level of the East orebody, White Caps mine, Manhattan district, Nye Co., Nevada, USA.

Name: For the locality that produced the first specimens.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 93773).

References: (1) Pekov, I.V., N.V. Zubkova, J. Göttlicher, V.O. Yapaskurt, N.V. Chukanov, I.S. Lykova, D.I. Belakovskiy, M.C. Jensen, J.F. Leising, A.J. Nikischer, and D.Yu. Pushcharovsky (2014) Whitecapsite, a new hydrous iron and trivalent antimony arsenate mineral from the White Caps mine, Nevada, USA. European Journal of Mineralogy, 26(3), 557-587. (2) (2014) Amer. Mineral., 99, 1812-1813 (abs. ref. 1).

Whiteite-(CaFeMg) $Ca(Fe^{2+},Mn^{2+})Mg_2Al_2(PO_4)_4(OH)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are warped, canoe-shaped, showing only $\{\bar{1}11\}$, {001}, to 2.3 cm. *Twinning:* By reflection on {001}, common, giving a pseudo-orthorhombic outline.

Physical Properties: *Cleavage:* On {001}, good to perfect. Hardness = 3–4
D(meas.) = 2.58(1) D(calc.) = 2.51

Optical Properties: Semitransparent. *Color:* Pale tan to gray; colorless in thin fragments. *Optical Class:* Biaxial (+), may be biaxial (–). *Orientation:* $X = b$; $Y = a$. $\alpha = 1.580(3)$ $\beta = 1.585(3)$ $\gamma = 1.590(3)$ 2V(meas.) = 40°–50°

Cell Data: *Space Group:* $P2_1/a$. $a = 14.85$–14.90 $b = 6.92$–6.98 $c = 10.13$ $\beta = 112°30'$–$113°7'$ Z = 2

X-ray Powder Pattern: Lavra da Ilha pegmatite, Brazil; close to other whiteites.
9.304 (100), 2.789 (65), 4.660 (30), 4.849 (20), 2.946 (20), 2.542 (20), 1.936 (20)

Chemistry:

	(1)	(2)
P_2O_5	36.0	37.68
Al_2O_3	12.0	11.54
Fe_2O_3		0.25
FeO	6.1	9.57
MnO	3.1	0.45
MgO	10.5	12.55
CaO	6.0	5.98
Na_2O		0.17
H_2O^+		11.21
H_2O^-		10.35
H_2O	n.d.	
Total		99.75

(1) Lavra da Ilha pegmatite, Brazil; by electron probe, partial analysis, total Fe as FeO, total Mn as MnO; corresponding approximately to $(Ca_{0.84}Mn^{2+}_{0.16})_{\Sigma=1.00}(Fe^{2+}_{0.67}Mn^{2+}_{0.18})_{\Sigma=0.85}Mg_{2.05}Al_{1.86}(PO_4)_4(OH)_2 \cdot 8H_2O$. (2) Blow River, Canada; corresponds to $(Ca_{0.53}Fe^{2+}_{0.34}Na_{0.08}Mn^{2+}_{0.03})_{\Sigma=0.98}Fe^{2+}_{1.00}Mg_{2.00}(Al_{1.70}Mg_{0.28}Fe^{3+}_{0.02})_{\Sigma=2.00}(PO_4)_4(OH)_2 \cdot 8H_2O$.

Mineral Group: Whiteite group; $Al > Fe^{3+}$ in the M(3) structural site.

Occurrence: In a complex zoned granite pegmatite (Lavra da Ilha pegmatite, Brazil); in an iron-formation (Blow River, Canada).

Association: Eosphorite, zanazziite, wardite, albite, quartz (Lavra da Ilha pegmatite, Brazil); siderite, lazulite, arrojadite, quartz (Blow River, Canada).

Distribution: From the Lavra da Ilha pegmatite, in the Jequitinhonha River, three km north of Taquaral, and at the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. Large crystals from the Blow River area, Yukon Territory, Canada.

Name: Honoring John Sampson White, Jr. (1933–), Associate Curator of Mineralogy, Department of Mineral Sciences, Smithsonian Institution, Washington, D.C., USA; the suffix indicates sequentially the dominant atom in the X, M(1), and M(2) structural positions.

Type Material: National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 123013.

References: (1) Moore, P.B. and J. Ito (1978) I. Whiteite, a new species, and a proposed nomenclature for the jahnsite-whiteite complex series. II. New data on xanthoxenite. III. Salmonsite discredited. Mineral. Mag., 42, 309–323. (2) (1979) Amer. Mineral., 64, 465–466 (abs. ref. 1).

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Whiteite-(CaMnMg) $CaMn^{2+}Mg_2Al_2(PO_4)_4(OH)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Dipyramidal crystals, to 1.5 mm; may be in etched anhedral blebs.

Physical Properties: *Cleavage:* Poor on {001}. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.63(2) D(calc.) = 2.64

Optical Properties: Transparent. *Color:* Yellow, greenish yellow, pink or pale lavender. *Streak:* White. *Luster:* Dull.
Optical Class: Biaxial (+). *Pleochroism:* Slight; X = mauve; Y = light mauve; Z = colorless. *Orientation:* $Y = b$; $Z \wedge c = 15°$. *Absorption:* $X > Y > Z$. $\alpha = 1.580(1)$ $\beta = 1.584(1)$ $\gamma = 1.591(1)$ 2V(meas.) = 81(5)° 2V(calc.) = 74°

Cell Data: *Space Group:* $P2/a$ or Pa. $a = 14.842(9)$ $b = 6.976(1)$ $c = 10.109(4)$ $\beta = 112.59(5)°$ Z = 2

X-ray Powder Pattern: Tip Top mine, South Dakota, USA; close to other whiteites.
9.31 (10), 2.790 (8), 4.85 (5), 3.51 (5), 2.953 (5), 3.256 (4), 2.867 (4)

Chemistry:

	(1)
P_2O_5	38.2
Al_2O_3	12.9
FeO	1.6
MnO	12.0
MgO	9.4
CaO	5.6
H_2O	20.8
Total	100.5

(1) Tip Top mine, South Dakota, USA; by electron microprobe, total Fe as FeO, total Mn as MnO; H_2O by TGA-EGA; corresponds to $(Ca_{0.76}Mn^{2+}_{0.24})_{\Sigma=1.00}Mn^{2+}_{1.00}(Mg_{1.78}Fe^{2+}_{0.17}Mn_{0.05})_{\Sigma=2.00}$ $Al_{1.93}(PO_4)_{4.11}(OH)_{1.46} \cdot 8.1H_2O$.

Mineral Group: Whiteite group; $Al > Fe^{3+}$ in the M(3) structural site.

Occurrence: Along fracture surfaces in beryl and quartz in a zoned complex granite pegmatite.

Association: Montgomeryite, tiptopite, roscherite, englishite, beryl.

Distribution: From the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota, USA.

Name: For its relation to sl whiteite-(CaFeMg); the suffix indicates sequentially the dominant atom in the X, M(1), and M(2) structural positions.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 49707, 49712; National Museum of Natural History, Washington, D.C., USA, 15085, 163775, R18801.

References: (1) Grice, J.D., P.J. Dunn, and R.A. Ramik (1989) Whiteite-(CaMnMg), a new mineral species from the Tip Top pegmatite, Custer, South Dakota. Can. Mineral., 27, 699–702. (2) (1990) Amer. Mineral., 75, 933 (abs. ref. 1).

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Whiteite-(CaMnMn) $CaMnMn_2Al_2[PO_4]_4(OH)_2 \cdot 8H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As crystals with dominant {$\bar{1}$ 01}, {100}, {010} and {001}, to 0.5 mm, elongated along [100] and tabular on {010}. *Twinning*: Simply or polysynthetically twinned on {001}.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: Stepped. *Tenacity*: Brittle. Hardness = ~ 3.5 D(meas.) = 2.70(3) D(calc.) = 2.768

Optical Properties: Transparent. *Color*: Colorless to pale yellow, colorless in transmitted light. *Streak*: White. *Luster*: Vitreous. *Pleochroism*: None.
Optical Class: Biaxial (+). α = 1.589(2) β = 1.592(2) γ = 1.601(2) 2V(meas.) = 60(10)° 2V(calc.) = 60.3° *Orientation*: $X = b$, $Z \wedge a = 5°$.

Cell Data: *Space Group*: *P*2/*a*. a = 15.020(5) b = 6.959(2) c = 10.237(3) β = 111.470(4)° Z = 2

X-ray Powder Pattern: Hagendorf-Süd granitic pegmatite no. 25, Germany.
2.7958 (100), 4.929 (80), 9.443 (65), 4.719 (47), 3.494 (46), 5.596 (25), 1.979 (24)

Chemistry:

	(1)
Na_2O	0.53
MgO	0.88
Al_2O_3	11.66
P_2O_5	34.58
CaO	4.29
MnO	17.32
FeO	8.32
ZnO	2.60
H_2O	2.27
Total	99.68

(1) Hagendorf-Süd granitic pegmatite no. 25, Germany; average of 65 electron microprobe analyses, H_2O by Penfield method; corresponding to $(Ca_{0.63}Zn_{0.26}Na_{0.14})_{\Sigma=1.03}(Mn_{0.60}Fe^{2+}_{0.40})_{\Sigma=1.00}(Mn_{1.40}Fe^{2+}_{0.37}Mg_{0.18}Fe^{3+}_{0.06})_{\Sigma=2.01}(Al_{1.88}Fe^{3+}_{0.12})_{\Sigma=2.00}[PO_4]_4(OH)_2 \cdot 7.89\ H_2O$.

Mineral Group: Jahnsite-whiteite group.

Occurrence: A secondary mineral in cavities within zwieselite crystals or as coronas (up to 1 mm in diameter) around cubic crystals of uraninite in the core zone of a complex granitic pegmatite that was altered and leached by low-temperature oxidizing hydrothermal solutions.

Association: Triplite-zwieselite, fluorapatite, nordgauite, columbite-(Fe), a Mn-analogue of montgomeryite, koninckite, jahnsite-(CaMnMn).

Distribution: From the Cornelia open pit, Hagendorf-Süd granitic pegmatite no. 25, Bavaria, Germany.

Name: For the chemical composition, in accordance with nomenclature for the whiteite group.

Type Material: Mineralogical Museum, St. Petersburg State University, Russia (1/19470).

References: (1) Yakovenchuk, V.N., E. Keck, S.V. Krivovichev, Y.A. Pakhomovsky, E.A. Selivanova, J.A. Mikhailova, A.P. Chernyatieva, and G.Yu. Ivanyuk (2012) Whiteite-(CaMnMn), $CaMnMn_2Al_2[PO_4]_4(OH)_2 \cdot 8H_2O$, a new mineral from the Hagendorf-Süd granitic pegmatite, Germany. Mineral. Mag., 76(7), 2761-2771. (2) (2015) Amer. Mineral., 100, 663 (abs. ref. 1).

Whiteite-(MnFeMg)

$(Mn^{2+}, Ca)(Fe^{2+}, Mn^{2+})$
$Mg_2Al_2(PO_4)_4(OH)_2 \cdot 8H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are warped, canoe-shaped, showing only $\{\bar{1}11\}$, {001}, to 1.5 cm. *Twinning:* By reflection on {001}, common, giving a pseudo-orthorhombic outline.

Physical Properties: *Cleavage:* On {001}, good to perfect. Hardness = 3–4
D(meas.) = 2.67(2) D(calc.) = 2.62

Optical Properties: Semitransparent. *Color:* Chocolate-brown; colorless in thin fragments. *Optical Class:* Biaxial (+). *Orientation:* $X \perp \{001\}$. $\alpha = 1.575(5)$ $\beta = 1.585(5)$ $\gamma = 1.595(5)$
2V(meas.) = 80°–90°

Cell Data: *Space Group:* $P2_1/a$. $a = 14.99(2)$ $b = 6.96(1)$ $c = 10.14(1)$ $\beta = 113°19(6)'$
Z = 2

X-ray Powder Pattern: Lavra da Ilha pegmatite; close to whiteite-(CaFeMg).
9.318 (100), 2.776 (90), 4.824 (50), 2.948 (45), 4.644 (40), 3.518 (35), 3.245 (35)

Chemistry:

	(1)
P_2O_5	36.4
Al_2O_3	12.7
FeO	7.9
MnO	7.6
MgO	10.1
CaO	1.4
H_2O	n.d.
Total	

(1) Lavra da Ilha pegmatite, Brazil; by electron probe, partial analysis, total Fe as FeO, total Mn as MnO; corresponding approximately to $(Mn^{2+}_{0.9}Ca_{0.2})_{\Sigma=1.1}(Fe^{2+}_{0.9}Mn^{2+}_{0.1})_{\Sigma=1.0}Mg_{2.0}Al_{2.0}(PO_4)_4(OH)_2 \cdot 8H_2O$.

Mineral Group: Whiteite group; $Al > Fe^{3+}$ in the M(3) structural site.

Occurrence: In complex zoned granite pegmatites.

Association: Eosphorite, zanazziite, wardite, albite, quartz (Lavra da Ilha pegmatite, Brazil).

Distribution: From the Lavra da Ilha pegmatite, in the Jequitinhonha River, three km north of Taquaral, and at the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil.

Name: For its relation to *whiteite*-(CaFeMg); the suffix indicates sequentially the dominant atom in the X, M(1), and M(2) structural positions.

Type Material: National Museum of Natural History, Washington, D.C., USA, 161211.

References: (1) Moore, P.B. and J. Ito (1978) I. Whiteite, a new species, and a proposed nomenclature for the jahnsite-whiteite complex series. II. New data on xanthoxenite. III. Salmonsite discredited. Mineral. Mag., 42, 309–323. (2) (1979) Amer. Mineral., 64, 465–466 (abs. ref. 1).

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Whitlockite $Ca_9(Mg,Fe^{2+})(PO_4)_6(PO_3OH)$

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Crystal Data: Hexagonal. *Point Group:* $3m$. Typically as rhombohedral crystals, $\{01\bar{1}2\}$, rarely flat tabular $\{0001\}$, with $\{11\bar{2}0\}$, $\{10\bar{1}4\}$, several other smaller forms, to 2 cm. May form cave pearls; as anhedral grains and microcrystalline crusts.

Physical Properties: *Fracture:* Uneven to subconchoidal. Hardness = 5 D(meas.) = 3.12 D(calc.) = 3.102 Piezoelectric and pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, yellowish; colorless in transmitted light. *Luster:* Vitreous to subresinous.
Optical Class: Uniaxial (–). $\omega = 1.629$ $\epsilon = 1.626$

Cell Data: *Space Group: R3c.* $a = 10.330(2)$ $c = 37.103(5)$ Z = 3

X-ray Powder Pattern: North Groton, New Hampshire, USA.
2.88 (10), 3.21 (9), 2.60 (9), 5.24 (8), 3.47 (7), 1.72 (7), 1.93 (6)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	45.68	45.8	Na_2O		3.3
Fe_2O_3	1.73		F	0.06	
FeO	1.91	0.2	Cl	trace	
MgO	2.53	3.7	H_2O	0.48	
CaO	46.90	46.1	insol.	0.51	
			Total	99.80	99.1

(1) Palermo #1 mine, New Hampshire, USA; corresponds to $Ca_{8.97}(Mg_{0.67}Fe_{0.52})_{\Sigma=1.19}(PO_4)_6(PO_3OH)$. (2) Dayton meteorite; by electron microprobe, corresponds to $(Ca_{7.65}Na_{0.90})_{\Sigma=8.55}(Mg_{0.87}Fe_{0.03})_{\Sigma=0.90}(PO_4)_6(PO_3OH)$.

Occurrence: An uncommon secondary mineral in complex zoned granite pegmatites; in phosphate rock deposits; may be formed in caves from leached guano; in chondrite meteorites.

Association: Ludlamite, fairfieldite, triphylite, siderite, apatite, quartz (pegmatites); hydroxylapatite (caves and islands); stanfieldite, farringtonite, brianite (meteorites).

Distribution: In the USA, from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, as large crystals; in the Bell pit and Dunton quarry, Newry, Oxford Co., Maine; at the Tip Top and Bull Moose mines, near Custer, Custer Co., South Dakota. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada. On Table Mountain, Curaçao, and on Sombrero Island, West Indies. From Enderbury Island, Phoenix Islands, Kiribati. On the Los Monges keys, Gulf of Venezuela. In Isla Mona Cave, Puerto Rico. At Cueva Atabex, Siboney, Cuba. From the Ødegården apatite mines, Bamble, Norway. In the Drachenhöhle, Hungary. From a cave at Sebdou, Oran, Algeria. At the Niah Great Cave, Sarawak, Malaysia. In the Dayton finest octahedrite meteorite.

Name: To honor Herbert Percy Whitlock (1868–1948), American mineralogist, Curator, American Museum of Natural History, New York City, New York, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 95030; National Museum of Natural History, Washington, D.C., USA, 146196.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 684–686. (2) Calvo, C. and R. Gopal (1975) The crystal structure of whitlockite from the Palermo quarry. Amer. Mineral., 60, 120–133. (3) Moore, P.B. and J. Shen (1983) Cerite, $RE_9(Fe^{3+},Mg)(SiO_4)_6(SiO_3OH)(OH)_3$: its crystal structure and relation to whitlockite. Amer. Mineral., 68, 996–1003. (4) Dowty, E. (1977) Phosphate in Angra dos Reis: structure and composition of the $Ca_3(PO_4)_2$ minerals. Earth and Planetary Science Letters, 35, 347–351. (5) Fuchs, L.H., E. Olsen, and E.P. Henderson (1967) On the occurrence of brianite and panethite, two new phosphate minerals from the Dayton meteorite. Geochim. Cosmochim. Acta, 31, 1711–1719. (6) Frondel, C. (1943) Mineralogy of the calcium phosphates in insular phosphate rock. Amer. Mineral., 28, 215–232.

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Whitmoreite $Fe^{2+}Fe^{3+}_2(PO_4)_2(OH)_2 \cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Uncommon as isolated pseudo-orthorhombic crystals, prismatic to acicular ‖ [001], showing {110}, {100}, {011}, {021}, {112}, with chisel-shaped terminations, to 2 mm; typically in fans, radial sprays, and balls resembling burrs or naval mines. *Twinning:* By reflection on {100}, common.

Physical Properties: *Cleavage:* On {100}, fair. Hardness = 3 D(meas.) = 2.87(1) D(calc.) = 2.85

Optical Properties: Semitransparent. *Color:* Deep brown to pale tan, greenish brown. *Luster:* Vitreous to subadamantine.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = light greenish brown to yellow; Z = dark greenish brown to yellowish green. *Orientation:* $X = a$; $Y = b$; $Z = c$. α = 1.670–1.676 β = 1.712–1.725 γ = 1.745–1.750 2V(meas.) = 60°–65°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.00(2)$ $b = 9.73(2)$ $c = 5.471(8)$ $\beta = 93°49(6)'$ Z = 2

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
10.05 (10), 7.01 (7), 4.98 (7), 4.21 (7), 2.802 (7), 4.42 (6), 3.476 (5)

Chemistry:

	(1)	(2)
P_2O_5	31.2	30.62
Fe_2O_3	40.0	34.45
FeO	4.9	15.50
MnO	4.2	
H_2O	[19.7]	19.43
Total	[100.0]	100.00

(1) Palermo #1 mine, New Hampshire, USA; by electron microprobe, originally given as Fe 27.8%, Mn 3.0%, P 13.0%; with H_2O by difference and $(OH)^{1-}$ for charge balance, corresponds to $(Fe^{2+}_{0.31}Fe^{3+}_{0.28}Mn^{2+}_{0.27})_{\Sigma=0.86}Fe^{3+}_{2.00}(PO_4)_{2.00}(OH)_{2.00} \cdot 3.97H_2O$. (2) $Fe^{2+}Fe^{3+}_2(PO_4)_2(OH)_2 \cdot 4H_2O$.

Mineral Group: Arthurite group.

Occurrence: A secondary mineral in complex zoned granite pegmatites.

Association: Siderite, triphylite, ludlamite, strunzite, laueite, beraunite, mitridatite, ushkovite, Fe–Mn oxides.

Distribution: In the USA, from the Palermo #1 mine, North Groton, Grafton Co., and at the Fitzgibbon mine, Alstead, Cheshire Co., New Hampshire; from the Bell Pit, Newry, Oxford Co., Maine; in the Big Chief mine, one km south of Glendale, Pennington Co., and the Tip Top mine, 8.5 km southwest of Custer, Custer Co., South Dakota. From the Gravel Hill mine, Perranzabuloe, Cornwall, England. In the Bendada pegmatite, near Guarda, Portugal. At Hagendorf, and Hühnerkobel, near Zwiesel, Bavaria, Germany.

Name: Honoring Robert William Whitmore (1936–), Weare, New Hampshire, USA, American collector of microscopic minerals and owner of the Palermo #1 mine.

Type Material: National Museum of Natural History, Washington, D.C., USA, 128069.

References: (1) Moore, P.B., A.R. Kampf, and A.J. Irving (1974) Whitmoreite, $Fe^{2+}Fe^{3+}_2(OH)_2(H_2O)_4[PO_4]_2$, a new species: its description and atomic arrangement. Amer. Mineral., 59, 900–905.

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Wickenburgite $Pb_3CaAl_2Si_{10}O_{27}\cdot 3H_2O$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Tabular holohedral crystals, dominated by {0001} and $\{10\bar{1}1\}$, to 1.5 mm. As spongy aggregates of small, highly perfect individuals; as subparallel aggregates or rosettes; granular.

Physical Properties: *Cleavage:* {0001}, indistinct. *Tenacity:* Brittle but tough. Hardness = 5 D(meas.) = 3.85 D(calc.) = 3.88 Fluoresces dull orange under SW UV.

Optical Properties: Transparent to translucent. *Color:* Colorless to white; rarely salmon-pink. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Dispersion:* $r < v$, moderate. $\omega = 1.692$ $\epsilon = 1.648$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 8.53$ $c = 20.16$ $Z = 2$

X-ray Powder Pattern: Near Wickenburg, Arizona, USA.
10.1 (100), 3.26 (80), 3.93 (60), 3.36 (40), 2.639 (40), 5.96 (30), 5.04 (30)

Chemistry:

	(1)	(2)
SiO_2	42.1	40.53
Al_2O_3	7.6	6.88
PbO	44.0	45.17
CaO	3.80	3.78
H_2O	3.77	3.64
Total	101.27	100.00

(1) Near Wickenburg, Arizona, USA. (2) $Pb_3CaAl_2Si_{10}O_{24}(OH)_6$. [needsnew??formula]

Occurrence: In oxidized hydrothermal veins, carrying galena and sphalerite, in quartz and fluorite gangue (near Wickenburg, Arizona, USA).

Association: Phoenicochroite, mimetite, cerussite, willemite, crocoite, duftite, hemihedrite, alamosite, melanotekite, luddenite, ajoite, shattuckite, vauquelinite, descloizite, laumontite.

Distribution: In the USA, in Arizona, at several localities south of Wickenburg, Maricopa Co., including the Potter-Cramer property, Belmont Mountains, and the Moon Anchor mine; on dumps at a Pb-Ag-Cu prospect in the Artillery Peaks area, Mohave Co.; and in the Dives (Padre Kino) mine, Silver district, La Paz Co.

Name: For Wickenburg, Arizona, USA, the community near which it was discovered.

Type Material: Harvard University, Cambridge, Massachusetts, 119099; National Museum of Natural History, Washington, D.C., USA, 122875.

References: (1) Williams, S.A. (1968) Wickenburgite, a new mineral from Arizona. Amer. Mineral., 53, 1433–1438.

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Wickmanite $Mn^{2+}Sn^{4+}(OH)_6$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Octahedra, to 4 mm.

Physical Properties: *Cleavage:* Good on {100}. Hardness = 3.5 D(meas.) = 3.89(5) D(calc.) = 3.72–3.75

Optical Properties: Transparent to translucent. *Color:* Brownish yellow, honey-yellow, yellow-orange, greenish yellow, colorless, pink. *Streak:* White. *Luster:* Resinous. *Optical Class:* Isotropic. n = 1.705–1.780

Cell Data: *Space Group: Pn3m.* a = 7.85–7.873 Z = 4

X-ray Powder Pattern: Långban, Sweden.
3.931 (10), 1.7618 (7), 2.778 (6), 1.6080 (5), 4.552 (4), 1.0536 (4), 2.372 (3)

Chemistry:

	(1)	(2)	(3)
SnO_2	59.9	55.1	54.67
MnO	21.4	15.3	25.73
FeO	0.1	8.5	
MgO	0.6	2.4	
CaO	0.4	0.0	
H_2O	[21.8]	[20.2]	19.60
Total	[104.2]	[101.5]	100.00

(1) Långban, Sweden; by electron microprobe, original analysis given as elements, here converted to oxides; total Fe as FeO, H_2O calculated from stoichiometry; corresponding to $(Mn_{0.78}Mg_{0.03}Ca_{0.01})_{\Sigma=0.82}Sn_{1.02}(OH)_{6.24}$. (2) Pitkäranta district, Russia; by electron microprobe, average of 17 points; total Fe as FeO, H_2O calculated from stoichiometry; corresponding to $(Mn_{0.58}Fe_{0.32}Mg_{0.16})_{\Sigma=1.06}Sn_{0.98}(OH)_{5.99}$. (3) $MnSn(OH)_6$.

Mineral Group: Schoenfliesite group.

Occurrence: A rare late-stage, low-temperature mineral in magnetite ore and jacobsite-richterite-manganoan biotite skarn in a metamorphosed Fe–Mn orebody (Långban, Sweden); in a nepheline syenite pegmatite (Tvedalen, Norway); in a hydrothermal mineral deposit in altered garnet skarn (Pitkäranta district, Russia).

Association: Bementite, allactite, calcite, barite, magnetite (Långban, Sweden); burtite, stokesite, datolite, pectolite, apophyllite (El Hamman, Morocco); stokesite, axinite, grossular, pargasite, apatite, titanite, orthoclase, chalcopyrite (Whealcock Zawn, England).

Distribution: From Långban, Värmland, Sweden. In the Heia quarry, Tvedalen, near Larvik, Norway. In the Pitkäranta district, Lake Ladoga, Karelia, Russia. At Whealcock Zawn, Botallack, Cornwall, England. On the west bank of the Beht River, El Hamman, central Morocco. At Tsumeb, Namibia. From Llallagua, Bolivia.

Name: To honor Professor Franz-Erik Wickman (1915–), Swedish-American mineralogist, for his contributions to Långban mineralogy.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 532405; National Museum of Natural History, Washington, D.C., USA, 120068, 162615.

References: (1) Moore, P.B. and J.V. Smith (1967) Wickmanite, $Mn^{+2}[Sn^{+4}(OH)_6]$, a new mineral from Långban. Arkiv Mineral. Geol., 4(16), 395–399. (2) (1968) Amer. Mineral., 53, 1063 (abs. ref. 1). (3) Nefedov, E.I., W.L. Griffen, and R. Kristiansen (1977) Minerals of the schoenfliesite–wickmanite series from Pitkäranta, Karelia, U.S.S.R. Can. Mineral., 15, 437–445.

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Wicksite $NaCa_2(Fe^{2+},Mn^{2+})_4MgFe^{3+}(PO_4)_6 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are platy on {010}, striated ‖ [100], to 1 cm; granular, massive.

Physical Properties: *Cleavage:* Good on {010}. Hardness = 4.5–5 D(meas.) = 3.54(2) D(calc.) = 3.58

Optical Properties: Opaque, transparent in thin fragments. *Color:* Dark blue to dark green, nearly black. *Streak:* Green. *Luster:* Submetallic.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = blue; Y = greenish blue; Z = pale yellowish brown. *Orientation:* $X = a$; $Y = b$; $Z = c$. *Dispersion:* $r < v$, strong. *Absorption:* $X = Y > Z$. $\alpha = 1.713(3)$ $\beta = 1.718(3)$ $\gamma = 1.728(3)$ 2V(meas.) = 66(2)° 2V(calc.) = 72°

Cell Data: *Space Group: Pcab.* $a = 12.524(1)$ $b = 12.907(2)$ $c = 11.646(2)$ Z = 4

X-ray Powder Pattern: Big Fish River, Canada.
2.753 (100), 3.015 (80), 2.910 (80), 2.118 (60), 2.571 (40), 2.868 (30), 2.837 (30)

Chemistry:

	(1)
P_2O_5	41.64
Al_2O_3	0.51
Fe_2O_3	7.98
FeO	22.66
MnO	4.72
MgO	3.77
CaO	11.05
Na_2O	3.08
H_2O	3.70
Total	99.11

(1) Big Fish River, Canada; by electron microprobe, FeO 22.66% by titration, excess Fe as Fe_2O_3, H_2O by DTA-TGA; corresponding to $Na_{1.00}Ca_{1.96}(Fe^{2+}_{3.16}Mn^{2+}_{0.66})_{\Sigma=3.82}Mg_{0.94}(Fe^{3+}_{1.00}Al_{0.10})_{\Sigma=1.10}(P_{0.98}O_4)_6 \cdot 2.06H_2O$.

Occurrence: In nodules in shale beds in an iron formation.

Association: Wolfeite, satterlyite, marićite, ludlamite, vivianite, pyrite, quartz.

Distribution: At Big Bend, on the Big Fish River, Big Fish River–Blow River area, Yukon Territory, Canada.

Name: To honor Dr. Frederick John Wicks (1937—), Curator of Mineralogy, Royal Ontario Museum, Toronto, Canada.

Type Material: Canadian Geological Survey, Ottawa, 61309; Royal Ontario Museum, Toronto, Canada, M37364; National Museum of Natural History, Washington, D.C., USA, 145607, 145968.

References: (1) Sturman, B.D., D.R. Peacor, and P.J. Dunn (1981) Wicksite, a new mineral from northeastern Yukon Territory. Can. Mineral., 19, 377–380. (2) (1982) Amer. Mineral., 67, 1077–1078 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1997) The crystal structure of wicksite. Can. Mineral., 35, 777–784.

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Widenmannite $Pb_2(UO_2)(CO_3)_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. Lathlike crystals, tabular on {010}, elongated along [001], to 100 μm, showing {100}, {010}, {001}, {101}; aggregated in tufts and mats.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = ∼2 D(meas.) = n.d. D(calc.) = 6.89 Radioactive.

Optical Properties: Transparent to translucent. *Color:* Colorless, very pale greenish yellow, yellow. *Streak:* Pale yellow. *Luster:* Pearly to silky.
Optical Class: Biaxial (–). *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.803(5)$ $\beta = 1.905(5)$ $\gamma = 1.945(5)$ 2V(meas.) = 63°

Cell Data: *Space Group:* $Pnmm$, $Pnm2_1$, or $P22_12_1$. $a = 8.971$–8.99 $b = 9.36$–9.381 $c = 4.95$–5.002 Z = 2

X-ray Powder Pattern: Michael mine, Germany.
4.16 (10), 2.34 (10), 3.19 (8b), 3.34 (7), 1.911 (5), 1.869 (5), 1.473 (5b)

Chemistry:

	(1)	(2)	(3)
CO_2	16.5	16.1	15.27
UO_3	34.2	31.8	33.09
PbO	48.3	51.7	51.64
Total	99.0	99.6	100.00

(1) Michael mine, Germany; by electron microprobe. (2) Loe Warren zawn, England; by electron microprobe, here recalculated to oxides. (3) $Pb_2(UO_2)(CO_3)_3$.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal As–Pb-bearing deposit (Michael mine, Germany); an alteration product of sulfides by sea water (Loe Warren zawn, England).

Association: Hügelite, hallimondite, cerussite, galena, quartz (Michael mine, Germany); dewindtite, uraninite (Loe Warren zawn, England).

Distribution: From the Michael mine, Weiler, near Lahr, Black Forest, Germany. At Jáchymov (Joachimsthal), Czech Republic. From Loe Warren zawn, 0.75 km west of Botallack, St. Just, Cornwall, England.

Name: To honor Johann Friedrich Wilhelm Widenmann (1764–1798), German mineralogist who discovered uranium in the Black Forest.

Type Material: [University of Strassburg, Strassburg, France.]

References: (1) Walenta, K. and W. Wimmenauer (1961) Die Mineralbestand des Michaelganges in Weiler bei Lahr (Schwarzwald). Jahreshefte geol. Landesamtes Baden-Württemberg, 4, 7–37 (in German). (2) (1962) Amer. Mineral., 47, 415 (abs. ref. 1). (3) Walenta, K. (1976) Widenmannit und Joliotit, zwei neue Uranylkarbonatmineralien aus dem Schwarzwald. Schweiz. Mineral. Petrog. Mitt., 56, 167–185 (in German with English abs.). (4) Elton, J.J. and J.J. Hooper (1995) Widenmannite from Cornwall, England: the second world occurrence. Mineral. Mag., 59, 745–749.

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Widgiemoolthalite $(Ni, Mg)_5(CO_3)_4(OH)_2 \cdot 4-5H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* [2/*m*.] Radiating fibrous spheroids, to 3 mm, and in felted masses.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. D(meas.) = 3.13(1) D(calc.) = 3.24

Optical Properties: Semitransparent. *Color:* Bluish green, grass-green; bluish green in transmitted light. *Streak:* Pale bluish green. *Luster:* Silky.
Optical Class: Biaxial (+). *Orientation:* Length-fast. $\alpha = 1.630(5)$ β = n.d. $\gamma = 1.640(5)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy to hydromagnesite). $a = 10.06(17)$ $b = 8.75(5)$ $c = 8.32(4)$ $\beta = 114.4(8)^\circ$ Z = 2

X-ray Powder Pattern: 132 North nickel mine, Western Australia.
5.75 (10), 6.30 (5), 4.36 (4), 2.871 (4), 4.14 (3), 2.120 (3), 2.458 (2)

Chemistry:

	(1)
CO_2	28.9
NiO	54.6
MgO	2.4
H_2O	17.0
Total	102.9

(1) 132 North nickel mine, Western Australia; by electron microprobe, average of 14 analyses, CO_2 and H_2O determined by CHN analyzer; corresponds to $(Ni_{4.62}Mg_{0.38})_{\Sigma=5.00}(CO_3)_{4.15}(OH)_{1.70} \cdot 5.12H_2O$.

Occurrence: In a stockpile of weathered ore from a hydrothermal nickel deposit.

Association: Gaspéite.

Distribution: From the 132 North nickel mine, 4 km southwest of Widgiemooltha, Western Australia.

Name: For its occurrence near Widgiemooltha, Western Australia.

Type Material: Western Australian Museum, Perth, Australia, M.1.1993.

References: (1) Nickel, E.H., B.W. Robinson, and W.G. Mumme (1993) Widgiemoolthalite: the new nickel analogue of hydromagnesite from Western Australia. Amer. Mineral., 78, 819–821.

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Wightmanite $Mg_5O(BO_3)(OH)_5 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Small rough prismatic unterminated pseudohexagonal crystals, showing {010}, {100}, $\{1\bar{1}0\}$, several other minor forms; commonly in radial aggregates.

Physical Properties: *Cleavage:* On {010}, perfect; on {100}, fair. Hardness = 5.5 D(meas.) = 2.60 D(calc.) = 2.58

Optical Properties: Semitransparent. *Color:* Colorless, may have a faint green tint. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Z \wedge c = 5°$; OAP $\wedge$ {010} $\simeq 8°$. *Dispersion:* $r < v$, strong. $\alpha = 1.585(3)$ $\beta = 1.603(3)$ $\gamma = 1.604(3)$ 2V(meas.) = 33°

Cell Data: *Space Group:* $I2/m$. $a = 13.46(2)$ $b = 3.102(5)$ $c = 18.17(2)$ $\beta = 91.60(5)°$ Z = 4

X-ray Powder Pattern: Commercial quarry, California, USA.
10.70 (10), 9.07 (10), 3.03 (3), 2.67 (3), 4.74 (2), 2.446 (2), 2.35 (2)

Chemistry:

	(1)	(2)
B_2O_3	11.30	10.97
TiO_2	0.16	
Al_2O_3	2.16	
FeO	2.26	
MgO	58.15	63.49
CaO	2.77	
F	1.85	
Cl	0.96	
H_2O^+	16.95	
H_2O^-	4.83	
H_2O		25.54
$-O = (F, Cl)_2$	1.01	
Total	[100.38]	100.00

(1) Commercial quarry, California, USA; recalculated after deduction of szaibélyite estimated 3%; corresponds to $(Mg_{4.74}Ca_{0.16}Fe_{0.10})_{\Sigma=5.00}O[(B_{1.07}Al_{0.14})_{\Sigma=1.21}O_3](OH)_5 \cdot 2H_2O$.
(2) $Mg_5O(BO_3)(OH)_5 \cdot 2H_2O$.

Occurrence: Very rare in contact metamorphosed limestone.

Association: Fluoborite, szaibélyite, dolomite, calcite (Commercial quarry, California, USA).

Distribution: In the USA, from the Commercial quarry, near Crestmore, Riverside Co., and north of Huntington Lake, Twin Lakes region, Fresno Co., California.

Name: Honors Randall H. Wightman (1915–1969), Director of Exploration and Mining of the Riverside Cement Co., Riverside, California, USA.

Type Material: n.d.

References: (1) Murdoch, J. (1962) Wightmanite, a new borate mineral from Crestmore, California. Amer. Mineral., 47, 718–722. (2) Moore, P.B. and T. Araki (1974) Pinakiolite, $Mg_2Mn^{3+}O_2[BO_3]$; warwickite, $Mg(Mg_{0.5}Ti_{0.5})O[BO_3]$; wightmanite, $Mg_5(O)(OH)_5[BO_3] \cdot nH_2O$: crystal chemistry of complex 3 Å wallpaper structures. Amer. Mineral., 59, 985–1004.

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Wilcoxite $MgAl(SO_4)_2F \cdot 17–18H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. As stubby crystals, showing {010}, {110}, {100}, {$\overline{1}$10}, {0$\overline{1}$1}, typically with rounded edges, to about 1 mm, aggregated in thick crusts and spongy masses, may be stalactitic.

Physical Properties: *Fracture:* Conchoidal. Hardness = 1–2 D(meas.) = 1.58(1) D(calc.) = 1.67 Soluble in H_2O; slightly heated, it will dissolve in its own H_2O.

Optical Properties: Transparent. *Color:* Colorless, pale blue, pale green, becoming milky white on exposure to air. *Luster:* Greasy.
Optical Class: Biaxial (–). $\alpha = 1.424–1.425$ $\beta = 1.436$ $\gamma = 1.437–1.438$ 2V(meas.) = n.d. 2V(calc.) = 48°

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 14.90$ $b = 6.65$ $c = 6.77$ $\alpha = 117°26'$ $\beta = 100°35'$ $\gamma = 89°10'$ Z = 1

X-ray Powder Pattern: Lone Pine mine, New Mexico, USA.
4.908 (10), 5.654 (9), 4.371 (6), 3.384 (5), 5.877 (4), 4.117 (4), 2.980 (4)

Chemistry:

	(1)	(2)	(3)
SO_3	27.50	27.89	27.29
SiO_2		0.29	
Al_2O_3	8.13	8.20	8.69
Fe_2O_3	0.46	0.30	
MnO	0.13		
MgO	6.61	7.25	6.87
F	3.48	4.00	3.24
H_2O	56.40	52.92	55.27
$-O = F_2$	1.47	1.68	1.36
Total	101.24	99.17	100.00

(1) Lone Pine mine, New Mexico, USA; by microanalysis, H_2O by the Penfield method.
(2) Deputatskoye deposit, Russia. (3) $MgAl(SO_4)_2F \cdot 18H_2O$.

Occurrence: A rare post-mine mineral deposited from solutions derived from an oxidizing breccia zone (Lone Pine mine, New Mexico, USA); in intensely oxidized cassiterite–tourmaline–quartz–polysulfide ore (Deputatskoye deposit, Russia).

Association: Fluorite, gypsum, khademite, lannonite, pyrite (Lone Pine mine, New Mexico, USA); melanterite, fibroferrite, gypsum, goethite, ice (Deputatskoye deposit, Russia).

Distribution: From the Lone Pine mine, Wilcox district, near Silver City, Catron Co., New Mexico, USA. In the Deputatskoye tin deposit, northeast Sakha, Russia. From the Valle del Cura, San Juan Province, Argentina.

Name: To honor William Wilcox (?–1880), discoverer of the Wilcox district, New Mexico, USA.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,545; National Museum of Natural History, Washington, D.C., USA, 149525.

References: (1) Williams, S.A. and F.P. Cesbron (1983) Wilcoxite and lannonite, two new fluosulphates from Catron Co., New Mexico. Mineral. Mag., 47, 37–40. (2) (1984) Amer. Mineral., 69, 407 (abs. ref. 1). (3) Zhdanov, Y.Y., L.I. Solov'yev, and V.S. Suknev (1993) Wilcoxite from Yakutia [Sakha], its second find in the world. Doklady Acad. Nauk SSSR, 317, 136–139 (in English).

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Wilhelmkleinite $ZnFe_2^{3+}(AsO_4)_2(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Spearhead-shaped crystals, to 5 mm, exhibiting {100}, {430}, {$31\overline{1}$}, in aggregates. *Twinning:* Interpenetration twins on {101}.

Physical Properties: *Cleavage:* On {$23\overline{2}$}. Hardness = 4.5 D(meas.) = n.d. D(calc.) = 4.364

Optical Properties: Translucent. *Color:* Blackish green. *Streak:* Green. *Luster:* Dull, adamantine on fractures.
Optical Class: Biaxial. *Pleochroism:* Strong; olive-green to emerald-green to reddish brown. $n = \sim 1.94$ α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/n$. $a = 6.631(1)$ $b = 7.611(1)$ $c = 7.377(1)$ $\beta = 91.80(1)^\circ$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.385 (100), 3.315 (78), 2.939 (47), 1.621 (34), 1.652 (32), 2.381 (29), 2.839 (28)

Chemistry:

	(1)	(2)
As_2O_5	46.69	47.01
Fe_2O_3	33.60	32.66
ZnO	13.81	16.65
H_2O	[5.90]	3.68
Total	[100.00]	100.00

(1) Tsumeb, Namibia; by electron microprobe, average of five analyses, total Fe as Fe_2O_3, H_2O by difference; corresponding to $Zn_{0.84}Fe_{2.07}(AsO_4)_2(OH_{1.6})_2$. (2) $ZnFe_2(AsO_4)_2(OH)_2$.

Occurrence: Very rare from a deep oxidation zone in a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Scorodite, gerdtremmelite, adamite.

Distribution: From Tsumeb, Namibia.

Name: To honor Wilhelm Klein (1889–1939), Manager of the Otavi Mining and Railroad Company mines in Namibia (1916–1939), an early collector of Tsumeb minerals.

Type Material: Mineralogical Museum, University of Hamburg, Hamburg, Germany.

References: (1) Schlüter, J., K.-H. Klaska, K. Friese, G. Adiwidjaja, and G. Gebhard (1998) Wilhelmkleinite, $ZnFe_2^{3+}(AsO_4)_2(OH)_2$, a new mineral from Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 558–564. (2) (1999) Amer. Mineral., 84, 1197 (abs. ref. 1).

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Wilhelmvierlingite $CaMn^{2+}Fe^{3+}(PO_4)_2(OH)\cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As prismatic to equant crystals, showing {100}, {010}, {110}, {001}, to 40μm, typically in radial fibrous aggregates.

Physical Properties: *Cleavage:* On {010}, perfect. Hardness = 4 D(meas.) = 2.58 D(calc.) = 2.60

Optical Properties: Translucent. *Color:* Yellow to brownish yellow. *Streak:* Pale yellow. *Luster:* Vitreous.
Optical Class: Biaxial (–) or (+). *Pleochroism:* $X = Y$ = light yellow; Z = dark yellow. *Orientation:* $X = b$; $Y = a$; $Z = c$. $\alpha = 1.637$ $\beta = 1.664$ $\gamma = 1.692$ 2V(meas.) = n.d. 2V(calc.) = 45°

Cell Data: *Space Group: Pbca.* $a = 14.80(5)$ $b = 18.70(5)$ $c = 7.31(2)$ Z = 8

X-ray Powder Pattern: Hagendorf, Germany.
2.86 (10), 9.34 (7), 5.00 (6d), 1.98 (5), 4.67 (4), 2.58 (4), 1.96 (4d)

Chemistry:

	(1)	(2)
P_2O_5	35.5	36.04
Fe_2O_3	19.0	20.27
MnO	17.6	18.01
ZnO	2.6	
CaO	11.9	14.24
H_2O	[13.4]	11.44
Total	[100.0]	100.00

(1) Hagendorf, Germany; by electron microprobe, originally given as PO_4 47.5%, Fe 13.3%, Mn 13.6%, Zn 2.1%, Ca 8.5%, H_2O 15.0% by difference, total 100.0%, here converted to oxides, total Fe as Fe_2O_3, total Mn as MnO, $(OH)^{1-}$ determined present by IR; stated to correspond to $(Ca_{0.85}Zn_{0.13})_{\Sigma=0.98}Mn^{2+}_{0.99}Fe^{3+}_{0.95}(PO_4)_2(OH)\cdot 2.33H_2O$. (2) $CaMn^{2+}Fe^{3+}(PO_4)_2(OH)\cdot 2H_2O$.

Mineral Group: Overite group.

Occurrence: A rare secondary mineral in a complex zoned granite pegmatite.

Association: Rockbridgeite, zwieselite.

Distribution: From Hagendorf, Bavaria, Germany.

Name: To honor Wilhelm Vierling (1901–1995), Weiden, Germany, a longtime student of Hagendorf minerals.

Type Material: Institute for Mineralogy and Crystallography, Technical University, Berlin, Germany.

References: (1) Mücke, A. (1983) Wilhelmvierlingit, $(Ca,Zn)MnFe^{3+}[OH|(PO_4)_2]2H_2O$, ein neues Mineral von Hagendorf/Oberpfalz. Aufschluss, 34, 267–274 (in German). (2) (1984) Amer. Mineral., 69, 568 (abs. ref. 1).

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Wilkinsonite $Na_2Fe^{2+}_4Fe^{3+}_2Si_6O_{20}$

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Crystal Data: Triclinic. *Point Group:* 1 or $\bar{1}$. As very small anhedral grains, < 50 μm.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ~5
D(meas.) = n.d. D(calc.) = 3.89

Optical Properties: Opaque to semitransparent. *Color:* Black. *Streak:* Brown.
Luster: Vitreous.
Optical Class: Biaxial (+). *Dispersion:* Strong. *Pleochroism:* Strong; X = olive-green; Y = gray-brown; Z = very dark brown. *Absorption:* $Z > Y > X$. $\alpha = 1.79(1)$ $\beta = 1.79(1)$ $\gamma = 1.90(1)$ 2V(meas.) = < 10°

Cell Data: *Space Group:* $P1$ or $P\bar{1}$. $a = 10.355(2)$ $b = 10.812(2)$ $c = 8.906(2)$ $\alpha = 105.05(1)°$ $\beta = 96.63(1)°$ $\gamma = 125.20(1)°$ Z = 2

X-ray Powder Pattern: Warrumbungle volcano, Australia.
8.10 (100), 3.149 (100), 2.696 (80), 2.533 (80), 2.115 (70), 2.935 (60), 1.481 (50)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.44	29.29	FeO	45.98	14.34
TiO_2	0.63	0.04	MnO	1.25	2.07
ZrO_2	0.20		NiO		0.15
Al_2O_3	0.66	0.06	MgO	0.02	5.50
Fe_2O_3		41.53	CaO	0.16	0.68
Cr_2O_3		0.06	Na_2O	7.23	5.94
Nb_2O_5	1.64		K_2O	0.05	0.75
			Total	98.26	100.41

(1) Warrumbungle volcano, Australia; by electron microprobe, average of 22 analyses of nine grains, Fe^{2+}:Fe^{3+} calculated from stoichiometry in empirical analysis; corresponds to $(Na_{2.04}Ca_{0.02}K_{0.01})_{\Sigma=2.07}(Fe^{2+}_{3.90}Mn_{0.15})_{\Sigma=4.05}(Fe^{3+}_{1.69}Nb_{0.11}Ti_{0.07}Zr_{0.01})_{\Sigma=1.88}(Si_{5.88}Al_{0.11})_{\Sigma=5.99}O_{20}$. (2) Wonchi volcano, Ethiopia; by electron microprobe, average of five analyses, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Na_{1.68}K_{0.14}Ca_{0.11})_{\Sigma=1.93}(Fe^{2+}_{1.75}Mg_{1.20}Fe^{3+}_{0.92}Mn_{0.26}Ni_{0.02})_{\Sigma=4.15}(Fe^{3+}_{1.93}Ti_{0.07})_{\Sigma=2.00}(Si_{4.27}Fe^{3+}_{1.71}Al_{0.01}Cr_{0.01})_{\Sigma=6.00}O_{20}$.

Polymorphism & Series: Forms a series with aenigmatite.

Mineral Group: Aenigmatite group.

Occurrence: In an eruptive peralkaline trachyte (Warrumbungle volcano, Australia); in syenite ejecta (Wonchi volcano, Ethiopia).

Association: Anorthoclase, sodalite, clinopyroxenes, nepheline, analcime, arfvedsonite, eudialyte (Warrumbungle volcano, Australia); riebeckite, biotite, aegirine, aenigmatite (Wonchi volcano, Ethiopia).

Distribution: At the Warrumbungle volcano and associated Bingie Grumble Mountain, New South Wales, Australia. On the Wonchi volcano, 90 km south of Addis Ababa, Ethiopia.

Name: For John Frederick George Wilkinson, Emeritus Professor of Geology, University of New England, Armidale, Australia.

Type Material: Petrological Museum, Bureau of Mineral Resources, Canberra, Australia, R29655.

References: (1) Duggan, M.B. (1990) Wilkinsonite, $Na_2Fe^{2+}_4Fe^{3+}_2Si_6O_{20}$, a new member of the aenigmatite group from the Warrumbungle Volcano, New South Wales, Australia. Amer. Mineral., 75, 694–701. (2) Gaeta, M. and A. Mottana (1991) Phase relations of aenigmatite minerals in a syenitic ejectum, Wonchi volcano, Ethiopia. Mineral. Mag., 55, 529–534.

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Wilkmanite Ni_3Se_4

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive (?).

Physical Properties: Hardness = n.d. VHN = n.d. D(meas.) = n.d. D(calc.) = 6.96

Optical Properties: Opaque. *Color:* Pale grayish yellow. *Pleochroism:* Distinct, pale yellow to grayish yellow. *Anisotropism:* Strong, pink to yellowish green.

R_1–R_2: n.d.

Cell Data: *Space Group:* $I2/m$. $a = 6.22$ $b = 3.63$ $c = 10.52$ $\beta = 90.53°$ Z = 2

X-ray Powder Pattern: Kuusamo, Finland.
2.70 (100), 2.02 (100), 1.800 (100), 2.00 (80), 1.815 (80), 1.532 (60), 1.497 (60)

Chemistry:

	(1)	(2)
Ni	33.7	35.80
Co	1.0	
Cu	trace	
Fe	trace	
Se	65.3	64.20
Total	100.0	100.00

(1) Kuusamo, Finland; by electron microprobe. (2) Ni_3Se_4.

Polymorphism & Series: Dimorphous with trüstedtite.

Occurrence: A primary phase and an alteration product of sederholmite, in albite diabase sills that cut a schist formation, associated with low-grade uranium mineralization.

Association: Sederholmite, penroseite, selenium, ferroselite, selenian vaesite, cattierite, calcite.

Distribution: From Kuusamo, northeastern Finland.

Name: For W.W. Wilkman, geologist.

Type Material: n.d.

References: (1) Vuorelainen, Y., A. Huhma, and A. Häkli (1964) Sederholmite, wilkmanite, kullerudite, mäkinenite, and trüstedtite, five new nickel selenide minerals. Compt. Rendus Soc. Géol. Finlande, 36, 113–125. (2) (1965) 50, 519 (abs. ref. 1).

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Willemite Zn_2SiO_4

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. Crystals prismatic, both stout and slender, terminated by rhombohedra and {0001}, to 10 cm. Coarse to fine granular, disseminated; in fibrous aggregates, botryoidal, and massive.

Physical Properties: *Cleavage:* Indistinct on {0001}, {$11\bar{2}0$}. *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = 5.5 D(meas.) = 3.89–4.19 D(calc.) = 4.224 Typically strongly fluorescent in yellow-green to yellow-orange under SW and LW UV; may be phosphorescent.

Optical Properties: Transparent to opaque. *Color:* Colorless to white, gray, flesh-red, dark brown, honey-yellow, apple-green, blue; colorless in thin section. *Streak:* White. *Luster:* Vitreous to resinous.
Optical Class: Uniaxial (+). $\omega = 1.691–1.694$ $\epsilon = 1.719–1.725$

Cell Data: *Space Group:* $R\bar{3}$ (synthetic). $a = 13.948(2)$ $c = 9.315(2)$ Z = 18

X-ray Powder Pattern: Synthetic.
2.634 (100), 2.834 (95), 3.486 (80), 2.318 (45), 4.026 (35), 1.8592 (35), 1.4205 (30)

Chemistry:

	(1)	(2)	(3)
SiO_2	26.55	26.56	26.96
Al_2O_3	1.00		
Fe_2O_3		0.23	
FeO	0.08	0.81	
MnO	0.12	8.96	
ZnO	72.11	61.38	73.04
PbO		0.005	
MgO	0.13	1.05	
CaO		0.75	
Total	99.99	99.74	100.00

(1–2) Franklin, New Jersey, USA. (3) Zn_2SiO_4.

Occurrence: Of secondary origin, especially in zinc deposits developed in limestones; while uncommon, locally an important ore of zinc.

Association: Nasonite, glaucochroite, leucophoenicite (Franklin, New Jersey, USA); malachite, mimetite, rosasite, duftite, cerussite (Tsumeb, Namibia).

Distribution: In Belgium, from Altenberg, near Moresnet. At Tsumeb and Guchab, Namibia. From Kabwe (Broken Hill), Zambia. In the USA, large crystals at Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; from Balmat, St. Lawrence Co., New York; in Arizona, from the Mammoth-St. Anthony mine, Tiger, Pinal Co., at the Red Cloud mine, La Paz Co., and other minor localities; in California, at the Ygnacis and Cerro Gordo mines, Inyo Co.; in the Tres Hermanas district, Luna Co., New Mexico. From Mont Saint-Hilaire, Quebec, Canada. In a large deposit at the Puttapa zinc mine, near Beltana, South Australia. There are many other minor localities.

Name: For William I (1772–1843), King of the Netherlands (1815–1840).

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 460–461. (2) Palache, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. U.S. Geol. Sur. Prof. Paper 180, 82–88. (3) Klaska, K.-H., J.C. Eck, and D. Pohl (1978) New investigations of willemite. Acta Cryst., 34, 3324–3325. (4) (1957) NBS Circ. 539, 7, 62.

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Willemseite $(Ni,Mg)_3Si_4O_{10}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* m or $2/m$. Fine-grained massive.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 2 D(meas.) = 3.31 D(calc.) = 3.348

Optical Properties: Translucent. *Color:* Pale green; in transmitted light, colorless. *Optical Class:* Biaxial (–). $\alpha = 1.600(2)$ $\beta = 1.652(2)$ $\gamma = [1.655]$ 2V(meas.) = 27(2)°

Cell Data: *Space Group:* Cc or $C2/c$. $a = 5.316(2)$ $b = 9.149(3)$ $c = 18.994(6)$ $\beta = 99.96(6)°$ Z = [4]

X-ray Powder Pattern: Bon Accord, South Africa.
9.40 (100), 3.12 (28), 2.503 (23), 4.57 (16), 2.245 (8), 1.524 (7), 3.55 (3)

Chemistry:

	(1)
SiO_2	51.83
Al_2O_3	0.38
Fe_2O_3	1.77
FeO	0.31
MnO	0.00
CoO	0.46
NiO	34.55
MgO	7.09
CaO	0.28
H_2O^+	3.61
H_2O^-	0.05
Total	100.33

(1) Bon Accord, South Africa; corresponds to $(Ni_{2.12}Mg_{0.80}Fe^{3+}_{0.10}Co_{0.03}Ca_{0.02}Fe^{2+}_{0.02})_{\Sigma=6.19}(Si_{3.94}Al_{0.04})_{\Sigma=3.98}O_{10.16}(OH)_{1.84}$.

Occurrence: A secondary mineral in a nickel-bearing layered igneous sill.

Association: Ferroan trevorite, nimite, violarite, millerite, reevesite, goethite, "opal."

Distribution: Found three km west of the Scotia talc mine, Bon Accord area, Barberton, Transvaal, South Africa.

Name: For Johannes Willemse, Professor of Geology, University of Pretoria, Pretoria, South Africa.

Type Material: National Museum of Natural History, Washington, D.C., USA, 132464, 132465.

References: (1) Hiemstra, S.A. and S.A. De Waal (1968) Nickel minerals from Barberton, III. Willemseite, a nickelian talc. Nat. Inst. Met. (South Africa) Res. Rept., 352, 1–14. (2) (1969) Amer. Mineral., 54, 1740 (abs. ref. 1). (3) De Waal, S.A. (1970) Nickel minerals from Barberton, South Africa: III. Willemseite, a nickel-rich talc. Amer. Mineral., 55, 31–42.

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Willhendersonite $KCaAl_3Si_3O_{12}\cdot 5H_2O$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As tabular crystals, flattened on {001}, with {100}, {010}, and {001}, and as trellislike twinned aggregates, to < 1 mm. *Twinning:* Complex, by rotation about [111]; reflection across (001); by rotation about $[1\bar{1}0]$ or reflection across $(1\bar{1}0)$.

Physical Properties: *Cleavage:* Perfect on {100}, {010}, and {001}. *Tenacity:* Brittle. Hardness = ~3 D(meas.) = 2.10–2.18 D(calc.) = 2.20

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (+) or (–). $\alpha = 1.505(3)$ $\beta = 1.511(3)$ $\gamma = 1.517(3)$ 2V(meas.) = 87(3)°

Cell Data: *Space Group:* $P\bar{1}$. $a = 9.206(2)$ $b = 9.216(2)$ $c = 9.500(4)$ $\alpha = 92.34(3)°$ $\beta = 92.70(3)°$ $\gamma = 90.12(3)°$ Z = 2

X-ray Powder Pattern: San Venanzo quarry, Italy.
9.16 (100), 2.907 (60), 2.804 (50), 4.09 (40), 5.18 (30), 3.71 (30), 3.93 (20)

Chemistry:

	(1)	(2)
SiO_2	35.5	34.8
Al_2O_3	30.1	28.1
CaO	11.6	10.7
Na_2O		trace
K_2O	6.8	8.0
H_2O	[16.0]	[18.4]
Total	[100.0]	[100.0]

(1) Ettringer Bellerberg volcano, Germany; by electron microprobe, H_2O by difference; corresponds to $K_{0.73}Ca_{1.03}Al_3Si_3O_{12}\cdot 4.5H_2O$. (2) San Venanzo quarry, Italy; by electron microprobe, H_2O by difference; corresponds to $K_{0.90}Ca_{1.01}Al_{2.93}Si_{3.08}O_{12}\cdot 5.4H_2O$.

Mineral Group: Zeolite group.

Occurrence: A secondary mineral formed by low-temperature hydrothermal alteration of potassic basaltic lavas (San Venanzo quarry, Italy); by contact metasomatism of limestone xenoliths in basalts (Ettringer Bellerberg volcano, Germany).

Association: Phillipsite, thomsonite, apophyllite, melilite (San Venanzo quarry, Italy); gismondine, chabazite, ettringite, thaumasite, phillipsite, thomsonite (Ettringer Bellerberg volcano, Germany).

Distribution: In the Vispi quarry, near San Venanzo, Umbria, Italy. In Germany, at the Ettringer Bellerberg volcano, near Mayen, Eifel district, Germany. From the Stradnerkogel, near Wilhelmsdorf, Styria, Austria.

Name: For Dr. William A. Henderson, Jr. of Stamford, Connecticut, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 119472; National Museum of Natural History, Washington, D.C., USA, 148655, 148656.

References: (1) Peacor, D.R., P.J. Dunn, W.B. Simmons, E. Tillmanns, and R.X. Fischer (1984) Willhendersonite, a new zeolite isostructural with chabazite. Amer. Mineral., 69, 186–189. (2) Tillmanns, E., R.X. Fischer, and W.H. Baur (1984) Chabazite-type framework in the new zeolite wilhendersonite, $KCaAl_3Si_3O_{12}\cdot 5H_2O$. Neues Jahrb. Mineral., Monatsh., 547–558.

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Willyamite $(Co, Ni)SbS$

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Crystal Data: Monoclinic or triclinic, pseudocubic. *Point Group:* n.d. Crystals several mm on a side, showing zonal growth patterns.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 VHN = Slightly higher than ullmannite. D(meas.) = 6.76(3) D(calc.) = n.d.

Optical Properties: Opaque. *Color:* Steel-gray. *Luster:* Metallic.

R_1–R_2: n.d.

Cell Data: *Space Group:* n.d. $a = 5.86$ $Z = 4$

X-ray Powder Pattern: Broken Hill, Australia. (ICDD 26-1106).
2.621 (100), 2.390 (70), 1.767 (60), 1.565 (50), 1.625 (40), 1.278 (40), 1.087 (40)

Chemistry:

	(1)	(2)	(3)
Co	13.88	20.6	23.2
Ni	13.41	6.9	3.8
Fe	trace	0.2	0.4
Sb	56.78	55.9	54.7
As		0.7	1.6
S	15.78	15.1	14.6
Total	99.85	99.4	98.3

(1) Broken Hill, Australia. (2–3) Do.; by electron microprobe.

Polymorphism & Series: Forms a series with ullmannite.

Mineral Group: Cobaltite group.

Occurrence: In calcite–siderite veins.

Association: Dyscrasite, costibite, calcite, siderite.

Distribution: In the Consols lode, Broken Hill, Willyama Township, New South Wales, Australia.

Name: For the locality in Willyama Township, New South Wales, Australia.

Type Material: National Museum of Natural History, Washington, D.C., USA, R849A.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 301–302. (2) Cabri, L.J., D.C. Harris, J.M. Stewart, and J.F. Rowland (1970) Willyamite redefined. Proc. Australasian Inst. Mining Met., 233, 95–100. (3) (1971) Amer. Mineral., 56, 361 (abs. ref. 2).

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Winchite $[NaCa][(Mg,Fe^{2+})_4Al]Si_8O_{22}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In stout prismatic to acicular crystals, to 4 cm. As blades, fibers, and in rosettes or spherules.

Physical Properties: *Cleavage:* [Perfect on {110}, intersecting at ∼56° and ∼124°; partings on {100}, {001}.] *Fracture:* [Uneven.] *Tenacity:* [Brittle.] Hardness = [5–6] D(meas.) = 2.97–3.175 D(calc.) = [3.02] Crystals are commonly strongly zoned chemically.

Optical Properties: Transparent to translucent. *Color:* Colorless, cobalt blue to bluish violet; colorless to pale blue in thin section. *Luster:* [Vitreous.]
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = light blue-violet; Z = light blue. *Orientation:* [$Z \wedge c = 16°$.] *Dispersion:* $r > v$, strong. $\alpha = 1.629$ $\beta = 1.643$ $\gamma = 1.650$ 2V(meas.) = 64(2)°

Cell Data: *Space Group:* $C2/m$. $a = 9.834$ (ICDD 20-1390). $b = 18.062$ $c = 5.300$ $\beta = 104.449°$ Z = 2

X-ray Powder Pattern: Kajlidongri mine, India. (ICDD 20-1390).
2.699 (100), 8.40 (90), 2.528 (90), 4.48 (70), 3.40 (70), 3.12 (50), 2.976 (40)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	56.08	54.41	FeO		6.09	Na_2O	3.48	4.01
TiO_2	0.00	0.20	MnO	0.67	0.04	K_2O	0.55	0.16
Al_2O_3	1.91	7.00	MgO	20.66	14.25	Total	97.18	97.20
Fe_2O_3	5.27	4.72	CaO	8.56	6.32			

(1) Kajlidongri mine, India; by electron microprobe, total Fe as Fe_2O_3; corresponds to $(Ca_{1.27}Na_{0.94}K_{0.10})_{\Sigma=2.31}(Mg_{4.27}Fe^{3+}_{0.55}Al_{0.09}Mn_{0.08})_{\Sigma=4.99}(Si_{7.78}Al_{0.22})_{\Sigma=8.00}O_{22}(OH)_2$.
(2) Margarita Island, Venezuela; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponds to $(Na_{1.09}Ca_{0.95}K_{0.03})_{\Sigma=2.07}(Mg_{2.97}Al_{0.79}Fe^{2+}_{0.71}Fe^{3+}_{0.50}Ti_{0.02}Mn_{0.01})_{\Sigma=5.00}(Si_{7.63}Al_{0.37})_{\Sigma=8.00}O_{22}(OH)_2$.

Polymorphism & Series: Forms a series with ferrowinchite.

Mineral Group: Amphibole (sodic-calcic) group: $Mg/(Mg + Fe^{2+}) \geq 0.5$; $(Na + K)_A < 0.5$; 0.67 Na_B 1.33; $(Ca + Na)_B \geq 1.34$; $Si \geq 7.5$.

Occurrence: In schists with low-grade metamorphosed manganese deposits; in metabasalts of the jadeite-glaucophane and amphibolite-eclogite facies; in manganiferous cherts that have undergone blueschist facies metamorphism.

Association: Calcite, microcline, diopside, plagioclase, apatite, tremolite (Kajlidongri mine, India); omphacite, garnet, rutile, quartz, actinolite, epidote, albite, titanite, apatite (Margarita Island, Venezuela); actinolite, glaucophane, albite, quartz (Ward Creek, California, USA).

Distribution: In the Kajlidongri mine, Jhabua district, Madhya Pradesh, India. From near El Valle del Espiritu Santo, Margarita Island, Venezuela. In the Praborna mine, near St. Marcel, Val d'Aosta, Italy. At Ward Creek, Cazadero, Sonoma Co., California, USA. From north of Kitami City, Hokkaido, Japan.

Name: For H.J. Winch, who first found the mineral.

Type Material: n.d.

References: (1) Ford, W.E. (1915) Dana's system of mineralogy, (6th edition), app. III, 4. (2) Nayak, V.K. and B.E. Leake (1975) On 'winchite' from the original locality at Kajlidongri, India. Mineral. Mag., 40, 395–399. (3) Maresch, W.V., O. Medenbach, and A. Rudolph (1982) Winchite and the actinolite-glaucophane miscibility gap. Nature, 296, 731–732. (4) Leake, B.E., C.M. Farrow, F. Chao, and V.K. Nayak (1986) Winchite rediscovered from the type locality in India. Mineral. Mag., 50, 173–175. (5) Liou, J.G. and S. Maruyama (1987) Parageneses and compositions of amphiboles from Franciscan jadeite-glaucophane type facies series metabasites at Cazadero, California. J. Metamorphic Geol., 5, 371–395.

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Winstanleyite $TiTe_3^{4+}O_8$

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Crystal Data: Cubic. *Point Group:* $2/m\ \overline{3}$. Cubes, rarely modified by the octahedron, with concave faces, to 0.5 mm, in castellated groups.

Physical Properties: *Tenacity:* Brittle but tough. Hardness = 4 D(meas.) = 5.57(4) D(calc.) = [5.63]

Optical Properties: Semitransparent. *Color:* Bright yellow, tan, cream. *Streak:* Very pale yellow.
Optical Class: Isotropic. $n = 2.34(2)$

Cell Data: *Space Group:* $Ia3$. a = 10.963 Z = [8]

X-ray Powder Pattern: Grand Central mine, Arizona, USA.
3.165 (10), 1.938 (8), 1.653 (8), 2.741 (7), 4.474 (6), 2.930 (4), 2.583 (4)

Chemistry:

	(1)	(2)
TeO_2	85.8	85.70
TiO_2	10.9	14.30
Fe_2O_3	3.2	
Total	99.9	100.00

(1) Grand Central mine, Arizona, USA; corresponds to $Ti_{0.76}Fe_{0.11}Te_{3.00}O_8$. (2) $TiTe_3O_8$.

Occurrence: Very rare in strongly altered and pyritized granodiorite from the dump of a hydrothermal Au–Te-bearing ore deposit.

Association: Jarosite, chlorargyrite, rodalquilarite, "opal".

Distribution: From the Grand Central mine, Tombstone, Cochise Co., Arizona, USA.

Name: To honor Betty Jo Winstanley Williams (1934–), who collected the first specimen.

Type Material: Natural History Museum, Paris, France; The Natural History Museum, London, England, 1980,538; Harvard University, Cambridge, Massachusetts, USA, 119095.

References: (1) Williams, S.A. (1979) Girdite, oboyerite, fairbankite, and winstanleyite, four new tellurium minerals from Tombstone, Arizona. Mineral. Mag., 43, 453–457. (2) (1980) Amer. Mineral., 65, 809 (abs. ref. 1).

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Wiserite $(Mn^{2+},Mg)_{14}B_8(Si,Mg)O_{22}Cl(OH)_{10}$

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Crystal Data: Tetragonal. *Point Group:* $4/m$. In prismatic to fibrous crystals, elongated $\parallel$ [001], to 1 cm, showing {100} and {110}; in platy aggregates, very fine grained, massive.

Physical Properties: Hardness = 2.5 D(meas.) = 3.54(8) D(calc.) = 3.57

Optical Properties: Transparent. *Color:* White to light pinkish brown. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* O = colorless to bright orange-brown; E = bright to dark orange-brown. ω = 1.751–1.753 ϵ = 1.700–1.715

Cell Data: *Space Group:* $P4/n$. $a = 20.192(6)$ $c = 3.281(2)$ Z = 2

X-ray Powder Pattern: Kombat mine, Namibia.
3.365 (100), 2.854 (90), 6.40 (85), 2.654 (80), 2.753 (70), 2.702 (65), 2.522 (65)

Chemistry:

	(1)	(2)	(3)
SiO_2	n.d.	2.0	3.5
B_2O_3	18.14	17.5	
FeO		0.2	0.7
MnO	65.13	64.3	63.8
MgO	2.88	4.9	1.2
CaO	3.33	0.3	0.0
Cl	3.12	2.1	1.7
H_2O	8.10	7.0	
$-O = Cl_2$	0.70	0.5	
Total	[100.00]	97.8	

(1) Gonzen, Switzerland; recalculated to 100.00% after deduction of Al_2O_3 1.00% and insoluble 1.20%. (2) Kombat mine, Namibia; by electron microprobe, B by titration, H_2O by TGA-EGA and the Penfield method; corresponds to $Mn_{12.98}Mg_{1.74}Ca_{0.08}Fe_{0.04}B_{7.17}Si_{0.48}O_{32.52}Cl_{0.85}H_{11.08}$. (3) Yaei mine, Japan; by electron microprobe, partial analysis.

Occurrence: An accessory mineral in stratiform manganese deposits.

Association: Hausmannite, jacobsite, alleghanyite, pyrochroite, pyrobelonite, calcite, rhodochrosite, jimboite, sussexite, alabandite, galaxite, tephroite, gageite.

Distribution: From the Gonzen mine, near Sargans, St. Gallen, Switzerland. In the Kombat mine, 49 km south of Tsumeb, Namibia. In Japan, at the Yaei mine, Tsuchiyama, Shiga Prefecture; the Kaso mine, Tochigi Prefecture; and the Azuma, Nakanoyama, and Rito mines, Gumma Prefecture.

Name: For David Friedrich Wiser (1802–1878), Swiss mineralogist who first analyzed the mineral.

Type Material: Federal Institute of Technology, Zurich, Switzerland, 194501; Harvard University, Cambridge, Massachusetts, 126918; National Museum of Natural History, Washington, D.C., USA, 163804, 163341.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 245. (2) Epprecht, W.T., W.T. Schaller, and A.C. Vlisidis (1959) Über Wiserit, Sussexit und ein weiteres Mineral aus den Manganerzen vom Gonzen (bei Sargans). Schweiz. Mineral. Petrog. Mitt., 39, 85–104 (in German, English summary). (3) Dunn, P.J., C.A. Francis, R.A. Ramik, J.A. Nelen, and J. Innes (1989) Wiserite, an occurrence at the Kombat mine in Namibia, and new data. Amer. Mineral., 74, 1374–1376. (4) Pertlik, F. and P.J. Dunn (1989) Crystal structure of wiserite. Amer. Mineral., 74, 1351–1354.

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Witherite $BaCO_3$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Pseudohexagonal dipyramidal due to repeated twinning, short prismatic to elongated along [001], {010}, {021}, {012}, other faces commonly rough and horizontally striated, to 12 cm. May be botryoidal to spherical, columnar fibrous, granular, massive. *Twinning:* On {110}, universal.

Physical Properties: *Cleavage:* On {010}, distinct; on {110}, {012}, poor. *Fracture:* Uneven. Hardness = 3–3.5 D(meas.) = 4.22–4.31 D(calc.) = 4.24–4.29 Fluorescent and phosphorescent under UV, X-rays, and electron beams.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, pale gray, may be tinted pale yellow, pale brown, or pale green; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous, resinous on fractures.
Optical Class: Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r > v$, very weak. $\alpha = 1.529$ $\beta = 1.676$ $\gamma = 1.677$ 2V(meas.) = 16°

Cell Data: *Space Group: Pmcn* (synthetic). $a = 5.314$ $b = 8.904$ $c = 6.430$ Z = 4

X-ray Powder Pattern: Synthetic.
3.72 (100), 3.68 (53), 2.150 (28), 2.628 (24), 2.590 (23), 2.019 (21), 3.215 (15)

Chemistry:

	(1)	(2)
CO_2	[22.50]	22.30
CaO	0.08	
SrO	0.68	
BaO	77.15	77.70
Total	[100.41]	100.00

(1) Anglezark, England; by electron microprobe, CO_2 calculated for stoichiometry; corresponds to $(Ba_{0.99}Sr_{0.01})_{\Sigma=1.00}CO_3$. (2) $BaCO_3$.

Polymorphism & Series: Forms a series with strontianite.

Mineral Group: Aragonite group.

Occurrence: Usually in minor amounts in low-temperature hydrothermal veins, typically an alteration product of barite; may be of anoxic sedimentary origin, barium supplied by volcanic hot-spring activity; uncommon in coal measures.

Association: Barite, fluorite, calcite, galena.

Distribution: Only a few localities are given here; in England, from Alston Moor, Cumbria; fine crystals from the Settlingstones mine, near Fourstones, and at Fallowfield, near Hexham, Northumberland. From Leogang and at Peggau, north of Graz, Styria, Austria. At Příbram, Czech Republic. From Freiberg and St. Andreasberg, Harz Mountains, Germany. In the Arkhyz deposit, Caucasus Mountains, Russia. In the USA, fine large crystals from several mines around Rosiclare, as in the Minerva #2 mine, Cave-in-Rock, Hardin Co., Illinois; at Pigeon Roost, Montgomery Co., Arkansas. In the Jason Pb–Zn deposits, Macmillan Pass, Yukon Territory, Canada. Large deposits occur from Ziyang to Chengkou, along the boundary between Shaanxi and Sichuan Provinces, China. At the Hasei mine, Akita Prefecture, Japan. In the Hunter Valley coal deposits, New South Wales, Australia.

Name: In honor of Dr. William Withering (1741–1799), English physician and mineralogist, who first noted the mineral.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 194–196. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 263–271. (3) De Villiers, J.P.R. (1971) Crystal structures of aragonite, strontianite, and witherite. Amer. Mineral., 56, 758–767. (4) Baldasari, A. and J.A. Speer (1979) Witherite composition, physical properties, and genesis. Amer. Mineral., 64, 742–747. (5) (1953) NBS Circ. 539, 2, 54.

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Wittichenite Cu_3BiS_3

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Crystal Data: Orthorhombic. *Point Group:* 222. Commonly massive. Crystals rare, prismatic parallel to [001]; prisms show striae and are typically blocky in aspect.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 2–3 VHN = 170–187 (100 g load). D(meas.) = 6.01, 6.19 (synthetic). D(calc.) = 6.19

Optical Properties: Opaque. *Color:* Steel-gray to tin-white, tarnishing pale lead-gray or brass-yellow; white to creamy white to grayish white in reflected light. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Weak, shades of dark brown.

R_1–R_2: (400) 35.0–36.9, (420) 34.1–35.8, (440) 33.2–34.7, (460) 32.7–34.0, (480) 32.6–34.1, (500) 32.9–34.7, (520) 33.2–35.0, (540) 33.5–35.2, (560) 33.6–35.3, (580) 33.5–35.3, (600) 33.2–35.2, (620) 33.0–35.2, (640) 32.8–35.2, (660) 32.4–35.0, (680) 31.7–34.6, (700) 30.8–34.0

Cell Data: *Space Group:* $P2_12_12_1$. $a = 7.723$ $b = 10.395$ $c = 6.716$ Z = 4

X-ray Powder Pattern: Wittichen, Germany.
2.85 (100), 3.08 (80), 4.55 (40), 2.66 (40), 3.83 (30), 3.19 (30), 2.39 (30)

Chemistry:

	(1)	(2)	(3)	(4)
Cu	37.79	38.0	37.7	38.46
Bi	42.56	42.8	43.4	42.15
S	19.13	18.3	18.7	19.39
Total	99.48	99.1	99.8	100.00

(1) Daniel mine, Wittichen, Germany; by electron microprobe. (2) Seathwaite Tarn, England; by electron microprobe. (3) Wittichen, Germany; by electron microprobe. (4) Cu_3BiS_3.

Occurrence: In hydrothermal veins with other bismuth minerals (Wittichen, Germany); with Cu-Fe sulfides (Seathwaite Tarn, England); with secondary uranium minerals and selenides of Cu, Pb, and Bi (Kletno, Poland).

Association: Bornite, chalcocite, chalcopyrite, djurleite, digenite, tennantite, pyrite, stromeyerite, bismuth, emplectite, rammelsbergite, calcite, aragonite, fluorite, barite.

Distribution: In the USA, at Butte, Silver Bow Co., Montana; in the Fairfax quarry, Centreville, Fairfax Co., Virginia; and at Bisbee, Cochise Co., Arizona. In Canada, in the Maid of Erin mine, Rainy Hollow district, British Columbia; and at Cobalt, Ontario. In Germany, in the Schapbachtal, and at the Neuglück, Daniel, and King David mines, near Wittichen, Black Forest. In the Sedmochislenitsi mine, Vratsa district, Bulgaria. At the Colquijirca mine, Junín, Peru. From Seathwaite Tarn, northwest of Coniston, Cumbria, England. At Tjøstulflaten, Norway. In the Kletno mine, Sudetes Mountains, Poland. Additional localities are known.

Name: After the type locality, Wittichen, Germany.

Type Material: Royal Ontario Museum, Toronto, Canada, M23304; Harvard University, Cambridge, Massachusetts, USA, 82408, 82409.

References: (1) Nuffield, E.W. (1947) Studies of mineral sulpho-salts: XI—wittichenite (klaprothite). Econ. Geol., 42, 147–160. (2) Criddle, A.J. and C.J. Stanley (1979) New data on wittichenite. Mineral. Mag., 43, 109–113. (3) Kocman, V. and E.W. Nuffield (1973) The crystal structure of wittichenite, Cu_3BiS_3. Acta Cryst., 29, 2528–2535. (4) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 373 (wittichenite) and 418–419 (klaprothite).

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Wittite **$Pb_3Bi_4(S,Se)_9$**

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Massive, striations parallel [010].

Physical Properties: *Cleavage:* Good, giving platy appearance. Hardness = 2–2.5 VHN = 45–63 (25 g load). D(meas.) = 7.12 D(calc.) = [6.91]

Optical Properties: Opaque. *Color:* Lead-gray; cream-white in reflected light. *Streak:* Black. *Luster:* Metallic.

R_1–R_2: (400) 43.2–45.3, (420) 42.8–44.9, (440) 42.4–44.5, (460) 41.9–44.2, (480) 41.5–43.8, (500) 41.1–43.3, (520) 40.5–42.8, (540) 40.0–42.3, (560) 39.4–41.8, (580) 38.9–41.3, (600) 38.4–40.9, (620) 38.0–40.6, (640) 37.7–40.4, (660) 37.4–40.2, (680) 37.3–39.8, (700) 37.2–39.7

Cell Data: *Space Group:* $P2/m$ subcell: $a = 4.19(1)$ $b = 4.08(1)$ $c = 15.56(4)$ $\beta = 101.35(16)°$ Z = [1] *Space Group:* $C2/m$ subcell: $a = 7.21(2)$ $b = 4.08(1)$ $c = 15.50(5)$ $\beta = 98.75(15)°$ Z = [1]

X-ray Powder Pattern: Falun, Sweden.
3.004 (s), 2.887 (sb), 2.041 (s), 3.434 (ms), 3.848 (m), 3.607 (m), 3.529 (m)

Chemistry:

	(1)	(2)
Pb	33.2	35.3
Bi	45.5	43.9
Se	9.7	7.7
S	11.8	12.6
Total	100.2	99.5

(1) Falun, Sweden; average of two analyses. (2) Do.; by electron microprobe.

Occurrence: In an amphibolite rock (Falun, Sweden); in garnet tactite (Middlemarch Canyon, Arizona, USA).

Association: Nordströmite, friedrichite, magnetite, pyrite, cordierite, quartz (Falun, Sweden).

Distribution: From Falun, Kopparberg, Sweden. Found in the Gottesehre mine, near Urberg, Black Forest, Germany. At Middlemarch Canyon, Cochise Co., Arizona, USA.

Name: For T. Witt, Swedish mining engineer.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden; Royal Ontario Museum, Toronto, Canada, M12992; National School of Mines, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 451. (2) Mumme, W.G. (1976) Proudite from Tennant Creek, Northern Territory, Australia: its crystal structure and relationship with weibullite and wittite. Amer. Mineral., 61, 839–852. (3) Mumme, W.G. (1980) Seleniferous lead–bismuth sulfosalts from Falun, Sweden: weibullite, wittite and nordströmite. Amer. Mineral., 65, 789–796.

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Wodginite $Mn^{2+}(Sn^{4+}, Ta)Ta_2O_8$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals commonly flattened, dipyramidal {111}, may be prismatic, to 15 cm; in radiating groups; granular, massive. *Twinning:* Very common, as penetration twins with {001} or {100} as composition plane.

Physical Properties: *Fracture:* [Irregular] (by analogy to the wodginite group). *Tenacity:* [Brittle.] Hardness = [5.5] D(meas.) = 7.19–7.36 D(calc.) = 7.69–7.81

Optical Properties: Opaque, translucent in thin fragments. *Color:* Reddish brown, dark brown to black; light yellow to reddish brown in transmitted light; grayish white in reflected light.
Optical Class: Biaxial. *Anisotropism:* Weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $C2/c$. $a = 9.417$–9.533 $b = 11.394$–11.504 $c = 5.082$–5.142 $\beta = 90.00°-91.21°$ Z = 4

X-ray Powder Pattern: Wodgina, Western Australia; may be confused with columbite. 3.00 (100), 3.67 (70), 2.95 (70), 2.50 (29), 1.774 (27), 2.87 (25), 2.55 (21)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
Nb_2O_5	7.63	3.96		FeO	1.34	0.00	
Ta_2O_5	70.49	68.64	66.60	MnO	10.87	10.74	10.69
TiO_2		1.44		MgO	0.37		
SnO_2	8.92	13.00	22.71	CaO	0.42		
Fe_2O_3		0.79		LOI	0.18		
				Total	100.22	98.57	100.00

(1) Wodgina, Western Australia; corresponds to $Mn_{1.00}(Ta_{0.44}Sn_{0.38}Fe_{0.12})_{\Sigma=0.94}(Ta_{1.63}Nb_{0.37})_{\Sigma=2.00}O_8$. (2) Tanco pegmatite, Canada; by electron microprobe, total Fe as Fe_2O_3; corresponds to $Mn_{0.99}(Sn_{0.56}Ta_{0.23}Ti_{0.12}Fe_{0.06})_{\Sigma=0.97}(Ta_{1.80}Nb_{0.20})_{\Sigma=2.00}O_8$. (3) $MnSnTa_2O_8$.

Mineral Group: Wodginite group: $Li_A \leq 0.5$; $Fe^{2+}_A \leq 0.5$; $Ti_B \leq 0.5$; $Fe^{3+}_B \leq 0.25$.

Occurrence: In a complex zoned pegmatite in amphibolite (Tanco pegmatite, Canada).

Association: Tantalite, albite, quartz, muscovite (Wodgina, Western Australia); tapiolite, microlite, microcline, albite, mica (Tanco pegmatite, Canada).

Distribution: A few localities for well-studied material include: from Wodgina, Marble Bar, and Greenbushes, Western Australia. An ore in the Tanco pegmatite, Bernic Lake, and elsewhere in Manitoba, Canada. In the USA, at the Strickland quarry, Portland, Middlesex Co., Connecticut; in the Herbb #2 pegmatite, six km northeast of Flat Rock, Powhatan Co., Virginia; from the McAllister mine, Rockford, Coosa Co., Alabama; in the Peerless mine, near Keystone, Pennington Co., South Dakota. In Brazil, from the Jabuti mine, Baixio, Galiléia, and large crystals from Araçuia and Sapucaia do Norte, Galilea, Minas Gerais; in the Seridozinho mine, Joazeiro, Paraíba; at the Alto do Giz pegmatite, near Parelhas, Rio Grande do Norte. From Krasonice, Czech Republic. In the Eräjärvi area, Orivesi, Finland. From Kalba, eastern Kazakhstan. From Ankole, Uganda. In the Benson pegmatite, Miami district, Zimbabwe. From Karibib and Kohero, Namibia.

Name: For its occurrence at Wodgina, Western Australia.

Type Material: Geological Survey, Perth, 8492; Western Australian Museum, Perth, Australia, S388B; Canadian Geological Survey, Ottawa, 12200; Royal Ontario Museum, Toronto, Canada, M25655.

References: (1) Nickel, E.H., J.F. Rowland, and R.C. McAdam (1963) Wodginite – a new tin-manganese tantalate from Wodgina, Australia and Bernic Lake, Manitoba. Can. Mineral., 7, 390–402. (2) (1963) Amer. Mineral., 48, 1417–1418 (abs. ref. 1). (3) Ercit, T.S., P. Černý, F.C. Hawthorne, and C.A. McCammon (1992) The wodginite group. II. Crystal chemistry. Can. Mineral., 30, 613–631. (4) Ercit, T.S., P. Černý, and F.C. Hawthorne (1992) The wodginite group. III. Classification and new species. Can. Mineral., 30, 633–638.

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Wöhlerite $NaCa_2(Zr,Nb)Si_2O_7(O,OH,F)_2$

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Crystal Data: Monoclinic. *Point Group:* 2. Crystals prismatic, to 3 cm, tabular on [100]; granular. *Twinning:* Twin plane {100}, common; may be complex, lamellar.

Physical Properties: *Cleavage:* {010}, distinct; {100} and {110}, poor. *Fracture:* Conchoidal to splintery. *Tenacity:* Brittle. Hardness = 6–6.5 D(meas.) = 3.40–3.44 D(calc.) = 3.42 Blue-green cathodoluminescence.

Optical Properties: Transparent to translucent. *Color:* Pale yellow to yellow, brown, or gray; in transmitted light, colorless to light yellow. *Streak:* Pale yellow. *Luster:* Vitreous, inclining to resinous, dull, and greasy.
Optical Class: Biaxial (–). *Pleochroism:* Weak to moderate; $X = Y$ = nearly colorless to pale yellow; Z = wine-yellow. *Orientation:* $Z = b$; $X \wedge c = 45°$. *Dispersion:* $r < v$, weak.
$\alpha = 1.700–1.705$ $\beta = 1.716–1.720$ $\gamma = 1.726–1.728$ 2V(meas.) = 70°–77°

Cell Data: *Space Group:* $P2_1$. $a = 10.823(3)$ $b = 10.244(3)$ $c = 7.290(2)$ $\beta = 109.00(4)°$ Z = 4

X-ray Powder Pattern: Langesundsfjord, Norway.
2.839 (100), 2.998 (70), 3.25 (60), 2.965 (50), 2.014 (40), 1.689 (40), 7.26 (30)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	30.12	30.30	La_2O_3		0.06	CaO	26.95	25.35
TiO_2	0.42	1.22	Fe_2O_3	0.48		SrO		0.02
ZrO_2	16.11	14.32	Nb_2O_5	12.85	12.11	Na_2O	7.50	7.67
HfO_2		0.58	Ta_2O_5		0.45	F	2.98	2.61
Al_2O_3		0.01	FeO	1.26	1.74	H_2O	0.74	
Y_2O_3		0.61	MnO	1.00	0.85	$-O = F_2$	1.24	[1.10]
Ce_2O_3	0.66	0.27	MgO	0.12	0.27	Total	99.95	[96.25]

(1) Langesundsfjord, Norway; corresponds to $Na_{0.97}(Ca_{1.93}Fe_{0.09}Mn_{0.06}Mg_{0.01})_{\Sigma=2.09}(Zr_{0.52}Nb_{0.39}Ce_{0.02}Ti_{0.02})_{\Sigma=0.95}Si_{2.01}O_7[O,(OH),F_{0.63}]_2$. (2) Do.; by electron microprobe, corresponds to $Na_{1.01}(Ca_{1.84}Fe_{0.10}Mn_{0.05}Mg_{0.03})_{\Sigma=2.02}(Zr_{0.47}Nb_{0.37}Ti_{0.06}Ta_{0.03}Y_{0.02}Ce_{0.01}Hf_{0.01})_{\Sigma=0.97}Si_{2.05}O_7[O,(OH),F_{0.56}]_2$.

Occurrence: A late phase in alkalic pegmatites; an accessory mineral in nepheline syenites; in fenites associated with alkaline intrusives; and in carbonatites.

Association: Cancrinite, ferro-hornblende, aegirine, astrophyllite, mosandrite, eudialyte, catapleiite, rosenbuschite, låvenite, zircon, pyrochlore, betafite, latrappite, niobian perovskite, niobian zirconolite, albite, nepheline, biotite, fluorite.

Distribution: On a number of islands in the Langesundsfjord, around Brevik, and at Tvedalen, Norway. In Russia, from the Khibiny and Lovozero massifs, Kola Peninsula; in Siberia, in the Burpala massif, about 120 km north of Lake Baikal, at Zaangar'ya, Yenisei Ridge, and in the Sangilene massif. At Kruft and Mendig, Eifel district, Germany. In the USA, at Red Hill, Moultonborough, Carroll Co., New Hampshire, and Magnet Cove, Hot Spring Co., Arkansas. In Canada, at Mont Saint-Hilaire and Oka, Quebec; in the Prairie Lake complex, Ontario. On the Los Islands, Guinea. From the Tchivira Mountains, Quilengues, Angola. In the Muri Mountains, Guyana. From carbonatites at In Imanal and Wadi Anezrouf, Mali.

Name: For Professor Friedrich Wöhler (1800–1882), German chemist, Göttingen, Germany.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 376–377. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 376–379. (3) Nickel, E.H. (1958) The composition and crystallography of niocalite. Can. Mineral., 6, 264–272. (4) Shibaeva, R.I. and N.V. Belov (1963) Crystal structure of wöhlerite, $Ca_2Na(Zr,Nb)[Si_2O_7](OH)_2$. Doklady Acad. Nauk SSSR, 146, 897–900 (in Russian). (5) Mellini, M. and S. Merlino (1979) Refinement of the crystal structure of wöhlerite. Tschermaks Mineral. Petrog. Mitt., 26, 109–123. (6) Mariano, A.N. and P.L. Roeder (1989) Wöhlerite: chemical composition, cathodoluminescence and environment of crystallization. Can. Mineral., 27, 709–720.

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Wolfeite $(Fe^{2+},Mn^{2+})_2(PO_4)(OH)$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Very rarely as tiny crystals; typically columnar to coarse fibrous aggregates, to 10 cm, or granular.

Physical Properties: *Cleavage:* {100}, good; {120}, fair; {010}, poor; {110}, very poor. *Fracture:* Uneven to subconchoidal. Hardness = 4.5–5 D(meas.) = 3.79–3.82 D(calc.) = 3.88

Optical Properties: Opaque, transparent in small grains. *Color:* Reddish brown, pinkish brown, clove-brown, pale brown. *Luster:* Vitreous to silky if fibrous.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, very strong. $\alpha = 1.741$–1.750 $\beta = 1.742$–1.750 $\gamma = 1.746$–1.759 2V(meas.) = 51°

Cell Data: *Space Group:* $P2_1/a$. $a = 12.319(1)$ $b = 13.230(2)$ $c = 9.840(1)$ $\beta = 108°24(1)'$ Z = 16

X-ray Powder Pattern: Hagendorf, Germany; close to triploidite.
3.098 (100), 3.191 (80), 2.929 (70), 2.817 (60), 2.881 (30), 3.649 (25), 3.381 (20)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	32.90	32.04	31.86	Li_2O	0.56		
As_2O_5		0.04		Na_2O	0.14		
SiO_2		0.03		K_2O	0.05		
Fe_2O_3	0.70			F	0.51		
FeO	44.44	50.09	32.25	H_2O	3.78	[5.44]	4.04
MnO	13.12	12.35	31.85	$-O = F_2$	[0.22]		
MgO	2.28			insol.	1.44		
CaO	0.19	0.01		Total	[99.89]	[100.00]	100.00

(1) Palermo #1 mine, New Hampshire, USA. (2) Hagendorf, Germany; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by difference; corresponding to $(Fe_{1.58}Mn_{0.40})_{\Sigma=1.98}(PO_4)_{1.02}(OH)_{1.18}$. (3) $(Fe,Mn)_2(PO_4)(OH)$ with Fe:Mn = 1:1.

Polymorphism & Series: Forms a series with triploidite.

Occurrence: A secondary mineral, formed by hydrothermal alteration of triphylite in complex zoned granite pegmatites; rarely in hydrothermal veins; in phosphatic nodules in shales.

Association: Triphylite, triplite, hagendorfite, arrojadite, apatite (pegmatites); wicksite, satterlyite, marićite (shales).

Distribution: In the USA, from the Palermo #1 mine, near North Groton, and at the Keyes mine, Orange, Grafton Co., New Hampshire; in the Big Chief, Bull Moose, and Ross (Highland Lode) mines, near Custer, Custer Co., South Dakota. Large examples from the Big Fish River–Rapid Creek area, Yukon Territory, Canada. In the Énio pegmatite mine, northeast of Galiléia, Minas Gerais, Brazil. At Hagendorf, Bavaria, Germany. From Congrier, Mayenne, France. At the Norrö pegmatite, on Rånö Island, and from Skrumpetorp, Sweden. In the Panasqueira Sn–W deposit, Portugal. From Wilson's quarry, Thackaringa district, 40 km southwest of Broken Hill, New South Wales, Australia.

Name: To honor Professor Caleb Wroe Wolfe (1908–1980), American crystallographer, Boston University, Boston, Massachusetts, USA.

Type Material: The Natural History Museum, London, England, 1963,230; Harvard University, Cambridge, Massachusetts, USA, 100868, 100870, 100871.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 853–855. (2) Clark, A.M. and A.G. Couper (1979) End-member triploidite from Cornwall. Mineral. Mag., 43, 325–326. (3) Antenucci, D., F. Fontan, and A.-M. Fransolet (1989) X-ray powder diffraction data for wolfeite: $(Fe_{0.59}Mn_{0.40}Mg_{0.01})_2PO_4(OH)$. Powder Diffraction, 4(1), 34–35.

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Wollastonite $CaSiO_3$

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Crystal Data: Monoclinic or triclinic. *Point Group:* $2/m$ or $\bar{1}$. Crystals tabular ∥ {100} or {001}, or short to long prismatic, to 20 cm. Commonly cleavable, parallel fibrous, or compact, massive. *Twinning:* Common; twin axis [010], composition plane {100}.

Physical Properties: *Cleavage:* {100} perfect; {001} and {$\bar{1}$02}, good; (100) ∧ (001) = 84.5°. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 4.5–5. D(meas.) = 2.86–3.09 D(calc.) = 2.90 May exhibit yellow catholuminescence.

Optical Properties: Transparent to translucent. *Color:* White, colorless, brown, red, yellow, pale green; colorless in thin section. *Streak:* White. *Luster:* Vitreous, pearly on cleavage. *Optical Class:* Biaxial (–). *Orientation:* $X \wedge c = 30°–44°$; $Y \wedge b = 0°–5°$; $Z \wedge a = 37°–50°$. *Dispersion:* $r > v$, weak. $\alpha = 1.616–1.640$ $\beta = 1.628–1.650$ $\gamma = 1.631–1.653$ 2V(meas.) = 36°–60°

Cell Data: *Space Group:* $P2_1/a$. $a = 15.409(3)$ $b = 7.322(1)$ $c = 7.063(1)$ $\beta = 95.30(2)°$ Z = 12, or *Space Group:* $P\bar{1}$. $a = 7.94$ $b = 7.32$ $c = 7.07$ $\alpha = 90°2'$ $\beta = 95°22'$ $\gamma = 103°26'$ Z = 6

X-ray Powder Pattern: Sampo mine, Okayama Prefecture, Japan (1A).
3.314 (100), 3.83 (84), 3.51 (77), 3.086 (58), 2.302 (52), 2.556 (44), 1.759 (35)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	50.82	50.24	CaO	48.16	35.93
Al_2O_3		0.46	Na_2O	0.12	
Fe_2O_3		trace	K_2O	0.07	
FeO	0.18	5.54	H_2O^+	0.08	0.00
MnO	0.03	8.16	S		0.14
MgO	0.22	0.07	Total	99.68	100.54

(1) Remonmaki, Finland; corresponds to $(Ca_{1.01}Mg_{0.01})_{\Sigma=1.02}Si_{0.99}O_3$. (2) North mine, Broken Hill, New South Wales, Australia; corresponds to $(Ca_{0.76}Mn_{0.14}Fe_{0.09})_{\Sigma=0.99}(Si_{1.00}Al_{0.01})_{\Sigma=1.01}O_3$.

Polymorphism & Series: 1A, 2M, 3A, 4A, 5A, 7A polytypes.

Occurrence: Common in thermally metamorphosed siliceous carbonates, the intruding igneous rock, and skarn deposits along their contact; also in some alkalic igneous rocks and carbonatites.

Association: Calcite, grossular, diopside, vesuvianite, åkermanite, merwinite, larnite, spurrite.

Distribution: A widely distributed mineral; some prominent localities are: in Romania, at Dognecea (Dognáczka) and Csiklova, Banat. In Italy, at Sarrabus, Sardinia, and from Monte Somma and Vesuvius, Campania. In Ireland, at Dunmorehead, Mourne Mountains, and Scawt Hill, near Larne, Co. Antrim. From Kongsberg, Norway. At Göckum, Sweden. In Germany, at Harzburg, Harz Mountains, and Auerbach, Odenwald, Hesse. In the USA, at Natural Bridge and Diana, Lewis Co., New York; from Crestmore, Riverside Co., and Darwin, Inyo Co., California; in a large deposit two miles southeast of Gilbert, Esmeralda Co., Nevada. In Canada, at Oka and Asbestos, Quebec; at Outlet Post, Leeds Co., Ontario. From Pichucalo, Chiapas, and in the Pilares deposit, 55 km north of Hermosillo, Sonora, Mexico. At Hiiagiyama, Ibaragi Prefecture; Ishiyamadera, Shiga Prefecture; and Kushiro, Hiroshima Prefecture, Japan. Large crystals from Belafa, Madagascar.

Name: For William Hyde Wollaston (1766–1828), English chemist and mineralogist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 371–373.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1978) Rock-forming minerals, (2nd edition),

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Wölsendorfite $(Pb,Ca)U_2O_7 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$, $mm2$, or 222. As spherulites and crystalline incrustations.

Physical Properties: *Cleavage:* {001}, good. Hardness = n.d. D(meas.) = 6.8(1) D(calc.) = 6.815 Radioactive.

Optical Properties: Semitransparent. *Color:* Red-orange to carmine-red. *Optical Class:* Biaxial. $\alpha = 2.05(3)$ β = n.d. $\gamma = 2.09(1)$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $C2/m\ 2/m\ 2/m$, $Cmm2$, or $C222$. $a = 11.95(5)$ $b = 13.99(7)$ $c = 7.02(5)$ Z = 6

X-ray Powder Pattern: Shinkolobwe, Congo.
3.09 (100), 3.44 (90b), 1.907 (60), 6.90 (40), 2.734 (30), 2.010 (30), 1.734 (30)

Chemistry:

	(1)	(2)
UO_3	69.80	69.05
SiO_2		0.32
Al_2O_3		0.10
FeO		0.39
PbO	23.14	22.50
CaO	1.24	0.09
BaO		3.27
K_2O		0.10
H_2O	4.30	[4.18]
insol.	0.48	
Total	98.96	[100.00]

(1) Wölsendorf, Germany; corresponds to $(Pb_{0.85}Ca_{0.18})_{\Sigma=1.03}U_{2.00}O_{7.14} \cdot 1.96H_2O$.
(2) Randboldal, Greenland; by electron microprobe, H_2O by difference; corresponds to $(Pb_{0.81}Ba_{0.17}Fe_{0.04}K_{0.02}Ca_{0.01})_{\Sigma=1.05}(U_{1.95}Si_{0.04}Al_{0.02})_{\Sigma=2.01}O_{7.00} \cdot 2H_2O$.

Occurrence: A rare alteration product of uraninite in the oxide zone of uranium-bearing mineral deposits.

Association: Uraninite, rutherfordine, becquerelite, masuyite, kasolite, metastudtite (Shinkolobwe, Congo).

Distribution: From Wölsendorf, Bavaria, Germany. At Kerségalec, near Lignol, Morbihan, France. In the Val Rendena, Trentino-Alto Adige, Italy. From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire). At Okla, near Franceville, Gabon. From Great Bear Lake, Northwest Territories, Canada. In the Williams quarry, near Easton, Northampton Co., Pennsylvania; at Branchville, Fairfield Co., Connecticut; and on the Hell Hole claims, Wheeler Basin, Grand Co., Colorado, USA. At Randboldal, northeastern Greenland. In the Córrego do Urucum pegmatite, near Galiléia, Minas Gerais, Brazil. From the Koongarra deposit, 225 km east of Darwin, Northern Territory, Australia.

Name: For the mineral's first-noted occurrence at Wölsendorf, Germany.

Type Material: National School of Mines, Paris, France.

References: (1) Protas, J. (1957) La wölsendorfite, nouvelle espèce uranifère. Compt. Rendus Acad. Sci. Paris, 244, 2942–2944 (in French). (2) (1957) Amer. Mineral., 42, 919 (abs. ref. 1). (3) Toussaint, J. (1961) Sur la structure de la wölsendorfite de Shinkolobwe. Ann. Soc. Géol. Belg., 84, 365–373 (in French). (4) Deliens, M. (1977) Review of the hydrated oxides of U and Pb, with new X-ray powder data. Mineral. Mag., 41, 51–57. (5) Beddoe-Stephens, B. and K. Secher (1982) Barian wölsendorfite from East Greenland. Mineral. Mag., 46, 130–132.

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Wonesite $(Na,K)_{0.5}(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH,F)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As irregularly shaped flakes, to about 0.5 mm; exsolves epitaxially-intergrown sodium-rich biotite and talc. *Twinning:* Twin axis [310] and composition plane {001}, common.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Elastic. Hardness = n.d. D(meas.) = n.d. D(calc.) = [2.89]

Optical Properties: Transparent. *Color:* Pale to dark brown; in thin section, light to dark brown.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = pale brown; $Y = Z$ = dark brown.
$\alpha = 1.544(4)$ $\beta = 1.608(2)$ $\gamma = 1.608(2)$ 2V(meas.) = 0°–5°

Cell Data: *Space Group:* $C2/m$. $a = 5.312(3)$ $b = 9.163(5)$ $c = 9.825(6)$ $\beta = 103.18(6)°$ Z = 2

X-ray Powder Pattern: n.d.

Chemistry:

	(1)		(1)
SiO_2	48.53	CaO	0.04
TiO_2	0.77	Na_2O	3.07
Al_2O_3	13.73	K_2O	0.85
Cr_2O_3	0.08	F	0.15
FeO	7.02	H_2O	[4.31]
MnO	0.04	$-O = F_2$	[0.06]
MgO	22.11	Total	[100.70]

(1) Mt. Cube quadrangle, Vermont, USA; by electron microprobe, H_2O content is ideal for phlogopite; corresponds to $(Na_{0.40}K_{0.07})_{\Sigma=0.47}(Mg_{2.20}Fe_{0.40}Al_{0.31}Ti_{0.04})_{\Sigma=2.95}(Si_{3.24}Al_{0.76})_{\Sigma=4.00}O_{10}(OH,F)_2$.

Mineral Group: Mica group.

Occurrence: In metavolcanics with high Mg:Fe, moderate sodium, and very little calcium, metamorphosed at an estimated 535 °C.

Association: Phlogopite, talc, anthophyllite, cordierite, gedrite, chlorite, quartz.

Distribution: From Norwich, Windsor Co., Vermont, and elsewhere in the Post Pond Volcanics, southwest corner of the Mt. Cube quadrangle, New Hampshire and Vermont, USA.

Name: To honor petrologist David R. Wones (1932–1984), Professor of Geology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 127103, 127104; National Museum of Natural History, Washington, D.C., USA, 145724, 162422–162428; The Natural History Museum, London, England, 1982,117.

References: (1) Spear, F.S., R.M. Hazen, and D. Rumble III (1981) Wonesite: a new rock-forming silicate from the Post Pond Volcanics, Vermont. Amer. Mineral., 66, 100–105.
(2) Veblen, D.R. (1983) Exsolution and crystal chemistry of the sodium mica wonesite. Amer. Mineral., 68, 554–565.

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Woodallite $Mg_6Cr_2(OH)_{16}Cl_2 \cdot 4H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$, $\overline{4}2m$, $4mm$, 422, $4/m$, $\overline{4}$, or 4. In very fine-grained, concentrically-layered, botryoidal crusts and masses.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 D(meas.) = 3.71–4.01 D(calc.) = [3.75]

Optical Properties: Opaque. *Color:* Iron-black to chocolate-brown; light gray to yellowish gray in reflected light. *Streak:* Brown. *Luster:* Dull.
Optical Class: Uniaxial. *Anisotropism:* Strong. *Bireflectance:* Weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P4/mmm$, $P\overline{4}2m$, $P\overline{4}m2$, $P4mm$, $P422$, $P4/m$, $P\overline{4}$, or $P4$. $a = 8.42$ $c = 9.28$ Z = [4]

X-ray Powder Pattern: Sandur, India.
4.66 (10), 2.66 (6), 2.48 (6), 9.34 (5), 1.48 (5), 1.86 (4), 1.69 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.86	1.28	BaO	0.12	0.62
MnO_2	64.27	68.29	Na_2O	0.06	0.04
Al_2O_3	0.14	0.96	K_2O	0.55	0.08
Fe_2O_3	0.26	0.89	H_2O^+		8.48
MnO	7.88	8.46	H_2O^-		0.83
ZnO	13.89	9.42	H_2O	10.48	
MgO	0.62	0.48	Total	99.13	[99.83]

(1) Sterling Hill, New Jersey, USA; Mn^{2+}:Mn^{4+} calculated from stoichiometry. (2) Sandur, India; original total given as 99.84%.

Occurrence: In the oxidized portion of a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA); in massive manganese ores (Sandur, India); in the oxidized zone of a Ag–Pb–Zn ore deposit (Lardeau, Canada); a component of ocean-floor Fe–Mn nodules.

Association: Franklinite, chalcophanite (Sterling Hill, New Jersey, USA); pyrolusite, cryptomelane (Sandur, India); smithsonite, gunningite, hydrozincite, aurichalcite (Lardeau, Canada).

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. At the Willett mine, Lardeau, British Columbia, Canada. From the Lecht mine, near Tomintoul, Aberdeenshire, Scotland. On Mont Chemin, Valais, Switzerland. From Maria Weitscach, near Hüttenberg, Carinthia, Austria. In Germany, at Juliushütte, Astfeld, Harz Mountains, in slag. From Sandur, Mysore, India.

Name: To honor Samuel Woodruff, American miner for the New Jersey Zinc Company, and prolific mineral collector of Franklin-Sterling Hill minerals.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 112987.

References: (1) Frondel, C. (1953) New manganese oxides: hydrohausmannite and woodruffite. Amer. Mineral., 38, 761–769. (2) Naganna, C. and V. Bouška (1963) X-ray study of woodruffite from Sandur ore deposits, Mysore State, India. Mineral. Mag., 33, 506–507.

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Woodhouseite $CaAl_3(PO_4)(SO_4)(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$. Pseudocubic rhombohedral $\{10\overline{1}2\}$ crystals, to 6 mm, may be tabular {0001}, with curved and striated faces.

Physical Properties: *Cleavage:* On {0001}, excellent. Hardness = 4.5 D(meas.) = 3.01 D(calc.) = 3.00

Optical Properties: Translucent to transparent. *Color:* Colorless, white, flesh-pink.
Luster: Vitreous, pearly on {0001}.
Optical Class: Uniaxial (+); may exhibit anomalous biaxial sectors. $\omega = 1.636(3)$ $\epsilon = 1.647(3)$
2V(meas.) = 0°–20°

Cell Data: *Space Group:* $R\overline{3}m$. $a = 6.993(2)$ $c = 16.386(6)$ Z = 3

X-ray Powder Pattern: Champion mine, California, USA. (ICDD 37-469).
2.932 (100), 2.163 (45), 4.847 (35), 2.971 (35), 3.488 (30), 2.704 (25), 5.658 (20)

Chemistry:

	(1)	(2)
SO_3	17.59	19.33
P_2O_5	18.13	17.14
SiO_2	0.30	
Al_2O_3	36.63	36.94
MgO	0.11	
CaO	12.31	13.54
SrO	0.25	
BaO	1.00	
Na_2O	0.08	
K_2O	0.02	
H_2O	13.45	13.05
Total	99.87	100.00

(1) Champion mine, California, USA. (2) $CaAl_3(PO_4)(SO_4)(OH)_6$.

Mineral Group: Beudantite group.

Occurrence: In quartz veins in an andalusite deposit (Champion mine, California, USA); a product of sulphatic argillic wall-rock alteration in hydrothermal vein and disseminated ore deposits, replacing apatite (Summitville, Colorado, USA); rarely a cave deposit, formed from guano.

Association: Topaz, augelite, lazulite, pyrophyllite (Champion mine, California, USA).

Distribution: From the Champion mine, White Mountains, Mono Co., California, large crystals; in the Summitville district, Rio Grande Co., Colorado, USA. From Brumado, Bahia, Brazil. At La Escondida, about 150 km south-southeast of Antofagasta, Chile. From Hökensås, Västergötland, Sweden. In the Ødegården apatite mines, Bamble, Norway. At the Iron Monarch quarry, Iron Knob, South Australia. In the Jade Lotus Cave, Yangshuo, Jiangxi Province, China.

Name: To honor Professor Charles Douglas Woodhouse (1888–1975), University of California, Santa Barbara, California, USA, American mineralogist and mineral collector.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1006–1007. (2) Kato, T. (1971) The crystal structures of goyazite and woodhouseite. Neues Jahrb. Mineral., Monatsh., 241–247. (3) Kato, T. (1977) Further refinement of the woodhouseite structure. Neues Jahrb. Mineral., Monatsh., 54–58.

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$, $\bar{4}2m$, $4mm$, 422, $4/m$, $\bar{4}$, or 4. In very fine-grained, concentrically-layered, botryoidal crusts and masses.

Physical Properties: *Fracture:* Conchoidal. Hardness = 4.5 D(meas.) = 3.71–4.01 D(calc.) = [3.75]

Optical Properties: Opaque. *Color:* Iron-black to chocolate-brown; light gray to yellowish gray in reflected light. *Streak:* Brown. *Luster:* Dull.
Optical Class: Uniaxial. *Anisotropism:* Strong. *Bireflectance:* Weak.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P4/mmm$, $P\bar{4}2m$, $P\bar{4}m2$, $P4mm$, $P422$, $P4/m$, $P\bar{4}$, or $P4$.
$a = 8.42$ $c = 9.28$ Z = [4]

X-ray Powder Pattern: Sandur, India.
4.66 (10), 2.66 (6), 2.48 (6), 9.34 (5), 1.48 (5), 1.86 (4), 1.69 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.86	1.28	BaO	0.12	0.62
MnO_2	64.27	68.29	Na_2O	0.06	0.04
Al_2O_3	0.14	0.96	K_2O	0.55	0.08
Fe_2O_3	0.26	0.89	H_2O^+		8.48
MnO	7.88	8.46	H_2O^-		0.83
ZnO	13.89	9.42	H_2O	10.48	
MgO	0.62	0.48	Total	99.13	[99.83]

(1) Sterling Hill, New Jersey, USA; Mn^{2+}:Mn^{4+} calculated from stoichiometry. (2) Sandur, India; original total given as 99.84%.

Occurrence: In the oxidized portion of a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA); in massive manganese ores (Sandur, India); in the oxidized zone of a Ag–Pb–Zn ore deposit (Lardeau, Canada); a component of ocean-floor Fe–Mn nodules.

Association: Franklinite, chalcophanite (Sterling Hill, New Jersey, USA); pyrolusite, cryptomelane (Sandur, India); smithsonite, gunningite, hydrozincite, aurichalcite (Lardeau, Canada).

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA. At the Willett mine, Lardeau, British Columbia, Canada. From the Lecht mine, near Tomintoul, Aberdeenshire, Scotland. On Mont Chemin, Valais, Switzerland. From Maria Weitscach, near Hüttenberg, Carinthia, Austria. In Germany, at Juliushütte, Astfeld, Harz Mountains, in slag. From Sandur, Mysore, India.

Name: To honor Samuel Woodruff, American miner for the New Jersey Zinc Company, and prolific mineral collector of Franklin-Sterling Hill minerals.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 112987.

References: (1) Frondel, C. (1953) New manganese oxides: hydrohausmannite and woodruffite. Amer. Mineral., 38, 761–769. (2) Naganna, C. and V. Bouška (1963) X-ray study of woodruffite from Sandur ore deposits, Mysore State, India. Mineral. Mag., 33, 506–507.

Woodwardite $Cu_4Al_2(SO_4)(OH)_{12}\cdot 2{-}4H_2O(?)$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$ (probable). Fibrous, spherulitic.

Physical Properties: Hardness = n.d. D(meas.) = 2.38 D(calc.) = n.d.

Optical Properties: Translucent to transparent. *Color:* Rich turquoise-blue to greenish blue. *Optical Class:* Biaxial (+). *Orientation:* Parallel extinction. α = 1.552–1.571 β = 1.555 γ = 1.565–1.576 2V(meas.) = n.d.

Cell Data: *Space Group:* $R\overline{3}m$ (probable). a = 5.306(2) c = 26.77(2) Z = n.d.

X-ray Powder Pattern: Cornwall, England.
8.9 (100), 4.47 (90), 2.55 (60), 2.28 (50), 2.65 (30), 1.98 (30), 1.53 (30)

Chemistry:

	(1)	(2)
SO_4	13.95	13.04
Al_2O_3	17.97	18.64
CuO	48.34	48.67
H_2O	18.48	[19.65]
Total	98.74	[100.00]

(1) Cornwall, England; corresponds to $Cu_{3.49}Al_{2.02}(SO_4)_{1.00}(OH)_{11.04}\cdot 0.36H_2O$. (2) Do.; H_2O by difference, corresponds to $Cu_{3.76}Al_{2.24}(SO_4)_{1.00}(OH)_{12.24}\cdot 0.58H_2O$. (3) Do.; by electron microprobe, analyses not given, Cu:Al ratios stated to fall between 1.73 and 2.03.

Occurrence: A rare secondary mineral in the oxidized zone of copper deposits.

Association: n.d.

Distribution: In England, from Cornwall, the original locality not known; at the South Caradon mine, St. Cleer, and from Wheals Cock and Hazard, and the Botallack mine, St. Just. At Klausen, Tirol, Italy. In the USA, from the Maid of Sunshine mine, Courtland, Cochise Co., Arizona, and at the Deer Trail mine, six km southwest of Marysvale, Paiute Co., Utah. From the Kabasaka and Nyukaku mines, Kyogo Prefecture, Japan. As the species definition is somewhat uncertain, all reported localities may need reassessment.

Name: Honors Samuel Pickford Woodward (1821–1865), English geologist and naturalist.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 962.
(2) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 580. (3) Meixner, H. (1940) Über Woodwardit aus Cornwall und von Klausen (hier fälschlich "Langit" gennant) in Südtirol. Zentr. Miner. Abt. A, 11, 238–244. (4) Nickel, E. (1976) New data on woodwardite. Mineral. Mag., 43, 644–647. (5) Raade, G., C.J. Elliott, and V.K. Din (1985) New data on glaucocerinite. Mineral. Mag., 49, 583–590.

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Wooldridgeite $Na_2CaCu_2(P_2O_7)_2 \cdot 10H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $mm2$. As equant rhombic-dipyramidal crystals, typically with curved faces, to 200 μm, isolated and in aggregates.

Physical Properties: *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 2–3
D(meas.) = n.d. D(calc.) = 2.279

Optical Properties: Transparent. *Color:* Pale blue-green; colorless in transmitted light.
Streak: Very pale blue-green. *Luster:* Vitreous.
Optical Class: Biaxial (–) [*sic*]. *Orientation:* $X = b$; $Y = c$; $Z = a$. $\alpha = 1.508(1)$ $\beta = 1.511(1)$ $\gamma = 1.517(1)$ $2V(meas.) = 76.2(5)^\circ$ $2V(calc.) = 71(10)^\circ$

Cell Data: *Space Group:* $Fdd2$. $a = 11.938(1)$ $b = 32.854(2)$ $c = 11.017(1)$ $Z = 8$

X-ray Powder Pattern: Judkins quarry, Warwickshire, England.
6.52 (100), 4.05 (40), 3.255 (40), 2.924 (40), 8.23 (30), 2.807 (25), 2.614 (20)

Chemistry:

	(1)	(2)
P_2O_5	39.37	38.30
CuO	20.24	21.46
MgO	0.24	
CaO	7.73	7.57
Na_2O	8.33	8.36
K_2O	0.17	
H_2O	[24.72]	24.31
Total	[100.80]	100.00

(1) Judkins quarry, Warwickshire, England; by electron microprobe, average of 10 analyses, presence of H_2O confirmed by IR and calculated from the structure analysis; corresponds to $(Na_{1.96}K_{0.03})_{\Sigma=1.99}Ca_{1.00}(Cu_{1.85}Mg_{0.04})_{\Sigma=1.89}(P_{2.02}O_7)_2 \cdot 10H_2O$. (2) $Na_2CaCu_2(P_2O_7)_2 \cdot 10H_2O$.

Occurrence: A rare weathering product of primary sulfides, the source of phosphorus enigmatic.

Association: Calcite, chalcopyrite, bornite, barite.

Distribution: From the Judkins quarry, Nuneaton, Warwickshire, England.

Name: Honoring James Wooldridge (1923–1995), amateur mineralogist and gemologist, who discovered the mineral.

Type Material: Manchester Museum, Manchester, England, N13200.

References: (1) Hawthorne, F.C., M.A. Cooper, D.I. Green, R.E. Starkey, A.C. Roberts, and J.D. Grice (1999) Wooldridgeite, $Na_2CaCu_2^{2+}(P_2O_7)_2(H_2O)_{10}$: a new mineral from Judkins Quarry, Warwickshire, England. Mineral. Mag., 63, 13–16. (2) (1999) Amer. Mineral., 84, 1466 (abs. ref. 1). (3) Cooper, M.A. and F.C. Hawthorne (1999) The crystal structure of wooldridgeite, $Na_2CaCu_2^{2+}(P_2O_7)_2(H_2O)_{10}$, a novel copper pyrophosphate mineral. Can. Mineral., 37, 73–81.

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Wroewolfeite $Cu_4(SO_4)(OH)_6 \cdot 2H_2O$

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Crystal Data: Monoclinic. *Point Group: m.* Lathlike crystals, to 1 mm. *Twinning:* By reflection on {001} and {100}, yielding fourlings.

Physical Properties: *Cleavage:* Perfect on {010}, {100}, {001}. Hardness = ∼2.5 D(meas.) = 3.27(1) D(calc.) = 3.30

Optical Properties: Translucent. *Color:* Dark greenish blue; blue in transmitted light. *Streak:* Pale blue. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Strong; X = pale blue; Y = deep greenish blue; Z = greenish blue. *Absorption:* $Y \gg Z > X$. $\alpha = 1.637(2)$ $\beta = 1.682(2)$ $\gamma = 1.694(2)$ 2V(meas.) = 53°

Cell Data: *Space Group: Pm.* $a = 6.045(1)$ $b = 5.646(1)$ $c = 14.337(6)$ $\beta = 93.39(1)°$ Z = 2

X-ray Powder Pattern: Loudville mine, Massachusetts, USA.
7.152 (100), 3.581 (70), 2.628 (35), 2.004 (30), 2.431 (20), 2.379 (20), 2.278 (20)

Chemistry:

	(1)	(2)
SO_3	16.48	16.40
CuO	64.22	65.16
H_2O	[19.30]	18.44
Total	[100.00]	100.00

(1) Loudville mine, Massachusetts, USA; by electron microprobe, H_2O by difference; with $(OH)^{1-}$ calculated for charge balance and H_2O adjusted for best agreement between measured and calculated densities, then corresponds to $Cu_{3.94}(SO_4)_{1.00}(OH)_{5.88} \cdot 2.11H_2O$.
(2) $Cu_4(SO_4)(OH)_6 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with langite.

Occurrence: An uncommon secondary mineral in the oxidation zone of copper-bearing hydrothermal mineral deposits; may be post-mine or formed in dumps and in slags.

Association: Langite, posnjakite, serpierite, brochantite, linarite, malachite, chalcocite, covellite.

Distribution: In the USA, from the Loudville mine, Southampton, Hampshire Co., Massachusetts. At Cumpas, Sonora, Mexico. In Wales, in the Ladywell mine, Shelve, Shropshire; at the Nantycagl (Eaglebrook) mine, Ceulanymaesmawr, in the Penrhiw mine, Ystumtuen, and the Frongoch mine, Dyfed; from the Drws-y-Coed mine, Llandwrog, Gwynedd. In the West Blackcraig mine, near Newton Stewart, Kirkcudbrightshire, Scotland. In England, from the Silver Gill and Red Gill mines, Carrock Fells, and the Tynebottom mine, near Garrigill, Cumbria; in the Penberthy Croft mine, St. Hilary, and the East Gunnislake mine, Calstock, Cornwall; at Wheal Friendship, Devon. In the Sheeffry mine, near Croagh Patrick, Co. Mayo, Ireland. From the Cap Garonne mine, near le Pradet, Var, France. In the Glücksrad mine, near Oberschulenberg, Harz Mountains, and at Ramsbeck, North Rhine-Westphalia, Germany. From Nandraž, Slovakia. In the Santa Lucia mine, Sardinia, Italy. At the Bastnäs mine, near Riddarhyttan, Västmanland, Sweden.

Name: To honor Professor Caleb Wroe Wolfe (1908–1980), American crystallographer, Boston University, Boston, Massachusetts, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 122277; National Museum of Natural History, Washington, D.C., USA, 127329.

References: (1) Dunn, P.J., R.C. Rouse, and J.A. Nelen (1975) Wroewolfeite, a new copper sulphate hydroxide hydrate. Mineral. Mag., 40, 1–5. (2) (1976) Amer. Mineral., 61, 179 (abs. ref. 1). (3) Hawthorne, F.C. and L.A. Groat (1985) The crystal structure of wroewolfeite, a mineral with $[Cu_4(OH)_6(SO_4)(H_2O)]$ sheets. Amer. Mineral., 70, 1050–1055.

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Wulfenite $PbMoO_4$

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Crystal Data: Tetragonal. *Point Group:* $4/m$ or $\overline{4}$. Crystals commonly square, flat tabular on [001], showing {001} and flat or rounded vicinal faces, {010}, to 11 cm; may be elongated along [001], or pyramidal {011}. Commonly other {0*kl*}, {*hkl*} forms, some showing pyramidal hemihedrism; granular, massive. *Twinning:* On {001}, as contact twins, common.

Physical Properties: *Cleavage:* On {011}, distinct; on {001}, {013}, indistinct. *Fracture:* Subconchoidal to uneven. *Tenacity:* Brittle. Hardness = 2.75–3 D(meas.) = 6.5–7.5 D(calc.) = 6.88–7.48 Individuals may be piezoelectric.

Optical Properties: Transparent to opaque. *Color:* Bright yellow, wax-yellow, yellow-orange, bright orange, red-orange, bright red; gray, grayish white, rarely white, colorless; siskin-green, olive-green, pale to dark blue, reddish brown, brown, black. *Streak:* White. *Luster:* Resinous, subadamantine to adamantine.
Optical Class: Uniaxial (–), may be anomalously biaxial. *Pleochroism:* Weak; orange and yellow. $\omega = 2.405$ $\epsilon = 2.283$ 2V(meas.) = $\leq 8°$

Cell Data: *Space Group:* $I4_1/a$, with $a = 5.436(2)$ $c = 12.068(8)$ Z = 4, or
Space Group: $I\overline{4}$, with $a = 5.441(1)$ $c = 12.068(6)$ Z = 4

X-ray Powder Pattern: Synthetic.
3.244 (100), 2.021 (30), 2.718 (25), 1.653 (25), 3.028 (20), 1.787 (18), 4.96 (12)

Chemistry:

	(1)	(2)	(3)
MoO_3	38.87	17.52	17.51
WO_3		28.22	28.20
PbO	60.91	54.25	54.29
Total	99.78	99.99	100.00

(1) Oudida, Morocco; corresponds to $Pb_{1.01}Mo_{1.00}O_{4.00}$. (2) Chillago, Australia; corresponds to $Pb_{1.00}(Mo_{0.50}W_{0.50})_{\Sigma=1.00}O_{4.00}$. (3) $Pb(Mo,W)O_4$ with Mo:W = 1:1.

Occurrence: A secondary mineral formed in the oxidized zone of hydrothermal lead deposits, the molybdenum commonly introduced externally.

Association: Cerussite, anglesite, smithsonite, hemimorphite, vanadinite, pyromorphite, mimetite, descloizite, plattnerite, Fe–Mn oxides.

Distribution: Hundreds of localities; a few for fine examples include: from Bleiberg, Carinthia, Austria. At Mežica (Mies) and Črna pri Prevaljah (Schwartzenbach), Slovenia. In the USA, from Arizona, at the Red Cloud and nearby mines, Silver district, La Paz Co., in the Old Yuma mine, near Tucson, Pima Co., at the Mammoth-St. Anthony mine, Tiger, Pinal Co., large crystals from the Glove mine, near Amado, Tyndall district, Santa Cruz Co., at the Hilltop mine, Chiricahua Mountains, and in the Defiance mine, Gleeson, Cochise Co.; in New Mexico, at the Stevenson-Bennett mine, Organ Mountains, Doña Ana Co.; in the Lucin District, Elko Co., Nevada. In Mexico, from the San Francisco mine, Cerro Prieta, Magdalena, Sonora; at Los Lamentos and Santa Eulalia, Chihuahua; in the Ojuela mine, Mapimí, Durango. Large crystals at Tsumeb, Namibia. Ponderous crystals from Mfouati, Congo Republic. In the Tchah Kharboze mine, Anarak district, Iran. At the Touissit mine, near Oujda, Morocco. From Sidjak, Uzbekistan. At the Christmas mine, Chillago, Queensland, Australia.

Name: To honor Franz Xavier Wulfen (1728–1805), Austrian–German Jesuit, who wrote a monograph on the lead ores of Bleiberg, Austria.

Type Material: Mining Academy, Freiberg, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1081–1086. (2) Hibbs, D.E., C.M. Jury, P. Leverett, I.R. Plimer, and P.A. Williams (2000) An explanation for the origin of hemihedrism in wulfenite: the single-crystal structures of $I4_1/a$ and $I\overline{4}$ wulfenites. Mineral. Mag., 64, 1057–1062. (3) (1957) NBS Circ. 539, 7, 23.

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Wülfingite $Zn(OH)_2$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. As very rare crystals, to 200 μm, in starlike clusters; in fine-grained incrustations.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3 D(meas.) = 3.05(2) D(calc.) = 3.06

Optical Properties: Transparent. *Color:* Colorless to whitish; colorless in transmitted light. *Streak:* White. *Luster:* Waxy.
Optical Class: Biaxial (–). *Dispersion:* $r \gg v$, extreme. $\alpha = 1.5722(3)$ $\beta = 1.5781(3)$ $\gamma = 1.5801(1)$ 2V(meas.) = 62.8(2)° 2V(calc.) = 60°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 8.490(1)$ $b = 5.162(1)$ $c = 4.917(1)$ Z = 4

X-ray Powder Pattern: Richelsdorf, Germany.
4.407 (100), 3.280 (100), 4.250 (80), 3.212 (80), 2.727 (80), 2.284 (80), 2.215 (80)

Chemistry:

	(1)	(2)
ZnO	81.5	81.88
H_2O	19.0	18.12
Total	100.5	100.00

(1) Richelsdorf, Germany; by electron microprobe, average of several determinations, H_2O by TGA. (2) $Zn(OH)_2$.

Polymorphism & Series: Trimorphous with ashoverite and sweetite.

Occurrence: A rare secondary mineral formed by weathering of zinc-bearing slag (Richelsdorf, Germany).

Association: Simonkolleite, hydrocerussite, diaboleite, zincite, hydrozincite, zinc (Richelsdorf, Germany); ashoverite, fluorite (near Ashover, England).

Distribution: On slag heaps from the foundry at Richelsdorf, Hesse, Germany. In a limestone quarry 200–300 m northwest of Milltown, near Ashover, Derbyshire, England.

Name: Honors Dr. Ernst Anton Wülfing (1860–1930), Professor of Mineralogy and Petrography, Heidelberg University, Heidelberg, Germany.

Type Material: Göttingen University, Göttingen; Heidelberg University, Heidelberg, Germany.

References: (1) Schmetzer, K., G. Schnorrer-Köhler, and O. Medenbach (1985) Wülfingite, ϵ–$Zn(OH)_2$, and simonkolleite, $Zn_5(OH)_8Cl_2 \cdot H_2O$, two new minerals from Richelsdorf, Hesse, F.R.G. Neues Jahrb. Mineral., Monatsh., 145–154. (2) (1988) Amer. Mineral., 73, 196–197 (abs. ref. 1). (3) Schnering, H.G. (1964) Zur Konstitution des ϵ–$Zn(OH)_2$. Zeits. Anorg. Allgem. Chem., 330, 170–178 (in German with English abs.).

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Wupatkiite $(Co, Mg)Al_2(SO_4)_4 \cdot 22H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Fibers, to 8 mm, in incrustations composed of cross-fiber veins.

Physical Properties: *Cleavage:* One at 70° to fiber length. Hardness = 1.5, in aggregates. D(meas.) = 1.92 D(calc.) = 1.87 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Rose-red. *Streak:* White. *Luster:* Silky in masses.
Optical Class: Biaxial. *Pleochroism:* Weak; very pale pink ∥ fiber bundles. *Orientation: Z* ∧ extinction up to 12°. $\alpha = 1.477$ β = n.d. $\gamma = 1.484$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy to halotrichite). $a = 6.819(4)$ $b = 24.234(10)$ $c = 21.204(10)$ $\beta = 100.33(5)°$ Z = [4]

X-ray Powder Pattern: Cameron district, Arizona, USA.
4.790 (100), 3.494 (92), 3.768 (33), 4.295 (27), 3.945 (26), 6.03 (22), 4.106 (22)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	35.97		CuO	0.12	
Al_2O_3	11.30	9.81	MgO	1.63	0.31
Fe_2O_3		[2.43]	CaO	0.10	
FeO	0.15	[3.25]	H_2O	42.26	
MnO	0.17	0.15	insol.	[4.37]	
CoO	3.41	3.92	Total	[100.00]	
NiO	0.52	0.29			

(1) Cameron district, Arizona, USA; by AA, CoO by colorimetry, CaO by ICP-ES, H_2O by the Penfield method, insoluble by difference, quartz and clay; corresponds to $(Co_{0.42}Mg_{0.38}Ni_{0.06}Mn_{0.02}Fe_{0.02}Ca_{0.02}Cu_{0.01})_{\Sigma=0.93}Al_{2.06}(SO_4)_{4.18} \cdot 21.83H_2O$. (2) Lorena deposit, Australia; by ICP, after deduction of insoluble 2.5%, original partial analysis here converted to oxides; FeO:Fe_2O_3 partitioned for stoichiometry; corresponds to $(Co_{0.47}Fe_{0.41}Mg_{0.07}Ni_{0.04}Mn_{0.02})_{\Sigma=1.01}(Al_{1.73}Fe_{0.27})_{\Sigma=2.00}(SO_4)_4 \cdot 22H_2O$.

Mineral Group: Halotrichite group.

Occurrence: A rare post-mine oxidation product of sooty U–Co–Ni–Mo primary mineralization (Cameron district, Arizona, USA).

Association: Pickeringite, moorhouseite, nickel-boussingaultite, quartz, clay (Cameron district, Arizona, USA).

Distribution: From a prospect 13 km east-southeast of Gray Mountain, Cameron district, Coconino Co., Arizona, USA. Abundant in the Lorena gold deposit, near Cloncurry, Queensland, Australia.

Name: For the prehistoric Wupatki Indian pueblos, now a National Monument, nearby the Cameron district, Arizona, USA.

Type Material: National School of Mines, Paris, France.

References: (1) Williams, S.A. and F.P. Cesbron (1995) Wupatkiite from the Cameron uranium district, Arizona, a new member of the halotrichite group. Mineral. Mag., 59, 553–556. (2) (1996) Amer. Mineral., 81, 518 (abs. ref. 1). (3) Lawrence, L.J., V. Munro-Smith, A.R. Ramsden, J.L. Sharpe, and P.A. Williams (1999) Geology and mineralogy of the Lorena gold mine, Cloncurry district, north-west Queensland. J. & Proc. Royal Society of New South Wales, 132, 29–35.

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Wurtzite **(Zn, Fe)S**

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Crystal Data: Hexagonal. *Point Group:* $6mm$. Crystals to 1.5 cm, commonly hemimorphic pyramidal $\{50\bar{5}2\}$ and $\{10\bar{1}1\}$; also short prismatic to tabular $\{0001\}$; typically striated horizontally on $\{10\bar{1}0\}$ and $\{10\bar{1}1\}$. The polytypes show steepening of the pyramid as the repeat distance increases along $\{0001\}$. As concentrically banded crusts, fibrous or columnar.

Physical Properties: *Cleavage:* Easy on $\{11\bar{2}0\}$; difficult on $\{0001\}$. *Tenacity:* Brittle. Hardness = 3.5–4 VHN = n.d. D(meas.) = 4.09 D(calc.) = 4.10

Optical Properties: Translucent. *Color:* Deep reddish brown to dark brown to brown-black; yellow to dark brown internal reflections common in reflected light. *Streak:* Brown.
Luster: Resinous, brilliant submetallic on crystal faces.
Optical Class: Uniaxial (+). $\epsilon = 2.378$ $\omega = 2.356$

R: (400) 19.2, (420) 18.7, (440) 18.2, (460) 17.8, (480) 17.4, (500) 17.1, (520) 16.9, (540) 16.6, (560) 16.4, (580) 16.3, (600) 16.2, (620) 16.1, (640) 16.1, (660) 16.1, (680) 16.0, (700) 15.8.

Cell Data: *Space Group:* $P6_3mc$ (synthetic, 2H). $a = 3.820$ $c = 6.260$ Z = 2

X-ray Powder Pattern: Synthetic (2H).
3.309 (100), 3.128 (86), 2.925 (84), 1.911 (74), 1.764 (52), 1.630 (45), 2.273 (29)

Chemistry:

	(1)	(2)
Zn	62.64	67.10
Fe	2.43	
Cd	1.84	
Pb	0.41	
S	32.10	32.90
Total	99.42	100.00

(1) Příbram, Czech Republic. (2) ZnS.

Polymorphism & Series: Trimorphous with matraite and sphalerite. Polytypes 2H, 4H, 6H, 8H, 10H, 15R, 18R, and 21R are known.

Occurrence: Of hydrothermal origin in veins with other sulfides. Also along shrinkage fractures in clay-ironstone concretions, of low-temperature origin.

Association: Sphalerite, pyrite, chalcopyrite, barite, marcasite.

Distribution: Numerous localities; a few of those providing good crystals or especially rich material follow. In the USA, from near the Thomaston Dam, Litchfield Co., Connecticut; at the Leonard mine, Butte, Silver Bow Co., Montana; at Frisco, Beaver Co., Utah; and from the Joplin district, Jasper Co., Missouri. From Rachelshausen, near Gladenbach, Hesse, Germany. At Liskeard, Cornwall, England. From Mežica (Mies), Serbia. At Příbram, Czech Republic. In Romania, from Baia Sprie (Felsőbánya). At Quispisiza, near Castro Virreyna, Peru. In a number of mines in the Huanuni district, Oruro, and Chocaya, Potosí, Bolivia.

Name: For Charles Adolphe Wurtz (1817–1884), French chemist, of Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 226–228. (2) Frondel, C. and C. Palache (1950) Three new polymorphs of zinc sulfide. Amer. Mineral., 35, 29–42. (3) (1953) NBS Circ. 539, 2, 14.

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Wüstite $Fe^{2+}O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As crusts, intergranular fillings, replacements of other minerals, massive; a component of microspherules, which may be hollow; may contain exsolved iron or magnetite.

Physical Properties: *Tenacity:* Brittle. Hardness = 5 D(meas.) = 5.88 D(calc.) = 5.97 Highly magnetic.

Optical Properties: Opaque. *Color:* Black to brown; gray in reflected light.
Luster: Metallic.
Optical Class: Isotropic.
R: n.d.

Cell Data: *Space Group:* $Fm3m$. a = 4.296 Z = 4

X-ray Powder Pattern: Scharnhausen, Germany.
2.146 (10), 1.518 (8), 2.476 (7), 1.297 (4), 1.243 (4), 1.074 (1), 0.985 (1)

Chemistry:

	(1)
SiO_2	0.14
TiO_2	0.01
Al_2O_3	0.01
Cr_2O_3	0.03
FeO	99.57
MnO	0.09
MgO	0.02
Total	[99.87]

(1) Pampa del Infierno meteorite; by electron microprobe; original total given as 99.82%.

Mineral Group: Periclase group.

Occurrence: Formed as an alteration product of other iron-bearing minerals at high temperatures in a highly reducing environment; in highly-reduced iron-bearing basalts; as inclusions in diamonds in kimberlites; in precipitates from deep-sea hot brines and in Fe–Mn nodules; in microspherules of likely extraterrestrial origin found in a variety of geological environments; in some meteorites.

Association: Iron, hematite, magnetite, goethite, akaganéite, lepidocrocite, ilmenite, maghemite, troilite, pyrrhotite, pyrite.

Distribution: At Scharnhausen, near Stuttgart, Baden-Württemberg, and at Bühl, near Weimar, Hesse, Germany. In Greenland, on Disko Island, near Uivfaq and Kitdlît. From the Pathardih colliery, Jharia coalfield, Bihar, India. In a number of diamond-bearing kimberlite pipes.

Name: The artificial compound was named for Friedrich Wüst (1860–1938), German metallurgist and Director for Iron Research of the Kaiser Wilhelm Institute, Düsseldorf, Germany; the name was then later transferred to the naturally-occurring equivalent.

Type Material: n.d.

References: (1) Walenta, K. (1960) Natürliches Eisen(II)-Oxyd (Wüstit) aus der vulkanischen Tuffbreccie von Scharnhausen bei Stuttgart. Neues Jahrb. Mineral., Monatsh., 150–159 (in German with English abs.). (2) Yamamoto, A. (1982) Modulated structure of wüstite ($Fe_{1-x}O$) (three-dimensional modulation). Acta Cryst., 38, 1451–1456. (3) Boctor, N.Z., P.M. Bell, H.K. Mao, and G. Kullerud (1982) Petrology and shock metamorphism of Pampa del Infierno chondrite. Geochim. Cosmochim. Acta, 46, 1903–1911. (4) Hazen, R.M. and R. Jeanloz (1984) Wüstite ($Fe_{1-x}O$): a review of its defect structure and physical properties. Reviews of Geophysics and Space Physics, 22, 37–46.

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Wyartite $CaU^{5+}(UO_2)_2O_4(CO_3)(OH)\cdot 7H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are flattened on {001}, striated and elongated along [010], with {110}, to 3 mm.

Physical Properties: *Cleavage:* On {001}, perfect; on {010}, less so. Hardness = 3–4 D(meas.) = 4.69(5) D(calc.) = n.d. Radioactive.

Optical Properties: Opaque to translucent. *Color:* Black, violet-black, greenish if altered. *Streak:* Brownish violet. *Luster:* Dull, vitreous to submetallic on cleavages. *Optical Class:* Biaxial (–). *Pleochroism:* Strong; X = gray; Y = violet; Z = lavender-blue. *Orientation:* $X = c$; $Y = b$; $Z = a$. α = n.d. $\beta = 1.89(2)$ $\gamma = 1.91(2)$ 2V(meas.) = 48°

Cell Data: *Space Group:* $P2_12_12_1$. $a = 11.2706(8)$ $b = 7.1055(5)$ $c = 20.807(1)$ Z = 4

X-ray Powder Pattern: Shinkolobwe, Congo.
10.3 (100), 8.54 (30), 5.19 (30), 4.26 (4b), 3.55 (4), 7.64 (3), 4.72 (3)

Chemistry:

	(1)	(2)	(3)
CO_2	3.6	3.4	4.05
UO_2	10.9	10.1	
UO_3	71.6	70.7	52.71
U_2O_5			25.62
CaO	6.8	6.3	5.17
H_2O	7.2	9.7	12.45
Total	100.1	100.2	100.00

(1–2) Shinkolobwe, Congo. (3) $CaU^{5+}(U^{6+}O_2)_2O_4(CO_3)(OH)\cdot 7H_2O$.

Occurrence: A rare secondary mineral formed as an alteration product of uraninite in the oxide zone of a uranium deposit.

Association: Wölsendorfite, rutherfordine, uranophane, masuyite, urancalcarite, uraninite.

Distribution: From Shinkolobwe, Katanga Province, Congo (Shaba Province, Zaire).

Name: Honors Dr. Jean Wyart (1902–1992), French crystallographer, Professor of Mineralogy, Sorbonne, Paris, France.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG2222; Natural History Museum, Paris, France, V 5686; National School of Mines, Paris, France; The Natural History Museum, London, England, 1969,47; National Museum of Natural History, Washington, D.C., USA, 150331.

References: (1) Guillemin, C. and J. Protas (1959) Ianthinite et wyartite. Bull. Minéral., 82, 80–86 (in French). (2) (1959) Amer. Mineral., 44, 908 (abs. ref. 1). (3) Bignand, C. (1955) Sur les propriétés et les synthèses de quelques minéraux uranifères. Bull. Minéral., 78, 1–26 (in French). (4) Clark, J.R. (1960) X-ray study of alteration in the uranium mineral wyartite. Amer. Mineral., 45, 200–208. (5) Burns, P.C., and R.J. Finch (1999) Wyartite: crystallographic evidence for the first pentavalent-uranium mineral. Amer. Mineral., 84, 1456–1460.

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Wycheproofite $NaAlZr(PO_4)_2(OH)_2 \cdot H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Finely fibrous anhedral crystals, to several mm, in compact masses.

Physical Properties: *Fracture:* Irregular. Hardness = 4–5 D(meas.) = 2.83 D(calc.) = 2.81

Optical Properties: Transparent. *Color:* Pale pinkish orange to pale brownish orange. *Streak:* White. *Luster:* Vitreous to pearly.
Optical Class: Biaxial. *Orientation:* Parallel extinction, length-slow. $\alpha = 1.62 \perp$ fiber length. β = n.d. $\gamma = 1.64 \parallel$ fiber length. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 10.926(5)$ $b = 10.986(5)$ $c = 12.479(9)$ $\alpha = 71.37(4)°$ $\beta = 77.39(4)°$ $\gamma = 87.54(3)°$ Z = 6

X-ray Powder Pattern: Wycheproof, Australia.
2.603 (100), 4.128 (80), 3.711 (65), 3.465 (60), 8.865 (40), 3.243 (35), 2.875 (30)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	35.85	37.04	CaO	0.66	
SiO_2	0.23		Na_2O	6.36	8.09
ZrO_2	32.43	32.16	K_2O	0.44	
HfO_2	1.24		Cs_2O	0.03	
Al_2O_3	12.03	13.31	F	0.34	
FeO	0.36		H_2O	9.0	9.40
MnO	0.21		$-O = F_2$	0.14	
			Total	99.04	100.00

(1) Wycheproof, Australia; by electron microprobe, average of five analyses, H_2O by CHN analyzer; corresponding to $(Na_{0.81}Ca_{0.05}K_{0.04})_{\Sigma=0.90}(Al_{0.93}Fe_{0.02}Mn_{0.01})_{\Sigma=0.96}(Zr_{1.03}Hf_{0.02})_{\Sigma=1.05}[(PO_4)_{1.99}(SiO_4)_{0.01}]_{\Sigma=2.00}[(OH)_{1.87}F_{0.07}]_{\Sigma=1.94} \cdot 1.0H_2O$. (2) $NaAlZr(PO_4)_2(OH)_2 \cdot H_2O$.

Occurrence: Filling cavities in pegmatitic veins in a granite quarry.

Association: Kosnarite, eosphorite, cyrilovite, schorl.

Distribution: From Wycheproof, Victoria, Australia.

Name: For the occurrence at Wycheproof, Australia.

Type Material: South Australian Museum, Adelaide, G18612; Museum Victoria, Melbourne, Australia, M42853, M42846.

References: (1) Birch, W.D., A. Pring, D.J.M. Bevan, and Kharisun (1994) Wycheproofite: a new hydrated sodium aluminium zirconium phosphate from Wycheproof, Victoria, Australia, and a new occurrence of kosnarite. Mineral. Mag., 58, 635–639. (2) (1995) Amer. Mineral., 80, 847 (abs. ref. 1).

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Wyllieite $(Na, Ca, Mn^{2+})(Mn^{2+}, Fe^{2+})(Fe^{2+}, Fe^{3+}, Mg)Al(PO_4)_3$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Granular, to 15 cm.

Physical Properties: Hardness = [> 4] (by analogy to ferrowyllieite). D(meas.) = n.d. D(calc.) = [3.61]

Optical Properties: Semitransparent. *Color:* Bottle-green, pale greenish gray. *Luster:* [Vitreous to submetallic].
Optical Class: Biaxial (+). *Pleochroism:* X = colorless; $Y = Z$ = bluish green. $\alpha = 1.685(2)$ $\beta = 1.688(2)$ $\gamma = 1.692(2)$ 2V(meas.) = 90° 2V(calc.) = 82°

Cell Data: *Space Group:* $P2_1/n$. $a = 11.967(2)$ $b = 12.462(3)$ $c = 6.409(1)$ $\beta = 114°38(1)'$ Z = 4

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
P_2O_5	45.41	44.32
Al_2O_3	6.48	7.91
Fe_2O_3	10.62	
FeO	14.73	15.81
MnO	11.22	17.82
ZnO	0.41	
MgO	1.71	2.17
CaO	3.12	0.33
Na_2O	3.93	9.70
K_2O	0.05	0.07
H_2O	0.92	
insol.	1.22	
Total	99.82	98.13

(1) Old Mike mine, South Dakota, USA; corresponds to $(Na_{0.59}Ca_{0.26}Mn^{2+}_{0.10})_{\Sigma=0.95}(Mn^{2+}_{0.64}Fe^{2+}_{0.36})_{\Sigma=1.00}(Fe^{2+}_{0.57}Fe^{3+}_{0.21}Mg_{0.20}Zn_{0.02})_{\Sigma=1.00}(Al_{0.59}Fe^{3+}_{0.41})_{\Sigma=1.00}(PO_4)_3$. (2) Buranga, Rwanda; corresponds to $(Na_{0.80}K_{0.01})_{\Sigma=0.81}(Na_{0.70}Mn^{2+}_{0.27}Ca_{0.03})_{\Sigma=1.00}(Mn^{2+}_{0.94}Fe^{2+}_{0.06})_{\Sigma=1.00}(Fe^{2+}_{0.84}Mg_{0.16})_{\Sigma=1.00}(Al_{0.75}Fe^{3+}_{0.15}Mg_{0.10})_{\Sigma=1.00}(PO_4)_3$.

Polymorphism & Series: Forms two series, with ferrowyllieite, and with rosemaryite; $Mn^{2+} > Fe^{2+}$ in M(1); Fe^{2+} dominant in M(2a).

Occurrence: In zoned complex granite pegmatites.

Association: Trolleite, scorzalite (Buranga, Rwanda).

Distribution: In the USA, in South Dakota, from the Old Mike mine, six km north-northwest of Custer, Custer Co. At the Buranga pegmatite, near Gatumba, Rwanda. From Hålsjöberg, Värmland, Sweden. At the Lavra do Énio pegmatite, northeast of Galiléia, Minas Gerais, Brazil.

Name: To honor Dr. Peter John Wyllie (1930–), Professor of Petrology and Geochemistry, University of Chicago, Chicago, Illinois, USA.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162557.

References: (1) Moore, P.B. and J. Ito (1979) Alluaudites, wyllieites, arrojadites: crystal chemistry and nomenclature. Mineral. Mag., 43, 227–235. (2) (1980) Amer. Mineral., 65, 810–811 (abs. ref. 1). (3) Fransolet, A.-M. (1995) Wyllieite et rosemaryite dans la pegmatite de Buranga, Rwanda. Eur. J. Mineral., 7, 567–575 (in French with English abs.).

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Xanthiosite $Ni_3(AsO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In microcrystalline to amorphous crusts, to 2 mm thick.

Physical Properties: Hardness = 4 D(meas.) = 4.98–5.42 D(calc.) = 5.388

Optical Properties: Semitransparent. *Color:* Sulfur-yellow, golden yellow.
Optical Class: [Biaxial.] α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/a$. $a = 10.174(5)$ $b = 9.548(2)$ $c = 5.766(1)$
$\beta = 92°58.5(1.0)'$ Z = 4

X-ray Powder Pattern: Johanngeorgenstadt, Germany.
2.529 (vvsb), 3.46 (vsb), 2.757 (vs), 2.739 (vs), 2.690 (vs), 2.666 (vs), 4.32 (sb)

Chemistry:

	(1)	(2)	(3)
As_2O_5	50.53	50.0	50.64
Bi_2O_3	0.62		
FeO		0.5	
CoO	0.21	1.0	
NiO	48.24	47.0	49.36
CuO	0.57	0.7	
Total	100.17	99.2	100.00

(1) Johanngeorgenstadt, Germany; corresponds to $(Ni_{2.96}Cu_{0.03}Co_{0.01})_{\Sigma=3.00}(AsO_4)_{2.01}$.
(2) South Terras mine, Cornwall, England; corresponds to $(Ni_{2.90}Co_{0.06}Cu_{0.04}Fe_{0.03})_{\Sigma=3.03}(AsO_4)_{2.00}$. (3) $Ni_3(AsO_4)_2$.

Occurrence: A rare secondary mineral in hydrothermal Ni–As–U ore deposits.

Association: Bismuth, bunsenite, aerugite (Johanngeorgenstadt, Germany); aerugite (South Terras mine, Cornwall, England).

Distribution: From Johanngeorgenstadt, Saxony, Germany. In the South Terras mine, St. Stephen-in-Brannel, Cornwall, England.

Name: From the Greek for *yellow* and *sulfur*, in allusion to its distinctive sulfur-yellow color.

Type Material: The Natural History Museum, London, England, 32590 and 1907,103.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 870. (2) Davis, R.J., M.H. Hey, and A.W.G. Kingsbury (1965) Xanthiosite and aerugite. Mineral. Mag., 35, 72–83.

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Xanthoconite Ag_3AsS_3

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Tabular on {001}, commonly producing flat rhombohedra, also as laths elongated along [010], to 0.5 cm; rarely pyramidal. Reniform and hemispherical radial aggregates. *Twinning:* On {001} producing pseudo-orthorhombic twins.

Physical Properties: *Cleavage:* Distinct on {001}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 2–3 VHN = 71–93 (25 g load). D(meas.) = 5.54(14) D(calc.) = 5.53

Optical Properties: Translucent. *Color:* Dark cochineal-red to dull orange to clove-brown; lemon-yellow in transmitted light. *Streak:* Orange-yellow. *Luster:* Adamantine. *Optical Class:* Biaxial (–). *Orientation:* $X \simeq c$; $Y \simeq a$; $Z = b$. *Dispersion:* $r < v$, very strong. $n = \sim 3$ 2V(meas.) = 34°

R_1–R_2: (400) 33.7–37.1, (420) 32.2–36.1, (440) 30.7–35.1, (460) 29.1–33.7, (480) 27.6–32.1, (500) 26.1–30.1, (520) 24.8–28.5, (540) 23.7–27.3, (560) 22.7–26.3, (580) 22.0–25.5, (600) 21.5–24.8, (620) 21.3–24.4, (640) 21.0–24.1, (660) 20.8–23.8, (680) 20.6–23.6, (700) 20.4–23.5

Cell Data: *Space Group:* $C2/c$. $a = 12.00(1)$ $b = 6.26(1)$ $c = 17.08(1)$ $\beta = 110.0°$ Z = 8

X-ray Powder Pattern: Jáchymov, Czech Republic.
3.00 (100), 2.82 (60), 3.14 (30), 2.13 (30), 5.5 (20), 4.02 (20), 3.38 (20)

Chemistry:

	(1)	(2)
Ag	65.15	65.42
As	14.63	15.14
S	19.07	19.44
Total	98.85	100.00

(1) Freiberg, Germany. (2) Ag_3AsS_3.

Polymorphism & Series: Dimorphous with proustite.

Occurrence: Typically associated with other silver sulfosalts in hydrothermal veins.

Association: Proustite, pyrargyrite, acanthite, arsenic, calcite.

Distribution: In small amounts at numerous localities. From Jáchymov (Joachimsthal), Příbram, and Třebsko, Czech Republic. In Saxony, Germany, at Freiberg, Annaberg, Marienberg, Johanngeorgenstadt, and Schneeberg; at St. Andreasberg, in the Harz Mountains. From Baia Sprie (Felsőbánya), Romania. At Sainte-Marie-aux-Mines, Haut-Rhin, France. From Chañarcillo, south of Copiapó, Atacama, Chile. In several mines at Cobalt, Ontario, Canada. At the General Petite mine, Atlanta district, Elmore Co., Idaho, and from about 13 km north of Niarada, in the Flathead mine, Flathead Co., Montana, USA. From the Batopilas district, Chihuahua, Mexico.

Name: From the Greek for *yellow* and *powder* in allusion to its color.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 371–372. (2) Peacock, M.A. (1950) Studies of mineral sulfo-salts: XV. Xanthoconite and pyrostilpnite. Mineral. Mag., 29, 346–358. (3) Engel, P. and W. Nowacki (1968) Die Kristallstruktur von Xanthokon, Ag_3AsS_3. Acta Cryst., 24, 77–81 (in German).

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Xanthoxenite $Ca_4Fe_2^{3+}(PO_4)_4(OH)_2 \cdot 3H_2O$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$ or 1. Platy or lathlike crystals, in lamellar aggregates and crusts.

Physical Properties: *Cleavage:* {010}, perfect. Hardness = 2.5 D(meas.) = 2.97 D(calc.) = 3.38

Optical Properties: Semitransparent. *Color:* Pale yellow, brownish yellow; pale yellow to pale lemon-yellow in transmitted light. *Luster:* Dull to slightly waxy.
Optical Class: Biaxial (–). *Pleochroism:* Faint in thick grains; in shades of yellow.
Dispersion: $r < v$, strong. *Absorption:* $Y > X = Z$. $\alpha = 1.704(3)$ $\beta = 1.715(3)$ $\gamma = 1.724(3)$ 2V(meas.) = Large.

Cell Data: *Space Group:* $P\bar{1}$. $a = 6.70(4)$ $b = 8.85(4)$ $c = 6.54(3)$ $\alpha = 92.1(2)°$ $\beta = 110.1(2)°$ $\gamma = 93.2(2)°$ Z = 1

X-ray Powder Pattern: Palermo #1 mine, New Hampshire, USA.
3.05 (10), 2.73 (9), 3.22 (8), 3.48 (7), 2.23 (6), 6.24 (5), 4.94 (4)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	37.62	38.1	38.37	Na_2O		0.10	
Al_2O_3	0.01	0.23		K_2O		0.05	
Fe_2O_3	21.68	16.6	21.58	H_2O^+	9.13	10.90	
MnO	4.55	4.10		H_2O^-	0.86		
MgO	0.91	0.50		H_2O			9.74
CaO	24.99	29.3	30.31	insol.	0.78		
SrO		0.11		Total	100.53	[100.0]	100.00

(1) Palermo #1 mine, New Hampshire, USA; corresponds to $(Ca_{3.28}Mn_{0.47}Mg_{0.17})_{\Sigma=3.92}Fe_{2.00}(PO_4)_{3.90}(OH)_{2.14} \cdot 2.69H_2O$. (2) Přibyslavice, Czech Republic; recalculated to 100% after deduction of quartz 3.90% from an original total of 99.89%; corresponds to $(Ca_{3.90}Mg_{0.10}Na_{0.02})_{\Sigma=4.02}Fe_{1.98}(PO_4)_{4.00}(OH)_2 \cdot 2.51H_2O$. (3) $Ca_4Fe_2(PO_4)_4(OH)_2 \cdot 3H_2O$.

Occurrence: An uncommon alteration product of triphylite in complex zoned granite pegmatites.

Association: Apatite, whitlockite, childrenite–eosphorite, laueite, strunzite, stewartite, mitridatite, amblygonite, siderite.

Distribution: In the USA, from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire; in the Tip Top, Linwood, and White Elephant mines, near Custer, Custer Co., South Dakota; at the Champion mine, White Mountains, Mono Co., California; in the Dunton quarry, Newry, and on Black Mountain and Red Hill, Rumford, Oxford Co., Maine. From Hühnerkobel, near Zwiesel, and at Hagendorf, Bavaria, Germany. From Přibyslavice and Otov, Czech Republic. At the Lavra da Ilha pegmatite, in the Jequitinhonha River, and Sabinópolis, near Taquaral, Minas Gerais, Brazil.

Name: From the Greek for *yellow* and supposed chemical resemblance to *cacoxenite*.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 119745 [xanthoxenite redefined]. The name was originally applied to a partially described mineral [= stewartite ?] from the Hühnerkobel pegmatite, Germany, type material destroyed in World War II.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 977–978. (2) Frondel, C. (1949) Wolfeite, xanthoxenite, and whitlockite from the Palermo mine, New Hampshire. Amer. Mineral., 34, 692–705. (3) Moore, P.B. and J. Ito (1978) I. Whiteite, a new species, and a proposed nomenclature for the jahnsite-whiteite complex series. II. New data on xanthoxenite. III. Salmonsite discredited. Mineral. Mag., 42, 309–323.

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Xenotime-(Y) YPO_4

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Short to long [001] prismatic crystals, with {010}, {110}, may be pyramidal {011}, equant, several other minor forms noted, to 5 cm. In radial or rosettelike aggregates of coarse crystals. *Twinning:* On {111}, rare.

Physical Properties: *Cleavage:* On {100}, good. *Fracture:* Uneven to splintery. *Tenacity:* Brittle. Hardness = 4–5 D(meas.) = 4.4–5.1 D(calc.) = 4.25 Paramagnetic; may exhibit yellow cathodoluminescence.

Optical Properties: Translucent to opaque. *Color:* Yellowish brown, reddish brown, flesh-red, grayish white, wine-yellow, pale yellow, greenish; in transmitted light, colorless to very pale yellowish green, yellow, or yellowish brown. *Luster:* Vitreous to resinous. *Optical Class:* Uniaxial (+). *Pleochroism:* Weak; O = pink, yellow, or yellowish brown; E = brownish yellow, grayish brown, greenish. $\omega = 1.720–1.721$ $\epsilon = 1.816–1.827$

Cell Data: *Space Group:* $I4_1/amd$. a = 6.884–6.902 $c = 6.021–6.038$ Z = 4

X-ray Powder Pattern: Synthetic.
3.443 (100), 2.558 (60), 1.762 (45), 4.54 (25), 2.145 (25), 1.820 (18), 1.721 (18)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
P_2O_5	34.37	33.89	38.60	Y_2O_3	44.03	46.49	61.40
SiO_2	0.31	0.10		RE_2O_3	20.18	17.22	
UO_2		0.96		CaO		0.07	
ThO_2		0.38		Total	98.89	99.11	100.00

(1) Gloserheia pegmatite, Froland, Norway; by electron microprobe, average of 8 analyses; RE_2O_3 = Nd_2O_3 0.17%, Sm_2O_3 0.49%, Eu_2O_3 0.07%, Gd_2O_3 2.69%, Tb_2O_3 0.58%, Dy_2O_3 4.93%, Ho_2O_3 1.27%, Er_2O_3 4.05%, Tm_2O_3 0.70%, Yb_2O_3 4.36%, Lu_2O_3 0.87%. (2) Switzerland; by electron microprobe, average of 82 analyses on 11 samples; RE_2O_3 = Eu_2O_3 0.04%, Gd_2O_3 1.89%, Tb_2O_3 0.60%, Dy_2O_3 5.15%, Ho_2O_3 1.06%, Er_2O_3 3.86%, Yb_2O_3 4.10%, Lu_2O_3 0.52. (3) YPO_4.

Mineral Group: Forms a series with chernovite-(Y).

Occurrence: An accessory mineral in alkalic to granitic rocks, well-developed in associated pegmatites; in gneiss and Alpine veins; a common detrital mineral in placers.

Association: Zircon, monazite, rutile, anatase, brookite, hematite, ilmenite, gadolinite, allanite, apatite, yttrotantalite, thorite.

Distribution: Numerous localities but fine crystals are unusual. In Norway, from Lindesnes; on Hidra (Hitterö) Island; around Tvedestrand and Arendal; at Raade, near Moss; and elsewhere. From Ytterby, on Resarö Island, near Vaxholm, Sweden. In Switzerland, from the Binntal, Valais; in the Maderanertal, Uri; in the Tavetsch, Graubünden; and many other places. Large crystals from the Yazgulem Ridge, western Pamir Mountains, Tajikistan. At Sahamandrevo, near Ampangabe, Madagascar. In the Ishikawa district, Fukushima Prefecture, Japan. In Brazil, from Ataleia and Ibitiara, Minas Gerais; at Brumado and Novo Horizonte, Bahia. In the USA, in North Carolina, from placers in Polk, McDowell, and Burke Cos.; on Cheyenne Mountain, El Paso Co., and elsewhere in Colorado. In the Gunter quarry, near McKenzie Lake, Ontario, Canada.

Name: From the Greek for *vain* and *honor*, as the contained *yttrium* had been mistaken for a new element.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 688–691. (2) Åmli, R. (1975) Mineralogy and rare earth geochemistry of apatite and xenotime from the Gloserheia granite pegmatite, Froland, Southern Norway. Amer. Mineral., 60, 607–620. (3) Demartin, F., T. Pilati, V. Diella, S. Donzelli, P. Gentile, and C.M. Gramaccioli (1991) The chemical composition of xenotime from fissures and pegmatites in the Alps. Can. Mineral., 29, 69–75. (4) Y. Ni, J.M. Hughes, and A.N. Mariano (1995) Crystal chemistry of the monazite and xenotime structures. Amer. Mineral., 80, 21–26. (5) (1958) NBS Cir. 539, 8.

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Xiangjiangite $(Fe^{3+}, Al)(UO_2)_4(PO_4)_2(SO_4)_2(OH)\cdot 22H_2O$

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Crystal Data: Monoclinic or orthorhombic (?); pseudotetragonal. *Point Group:* n.d. Platy crystals, with squarish to octagonal outlines; microcrystalline, in earthy or powdery aggregates.

Physical Properties: Hardness = 1–2 D(meas.) = 2.9–3.1 D(calc.) = 2.78 Radioactive.

Optical Properties: Semitransparent. *Color:* Yellow to bright yellow; pale yellow in transmitted light. *Streak:* Pale yellow. *Luster:* Silky.
Optical Class: Biaxial (–). *Pleochroism:* Weak. *Orientation:* Parallel or symmetrical extinction. $\alpha = 1.558$ $\beta = 1.576$ $\gamma = 1.593$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 7.17$ $b = 7.17$ $c = 22.22$ $Z = 1$

X-ray Powder Pattern: "Hunan, China".
11.11 (10), 3.74 (8), 3.294 (8), 2.938 (7), 4.621 (6), 5.58 (5), 2.175 (5)

Chemistry:

	(1)
UO_3	59.96
SO_3	6.02
P_2O_5	8.69
Al_2O_3	0.96
Fe_2O_3	2.17
CaO	0.28
H_2O^+	10.51
H_2O^-	11.41
Total	[100.00]

(1) "Hunan, China"; recalculated to 100% after deduction of quartz, pyrite, and insoluble 5.36%, from an original total of 99.16%; corresponds to $(Fe_{0.52}Al_{0.36})_{\Sigma=0.88}Ca_{0.10}(UO_2)_{4.00}(PO_4)_{2.34}(SO_4)_{1.44}(OH)_{0.95}\cdot 22.79H_2O$.

Occurrence: In the oxidized zone of a uranium deposit.

Association: Sabugalite, variscite, pyrite, quartz.

Distribution: In an unspecified uranium deposit in "Hunan [Province], China".

Name: For the Xiang Jiang (Hsiang Chiang) River, China.

Type Material: n.d.

References: (1) Hunan 230 Institute and X-ray Laboratory, Wuhan Geologic College (1978) Xiangjiangite – a new uranium mineral discovered in China. Sci. Geol. Sinica, 2, 183–188 (in Chinese with English abs.). (2) (1979) Amer. Mineral., 64, 466 (abs. and discussion of ref. 1). (3) (1978) Mineral. Abs., 29, 483 (abs. ref. 1).

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Xifengite Fe_5Si_3

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As cores of spheres, to 0.5 mm, surrounded by other iron minerals.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 633–694 (50 g load). D(meas.) = n.d. D(calc.) = 6.43 Strongly magnetic.

Optical Properties: Opaque. *Color:* Steel-gray; gray with a yellow tint under reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Uniaxial. *Anisotropism:* Moderate; bluish gray to pale brown.
R_1–R_2: (402) 38.3–37.9, (439) 38.4–38.9, (480) 40.1–39.8, (495) 42.0–40.4, (546) 44.1–43.0, (590) 46.2–44.9, (624) 47.6–44.7, (644) 45.3–44.2, (657) 45.9–45.3

Cell Data: *Space Group:* $[P6_3/mcm]$ (by analogy to synthetic Mn_5Si_3). $a = 6.759(5)$ $c = 4.720(5)$ Z = 2

X-ray Powder Pattern: Yanshan Mountains, China.
2.00 (100), 1.94 (80), 1.92 (80), 1.282 (80), 2.21 (60), 1.050 (60), 1.375 (50)

Chemistry:

	(1)	(2)
Fe	75.5	76.82
Mn	0.2	
Ni	0.3	
Si	23.7	23.18
Total	99.7	100.00

(1) Yanshan Mountains, China; by electron microprobe, corresponding to $(Fe_{4.90}Ni_{0.02}Mn_{0.01})_{\Sigma=4.93}Si_{3.06}$. (2) Fe_5Si_3.

Occurrence: Innermost in spheres, surrounded by nickel-iron minerals and their oxidation products, apparently of extraterrestrial origin, found in placers.

Association: Gupeiite, kamacite, taenite, magnetite, wüstite, maghemite.

Distribution: In the Yanshan Mountains, Hebei Province, China.

Name: For an eastern passageway, Xifengkou, of the Great Wall of China.

Type Material: Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China.

References: (1) Yu Zuxiang (1984) Two new minerals gupeiite and xifengite in cosmic dusts from Yanshan. Acta Petrologica Mineralogica et Analytica, 3, 231–238 (in Chinese with English abs.). (2) (1986) Amer. Mineral., 71, 228 (abs. ref. 1).

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Xilingolite $Pb_3Bi_2S_6$

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Crystal Data: Monoclinic. *Point Group:* $2/m$, 2, or m. As prismatic crystals, elongated and striated on {010}, to 8 mm. *Twinning:* On {001}.

Physical Properties: Hardness = n.d. VHN = 103 average (5 to 200 g load).
D(meas.) = 7.08 D(calc.) = 7.07

Optical Properties: Opaque. *Color:* Lead-gray; in reflected light, white with a faint blue tint. *Streak:* Gray. *Luster:* Metallic. *Pleochroism:* Distinct, white to white with blue tint. *Anisotropism:* Distinct, dark gray to gray.

R_1–R_2: (405) 43.2–46.6, (436) 44.5–46.8, (480) 44.3–46.8, (526) 44.2–44.9, (546) 41.8–44.5, (578) 41.4–44.1, (589) 40.9–43.8, (622) 40.5–43.3, (644) 40.0, 43.0, (656) 39.9–43.0, (664) 39.8–43.0, (700) 37.5–41.2

Cell Data: *Space Group:* $C2/m$, $C2$, or Cm. $a = 13.65$ $b = 4.078$ $c = 20.68$
$\beta = 93.0°$ Z = 4

X-ray Powder Pattern: Chaobuleng district, China.
3.386 (100), 2.177 (90), 2.073 (80), 2.051 (70), 1.955 (70), 1.788 (6), 1.396 (5)

Chemistry:

	(1)	(2)	(3)
Pb	52.074	52.06	50.45
Zn	0.653		
Cu	0.16		
Ag	0.75	0.50	
Bi	29.72	29.81	33.93
Sb	0.09		
S	15.09	15.25	15.62
oxides	1.333	1.62	
Total	99.87	99.24	100.00

(1) Chaobuleng district, China; ignoring minor components and oxides, corresponds to $Pb_{3.18}Bi_{1.81}S_{6.00}$. (2) Do.; by electron microprobe. (3) $Pb_3Bi_2S_6$.

Occurrence: In a skarn-type iron deposit.

Association: Magnetite, sphalerite, pyrrhotite, pyrite, arsenopyrite, chalcopyrite, digenite, bornite, molybdenite, galena, bismuth, bismuthinite.

Distribution: In the Chaobuleng district, Xilingola League, Inner Mongolia, China.

Name: For the Xilingola locality in China.

Type Material: n.d.

References: (1) Hong Huidi, Wang Xiangwen, Shi Nicheng, and Peng Zhizhong (1982) Xilingolite, a new sulfide of lead and bismuth, $Pb_{3+x}Bi_{2-2/3x}S_6$. Acta Petrologica Mineralogica et Analytica, 1, 14–18 (in Chinese with English abs.). (2) (1984) Amer. Mineral., 69, 409 (abs. ref. 1).

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Ximengite $BiPO_4$

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Crystal Data: Hexagonal. *Point Group:* 32. Granular, to 0.1 mm, in veinlets and earthy aggregates.

Physical Properties: *Tenacity:* Brittle. Hardness = n.d. VHN = 297–283, average 281. D(meas.) = n.d. D(calc.) = 5.534 Yellowish green cathodoluminescence under the electron beam.

Optical Properties: Transparent. *Color:* Colorless. *Streak:* White. *Luster:* Vitreous to greasy.
Optical Class: Uniaxial (+). $\omega = > 1.77$ $\epsilon = > 1.77$

Cell Data: *Space Group:* $[P3_121]$ (by analogy to synthetic material). $a = 6.986(2)$ $c = 6.475(3)$ $Z = 3$

X-ray Powder Pattern: Ximeng Co., China.
3.024 (100), 4.420 (91), 3.493 (88), 6.052 (73), 2.854 (65), 1.7474 (48), 2.157 (47)

Chemistry:

	(1)	(2)
P_2O_5	22.92	23.35
Bi_2O_3	76.34	76.65
H_2O	0.76	
Total	100.02	100.00

(1) Ximeng Co., China; by electron microprobe, corresponding to $Bi_{1.01}P_{0.90}O_4$. (2) $BiPO_4$.

Occurrence: An alteration product of bismuthinite in a tin deposit.

Association: Bismuthinite, waylandite, monazite, cassiterite, tourmaline.

Distribution: From an undefined locality in Ximeng Co., about 420 km southwest of Kunming, Yunnan Province, China.

Name: For Ximeng Co., China, in which it was first noted to occur.

Type Material: Bureau of Geology and Mineral Resources, Kunming, China.

References: (1) Jiaxin Shi (1989) Ximengite – a new mineral. Acta Mineralogica Sinica, 9(1), 15–19 (in Chinese with English abs.). (2) (1991) Amer. Mineral., 76, 1436 (abs. ref. 1). (3) Jiaxin Shi (1989) A new mineral – ximengite. Chinese J. Geochem., 8(4), 385–391 (in English).
(4) Mooney-Slater, R.C.L. (1962) Polymorphic forms of bismuth phosphate. Zeits. Krist., 117, 371–385.

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Xingzhongite $(Pb, Cu, Fe)(Ir, Pt, Rh)_2S_4$

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Crystal Data: Cubic or pseudocubic. *Point Group:* n.d. As a rim around iridosmine.

Physical Properties: Hardness = n.d. VHN = 753 (50 g load). D(meas.) = n.d. D(calc.) = [7.94]

Optical Properties: Opaque. *Color:* Steel-gray; in reflected light, bluish gray. *Luster:* Metallic.

R: (466) 40.5, (544) 38.9, (589) 41.1, (656) 41.0

Cell Data: *Space Group:* n.d. $a = 9.970$ $Z = [8]$

X-ray Powder Pattern: China.
1.765 (10), 5.80 (8), 3.00 (8), 1.208 (8), 2.49 (6), 2.88 (5), 1.335 (4)

Chemistry:

	(1)
Pb	12.80
Cu	3.81
Fe	1.58
Ir	43.49
Pt	9.67
Rh	7.19
S	21.68
Total	100.22

(1) China; by electron microprobe, giving $(Pb_{0.37}Cu_{0.35}Fe_{0.17})_{\Sigma=0.89}(Ir_{1.33}Rh_{0.41}Pt_{0.29})_{\Sigma=2.03}S_{4.00}$.

Mineral Group: Linnaeite group.

Occurrence: In dunite-hosted platinum ores, related to chromium mineralization (China).

Association: Pt–Fe alloy, osmiridium, iridosmine, osmium, iridium, erlichmanite, cooperite, irarsite, osarsite, chromite, magnetite, pyrite, olivine, serpentine, talc (China).

Distribution: From an unstated locality in China. At Fox Gulch, Goodnews Bay, Alaska, USA. From Tiébaghi, New Caledonia.

Name: Presumably for the undefined Chinese type locality.

Type Material: n.d.

References: (1) Yu Tsu-Hsiang, Lin Shu-Jen, Chao Pao, Fang Ching-Sung, and Huang Chi-Shun (1974) A preliminary study of some new minerals of the platinum group and another associated new one in platinum-bearing intrusions in a region in China. Acta Geol. Sinica, 2, 202–218 (in Chinese with English abs.). (2) (1976) Amer. Mineral., 61, 184–185 (abs. ref. 1). (3) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 146–147. (4) Peng Zhizhong, Chang Chiehung, and Ximen Lovlov (1978) Discussion on published articles in the research of new minerals of the platinum-group discovered in China in recent years. Acta Geol. Sinica, 4, 326–336 (in Chinese with English abs.). [Peng Zhizhong formerly Pen Chih-Zhong]. (5) (1980) Amer. Mineral., 65, 408 (abs. ref. 4). (6) Institute of Geochemistry, Chinese Academy of Sciences (1981) Platinum deposits in China, geochemistry of the platinum group elements, and platinum group minerals. Science Publishing Agency, Beijing, China, 190 p. (in Chinese). (7) (1984) Amer. Mineral., 69, 412 (abs. ref. 6).

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Xitieshanite $Fe^{3+}(SO_4)Cl \cdot 6H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Rare in rhombic crystals, to 2 cm; massive.

Physical Properties: *Cleavage:* One, imperfect. *Fracture:* Uneven to conchoidal. Hardness = 2.7 D(meas.) = 1.98–1.99 D(calc.) = 1.997 Soluble in H_2O.

Optical Properties: Translucent to nearly transparent. *Color:* Bright yellowish green; brownish red if surficially oxidized. *Streak:* Yellow. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = colorless to pale yellow; Y = pale yellow; Z = pale yellow with greenish tint. *Orientation:* Positive or negative elongation; parallel or inclined extinction. *Dispersion:* $r > v$. $\alpha = 1.536$ $\beta = 1.570$ $\gamma = 1.628$ 2V(meas.) = n.d. 2V(calc.) = 77°

Cell Data: *Space Group:* $P2_1/c$. $a = 10.6776(23)$ $b = 6.9148(13)$ $c = 14.1193(29)$ $\beta = 111.407(15)°$ Z = 4

X-ray Powder Pattern: Xitieshan mine, China.
4.96 (10), 4.81 (10), 3.90 (9), 6.67 (6), 6.09 (5), 5.69 (5), 5.44 (5)

Chemistry:

	(1)	(2)	(3)
SO_3	27.69		27.10
Al_2O_3	0.01		
Fe_2O_3	26.15		27.02
FeO	0.18		
MgO	0.03		
CaO	0.09		
Na_2O	0.07		
K_2O	0.03		
Cl	n.d.	10.05	12.00
H_2O	45.02		36.59
$-O = Cl_2$			2.71
Total	99.27		100.00

(1) Xitieshan mine, China. (2) Do.; separate analysis on type material. (3) $Fe(SO_4)Cl \cdot 6H_2O$.

Occurrence: Formed in the oxidation zone of a pyrite-rich orebody in a very arid climate.

Association: Copiapite, römerite, coquimbite, amarillite, sideronatrite, melanterite.

Distribution: From the Xitieshan Pb–Zn mine, south of Mt. Qilianshan, Chaidamu, Qinghai Province, China.

Name: For its occurrence in the Xitieshan mine, China.

Type Material: Institute of Geochemistry, Guiyang; Museum of Geology, Beijing, China.

References: (1) Li Xilin, Zhou Jingliang, and Li Jiaju (1983) Xitieshanite – a new ferric sulphate mineral. Geochemistry (China), 2, 261–267 (in English). (2) (1984) Amer. Mineral., 69, 1194 (abs. ref. 1). (3) Zhou Jingliang, Li Xilin, and Dong Wei (1988) The crystal structure of xitieshanite. Kexue Tongbao, 33(6), 502–505 (in English).

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Xocomecatlite $Cu_3(Te^{6+}O_4)(OH)_4$

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Crystal Data: Orthorhombic (probable). *Point Group:* n.d. Needlelike crystals in subparallel radial and spherulitic aggregates, to 0.15 mm.

Physical Properties: *Tenacity:* Brittle but tough. Hardness = 4 D(meas.) = 4.65(1) D(calc.) = 4.42

Optical Properties: Semitransparent. *Color:* Bright emerald-green. *Streak:* Pale green. *Optical Class:* Biaxial (–). *Pleochroism:* In rich bluish greens. *Orientation:* $X \perp$ length; $Z \parallel$ length. *Absorption:* $Z > X = Y$. $\alpha = 1.775(5)$ $\beta = 1.900(5)$ $\gamma = 1.920(5)$ 2V(meas.) = n.d. 2V(calc.) = 41°

Cell Data: *Space Group:* n.d. $a = 12.140(60)$ $b = 14.318(100)$ $c = 11.662(60)$ Z = 12

X-ray Powder Pattern: Bambollita mine, Mexico.
4.627 (10), 2.673 (6), 3.439 (4), 3.099 (4), 2.434 (4b), 3.320 (3), 2.831 (3)

Chemistry:

	(1)	(2)
TeO_3	38.7	39.00
CuO	51.3	53.00
ZnO	2.4	
H_2O	8.0	8.00
Total	100.4	100.00

(1) Bambollita mine, Mexico; results of several partial microchemical analyses, CuO, ZnO by AA, TeO_3 by spectrophotometry, presence of Te^{6+} confirmed by microchemical test; after deduction of insoluble 12.4%, then corresponds to $(Cu_{2.93}Zn_{0.14})_{\Sigma=3.07}(TeO_4)_{1.0}(OH)_{4.13}$.
(2) $Cu_3(TeO_4)(OH)_4$.

Occurrence: A rare secondary mineral in the oxidized zone of hydrothermal Au–Te deposits.

Association: Parakhinite, dugganite (Emerald mine, Arizona, USA); mcalpineite, leisingite, jensenite, hinsdalite–svanbergite, goethite (Centennial Eureka mine, Utah, USA).

Distribution: From the Oriental (Bambollita) mine, northeast of the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico. In the USA, at the Emerald mine, Tombstone, Cochise Co., Arizona; from the dump of the Centennial Eureka mine, Tintic district, Juab Co., Utah.

Name: From the Nahua language *xocomecatl*, for *grape*, in allusion to its appearance as a bunch of grapes.

Type Material: Natural History Museum, Paris, France; National Museum of Natural History, Washington, D.C., USA, 135059.

References: (1) Williams S.A. (1975) Xocomecatlite, $Cu_3TeO_4(OH)_4$, and tlalocite, $Cu_{10}Zn_6(TeO_3)(TeO_4)_2Cl(OH)_{25} \cdot 27H_2O$, two new minerals from Moctezuma, Sonora, Mexico. Mineral. Mag., 40, 221–226. (2) (1976) Amer. Mineral., 61, 504 (abs. ref. 1).

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Xonotlite $Ca_6Si_6O_{17}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As needlelike crystals, elongated ‖ [010], to 2 cm, with striated prism zones and tapering terminations; as flaky fibrous radiating bundles and rosettes; massive.

Physical Properties: *Cleavage:* Perfect in one $\{h0l\}$ direction. *Fracture:* Splintery. *Tenacity:* Tough. Hardness = 6–6.5 D(meas.) = 2.71–2.72 D(calc.) = 2.71

Optical Properties: Translucent. *Color:* Chalky white to bluish gray, pale pink, fading on exposure. *Luster:* Pearly, greasy.
Optical Class: Biaxial (+). *Orientation:* $Z = b$. $\alpha = 1.581–1.583$ $\beta = 1.581–1.583$ $\gamma = 1.591–1.593$ 2V(meas.) = Very low.

Cell Data: *Space Group:* $C2/m$. $a = 17.03$ $b = 3.678$ $c = 7.003$ $\beta = 90.32°$ Z = 1

X-ray Powder Pattern: Tetela de Xonotla, Mexico.
3.07 (vs), 2.04 (s), 1.95 (s), 3.65 (ms), 3.23 (ms), 2.83 (m), 2.71 (mw)

Chemistry:

	(1)	(2)
SiO_2	49.58	50.42
FeO	1.31	
MnO	1.79	
CaO	43.56	47.06
H_2O	3.70	2.52
Total	99.94	100.00

(1) Tetela de Xonotla, Mexico. (2) $Ca_6Si_6O_{17}(OH)_2$.

Occurrence: In contact metamorphic deposits within limestones, serpentinites, and metavolcanic rocks.

Association: Tobermorite, clinohedrite, wollastonite, diopside, thaumasite, laumontite, stilbite, apophyllite.

Distribution: Many localities. At Tetela de Xonotla, Puebla, Mexico. In the USA, at Leesburg, Loudoun Co., Virginia; from Franklin, Sussex Co., New Jersey; in the Hunting Hill quarry, Rockland, Montgomery Co., Maryland; on Isle Royale, Lake Superior, Michigan; at Crestmore, Riverside Co., California; and at Christmas, Gila Co., Arizona. In Canada, at Point Shivery, Bay of Islands, Newfoundland. Found near Yauco, Puerto Rico. At Arsiero, Vicenza, Italy. From Scawt Hill, near Larne, Co. Antrim, Ireland. At Broadford, Isle of Skye, Scotland. From Marrait, Greenland. At Hashidate and Kotaki, Niigata Prefecture; Kaisuka, Chiba Prefecture; and in the Mihara mine, Okayama Prefecture, Japan. From the Wessels and N'Chwaning mines, near Kuruman, Cape Province, South Africa.

Name: For the Mexican locality at Tetela de Xonotla, from which it was first described.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 569. (2) Heller, L. and H.F.W. Taylor (1956) Crystallographic data for the calcium silicates. H.M. Stationary Office, London, 46–48. (3) Eberhard, E., S.A. Hamid, and B. Röttger (1981) Strukturverfeinerung und Polytypie von Xonotlit $Ca_6[Si_6O_{17}](OH)_2$. Zeits. Krist., 154, 271–272 (in German).

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Yafsoanite **$Ca_3Zn_3(Te^{6+}O_6)_2$**

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are cubo-octahedra or dodecahedra, to 0.5 mm; also radiating, forming spherical aggregates.

Physical Properties: Hardness = ∼6 VHN = 696 (30 g load). D(meas.) = 5.40–5.55 D(calc.) = 5.54

Optical Properties: Transparent to translucent. *Color:* Colorless, pale to dark brown. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.800(5)$

Cell Data: *Space Group: Ia3d.* $a = 12.632(2)$ Z = 8

X-ray Powder Pattern: Kuranakh deposit, Russia.
2.581 (10), 1.683 (10), 2.821 (9), 3.16 (8), 1.024 (5), 4.47 (3), 1.751 (3)

Chemistry:

	(1)	(2)	(3)
TeO_3	42.11	39.91	46.00
SiO_2	0.21	1.56	
ZnO	24.65	27.38	31.97
PbO	12.82	8.88	
CaO	16.79	18.47	22.03
excess O	2.02	2.77	
Total	98.60	98.97	100.00

(1) Kuranakh deposit, Russia; by electron microprobe, here calculated to oxides; corresponds to $(Ca_{2.62}Pb_{0.50})_{\Sigma=3.12}Zn_{2.64}(Te_{1.04}O_6)_2$. (2) Do.; corresponds to $(Ca_{2.84}Pb_{0.52})_{\Sigma=3.36}Zn_{2.92}(TeO_6)_2$. (3) $Ca_3Zn_3(TeO_6)_2$.

Occurrence: Very rare in a tellurium-bearing gold quartz deposit in dolomite–calcite (Kuranakh deposit, Russia); in the oxidized zone of a hydrothermal ore deposit (Empire mine, Arizona, USA).

Association: Gold, tiemannite, naumannite, clausthalite, altaite, cinnabar, orpiment, kuranakhite, Si-rich dugganite, cheremnykhite, kuksite, descloizite, calcite, quartz, iron oxides (Kuranakh deposit, Russia).

Distribution: From the Kuranakh gold deposit, near Aldan, southern Sakha, Russia. At the Empire mine, Tombstone, Cochise Co. Arizona, USA. In the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: For the *Yakutskii Filial Sibirskogo Otdeleniya Akademii Nauk* (Yakut Filial, Siberian Branch, Academy of Sciences, YAFSOAN in Russian).

Type Material: Geological Museum, Yakutsk Scientific Center, Academy of Sciences, Yakutsk, mk-111; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84397.

References: (1) Kim, A.A., N.V. Zayakina, and Y.G. Lavrent'ev (1982) Yafsoanite – $(Zn_{1.38}Ca_{1.36}Pb_{0.26})_3TeO_6$, a new tellurium mineral. Zap. Vses. Mineral. Obshch., 111, 118–121 (in Russian). (2) (1983) Amer. Mineral., 68, 282–283 (abs. ref. 1). (3) Jarosch, D. and J. Zemann (1989) Yafsoanite: a garnet type calcium-tellurium(VI)-zinc oxide. Mineral. Petrol., 40, 111–116.

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Yagiite $(Na,K)_{1.5}Mg_2(Al,Mg)_3(Si,Al)_{12}O_{30}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Interstitially in a 0.8 mm silicate inclusion surrounded by nickel-iron.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.70

Optical Properties: Semitransparent. *Color:* Colorless; colorless to very light blue in thin section.
Optical Class: Uniaxial (+). *Pleochroism:* Faint; O = very light blue; E = colorless.
$\omega = 1.536(2)$ $\epsilon = 1.544(2)$

Cell Data: *Space Group:* $P6/mcc$. $a = 10.09(1)$ $c = 14.29(3)$ $Z = 2$

X-ray Powder Pattern: Colomera meteorite.
3.228 (100), 5.059 (65), 3.726 (50), 2.765 (50), 2.909 (40), 7.12 (30), 2.003 (30)

Chemistry:

	(1)
SiO_2	61.7
TiO_2	0.8
Al_2O_3	19.1
Cr_2O_3	0.1
FeO	2.4
MnO	0.2
MgO	10.5
CaO	0.1
Na_2O	3.7
K_2O	1.4
Total	100.0

(1) Colomera meteorite; by electron microprobe, corresponds to $(Na_{1.20}K_{0.30})_{\Sigma=1.50}Mg_{2.00}(Al_{1.96}Mg_{0.60}Fe_{0.34}Ti_{0.10})_{\Sigma=3.00}(Si_{10.22}Al_{1.78})_{\Sigma=12.00}O_{30}$.

Mineral Group: Milarite group.

Occurrence: In silicate inclusions of an iron meteorite, crystallized in a magnesium-rich environment.

Association: Diopside, whitlockite, tridymite, plagioclase, nickel-iron.

Distribution: In the Colomera iron meteorite.

Name: For Dr. Kenzo Yagi, Professor of Geology, Hokkaido University, Sapporo, Japan.

Type Material: n.d.

References: (1) Bunch, T.E. and L.H. Fuchs (1969) Yagiite, a new sodium-magnesium analogue of osumilite. Amer. Mineral., 54, 14–18.

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Yakhontovite $(Ca,K)_{0.5}(Cu,Fe^{3+},Mg)_2Si_4O_{10}(OH)_2 \cdot 3H_2O$

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Crystal Data: Monoclinic, probable. *Point Group:* n.d. In aggregates of equant crystals, to 10 μm.

Physical Properties: *Fracture:* Conchoidal. Hardness = 2–3 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Pistachio-green. *Luster:* Dull. *Optical Class:* Biaxial. *Pleochroism:* In blue-greens. *Orientation:* $Z \wedge c = 12°–14°$. $\alpha = 1.530–1.547$ β = n.d. $\gamma = 1.560–1.570$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. $a = 5.26$ $b = 9.108$ $c = 13.89$ (c•sin β) β = n.d. Z = n.d.

X-ray Powder Pattern: Pridorozhnoye deposit, Russia; 13.9 Å expands to 17.9 Å after treatment with glycerin.
13.9, 7.30, 4.5, 3.2, 2.88 [strongest lines only].

Chemistry:

	(1)
SiO_2	54.83
TiO_2	0.00
Al_2O_3	0.08
Fe_2O_3	15.03
MnO	0.00
CuO	15.20
ZnO	0.40
MgO	6.21
CaO	2.62
Na_2O	0.00
K_2O	0.15
Total	94.52

(1) Pridorozhnoye deposit, Russia; by electron microprobe, corresponding to $(Ca_{0.20}K_{0.01})_{\Sigma=0.21}(Cu_{0.84}Fe^{3+}_{0.83}Mg_{0.67}Zn_{0.02}Al_{0.01})_{\Sigma=2.37}Si_4O_{10}(OH)_2$; wet chemical analysis of a mixture with malachite and pseudomalachite gives H_2O 14.5% and all Fe as Fe^{3+}.

Mineral Group: Smectite group.

Occurrence: As veins and coatings in deeply oxidized sulfide-cassiterite ores.

Association: Pyrrhotite, chalcopyrite, pyrite, stannite, malachite, pseudomalachite, chrysocolla, iron oxides, quartz.

Distribution: From the Pridorozhnoye [Roadside] tin deposit, right bank of the Silinka River, nine km from its confluence with the Amur River, near Komsomol'sk-on-Amur, Russia.

Name: For Liya Konstantinova Yakhontova (1925–), Russian mineralogist, Moscow Univesity, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84395.

References: (1) Postnikova, V.P., S.I. Tsipurskii, G.A. Sidorenko, and A.V. Mokhov (1986) Yakhontovite–a new copper-bearing smectite. Mineral. Zhurnal, 8(6), 80–84 (in Russian). (2) (1988) Mineral. Abs., 39, 122 (abs. ref. 1). (3) (1991) Amer. Mineral., 76, 668–669 (abs. ref. 1).

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Yangzhumingite $KMg_{2.5}Si_4O_{10}F_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m.* As platy crystals to 0.5 mm.

Physical Properties: *Cleavage*: Perfect on {001}. *Fracture*: n.d. *Tenacity*: Flexible and elastic. Hardness = 3 [Synthetic] D(meas.) = n.d. D(calc.) = 2.807

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Pearly. *Optical Class*: Biaxial (n.d.). n = 1.532-1.537 2V(meas.) = 5-10°

Cell Data: *Space Group*: *C*2/*m*. a = 5.249(4) b = 9.095(5) c = 10.142(5) β = 99.96(6)° Z = 2

X-ray Powder Pattern: Bayan Obo, Inner Mongolia, China.
2.41 (100), 10.03 (95), 2.59 (67), 2.90 (49), 3.37, (48), 4.51 (45), 2.62 (43)

Chemistry:

	(1)	(2)
SiO_2	58.8	58.59
Al_2O_3	0.41	
MgO	24.7	24.56
FeO	1.00	
MnO	0.02	
TiO_2	0.01	
K_2O	8.20	11.48
Li_2O	1.10	
Na_2O	0.06	
CaO	0.04	
BaO	0.03	
F	9.04	9.26
H_2O	0.17	
-O=F	3.81	3.90
Total	99.75	100.00

(1) Bayan Obo, Inner Mongolia, China; average of 15 electron microprobe analyses, SIMS analysis for Li, H_2O calculated from stoichiometry; corresponding to $(K_{0.70}Li_{0.30}Na_{0.01})_{\Sigma=1.01}(Mg_{2.48}Fe_{0.06})_{\Sigma=2.54}(Si_{3.96}Al_{0.03})_{\Sigma=3.99}O_{10}[F_{1.92}(OH)_{0.08}]_{\Sigma=2.00}$. (2) $KMg_{2.5}Si_4O_{10}F_2$.

Mineral Group: Mica group; Mg-analog of montdorite.

Occurrence: Formed in metamorphosed carbonate rock in the transition zone between dolomite and slate in a rare earth-bearing deposit.

Association: Dolomite, calcite, tremolite, norbergite, huanghoite-(Ce); with minor phlogopite, barite, bastnäsite-(Ce), parisite-(Ce), fluorite.

Distribution: From the southern part of the East orebody, Bayan Obo, Inner Mongolia, People's Republic of China.

Name: Honors Professor Yang Zhuming (b. 1951), mineralogist and crystallographer, for his contributions to the mineralogy of the Bayan Obo deposit.

Type Material: National Museum of Nature and Science, Tokyo, Japan (NSM-MF15361) and the Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, People's Republic of China (KDX015).

References: (1) Miyawaki, R., H. Shimazaki, M. Shigeoka, K. Yokoyama, S. Matsubara, and H. Yurimoto (2011) Yangzhumingite, $KMg_{2.5}Si_4O_{10}F_2$, a new mineral in the mica group from Bayan Obo, Inner Mongolia, China. Eur. J. Mineral., 23, 467-473. (2) (2012) Amer. Mineral., 97, 761 (abs. ref. 1).

Yanomamite $InAsO_4 \cdot 2H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Dipyramidal crystals, to 0.2 mm, epitaxially overgrown by scorodite; typically in crusts.

Physical Properties: Hardness = 3.5–4 VHN = 571–743, 631 average (25 g load). D(meas.) = n.d. D(calc.) = 3.876(3)

Optical Properties: Semitransparent. *Color:* Pale green to yellow-green; colorless in transmitted light. *Streak:* White. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Orientation:* $X = a$; $Y = c$; $Z = b$. $n = 1.65$ 2V(meas.) = 55°–76°

Cell Data: *Space Group: Pbca.* $a = 10.446(6)$ $b = 9.085(4)$ $c = 10.345(6)$ $Z = 8$

X-ray Powder Pattern: Mangabeira deposit, Brazil.
4.53 (100), 5.70 (70), 3.874 (60), 3.250 (60), 4.163 (50), 3.110 (50), 5.16 (40)

Chemistry:

	(1)	(2)
As_2O_5	40.10	39.66
In_2O_3	45.80	47.91
Al_2O_3	0.21	
Fe_2O_3	1.11	
H_2O	[12.78]	12.43
Total	[100.00]	100.00

(1) Mangabeira deposit, Brazil; by electron microprobe, average of 12 determinations on several crystals, H_2O by difference; corresponds to $(In_{0.94}Fe_{0.04}Al_{0.01})_{\Sigma=0.99}As_{1.00}O_4 \cdot 2.02H_2O$.
(2) $InAsO_4 \cdot 2H_2O$.

Mineral Group: Variscite group.

Occurrence: A rare secondary mineral replacing arsenopyrite in quartz-topaz greisen veins in granite.

Association: Scorodite, arsenopyrite, indium-rich sphalerite, topaz, cassiterite.

Distribution: From the Mangabeira tin deposit, near Passa e Fica, Goiás, Brazil.

Name: For the Yanomami Indians, residents of the Amazon basin.

Type Material: Institute of Geosciences, University of Brasilia, Brasilia, Brazil; National School of Mines, Paris, France.

References: (1) Botelho, N.F., G. Roger, F. d'Yvoire, Y. Moëlo, and M. Volfinger (1994) Yanomamite, $InAsO_4 \cdot 2H_2O$, a new indium mineral from topaz-bearing greisen in the Goiás tin province, Brazil. Eur. J. Mineral., 6, 245–254. (2) (1995) Amer. Mineral., 80, 186 (abs. ref. 1).

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Yaroslavite $Ca_3Al_2F_{10}(OH)_2 \cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. As compact oval to spherical growths with radiating fibrous structure, to 3 mm.

Physical Properties: *Cleavage:* One direction, pinacoidal. *Fracture:* Irregular. Hardness = n.d. VHN = 264 D(meas.) = 3.09 D(calc.) = 3.15 Pale violet fluorescence under UV.

Optical Properties: Transparent. *Color:* White. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* Elongation negative. $\alpha = 1.413$ β = n.d. $\gamma = 1.423$ 2V(meas.) = 74°

Cell Data: *Space Group:* n.d. $a = 8.74(1)$ $b = 5.53(3)$ $c = 4.51(2)$ Z = [1]

X-ray Powder Pattern: Yaroslavsk deposit, Russia.
3.445 (10), 2.222 (8), 3.653 (7), 4.50 (6), 1.835 (6), 1.454 (6), 2.827 (5)

Chemistry:

	(1)	(2)
Al_2O_3	21.55	24.50
MgO	0.24	
CaO	42.77	40.42
F	46.90	45.64
H_2O^+	8.97	8.66
$-O = F_2$	19.70	19.22
Total	[100.73]	100.00

(1) Yaroslavsk deposit, Russia; original total given as 100.77%; corresponds to $Ca_{3.09}Al_{1.76}F_{10.08}(OH)_2 \cdot H_2O$. (2) $Ca_3Al_2F_{10}(OH)_2 \cdot H_2O$.

Occurrence: From the oxidized zone of a banded sellaite-tourmaline-fluorite deposit.

Association: Sellaite, gearksutite, chukhrovite-(Ce).

Distribution: From Russia, in the Yaroslavsk tin deposit, 50 km south of Lake Khanka, Primorskiy Territory, Siberia.

Name: For its occurrence in the Yaroslavsk deposit, Russia.

Type Material: Vernadsky Geological Museum, Moscow, Russia.

References: (1) Novikova, M.I., G.A. Sidorenko, and M.N. Kuznetsova (1966) Yaroslavite – a new calcium aluminum fluoride. Zap. Vses. Mineral. Obshch., 95, 39–44 (in Russian). (2) (1966) Amer. Mineral., 51, 1546–1547 (abs. ref. 1).

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Yarrowite Cu_9S_8

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\ 2/m$, $3m$, or 32. Massive and as stellate aggregates.

Physical Properties: *Cleavage:* {0001}. Hardness = n.d. VHN = 93–98 (15 g load). D(meas.) = n.d. D(calc.) = 4.89

Optical Properties: Opaque. *Color:* Blue; blue with a slight violet tint in oil under reflected light. *Streak:* n.d. *Luster:* Metallic. *Pleochroism:* Blue to bluish white. *Anisotropism:* Strong, orange-red.

R_1–R_2: (400) 19.2–32.9, (420) 18.6–32.3, (440) 17.9–31.4, (460) 16.9–30.5, (480) 15.6–29.5, (500) 14.2–28.2, (520) 12.4–27.0, (540) 10.7–25.6, (560) 9.08–24.3, (580) 7.51–23.1, (600) 6.15–22.2, (620) 5.02–22.2, (640) 4.33–23.0, (660) 4.38–23.6, (680) 5.96–23.4, (700) 9.44–23.0

Cell Data: *Space Group:* $P\overline{3}m1$, $P3m1$, $P31m$, or $P321$. $a = 3.800(1)$ $c = 67.26(4)$ $Z = 3$

X-ray Powder Pattern: Spionkop Creek, Canada.
1.899 (100), 3.061 (55), 2.767 (35), 5.032 (30), 3.678 (25), 2.849 (25), 5.955 (20)

Chemistry:

	(1)	(2)	(3)
Cu	68.5	68.5	69.03
Fe		0.1	
Ag		0.2	
S	30.4	31.5	30.97
Total	98.9	100.3	100.00

(1) Yarrow and Spionkop Creeks, Canada; by electron microprobe. (2) Cannington Park, England; by electron microprobe. (3) Cu_9S_8.

Occurrence: As weathering-produced lamellar replacements of other copper sulfides in stratabound red-bed copper deposits (Yarrow and Spionkop Creeks, Canada).

Association: Anilite, djurleite, spionkopite, tennantite (Yarrow and Spionkop Creeks, Canada).

Distribution: In the Upper Grinnell Formation, Spionkop Creek and Yarrow Creek areas of southwestern Alberta, Canada. In the High Rolls district, Otero Co., New Mexico, and at Washington Pass, Okanogan Co., Washington, USA. From Cannington Park, Bridgwater, Somerset, England. In the Lubin and Rudna copper mines, near Legnica, Zechstein copper district, Lower Silesia, Poland.

Name: For the type locality at Yarrow Creek, Canada.

Type Material: Canadian Geological Survey, Ottawa; Queen's University, Kingston, Ontario, Canada; National Museum of Natural History, Washington, D.C., 149430, 149431; Harvard University, Cambridge, Massachusetts, USA, 122290.

References: (1) Goble, R.J. (1980) Copper sulfides from Alberta: yarrowite, Cu_9S_8, and spionkopite, $Cu_{39}S_{28}$. Can. Mineral., 18, 511–518. (2) (1981) Amer. Mineral., 66, 1279 (abs. ref. 1).

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Yavapaiite $KFe^{3+}(SO_4)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 0.6 mm, slightly elongated along [010], showing poorly developed {001}, {101}, {100}, {201}, {110}; commonly equidimensional granular.

Physical Properties: *Cleavage:* Perfect on {001}, {100}; distinct on {110}. *Fracture:* Subconchoidal to uneven. *Tenacity:* Very brittle. Hardness = 2.5–3 D(meas.) = 2.88 D(calc.) = 2.891 Soluble in H_2O, with separation of $Fe(OH)_3$ from a weakly acid solution.

Optical Properties: Transparent. *Color:* Very pale purplish pink; colorless in transmitted light. *Streak:* White to pale yellow. *Luster:* Vitreous to nearly adamantine. *Optical Class:* Biaxial (–). *Orientation:* $Z = b$; $X \wedge c = 6°$. *Dispersion:* $r > v$, strong, horizontal. $\alpha = 1.593(2)$ $\beta = 1.684(2)$ $\gamma = 1.698(1)$ 2V(meas.) = 30.5°

Cell Data: *Space Group:* $C2/m$. $a = 8.152(5)$ $b = 5.153(4)$ $c = 7.877(5)$ $\beta = 94.90(7)°$ Z = 2

X-ray Powder Pattern: Jerome, Arizona, USA.
2.97 (100), 7.85 (90), 3.87 (80), 2.394 (80), 3.73 (75), 2.842 (75), 3.49 (60)

Chemistry:

	(1)	(2)
SO_3	55.84	55.78
Al_2O_3	0.11	
Fe_2O_3	27.82	27.81
FeO	0.07	
MgO	0.08	
Na_2O	0.62	
K_2O	15.46	16.41
Total	[100.00]	100.00

(1) Jerome, Arizona, USA; recalculated to 100% from an original total of 99.94% after deduction of H_2O^- 0.14% and SiO_2 + insoluble 0.26%; corresponds to $(K_{0.93}Na_{0.06})_{\Sigma=0.99}(Fe_{1.00}Mg_{0.01})_{\Sigma=1.01}(SO_4)_{2.00}$. (2) $KFe(SO_4)_2$.

Occurrence: In the fire zone of a pyritic orebody, formed under fumarolic conditions.

Association: Voltaite, sulfur, jarosite.

Distribution: From the open pit at the United Verde mine, Jerome, Yavapai Co., Arizona, USA.

Name: For the Yavapai Indian tribe who inhabit the region around Jerome, Arizona, USA.

Type Material: n.d.

References: (1) Hutton, C.O. (1959) Yavapaiite, an anhydrous potassium, ferric sulphate from Jerome, Arizona. Amer. Mineral., 44, 1105–1114. (2) Graeber, E.J. and A. Rosenzweig (1971) The crystal structures of yavapaiite, $KFe(SO_4)_2$, and goldichite, $KFe(SO_4)_2 \cdot 4H_2O$. Amer. Mineral., 56, 1917–1933. (3) Anthony, J.W., W.J. McLean, and R.B. Laughon (1972) The crystal structure of yavapaiite: a discussion. Amer. Mineral., 57, 1546–1549.

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Yazganite $NaFe^{3+}_2(Mg,Mn)(AsO_4)_3 \cdot H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As prismatic crystals or aggregtes, to 10 mm., elongated on [001], flattened on {010} with forms {010}, {100}, {110}, {131}, {111}, and $\{\bar{3}\ 11\}$.

Physical Properties: *Cleavage*: None. *Fracture*: Conchoidal. *Tenacity*: Brittle.
Hardness = 5 D(meas.) = 4.18(2) D(calc.) = 4.182(1)

Optical Properties: Translucent (slightly metallic). *Color*: Brown or brown-black.
Streak: Bright brown to yellow-gray. *Luster*: Adamantine.
Optical Class: Biaxial (-). α = 1.870(2) β = 1.897(2) γ = 1.900(2) 2V(meas.) = 35(2)°
2V(calc.) = 36.5(3)° *Dispersion*: $r < v$, strong. *Orientation*: $X \wedge a = 5°$, $Y = b$, $Z \wedge c = 17°$.
Pleochroism: Moderate; X = orange brown, yellow; $Z = Y$ = grayish yellow, colorless.

Cell Data: *Space Group: C2/c.* a = 12.181(1) b = 12.807(1) c = 6.6391(5) β = 112.441(9)°
Z = 4

X-ray Powder Pattern: Erciyes volcanic complex, Kiranardi, Turkey.
2.780 (100), 3.202 (40), 2.611 (40), 3.575 (30), 6.400 (20), 5.630 (20), 3.766 (15)

Chemistry:

	(1)
Na_2O	5.10
MgO	4.12
MnO	3.70
ZnO	0.30
Fe_2O_3	27.20
As_2O_5	56.94
H_2O	2.64
Total	100.00

(1) Erciyes volcanic complex, Kiranardi, Turkey; average of 5 electron microprobe analyses, H_2O by difference and confirmed by IR spectroscopy; corresponding to $Na_{0.99}Fe^{3+}_{2.05}(Mg_{0.61}Mn_{0.32}Zn_{0.02})_{\Sigma=0.95}As_{2.99}O_{12} \bullet 0.88H_2O$.

Occurrence: A hydrothermal mineral in fissures cutting porphyritic andesite in a stratovolcano.

Association: Cassiterite, hematite, magnetite, orpiment, realgar, tridymite.

Distribution: Erciyes stratovolcanic complex, 10 km south of the prefecture of Kayseri, near Hisarcik, Kiranardi, Turkey.

Name: Honors Dr. Evren Yazgan (b. 1943), a geologist who found the first specimens.

Type Material: Department of Mineralogy, Natural History Museum of Geneva, Switzerland, (478.188).

References: (1) Sarp, H. and R. Černý (2005) Yazganite, $NaFe^{3+}_2(Mg,Mn)(AsO_4)_3 \cdot H_2O$, a new mineral: its description and crystal structure. Eur. J. Mineral., 17, 367-373. (2) (2005) Amer. Mineral., 90, 1950 (abs. ref. 1).

Yeatmanite $Mn_9^{2+}Zn_6Sb_2^{5+}Si_4O_{28}$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As euhedral crystals, typically lath-shaped, rarely pseudohexagonal by twinning; as warped foliae. *Twinning:* Multiple lamellar on {010}; also on {023}.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Brittle. Hardness = 4
D(meas.) = 5.02 D(calc.) = 5.04

Optical Properties: Semitransparent. *Color:* Clove-brown. *Streak:* Very light brown. *Optical Class:* Biaxial (–). *Orientation:* $X \perp$ {100} cleavage. *Dispersion:* $r > v$, distinct. $\alpha = 1.864(4)$ $\beta = 1.895(4)$ $\gamma = 1.905(2)$ 2V(meas.) = 52° 2V(calc.) = 59°

Cell Data: *Space Group:* $P\bar{1}$. $a = 5.604(2)$ $b = 11.602(7)$ $c = 9.058(4)$ $\alpha = 92°10(3)'$ $\beta = 100°54(2)'$ $\gamma = 77°18(5)'$ Z = 1

X-ray Powder Pattern: Franklin, New Jersey, USA.
2.969 (100), 2.782 (60), 2.587 (60), 2.474 (60), 1.605 (60), 2.547 (40), 2.146 (40)

Chemistry:

	(1)
SiO_2	14.7
Sb_2O_5	18.9
FeO	1.0
MnO	37.8
ZnO	29.1
MgO	0.0
Total	101.5

(1) Franklin, New Jersey, USA; by electron microprobe, corresponds to $Mn_{8.89}Zn_{5.97}Sb_{1.95}Fe_{0.23}Si_{4.08}O_{28}$.

Occurrence: In veins in massive granular ore in a metamorphosed stratiform zinc deposit.

Association: Sarkinite, willemite, calcite, diopside, andradite, roméite.

Distribution: From Franklin, Sussex Co., New Jersey, USA.

Name: For Pope Yeatman (1861–1953), mining engineer at Franklin, New Jersey, USA.

Type Material: National School of Mines, Paris, France; Harvard University, Cambridge, Massachusetts, 92878; National Museum of Natural History, Washington, D.C., USA, C6290.

References: (1) Palache, C., L.H. Bauer, and H. Berman (1938) Yeatmanite, a new mineral, and sarkinite from Franklin, New Jersey. Amer. Mineral., 23, 527–530. (2) Moore, P.B. (1966) Catoptrite and yeatmanite – stuffed pyrochroite structures? Amer. Mineral., 51, 1494–1500. (3) Moore, P.B., T. Araki, and G.D. Brunton (1976) Catoptrite, $(Mn_5^{2+}Sb_2^{5+})(Mn_8^{2+}Al_4Si_2)O_{28}$, a novel close-packed oxide sheet structure. Neues Jahrb. Mineral., Abh., 127, 47–61. (4) Dunn, P.J. and P.B. Leavens (1980) Yeatmanite: new data. Amer. Mineral., 65, 196–199. (5) Kato, T. (1986) The crystal structure of yeatmanite. Mineral. J. (Japan), 13, 53–64.

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Yecoraite $\mathbf{Bi_5Fe_3^{3+}O_9(Te^{4+}O_3)(Te^{6+}O_4)_2 \cdot 9H_2O}$

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Crystal Data: Tetragonal or hexagonal. *Point Group:* n.d. Fibrous, to 5 μm, in matted massive aggregates.

Physical Properties: *Fracture:* Conchoidal. Hardness = 3 D(meas.) = 5.59(11) D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Yellow, orange, brown if impure. *Luster:* Pitchy.
Optical Class: Uniaxial (+). *Orientation:* Length-slow. $\omega = 1.812$ $\epsilon = 1.824$

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Near Yecora, Mexico.
2.743 (10), 3.212 (7), 5.45 (4), 3.722 (4), 2.962 (4), 1.940 (3), 1.625 (3)

Chemistry:

	(1)	(2)
TeO_3	16.83	16.91
TeO_2	7.65	7.68
As_2O_5	0.96	
Bi_2O_3	55.37	56.08
Fe_2O_3	10.45	11.53
H_2O	8.06	7.80
Total	99.32	100.00

(1) Near Yecora, Mexico; by electron microprobe, total Fe as Fe_2O_3, H_2O by the Penfield method, TeO_2:TeO_3 = 1:2 by wet methods; corresponding to $Bi_{4.96}Fe_{2.73}O_9(Te^{4+}O_3)_{1.00}(Te^{6+}O_4)_{2.00} \cdot 9.33H_2O$. (2) $Bi_5Fe_3O_9(Te^{4+}O_3)(Te^{6+}O_4)_2 \cdot 9H_2O$.

Occurrence: In fractures in a quartz vein emplaced in quartz monzonite, an oxidation product of tetradymite and pyrite.

Association: Tetradymite, pyrite, chalcopyrite, quartz, iron oxides.

Distribution: From the San Martin de Porres mine, west of Yecora, Sonora, Mexico.

Name: For the proximity of its first occurrence to Yecora, Sonora, Mexico.

Type Material: National School of Mines, Paris, France; The Natural History Museum, London, England, 1984,479.

References: (1) Williams, S.A. and F.P. Cesbron (1985) Yecoraite $Fe_3Bi_5(TeO_3)(TeO_4)_2O_9$, nH_2O. Bolletin Sociedad Mexicana de Mineralogia, A.C., 1, 10–16 (in English).
(2) Amer. Mineral., 71, 1547 (abs. ref. 1).

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Yedlinite $Pb_6CrCl_6(O,OH)_8$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}$. As prismatic hexagonal crystals, to 1 mm, with dominant $\{11\overline{2}0\}$ and $\{1101\}$, and $\{0001\}$, $\{10\overline{1}0\}$, $\{20\overline{2}1\}$.

Physical Properties: *Cleavage:* $\{11\overline{2}0\}$, distinct. *Tenacity:* Somewhat sectile. Hardness = ∼2.5 D(meas.) = 5.85(4) D(calc.) = 5.80

Optical Properties: Transparent to translucent. *Color:* Red-violet, may be zoned. *Streak:* White.
Optical Class: Uniaxial (–). *Pleochroism:* Moderate; O = pale Cobalt blue; E = lavender.
$\omega = 2.125$ $\epsilon = 2.059$

Cell Data: *Space Group:* $R\overline{3}$. $a = 12.868(2)$ $c = 9.821(2)$ Z = 3

X-ray Powder Pattern: Mammoth-St. Anthony mine, Arizona, USA.
2.952 (100), 2.622 (68), 4.506 (65), 6.44 (32), 2.473 (27), 3.879 (23), 1.787 (19)

Chemistry:

	(1)	(2)
Pb	79.4	75.81
Mn	0.7	
Cr	3.8	3.17
Cl	7.5	12.97
H		0.25
O	[8.6]	7.80
Total	[100.0]	100.00

(1) Mammoth-St. Anthony mine, Arizona, USA; by electron microprobe, average of ten analyses, O by difference. (2) $Pb_6CrCl_6O_4(OH)_4$.

Occurrence: A very rare late-stage secondary mineral in an oxidized polymetallic hydrothermal ore deposit.

Association: Diaboleite, phosgenite, matlockite, wherryite, wulfenite, dioptase, cerussite, mimetite, willemite, hemimorphite, fluorite, quartz.

Distribution: From the Mammoth-St. Anthony mine, Tiger, Pinal Co., Arizona, USA.

Name: To honor Leo Neal Yedlin (1908–1977), American mineral collector of microscopic specimens, of New Haven, Connecticut, USA, who first noted the mineral.

Type Material: Mineral Museum, University of Arizona, Tucson, Arizona, X5562; National Museum of Natural History, Washington, D.C., USA, R8171.

References: (1) McLean, W.J., R.A. Bideaux, and R.W. Thomssen (1974) Yedlinite, a new mineral from the Mammoth mine, Tiger, Arizona. Amer. Mineral., 59, 1157–1159. (2) Wood, M.M., W.J. McLean, and R.B. Laughon (1974) The crystal structure and composition of yedlinite. Amer. Mineral., 59, 1160–1165.

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Ye'elimite $Ca_4Al_6O_{12}(SO_4)$

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Crystal Data: Cubic. *Point Group:* 432. Crystals, to 15 μm, in aggregates.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.61 Decomposes in H_2O to give ettringite and $Al(OH)_3$.

Optical Properties: Semitransparent. *Color:* Colorless.
Optical Class: Isotropic. $n = 1.568(2)$

Cell Data: *Space Group:* $I4_132$ (synthetic). $a = 18.392$ Z = 16

X-ray Powder Pattern: Hatrurim Formation, Israel.
3.754 (100), 2.909 (15), 3.915 (10), 6.52 (4)

Chemistry:

	(1)	(2)
SO_3	14.54	13.12
Al_2O_3	47.84	50.12
Fe_2O_3	1.04	
CaO	36.56	36.76
Total	99.98	100.00

(1) Hatrurim Formation, Israel; by electron microprobe, average of two analyses, total Fe as Fe_2O_3; corresponds to $Ca_{3.98}(Al_{5.71}Fe_{0.08})_{\Sigma=5.79}O_{12}(S_{1.11}O_4)$. (2) $Ca_4Al_6O_{12}(SO_4)$.

Occurrence: In a high-temperature (> 900 °C) metamorphic assemblage in cobbles in a pseudo-conglomerate.

Association: Larnite, brownmillerite, sulfatian-phosphatian fluorapatite.

Distribution: In the lower part of the Hatrurim Formation, west of the Dead Sea, Israel.

Name: For Har Ye'elim and Nahal Ye'elim, the most conspicuous hill and wadi in the Hatrurim Basin, Israel.

Type Material: Geochemistry Department, Geological Survey of Israel; Department of Geology, Hebrew University, Jerusalem, Israel, 62815.

References: (1) Gross, S. (1984) Occurrence of ye'elimite and ellestadite in an unusual cobble from the "pseudo-conglomerate" of the Hatrurim Basin, Israel. Geol. Surv. Israel, Current Research 1983–84, 1–4. (2) (1987) Amer. Mineral., 72, 226–227 (abs. ref. 1).

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Yimengite $K(Cr^{3+}, Ti, Fe^{3+}, Mg)_{12}O_{19}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As irregular platy to tabular grains, to 2 mm; as rims around spinel grains.

Physical Properties: *Cleavage:* {0001}, perfect; $\{11\bar{2}1\}$, good; $\{10\bar{1}1\}$, poor. Hardness = 4.1 VHN = 273 (20 g load). D(meas.) = 4.34 D(calc.) = 4.35

Optical Properties: Opaque. *Color:* Black; gray to grayish white in reflected light. *Streak:* Brown. *Luster:* Metallic.
Optical Class: Uniaxial. *Pleochroism:* Weak.
R_1–R_2: (402) 12.7–17.7, (438) 11.3–18.2, (498) 15.1–16.0, (548) 15.7–16.2, (588) 13.0–16.5, (624) 13.5–16.7, (641) 12.6–15.5

Cell Data: *Space Group:* $P6_3/mmc$. $a = 5.875(11)$ $c = 22.9403(54)$ $Z = 2$

X-ray Powder Pattern: Yimeng Mountain area, China.
2.630 (10), 2.780 (9), 1.622 (9), 1.475 (8), 1.665 (6), 2.240 (5), 2.450 (4)

Chemistry:

	(1)	(2)
SiO_2	0.55	0.52
TiO_2	29.15	30.57
Al_2O_3	1.61	3.61
Fe_2O_3		2.76
Cr_2O_3	37.06	39.37
FeO	18.36	9.88
MgO	7.89	6.19
BaO	1.61	2.31
SrO		0.36
K_2O	3.75	4.50
Total	99.98	100.07

(1) Yimeng Mountain area, China; by electron microprobe, total Fe as FeO. (2) Guaniamo district, Venezuela; by electron microprobe, Fe^{2+}:Fe^{3+} calculated from stoichiometry; corresponding to $(K_{0.88}Ba_{0.14}Sr_{0.03})_{\Sigma=1.05}(Cr_{4.74}Ti_{3.50}Mg_{1.40}Fe^{2+}_{1.26}Al_{0.65}Fe^{3+}_{0.32}Si_{0.08})_{\Sigma=11.95}O_{19}$.

Mineral Group: Magnetoplumbite group.

Occurrence: A metasomatic alteration product of chromian spinel in kimberlites.

Association: Chromian spinel, mathiasite, olivine, phlogopite, pyrope, chromite, ilmenite, chromian diopside, apatite, zircon, moissanite, perovskite (Yimeng Mountain area, China).

Distribution: From the Yimeng Mountain area, Shandong Province, China. In the Guaniamo district, Bolivar Province, Venezuela.

Name: For its occurrence in the Yimeng Mountain area, China.

Type Material: n.d.

References: (1) Dong Zhenxin, Zhou Jianxiong, Lu Qi, and Peng Zhizhong (1983) Yimengite, $K(Cr, Ti, Fe, Mg)_{12}O_{19}$, a new mineral from China. Kexue Tongbao, 15, 932–936 (in Chinese). (2) (1985) Amer. Mineral., 70, 218 (abs. ref. 1). (3) Peng Zhizhong and Lu Qi (1985) The crystal structure of yimengite. Scientia Geologia Sinica, 28, 882–887 (in Chinese). (4) Nixon, P.H. and E. Condliffe (1989) Yimengite of K–Ti metasomatic origin in kimberlitic rocks from Venezuela. Mineral. Mag., 53, 305–309.

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Yingjiangite $K_2Ca(UO_2)_7(PO_4)_4(OH)_6 \cdot 6H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. Granular massive, to 0.015 mm.

Physical Properties: Hardness = 3–4 D(meas.) = 4.15; 4.54 D(calc.) = 4.17; 4.60 Radioactive; weak yellowish green fluorescence under UV.

Optical Properties: Transparent to translucent. *Color:* Golden yellow to yellow. *Luster:* Subadamantine to resinous.
Optical Class: Biaxial (–). *Pleochroism:* X = almost colorless; Y = pale yellow; Z = yellow. *Orientation:* Length-slow. α = 1.666–1.669 β = 1.692–1.703 γ = 1.707–1.710 2V(meas.) = 36°–38° 2V(calc.) = 36°

Cell Data: *Space Group:* $[C222_1]$ (by analogy to phosphuranylite). a = 13.73(1) b = 15.99(1) c = 17.33(2) Z = 8, or *Space Group:* $Bmmb$. a = 15.707(3) b = 17.424(3) c = 13.692(2) Z = 4

X-ray Powder Pattern: Tongbiguan village, China.
8.03 (100), 3.99 (90), 3.17 (70), 3.10 (70), 2.886 (60), 5.90 (40), 3.88 (40)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3	76.54	75.42	77.05	MnO		0.03	
P_2O_5	11.10	10.50	10.92	MgO		0.10	
ThO_2	0.51			CaO	1.57	2.00	2.16
SiO_2		1.20		Na_2O		0.15	
TiO_2		0.09		K_2O	2.46	3.37	3.63
Ce_2O_3	0.34			H_2O^+		6.19	
Y_2O_3	0.11			H_2O^-		0.25	
Fe_2O_3		0.31		H_2O	7.37		6.24
				Total	100.00	99.61	100.00

(1) Tongbiguan village, China; by electron microprobe, average of four analyses, H_2O may be by difference; then corresponds to $(K_{1.26}RE_{0.06}Th_{0.04})_{\Sigma=1.36}Ca_{0.68}(UO_2)_{6.42}(PO_4)_{3.76}(OH)_4 \cdot 8H_2O$. (2) Xiazhuang uranium deposit, China; corresponds to $(K_{1.90}Na_{0.12})_{\Sigma=2.02}Ca_{0.95}(UO_2)_{7.02}(PO_4)_{3.93}(OH)_{6.16} \cdot 6.07H_2O$. (3) $K_2Ca(UO_2)_7(PO_4)_4(OH)_6 \cdot 6H_2O$.

Occurrence: A secondary mineral in an oxidized zone of a uranium deposit (Tongbiguan village, China).

Association: Studtite, calcurmolite, tengchongite, autunite (Tongbiguan village, China).

Distribution: From Tongbiguan village, Yingjiang Co., Yunnan Province, and in the Xiazhuang uranium deposit, Guangdong Province, China.

Name: For Yingjiang Co., China, within which it was first noted.

Type Material: National Geological Museum, Beijing, China.

References: (1) Zhangru Chen, Zuzhu Huang, and Xiaofa Gu (1990) A new uranium mineral – yingjiangite. Acta Mineral. Sinica, 10(2), 102–105 (in Chinese with English abstract). (2) (1991) Amer. Mineral., 76, 1731–1732 (abs. ref. 1). (3) Jingyi Zhang, Anwa Wan, and Wenshu Gong (1992) New data on yingjiangite. Acta Petrologica Mineralogica, 11(2), 178–184 (in Chinese with English abs.). (4) (1994) Amer. Mineral., 79, 1214 (abs. ref. 3).

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Yixunite Pt_3In

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. A component of polycrystalline globules, to 2 mm, typically associated with damiaoite, always in the interior.

Physical Properties: *Tenacity:* "weakly malleble." Hardness = 5.8 VHN = 573–681, 634 average (50 g load). D(meas.) = n.d. D(calc.) = 18.21

Optical Properties: Opaque. *Color:* Steel-black; bright white with a yellowish tint in reflected light. *Streak:* Black. *Luster:* Metallic.
Optical Class: Isotropic.

R: (400) 49.9, (420) 51.7, (440) 53.8, (460) 55.3, (480) 56.9, (500) 58.5, (520) 60.1, (540) 61.7, (560) 63.5, (580) 64.9, (600) 66.5, (620) 68.4, (640) 70.3, (660) 72.4, (680) 74.5, (700) 76.6

Cell Data: *Space Group:* $Pm3m$. a = 3.988(3) Z = 1

X-ray Powder Pattern: Near Damiao village, China.
2.30 (100), 1.203 (80), 1.99 (60), 1.41 (40), 1.151 (40), 0.997 (20), 1.33 (10)

Chemistry:

	(1)	(2)
Pt	82.8	83.60
In	16.4	16.40
Total	99.2	100.00

(1) Near Damiao village, China; by electron microprobe, averge of eight analyses. (2) Pt_3In.

Occurrence: In a contact metasomatic Co–Cu–Pt-bearing vein in garnet-amphibole pyroxenite in contact with anorthosite and granite.

Association: Moncheite, sperrylite, cooperite, damiaoite, cobaltian malanite, bornite, chalcopyrite, carrolite, magnetite.

Distribution: From near Damiao village and the Yixun River, about 270 km north of Beijing, Hebei Province, China [TL].

Name: For its occurrence near the Yixun River, China.

Type Material: n.d.

References: (1) Yu Zuxiang (1997) Yixunite – an ordered new native indium and platinum alloy. Acta Geol. Sinica, 71(4), 332–335 (in Chinese with English abs.). (2) (1998) Amer. Mineral., 83, 655 (abs. ref. 1).

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Yoderite $Mg_2(Al,Fe^{3+})_6Si_4O_{18}(OH)_2$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. As anhedral grains, bladed or lathlike ‖ [010], to 12 mm.

Physical Properties: *Cleavage:* Partings [001], good and {100}, poor. Hardness = 6 D(meas.) = 3.39 D(calc.) = [3.33]

Optical Properties: Transparent. *Color:* Deep purple, emerald-green; in transmitted light, deep blue to olive-green, green to yellow. *Luster:* Vitreous.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = pale Prussian blue, green; Y = indigo, light yellow; Z = pale olive-green, yellow. *Orientation:* $Y = b$; $X \wedge a \simeq 9°$; $Z \wedge c \simeq 7°$. *Absorption:* $Y > X > Z$. α = 1.689–1.691 β = 1.691–1.693 γ = 1.712–1.715 2V(meas.) = 25°–30°

Cell Data: *Space Group:* $P2_1/m$. $a = 8.022(2)$ $b = 5.816(1)$ $c = 7.250(2)$ $\beta = 104.9(1)°$ Z = [1]

X-ray Powder Pattern: Mautia Hill, Tanzania.
3.50 (100), 3.03 (80), 2.61 (60), 2.00 (60), 1.82 (60), 3.23 (50), 3.19 (50)

Chemistry:

	(1)	(2)
SiO_2	35.94	36.07
TiO_2	0.11	0.07
Al_2O_3	42.95	42.76
Fe_2O_3	5.16	4.08
Mn_2O_3	0.62	0.85
FeO	0.24	0.19
MnO	0.23	0.13
MgO	12.05	11.83
H_2O^+	2.69	[2.69]
P_2O_5		0.36
Total	[99.99]	[99.03]

(1) Mautia Hill, Tanzania; Fe^{2+}:Fe^{3+} from Mössbauer spectroscopy. (2) Do.; by electron microprobe, Fe^{2+}:Fe^{3+} from Mössbauer spectroscopy, H_2O from (1); corresponds to $(Mg_{1.95}Fe^{2+}_{0.02}Mn^{2+}_{0.01})_{\Sigma=1.98}(Al_{5.57}Fe^{3+}_{0.34}Mn^{3+}_{0.07}Ti_{0.01})_{\Sigma=5.99}(Si_{3.98}P_{0.03})_{\Sigma=4.01}O_{18.02}(OH)_{1.98}$.

Occurrence: A major phase in quartz-kyanite-talc schist formed under conditions of ~10 kbar H_2O pressure and 800 °C.

Association: Kyanite, talc, hematite, quartz.

Distribution: On Mautia Hill, Kongwa, Central Province, Tanzania.

Name: For Hatten Schuyler Yoder, Jr. (1921–), petrologist with the Geophysical Laboratory, Washington, D.C., USA.

Type Material: Geological Survey of Tanzania, JH 2563/2, JH 2563/14; National Museum of Natural History, Washington, D.C., USA, 137854.

References: (1) McKie, D. (1959) Yoderite, a new hydrous magnesium iron alumino-silicate from Mautia Hill, Tanganyika. Mineral. Mag., 32, 282–307. (2) (1960) Amer. Mineral., 45, 753 (abs. ref. 1). (3) Abu-Eid, R.M., K. Langer, and F. Seifert (1978) Optical absorption and Mössbauer spectra of purple and green yoderite, a kyanite-related mineral. Phys. Chem. Minerals, 3, 271–289. (4) Higgins, J.B., P.H. Ribbe, and Y. Nakajima (1982) An ordering model for the commensurate antiphase structure of yoderite. Amer. Mineral., 67, 76–84. (5) Fockenberg, T. and W. Schreyer (1991) Yoderite, a mineral with essential ferric iron: its lack of occurrence in the system $MgO–Al_2O_3–SiO_2–H_2O$. Amer. Mineral., 76, 1052–1060.

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Yofortierite $(Mn^{2+},Mg)_5Si_8O_{20}(OH)_2 \cdot 8-9H_2O$

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Crystal Data: Monoclinic, probable. *Point Group:* m. As very fine radiating fibers, to 3 cm, divergent sprays, spherical aggregates.

Physical Properties: *Tenacity:* Elastic. Hardness = 2.5 D(meas.) = 2.18 D(calc.) = [2.82]

Optical Properties: Transparent to opaque. *Color:* Pink, purple, violet, beige, reddish to orange-brown, dark brown, bronze; in transmitted light, pale maroon. *Luster:* Silky. *Optical Class:* Biaxial. *Pleochroism:* Distinct. *Orientation:* $X \wedge$ fiber axis = 8°. *Absorption:* Maximum $\perp$ length of fibers. $\alpha = 1.530$ β = n.d. $\gamma = 1.559$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $[Pn]$ (ICDD 27-312, by analogy to paligorskite). $a = 12.759$ $b = 18.369$ $c = 5.024$ $\beta = 91.98°$ Z = 2

X-ray Powder Pattern: Mont Saint-Hilaire, Canada.
10.5 (100), 3.302 (90), 2.621 (30), 2.510 (20), 4.41 (18), 3.680 (15), 2.526 (15)

Chemistry:

	(1)
SiO_2	48.44
TiO_2	0.09
Al_2O_3	1.49
Cr_2O_3	0.007
MnO	28.41
ZnO	1.10
MgO	2.35
CaO	0.90
K_2O	0.05
H_2O	17.22
Total	100.057

(1) Mont Saint-Hilaire, Canada; by XRF, AA, and TGA; corresponds to $(Mn_{3.97}Mg_{0.58}Al_{0.29}Ca_{0.16}Zn_{0.13}K_{0.01}Ti_{0.01})_{\Sigma=5.15}Si_8O_{20.31}(OH)_{1.99} \cdot 9.06H_2O$.

Occurrence: A late-stage hydrothermal mineral in pegmatite veins within nepheline syenite in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada);

Association: Analcime, sérandite, eudialyte, polylithionite, aegirine, microcline, albite (Mont Saint-Hilaire, Canada).

Distribution: From Mont Saint-Hilaire and in the Saint-Amable sill, near Varennes, Quebec, Canada. On Mt. Karnasurt, Lovozero massif, Russia.

Name: For Yves Oscar Fortier (1914–), former Director of the Geological Survey of Canada (1964–1972).

Type Material: École Polytechnique, Montreal, 13017; Royal Ontario Museum, Toronto, M33627; Canadian Museum of Nature, Ottawa, Canada; National Museum of Natural History, Washington, D.C., USA, 131952; The Natural History Museum, London, England, 1975,418; University of Paris, Paris; Museum of Natural History, Paris; National School of Mines, Paris, France.

References: (1) Perrault, G., Y. Harvey, and R. Pertsowsky (1975) La yofortierite, un nouveau silicate hydraté de manganèse de St-Hilaire, P.Q. Can. Mineral., 13, 68–74 (in French with English abs.). (2) (1976) Amer. Mineral., 61, 341 (abs. ref. 1). (3) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 112.

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Yoshimuraite $(Ba,Sr)_2Mn_2^{2+}Ti(SiO_4)_2(PO_4,SO_4)(OH,Cl)$

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Crystal Data: Triclinic. *Point Group:* $\bar{1}$. As platy to bladed or tabular crystals, to 5 cm; in stellate groups and platy masses. *Twinning:* Polysynthetic on {010}, common.

Physical Properties: *Cleavage:* Perfect on {010}, distinct on {101}. *Tenacity:* Brittle. Hardness = 4.5 D(meas.) = 4.13–4.20 D(calc.) = 4.21

Optical Properties: Transparent to translucent. *Color:* Orange, red, dark brown; in transmitted light, brown, orange-brown to yellow.
Optical Class: Biaxial (+). *Pleochroism:* X = bright yellow; Y = orange-brown; Z = brown. *Orientation:* $X' \simeq a$; $Z' \simeq c$. *Dispersion:* $r > v$. *Absorption:* $Z \geq Y > Z$. $\alpha = 1.763$–1.768 $\beta = 1.777$ $\gamma = 1.785$–1.794 2V(meas.) = 80°–90°

Cell Data: *Space Group:* $P\bar{1}$. $a = 7.00(1)$ $b = 14.71(2)$ $c = 5.39(1)$ $\alpha = 93.5(2)°$ $\beta = 90.2(2)°$ $\gamma = 95.3(2)°$ Z = 2

X-ray Powder Pattern: Noda-Tamagawa mine, Japan.
3.40 (10), 2.94 (10), 4.90 (6), 3.24 (6), 2.78 (6), 4.11 (4), 3.13 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	18.25	17.20	SrO	4.62	3.03
TiO_2	10.00	7.47	BaO	33.51	38.11
Al_2O_3		0.21	Na_2O	0.16	0.10
Fe_2O_3	1.32	3.48	K_2O	0.03	0.01
FeO	1.47	3.16	Cl	0.41	
MnO	17.64	15.83	H_2O	2.34	1.06
ZnO	0.50		P_2O_5	3.98	4.62
MgO	0.56	0.31	SO_3	5.40	3.84
CaO		1.45	$-O = Cl_2$	0.09	
			Total	100.10	99.88

(1) Noda-Tamagawa mine, Japan; corresponds to $(Ba_{1.50}Sr_{0.30}Na_{0.04})_{\Sigma=1.84}(Mn_{1.70}Fe^{2+}_{0.14}Mg_{0.10}Zn_{0.04})_{\Sigma=1.98}(Ti_{0.85}Fe^{3+}_{0.11})_{\Sigma=0.96}Si_{2.08}O_8[(P_{0.76}S_{0.92})_{\Sigma=1.68}O_4](OH,Cl)_{1.45}$. (2) Taguchi mine, Japan; corresponds to $(Ba_{1.72}Sr_{0.20}Na_{0.01})_{\Sigma=1.93}(Mn_{1.55}Fe^{2+}_{0.30}Ca_{0.18}Mg_{0.04})_{\Sigma=2.07}(Ti_{0.65}Fe^{3+}_{0.29}Al_{0.02})_{\Sigma=0.96}Si_{1.99}O_{8.40}[(P_{0.44}S_{0.33})_{\Sigma=0.77}O_{3.08}](OH)_{0.82}$.

Occurrence: In the border facies of an alkalic pegmatite cutting a stratiform manganese deposit (Noda-Tamagawa mine, Japan).

Association: Richterite, rhodonite, barian potassic feldspar, "aegirine-augite," riebeckite, quartz.

Distribution: In the Noda-Tamagawa mine, Tamagawamura, and the Hijikuzu mine, Iwate Prefecture, and the Taguchi mine, Shidara, Aichi Prefecture, Japan.

Name: In honor of Professor Toyofumi Yoshimura, Kyushu University, Hakozaki, Japan.

Type Material: National Science Museum, Tokyo, Japan, M15110; The Natural History Museum, London, England; Harvard University, Cambridge, Massachusetts, 106170; National Museum of Natural History, Washington, D.C., USA, 107416.

References: (1) Watanabe, T., Y. Takeuchi, and J. Ito (1961) The minerals of the Noda-Tamagawa mine, Iwate Prefecture, Japan. III. Yoshimuraite, a new barium-titanium-manganese-silicate mineral. Mineral. J. (Japan), 3, 156–167. (2) (1961) Amer. Mineral., 46, 1515–1516 (abs. ref. 1). (3) Hirowatari, F. and K. Isono (1966) Yoshimuraite from the manganese ore deposits of Taguchi mine, Aichi Pref., Japan. J. Mineral. Soc. Japan, 6, 230–243 (in Japanese). (4) (1966) Mineral. Abs., 17, 694 (abs. ref. 3).

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Yoshiokaite $Ca(Al,Si)_2O_4$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. As anhedral, angular, strongly fractured crystal fragments, to 235 μm, in glass.

Physical Properties: *Cleavage:* Poor on {100}; commonly showis sets of {201} and {200} lamellae which are believed not to be related by twinning, but were probably shock-induced. Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* [White (?).]
Optical Class: Uniaxial (+); anomalously biaxial due to strain. ω = n.d. ϵ = n.d.
2V(meas.) = $< 5°$

Cell Data: *Space Group:* $P\bar{3}$, (probable). $a = 9.939(2)$ $c = 8.245(2)$ Z = n.d.

X-ray Powder Pattern: Moon.
8.57 (100), 2.979 (91), 3.718 (79), 2.871 (78), 1.158 (51), 2.062 (41), 4.123 (36)

Chemistry:

	(1)	(2)
SiO_2	28.0	15.8
TiO_2	0.07	0.12
Al_2O_3	45.9	56.3
FeO	0.18	0.41
MgO	0.98	0.40
CaO	25.5	27.8
Na_2O	0.00	0.09
K_2O	0.00	0.01
Total	100.7	100.9

(1) Moon; by electron microprobe, corresponding to $(Ca_{0.66}Mg_{0.04})_{\Sigma=0.70}(Al_{1.30}Si_{0.67})_{\Sigma=1.97}O_4$.
(2) Do.; by electron microprobe, corresponding to $(Ca_{0.73}Mg_{0.02}Fe_{0.01})_{\Sigma=0.76}$ $(Al_{1.64}Si_{0.39})_{\Sigma=2.03}O_4$.

Occurrence: A metastable phase, as shocked crystal fragments and in devitrified glasses in a regolith breccia. The glass may have resulted from shock melting of alkali anorthite on the ancient lunar highlands.

Association: Glass.

Distribution: On the Moon, near the Apollo 14 landing site.

Name: For T. Yoshioka (1935–1983), who studied the synthetic phase.

Type Material: NASA, Johnson Space Center, Houston, Texas, USA, regolith breccia 14076.

References: (1) Vaniman, D.T. and D.L. Bish (1990) Yoshiokaite, a new Ca,Al-silicate mineral from the Moon. Amer. Mineral., 75, 676–686.

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Yttrialite-(Y) $(Y,Th)_2Si_2O_7$

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Crystal Data: Monoclinic; commonly metamict. *Point Group:* $2/m$. Massive.

Physical Properties: *Cleavage:* Platy [*sic*]. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 4.56–4.58 D(calc.) = 4.0 Radioactive.

Optical Properties: Translucent to nearly opaque. *Color:* Olive-green, becoming yellow-orange with alteration. *Luster:* Vitreous to greasy or dull.
Optical Class: Biaxial. $n = 1.760$, metamict. $\alpha = 1.749$ (synthetic $Y_2Si_2O_7$). $\beta = 1.751$–1.758 $\gamma = 1.754$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $P2_1/m$ (synthetic $Y_2Si_2O_7$). $a = 7.50$ $b = 8.06$ $c = 5.02$ $\beta = 112.00°$ Z = 2

X-ray Powder Pattern: Baringer Hill, Texas, USA; after heating to 985 °C.
3.056 (100), 3.463 (80), 2.627 (70), 2.058 (65), 2.393 (60), 4.696 (50), 3.177 (40)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	29.17	28.70	FeO	2.89	
ThO_2	12.00	6.97	MnO	0.77	0.48
UO_2	0.83	2.59	PbO	0.85	
Al_2O_3	0.55		MgO		0.15
Y_2O_3	46.50	31.37	CaO	0.60	0.93
Ce_2O_3	1.86	0.66	H_2O		3.68
RE_2O_3	2.94	23.47	LOI	0.79	
Fe_2O_3		1.18	Total	99.75	100.18

(1) Baringer Hill, Texas, USA. (2) Ivedal, Norway; $RE_2O_3 = La_2O_3$ 0.14%, Pr_2O_3 0.15%, Nd_2O_3 1.09%, Sm_2O_3 1.17%, Eu_2O_3 0.05%, Gd_2O_3 2.44%, Tb_2O_3 0.61%, Dy_2O_3 5.35%, Ho_2O_3 1.00%, Er_2O_3 3.69%, Tm_2O_3 0.75%, Yb_2O_3 5.58%, Lu_2O_3 1.45%.

Occurrence: A late-stage mineral in some rare-earth-bearing pegmatites.

Association: Gadolinite, thalenite, thortveitite, britholite-(Y), fergusonite, xenotime, allanite, microcline, albite, quartz, biotite, zircon, magnetite, spessartine, fluorite, tombarthite.

Distribution: In the USA, in Texas, from the Baringer Hill pegmatite, 26 km west of Burnet, and from Rode Ranch, near Bluffton, Llano Co., and in the Clear Creek pegmatite, Burnet Co. At Ivedal and Högetveit, Evje, Norway. From Åskagen, Vårmland, Sweden. At Fusamata and Suishoyama, Fukushima Prefecture; Yashima, Kagawa Prefecture; and Komenono, Ehime Prefecture, Japan.

Name: For the *yttrium* in its composition.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 512. (2) Omori, K. and S. Hasegawa (1953) Yttrialite and abukumalite from Iizaka Village, Fukushima Prefecture. Sci. Reports, Tohoku Univ., 4, 151–155. (3) (1953) Chem. Abs., 47, 8595 (abs. ref. 2). (4) Ito, J. and H. Johnson (1968) Synthesis and study of yttrialite. Amer. Mineral., 53, 1940–1952. (5) Nilssen, B. (1971) Yttrialite from Ivedal, Iveland, south Norway. Norsk. Geol. Tidsskr., 51, 1–8. (6) (1971) Mineral. Abs., 22, 290 (abs. ref. 5). (7) Batalieva, N.G. and Y.A. Pyatenko (1972) Artificial yttrialite ("y-phase") – a representative of a new structure type in the rare earth diorthosilicate series. Kristallografiya (Sov. Phys. Crystal.), 16, 905–910 (in Russian).

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Yttrobetafite-(Y) $(Y,U,Ce)_2(Ti,Nb,Ta)_2O_6(OH)$

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Crystal Data: Cubic; metamict. *Point Group:* $[4/m\ \overline{3}\ 2/m]$ (by analogy to betafite). As grains, to 200 μm.

Physical Properties: *Fracture:* [Conchoidal to uneven.] *Tenacity:* [Brittle.]
Hardness = [3–5.5] D(meas.) = 4.90 D(calc.) = 5.05 Radioactive.

Optical Properties: Transparent. *Color:* Greenish to reddish. *Luster:* Dull, greasy on fresh fractures.
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group:* $[Fd3m.]$ a = n.d. Z = [8]

X-ray Powder Pattern: Alakurtti, Russia; after heating at 900 °C.
1.694 (10), 3.258 (8), 2.985 (7), 2.501 (6), 1.180 (6), 1.631 (3), 1.104 (3)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
UO_3		5.80		Ce_2O_3	6.03	4.01	3.13
WO_3			0.44	RE_2O_3			9.98
U_3O_8	12.84			Fe_2O_3	4.30	4.00	
Nb_2O_5	27.87	36.35	17.67	FeO			5.91
Ta_2O_5	7.73	8.50	1.16	MnO	0.75	1.10	0.20
SiO_2	3.40	3.92		PbO	0.55		8.94
TiO_2	15.20	14.90	22.69	MgO	0.09	0.30	
ZrO_2	0.11		0.26	CaO	2.23	1.66	7.79
ThO_2	1.20	0.90	6.95	$(Na,K)_2O$	0.20	0.34	
UO_2		0.20	4.33	F	0.30		
Al_2O_3	0.86	0.98		H_2O^+	4.47	5.93	
Y_2O_3	10.60	5.12	10.85	H_2O^-	1.20	5.80	
La_2O_3			0.63	$-O = F_2$	0.12		
				Total	99.81	[99.81]	100.93

(1) Alakurtti, Russia. (2) Do.; original total given as 99.88%. (3) Moon; by electron microprobe, total Fe as FeO, average of 13 analyses of several grains; $RE_2O_3 = Sm_2O_3$ 0.76%, Eu_2O_3 0.03%, Gd_2O_3 1.11%, Yb_2O_3 1.38%, remaining RE 6.70%; Fe^{2+}:Fe^{3+} calculated from stoichiometry, then corresponding to $(Ca_{0.61}Y_{0.42}RE_{0.32}Fe^{2+}_{0.25}Pb_{0.18}Th_{0.12}U_{0.07}La_{0.02}Mn_{0.01})_{\Sigma=2.00}(Ti_{1.24}Nb_{0.58}Fe_{0.14}Ta_{0.02}Zr_{0.01}W_{0.01})_{\Sigma=2.00}O_{6.80}$.

Mineral Group: Pyrochlore group, betafite subgroup; $RE_A > 20\%$ (with Y > Ce); $2Ti_B \geq (Nb + Ta)_B$.

Occurrence: In replacement bodies in a quartz-plagioclase-microcline pegmatite (Alakurtti, Russia); in a fragment of granophyre from soil and breccia (Moon).

Association: Yttropyrochlore-(Y), plumbian uranpyrochlore, garnet, fergusonite, columbite (Alakurtti, Russia); potassian feldspar, zircon, apatite, quartz, silica glass (Moon).

Distribution: From Alakurtti, northwestern Karelia, Russia. On the surface of the Moon.

Name: As the YTTRium-dominant *betafite* member of the pyrochlore group.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, vis337.

References: (1) Kalita, A.P., A.V. Bykova, and M.V. Kukharchik (1962) Varieties of pyrochlore and betafite in pegmatites. Inst. mineral. geokhim. kristallokhim. redkikh. elementov., Trudy, 8, 210–211 (in Russian). (2) Kalita, A.P. (1959) New data on some minerals of the Alakurtti veins. Inst. mineral. geokhim. kristallokhim. redkikh. elementov., Trudy, 2, 164–172 (in Russian). (3) (1964) Amer. Mineral., 49, 440–441 (abs. refs. 1 and 2). (4) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (5) Meyer, C. and S. V. Yang (1988) Tungsten-bearing yttrobetafite in lunar granophyre. Amer. Mineral., 73, 1420–1425.

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Yttrocolumbite-(Y) $(Y, U, Fe^{2+})(Nb, Ta)O_4$

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Crystal Data: [Orthorhombic; metamict] [by analogy to yttrotantalite-(Y)]. *Point Group:* n.d. Habit not stated.

Physical Properties: Hardness = 5 D(meas.) = 5.49 D(calc.) = n.d. Strongly radioactive.

Optical Properties: [Opaque.] *Color:* Black. *Streak:* Brown. *Luster:* Vitreous. *Optical Class:* [Isotropic.] n = n.d.
R: n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)		(1)
UO_3	3.10	Al_2O_3	1.62
Nb_2O_5	31.21	Y_2O_3	14.06
Ta_2O_5	21.50	Ce_2O_3	2.01
As_2O_5	0.10	Fe_2O_3	10.52
SiO_2	1.78	MnO	5.08
TiO_2	1.20	MgO	0.66
ZrO_2	0.25	CaO	1.87
SnO_2	0.66	LOI	1.33
ThO_2	2.65	Total	99.60

(1) Mozambique.

Occurrence: [A rare accessory mineral in granite pegmatites.]

Association: n.d.

Distribution: From an unspecified locality in Mozambique.

Name: As the niobium (*columbium*) analog of yttrotantalite.

Type Material: n.d.

References: (1) Lepierre, C. (1937) Ytrocolumbite de Moçambique. Mem. Acad. Ciên. Lisboa, Cl. Ciên., 1, 374 (in Portuguese) [ytrocolumbite = yttrocolumbite-(Y)]. (2) (1940) Mineral. Abs., 7, 470 (abs. ref. 1).

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Yttrocrasite-(Y) $(Y, Th, Ca, U)(Ti, Fe^{3+})_2(O, OH)_6$

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Crystal Data: Orthorhombic (probable); metamict. *Point Group:* n.d. Crystals rough, showing three pinacoids, a prism, and an orthodome.

Physical Properties: *Fracture:* Uneven, small conchoidal. Hardness = 5.5–6 D(meas.) = 4.80 D(calc.) = n.d. Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black, brown where altered; in transmitted light, amber-yellow to light yellow. *Luster:* Bright pitchy to resinous. *Optical Class:* Isotropic; weakly anisotropic in part. n = 2.12–2.15

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)		(1)
UO_3	0.64	$(Ce, La)_2O_3$	2.92
WO_3	1.87	Fe_2O_3	1.44
Nb_2O_5	trace	MnO	0.13
Ta_2O_5	trace	PbO	0.48
SiO_2	trace	MgO	trace
TiO_2	49.72	CaO	1.83
ThO_2	8.75	H_2O^+	4.36
UO_2	1.98	H_2O^-	0.10
$(Y, Er)_2O_3$	25.67	CO_2	0.68
		Total	100.57

(1) Burnet Co., Texas, USA.

Occurrence: In granite pegmatite.

Association: n.d.

Distribution: In the USA, from Burnet Co., Texas, about five km east of Baringer Hill.

Name: From a dominance of YTTRium in the composition, and the Greek for *a mixing*, as there are many other elements in addition to yttrium.

Type Material: National Museum of Natural History, Washington, D.C., USA, 119841.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 793.

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Yttropyrochlore-(Y) $(Y, Na, Ca, U)_{1-2}(Nb, Ta, Ti)_2(O, OH)_7$

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Crystal Data: Cubic; metamict. *Point Group:* $[4/m\ \overline{3}\ 2/m]$ (by analogy to the pyrochlore group). Massive.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* [Brittle.] Hardness = 4.5–5 D(meas.) = 3.60–3.80 D(calc.) = [4.07] Radioactive.

Optical Properties: Semitransparent. *Color:* Chocolate-brown. *Luster:* Vitreous to adamantine.
Optical Class: Isotropic. $n = 1.830–1.835$

Cell Data: *Space Group:* $[Fd3m]$ after heating at 1100 °C. $a = 10.0–10.34$ Z = 8

X-ray Powder Pattern: Alakurtti, Russia; after heating at 1100 °C.
2.975 (10), 1.695 (9), 1.488 (7), 3.152 (5), 1.550 (5), 3.45 (4), 2.578 (3)

Chemistry:

	(1)		(1)
UO_3	9.72	Fe_2O_3	4.30
Nb_2O_5	37.54	MnO	0.35
Ta_2O_5	5.47	MgO	0.26
SiO_2	3.78	CaO	2.82
TiO_2	6.29	Na_2O	2.43
ThO_2	0.26	K_2O	0.31
Y_2O_3	11.34	H_2O^+	7.77
Ce_2O_3	0.66	H_2O^-	6.48
		Total	99.78

(1) Alakurtti, Russia; corresponding to $(Y, Na, Ca, U)_{1.27}(Nb, Ta, Ti, Fe)_2O_{5.40}(OH)_{0.60} \cdot 1.13H_2O$.

Mineral Group: Pyrochlore group and subgroup; $RE_A > 20\%$ (with Y > Ce); $(Nb + Ta)_B > 2Ti_B$; $Nb_B > Ta_B$.

Occurrence: In replacement zones in a pegmatite.

Association: Yttrobetafite-(Y), plumbian uranpyrochlore, garnet, fergusonite, columbite, albite, muscovite.

Distribution: From Alakurtti, northwestern Karelia, Russia.

Name: As the YTTRium-dominant member of the *pyrochlore* group.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 62258.

References: (1) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410 [obruchevite = yttropyrochlore-(Y)]. (2) Kalita, A.P. (1957) On the composition of obruchevite – a hydrated uranium–yttrium variety of pyrochlore. Doklady Acad. Nauk SSSR, 117, 120 (in Russian). (3) (1958) Amer. Mineral., 43, 797 (abs. ref. 2).

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Yttrotantalite-(Y) $(Y, U, Fe^{2+})(Ta, Nb)O_4$

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Crystal Data: Orthorhombic; metamict. *Point Group:* n.d. Crystals rough, prismatic ‖ [001], {110} and {010} prominent, several other forms; may be tabular on {010}.

Physical Properties: *Cleavage:* {010}, indistinct. *Fracture:* Small conchoidal. Hardness = 5–5.5 D(meas.) = 5.7(2) D(calc.) = n.d. Weakly magnetic.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black, brownish black, brown; red-brown to dark brown in transmitted light, may show zonation; light grayish brown in reflected light, with brown or yellowish gray internal reflections. *Streak:* Gray. *Luster:* Submetallic to vitreous, greasy.
Optical Class: Isotropic. $n = 2.15(2)$ *Anisotropism:* Discernible.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Ytterby, Sweden; after heating at 1000 °C for one hour.
2.95 (10), 1.81 (9), 1.55 (9), 2.56 (6), 1.183 (6), 1.152 (6), 1.053 (5)

Chemistry:

	(1)	(2)		(1)	(2)
WO_3	0.66	2.02	Ce_2O_3	0.42	0.51
Nb_2O_5	20.38	17.75	Er_2O_3	3.58	3.54
Ta_2O_5	39.53	37.26	FeO	7.48	7.61
SiO_2	0.96	0.61	MnO	1.85	1.01
TiO_2	1.67	2.63	PbO		0.30
ZrO_2	0.57	0.46	BeO	0.35	0.58
SnO_2	1.20	2.96	MgO	0.15	0.15
ThO_2	0.67	0.81	CaO	1.28	2.42
UO_2	3.85	4.48	Na_2O	0.57	0.81
Y_2O_3	12.48	12.52	K_2O		0.10
La_2O_3	1.71	0.41	H_2O	0.51	1.16
			Total	99.87	100.10

(1) Berg, Norway. (2) Hattevik, Norway.

Polymorphism & Series: Dimorphous with formanite-(Y).

Occurrence: A rare accessory mineral in granite pegmatites.

Association: Albite, garnet, topaz, fergusonite (Ytterby, Sweden); monazite, columbite, allanite, samarskite, xenotime, gadolinite, mica (Norway).

Distribution: In Sweden, from Ytterby, on Resarö Island, near Vaxholm, near Falun, at Finbo and Broddbo; and in the Skuleboda pegmatite, near Väne Ryr, Västergötland. In Norway, at Hattevik, east of Dillingö, and near Berg. In the Rare Metals mine, Aquarius Mountains, Mohave Co., Arizona, USA. From the Tanokamiyama district, Shiga Prefecture, Japan.

Name: For YTTRium in its composition and relation to *tantalite*.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 763–764. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 534–538.

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Yttrotungstite-(Y) $YW_2O_6(OH)_3$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Lathlike crystals, flattened on {100} and elongated along [001], with {110} and very rare {101}, to 0.2 mm, in druses; typically earthy. *Twinning:* On {100}, probably universal, as contact twins.

Physical Properties: *Cleavage:* {010}, good; on $\{10\overline{1}\}$, probable, very poor. Hardness = n.d. D(meas.) = 5.96 D(calc.) = [5.98]

Optical Properties: Semitransparent. *Color:* Pale yellow.
Optical Class: Biaxial (–). *Pleochroism:* X = pale yellow; $Y = Z$ = dark yellow. *Orientation:* $Z = b$; $X \wedge c = 26°$. $\alpha = 1.89$ $\beta = 1.98$ $\gamma = 2.02$ 2V(meas.) = 68° 2V(calc.) = 65°

Cell Data: *Space Group:* $P2_1/m$. $a = 6.954(6)$ $b = 8.637(9)$ $c = 5.771(6)$ $\beta = 104°56(4)'$ Z = 2

X-ray Powder Pattern: Kramat Pulai mine, Malaysia.
4.69 (vvs), 3.26 (vvs), 2.028 (vs), 6.73 (ms), 3.36 (ms), 2.869 (ms), 2.790 (ms)

Chemistry:

	(1)	(2)	(3)
WO_3	71.45	71.64	76.82
SiO_2	0.37	0.34	
TiO_2	0.01		
Al_2O_3	0.87	0.90	
Y_2O_3	10.29		18.70
RE_2O_3	11.24	20.58	
Fe_2O_3	0.36	0.09	
MgO	0.17	0.37	
CaO	0.32	0.77	
H_2O^+	4.96	4.88	4.48
H_2O^-	0.07	0.20	
Total	100.11	99.77	100.00

(1) Kramat Pulai mine, Malaysia; $Y_2O_3 + RE_2O_3$ normalized from a detailed analysis totaling 18.96% to the 21.53% total determined here, to give: La_2O_3 0.28%, Ce_2O_3 2.06%, Pr_2O_3 0.33%, Nd_2O_3 2.33%, Sm_2O_3 0.76%, Gd_2O_3 1.27%, Tb_2O_3 0.23%, Dy_2O_3 1.38%, Er_2O_3 1.15%, Tm_2O_3 0.14%, Yb_2O_3 1.18%, Lu_2O_3 0.13%; then corresponding to $(Y_{0.55}RE_{0.38}Ca_{0.04}Mg_{0.02})_{\Sigma=0.99}$ $(W_{1.85}Al_{0.10}Si_{0.04}Fe_{0.03})_{\Sigma=2.02}O_6(OH)_3$. (2) Do.; corresponding to $(RE_{0.95}Ca_{0.08}Mg_{0.06})_{\Sigma=1.09}$ $(W_{1.87}Al_{0.10}Fe_{0.03})_{\Sigma=2.00}O_{5.72}(OH)_{3.28}$. (3) $YW_2O_6(OH)_3$.

Occurrence: In eluvial cassiterite mines, probably altered from wolframite or scheelite.

Association: Kaolinite, quartz, muscovite, hydrobiotite, hematite, cassiterite, tourmaline, scheelite, rutile, stolzite, raspite, plagioclase, gypsum.

Distribution: From the Kramat Pulai mine and at Tapah, Kinta district, Perak, Malaysia.

Name: For YTTRium and TUNGSTen in the composition.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 1097 [thorotungstite = yttrotungstite]. (2) Sahama, T.G., O. von Knorring, and M. Lehtinen (1970) Cerotungstite, a cerian analogue to yttrotungstite, from Uganda. Bull. Geol. Soc. Finland, 42, 223–228. (3) Davis, R.J. and G.W. Smith (1971) Yttrotungstite. Mineral. Mag., 38, 261–285.

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Yuanfuliite $Mg(Fe^{3+}, Al)O(BO_3)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Poorly formed crystals, elongated along [001], to 2 mm, commonly anhedral granular, massive.

Physical Properties: *Cleavage:* Perfect on {100}. *Tenacity:* Brittle. Hardness = 5–6 VHN = 843 (50 g load). D(meas.) = n.d. D(calc.) = [3.40–3.43]

Optical Properties: Nearly opaque. *Color:* Black; brown in thin section; pale gray in reflected light, with dark red internal reflections. *Streak:* Black. *Luster:* Submetallic to adamantine. *Optical Class:* Biaxial. *Pleochroism:* Brown to very dark brown or dark brownish red. *Anisotropism:* Weak.
R: (400) — , (420) 1.2, (440) 7.70, (460) 9.77, (480) 10.11, (500) 10.12, (520) 10.03, (540) 9.66, (560) 9.40, (580) 9.38, (600) 9.27, (620) 9.22, (640) 8.98, (660) 8.79, (680) 5.33, (700) 1.33

Cell Data: *Space Group: Pnam.* $a = 9.198$–9.258 $b = 9.351$–9.355 $c = 3.081$–3.091 $Z = 4$

X-ray Powder Pattern: Zhuanmiao deposit, China.
2.570 (100), 4.176 (38), 2.957 (30), 6.563 (23), 2.088 (20), 1.550 (19), 1.591 (18)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	0.15		FeO		6.06
B_2O_3	20.44	23.37	MnO		0.28
SiO_2	0.07		CoO	0.04	
TiO_2	5.76	3.80	MgO	27.71	25.99
MnO_2	0.02		CaO	0.04	
Al_2O_3	6.02	7.80	Na_2O	0.70	
$Fe_2O_3 + FeO$	36.87		K_2O	0.03	
Fe_2O_3		31.76	Total	97.89	100.00
Cr_2O_3	0.04	0.94			

(1) Zhuanmiao deposit, China; by electron microprobe, average of four analyses, B_2O_3 by wet methods, Fe_2O_3:FeO determined by Mössbauer spectroscopy; corresponds to $(Mg_{0.91}Fe^{2+}_{0.09})_{\Sigma=1.00}(Fe^{3+}_{0.56}Al_{0.19}Mg_{0.17}Ti_{0.11}Fe^{2+}_{0.10})_{\Sigma=1.13}O(B_{0.92}O_{3.00})$. (2) Inglefield Land, Greenland; by electron microprobe, B_2O_3 by ion microprobe; corresponds to $(Mg_{0.59}Al_{0.23}Fe^{2+}_{0.12}Fe^{3+}_{0.06}Mn_{0.01})_{\Sigma=1.01}(Fe^{3+}_{0.53}Mg_{0.38}Ti_{0.07}Cr_{0.02})_{\Sigma=1.00}O(B_{1.00}O_3)$.

Occurrence: In metamorphosed magnesian marble in a boron deposit (Zhuanmiao deposit, China); in ultramafic rocks (Inglefield Land, Greenland).

Association: Suanite, anhydrite, apatite (Zhuanmiao deposit, China); sinhalite, forsterite, calcite (Huayuangou deposit, China); forsterite, pleonaste, phlogopite, magnetite, apatite, tourmaline (Inglefield Land, Greenland).

Distribution: From the Zhuanmiao boron deposit, Kuandian Co., and the Huayuangou boron deposit, both in Liaoning Province, China. Found in central Inglefield Land, northwest Greenland.

Name: In honor of Professor Yuan Fuli (1893–1987), Chinese geologist, China University of Geosciences, Wuhan, China.

Type Material: Geological Museum of China, Beijing, China.

References: (1) Huang Zouliang and Wang Pu (1994) Yuanfuliite – a new borate mineral. Acta Petrologica Mineralogica, 13(4), 328–334 (in Chinese with English abs.). (2) (1996) Amer. Mineral., 81, 252–253 (abs. ref. 1). (3) Appel, P.W.U., S. Biga, and M.F. Brigatti (1999) Crystal structure and chemistry of yuanfuliite and its relationships with warwickite. Eur. J. Mineral., 11, 483–491.

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Yuanjiangite AuSn

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d.
VHN = D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) = *Anisotropism: Bireflectance:*
R:
R_1–R_2:

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
Na			
K			
Os			
Ir			
Ru			
Pt			
Rh			
Pd			
Hg			
Ag			
Au			
Pb			
Cu			
Zn			
Fe			
Te			
Se			
As			
Sb			
Bi			
S			
F			
Cl			
Br			
I			
LOI			
rem.			
insol.			
Total			

(1)

Polymorphism & Series:

Mineral Group:

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Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Yugawaralite $CaAl_2Si_6O_{16}\cdot 4H_2O$

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Crystal Data: Monoclinic. *Point Group:* m. Crystals flat tabular ‖ {010}, to 8 cm; in groups of nearly parallel crystals.

Physical Properties: *Cleavage:* $\{40\bar{1}\}$, {100} distinct, $\{10\bar{1}\}$ imperfect; parting on {010}. *Fracture:* Conchoidal. *Tenacity:* Very brittle. Hardness = 4.5–5 D(meas.) = 2.20–2.23 D(calc.) = 2.26 Piezoelectric and pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless to white; colorless in thin section. *Luster:* Vitreous to pearly, iridescent on {010}. *Streak:* White.
Optical Class: Biaxial (–) or (+). *Orientation:* $Z = b$; $X \wedge c = -9°$; $Y \wedge c = 6°$–$9°$.
Dispersion: $r < v$, weak to distinct. $\alpha = 1.492$–1.496 $\beta = 1.497$–1.499 $\gamma = 1.502$–1.504
2V(meas.) = 48°–89°

Cell Data: *Space Group:* Pc. $a = 6.72(2)$ $b = 13.98(2)$ $c = 10.05(2)$ $\beta = 111°31'$
Z = 2

X-ray Powder Pattern: Yugawara Hot Spring, Japan.
3.057 (100), 4.672 (70), 4.652 (67), 5.81 (52), 7.01 (31), 3.237 (29), 4.295 (26)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	57.94	61.81	Na_2O	0.38	0.05
Al_2O_3	17.65	16.85	K_2O	0.41	0.00
Fe_2O_3	0.35	0.00	H_2O^+	10.70	
MgO	0.86	0.00	H_2O^-	1.80	
CaO	9.79	9.28	H_2O		[12.01]
			Total	99.88	[100.00]

(1) Yugawara Hot Spring, Japan. (2) Khandivali quarry, India; by electron microprobe, H_2O by difference; corresponds to $(Ca_{0.97}Na_{0.01})_{\Sigma=0.98}Al_{1.95}Si_{6.05}O_{16}\cdot 4H_2O$.

Mineral Group: Zeolite group.

Occurrence: As crystals lining cavities, and veinlets, typically deposited in active geothermal areas.

Association: Zeolites, gyrolite, okenite, prehnite, quartz, calcite.

Distribution: In Japan, from the Yugawara Hot Spring, Kanagawa Prefecture; at Shimoda, and in the Toi and Seikoshi mines, Shizuoka Prefecture; and at Takinoue, Kakkonda Hot Springs, Iwate Prefecture; several other localities are known. In the Khandivali and Malad quarries, near Bombay, Maharashtra, India. At Heinabergsjökull and Hvalsgod (Klif), Hvalfjord, and elsewhere in Iceland. From Osilo, near Sassari, Sardinia, Italy. In the USA, from Yellowstone National Park, Wyoming, and the Chena Hot Springs area, about 65 km east of Fairbanks, Alaska. From Yellow Lake, near Olalla, British Columbia, Canada.

Name: For the locality where first found, Yugawara Hot Spring, Japan.

Type Material: National Science Museum, Tokyo, Japan; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 106164, 106931.

References: (1) Sakurai, K. and A. Hayashi (1952) "Yugawaralite," a new zeolite. Sci. Reports, Yokohama National Univ., Sec. II, no. 1, 69–77. (2) (1953) Amer. Mineral., 38, 426 (abs. ref. 1). (3) Eberlein, G.D., R.C. Erd, F. Weber, and L.B. Beatty (1971) New occurrence of yugawaralite from the Chena Hot Springs area, Alaska. Amer. Mineral., 56, 1699–1717. (4) Wise, W.S. (1978) Yugawaralite from Bombay, India. Mineral. Record, 9, 296. (5) Akizuki, M. (1987) An explanation of the optical variation in yugawaralite. Mineral. Mag., 51, 615–620. (6) Kvick, Å (1986) Neutron diffraction study of the zeolite yugawaralite at 13 K. Zeits. Krist., 174, 265–281.

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Yukonite $Ca_7Fe^{3+}_{12}(AsO_4)_{10}(OH)_{20}\cdot 15H_2O(?)$

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Crystal Data: Amorphous, gellike to very poorly crystalline. *Point Group:* n.d.
As irregular concretionary masses, typically strongly crackled.

Physical Properties: *Fracture:* Smooth to conchoidal. *Tenacity:* Extremely brittle. Hardness = 2–3 D(meas.) = 2.65; 2.86 after gas evolution. D(calc.) = n.d. May decrepitate when fresh, on exposure to air, H_2O, or warmth, with evolution of primarily CO_2.

Optical Properties: Translucent. *Color:* Dark brown, brownish black, violet to deep blood-red; in thin splinters, deep brown, yellowish brown, reddish purple. *Streak:* Brownish yellow. *Luster:* Vitreous to resinous.
Optical Class: Isotropic. n = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Tagish Lake, Canada.
14.1 (100), 2.79 (60), 3.25 (57), 5.58 (37), 2.61 (20), 1.63 (20), 2.24 (11)

Chemistry:	(1)	(2)	(3)		(1)	(2)	(3)
SO_3		0.12		ZnO		0.56	
P_2O_5		0.22		MgO		0.41	
As_2O_5	36.3	39.68	38.95	CaO	10.6	12.86	13.30
SiO_2		0.21		H_2O^+		[5.22]	
Fe_2O_3	36.6	30.25	32.48	H_2O^-		[10.03]	
MnO		0.44		H_2O	17.9		15.27
				Total	101.4	[100.00]	100.00

(1) Tagish Lake, Canada; by electron microprobe, total Fe as Fe_2O_3, H_2O by TGA.
(2) Rędziny, Poland; by electron microprobe, total Fe as Fe_2O_3, H_2O calculated for charge balance; corresponds to $(Ca_{6.48}Mg_{0.29}Zn_{0.19}Mn_{0.17})_{\Sigma=7.13}Fe_{10.70}[(AsO_4)_{9.75}(SiO_4)_{0.10}(PO_4)_{0.09}(SO_4)_{0.04}]_{\Sigma=9.98}(OH)_{16.37}\cdot 15.72H_2O$. (3) $Ca_7Fe_{12}(AsO_4)_{10}(OH)_{20}\cdot 15H_2O$.

Occurrence: A secondary mineral typically altered from arsenopyrite.

Association: Symplesite, argentian galena, pyrargyrite, argentite, chalcopyrite, arsenopyrite, quartz (Tagish Lake, Canada); parasymplesite, köttigite, ogdensburgite, pharmacosiderite, legrandite, willemite, franklinite, sphalerite (Sterling Hill, New Jersey, USA); arsenopyrite, arseniosiderite, arsenolite, barian pharmacosiderite (Trout Creek, Colorado, USA); arsenopyrite, pharmacosiderite (Rędziny, Poland).

Distribution: Found on the west side of Windy Arm, Tagish Lake, Yukon Territory, Canada. In the USA, from Sterling Hill, Ogdensburg, Sussex Co., New Jersey, and the Crystal No. 8 mine, Trout Creek pegmatites, Chaffee Co., Colorado. In Germany, from Saalfeld, Thuringia; at Graulai mountain, near Lammersdorf, Eifel district; from Hasserode, near Wernigerode, Harz Mountains; and at Heubachtal, Black Forest. From Rędziny, Poland.

Name: For Yukon Territory, Canada, within which the mineral was first found.

Type Material: The Natural History Museum, London, England, 1916,454; Geological Survey of Canada, Ottawa, 18594; Royal Ontario Museum, Toronto, Canada, M11468; National Museum of Natural History, Washington, D.C., USA, R5783.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 953–955 [arseniosiderite, part]. (2) Tyrrell, J.B. and R.P.D. Graham (1913) Yukonite, a new hydrous arsenate of iron and calcium, from the Tagish Lake, Yukon Territory, Canada; with a note on the associated symplesite. Trans. Roy. Soc. Canada, 7(IV), 3, 13–18. (3) Dunn, P.J. (1982) New data for pitticite and a second occurrence of yukonite at Sterling Hill, New Jersey. Mineral. Mag., 46, 261–264. (4) Pieczka, A., B. Gołębiowska, and W. Franus (1998) Yukonite, a rare Ca-Fe arsenate, from Rędziny (Sudetes, Poland). Eur. J. Mineral., 10, 1367–1370. (5) Ross, D.R. and J.E. Post (1997) New data on yukonite. Powder Diffraction, 12, 113–116.

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Yuksporite $(K, Ba)(Na, Sr)Ca_2(Si, Ti)_4O_{11}(F, OH)\cdot H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Fibrous, scaly, or lamellar; in irregular aggregates, to 10 cm.

Physical Properties: Hardness = 5 D(meas.) = 3.05(3) D(calc.) = [2.98]

Optical Properties: Semitransparent. *Color:* Rose-red to straw-yellow.
Optical Class: Biaxial (+). *Pleochroism:* Marked; X = pale rose-yellow; $Y = Z$ = rose-yellow.
$\alpha = 1.644(2)$ β = n.d. $\gamma = 1.660(2)$ 2V(meas.) = 46°–76°

Cell Data: *Space Group:* n.d. $a = 24.869(8)$ $b = 16.756(6)$ $c = 7.057(3)$ Z = 10

X-ray Powder Pattern: Khibiny massif, Russia.
2.778 (10), 3.00 (9), 1.786 (9), 3.10 (8), 3.05 (8), 1.888 (7), 2.92 (6)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	40.92	38.40	BaO		8.60
TiO_2		11.00	Na_2O	7.94	3.84
Al_2O_3		0.07	K_2O	12.57	6.15
Fe_2O_3	9.10	0.75	F		3.05
MnO	0.91	0.29	Cl		0.80
MgO	0.42		H_2O^+		2.20
CaO	20.56	18.90	H_2O	8.52	
SrO		5.87	$-O = (F, Cl)_2$		1.46
			Total	100.94	[98.46]

(1) Khibiny massif, Russia. (2) Murun massif, Russia; original total given as 99.07%, corresponds to $(K_{0.70}Ba_{0.30})_{\Sigma=1.00}(Na_{0.66}Sr_{0.30})_{\Sigma=0.96}(Ca_{1.80}Ti_{0.19}Fe^{3+}_{0.06}Mn_{0.02})_{\Sigma=2.07}(Si_{3.42}Ti_{0.57}Al_{0.01})_{\Sigma=4.00}O_{11}[F_{0.86}Cl_{0.12}(OH)_{0.02}]_{\Sigma=1.00}\cdot 0.6H_2O$.

Occurrence: In veins in nepheline syenite in a differentiated alkalic massif (Khibiny massif, Russia).

Association: Titanite, pectolite, astrophyllite, biotite, aegirine (Khibiny massif, Russia); aegirine, kalsilite, potassic feldspar, titanite, lamprophyllite, barium lamprophyllite, wadeite, tausonite (Murun massif, Russia).

Distribution: From the Hackmann Valley, in Yuksporlak Pass, and on the upper Vuonnemiok River, all near Mt. Yukspor, in the Khibiny massif, Kola Peninsula, and in the Murun massif, southwest of Olekminsk, Yakutia, Russia.

Name: For the localities near Mt. Yukspor, Kola Peninsula, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 25847.

References: (1) Fersman, A.E. (1923) [Minerals of the Khibina and Lovozero Tundras.] Trans. Northern Sc. Econ. Exped., 16, pp. 16, 52, 68, 73. (2) (1927) Amer. Mineral., 12, 58 (abs. ref. 1). (3) Kostyleva, E.E. (1925) Pectolite from Khibinsky tundra. Bull. Acad. Sci. Russie, 19, 383–404 (in Russian). (4) (1928) Mineral. Abs., 3, 111 (abs. ref. 3). (5) Konev, A.A., Y.I. Vorob'ev, A.N. Sapozhnikov, Y.U. Malyshonok, L.F. Paradina, and I.L. Lapides (1985) New data on yuksporite. Mineral. Zhurnal, 7(4), 74–78 (in Russian).

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Yushkinite $V_{1-x}S \cdot n(Mg, Al)(OH)_2$

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Crystal Data: Hexagonal. *Point Group:* $3m$ (?). Fine flaky, scaly aggregates, up to 8 mm, and in veinlets, to 12 mm.

Physical Properties: *Tenacity:* Plastic. Hardness = < 1 VHN = n.d. D(meas.) = 2.94 D(calc.) = 3.00

Optical Properties: Opaque. *Color:* Pinkish violet. *Anisotropism:* Strong, orange-red with weak lilac tint in isotropic sections, red-lilac to pinkish dark gray in anisotropic sections.

R: (400) — , (420) — , (440) 26.0, (460) 22.4, (480) 19.0, (500) 17.6, (520) 17.8, (540) 18.7, (560) 20.7, (580) 23.3, (600) 26.4, (620) 29.6, (640) 32.8, (660) 35.7, (680) 38.2, (700) 40.1

Cell Data: *Space Group:* $P3m1$ (?). $a = 3.21$ $c = 11.3$ Z = n.d.

X-ray Powder Pattern: Pay-Khoy Mountains, Russia.
5.68 (10), 2.76 (6), 1.575 (6), 1.596 (4), 11.4 (3), 1.534 (3), 1.386 (3)

Chemistry:

	(1)
V	32.48
S	32.93
Mg	10.17
Al	5.66
O	19.89
H	1.26
Total	102.39

(1) Pay-Khoy Mountains, Russia; by electron microprobe, O and H calculated, average of three analyses, corresponding to $V_{1-x}S \cdot n(Mg, Al)(OH)_2$, n = 0.612, assigned by analogy to valleriite.

Occurrence: In quartz-carbonate veins in carbonate rocks.

Association: Cadmian sphalerite, sulvanite, fluorite.

Distribution: From near the Dolgozhdanny [Long-awaited] Waterfall, middle Silova-Yakha River, Pay-Khoy Mountains, far Northern Ural Mountains, Yugorskii Peninsula, Russia.

Name: For Academician Nikolai Pavlovich Yushkin (1936–), Russian mineralogist, Director of the Institute of Geology, Syktyvkar, Russia.

Type Material: Komi Branch of Academy of Sciences, Syktyvkar; Mining Institute, St. Petersburg, 1501/1; Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 84284.

References: (1) Makeev, A.B., T.L. Evstigneeva, N.V. Troneva, L.N. Vyal'sov, A.I. Gorshkov, and N.V. Trubkin (1984) Yushkinite, $V_{1-x}S \cdot [n(Mg, Al)(OH)_2]$ – a new mineral. Mineral. Zhurnal, 6(5), 91–97 (in Russian). (2) (1986) Amer. Mineral., 71, 846 (abs. ref. 1).

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Yvonite $Cu(AsO_3OH)\cdot 2H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$. As crystals, to 0.15 mm, elongated along [001], flattened on {010}, with prominent {100} and {010}, in radiated spherules and aggregates. *Twinning:* Multiple laminae, with composition plane {010}, twin axis $\perp$ {010}.

Physical Properties: *Cleavage:* On {100}, perfect; on {010}, poor. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = 3.5–4 D(meas.) = 3.20(2) D(calc.) = 3.22

Optical Properties: Transparent. *Color:* Turquoise-blue. *Streak:* Blue. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Pleochroism:* Weak; X = light blue to colorless; Y = light blue; Z = blue. *Orientation:* $Z \simeq b$; $X \wedge c = 42°$. *Dispersion:* $r > v$, medium. *Absorption:* $Z > Y > X$. $\alpha = 1.615(2)$ $\beta = 1.660(2)$ $\gamma = 1.700(2)$ 2V(meas.) = 82(2)° 2V(calc.) = 84(1)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.632(3)$ $b = 11.168(3)$ $c = 6.020(3)$ $\alpha = 89.32(3)°$ $\beta = 86.55(5)°$ $\gamma = 74.43(3)°$ Z = 4

X-ray Powder Pattern: Salsigne mine, France.
7.35 (100), 4.40 (60), 3.936 (60), 5.239 (50), 3.008 (50), 3.302 (40), 2.840 (35)

Chemistry:

	(1)	(2)
As_2O_5	47.8	47.98
Al_2O_3	0.4	
CuO	33.3	33.21
H_2O	19.0	18.81
Total	100.5	100.00

(1) Salsigne mine, France; by electron microprobe, average of eight analyses; H_2O taken as loss on ignition; corresponds to $Cu_{0.99}Al_{0.02}H_{0.93}(AsO_4)_{0.99}\cdot 2.04H_2O$. (2) $Cu(AsO_3OH)\cdot 2H_2O$.

Occurrence: A secondary mineral formed on specimens from mine dumps at a gold-bearing arsenic sulfide deposit.

Association: Geminite, lindackerite, arsenopyrite, bismuth, chalcopyrite, pushcharovskite.

Distribution: From the Salsigne mine, 15 km north of Carcassone, Aude, France.

Name: To honor Klaus Yvon (1943–), Professor of Crystallography, Geneva University, Geneva, Switzerland.

Type Material: Natural History Museum, Geneva University, Geneva, Switzerland, 450/33.

References: (1) Sarp, H. and R. Černý (1998) Description and crystal structure of yvonite, $Cu(AsO_3OH)2H_2O$. Amer. Mineral., 83, 383–389.

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Zabuyelite Li_2CO_3

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, with pyramidal double terminations, to 1.2 mm. *Twinning:* Common on {100}.

Physical Properties: *Cleavage:* On {100}, perfect; on {011}, good. *Tenacity:* Brittle. Hardness = 3 D(meas.) = 2.09(1) D(calc.) = 2.10 Slightly soluble in hot H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous. *Optical Class:* Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 10°$. $\alpha = 1.428(1)$ $\beta = 1.567(1)$ $\gamma = 1.574(1)$ 2V(meas.) = ∼25°

Cell Data: *Space Group:* $C2/c$ (by analogy with synthetic). $a = 8.361(1)$ $b = 4.976(2)$ $c = 6.193(3)$ $\beta = 114.69(3)°$ Z = 4

X-ray Powder Pattern: Zabuye Salt Lake, Tibet, China.
2.811 (10), 4.15 (8), 2.92 (8), 2.481 (4b), 2.42 (4), 2.62 (3), 2.11 (3)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	0.57		Na_2O	2.49	
NO_3	0.44		K_2O	0.75	
CO_2	52.70	59.56	Li_2O	34.20	40.44
B_2O_3	0.10		Cl	1.09	
Fe_2O_3	0.88		H_2O^+	1.88	
MnO	0.02		$-O = Cl_2$	[0.25]	
MgO	1.81		insol.	1.89	
CaO	1.24		Total	[99.81]	100.00

(1) Zabuye Salt Lake, Tibet, China; after deduction of "gaylussite 5.84%, northupite 4.51%, lithium-rich magnesite 2.59%, sylvite 0.94%, aphthitalite 1.18%, borax 0.25%, aragonite 0.23%, nitratine 0.64%, and silicate, etc. 2.79%" then stated to correspond to $Li_{2.18}C_{1.18}O_3$. (2) Li_2CO_3.

Occurrence: Imbedded in halite in rock salt, and precipitated on the margins of a lithium-rich salt lake (Zabuye Salt Lake, Tibet, China); as solid inclusions in fluid inclusions in spodumene.

Association: Halite, gaylussite, northupite (Zabuye Salt Lake, Tibet, China).

Distribution: From the Zabuye Salt Lake, Nagri, Tibet, China. At Bikita and Kamativi, Zimbabwe. From Kings Mountain, Cleveland Co., North Carolina, USA. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada.

Name: For its initially-noted occurrence at the Zabuye Salt Lake, Tibet, China.

Type Material: Geology Museum, Beijing, China.

References: (1) Zheng Mianping and Liu Wengao (1987) Zabuyelite, a new Li mineral. Acta Mineralogica Sinica, 7, 221–226 (in Chinese with English abs.). (2) (1990) Amer. Mineral., 75, 243–244 (abs. ref. 1). (3) Lin Yueling, Zhang Hanqing, and Zheng Mianping (1990) The crystal structure of zabuyelite. Kexue Tongbao, 35(6), 489–492 (in English).

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Zaccagnaite $Zn_4Al_2(CO_3)(OH)_{12}\cdot 3H_2O$

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Crystal Data: n.d. *Point Group:* n.d. *Twinning:*

Physical Properties: *Cleavage: Fracture: Tenacity:* Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: n.d. *Color: Streak: Luster:*
Optical Class: Pleochroism: Orientation: Dispersion: Absorption:
$n =$ $\omega =$ $\epsilon =$ $\alpha =$ $\beta =$ $\gamma =$ 2V(meas.) = n.d. 2V(calc.) =

Cell Data: *Space Group:* n.d. $a =$ $b =$ $c =$ $\alpha =$ $\beta =$ $\gamma =$ Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
SO_3			
P_2O_5			
CO_2			
B_2O_3			
Al_2O_3			
Fe_2O_3			
FeO			
MnO			
CoO			
NiO			
CuO			
ZnO			
PbO			
MgO			
CaO			
Na_2O			
K_2O			
F			
Cl			
H_2O^+			
H_2O^-			
H_2O			
$-O = (F, Cl)_2$			
Total			

(1)

Polymorphism & Series:

Mineral Group:

Occurrence:

Association: n.d.

Distribution:

Name:

Type Material: n.d.

References: (1)

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Zaccariniite RhNiAs

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As irregular grains to 20 μm.

Physical Properties: *Cleavage*: None. *Fracture*: Irregular. *Tenacity*: Brittle. Hardness = 3.5-4 VHN = 218 (5 g load on synthetic material). D(meas.) = 10.09 D(calc.) = 10.19

Optical Properties: Opaque. *Color*: Gray, white with brownish to pinkish tints in reflected light. *Streak*: Gray. *Luster*: Metallic.
Optical Class: Isotropic. *Bireflectance*: Strong. *Pleochroism*: Strong, white to pinkish brownish white. *Anisotropism*: Moderate to strong, orange to blue–green.
R_1-R_2: (470) 49.4-52.6, (546) 52.4-53.2, (589) 54.2-53.2, (650) 56.6-53.3

Cell Data: *Space Group: P*4/*nmm*. a = 3.5498(1) c = 6.1573(2) Z = 2

X-ray Powder Pattern: Loma Peguera chromitite, Cordillera Central, Dominican Republic. 2.325 (100), 1.776 (80), 1.945 (51), 0.9730 (42), 2.509 (40), 1.256 (40), 1.055 (23)

Chemistry:

	(1)
Rh	41.77
Os	0.51
Ir	0.64
Ru	0.46
Pd	0.34
Ni	23.75
Fe	0.53
As	27.84
S	0.10
Total	96.09

(1) Loma Peguera chromitite, Cordillera Central, Dominican Republic; average of 3 electron microprobe analyses, corresponding to $(Rh_{1.01}Os_{0.01}Ir_{0.01}Ru_{0.01}Pd_{0.01})_{\Sigma=1.05}(Ni_{1.00}Fe_{0.02})_{\Sigma=1.02}(As_{0.92}S_{0.01})_{\Sigma=0.93}$.

Occurrence: A low temperature mineral formed during alteration of ophiolite, now in heavy-mineral concentrate derived from ophiolitic chromitite.

Association: Garutiite, hexaferrum, Ru-Os-Ir-Fe alloys, Ru-Os-Ir-Fe oxygenated compounds, chromite.

Distribution: Loma Peguera chromitite, Loma Caribe peridotite, Cordillera Central, Dominican Republic. From the Koryako-Kamchatskiy region and Nizhny Tagil, Ural-Alaskan chromitites, Urals, Russia. Also from the Chindwin area, Burma; the Onverwacht pipe, Bushveld Complex, South Africa; Thetford mine, Quebec, Canada; the Vourinos chromitites, Greece, and the Kempirsai chromitites, Kazakhstan.

Name: Honors Professor Federica Zaccarini (b. 1962), University of Leoben, Austria, in recognition of her contributions to the mineralogy of platinum-group elements and their deposits.

Type Material: Mineralogical Museum of Leoben, Austria (8241).

References: (1) Vymazalová, A., F. Laufek, M. Drábek, C.J. Stanley, R.J. Baker, R. Bermejo, G. Garuti, O. Thalhammer, J.A. Proenza, and F. Longo (2012) Zaccariniite, RhNiAs, a new platinum-group mineral from Loma Peguera, Dominican Republic. Canadian Mineralogist, 50, 1321-1329. (2) (2014) Amer. Mineral., 99, 875 (abs. ref. 1).

Zaherite $Al_{12}(SO_4)_5(OH)_{26}\cdot 20H_2O$

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Crystal Data: Triclinic. *Point Group:* $\overline{1}$ or 1. Fibers, which may be tubular, with a wavy texture, to hundreds of μm, in dense extremely fine-grained aggregates.

Physical Properties: *Cleavage:* One, well-developed. Hardness = ~3.5, in aggregates. D(meas.) = 2.007–2.011 D(calc.) = 2.01 Reversibly hydrates at room temperature, with changes in the most intense X-ray diffraction peak position.

Optical Properties: Semitransparent. *Color:* Chalk-white to pale bluish green; colorless in transmitted light. *Luster:* Pearly to earthy.
Optical Class: Biaxial (+), with extremely low birefringence, ~0.001. $\alpha = 1.498(1)$ β = n.d. $\gamma = 1.499(1)$ 2V(meas.) = Moderate.

Cell Data: *Space Group:* $P\overline{1}$ or $P1$. $a = 18.475(0.942)$ $b = 19.454(0.591)$ $c = 3.771(0.231)$ $\alpha = 95°14.40'(1°6.60')$ $\beta = 91°21.80'(2°7.38')$ $\gamma = 80°14.40'(1°9.24')$ Z = 1

X-ray Powder Pattern: Punjab Salt Range, Pakistan.
17.9 (100), 3.22 (8), 4.61 (7), 4.58 (7), 4.56 (7), 3.55 (6), 9.5 (5), 4.82 (5)

Chemistry:

	(1)	(2)	(3)
SO_3	24.87	24.63	24.92
P_2O_5	0.02	0.06	
CO_2	0.00		
SiO_2	0.63	0.11	
Al_2O_3	37.79	37.85	38.08
Fe_2O_3		0.08	
MnO		0.01	
MgO	0.01	0.19	
CaO	0.09	0.21	
Na_2O	0.03	0.08	
K_2O	0.01	0.01	
H_2O	36.55	36.05	37.00
Total	100.00	99.28	100.00

(1) Punjab Salt Range, Pakistan; average of two analyses. (2) Hotson farm, South Africa; by XRF, H_2O by the Penfield method. (3) $Al_{12}(SO_4)_5(OH)_{26}\cdot 20H_2O$.

Occurrence: In veinlets in a kaolinite-böhmite rock (Punjab Salt Range, Pakistan); an alteration product of natroalunite or directly by hydrothermal sulfatization of sillimanite in massive sillimanite veins (Hotson farm, South Africa).

Association: Kaolinite, böhmite, aluminite (Punjab Salt Range, Pakistan); natroalunite, hotsonite (Hotson farm, South Africa).

Distribution: From the Punjab Salt Range, Pakistan. On the Hotson farm, 65 km west of Pofadder, Cape Province, South Africa.

Name: In honor of Mohammed Abduz Zaher (1935–), Geological Survey of Bangladesh, who discovered the mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA, 143793.

References: (1) Ruotsala, A.P. and L.L. Babcock (1977) Zaherite, a new hydrated aluminum sulfate. Amer. Mineral., 62, 1125–1128. (2) Beukes, G.J., A.E. Schoch, H. de Bruiyn, W.A. van der Westhuizen, and L.D.C. Bok (1984) A new occurrence of the hydrated aluminium sulphate zaherite, from Pofadder, South Africa. Mineral. Mag., 48, 131–135. (3) de Bruiyn, H., A.E. Schoch, G.J. Beukes, L.D.C. Bok, and W.A. van der Westhuizen (1985) Note on cell parameters of zaherite. Mineral. Mag., 49, 145–146. (4) Schoch, A.E., G.J. Beukes, and H.E. Praekelt (1985) A natroalunite-zaherite-hotsonite paragenesis from Pofadder, Bushmanland, South Africa. Can. Mineral., 23, 29–34.

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Zairite $Bi(Fe^{3+},Al)_3(PO_4)_2(OH)_6$

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Crystal Data: Hexagonal. *Point Group:* $\overline{3}\,2/m$. As small masses.

Physical Properties: Hardness = 4.5 D(meas.) = 4.37(5) D(calc.) = 4.42(3)

Optical Properties: Translucent. *Color:* Green; greenish yellow in transmitted light.
Luster: Waxy.
Optical Class: Uniaxial (–). n = 1.82–1.83

Cell Data: *Space Group:* $R\overline{3}m$. a = 7.015(5) c = 16.365(15) Z = 3

X-ray Powder Pattern: Eta-Etu district, Congo.
2.945 (100), 5.710 (95), 3.503 (40), 2.727 (20), 2.851 (15), 2.158 (15), 1.897 (15)

Chemistry:

	(1)	(2)
SO_3	0.29	
TeO_3	0.20	
P_2O_5	21.93	21.23
SiO_2	0.33	
Al_2O_3	5.35	
Fe_2O_3	30.75	35.83
Bi_2O_3	28.71	34.85
CuO	0.82	
ZnO	0.05	
CaO	0.72	
BaO	1.98	
H_2O	9.05	8.09
Total	100.18	100.00

(1) Eta-Etu district, Congo; SrO 0.05%–0.10% present but not included in the total, corresponding to $(Bi_{0.76}Ba_{0.08}Ca_{0.08}Cu_{0.06})_{\Sigma=0.98}(Fe_{2.38}Al_{0.65})_{\Sigma=3.03}[(PO_4)_{1.91}(SiO_4)_{0.03}(SO_4)_{0.02}(TeO_4)_{0.01}]_{\Sigma=1.97}(OH)_6$. (2) $BiFe_3(PO_4)_2(OH)_6$.

Mineral Group: Crandallite group.

Occurrence: A rare mineral in the weathering zone of quartz wolframite deposits.

Association: Bismuth, bismutite, quartz, mica.

Distribution: From the Eta-Etu district, northern Kivu Province, Congo (Zaire).

Name: For the country, Zaire (now Congo), where the first specimens were collected.

Type Material: Royal Museum of Central Africa, Tervuren, Belgium, RMG14065.

References: (1) Van Wambeke, L. (1975) La zaïrite, un nouveau minéral appartenant à la série de la crandallite. Bull. Soc. fr. Minéral., 98, 351–353 (in French with English abs.). (2) (1977) Amer. Mineral., 62, 174–175 (abs. ref. 1).

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Zajacite-(Ce) $Na(Ca,Ce,La)_2F_6$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As very fine-grained crusts and films on, and complete replacements of, bismuthinite crystals.

Physical Properties: Hardness = n.d. D(meas.) = 7.88–8.34 D(calc.) = 9.21

Optical Properties: Transparent in thin layers. *Color:* Gray; colorless in transmitted light. *Luster:* Semimetallic to greasy.
Optical Class: Uniaxial; anomalous weak birefringence. $n = 2.213(5)$

Cell Data: *Space Group:* $P4/nmm$ (synthetic). $a = 3.75(1)$ $c = 6.23(1)$ $Z = 2$

X-ray Powder Pattern: Mt. Sherlova, Russia.
1.028–1.025 (10), 0.998 (10), 1.141 (9), 1.108 (9), 1.037 (9), 3.18 (8), 1.614 (8b)

Chemistry:

	(1)	(2)
Bi_2O_3	94.93	95.49
F	4.33	7.79
H_2O	0.51	
CO_2	1.84	
S	0.50	
$-O = F_2$	1.82	3.28
$-O = S$	0.25	
Total	100.04	100.00

(1) Mt. Sherlova, Russia; after deduction of bismuthinite and bismutite, corresponds to $Bi_{1.10}O_{1.00}[F_{0.80}(OH)_{0.20}]_{\Sigma=1.00}$. (2) BiOF.

Occurrence: An alteration product of bismuthinite in bismuth-bearing hydrothermal ore deposits in quartz-topaz-siderophyllite greisens cutting a granite pluton (Mt. Sherlova, Russia); in a quartz-muscovite-topaz greisen (Torrington, Australia).

Association: Bismuthinite, bismuth, bismutite, gold (Mt. Sherlova, Russia); bismuthinite (Torrington, Australia).

Distribution: From Mt. Sherlova, Chita region, eastern Transbaikal, Siberia, Russia. At the Fielders Hill mine, near Torrington, New South Wales, Australia. In Japan, from the Ebisu mine, Hirugawa, Gifu Prefecture. In the Moldava fluorite mine, about 20 km northwest of Teplice, Krušné hory Mountains, Czech Republic. From the Evans-Lou quarry, near Wakefield Lake, Quebec, Canada.

Name: To honor Academician Aleksandr Nikolaevich Zavaritskii (1884–1952), Russian petrographer, Institute of Geology, Moscow, Russia.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 64103, 64254–64256.

References: (1) Dolomanova, Y.I., V.M. Senderova, and M.T. Yanchenko (1962) Zavaritskite (BiOF), a new oxyfluoride mineral. Doklady Acad. Nauk SSSR, 146, 680–682 (in Russian).
(2) (1963) Amer. Mineral., 48, 210 (abs. ref. 1).

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Zakharovite $Na_4Mn_5^{2+}Si_{10}O_{24}(OH)_6 \cdot 6H_2O$

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Crystal Data: Hexagonal. *Point Group:* $3m$. As platy aggregates in small nestlike deposits, to 1 cm.

Physical Properties: *Cleavage:* {0001}, perfect. *Fracture:* Conchoidal. Hardness = ∼2 D(meas.) = 2.58–2.64 D(calc.) = [2.67] Strongly electromagnetic.

Optical Properties: Translucent to opaque. *Color:* Yellowish to bright yellow, orange, grenish yellow. *Luster:* Pearly, vitreous to dull waxy.
Optical Class: Uniaxial (–). $\omega = 1.565(2)$ $\epsilon = 1.535(2)$

Cell Data: *Space Group:* $P31m$ or $P3m1$. $a = 14.58$ $c = 37.71$ Z = 9

X-ray Powder Pattern: Kola Peninsula, Russia.
12.57 (100), 3.160 (40), 3.427 (15), 3.064 (15), 2.820 (15), 2.631 (15), 3.986 (10)

Chemistry:

	(1)
SiO_2	48.74
Fe_2O_3	2.70
MnO	25.63
MgO	0.05
CaO	2.11
SrO	0.09
Na_2O	7.95
K_2O	0.41
H_2O	12.25
Total	99.93

(1) Kola Peninsula, Russia; corresponds to $(Na_{3.16}Ca_{0.46}K_{0.11}Sr_{0.01})_{\Sigma=3.74}$ $(Mn^{2+}_{4.45}Fe^{3+}_{0.42}Mg_{0.02})_{\Sigma=4.89}Si_{10}O_{24}[(OH)_{5.60}O_{0.40}]_{\Sigma=6.00} \cdot 5.59H_2O$.

Occurrence: In ussingite veinlets cutting foyaite in differentiated alkalic massifs (Kola Peninsula, Russia).

Association: Ussingite (Kola Peninsula, Russia); terskite, lovozerite, ussingite, natrolite, microcline, yofortierite, analcime, natrolite, polylithionite (Mont Saint-Hilaire, Canada); eudialyte, varennesite, catapleiite, labuntsovite (Saint-Amable, Canada).

Distribution: At Mt. Karnasurt, Lovozero massif, and on Mts. Yukspor and Koashva, Khibiny massif, Kola Peninsula, Russia. From the Saint-Amable sill, near Varennes, and at Mont Saint-Hilaire, Quebec, Canada.

Name: For Professor Evgeii Evgen'evich Zakharov (1902–1980), Director of the Moscow Geological Exploration Institute, Moscow, Russia.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 5713/6; Mining Institute, St.Petersburg, 1199; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 81688; The Natural History Museum, London, England, 1994,38.

References: (1) Khomyakov, A.P., M.E. Kazakova, Z.V. Vrublevskaya, B.B. Zvyagin, and G.O. Piloyan (1982) Zakharovite, $Na_4Mn_5^{2+}Si_{10}O_{24}(OH)_6 \cdot 6H_2O$, a new hydrous silicate of sodium and manganese. Zap. Vses. Mineral. Obshch., 111, 491–495 (in Russian). (2) (1983) Amer. Mineral., 68, 1040 (abs. ref. 1). (3) (1983) Mineral. Abs., 34, 477 (abs. ref. 1). (4) Horváth, L., E. Pfenninger-Horváth, R.A. Gault, and P. Tarassoff (1998) Mineralogy of the Saint-Amable Sill, Varennes and Saint-Amable, Québec. Mineral. Record, 29, 83–118, esp. 112–113.

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Zanazziite $\mathbf{Ca_2(Mg,Fe^{2+})(Mg,Fe^{2+},Al)_4Be_4(PO_4)_6(OH)_4 \cdot 6H_2O}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. In barrel-shaped pseudohexagonal crystals, to 4 mm, showing {100}, {110}, and {001}, in subparallel groups and divergent hemispherical sprays, with mosaic terminations; rarely as bladed crystals.

Physical Properties: *Cleavage:* {100}, good; {010}, distinct. Hardness = ~5
D(meas.) = 2.76 D(calc.) = 2.77

Optical Properties: Translucent. *Color:* Pale to dark olive-green, antithetically zoned in Fe:Mn content, yellowish green; nearly colorless to tan. *Streak:* White. *Luster:* Vitreous to pearly on cleavages.
Optical Class: Biaxial (+). *Orientation:* $X = b$; $Z \wedge a = 3°$. $\alpha = 1.606(2)$ $\beta = 1.610(2)$ $\gamma = 1.620(2)$ 2V(meas.) = 72° 2V(calc.) = 65°

Cell Data: *Space Group:* $C2/c$. $a = 15.874(4)$ $b = 11.854(3)$ $c = 6.605(1)$ $\beta = 95.34°$ Z = 2

X-ray Powder Pattern: Lavra da Ilha pegmatite, Brazil; close to roscherite.
5.91 (100), 9.50 (90), 3.16 (70), 3.05 (50), 2.766 (50), 1.642 (50b), 2.682 (40b)

Chemistry:

	(1)
SiO_2	0.36
P_2O_5	39.27
Al_2O_3	1.54
Fe_2O_3	0.76
FeO	9.63
MnO	1.77
BeO	9.81
MgO	11.66
CaO	10.65
H_2O	13.32
Total	98.77

(1) Lavra da Ilha pegmatite, Brazil; by electron microprobe, average of 25 analyses on four grains, Fe^{2+}:Fe^{3+} from titrimetric analysis, Be by AA, H_2O by H analyzer; corresponds to $(Ca_{1.97}Mn_{0.03})_{\Sigma=2.00}(Mg_{0.61}Fe^{2+}_{0.40})_{\Sigma=1.01}(Mg_{2.38}Fe^{2+}_{1.08}Al_{0.31}Mn_{0.23}Fe^{3+}_{0.10})_{\Sigma=4.10}Be_4[(P_{0.96}Be_{0.01}Si_{0.01})_{\Sigma=0.98}O_4]_6(OH)_{3.4} \cdot 6.6H_2O$.

Occurrence: In a simply zoned granite pegmatite with other phosphates (Lavra da Ilha pegmatite, Brazil).

Association: Quartz, albite, muscovite, wardite, eosphorite, whiteite, apatite, pyrite, manganese oxides (Lavra da Ilha pegmatite, Brazil); fluorapatite, albite (Martin prospect, Newry, Maine, USA).

Distribution: From the Lavra da Ilha pegmatite, in the Jequitinhonha River, three km north of Taquaral, Minas Gerais, Brazil. In the Bell pit and from the Martin prospect, Newry, Oxford Co., Maine, USA.

Name: To honor Dr. Pier Francesco Zanazzi (1939–), Professor of Mineralogy, University of Perugia, Perugia, Italy, for his structural studies of many minerals, including this one.

Type Material: National Museum of Natural History, Washington, D.C., USA, R17847, 154805.

References: (1) Leavens, P.B., J.S. White, and J.A. Nelen (1990) Zanazziite, a new mineral from Minas Gerais, Brazil. Mineral. Record, 21, 413–417. (2) (1991) Amer. Mineral., 76, 1732 (abs. ref. 1). (3) Fanfani, L., A. Nunzi, P.F. Zanazzi, and A.R. Zanzari (1975) The crystal structure of roscherite. Tschermaks Mineral. Petrog. Mitt., 22, 266–277.

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Zangboite $TiFeSi_2$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As tabular grains, to 0.15 mm.

Physical Properties: *Cleavage*: None discernable. *Fracture*: Conchoidal.
Tenacity: Brittle. Hardness = ~ 5.5 D(meas.) = n.d. D(calc.) = 5.09

Optical Properties: Opague. *Color*: Steel gray. *Streak*: Black. *Luster*: Metallic.
Optical Class: n.d.
R (synthetic $TiFeSi_2$): (400) 26.41, (470) 34.90, (546) 37.45, (589) 42.10, (650) 43.86

Cell Data: *Space Group*: *Pbam*. *a* = 8.6053(10) *b* = 9.5211(11) *c* = 7.6436(9) *Z* = 12

X-ray Powder Pattern: Luobusha mining district, Shannan Prefecture, Tibet, China.
2.1291 (100), 2.0251 (65), 1.9155 (57), 3.8358 (50), 2.2318 (50), 2.3010 (30), 1.2996 (20)

Chemistry:

	(1)	(2)
Fe	34.31 – 35.38	34.92
Si	33.56 – 36.10	35.13
Ti	27.67 – 29.35	29.95
Cr	n.d. – 1.01	
Mn	n.d. – 1.03	
Zr	n.d. – 1.52	
Al	n.d. – 1.60	
Total		100.00

(1) Luobusha mining district, Qusum county, Shannan Prefecture, Tibet, China; range of 10 electron microprobe analyses, corresponding to $(Ti_{0.99}\ Zr_{0.01})(Fe_{1.01}Cr_{0.02}Mn_{0.02})(Si_{2.00}\ Al_{0.03})$.
(2) $TiFeSi_2$.

Occurrence: In a heavy mineral separate from mining podiform chromitites hosted in harzburgite in an ophiolite complex.

Association: Native silicon, an unidentified Fe-Si mineral.

Distribution: No. 31 orebody, group II in the Luobusha mining district, Qusum county, Shannan Prefecture, Tibet, China.

Name: For the Yarlong Zangbo River (also known as the Brahmaputra River) that flows near the first described locality.

Type Material: Geological Museum of China (Beijing), (M11651).

References: (1) Guowu, L., F. Quingsong, S. Nicheng, B. Wenji, Y. Jingsui, X. Ming, M. Zhesheng, and R. He (2009) Zangboite, $TiFeSi_2$, a new mineral species from Luobusha, Tibet, China, and its crystal structure. Can. Mineral., 47, 1265–1274. (2) (2010) Amer. Mineral., 95, 1124 (abs. ref. 1).

Zapatalite $Cu_3Al_4(PO_4)_3(OH)_9 \cdot 4H_2O$

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Crystal Data: Tetragonal. *Point Group:* n.d. Massive, as botryoidal crusts and filling cavities.

Physical Properties: *Cleavage:* {001}, good. *Tenacity:* Sectile or gummy. Hardness = 1.5 D(meas.) = 3.016(26). D(calc.) = 3.017

Optical Properties: Semitransparent. *Color:* Pale blue to turquoise-blue. *Streak:* Paler blue. *Luster:* [Dull.]
Optical Class: Uniaxial (–), may be biaxial. *Pleochroism:* Weak; in shades of pale green. *Absorption:* $E > O$. $\omega = 1.646$ $\epsilon = 1.635$ 2V(meas.) = Small to moderate.

Cell Data: *Space Group:* n.d. $a = 15.223$ $c = 11.518$ Z = 6

X-ray Powder Pattern: Cerro Morita, Mexico.
7.617 (100), 11.60 (99), 5.754 (73), 6.817 (69), 3.042 (48), 2.531 (45), 4.584 (44)

Chemistry:

	(1)	(2)
P_2O_5	25.63	26.33
Al_2O_3	23.98	25.22
Fe_2O_3		
CuO	31.85	29.51
ZnO		
H_2O	18.54	18.94
Total	[100.00]	100.00

(1) Cerro Morita, Mexico; average of two analyses, recalculated to 100%; corresponds to $Cu_{3.23}Al_{3.80}(PO_4)_{2.93}(OH)_{9.23} \cdot 3.70H_2O$. (2) $Cu_3Al_4(PO_4)_3(OH)_9 \cdot 4H_2O$.

Occurrence: A secondary mineral in the oxidized zone of a hydrothermal base-metal prospect in silicified brecciated limestone.

Association: Libethenite, pseudomalachite, chrysocolla.

Distribution: In a prospect pit at the northwest end of Cerro Morita, about 27 km southwest of Agua Prieta, Sonora, Mexico. At Battle Mountain, Lander Co., Nevada, USA. From the Miguel Vacas mine, Villa Viçosa, near Estremoz, Portugal.

Name: To honor Emiliano Zapata (1879–1919), Mexican revolutionary.

Type Material: The Natural History Museum, London, England, 1972,174; National Museum of Natural History, Washington, D.C., USA, 135060.

References: (1) Williams, S.A. (1972) Zapatalite, a new mineral from Sonora, Mexico. Mineral. Mag., 38, 541–544. (2) (1972) Amer. Mineral., 57, 1911–1912 (abs. ref. 1).

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Zaratite $Ni_3(CO_3)(OH)_4 \cdot 4H_2O$

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Crystal Data: n.d. *Point Group:* n.d. Coatings composed of fibrous to spherulitic microcrystals and gellike amorphous material.

Physical Properties: *Fracture:* Conchoidal, in aggregates. *Tenacity:* Brittle. Hardness = 3.5 D(meas.) = 2.57–2.69 D(calc.) = n.d.

Optical Properties: Transparent to translucent. *Color:* Emerald-green; green in transmitted light. *Luster:* Vitreous to greasy.
Optical Class: Biaxial, may be weakly birefringent, banded. *Pleochroism:* Emerald-green along fiber length; yellow-green perpendicular to fiber length. $n = 1.56–1.62$ $\alpha = 1.597$ $\beta = 1.602$ $\gamma = 1.609$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Lancaster Co., Pennsylvania, USA or Heazlewood, Tasmania, Australia; diffuse pattern, probably of a mixture.
5.07 (vs), 8.93 (s), 2.45 (s), 2.73 (m), 2.00 (mw), 1.91 (w), 1.55 (w)

Chemistry:

	(1)	(2)
CO_2	11.69	11.70
NiO	58.81	59.57
H_2O	29.50	28.73
Total	100.00	100.00

(1) Texas, Pennsylvania, USA. (2) $Ni_3(CO_3)(OH)_4 \cdot 4H_2O$.

Occurrence: An uncommon secondary mineral formed by alteration of chromite, pentlandite, pyrrhotite, and millerite in serpentinites and ultramafic rocks.

Association: Brucite, hydromagnesite, calcite, aragonite, dolomite.

Distribution: In the USA, in Pennsylvania, from Wood's, Carter's, and Low's mines, Texas, Lancaster Co., and at Phillip's chrome mine, West Nottingham, Chester Co. At Igdlokunguak, Greenland. In the Talmessi mine, 35 km west of Anarak, Iran. On Dun Mountain, Nelson, New Zealand. At the Lord Brassey mine, Heazlewood, Tasmania, Australia. In the Hagdale quarry, Unst, Shetland Islands, Scotland. On Cape Ortegal, Galicia, Spain. At Lillaz, Val d'Aosta, Piedmont, Italy. In Austria, at Kraubath, Styria, and in the Stubachtal, Tirol. From Vrapice and Dubi, near Kladno, Czech Republic. On Mabilikwe Hill, Cape Province, South Africa. A few additional minor occurrences are known.

Name: To honor Antonio Gil y Zarate (1793–1861), Spanish dramatist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 245–246. (2) Isaacs, T. (1963) The mineralogy and chemistry of the nickel carbonates. Mineral. Mag., 33, 663–678.

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Zavalíaite $(Mn^{2+},Fe^{2+},Mg)_3(PO_4)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As exsolution lamellae to 70 μm thick and 1.5 mm long in lithiophilite nodules.

Physical Properties: *Cleavage*: Perfect on {100} and {001}. *Fracture*: n.d. *Tenacity*: Brittle. Hardness = ~ 4 D(meas.) = n.d. D(calc.) = 3.68

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous to resinous.
Optical Class: Biaxial (-). n = 1.66(1) 2V(meas.) = 15(5)° *Orientation*: $X \perp$ the cleavage plane at 45° to elongation.

Cell Data: *Space Group*: $P2_1/c$. a = 6.088(1) b = 4.814(2) c = 10.484(2) β = 89.42(3)° Z = 2

X-ray Powder Pattern: La Empleada pegmatite, Totoral pegmatite field, Argentina.
6.75 (vs), 1.894 (vs), 1.848 (vs), 1.652 (vs), 2.964 (s), 2.537 (s), 3.54 (w)

Chemistry:

	(1)	(2)
MgO	6.09	6.04
MnO	27.08	26.90
FeO	24.94	25.34
P_2O_5	41.38	41.72
Total	99.49	100.00

(1) La Empleada pegmatite, Totoral pegmatite field, Argentina; average of 27 electron microprobe analyses, absence of CO_2 and H_2O confirmed by structure analysis; corresponding to $(Mn^{2+}_{1.31}Fe^{2+}_{1.19}Mg_{0.52})_{\Sigma=3.02}(P_{1.00}O_4)_2$. (2) $(Mn^{2+}_{1.29}Fe^{2+}_{1.20}Mg_{0.51})_{\Sigma=3.00}(PO_4)_2$.

Mineral Group: Sarcopside group.

Occurrence: In the core margin of a zoned granitic pegmatite (beryl-columbite-phosphate subtype) as exsolution lamellae in ellipsoidal phosphate nodules.

Association: Lithiophilite, reddingite (by hydration).

Distribution: From the La Empleada granitic pegmatite, Totoral pegmatite field, San Luis Province, Argentina.

Name: Honors María Florencia de Fátima Márquez Zavalía (b. 1855), researcher and Head of the Department of Mineralogy, Petrography and Geochemistry, of the Argentine Institute of Snow Research, Glaciology and Environmental Sciences (IANIGLA), CCT Mendoza, National Research Council of Argentina (CONICET).

Type Material: Laboratory of Mineralogy, University of Liège, Belgium (# 20384).

References: (1) Hatert, F., E. Roda-Robles, P. De Parseval, and J. Wouters (2012) Zavalíaite, $(Mn^{2+},Fe^{2+},Mg)_3(PO_4)_2$, a new member of the sarcopside group from the La Empleada pegmatite, San Luis Province, Argentina. Can. Mineral., 50(6), 1445-1452. (2) (2014) Amer. Mineral., 99, 2156-2157 (abs. ref. 1).

Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. As very fine-grained crusts and films on, and complete replacements of, bismuthinite crystals.

Physical Properties: Hardness = n.d. D(meas.) = 7.88–8.34 D(calc.) = 9.21

Optical Properties: Transparent in thin layers. *Color:* Gray; colorless in transmitted light. *Luster:* Semimetallic to greasy.
Optical Class: Uniaxial; anomalous weak birefringence. $n = 2.213(5)$

Cell Data: *Space Group:* $P4/nmm$ (synthetic). $a = 3.75(1)$ $c = 6.23(1)$ $Z = 2$

X-ray Powder Pattern: Mt. Sherlova, Russia.
1.028–1.025 (10), 0.998 (10), 1.141 (9), 1.108 (9), 1.037 (9), 3.18 (8), 1.614 (8b)

Chemistry:

	(1)	(2)
Bi_2O_3	94.93	95.49
F	4.33	7.79
H_2O	0.51	
CO_2	1.84	
S	0.50	
$-O = F_2$	1.82	3.28
$-O = S$	0.25	
Total	100.04	100.00

(1) Mt. Sherlova, Russia; after deduction of bismuthinite and bismutite, corresponds to $Bi_{1.10}O_{1.00}[F_{0.80}(OH)_{0.20}]_{\Sigma=1.00}$. (2) BiOF.

Occurrence: An alteration product of bismuthinite in bismuth-bearing hydrothermal ore deposits in quartz-topaz-siderophyllite greisens cutting a granite pluton (Mt. Sherlova, Russia); in a quartz-muscovite-topaz greisen (Torrington, Australia).

Association: Bismuthinite, bismuth, bismutite, gold (Mt. Sherlova, Russia); bismuthinite (Torrington, Australia).

Distribution: From Mt. Sherlova, Chita region, eastern Transbaikal, Siberia, Russia. At the Fielders Hill mine, near Torrington, New South Wales, Australia. In Japan, from the Ebisu mine, Hirugawa. Gifu Prefecture. In the Moldava fluorite deposit, Krusňé Hory Mountains, Czech Republic.

Name: To honor Academician Aleksandr Nikolayevich Zavaritskii (1884–1952), Russian petrographer.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Dolomanova, Y.I., V.M. Senderova, and M.T. Yanchenko (1962) Zavaritskite (BiOF), a new oxyfluoride mineral. Doklady Acad. Nauk SSSR, 146, 680–682 (in Russian).
(2) (1963) Amer. Mineral., 48, 210 (abs. ref. 1).

Zdenekite $NaPbCu_5(AsO_4)_4Cl \cdot 5H_2O$

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Crystal Data: Tetragonal. *Point Group:* 422. Tabular crystals, to 0.1 mm, flattened on {001}, showing {001}, {100}, {110}, in spherical aggregates and crusts.

Physical Properties: *Cleavage:* On {001}, perfect. *Fracture:* Irregular. *Tenacity:* Fragile [*sic*]. Hardness = Soft. D(meas.) = 4.1(1) D(calc.) = [4.08]

Optical Properties: Translucent. *Color:* Turquoise-blue. *Streak:* Pale blue.
Luster: Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* Strong; O = turquoise-blue; E = pale blue to light green. $\omega = 1.770(5)$ $\epsilon = 1.710(5)$

Cell Data: *Space Group:* $P4_122$ or $P4_322$. $a = 10.066(1)$ $c = 39.39(4)$ Z = 8

X-ray Powder Pattern: Cap Garonne mine, France.
9.83 (100), 3.132 (90), 4.925 (60), 4.482 (50b), 2.515 (50), 2.772 (40), 1.778 (40)

Chemistry:

	(1)	(2)
As_2O_5	36.66	37.40
CuO	32.97	32.36
PbO	16.79	18.16
CaO	0.62	
Na_2O	2.92	2.52
Cl	3.54	2.88
H_2O	7.2	7.33
$-O = Cl_2$	0.80	0.65
Total	99.90	100.00

(1) Cap Garonne mine, France; by electron microprobe, average of 16 analyses, H_2O by TGA; corresponding to $Na_{1.15}Ca_{0.13}Pb_{0.92}Cu_{5.09}(AsO_4)_{3.90}Cl_{1.23} \cdot 4.91H_2O$.
(2) $NaPbCu_5(AsO_4)_4Cl \cdot 5H_2O$.

Occurrence: A rare post-mining mineral formed in the oxidized zone of a red-bed sandstone Pb–Cu deposit (Cap Garonne mine, France).

Association: Olivenite, geminite, antlerite, anglesite, covellite, tennantite, galena (Cap Garonne mine, France); mimetite, beudantite–segnitite (Broken Hill, Australia).

Distribution: From the Cap Garonne mine, near le Pradet, Var, France. At Broken Hill, New South Wales, Australia.

Name: Honoring Dr. Zdenek Johan (1935–), mineralogist and Director of Scientific Affairs, Bureau de Recherches Géologiques et Minières, Orlèans, France.

Type Material: Natural History Museum, Geneva, Switzerland; Natural History Museum, Paris, France.

References: (1) Chiappero, P.-J. and H. Sarp (1995) Zdenekite, $NaPbCu_5(AsO_4)_4Cl \cdot 5H_2O$, a new mineral from the Cap Garonne mine, Var, France. Eur. J. Mineral.. 7, 553–557. (2) (1996) Amer. Mineral., 81, 253 (abs. ref. 1).

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Zektzerite $NaLiZrSi_6O_{15}$

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Crystal Data: Orthorhombic, pseudohexagonal. *Point Group:* $2/m\ 2/m\ 2/m$. As stout pseudohexagonal prisms, showing {100}, {010}, and {011}, to 3.7 cm; flattened on {100} and lightly striated on {011}.

Physical Properties: *Cleavage:* {100} and {010}, perfect. Hardness = ∼6 D(meas.) = 2.79 D(calc.) = 2.80 Fluoresces light yellow under SW UV.

Optical Properties: Translucent. *Color:* Colorless to pink, cream, or white, commonly zoned. *Streak:* White. *Luster:* Vitreous, pearly on {100}.
Optical Class: Biaxial (–); almost isotropic. *Orientation:* $X = a$; $Y = b$; $Z = c$.
Dispersion: $r > v$, very weak. $\alpha = 1.582(3)$ $\beta = 1.584(3)$ $\gamma = 1.584(3)$ 2V(meas.) = ∼0°

Cell Data: *Space Group: Cmca.* $a = 14.330(2)$ $b = 17.354(2)$ $c = 10.164(2)$ Z = 8

X-ray Powder Pattern: Washington Pass, Washington, USA.
4.850 (100), 3.145 (85), 7.190 (78), 4.336 (78), 3.480 (75), 2.665 (63), 4.374 (47)

Chemistry:

	(1)
SiO_2	68.24
TiO_2	0.75
ZrO_2	21.84
HfO_2	0.50
Li_2O	2.8
Na_2O	5.9
Total	100.0

(1) Washington Pass, Washington, USA; by electron microprobe, Li by flame photometry; corresponds to $Na_{1.01}Li_{0.99}Zr_{1.00}Si_{6.00}O_{15}$.

Occurrence: Rarely in miarolitic cavities in a riebeckite granite (Washington Pass, Washington, USA).

Association: Quartz, microcline, aegirine, riebeckite, astrophyllite, zircon, elpidite.

Distribution: From Kangaroo Ridge, near Washington Pass, Okanogan Co., Washington, USA. In the Dara-i-Pioz massif, Alai Range, Tien Shan, Tajikistan.

Name: For Jack Zektzer (1936–), of Seattle, Washington, USA, who presented the mineral for study.

Type Material: Canadian Geological Survey, Ottawa; Royal Ontario Museum, Toronto, Canada, M34553; The Natural History Museum, London, England, 1976,423; Harvard University, Cambridge, Massachusetts, 116456; National Museum of Natural History, Washington, D.C., USA, 136030.

References: (1) Dunn, P.J., R.C. Rouse, B. Cannon, and J.A. Nelen (1977) Zektzerite: a new lithium sodium zirconium silicate related to tuhualite and the osumilite group. Amer. Mineral., 62, 416–420. (2) Ghose, S. and C. Wan (1978) Zektzerite, $NaLiZrSi_6O_{15}$: a silicate with six-tetrahedral-repeat double chains. Amer. Mineral., 63, 304–310.

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Zellerite $Ca(UO_2)(CO_3)_2 \cdot 5H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As fine hairlike fibers, to 2 mm, in roughly radial aggregates, veinlets, and incrustations.

Physical Properties: *Cleavage:* One, ‖ elongation, possible. Hardness = ∼2
D(meas.) = 3.25(1) D(calc.) = 3.242 Radioactive; fluoresces patchy green under SW and LW UV.

Optical Properties: Transparent. *Color:* Pale lemon-yellow; very pale yellow in transmitted light.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = colorless; Z = pale yellow. *Orientation:* $Z = c$. *Dispersion:* $r < v$. $\alpha = 1.536(5)$ $\beta = 1.559(5)$ $\gamma = 1.697(5)$ 2V(meas.) = 25°–30°

Cell Data: *Space Group:* $Pmmm$ or $Pmn2_1$. $a = 11.220(15)$ $b = 19.252(16)$ $c = 4.933(16)$ Z = 4

X-ray Powder Pattern: Lucky Mc mine, Wyoming, USA.
9.66 (100), 4.848 (50), 5.591 (35), 3.651 (35), 4.407 (25), 7.33 (18), 2.947 (13)

Chemistry:

	(1)	(2)
CO_2	16.9	16.92
UO_3	53.9	54.98
CaO	10.3	10.78
H_2O^+	12.3	
H_2O^-	6.6	
H_2O		17.32
Total	[100.0]	100.00

(1) Lucky Mc mine, Wyoming, USA; CO_2 and H_2O by CHN analyzer; recalculated to 100.0% after deduction of R_2O_3 1.0%, Na_2O 0.4%, K_2O 0.2%, SiO_2 + insoluble 0.5% from an original total of 100.2%; corresponds to $Ca_{1.00}(UO_2)_{1.03}(CO_3)_{2.09} \cdot 3.72H_2O$. (2) $Ca(UO_2)(CO_3)_2 \cdot 5H_2O$.

Occurrence: A rare weathering product of uranium ores, formed at low pH in the presence of oxidizing pyrite.

Association: Metazellerite, gypsum, "limonite", iron sulfides, schoepite, meta-autunite, uranophane, "opal".

Distribution: In the USA, from the Lucky Mc mine, Wind River Basin, Fremont Co., and the Pat No. 8 mine, Powder River Basin, Converse Co., Wyoming; in the White Canyon No. 1 mine, Frey Point, San Juan Co., Utah; at the Alta mine, Ambrosia Lake district, and Westwater Canyon, McKinley Co., New Mexico. In the Hatrurim Formation, Israel. From Jáchymov (Joachimsthal), Czech Republic.

Name: To honor Howard Davis Zeller (1922–), geologist with the U.S. Geological Survey, who discovered the mineral.

Type Material: National Museum of Natural History, Washington, D.C., USA, 112827.

References: (1) Coleman, R.G., D.R. Ross, and R. Meyrowitz (1966) Zellerite and metazellerite, new uranyl carbonates. Amer. Mineral., 51, 1567–1578.

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Zemannite $\mathbf{Mg_{0.5}ZnFe^{3+}(Te^{4+}O_3)_3 \cdot 4.5H_2O}$

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Crystal Data: Hexagonal. *Point Group:* $6/m$. Crystals are hexagonal, prismatic $\{10\bar{1}0\}$, terminated by $\{10\bar{1}1\}$, to 1 mm.

Physical Properties: *Tenacity:* Very brittle. Hardness = "Soft". D(meas.) = n.d. D(calc.) = 4.19

Optical Properties: Translucent to transparent. *Color:* Pale to dark brown. *Streak:* White. *Luster:* Adamantine.
Optical Class: Uniaxial (+). *Pleochroism:* O = reddish brown; E = yellowish brown. *Absorption:* $O > E$. $\omega = 1.85$ $\epsilon = 1.93$

Cell Data: *Space Group:* $P6_3/m$. $a = 9.404(2)$ $c = 7.636(4)$ Z = 2

X-ray Powder Pattern: Moctezuma mine, Mexico.
8.15 (10), 2.778 (9), 4.07 (8), 2.96 (6), 2.845 (6), 1.726 (6), 2.345 (5)

Chemistry:

	(1)
TeO_2	62.9
SeO_2	0.07
Fe_2O_3	10.8
MnO	0.11
ZnO	10.5
MgO	2.53
H_2O	10.25
Total	97.16

(1) Moctezuma mine, Mexico; by electron microprobe, H_2O by TGA, total Fe^{3+} as Fe_2O_3, confirmed by Mössbauer spectroscopy; corresponds to $Mg_{0.47}Zn_{1.04}Mn^{2+}_{0.01}Fe^{3+}_{1.02}(TeO_3)_{2.97} \cdot 4.2H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a hydrothermal Au–Te deposit.

Association: Tellurium, tellurite, paratellurite, spiroffite, mroseite.

Distribution: From the Moctezuma (Bambolla) mine, 12 km south of Moctezuma, Sonora, Mexico.

Name: To honor Dr. Josef Zemann (1923–), Austrian crystallographer, Professor of Mineralogy, University of Vienna, Vienna, Austria, specialist in tellurium minerals.

Type Material: Natural History Museum, Paris, France; Royal Ontario Museum, Toronto, Canada, M25933; National Museum of Natural History, Washington, D.C., USA, 128390.

References: (1) Mandarino, J.A., E. Matzat, and S.J. Williams (1976) Zemannite, a zinc tellurite from Moctezuma, Sonora, Mexico. Can. Mineral., 14, 387–390. (2) (1969) Amer. Mineral., 55, 1448 (abs. ref. 1). (3) Miletich, R. (1995) Crystal chemistry of the microporous tellurite minerals zemannite and kinichilite, $Mg_{0.5}[Me^{2+}Fe^{3+}(TeO_3)_3] \cdot 4.5H_2O$, ($Me^{2+} = Zn, Mn$). Eur. J. Mineral., 7, 509–523.

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Zemkorite $Na_2Ca(CO_3)_2$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$, $\overline{6}m2$, or $6mm$. Rare fanlike aggregates of anhedral crystals, to 0.5 mm; granular massive in veinlets and fracture fillings.

Physical Properties: *Cleavage:* Lamellar, perfect. *Tenacity:* Brittle. Hardness = 2 D(meas.) = 2.46(2) D(calc.) = 2.47 Soluble in H_2O.

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous to pearly. *Optical Class:* Uniaxial (–). $\omega = 1.535(1)$ $\epsilon = 1.513(1)$

Cell Data: *Space Group:* $P6_3/mmc$, $P\overline{6}2c$, or $P6_3mc$. $a = 10.06(2)$ $c = 12.72(1)$ $Z = 8$

X-ray Powder Pattern: Udachnaya pipe, Russia.
4.36 (10), 3.04 (10), 2.52 (10), 2.06 (10), 6.36 (9), 1.797 (8), 2.18 (7)

Chemistry:

	(1)	(2)
CO_2	39.20	42.71
Al_2O_3	0.05	
CaO	28.39	27.21
Na_2O	25.72	30.08
K_2O	6.40	
Total	99.76	100.00

(1) Udachnaya pipe, Russia; by electron microprobe, average of two analyses, CO_2 by wet methods, corresponding to $(Na_{1.80}K_{0.29})_{\Sigma=2.09}Ca_{1.10}(CO_3)_{1.93}$. (2) $Na_2Ca(CO_3)_2$.

Polymorphism & Series: Trimorphous with natrofairchildite and nyerereite.

Occurrence: Filling fractures and as inclusions in unserpentinized but sodium metasomatized kimberlite at about 400–450 m depth.

Association: Shortite, halite.

Distribution: From the east Udachnaya twin pipe, Daldyn kimberlite field, Sakha, Russia.

Name: For Institute of the Earth's Crust (Institut ZEMnoy KORY in Russian), Russian Academy of Sciences, Siberian Branch, Irkutsk, Russia, where the mineral was studied.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87573.

References: (1) Yegorov, N.K., Z.F. Ushchapovskaya, A.A. Kashayev, G.V. Bogdanov, and Y.I. Sizykh (1988) Zemkorite – a new carbonate from kimberlites of Yakutia [Sakha]. Doklady Acad. Nauk SSSR, 301, 188–193 (in Russian). (2) (1990) Amer. Mineral., 75, 933–934 (abs. ref. 1).

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Zenzénite $Pb_3(Fe^{3+},Mn^{3+})_4Mn_3^{4+}O_{15}$

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As euhedral to subhedral grains, to 150 μm, tabular on {0001}.

Physical Properties: *Cleavage:* {0001}, distinct. Hardness = 5.7 VHN = 739–795, 764 average (50 g load). D(meas.) = n.d. D(calc.) = 6.83 Weakly magnetic.

Optical Properties: Opaque. *Color:* Black; bright white in reflected light.
Optical Class: Uniaxial. *Anisotropism:* Distinct; in shades of gray and pale brown.
Bireflectance: Weak; visible only in oil.
R_1–R_2: (400) 32.0–25.9, (420) 31.7–26.2, (440) 31.6–26.5, (460) 31.2–26.2, (480) 30.8–25.9, (500) 30.4–25.6, (520) 30.0–25.4, (540) 29.6–25.1, (560) 29.2–24.8, (580) 28.7–24.5, (600) 28.3–24.2, (620) 27.8–23.9, (640) 27.4–23.6, (660) 27.1–23.3, (680) 26.8–22.9, (700) 26.5–22.6

Cell Data: *Space Group:* $P6_3/mcm$. $a = 10.008(4)$ $c = 13.672(8)$ $Z = 4$

X-ray Powder Pattern: Långban, Sweden.
2.663 (10), 3.18 (8), 1.687 (8), 2.828 (7), 2.366 (6), 3.42 (5), 2.104 (4)

Chemistry:

	(1)
SiO_2	0.03
TiO_2	0.19
MnO_2	23.63
Al_2O_3	0.19
Fe_2O_3	15.36
Mn_2O_3	8.88
ZnO	0.00
PbO	53.68
MgO	0.12
BaO	0.06
Total	[102.14]

(1) Långban, Sweden; by electron microprobe, Mn^{3+}:Mn^{4+} and Fe^{3+} from crystal-structure analysis, original total given as 102.15%; corresponding to $Pb_{2.87}Ba_{0.01}(Fe^{3+}_{2.30}Mn^{3+}_{1.35}Mg_{0.04}Al_{0.04})_{\Sigma=3.73}(Mn^{4+}_{3.24}Ti_{0.03}Si_{0.01})_{\Sigma=3.28}O_{15}$.

Occurrence: In a carbonate-phyllosilicate skarn rock, in a metamorphosed Fe–Mn orebody.

Association: Dolomite, hausmannite, jacobsite, calcite, barytocalcite, norsethite, manganoan chlorite, kinoshitalite, pinakiolite, macedonite.

Distribution: From Långban, Värmland, Sweden.

Name: For Dr. Nils Zenzén (1883–1959), formerly Senior Curator of the Swedish Museum of Natural History, Stockholm, Sweden.

Type Material: Swedish Museum of Natural History, Stockholm, Sweden, 401841.

References: (1) Holtstam, D., B. Lindqvist, M. Johnsson, and R. Norrestam (1991) Zenzénite: $Pb_3(Fe^{3+},Mn^{3+})_4Mn_3^{4+}O_{15}$, a new mineral species from Långban, Filipstad, Sweden, and its crystal structure. Can. Mineral., 29, 347–354. (2) (1991) Amer. Mineral., 76, 2024–2025 (abs. ref. 1).

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Zeophyllite $Ca_4Si_3O_8(OH,F)_4 \cdot 2H_2O$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}$. As radiating platy crystals, to 1 cm; in hemispherical and spherical aggregates, or as botryoidal and spherulitic crusts.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = 3 D(meas.) = 2.747–2.764 D(calc.) = [2.75]

Optical Properties: Translucent. *Color:* White; in transmitted light, colorless.
Luster: Pearly.
Optical Class: Uniaxial (–); anomalously biaxial. ω = 1.565–1.577 ϵ = 1.560–1.569
2V(meas.) = 0°–10°

Cell Data: *Space Group:* $R\bar{3}$. $a = 9.36$ $c = 36.48$ Z = [9]

X-ray Powder Pattern: Litoměřice, Czech Republic.
12.0 (100), 3.03 (80), 6.09 (60), 2.946 (60), 3.71 (50), 2.648 (50), 2.547 (50)

Chemistry:

	(1)	(2)
SiO_2	36.0	38.84
Al_2O_3	1.5	1.73
Fe_2O_3	0.0	0.10
MgO	< 0.5	0.17
CaO	46.3	44.32
Na_2O	0.48	0.32
K_2O	0.09	0.24
F	7.49	8.23
H_2O	11.0	8.98
$-O = F_2$	3.15	3.47
Total	99.71	99.46

(1) Litoměřice, Czech Republic; corresponds to $(Ca_{4.20}Na_{0.08}Mg_{<0.06}K_{0.01})_{\Sigma=\sim4.3}(Si_{3.05}Al_{0.15})_{\Sigma=3.20}O_9F_{2.01} \cdot 6.22H_2O$. (2) Březno nad Lábem, Czech Republic; corresponds to $(Ca_{4.04}Al_{0.17}Na_{0.06}K_{0.03}Mg_{0.02}Fe_{0.01})_{\Sigma=4.33}Si_{3.31}O_9F_{2.22} \cdot 5.10H_2O$.

Occurrence: In cavities, as a secondary mineral from hydrothermal alteration of basalt (Litoměřice, Czech Republic); a late-stage mineral in low-temperature hydrothermal veins cutting alkalic intrusive rocks in a differentiated alkalic massif (Khibiny massif, Russia); in marble xenoliths in nepheline syenite in an intrusive alkalic gabbro-syenite complex (Mont Saint-Hilaire, Canada).

Association: Zeolites, apophyllite.

Distribution: In the Czech Republic, at Litoměřice (Leitmeritz), Březno nad Lábem (Gross-Priesen), Radejčín (Radzein), and near Teplice (Teplitz). In Germany, at the Schellkopf, near Brenk, Eifel district. From Monte Somma, Campania, Italy. In the Khibiny massif, Kola Peninsula, Russia. From Göbnehall Yuglingarum, Skåne, Sweden. In the Salmon River district, near Riggins, Idaho Co., Idaho, USA. At Mont Saint-Hilaire, Quebec, Canada.

Name: From the Greek *to boil* and *a leaf*, in allusion to its habit.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 86427.

References: (1) Dana, E.S. and W.E. Ford (1909) Dana's system of mineralogy, (6th edition), app. II, 113. (2) Parry, J., A.F. Williams, and F.E. Wright (1932) On bultfonteinite, a new fluorine-bearing hydrous calcium silicate from South Africa. Mineral. Mag., 23, 145–162.
(3) Chalmers, R.A., L.S. Dent, and H.F.W. Taylor (1958) Zeophyllite. Mineral. Mag., 31, 726–735.
(4) Merlino, S. (1972) The crystal structure of zeophyllite. Acta Cryst., 28, 2726–2732.

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Zeunerite $Cu(UO_2)_2(AsO_4)_2 \cdot 10-16H_2O$

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Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals, to 4 cm, flat tabular on {001}, commonly in subparallel growths.

Physical Properties: *Cleavage:* On {001}, perfect; on {100}, distinct. Hardness = 2.5 D(meas.) = 3.47 D(calc.) = [3.57] for $16H_2O$. Radioactive; commonly dehydrates to metazeunerite.

Optical Properties: Transparent, becoming translucent on dehydration. *Color:* Green to emerald-green. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = blue-green; E = pale blue-green.
$\omega = 1.610–1.613$ $\epsilon = 1.582–1.585$

Cell Data: *Space Group:* $I4/mmm$. a = 7.18 $c = 21.06$ Z = 2

X-ray Powder Pattern: Synthetic $Cu(UO_2)_2(AsO_4)_2 \cdot 16H_2O$.
10.65 (10), 3.59 (9), 5.04 (8), 3.39 (7), 1.926 (6), 6.86 (5), 2.08 (5)

Chemistry: (1) Identification rests on comparison of the X-ray powder pattern and optical data with those of synthetic $Cu(UO_2)_2(AsO_4)_2 \cdot 16H_2O$.

Mineral Group: Autunite group.

Occurrence: An uncommon secondary mineral in the oxidized zone of arsenic-bearing hydrothermal uranium deposits.

Association: Olivenite, mansfieldite, scorodite, azurite, malachite.

Distribution: Material which is fully hydrated at the time of study is relatively rare, although most meta-zeunerite is a dehydration product of pre-existing zeunerite. In Germany, from the Walpurgis vein, Weisser Hirsch mine, Neustädtel-Schneeberg, Saxony; at Sailauf, northeast of Aschaffenburg, Bavaria; in the Anton mine, Heubachtal, near Schiltach, from Menzenschwand, and elsewhere in the Black Forest. In England, at a number of places in Cornwall, as at Wheals Gorland and Maid, Gwennap; in the South Terras mine, St. Stephen-in-Brannel; at Wheal Edward, St. Just. In France, from the Cap Garonne mine, near le Pradet, Var; at the Margnac mine, Compreignac, Haute-Vienne; in the Rabéjac uranium deposit, seven km south-southeast of Lodève, Hérault. In the USA, from the Dexter mine, Calf Mesa, San Rafael district, Emery Co., Utah; at the Majuba Hill mine, Antelope district, Pershing Co., Nevada; in various of the Colorado Plateau-type U–V deposits, Colorado. Large crystals from Brumado, Bahia, Brazil.

Name: Honoring Gustav Anton Zeuner (1828–1907), Director, School of Mines, Freiberg, Germany.

Type Material: State Museum of Mineralogy and Geology, Dresden; Mining Academy, Freiberg, Germany, 21730; now metazeunerite.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 989–990 [name reserved for natural occurrence of the higher hydrate].
(2) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 191–195.

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Zhanghengite CuZn

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As small irregular plates, which may be striated in multiple directions producing a cross-hatching, and with hummocky surfaces.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Brittle. Hardness = 2 VHN = n.d. D(meas.) = 6.9–7.2 D(calc.) = 7.135

Optical Properties: Opaque. *Color:* White. *Streak:* White and slightly grayish. *Luster:* Metallic.

R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.665$ $c = 4.947$ Z = 2

X-ray Powder Pattern: Synthetic.
2.091 (100), 2.473 (3), 2.308 (40), 1.687 (28), 1.342 (25), 1.1729 (23), 1.332 (21)

Chemistry:

	(1)
Zn	~90
Sn, Pb, Cd	~10
Fe, Mn, B, Si, Cu, Ag, Ca, Ba	trace
Total	

(1) Elsa mine, Canada; combined X-ray fluorescence and spectrographic analyses.

Occurrence: In the oxidized zone of Pb-Zn-Ag sulfide deposits, derived from sphalerite by oxidation (Elsa mine, Canada); coatings on fibrous volcanic glass, as a volcanic sublimate (Mount Elbrus, Russia); in platinum concentrates (Aurora deposit, Russia).

Association: Silver, sulfur, oxidized sphalerite, "limonite", manganese oxides, cerussite, anglesite, freibergite, galena (Elsa mine, Canada); copper, Cu–Zn alloy, sphalerite, djurleite, cuprite (Dulcina de Lampos mine, Chile).

Distribution: In the Elsa mine, Keno Hill-Galena Hill area, Yukon Territory, Canada. From Mount Elbrus, Caucasus Mountains, and the Aurora deposit, locality not otherwise specified, Russia. From the Burobaiskii massif, eastern Kazakhstan. In the Dulcina de Lampos copper mine, near Copiapó, Atacama, Chile.

Name: From the German *zink*, of obscure origin.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 127. (2) (1953) NBS Circ. 539, 1, 16. (3) Boyle, R.W. (1961) Native zinc at Keno Hill. Can. Mineral., 6, 692–694. (4) Bartikyan, P.M. (1966) Native lead and zinc in the rocks of Armenia. Zap. Vses. Mineral. Obshch., 95, 99–102 (in Russian). (5) (1962) Mineral. Abs., 18, 200 (abs. ref. 4).

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Zhangpeishanite BaFCl

Crystal Data: Tetragonal. *Point Group*: 4/*m* 2/*m* 2/*m*. As irregular grains, to 0.1 mm.

Physical Properties: *Cleavage*: Perfect on {001} (synthetic). *Tenacity*: n.d. *Fracture*: n.d. Hardness = 2.5 (synthetic). D(meas.) = n.d. D(calc.) = 4.54 Soluble in water.

Optical Properties: Transparent. *Color*: Colorless. *Streak*: White. *Luster*: Vitreous. *Optical Class*: Uniaxial (-). $\omega = 1.656(2)$ $\varepsilon = 1.652(2)$ (synthetic).

Cell Data: *Space Group*: *P*4/*nmm*. $a = 4.3951(8)$ $c = 7.223(2)$ $Z = 2$

X-ray Powder Pattern: Bayan Obo, Inner Mongolia, China.
3.75 (100), 3.11 (94), 2.36 (82), 2.79 (67), 1.898 (49), 1.670 (39), 1.726 (34)

Chemistry:

	(1)	(2)
Ba	70.90	71.61
F	9.88	9.91
Cl	18.85	18.48
Total	99.63	100.00

(1) Bayan Obo, Inner Mongolia, China; average of 12 electron microprobe analyses, corresponding to $Ba_{0.99}F_{0.99}Cl_{1.02}$. (2) BaFCl.

Mineral Group: Matlockite group.

Occurrence: As inclusions in fluorite in a polymetallic Nb–REE–Fe deposit.

Association: Barite, hematite, norsethite, fluorite.

Distribution: Bayan Obo deposit, Inner Mongolia, China.

Name: Honors Professor Zhang Peishan (b. 1925) for his contributions to the mineralogy of Bayan Obo.

Type Material: National Museum of Nature and Science, Tokyo, Japan, NSM-MF14696; Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China, KDX013.

References: (1) Shimazaki, H., R. Miyawaki, K. Yokoyama, S. Matsubara, and Z. Yang (2008) Zhangpeishanite, BaFCl, a new mineral in fluorite from Bayan Obo, Inner Mongolia, China. Eur. J. Mineral., 20, 1141–1144. (2) (2009) Amer. Mineral., 94, 1081-1082 (abs. ref. 1).

Zharchikhite $AlF(OH)_2$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Crystals are prismatic, to 2.5 mm, elongated along [001], showing {110}, {010}, {101}, {111}, may be isolated; commonly in fine-grained masses and drusy aggregates.

Physical Properties: *Cleavage:* {010}, perfect. *Tenacity:* Very brittle. Hardness = 4.5 VHN = 596 ∥ elongation, 426 ⊥ elongation, 500 average. D(meas.) = 2.81(1) D(calc.) = 2.82

Optical Properties: Transparent. *Color:* Colorless. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge c = 43°$–$44°$. *Dispersion:* $r > v$, inclined.
$\alpha = 1.532(2)$ $\beta = 1.552(2)$ $\gamma = 1.567(2)$ 2V(meas.) = n.d. 2V(calc.) = 80°

Cell Data: *Space Group:* $P2_1/a$. $a = 5.164(1)$ $b = 7.834(1)$ $c = 5.179(1)$
$\beta = 116.244(8)°$ Z = [4]

X-ray Powder Pattern: Zharchikha deposit, Russia.
3.98 (10), 1.833 (9), 2.92 (8), 2.31 (7), 1.737 (7), 1.289 (7), 1.926 (5)

Chemistry:

	(1)	(2)	(3)
SiO_2	2.54	0.5	
Al_2O_3	59.03	61.8	63.73
MnO	0.07		
MgO	0.13		
CaO	0.39		
F	22.96		23.75
H_2O	24.55		22.52
$-O = F_2$	9.67		10.00
Total	100.00		100.00

(1) Zharchikha deposit, Russia; $(OH)^{1-}$ confirmed present by IR. (2) Do., by electron microprobe, partial analysis. (3) $AlF(OH)_2$.

Occurrence: In cavities in hydrothermally mineralized fault breccia in trachyte in a stockwork molybdenum deposit.

Association: Prosopite, ralstonite, gearksutite, barite, siderite.

Distribution: In the Zharchikha molybdenum deposit, 60 km south-southwest of Ulan-Ude, on the west side of Lake Baikal, Buryatia, eastern Siberia, Russia.

Name: For its occurrence in the Zharchikha deposit, Russia (the name simplified in transliteration).

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 87567.

References: (1) Bolokhontseva, S.V., S.V. Baturin, E.S. Ilmeyev, M.A. Papova, and S.P. Purusova (1988) Zharchikhite $AlF(OH)_2$ – a new mineral. Zap. Vses. Mineral. Obshch., 117, 79–83 (in Russian). (2) (1989) Amer. Mineral., 74, 504 (abs. ref. 1).

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Zhemchuzhnikovite $NaMg(Al, Fe^{3+})(C_2O_4)_3 \cdot 8H_2O$

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Crystal Data: Hexagonal. *Point Group:* n.d. Crystals acicular to fibrous, showing {0001}, $\{11\bar{2}0\}$, $\{22\bar{4}1\}$.

Physical Properties: *Cleavage:* On {0001}, good. Hardness = 2 D(meas.) = 1.69 D(calc.) = 1.66 Soluble in H_2O, yielding a solution of about pH 5.51.

Optical Properties: Semitransparent. *Color:* Smoky green in daylight; may be violet-amethyst under artificial light. *Luster:* Vitreous.
Optical Class: Uniaxial (–). *Pleochroism:* O = greenish yellow; E = reddish violet. $\omega = 1.479$ $\epsilon = 1.408$

Cell Data: *Space Group:* n.d. $a = 16.67(5)$ $c = 12.51(3)$ $Z = 6$

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
C_2O_3	42.88
Al_2O_3	6.14
Fe_2O_3	5.95
MnO	0.06
MgO	8.57
Na_2O	5.69
K_2O	0.12
H_2O	29.09
insol.	1.13
Total	[99.63]

(1) Chai-Tumus coal deposit, Russia; here converted to oxides, insoluble is coal; corresponds to $(Na_{0.92}K_{0.01})_{\Sigma=0.93}Mg_{1.06}(Al_{0.60}Fe^{3+}_{0.37})_{\Sigma=0.97}(C_2O_4)_{2.97} \cdot 8.07H_2O$.

Occurrence: In veinlets found at a depth of 230 m in a drill core in the permafrost zone, in brown coal naturally saturated with acetic acid.

Association: Calcite, dolomite, stepanovite.

Distribution: Chai-Tumus coal deposit, 200 km south of the Lena River estuary, Bulun district, polar Sakha, Russia.

Name: Honors Yurii Apollonovich Zhemchuzhnikov (1885–1957), specialist in coal geology and petrology, Karpinskii Russian Research Institute of Geology, St. Petersburg, Russia.

Type Material: Mining Institute, St. Petersburg, Russia, 1955/1.

References: (1) Knipovich, Y.N., A.I. Komkov, and E.I. Nefedov (1963) On stepanovite and the new mineral zhemchuzhnikovite. Trudy. Vses. Nauchno-Issled. Geol. Inst. 96, 131–135 (in Russian). (2) (1964) Amer. Mineral., 49, 442 (abs. ref. 1). (3) Pekov, I.V. (1998) Minerals first discovered on the territory of the former Soviet Union. Ocean Pictures, Moscow, 241.

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Ziesite β–$\mathbf{Cu_2V_2^{5+}O_7}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Anhedral crystals, to 200 μm, incrusting basalt.

Physical Properties: Hardness = n.d. D(meas.) = 3.86(5) (synthetic). D(calc.) = 3.87

Optical Properties: Opaque, transparent on very thin edges. *Color:* Black; reddish brown to dark reddish brown in transmitted light; white in reflected light. *Streak:* Reddish brown. *Luster:* Metallic.
Optical Class: Biaxial. *Absorption:* Weak. n = [2.055] *Anisotropism:* Moderate to strong.

Cell Data: *Space Group:* $C2/c$ (synthetic). $a = 7.6890(8)$ $b = 8.0289(9)$ $c = 10.1065(8)$ $\beta = 110.252(7)^\circ$ Z = 2

X-ray Powder Pattern: Synthetic.
3.60 (10), 3.09 (10), 3.06 (10), 5.34 (8), 2.302 (8), 2.111 (8), 2.641 (6)

Chemistry:

	(1)	(2)
V_2O_5	52.82	53.34
CuO	45.37	46.66
Total	98.19	100.00

(1) Izalco volcano, El Salvador; by electron microprobe, average of two analyses; corresponds to $Cu_{1.97}V_{2.01}O_7$. (2) $Cu_2V_2O_7$.

Polymorphism & Series: Dimorphous with blossite; stable above 712 °C.

Occurrence: In vanadium-bearing sublimates in fumaroles on a basaltic volcanic cone.

Association: Stoiberite, shcherbinaite, bannermanite, fingerite, mcbirneyite, blossite, chalcocyanite, chalcanthite.

Distribution: From the summit crater of the Izalco volcano, El Salvador.

Name: To honor Dr. Emanuel G. Zies, Carnegie Institute, Washington, D.C., USA.

Type Material: Carnegie Institute, Washington, D.C., USA.

References: (1) Hughes, J.M. and R.W. Birnie (1980) Ziesite, β–$Cu_2V_2O_7$, a new copper vanadate and fumarole temperature indicator. Amer. Mineral., 65, 1146–1149. (2) Hughes, J.M. and M.A. Brown (1989) The crystal structure of ziesite, β–$Cu_2V_2O_7$, a thortveitite-type structure with a non-linear X–O–X inter-tetrahedral bond. Neues Jahrb. Mineral., Monatsh., 41–47. (3) Mercurio-Lavaud, D. and M.B. Frit (1973) Structure cristalline de la variété haute température du pyrovanadate de cuivre: $Cu_2V_2O_7$. Compt. Rendus Acad. Sci. Paris, Ser. C., 277, 1101–1104 (in French).

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Zimbabweite $(Na,K)_2PbAs_4^{3+}(Ta,Nb,Ti)_4O_{18}$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals euhedral to subhedral, to 2 cm, with {010}, {201}, also {100}, {111}.

Physical Properties: *Cleavage:* {010}, perfect. *Tenacity:* Brittle. Hardness = 5–5.5 D(meas.) = 6.20(3) D(calc.) = 6.16

Optical Properties: Translucent. *Color:* Honey-yellow-brown; in transmitted light, pale yellow. *Streak:* White. *Luster:* Adamantine.
Optical Class: Biaxial (+). *Pleochroism:* Moderate; X = pale yellow-brown; Y = light reddish brown; Z = reddish brown. *Orientation:* $X = c$; $Y = b$; $Z = a$. *Dispersion:* $r < v$, very strong. $\alpha = > 2.10$ $\beta = > 2.10$ $\gamma = > 2.10$ 2V(meas.) = 80(4)°
R_1–R_2: (470) 17.6–17.8, (546) 17.0–17.1, (589) 16.6–16.7, (650) 16.2–16.5

Cell Data: *Space Group: Ccmb.* $a = 12.245(2)$ $b = 15.287(4)$ $c = 8.684(1)$ Z = 4

X-ray Powder Pattern: St. Ann's mine, Zimbabwe.
3.195 (100), 2.990 (70), 2.882 (70), 3.033 (60), 3.823 (55), 2.548 (50), 1.913 (50)

Chemistry:

	(1)		(1)
Nb_2O_5	4.8	SrO	0.02
Ta_2O_5	46.5	BaO	0.4
TiO_2	1.4	Na_2O	3.1
SnO_2	0.1	K_2O	1.5
UO_2	0.3	F	0.04
As_2O_3	26.5	H_2O^+	0.13
Bi_2O_3	0.2	H_2O^-	0.06
PbO	15.0	$-O = F_2$	0.02
		Total	100.03

(1) St. Ann's mine, Zimbabwe; by electron microprobe and a variety of other methods, total As as As_2O_3, H_2O by microcoulometry; corresponding to $(Na_{1.51}K_{0.48}Ba_{0.04})_{\Sigma=2.03}Pb_{1.01}(As_{4.03}Bi_{0.01})_{\Sigma=4.04}(Ta_{3.17}Nb_{0.55}Ti_{0.26}U_{0.02}Sn_{0.01})_{\Sigma=4.01}O_{18}$.

Occurrence: In a hydrothermally altered kaolinized zone of a complex rare-metal and fluorine-rich granite pegmatite.

Association: Kaolinite.

Distribution: From the St. Ann's mine, southeast of Miami, Karoi district, Zimbabwe.

Name: For Zimbabwe, the country where it was first found.

Type Material: National Museum of Natural History, Washington, D.C., USA, 162513.

References: (1) Foord, E.E., J.E. Taggart, Jr., R.V. Gaines, P.L.C. Grubb, and R. Kristiansen (1986) Zimbabweite, a new alkali-lead-arsenic tantalate from St Anns mine, Karoi District, Zimbabwe. Bull. Minéral., 109, 331–336. (2) (1990) Amer. Mineral., 75, 244 (abs. ref. 1). (3) Duesler, E.N., B.C. Chakoumakos, and E.E. Foord. (1988) Zimbabweite, $Na(Pb,Na,K)_2As_4(Ta,Nb,Ti)_4O_{18}$, an arsenite-tantalate with a novel corner-linked octahedral sheet. Amer. Mineral., 73, 1186–1190.

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. As small irregular plates, sometimes striated in multiple directions producing a cross-hatching, and with hummocky surfaces.

Physical Properties: *Cleavage:* Perfect on {0001}. *Tenacity:* Brittle. Hardness = 2 VHN = n.d. D(meas.) = 6.9–7.2 D(calc.) = 7.135

Optical Properties: Opaque. *Color:* White. *Streak:* White and slightly grayish. *Luster:* Metallic.
R_1–R_2: n.d.

Cell Data: *Space Group:* $P6_3/mmc$. $a = 2.665$ $c = 4.947$ Z = 2

X-ray Powder Pattern: Synthetic.
2.091 (100), 2.473 (3), 2.308 (40), 1.687 (28), 1.342 (25), 1.1729 (23), 1.332 (21)

Chemistry:

	(1)
Zn	~90
Sn, Pb, Cd	~10
Fe, Mn, B, Si, Cu, Ag, Ca, Ba	trace
Total	

(1) Elsa mine, Canada; combined X-ray fluorescence and spectrographic analyses.

Occurrence: In the oxidized zone of Pb-Zn-Ag deposits, derived from sphalerite by oxidation (Elsa mine, Canada); coatings on fibrous volcanic glass, as a volcanic sublimate (Mount Elbrus, USSR); in platinum concentrates (Aurora deposit, USSR).

Association: Silver, sulfur, oxidized sphalerite, "limonite", manganese oxides, cerussite, anglesite, freibergite, galena (Elsa mine, Canada); copper, Cu–Zn alloy, sphalerite, djurleite, cuprite (Dulcina mine, Chile).

Distribution: In the Elsa mine, Keno Hill-Galena Hill area, Yukon Territory, Canada. From Mount Elbrus, Caucasus Mountains, and the Aurora deposit, locality not otherwise specified, USSR. In the Dulcina de Lampos copper mine, near Copiapó, Chile.

Name: From the German *zink*, of obscure origin.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 127. (2) (1953) NBS Circ. 539, 1, 16. (3) Boyle, R.W. (1961) Native zinc at Keno Hill. Can. Mineral., 6, 692–694. (4) Bartikyan, P.M. (1966) Native lead and zinc in the rocks of Armenia. Zap. Vses. Mineral. Obshch., 95, 99–102 (in Russian). (5) (1962) Mineral. Abs., 18, 200. (abs. ref. 4).

Zincaluminite $Zn_6Al_6(SO_4)_2(OH)_{26}\cdot 5H_2O$

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Crystal Data: Hexagonal or orthorhombic (?). *Point Group:* n.d. Minute thin hexagonal crystals, in tufts and crusts.

Physical Properties: Hardness = 2.5–3 D(meas.) = 2.26 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White, bluish white, pale blue; colorless in transmitted light.
Optical Class: Uniaxial (–), may be biaxial. $\omega = 1.534(3)$ $\epsilon = 1.514(3)$ 2V(meas.) = Small.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)
SO_3	12.94	12.53
Al_2O_3	25.48	23.92
CuO	1.85	
ZnO	34.69	38.19
H_2O	25.04	25.36
Total	100.00	100.00

(1) Laurium, Greece; recalculated to 100% after deduction of minor gangue.
(2) $Zn_6Al_6(SO_4)_2(OH)_{26}\cdot 5H_2O$.

Occurrence: A rare secondary mineral in the oxidized zone of a Ag–Zn mine.

Association: Smithsonite, aurichalcite, hydrozincite, serpierite, cyanotrichite, azurite, cuproadamite, agardite-(La), calcite, chrysocolla, gibbsite.

Distribution: In Greece, from Laurium, at the Kamariza mine.

Name: For *zinc* and *aluminum* in the composition, and its similarity to *aluminite*.

Type Material: Natural History Museum, Paris, France, 96.1432.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 579–580.

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Zincgartrellite $\mathbf{Pb(Zn,Fe,Cu)_2(AsOI_4)_2(H_2O,OH)_2}$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals lathlike, elongated and striated along [001], with minor {$hk0$} and {hkl} forms, to 2 cm, in subparallel aggregates. *Twinning:* Common on {100}.

Physical Properties: *Cleavage:* {010}, good to perfect; {001}, traces. *Tenacity:* Brittle. Hardness = ∼3 D(meas.) = 3.75 D(calc.) = 3.77

Optical Properties: Transparent to translucent. *Color:* Colorless, white. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 0°$–$5°$. *Dispersion:* $r \ll v$, strong. $\alpha = 1.703(3)$ $\beta = 1.710(4)$ $\gamma = 1.720(3)$ 2V(meas.) = 50° 2V(calc.) = 57°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.832(2)$ $b = 12.889(4)$ $c = 5.644(2)$ $\beta = 107.72(3)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.00 (10), 3.22 (8), 2.78 (8), 5.10 (6), 6.44 (5), 3.40 (5), 3.36 (5)

Chemistry:

	(1)	(2)
As_2O_5	49.3	50.03
FeO	0.2	
MnO	0.9	
ZnO	15.9	17.72
MgO	0.4	
CaO	25.0	24.41
H_2O	7.7	7.84
Total	99.4	100.00

(1) Tsumeb, Namibia; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by LOI; corresponds to $Ca_{2.06}(Zn_{0.90}Mn_{0.06}Mg_{0.05}Fe_{0.01})_{\Sigma=1.02}(AsO_4)_{1.98} \bullet 1.97H_2O$.
(2) $Ca_2Zn(AsO_4)_2 \bullet 2H_2O$.

Polymorphism & Series: Dimorphous with gaitite.

Mineral Group: Roselite group.

Occurrence: A rare secondary mineral in an oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tsumcorite, stranskiite, leiteite, quartz, tennantite.

Distribution: From Tsumeb, Namibia.

Name: For its content of *zinc* and relation to *roselite*.

Type Material: University of Stuttgart, Stuttgart, Germany, NM16; National Museum of Natural History, Washington, D.C., USA, 163340.

References: (1) Keller, P., J. Innes, and P.J. Dunn (1986) Zincroselite, $Ca_2Zn(AsO_4)_2 \bullet 2H_2O$, a new mineral from Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 523–527. (2) (1988) Amer. Mineral., 73, 932 (abs. ref. 1).

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Zincite $(Zn, Mn^{2+})O$

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Crystal Data: Hexagonal. *Point Group:* $6mm$. Crystals rare, typically pyramidal, hemimorphic, with large $\{000\overline{1}\}$, to 2.5 cm, rarely curved; in broad cleavages, foliated, granular, compact, massive. *Twinning:* On $\{0001\}$, with composition plane $\{000\overline{1}\}$.

Physical Properties: *Cleavage:* $\{10\overline{1}0\}$, perfect; parting on $\{000\overline{1}\}$, commonly distinct. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 4 VHN = 205–221 (100 g load). D(meas.) = 5.66(2) D(calc.) = 5.6730 Rare pale yellow fluorescence under LW UV.

Optical Properties: Translucent, transparent in thin fragments. *Color:* Yellow-orange to deep red, rarely yellow, green, colorless; deep red to yellow in transmitted light; light rose-brown in reflected light, with strong red to yellow internal reflections. *Streak:* Yellow-orange. *Luster:* Subadamantine to resinous.
Optical Class: Uniaxial (+). $\omega = 2.013$ $\epsilon = 2.029$
R_1–R_2: (400) 13.0–13.6, (420) 12.8–13.2, (440) 12.6–12.8, (460) 12.3–12.6, (480) 12.1–12.4, (500) 12.0–12.2, (520) 11.8–12.1, (540) 11.8–12.0, (560) 11.7–11.9, (580) 11.6–11.8, (600) 11.4–11.7, (620) 11.3–11.6, (640) 11.2–11.5, (660) 11.1–11.4, (680) 11.0–11.2, (700) 11.0–11.2

Cell Data: *Space Group:* $P6_3mc$ (synthetic). $a = 3.24992(5)$ $c = 5.20658(8)$ $Z = 2$

X-ray Powder Pattern: Synthetic.
2.476 (100), 2.816 (71), 2.602 (56), 1.626 (40), 1.477 (35), 1.911 (29), 1.379 (28)

Chemistry:

	(1)	(2)
SiO_2	0.08	
FeO	0.01	0.23
MnO	0.27	0.29
ZnO	99.63	98.88
Total	99.99	[99.40]

(1) Sterling Hill, New Jersey, USA. (2) Do.; by electron microprobe, original total given as 99.39%.

Occurrence: A primary mineral in metamorphosed stratiform zinc orebodies (New Jersey, USA); a secondary mineral altered from other zinc minerals in oxidized zinc-rich ore deposits; a product of volcanism.

Association: Franklinite, willemite, calcite (New Jersey, USA); zinc, sphalerite, smithsonite, hemimorphite, hausmannite.

Distribution: In the USA, from Franklin and Sterling Hill, Ogdensburg, Sussex Co., New Jersey; in the Tonopah-Belmont mine, Osborne district, Maricopa Co., Arizona, the result of a mine fire; in volcanic ash from Mt. St. Helens, Skamania Co., Washington. At Tsumeb, Namibia. From Kipushi, 28 km southwest of Lubumbashi, Katanga Province, Congo (Shaba Province, Zaire). Other localities have been reported but lack supporting data or an accurate location.

Name: For ZINC in the composition.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 504–506. (2) Dunn, P.J. (1979) Light green zincite from Sterling Hill, Ogdensburg, New Jersey. Mineral. Record, 10, 45–46. (3) Albertsson, J., S.C. Abrahams, and Å. Kvick (1989) Atomic displacement, anharmonic thermal vibration, expansivity and pyroelectric coefficient thermal dependences in ZnO. Acta Cryst., 45, 34–40. (4) Dunn, P.J. (1995) Franklin and Sterling Hill, New Jersey. No publisher, n.p., 558–565. (5) (1953) NBS Circ. 539, 2, 25.

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Zinc-melanterite $(Zn, Cu, Fe^{2+})SO_4 \cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals are short prismatic, to 1.8 mm; in stalactites, crusts, granular and massive columnar aggregates.

Physical Properties: *Fracture:* Uneven. Hardness = 2–2.5 D(meas.) = 2.02–2.03 D(calc.) = 1.93 Dehydrates readily under ambient conditions.

Optical Properties: Transparent. *Color:* Yellowish green, greenish blue, apple-green; very pale blue-green in transmitted light. *Streak:* White. *Luster:* Vitreous to resinous. *Optical Class:* Biaxial (+). *Orientation:* $Y \wedge$ elongation $\simeq 34°$. *Dispersion:* Slight. $\alpha = 1.477$–1.479 $\beta = 1.483$–1.487 $\gamma = 1.488$–1.489 2V(meas.) = 80°–90° 2V(calc.) = 78.7°

Cell Data: *Space Group:* $[P2_1/c]$ (by analogy with the melanterite group). Z = 4

X-ray Powder Pattern: n.d.

Chemistry:

	(1)	(2)	(3)
SO_3	28.78	28.66	27.93
FeO	2.14	8.86	
CuO	12.37	< 0.01	13.88
ZnO	12.89	16.35	14.20
MgO		1.40	
CaO		0.14	
H_2O	42.61	44.58	43.99
insol.	1.11		
Total	99.90	99.99	100.00

(1) Vulcan, Colorado, USA; corresponds to $(Zn_{0.46}Cu_{0.45}Fe_{0.09})_{\Sigma=1.00}(SO_4)_{1.04} \cdot 6.87H_2O$. (2) Leh-Yang Co., China; average of two analyses; corresponds to $(Zn_{0.57}Fe_{0.35}Mg_{0.10}Ca_{0.02})_{\Sigma=1.04}(SO_4)_{0.99} \cdot 6.88H_2O$. (3) $(Zn, Cu)SO_4 \cdot 7H_2O$ with Zn:Cu = 1:1.

Mineral Group: Melanterite group.

Occurrence: A rare mineral formed in the oxidation zone of pyritic ore deposits.

Association: Sphalerite, chalcopyrite, pyrite.

Distribution: In the USA, from the Good Hope and Vulcan mines, Vulcan, Gunnison Co., Colorado. In Leh-Yang Co., southern Shaanxi Province, China.

Name: As the *zinc*-dominant member of the *melanterite* group.

Type Material: National Museum of Natural History, Washington, D.C., USA, 93244.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 508. (2) Tiegeng Liu, Guohong Gong, and Lin Ye (1995) Discovery and investigation of zinc-melanterite in nature. Acta Mineralogica Sinica, 15(3), 286–290 (in Chinese with English abs.).

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Zincobotryogen $(Zn, Mg, Mn^{2+})Fe^{3+}(SO_4)_2(OH)\cdot 7H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Prismatic crystals, to a few mm, showing {010}, {$\bar{1}$01}, {120}, {110}, minor {$\bar{1}$11}, {101}, singly and in conical radiating aggregates.

Physical Properties: Hardness = ∼2.5 D(meas.) = 2.19–2.20 D(calc.) = [2.24]

Optical Properties: Transparent to translucent. *Color:* Bright red-orange to chestnut-brown. *Luster:* Vitreous to greasy.
Optical Class: Biaxial (+). *Pleochroism:* Strong. *Orientation:* Negative elongation, parallel extinction. *Dispersion:* $r > v$. $\alpha = 1.542$ $\beta = 1.551$ $\gamma = 1.587$ 2V(meas.) = n.d. 2V(calc.) = 54°

Cell Data: *Space Group:* $P2_1/n$. $a = 10.488$–10.51 $b = 17.819$–17.85 $c = 7.14$–7.185 $\beta = 100°00'$–$100°50'$ Z = 4

X-ray Powder Pattern: Synthetic.
8.963 (100), 5.163 (75), 3.027 (61), 6.354 (58), 4.095 (53), 2.762 (52), 3.219 (51)

Chemistry:

	(1)	(2)
SO_3	36.03	36.1
Al_2O_3	0.01	
Fe_2O_3	18.34	18.4
FeO	0.85	1.2
MnO	1.75	3.6
ZnO	11.77	7.7
MgO	2.50	1.6
Na_2O	0.05	
K_2O	0.00	
H_2O^+	29.13	30.9
H_2O^-	0.22	
Total	100.65	99.5

(1) Xitieshan mine, China; corresponds to $(Zn_{0.64}Mg_{0.27}Mn^{2+}_{0.11}Fe^{2+}_{0.05})_{\Sigma=1.07}Fe^{3+}_{1.00}(SO_4)_{1.96}(OH)_{1.00}\cdot 6.61H_2O$. (2) Rammelsberg mine, Germany; corresponds to $(Zn_{0.47}Mn^{2+}_{0.25}Mg_{0.20}Fe^{2+}_{0.08})_{\Sigma=1.00}Fe^{3+}(SO_4)_2(OH)\cdot 7H_2O$.

Occurrence: A rare secondary mineral formed in the oxidation zone, typically in an arid climate.

Association: Pickeringite, chaidamuite, coquimbite, copiapite, butlerite, pyrite (Xitieshan mine, China); zincian melanterite (Rammelsberg mine, Germany).

Distribution: From an undisclosed Pb–Zn deposit [Xitieshan mine, south of Mt. Qilianshan, Chaidamu], Qinghai Province, China. At the Rammelsberg mine, near Goslar, Harz Mountains, Germany. In the USA, from Bisbee, Cochise Co., Arizona; in Colorado, from the Prompt Pay and Running Lode mines, Central City district, Gilpin Co., in the Summitville mine, Rio Grande Co., and at the Bonanza mine, Bonanza district, Saguache Co.

Name: For its dominant content of *zinc* and relation to *botryogen*.

Type Material: n.d.

References: (1) Tu Kwang-chih, Li Hsi-lin, Hsieh Hsien-deh, and Yin Shu-sen (1964) Zincobotryogen and zincocopiapite, two new varieties of sulphate minerals. Acta Geologica Sinica, 44(1), 99–101. (in Chinese with English abs.). (2) (1964) Amer. Mineral., 49, 1776 (abs. ref. 1). (3) Zemann, J. (1961) Über den Botryogen vom Rammelsberg. Fortschr. Mineral., 39, 84 (in German). (4) (1983) NBS Mono. 25, 20, 67.

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Zincochromite $ZnCr_2^{3+}O_4$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals euhedral, showing hexagonal sections of dodecahedra, to 50 μm, strongly zoned.

Physical Properties: Hardness = 5.8 VHN = 620 D(meas.) = n.d. D(calc.) = 5.434 Weakly paramagnetic.

Optical Properties: Opaque, translucent in thin slivers. *Color:* Brownish black; brown in transmitted light; brownish gray in reflected light, with rare brown internal reflections. *Streak:* Brown. *Luster:* Semimetallic.
Optical Class: Isotropic.
R: (400) —, (420) —, (440) 13.0, (460) 12.4, (480) 12.1, (500) 12.0, (520) 11.9, (540) 11.8, (560) 11.7, (580) 11.6, (600) 11.6, (620) 11.6, (640) 11.6, (660) 11.6, (680) 11.6, (700) 11.6

Cell Data: *Space Group: Fd3m* (synthetic). $a = 8.3271(2)$ $Z = 8$

X-ray Powder Pattern: Onega Lake, Russia.
2.519 (100), 2.954 (50), 1.476 (35), 1.607 (30), 2.088 (25), 4.822 (15), 1.705 (15)

Chemistry:

	(1)	(2)
SiO_2	2.82	
TiO_2	0.14	
Al_2O_3	1.14	
Fe_2O_3	2.03	
V_2O_3	3.52	
Cr_2O_3	53.30	65.13
ZnO	37.05	34.87
Total	100.00	100.00

(1) Onega Lake, Russia; by electron microprobe, weighted average of four zones in six grains; total Fe as Fe_2O_3, total Cr as Cr_2O_3, total V as V_2O_3; corresponding to $Zn_{1.04}(Cr_{1.61}V_{0.11}Si_{0.11}Fe_{0.06}Al_{0.05})_{\Sigma=1.94}O_4$. (2) $ZnCr_2O_4$.

Mineral Group: Spinel group.

Occurrence: Replacing chromian aegirine in micaceous metasomatites.

Association: Quartz, chromian aegirine, and its amorphous breakdown products.

Distribution: From the Velikaya Guba uranium deposit, near Onega Lake, Padma, Zaonezhskii Peninsula, southern Karelia, Russia.

Name: For ZINC and CHROMium in the composition.

Type Material: Mining Institute, St. Petersburg, Russia, 1238/1.

References: (1) Nesterov, A.R. and Y.V. Rumyantseva (1987) Zincochromite $ZnCr_2O_4$ – a new mineral from Karelia. Zap. Vses. Mineral. Obshch., 116, 367–371 (in Russian with English abs.). (2) (1988) Amer. Mineral., 73, 931–932 (abs. ref. 1). (3) (1988) Mineral. Abs., 39, 122–123 (abs. ref. 1). (4) O'Neill, H.St.C. and W.A. Dollase (1994) Crystal structures and cation distributions in simple spinels from powder XRD structural refinements: $MgCr_2O_4$, $ZnCr_2O_4$, Fe_3O_4 and the temperature dependence of the cation distribution in $ZnAl_2O_4$. Phys. Chem. Minerals, 20, 541–555. (5) (1971) NBS Mono. 25, 9, 59.

; zinchögbomite-8H = zinchögbomite-2N2S; zinchögbomite-16H = zinchögbomite-2N6S; [full list given under högbohmite];

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Zincocopiapite $ZnFe_4^{3+}(SO_4)_6(OH)_2 \cdot 18H_2O$

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Crystal Data: Triclinic, pseudo-orthorhombic. *Point Group:* $\overline{1}$. Thin scaly crystals, to 1 mm, showing {010}, {100}, {101}, {$0\overline{1}1$}, minor {$1\overline{2}0$}, {001}; also in compact massive aggregates.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = 2 D(meas.) = 2.181 D(calc.) = 2.15

Optical Properties: Transparent to translucent. *Color:* Canary-yellow, yellowish green. *Luster:* Vitreous, pearly to greasy.
Optical Class: Biaxial (+). *Pleochroism:* Strong; X = yellow; Y = colorless; Z = deep canary-yellow. *Orientation:* $X \simeq b$; $Y \wedge c = 39°$; $Z \wedge a = 51°$; OAP $\simeq$ {101}. *Dispersion:* $r > v$, strong. α = 1.532–1.534 β = 1.540–1.554 γ = 1.586–1.592 2V(meas.) = n.d. 2V(calc.) = 44°–78°

Cell Data: *Space Group:* $P\overline{1}$. a = 7.35–7.36 b = 18.16–18.40 c = 7.28 $\alpha = 93.8°–95.83°$ $\beta = 101.5°–102.8°$ $\gamma = 98.5°–99.37°$ Z = 1

X-ray Powder Pattern: Les Vallettes, Switzerland.
18.2 (100), 9.06 (90), 6.06 (50), 3.568 (50), 6.55 (30), 5.20 (30), 4.87 (25)

Chemistry:

	(1)	(2)		(1)	(2)
SO_3	41.23	39.7	CaO	0.20	
Al_2O_3	0.00		Na_2O	0.05	
Fe_2O_3	25.35	26.1	K_2O	0.15	
FeO	0.42		H_2O^+	22.03	
MnO	0.39		H_2O^-	5.58	
ZnO	5.22	6.3	H_2O		27.0
MgO	0.00		Total	100.62	99.1

(1) Xitieshan mine, China; corresponds to $(Zn_{0.82}Fe^{2+}_{0.08}Mn^{2+}_{0.06}Ca_{0.04})_{\Sigma=1.00}Fe^{3+}_{4.00}(SO_4)_{6.50}(OH)_2 \cdot 18.4H_2O$. (2) Les Vallettes, Switzerland; H_2O by TGA; corresponds to $Zn_{0.97}Fe^{3+}_{4.03}(SO_4)_{6.13}(OH)_{1.75} \cdot 17.69H_2O$.

Mineral Group: Copiapite group.

Occurrence: A rare secondary mineral formed in the oxidation zone of a Pb–Zn deposit in a very arid climate (Xitieshan mine, China); a precipitate from thermal hot springs (Kopet-Dag Mountains, Turkmenistan); an alteration product of pyrite and sphalerite in schists (Les Vallettes, Switzerland).

Association: Copiapite, halotrichite, coquimbite, römerite, sideronatrite, melanterite (Xitieshan mine, China); sulfur, gypsum, calcite, pyrite, sphalerite, quartz, "limonite" (Kopet-Dag Mountains, Turkmenistan); boyleite, gunningite, coquimbite, jarosite, melanterite, römerite, siderotil, voltaite, chalcanthite, hexahydrite, gypsum (Les Vallettes, Switzerland).

Distribution: From an undisclosed Pb–Zn deposit [Xitieshan mine, south of Mt. Qilianshan, Chaidamu], Qinghai Province, China. Along the northern front range of the Kopet-Dag Mountains, Turkmenistan. From Băişoara, Romania. At Les Vallettes, Valais, Switzerland.

Name: For its dominant content of *zinc* and relation to *copiapite*.

Type Material: n.d.

References: (1) Tu Kwang-chih, Li Hsi-lin, Hsieh Hsien-deh, and Yin Shu-sen (1964) Zincobotryogen and zincocopiapite, two new varieties of sulphate minerals. Acta Geologica Sinica, 44(1), 99–101. (in Chinese with English abs.). (2) (1964) Amer. Mineral., 49, 1777 (abs. ref. 1). (3) Perroud, P., N. Meisser, and H. Sarp (1987) Présence de zincocopiapite en Valais. Schweiz. Mineral. Petrog. Mitt., 67, 115–117 (in French with English abs.).

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Zincolibethenite $CuZnPO_4OH$

Crystal Data: Orthorhombic. *Point Group*: 2/*m* 2/*m* 2/*m*. As prismatic crystals along [100], to 1 mm., exhibiting {011}, {100}, {110} and possibly {111} or {101}, also as compact radial aggregates.

Physical Properties: *Cleavage*: One poor direction perpendicular to crystal length. *Fracture*: Uneven to conchoidal. *Tenacity*: Brittle. Hardness = 3.5 D(meas.) = n.d. D(calc.) = 3.972

Optical Properties: Transparent to translucent. *Color*: Bright blue-green to green. *Streak*: Very pale bluish. *Luster*: Vitreous.
Optical Class: Biaxial (-). $\alpha = 1.660$ $\beta = 1.705$ $\gamma = 1.715$ 2V(meas.) = n.d. 2V(calc.) = 49°
Dispersion: $r < v$, medium. *Pleochroism*: Weak or absent, $X = Y$ = nearly colorless with a greenish tint, and Z = pale bluish green. *Absorption*: $Z > X \sim Y$. *Orientation*: $Z = a$.

Cell Data: *Space Group: Pnnm*. $a = 8.3263(3)$ $b = 8.2601(3)$ $c = 5.8771(2)$ Z = 4

X-ray Powder Pattern: Broken Hill mines, Kabwe, Zambia.
4.7937 (100), 2.6325 (47), 5.8676 (39), 2.9351 (33), 3.6993 (22), 2.4049 (19), 2.3040 (18)

Chemistry:

	(1)	(2)
Cu	26.0	26.4
Zn	27.7	27.1
P	12.8	12.9
H_2O	3.63	3.66

(1) Broken Hill mines, Kabwe, Zambia; average of 15 electron microprobe analyses, H_2O by difference, OH^- and PO_4 confirmed by IR spectroscopy; corresponding to $Cu_{0.987}Zn_{1.022}(P_{0.997}O_4)OH$. (2) $CuZnPO_4OH$.

Polymorphism & Series: Forms a solid-solution series with libethenite.

Occurrence: A secondary mineral in the oxidized zone of a polymetallic mineral deposit.

Association: Hopeite, tarbuttite (Zambia); corkite-hinsdalite, tsumebite, pyromorphite, sampleite, torbernite, dufienite, strengite, beraunite (Australia).

Distribution: Broken Hill mines, Kabwe, Zambia (formerly Northern Rhodesia). From Australia in the No 3 lens, 280RL level, Block14 open cut, Broken Hill, New South Wales.

Name: For its composition and relationship to *libethenite*.

Type Material: Institut für Mineralogie, Universität Salzburg, Austria; at the Royal Scottish Museum, Edinburgh, Scotland (RSWB 83-8), and the Natural History Museum, London, England.

References: (1) Braithwaite, R.S.W., R.G. Pritchard, W.H. Paar, and R.A.D. Pattrick (2005) A new mineral, zincolibethenite, $CuZnPO_4OH$, a stoichiometric species of specific site occupancy. Mineral. Mag., 69, 145-153. (2) (2005) Amer. Mineral., 90, 1950 (abs. ref. 1). (3) Williams, P. A., P. Leverett, W. D. Birch, D. E. Hibbs, Uwe Kolitsch and T. Mihajlovic (2006) Zinc-rich zincolibethenite from Broken Hill, New South Wales. Austral. J. Mineral., 12(1), 3-7.

Zincospiroffite $Zn_2Te_3O_8$

Crystal Data: Monoclinic. *Point Group:* 2/*m*. As micrometric aggregates to 0.35 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = Soft. D(meas.) = n.d. D(calc.) = 5.57

Optical Properties: Translucent. *Color:* Gray, in reflected light with no internal reflections. *Streak:* Dark green. *Luster:* Vitreous. Weak anisotropy, bireflectance and reflection pleochroism. R_1-R_2: (470 nm) 7.0-7.5, (546) 7.1-7.3, (589) 6.1-6.2, (650) 4.4-5.0

Cell Data: *Space Group: C*2/*c*. a = 12.72(4) b= 5.15(1) c = 11.82(3) β = 99.2(3)° Z = 4

X-ray Powder Pattern: Zhongshangou gold deposit, Hebei Province, China. 4.758 (w), 3.240 (w), 2.928 (m), 2.820 (w), 2.155 (w), 1.985 (w), 1.599 (w)

Chemistry:

	(1)
ZnO	24.57
PbO	1.64
MgO	0.24
TeO_2	71.90
Total	98.89

(1) Zhongshangou gold deposit, Hebei Province, China; electron microprobe analysis, minor FeO and SeO_2; corresponding to $(Zn_{1.97}Pb_{0.05}Mg_{0.04}Fe_{0.02})_{\Sigma=2.08}(Te_{2.95}Se_{0.01})_{\Sigma=2.96}O_{8.00}$.

Occurrence: A secondary mineral in an oxidized Te- and Au-bearing quartz vein.

Association: Occurs as a rim on, or a replacement of, calaverite, contains blebs of gold, sphalerite.

Distribution: Zhongshangou gold deposit, Chongli County, Hebei Province, People's Republic of China.

Name: As the zinc-dominant analogue of *spiroffite*.

Type Material: Geological Museum of China, Beijing, People's Republic of China; M10442.

References: (1) Zhang, Pei-Hua, Jin-Chu Zhu, Zhen-Hua Zhao, Xiang-Ping Gu, and Jin-Fu Lin (2004) Zincospiroffite, a new tellurite mineral species from the Zhongshangou gold deposit, Hebei Province, People's Republic of China. Can. Mineral., 42, 763-768. (2) (2005) Amer. Mineral., 90, 521 (abs. ref. 1).

Zincovoltaite $K_2Zn_5Fe^{3+}_3Al(SO_4)_{12}\cdot 18H_2O$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals show {111}, {100}, {110}, {211}, to 2 mm, in granular aggregates and irregular veinlets.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = ∼3
D(meas.) = 2.765 D(calc.) = 2.767 Slowly soluble in H_2O, decomposes on exposure to the atmosphere.

Optical Properties: Transparent to translucent. *Color:* Green-black to oil-green; yellowish green in transmitted light. *Streak:* Grayish green. *Luster:* Vitreous on crystal surfaces, pitchy to resinous.
Optical Class: Isotropic, anomalously uniaxial. $n = 1.605(3)$

Cell Data: *Space Group:* $Fd3c$. a = 27.180(1) Z = 16

X-ray Powder Pattern: Xitieshan mine, China.
3.39 (100), 3.54 (67), 5.53 (48), 3.13 (39), 3.84 (32), 4.24 (28), 3.03 (28)

Chemistry:

	(1)	(2)
SO_3	46.93	46.26
Al_2O_3	2.50	2.46
Fe_2O_3	11.21	11.53
FeO	3.20	
MnO	1.20	
ZnO	14.61	19.60
CaO	0.69	
K_2O	4.11	4.54
H_2O	15.69	15.61
Total	100.14	100.00

(1) Xitieshan mine, China; corresponding to $(K_{1.79}Ca_{0.25})_{\Sigma=2.04}(Zn_{3.69}Fe^{2+}_{0.91}Mn_{0.35})_{\Sigma=4.95}Fe^{3+}_{2.89}Al_{1.01}(SO_4)_{12.06}\cdot 17.92H_2O$. (2) $K_2Zn_5Fe^{3+}_3Al(SO_4)_{12}\cdot 18H_2O$.

Occurrence: In the oxidation zone of a Zn–Pb–Fe sulfide deposit, formed in an arid climate.

Association: Römerite, melanterite, gypsum, pyrite, quartz.

Distribution: From the Xitieshan Pb–Zn mine, south of Mt. Qilianshan, Chaidamu, Qinghai Province, China.

Name: As the *zinc* analog of *voltaite*.

Type Material: Lanzhou University, Lanzhou; Geological Museum, Ministry of Geology, Beijing, China.

References: (1) Wanmao Li, Guoying Chen, and Shurong Sun (1987) Zincovoltaite – a new sulfate mineral. Acta Mineralogica Sinica, 7, 307–312 (in Chinese with English abs.). (2) (1990) Amer. Mineral., 75, 244–245 (abs. ref. 1).

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Zincowoodwardite $ZnAl(SO_4)(OH)_2 \cdot H_2O$

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Crystal Data: Monoclinic (by analogy to rosasite). *Point Group:* n.d. Radial fibrous, to 1.5 mm; in crusts.

Physical Properties: Hardness = ∼1 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Pale blue to almost white. *Streak:* Pale blue. *Optical Class:* Biaxial (–) (by analogy to rosasite).

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry: (1) Tsumeb, Namibia; no analysis presented, stated to have a ratio of Zn:Cu = 58.60:51.94 or greater.

Mineral Group: Rosasite group.

Occurrence: In an oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Azurite, cerussite, hemimorphite (Tsumeb, Namibia); cerussite, aurichalcite, malachite (Rudabánya, Hungary).

Distribution: From Tsumeb, Namibia. At Rudabánya, Hungary. In the Kamariza mine, Laurium, Greece.

Name: For its predominance of *zinc* content over copper content, and its relation to *rosasite*.

Type Material: Technical University, Berlin; National Museum of Natural History, Washington, D.C., USA, 163340.

References: (1) Strunz, H. (1959) Tsumeb, seine Erze und Sekundär-mineralien, insbesondere der neu aufgeschlossen zweiten Oxydationszone. Fortschr. Mineral., 37, 87–90 (in German).
(2) (1959) Amer. Mineral., 44, 1373 (abs. ref. 1).

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Zincrosasite $(Zn, Cu)_2(CO_3)(OH)_2$

Crystal Data: Monoclinic (by analogy to rosasite). *Point Group:* n.d. Radial fibrous, to 1.5 mm; in crusts.

Physical Properties: Hardness = ~1 D(meas.) = n.d. D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Pale blue to almost white. *Streak:* Pale blue. *Optical Class:* Biaxial (–) (by analogy to rosasite).

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry: (1) Tsumeb, Namibia; no analysis presented, stated to have a ratio of Zn:Cu = 58.60:51.94 or greater.

Mineral Group: Rosasite group.

Occurrence: In an oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia).

Association: Azurite, cerussite, hemimorphite (Tsumeb, Namibia); cerussite, aurichalcite, malachite (Rudabánya, Hungary).

Distribution: From Tsumeb, Namibia. At Rudabánya, Hungary. In the Kamariza mine, Laurium, Greece.

Name: For its predominance of *zinc* content over copper content, and its relation to *rosasite*.

Type Material: Technical University, Berlin; National Museum of Natural History, Washington, D.C., USA, 163340.

References: (1) Strunz, H. (1959) Tsumeb, seine Erze und Sekundär-mineralien, insbesondere der neu aufgeschlossen zweiten Oxydationszone. Fortschr. Mineral., 37, 87–90 (in German).
(2) (1959) Amer. Mineral., 44, 1373 (abs. ref. 1).

Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals lathlike, elongated and striated along [001], with minor {$hk0$} and {hkl} forms, to 2 cm, in subparallel aggregates. *Twinning:* Common on {100}.

Physical Properties: *Cleavage:* {010}, good to perfect; {001}, traces. *Tenacity:* Brittle. Hardness = ~3 D(meas.) = 3.75 D(calc.) = 3.77

Optical Properties: Transparent to translucent. *Color:* Colorless, white. *Luster:* Vitreous. *Optical Class:* Biaxial (+). *Orientation:* $Y = b$; $X \wedge c = 0°–5°$. *Dispersion:* $r \ll v$, strong. $\alpha = 1.703(3)$ $\beta = 1.710(4)$ $\gamma = 1.720(3)$ 2V(meas.) = 50° 2V(calc.) = 57°

Cell Data: *Space Group:* $P2_1/c$. $a = 5.832(2)$ $b = 12.889(4)$ $c = 5.644(2)$ $\beta = 107.72(3)°$ Z = 2

X-ray Powder Pattern: Tsumeb, Namibia.
3.00 (10), 3.22 (8), 2.78 (8), 5.10 (6), 6.44 (5), 3.40 (5), 3.36 (5)

Chemistry:

	(1)	(2)
As_2O_5	49.3	50.03
FeO	0.2	
MnO	0.9	
ZnO	15.9	17.72
MgO	0.4	
CaO	25.0	24.41
H_2O	7.7	7.84
Total	99.4	100.00

(1) Tsumeb, Namibia; by electron microprobe, total Fe as FeO, total Mn as MnO, H_2O by LOI; corresponds to $Ca_{2.06}(Zn_{0.90}Mn_{0.06}Mg_{0.05}Fe_{0.01})_{\Sigma=1.02}(AsO_4)_{1.98} \cdot 1.97H_2O$.
(2) $Ca_2Zn(AsO_4)_2 \cdot 2H_2O$.

Polymorphism & Series: Dimorphous with gaitite.

Mineral Group: Roselite group.

Occurrence: A rare secondary mineral in an oxidized zone of a dolostone-hosted hydrothermal polymetallic ore deposit.

Association: Tsumcorite, stranskiite, leiteite, quartz, tennantite.

Distribution: From Tsumeb, Namibia.

Name: For its content of *zinc* and relation to *roselite*.

Type Material: University of Stuttgart, Stuttgart, Germany, NM16; National Museum of Natural History, Washington, D.C., USA, 163340.

References: (1) Keller, P., J. Innes, and P.J. Dunn (1986) Zincroselite, $Ca_2Zn(AsO_4)_2 \cdot 2H_2O$, a new mineral from Tsumeb, Namibia. Neues Jahrb. Mineral., Monatsh., 523–527. (2) (1988) Amer. Mineral., 73, 932 (abs. ref. 1).

Zincsilite $Zn_3Si_4O_{10}(OH)_2 \cdot 4H_2O(?)$

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Crystal Data: n.d. *Point Group:* n.d. As fine foliae or lamellae, to 2 mm.

Physical Properties: *Cleavage:* {001}, perfect. Hardness = 1.5–2 D(meas.) = 2.67–2.71 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* White to bluish. *Luster:* Pearly on cleavage. *Optical Class:* Biaxial (–). *Orientation:* $X \simeq \perp \{001\}$; $Z \wedge c = 3°$. $\alpha = 1.514(2)$ $\beta = 1.559(3)$ $\gamma = 1.562(2)$ 2V(meas.) = 0°–22°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Batystau, Kazakhstan; strongest line 17.6 Å after glycerol treatment.
15.3 (100), 4.09 (70), 1.528 (60)

Chemistry:

	(1)	(2)	(3)
SiO_2	47.60	42.75	41.83
Al_2O_3	0.84	0.70	
Fe_2O_3	2.16	1.55	
MnO	0.40		
CuO	0.60	3.07	
ZnO	26.64	35.00	42.49
MgO	4.62	1.08	
CaO	6.40	2.00	
H_2O^+	4.35	6.00	
H_2O^-	6.35	8.50	
H_2O			15.68
Total	99.96	100.65	100.00

(1–2) Batystau, Kazakhstan; after recalculation by subtracting total Al_2O_3 and Fe_2O_3 and corresponding CaO and SiO_2 as garnet; remaining CaO and MgO and corresponding SiO_2 as diopside; and CuO, SiO_2, and H_2O as chrysocolla, the average corresponds to $Zn_3Si_{4.59}O_{12.18} \cdot 5.34H_2O$. (3) $Zn_3Si_4O_{10}(OH)_2 \cdot 4H_2O$.

Occurrence: In the zone of oxidation of a galena-sphalerite-chalcopyrite skarn deposit, as a pseudomorph after diopside.

Association: Chrysocolla, fluorite, "opal," manganese oxides.

Distribution: From the Batystau polymetallicdeposit, central Kazakhstan.

Name: For ZINC and SILicon in the composition.

Type Material: Vernadsky Geological Museum, Moscow, 46337; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 61517, 80086, vis5396.

References: (1) Smol'yaninova, N.N., V.A. Moleva, and N.I. Organova (1960) A new aluminum-free member of the montmorillonite-sauconite series. Acad. Sci. URSS, Comm. for Study of Clays, Rept. to Meeting of Int. Comm. for Study of Clays, 45–52 (in Russian). (2) (1961) Amer. Mineral., 46, 241–242 (abs. ref. 1).

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Zinc-zippeite $Zn_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$

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Crystal Data: Monoclinic (probable). *Point Group:* n.d. Minute curved crystals and in coatings.

Physical Properties: Hardness = n.d. D(meas.) = n.d. D(calc.) = n.d. Radioactive.

Optical Properties: Semitransparent. *Color:* Yellow, orange, reddish brown.
Optical Class: Biaxial (–). *Pleochroism:* X = colorless; Y = pale yellow; Z = yellow.
$\alpha = 1.70$–1.715 $\beta = 1.75$–1.763 $\gamma = > 1.7$ 2V(meas.) = n.d.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Synthetic.
7.08 (100), 3.54 (50), 3.44 (35), 9.62 (33), 3.100 (26), 2.567 (15), 1.943 (15)

Chemistry:

	(1)	(2)
SO_3	9.69	9.62
UO_3	69.10	68.71
ZnO	3.4	6.52
PbO	1.6	
MgO	0.87	
H_2O	14.26	15.15
insol.	2.1	
Total	101.02	100.00

(1) Hillside mine, Arizona, USA; by microchemical analysis. (2) $Zn_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$; synthetic material has 8 H_2O essential and 8 H_2O held zeolitically.

Occurrence: In quartzose ore containing uraninite and disseminated sulfides.

Association: Sodium-zippeite, johannite, schröckingerite, bayleyite, gypsum.

Distribution: From the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co., Arizona, USA.

Name: For its content of *zinc* and relation to other *zippeite* group species.

Type Material: n.d.

References: (1) Frondel, C., J. Ito, R.M. Honea, and A.M. Weeks (1976) Mineralogy of the zippeite group. Can. Mineral., 14, 429–436. (2) Haacke, D.F. and P.A. Williams (1979) The aqueous chemistry of uranium minerals. Part I. Divalent cation zippëite. Mineral. Mag., 43, 539–541.

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Zinkenite $Pb_9Sb_{22}S_{42}$

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Crystal Data: Hexagonal. *Point Group:* 6. Thin prismatic with striations along [0001], to 5 cm long, also as columnar or radial fibrous to felted aggregates; massive.

Physical Properties: *Cleavage:* Indistinct on $\{11\bar{2}0\}$. *Fracture:* Uneven. Hardness = 3–3.5 VHN = n.d. D(meas.) = 5.33 D(calc.) = 5.34

Optical Properties: Opaque. *Color:* Steel-gray, may be tarnished iridescent; gray-white in reflected light. *Streak:* Steel-gray. *Luster:* Metallic. *Anisotropism:* Distinct.
R_1–R_2: (400) 39.1–44.2, (420) 39.2–44.4, (440) 39.3–44.6, (460) 39.2–44.5, (480) 39.0–44.2, (500) 38.8–43.8, (520) 38.4–43.2, (540) 37.9–42.5, (560) 37.3–41.8, (580) 36.7–41.0, (600) 36.0–40.4, (620) 35.4–39.8, (640) 34.6–39.0, (660) 34.0–38.2, (680) 33.2–37.3, (700) 32.4–36.3

Cell Data: *Space Group:* $P6_3$. $a = 44.15$ $c = 8.62$ $Z = 12$

X-ray Powder Pattern: Wolfsberg, Germany.
3.45 (100), 2.81 (40), 1.985 (30), 1.828 (30), 3.02 (20), 2.13 (20), 2.06 (20)

Chemistry:

	(1)	(2)	(3)
Pb	34.33	32.77	31.66
Cu	0.70	1.20	
Fe	0.06	0.02	
Sb	42.15	35.00	45.48
As		5.64	
S	22.63	22.50	22.86
rem.		1.58	
Total	99.87	98.71	100.00

(1) Wolfsberg, Germany. (2) Red Mountain district, Colorado, USA. (3) $Pb_9Sb_{22}S_{42}$.

Occurrence: A constituent of hydrothermal veins, associated with base metal and tin sulfides and sulfosalts.

Association: Stibnite, jamesonite, boulangerite, bournonite, plagionite, fülöppite, cassiterite, stannite, andorite, pyrite, sphalerite, chalcopyrite, arsenopyrite, galena.

Distribution: In Germany, from Wolfsberg, in the Harz Mountains; and at Aldersbach, in the Kinzigtal, Bavaria. From Săcărîmb (Nagyág) and Baia Mare (Nagybánya), Romania. At Peschadoire, near Pontgibaud, Puy-de-Dôme; Saint-Pons, Alpes-de-Haute-Provence; and Bournac, Montagne Noire, Finistère, France. Fine crystals from the San José, Itos, and other mines, Oruro, Bolivia. At the Brobdignag prospect, near Silverton, Red Mountain district, San Juan Co., Colorado; from the Morey mine, Morey district, Nye Co., and Eureka, Eureka Co., Nevada, USA. In Canada, from Bonanza Creek, Bridge River district, British Columbia; and the Yellowknife Bay area, Northwest Territories. From Carrock Fell, Cumbria, England. Known from a few additional localities.

Name: For J.K.L. Zinken (sometimes Zincken) (1798–1862), German mineralogist and mining geologist.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 476–478. (2) Berry, L.G. and R.M. Thompson (1962) X-ray powder data for the ore minerals. Geol. Soc. Amer. Mem. 85, 165–166. (3) Harris, D.C. (1965) Zinckenite. Can. Mineral., 9, 381–382. (4) Portheine, J.C. and W. Nowacki (1975) Refinement of the crystal structure of zinckenite, $Pb_6Sb_{14}S_{27}$. Zeits. Krist., 141, 79–96. (5) Lebas, G. and M.-T. Le Bihan (1976) Étude chimique et structurale d'un sulfure naturel; la zinkénite. Bull. Soc. fr. Minéral., 99, 351–360 (in French). (6) Smith, P.P.K. (1986) Direct imaging of tunnel cations in zinkenite by high-resolution electron microscopy. Amer. Mineral., 71, 194–201.

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Zinnwaldite $KLiFe^{2+}Al(AlSi_3)O_{10}(F,OH)_2$

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Crystal Data: Monoclinic; rarely hexagonal. *Point Group:* m. Well-formed short prismatic or tabular crystals, pseudohexagonal, to 20 cm. In rosettes or fan-shaped groups; lamellar or scaly aggregates; disseminated. *Twinning:* On composition plane {001}, twin axis [310].

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Laminae flexible, elastic. Hardness = 2.5–4 D(meas.) = 2.90–3.02 D(calc.) = 2.831

Optical Properties: Transparent to translucent. *Color:* Gray-brown, yellow-brown, pale violet, dark green, color zoning common; colorless to light brown in thin section. *Luster:* Vitreous, pearly on cleavage.
Optical Class: Biaxial (–). *Pleochroism:* Distinct; X = colorless to yellow-brown; Y = gray-brown; Z = colorless to gray-brown. *Orientation:* $Y = b$; $X \wedge a = 88°–90°$; $Z \wedge a = 0°–2°$. *Dispersion:* $r > v$, weak. *Absorption:* $Z > Y > X$. $\alpha = 1.535–1.558$ $\beta = 1.570–1.589$ $\gamma = 1.572–1.590$ 2V(meas.) = 0°–40°

Cell Data: *Space Group:* $C2$ (1M). $a = 5.296(1)$ $b = 9.140(2)$ $c = 10.096(3)$ $\beta = 100.83(2)°$ Z = 2

X-ray Powder Pattern: Cínovec, Czech Republic, 1M; resembles siderophyllite. 3.29 (100), 9.82 (82), 1.98 (54), 3.085 (38), 3.34 (36), 2.89 (32), 2.59 (30)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	46.74	40.70	Li_2O	3.72	2.19
TiO_2	0.00	0.20	Na_2O	0.54	0.36
Al_2O_3	21.78	21.95	K_2O	10.37	9.29
Fe_2O_3	1.19	2.85	F	7.54	5.67
FeO	10.22	12.19	H_2O^-		0.96
MnO	0.37	0.70	H_2O	0.89	
MgO	0.00	0.04	$-O = F_2$	3.17	[2.39]
CaO	0.00	0.00	Total	100.19	[94.71]

(1) Cínovec, Czech Republic; corresponds to $(K_{0.92}Na_{0.07})_{\Sigma=0.99}Li_{1.04}(Fe^{2+}_{0.60}Fe^{3+}_{0.06}Mn^{2+}_{0.04})_{\Sigma=0.70}Al_{1.05}(Si_{3.26}Al_{0.74})_{\Sigma=4.00}O_{10}[F_{1.66}(OH)_{0.41}]_{\Sigma=2.07}$. (2) Sadisdorf, Saxony, Germany; by electron microprobe, Li_2O and Fe^{2+}:Fe^{3+} by wet chemical analysis; corresponds to $(K_{0.90}Na_{0.05})_{\Sigma=0.95}Li_{0.67}(Fe^{2+}_{0.77}Fe^{3+}_{0.16}Mn_{0.04}Mg_{0.01}Ti_{0.01})_{\Sigma=0.99}Al_{1.05}(Si_{3.09}Al_{0.91})_{\Sigma=4.00}O_{10}[F_{1.21}(OH)_{0.79}]_{\Sigma=2.00}$.

Polymorphism & Series: 1M, $2M_1$, 3A polytypes.

Mineral Group: Mica group.

Occurrence: In tin-bearing pneumatolytic deposits in greisen; more rarely in granites, granite pegmatites, and high-temperature quartz veins.

Association: Topaz, cassiterite, wolframite, lepidolite, spodumene, beryl, tourmaline, fluorite.

Distribution: Numerous localities. From Cínovec (Zinnwald), Czech Republic. At Altenberg, Saxony, and Waldstein, Bavaria, Germany. From Törndal, Norway. Around St. Just, Cornwall, England. From Antaboaka and Ambatofinandrahana, Madagascar. In the USA, at Amelia, Amelia Co., Virginia; from the Pala district, San Diego Co., and Crestmore, Riverside Co., California; in the Black Hills, around Keystone, Pennington Co., South Dakota. From the York district, Seward Peninsula, Alaska. At Narssârssuk and on the Kangerdluarssuk Plateau, in the Ilímaussaq intrusion, southern Greenland. From Kurobera, Yamanashi Prefecture, and in the Naegi district, Gifu Prefecture, Japan.

Name: For the locality Cínovec (Zinnwald), Czech Republic.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 626–627. (2) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 92–94. (3) Cundy, E.K., W. Windle, and I.H. Warren (1963) The occurrence of zinnwaldite in Cornwall. Clay Minerals Bull., 5, 151–156. (4) Guggenheim, S. and S.W. Bailey (1977) The refinement of zinnwaldite-1M in subgroup symmetry. Amer. Mineral., 62, 1158–1167.

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Zippeite $K(UO_2)_2(SO_4)(OH)_3 \cdot H_2O$

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Crystal Data: Monoclinic, pseudo-orthorhombic. *Point Group:* $2/m$. Rare crystals are rhomboidal or elongated along [001], to 0.5 mm; in radial or vermicular aggregates, earthy efflorescences, powdery coatings, and crusts. *Twinning:* Probable, observed in synthetic material.

Physical Properties: Hardness = ∼2 D(meas.) = 4.8 D(calc.) = 4.696 Radioactive; commonly fluoresces yellow-green to green under SW and LW UV.

Optical Properties: Semitransparent. *Color:* Deep yellow, yellow-orange, red, brownish yellow, brownish orange. *Luster:* Vitreous.
Optical Class: Biaxial (–) (synthetic). *Pleochroism:* X = nearly colorless; Y = pale yellow to yellow-orange; Z = deep yellow to yellow-orange. $\alpha = 1.625(1)$ $\beta = 1.710(2)$ $\gamma = 1.740(2)$ 2V(meas.) = Large. 2V(calc.) = 59°

Cell Data: *Space Group:* $C2/c$. $a = 8.656(2)$ $b = 14.240(4)$ $c = 17.706(5)$ $\beta = 104.112(4)°$ Z = 8

X-ray Powder Pattern: Jáchymov, Czech Republic.
7.06 (10), 3.50 (9), 3.12 (8), 2.87 (4), 2.65 (4), 2.22 (4), 5.45 (3)

Chemistry:

	(1)	(2)	(3)
SO_3	10.02		10.76
UO_3	71.98		76.86
Fe_2O_3	1.17		
CaO	1.88		
Na_2O		0.62	
K_2O	n.d.	8.06	6.33
H_2O	13.95		6.05
Total	99.00		100.00

(1) Jáchymov, Czech Republic; probably an analysis of several undifferentiated "zippeite" species. (2) Do.; partial analysis. (3) $K(UO_2)_2(SO_4)(OH)_3 \cdot H_2O$, determined from the structure of the synthetic compound.

Occurrence: An uncommon secondary mineral, in part post-mine, in oxidized uranium deposits containing sulfides.

Association: Uranopilite, sodium-zippeite, nickel-zippeite, magnesium-zippeite, johannite, uranophane, schröckingerite, gypsum.

Distribution: From Jáchymov (Joachimsthal), Czech Republic. At Nowa Ruda, Lower Silesia, Poland. In England, from Cornwall, at the Gunnislake mine, Calstock; the South Terras mine, St. Stephen-in-Brannel; the Carharrack mine, St. Day; Wheal Buller, Redruth; Wheal Edward and Wheal Owles, St. Just. From the USA, in Colorado, at the Diamond Joe and Remington mines, Idaho Springs district, Clear Creek Co., and in the Telegraph, Wood, and Kirk mines, Gilpin Co.; at the Apex mine, Reese River district, Lander Co., Nevada; in Arizona, from the Hillside mine, about 5.5 km north of Bagdad, Eureka district, Yavapai Co., in the Monument No. 1 and Mitten No. 2 mines, Navajo Co., and at the Huskon No. 7 and No. 8 claims, and the Sun Valley mine, in the Cameron area, Coconino Co. Other localities are probable but require modern confirmation.

Name: To honor Dr. František Xaver Maximillian Zippe (1791–1863), Austrian mineralogist and geologist.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 598–599. (2) Frondel, C., J. Ito, R.M. Honea, and A.M. Weeks (1976) Mineralogy of the zippeite group. Can. Mineral., 14, 429–436. (3) Vochten, R., L. Van Haverbeke, K. Van Springel, N. Blaton, and O.M. Peeters (1995) The structure and physicochemical characteristics of synthetic zippeite. Can. Mineral., 33, 1091–1101. (4) Ondruš, P., F. Veselovský, J. Hloušek, R. Skála, I. Vavřín, J. Frýda, J. Čejka, and A. Gabašová (1997) Secondary minerals of the Jáchymov (Joachimsthal) ore district. J. Czech Geol. Soc., 42(4), 3–76, esp. 57–58.

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Zircon $ZrSiO_4$

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Crystal Data: Tetragonal; may be metamict. *Point Group:* $4/m\ 2/m\ 2/m$. Most commonly as tabular to prismatic crystals, with square cross sections, terminated by {111}, to 30 cm; as irregular grains, massive. *Twinning:* On {101}, geniculated.

Physical Properties: *Cleavage:* Indistinct on {110} and {111}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 7.5 D(meas.) = 4.6–4.7 D(calc.) = 4.714 Radioactive when metamict; thermoluminescent, cathodoluminescent, may fluoresce under UV.

Optical Properties: Transparent to opaque. *Color:* Reddish brown, yellow, green, blue, gray, colorless; in thin section, colorless to pale brown. *Streak:* White. *Luster:* Vitreous to adamantine; greasy when metamict.
Optical Class: Uniaxial (+); isotropic when metamict. *Pleochroism:* Very weak.
Absorption: In thick sections; $E > O$. *Dispersion:* Very strong. ω = 1.925–1.961
ϵ = 1.980–2.015

Cell Data: *Space Group:* $I4_1/amd$. a = 6.607(1) c = 5.982(1) Z = 4

X-ray Powder Pattern: Locality unspecified; nearly indistinguishable from hafnon.
3.302 (100), 4.434 (45), 2.518 (45), 1.712 (40), 2.066 (20), 1.908 (14), 1.651 (14)

Chemistry:

	(1)
SiO_2	32.86
ZrO_2	66.72
HfO_2	1.15
ThO_2	0.01
U_3O_8	0.027
Total	100.767

(1) Sitarampuram, India; corresponds to $(Zr_{0.99}Hf_{0.01})_{\Sigma=1.00}Si_{1.00}O_4$.

Occurrence: An accessory mineral in igneous and metamorphic rocks, with crystals reaching large size in mafic pegmatites and carbonatites; in sedimentary rocks and alluvial heavy-mineral sands.

Association: Feldspars, amphiboles, mica, quartz.

Distribution: An unusually common and widely distributed mineral, but fine crystals are rare. In Norway, at Larvik and Hakedal; on Seiland Island, Alta River, Finnmark. At Sillinjärvi, Finland. From Sibnitz, Saxony, Germany. At Miass, Ilmen Mountains, Southern Ural Mountains, Russia. In the USA, at Deer Hill, Orange Co., and Fine, St. Lawrence Co., New York; from near Franklin, Sussex Co., New Jersey; near Green River, Henderson Co., North Carolina; at Tigerville, Greenville Co., South Carolina; and from Cheyenne Mountain and St. Peters Dome, near Pikes Peak, El Paso Co., Colorado. On Turner's Island, in Lake Clear, and at Kuehl Lake, Renfrew Co., Ontario, Canada. In the Matura and Saffragam districts, Sri Lanka. From Mt. Ampanobe, near Fianarantsoa, and Itrongahy, near Betroka, Madagascar. At Teete, Mozambique. Large crystals from Mud Tank, Valley Bore, Northern Territory, Australia.

Name: Thought to be derived from the Persian *zar*, for *gold*, and *gun*, for *color*, through the Arabic *zarqun*.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 482–488.
(2) Deer, W.A., R.A. Howie, and J. Zussman (1982) Rock-forming minerals, (2nd edition), v. 1A, orthosilicates, 418–442. (3) Robinson, K., G.V. Gibbs, and P.H. Ribbe (1971) The structure of zircon: a comparison with garnet. Amer. Mineral., 56, 782–790. (4) (1955) NBS Circ. 539, 4, 68–71.

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Zirconolite $CaZrTi_2O_7$

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Crystal Data: Monoclinic; hexagonal; orthorhombic; commonly metamict. *Point Group:* $2/m$; 32; $2/m$ $2/m$ $2/m$. Crystals, typically prismatic, elongated along [001], to 5 cm; polytypes are commonly intergrown. *Twinning:* Polysynthetic.

Physical Properties: *Cleavage:* {100}, {010} in traces. *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 4.017–4.237; 4.77–4.85 D(calc.) = [4.38] Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Brown to black; yellowish or brownish in thin section. *Streak:* Brownish yellow to dark brown. *Luster:* Submetallic; adamantine to greasy.
Optical Class: Isotropic. n = 2.06–2.17; 2.215 ("polymignyte").

Cell Data: *Space Group:* $C2/c$ or Cc (2M), with $a = 12.431(1)$ $b = 7.224(1)$ $c = 11.483(3)$ $\beta = 100.33(1)°$ Z = 8, or *Space Group:* $P3_121$ (3T), with $a = 7.287(2)$ $c = 16.886(9)$ Z = 3, or *Space Group:* *Acam* (3O), with $a = 10.148(4)$ $b = 14.147(5)$ $c = 7.278(3)$ Z = [8]

X-ray Powder Pattern: Afrikanda massif, Russia; after heating at 1000 °C for two hours; polytypes cannot be distinguished by powder X-ray methods.
2.914 (10), 1.980 (9), 1.792 (9), 2.506 (4), 3.176 (3), 1.517 (1), 1.156 (1)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
U_3O_8	1.53		UO_2		1.4	MgO	0.45	
Nb_2O_5	3.26	15.7	Al_2O_3	1.03		CaO	11.05	12.5
SiO_2	2.05		RE_2O_3	6.22	0.9	Na_2O	0.37	
TiO_2	31.69	22.7	Fe_2O_3	5.49	5.32	H_2O	3.35	
ZrO_2	32.84	34.8	FeO		2.28	Total	99.97	99.9
ThO_2	0.58	4.1	MnO	0.06	0.2			

(1) Afrikanda massif, Russia; LOI taken as H_2O, corresponds to $(Ca_{0.76}Ce_{0.15}Na_{0.04}U_{0.02}Th_{0.01})_{\Sigma=0.98}Zr_{1.03}(Ti_{1.53}Fe_{0.27}Nb_{0.09}Al_{0.08}Mg_{0.04})_{\Sigma=2.01}O_7$. (2) Kaiserstuhl, Germany; by electron microprobe, corresponding to $(Ca_{0.85}Th_{0.06}U_{0.02}RE_{0.02})_{\Sigma=0.95}Zr_{1.08}(Ti_{1.08}Nb_{0.45}Fe^{3+}_{0.25}Fe^{2+}_{0.12}Mn_{0.01})_{\Sigma=1.91}O_7$.

Polymorphism & Series: Polytypoids 2M, 3T, 3O are known.

Occurrence: In alkaline rocks, as carbonatites, kimberlites, syenites, sanidinites; more rarely in ultramafic rocks; in felsic pegmatite in gabbro; a detrital mineral.

Association: Apatite, clinohumite, phlogopite, richterite, pyrochlore, baddeleyite, perovskite, titanite, pyrrhotite, calcite.

Distribution: In the Afrikanda pyroxenite massif, Kola Peninsula, Russia. At Fredriksvärn, and Agnes Sandefjord, Vestfold, Norway. In the Kaiserstuhl carbonatite, Baden-Württemberg, Germany. From Monte di Procida, Campi Flegrei, Campania, Italy. In the Laouni intrusive, 250 km south of Tamanrasset, Algeria. In Sri Lanka, from Walaweduwa; in the Alupola stream, Bambarabotuwa district; and elsewhere in Sabaragamuwa Province. In some basalt samples from the Moon.

Name: As a ZIRCONium-bearing mineral.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 59249–59251, vis6008, vis6012, vis6018.

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Zirconolite $CaZrTi_2O_7$

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Crystal Data: Monoclinic; hexagonal; orthorhombic; commonly metamict. *Point Group:* $2/m$; 32; $2/m$ $2/m$ $2/m$. Crystals, typically prismatic, elongated along [001], to 5 cm; polytypes are commonly intergrown. *Twinning:* Polysynthetic.

Physical Properties: *Cleavage:* {100}, {010} in traces. *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 4.017–4.237; 4.77–4.85 D(calc.) = [4.38] Radioactive.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Brown to black; yellowish or brownish in thin section. *Streak:* Brownish yellow to dark brown. *Luster:* Submetallic; adamantine to greasy.
Optical Class: Isotropic. n = 2.06–2.17; 2.215 ("polymignyte").

Cell Data: *Space Group:* $C2/c$ or Cc (2M), with $a = 12.431(1)$ $b = 7.224(1)$ $c = 11.483(3)$ $\beta = 100.33(1)°$ Z = 8, or *Space Group:* $P3_121$ (3T), with $a = 7.287(2)$ $c = 16.886(9)$ Z = 3, or *Space Group:* *Acam* (3O), with $a = 10.148(4)$ $b = 14.147(5)$ $c = 7.278(3)$ Z = [8]

X-ray Powder Pattern: Afrikanda massif, Russia; after heating at 1000 °C for two hours; polytypes cannot be distinguished by powder X-ray methods.
2.914 (10), 1.980 (9), 1.792 (9), 2.506 (4), 3.176 (3), 1.517 (1), 1.156 (1)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
U_3O_8	1.53		UO_2		1.4	MgO	0.45	
Nb_2O_5	3.26	15.7	Al_2O_3	1.03		CaO	11.05	12.5
SiO_2	2.05		RE_2O_3	6.22	0.9	Na_2O	0.37	
TiO_2	31.69	22.7	Fe_2O_3	5.49	5.32	H_2O	3.35	
ZrO_2	32.84	34.8	FeO		2.28	Total	99.97	99.9
ThO_2	0.58	4.1	MnO	0.06	0.2			

(1) Afrikanda massif, Russia; LOI taken as H_2O, corresponds to $(Ca_{0.76}Ce_{0.15}Na_{0.04}U_{0.02}Th_{0.01})_{\Sigma=0.98}Zr_{1.03}(Ti_{1.53}Fe_{0.27}Nb_{0.09}Al_{0.08}Mg_{0.04})_{\Sigma=2.01}O_7$. (2) Kaiserstuhl, Germany; by electron microprobe, corresponding to $(Ca_{0.85}Th_{0.06}U_{0.02}RE_{0.02})_{\Sigma=0.95}Zr_{1.08}(Ti_{1.08}Nb_{0.45}Fe^{3+}_{0.25}Fe^{2+}_{0.12}Mn_{0.01})_{\Sigma=1.91}O_7$.

Polymorphism & Series: Polytypoids 2M, 3T, 3O are known.

Occurrence: In alkaline rocks, as carbonatites, kimberlites, syenites, sanidinites; more rarely in ultramafic rocks; in felsic pegmatite in gabbro; a detrital mineral.

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Name: As a ZIRCONium-bearing mineral.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 59249–59251, vis6008, vis6012, vis6018.

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Zirconolite $CaZrTi_2O_7$

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Physical Properties: *Cleavage:* {100}, {010} in traces. *Fracture:* Irregular to conchoidal. *Tenacity:* Brittle. Hardness = 6.5 D(meas.) = 4.017–4.237; 4.77–4.85 D(calc.) = [4.38] Radioactive.

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X-ray Powder Pattern: Afrikanda massif, Russia; after heating at 1000 °C for two hours; polytypes cannot be distinguished by powder X-ray methods.
2.914 (10), 1.980 (9), 1.792 (9), 2.506 (4), 3.176 (3), 1.517 (1), 1.156 (1)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
U_3O_8	1.53		UO_2		1.4	MgO	0.45	
Nb_2O_5	3.26	15.7	Al_2O_3	1.03		CaO	11.05	12.5
SiO_2	2.05		RE_2O_3	6.22	0.9	Na_2O	0.37	
TiO_2	31.69	22.7	Fe_2O_3	5.49	5.32	H_2O	3.35	
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Polymorphism & Series: Polytypoids 2M, 3T, 3O are known.

Occurrence: In alkaline rocks, as carbonatites, kimberlites, syenites, sanidinites; more rarely in ultramafic rocks; in felsic pegmatite in gabbro; a detrital mineral.

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Zirconolite $CaZrTi_2O_7$

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Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
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Occurrence: In alkaline rocks, as carbonatites, kimberlites, syenites, sanidinites; more rarely in ultramafic rocks; in felsic pegmatite in gabbro; a detrital mineral.

Association: Apatite, clinohumite, phlogopite, richterite, pyrochlore, baddeleyite, perovskite, titanite, pyrrhotite, calcite.

Distribution: In the Afrikanda pyroxenite massif, Kola Peninsula, Russia. At Fredriksvärn, and Agnes Sandefjord, Vestfold, Norway. In the Kaiserstuhl carbonatite, Baden-Württemberg, Germany. From Monte di Procida, Campi Flegrei, Campania, Italy. In the Laouni intrusive, 250 km south of Tamanrasset, Algeria. In Sri Lanka, from Walaweduwa; in the Alupola stream, Bambarabotuwa district; and elsewhere in Sabaragamuwa Province. In some basalt samples from the Moon.

Name: As a ZIRCONium-bearing mineral.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 59249–59251, vis6008, vis6012, vis6018.

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References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 764–766 [polymignyte]; 741–742 [unnamed mineral]. (2) Borodin, L.S., I.I. Nazarenko, and T.L. Richter (1956) On a new mineral zirconolite – a complex oxide of AB_3O_7 type. Doklady Acad. Nauk SSSR, 110, 845–848 (in Russian). (3) (1957) Amer. Mineral., 42, 581–582 (abs. ref. 2). (4) Sinclair, W. and R.A. Eggleton (1982) Structure refinement of zirkelite [zirconolite] from Kaiserstuhl, Germany. Amer. Mineral., 67, 615–620. (5) Mazzi, F. and R. Munno (1983) Calciobetafite (new mineral of the pyrochlore group) and related minerals from Campi Flegrei, Italy; crystal structures of polymignyte and zirkelite: comparison with pyrochlore and zirconolite. Amer. Mineral., 68, 262–276. (6) Bayliss, P., F. Mazzi, R. Munno, and T.J. White (1989) Mineral nomenclature: zirconolite. Mineral. Mag., 53, 565–569 [polymignite = zirconolite].

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Zircophyllite $(K,Na)_3(Fe^{2+},Mn^{2+})_7(Zr,Nb)_2Si_8O_{24}(OH,F)_7$

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Crystal Data: Triclinic, probable. *Point Group:* n.d. In platy micaceous crystals, to 2 cm.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Extremely brittle. Hardness = 4–4.5 D(meas.) = 3.34 D(calc.) = n.d.

Optical Properties: Semitransparent. *Color:* Dark brown to nearly black. *Streak:* Pale brown. *Luster:* Vitreous to adamantine.
Optical Class: Biaxial (–). *Pleochroism:* $X = Y$ = dark yellow; Z = brown. *Orientation:* Y = a; $X \wedge b = 9°$–$11°$; $Z \perp \{001\}$. *Dispersion:* $r > v$, strong. $\alpha = 1.708$ $\beta = 1.738$ $\gamma = 1.747$ 2V(meas.) = 62°

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: Korgeredabinsh massif, Russia.
3.50 (10), 2.80 (7), 2.66 (5), 2.10 (5), 9.80 (4), 3.75 (3), 3.26 (3)

Chemistry:

	(1)
SiO_2	32.64
TiO_2	2.30
ZrO_2	13.61
HfO_2	1.2
Nb_2O_5	2.30
FeO	18.06
MnO	18.83
CaO	0.94
Na_2O	1.55
K_2O	5.61
F	1.20
H_2O	3.20
$-O = F_2$	0.49
Total	99.75

(1) Korgeredabinsh massif, Russia; Hf by spectrographic analysis, traces of Y, Pb, Be, Sr, Ba; corresponds to $(K_{1.70}Na_{0.71}Mn_{0.35}Ca_{0.24})_{\Sigma=3.00}(Fe_{3.57}Mn_{3.43})_{\Sigma=7.00}(Zr_{1.58}Nb_{0.25}Ti_{0.17})_{\Sigma=2.00}(Si_{7.76}Ti_{0.24})_{\Sigma=8.00}O_{24}[(OH)_{3.24}O_{2.84}F_{0.90}]_{\Sigma=6.98} \bullet 0.9H_2O$.

Mineral Group: Astrophyllite group.

Occurrence: In the natrolite zone of alkalic pegmatites.

Association: "Aegirine-augite," leucophanite, fluorite, apatite, apophyllite.

Distribution: From the Korgeredaba alkaline massif, Sangilen Upland, southeastern Tuva, Russia.

Name: For ZIRCOnium in the composition and the Greek for *leaf*, in reference to its foliated, micaceous habit.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia.

References: (1) Kapustin, Y.L. (1972) Zircophyllite, the zirconium analogue of astrophyllite. Zap. Vses. Mineral. Obshch., 101, 459–463 (in Russian). (2) (1973) Amer. Mineral., 58, 967 (abs. ref. 1).

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Zircosulfate $Zr(SO_4)_2 \cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Rounded to rhomboidal forms, to 0.03 mm, powdery to compact massive aggregates.

Physical Properties: Hardness = 2.5–3 D(meas.) = 2.85 D(calc.) = 2.833 Soluble in cold H_2O.

Optical Properties: Semitransparent. *Color:* Colorless to white. *Luster:* Dull. *Optical Class:* Biaxial (+). $\alpha = 1.620$ $\beta = [1.644]$ $\gamma = 1.674$ 2V(meas.) = n.d. 2V(calc.) = 75°

Cell Data: *Space Group:* $Fddd$ (synthetic). $a = 25.92$ $b = 11.62$ $c = 5.532$ Z = 8

X-ray Powder Pattern: Korgeredaba massif, Russia.
4.33 (10), 2.98 (9), 2.33 (6), 6.50 (5), 3.46 (4), 1.97 (4), 1.62 (4)

Chemistry:

	(1)	(2)
SO_3	43.80	45.05
ZrO_2	35.30	34.67
H_2O^+	19.00	
H_2O^-	1.75	
H_2O		20.28
Total	99.85	100.00

(1) Korgeredaba massif, Russia; corresponds to $Zr_{0.97}(SO_4)_{2.00} \cdot 3.86H_2O$. (2) $Zr(SO_4)_2 \cdot 4H_2O$.

Occurrence: In a cavity in intensely hydrothermally altered nepheline syenite pegmatite, perhaps formed by acid sulfatic solutions attacking eudialyte.

Association: Hisingerite, smithsonite, "limonite".

Distribution: From the Korgeredaba alkalic massif, Sangilen Upland, southeastern Tuva, Russia.

Name: For *zirconium* and *sulfate* in its composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 72031.

References: (1) Kapustin, Y.L. (1965) Zircosulfate – a new mineral. Zap. Vses. Mineral. Obshch., 94, 530–533 (in Russian). (2) (1966) Amer. Mineral., 51, 259 (abs. ref. 1). (3) (1957) NBS Circ. 539, 7, 66.

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Zirkelite $(Ca, Th, Ce)Zr(Zr, Ti)_2O_7$

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Crystal Data: Cubic; commonly metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals are flattened octahedra, to 3 cm. *Twinning:* On {111}, very common, as complex fourlings and polysynthetic.

Physical Properties: *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 5.5
D(meas.) = 4.741 D(calc.) = n.d. Commonly radioactive.

Optical Properties: Opaque, transparent in very thin fragments. *Color:* Black; reddish brown to dark brown in transmitted light. *Luster:* Resinous.
Optical Class: Isotropic. $n = 2.19(1)$

Cell Data: *Space Group:* $Fm3m$. $a = 5.02$–5.06 Z = 2

X-ray Powder Pattern: Arbarastkh massif, Russia; after heating at 700–800 °C.
2.98 (100), 1.82 (50), 2.53 (30), 1.75 (30), 2.84 (20), 2.30 (10), 1.51 (10)

Chemistry:

	(1)
TiO_2	14.95
ZrO_2	52.89
ThO_2	7.31
UO_2	1.40
Y_2O_3	0.21
CeO_2	2.64
FeO	7.72
MgO	0.22
CaO	10.79
LOI	1.02
Total	99.15

(1) Jacupiranga, Brazil; corresponds to $[(Ca, Na)_{0.82}Th_{0.12}RE_{0.07}U_{0.02}]_{\Sigma=1.03}$ $[Zr_{1.84}Ti_{0.80}(Fe, Mn, Mg, Al)_{0.48}]_{\Sigma=3.12}O_7$.

Polymorphism & Series: Dimorphous with calciobetafite.

Occurrence: In a magnetite-pyroxenite carbonatite (Jacupiranga, Brazil); a late-stage differentiate in a layered intrusion (Rhum, Scotland).

Association: Perovskite, baddeleyite.

Distribution: From the Jacupiranga carbonatite, São Paulo, Brazil. On St. Kilda, Outer Hebrides, and Rhum, Inner Hebrides, Scotland. In Russia, in the Vouriyarvi and Kovdor massifs, and in the Sevlyavr carbonatite complex, Kola Peninsula; from the Arbarastkh massif, Aldan Shield, Sakha. At Phalaborwa, Transvaal, South Africa. From Walawada, Sri Lanka. In some soils and breccia derived from granophyre on the Moon.

Name: Honors Ferdinand Zirkel (1838–1912), German petrographer, Professor of Mineralogy, University of Leipzig, Leipzig, Germany.

Type Material: The Natural History Museum, London, England, 80142.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 740. (2) Mazzi, F. and R. Munno (1983) Calciobetafite (new mineral of the pyrochlore group) and related minerals from Campi Flegrei, Italy; crystal structures of polymignyte and zirkelite: comparison with pyrochlore and zirconolite. Amer. Mineral., 68, 262–276. (3) Bayliss, P., F. Mazzi, R. Munno, and T.J. White (1989) Mineral nomenclature: zirconolite. Mineral. Mag., 53, 565–569. (4) Borodin, L.S., A.B. Bykova, T.A. Kapitonova, and Y.A. Pyatenko (1960) New data on zirconolite and its niobium variety. Doklady Acad. Nauk SSSR, 134, 1188–1191.

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Zirklerite $(Fe^{2+}, Mg, Ca)_9Al_4Cl_{18}(OH)_{12} \cdot 14H_2O(?)$

Crystal Data: Hexagonal. *Point Group:* n.d. Fibrous to granular, massive.

Physical Properties: *Cleavage:* Rhombohedral. Hardness = ~3.5 D(meas.) = ~2.6 D(calc.) = n.d. Decomposed by water with separation of Al_2O_3 and $Fe(OH)_2$.

Optical Properties: Semitransparent. *Color:* Light gray.
Optical Class: Uniaxial (+). n = ~1.552, birefringence < 0.009.

Cell Data: *Space Group:* n.d. Z = n.d.

X-ray Powder Pattern: n.d.

Chemistry:

	(1)
Al_2O_3	12.29
$FeCl_2$	57.20
$MgCl_2$	6.83
$CaCl_2$	2.47
H_2O	21.23
Total	[100.02]

(1) Hope, Germany; recalculated after deduction of anhydrite 5.08%, halite 15.64%, and insoluble 31.26%.

Occurrence: As the principal constituent of a rock composed of halite, anhydrite, quartz, and clay minerals, in brecciated layers intercalcated with halite and potash layers.

Association: Halite, anhydrite, rinneite, dolomite, chlorite, quartz, clay minerals.

Distribution: In the Adolfsglück mine, Hope, west of Hamelyn, Lower Saxony, Germany.

Name: For Dr.-Ing. Zirkler, General Director of the Aschersleben Potash Works, Germany.

Type Material: The Natural History Museum, London, England, 1929,40.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 87. (2) Harbort, E. (1928) Über Zirklerite. Ein neues durch Thermo-Dynamometamorphose gebildetes Mineral aus einigen Salzstöcken der norddeutschen Tiefebene. Kali und Verwandte Salze, 22, 157–161. (3) (1928) Amer. Mineral., 13, 592 (abs. ref. 2). (4) (1929) Mineral. Abs., 4, 14–15 (abs. ref. 2).

Zirsinalite $\mathbf{Na_6(Ca,Mn^{2+},Fe^{2+})ZrSi_6O_{18}}$

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Crystal Data: Hexagonal. *Point Group:* $\bar{3}\,2/m$. As rounded or irregular grains, to 1.5 cm.

Physical Properties: *Fracture:* Small conchoidal. Hardness = 5.5 VHN = 640–720
D(meas.) = 2.88–2.92 D(calc.) = 3.08 In air, rapidly coated with white sodium carbonate.

Optical Properties: Transparent. *Color:* Colorless to slightly yellowish gray.
Luster: Vitreous.
Optical Class: Uniaxial (–). $\omega = 1.610$ $\epsilon = 1.605$

Cell Data: *Space Group:* $R\bar{3}m$. $a = 10.29(4)$ $c = 13.11(4)$ $Z = 3$

X-ray Powder Pattern: Mt. Koashva, Russia.
1.842 (10), 2.637 (9), 2.569 (8), 3.26 (6), 4.22 (4), 3.68 (4), 3.33 (4)

Chemistry:

	(1)	(2)	(3)
SiO_2	52.10	52.00	49.67
TiO_2	0.40	0.56	
ZrO_2	12.84	12.84	16.98
FeO	0.40	0.80	
MnO	2.62	2.60	
CaO	4.80	4.75	7.73
Na_2O	26.00	25.67	25.62
H_2O	0.90	0.80	
Total	100.06	100.02	100.00

(1–2) Mt. Koashva, Russia; spectrographic analysis gives HfO_2 0.42% and traces of Y, Zn, Be, Sr, Ba, K. (3) $Na_6CaZrSi_6O_{18}$.

Mineral Group: Lovozerite group.

Occurrence: In pegmatitic veinlets cutting alkalic rocks in differentiated alkalic massifs.

Association: Aegirine, lomonosovite, barian lamprophyllite, lovozerite, eudialyte (Mt. Koashva, Russia).

Distribution: On Mts. Koashva and Yukspor, Khibiny massif, and in the Lovozero massif, Kola Peninsula, Russia.

Name: For ZIRconium, SIlicon, and sodium, NAtrium, in the composition.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 75149.

References: (1) Kapustin, Y.L., Z.V. Pudovkina, and A.V. Bykova (1974) Zirsinalite, a new mineral. Zap. Vses. Mineral. Obshch., 103, 551–558 (in Russian). (2) (1975) Amer. Mineral., 60, 489 (abs. ref. 1). (3) Pudovkina, Z.V., N.M. Chernitsova, A.A. Voronkov, and Y.A. Pyatenko (1980) Crystal structure of zirsinalite. Doklady Acad. Nauk SSSR, 250, 865–867 (in Russian).

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Zlatogorite $CuNiSb_2$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Long, irregular lath-shaped grains to 0.5 mm.

Physical Properties: *Fracture:* Uneven. Hardness = ∼3 VHN = 154–170, 166 average (15.2 g load). D(meas.) = n.d. D(calc.) = 5.15

Optical Properties: Opaque. *Color:* Steel-gray; in reflected light, white with a faint yellowish tint to light gray. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Strong, from light to dark gray with a faint greenish tint.

R_1–R_2: (400) — , (420) 38.6–44.3, (440) 38.5–44.0, (460) 38.4–44.0, (480) 38.0–43.7, (500) 37.9–43.8, (520) 37.9–43.9, (540) 37.6–43.6, (560) 37.4–43.1, (580) 36.9–42.6, (600) 36.5–41.9, (620) 36.2–41.5, (640) 35.6–40.9, (660) 35.4–40.2, (680) 34.9–39.2, (700) 34.2–38.1

Cell Data: *Space Group:* n.d. $a = 18.698(8)$ $b = 6.492(3)$ $c = 4.577(1)$ $Z = 1$

X-ray Powder Pattern: Příbram, Czech Republic.
1.797 (10), 2.222 (9), 1.325 (8), 2.392 (6), 3.070 (5), 1.956 (5), 3.670 (4)

Chemistry:

	(1)	(2)	(3)
Ag	5.75	5.88	6.18
Pb	46.30	47.26	47.52
Zn	0.35	0.22	
Cu	0.27	0.22	
Fe	0.02	0.05	
Sb	27.39	28.53	27.92
S	18.30	18.75	18.38
Total	98.38	100.91	100.00

(1–2) Příbram, Czech Republic; by electron microprobe, each an average of 15 analyses on 2 different specimens, corresponding to $(Ag_{0.93}Cu_{0.07})_{\Sigma=1.00}(Pb_{3.92}Zn_{0.10}Fe_{0.01})_{\Sigma=4.03}Sb_{3.94}S_{10.00}$. (3) $AgPb_4Sb_4S_{10}$.

Occurrence: In hydrothermal veins.

Association: Boulangerite, galena, diaphorite, argentian tetrahedrite, sphalerite.

Distribution: From Příbram, Czech Republic.

Name: To honor Academician Vladimír Zoubek, former Director of the Geological Survey and Geological Institute of the Czechoslovak Academy of Science, Prague, Czech Republic.

Type Material: Mining Museum, Příbram, 432, 220; National Museum, Prague, Czech Republic, PIN87272.

References: (1) Megarskaya, L., D. Rykl, and Z. Táborský (1986) Zoubekite, $AgPb_4Sb_4S_{10}$, a new mineral from Příbram, Czechoslovakia. Neues Jahrb. Mineral., Monatsh., 1–7. (2) (1987) Amer. Mineral., 72, 227 (abs. ref. 1).

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Znucalite $CaZn_{11}(UO_2)(CO_3)_3(OH)_{20}\cdot 4H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Crystals are thin lamellar, to 100 μm, in spherical boxworklike aggregates; forms coatings.

Physical Properties: *Cleavage:* Perfect on {010}. Hardness = n.d. D(meas.) = 3.01–3.1 D(calc.) = 3.15 Radioactive; may fluoresce intense yellow-green under SW and LW UV.

Optical Properties: Translucent. *Color:* White, pale grayish yellow, yellow. *Luster:* Silky. *Optical Class:* Biaxial (–). *Orientation:* $X = c$; $Y = b$; $Z = a$. $\alpha = 1.556$–1.563 $\beta = 1.600$ $\gamma = 1.620$–1.621 2V(meas.) = 50°–60° 2V(calc.) = 66.4°

Cell Data: *Space Group:* n.d. $a = 10.72(1)$ $b = 25.16(1)$ $c = 6.325(4)$ Z = 2

X-ray Powder Pattern: Příbram, Czech Republic.
2.708 (100), 2.728 (90), 6.141 (78), 3.165 (70), 25.1 (62), 2.682 (56), 5.650 (54)

Chemistry:

	(1)	(2)	(3)
CO_2	8.25	n.d.	8.14
UO_3	17.42	18.51	17.64
ZnO	56.75	53.52	55.21
CaO	4.06	3.55	3.46
H_2O	15.37	n.d.	15.55
Total	101.85		100.00

(1) Příbram, Czech Republic; by electron microprobe, average of 15 analyses, CO_2 and H_2O by thermal analysis; corresponds to $Ca_{1.15}Zn_{11.01}(UO_2)_{0.96}(CO_3)_{2.97}(OH)_{20.30}\cdot 3.34H_2O$.
(2) Mas-d'Alary deposit, France; by electron microprobe, average of 17 partial analyses; utilizing CO_2 and H_2O from (1), corresponds to $Ca_{1.02}Zn_{10.70}(UO_2)_{1.06}(CO_3)_{3.06}(OH)_{19.44}\cdot 4.16H_2O$.
(3) $CaZn_{11}(UO_2)(CO_3)_3(OH)_{20}\cdot 4H_2O$.

Occurrence: A rare secondary species at carbonate-hosted polymetallic veins, and nearby oxidizing uranium veins; on dump material and coating mine walls, apparently of post-mine origin.

Association: Gypsum, hydrozincite, serpierite, römerite, sphalerite, galena, pyrite, calcite, aragonite (Příbram, Czech Republic); adamite, metalodèvite, umohoite, calcurmolite, uranophane, studtite (Mas-d'Alary deposit, France).

Distribution: In the Czech Republic, from the Lill mine, Příbram, and in the Evangelista and Ondřej veins, Jáchymov (Joachimsthal). At the Mas-d'Alary uranium deposit, three km south-southeast of Lodève, Hérault, France. In the St. Christophe mine, near Bärenhecke, Saxony, Germany.

Name: For Zn, U, and Ca in the composition.

Type Material: National Museum, Prague; Charles University, Prague, Czech Republic.

References: (1) Ondruš, P., F. Veselovský, and R. Rybka (1990) Znucalite, $Zn_{12}(UO_2)Ca(CO_3)_3(OH)_{22}\cdot 4H_2O$, a new mineral from Příbram, Czechoslovakia. Neues Jahrb. Mineral., Monatsh., 393–400. (2) (1991) Amer. Mineral., 76, 1732–1733 (abs. ref. 1). (3) Chiappero, P.J. and H. Sarp (1993) Nouvelles données sur la znucalite et seconde occurrence: Le Mas d'Alary, Lodève (Hérault, France). Archs Sci. Genève, 46, 291–301 (in French with English abs.).

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Zodacite $Ca_4Mn^{2+}Fe_4^{3+}(PO_4)_6(OH)_4 \cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$ or m. Crystals, to 0.2 mm, may be isolated, usually in flat radial sprays.

Physical Properties: *Cleavage:* [On {010}] (by analogy to montgomeryite). Hardness = ∼4 D(meas.) = 2.68 D(calc.) = 2.65

Optical Properties: Semitransparent. *Color:* Pale to medium yellow, colorless. *Streak:* Pale yellow to white. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Pleochroism:* Very weak; Y = very pale green; Z = pale green. *Orientation:* $X = b$; $Y \wedge c = 24°$; $Z \wedge a = 23°$. *Absorption:* $Y < Z$. $\alpha = 1.598(1)$ $\beta = 1.601(1)$ $\gamma = 1.602(1)$ 2V(meas.) = 83(1)° 2V(calc.) = 60°

Cell Data: *Space Group:* $C2/c$ or Cc. $a = 10.152(8)$ $b = 24.14(3)$ $c = 6.308(6)$ $\beta = 91.14(7)°$ Z = 2

X-ray Powder Pattern: Mangualde pegmatite, Portugal.
5.18 (10), 12.00 (6), 2.907 (5), 3.150 (4), 6.31 (3), 9.38 (2), 2.985 (2)

Chemistry:

	(1)	(2)
P_2O_5	34.8	32.94
Al_2O_3	7.7	
Fe_2O_3	14.1	24.71
MnO	4.8	5.49
MgO	0.2	
CaO	18.0	17.35
H_2O	[20.4]	19.51
Total	[100.0]	100.00

(1) Mangualde pegmatite, Portugal; by electron microprobe, total Fe as Fe_2O_3, total Mn as MnO, H_2O by difference; corresponds to $Ca_{3.96}(Mn_{0.83}Mg_{0.06})_{\Sigma=0.89}(Fe_{2.18}Al_{1.86})_{\Sigma=4.04}(PO_4)_{6.05}(OH)_{3.67} \cdot 12.13H_2O$. (2) $Ca_4MnFe_4(PO_4)_6(OH)_4 \cdot 12H_2O$.

Mineral Group: Montgomeryite group; Mn > Mg or Fe^{2+}; Fe^{3+} > Al.

Occurrence: Initially found on a museum specimen from a complex zoned granite pegmatite.

Association: Jahnsite-(CaMnMn), huréaulite, phosphosiderite, varulite, microcline.

Distribution: From the Mangualde pegmatite, near Mesquitela, Portugal.

Name: To honor Peter Zodac (1894–1967), American founder of Rocks and Minerals magazine.

Type Material: Canadian Museum of Nature, Ottawa, Canada, 53452; National Museum of Natural History, Washington, D.C., USA, 149953.

References: (1) Dunn, P.J., J.D. Grice, and W.C. Metropolis (1988) Zodacite, the Mn analogue of montgomeryite, from Mangualde, Portugal. Amer. Mineral., 73, 1179–1181.

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Zoisite $Ca_2Al_3(SiO_4)(Si_2O_7)O(OH)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals prismatic, to 10 cm, typically deeply striated ‖ [010] and poorly terminated; columnar to compact, massive.

Physical Properties: *Cleavage:* {010}, perfect; {100}, imperfect. *Fracture:* Uneven, conchoidal. *Tenacity:* Brittle. Hardness = 6–7 D(meas.) = 3.15–3.36 D(calc.) = 3.35

Optical Properties: Transparent to translucent. *Color:* White, gray, greenish brown, greenish gray, pink, blue, purple; colorless to pink in thin section. *Luster:* Vitreous, pearly on cleavage. *Optical Class:* Biaxial (+). *Pleochroism:* X = pale pink to red-violet; Y = nearly colorless to bright pink or deep blue; Z = pale yellow to yellow-green. *Orientation:* $X = b$; $Y = c$; $Z = a$. *Dispersion:* $r > v$ or $r < v$, strong. α = 1.685–1.707 β = 1.688–1.711 γ = 1.697–1.725 2V(meas.) = 0°–69°

Cell Data: *Space Group: Pnma.* $a = 16.1909(15)$ $b = 5.5466(5)$ $c = 10.0323(6)$ Z = 4

X-ray Powder Pattern: Synthetic.
2.693 (100), 2.874 (65), 4.03 (50), 8.09 (40), 2.019 (35), 1.601 (35), 5.01 (30)

Chemistry:

	(1)		(1)
SiO_2	39.55	MgO	0.07
Al_2O_3	33.39	CaO	[24.44]
Fe_2O_3	0.04	SrO	0.05
V_2O_3	0.20	H_2O^+	2.00
		Total	[99.74]

(1) "Umba Valley," Tanzania; CaO originally given as 22.44%, and total given as 99.69%; corresponds to $(Ca_{1.99}Mg_{0.01})_{\Sigma=2.00}(Al_{2.98}V_{0.01})_{\Sigma=2.99}Si_3O_{12}(OH)_{1.01}$.

Polymorphism & Series: Dimorphous with clinozoisite.

Mineral Group: Epidote group.

Occurrence: Typically in medium-grade regionally metamorphosed crystalline schists formed from igneous, sedimentary, or metamorphic rocks relatively high in calcium; in eclogites and blueschist facies metamorphic rocks.

Association: Garnet, albite, biotite, "hornblende," quartz, calcite.

Distribution: Widespread. Classic localities for fine crystals and decorative rocks follow. On the Saualpe, Carinthia, and in the Zillertal, Tirol, Austria. From near Trondheim, Norway. In the USA, at Goshen and Williamsburg, Hampshire Co., Massachusetts; in the Keystone quarry, near Cornog, Chester Co., Pennsylvania; at Milford Heights, Baltimore Co., Maryland. From around Spruce Pine, Mitchell Co., North Carolina; from Ducktown, Polk Co., Tennessee; in Washington, in the Tunk Creek area, east of Riverside, Okanogan Co. From Asbestos, Quebec, Canada. In the Juarez district, Baja California, Mexico. From Tanzania, exceptional gem material in the Merelani Hills, Lelatema Mountains, 40 km southeast of Arusha. Well crystallized from Alchuri village, Shigar Valley, Baltistan, Pakistan.

Name: For Siegmund Zois, Baron von Edelstein (1747–1819), Austrian supporter of mineralogy who supplied the first specimens.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 513–515. (2) Deer, W.A., R.A. Howie, and J. Zussman (1986) Rock-forming minerals, (2nd edition), v. 1B, disilicates and ring silicates, 4–43. (3) Pistorius, C.W.F.T. (1961) Synthesis and lattice constants of pure zoisite and clinozoisite. J. Geol., 69, 604–609. (4) Hurlbut, C.S., Jr. (1969) Gem zoisite from Tanzania. Amer. Mineral., 54, 702–709. (5) Smith, J.V., J.J. Pluth, J.W. Richardson, Jr., and Å. Kvick (1987) Neutron diffraction study of zoisite at 15 K and X-ray study at room temperature. Zeits. Krist., 179, 305–321.

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Zorite $Na_6(Ti,Nb)_5(Si_6O_{17})_2(O,OH)_5 \cdot 11H_2O(?)$

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Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$ or $mm2$. As intergrowths of prismatic, acicular crystals, to 2 mm, and as polycrystalline plates, perhaps pseudomorphs.

Physical Properties: *Cleavage:* {010} and {001}, perfect; {110}, less so. Hardness = 3–4 D(meas.) = 2.27–2.40 D(calc.) = 2.23

Optical Properties: Semitransparent. *Color:* Rose. *Luster:* Vitreous. *Optical Class:* Biaxial. *Pleochroism:* X = rose; Y = nearly colorless; Z = bluish. α = n.d. β = n.d. γ = n.d. 2V(meas.) = n.d.

Cell Data: *Space Group:* $Cmcm$, $Cmc2_1$, or $C2cm$. $a = 23.9(1)$ $b = 7.23(2)$ $c = 14.24(5)$ Z = 6

X-ray Powder Pattern: Lovozero massif, Russia.
6.9 (100), 11.6 (80), 3.38 (80), 3.067 (80), 2.979 (80), 2.588 (80), 1.742 (80)

Chemistry:

	(1)		(1)
SiO_2	41.70	Na_2O	15.09
TiO_2	15.21	K_2O	0.69
ZrO_2	0.21	F	0.29
Al_2O_3	4.92	H_2O^+	11.31
Fe_2O_3	0.53	H_2O^-	3.17
$(Nb,Ta)_2O_5$	5.95	CO_2	0.18
MnO	0.10	P_2O_5	0.05
MgO	0.10	$-O = F_2$	0.11
CaO	0.58	Total	99.97

(1) Lovozero massif, Russia; spectrographic traces of Ta, Pb, Ba, Be.

Occurrence: On walls of fractures filled with nepheline in the central natrolite region of a pegmatite vein in a differentiated alkalic massif.

Association: Nepheline, aegirine, mountainite, natrolite, raite.

Distribution: In the Jubilee pegmatite, on Mt. Karnasurt, Lovozero massif, Kola Peninsula, Russia.

Name: In reference to the Russian for "the rosy radiance of the sky at dawn" for the color.

Type Material: Geology Museum, Kola Branch, Academy of Sciences, Apatity, 3144, 3207; Mineralogical Museum, St. Petersburg University, St. Petersburg, 15286, 18102, 18155; Mining Institute, St. Petersburg, 1059/1–5; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 74486–74488.

References: (1) Mer'kov, A.N., I.V. Bussen, E.A. Goiko, E.A. Kul'chitskaya, Y.P. Men'shikov, and A.P. Nedorezova (1973) Raite and zorite, new minerals from the Lovozero Tundra. Zap. Vses. Mineral. Obshch., 102, 54–62 (in Russian). (2) (1973) Amer. Mineral., 58, 1113–1114 (abs. ref. 1). (3) Sandomirskii, P.A. and N.V. Belov (1979) The OD structure of zorite. Kristallografiya (Sov. Phys. Crystal.), 24, 1198–1210 (in Russian).

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Crystal Data: Orthorhombic. *Point Group:* n.d. Long, irregular lath-shaped grains to 0.5 mm.

Physical Properties: *Fracture:* Uneven. Hardness = ~3 VHN = 154–170, 166 average (15.2 g load). D(meas.) = n.d. D(calc.) = 5.15

Optical Properties: Opaque. *Color:* Steel-gray; in reflected light, white with a faint yellowish tint to light gray. *Streak:* Black. *Luster:* Metallic. *Anisotropism:* Strong, from light to dark gray with a faint greenish tint.
R_1–R_2: (400) — , (420) 38.6–44.3, (440) 38.5–44.0, (460) 38.4–44.0, (480) 38.0–43.7, (500) 37.9–43.8, (520) 37.9–43.9, (540) 37.6–43.6, (560) 37.4–43.1, (580) 36.9–42.6, (600) 36.5–41.9, (620) 36.2–41.5, (640) 35.6–40.9, (660) 35.4–40.2, (680) 34.9–39.2, (700) 34.2–38.1

Cell Data: *Space Group:* n.d. $a = 18.698(8)$ $b = 6.492(3)$ $c = 4.577(1)$ $Z = 1$

X-ray Powder Pattern: Příbram, Czechoslovakia.
1.797 (10), 2.222 (9), 1.325 (8), 2.392 (6), 3.070 (5), 1.956 (5), 3.670 (4)

Chemistry:

	(1)	(2)	(3)
Ag	5.75	5.88	6.18
Pb	46.30	47.26	47.52
Zn	0.35	0.22	
Cu	0.27	0.22	
Fe	0.02	0.05	
Sb	27.39	28.53	27.92
S	18.30	18.75	18.38
Total	98.38	100.91	100.00

(1–2) Příbram, Czechoslovakia; by electron microprobe, each an average of 15 analyses on 2 different specimens, corresponding to $(Ag_{0.93}Cu_{0.07})_{\Sigma=1.00}(Pb_{3.92}Zn_{0.10}Fe_{0.01})_{\Sigma=4.03}Sb_{3.94}S_{10.00}$. (3) $AgPb_4Sb_4S_{10}$.

Occurrence: In hydrothermal veins.

Association: Boulangerite, galena, diaphorite, argentian tetrahedrite, sphalerite.

Distribution: From Příbram, Czechoslovakia.

Name: To honor Academician Vladimír Zoubek, former Director of the Geological Survey and Geological Institute of the Czechoslovak Academy of Science, Prague, Czechoslovakia.

Type Material: Mining Museum, Příbram, 432, 220; Department of Mineralogy, National Museum, Prague, Czechoslovakia.

References: (1) Megarskaya, L., D. Rykl, and Z. Táborský (1986) Zoubekite, $AgPb_4Sb_4S_{10}$, a new mineral from Příbram, Czechoslovakia. Neues Jahrb. Mineral., Monatsh., 1–7. (2) (1987) Amer. Mineral., 72, 227 (abs. ref. 1).

Zugshunstite-(Ce) $(Ce,Nd)Al(SO_4)_2(C_2O_4)\cdot 12H_2O$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Stubby crystals, somewhat elongated along [100], showing {010} and {012}, with minor {111}, to 1 mm; in subparallel aggregates.

Physical Properties: *Cleavage:* On {010}, poor. *Fracture:* Irregular. *Tenacity:* Brittle. Hardness = n.d. D(meas.) = n.d. D(calc.) = 2.121 Soluble in H_2O.

Optical Properties: Semitransparent. *Color:* Very pale pink under incandescent light, pale blue under fluorescent room light. *Streak:* White.
Optical Class: Biaxial (+). *Dispersion:* $r > v$, medium. $\alpha = 1.455(5)$ $\beta = 1.485(2)$ $\gamma = 1.528(3)$ 2V(meas.) = 85(5)°

Cell Data: *Space Group:* $C2/c$. $a = 8.718(1)$ $b = 18.313(2)$ $c = 13.128(2)$ $\beta = 93.90(1)°$ Z = 4

X-ray Powder Pattern: Alum Cave Bluff, Tennessee, USA.
7.9 (100), 3.93 (70), 5.36 (50), 5.01 (40), 3.74 (20), 3.29 (20), 3.07 (20)

Chemistry:

	(1)		(1)
SO_3	24.01	Sm_2O_3	0.80
C_2O_3	[10.80]	Eu_2O_3	0.27
Al_2O_3	6.92	Gd_2O_3	0.14
La_2O_3	2.16	Fe_2O_3	1.11
Ce_2O_3	13.17	CaO	0.04
Pr_2O_3	1.68	H_2O	[32.41]
Nd_2O_3	6.50	Total	[100.01]

(1) Alum Cave Bluff, Tennessee, USA; by electron microprobe, C_2O_3 and H_2O calculated from stoichiometry; corresponding to $(Ce_{0.54}Nd_{0.26}La_{0.09}Pr_{0.07}Sm_{0.03}Eu_{0.01}Gd_{0.01})_{\Sigma=1.01}Al_{1.00}(SO_4)_{2.00}(C_{2.00}O_4)\cdot 12.00H_2O$.

Occurrence: Formed by evaporative precipitation during weathering of pyritiferous phyllite, the rare earths probably derived from monazite and xenotime.

Association: Levinsonite-(Y), epsomite, halotrichite.

Distribution: From Alum Cave Bluff, Great Smoky Mountains National Park, Tennessee, USA.

Name: Derived from the Cherokee Indian term for the Great Smoky Mountains, source of the mineral.

Type Material: University of Michigan, Ann Arbor, Michigan; National Museum of Natural History, Washington, D.C., USA.

References: (1) Rouse, R.C., D.R. Peacor, E.J. Essene, T.D. Coskren, and R.J. Lauf (2001) The new minerals levinsonite-(Y) $[(Y,Nd,Ce)Al(SO_4)_2(C_2O_4)\cdot 12H_2O]$ and zugshunstite-(Ce) $[(Ce,Nd,La)Al(SO_4)_2(C_2O_4)\cdot 12H_2O]$: coexisting oxalates with different structures and differentiation of LREE and HREE. Geochim. Cosmochim. Acta, 65, 1101–1115. (2) (2001) Amer. Mineral., 86, 1535–1536 (abs. ref. 1).

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Zunyite $Al_{13}Si_5O_{20}Cl(OH,F)_{18}$

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Crystal Data: Cubic. *Point Group:* $\bar{4}3m$. As excellent tetrahedral or pseudo-octahedral crystals, may be modified by the cube, up to 2 cm. *Twinning:* On {111}, contact and penetration.

Physical Properties: *Cleavage:* Good on {111}. *Tenacity:* Brittle. Hardness = 7
D(meas.) = 2.874(5) D(calc.) = 2.87–2.90 May fluoresce red under UV.

Optical Properties: Transparent; may be more or less opaque from inclusions. *Color:* Grayish white, flesh-red; colorless in thin section. *Luster:* Vitreous.
Optical Class: Isotropic. $n = 1.592$–1.600

Cell Data: *Space Group:* $F\bar{4}3m$. a = 13.8654–13.8882 Z = 4

X-ray Powder Pattern: Beni-Embarek, Algeria.
8.07 (100), 4.21 (100), 2.679 (90), 1.639 (90), 4.02 (60), 2.840 (50), 2.008 (50)

Chemistry:

	(1)
SiO_2	24.33
Al_2O_3	57.88
Fe_2O_3	0.20
Li_2O	trace
Na_2O	0.24
K_2O	0.10
F	5.61
Cl	2.91
H_2O	10.89
P_2O_5	0.60
$-O = (F,Cl)_2$	3.02
Total	99.74

(1) Zuñi mine, Colorado, USA; corresponds to $Al_{13.21}Fe^{3+}_{0.03}P_{0.10}Si_{4.66}O_{20}Cl_{0.96}[(OH)_{14.04}F_{3.44}]_{\Sigma=17.48}$.

Occurrence: In highly aluminous shales and hydrothermally altered volcanic rocks.

Association: Pyrophyllite, kaolinite, alunite, diaspore, rutile, pyrite, hematite, quartz.

Distribution: In the USA, in the Zuñi mine, near Silverton, San Juan Co., and in the Charter Oak mine, Ouray Co., Colorado; near Silver City, Tintic district, Juab Co., Utah; in the Dome Rock Mountains, near Quartzsite, La Paz Co., Arizona, large crystals. At Postmasburg, Cape Province, South Africa. From Balıkesir, Balıkesir Province, Turkey. At Beni Embarek, Algeria. From Aït Azegour, High Atlas Mountains, Morocco. At Banská Belá, Banská Štiavnica district, Slovakia. In the Embleton quarry, near Cockermouth, Cumbria, England. From Aksakat, Uzbekistan. At Kochi, Iwate Prefecture; Iriyama, Gumma Prefecture; and several mines in Nagano Prefecture, Japan. Several other localities are known.

Name: For the Zuñi mine, Colorado, USA, where it was discovered.

Type Material: National Museum of Natural History, Washington, D.C., USA, 49082.

References: (1) Dana, E.S. (1892) Dana's system of mineralogy, (6th edition), 436.
(2) Vermaas, F.H.S. (1952) Zunyite from Postmasburg, South Africa. Amer. Mineral., 37, 960–965. (3) Turco, G. (1962) La zunyite: recherches expérimentales physico-chemiques en liaison avec l'étude du nouveau gisement de Beni-Embarek. Bull. Soc. fr. Minéral., 85, 407–458 (in French). (4) Baur, W.H. and T. Ohta (1982) The Si_5O_{16} pentamer in zunyite refined and empirical relations for individual silicon–oxygen bonds. Acta Cryst., 38, 390–401.

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Zussmanite $K(Fe^{2+}, Mg, Mn^{2+})_{13}(Si, Al)_{18}O_{42}(OH)_{14}$

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Crystal Data: Hexagonal. *Point Group:* 3 or $\overline{3}$. As tabular crystals, to about 1 mm.

Physical Properties: *Cleavage:* {0001}, perfect. Hardness = n.d. D(meas.) = 3.146 D(calc.) = [3.14]

Optical Properties: Translucent. *Color:* Pale green in thin section. *Luster:* Vitreous. *Optical Class:* Uniaxial (–). *Pleochroism:* Weak; O = pale green; E = colorless. $\omega = 1.643$ $\epsilon = 1.623$

Cell Data: *Space Group:* $R3$ or $R\overline{3}$. $a = 11.66(2)$ $c = 28.69(2)$ Z = 3

X-ray Powder Pattern: Laytonville district, California, USA. (ICDD 19-1500). 9.60 (100), 4.78 (45), 3.19 (25), 2.51 (16), 3.78 (10), 2.74 (10), 2.20 (10)

Chemistry: (1) No chemical analysis appears to have been published; the type description, however, gives the empirical formula $(K_{0.92}Na_{0.07})_{\Sigma=0.99}(Fe^{2+}_{10.85}Mg_{1.33}Mn_{0.46}Al_{0.34}Fe^{3+}_{0.11}Ti_{0.01})_{\Sigma=13.10}(Si_{16.6}Al_{1.4})_{\Sigma=18.0}O_{42.2}(OH)_{13.8}$.

Occurrence: In an exotic block of metamorphosed shales, siliceous ironstones, and impure limestones, probably representing deep ocean sediments subjected to blueschist facies metamorphism.

Association: Deerite, howieite, stilpnomelane, spessartine, riebeckite, quartz, aegirine, grunerite, aragonite, manganoan siderite, ferroan kutnohorite, graphite.

Distribution: In the Laytonville quarry, Mendocino Co., California, USA.

Name: For Jack Zussman (1924–), mineralogist-crystallographer, Manchester University, Manchester, England.

Type Material: National Museum of Natural History, Washington, D.C., USA, 109454; The Natural History Museum, London, England, 1964,545.

References: (1) Agrell, S.O., M.G. Bown, and D. McKie (1965) Deerite, howieite and zussmanite, three new minerals from the Franciscan of the Laytonville District, Mendocino Co., California. MSA meeting, Bozeman, Montana, July 26–31, 1964. Amer. Mineral., 50, 278 (abs.). (2) Lopes-Vieira, A. and J. Zussman (1969) Further detail on the crystal structure of zussmanite. Mineral. Mag., 37, 49–60. (3) Muir Wood, R. (1980) The iron-rich blueschist-facies minerals: 3. Zussmanite and related minerals. Mineral. Mag., 43, 605–614. 5/9/91

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Zvyaginite $NaZnNb_2Ti[Si_2O_7]_2O(OH,F)_3(H_2O)_{4+x}$ ($x < 1$)

Crystal Data: Triclinic. *Point Group*: $\bar{1}$. As rectangular platy crystals to 2 cm, flattened on {001}, probably pseudomorphs after vuonnemite.

Physical Properties: *Cleavage*: Perfect on {001}, two other distinct sets are nearly perpendicular to each other and to {001} under a microscope. *Fracture*: Stepped. *Tenacity*: Brittle. Hardness = 2.5-3 D(meas.) = 2.88(3) D(calc.) = 2.94

Optical Properties: Transparent to translucent. *Color*: Colorless, pearly-white, creamy, yellowish brown, pale pink or lilac-pink. *Streak*: White. *Luster*: Pearly on crystal faces, greasy on breaks. *Optical Class*: Biaxial (-). $\alpha = 1.626(5)$ $\beta = 1.714(3)$ $\gamma = 1.740(5)$ 2V(meas.) = 45(15)° 2V(calc.) = 55° *Dispersion*: Weak, $r < v$. *Orientation: Y* and *Z* in the (001) plane.

Cell Data: *Space Group*: $P\bar{1}$. $a = 8.975(3)$ $b = 8.979(3)$ $c = 12.135(4)$ $\alpha = 74.328(9)°$ $\beta = 80.651(8)°$ $\gamma = 73.959(8)°$ Z = 2

X-ray Powder Pattern: Mt. Malyi Punkaruaiv, Lovozero complex, Kola Peninsula, Russia. 11.72 (100), 4.289 (86), 2.862 (72), 2.916 (57), 5.28 (53), 5.83 (40), 3.896 (36)

Chemistry:

	(1)	(2)		(1)	(2)
Na_2O	4.74	3.89	SiO_2	29.42	30.13
K_2O	0.22		TiO_2	12.33	10.02
CaO	0.77		Nb_2O_5	27.22	33.33
MnO	1.36		F	1.94	
FeO	0.24		H_2O	12.65	12.43
ZnO	9.61	10.20	$-O=F_2$	0.82	.
Al_2O_3	0.19		Total	99.87	100.00

(1) Mt. Malyi Punkaruaiv, Kola Peninsula, Russia; average of 5 electron microprobe analyses, H_2O by modified Penfield method; corresponding to $Na_{1.24}K_{0.04}Ca_{0.11}Mn_{0.16}Fe_{0.03}Zn_{0.96}Nb_{1.66}Ti_{1.25}(Si_{3.97}Al_{0.03})_{\Sigma=4}O_{15.07}(OH)_{2.10}F_{0.83}(H_2O)_{4.64}$. (2) $NaZnNb_2Ti[Si_2O_7]_2O(OH)_3(H_2O)_4$.

Mineral Group: Epistolite group.

Occurrence: In a hydrothermally-altered peralkaline pegmatite lens in a peripheral part of the ussingite core near its contact with the aegirine-eudialite zone; the pegmatite is part of a larger complex alkaline igneous intrusion. Possibly the product of a cation exchange reaction between epistolite and low-alkali aqueous (late hydrothermal) solutions enriched in Zn^{2+}.

Association: Microcline, sodalite, arfvedsonite, sphalerite, pectolite-sérandite, mangan-neptunite, murmanite, vigrishinite, epistolite, belovite-(Ce), steenstrupine, chkalovite, tugtupite, polylithionite, galenite.

Distribution: From pegmatite #71, Mt. Malyi Punkaruaiv, Lovozero alkaline complex, Kola Peninsula, Russia.

Name: Honors Russian crystallographer, crystal chemist and physicist Boris Borisovich Zvyagin (1921-2002), who was a pioneer and expert in electron diffraction studies of materials.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (# 94140).

References: (1) Pekov, I.V., I.S. Lykova, N.V. Chukanov, V.O. Yapaskurt, D.I. Belakovskiy, A.A. Zolotarev Jr., and N.V. Zubkova (2014) Zvyaginite $NaZnNb_2Ti[Si_2O_7]_2O(OH,F)_3(H_2O)_{4+x}$ ($x < 1$) - a new mineral of the epistolite group from the Lovozero alkaline pluton, Kola Peninsula, Russia. Zap. Ross. Mineral. Obshch., 143(2), 45-63 (in Russian with English abstract). Geol. Ore Deposits, 56(8), 644-656 (in English). (2) (2015) Amer. Mineral., 100, 338-339 (abs. ref. 1).

Zvyagintsevite $(Pd, Pt, Au)_3(Pb, Sn)$

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Crystal Data: Cubic. *Point Group:* $4/m\ \overline{3}\ 2/m$. As irregular grains up to 250 μm; massive in veinlets up to 120 μm long.

Physical Properties: Hardness = n.d. VHN = 241–318, 279 average (15 g load). D(meas.) = 13.32 (synthetic). D(calc.) = 13.42

Optical Properties: Opaque. *Color:* In reflected light, bright white with a cream tint. *Streak:* Black. *Luster:* Metallic.

R: (400) — , (420) — , (440) 62.0, (460) 63.3, (480) 63.0, (500) 63.7, (520) 64.6, (540) 65.5, (560) 66.7, (580) 67.7, (600) 67.4, (620) 67.3, (640) 67.9, (660) 68.0, (680) 68.0, (700) 68.1

Cell Data: *Space Group: Pm3m* (synthetic). a = 4.02(1) Z = 1

X-ray Powder Pattern: Synthetic Pd_3Pb.
2.32 (100), 1.215 (90), 2.01 (80), 1.423 (70), 0.923 (60), 0.900 (50), 1.163 (40)

Chemistry:

	(1)	(2)
Pd	55.0	57.3
Pt	7.5	
Au		3.6
Pb	25.0	38.7
Sn	12.0	
Cu	1.0	
Fe	1.0	
Ni	1.0	
Total	102.5	99.6

(1–2) Noril'sk region, Russia; by electron microprobe, averages.

Occurrence: As small irregular grains and veinlets in copper sulfides, associated with differentiated gabbro-diabase intrusives (Noril'sk region, Russia).

Association: Pt–Fe alloy, polarite, talnakhite, cubanite, pentlandite, magnetite, valleriite, Ag–Au alloy (Noril'sk region, Russia).

Distribution: From the Zapolyarni and Taimryskii mines, Noril'sk region, western Siberia, Russia. From the Upper and Banded zones of the Stillwater complex, Montana, USA. In the Kirakkajuppura deposit, Penikat layered complex, northeast of Kemi, Finland.

Name: For Professor Orest Evgen'evich Zvyagintsev (1894–1967), who did geochemical research on the platinum metals, Institute of General andInorganic Chemistry, Moscow, Russia.

Type Material: Canadian Geological Survey, Ottawa, Canada, 10401; A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 73001.

References: (1) Genkin, A.D., I.V. Murav'eve, and N.V. Troneva (1966) Zvyagintsevite, a natural intermetallic compound of palladium, platinum, lead and tin. Geol. Rudn. Mestorozhd., 8, 94–100 (in Russian). (2) (1967) Amer. Mineral., 52, 299 (abs. ref. 1). (3) Cabri, L.J. and R.J. Traill (1966) New palladium minerals from Noril'sk, western Siberia. Can. Mineral., 8, 541–550. (4) (1967) Amer. Mineral., 52, 1587 (abs. ref. 3). (5) Cabri, L.J., Ed. (1981) Platinum group elements: mineralogy, geology, recovery. Can. Inst. Min. & Met., 147.

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Zwieselite $(Fe^{2+}, Mn^{2+})_2(PO_4)F$

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Crystal Data: Monoclinic. *Point Group:* $2/m$. Cleavable, massive, to several cm.

Physical Properties: *Cleavage:* [On {001}, good; on {010}, fair; on {100}, poor] (by analogy to triplite). *Fracture:* [Uneven to subconchoidal.] Hardness = [5–5.5] D(meas.) = 3.89–3.97 D(calc.) = 3.92

Optical Properties: Translucent to opaque. *Color:* Dark brown, clove-brown, yellowish brown; brownish black to black if altered. *Luster:* Vitreous to resinous.
Optical Class: Biaxial (+). *Pleochroism:* [Distinct; yellow-brown to reddish brown.]
Dispersion: [$r > v$, , moderate to strong.] $\alpha = 1.696$ $\beta = 1.704$ $\gamma = 1.713$ 2V(meas.) = n.d.

Cell Data: *Space Group:* $I2/a$. $a = 12.085$ $b = 6.536$ $c = 9.910$ $\beta = 105°38'$ Z = 8

X-ray Powder Pattern: Horní Slavkov, Czech Republic; close to triplite.
2.874 (10), 3.053 (9), 3.257 (7), 3.695 (5), 3.431 (4), 2.120 (4), 2.024 (4)

Chemistry:

	(1)	(2)
P_2O_5	32.85	31.58
FeO	41.96	31.97
MnO	18.40	31.56
MgO	0.80	
CaO	1.69	
F	7.21	8.45
$-O = F_2$	3.03	3.56
Total	99.88	100.00

(1) Hühnerkobel, Germany. (2) $(Fe, Mn)_2(PO_4)F$ with Fe:Mn = 1:1.

Mineral Group: Forms a series with triplite.

Occurrence: A primary phosphate in complex zoned granite pegmatites.

Association: Triphylite, huréaulite, rockbridgeite.

Distribution: In Germany, in Bavaria, from Hühnerkobel and in the Birkhöhe pegmatite, near Zwiesel; at Hörlberg; from Döfering; and at Hagendorf. From Horní Slavkov (Schlaggenwald), Czech Republic. In the Mangualde pegmatite, near Mesquitela, Portugal. At the Tremearne pegmatite, Breage, Cornwall, England. From the Storm Mountain pegmatite, Larimer Co., Colorado, USA.

Name: For its first-noted occurrence at Hühnerkobel, nearby Zwiesel and Rabenstein, Germany.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 849–852 [zwieselite, part]. (2) Pfaffl, F.A. (1986) Chemical composition of zwieselite. Int. Mineral. Assoc. 14th Meeting (abs. with prog.), 198. (3) Fisher, D.J. (1957) Isokite and triplite from Bohemia. Mineral. Mag., 31, 587–602.

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Zýkaite $Fe_4^{3+}(AsO_4)_3(SO_4)(OH)\cdot 15H_2O$

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Crystal Data: Orthorhombic. *Point Group:* n.d. Fine acicular crystals, to 0.02 mm, covering and composing nodules, to 3 cm, and as a massive cavity filling.

Physical Properties: *Fracture:* Uneven. *Tenacity:* Greasy. Hardness = Very soft. D(meas.) = 2.50 D(calc.) = 2.504

Optical Properties: Semitransparent. *Color:* Grayish white with pale yellowish green or brownish tint; colorless in transmitted light. *Streak:* Pale yellowish. *Luster:* Dull. *Optical Class:* Biaxial (–). *Orientation:* Positive elongation, parallel extinction. $\alpha = 1.632$ β = n.d. $\gamma = 1.646$ 2V(meas.) = Large.

Cell Data: *Space Group:* n.d. $a = 20.853(20)$ $b = 7.033(4)$ $c = 36.991(23)$ Z = 8

X-ray Powder Pattern: Kaňk, Czech Republic.
10.4 (10), 10.6 (7), 6.92 (4), 5.610 (4), 3.812 (4), 2.831 (4), 3.516 (3)

Chemistry:

	(1)	(2)
SO_3	8.36	7.82
P_2O_5	0.12	
As_2O_5	33.67	33.69
Fe_2O_3	30.58	31.21
CaO	0.02	
H_2O	26.50	27.28
insol.	0.49	
Total	99.74	100.00

(1) Kaňk, Czech Republic; average of two analyses, H_2O by TGA; after deduction of gypsum, corresponds to $Fe_{3.96}[(AsO_4)_{3.03}(PO_4)_{0.02}]_{\Sigma=3.05}(SO_4)_{1.08}(OH)\cdot 14.91H_2O$.
(2) $Fe_4(AsO_4)_3(SO_4)(OH)\cdot 15H_2O$.

Occurrence: An alteration product of arsenopyrite and pyrite in ancient mine dumps.

Association: Kaňkite, scorodite, pitticite, "limonite", arsenopyrite, gypsum, quartz.

Distribution: From the Šafary mine dump, near Kaňk, Kutná Hora district, Czech Republic.

Name: To honor Dr. Václav Zýka (1926–), Director, Institute of Raw Materials, Kutná Hora, Czech Republic.

Type Material: Charles University, Prague, Czech Republic, 20558; National School of Mines, Paris, France; National Museum of Natural History, Washington, D.C., USA, 144940, 144941.

References: (1) Čech, F., J. Jansa, and F. Novák (1978) Zýkaite, $Fe_4^{3+}(AsO_4)_3(SO_4)(OH)\cdot 15H_2O$, a new mineral. Neues Jahrb. Mineral., Monatsh., 134–144. (2) (1978) Amer. Mineral., 63, 1284 (abs. ref. 1).

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